Information Request Package 5 from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment: Responses

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IR5-01 Marine Shipping – Anchorages

Information Source(s)

EIS Volume 1: Section 4.4.2.1

Marine Shipping Addendum: Section 4.2.2.2

EIS Volume 5: Section 30.4.5

Proponent Response to IR1-01 (CEAR Doc#897): Section 14.6 Appendix IR1-01-A

Context

In Section 4.4.2.1 of the EIS, the Proponent stated that there are no plans, or foreseen terminal operating requirements, for off-terminal anchoring of container ships waiting for a berth at the new marine terminal and that container ships operate on a scheduled service, usually between Asia and the West Coast, and adjust their speeds as required to arrive at the terminal within their assigned berthing window.

The Proponent further stated that exceptions could occur in the event of an extreme storm in the Pacific, resulting in a refuge anchorage requirement for safety reasons, or to accommodate unexpected ship specific maintenance, accidents, personnel or operation issues that may arise.

According to the Proponent, container ship anchorages for Deltaport Terminal in 2012 and 2013 had a frequency range of 3 to 4 per year out of an approximate annual total of 270 ship calls. The Proponent proposed that the same frequency can be assumed for the proposed Project, resulting in approximately one unforeseen container ship anchorage every 1.5 to 2 months (6-8 per year) for the two Roberts Bank container terminals, or one anchorage every three to four months (3-4 per year) for the Project alone. These vessels would use existing anchorages in English Bay, or in the Gulf Islands, as determined by the pilot and the port authority having jurisdiction. The Proponent stated that, in the case of an accident, a decision could be taken to tow the vessel with tug assistance to a safe anchorage. In such a case, there is no reference to priority sites.

Some participants in the environmental assessment, including Indigenous groups, have questioned these estimates of current and future frequency of anchorage use by Roberts Bank terminal vessels. They have underlined the lack of contingency plans for potential disruption during construction requiring last minute refuge for ships.

In Appendix IR1-01-A of its response to Review Panel information request IR1-01, the Proponent presented the list of anchorage sites under its jurisdiction; the practices and procedures that would be applied to these anchorages such as the maximum length of stay; and the non-availability of anchorage sites.

No information was given on the current or projected use of anchorage sites in the Gulf Islands by the Proponent; the need or projected need for additional sites under the Proponent's jurisdiction; or contingency plans for potential disruptions during construction and operation of the Project.

Information Request

Provide a map showing the location of existing anchorage sites - both under and outside of the Proponent's jurisdiction - that could be used by Roberts Bank terminal vessels during construction and operation of the proposed Project.

Provide details of contingency plans to meet anchorage needs of the existing Roberts Bank terminals during potential disruptions from Project construction, such as an emergency navigation closure, that may occur during the five and a half year construction period of the proposed Project.

Describe measures that would be taken when the maximum number of days (seven) allowed at anchorages under the Proponent's jurisdiction is reached.

Confirm the need for any new anchorage sites for the Project that would be located under the Proponent's jurisdiction during construction and operation of the Project.

VFPA Response

Provide a map showing the location of existing anchorage sites - both under and outside of the Proponent's jurisdiction - that could be used by Roberts Bank terminal vessels during construction and operation of the proposed Project.

Existing anchorage locations are provided in a map in Transport Canada Appendix C Figure 1 of CEAR Document #982[1], along with very detailed information regarding anchorages in its response to Panel information request TC IR-07. As part of this response, Appendix C (Pacific Pilotage Authority Marine Shipping Area Anchorage Locations and Specifications) provided the longitudinal and latitude coordinates for all anchorages along with the associated maps for the anchorages outside of VFPA jurisdiction. The anchorages within VFPA jurisdiction are shown on pages 85 and 86 of the Port Information Guide issued as Appendix IR1-01-A in IR1-01 (CEAR Document #897[2]).

Anchorages that do not fall under the jurisdiction of a port authority, such as the VFPA or the Nanaimo Port Authority, may be used by commercial vessels as part of the common law right of navigation recognised by Canada. Therefore, any of these suitably sized anchorages, plus any assigned by the VFPA in its jurisdiction, could be used by RBT2-associated vessels during construction and operation, if necessary. Additional information on the management and use of anchorages has been provided by Transport Canada in the response to TCIR-07 in CEAR Document #982.

[1] CEAR Document #982 From Transport Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on May 10, 2017 (See Reference Document 962).
[2] CEAR Document #897 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 1 (See Reference Document #559).

Provide details of contingency plans to meet anchorage needs of the existing Roberts Bank terminals during potential disruptions from Project construction, such as an emergency navigation closure, that may occur during the five and a half year construction period of the proposed Project.

Navigation closure of the international shipping lanes adjacent to the Roberts Bank terminals requiring anchoring of vessels due to a construction disruption at RBT2 is a highly unlikely or improbable event. A major incident such as a ship collision, a ship sinking, or a major fire as a result of RBT2 construction could temporarily cause disruption of the RBT2 construction activities, but would likely not affect operation activities at Deltaport Terminal, Westshore Terminals, the B.C. Ferries Terminal, nor disrupt traffic in the international shipping lanes. In the event of a RBT2 construction-related navigation disruption, should one occur and depending on the location of the occurrence, vessels might be diverted around the incident area for the period until the situation has been contained, and would not likely anchor.

EIS Section 33.3.9 identifies that a Land and Marine Management Plan will be established as part of the Construction Environmental Management Plans. The marine portion of the plan will be based on the final design and construction approach to minimise interference with the adjacent terminals and shipping lanes. No additional contingency plans are anticipated to be required for emergency anchorages.

Describe measures that would be taken when the maximum number of days (seven) allowed at anchorages under the Proponent's jurisdiction is reached.

Based on Pacific Pilotage Authority Anchorage Usage Data for VFPA jurisdiction anchorages, container ships did not anchor for more than seven days, except in 2015, as shown in **Table IR5-01-1**.

Table IR5-01-1 Actual Anchorage Data for Container Vessels at VFPA Jurisdiction Anchorage Sites

		Duration of Anchorage (days)		
Year	**Number of Anchorages**	**Mean**	**Min**	**Max**
2012	13	1.63	0.13	5.09
2013	9	0.53	0.07	3.02
2014	16	1.88	0.12	5.40
2015	34	1.68	0.10	7.69
2016	26	1.01	0.05	2.99
Total	98			
Average		1.35	0.09	4.84

Data Source: TC IR-07, Appendix D (CEAR Document #982).

If a vessel has stayed for seven days and the anchorage is not required by another vessel, the VFPA can extend the anchorage period upon request. For the five-year period, the average mean for anchorage of a container ship was 1.35 days of the total of 98 anchorages in VFPA jurisdiction. As stated on page 121 of the Port Information Guide issued as Appendix IR1-01-A

in IR1-01 (CEAR Document #897), in the event a vessel stays longer than seven days at a VFPA anchorage, and the anchorage is required by another vessel, the vessel will be required to shift to a berth, or to an anchorage in Nanaimo Port Authority jurisdiction or the Gulf Islands[3]. The VFPA will endeavour to inform the ship's agent of a required shift with as much time as possible.

Transport Canada's response to information request TC IR-07 in CEAR Document #982 tabulates detailed information regarding anchorages and minimum, mean, and maximum number of days in Appendix D (Pacific Pilotage Authority Anchorage Usage Data 2012 – 2016 for the Pacific Pilotage Authority Marine Shipping Area). As shown in these tables, a total of 124 anchorages occurred between 2012 and 2016 for container vessels destined for VFPA jurisdiction, and the mean number of anchorage days was 2.69, with a minimum of 0.05 days and a maximum of 83.6[4] days.

Confirm the need for any new anchorage sites for the Project that would be located under the Proponent's jurisdiction during construction and operation of the Project.

For the construction phase, there are no new anchorages required since there are no large vessels such as container ships or bulk carriers envisioned to be required for the early years of construction. Large equipment supply vessels as depicted in EIS Figure 4-25 will arrive near the end of the construction phase and will dock directly at the new RBT2 berths and will not require anchorages. The same applies to container vessels that will deliver containers for the initial terminal testing prior to entering into the operation phase.

In the early years of construction, delivery of materials and supplies will be by tug and barges, which will offload at the temporary barge ramps as described in Section 4.0 of the EIS. Each barge ramp also has temporary moorages for two additional barges, thus not requiring any additional anchorages. These temporary moorages along with the barge ramps will be removed at the end of the construction phase.

In summary, neither the construction phase nor the operation phase of RBT2 will require new anchorages.

[3] As stated in TC IR-07 in CEAR Document #982, "They [anchorages outside of port authority jurisdiction] may be used freely by commercial vessels and their use is not assigned by any single authority. Rather, if a vessel requires an anchorage, it is the ship's shore-based agent who will instruct the vessel on where to go based on such factors as size, availability and the proximity to terminal. As these anchorages are located within a mandatory pilotage area, vessel masters collaborate with the Pacific Pilotage Authority (PPA) when moving to and from anchor, as mentioned above. The PPA has a 24-hour dispatch that helps to coordinate vessels to prevent two or more vessels from steaming to the same anchorage, however this is not a formal management role."

[4] This extraordinary anchorage duration was due to the receivership of South Korea's Hanjin Shipping Line with one vessel affected by this financial collapse anchoring for an extended period at a Plumper Sound anchorage (located between North Pender and Saturna islands).

IR5-01a Marine Shipping – Anchorages (Clarification)

Information Source(s)

EIS Volume 1: Section 4.4.2.1

Marine Shipping Addendum: Section 4.2.2.2

Proponent Response to Information Request IR1-01, Appendix IR1-01-A (CEAR Doc#897)

Proponent Response to Additional Information Requirements of June 6, 2017 (CEAR Doc#1078) IR5-01

Transport Canada Response to Information Request IR07 (CEAR Doc#982), Appendix C, Appendix D

Context

In response to IR-07, Appendix C (CEAR Doc#982), Transport Canada presented, for all segments of the Marine Shipping Area associated with the proposed Project, location maps and detailed information for each anchorage site, including latitude, longitude, maximum length overall, swing radius, maximum depth, and timing as to when and how the sites would be utilized (e.g. year-round, on a trial basis, for emergencies, conditions for vessels over 240 m requiring daily transit). Transport Canada advised the Panel that the Proponent should be consulted for information on anchorage sites under its jurisdiction.

In its response to IR5-01 on anchorage sites under its authority, the Proponent indicated that the information was reported in the anchorage tables in Appendix IR1-01-A (CEAR Doc#897); however, no data on the swing radius was provided, nor was a discussion provided on the need to accommodate future ships sizes during Project operations. Likewise, location maps for English Bay and Indian Arm were presented in Appendix IR1-01-A in Section 8.19 covering safe boating practices for recreational vessels; however, no maps were provided for anchorage locations at Roberts Bank and Sand Heads.

Further, according to the Proponent, container ship anchorages for Deltaport Terminal in 2012 and 2013 had a frequency range of 3 to 4 per year out of an approximate annual total of 270 ship calls. The Proponent proposed that the same frequency can be assumed for the Project, resulting in approximately one unforeseen container ship anchorage every 1.5 to 2 months (6-8 per year) for the Roberts Bank container terminals, or one anchorage every three to four months (3-4 per year) for the Project alone. These vessels would use existing anchorages in English Bay or in the Gulf Islands, as determined by the pilot and the port authority having jurisdiction.

In its response to IR5-01, the Proponent confirmed the information provided by Transport Canada (Doc#982, Appendix D), namely that there were 98 container vessel anchorage events at sites under its jurisdiction. The response mentioned that between 2012 and 2016, there were 124 anchorage events for container vessels.

In order to reconcile the Proponent statement on the frequency of anchorage sites used presently and needed in the future with the Project, information is required on the ports of call for these 124 container vessels.

Further, the Proponent indicated that a Land and Marine Management Plan will be established as part of the Construction Environmental Management Plans, and that no additional contingency plans are anticipated to be required for emergency anchorages. The Proponent further stated that the marine portion of the plan will be designed to minimize potential interference with adjacent terminals and shipping lanes. No information is provided as to how this would be done or how frequently the anchorage sites under the Proponent's jurisdiction could be used if and when the need arises for Deltaport and Westshore terminals.

Information Request

Provide a location map for anchorage sites at Roberts Bank and Sand Heads under the jurisdiction of the Proponent. Update the anchorages tables in Appendix IR1-01-A to include the swing radius for all sites under the Proponent's jurisdiction.

For the 124 anchorages events that occurred during the 2012-2016 period, indicate the port destination of each container vessel, for their inbound and outbound movements, that required anchorage at sites under the Proponent's jurisdiction and in other locations listed by Transport Canada in its response to the Panel (CEAR Doc#982, IR-07).

Indicate which anchorage sites, under the jurisdiction of the Proponent (English Bay, Indian Arm, Roberts Bank and Sand Heads) would be used during Roberts Bank Terminal 2 operations.

If the need arises during construction for vessels bound for Deltaport and Westshore terminals, indicate which of the sites could be considered for emergency events and would be part of the Land and Marine Management Plan.

VFPA Response

Provide a location map for anchorage sites at Roberts Bank and Sand Heads under the jurisdiction of the Proponent.

As discussed in the EIS and Marine Shipping Addendum (MSA), container vessels calling on terminals within the Port of Vancouver operate on a scheduled service and adjust their speeds as required to arrive at the terminal within an assigned arrival window. Thus, anchorages are anomalies and occur infrequently (approximately 3% of all vessel calls based on historical VFPA call data[1]) as a result of extreme storm events requiring refuge anchorage for safety reasons, or to accommodate unexpected ship-specific maintenance, personnel, or operation issues that may arise. The two VFPA anchorages at Roberts Bank and Sandheads are referred to as Anchorage R and Anchorage S, respectively. Both Anchorage R and Anchorage S are short-term anchorages that are also used under atypical operating conditions. These short-term anchorages allow a vessel to anchor while a berth space is being freed up at one of the Roberts Bank terminals, at Fraser Surrey Docks, or infrequently while waiting for tugs to

[1] In the period 2012 to 2016, the VFPA has recorded 4,059 container vessel calls against 129 instances of anchoring, which represents 3% of container vessels requiring an anchorage.

become available in case they are supporting another vessel for berthing/unberthing. These anchorages require the pilot to remain onboard during the short-term period.

Refer to Figure IR5-01a-A1 in **Appendix IR5-01a-A** for the location details of these two anchorages in relation to the Project site.

Update the anchorages tables in Appendix IR1-01-A to include the swing radius for all sites under the Proponent's jurisdiction.

The Port Information Guide referenced in Appendix IR1-01-A (CEAR Document #897[2]) was amended in May 2018[3]. The Anchorage Tables included in section 14.6 of this amended guide have been modified for the purposes of this information request to include the swing radius for each anchorage under the VFPA's jurisdiction (i.e., English Bay, Inner Harbour, Indian Arm, Roberts Bank, and Sandheads) and are included in **Appendix IR5-01a-B**.

For the 124 anchorages events that occurred during the 2012-2016 period, indicate the port destination of each container vessel, for their inbound and outbound movements, that required anchorage at sites under the Proponent's jurisdiction and in other locations listed by Transport Canada in its response to the Panel (CEAR Doc#982, IR-07).

To respond to this information request, the VFPA requested and received anchorage data for container ship anchorages for the 2012 to 2016 period from the Pacific Pilotage Authority (PPA). The result of filtering for only container ships resulted in a new total of 129 anchorages, instead of the previously identified 124 by Transport Canada in its response to the Panel (CEAR Document #982[4], TC IR-07). **Appendix IR5-01a-C** provides the details of the terminals associated with the 129 anchorages and whether the anchorage was during inbound or outbound movements. The destination following an outbound anchorage is not available in either PPA's or the VFPA's data.

Indicate which anchorage sites, under the jurisdiction of the Proponent (English Bay, Indian Arm, Roberts Bank and Sand Heads) would be used during Roberts Bank Terminal 2 operations.

For container vessels requiring a short-term anchorage while waiting for another vessel to clear a berth or while waiting for assist tugs, the Sandheads Anchorage S could be considered provided the vessel's length overall (LOA) does not exceed 320 m. Anchorage R has not been used by container vessels in prior years, as indicated by the lack of anchorage records in the **Appendix IR5-01a-C** tables.

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[2] CEAR Document #897 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 1 (See Reference Document #559).

[3] https://www.portvancouver.com/wp-content/uploads/2015/03/Port-of-Vancouver-Port-Information-Guide.pdf

[4] CEAR Document #982 From Transport Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on May 10, 2017 (See Reference Document 962).

In general, the same anchorages identified for the Deltaport Terminal in the **Appendix IR5-01a-C** tables will be suitable for RBT2 anchorages. These include the following[5]:

- **English Bay 01**
- English Bay 03
- **English Bay 06**
- **English Bay 10**
- English Bay 14
- **English Bay U**
- **Vancouver Harbour A**
- Vancouver Harbour B
- Vancouver Harbour D
- Vancouver Harbour W
- Vancouver Harbour X

The VFPA anchorages that are used when necessary by vessels calling at the Deltaport Terminal are shown in **bold** in the list above; however, the LOA of the vessel and the availability of an anchorage site will be the actual determinant of the anchorage assigned.

If the need arises during construction for vessels bound for Deltaport and Westshore terminals, indicate which of the sites could be considered for emergency events and would be part of the Land and Marine Management Plan.

In this unlikely event, the English Bay sites having the appropriate LOA allowance would be the most likely anchorage sites to be considered for emergency events. The sites that could be considered for emergency anchorages (i.e., refuge anchorage requirement for safety reasons, or to accommodate unexpected ship-specific maintenance, personnel, or operation issues that may arise) will be identified in the Land and Marine Management Plan.

Appendices

Appendix IR5-01a-A Supporting Figure

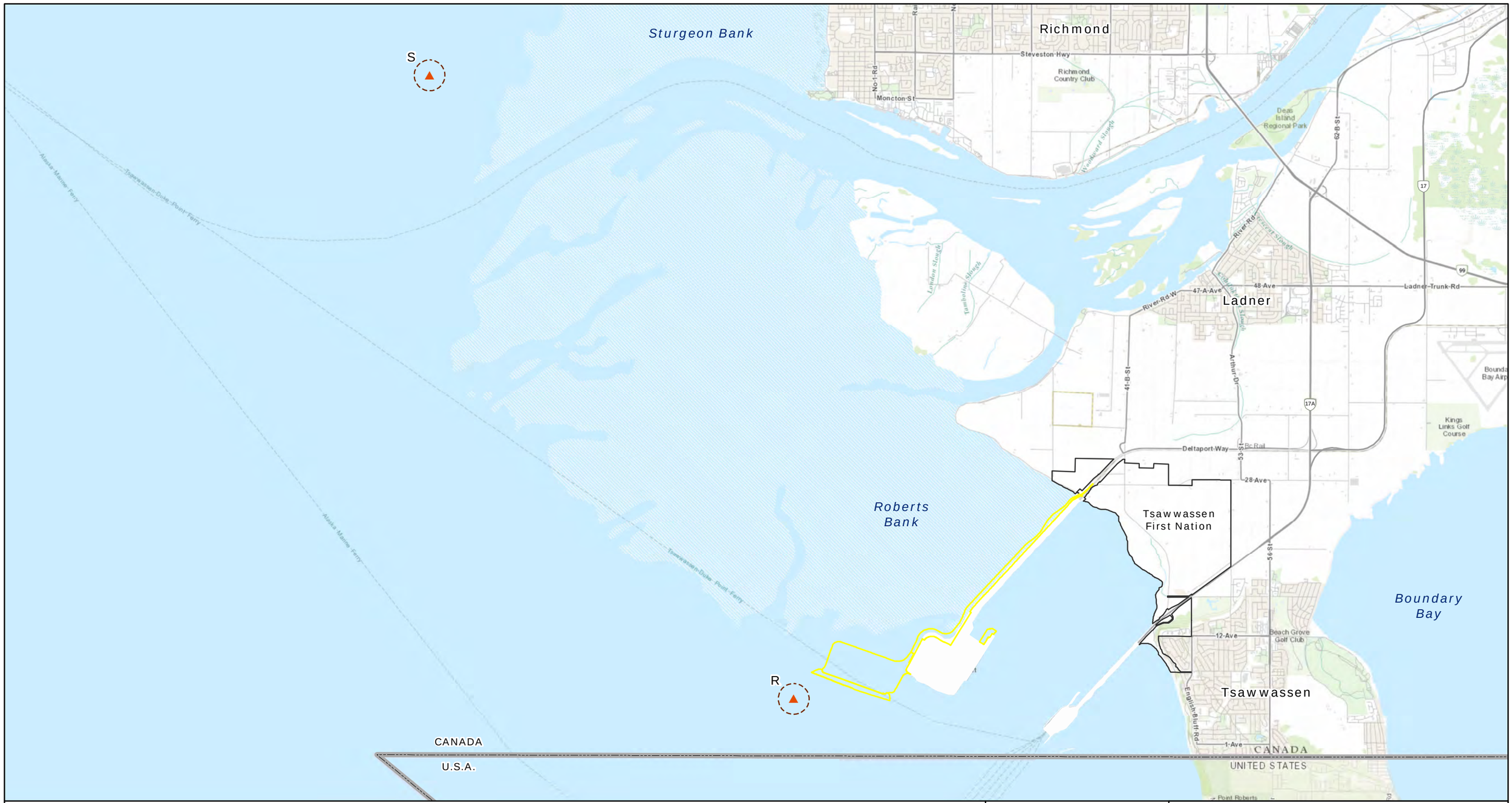
Appendix IR5-01a-B VFPA Anchorage Tables including Swing Radius

Appendix IR5-01a-C Container Ship Anchorages in Southern B.C. – 2012-2016

[5] The PPA identifies anchorages in Burrard Inlet as Vancouver Harbour anchorages, while the VFPA refers to the same anchorages as Inner Harbour anchorages (as referred to in **Appendix 5-01a-B**).

APPENDIX IR5-01a-A
SUPPORTING FIGURE

Path: S:\Geomatics\Projects\102738\EIS IRs\IR5_01a\mxd\IR5-01a-A1_VFPA_Anchorages_180928.mxd



Legend

- SHORT TERM ANCHORAGE
- MAX LOA (320 m)
- BOUNDARY OF PROJECT AREA
- CANADA-U.S.A. BORDER

0 2 4
Kilometres

1:75,000

NAD 1983 UTM Zone 10N

N

PORT of vancouver

ROBERTS BANK TERMINAL 2

VFPA ANCHORAGES AT
ROBERTS BANK AND SANDHEADS

DATE: 09/28/2018

FIG No. IR5-01a-A1

Basemap Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Imagery Source: BING Maps Aerial

APPENDIX IR5-01a-B

VFPA ANCHORAGE TABLES INCLUDING SWING RADIUS

VFPA ANCHORAGE TABLES INCLUDING SWING RADIUS

(Sourced from VFPA Port Information Guide – May 2018)

Table 1 - English Bay

Anchorage	**Coordinates** Latitude ⁰ ' " Longitude ⁰ ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
English Bay Anchorage 1	49 17 57 N 123 14 19 W	400	2.3	60	48	Cape size capable
English Bay Anchorage 2	49 17 33 N 123 13 53 W	260	2.3	37	14	
English Bay Anchorage 3	49 18 04 N 123 13 33 W	400	2.3	45	37	
English Bay Anchorage 4	49 17 39 N 123 13 11 W	260	2.3	37	28	
English Bay Anchorage 5	49 17 15 N 123 12 42 W	230	2.3	21	12	
English Bay Anchorage 6	49 18 12 N 123 12 48 W	400	2.3	40	30	Cape size capable
English Bay Anchorage 7	49 17 47 N 123 12 25 W	260	2.3	27	23	
English Bay Anchorage 8	49 17 22 N 123 11 59 W	230	2.3	19	16	
English Bay Anchorage 9	49 16 56 N 123 11 33 W	190	2.3	12.3	10	
English Bay Anchorage 10	49 18 19 N 123 12 03 W	400	2.3	30	24	Cape size capable

Anchorage	**Coordinates** Latitude ⁰ ' " Longitude ⁰ ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
English Bay Anchorage 11	49 17 54 N 123 11 38 W	260	2.3	25	19	
English Bay Anchorage 12	49 17 29 N 123 11 14 W	230	2.3	18	14	
English Bay Anchorage 13	49 17 05 N 123 10 49 W	190	2.3	11.8	10	
English Bay Anchorage 14	49 18 25 N 123 11 19 W	400	2.3	24	21	Cape size capable
English Bay Anchorage 15	49 18 01 N 123 10 53 W	260	2.3	19	17	
English Bay Anchorage 16	49 19 57 N 123 13 08 W	260	2.3	40	20	
English Bay Anchorage 17	49 19 56 N 123 13 54 W	260	2.3	52	32	
English Bay Anchorage 18	49 19 55 N 123 14 39 W	260	2.3	55	32	
English Bay Anchorage Uniform (U)	49 17 45 N 123 15 13 W	400	3.0	47	28	Short term only
English Bay Anchorage Zulu (Z)	49 17 09 N 123 10 00 W	100	1.3	10.3	9	

Table 2 - Inner Harbour

Anchorage	**Coordinates** Latitude ⁰ ' " Longitude ⁰ ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
Inner Harbour Anchorage Alpha (A)	49 18 11 N 123 05 26 W	300	1.6	35	24	
Inner Harbour Anchorage Bravo (B)	49 18 06 N 123 04 46 W	260	1.4	23	19.4	
Inner Harbour Anchorage Charlie (C)	49 18 01 N 123 04 11 W	260	1.4	21	16.2	
Inner Harbour Anchorage D	49 17 39 N 123 05 03 W	300	1.6	35	29.8	
Inner Harbour Anchorage E	49 17 44 N 123 03 55 W	230	1.1	16	15.7	
Inner Harbour Anchorage W	49 17 43 N 123 05 54 W	300	1.6	55	30	Short term only; pilot to remain onboard
Inner Harbour Anchorage X	49 18 17 N 123 06 05 W	185	1.0	20	17	
Inner Harbour Anchorage Y	49 18 01 N 123 03 35 W	260	1.4	16	14.8	Short term only; pilot to remain onboard

Table 3 - Indian Arm

Anchorage	**Coordinates** Latitude ⁰ ' " Longitude ⁰ ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
Indian Arm Anchorage Kilo (K)	49 18 03 N 122 56 41 W	185	2.0	27	15.3	
Indian Arm Anchorage Lima (L)	49 17 59 N 122 56 06 W	250	2.2	18.5	15.2	
Indian Arm Anchorage Mike (M)	49 18 23 N 122 56 17 W	250	2.2	25.5	17.8	Use only if no other suitable anchorages are available
Indian Arm Anchorage November (N)	49 17 38 N 122 58 03 W	185	1.7	16	15.3	Outbound vessels waiting for transit window

Table 4 - Roberts Bank

Anchorage	**Coordinates** Latitude ⁰ ' " Longitude ⁰ ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
Roberts Bank Anchorage Romeo (R)	49 00 46 N 123 12 14 W	320	2.5	70	40	Short term only; pilot to remain onboard

Table 5 - Sandheads

Anchorage	**Coordinates** Latitude º ' " Longitude º ' "	**Maximum Vessel Length Overall** (metres)	**Swing Radius** (cables)	**Depth at Centre of Anchorage Area** (metres)	**Control Depth within Anchorage Area** (metres)	**Notes**
Sandheads Anchorage Sierra (S)	49 07 45 N 123 18 29 W	320	2.5	70	40	Short term only; pilot to remain onboard

APPENDIX IR5-01a-C

CONTAINER SHIP ANCHORAGES IN SOUTHERN B.C. – 2012-2016

CONTAINER SHIP ANCHORAGES IN SOUTHERN B.C. – 2012-2016

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
Cowichan Bay Anchorage 2	2014	4	9.01	*Budapest Express*	Deltaport	X		
				Vienna Express	Deltaport	X		
				Halifax Express	Centerm	X		
				Santa Rafaela	Fraser Surrey Docks		X	PPA identified additional anchorage
Cowichan Bay Anchorage 3	2015	0	0.00					Identified in TC table as anchorage at this location. No anchorage info found. Possible modified anchorage location upon arrival.
Cowichan Bay Anchorage 4	2015	1	4.71	*Rio de Janeiro Express*	Assume Fraser Surrey Docks	Via Sandheads Anchorage S		Routing from short term anchorage to a specific terminal not identified
Cowichan Bay Anchorage C	2015	1	1.94	*MOL Precision*	Vanterm	X		PPA identified additional anchorage
English Bay Anchorage 1	2012	1	1.25	*Alexandra P*	Deltaport	X		
	2014	2	5.17	*Zim Antwerp*	Deltaport	X	X	
				Hanover Express	Deltaport	X		
	2015	2	7.55	*Chiswick Bridge*	Vanterm	X		
				Hyundai Force	Centerm	X		
	2016	1	1.90	*Ever Ethic*	Vanterm	X		
English Bay Anchorage 2	2015	1	0.16	*APL Commodore*	Centerm	X		PPA identified additional anchorage
English Bay Anchorage 3	2013	1	0.69	*Hyundai Shanghai*	Centerm	X		
	2014	1	5.40	*Kyoto Express*	Deltaport	X		
	2015	3	6.13	*Granville Bridge*	Vanterm	X		
				Wide Alpha	Deltaport	X	X	

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
				Sofia Express	Vanterm	X		
	2016	2	3.42	*E.R. Texas*	Vanterm	X		
				UASC Umm QASR	Vanterm	X		
English Bay Anchorage 4	2013	2	3.29	*YM Hamburg*	Vanterm	X		VFPA identified IMO Vessel #: 9157648 as *RI Zhao Hong Yun* (vessel name changed)
				Westwood Pacific	Centerm		X	VFPA identified IMO Vessel #: 9162265 as *Xin Long Yun 86* (vessel name changed)
English Bay Anchorage 6	2012	3	7.07	*Savannah Express*	Deltaport	X		VFPA identified IMO Vessel #: 9294989 as *Northern Julie* (vessel name changed)
				CSAV Brasilia	Vanterm	X		VFPA identified IMO Vessel #: 9437062 as *Balbina* (vessel name changed)
				Cosco Guangzhou	Centerm	X		
	2013	1	0.27	*OOCL Luxembourg*	Deltaport	X		
	2014	3	8.94	*Vienna Express*	Deltaport	X		
				Vienna Express	Deltaport	X		
				Sofia Express	Deltaport	X		
	2016	2	0.78	*Kyoto Express*	Vanterm to Deltaport		X	
				Frankfurt Express	Deltaport	X		
English Bay Anchorage 8	2012	1	0.64	*Australia Express*	Fraser Surrey Docks		X	PPA identified additional anchorage. VFPA identified IMO Vessel #: 929454 as *Nordwoge* (vessel name changed).
English Bay Anchorage 10	2013	1	0.14	*Northern Vigour*	Fraser Surrey Docks	X		
	2014	1	1.48	*Budapest Express*	Deltaport	X		
	2015	9	27.45	*Seaspan Ningbo*		X	X	PPA identified additional anchorage. No terminal assignment found.
				YM Success	Vanterm	X		

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
				Hyundai Mercury	Centerm	From Plumper Sound Anchorage 4		
				Venetiko	Deltaport	X		
				Sofia Express	Deltaport	X		
				MOL Precision	Vanterm	X	X	
				Vienna Express	Deltaport	X		
				Greenwich Bridge	Vanterm		X	
				YM Movement	Vanterm	X		
	2016	2	1.05*	*Hyundai Splendor*	Vanterm to Deltaport		X	
				CMA CGM Titus	Vanterm	X		
								Identified in TC table as 3rd anchorage at this location. No anchorage info found. Possible modified anchorage location upon arrival.
English Bay Anchorage 11	2012	1	0.13	*APL Duke*	Centerm	X		
	2015	1	1.20	*Deva*	Vanterm	X		
English Bay Anchorage 12	2012	1	0.81	*Hyundai Jakarta*	Centerm		X	
English Bay Anchorage 13	2012	1	5.09	*Westwood Pacific*	Lynnterm to Centerm	X	X	Outbound from Lynnterm - Inbound to Centerm. VFPA identified IMO Vessel #: 9162265 as *Xin Long Yun 86* (vessel name changed)
English Bay Anchorage 14	2014	2	2.54	*Hanover Express*	Deltaport	X		
				Seaspan Ningbo	Fraser Surrey Docks	X		
	2015	3	8.67	*NYK Nebula*	Centerm	X		
				Ever Union	Vanterm	X		
				Seattle Express	Centerm	X		

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
	2016	3	6.97	*Hanjin Vienna*	Vanterm		X	VFPA identified IMO Vessel #: 9215634 as *Jin V* (vessel name changed)
				Ever Salute	Vanterm back to Vanterm	X	X	PPA identified additional anchorage
				Ever Utile	Vanterm	X		
English Bay Anchorage Uniform	2013	2	0.31	*MOL Modern*	Centerm	X		
				Hanjin Paris	Vanterm	X		
	2014	4	2.12	*Hyundai Courage*	Centerm	X		
				Cap Blanche	Fraser Surrey Docks		X	
				Ever Unity	Vanterm		X	
				CMA CGM Attila	Deltaport to Centerm	X	X	PPA identified additional anchorage. Outbound from Deltaport - Inbound to Centerm
	2015	5	3.37*	*Ever Sigma*	Vanterm	X		
				Frankfurt Express	Deltaport		X	
				CMA CGM Parsifal	Deltaport	X		
				MSC Nerissa	Deltaport	X		
				OOCL Rotterdam	Deltaport	X		
								Identified in TC table as 6th anchorage at this location. No anchorage info found. Possible modified anchorage location upon arrival.
	2016	6	2.76	*Ever Envoy*	Vanterm	X		
				Seoul Express	Centerm	X		
				Hanjin Marine	Vanterm		X	
				NYK Meteor	Centerm	X		
				Puelo	Deltaport	X		

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
				OOCL Tianjin	Deltaport	X		
Nanaimo Anchorage 2	2014	1	0.23	*Zim Antwerp*	Deltaport		X	
Nanaimo Anchorage 4	2014	1	0.34	*Westwood Cascade*	Duke Point		X	
Nanaimo Anchorage 6	2016	1	0.63	*Shengking*	Harmac Pulp	X		
Plumper Sound Anchorage B	2016	1	83.64	*Hanjin Scarlet*	N.A.			Shipping Line insolvency
Plumper Sound Anchorage 1	2015	6	26.7	*Ever Ethic*	Vanterm to Vanterm	Inbound to Vanterm	Outbound from Vanterm	Terminal - Anchorage - Terminal
				Lions Gate Bridge	Vanterm	X		
				MOL Promise	Vanterm	X		
				Conti Basel	Centerm	X		
				Hyundai Courage	Centerm	X		
				Hyundai Brave	Centerm	X		
Plumper Sound Anchorage 3	2014	1	23.83	*MSC Veronique*	Deltaport to Deltaport	Inbound to Deltaport	Outbound from Deltaport	Terminal - Anchorage - Terminal
	2015	4	27.43	*HS Mozart*	Vanterm	X		
				Santa Barbara	Vanterm	X		
				YM March	Vanterm	X		
				MOL Precision	Centerm	X		
Plumper Sound Anchorage 4	2015	2	6.35	*Ever Ulysses*	Vanterm	X		
				Hyundai Mercury	N.A.	To English Bay Anchorage 10		

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
Royal Roads Anchorage C	2015	1	1.14	*Viktoria Wulff*	Deltaport	X		
Royal Roads Anchorage D	2012	1	0.50	*Buxharmoney*	Deltaport	X		
	2015	2	6.51	*MSC Carment*	Deltaport	X		
				Tasman	Deltaport to Vanterm	Inbound to Vanterm	Outbound from Deltaport	
Vancouver Harbour Anchorage A	2012	4	1.21	*Colombo Express*	Deltaport		X	
				APL Norway	Centerm	X		
				Cosco Yokohama	Centerm	X		
				Hyundai Oakland	Centerm	X		
	2014	3	1.99	*Ever Ulysses*	Vanterm	X		
				Ever Elite	Vanterm	X		
				Northern Promotion	Deltaport		X	
	2015	4	9.15	*MSC Lisa*	Deltaport		X	
				James River Bridge	Vanterm	X		VFPA identified IMO Vessel #: 9224520 as *Wan Hai 613* (vessel name changed)
				Venetiko	Deltaport		X	
				Cauquenes	N.A.	X	X	No terminal assignment. Sea - Anchorage - Sea.
	2016	6	5.81	*Guang Dong Bridge*	Vanterm	X		
				Hanjin Scarlet	Centerm		X	To Plumper Sound Anchorage B. VFPA identified IMO Vessel #: 9624287 as *Maersk IYO* (vessel name changed).
				CMA CGM Rhone	Vanterm	X	X	Terminal - Anchorage - Terminal

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
				MSC Antalya	Deltaport		X	
				Greenwich Bridge	Deltaport		X	
				MSC Arbatax	Deltaport		X	
Vancouver Harbour Anchorage B	2015	3	0.99	*Safmarine Chilka*	Deltaport		X	
				Manulani	N.A.		X	PPA identified additional anchorage. Drydock - Anchorage - Seattle
				Cap Blanche	Fraser Surrey Docks		X	
	2016	1	0.26	*Bardu*	Centerm	X	X	
Vancouver Harbour Anchorage D	2013	2	0.58	*Savannah Express*	Deltaport		X	VFPA identified IMO Vessel #: 9294989 as *Northern Julie* (vessel name changed)
				Kyoto Express	Deltaport		X	
	2014	1	0.12	*Halifax Express*	Centerm	X		
	2015	2	0.34	*MOL Promise*	Vanterm	X		
				Ever Excel	Vanterm	X		
	2016	3	3.08	*Shengking*	Lynnterm	X		
				Hanjin Vienna	N.A.	X	X	Sea - Anchorage - Sea *VFPA identified IMO Vessel #: 9215634 as Jin V (vessel name changed)*
				NYK Romulus	Centerm	X		
Vancouver Harbour Anchorage E	2015	2	3.72	*Westwood Discovery*	Lynnterm to Centerm	To Centerm	From Lynnterm	VFPA identified IMO Vessel #:9162253 as *Santa Fiorenza* (vessel name changed)
				Westwood Discovery	Centerm		X	VFPA identified IMO Vessel #: 9162253 as *Santa Fiorenza* (vessel name changed)
Vancouver Harbour Anchorage W	2012	1	0.24	*Colombo Express*	Deltaport	X		

Anchorage	Year	Number	Total Days	Vessel	VFPA Terminal	Inbound Anchorage	Outbound Anchorage	Comments
Vancouver Harbour Anchorage X	2012	1	2.89	*Westwood Cascade*	Lynnterm to Centerm	To Centerm	From Lynnterm	VFPA identified IMO Vessel #: 9173135 as *Thorswind* (vessel name changed)
	2015	1	0.16	*EM Hydra*	Deltaport		X	
Total container vessel anchorages	**2012 -2016**	**129**						

Notes:
* indicates duration from CEAR Document #982, which included an additional anchorage that is now covered elsewhere. Therefore, number of days is larger than actual.

IR5-02 Marine Invertebrates, Vegetation and Fish – Productivity Assessments

Information Source(s)

EIS Volume 3: Section 11; Section 12; Section 13

Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): IR7

Context

In its response to information requirement #7 from the Canadian Environmental Assessment Agency (CEAR Doc#314), the Proponent stated that the use of percentages, rather than absolute biomass numbers, to create the ranges of productivity change ensured that results were comparable across valued components and sub-components. According to the Proponent, percentages provided better comparisons because they are proportional, or relative, to each species' or group's initial productivity values. For example, a 3% change in native eelgrass productivity equates to 9.1 tonnes of biomass while a 3% change in adult Chinook Salmon equates to 5.6 tonnes of biomass.

However, in the summaries of changes to productivity for marine vegetation, marine invertebrates, and marine fish valued components and sub-components provided in Table 11-21; Table 12-11; and Table 13-12 of the EIS, the Proponent reported predicted changes to productive potential as absolute biomass changes. These biomass changes were used to describe changes to sub-components and to consolidate changes to sub-components at the valued component level.

Predicted changes to productive potential should be expressed as percent change to allow for comparison across valued components and sub-components.

Information Request

Provide tables similar to Table 11-21; Table 12-11; and Table 13-12 of the EIS to summarize both absolute and percent change in biomass values for the marine vegetation, marine invertebrates and marine fish sub-components.

VFPA Response

Absolute changes in biomass were originally presented in Tables 11-21, 12-11, and 13-12 of the EIS, as well as summarised in accompanying text (EIS Sections 11.6.3, 12.6.3, and 13.6.3) and are depicted in bold in Tables IR5-02-A1 to IR5-02-A3 in **Appendix IR5-02-A.** Percent change values were originally presented in EIS Tables 11-17, 12-8, and 13-10, as well as summarised in accompanying text (EIS Sections 11.6.3, 12.6.3, and 13.6.3).

Updated tables summarising both absolute and percent change in biomass values for the marine vegetation, marine invertebrates, and marine fish sub-components are appended to

this response (**Appendix IR5-02-A**); per the information request, the summary tables have been updated to include percent change in biomass values, depicted in italics. Otherwise, the tables remain unchanged from those presented in the EIS, such that the text in the 'Comments' column may appear out of context; please refer to EIS Sections 11.6.3, 12.6.3, and 13.6.3 respectively for the narrative that contextualises these summary comments.

Table IR5-02-A2 also provides empirically calculated estimates of productivity change for infaunal and epifaunal invertebrates and bivalve shellfish, which were included in EIS text (see EIS pages 12-54 and 12-59, respectively), but inadvertently omitted from EIS Table 12-11.

Appendices

Appendix IR5-02-A Supporting Tables

APPENDIX IR5-02-A
SUPPORTING TABLES

Table IR5-02-A1 Marine Vegetation Productivity Summary (Prior to Mitigation) Based on Weight of Evidence Updated to Include Ecosystem Model Percent Change

Sub-component	Empirically Estimated/Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project	Comments
	Gain	Loss	Gain	Loss			
Eelgrass							
Native	4 to 8†	14.9	**11**	**-**	*+4*	Negligible	• Temporal loss due to direct mortality is negligible (2.9 t, 0.7% of total existing biomass) • Empirically estimated loss includes direct loss (2.9 t, 0.7% of total existing biomass) and assumes entire area of increased sedimentation (12 t) will be lost (worst case scenario and not likely) • Changes in sedimentation will offset some gains from the wave shadow
Non-native	◇	0.3*	**-**	**0.05**	*-1*	Negligible	• Temporal loss due to direct mortality is only 1.7% of total existing biomass and considered negligible • Changes in TSS and salinity negligible • Empirical gain due to longer-term sediment deposition anticipated from Project in localised areas
Intertidal Marsh							
Intertidal Marsh	◇	1.1*	**335**	**-**	*+25*	Minor Increase	• Temporal loss due to direct mortality is negligible (1.1 t, less than 0.1% of total existing biomass) • Empirically estimated losses will be offset by longer-term sediment deposition anticipated from Project in localised areas • Based on scientific literature, changes in salinity may increase intertidal marsh productivity
Macroalgae							
Ulva	-	258.8*	**-**	**583**	*-8*	Negligible	• Temporal loss due to direct mortality is negligible (258.8 t, 1.5% of total existing biomass) • Ecosystem modelling predicted food web-related adverse effects, which are considered to be overestimated based on macrofauna increases • Opportunistic, and reproduces asexually and sexually; therefore, it will recolonise quickly • Ephemeral nature and large abiotic (e.g., TSS and salinity) tolerance will result in negligible change in productivity
Rockweed	-	82.6*	**-**	**-**	-	Minor Decrease	• Temporal loss of rockweed due to direct mortality is a minor decrease in productivity (82.6 t, 27.5% of total existing biomass) • Ecosystem modelling predicted food web-related adverse effects, which are considered to be overestimated (i.e., macrofauna) • Proposed terminal will create more substrate for rockweed attachment
Kelp	-	1.9*	**-**	**53**	*-12*	Negligible	• Temporal loss due to kelp direct mortality is negligible (1.9 t, 0.5% of total existing biomass)
Biomat							
Biomat	-	-	**-**	**356**	*-29*	Negligible	• Studies indicate biomat increasing naturally (not related to Project) • The ecosystem model and environmental preferences do not fully capture how biomat establishes and propagates • Based on scientific literature, predicted salinity changes due to the Project will have a negligible effect on biomat • Increase in waterfowl was modelled to have a large negative effect on biomat but is not supported by scientific literature

Sub-component	Empirically Estimated/Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project	Comments
	Gain	Loss	Gain	Loss			
Biofilm							
Marine Biofilm	◇	◇	**-**	**420**	*-23*	Negligible	• Empirical studies indicate loss of marine-influenced biofilm productivity due to changes in salinity • Changes in productivity due to changes in wave height are predicted to be negligible • Shorebird foraging opportunity model indicates short-term (during large than average freshet) minor decreases in biofilm associated with salinity decreases and an overall short-term minor increase during an average freshet (see Appendices 15-B Shorebird Foraging Opportunity during Migration and 15-C Overwintering Dunlin Foraging Opportunity) • Increases in predators are contributing to estimated loss; however, empirical studies have shown that there is a large surplus of biofilm at Roberts Bank
Freshwater Biofilm			**1470**	**-**	*+89*	Negligible	• Empirical studies indicate increase in freshwater-influence biofilm productivity due to changes in salinity • Changes in productivity due to changes in wave height are predicted to be negligible • Changes in wave height due to model inputs are overestimating increase by 622 t • Increase is deemed to be an overestimation. Some of the predicted biomass increase is within the existing marsh at Brunswick Point, thus, the biomass increase in this area is not anticipated and is approximately 10% to 15% (311 t to 467 t; average: 389 t) of the predicted increase

Notes: quantitative productivity estimates presented here do not include anticipated productivity gains from mitigation.

* Productivity loss due to direct mortality

† estimate based on area affected by wave shadow (i.e., decrease in wave energy) due to the Project

◇ Productivity change predicted: quantitative productivity change estimate not available

** Professional opinion/conclusion on productivity change based on integration and consideration of all available lines of evidence (including empirical evidence, ecosystem model results, and other models or evidence of change). Change Ratings (applicable to both increases and decreases): Negligible: 0% to 5% change; Minor: 6% to 30% change.

Change ratings take into consideration physical and biological aspects of natural ecosystem variability.

Table IR5-02-A2 Marine Invertebrate Productivity Summary (Prior to Mitigation) Based on Weight of Evidence Updated to Include Ecosystem Model Percent Change

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project		Comments
	Gain	Loss	Gain	Loss		Construction	Operation	
Infaunal and Epifaunal Invertebrates (Macrofauna)	◇	127	**733**	**-**	*+27*	Minor Decrease	Minor Increase	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., dredging) • Long-term increases (i.e., during operation phase) in productive potential predicted by ecosystem model likely driven by improved environmental conditions shoreward of the terminal (e.g., wave shadow) • Sensitivity analyses support potential for positive direction of change but suggest predicted increase likely an overestimate (i.e., up to 5%) • SFOM (Appendix 15-B) predicts a minor decrease in available biomass, and discrepancy between ecosystem model and SFOM results can be partially attributed to lack of food web impacts considered in SFOM and differences in spatial and temporal scales • Note that other infaunal and epifaunal invertebrate functional groups also predicted to increase, including "meiofauna" by 11% (175 t) and "polychaetes" by 11% (120 t)
Infaunal Bivalve Shellfish (clams, cockles)	-	212	**-**	**519**	*-8*	Minor Decrease	Minor Decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., dredging) • Long-term decreases (i.e., during operation phase) in productive potential predicted by ecosystem model primarily due to habitat loss associated with footprint, but also less favourable environmental conditions behind the terminal over the long-term (e.g., fine sediment deposition) • Sensitivity analyses suggest magnitude of decrease is slightly underestimated (i.e., by 2%) • Possess biological attributes (e.g., short generation time, broadcast spawning, pelagic larvae) that facilitate re-colonisation • Quantitative and qualitative/empirical predictions around a minor decrease align • Note that the "epifauna sessile" functional group, which includes bay mussels and Pacific oysters is predicted to increase by 19% (9.5 t) due to increased hard attachment substrate with the Project
Dungeness Crab	-	◇	**-**	**9**	*-3*	Minor Decrease	Minor Decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., dredging) • Long-term (i.e., during operation phase) change predicted by ecosystem model (-3%) is negligible, falling within margin of error of the model (±5%) • Long-term decreases in productive potential predicted qualitatively/empirically primarily due to permanent habitat loss associated with footprint • Changes in marine vegetation upon which crabs (particularly juveniles) depend are deemed negligible • Sensitivity analyses suggest magnitude of decrease is slightly underestimated (i.e., by 2%) • Local populations are sustained by larvae originating over a large geographical area, which may help to replenish productivity losses
Orange Sea Pen	-	◇	**-**	**4**	*-55*	Moderate Decrease	Moderate Decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., dredging) • Long-term decreases (i.e., during operation phase) in productive potential predicted by ecosystem model primarily due to habitat loss associated with footprint • Sensitivity analyses suggest magnitude of decrease is accurate • Presence of terminal predicted to cause localised accelerations in current flow at edges, which may enhance food delivery rates and attract sea pens back to area over time • Modelled and empirical predictions around a moderate decrease align

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project		Comments
	Gain	Loss	Gain	Loss		Construction	Operation	

Notes: quantitative productivity estimates presented here do not include anticipated productivity gains from mitigation.

* Productivity loss due to direct mortality

† estimate based on area affected by wave shadow (i.e., decrease in wave energy) due to the Project

◇ Productivity change predicted: quantitative productivity change estimate not available

** Professional opinion/conclusion on productivity change based on integration and consideration of all available lines of evidence (including empirical evidence, ecosystem model results, and other models or evidence of change). Change Ratings (applicable to both increases and decreases): Negligible: 0% to 5% change; Minor: 6% to 30% change. Change ratings take into consideration physical and biological aspects of natural ecosystem variability.

Table IR5-02-A3 Marine Fish Productivity Summary (Prior to Mitigation) Based on Weight of Evidence Updated to Include Ecosystem Model Percent Change

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project*		Comments
	Gain	Loss	Gain	Loss		Construction	Operation	
Pacific Salmon								
Chinook adult	-	◇	**-**	**9.5**	*-5*	Minor decrease	Negligible	• Short-term decreases in productive potential due to minor acoustic impacts (conservatively assuming impact piling is required) from construction • Longer-term decreases related to loss of habitat availability from terminal footprint, though this is unlikely to be a key mechanism, given Chinook adult are not likely habitat-limited in the LAA, with minimal feeding during return migration) • Sensitivity analyses suggest ecosystem model predictions are accurate
Chinook juvenile	-	◇	**0.1**	**-**	*+16*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment), minor acoustic impacts (conservatively assuming impact piling is required), changes in lighting, and migration disruption • Long-term minor decreases during operation due to changes in lighting and migration disruption, despite benefits from predicted increases in main food source (i.e., infaunal and epifaunal invertebrates) • Sensitivity analyses suggest increase predicted by ecosystem model is over-estimated (i.e., by 6%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction, acoustic, lighting, and migration mechanisms
Chum adult	-	◇	**-**	**5**	*-5*	Minor decrease	Negligible	• Short-term decreases in productive potential due to minor acoustic impacts (conservatively assuming impact piling is required) from construction • Longer-term decreases related to loss of habitat availability from terminal footprint, though this is unlikely to be a key mechanism given adult chum are not likely habitat-limited in the LAA, with minimal feeding during return migration) • Sensitivity analyses suggest ecosystem model predictions are accurate
Chum juvenile	-	◇	**0.07**	**-**	*+14*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment), minor acoustic impacts (conservatively assuming impact piling is required), changes in lighting, and migration disruption • Long-term minor decreases during operation due to changes in lighting and migration disruption, despite benefits from predicted increases in main food source (i.e., infaunal and epifaunal invertebrates) • Sensitivity analyses suggest increase predicted by ecosystem model is over-estimated (i.e., by 4%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction, acoustic, lighting, and migration mechanisms

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project*		Comments
	Gain	Loss	Gain	Loss		Construction	Operation	
Reef Fish								
Lingcod	-	◇	**-**	**0.98**	*-3*	Minor decrease	Negligible	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment), minor acoustic impacts (conservatively assuming impact piling is required), and loss of habitat availability (i.e., small Project footprint overlap with artificial reefs) • Long-term change expected to be negligible due to neutral biotic interactions and increases in hard substrate due to Project infrastructure • Sensitivity analyses suggest decrease predicted by ecosystem model over-estimated (i.e., by 2%) • Quantitative and qualitative predictions around a negligible change align
Rockfish (including copper and quillback rockfish)	-	◇	**-**	**1.6**	*-9*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment), minor acoustic impacts (conservatively assuming impact piling is required), and loss of habitat availability (i.e., small Project footprint overlap with artificial reefs; minor decrease in macroalgae productive potential) • Long-term minor decreases due to biotic interactions (reduced prey) • Sensitivity analyses suggest decrease predicted by ecosystem model over-estimated (i.e., by 2%) • Quantitative and qualitative predictions around a minor decrease align
Forage Fish								
Pacific sand lance	-	◇	**0.65**	**-**	*+6*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (conservatively assuming impact piling is required) • Long-term minor decreases due to reduction in availability and quality of both subtidal and intertidal sand, used as burying habitat, due to Project footprint • Sensitivity analyses suggest increase predicted by ecosystem model over-estimated (i.e., by 3%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms
Other forage fish (including surf smelt)	-	◇	**-**	**8**	*-1*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (conservatively assuming impact piling is required) • Long-term minor decreases due to reduction in availability and quality of both subtidal and intertidal sand, particularly beach spawning habitat in the high intertidal zone • Sensitivity analyses suggest decrease predicted by ecosystem model slightly under-estimated (i.e., by 1%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project*		Comments
	Gain	Loss	Gain	Loss		Construction	Operation	
Pacific herring	-	◇	**-**	**5.6**	*-2*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (if either vibratory or impact pile driving employed) • Long-term minor decreases due to reduction in availability and quality of both subtidal and intertidal sand habitat • Sensitivity analyses suggest decrease predicted by ecosystem model under-estimated (i.e., by 1%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms
Shiner perch	◇	◇	**1.6**	**-**	*+18*	Minor decrease	Minor increase	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (conservatively assuming impact piling is required) • Long-term minor increases due to biotic interactions (increased prey) and increased habitat availability from infrastructure placement (i.e., vertical, hard substrate) • Sensitivity analyses suggest increase predicted by ecosystem model over-estimated (i.e., by 5%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms
Flatfish								
Other flatfish (including English sole)	-	◇	**-**	**0.3**	*-2*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (conservatively assuming impact piling is required), and increases in TSS • Long-term minor decreases due to loss of highly productive subtidal sand habitat • Sensitivity analyses suggest decrease predicted by ecosystem model over-estimated (i.e., by 1%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms
Starry flounder	-	◇	**0.69**	**-**	*+6*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (conservatively assuming impact piling is required), and increases in TSS • Long-term minor decreases due to loss of highly productive subtidal sand habitat • Sensitivity analyses suggest increase predicted by ecosystem model over-estimated (i.e., by 4%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms

Sub-component	Empirically Estimated/ Other Evidence of Productivity Change (t)		Ecosystem Model Productivity Change (t)		*Ecosystem Model Percent Change (%)*	Professional Opinion/ Conclusion on Productivity Change due to Project*		Comments
	Gain	**Loss**	**Gain**	**Loss**		**Construction**	**Operation**	
Demersal Fish								
Small demersal fish (including threespine stickleback and Pacific staghorn sculpin)	-	◇	**-**	**0.2**	*-5*	Minor decrease	Minor decrease	• Short-term decreases in productive potential due to direct mortality from construction activities (i.e., entrainment) and minor acoustic impacts (if impact pile driving employed) • Long-term minor decreases due to reduction in availability and quality of both subtidal and intertidal sand habitat • Sensitivity analyses suggest decrease predicted by ecosystem model under-estimated (i.e., by 1%) • Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction or acoustic mechanisms
VC Total Change	-	◇	**-**	**28.1**		Minor decrease	Minor decrease	• Ecosystem model predicts no change to minor decrease in marine fish productivity (≤ 5%) with the Project • On a sub-component level, the ecosystem model predicts no change to minor decreases (≤ 5%) in the productivities of Pacific salmon, reef fish, forage fish, and small demersal fish; and no change to a minor increase (≤ 5%) in the productivity of flatfish • Based on all lines of evidence, all sub-components are predicted to experience minor decreases in productivity during one or both phases of the Project, resulting in an overall minor decrease in marine fish productivity

Legend

◇ Productivity change predicted: quantitative productivity change estimate not available

* Professional opinion/conclusion on productivity change based on integration and consideration of all available lines of evidence (including empirical evidence, ecosystem model results, and other models or evidence of change). Change ratings (applicable to both increases and decreases): Negligible: 0% to 5% change; Minor: 6% to 30% change. Change ratings take into consideration physical and biological aspects of natural ecosystem variability.

Note: quantitative productivity estimates presented here do not include anticipated productivity gains from mitigation.

IR5-03 Marine Invertebrates – Indicators

Information Source(s)

EIS Volume 3: Section 12

Context

In Section 12.2.2 of the EIS, the Proponent stated that indicators for marine invertebrates were chosen as measurable parameters that provided a means of determining a Project-related change to marine invertebrates. Table 12-2 of the EIS provided a rationale for the selection of each indicator used in the assessment, including productivity (biomass), abundance, diversity, distribution, contaminant levels, density and suitable habitat area.

However, it is not clear how some indicators, such as abundance, distribution and density, were applied in the marine invertebrate assessment and which indicators would be used in any follow-up programs developed for marine invertebrates. Further, it is not clear how temporal and spatial variations were integrated into the indicator values used in the effects assessment for marine invertebrates.

Additional information is required to understand how these indicators were used in the assessment of the potential effects of the proposed Project on marine invertebrates and review the adequacy of any proposed follow-up programs for marine invertebrates.

Information Request

Provide a summary of baseline conditions for each indicator used in the assessment of marine invertebrates.

Describe how the abundance, distribution, and density indicators were used in the effects assessment to predict possible Project-related changes to marine invertebrates.

Provide an explanation of how temporal and spatial variations were integrated into indicator values used in the effects assessment for marine invertebrates.

Identify which indicators are proposed for use in the marine invertebrate follow-up program.

VFPA Response

The VFPA would like to clarify that the term 'indicator' is used in the EIS (and this response) to characterise existing conditions and/or quantify effects, and not to act as an indicator for change for a follow-up program.

Provide a summary of baseline conditions for each indicator used in the assessment of marine invertebrates.

Existing conditions[1] for each indicator are summarised in **Table IR5-03-1** by sub-component. The indicators used for each sub-component may differ slightly, depending on the objectives of studies; for example, diversity data were collected for infaunal and epifaunal invertebrates, but is not relevant for orange sea pens or Dungeness crab (given that these are individual species and not assemblages); this information is re-packaged from the EIS and supporting technical documents. **Table IR5-03-2** explains which indicators are applicable to which sub-components. This information is also available in EIS Section 12.5 and EIS Appendix 10-B; note that 'density' was erroneously omitted as an indicator for bivalve shellfish in EIS Table 12-2, but is included in **Table IR5-03-2**.

[1] The term 'existing conditions', rather than 'baseline conditions', is used throughout the EIS to denote pre-Project conditions and will be the term used herein.

Table IR5-03-1 Summary of Information Provided in the EIS (Section 12.5) and Associated Technical Data Reports for each of the Applicable Indicators

Indicator	Summary of Existing Conditions
Infaunal and Epifaunal Invertebrates	
Productivity (biomass)	Maximum infaunal and epifaunal invertebrate **biomass** and densities have been reported adjacent to emergent vegetation in the high intertidal zone in the Fraser River estuary (Levings and Coustalin 1975, McEwan and Gordon 1985), and results from RBT2 studies confirm a statistically significant trend of lower meiofaunal **biomass**, abundance, and diversity further out from shore (Hemmera 2014c). *EIS Volume 3, Section 12.0, page 12-15* During 2012-2013 northward and southward shorebird migrations, mean meiofaunal **biomass** was highest in the inter-causeway area (54.9 g/m^2), followed by Boundary Bay (31.2 g/m^2) and Brunswick Point (i.e., north of the Roberts Bank causeway; 30.9 g/m^2) ([EIS] Figure 12-7). *EIS Volume 3, Section 12.0, page 12-15* Over the same timeframe, mean macrofaunal **biomass** was highest at Boundary Bay (86.6 g/m^2), followed by the inter-causeway area (60.4 g/m^2) and Brunswick Point (37.7 g/m^2), and lowest at Westham Island (24.4 g/m^2; [EIS] Figure 12-9). *EIS Volume 3, Section 12.0, page 12-16* As shown in [EIS] Figure 12-9, macrofauna **biomass** in the inter-causeway area did not change based on migration period, but **biomass** was higher north of the causeway during northward migration. *EIS Volume 3, Section 12.0, page 12-16* Section 4.1.1 of the Infaunal and Epifaunal Communities Technical Data Report (TDR MI-1 in Appendix AIR10-C of CEAR Document #388[2]) provides a summary of biomass results from all sampling locations across all sampling events (656 sampling points total). Biomass and production estimates for macrofauna, meiofauna, and polychaetes, used as inputs to the Roberts Bank ecosystem model, are presented in Sections 5.9.11, 5.9.12, and 5.9.13 of EIS Appendix 10-B, respectively.
Abundance	Maximum infaunal and epifaunal invertebrate biomass and densities have been reported adjacent to emergent vegetation in the high intertidal zone in the Fraser River estuary (Levings and Coustalin 1975, McEwan and Gordon 1985), and results from RBT2 studies confirm a statistically significant trend of lower meiofaunal biomass, **abundance**, and diversity further out from shore (Hemmera 2014c). *EIS Volume 3, Section 12.0, page 12-15* Community assemblages were also shown to differ on either side of the causeway, with polychaete, cumacean, and oligochaete **abundance** highest at Brunswick Point to the north, nematode, foraminifera, and harpacticoid copepod **abundance** highest within the inter-causeway area, and ostracod **abundance** highest off Westham Island (Hemmera 2014c). *EIS Volume 3, Section 12.0, page 12-15* Similar to meiofauna, community composition differed by strata, with polychaete, nematode, harpacticoid, and ostracod **abundance** highest at Boundary Bay and the inter-causeway areas, oligochaete **abundance** highest at Brunswick Point, and bivalve **abundance** highest at Sturgeon Bank. *EIS Volume 3, Section 12.0, page 12-16*

[2] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

Indicator	Summary of Existing Conditions
	Section 4.1.1 of TDR MI-1 (Appendix AIR10-C of CEAR Document #388) provides a summary of abundance results from all sampling locations across all sampling events (656 sampling points total).
Diversity	Maximum infaunal and epifaunal invertebrate biomass and densities have been reported adjacent to emergent vegetation in the high intertidal zone in the Fraser River estuary (Levings and Coustalin 1975, McEwan and Gordon 1985), and results from RBT2 studies confirm a statistically significant trend of lower meiofaunal biomass, abundance, and **diversity** further out from shore (Hemmera 2014c). *EIS Volume 3, Section 12.0, page 12-15* Among all strata across the RAA [regional assessment area], meiofaunal community composition was consistently most **diverse** at Brunswick Point ([EIS] Figure 12-8). *EIS Volume 3, Section 12.0, page 12-15* Macrofaunal **diversity** was consistently highest in the inter-causeway area ([EIS] Figure 12-10). Subtidal macrofaunal **diversity** (nine taxa) is considerably lower than intertidal **diversity** (33 taxa) (Hemmera 2014c). *EIS Volume 3, Section 12.0, page 12-16* Section 4.1.1 of TDR MI-1 (Appendix AIR10-C of CEAR Document #388) provides a summary of diversity results from all sampling locations across all sampling events (656 sampling points total). Section 4.1.2 of TDR MI-1 (Appendix AIR10-C of CEAR Document #388) provides a summary of the taxonomic composition of samples, broken down by meiofaunal and macrofaunal size fractions.
Distribution	Chapman and Brinkhurst (1981) documented seasonal shifts in benthic invertebrate **distributions** in relation to the spring freshet… *EIS Volume 3, Section 12.0, page 12-16* Spatially, benthic invertebrate **distribution** is often described as patchy (Barry and Dayton 1991, McIntosh 1991) with high abundance in some areas and total absence in others (Morrisey et al. 1992). Fine-scale spatial variation is likely influenced by physical environmental factors and associated behavioural responses (Morrisey et al. 1992, Underwood and Chapman 1996). *EIS Volume 3, Section 12.0, page 12-16.* The spatial distribution of meiofaunal biomass, abundance, and diversity during the 2012 spring and summer sampling periods is illustrated in TDR MI-1 (Appendix AIR10-C of CEAR Document #388) Appendix B: Figures B1 through B3, while 2013 sampling periods are presented in Appendix B: Figures B4 through B6. Regression kriging models were used to generate spatial estimates of shorebird food abundance (i.e., meiofauna and macrofauna) under existing and with-Project conditions and are presented in EIS Appendix 15-B/TDR CB-1 (Appendix AIR10-C of CEAR Document#388).
Contaminant Levels	Analysis of metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenals (PCBs), sulfides, and coal in surface sediments is provided in Section 3.5.1 of EIS Appendix 9.6-A.
Density	Linked to the Abundance indicator above.
Suitable Habitat Area	While a habitat suitability model was not developed specifically for infaunal and epifaunal invertebrate communities, a geospatial interpolation (IDW) using data from all sampling locations across all sampling events is presented in Figures 4-1 and 4-2 of TDR MI-1 (Appendix AIR10-C of CEAR Document #388) for meiofauna and macrofauna, respectively. These figures indicate 'hotspots' of biomass and abundance, and can help identify areas where the habitat appears particularly suitable.

Indicator	Summary of Existing Conditions
Bivalve Shellfish	
Productivity (biomass)	Biomass and production estimates for infaunal bivalves, used as inputs to the Roberts Bank ecosystem model, are presented in Section 5.9.2 of EIS Appendix 10-B.
Abundance	Within the LAA [local assessment area], cockles are common, but not found in high **abundance** (Hemmera 2014d). *EIS Volume 3, Section 12.0, page 12-19* Littleneck clams are particularly **abundant** in shallow nearshore areas (i.e., most common above −3 m CD [chart datum]). *EIS Volume 3, Section 12.0, page 12-19*
Diversity	While not quantified in the EIS, the selection of five representative species illustrates bivalve shellfish diversity in the LAA.
Distribution	The heart cockle is widely **distributed** and generally common along the Pacific coast, from southern California to Alaska (Quayle 1960). Pacific littleneck clams are widely **distributed** from Alaska to California; within the LAA, littleneck clam distribution is clumped and patchy (Hemmera 2014d). *EIS Volume 3, Section 12.0, page 12-19* *Macoma* clams are widely **distributed** across the northern Pacific Ocean (Coan et al. 2000). *EIS Volume 3, Section 12.0, page 12-19* The Bay mussel (*Mytilus trossulus*) is native to the north Pacific Ocean, and is **distributed** from Alaska to central California (Seed 1992, Riginos and Cunningham 2005). *EIS Volume 3, Section 12.0, page 12-19* Bivalve distribution is reported on in Section 4.1 of EIS Appendix 27-C.
Contaminant Levels	Analysis of metals, PAHs, PCBs, sulfides, and coal in surface sediments is provided in Section 3.5.1 of EIS Appendix 9.6-A. Analysis of existing conditions for PAHs and coal indicator elements in bivalve tissue is provided in Section 4.3 of EIS Appendix 27-C. PAH tissue concentrations in bivalve shellfish were generally a reflection of the local sediment PAH concentrations. *EIS Volume 4, Appendix 27-C, Section 4.3 page 58*
Density	Within the LAA, cockles are common, but not found in high abundance, with **densities** averaging 0.15 cockles/m^2 in the sandy substrates of the low intertidal (Hemmera 2014d). *EIS Volume 3, Section 12.0, page 12-19* Littleneck clam **densities** averaging 14.6 clams/m^2 (Hemmera 2014d). *EIS Volume 3, Section 12.0, page 12-19* *Macoma* clams are the most ubiquitous and abundant bivalve species in the mid to low intertidal zone at Roberts Bank, with **densities** ranging from 16 to 336 clams per square metre (Hemmera 2014d). *EIS Volume 3, Section 12.0, page 12-19* In the LAA, Pacific oyster were recorded in the low intertidal zone attached to the rip-rap on the northwest edge of Westshore Terminals at average **densities** of 1.2 oysters/m^2 (Hemmera 2014h). *EIS Volume 3, Section 12.0, page 12-19*

Indicator	Summary of Existing Conditions
Suitable Habitat Area	Bivalve distribution is ubiquitous yet patchy; thus, the entire LAA is considered potentially suitable bivalve habitat.
Dungeness Crab	
Productivity (biomass)	Production patterns predicted by the crab population dynamics model suggest that there were three years of exceptional crab production in Area 29 and sub-area 29-6 that subsequently influenced **biomass** and fishery catch for the four-year period 2006 to 2009 (Hemmera 2014b). *EIS Volume 3, Section 12.0, page 12-25* Estimates of Dungeness crab biomass and production, as predicted by a Bayesian model developed for the EIS, are presented in Section 4.2.2 of the Dungeness Crab Productivity TDR (TDR MI-4 in Appendix AIR10-C of CEAR Document #388). Biomass and production estimates for Dungeness crab, used as inputs to the Roberts Bank ecosystem model, are presented in Section 5.5.2 of EIS Appendix 10-B.
Abundance	Deltaport Third Berth construction (2007 to 2010) and operation (2010 to present) have not appeared to adversely affect local crab **abundance**, as they are currently among the most abundant organisms in subtidal waters at Roberts Bank (Archipelago 2014, Hemmera 2014h). *EIS Volume 3, Section 12.0, page 12-22* Adult Dungeness crabs are among the most **abundant** organisms at Roberts Bank in shallow (i.e., intertidal to −30 m CD), sandy habitat along the delta foreslope (Archipelago 2014, Hemmera 2014h). *EIS Volume 3, Section 12.0, page 12-24* Self-contained underwater breathing apparatus (SCUBA) surveys conducted in late January 2013 to document use of sandy subtidal habitat in the Project footprint found four solitary gravid female crabs and no aggregations (Hemmera 2014f). *EIS Volume 3, Section 12.0, page 12-25* Abundance of Dungeness crabs, including gravid females, along the subtidal delta foreslope is summarised in Section 4.1 of the Marine Benthic Subtidal Study (TDR MF-2 in Appendix AIR10-C of CEAR Document#388).
Diversity	Not applicable.
Distribution	Dungeness crabs are widely **distributed** along the western coast of North America where they occur from the low intertidal to depths of −230 m CD (DFO 2014). *EIS Volume 3, Section 12.0, page 12-22*
Contaminant Levels	Analysis of metals, PAHs, PCBs, sulfides, and coal in surface sediments is provided in Section 3.5.1 of EIS Appendix 9.6-A. Analysis of existing conditions for PAHs and coal indicator elements in bivalve tissue is provided in Section 4.6 of EIS Appendix 27-C. Results indicate that there were no detectable PAHs in samples of leg muscle from Dungeness crabs collected on Roberts Bank, based on use of sensitive analytical techniques with extremely low detection limits (EIS Appendix 27-C). Concentrations of arsenic were higher in crab from the RBT2 sampling location, consistent with concentrations in local sediment, but this could be attributable to the general decrease in fine sediment deposition from the Fraser River discharge with increased distance from the river mouth (*EIS Volume 4, Appendix 27-C, Section 4.2, Page 40*). Concentrations of PCBs, PAHs, coal indicator elements, and

Indicator	Summary of Existing Conditions
	arsenic compounds in crab hepatopancreas are presented in the response to IR4-33 (CEAR Document #1078[3]), and no statistically significant differences among sampling sites were identified in that analysis.
Density	Results of recent sampling (2012 and 2013) indicate that while juvenile Dungeness crabs settle and rear within the local assessment area, **densities** fluctuate extensively across survey years, which aligns with findings reported from other northeast Pacific sites (Dumbauld et al. 1993, Visser et al. 2004, Hemmera 2014e). *EIS Volume 3, Section 12.0, page 12-24* Within the LAA, **densities** of recently settled crabs were higher in areas of *Ulva* than in eelgrass beds (Hemmera 2014e). *EIS Volume 3, Section 12.0, page 12-24* Remote-operated vehicle surveys of proposed DAS [disposal at sea] areas found that total **densities** of Dungeness crabs were also high at depths up to −45 m CD, decreasing with increasing depth (Hemmera 2014a). *EIS Volume 3, Section 12.0, page 12-24* **Densities** found in the LAA (0.0008 gravid crabs/m^2) are considerably lower than what has been reported for other northern estuarine ecosystems (i.e., Alaska) with reports ranging from 0.75 to 0.86 crabs/m^2 (Scheding et al. 2001), to 2.6-5.6 crabs/m^2 (O'Clair et al. 1996) to more than 20 crabs/m^2 (Stone and O'Clair 2002). *EIS Volume 3, Section 12.0, page 12-25* Densities of juvenile Dungeness crab collected during field sampling, and results of statistical analysis comparing densities across years and habitat types, are reported in Section 4.1 of the Juvenile Dungeness Crab TDR (TDR MI-2 in Appendix AIR10-C of CEAR Document#388). Densities of Dungeness crab along the delta foreslope (-5 to -40 m CD) collected via remote-operated vehicle sampling are reported in Section 4.2.1.1 of TDR MF-2 (Appendix AIR10-C of CEAR Document#388).
Suitable Habitat Area	Habitat suitability modelling indicates Roberts Bank currently contains **1,951 ha of moderate to highly suitable** adult Dungeness crab habitat; **3,001 ha of moderate to highly suitable** juvenile Dungeness habitat; and **854 ha of moderate to highly** suitable gravid female Dungeness crab habitat. *EIS Volume 3, Section 12.0, page 12-26* A model was developed combining environmental parameters with known Dungeness crab habitat preferences to quantitatively model suitable habitat for multiple life stages (juvenile, adult, and female) to determine suitable habitat area with and without the Project; the model is presented in Section 5.0 in EIS Appendix 12-A.
Orange Sea Pens	
Productivity (biomass)	Biomass and production estimates for orange sea pen, used as inputs to the Roberts Bank ecosystem model, are presented in Section 5.14.2 of EIS Appendix 10-B.

[3] CEAR Document #1078 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR4-33, IR5-01, IR5-12, IR5-15, IR5-16, IR5-23, IR5-24, IR5-32, IR5-33, IR5-34, IR5-35, IR5-36, IR6-26, IR7-03, and IR7-05 (See Reference Documents #946, #975, #991, and #1000).

Indicator	Summary of Existing Conditions
Abundance	Sediment sampling in sea pen areas at Roberts Bank show that sea pens are most **abundant** in areas of coarse sand, and that density is strongly and negatively correlated with percent fines (i.e., clay) (Hemmera 2014g). *EIS Volume 3, Section 12.0, page 12-30*
Diversity	Not applicable.
Distribution	Orange sea pens are widely **distributed** along the Pacific coast from Alaska to southern California (Gotshall and Laurent 1979, Shimek 2011). *EIS Volume 3, Section 12.0, page 12-27* At Roberts Bank, underwater video surveys were conducted (2003, 2008, and 2011) to delineate the extent of orange sea pen **distribution**. Two large patches of continuous to densely **distributed** sea pens (i.e., 15.6 hectares (ha) and 7.6 ha) were documented in mixed sand-silt and diatom-covered substrates along the delta foreslope between −2.5 m chart datum (CD) and −19 m CD, surrounded by a larger area (114 ha) with few to patchy sea pens (Hemmera and Archipelago 2014). *EIS Volume 3, Section 12.0, page 12-29* EIS Figure 12-12 depicts orange sea pen distribution at Roberts Bank. Orange sea pen distribution is also discussed in Section 3.4.1 of TDR MI-3 (Appendix AIR10-C of CEAR Document#388).
Contaminant Levels	Analysis of metals, PAHs, PCBs, sulfides, and coal in surface sediments is provided in Section 3.5.1 of EIS Appendix 9.6-A.
Density	In 2011, SCUBA surveys found sea pen **densities** ranged from 2 to 13 sea pens/m^2 in the dense portion of the aggregation and from 0 to 2 sea pens/m^2 in the patchy portion (Hemmera and Archipelago 2014). These numbers align with earlier surveys, which reported **density** ranges from 1 to 8 sea pens/m^2 (Gartner Lee 1992, Triton 2004b, Archipelago 2009). *EIS Volume 3, Section 12.0, page 12-29* Orange sea pen densities, recorded during SCUBA surveys, are presented in Section 3.4.2 of TDR MI-3 (Appendix AIR10-C of CEAR Document #388).
Suitable Habitat Area	The model predicted that approximately **318 ha of suitable** sea pen habitat currently exists at Roberts Bank, of which **110.5 ha is high suitability** and **207.9 ha is moderately suitable**. *EIS Volume 3, Section 12.0, page 12-30* A species distribution model was developed combining environmental parameters with known orange sea pen presence/absence data to predict probability of occurrence across the LAA; the model is presented in Section 4.0 in EIS Appendix 12-A.

Table IR5-03-2 Indicators Used for each Marine Invertebrate Sub-component

Indicator	Sub-component			
	Infauna and Epifauna	Bivalve Shellfish	Dungeness Crab	Orange Sea Pens
Productivity (biomass)	✓	✓	✓	✓
Abundance	✓	✓	✓	~
Diversity	✓	~	x[a]	x[a]
Distribution	✓	✓	✓	✓
Contaminant Levels	~	✓	✓	~
Density	~	✓	✓	✓
Suitable Habitat Area	~	~	✓	✓

Notes: Legend: ✓ = indicator used; ~ = proxy indicator used or indicator linked to another; x = indicator not relevant to the sub-component.
a. As discussed in the text above, the diversity indicator is not relevant for orange sea pens or Dungeness crab given that these are individual species and not assemblages.

Describe how the abundance, distribution, and density indicators were used in the effects assessment to predict possible Project-related changes to marine invertebrates.

Abundance, distribution, and density indicators were used in the effects assessment in several ways.

First, where relevant, these indicators were used to characterise and describe existing conditions of certain sub-components; **Table IR5-03-1** summarises this information and signposts where it can be located within the EIS.

Second, these indicators were indirectly used to predict Project-related change by contributing to the development of site-specific empirical inputs into the Roberts Bank ecosystem model, which, in turn, provided quantitative predictions of productivity change due to the Project. For example, density and/or abundance data were used to generate biomass estimates (using literature-derived weight estimates), which were extrapolated across the study area; the distribution data were used to spatially correct the estimates (see EIS Appendix 10-B for further details).

Third, these indicators were used to inform qualitative predictions of Project-related change. For example, strong correlative relationships exist between the distribution and abundance indicators of infaunal and epifaunal invertebrates inhabiting soft-bottom environments and the size and texture of sediments (Wieser 1959, Heip et al. 1985, Mendez and Ruiz 1998, Lourido et al. 2008). In general, higher infaunal and epifaunal invertebrate abundance, biomass, and diversity indicators are correlated with smaller grain sizes. The deposition of fine sediments north of the terminal, therefore, is anticipated to create more favourable environmental conditions for infaunal and epifaunal invertebrates than currently exist in the local assessment area. This mechanism is likely driving the increase in infaunal and epifaunal invertebrate productive potential predicted by the Roberts Bank ecosystem model. Hence,

these invertebrate indicators (abundance, density) were used to qualitatively inform how the Project may affect marine invertebrates.

Provide an explanation of how temporal and spatial variations were integrated into indicator values used in the effects assessment for marine invertebrates.

Temporal and spatial variability were integrated quantitatively into the EIS where data were available to do so (e.g., see following crab example). Where such quantitative data were not available, qualitative information on this variability, primarily from the literature, was integrated into the EIS to describe existing conditions, trends, and ecological context.

Temporal variations were quantitatively accounted for in indicator values by presenting and analysing mean values, where possible. For example, a Dungeness crab productivity model was developed based in part on a 21-year DFO time-series of commercial landings data, which generated annual estimates of production, recruitment, and biomass in Pacific Fishery Management Area 29. The Roberts Bank ecosystem model input value was based on mean biomass values generated by this model. Within the Roberts Bank ecosystem model itself, temporal variation was accounted for by normalising seasonal input parameters to create annual averages[4], as discussed in greater detail in IR3-13 of CEAR Document #984[5].

In some cases, temporal variation was integrated into effects predictions qualitatively. For example, EIS Section 12.6.3.1 reports on potential seasonal salinity-driven changes in infaunal and epifaunal invertebrate distribution: "in the Fraser River estuary, Chapman and Brinkhurst (1981) found that seasonal variations in interstitial salinities are correlated with the distribution of benthic infaunal species. The authors showed that distributions of two freshwater oligochaete species shifted downstream during freshet (i.e., when interstitial salinities are lowest), and distributions of three marine polychaete species shifted upstream during winter (i.e., when interstitial salinities are highest). Because infaunal and epifaunal invertebrate communities within the local assessment area are so diverse, shifts in salinity are expected to be tolerable to some species and less so for others (e.g., as salinity changes during freshet conditions, more saline tolerant meio- and macrofauna will be replaced by more freshwater-associated species), resulting in an overall unmeasurable effect on invertebrate community productivity".

Spatial variation was accounted for quantitatively through the development of spatially explicit outputs, where possible. For example, inverse distance weighted (IDW) 'heat maps' of macrofaunal and meiofaunal biomass were created and presented as Figures 12-7 and 12-9 in Section 12.5.1.3 of the EIS. Habitat suitability models were created for orange sea pens and Dungeness crabs, where environmental variables were used to predict species' distributions; see EIS Appendix 12-A for more detailed information. Additionally, within the

[4] The use of annual averages is an ecologically valid approach to predicting annual changes in productivity with and without the Project because they have been identified as a standard metric for ecological questions and considered necessary when conducting an ecosystem level assessment (Harvey et al. 2012; Preikshot et al. 2012; Mackinson and Daskalov 2007).
[5] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).

Roberts Bank ecosystem model, the Ecospace module used a spatially explicit habitat capacity model (a combination of habitat suitability and food web conditions) to evaluate overall change to productivity on a cell by cell basis within the study area grid. The Roberts Bank ecosystem model accounts for species distribution by averaging environmental preferences for the abiotic parameters of current velocity, wave height, salinity, depth, and hard/soft substrate; see question 2.11 in CEAR Document #547[6] for a detailed explanation of how environmental preferences were derived and applied.

Identify which indicators are proposed for use in the marine invertebrate follow-up program.

The VFPA is currently in the early stages of developing the Follow-up Program identified in the EIS. More details on what the program will entail can be found in EIS Section 33.5. The development of the Follow-up Program, which is ongoing, will include the selection of indicators. Specific parameters will be defined in discussion with regulatory agencies and in consultation with Aboriginal groups.

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[6] CEAR Document #547 From the Vancouver Fraser Port Authority to the Review Panel re: Answers to preliminary technical questions submitted during the completeness phase from Fisheries and Oceans Canada, Natural Resources Canada, and Environment and Climate Change Canada, concerning the ecosystem modelling to support the Roberts Bank Terminal 2 Project environmental review (NOTE: Updated September 28th, 2016).

IR5-04 Marine Invertebrates – Dungeness Crab Salvages

Information Source(s)

EIS Volume 1: Section 4, Figure 4-9

EIS Volume 3: Section 12, Figure 12-11

TDR MF-2 Marine Benthic Subtidal Study: Section 5.2

Context

In Section 12.7 of the EIS, the Proponent proposed mitigation measures to reduce the direct mortality of Dungeness Crabs from construction activities. These measures include crab salvages to capture and move crabs prior to dredging, infilling dykes, storing sand and scheduling of dredging activities at depths greater than -5 metres so that they are undertaken outside of gravid female crab brooding times.

Fisheries and Oceans Canada identified the following concerns regarding the effectiveness of these mitigation measures:

- Figure 12-11 of the EIS, which depicts the results of the Habitat Suitability Model, indicated that the terminal footprint would overlap with high to moderately suitable habitat for gravid female Dungeness crabs, most of which is within the 0 to -5 metres depth range (see Figure 12 of Appendix 9.5-A). As presented in Figure 4-9 of the EIS, construction in this depth range would be scheduled during the winter when gravid female crabs could be present.
- Figure 4-9 of the EIS, indicated that other proposed Project activities, such as native soil densification and creation of containment dykes, are planned to occur at depths greater than -5 metres during the winter when gravid female Dungeness crabs could be present. However, according to Section 5.2 of the Marine Benthic Subtidal Study, the behaviour of brooding female crabs makes them difficult to observe and capture via SCUBA and may reduce the likelihood of successful capture;
- Dungeness Crab salvage efforts may overlap with the female soft-shell period which could expose crabs to handling stress during this sensitive life stage; and
- Sub-legal Dungeness Crabs are less likely to be effectively salvaged via traps due to their small size.

Fisheries and Oceans Canada is of the view that not all of the Project activities that could result in direct mortality to Dungeness crabs have been identified, and therefore the requirements for crab salvage may have been underestimated.

Clarification is required to understand which Project activities, of those likely to cause direct mortality or injury to crab, are being considered for crab salvage mitigation.

Additional rationale for the salvage and timing window mitigation approaches is required to predict the effectiveness of the proposed mitigation in reducing mortality of Dungeness Crabs.

Information Request

Provide a complete list and schedule of proposed Project activities for which Dungeness crab salvages are planned.

Where Dungeness crab salvages are not planned for Project activities that have the potential to cause direct mortality to legal-sized male, gravid female and juvenile crabs, provide a rationale for omitting these salvages.

Clarify which Project activities could cause injury to Dungeness crabs and whether crab salvages are planned for these Project activities.

Describe alternative approaches for mitigating the potential effects of these Project activities on the Dungeness crab population in the local assessment area for the Project.

VFPA Response

Provide a complete list and schedule of proposed Project activities for which Dungeness crab salvages are planned.

Salvages are planned for all Project activities that have the potential to cause direct mortality to legal-sized male and gravid female Dungeness crabs. A list and schedule of proposed Project activities is provided in **Table IR5-04-1**; the activities for which Dungeness crab mortality or injury may occur are indicated, and for those activities that may cause mortality or injury, plans for salvages are also indicated.

The VFPA would like to highlight that sand storage and dredging at the intermediate transfer pit and vibro-replacement in the marine environment in the dredge basin and underneath buildings are no longer planned, such that crab salvages are not required for these activities (see *Preamble in Support of Responses to IR3-25 to IR3-40* of CEAR Document #984[1]).

The VFPA would also like to acknowledge an omission in the crab salvage mitigation paragraph of EIS Section 12.7.2.1, where land development (piling, densification, placement of fill, removal of existing and temporary infrastructure, and placement of new infrastructure) was inadvertently excluded from the text, though still considered in the assessment.

Where Dungeness crab salvages are not planned for Project activities that have the potential to cause direct mortality to legal-sized male, gravid female and juvenile crabs, provide a rationale for omitting these salvages.

As indicated in the response above, salvages are planned for all Project activities that have the potential to cause direct mortality to legal-sized male and gravid female Dungeness crabs. Since proposed salvages require crabs to enter baited traps, or possibly be retrieved by hand using SCUBA, this mitigation measure is not appropriate for recently settled or early instar juvenile Dungeness crabs, but would be effective for larger juveniles near the sub-adult stage.

[1] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).

Additional rationale for not conducting salvages specifically for juvenile crabs includes the following:

- There is little spatial overlap between Project components/activities that are expected to cause injury/mortality (predominantly subtidal) and the areas inhabited by juvenile crabs (predominantly low to mid-intertidal zones);
- Local Dungeness crab populations are sustained by larvae originating over a large geographical area, such that larval supply to Roberts Bank is expected to continue; and
- Larger juveniles and sub-adults will benefit from proposed salvages.

Clarify which Project activities could cause injury to Dungeness crabs and whether crab salvages are planned for these Project activities.

Project activities that could cause injury to larger Dungeness crabs are provided in **Table IR5-04-1**; please refer to the 'Potential for Injury' and 'Salvage Planned' columns.

Describe alternative approaches for mitigating the potential effects of these Project activities on the Dungeness crab population in the local assessment area for the Project.

Given the nature of direct mortality effects, mitigation options are limited and crab salvage is the only viable and feasible mitigation.

Salvages were conducted to meet the conditions of the *Fisheries Act* Authorization for the Deltaport Third Berth Project. Cutter suction dredging was preceded by ongoing crab salvages (where baited traps were set in advance of dredging and crabs relocated approximately 2 km from the project area) and a visual dive survey (where divers provided visual confirmation of no crabs prior to initial dredging) (Hemmera 2009). In the case of clamshell dredging, visual inspections of the collected dredgeate were made by the contractor's crews and the environmental monitor; only one crab was identified within the dredgeate during the entire project (Hemmera 2009), underscoring the effectiveness of this measure. In consultation with Aboriginal groups, the VFPA has heard a suggestion to bait outside the Project area to draw crabs away as opposed to baiting within the Project area and relocating them. The VFPA is currently exploring this option and will determine an appropriate approach to this mitigation method through engagement with relevant regulatory agencies, stakeholders, and Aboriginal groups.

Table IR5-04-1 List and Schedule of Proposed Project Activities that May or May Not Cause Injury or Mortality to Dungeness Crab, and for which Salvages are Planned

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
Marine Terminal – Land Development	Install piles and barge ramps	Years 1 and 2 (Aug)	Y	Y	A	Y	
	Construct permanent containment dykes around east and west terminal basins	Years 1 and 2 (Aug–Feb)	Y	Y	A	Y	Salvage to occur in footprint of dykes as well as within basins.
	Transport Fraser River and existing quarry sand to the Project site	Years 2 and 3 (Jul–Feb)	N	N	-	N/A	
	Dredge the dredge basin and pump dredged material to fill sites	Years 2 and 3 (Apr–Oct)	Y	Y	A Jv	Y	Salvages will occur daily before dredging activities commence. Potential for injury/ mortality with regard to fill assumed for initial fill layer only; salvage will occur prior to initial filling.
	Pump excess water in terminal basin areas (from filling with Fraser River sand, existing quarry sand, dredge basin material, and tug basin material) to supernatant discharge site	Years 1 to 4	Y	Y	A	Y	Salvage planned prior to initial pumping; once removed, crabs expected to avoid localised area at end of pipe due to TSS plume. No gravid females expected at this depth.
	Fill terminal basins to final grade with sand	Years 3 to 4	Y	Y	A	Y	Potential for injury/ mortality with regard to fill assumed for initial fill layer only; salvage will occur prior to initial filling.
	Preload east basin with sand	Years 3 to 5	N	N	-	N/A	Area already filled; salvage occurred prior to initial filling.
	Preload west basin with sand	Years 4 to 7	N	N	-	N/A	Area already filled; salvage occurred prior to initial filling.

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
	Vibro-replacement of native soil under terminal building foundation areas once terminal fill in place – no longer planned to occur in the marine environment in Year 1 of construction; will occur in Year 4 from the surface of terminal fill.	Year 4	N	N	-	N/A	Area already salvaged.
Marine Terminal – Wharf Construction	Place mattress rock in dredge basin	Years 1 to 3	Y	Y	A	Y	
	Vibro-densify mattress rock in dredge basin	Years 2 to 3	N	N	-	N/A	Assumes crabs will not use dredge basin once mattress rock is placed because they prefer soft sediment habitat.
	Level mattress rock layer; apply screed layer in caisson area	Years 2 to 3	N	N	-	N	Assumes crabs will not use dredge basin once mattress rock is placed because they prefer soft sediment habitat.
	Transport precast concrete caisson infrastructure to Roberts Bank via marine transport	Year 3	N	N	-	N/A	
	Place caissons, ballast, berm, and berm filter rock in wharf area, and install keys to lock structure together	Years 3 to 4	N	N	-	N/A	Assumes crabs will not use dredge basin once mattress rock is placed because they prefer soft sediment habitat.
	Add toe and scour protection rock in berth pocket	Year 4	Y	Y	A	Y	
	Install precast cover and connecting slabs on top of caissons; install cope and crane walls, and concrete crane beam	Years 3 to 4	N	N	-	N/A	

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
	Fill apron with basin preload material; vibro-replace native soil underneath closure dykes from surface, and compact fill material	Year 4 (closure dykes Aug–Nov) Years 4 to 6 (apron fill and preload)	Y	Y	A	Y	
Marine Terminal – Terminal Utilities and Infrastructure	Install underground utilities in terminal buildings area, container yard (CY), intermodal yard (IY), apron area, and main wharf. All Project activities associated with terminal utilities and infrastructure will be conducted above-ground and not in the marine environment; thus, no interaction with Dungeness crabs will occur.	Years 4 to 7	N	N	-	N/A	
Widened Causeway – West Widening	Construct containment dyke along west portion of causeway	Year 1 (Aug–Feb)	Y	Y	A Jv	Y	Salvage to occur in widened causeway footprint prior to dyke construction.
	Remove rip-rap/shore protection from north side of existing causeway and use for containment dyke or place in aggregate storage site at S-bend	Year 1 (Aug–Feb)	N	N	-	N/A	

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
	Fill contained areas with Fraser River sand pumped directly from dredge equipment with pump ashore capability, dredge basin sand, and quarry sand delivered to barge ramps for direct loading, then preload with Fraser River sand pumped directly from dredge equipment with pump ashore capability and quarry sand delivered to barge ramps for direct loading.	Year 2 (Jul–Feb)	Y	Y	A Jv	Y	Salvage to occur in contained areas prior to filling, post-containment dyke construction.
	Vibro-densify dyke	Year 3	N	N	-	N/A	
Widened Causeway – East Widening	Construct containment dyke along east portion of causeway	Year 2 (Aug–Feb)	N	N	-	N/A	No spatial overlap between east causeway footprint and adult Dungeness crab habitat use. East causeway footprint is in upper and high-mid intertidal zone while adult crabs occupy low intertidal/subtidal areas.
	Remove rip-rap/shore protection from north side of existing causeway and use for containment dyke or place in aggregate storage site at S-bend	Year 2 (Aug–Feb)	N	N	-	N/A	
	Fill and preload east causeway area with west causeway preload (dry material)	Years 2 to 3	N	N	-	N/A	

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
Widened Causeway – Infrastructure and Utilities	All Project activities associated with causeway utilities and infrastructure will be conducted above-ground and not in the marine environment; thus, no interaction with Dungeness crabs will occur.	Not applicable – all land based	N	N	-	N/A	
Expanded Tug Basin	Dredge entire tug basin area	Year 2 (Aug–Oct)	Y	Y	A Jv	Y	
	Use dredge material for general fill in terminal	Year 2 (Aug–Oct)	N	N	-	N/A	
	Install piles, mooring floats, gangways and navigation piles, and construct crest protection dyke	Year 2 (Aug–Oct)	Y	Y	A	Y	

	Project Activity	Schedule	Potential for Mortality	Potential for Injury	Life Stage Affected*	Salvage Planned	Comment
Decommissioning of Temporary Construction Infrastructure	Remove supernatant discharge pipe/pump infrastructure	Year 4	N	N	-	N/A	
	Remove temporary piles at barge ramps, ramps, pivot ramp abutments, and navigation markers	Year 6	Y	Y	A	Y	

Notes: * Legend: A = adult (includes both legal-sized males and females, as well as gravid females; Jv = juvenile.

References

Hemmera. 2009. Environmental Monitoring Summary Following Completion of In-water Works at Deltaport Third Berth. Prepared for Port Metro Vancouver. File 499-002.09. 42 pp.

IR5-05 Marine Invertebrates – Orange Sea Pen Transplant Pilot Study

Information Source(s)

EIS Volume 3: Section 12

EIS Volume 5: Section 33.3.12

Context

In Section 12.7.2.2 of the EIS, the Proponent proposed to use an Orange Sea Pen transplant program to partially mitigate direct mortality of Orange Sea Pens from the construction of the terminal.

The Proponent provided a brief description of a pilot study carried out to examine the ecological and logistical feasibility of transplanting Orange Sea Pens. The Proponent stated that 1,200 Orange Sea Pens were transplanted to three sites within the local assessment area for the Project and that survivorship averaged 72% across treatments and sites after a single monitoring event, conducted one month after the transplant. The Proponent also stated that additional monitoring was planned to confirm success of the transplant pilot study over the mid to long-term.

In order to evaluate the predicted effectiveness of this proposed mitigation measure, additional information about the pilot study is required.

Information Request

Provide further information related to the Orange Sea Pen transplant pilot study including the:

- time period of the study;
- location and the extent of the Orange Sea Pen transplant;
- rationale for choice of transplant location;
- survey methodology;
- estimate of survival and post-transplant Orange Sea Pen recruitment;
- potential success of future Orange Sea Pen transplants; and
- ecological and logistical feasibility of Orange Sea Pen transplants as a mitigation measure.

Provide an update on any subsequent monitoring carried out as a part of the pilot study.

VFPA Response

The requested information can be found in the attached Orange Sea Pen Transplant Pilot and Monitoring Program report (**Appendix IR5-05-A**). Specifically:

- Time period of the study is discussed in Section 2.5 Harvest and Transplant and Section 2.6 Monitoring;

- Location and the extent of the orange sea pen transplant is presented in Section 1.3 Study Area;
- Rationale for choice of transplant location is discussed in Section 2.2 Habitat Modelling and Site Selection;
- Survey methodology is presented in Section 2.0 Methods;
- Estimate of survival and post-transplant orange sea pen recruitment are presented in Section 3.0 Results;
- Potential success of future orange sea pen transplants is discussed in Section 4.0 Discussion and Section 5.0 Conclusions; and
- Ecological and logistical feasibility of orange sea pen transplants as a mitigation measure is discussed in Section 5.0 Conclusions and in the body of this response, below.

In summary, the pilot sea pen transplant was successful. Stable densities, and evidence of recruitment, at two of the three transplant sites demonstrate that not only can environmental conditions successfully be used to predict habitat suitability for orange sea pens across a larger study area, but also attests to the ecological viability of transplantation as a potential mitigation method.

The VFPA would like to note, however, that it is not logistically feasible to transplant the entire orange sea pen aggregation out of the RBT2 footprint; there are too many colonies over too expansive an area to be able to transplant each by SCUBA, which is constrained by depth and time. Additionally, the ability to transplant the entire aggregation is limited by the availability of suitable habitat at SCUBA-appropriate depths in areas outside the Project footprint. However, transplanting a portion of the existing aggregation is considered achievable from both time and space perspectives, and the VFPA will work with regulators and other stakeholders to determine an appropriate transplant target.

Appendices

Appendix IR5-05-A Orange Sea Pen (*Ptilosarcus gurneyi*) Transplant Pilot and Monitoring Program

APPENDIX IR5-05-A
ORANGE SEA PEN (*Ptilosarcus gurneyi*) TRANSPLANT PILOT AND MONITORING PROGRAM

Orange Sea Pen (*Ptilosarcus gurneyi*) Transplant Pilot and Monitoring Program

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February 2018

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EXECUTIVE SUMMARY

An aggregation of orange sea pens (*Ptilosarcus gurneyi*) is located within the proposed Roberts Bank Terminal 2 (RBT2) footprint, a new three berth marine container terminal at Roberts Bank in Delta, B.C., proposed by the Vancouver Fraser Port Authority (VFPA). The effects of the RBT2 Project on orange sea pens were assessed and described in the RBT2 Environmental Impact Statement (EIS). As reported in the EIS, the current state of knowledge on orange sea pens, and on cold-water corals in general, is limited; for this reason, the VFPA has initiated a pilot study and monitoring program to assess the feasibility and effectiveness of transplants as a potential mitigation measure.

The objectives of the pilot study (i.e., trial transplant and monitoring program) were to develop and test a method for transplanting orange sea pens and, subsequently, monitor the three transplant sites (T1, T2, and T3) and an area control site in the existing sea pen bed. To accomplish this, a Species Distribution Model was developed that predicted orange sea pen occurrence at Roberts Bank by relating presence and absence to environmental variables. Based on model outputs, sites that were i) outside the Project footprint; and ii) suitable (i.e., >0.55 probability of occurrence) under both, pre- and post- terminal construction scenarios were selected as candidate transplant sites.

Twelve hundred orange sea pens were transplanted in August 2014 using two transplant density treatments (four and six sea pens/m^2) at each transplant site and have been monitored five times since. Overall, sites T1 and T3 have shown relative stability over time despite fluctuations between monitoring periods. The sites have also shown signs of recruitment, particularly in the form of juvenile sea pens which were not part of the initial transplant. Localised movements of sea pens, in the form of spreading into areas bordering the transplanted quadrats, may explain some of the decreases in density observed in the transplant beds as well as concomitant increases in the site control plots adjacent to each transplant site, particularly at site T3. Density declines recorded between April 2016 and April 2017 occurred across all sites, including the area control site; this suggests the decline is a regional trend and likely driven by external factors, such as temperature, rather than reflective of transplant methodology and success.

Steady declines in densities at site T2 suggest some combination of mortality, movement, or sub-optimal habitat quality at this site. This is attributed largely to predation by the striped nudibranch, which has been observed preying directly on orange sea pens at the site. Different sediment characteristics at this site relative to the other two may also have played a factor.

The results of the monitoring program indicate that both density treatments of 4 and 6 sea pens/m^2 are considered both biologically appropriate and logistically feasible for the SCUBA divers transplanting the organisms. Over the course of the monitoring period, the 6 sea pen treatment maintained slightly higher densities than the 4 sea pen treatment; this consistency over time suggests planting at either density adequately represents natural densities.

Stable densities at sites T1 and T3 demonstrate that environmental conditions can be successfully used to predict habitat suitability for orange sea pens across a larger study area, and also supports the viability of transplantation as a potential measure to mitigate potential effects of the RBT2 Project on orange sea pens. While transplants of hard corals in tropical environments is common and well-established, this pilot program represents the first large-scale in-field transplant of orange sea pens in a temperate climate.

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1.0 INTRODUCTION

1.1 OVERVIEW

An aggregation of orange sea pens (*Ptilosarcus gurneyi*) is located within the proposed Roberts Bank Terminal 2 (RBT2) footprint, a new three berth marine container terminal at Roberts Bank in Delta, B.C., proposed by the Vancouver Fraser Port Authority (VFPA). The effects of the RBT2 Project on orange sea pens were assessed and are described in the RBT2 Environmental Impact Statement (EIS) (PMV 2015).

Orange sea pens are a colonial soft coral that are broadly distributed along the Pacific coast of North America, from Alaska to California (Lamb and Hanby 2005). The current state of knowledge on orange sea pens is limited with little known about the abundance, distribution, or ecological role of this species in British Columbia and throughout its geographic range. For this reason, the VFPA initiated a pilot study and monitoring program to assess the feasibility and effectiveness of transplants as a potential measure to mitigate potential effects of the RBT2 Project on orange sea pens.

A large, dense aggregation of orange sea pens is located within the proposed RBT2 footprint. A total of 91.2 ha of orange sea pen habitat may be affected by RBT2 development including 15.6 ha of continuous to densely distributed orange sea pens, and 75.6 ha of sparsely distributed orange sea pens, which together represent approximately 55% of known sea pen productivity at Roberts Bank. The VFPA initiated a pilot study and monitoring program to assess the feasibility and effectiveness of a trial transplant of orange sea pens at Roberts Bank. While transplants of hard corals in tropical environments is common and well-established, this pilot program represents the first large-scale in-field transplant of orange sea pens in a temperate climate. This report presents the results of this pilot study and monitoring program.

1.2 OBJECTIVES

The objectives of this pilot study and monitoring program are to:

1. Develop and test a method for transplanting orange sea pens;
2. Monitor success of transplanted orange sea pens to estimate effectiveness and inform feasibility of large-scale transplants; and
3. Determine any difference in success between the two transplant densities (i.e., transplanting densities of 4 versus 6 individuals/m^2).

1.3 STUDY AREA

The orange sea pen transplant program was undertaken at Roberts Bank, Tsawwassen, B.C. Documented orange sea pen habitat at Roberts Bank starts off the face of the Westshore Coal Terminal and extends 3.5 km northwest towards Canoe Passage, along the delta slope, at depths between −1.5 and −35 m chart datum (CD) (**Figure 1**). The donor bed is located within the proposed RBT2 footprint, while transplant sites are located along the delta front slope both to the north and south of the donor bed (**Figures 2** and **3**).

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Sea Pen - Dense
Sea Pen - Sparse
RBT2 Footprint
Canada / USA Border

N

0 250 500 750 1,000
Metres

NAD 1983 UTM Zone 10N

PORT of vancouver

Hemmera
An Ausenco Company

FIG No. 1

Orange Sea Pen
Transplant Study Area

DATE: 21/12/2017

Document Path: O:\1300-3251\302-035_HEP\RBT2 On Site Mitigation\mxd\302_035_05_HEP_OnsiteMitigation_SeaPen_Fig2_HSI_PreProject_171026.mxd



- Sea Pen Translocation Site
- Sea Pen Area Control Site
- Sea Pen Donor/Harvest Site
- RBT2 Footprint
- Sea Pen - Dense
- Canada / USA Border

HSI Rating (pre-RBT2)

- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0

N

0 250 500 750 1,000

Metres

NAD 1983 UTM Zone 10N

PORT of vancouver

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FIG No. 2

Habitat Suitability Model Output
pre-RBT2 and Sea Pen Donor,
Area Control and Transplant Sites

DATE: 21/12/2017

Document Path: O:\I300-3251302-035_HEP\RBT2 On Site Mitigation\mxd\302_035_05_HEP_OnsiteMitigation_SeaPen_Fig3_HSI_PostProject_171026.mxd



- Sea Pen Translocation Site
- Sea Pen Area Control Site
- Sea Pen Donor/Harvest Site
- RBT2 Footprint
- Sea Pen - Dense
- Canada / USA Border

HSI Rating (post-RBT2)

- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0

N

0 250 500 750 1,000

Metres

NAD 1983 UTM Zone 10N

PORT of vancouver

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FIG No. 3

Habitat Suitability Model Output post-RBT2 and Sea Pen Donor, Area Control and Transplant Sites

DATE: 21/12/2017

2.0 METHODS

2.1 OVERVIEW

The orange sea pen transplant pilot program occurred in five phases, as depicted in **Figure 4** below. First, a predictive species distribution model was developed using existing georeferenced sea pen presence/absence data along with data on environmental parameters (e.g., wave height and bottom current velocity) to identify potential transplant locations (Hemmera 2014). Second, an experimental design was defined, including plans for site layout, treatments, controls, data collection, and analysis. Third, transplant sites reconnaissance field surveys using both a drop camera and SCUBA methods were performed to ground-truth model predictions at each selected transplant site. Fourth, orange sea pens were harvested from the donor bed and relocated to the transplant sites in August 2014; and, lastly, the sites were monitored five times over a three-year period, until April 2017. Each phase is explained in greater detail in the following subsections.

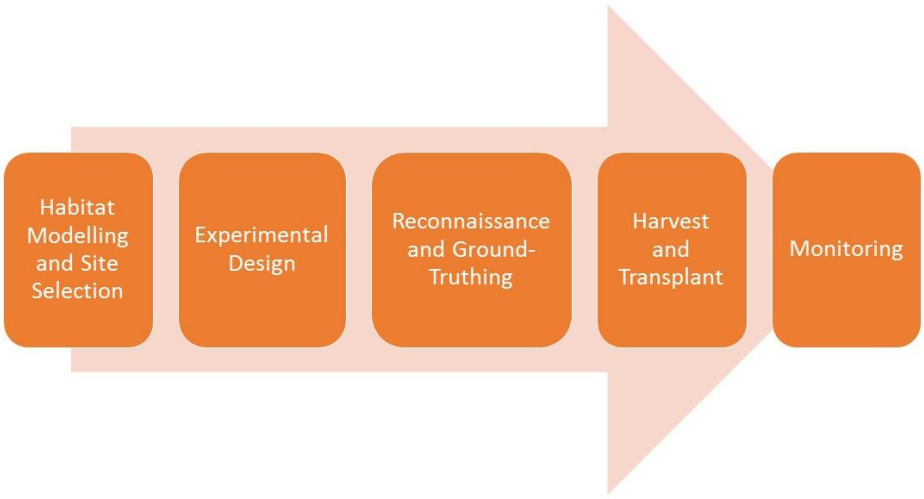


Figure 4 Workflow (5 phases) of Orange Sea Pen Transplant Pilot Program

2.2 HABITAT MODELLING AND SITE SELECTION

The first phase of this pilot program involved the identification and selection of candidate transplant locations, where orange sea pens would have a high likelihood of survival. To achieve this, a Species Distribution Modeling (SDM) approach was used. SDMs are statistical tools that forecast spatial distributions by relating species presence, or presence and absence, with environmental variables. It is possible to predict the environmental conditions that are suitable for a species by classifying grid cells according to the degree in which they are suitable/unsuitable for a species, resulting in a predictive model describing the suitability of any site for that species (Guisan and Thuiller 2005). For this pilot program, SDM was used to develop a predictive model of orange sea pen occurrence at Roberts Bank to identify areas of

highest habitat suitability (i.e., areas where orange sea pens are most likely to occur). The general workflow of SDM includes:

1. Collecting the locations (geographical coordinates) of occurrence of the target species. In this case, georeferenced presence/absence points were used from underwater video (SIMS) surveys conducted by Archipelago in 2008 and 2012; specifically, a total of 34,555 data points comprise the orange sea pen dataset: 16,457 absence points and 18,098 presence points[1].
2. Assemble values of environmental predictor variables at these locations. In this case, these data were sourced from both publicly available spatial databases as well as from a predictive hydrodynamic model developed by Northwest Hydraulic Consultants (NHC) for the RBT2 environmental assessment (NHC 2014).
3. Use the environmental values to fit a model to estimate similarity to sites of sea pen occurrence. Here, a logistic regression generalized linear model was created using georeferenced orange sea pen presence/absence data as a function of bottom current velocity, wave height, sediment grain size, depth, and both a broad and fine scale bathymetric position index (BPI). Further details on model selection are provided in the text below.
4. Predict the variable(s) of interest across the study area (in this case, Roberts Bank from Canoe Pass to south of the B.C. Ferries Causeway).

For Step 3 above, model selection, predictions, and validation were performed using Marine Geospatial Ecological Tools (MGET) within ArcGIS and integrated with the R statistical package (R Development Core Team 2014). Each environmental spatial data layer (e.g., slope, depth, bottom current velocity and BPI) was used in combination with the training dataset (i.e., 70% of the orange sea pen presence-absence locations) to generate a series of plausible models. A backwards stepwise Akaike's information criterion (AIC) analysis was then used to determine the best fit model (Posada and Buckley 2004) by adding or removing variables and assessing how the model performs; a model with too many variables may have low precision whereas a model with too few variables may be biased (Burnham and Anderson 2002). As a result of model selection, both broad and fine scale BPI, bottom current velocity, and wave height were kept in the model, while sediment size distribution and depth were dropped. Depth was dropped due to high collinearity with most other variables considered in the model while sediment grain size was also dropped as it did not improve the model's ability to describe the data.

For Step 4 above, once the best fit model was determined, it was used to create a probability of occurrence raster for all of Roberts Bank, including unsampled locations. In other words, orange sea pen occurrence was predicted across all of Roberts Bank based on their association with the environmental parameters

[1] Data points were separated into a "training" data set that a model was created from, and an "evaluation" data set that was used to independently quantify the accuracy of the model; seventy percent (70%) of the presence and absence points were randomly selected for use in model development (i.e., training), while the remaining 30% were set aside for assessing the accuracy of model predictions (i.e., evaluation).

associated with the habitat in which they were observed. The model predicted high probability of sea pen occurrence in areas with moderately high wave height, moderate bottom current velocities, and along the delta foreslope.

Once completed, the best fit model was tested for its predictive capabilities by comparing the predicted occurrence of orange sea pens to the evaluation dataset (i.e., the 30% of the observational data not used in the creation of the model) using a standard AUC[2] method: an AUC value above 0.7 is considered an acceptable level of performance, between 0.8 and 0.9 is excellent, above 0.9 is outstanding, and 1 is a perfect classifier (Hosmer and Lemeshow 2004). This sea pen habitat model had an AUC of 0.85 and an accuracy rate of 0.79 suggesting it performs at an excellent level.

Subsequently, a binary presence/absence raster was derived from the probability of occurrence raster by setting a threshold probability of 0.55; in other words, the model was told to count all grid cells in which the probability of occurrence >0.55 (55%) as a “presence” (i.e., 1 or suitable habitat classification) and count all grid cells in which the probability of occurrence <0.55 as an “absence” (i.e., 0 or unsuitable habitat classification). The value of 0.55 was chosen as a threshold probability because it falls within a range that is commonly used in published Generalized Linear Model (GLM) studies (i.e., 0.5 to 0.7; Austin 1998, Hirzel and Guisan 2002). To examine the potential impact of the proposed terminal on the transplant sites, the model was then run under two scenarios, one without the Project and one with the Project, producing two suitability surfaces (**Figures 2** and **3**).

Overall, three sites were selected as potential transplant locations (**Figures 2** and **3**). Criteria for site selection included:

- Sites had to fall within suitable habitat area (i.e., in areas of at least 0.55 probability of occurrence);
- Depth of sites had to be accessible by SCUBA and within the range stipulated by WCB (i.e., <18 m CD); and
- Sites had to fall within VFPA jurisdiction.

An area along the subtidal slope was masked or removed from the final results, as it encompasses subtidal channels that have geomorphic patterns suspected to result from localised sediment slumping, erosion or slope failure (**Figures 2** and **3**). It was hypothesised that the lack of sea pen sightings in this region may be due to physical disturbance caused by extensive channelisation. Similar conditions at the confluence of the Canoe Passage channel and the subtidal slope further north may also be present, although this area was not included in reconnaissance surveys conducted for this study.

[2] AUC is the probability that a randomly chosen observation of presence would be assigned a higher ranked prediction than a randomly chosen observation of absence.

2.3 EXPERIMENTAL DESIGN

A randomized block design was employed, where a block is represented by each of the three transplant sites (i.e., sites T1, T2, and T3) outside the existing sea pen bed and two control sites in the donor (existing) sea pen bed (i.e., the area control and donor/harvest sites; see **Figure 2** and **3**). Again, sites were selected using the SDM approach outlined above.

The area control was established to estimate non-transplant effects (i.e., if all sea pens die, including those in the untouched control), and measure natural mortality and migration. A transplant control was also established to measure transplant effect by removing individuals and re-planting in the donor site. If transplanted individuals in the transplant control die, but not those in the area control, it is reasonable to conclude that it is the result of transplanting (transplant shock) and not effects extraneous to the study[3].

Each block, totalling 80 m^2, was subdivided into four 20 m^2 (5 m x 4 m) quadrants (see **Figure 5**), and each of the 20 m^2 quadrants were assigned one of two sea pen density treatments (4 individuals/m^2 or 6 individuals/m^2), effectively creating two replicates within each site. The treatment densities of 4 and 6 individuals/m^2 were selected to mimic observed sea pen densities in the donor bed.

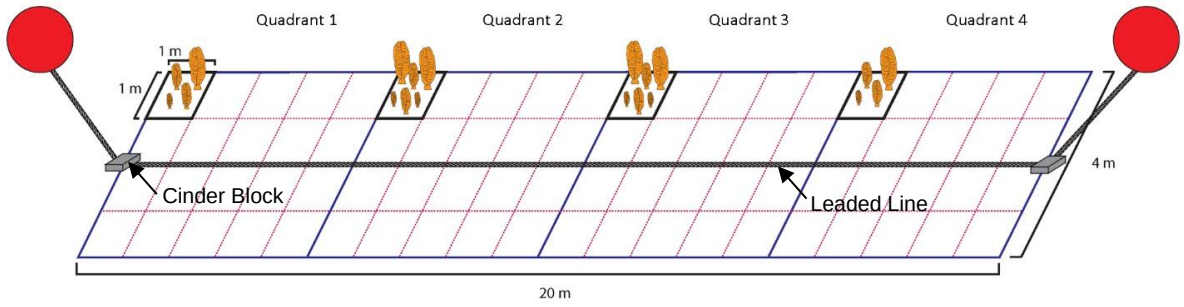


Figure 5 Randomized Block Design for Orange Sea Pen Pilot Transplant Study

Additionally, during the April 2015 monitoring, increases in orange sea pens next to the transplanted blocks was observed, possibly a result of transplanted sea pens expanding or possibly representative of immigration or recruitment to the area. Accordingly, two *site control* quadrants, each 20 m^2, were established immediately adjacent to each transplant site (T1, T2, T3) to measure localised changes in sea pen abundance. Collection of these data enables greater understanding of how the transplants may be influencing neighbouring seabed communities or how the surrounding areas may influence the transplants. For example, whether the transplants are attracting other sea pens to the area or whether the transplanted sea pens are spreading to surrounding areas.

[3] Ultimately the Transplant Control was compromised by commercial crab operations that pulled up the entire sampling transect and deposited it a few hundred metres away. Further details are provided in **Section 2.6**.

2.4 RECONNAISSANCE AND GROUND-TRUTHING

The project team liaised with Canada Coast Guard, VFPA Communications, Environmental Programs and First Nations engagement teams to ensure the transplants did not interfere with fisheries and other activities at Roberts Bank. Reconnaissance surveys and site preparations were completed using drop camera and SCUBA over a two-day period (August 13 and 14, 2014). Shark-Bite Marine Charters of Tsawwassen First Nation provided vessel support services to Hemmera's dive team during all reconnaissance, transplant and monitoring operations.

Reconnaissance enabled divers to assess habitat features at both control and transplant sites and to visually validate (i.e., ground-truth) model predictions and collect baseline information to validate the study design prior to its implementation. Two reconnaissance drop camera transects were completed at each site to assess bottom conditions before a SCUBA survey. Presence of sea pens, sandy substrate, and an absence of predators were visual criteria used to rapidly assess whether an exploratory dive at that particular site was warranted. Where the drop camera surveys indicated that a candidate site met model predictions, the SCUBA team was deployed to: i) set up a sampling grid for the future transplant, and ii) collect baseline data of each site including video and photograph documentation.

At each of the five sites (i.e., two control and three transplant sites), a 22 m transect consisting of two concrete blocks joined by a lead line, was deployed along the seafloor. The lead line was used as the centre of each site from which divers collected baseline data (**Figure 5**). Each site was marked with an orange floating buoy attached to one of the cinder blocks. The position of each floating buoy was recorded using a handheld GPS unit.

Once each site was established, divers completed a baseline survey using a 20 m belt transect. Sampling began and ended one metre from each cinder block to avoid any potential effects from disturbance of the sea floor due to the presence of the cinder block. The first pass of the transect line included a fish survey conducted by Diver 1 (where all species of fish observed within two metres of the transect were identified and recorded), while video footage was recorded by Diver 2. On the way back, five quadrats were sampled (i.e., every five metres) and the following information was recorded on underwater data sheets (**Photo 1**):

- Quadrat Number;
- Substrate (sand, silt, clay);
- Macroalgae cover, species;
- Marine invertebrates, species and density;
- Marine fish, species and density; and
- Sea pen, density, height.

When sea pens were encountered, they were enumerated and their height recorded using a measuring stick in order determine what proportion were reproductively active (greater or less than 24 cm from the base of the peduncle (Boutillier pers. comm. 2014).

In addition to surveying biota, divers visually documented substrate type and recorded evidence of geomorphic changes along the slope, particularly at site T1 near Canoe Pass. This was necessary since video evidence from previous surveys (Archipelago 2011) showed possible sediment slumping, erosion or slope failure northwest of the proposed terminal, toward Canoe Passage, creating an environment unsuitable for sea pens (see **Figure 2** and **3**). Although these geomorphic changes are not predictable variables, the model identified this area as highly suitable based on other environmental parameters.

2.5 HARVEST AND TRANSPLANT

Between August 15 and 20, 2014, SCUBA divers harvested sea pens along randomly placed 60 m transects within the donor bed (**Photo 2**). Collection of sea pens along the transect line (two to three metres on either side) ensured that natural population characteristics of the donor bed were transferred to the transplant sites (i.e., sex ratio, age/size structure). Sea pens were measured on the seafloor to record whether they were greater than or less than 24 cm, the reported size at maturity.

Divers extracted expanded orange sea pens from the substrate by hand, taking care to prevent damage to delicate tissue and structures, including the peduncle, rachis, and leaves (see **Photo 2**). Each diver used only their thumb and forefinger to gently pinch the orange sea pen at the junction of the peduncle and rachis, and gently pull the expanded sea pen from the substrate; this technique is illustrated in **Photos 3** to **5**. Care was taken to apply the right amount of pressure, and not let the finger and thumb slide up the rachis, damaging soft tissue including leaves.

Once extracted, sea pens were immediately placed in a transparent 3 litre plastic bag that could not collapse onto the animal and cause tissue damage (**Photo 6**). The bag was filled with seawater from depth, and no more than 20 orange sea pens were placed into each bag. Collection bags were sealed at depth with elastic bands so that sea pens were not exposed to lower salinity surface water. Sea pens housed in the collection bags were placed into coolers with ice packs upon return to the surface.

Orange sea pens remained on ice during the divers' surface interval, typically about an hour. Once the surface interval was complete, the boat was positioned on top of the transplant site coordinates and the divers re-entered the water with the plastic bags. Typically, sea pens were in a deflated position prior to transplanting with a decreased diameter of the peduncle and increased rigidity of the animal in preparation for insertion into the substrate. A stainless-steel planting trowel was used to excavate a hole into which a single orange sea pens was placed, peduncle-first (**Photos 7** and **8**). Care was exercised when back-filling the hole around the peduncle, so as not to displace the sea pen. A total of 1,200 orange sea pens were relocated to each of the three transplant sites.

2.6 MONITORING

Monitoring was conducted five times between September 2014 and April 2017. Ideally, monitoring was conducted each April, before the spring freshet delivered high volumes of turbid fresh water to the estuary, greatly impacting visibility, and each September. However, the September 2016 monitoring event was cancelled due to a combination of geotechnical works occurring at the Project site and inclement weather. Specific monitoring dates are as follows:

1) September 29 and 30, 2014;
2) April 1 and 2, 2015;
3) September 9, 2015;
4) April 14 and 15, 2016; and
5) April 20, 2017.

Unfortunately, by the first monitoring period (i.e., September 2014), the *transplant control* (see **Section 2.3**) was compromised by commercial crab operations; commercial crab fishers pulled up the entire sampling transect and deposited it a few hundred metres away. Since the exact transect for which baseline data was collected could not be monitored, it is not possible to describe sea pen density at the transplant control site quantitatively. However, results suggest that transplanted orange sea pens may have experienced minor transplant shock, as densities decreased across all transplanted sites relative to initial planting densities (not relative to a control), but quickly appeared to stabilise thereafter (see **Section 3.3.1** for further details); the stabilisation of densities by monitoring period 2 (i.e., April 2015) supports a characterisation of possible transplant shock as minor. Further, the removal of the sampling grid at the transplant control is not considered to have affected the overall integrity of the study because the area control remained intact such that control comparisons could still be made.

Each of the four sites (i.e., three transplant sites and area control site) were located using a GPS with an accuracy of approximately five metres. To locate each site underwater, a weighted drop line with a buoy was placed nearest to the waypoint position and used to establish an anchored position to systematically search for the sites underwater, which were marked with cinder blocks. It was not possible to locate the exact transect coordinates within the dense sea pen bed at the area control site, because the blocks and flagging tape were obscured by the density of sea pens and/or poor visibility; therefore, a random starting point was used in the vicinity of the original transect each time. Once located, a 20 m transect line was placed along the centre of the transplant to guide sampling. Sampling consisted of using 1 m^2 quadrats systematically within each treatment block to conduct counts of all sea pens across the entire site.

3.0 RESULTS

3.1 RECONNAISSANCE AND GROUND-TRUTHING

Overall, reconnaissance surveys were useful in ground-truthing model predictions such that study design could be validated prior to its implementation. Selected transplant locations appeared to be located in coarse sand, with no evidence of sediment slumping or damage from crab traps; though there was no evidence of commercial crab activity at the time of reconnaissance, the transplant control site was later compromised by crab operations, as discussed in **Section 2.6** above. Several striped nudibranchs (*Armina californica*), which are orange sea pen predators, were observed at sites T2 and T3, and within the transplant control bed.

During reconnaissance (i.e., August 13 and 14, 2014), sea pen densities averaged 5.6 sea pens/m^2 and 5.2 sea pens/m^2 at the area control and transplant control sites, respectively. These observations align with those recorded in baseline surveys for the RBT2 Environmental Assessment (which reported a mean of 5.7 sea pens/m^2) and reinforce that selected planting densities of 4 and 6 sea pens/m^2 are reflective of naturally occurring densities. No sea pens were present within quadrats surveyed at selected transplant sites T1 or T2, and were sparse at T3 averaging 2 sea pens/m^2 (**Table 1**).

Of the sites with sea pens already present, the proportion of sexually mature specimens (greater than 24 cm in height when inflated) varied from 10% (2/20) at the transplant control site, to 25% (1/4) at site T3, to 41% (7/17) at the area control site. The presence of mature adults within the transplant control site suggests that the bed is reproductively active, while the presence of smaller juveniles suggests active recruitment to the area. These data contradict past observations (Archipelago 2009), which posited that these aggregations represented a reproductively inactive remnant population. Whether spawning and/or recruitment are controlled by density dependent factors (i.e., require a minimum number of sea pens present) is unknown.

Table 1 Summary of Sea Pen Observations during Reconnaissance Surveys

Site	Sea Pen Presence	Number of Sea Pens within Quadrats			Number of Sea Pens Measured[4]
		Buried	Non-Buried	Total	
T1	None	0	0	0	0
T2	None	0	0	0	0
T3	Sparse	0	4	4	4
Area Control	Dense	11	17	28	17
Transplant Control	Dense	6	20	26	20

[4] Only sea pens that were not buried were measured.

3.2 HARVEST AND TRANSPLANT

In total, 1,200 sea pens were harvested and transplanted over 7 days in August 2014; 400 at each of the three transplant sites. Ocean conditions were favourable for the duration of the transplant, with minimal waves and only one day of heavy rainfall.

There were no complications during harvest or transplantation and only one sea pen appeared damaged from handling. Sea pens are resilient to handling and though several appeared bent over upon planting, they began to re-inflate by the end of each dive (**Photo 9**). This observation was further confirmed when visiting sites over the course of the monitoring period. Integration of sea pens into the local marine community was observed as other species, notably Dungeness crab and flatfish, moved into the transplanted areas within a single dive period.

Of the 1,200 sea pens harvested, 874 *in situ* height measurements were recorded to determine whether sea pens were greater or less than 24 cm, the reported size at maturity (Shimek 2011). Of this total, 502 (57%) were greater than 24 cm, or sexually mature, while 372 (43%) were less than 24 cm, or sexually immature.

3.3 MONITORING

Transplant sites were monitored a total of five times between September 2014 and April 2017. In general, across the monitoring period, visibility was fair to poor, ranging from about 3 to 8 metres.

3.3.1 Success Rate by Site

Orange sea pen densities over time, by site, are presented in **Table 2** and **Figure 6**. A generalized linear model (GLM) was used to statistically compare sites and treatments through time (**Table 3**; **Figure 7**). Results show that densities at sites T1 and T3 are not significantly different from one another, but are significantly higher than at site T2. All sites exhibited statistically significant lower density compared to initial planting densities (August 2014).

In general, sites T1 and T3 are considered successful, with success rates (i.e., # of sea pens/m^2 relative to initial transplant density) of 58% and 52%, respectively, based on observations made in April 2017. Prior to April 2016, the success rates were 80% and 64%, respectively, but a decline in densities was noted across all sites, including the area control, between April 2016 and April 2017. In contrast, the transplanted bed at site T2 has steadily declined in densities over the monitoring period.

Orange sea pen density at the area-control site also fluctuated over the monitoring period. A statistically significant decline was noted between September 2014 and April 2015. A second decline was noted between April 2016 and April 2017; however, this trend was observed across all sites.

Table 2 Summary of Sea Pen Densities as a Function of Transplant Density, Site, and Time

			August 2014		September 2014		April 2015		September 2015		April 2016		April 2017	
Site	**Sea Pen Density Treatment (#/m^2)**	**Sea Pens Planted (#)**	**Mean Sea Pen Density**	**SD**	**Mean Sea Pen Density**	**SD**	**Mean Sea Pen Density**	**SD**	**Mean Sea Pen Density**	**SD**	**Mean Sea Pen Density**	**SD**	**Mean Sea Pen Density**	**SD**
Area Control	0	0	5.8	1.7	6.7	2.7	2.6	1.9	6.4	2.4	6.7	2.7	4.9	1.9
T1	0	0	0.0	0.0			0.1	0.2	0.1	0.3	0.2	0.4	0.2	0.4
	4	160	4.0	0.0	3.0	1.1	3.2	1.9	3.3	1.4	3.0	1.2	2.5	1.5
	6	240	6.0	0.0	4.1	1.6	4.8	1.9	4.7	1.8	4.9	1.8	3.2	1.6
Mean T1	**-**	**400**	5.0	1.0	3.5	1.5	4.0	2.1	4.0	1.8	4.0	1.8	2.9	1.6
T2	0	0	0.0	0.0			0.0	0.2	0.2	0.4	0.2	0.5	0.1	0.2
	4	160	4.0	0.0	2.2	1.5	0.4	0.6	0.6	0.8	0.6	0.8	0.3	0.5
	6	240	6.0	0.0	3.5	1.9	1.3	1.3	1.0	1.2	0.8	1.0	0.3	0.5
Mean T2	-	**400**	5.0	1.0	3.0	1.8	0.9	1.1	0.8	1.1	0.7	0.9	0.3	0.5
T3	0	0	0.7	1.2			1.2	1.2	1.0	1.1	1.4	1.5	1.8	2.1
	4	160	4.0	0.0	4.2	1.4	3.3	1.4	3.9	1.8	3.0	1.5	2.5	1.6
	6	240	6.0	0.0	4.2	1.1	4.5	1.7	4.4	1.8	3.4	1.8	2.8	1.6
Mean T3	-	**400**	5.0	1.0	4.2	1.2	4.0	1.6	4.1	1.8	3.2	1.7	2.6	1.6

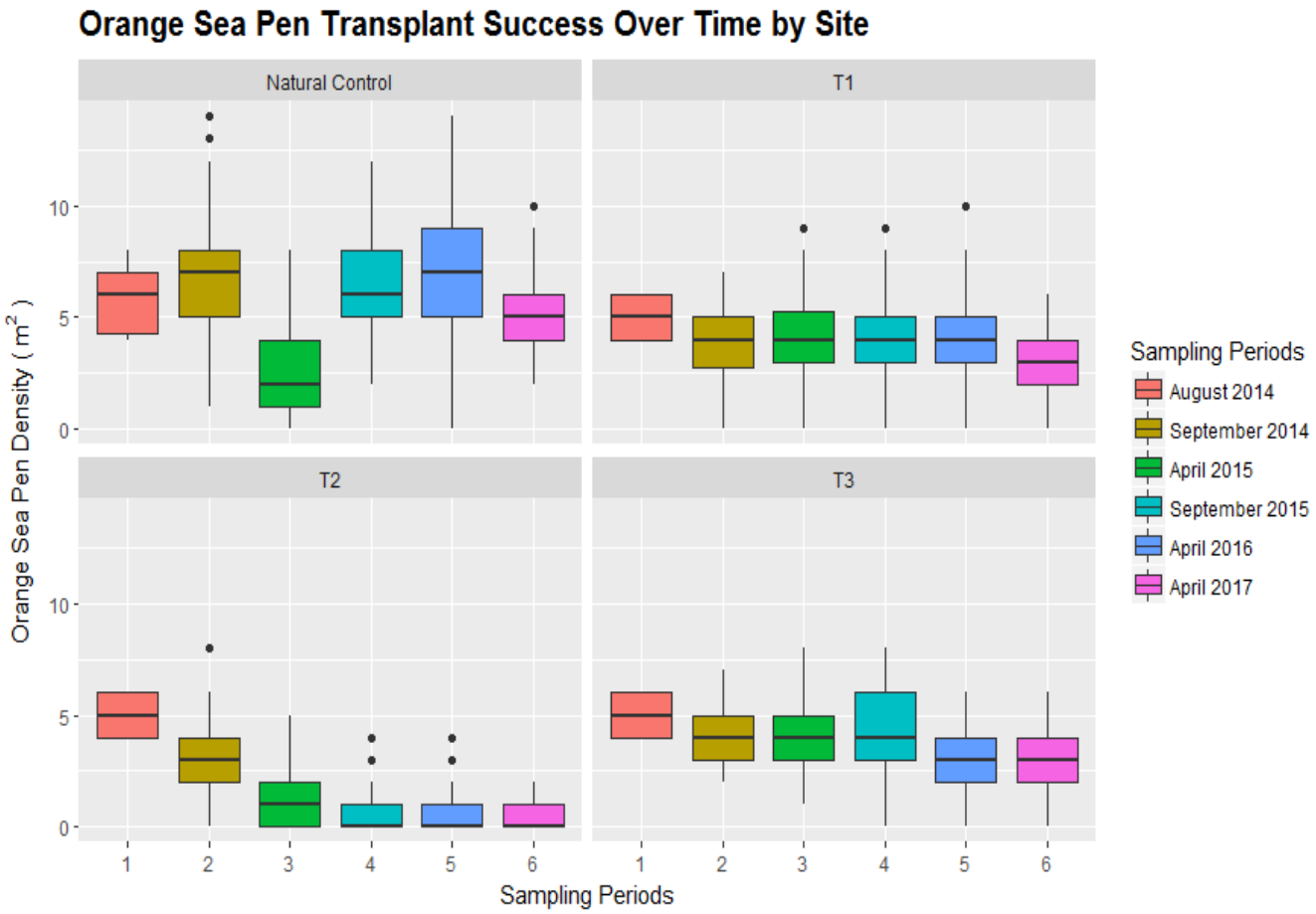


Figure 6 Orange Sea Pen Transplant Success by Site (Control, T1, T2, T3), Over Time

Table 3 Outputs of a Generalized Linear Model (GLM) Comparing Results by Site and Density Treatment over Time

Variable	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	1.6	0.0	43.4	<0.0001
SiteT2	-0.8	0.0	-19.0	<0.0001
SiteT3	0.0	0.0	-0.4	0.7
Treatment6	0.3	0.0	10.2	<0.0001
Period2	-0.3	0.0	-7.5	<0.0001
Period3	-0.5	0.0	-11.0	<0.0001
Period4	-0.5	0.0	-11.1	<0.0001
Period5	-0.7	0.0	-13.3	<0.0001
Period6	-1.0	0.1	-17.4	<0.0001

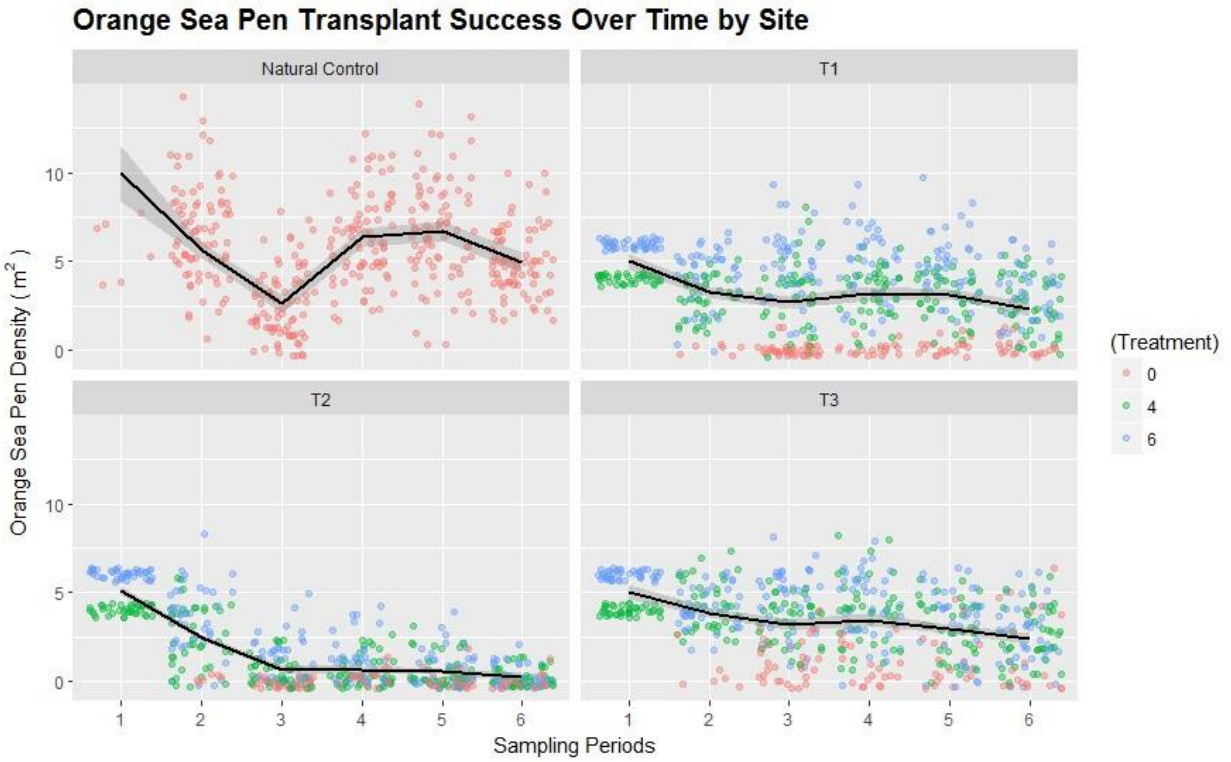


Figure 7 Trendlines of Orange Sea Pen Success Over Time, by Site

3.3.2 Site Controls

As described in **Section 2.3** above, in April 2015, site control quadrants (each 20 m^2) were established at each transplant site (T1, T2, T3) in an attempt to capture changes in orange sea pen density in areas immediately bordering the transplanted quadrants.

Sea pens were not observed adjacent to site controls at sites T1 and T2 in September 2014; however, several sea pens were recorded in these control plots in April 2015, with low numbers remaining consistent over the duration of the monitoring period. Orange sea pens were observed in the site control plot of site T3 during all monitoring periods, with density in these plots slightly increasing over time (**Figure 8**).

3.3.3 Success Rate by Density Treatment

Small but statistically significant differences were noted between the two treatment densities, with the 6 individuals/m^2 treatment maintaining slightly more sea pens than the 4 individuals/m^2 treatment (**Figure 9**). This indicates that the treatments show no density dependent effects and were stable during the monitoring period.

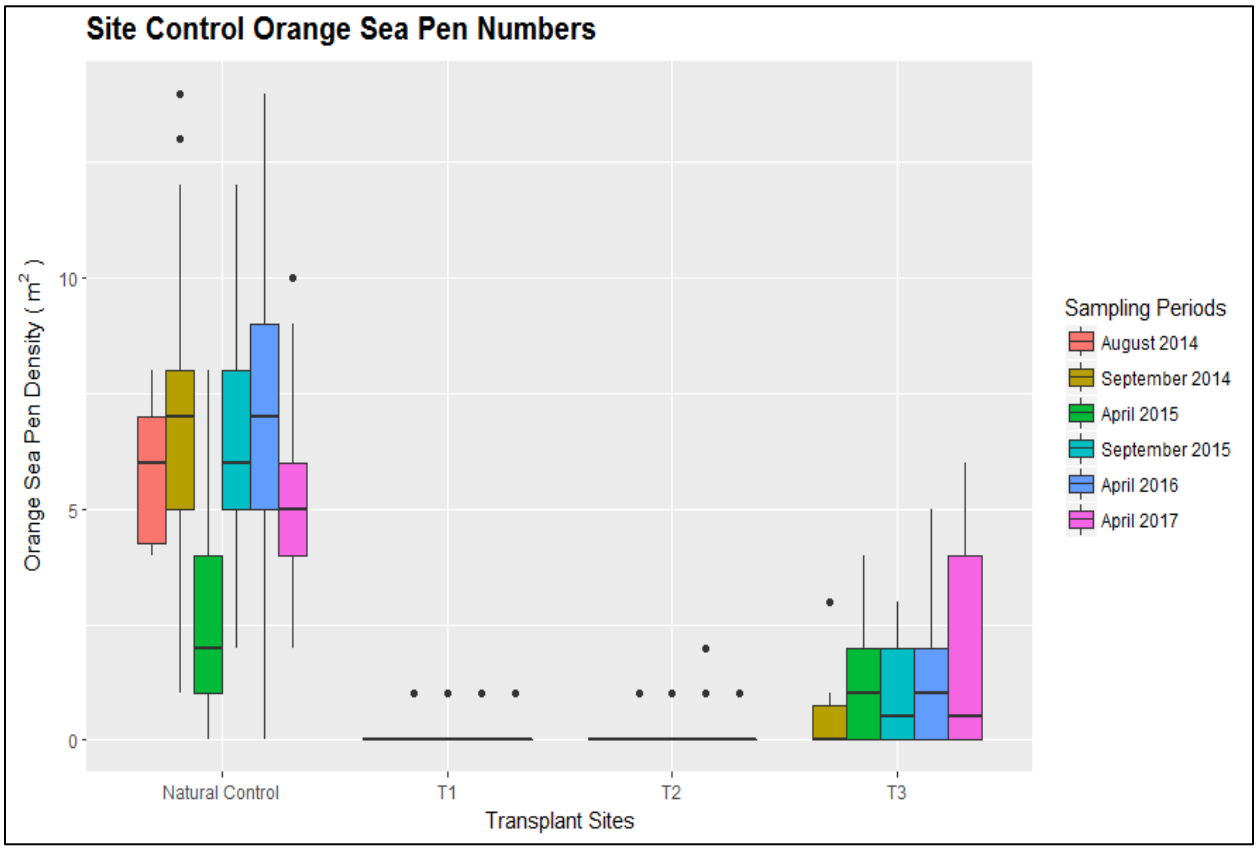


Figure 8 Sea Pen Site Control Density Changes by Site (T1, T2, T3), Over Time

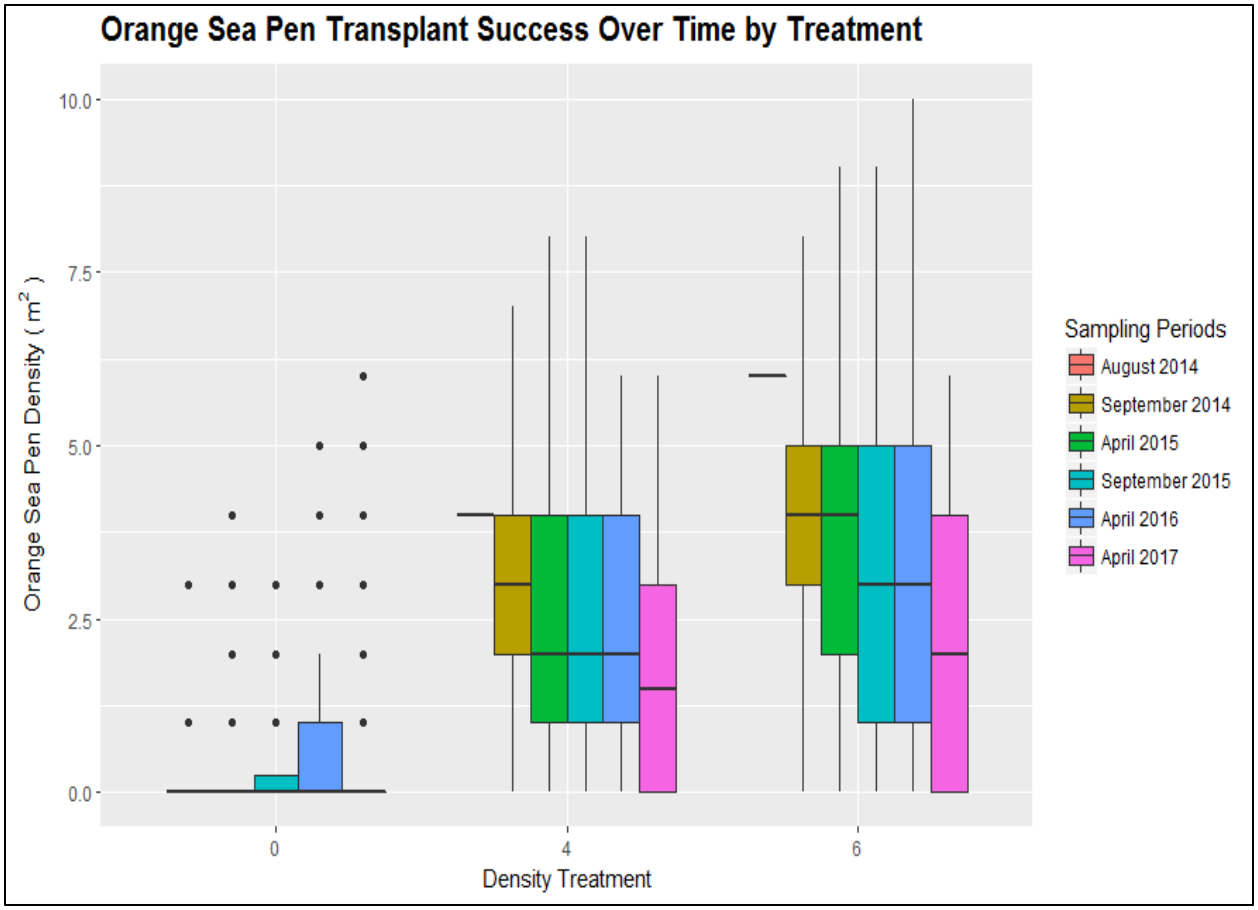


Figure 9 Sea Pen Transplant Density Changes by Density Treatment (0, 4, 6) over Time

4.0 DISCUSSION

As presented in **Section 3.3.1**, all sites exhibited statistically significant lower density compared to initial planting densities (August 2014). This may have been a result of transplant shock, as lower densities were observed across all three transplant sites during the first monitoring event post-transplant (i.e., September 2014), relative to initial planting; however, densities stabilised over subsequent monitoring events, suggesting any transplant shock experienced was temporary. Unfortunately, due to the destruction of the transplant control site, no further inferences can be drawn.

Overall, sites T1 and T3 have shown an overall trend of relative stability over time, despite fluctuations between monitoring periods. Small-scale movement (i.e., spreading out of transplanted individuals) is hypothesised to account for some of the decreases in density observed in transplanted quadrats, and the increases in density observed in the site control plots adjacent to each transplant site, particularly at site T3. In other words, the decreases in the transplant beds appear to be driving some of the increases in the site control plots. Increases in density at the site controls may be partially driven by immigration or recruitment, with individuals sourced from other areas within the large donor bed or from further afield (e.g., Puget Sound, Gulf Islands). Additionally, slight differences in quadrat placement for each monitoring period may have introduced variability in density estimates. Reasons for observed fluctuations are posited in **Section 4.1** below.

Within the area control, a statistically significant decline was noted between September 2014 and April 2015. This is attributed to spatial variation in density within the sea pen bed rather than an actual bed-wide decline. Quadrat placement varied within the donor bed at the area control site each monitoring event (i.e., the original quadrat locations were not re-sampled as planned) because the flagging tape marking the exact locations could not be found due to a combination of high densities of orange sea pens and poor visibility. A second decline within the area control was noted between April 2016 and April 2017; however, this trend was observed across all sites, which suggests a regional trend likely driven by large scale factors (e.g., temperature or food availability, etc.) and does not reflect the success of the transplant methodology used.

Steady declines in densities at site T2 suggest some combination of mortality, movement, or sub-optimal habitat quality at this site. This is attributed largely to predation by the striped nudibranch, which was observed preying directly on orange sea pens at the site (see **Photos 11** and **12**). Declines may also reflect site-specific differences in sediment characteristics, particularly grain size; sediment data could not be incorporated into the species distribution model because (i) data do not exist at a small enough spatial scale to meaningfully inform site selection and (ii) existing data cannot be used to predict changes in grain size distribution with the Project. Since sediment grain size preferences of orange sea pens at Roberts Bank have been empirically measured as part of EIS technical studies (see TDR MI-3), should a larger-scale transplant be pursued in the future, sediment sampling could easily be incorporated into the ground-truthing phase to ensure grain size at potential transplant sites lies within an appropriate range.

Both density treatments of 4 and 6 sea pens/m^2 are considered appropriate. Over the course of the monitoring period, the 6 sea pen treatment maintained slightly higher densities than the 4 sea pen treatment. Consistency in densities over the course of the monitoring period suggests that there are no density dependent effects and that both treatments suitably reflect natural conditions.

While some localised movement of individuals is evident and expected, stable densities at sites T1 and T3 demonstrate that not only can environmental conditions successfully be used to predict habitat suitability for orange sea pens across a larger study area, but also attests to the viability of transplantation as a potential mitigation method.

4.1 POSSIBLE REASONS FOR DENSITY FLUCTUATIONS

4.1.1 Visibility

Relatively poor visibility throughout the monitoring period challenged the ability of divers to detect the sea pens, particularly individuals that were buried within the sediment. In some instances, divers had to rely on feeling around for buried sea pens. It is possible that some individuals were missed by the divers and not counted, leading to underestimates of sea pen density and, hence, success rate.

4.1.2 Burial

Sea pens naturally inflate and bury throughout the day (Birkeland 1974, Shimek 2011). Sometimes they are visible, forming a button like depression at the surface (see **Photos 2 and 10**); other times they are not easily visible as they may bury up to 30 cm. Literature reports that as few as 25% of sea pens can be inflated at any one time (Birkeland 1968). While divers were able to see and account for some of the buried sea pens, it is likely that all sea pens present were not recorded, which may have resulted in lower counts and underestimates of transplanted individuals and, by extension, success rate.

4.1.3 Natural Movement

Unlike other octocorals, sea pens are capable of some locomotion by inflating their bodies with water, climbing out of the sediment and turning into the currents, allowing them to drift above the seafloor and relocate (Shimek 2011). While this behaviour has rarely been observed at Roberts Bank, relocation of individual sea pens could account for fewer sea pens observed during the monitoring dives and, possibly, the corresponding increases in numbers in the site controls adjacent to the transplant beds. While exploring reasons for natural movement was outside the scope of this report, it is likely at least partially driven by habitat suitability (see **Section 4.5** below).

4.1.4 Predation

Sea pens are preyed upon by several species of sea stars and nudibranchs, some of which feed on sea pens almost exclusively (e.g., *Armina californica*; *Hippasteria spinosa*; Birkeland 1974). Up to this point, such predators were rarely observed at Roberts Bank (i.e., very few have been reported in Archipelago's underwater video and SCUBA surveys; Archipelago 2009). However, during monitoring, divers noted high numbers of the striped nudibranch, *Armina californica*, at transplant site T2, as well as at the control site (**Photo 11**). Furthermore, several *Armina* were observed advancing towards, or directly feeding on, sea pens (**Photo 12**). In contrast, very few *Armina* were observed during the reconnaissance portion of the study, and most were smaller individuals (1-3 cm in length). It is possible that some *Armina* were missed in initial surveys because they can burrow into the substrate for several days at a time when not foraging (Eyster 1981). Alternatively, strong current conditions may have limited *Armina* foraging activity during the reconnaissance survey, as *Armina* occurrence above the substratum and feeding appears to be greatest at low current conditions (Kastendiek 1982).

While the number of studies on prey-predator interactions in orange sea pen populations are limited, literature suggests that predation by *Armina* is a major source of mortality among sea pens, with recorded predation rates exceeding 90% in some populations (i.e., Puget Sound; Birkeland 1974). Laboratory experiments have shown that *Armina* predation effects can be rapid, as mature nudibranchs are capable of consuming a single colony in 1 to 3 days (i.e., sea pansy, *Renilla reniformes;* Eyster 1981). Nudibranch predation is also size dependent (i.e., size selective mortality), where the smallest sea pens are believed to be the most susceptible to predation by nudibranchs (Birkeland 1974, Kastendiek 1982, Shimek 2011). While *Armina* predation may potentially have that greatest effects on juvenile sea pens, evidence on the size of sea pens being predated on during the course of this study, is not available. Nevertheless, strong predation by *Armina* on transplanted individuals could account for fewer sea pens observed during the monitoring dive, relative to initial planting densities.

Going forward, this could be addressed by imposing a size limit as a criterion for transplant, such that only larger colonies are transplanted, thereby increasing the potential success of future orange sea pen transplants.

4.1.5 Environmental Parameters

Sediment characteristics at sites T1 and T3 were qualitatively similar to each other, dominated by fine to medium sized sand with little evidence of shell debris. In comparison, site T2 sediments were composed of medium and coarse sand mixed with gravel and large shell hash distributed throughout the site. This difference in sediment substrate may decrease suitability for sea pens by impeding their ability to effectively bury. Additionally, site T2 is located adjacent to an artificial rocky reef, which may influence small scale environmental characteristics such as localized current movement which, in turn, may affect food availability. Both sediment characteristics and proximity to the rocky reef at site T2 may make habitat sub-optimal, thereby promoting movement away from the site, as evidenced by observations of sea pens fully extracted from the sediment during monitoring (**Photo 13**).

It should be noted that sediment grain size was not included as a parameter in the species distribution model for the reasons outlined in **Section 4.0** above. Going forward, this could be addressed by analysing sediment samples for grain size during the reconnaissance and ground-truthing stage, before the organisms are transplanted, thereby increasing the potential success of future transplants.

5.0 CONCLUSIONS

An orange sea pen transplant methodology, including predictive modelling of suitable habitat, has been developed and tested at Roberts Bank and, results of a three-year monitoring program suggest the method is ecologically feasible, demonstrating success over the medium term: despite fluctuations, mean densities at sites T1 and T3 are considered stable and functioning. At these sites, decreases in densities within the transplanted sites may be linked to increases in adjacent site control plots, representing shuffling or spreading out of transplanted sea pens. Thus, the numbers presented are considered conservative, because only two 20 m^2 site control plots were surveyed, and therefore may underestimate the extent of localised movement. Similarly, densities at sites T1 and T3 are considered underestimated for the reasons outlined in **Section 4.1,** while the overall success rate was lowered by regional factors, external to the transplant, during the last monitoring period in April 2017. Therefore, it is possible that success rates are actually higher than have been characterised here.

In contrast, declines in densities at site T2 are attributed to heavy *Armina* predation, which is a commonly reported limiting factor of orange sea pen populations (see the Local Knowledge Survey in RBT2 TDR MI-3) and, possibly, localised habitat suitability.

A larger-scale transplant is considered to be a viable and effective mitigation option, and there is high confidence in the handling/transplant methodology. However, logistically, it is not feasible to transplant the entire orange sea pen aggregation as there are too many colonies over too expansive an area (~100 ha) to be able to transplant each by SCUBA, which is constrained by depth and time. Additionally, the ability to transplant the entire aggregation is limited by the availability of suitable habitat at SCUBA-appropriate depths in areas outside the Project footprint, though there is ample suitable habitat to transplant a portion of the aggregation. Overall, based on the experience and knowledge gained from the pilot program, the likelihood of success of future orange sea pens transplants is considered moderate.

6.0 CLOSURE

This Work was performed in accordance with Professional Services Agreement between Hemmera Envirochem Inc. (“Hemmera”) and Vancouver Fraser Port Authority (“Client”), dated July 1, 2015 (“Contract”). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by Vancouver Fraser Port Authority. In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

We appreciate the opportunity to work with the VFPA on this assignment. If you have any questions regarding our report, please feel free to contact us at your convenience.

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7.0 PHOTO DOCUMENTATION



Photo 1 Baseline Data Collection at Donor Site

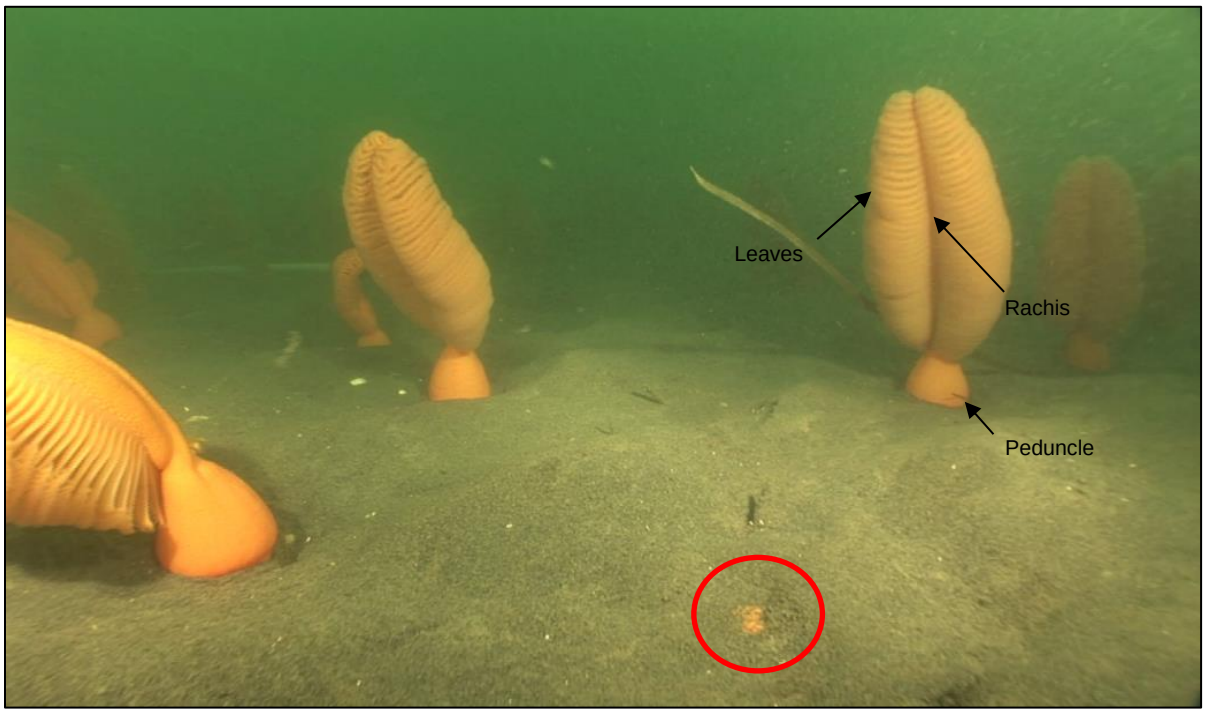


Photo 2 Inflated Sea Pens at the Donor Site – Note Evidence of Buried Sea Pen



Photo 3 Orange Sea Pen Collection at Donor Site – Preparing to Measure Height



Photo 4 Orange Sea Pen Collection at Donor site – Gently Grabbing Peduncle



Photo 5 Orange Sea Pen Collection at Donor Site – Extraction from Sediment



Photo 6 Orange Sea Pen Collection at Donor Site – Placement in Collection Bag

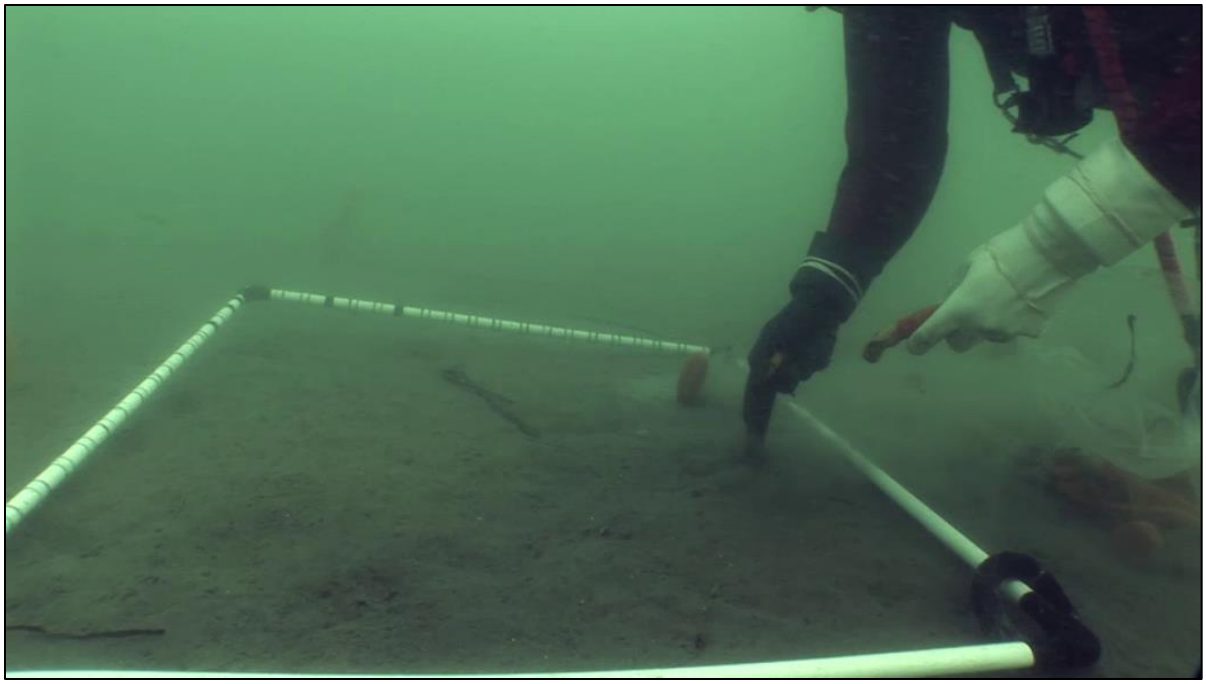


Photo 7 Orange Sea Pen Transplanting – Excavating Hole

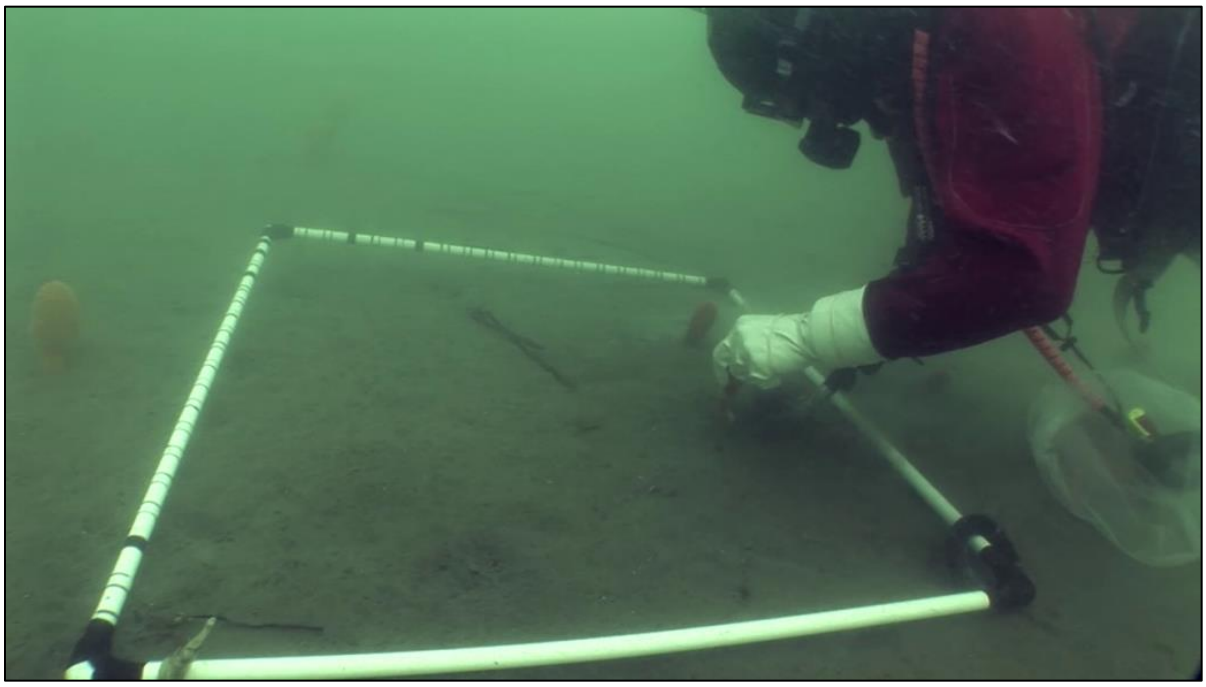


Photo 8 Orange Sea Pen Transplanting – Placing Orange Sea Pen in Hole



Photo 9 Inflated Orange Sea Pens during Monitoring Event, One Day Post-Transplant

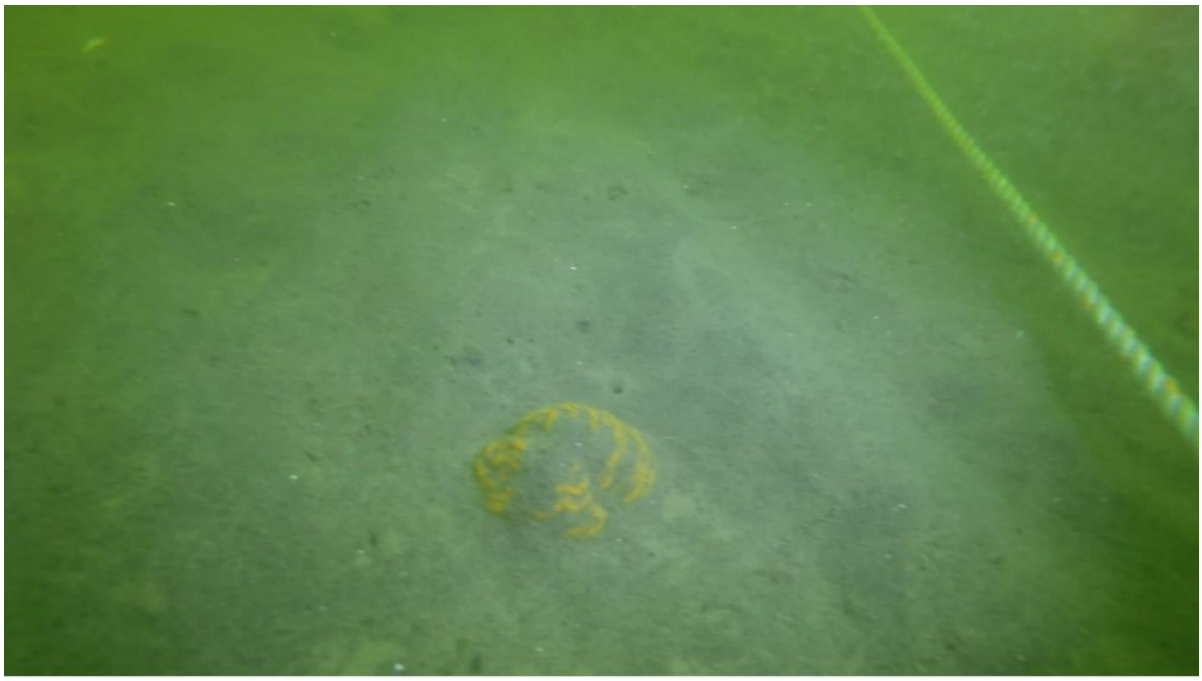


Photo 10 Buried Orange Sea Pen at Transplant Site T3



Photo 11 Striped Nudibranch, *Armina californica* – Orange Sea Pen Predator at Site T2



Photo 12 *Armina californica* Feeding on an Orange Sea Pen at Site T2



Photo 13 Evidence of Movement – Orange Sea Pen Fully Extracted from Sediment at Site T2



Photo 14 Evidence of Juvenile Recruitment at Site T1

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IR5-06 Marine Invertebrates – Orange Sea Pen Transplant Program

Information Source(s)

EIS Volume 3: Section 12

Context

In Section 12 of the EIS, the Proponent stated that the proposed Project would result in a moderate reduction in Orange Sea Pen productivity, and that the Proponent's level of confidence in this assessment was considered to be moderate. A moderate level of confidence was defined as a prediction that was based on data sources such as predictive model outputs and published literature and a low level of confidence was assigned to predictions with little or no empirical data.

Throughout Section 12 of the EIS, the Proponent described uncertainties in the environmental effects assessment for Orange Sea Pens, stating that little is known about the ecological role of Orange Sea Pens in the Fraser River estuary and that future re-colonization in areas around the proposed terminal was uncertain.

In Section 12 of the EIS, the Proponent proposed several mitigation measures, including an Orange Sea Pen transplant program, to reduce direct mortality and Orange Sea Pen productivity loss. However, no detailed information about the proposed Orange Sea Pen transplant program was provided. Additionally, the Proponent stated that Orange Sea Pen transplantation is a novel mitigation measure and concluded that mitigation would reduce, but not fully avoid, Orange Sea Pen productivity loss.

Further explanation of how uncertainties were considered in the assessment of potential environmental effects and the success of the proposed mitigation measures for Orange Sea Pens is required.

Information Request

Provide a rationale for rating the confidence of the assessment of effects on Orange Sea Pens as moderate, despite the lack of precedence for the mitigation measures proposed.

Provide a description of the level of confidence for the magnitude criterion rating of moderate, given the uncertainties discussed in the assessment of potential effects to Orange Sea Pens.

Provide additional details of the Orange Sea Pen transplant program including a map of the proposed Orange Sea Pen transplant area in relation to the Project area and current distribution of Orange Sea Pens.

Describe any additional mitigation measures that would be carried out if the Orange Sea Pen transplant program is found to be unsuccessful, as well as plans for a follow-up program for Orange Sea Pen during construction and operation of the proposed Project.

VFPA Response

Provide a rationale for rating the confidence of the assessment of effects on Orange Sea Pens as moderate, despite the lack of precedence for the mitigation measures proposed.

In summary, the moderate confidence ranking was rooted in four main points (each of which are described below):

- The success of the orange sea pen pilot transplant and monitoring program (see IR5-05);
- Remaining orange sea pen productivity with the Project (before mitigation) is considerable (45%) such that the population will persist at Roberts Bank;
- Reproductive and larval biological characteristics of orange sea pens, which confer a high ability to replenish stocks; and
- Coral transplants are common and successful elsewhere.

The orange sea pen transplant pilot and monitoring program mentioned in Section 12.7.2.2 of the EIS was subsequently determined to be successful (as confirmed by monitoring); the final report has been appended to IR5-05 as Appendix IR5-05-A. The monitoring results demonstrate that the proposed mitigation measure is effective, thereby increasing certainty in the conclusion made in the EIS that the Project will not result in significant effects to orange sea pens at Roberts Bank.

It is predicted that 45% of orange sea pen productivity will remain in the local assessment area (near the southwest corner of Westshore Terminals), not including sea pens that are transplanted as mitigation. Further, gains in high suitability orange sea pen habitat (3.4 hectares (ha)) are anticipated post Project, while ample moderate suitability habitat will remain available (118.4 ha; see EIS Appendix 12-A). Since substantial productivity and suitable habitat will remain, the local population is expected to persist and remain reproductively active.

Certain characteristics of orange sea pen reproductive and larval biology confer an ability to replenish stocks and maintain a steady-state population, in defiance of heavy productivity losses, such as those incurred by predation; these characteristics are reviewed by Chia and Crawford (1973). Firstly, orange sea pens are highly fecund: a large adult is capable of producing over 200,000 eggs in one season, such that total output of eggs by an aggregation would be considerable. Secondly, orange sea pen eggs undergo lecithotrophic development, which means that the larvae are nutritionally independent; this greatly reduces larval mortality by starvation. Thirdly, the larvae are capable of delaying metamorphosis (by up to one month) until favourable conditions for settlement are encountered. Chia and Crawford (1973) argue that these three characteristics explain the success of orange sea pens in maintaining population numbers. Based on this, larval recruitment is expected to continue in the local assessment area. A fresh supply of larvae from nearby, coupled with remaining productivity and suitable habitat, creates conditions favourable for the maintenance of population integrity.

Additionally, transplantation of coral (sea pens are a type of coral) as mitigation is well documented worldwide, particularly hard corals in tropical environments (e.g., Rinkevich 2014; Rodgers et al. 2017; U.S. Army Corps of Engineers 2017). Success rates of hard coral transplants are typically high; for instance, Hofstede et al. (2016) recorded a survival rate of 91% in transplanted corals after one year of monitoring in the Bahamas while Thorton et al. (2000) recorded success rates of 87% two years post-transplantation of hard corals in Florida. There are limited examples of soft coral transplants in the literature, and none in soft-bottom environments; for this reason, the VFPA initiated this multi-year pilot study and monitoring program to assess the feasibility and effectiveness of transplants as a potential mitigation measure. This large-scale undertaking has provided a better understanding on the options for mitigating Project effects on orange sea pens, thereby increasing confidence in assessment conclusions.

Provide a description of the level of confidence for the magnitude criterion rating of moderate, given the uncertainties discussed in the assessment of potential effects to Orange Sea Pens.

There is moderate confidence in the magnitude rating of 'moderate' for the reasons outlined above, namely the following:

- Remaining sea pen productivity (with the Project) is considerable (45%) such that it is expected that population integrity will be maintained;
- Reproductive and larval biological characteristics of orange sea pens, which confer a high ability to replenish stocks and which ensure that larvae will continue to be supplied to Roberts Bank; and,
- The success of the orange sea pen pilot transplant and monitoring program (see IR5-05) indicates that the planned transplant as mitigation is an economically and technically feasible measure.

Provide additional details of the Orange Sea Pen transplant program including a map of the proposed Orange Sea Pen transplant area in relation to the Project area and current distribution of Orange Sea Pens.

The requested details and map of the orange sea pen pilot transplant and monitoring program can be found in the report appended to IR5-05 (Appendix IR5-05-A); these materials apply to the pilot transplant conducted in 2014.

Based on the results and lessons learned from the pilot program, the VFPA is considering a larger-scale transplant as mitigation for predicted productivity losses documented in the EIS. The maps referred to above in the orange sea pen pilot transplant and monitoring program report denote areas based on habitat suitability, but do not yet identify specific locations where orange sea pens may be transplanted. This proposed transplant mitigation program has not yet been developed.

Describe any additional mitigation measures that would be carried out if the Orange Sea Pen transplant program is found to be unsuccessful, as well as plans for a follow-up program for Orange Sea Pen during construction and operation of the proposed Project.

In Section 12.7.2.2 of the EIS, the VFPA made the commitment that should transplants be deemed a feasible mitigation measure, a transplant strategy would be developed in conjunction with Fisheries and Oceans Canada. Further, in EIS Appendix 33-A, the VFPA committed to monitoring orange sea pen transplant sites during the Project construction phase.

The success of the pilot program over a three-year monitoring period indicates that transplantation is a feasible mitigation method. As mentioned above, based on this success, the VFPA is currently considering a large-scale transplant to mitigate residual effects to orange sea pen productivity. No additional mitigation measures (i.e., beyond transplantation) for orange sea pens are proposed.

As outlined in IR5-03 of CEAR Document #1140[1], the Follow-up Program is currently being developed, in discussion with regulators and Aboriginal groups; as such, there is no further information available to be shared at this time.

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[1] CEAR Document #1140 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR5-03, IR5-21, IR6-06, IR6-07, IR6-17, and IR6-36 (See Reference Documents #975 and #991).

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IR5-07 Marine Invertebrates – Orange Sea Pen Ecological Effects

Information Source(s)

EIS Volume 3: Section 12; Section 17

Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): IR24

Context

In Sections 12 and 17 of the EIS, the Proponent noted that little is known about Orange Sea Pen abundance and distribution, and that many aspects of Orange Sea Pen biology and its ecological role were not well studied or understood. The Proponent further indicated that the importance of Orange Sea Pens in the demography of fish and invertebrate populations and communities remained to be established, though it is known that Orange Sea Pens contribute to structural habitat complexity for marine invertebrates and marine fish.

In section 12 of the EIS, the Proponent stated that the proposed Project would reduce the productive potential of Orange Sea Pens by an estimated 55% and that the marine terminal footprint was expected to remove approximately 92 ha (27%) of moderate to highly suitable habitat Orange Sea Pen habitat based on the results of the habitat suitability model. Additionally, in its responses to information requirement #24 from the Canadian Environmental Assessment Agency (CEAR Doc#314), the Proponent stated that habitat associations, such as the potential role of Orange Sea Pens as habitat, were not considered by the ecosystem model.

Regarding mitigation, the Proponent stated that certain measures would reduce, but not fully avoid, Orange Sea Pen productivity loss. The Proponent also stated that there was no precedence for the Orange Sea Pen transplant program, and as such, the outcome of the program as a mitigation measure was uncertain.

Given the uncertainty in the assessment and the potential ecological importance of Orange Sea Pens, as well as the uncertainty in the effectiveness of the proposed mitigation measures, additional information and an assessment of the potential effects resulting from a decrease in the Orange Sea Pen population due to Project activities on other components of the environment is required.

Information Request

Provide an assessment of the potential ecological effects on other components of the environment such as marine invertebrates and marine fish resulting from a decrease in the Orange Sea Pen population due to the proposed Project activities.

Include a scenario in which the mitigation measures for Orange Sea Pens are partly or completely unsuccessful and result in a decrease in the population of Orange Sea Pens in the local assessment area for the Project.

VFPA Response

The orange sea pen transplant pilot and monitoring program mentioned in Section 12.7.2.2 of the EIS was subsequently determined to be successful (as confirmed by monitoring); the final report has been appended to IR5-05 as Appendix IR5-05-A. The monitoring results demonstrate that the proposed mitigation measure is effective, thereby increasing certainty in the conclusion made in the EIS that the Project will not result in significant effects to orange sea pens at Roberts Bank.

Provide an assessment of the potential ecological effects on other components of the environment such as marine invertebrates and marine fish resulting from a decrease in the Orange Sea Pen population due to the proposed Project activities.

An assessment of the potential effects on other components (marine invertebrates and fish) resulting from decreases in orange sea pens is provided in EIS Sections 13.6.3.4, 13.6.3.5, and 16.5.1.4 as well as in Section 3.5.1 of TDR MI-3 in Appendix AIR10-C of CEAR Document #388[1].

The Roberts Bank ecosystem model, used as a line of evidence within the effects assessment, considered trophic interactions between orange sea pens and their predators and predicted that ecosystem structure and function will be maintained (see IR3-24 in CEAR Document #984[2]). Moreover, results from the orange sea pen pilot transplant and monitoring program (Appendix IR5-05-A) indicate that, not only is it possible to successfully relocate orange sea pens, but that other species will continue to be associated with sea pen habitat, further reducing the potential for ecological effects on other components of the environment resulting from orange sea pen loss.

The assessment of potential effects of the Project on orange sea pens, as described in the EIS, concluded that while orange sea pens may enhance marine invertebrate and fish habitat in localised areas, they are not essential in supporting the ongoing productivity, or life functions, of other fauna (see EIS Section 16.5.1.4). Marine invertebrate (e.g., Dungeness crab) and fish (e.g., flatfish, demersal fish) species that have been observed in orange sea pen habitat in the local assessment area (LAA) have also been widely documented, and harvested, elsewhere in the LAA without orange sea pens, as well as the regional assessment area and throughout the Pacific Northwest, also in areas without orange sea pens. There is no evidence of a functional link between the physical habitat provided by orange sea pens and population processes of other components of the Roberts Bank environment, including fish and invertebrate populations based on a review of existing information summarised below.

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.
[2] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).

Literature provides some insight into other relationships between fish and structure-forming invertebrates. There is evidence that suggests that biogenic habitat, like orange sea pens, may not play a role in mediating populations of other components of the environment such as marine invertebrates or marine fish; hence, there would be no potential ecological effects on these other components resulting from a decrease in the orange sea pen population due to Project activities. Specifically, some studies posit that biological and geological habitats may be functionally equivalent for fish that favour structural relief; for example, Auster (2005) demonstrated the false boarfish (*Neocyttus helgae*) used both fan-shaped corals (i.e., biogenic habitat) and depressions in basalt pavement (i.e., physical habitat) as shelter or flow refuge (i.e., the heterogeneity of habitat generated by soft corals was indistinguishable from equivalent habitat formed by rock alone). By extension, this implies that the same might hold true at Roberts Bank, where Dungeness crab and flatfish that may use orange sea pen habitat as shelter could achieve the same purpose or functional equivalent by, for instance, burying in the sand.

It is also suggested in the literature that fishes and structural fauna (such as orange sea pens) may simply co-occur because they have similar habitat preferences but have no direct association; for example, Tissot et al. (2006) found that rockfishes (*Sebastes* sp.) and structure-forming invertebrates (including corals) off California co-occur in the same types of habitats with accelerated flows (likely for enhanced prey delivery) but found no demonstrable functional relationship between individual invertebrates and fishes. Similarly, while orange roughy (*Hoplostethus atlanticus*), a species of fish off New Zealand, generally occur in large spawning and feeding aggregations over seamount summits that support dense coral assemblages, there is little direct association between fishes and the coral (Koslow et al. 2000). Similar trends have been noted in tropical coral reef systems, where Syms and Jones (2001) found no effect of soft coral removal on fish assemblages, despite correlative evidence that soft corals might be important. In other words, high densities of fishes in biogenic habitat do not necessarily indicate that it provides a unique functional role; rather, structural fauna and co-located invertebrates and fish may simply share similar habitat preferences and hence are found together in the same area.

For these reasons, the conclusion of no significant effects to marine invertebrates and fish remain unchanged.

Include a scenario in which the mitigation measures for Orange Sea Pens are partly or completely unsuccessful and result in a decrease in the population of Orange Sea Pens in the local assessment area for the Project.

As indicated in Appendix IR5-05-A of IR5-05, the orange sea pen pilot transplant and monitoring program was successful, such that the VFPA is confident that transplants can be used to maintain or enhance post-Project sea pen productivity. In addition, pre-mitigation, 45% of orange sea pen productivity would remain in the LAA (near the southwest corner of Westshore Terminals) and, therefore, reproduction and recruitment are expected to continue

based on the life history strategy of orange sea pens[3] and predicted gains in high suitability habitat post-Project (see EIS Appendix 12-A and IR5-06). Given the regional nature of the orange sea pen population (all one genetic group with individuals found at Roberts Bank being sourced from inside and outside Roberts Bank (e.g., Puget Sound, Gulf Islands)), it is unlikely population integrity will be compromised and the conclusion of the assessment of potential effects of the Project on orange sea pen remains not significant.

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[3] This prediction is based on a study published by Chia and Crawford (1973), which demonstrated that high fecundity, lecithotrophic development (i.e., larvae are nutritionally independent), and the ability of substratum selection by larvae explain their success in maintaining a steady state population despite substantial productivity losses driven by heavy predation.

IR5-08 Marine Invertebrates – Residual Effects, Duration Criteria

Information Source(s)

EIS Volume 3: Section 12

Context

In Table 12-14 of the EIS, the Proponent described the duration of the proposed Project effects on marine invertebrates as long term. In Section 12.8.1 of the EIS, however, the Proponent stated that the loss of subtidal sand habitat from terminal placement would be permanent because no mitigation was available.

A rationale for the duration criterion rating in Table 12-14 is required in order to evaluate whether the conclusions are supported by the information.

Information Request

Provide a rationale for duration criterion rating of long term, rather than permanent, in Table 12-14 given the permanent nature of the proposed marine terminal and the productivity losses due to subtidal marine habitat loss.

VFPA Response

There was a typographical error in the duration criteria rating in EIS Table 12-14. As outlined in the narrative text accompanying the table, "duration is rated as long-term to permanent" (EIS p. 12-81); thus, the duration criteria rating in EIS Table 12-14 should also read long-term to permanent. The exclusion of the permanent rating from the summary EIS Table 12-14 was inadvertent.

Additionally, for further clarification, under the rationale for duration on p. 12-81 of the EIS, the text currently reads "Changes in geomorphic processes that cause changes in water and sediment (i.e., salinity, deposition) are due to terminal placement, which is permanent; however, loss of productivity is not considered indefinite as recovery is expected, both naturally and through mitigation or onsite offsetting measures". Rather, the second bullet should read "Changes in geomorphic processes that cause changes in water and sediment (i.e., salinity, deposition) are due to terminal placement, which is permanent; however, loss of productivity is not considered *permanent* as recovery is expected, both naturally and through mitigation or onsite offsetting measures, *such that duration of the residual effect on productivity is characterised as long-term*".

The rationale for the long-term duration rating is that this rating applies to the residual effect of productivity loss, not the duration of the Project component or activity (terminal placement) that causes the effect. Although the RBT2 terminal placement is permanent, the residual effect of productivity loss of marine invertebrates is not permanent because recovery of

productivity, both naturally and enhanced by mitigation[1] (including offsetting; see EIS Section 17.0), is expected. Natural recovery is facilitated by invertebrate life history characteristics (e.g., high fecundity, broadcast spawning, pelagic larval stages) that make them resilient to physical and environmental changes.

[1] Proposed mitigation for marine invertebrates includes avoidance measures such as modifications to Project placement and design and the implementation of DFO fisheries sensitive timing windows; reduction measures such as salvages, transplants, and the implementation of environmental management plans; and onsite offsetting measures, including creation of eelgrass, intertidal marsh, mudflat, sandy gravel beach, and subtidal rock reef habitats.

IR5-09 Marine Invertebrates – Residual Effects, Frequency Criteria

Information Source(s)

EIS Volume 3: Section 12

Context

In Table 12-14 of the EIS, the Proponent indicated that residual effects are expected to occur frequently. Section 12.8.1 of the EIS, however, stated that terminal placement would be permanent and losses in productivity resulting from reduced habitat quality or changes in geomorphic process from RBT2 placement would occur on an annual basis.

Section 12.8.1 of the EIS also stated that placement of the terminal and associated habitat loss was considered infrequent because it would be a one-time event. The loss of subtidal sand from terminal placement, however, was considered permanent.

A rationale for the frequency criterion ratings in Table 12-14 is required in order to evaluate whether the conclusions are supported by the information.

Information Request

Provide a rationale for the frequency criterion rating of frequent and infrequent, rather than continuous, in Table 12-14 in view of the permanent nature of the proposed marine terminal and the productivity losses due to subtidal marine habitat loss.

Provide a rationale for using the frequency criterion rating, rather than the duration rating, to describe a permanent effect.

VFPA Response

Provide a rationale for the frequency criterion rating of frequent and infrequent, rather than continuous, in Table 12-14 in view of the permanent nature of the proposed marine terminal and the productivity losses due to subtidal marine habitat loss.

To clarify the rationale for the frequency criterion rating on p. 12-82 of the EIS, the VFPA makes the following amendments to the text under the second and third bullets; these amendments also apply to EIS Table 12-14. The text currently reads as follows:

> Frequency was rated as frequent based on the following rationale:
>
> - Placement of terminal and associated habitat loss is a one-time event and thus considered infrequent;
> - Losses of productivity through injury or direct mortality are only anticipated during the Project's construction phase but may result from

different construction activities (e.g., dredging, infilling) at different times over several years; and

- Losses in productivity resulting from reduced habitat quality or changes in geomorphic processes from RBT2 placement will occur on an annual basis, but are strongest on a seasonal basis: changes are expected for both freshet and non-freshet periods, but are expected to be less intense during non-freshet.

However, the second and third bullets should read (change italicized):

- Losses of productivity through injury or direct mortality are only anticipated during the Project's construction phase resulting from different construction activities (e.g., dredging, infilling) at different times over several years *and thus are considered frequent*; and
- Losses in productivity resulting from reduced habitat quality or changes in geomorphic processes from RBT2 placement will occur on an annual basis, but are strongest on a seasonal basis: changes are expected for both freshet and non-freshet periods, but are expected to be less intense during non-freshet *and thus are considered frequent*.

The VFPA's rationale for the rating of residual productivity losses as infrequent to frequent is discussed below.

The frequency[1] criterion refers to how often the residual effect is expected to occur, not the frequency of Project components or activities that cause the effect nor the length of time the residual effect is expected to persist (the length of time the residual effect persists is characterised by the 'duration' term; see EIS Section 12.8.1 and response to IR5-08).

In view of the permanent nature of the proposed marine terminal and the productivity losses due to subtidal marine habitat loss, the residual effect of 'productivity loss of marine invertebrates' (i.e., at the valued component level) is considered 'infrequent' (and not considered continuous) because it stems from the one-time event of RBT2 terminal placement. Rationale for the 'frequent' component of the rating is provided in the amendments to the second and third bullets presented above.

Provide a rationale for using the frequency criterion rating, rather than the duration rating, to describe a permanent effect.

Both frequency and duration criteria were used to describe the residual effect of productivity loss—one criterion was not used in lieu of the other. Both criteria are described in EIS Table 12-14. As noted above, the frequency criterion refers to how often the residual effect

[1] Ratings of the frequency criterion are defined in EIS Table 12-14 as follows:

- Infrequent – Effect(s) occur once.
- Frequent – Effect(s) occur repeatedly during Project construction or operation.
- Continuous – Effect(s) occur continuously throughout the Project phases.

is expected to occur, while the duration criterion refers to the length of time the residual effect is expected to persist.

IR5-10 Marine Invertebrates – Residual Effects, Magnitude Criteria

Information Source(s)

EIS Volume 3: Section 12

Context

In Table 12-13 of the EIS, the Proponent described the criteria used to characterize adverse residual effects on marine invertebrates. The definition of a high magnitude effect is presented as a measurable change that exceeds the limits of natural variability and may affect long-term population integrity and function.

However, in Table 12-14 and in Section 12.8.1 of the EIS, the magnitude of effects on Orange Sea Pen is described as moderate instead of high although the prediction is based on a 55% decrease in productive potential that is likely outside the natural range of variability and which may affect marine ecosystem interactions in the local assessment area.

Information Request

Provide a rationale for the magnitude of Orange Sea Pen being described as moderate despite meeting the criteria used in the definition for a high magnitude effect.

VFPA Response

The VFPA would like to provide further clarification of EIS Section 12.8.1 regarding the magnitude rating for orange sea pens (as explained further below).

For context, the magnitude ratings are defined as follows (see EIS Table 12-13):

- **Low (L)** – a measurable change but within the range of natural variability that will not affect population integrity or function;
- **Moderate (M)** – measurable change outside natural variability that may affect population integrity OR function, but not both; and
- **High (H)** – measurable change that exceeds the limits of natural variability and may affect long-term population integrity AND function.

The justification provided in the EIS (EIS Section 12.8.1, page 12-81, bullet 1) states that, "for orange sea pens, a 55% decrease in productive potential is considered moderate as it is likely outside the natural range of variability and may affect ecological function in the LAA [local assessment area], as no other species can substitute the extent of habitat complexity and sediment bio-turbation provided by sea pens" (underlining added here for emphasis).

However, for clarification, this text (EIS Section 12.8.1, page 12-81, bullet 1) should read as follows: "for orange sea pens, a 55% decrease in productive potential is considered moderate

as it is likely outside the natural range of variability *but is not expected to compromise population integrity*; ecological function in the LAA may be affected, as no other species can substitute the extent of habitat complexity and sediment bio-turbation provided by sea pens". Therefore, all criteria of a high magnitude rating (outside of natural range of variability, compromise population integrity and compromise ecological function) are not met and, hence, the residual effect characterisation magnitude was considered to be moderate.

Population integrity is expected to be maintained for the following reasons:

- Orange sea pen transplant trials have been proven to be an effective mitigation measure (see IR5-05);
- 45% of orange sea pen productivity remains in the LAA (near the southwest corner of Westshore Terminals) and, therefore, reproduction and recruitment are expected to continue in the LAA based on the broadcast spawning life history strategy of orange sea pens (Chia and Crawford 1973, Shimek 2011); and
- A Species Distribution Model (see EIS Appendix 12-A) predicted that, with the Project, an estimated 73% (231.4 hectares (ha)) of moderate to high suitability habitat will remain and continue to be available for orange sea pens;
    - A net gain of 3% (or 3.4 ha) of high suitability habitat for orange sea pens is predicted with RBT2, where flow acceleration around the corners of the terminal structure may enhance food delivery rates to these passive suspension feeders.

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IR5-11 Marine Invertebrates – Natural Variability

Information Source(s)

EIS Volume 3: Section 12

Context

The term natural ecosystem variability was used throughout Section 12 of the EIS. For example, in Section 12.6 of the EIS, the Proponent stated that changes in productivity for marine invertebrates took into consideration physical and biological aspects of natural ecosystem variability.

In addition, in Table 12-13, the term range of natural variability was used to differentiate between low, moderate and high magnitude effects. For example, a moderate magnitude effect is defined as a measurable change outside natural variability that may affect population integrity or function, but not both, and a high magnitude effect is defined as a measurable change that exceeds the limits of natural variability and may affect long-term population integrity and function.

Clarification of the terms natural ecosystem variability and range of natural variability is needed to better understand the potential effects of the proposed Project on marine invertebrate subcomponents.

Information Request

Provide a definition for the terms natural ecosystem variability and discuss how it was used in the assessment of potential environmental effects to marine invertebrate sub-components.

Provide a definition and an explanation of how the range of natural variability was determined for each invertebrate sub-component and how it was used to differentiate between low, moderate and high magnitude effects.

VFPA Response

Provide a definition for the terms natural ecosystem variability and discuss how it was used in the assessment of potential environmental effects to marine invertebrate sub-components.

Natural ecosystem variability refers to the heterogeneity and multiplicity in population parameters across spatial and temporal dimensions (Wu and Loucks 1995). Natural variability is a useful reference for evaluating the influence of anthropogenic change in ecological systems (Landres et al. 1999).

Natural variability was used in the assessment to contextualise potential effects from RBT2. Roberts Bank is a highly dynamic environment with daily (wave action, tidal cycles), seasonal

(freshet), and large-scale oceanic and climatic regimes (El Niño Southern Oscillation, Pacific Decadal Oscillation). These constantly changing abiotic conditions (refer to IR2-02 of CEAR Document #961[1] and Figure IR2-02-4 therein for an example illustrating this variability with salinity) result in variable population indicators for species residing in the Fraser River estuary under existing conditions.

As discussed in IR-7.31.15-07 (CEAR Document #314[2]), it should be noted that the assessment did not articulate that minor, moderate, and high categories *represent* natural variation; rather, it stated that biological and physical natural variation was *considered* when assessing potential productivity changes. The reason it is important to consider natural variation is because it can help contextualise the scale of Project-induced changes.

Provide a definition and an explanation of how the range of natural variability was determined for each invertebrate sub-component.

In the EIS, the term 'range of natural variability' is intended to reflect the bounds within which population parameters may fluctuate given existing conditions. Natural variation was considered both quantitatively and qualitatively in the assessment, depending on the data available, and illustrated using examples below.

Sufficient time-series data (21 years; 1990-2011) are available for Dungeness crabs to attempt to quantify a range of natural variability. Mean annual percent change and associated standard deviation (see **Table IR5-11-1** below) were used as proxies to reflect the range of natural variability and were calculated for Dungeness crab using commercial landings data provided by Fisheries and Oceans Canada (DFO).

Table IR5-11-1 Examples of Natural Variability in RBT2 Sub-components / Representative Species Using Long-term Population Indicator Datasets

Sub-component / Representative Species	Mean Annual Percent Change in Landings	Standard Deviation
Dungeness Crab[a]	26.5	25.6

Note: a. Annual variability calculated from DFO commercial landings data in Area 29 (which includes Roberts Bank) for the period 1990 to 2011.

Variation in Dungeness crab fisheries landings ranges from 0.9% to 52.1% year over year, with an average of approximately 26.5%, calculated as mean annual percent change. This is corroborated by literature, which characterises Dungeness crab population dynamics as erratic, dramatically increasing/decreasing from one year to the next and at different geographic scales (McConnaughey et al. 1994, Higgins et al. 1997, Armstrong et al. 2003). Several hypotheses have been proposed to explain these fluctuations, including density-

[1] CEAR Document #961 From the Vancouver Fraser Port Authority to the Review Panel re: Revised Responses to Information Request Package 2 (See Reference Documents #946 and #908).
[2] CEAR Document #314 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements (See reference document # 271) for the Environmental Impact Statement.

dependent biological mechanisms such as competition, egg and larval predation, and cannibalism of young. External environmental mechanisms such as changes in water temperature, ocean currents, wind stress, and other aspects of crab habitat that might affect larval advection, survival, and settlement have also been proposed (Johnson et al. 1986, Berryman 1991, McConnaughey et al. 1992, Botsford 2001).

For sub-components for which quantitative historical data was not available (infauna, bivalve shellfish, orange sea pens), inferences about variability were drawn qualitatively from biological characteristics. For example, all three of these sub-components employ broadcast spawning[3] as a reproductive strategy where ensuing larvae undergo a pelagic phase that lasts weeks to months. The process of larval recruitment is highly unpredictable and variable (Keough 1983; Hutchinson and Williams 2001; Ronowicz et al. 2014), characterised by strong spatio-temporal interactions, which reflect recruitment signals that are patchy in time and space across a variety of scales (Keogh 1983; Lively et al. 1993). Therefore, the range in variability of population parameters (i.e., density, abundance, biomass) for infauna and epifauna, bivalve shellfish, and orange sea pen sub-components was assumed to be high, but less than that calculated for Dungeness crab. Dungeness crab have the longest pelagic phase of all sub-components (the longer the larvae persist at the planktonic stage, the further they can be distributed; Todd 1998), and are thus more exposed to factors that contribute to variability.

In summary, natural variation was considered through both quantitative and qualitative lenses within the EIS, depending on the data available. Qualitative inferences were drawn largely from biological characteristics of marine invertebrate sub-components while quantitative estimates were calculated based on fisheries landings data.

How the range of natural variability was used to differentiate between low, moderate and high magnitude effects.

The range of natural variability was used to differentiate between low, moderate, and high magnitude effects by (i) evaluating what the range of natural variability is (i.e., qualitatively or quantitatively, as described above), (ii) comparing this to predicted Project-related change and, finally, (iii) ranking the magnitude of effect, as defined in the EIS (and repeated below).

- **Low (L)** – a measurable change but within the range of natural variability that will not affect population integrity or function;
- **Moderate (M)** – measurable change outside natural variability that may affect population integrity OR function, but not both; and
- **High (H)** – measurable change that exceeds the limits of natural variability and may affect long-term population integrity and function.

As described in the sub-section above, for most populations at Roberts Bank, quantitative information on the range of natural variability is not available; in these cases, variability was

[3] Broadcast spawning is defined as the release of eggs and sperm into the water column, where fertilisation occurs externally (Levitan 1998). Rates of fertilisation commonly vary between 0% and 100% within a single species (Levitan 2005).

evaluated qualitatively based on what is known about their biology and life history. For example, the natural variability of bivalve shellfish is considered high on the basis of broadcast spawning reproductive strategies and extended pelagic larval phases. This assumption is supported by the literature, which has demonstrated that bivalve biomass in coastal marine areas tends to fluctuate heavily from year to year (Essink et al. 1998; Beukema et al. 2010); for example, data from the Wadden Sea show that species-specific biomass may range from close to zero values in some years to over a hundred grams of ash-free dry mass per square metre in other years, as reported for *Cerastoderma edule* (Beukema and Dekker 2006), *Mytilus edulis* (Obert and Michaelis 1991; Beukema and Dekker 2007), *Macoma balthica* (Beukema et al. 2009) and *Mya arenaria* (Möller 1986). Moreover, Dethier (2006) has shown that commercial and recreational landings of clams in Puget Sound also vary on decadal scales.

The measurable change from the Project on infaunal bivalves was determined to be in the range of 212 to 519 tonnes, on the basis of field studies and ecosystem modelling, respectively (see EIS Section 12.6.3.2 and Table IR5-02-A2 in IR5-02). Overall, the magnitude of effect was determined to be 'low', given the measurable change from the Project (~519 tonnes, upper estimate, relative to approximately 6,600 tonnes standing stock) is within a highly variable natural system and the effect will not change population integrity or function.

In the case of Dungeness crabs, quantitative information on natural variability is available. As outlined in the sub-section above, mean annual percent change in Dungeness crab fisheries landings (as a proxy for natural variability) was calculated as 26.5%. The measurable change from the Project on Dungeness crabs was determined to be 3% (~9 tonnes) by the Roberts Bank ecosystem model key run, and 5% (~15 tonnes) based on sensitivity analyses. Overall, the magnitude of effect was determined to be 'low' given there will be a measurable change from the Project (~5%, upper estimate); however, this is within a highly variable natural system where average year-over-year changes are 26.5% (and up to 52.1% when counting standard deviation), and given the effect will not change population integrity or function.

In summary, the low, moderate, and high categories are not intended to exactly represent natural variability for every sub-component or representative species assessed; rather, they were created to assess Project-induced productivity changes relative to a natural context and to help streamline the assessment to focus on potential effects of highest consequence.

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Information Request Package 5 – Response to Information Requests Relating to Represented Species

In information request (IR) package 5, the Panel has asked nine[1] questions pertaining to species that are represented by valued components (VCs), sub-components, or representative species used to assess the potential effects of the Roberts Bank Terminal 2 Project (RBT2 or Project) and described in the Environmental Impact Statement (EIS) and Marine Shipping Addendum. As requested, the Vancouver Fraser Port Authority (VFPA) has provided additional information on the biology, management, and status of these additional species, and a rationale for the appropriateness of the selected sub-component, representative species, and/or VC in representing these additional species in the environmental assessment of the Project and marine shipping associated with the Project. The conclusions of the assessment of the effects of the Project and marine shipping associated with the Project on those represented species have not changed from the assessment previously provided for the representative species.

Representative Species Selection

Biophysical VCs, sub-component species or groups were chosen for their ability to represent other species that are similar in nature, occupy comparable types of habitats, serve similar ecological roles, or could otherwise be affected by the Project in an analogous way.

Representative species are also considered in terms of the biological and ecological similarities they share with other species within the sub-component, and for potential similarities in how the Project may interact with and affect them. In some cases, biological attributes may differ within a sub-component grouping, but their interactions with the Project and mechanisms contributing to potential effects from the Project are considered to be analogous. As a result, the VFPA selected representative species for each sub-component for which sufficient information is known, in order to provide an assessment that considers all potential interactions and Project-related effects.

For example, substantial information exists for the southern resident killer whale (the representative species used for toothed marine mammals) and much less so for the transient killer whale. While there are some biological differences between the two, they are considered the same species; both rely on underwater noise for prey detection; and potential Project effects and mitigation measures are the same. In this example, it would be both impractical and inefficient to undertake an assessment on both species as the conclusions of the

[1] IR5-12, -15, -16, -24, -32, -33, -34, -35, and -36.

assessment would be the same (see response to IR5-32 for additional details on the assessment of transient killer whales).

Moreover, in selecting representative species, or in some cases species groups, consideration was given to species of specific importance to regulatory agencies, Aboriginal groups, and the public, as identified by community knowledge and Aboriginal traditional knowledge, and during consultation and engagement, and assessment planning.

This approach was taken as it would be impractical to characterise existing conditions and assess effects a on every species that may frequent the Roberts Bank area. In this way, the use of VCs, sub-components, or representative species improves the effectiveness and efficiency of assessment by focusing on the key Project interactions.

Engagement

Aboriginal Engagement

During the scoping phase of the RBT2 environmental assessment, specific feedback was sought from Aboriginal groups on a list of proposed VCs and sub-components. As described in Appendix 7.2-A of the EIS, a VC selection and rationale document was sent to Aboriginal groups for review and feedback in April 2014.[2] An additional opportunity for input on VC and sub-component selection was provided through participation by Aboriginal groups in VC selection workshops held in June and July of 2014.[3] In addition to these specific opportunities to provide feedback on VC and sub-component selection, as engagement activities continued, relevant information provided by Aboriginal groups was taken into consideration (as described in EIS Section 7.2). For example:

- In spring of 2014, Tsawwassen First Nation hunters and Elders identified killer whales as holding cultural significance. This input supported the identification of southern resident killer whale as the representative species for toothed whales in the assessment;

[2] The VC selection and rationale document was sent on April 10, 2014 to the following Aboriginal groups for review and feedback: Tsawwassen First Nation, Musqueam First Nation, Cowichan Tribes, Halalt First Nation, Hwlitsum First Nation, Lake Cowichan First Nation, Lyackson First Nation, Métis Nation BC, Penelakut Tribe, Semiahmoo First Nation, Stz'uminus First Nation, and Tsleil-Waututh Nation. In addition, the VC selection and rationale document was sent on April 10, 2014 to Sto:lo Nation and the Sto:lo Tribal Council for information purposes. Feedback was received in written or email form from Cowichan Tribes (acting with Cowichan Nation Alliance, including Stz'uminus, Penelakut, Hwlitsum, and Halalt communities), Métis Nation BC, and Tsleil-Waututh Nation.

[3] Two Aboriginal group VC workshops were held. The first was held on June 6, 2014, and representatives from Tsawwassen First Nation, Musqueam First Nation, Tsleil-Waututh Nation, Lake Cowichan First Nation, Métis Nation BC, Cowichan Tribes (and Cowichan Nation Alliance), Semiahmoo First Nation, Lyackson First Nation, and Penelakut Tribe were in attendance. Representatives from Halalt First Nation, Hwlitsum First Nation, and Stz'uminus First Nation were invited but did not attend. The second workshop was held on July 3, 2014, and representatives from Tsawwassen First Nation, Musqueam First Nation, Tsleil-Waututh Nation, Lake Cowichan First Nation, Cowichan Tribes (and Cowichan Nation Alliance), Métis Nation BC, Halalt First Nation, and Lyackson First Nation were in attendance. Representatives from Hwlitsum First Nation, Penelakut Tribe, Semiahmoo First Nation, and Stz'uminus First Nation were invited but did not attend.

- At a working group meeting on May 27, 2014, a representative from Lyackson First Nation indicated grey whales have occurred off the eastern shore of Valdez Island. This information supported identification of baleen whales as a sub-component and confirmed scientific information on grey whale presence; and
- In light of Aboriginal input about the importance of fish species such as sockeye salmon, eulachon, and sturgeon, additional consideration was given to selection of these species as sub-components, and additional rationale for not choosing these species as representative species themselves was provided in EIS Section 13.2.1. The VFPA's response to IR5-15, IR-7.31.15-09 (CEAR Document #314), and AIR-12.04.15-09 (CEAR Document #388) further discuss why the species are considered to be represented in the assessment by other fish.

Since submission of the RBT2 EIS, engagement with Aboriginal groups has continued. Aboriginal groups have continued to express concerns over potential effects of the Project on sockeye salmon and eulachon, in particular. The VFPA will continue to consult with Aboriginal groups about these concerns.

Regulator Engagement

The VFPA has also engaged with regulators on the selection of marine VCs, sub-components, and representative species since 2011 (see EIS Section 7.1). One-on-one agency meetings, with Fisheries and Oceans Canada (DFO) and the Canadian Wildlife Service (on marine biophysical related VCs, sub-components, and representative species), as well as working group meetings were conducted.

Specific activities with regard to marine biophysical VCs, sub-components, and/or representative species are outlined below:

- Initially discussed in early regulatory meetings and proposed in the RBT2 Project Description (September 2013; CEAR Document #1[4]);
- Influenced by regulators commenting on the draft EIS Guidelines; for example, input from the Canadian Wildlife Service on the guidelines indicated that biofilm be considered a VC (CEAR Document #31[5]; biofilm was included in the RBT2 effects assessment as a sub-component of the marine vegetation VC);
- Discussed as a central topic during the May 27, 2014 Working Group #3 meeting (e.g., proposed biophysical VCs, sub-components, and/or representative species were presented) with DFO, Environment Canada, Metro Vancouver, Ministry of Transportation and Infrastructure, Natural Resources Canada, Transport Canada, and Aboriginal groups in attendance (Tsawwassen First Nation, Musqueaum First Nation, Hwlitsum First Nation, Lyackson First Nation, Métis Nation BC, and Tsleil-Waututh Nation); and

  Discussed as a key topic during a meeting with DFO and the VFPA on November 20, 2014. In particular, DFO asked why sockeye salmon was not proposed as a sub-

[4] CEAR Document #1 Project Description of a Designated Project.
[5] CEAR Document #31 From Environment Canada to the Canada to the Canadian Environmental Assessment Agency re: comments on the Draft EIS Guidelines - Regional and Local Study Areas; Birds.

component. The VFPA responded that according to the data collected for RBT2, the local assessment area is less important an area for sockeye salmon (and more important for chum salmon, which was chosen as the representative species) and therefore the Project interaction would therefore be minimal with sockeye.

Existing Conditions

All species with the potential to occur at Roberts Bank including those highlighted in the current IR package 5 were considered in the assessment—either as sub-components or representative species themselves, or represented by another species (i.e., a proxy) with similar ecological niches, life history traits, or habitat preferences. The information provided for representative species, therefore, is representative of the conditions of (and effects on) the other species that are represented. The assessment of the representative species stands in for the assessment of all the species it represents. While there may be differences in some characteristics (including distribution, abundance, density, etc.) the existing conditions are materially the same (i.e., both the representative and represented species occur in the local assessment area and would interact with the Project) and the potential effects are materially the same (e.g., the assessment of the potential effects of underwater noise will be materially the same for the representative southern resident killer whale and represented transient killer whale). Hence, while the VFPA has provided additional information about existing conditions for represented species as requested by the Panel in IR package 5, the conclusions of the assessment of the effects of the Project and marine shipping associated with the Project on those represented species have not changed from the assessment previously provided for the representative species.

Mitigation Measures and Follow-up Monitoring

Mitigation measures proposed and residual effects identified for VCs, sub-components, and representative species will also be the same for 'represented' species. To illustrate this, **Table IR5-1** summarises the effects assessment for changes in productivity associated with English sole (representative flat fish species) and sand sole (represented flat fish species) from infilling of containment dykes (see EIS Section 13.0 for full assessment). In this example, effects of the Project on English sole will be mitigated by developing and implementing a fish salvage strategy (salvaging prior to containment dyke infilling). This strategy will mitigate adverse effects on all marine fish, including representative and represented species.

Table IR5-1 Summary of Project Effect Assessment for Infilling of Containment Dykes on English Sole and Sand Sole (as example; see EIS Section 13.0 for full assessment)

Element of Assessment	English Sole: Representative Species	Sand Sole: Represented Species
Project activity interaction (infilling of containment dykes)	Yes	Yes
Project effect	Productivity loss	Productivity loss
Project effect mechanism	Injury and direct mortality	Injury and direct mortality
Mitigation measures	Fish salvage strategy	Fish salvage strategy

Element of Assessment	English Sole: Representative Species	Sand Sole: Represented Species
Residual effect	Yes	Yes
Residual effect characterisation	Magnitude = low Extent = local Duration = short-term to permanent Reversibility = partial Frequency = infrequent	Magnitude = low Extent = local Duration = short-term to permanent Reversibility = partial Frequency = infrequent
Significance determination	Not significant	Not significant

Similarly, follow-up monitoring (EIS Section 33.0) of residual effect predictions and/or efficacy of mitigation measures on sub-components or representative species will also be effective for represented species. For example, targeted follow-up monitoring for residual Project effects on the flat fish representative species (starry flounder and English sole) will constitute follow-up monitoring for residual effects to all represented flat fish species (such as sand or rock sole; see AIR-12.04.15-09 of CEAR Document #388; i.e., field-related monitoring studies of English sole are also likely to capture rock sole). The VFPA notes that details (target species, indicator parameters, temporal and spatial scope) of the follow-up program are subject to future input from regulators, Aboriginal groups, and affected stakeholders during its development.

Summary

In summary, the RBT2 effects assessment applied best practices to identify VCs, sub-components, and representative species, and sought input from agencies, Aboriginal groups, and the public on the selection of representative species.

The nine species/groups for which the Panel have asked for additional information have been previously assessed via application of the representative species approach; however, additional information requested by the Panel has been provided in each response to address their request. This additional information on the nine species/groups (provided in the following IR specific responses) has not changed effects assessment conclusions, mitigation, or monitoring proposed for the Project or shipping associated with the Project.

Since submission of the RBT2 EIS, engagement with Aboriginal groups has continued. Aboriginal groups have continued to express concerns over potential effects of the Project on sockeye salmon and eulachon, in particular. The VFPA will continue to consult with Aboriginal groups about these concerns.

IR5-12 Marine Invertebrates – Representative Species

Information Source(s)

EIS Volume 2: Appendix 10-B (Table 1-1)

EIS Volume 3: Section 12

Proponent Response to Follow-up Additional Information Requirements of July 31, 2015 (CEAR Doc#388): IR9

CEAR Doc#241; CEAR Doc#243; CEAR Doc#643

Context

In Table 12-1 of the EIS, the Proponent identified four sub-component groups to structure and streamline the assessment of potential environmental effects on marine invertebrates. In Section 12.2.1 of the EIS, the Proponent stated that the sub-components could be representative of species that were similar in nature, occupied comparable habitats, played similar ecological roles, or could be affected by the Project in similar ways. The Proponent selected the following sub-components:

- infaunal and epifaunal invertebrate communities;
- bivalve shellfish;
- Dungeness Crabs; and
- Orange Sea Pens.

In Appendix IR9-A, Table 1 of its response to information requirement #9 from the Canadian Environmental Assessment Agency (CEAR Doc#314), the Proponent provided additional information regarding the sub-components, as well as for representative species and represented species found in the regional assessment area. This included information regarding habitat use, biological, and ecological attributes and a qualitative assessment of abundance but did not include information on the distribution and density of the species in the local assessment area and regional assessment area for the proposed Project. The Proponent also stated that the characterizations provided for representative species were considered sufficient for the represented species for which they were a proxy.

Some participants, including Indigenous groups, have expressed concerns that some species of invertebrates found in the local assessment area and regional assessment area may not be adequately represented by Dungeness Crab, including specific concerns for octopus, sea cucumbers, sea stars and sea urchins.

According to the information provided in Appendix AIR 9-A, Table 1, the Dungeness crab was used as a representative species for 55 different species of echinoderm, mollusc and crustacean including sea cucumbers, sea urchins, octopus, squid, shrimp and prawns with different life histories, biology, habitat use and ecological roles and could therefore, due to these differences, be affected by the Project in different ways than the Dungeness crab. Some

of the species in Appendix AIR9-A, Table 1 may not be adequately represented by the Dungeness Crab, particularly for echinoderms (e.g. sea stars) and molluscs (e.g. octopus and squid).

In addition, invertebrate functional groups defined for the Roberts Bank Ecosystem Model (EwE model) (Table 1-1 of Appendix 10-B) mostly considered broad categories of invertebrates, such as macrofaunal and meiofauna. The results of the EwE model may not provide sufficient resolution for the prediction of Project operation effects on marine invertebrates and does not consider Project construction effects.

Additional information on the life histories, biology, habitat use and ecological roles of echinoderms and molluscs in the local assessment area and regional assessment area is required in order to provide a complete assessment of the potential environmental effects of the Project on marine invertebrates.

Information Request

Quantify the terms used to describe abundance in Appendix AIR9-A, Table 1:

- A - abundant
- C - common
- U - uncommon: present but infrequently occur
- R - rare: only occasionally documented

Provide life history, ecological and habitat use information on existing conditions (baseline) for echinoderms and cephalopods including abundance, distribution, and density in the local assessment area and regional assessment area for the proposed Project. Include maps where applicable.

Provide an assessment of the potential effects of the Project on echinoderms and cephalopods in the local assessment area for the Project.

VFPA Response

Quantify the terms used to describe abundance in Appendix AIR9-A, Table 1: A – abundant; C – common; U – uncommon: present but infrequently occur; R – rare: only occasionally documented

The abundance categories A, C, U, and R used in Appendix AIR9-A[1] tables are intentionally qualitative because there is limited or insufficient quantitative data on abundance in the literature for many of the species listed in the tables. The categories were assigned based on the information available in the references listed in Appendix AIR9-A, Table 1.

[1] Appendix AIR9-A of Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388).

Provide life history, ecological and habitat use information on existing conditions (baseline) for echinoderms and cephalopods including abundance, distribution, and density in the local assessment area and regional assessment area for the proposed Project. Include maps where applicable.

Echinoderms – Sea Stars

Life History

Sea stars have separate sexes and reproduce through external fertilisation, where eggs and sperm are discharged in the water column; female sea stars may produce over two million eggs in one spawn, though few survive to adulthood due to heavy predation. Sex ratios are usually 1:1 in temperate sea stars, and in echinoderms in general. Gonads mature through late autumn and winter, and spawning typically occurs in early spring, coincident with the spring phytoplankton bloom.

There are three types of developmental patterns in sea stars found in the Pacific Northwest, based on the type of larva development involved:

- Planktotrophic (e.g., *Pisaster ochraceus*), where free-swimming feeding larvae are produced from relatively small eggs. Larvae remain pelagic for several weeks, and feed on phytoplankton. They then transform into non-feeding larvae that settle on the ocean floor. Once settled in appropriate habitat, they develop radial symmetry and begin metamorphosing into adults;
- Pelagic lecithotrophic (e.g., *Crossaster papposus*), where eggs are large and yolky, and develop into swimming or floating non-feeding larvae. These larvae may have special attachment structures for use during settlement. Because parental investment is higher in this type of development, fewer eggs are produced; and
- Brooding (e.g., *Leptasterias* spp.), where eggs are held within the arms of a hunched-up female. The young are released as crawling juveniles.

Sea stars are also capable of asexual reproduction, most often used in regenerating limbs and, in some cases, entire bodies. They accomplish this by housing most or all of their vital organs in their arms.

Ecology

Sea stars employ a diverse array of feeding strategies. The majority are carnivorous—and occasionally scavengers—while some are omnivorous or ciliary-mucous feeders (i.e., use mucous secretions to trap organic particles). Sea stars feed by either swallowing their prey or by enveloping the food with their bodies while extruding their cardiac stomachs to digest the meal externally; the latter method enables sea stars to consume large prey, such as clams, that are too big to be swallowed whole. Diet includes bivalves (butter, littleneck, and geoduck clams, cockles, and mussels), barnacles, limpets, sand dollars, etc.

Sea stars have relatively few predators, deterred by their rigid calcareous skeletons. Predators include gulls, crabs, and other species of sea stars.

Habitat Use

Most species of sea stars in the Pacific Northwest range from Alaska to California, and occur from the intertidal zone to abyssal depths.

Six species of sea stars have been observed at Roberts Bank, including the leather star (*Dermasterias imbricata*), the mottled star (*Evasterias troscheli*), the spiny mud star (*Luidia foliolata*), the sunflower star (*Pycnopodia helianthoides*), the ochre star (*Pisaster ochraceus*), and the spiny pink star (*Pisaster brevispinus*). Information on sea stars in the local assessment area is incidental, collected during underwater video surveys for orange sea pens (see Figure 3-7 in TDR MI-3 in Appendix AIR10-C of Additional Information Request #10 (AIR-12.04.15-10 of CEAR Document #388[2])); as sea stars are represented by Dungeness crab in the effects assessment of the Project and were thus not the focus of directed field studies, no additional data on densities or abundance is available.

Sea stars have been observed both along the sandy delta foreslope, as well as associated with rocky substrates that comprise the artificial reefs and existing terminal structures. Habitat value in the Project area depends on the species; value is considered highest for species that prefer sand and mud substrates (which dominate the area), such as the spiny mud star and the spiny pink star. Habitat is considered suitable, but not optimal, for species such as mottled, leather, and sunflower stars, which prefer rocks and cobbles but are occasionally found on sand. Finally, species such as the ochre star require rocky substrate, and are thus relegated to anthropogenic structures. Overall, however, habitat value is not considered optimal, as sea stars are strictly marine (i.e., do not occur in fresh or brackish waters) and, in the estuary, freshwater inputs from the Fraser River are considerable.

Echinoderms – Sea Cucumber

Life History

The giant red or California sea cucumber (*Parastichopus californicus*) is the largest of approximately 30 sea cucumber species in B.C. and the only one that is commercially harvested.

Sea cucumbers have separate sexes and spawn in the spring and summer. Eggs and sperm are broadcast directly into the water column and adults do not aggregate during spawning. Distances of greater than 10 m have been observed separating spawning individuals (Cameron and Fankboner 1989). Larvae are planktonic for two to four months and are approximately 0.25 mm at settlement. Juveniles will grow to approximately 4 cm to 10 cm by two years (DFO 2014). Although no method has yet been found to age the animals, adults are believed to achieve sizes legal for harvest (>15 cm) in four years, sexual maturity between four and eight years, and reach a maximum 12 years old in B.C.

[2] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document #345) including 22 Technical Data Reports.

Ecology

Sea cucumbers are detritus feeders and play an important role in nutrient cycling. They feed by picking up organic detritus, like algae, minute aquatic animals, or waste materials, with mop-shaped adhesive tentacles as they move over the seafloor. The animals break down these particles, which are then consumed by bacteria, and recycled back into the ocean ecosystem.

Sea cucumbers, particularly eggs and young larvae, are prey for fish and other marine animals, predominantly sea stars. Individuals have limited mobility, but can travel up to 4 m per day while feeding and are known to undertake seasonal migrations to different depths.

Habitat Use

The California sea cucumber ranges from the Gulf of Alaska to southern California, and is found throughout the coastal waters of B.C. from the low intertidal to depths of 250 m. California sea cucumbers are found on a wide variety of substrates, but are most abundant in areas of moderate current on cobble, boulder, and bedrock (DFO 1999). During early life stages (<10 cm), cucumbers have been observed on the underside of rocks, in red algae mats, and among solitary tunicates, but have also been reported from many different habitats (DFO 2014).

The species was documented in the dredge basin and in front of Westshore Terminal during underwater video surveys conducted at Roberts Bank in 2003, 2008, and 2011 (see Figure 3-8 in TDR MI-3 in Appendix AIR10-C of AIR-12.04.15-10).

Echinoderms – Sea Urchin

Life History

Red sea urchins (*Strongylocentrotus franciscanus*) have separate sexes, and generally spawn from June to September, peaking in July. Mass fertilisation occurs in the water column. Fertilised eggs develop into free-swimming larvae, which drift and feed in plankton. After six to eight weeks, larvae settle and develop into juvenile sea urchins. Often they seek aggregations of adults and remain under spines until they reach test diameter of 40 mm. Nishizaki and Ackerman (2005) found that adult urchins release a chemical cue that causes the young to aggregate underneath them when the adults detect the presence of the sunflower star (*Pycnopodia helianthoides*).

They become sexually mature at 50 mm test diameter (approximately two years of age), while reaching commercial size of 100 mm between four to five years of age. Sea urchins are vulnerable to predation between 50 mm to 80 mm. Adult urchins may reach 180 mm and can have very long life spans; Ebert (1998) and Ebert and Southon (2003) reported red sea urchins live over 100 years, and found some near Vancouver Island that may be 200 years old.

Ecology

Sea urchins are herbivores that primarily feed on kelp, particularly giant (*Macrocystis*) or bull (*Nereocystis*) kelp. Their grazing limits kelp distribution. Predators include sea stars, sea otter, octopus, crabs, and wolf eels.

Habitat Use

Red sea urchins are found in the Pacific Ocean, from the coast of Alaska and the Aleutian Islands to Baja California in the east, and in the west, from Siberia to the northern reaches of Japan.

Sea urchins prefer rocky, protected areas of the ocean in shallow water close to shore (e.g., rocky reefs), though occasionally they are found as deep as 100 m (DFO 2017). They prefer to inhabit ledges and crevices and locate near or in giant or bull kelp beds and other brown algae in areas of moderate to swift currents. At depths over 70 m in the Salish Sea area, they aggregate on shallow-slope bottoms near deposits of drift kelp, on which they feed (Britton-Simmons et al. 2012)

***Cephalopods (e.g., octopus*)**

Life History

During the breeding process, the giant Pacific octopus (*Enteroctopus dofleini*) male transfers its spermatophore (i.e., a pencil-shaped, transparent, gelatinous sack of sperm found on its third right arm) to the female. Once bred, the female searches for a proper lair in which to lay her eggs, usually settling in a cave twice her size and with an opening barely large enough for her to enter; eggs are laid throughout the year but primarily in winter, with 35,000 to 70,000 eggs in a single clutch. Females brood their eggs on the ceiling of their dens for five to seven months until they hatch. To avoid contamination and the risk of predators, the female will not leave the lair while guarding her eggs. She lives off the fats and proteins of her own body and will ultimately die having consumed herself during this brooding process.

In B.C., hatching occurs throughout the year, with a peak in April. The hatching period for individual broods may be as short as one week or fairly long, ranging between 40 to 60 days. Hatching of individual eggs takes several hours, and may be accompanied by an expulsion of ink. The young are planktonic and remain in the water column until they are 50 mm in length, at which point they descend to the bottom. Octopi mature in about two to three years, at a size of 12 kilograms (kg) for males and 20 kg for females, and total lifespan is thought to be four to five years. They may grow to 9 m in length, measured from tip of tentacle to tip of tentacle.

Ecology

Giant Pacific octopus are primarily nocturnal predators that feed on crustaceans (shrimp and crabs), molluscs (scallops, clams, other small octopi), and fish (rockfish, flatfish, sculpins);

females can be cannibalistic. They are able to kill crabs by rasping a tiny hole through the carapace with their radula, presumably injecting poison with their beak.

The octopus can change colour from a mottled white to a deep red and brown in one-tenth of a second. They are also adept at squeezing into tiny places and changing their skin to match the texture of their surroundings. Predators include seals, sea otters, dogfish, and lingcod.

Habitat Use

The giant Pacific octopus is distributed along rocky areas of the Pacific coast from the intertidal zone to depths of over 100 m. Adult and juvenile octopuses establish dens in caves, rocks, or soft-shell substrates (Gillespie et al. 1998).

Provide an assessment of the potential effects of the Project on echinoderms and cephalopods in the local assessment area for the Project.

Potential effects of the Project on echinoderms and cephalopods have been considered through the assessment of potential Project-related changes in productivity of Dungeness crab (as representative species; see EIS Section 12.6). Further, Table IR5-12-A1 in **Appendix IR5-12-A** provides additional rationale as to why the representative species used in the effects assessment of the Project adequately represent each of the species listed in this information request, and highlights similarities between Dungeness crab and echinoderm and cephalopod species as they pertain to existing conditions (e.g., life history and habitat requirements), the mechanisms through which the Project may affect them, as well as the effectiveness of mitigation. Table IR5-12-A1 in **Appendix IR5-12-A** also provides links to appropriate EIS sections specific to the assessment of Project-related effects on Dungeness crab, as well as applicable mitigation measures.

In summary, assessment conclusions and mitigation measures for Dungeness crabs (as representative species) also apply to echinoderms and cephalopods, and remain unchanged.

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Appendices

Appendix IR5-12-A Supporting Table

APPENDIX IR5-12-A
SUPPORTING TABLE

Table IR5-12-A1 Summary of Representative Species Selection Rationale and Update to the Effects Assessment for Echinoderm and Cephalopod Species

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
Sea Star	Sea stars are represented by Dungeness crab for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 1): • Like Dungeness crab, sea stars are mobile benthic species that are highly associated with bottom substrate. Several species show similar habitat preferences as Dungeness crabs (coarse sand) while difference is noted for others that prefer rockier substrates. • Project interactions are expected to be the same, largely driven by the terminal footprint (i.e., sea cucumbers do not occur intertidally in the local assessment area (LAA), and are thus unlikely to interact with the causeway footprint). • Mechanisms affecting sea star productivity (i.e., injury/direct mortality, changes in habitat availability, and changes in biotic interactions) and sea star response to Project-related effects, are similar as those for Dungeness crab. • The use of Dungeness crab to assess Project-related effects on sea stars is considered conservative, as Dungeness crab are more likely to interact with the Project due to higher local abundance and broader distribution within the LAA.	Potential Project-related effects on sea stars have been assessed in the EIS through the use of Dungeness crab as a representative species. Details are provided below: • Potential effects on Dungeness crab from changes in water quality (EIS Section 12.6.2.1, pages 12-44 to 12-48) are assessed as negligible. Assessment result is the same for sea stars as the maximum concentration of total suspended solids (TSS) resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Dungeness crab from changes in sedimentation and coastal processes (EIS Section 12.6.2.2, page 12-49) are assessed as negligible. Assessment result is the same for sea stars, as there is less spatial overlap with predicted areas of sediment deposition (i.e., sea stars are not found in the intertidal zone in the LAA). • Potential effects on Dungeness crab from injury/direct mortality (EIS Section 12.6.3.3, pages 12-64 to 12-65) are assessed as minor, as some mortality is expected from construction activities. Assessment result is the same for sea stars due to similar broadcast spawning life history strategies. • Potential effects on Dungeness crab from changes in habitat availability (EIS Section 12.6.3.3, pages 12-65 to 12-66) are assessed as minor. Changes in habitat availability for sea stars are of lesser magnitude largely due to the fact that several species observed in the area prefer rocky habitat and are not associated with soft substrate and because sea stars are strictly marine (i.e., do not occur in fresh or brackish waters) and, in the estuary, freshwater inputs from the Fraser River are considerable. Sea stars are not habitat limited within the LAA or regional assessment area.	• A Dungeness crab fisheries-sensitive window (<-5.0 m chart datum (CD)) from October 15 to March 30 will be adhered to, to minimise injury and direct mortality (see EIS Section 12.7.1.2) during the sensitive spawning period (late winter/early spring). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 12.7.3).
Sea Cucumber	Sea cucumbers are represented by Dungeness crab for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 1): • Like Dungeness crab, sea cucumbers are mobile benthic species that are highly associated with bottom substrate. • Like Dungeness crab, Project interactions are expected to be largely driven by the terminal footprint (i.e., sea cucumbers do not occur intertidally in the LAA, and are thus unlikely to interact with the causeway footprint). • Mechanisms affecting sea cucumber productivity (i.e., injury/direct mortality, changes in habitat availability, and changes in biotic interactions) and sea cucumber response to Project-related effects, are similar as those for Dungeness crab, based on similar broadcast spawning reproductive strategies. • The use of Dungeness crab to assess Project-related effects on sea cucumber is considered conservative, as Dungeness crab are more likely to interact with the Project due to higher local abundance and broader distribution within the LAA. Sea cucumbers prefer rocky/gravelly substrate (i.e., habitat in LAA is not optimal), and there will be a net increase of hard substrate habitat with the Project.	Potential Project-related effects on sea cucumbers have been assessed in the EIS through the use of Dungeness crab as a representative species. Details are provided below: • Potential effects on Dungeness crab from changes in water quality (EIS Section 12.6.2.1, pages 12-44 to 12-48) are assessed as negligible. Assessment result is the same for sea cucumber as the maximum concentration of TSS resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Dungeness crab from changes in sedimentation and coastal processes (EIS Section 12.6.2.2, page 12-49) are assessed as negligible. Assessment result is the same for sea cucumber, as there is less spatial overlap with predicted areas of sediment deposition (i.e., sea cucumber are not found in the intertidal zone in the LAA). • Potential effects on Dungeness crab from injury/direct mortality (EIS Section 12.6.3.3, pages 12-64 to 12-65) are assessed as minor, as some mortality is expected from construction activities. Assessment result is conservative for sea cucumber, as their habitat preferences (rock) limit spatial overlap with the terminal footprint (sand). • Potential effects on Dungeness crab from changes in habitat availability (EIS Section 12.6.3.3, pages 12-65 to 12-66) are assessed as minor. Changes in habitat availability for sea cucumbers are of lesser magnitude due to preferences for rocky habitat and a net gain in hard substrate with the Project.	• A juvenile salmon fisheries-sensitive window (>-5.0 m CD) from March 30 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 12.7.1.2) to sea cucumbers above -5 m CD during the sensitive spawning period which extends from April to August. • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 12.7.3).

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
Sea Urchin	Sea urchins are represented by Dungeness crab for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 1): • Like Dungeness crab, sea urchins are mobile benthic species that are highly associated with bottom substrate. • Like Dungeness crab, Project interactions are expected to be largely driven by the terminal footprint (i.e., sea urchins do not occur intertidally in the LAA, and are thus unlikely to interact with the causeway footprint). • Mechanisms affecting sea urchin productivity (i.e., injury/direct mortality, changes in habitat availability, and changes in biotic interactions) and sea urchin response to Project-related effects are similar. • The use of Dungeness crab to assess Project-related effects on sea urchin is considered conservative, as Dungeness crab are more likely to interact with the Project due to higher local abundance and broader distribution within the LAA. Sea urchin prefer rocky substrate, and there will be a net increase of hard substrate habitat with the Project.	Potential Project-related effects on sea urchin have been assessed in the EIS through the use of Dungeness crab as a representative species. Details are provided below: • Potential effects on Dungeness crab from changes in water quality (EIS Section 12.6.2.1, pages 12-44 to 12-48) are assessed as negligible. Assessment result is the same for sea urchin as the maximum concentration of TSS resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Dungeness crab from changes in sedimentation and coastal processes (EIS Section 12.6.2.2, page 12-49) are assessed as negligible. Assessment result is the same for sea urchin, as there is less spatial overlap with predicted areas of sediment deposition (i.e., sea urchin are not found in the intertidal zone in the LAA). • Potential effects on Dungeness crab from injury/direct mortality (EIS Section 12.6.3.3, pages 12-64 to 12-65) are assessed as minor, as some mortality is expected from construction activities. Assessment result is conservative for sea urchin, as their habitat preferences (rock) limit spatial overlap with the terminal footprint (sand). • Potential effects on Dungeness crab from changes in habitat availability (EIS Section 12.6.3.3, pages 12-65 to 12-66) are assessed as minor. Changes in habitat availability for sea urchins are of lesser magnitude due to preferences for rocky habitat and a net gain in hard substrate with the Project.	• A juvenile salmon fisheries-sensitive window (>-5.0 m CD) from March 30 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 12.7.1.2) to sea urchins above -5 m CD during the sensitive spawning period which extends from March to September. • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 12.7.3).
Giant Pacific Octopus (GPO)	GPO is represented by Dungeness crab for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 1): • Like Dungeness crab, GPO is a mobile predator. • Like Dungeness crab, Project interactions are expected to be largely driven by the terminal footprint (i.e., GPO do not occur intertidally in the LAA, and are thus unlikely to interact with the causeway footprint). • Mechanisms affecting GPO productivity (i.e., injury/direct mortality, changes in habitat availability, and changes in biotic interactions) and GPO response to Project-related effects are similar as those for Dungeness crab. • The use of Dungeness crab to assess Project-related effects on GPO is considered conservative, as Dungeness crab are more likely to interact with the Project due to higher local abundance and broader distribution within the LAA. GPO prefer rocky substrate, though occasionally are found over sand, and there will be a net increase of hard substrate habitat with the Project (and onsite reef habitat, see EIS Section 17, will also increase future habitat availability for GPO).	Potential Project-related effects on GPO have been assessed in the EIS through the use of Dungeness crab as a representative species. Details are provided below: • Potential effects on Dungeness crab from changes in water quality (EIS Section 12.6.2.1, pages 12-44 to 12-48) are assessed as negligible. Assessment result is the same for GPO as the maximum concentration of TSS resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Dungeness crab from changes in sedimentation and coastal processes (EIS Section 12.6.2.2, page 12-49) are assessed as negligible. Assessment result is the same for GPO, as there is less spatial overlap with predicted areas of sediment deposition (i.e., GPO are not found in the intertidal zone in the LAA). • Potential effects on Dungeness crab from injury/direct mortality (EIS Section 12.6.3.3, pages 12-64 to 12-65) are assessed as minor, as some mortality is expected from construction activities. Assessment result is conservative for GPO, as their habitat preferences limit spatial overlap with the terminal footprint. • Potential effects on Dungeness crab from changes in habitat availability (EIS Section 12.6.3.3, pages 12-65 to 12-66) are assessed as minor. Changes in habitat availability for GPO are likely of lesser magnitude due to preferences for rocky habitat and a net gain in hard substrate with the Project.	• A Dungeness crab fisheries-sensitive window (<-5.0 m CD) from October 15 to March 30 will be adhered to, to minimise injury and direct mortality (see EIS Section 12.7.1.2). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 12.7.3).

IR5-13 Marine Invertebrates – Negligible Effects, Total Suspended Solids

Information Source(s)

Review Panel Information Request Package 3 of February 14, 2017 (CEAR Doc#929): IR3-34

EIS Volume 1: Appendix 4-E

EIS Volume 2: Appendix 9.6-C, Figure 5.2.29

EIS Volume 3: Section 12, Section 13

Context

The Proponent, in Appendix 9.6-C, reported on the probability of total suspended solid (TSS) plumes exceeding 1.0 mg/L, 5.0 mg/L, and 10 mg/L, the extent of instantaneous TSS plumes during ebb and flood tide, total deposition of fine sediment, and D50 (median particle size) of deposited fine sediment from the following activities:

- dredging operations;
- disposal at sea activities; and
- tug basin dredging.

In IR3-34, the Review Panel requested that the Proponent carry out further modelling to quantify the suspended sediment generated by simultaneous dredging and disposal at sea activities, and to determine whether other activities not included in the model could result in measurable changes in suspended sediment.

The Proponent used 25mg/L TSS concentrations as the basis for its assessment of potential effects of the Project on marine invertebrates and marine fish based on the flow guidelines from the Canadian Council of Ministers of the Environment's *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. Additional information about TSS is required.

Information Request

Provide maps, similar to the figures in Appendix 9.6-C, to illustrate the percentage of time that peak TSS exceeds the threshold of 25 mg/L, for the following proposed Project activities:

- dredging operations planned for the first year (spring, summer and fall) and second year (winter) of construction;
- disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment;
- tug basin dredging; and
- simultaneous dredging and disposal at sea activities.

Provide maps, using an appropriate TSS scale from 1 to the maximum predicted value (in intervals of 25mg/l) to illustrate the extent of the instantaneous TSS plume during ebb and flood tides for the following proposed Project activities:

- disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment; and
- simultaneous dredging and disposal at sea activities.

Provide a map displaying the percentage of time that peak TSS exceeds the threshold of 25 mg/L for the full period of dredge basin dredging operations similar to Figure 5.2.29 of Appendix 9.6-C of the EIS.

VFPA Response

In order to respond to this information request regarding the provision of additional maps, it is necessary to clarify elements of the construction schedule and explain the approach taken to simulate the requested activities. The subsections below provide information and assumptions on the following activities:

a. Dredging operations for the east dredge basin;
b. Discharge activities at 45 metre outfall;
c. Tug basin dredging; and
d. Simultaneous dredging and discharge activities.

In addition, information is provided to assist with the interpretation of model results and figures.

Modelling Assumptions

a. Dredging Operations for East Basin

The first part of the first request is to provide maps for "dredging operations planned for the first year (spring, summer and fall) and second year (winter) of construction". The construction schedule identifies that only the construction of east basin containment dykes will occur in the first (calendar) year of construction, from August to the end of December, as shown in **Figure IR5-13-1**. Dyke completion, expected by the end of February in Year 2, is required prior to dredging and filling activities commencing.

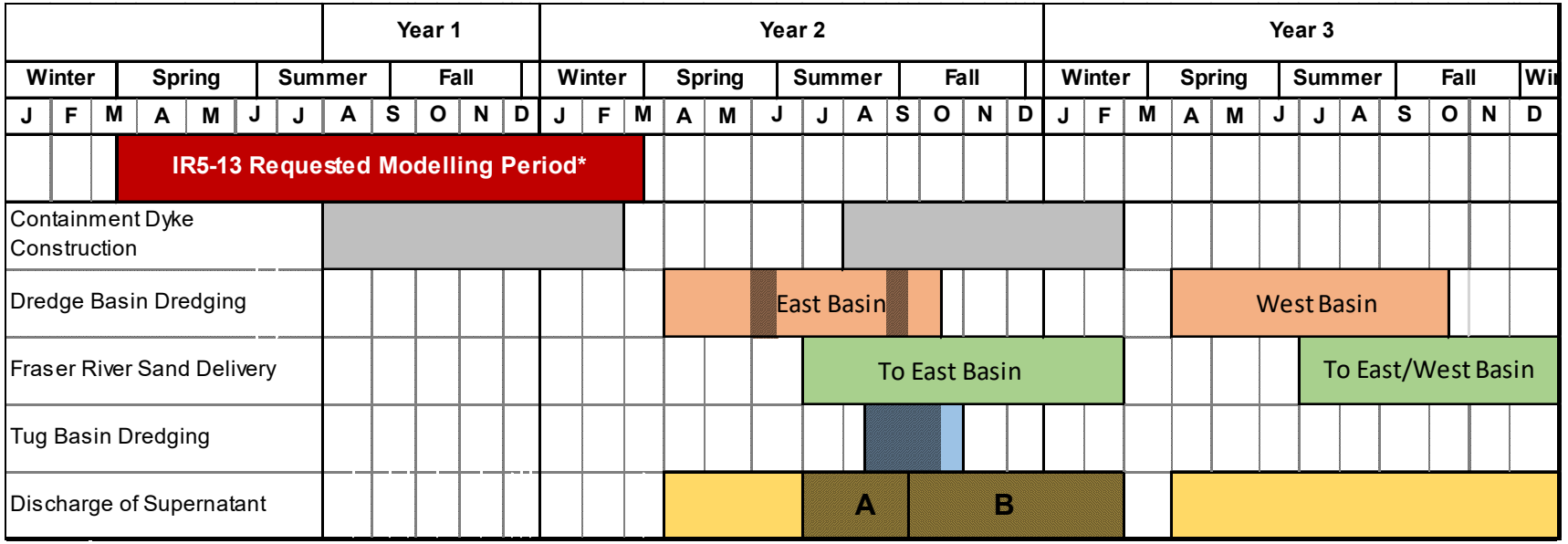
Initial dredging activities, therefore, are scheduled to occur within a work window period of April 1 to October 14 in Year 2, corresponding to the spring, summer and fall periods[1] (**Figure IR5-13-1**). Dredging is not planned to occur during the winter, as the construction schedule assumed that the timing of dredging activities would respect the crab timing window (October 15 to March 30 annually) for dredging at depths greater than 5.0 m CD (chart datum).

[1] Seasonal breakdowns are assumed as follows: Spring, March 21 to June 20; Summer, June 21 to September 22; Fall, September 23 to December 20; and Winter, December 21 to March 20.

Modelling simulations for dredging in the east basin have been carried out for spring (June 1 to 21) and summer (September 1 to 18) in Year 2. It was conservatively assumed that dredging would occur over 109 days, representing the maximum anticipated sediment release associated with a continuous dredging operation, as presented previously in EIS Appendix 9.6-C and the response to IR3-34 (CEAR Document #984[2]).

[2] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).

Figure IR5-13-1 Preliminary Construction Schedule for Project Years 1 to 3 and Model Simulation Periods



Notes: *The period shown in red reflects the Panel's requested period of modelling. Hatched periods represent the period simulated by the model for each of the activities requested by the Panel to be modelled.

A - Simultaneous dredging in the east basin and discharge of supernatant from filling with east dredge basin dredgeate and Fraser River sand.

B - Discharge of supernatant from filling with Fraser River sand.

b. Discharge Activities at 45 Metre Outfall

The second part of the first request is to provide maps for "disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment". Modelling conducted to produce such maps incorporated updated Project construction information, which was explained in the *Information Request Package 3 Preamble in Support of Responses to IR3-25 to IR3-40 – General and Disposal at Sea-related Project Construction Update* (IR Package 3 Preamble, CEAR Document #984). The elements pertinent to this response include the following:

- The Project construction sequence has been revised to incorporate the placement of Fraser River sand directly into fill areas using a vessel with pump-ashore capability, eliminating the need for temporary storage in the intermediate transfer pit (ITP); and
- Discharge of supernatant containing unsettled fines from the containment dykes during filling is not expected to be subject to disposal at sea permitting; therefore, the pumping of sediment-laden water via an outfall at -45 m CD to the receiving environment is referred to as discharge of supernatant (or sediment-laden water), not as disposal at sea.

For the purposes of modelling, it was assumed that discharge of supernatant will occur as follows:

1. Simultaneously with dredging in the east dredge basin and filling of the east containment basin with east dredge basin dredgeate and Fraser River sand (using a vessel with pump-ashore capability). For the purposes of modelling, it was assumed that this activity would occur during the summer in Year 2 (July 1 to September 18, as shown in **Figure IR5-13-1** as 'A'); and
2. Filling of the east basin with Fraser River sand using a vessel with pump-ashore capability during the fall and winter months. For the purposes of modelling, it was assumed that this activity would occur during the fall and winter (from September 19 in Year 2 to end of February in Year 3, as shown in **Figure IR5-13-1** as 'B').

With respect to the discharge of the sediment-laden water for the combined sediment stream (bullet 1 above), assumptions related to the non-retention rate is as per Table IR3-34-3 provided in the response to IR3-34 (CEAR Document #984). For the discharge of sediment-laden water from the Fraser River sand only sediment stream (bullet 2 above), the non-retention rate is as per Section 5.3 of EIS Appendix 9.6-C.

c. Tug Basin Dredging

The third part of the first request is to provide maps for "tug basin dredging". As stated in the IR Package 3 Preamble, the tug basin dredgeate material is considered suitable for use as general fill for terminal development or causeway widening. Tug basin dredgeate will be pumped directly into terminal or causeway containment dykes using a scow barge. As pumping from a scow barge is significantly slower than dumping via a hopper barge (as assessed in the EIS Appendix 9.6-C), dredging of the tug basin is anticipated to occur within the period of mid-August to October in Year 2 (**Figure IR5-13-1**). For the purposes of

modelling, this activity is assumed to occur over a 60-day period from mid-August to mid-October (as shown in **Figure IR5-13-1**), to respect both the juvenile salmon and crab closures and was simulated as an independent activity due to the flexibility of construction timing, the relatively isolated location of dredging activities, and relatively small volume of material to be dredged (compared to dredge basin dredging and discharge activities).

d. Simultaneous Dredging and Discharge Activities

As outlined above, simultaneous dredging in the dredge basin and discharge activities from filling with dredge basin dredgeate and Fraser River dredgeate are simulated to occur from June 1 to September 18. The data previously presented in the response to IR3-34 (CEAR Document #984) for the simultaneous discharge of dredge basin and Fraser River sand supernatant assumed a 100% fine sediment non-retention rate; this rate was used in this model simulation as it is more conservative than the requested 15% non-retention rate. Based on the blended sediment properties, the overall and fine-sediment non-retention rates for simultaneous infilling with dredge basin and Fraser River derived sediment sources are 11.8% and 100%, respectively, as presented in Table IR3-34-3 in the response to IR3-34 (CEAR Document #984).

Modelling Results

Interpretation of Depth-Maximum Total Suspended Solids Concentrations

In order to quantify the dispersion of sediments during Project construction activities, the total suspended solids (TSS) content of the sediment plume was tracked in the model as sediments were released over a range of dredging and supernatant discharge activities. At hourly intervals, the maximum TSS concentration in the water column was reported at a 200 m horizontal spatial resolution. This data representation, therefore, illustrates the absolute maximum TSS concentration that could occur in the water column at each location on a 200 m by 200 m grid. This approach was selected to give a conservative representation of the TSS concentration in the water column, and is referred to as the depth maximum concentration.

As an explanatory example: if the water depth is 40 m, and there is a near bed (i.e., within 1 m of the seabed) TSS concentration of 100 mg/L with a 2 mg/L TSS concentration throughout the remainder of the water column, the maximum TSS concentration would be 100 mg/L, while the water column average (arithmetic mean) TSS would be 4.5 mg/L. The TSS value reported would be the maximum value of 100 mg/L, rather than the depth averaged value of 4.5 mg/L. This approach has been used in the modelling results presented in EIS Appendix 9.6-C and in the response to IR3-34 (CEAR Document #984).

Interpretation of Requested Maps

The exceedance probability maps represent the cumulative percentage of time a given TSS threshold is exceeded at any one location in the water column (i.e., not over the entire water column, but at a discrete location) over a given dredging or discharge activity. This cumulative percentage is derived as a composite of maximum TSS concentrations in space and time over the activity duration period (e.g., 5 months) and should not be interpreted as a continuous

or prevailing condition; the actual size of the plume at any time will fill only a relatively small part of the shaded probability area. It does not represent the instantaneous TSS plume footprint or a static plume position.

For example, a 25 mg/L exceedance probability of 1% at a given location in the Strait of Georgia means that the water column maximum TSS concentration in that specific 200 m by 200 m grid cell may exceed 25 mg/L at some location in the water column for a cumulative 1% of the total dredging or discharge operation. For the 109-day duration of simultaneous dredge basin dredging and Fraser River sand delivery (June 1 to September 18), that represents 26 hours, which are likely non-continuous, in which the water column maximum TSS exceeds 25 mg/L.

As requested in the first and third information requests, the maps presented in this response show the percentage of time that peak TSS exceeds 25 mg/L (i.e., the probability that the instantaneous depth maximum TSS will exceed 25 mg/L). For the second request to provide maps illustrating the extent of the instantaneous TSS plume during ebb and flood tides, depth maximum TSS concentrations (colour bars) are presented in the following increments to show the full range of TSS concentrations for that particular activity: 1 mg/L to 5 mg/L, greater than 5 mg/L to 25 mg/L, then in increases of 25 mg/L increments.

Incorporating the assumptions described above, **Table IR5-13-1** summarises the requested information, corresponding assumptions, and figures provided in the response. Note that this information is tabulated in the order requested by the Panel, not in the order the results are discussed in the next section.

Table IR5-13-1 Summary of Scenarios Requested and Corresponding Figure Numbers

Requested Scenario	Notes	Scenario Provided	Appendix IR5-13-A Figure Number
Maps illustrating peak TSS from dredging operations planned for the first year (spring, summer, and fall) and second year (winter) of construction – as percentage of time exceeding 25 mg/L threshold	Spring and summer: East dredge basin dredging occurs in Year 2 of construction. For the purposes of modelling the duration was assumed to be 109 days (based on continuous dredging in the June 1 to September 18 period). There is no dredging at the ITP as Fraser River sand will be pumped directly into terminal east basin.	East dredge basin dredging – Spring (modelled for June 1 to 21)	**IR5-13-A1**
		Dredge basin dredging – Summer (modelled for September 1 to 18)	**IR5-13-A2**
	Fall and winter: For the purpose of modelling, dredging is assumed to not occur during the fall and winter periods as east dredge basin dredging ends September 18. Fraser River sand delivery occurs in the summer, fall, and winter, but material is pumped directly into terminal footprint (i.e., dredging of material temporarily stored in the ITP is no longer required).	If dredging were to occur in the fall, summer results (shown in **Figure IR5-13-A2**) may be broadly representative of the resulting sediment dispersion patterns.	None
Maps illustrating peak TSS from disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment – as percentage of time exceeding 25 mg/L threshold	Supernatant will be discharged either as discharge of Fraser River sand supernatant (September 19 to February 28) or as combined activities (dredging of the east basin and corresponding discharge of supernatant plus Fraser River sand supernatant during July 1 to September 18). Since discharge from east basin dredging has to coincide with dredging activities, simultaneous discharge of Fraser River sand supernatant with discharge of dredgeate supernatant has been addressed in the map illustrating simultaneous dredging and discharge activities (**Figure IR5-13-A6**).	Discharge of Fraser River sand supernatant at 45 metre outfall with a non-retention rate of 15% (September 19 to February 28)	**IR5-13-A5**

Requested Scenario	Notes	Scenario Provided	Appendix IR5-13-A Figure Number
Maps illustrating peak TSS from tug basin dredging – as percentage of time exceeding 25 mg/L threshold	It is assumed for the simulation that tug basin dredging using clamshell dredge equipment will take place over the course of 60 days in Year 2 of construction commencing mid-August, coinciding with the end of the juvenile salmon protection window. Tug basin dredging was simulated as an independent activity due to the flexibility of construction timing, the relatively isolated location of dredging activities, and relatively small volume of material to be dredged (compared to dredge basin dredging and discharge activities).	Tug basin dredging, full period of activity (modelled from mid-August to mid-October)	**IR5-13-A4**
Maps illustrating peak TSS from simultaneous dredging and disposal at sea activities – as percentage of time exceeding 25 mg/L threshold	Simultaneous activities include dredging of the east basin and supernatant discharged from the combined activities of filling of the east containment basin with east dredge basin dredgeate and Fraser River sand from July 1 to September 18. For the combined discharge, it was assumed that there would be a 15% loss rate of fine sediment.	Simultaneous dredging of the east basin and discharge of supernatant from filling with dredgeate and Fraser River sand (July 1 to September 18)	**IR5-13-A6**
Maps illustrating maximum predicted TSS extent from disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment during ebb and flood tides	See notes associated with **Figure IR5-13-A5**.	Discharge of Fraser River sand supernatant at 45 metre outfall with a non-retention rate for fine material of 15% during an ebb tide (September 19 to February 28)	**IR5-13-A8**
		Discharge of Fraser River sand supernatant at 45 metre outfall with a non-retention rate for fine material of 15% during a flood tide (September 19 to February 28)	**IR5-13-A7**

Requested Scenario	Notes	Scenario Provided	Appendix IR5-13-A Figure Number
A map illustrating maximum predicted TSS extent from simultaneous dredging and disposal at sea activities during ebb and flood tides	See notes associated with **Figure IR5-13-A6**.	Simultaneous dredging and discharge activities, maximum ebb tide excursion (July 1 to September 18)	**IR5-13-A10**
		Simultaneous dredging and discharge activities, maximum flood tide excursion (July 1 to September 18)	**IR5-13-A9**
Map displaying the full period of dredge basin dredging operations – as percentage of time exceeding 25 mg/L threshold	The full period of dredging in the east dredge basin is assumed from June 1 to September 18 in Year 2 of construction (approximately three and a half months).	East dredge basin dredging – Full Period (modelled for June 1 to Sept 18)	**IR5-13-A3**

Note: All dates are assumed, and were defined for the purposes of modelling based on the schedule of activities shown in **Figure IR5-13-1**.

Maps Illustrating the Percentage of Time Peak TSS Exceeds 25 mg/L Threshold

All maps produced for this response are provided in **Appendix IR5-13-A**. All concentrations are presented on an assumed ambient background of 0 mg/L for the purpose of clearly identifying and evaluating potential Project-related changes (i.e., the TSS concentrations presented are from the modelled activities without the influence of background TSS concentrations, which can exceed 250 mg/L during freshet (EIS Section 9.7.6.4)).

Figure IR5-13-A1 presents the 25 mg/L exceedance probability map for the depth maximum TSS concentration arising from dredging activities in spring (June 1 to 21) and **Figure IR5-13-A2** presents the corresponding 25 mg/L exceedance probability map for summer conditions based on the period of September 1 to 18. **Figure IR5-13-A3** presents the 25 mg/L exceedance probability map for dredging taking place from June 1 to September 18 and is representative of the total east basin dredging period in Year 2 of construction. As shown in these figures for dredging at the east basin, 25 mg/L is exceeded generally less than 20% of the time and exceedances are localised to the area immediately adjacent to the activity area. The plume disperses past the local activity area at a concentration greater than 25 mg/L less than 1% of the time.

Figure IR5-13-A4 presents the 25 mg/L exceedance probability map for the depth maximum TSS concentration arising from dredging activities in the tug basin from mid-August to mid-November in Year 2. In the vicinity of the tug basin, within 100 m of the dredge site, 25 mg/L is exceeded 5% of the time. Between approximately 100 m and 600 m from the dredge site, the 25 mg/L threshold is exceeded less than 1% of the time and beyond 600 m there is a less than 0.1% probability that the threshold will be exceeded.

Figure IR5-13-A5 presents the 25 mg/L exceedance probability map for the depth maximum TSS concentration resulting from supernatant discharge via an outfall at 45 m CD from infilling of Fraser River sand from September 19 (Year 2) to February 28 (Year 3). The only area with an elevated probability of exceeding 25 mg/L is directly at the outfall pipe itself, indicating that concentration of TSS released during the discharge of Fraser River sand supernatant is generally diluted below 25 mg/L within a few hundred metres of outfall pipe.

Figure IR5-13-A6 presents the 25 mg/L exceedance probability map for the depth maximum TSS concentration resulting from dredging and discharge of supernatant from combined dredge basin and Fraser River sand via an outfall at 45 m CD for the period of July 1 to September 18 in Year 2. More than 99% of the time, TSS concentrations exceeding 25 mg/L are not predicted to extend beyond the northwest-southeast extent of the Project footprint or more than 400 m seaward of the outfall pipe terminus. The 25 mg/L threshold will be exceeded less than 50% of the time outside of a few hundred metres from outfall pipe.

Maps Illustrating the Maximum Predicted TSS Concentrations During Ebb and Flood Tides

Figures IR5-13-A7 and **IR5-13-A8** present the depth maximum concentration of the Fraser River sand supernatant TSS plume at its maximum flood tide and ebb tide extent, respectively. The figures represent a single moment in time, and consequently represent the

actual instantaneous plume position and not a seasonal or monthly aggregation of data. Concentrations are presented in 25 mg/L increments, as requested, except for the 1 mg/L to 25 mg/L increment, which has been split into two increments (i.e., 1 mg/L to 5 mg/L and 6 mg/L to 25 mg/L) to allow for a more meaningful interpretation of the results. The figures present the instantaneous depth maximum TSS levels at the time of maximum flood tide and ebb tide extent of TSS dispersion within the September 19 to February 28 period of only Fraser River sand supernatant discharge. As the exact conditions occurring during simultaneous dredging and discharge cannot be known in advance, these figures are indicative, rather than predictive, of the maximum TSS plume extent during discharge of Fraser River sand supernatant during east basin infilling in the first two years of construction.

At its maximum flood tide extent (shown in **Figure IR5-13-A7**), the plume is not carried onto Roberts Bank. The Canadian Council of Ministers of the Environment (CCME) high flow guideline of 25 mg/L is not predicted to be exceeded outside the immediate vicinity of the outfall pipe. At the particular instance displayed in **Figure IR5-13-A7**, a maximum TSS concentration of 3 mg/L is predicted to be beyond 200 m from the outfall pipe (shown as 5 mg/L or less in the figure, based on the legend increments).

At its maximum ebb extent (**Figure IR5-13-A8**), the plume is carried a short distance south of the BC Ferries Terminal at a concentration between 1 mg/L and 2 mg/L. The CCME high flow guideline of 25 mg/L is not predicted to be exceeded outside of the immediate vicinity of the outfall pipe. At the particular instance displayed in **Figure IR5-13-A8**, a maximum concentration of 15 mg/L is predicted beyond 200 m from the pipe terminus (shown as 25 mg/L or less in the figure, based on the legend increments).

The predicted maximum dispersion of the TSS plume resulting from simultaneous dredge and discharge activities under flood and ebb tidal conditions are plotted on **Figures IR5-13-A9** and **IR5-13-A10**, respectively. The figures present a snapshot of the instantaneous depth maximum TSS levels at the instant of the maximum flood and ebb tide excursion of the TSS plume simulated over the June 1 to September 18 period where dredging and discharge are assumed to occur simultaneously. The figures represent a single moment in time, and consequently represent the actual instantaneous plume position and not a seasonal or monthly aggregation of data. As the exact conditions occurring during simultaneous dredging and discharge cannot be know in advance, these figures are indicative, rather than predictive, of conditions at the exact time of the operation.

At its maximum flood tide extent (shown in **Figure IR5-13-A9**), the plume travels approximately 3 km before being carried onto the adjacent tidal flat at TSS concentration less than 2 mg/L. Project-derived TSS concentrations on the tidal flat are expected to exceed 1 mg/L less than 10% of the time that simultaneous activities are occurring (as shown in Figure IR3-34-A1 of the IR3-34 response (CEAR Document #984)). The CCME high flow guideline of 25 mg/L is predicted to only be exceeded in the immediate vicinity of the outfall pipe. At the particular instance displayed in **Figure IR5-13-A9**, a maximum concentration of 28 mg/L is predicted outside of 200 m from the outfall pipe (shown as 50 mg/L or less in the figure, based on the legend increments).

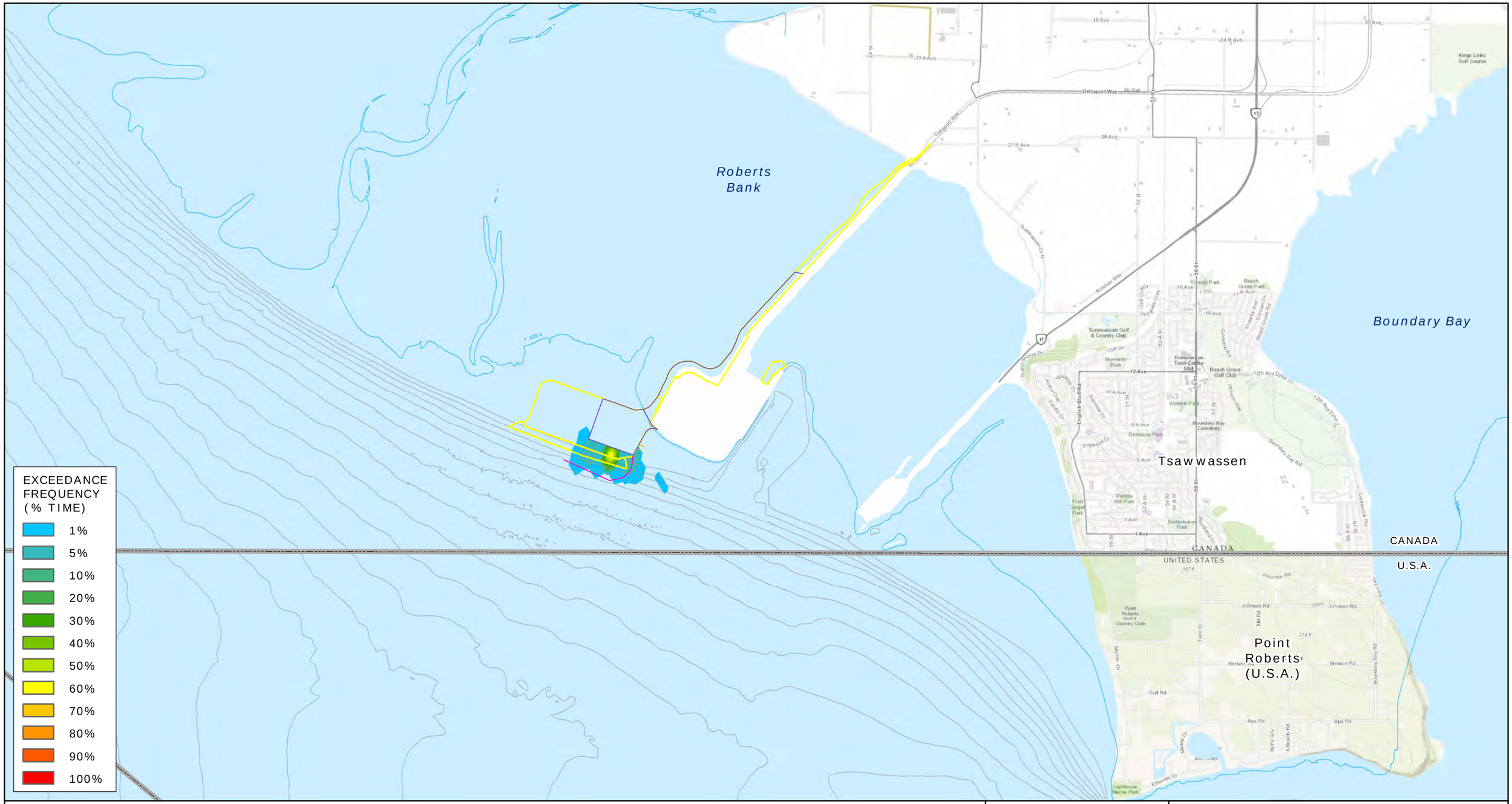
At its maximum ebb tide extent (shown in **Figure IR5-13-A10**), Project-derived sediments are predicted to be carried to the southeast at a concentration less than 3 mg/L. The CCME high flow guideline of 25 mg/L is predicted to be exceeded in the immediate vicinity of the outfall. At the particular instance displayed in **Figure IR5-13-A10**, a maximum concentration of 169 mg/L is predicted outside of 200 m from the outfall pipe. This concentration is higher than that displayed in **Figures IR5-13-A6**, **IR5-13-A7**, or **IR5-13-A9**, and serves to demonstrate the variability in TSS concentration that is possible due to the tidal environment.

Appendices

Appendix IR5-13-A Supporting Figures

APPENDIX IR5-13-A
SUPPORTING FIGURES

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Legend

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- CONSTRUCTION PROGRESS
- CONTAINMENT DYKES
- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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Kilometres

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ROBERTS BANK TERMINAL 2

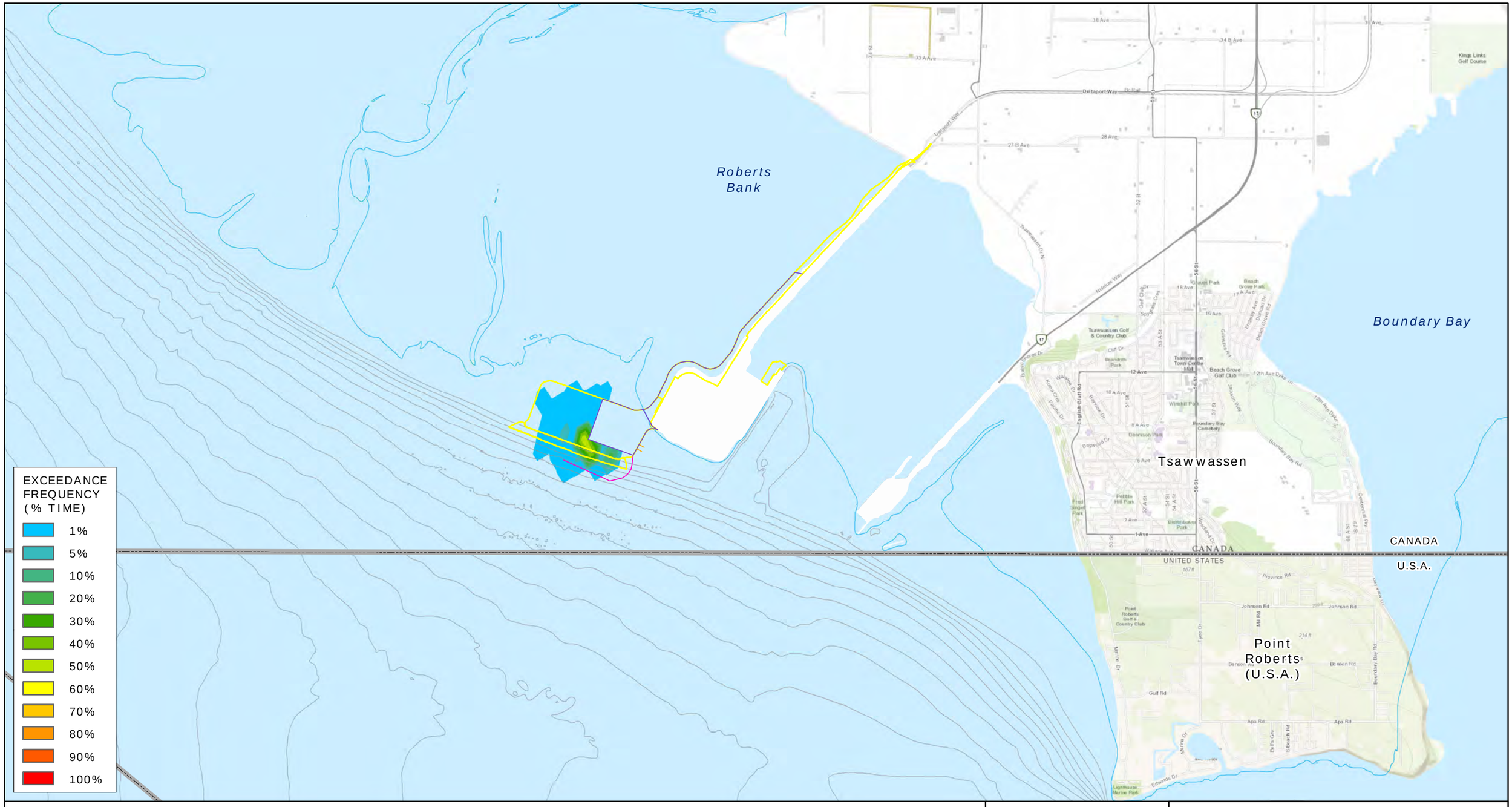
PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING SPRING DREDGING ACTIVITIES

DATE: 02/06/2018

FIG No. IR5-13-A1

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- BATHYMETRY (10 M CHART DATUM)
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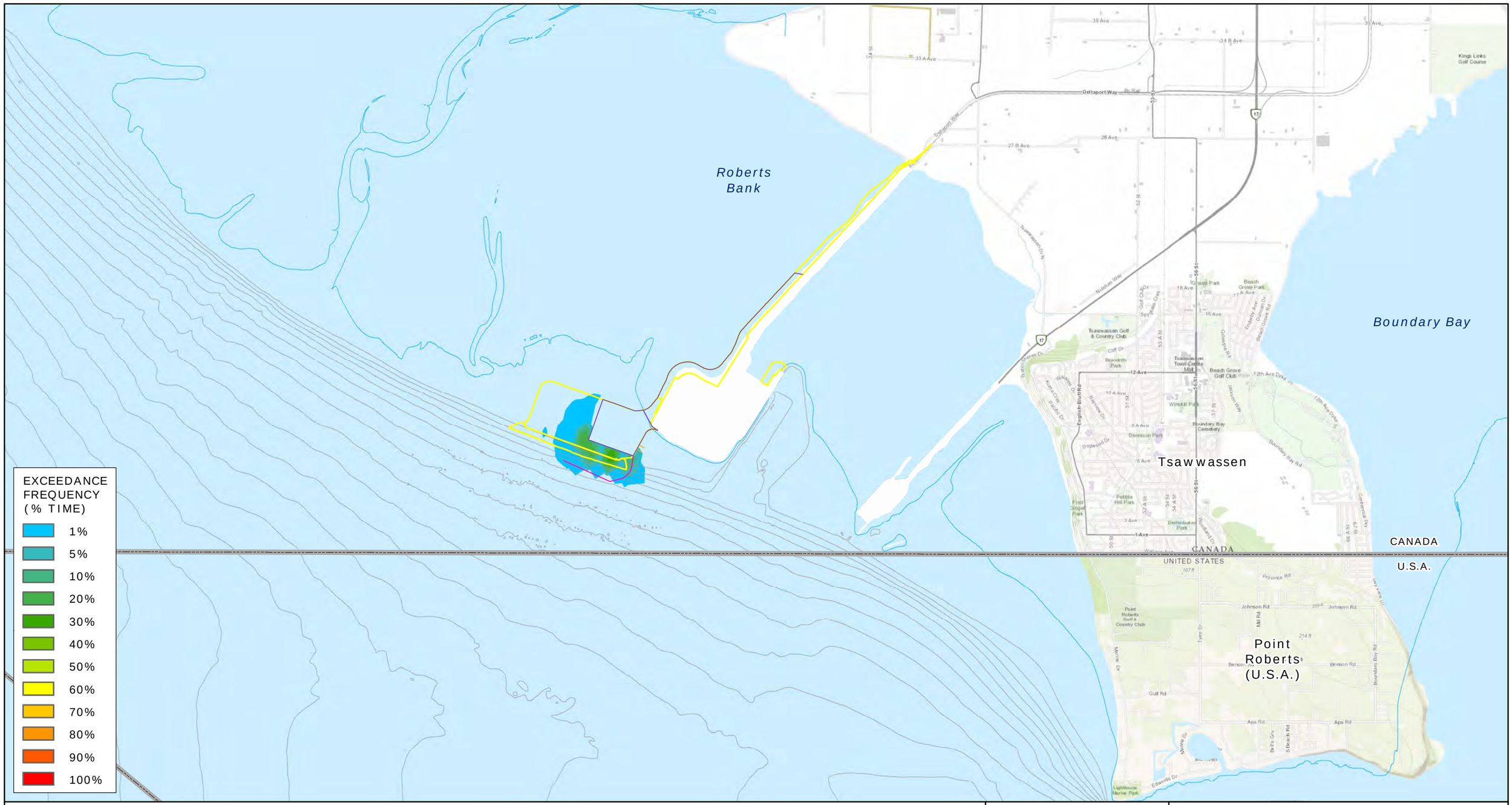
PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING SUMMER DREDGING ACTIVITIES

DATE: 02/06/2018

FIG No. IR5-13-A2

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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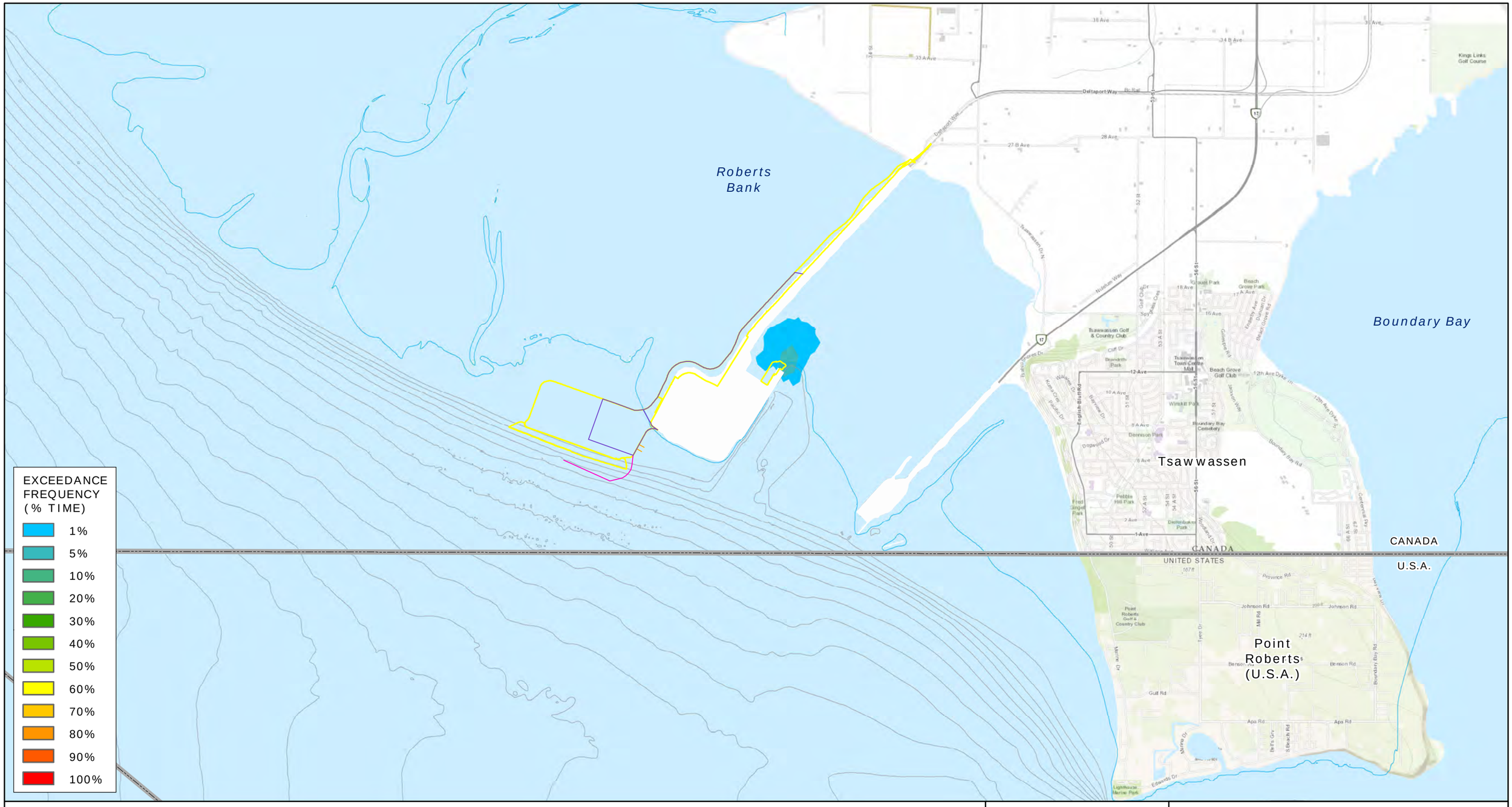
PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING EAST BASIN DREDGING ACTIVITIES

DATE: 02/06/2018

FIG No. IR5-13-A3

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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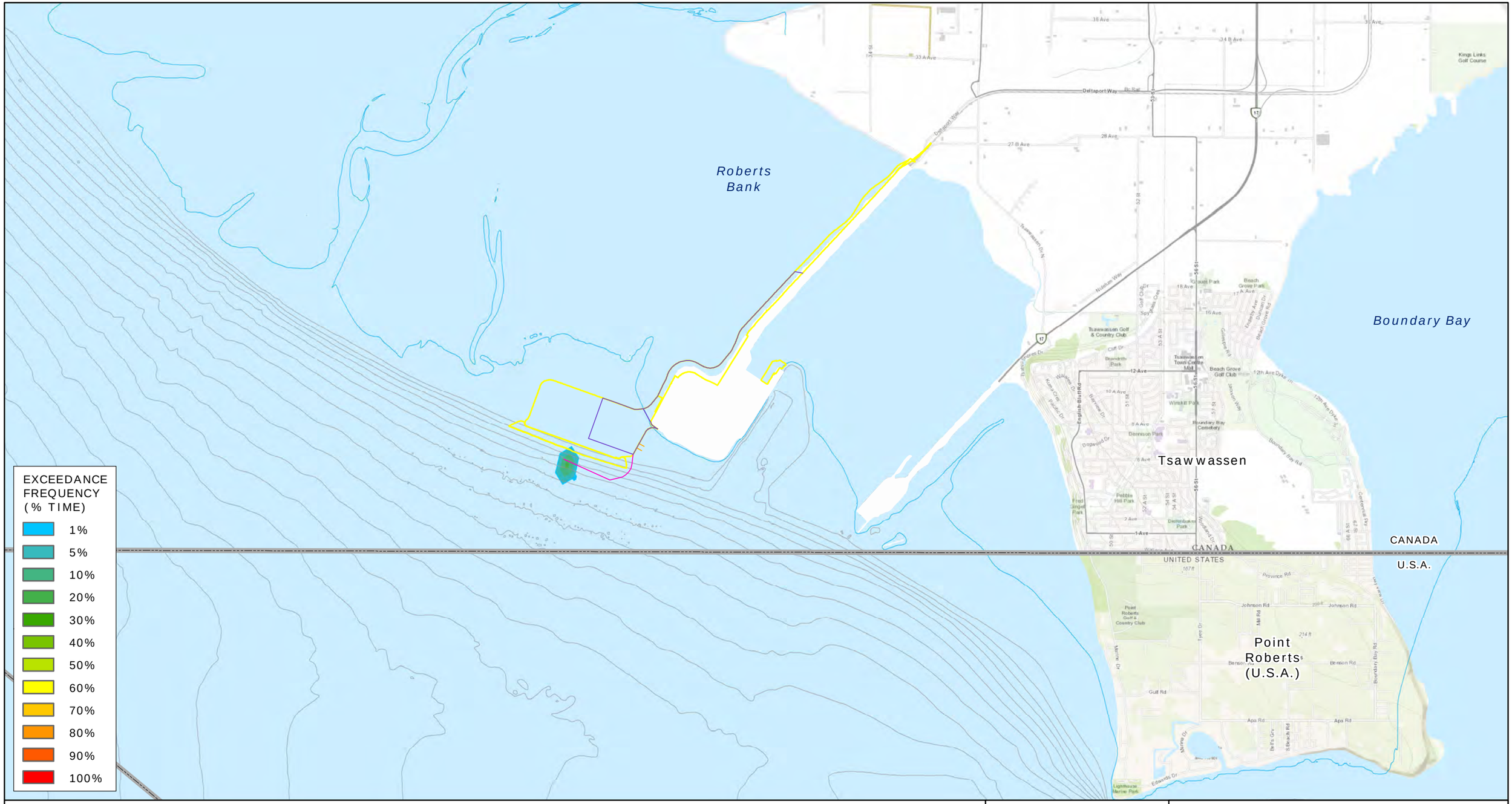
PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING TUG BASIN DREDGING

DATE: 02/06/2018

FIG No. IR5-13-A4

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- CONTAINMENT DYKES
- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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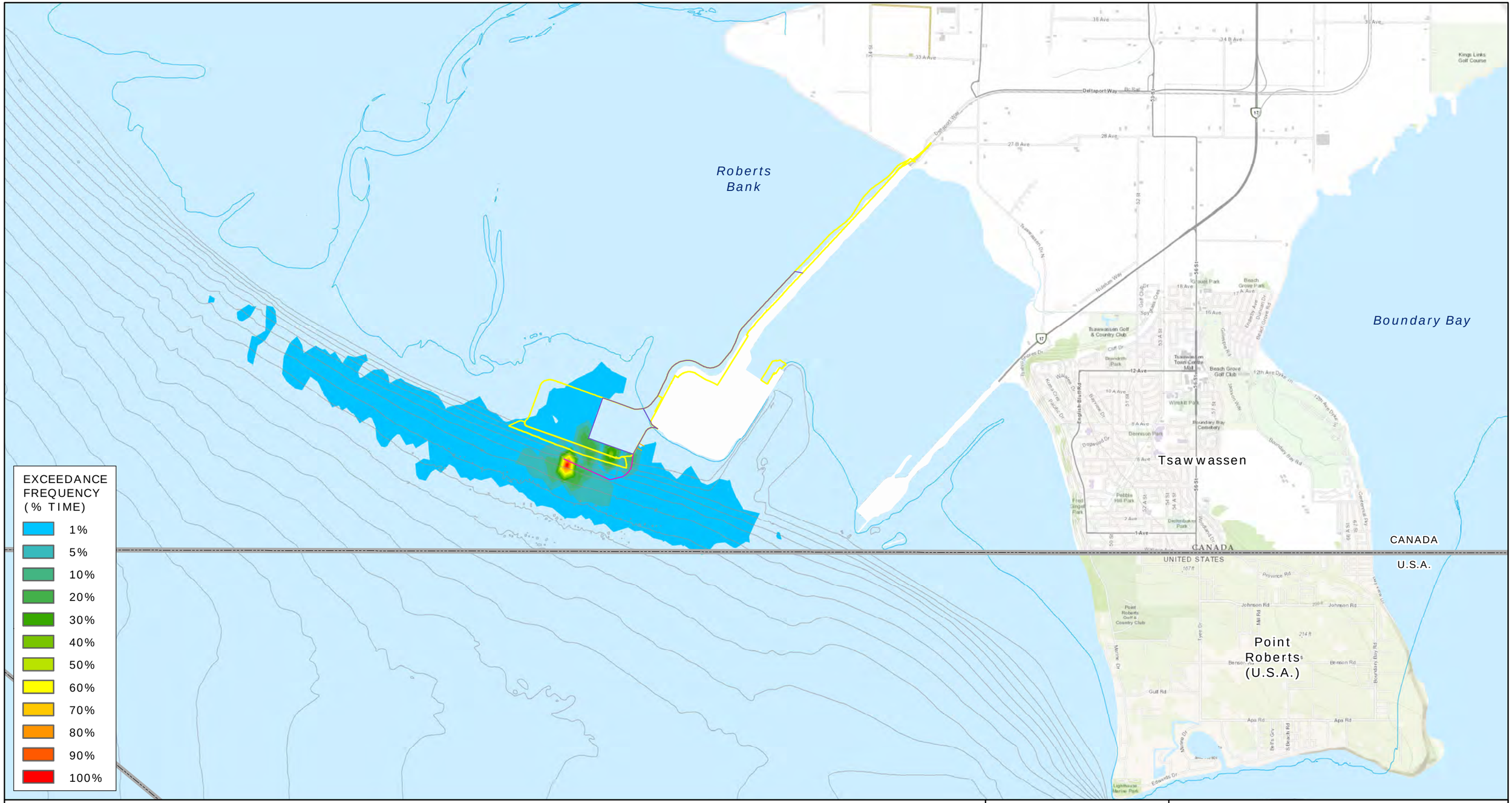
PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING DISCHARGE OF FRASER RIVER SAND SUPERNATANT

DATE: 02/06/2018

FIG No. IR5-13-A5

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
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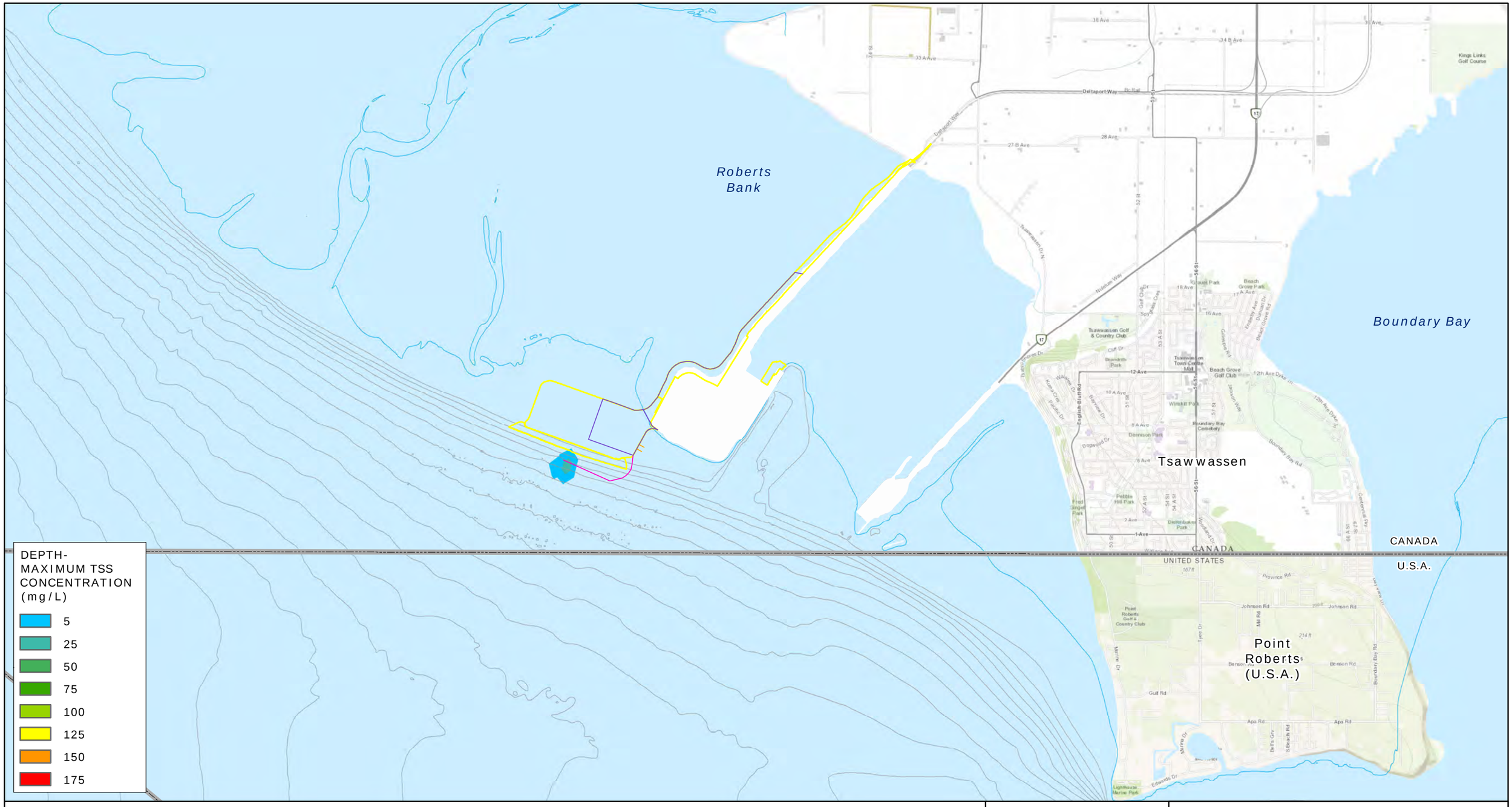
ROBERTS BANK TERMINAL 2

PREDICTION OF DEPTH-MAXIMUM TSS LEVELS EXCEEDING 25 mg/L DURING SIMULTANEOUS DREDGING AND INFILLING ACTIVITIES

DATE:	FIG No.
02/06/2018	IR5-13-A6

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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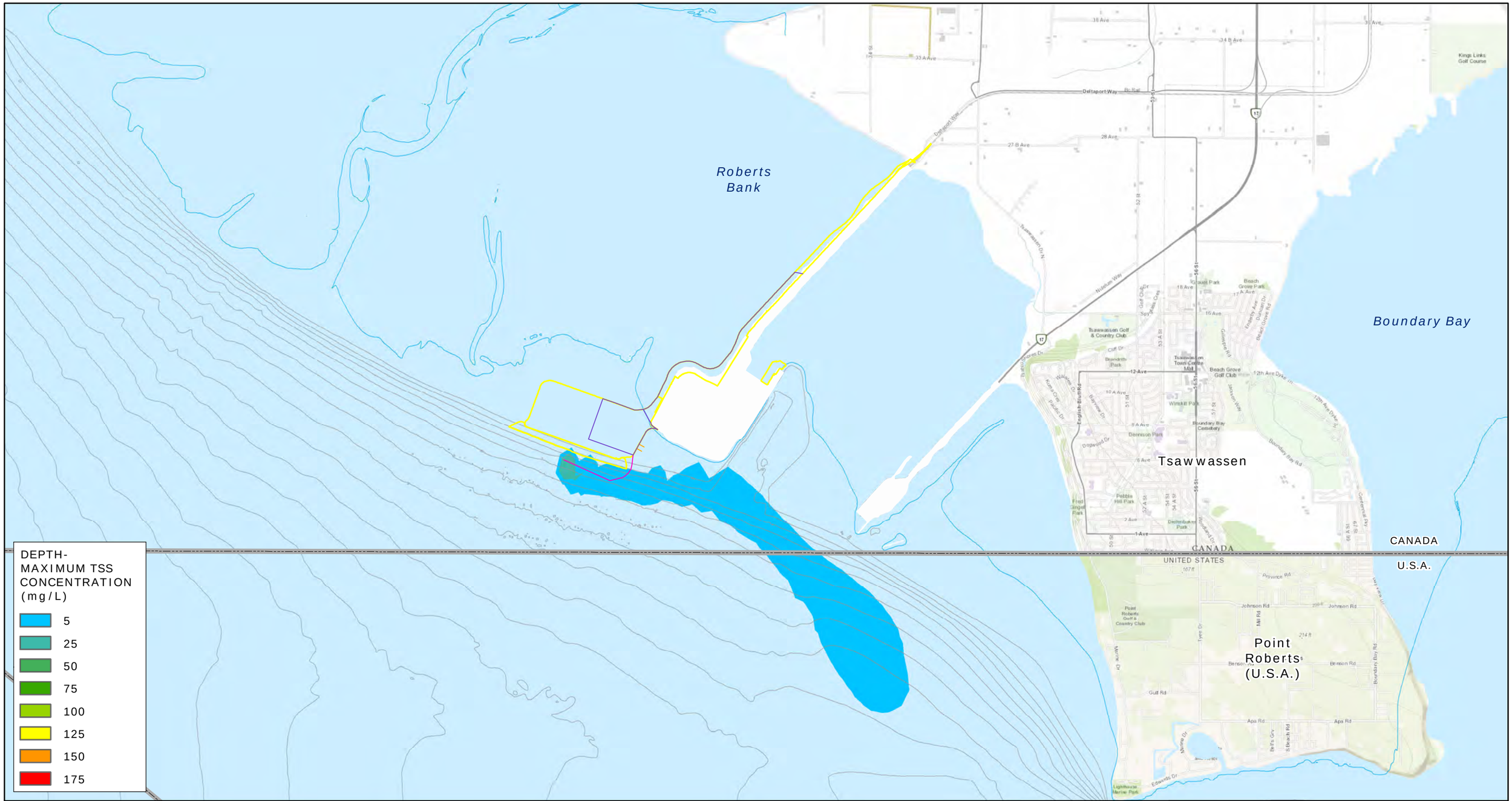
INSTANTANEOUS MAXIMUM FLOOD TIDE PLUME EXTENT DURING DISCHARGE OF FRASER RIVER SAND SUPERNATANT

DATE: 02/06/2018

FIG No. IR5-13-A7

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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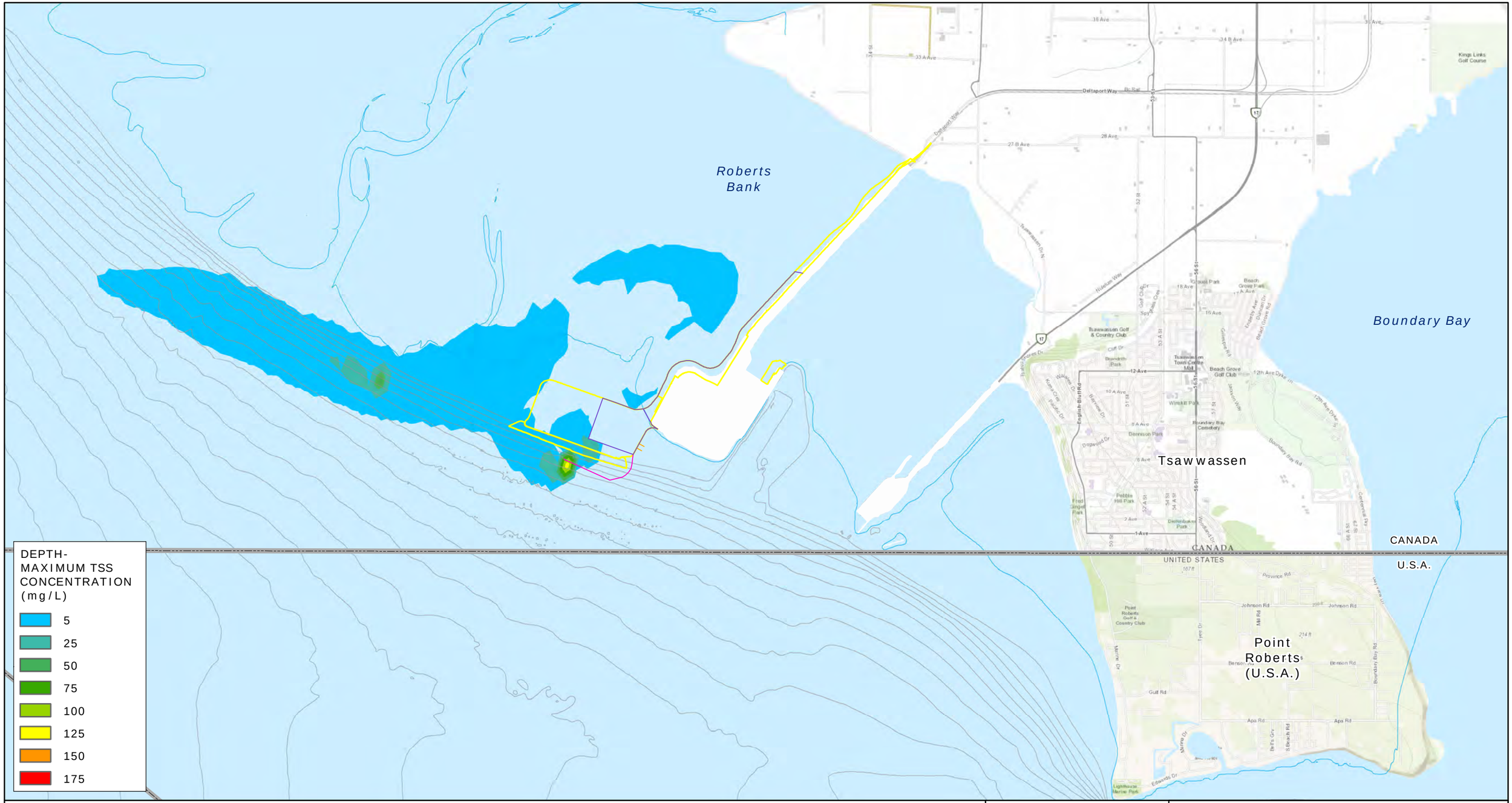
INSTANTANEOUS MAXIMUM EBB TIDE PLUME EXTENT DURING DISCHARGE OF FRASER RIVER SAND SUPERNATANT

DATE: 02/06/2018

FIG No. IR5-13-A8

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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CONSTRUCTION PROGRESS

- CONTAINMENT DYKES
- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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Kilometres

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NAD 1983 UTM Zone 10N

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INSTANTANEOUS MAXIMUM FLOOD TIDE PLUME EXTENT DURING SIMULTANEOUS DREDGING AND INFILLING ACTIVITIES

DATE: 02/06/2018

FIG No. IR5-13-A9

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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Roberts Bank

Boundary Bay

Tsawwassen

Point Roberts (U.S.A.)

CANADA

U.S.A.

UNITED STATES

DEPTH-MAXIMUM TSS CONCENTRATION (mg/L)

- 5
- 25
- 50
- 75
- 100
- 125
- 150
- 175

Legend

- BOUNDARY OF PROJECT AREA
- CONSTRUCTION PROGRESS
- CONTAINMENT DYKES
- PIPELINE
- TEMPORARY BARGE RAMPS
- DEPTH 0 METRES (CHART DATUM)
- BATHYMETRY (10 M CHART DATUM)
- CANADA-U.S.A. BORDER

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Kilometres

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NAD 1983 UTM Zone 10N

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ROBERTS BANK TERMINAL 2

INSTANTANEOUS MAXIMUM EBB TIDE PLUME EXTENT DURING SIMULTANEOUS DREDGING AND INFILLING ACTIVITIES

DATE: 02/06/2018

FIG No. IR5-13-A10

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

IR5-14 Marine Invertebrates and Marine Fish – Negligible Effects, Localised and Temporary

Information Source(s)

EIS Volume 3: Section 12-6, Table 12-6, Table 12-7; Section 13.6.3, Table 13-8, Table 13-9

Context

In Sections 12.6 and 13.6 of the EIS, the Proponent stated that it conducted a preliminary evaluation of the potential effects of the proposed Project on marine invertebrates and marine fish to focus the assessment on those interactions of greatest importance. Negligible effects were not carried forward for further assessment.

In Tables 12-6 and 12-7, as well as in Tables 13-8 and 13-9, the Proponent presented the results of the preliminary evaluation. The Proponent used the terms localized and temporary to describe the nature of the interactions and effects, as well as to provide a rationale for the effects rating. For example, for several Project activities to be carried out during wharf construction (such as placing sacrificial rock, slope buttress rock, then mattress rock in dredge basin), the Proponent determined that the effects would be negligible because elevated TSS levels would be localized and temporary.

It is not clear how the terms localized and temporary were defined and applied in the preliminary evaluation of the potential effects on marine invertebrates.

Information Request

Provide quantitative definitions of the terms localized and temporary used in Tables 12-6 and 12-7, as well as in Tables 13-8 and 13-9 of the EIS and apply these definitions to the preliminary evaluation of the potential effects of the proposed Project on marine invertebrates and marine fish.

VFPA Response

The VFPA wishes to clarify that the preliminary evaluation of potential effects was a qualitative screening exercise conducted for the purpose of focusing the assessment on those interactions of greatest importance and consequence (see EIS Section 8.1.5), and is not based on quantitative evaluation; therefore, the terms used to characterise the interactions and potential effects at this stage of the environmental assessment methodology were not quantitatively defined in the EIS. During this preliminary phase of the assessment, Project intermediate/valued component interactions for which a potential effect was qualitatively deemed to be negligible or to not occur at all were further justified in EIS Sections 11.6.2, 12.6.2, and 13.6.2, respectively. Interactions for which a measurable (minor, moderate, or high) effect was identified were carried forward in the subsequent step in the EIS methodology, which did incorporate both qualitative and quantitative evaluation (see EIS

Sections 11.6.3, 11.6.4, 12.6.3, and 13.6.3, respectively). The results of this preliminary process are provided in the tables identified by the Panel in this information request.

For EIS Tables 12-6, 12-7, 13-8, and 13-9, the term 'localised' refers to potential effects that are restricted to particular sub-areas of the local assessment area (LAA; i.e., potential effects on spatial scales smaller than that denoted for the LAA). For EIS Tables 12-6, 12-7, 13-8, and 13-9, the term 'temporary' refers to potential effects that are not anticipated to persist beyond the duration of the particular Project activity that causes them.

The context to this information request above refers to several Project activities to be carried out during wharf construction (such as placing sacrificial rock, slope buttress rock, then mattress rock in the dredge basin) that were ranked as 'negligible' during the preliminary phase of the effects assessment described above. While it is recognised that wharf construction activities may generate a total suspended solids (TSS) plume, the potential effects of which were qualitatively characterised as 'localised' and 'temporary', the predominant rationale behind the negligible rating stems from the fact that this area will already have been dredged and surrounded partially by containment dykes, such that there will be little to no productivity (i.e., marine invertebrate and fish species) remaining in the area of these subsequent activities.

Preliminary evaluation of the proposed effects of the Project identified dredging and discharge of supernatant as the activities that are expected to generate the most intense TSS plumes, in terms of both concentration and dispersion, and thus are deemed to be of greater importance and consequence to marine fish and invertebrates; consequently, it is these project activities that were carried forward in the assessment of the effects of the Project.

As described in the EIS, quantitative modelling was conducted to predict sediment dispersion and corresponding TSS concentrations, and sediment deposition resulting from construction activities such as dredging, loading and removal of sand from the intermediate transfer pit, and discharge of supernatant from the containment basins. (see EIS Appendix 9.6-C). This work was later updated in response to IR3-34 (CEAR Document #984[1]) and IR5-13 (CEAR Document #1153[2]), which asked for further modelling to quantify the suspended sediment generated by simultaneous dredging and discharge activities (IR3-34) and to quantify activities occurring during initial construction period using a 25 mg/L[3] threshold (IR5-13).

Results of both the original TSS dispersion modelling presented in the EIS, and the updated modelling presented in the responses to IR3-34 and IR5-13, show that potential effects of TSS from construction activities are generally localised and temporary. For the model presented in the EIS, this is illustrated in EIS Table 9.7-4, which summarises the temporal

[1] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).
[2] CEAR Document #1153 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR5-02, IR5-11, IR5-13, IR5-17, IR5-18, IR5-22, IR-25, IR-26, IR-27, IR-43, and IR5-44 (See Reference Document # 975).
[3] 25 mg/L above ambient is the Canadian Council of Ministers of the Environment (CCME) high flow guideline used as the threshold of measurable effects to marine invertebrates and fish.

and spatial characteristics of the plume under different construction scenarios. The remainder of this response will illustrate the application of the terms 'localised' and 'temporary' using the scenario of simultaneous dredging of the east basin, infilling with this dredged material and Fraser River sand, and discharging of supernatant from the containment basins because it is the most conservative scenario modelled (see IR5-13 of CEAR Document #1153).

Predicted maximum dispersion of TSS plumes[4] at concentrations above 25 mg/L are spatially limited. In both flood and ebb tide scenarios (showing maximum instantaneous concentrations), the 25 mg/L guideline was only exceeded in the immediate vicinity (i.e., within several hundred metres) of the outfall pipe. As illustrated in Figure IR5-13-A5 of the response to IR5-13 (CEAR Document #1153), the concentration of TSS released during the discharge of Fraser River sand supernatant was generally diluted below 25 mg/L within 200 m of the outfall pipe; therefore, based on the definition provided above, effects driven by TSS were characterised as 'localised'.

On a temporal basis, more than 90% of the time that combined dredging and discharge activities occur simultaneously, TSS concentrations exceeding 25 mg/L were not predicted to extend beyond the length of the terminal face or more than 400 m seaward of the outfall pipe terminus (refer to Figure IR5-13-A6 of the response to IR5-13 (CEAR Document #1153), which presents the 25 mg/L exceedance probability map for the depth maximum TSS concentration). Further, once dredging and discharge activities cease, TSS concentrations are expected to return to ambient levels; therefore, based on the definition provided above, effects driven by TSS were characterised as 'temporary'.

Based on results of the updated TSS dispersion modelling, potential effects of the plume generated by simultaneous dredging and discharge of supernatant (i.e., as compared to rock placement during wharf construction) are expected to have a negligible effect on marine invertebrates and fish under both flood and ebb tidal conditions (see response to IR5-13 (CEAR Document #1153), specifically Figures IR5-13-A9 and IR5-13-A10). In comparison, the plume produced by rock placement during wharf construction, as identified in this information request, is expected to generate far lower levels of TSS in an area that will already have been disturbed by dredging. While this was determined qualitatively during the preliminary stages of the effects assessment methodology, the modelling conducted as part of the more detailed assessment corroborate the characterisation of the potential TSS-related effects of rock placement during wharf construction as localised and temporary in nature.

Additionally, marine invertebrates and fish that occupy the estuary are adapted to high background TSS levels as well as large seasonal variations (predominantly driven by freshet). Predicted TSS concentrations resulting from dredging activities are not likely to exceed the existing maximum levels associated with estuarine circulation. Overall, given that Roberts Bank is a naturally turbid environment, the resilience and adaptation of estuarine fauna, the localised nature of above CCME high-flow guideline plumes, and minimal plume dispersion

[4] The plumes represent a snapshot of the aggregate predicted maximum dispersion (i.e., greatest extent of the plume under flood and ebb tide conditions) of instantaneous depth maximum TSS levels during simultaneous activities.

into productive intertidal and shallow subtidal habitats, effects of Project-related increases in TSS on marine invertebrate and marine fish productivity is considered negligible.

IR5-15 Marine Fish – Representative Species

Information Source(s)

EIS Volume 3: Section 10, Table 10-2.2; Section 13.2.1

Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): Table IR11-1

CEAR Doc#776

Context

As reported by the Musqueam Indian Band, EIS Section 13 does not provide sufficient information for assessing two culturally important fish species: Eulachon and sturgeon. Musqueam fishers are aware that Eulachon migrate across the Salish Sea onto Roberts Bank before entering the South Arm of the Fraser River via Canoe Passage.

The Proponent, in Table 10-2-2 of the EIS and Table 11-1 of its response to information requirement #11 from the Canadian Environmental Assessment Agency (CEAR Doc#314), identified the marine fish that are: listed on Schedule 1 of the federal Species at Risk Act; classified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); and provincial listed species in the local assessment area for the proposed Project. However, the list of species provided is incomplete. Interior Fraser Coho Salmon and Cultus Lake Sockeye Salmon are both designated as endangered by COSEWIC, and transit the regional assessment area for the proposed Project during juvenile and adult migrations, as do Steelhead Trout. Other listed fish species in the regional assessment area include White Sturgeon (Lower Fraser Population) - threatened under COSEWIC, and Green Sturgeon - special concern under COSEWIC.

Additional information is needed to provide a baseline and predict Project effects on fish species that are culturally important to Indigenous groups or have a conservation concern or status.

Information Request

Provide information on the biology, migration behavior, habitat utilization in the local assessment area and regional assessment area, management practices, and ongoing recovery activities of the following fish populations, with maps as necessary:

- Fraser River Eulachon, both larvae and adults;
- White Sturgeon (Lower Fraser Population);
- Green Sturgeon;
- Cultus Lake Sockeye;
- Interior Fraser Coho Salmon; and
- Steelhead Trout.

Provide a biological effects assessment of the proposed Project on the above listed fish species or populations and fish habitat. For Eulachon larvae and adults, evaluate the effects of underwater noise during construction and operation of the Project, including container ship and support vessel-related underwater noise, on Eulachon behavior.

If the analysis concludes there are adverse effects of the Project, provide proposed measures to mitigate the adverse effects.

VFPA Response

Provide information on the biology, migration behavior, habitat utilization in the local assessment area and regional assessment area, management practices, and ongoing recovery activities of the following fish populations, with maps as necessary: Fraser River Eulachon, both larvae and adults; White Sturgeon (Lower Fraser Population); Green Sturgeon; Cultus Lake Sockeye; Interior Fraser Coho Salmon; and Steelhead Trout.

Information on the biology, migration behaviour, habitat utilisation in the local assessment area (LAA) and regional assessment area (RAA), management practices, and ongoing recovery activities is provided below for the at-risk populations of marine fish species included in this request. EIS Section 32.2.4 (and references therein pertinent to the at-risk species included in this request) was also reviewed and information is incorporated in this response where appropriate. The response will also demonstrate that each of these species was adequately represented in the assessment of effects of the Project. The assessment findings here, therefore, have not changed the assessment effects laid out in the EIS.

As mentioned in the Preamble at the beginning of this response package, the VFPA has continued to hear from Aboriginal groups that their concerns regarding Project interaction with sockeye salmon and eulachon, specifically, have not been addressed. The VFPA is continuing to consult with Aboriginal groups to determine how these concerns can be addressed.

Fraser River Eulachon, both Larvae and Adults

Life History Requirements

Eulachon (*Thaleichthys pacificus*) are small anadromous smelt that have historically spawned in approximately 95 rivers along the Pacific Northwest coast, including at least 40 rivers in B.C. (Levesque and Therriault 2011). Surveys of genetic variation indicate that eulachon spawning in the Fraser River fall within the southern distinct population segment comprising sub-populations that spawn in rivers from northern California to northern B.C., likely south of the Nass River (Gustafson et al. 2016).

Eulachon spend most of their lives in the marine environment, where they feed on zooplankton, primarily copepods, and euphausiids (Gustafson et al. 2016). When occupying the marine environment, Fraser River eulachon are primarily distributed in waters off the west coast of Vancouver Island (Gustafson et al. 2016).

In the Fraser River, eulachon return to spawn at three years of age (Clarke et al. 2007). They hold in the brackish lower reaches of the Fraser River Main Arm to finalise their sexual maturation and adapt physiologically to salinity changes (Willson et al. 2006). They enter the Fraser River aided by the salt water wedge during high tide (Lower Fraser Fisheries Alliance 2015).

Spawning migration spans from mid-March to mid-May, and peaks in April (Hay and McCarter 2000, LGL and Terra Remote Sensing 2009). Aboriginal groups have noted that runs may begin as early as February (Lower Fraser Fisheries Alliance 2015, Hemmera 2016). There is anecdotal evidence that eulachon hold at Canoe Passage prior to upstream spawning, but no evidence that they are holding at Roberts Bank. To reach spawning habitat, eulachon transit through areas of relatively slow current that are five to 12 metres deep and with stable sandy substrates (LGL and Terra Remote Sensing 2009). Preferred spawning habitat is located in areas of relatively slow current (<0.7 metres per second (m/s)), on plateaus or edges composed of stable fine-medium and coarse sand, pebbles, and gravel, in depths of less than seven metres (LGL and Terra Remote Sensing 2009). Spawning occurs in the Fraser River mainstem within the RAA, primarily between Chilliwack and Mission, but occasionally also in localised areas of the North and Main arms and in the vicinity of the mouths of the Pitt and Alouette rivers (Higgins et al. 1987). Information from local fishery officers also suggests that potential spawning sites exist in the lower Fraser River adjacent to Barnston, McMillan, and Matsqui islands, approximately 100 river km, 130 river km, and 175 river km upstream of the Fraser River mouth, respectively (Higgins et al. 1987). Spawning locations vary widely and inexplicably from year to year (Hay and McCarter 2000, Hay et al. 2002, Stables et al. 2005). Eulachon generally die after spawning, although some individuals may spawn twice in a lifetime (Willson et al. 2006).

Eggs become adhesive after fertilisation and attach to pea-sized gravel. Eulachon eggs may tolerate low- to mid-range salinities during incubation but higher salinities (>16 parts per thousand (ppt)) lead to mortality (Lewis et al. 2002). Egg mortality also increases in areas with higher silt and organic accumulation (Langer et al. 1977). Eulachon eggs hatch in three to five weeks depending on temperature, typically from late April to early June (DFO 2016). Immediately after hatching, larvae are flushed into the Strait of Georgia rapidly by spring freshet, likely in minutes or, at most, hours (McCarter and Hay 2003). Rearing occurs for up to two months (McCarter and Hay 1999, Hay and McCarter 2000, Willson et al. 2006) in near-surface waters off the Gulf Islands that are influenced by the Fraser River plume (DFO 2016). As they grow, juveniles are advected southward and seaward toward Juan de Fuca Strait, as supported by larger (25-30 mm body length) eulachon larvae caught during plankton net tows conducted by DFO (DFO 2016).

Past surveys at Sturgeon and Roberts Banks (including in the LAA) yielded very low or no catches of eulachon (Greer et al. 1980, Levings 1980, Conlin et al. 1982, Levings et al. 1983, Gordon and Levings 1984, MacDonald 1984, Triton 2004, Martel 2009). Historically, eulachon in the Fraser River estuary were caught in brackish waters off Steveston (outside LAA boundaries) (Levings 1980, Conlin et al. 1982, Gordon and Levings 1984). Greer et al. (1980) reported a catch of 50 eulachon (as a smelt aggregate, combined with surf smelt) from Sturgeon and Roberts banks, combined, during field surveys conducted in 1979. Numerous

stations were sampled including waters off the Steveston Jetty, the Fraser River Main and Middle arms, and the inter-causeway area (Greer et al. 1980). Smelt were caught in the deeper waters of the inter-causeway area; however, the report does not indicate if smelt from the inter-causeway area included eulachon (Greer et al. 1980). Limited harvesting of eulachon for food, social, and ceremonial purposes occurs in Canoe Passage, Ladner Reach, and in waters around the Woodward Island complex (for details see EIS Sections 32.2.4.1 and 32.2.4.2, and references therein, specifically Blakley et al. (2011, 2012, 2013), Woolman (2014)), but these locations are upstream and outside LAA boundaries. As such, and based on published literature, evidence of eulachon presence in the LAA is inconclusive. In addition, during field studies conducted for the Project in 2012 and 2013, no eulachon were caught (see TDR MF-3, TDR MF-6, and TDR MF-7 in Appendix AIR10-C of CEAR Document #388).

By mid-summer, juveniles disperse onto the continental shelf of the west coast of Vancouver Island where they occupy depths between 20 m and 200 m (Hay and McCarter 2000, Gustafson et al. 2010, 2016). Juvenile, sub-adult, and adult eulachon exhibit schooling behaviour and live near the ocean bottom commonly at depths of 20 m to 200 m, but may occur as deep as 500 m (Hay and McCarter 2000). They may occur in extensive mixed-species schools with young herring and anchovy (Willson et al. 2006).

Status and Management Practices

Eulachon (Central Pacific Coast and Fraser River populations) were designated in 2011 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered (COSEWIC 2011), and are provincially Blue-listed (B.C. CDC 2017). The Fraser River and Central Pacific Coast populations of eulachon are currently being considered for listing as Endangered under the *Species at Risk Act* (*SARA*) (DFO 2017*a*).

Although historically abundant, Fraser River eulachon began declining steadily in the mid-1940s, exhibited a steeper decline in the 2000s, and remain at extremely low levels since (Moody 2008, Schweigert et al. 2012, DFO 2017*b*). Factors that may have contributed to this decline include targeted fisheries, degradation of spawning habitat (due to in-river dredging, gravel mining, forest practices), incidental capture in offshore groundfish and shrimp trawl fisheries, as well as changing climate conditions leading to reduced marine productivity and poor feeding conditions for eulachon (Schweigert et al. 2012, Gustafson et al. 2016).

Fraser River eulachon have been harvested commercially since the 1870s. Catches peaked at about 300 metric tonnes (mt) in the early 1950s (Gustafson et al. 2010), dropped to an average of 20 mt per year from the 1980s to the mid-1990s, and reached 63 mt in 1996 (DFO 2017*b*). Up to 1995, the fishery was passively managed with an opening from March 15 to May 31 for commercial drift gill nets with a closure of one day per week. In 1995, the fishery was restricted to three days per week. However, due to increasing catch and low levels of abundance, the fishery was closed in 1997. It opened only briefly in 2002 and 2004, with catches of 5.8 mt and 0.4 mt, respectively (Gustafson et al. 2010). Commercial fisheries remain closed due to low stock levels and associated conservation concerns (Gustafson et al. 2010).

A recreational eulachon fishery has also occurred in the Fraser River since the late 1800s, using dip nets, gillnets, minnow nets, or cast nets. Due to conservation concerns, this fishery has been closed since 2005 (DFO 2017*b*).

A small Aboriginal ceremonial fishery continues today, and fishing is primarily conducted by drift net (e.g., gill net) (for details see EIS Section 32.2.4.2). Aboriginal groups' access to Fraser River eulachon for food, social, and ceremonial purposes is managed through communal Aboriginal fishing licences issued on a case by case basis (DFO 2017*b*). Fishing times are restricted to six hours per day for each communal licence and participants must report catches to DFO (DFO 2017*b*). Eulachon remain particularly important ceremonially, nutritionally, medicinally, and economically to Aboriginal groups in B.C. (Moody 2008). They are used for sustenance, they are widely bartered among Aboriginal communities, and they are given as gifts in potlatch ceremonies (DFO 2017*b*).

A DFO test fishery for eulachon was operated from 1995 to 2005 (except for 1999) in the lower Fraser River at New Westminster. The test fishery was designed to provide an in-season index of eulachon returns to the Fraser River. Due to conservation concerns of the stock status, however, the test fishery has not operated since 2006 (DFO 2017*b*).

The recovery potential for the Fraser River eulachon population was evaluated using a Bayesian stock reduction model (Gustafson et al. 2016). The analysis indicates that stock levels for 2009 to 2011 are at only about 3% to 11% of the original (1900s) unfished stock size (McAllister 2012). The population should rebuild to 33% to 49% of the unfished abundance over a period of 16 years to 18 years, under conditions of average historical productivity, no increase in bycatch mortality from shrimp trawling effort, and no direct exploitation. The analysis suggests that the population is relatively unproductive and can sustain a maximum fishing mortality rate of only 0.10 of the unfished population. A directed catch of 30 mt would reduce stock rebuilding up to 30% of the unfished population (Gustafson et al. 2016).

White Sturgeon (Lower Fraser Population)

Life History Requirements

White sturgeon (*Acipenser transmontanus* pop. 4), a demersal species resident in the lower Fraser River downstream of Hell's Gate (km 211, measured from the river mouth at Sand Heads), are genetically distinct from the rest of the Fraser River system (Nelson et al. 1999, Smith 2002). White sturgeon in the lower Fraser River are considered anadromous, with limited migration into marine waters and juvenile rearing in the estuary (COSEWIC 2003*a*). Spawning occurs during peak freshet (from May to July; COSEWIC 2003*a*) in side-channels and large tributary river fans, in low velocity near-bed flows, over gravel, cobble, and sand (Levings and Nelson 2003, Perrin et al. 2003). Spawning occurs in the meandering reach of the lower Fraser River from the confluence of the Sumas River upstream to the Coquihalla River, with no evidence of spawning in the tidally-influenced river mainstem, downstream of the Port Mann Bridge (Levings and Nelson 2003).

After hatching, larvae remain near the riverbed in close proximity to spawning habitat, where they feed on zooplankton and dipteran chironomids (Perrin et al. 2003). As they grow, juveniles disperse to rearing and overwintering habitats. Rearing occurs in the lower reaches of tributaries, large backwaters, side-channels, and sloughs throughout the lower Fraser River (Fraser River White Sturgeon Working Group 2005). Juveniles rear in a wide range of water depths (1.3-6.0 m), but are more commonly found in slow-moving areas less than five metres deep, over substrates consisting mainly of sand, silt and clay, mixed with gravel, in side-channels, side pools, backwaters, and nearshore mainstem open channels (Lane and Rosenau 1995, Glova et al. 2008). In general, the influence of the salt wedge in estuarine and brackish environments precludes use by smaller juveniles, as the ability of white sturgeon to tolerate brackish and saline waters increases with size; juveniles smaller than 10 cm fork length (FL) are not tolerant of salinities greater than 15 ppt (McEnroe and Cech 1985, Parsley and Beckman 1994).

During spring and summer, adult white sturgeon are typically found in deep nearshore areas, adjacent to heavy flows, and defined by deposits of sand and fine gravel with backwater and eddy flow characteristics. On occasion, they may briefly move into shallower areas to feed (COSEWIC 2003*a*). Important spring and summer feeding areas for adult white sturgeon include the Matsqui Channel and Hatzic Eddy upstream of Mission, the mouth of the Pitt River, the waters at the Port Mann Bridge, Barnston, Douglas, and Annacis islands, and the mouth of the Fraser River (including Canoe Passage) (Glova et al. 2010, Robichaud et al. 2017, Stoddard 2017). During consultation on the George Massey Tunnel Replacement project (Hemmera 2016), Aboriginal groups noted that adult white sturgeon are present seasonally in the Fraser River Main Arm (within the RAA, but outside the LAA), and identified two main white sturgeon staging areas—one in the direct vicinity of the George Massey tunnel and the other in Canoe Passage (see EIS Section 32.2.4.2) and Ladner Reach (just upstream of Canoe Passage) (Hemmera 2016). Aboriginal groups also indicated that white sturgeon, when in Ladner Reach in April and May, feed on spent/dead eulachon and herring (Hemmera 2016); other prey include salmon eggs and carcasses (when available from August to late November), and cyprinids (Lane and Rosenau 1995, McAdam 1995).

During winter, juvenile and adult white sturgeon migrate to overwintering areas, where they become sedentary and congregate in densely spaced groups in slow-moving pools as water temperatures drop below 7°C (Neufeld et al. 2010, Ghilarducci and Reeve 2012, Robichaud et al. 2017). Overwintering habitats are widely scattered from Deas Island to the Sumas River confluence, but mainly concentrated in the waters near Annacis Island, the Port Mann Bridge, the mouth of the Pitt and Stave rivers, and Matsqui (Neufeld et al. 2010, Ghilarducci and Reeve 2012). In the Pitt River, important overwintering locations include Sturgeon Slough, and Pitt Lake (Robichaud et al. 2017). Overwintering typically occurs in slow moving water and depths greater than 10 m (Neufeld et al. 2010, Ghilarducci and Reeve 2012).

In 2013/14, the Ministry of Forests, Lands and Natural Resource Operations, with the support of the VFPA, the Habitat Conservation Trust Foundation, and the Ocean Tracking Network, initiated a ten-year long acoustic telemetry study in the lower Fraser River to determine sturgeon movements, migration, and habitat use within and between overwintering, feeding, and spawning habitats in the lower Fraser River upstream of the river mouth. Preliminary

results are in agreement with existing literature (summarised above) regarding the distribution of sturgeon spawning habitat, as well as juvenile and adult holding areas in the lower Fraser River (Stoddard 2017).

There is some evidence for the use of marine habitats by larger juvenile and adult white sturgeon (DeVore et al. 1999, Veinott et al. 1999, Welch et al. 2006). Genetic work done recently has shown that white sturgeon in Puget Sound originate from various locations including the lower Fraser River (A. Drauch Schreier, University of California at Davis, unpublished data in Robichaud et al. 2017); however, marine excursions are likely rare among individuals and highly variable in duration (Veinott et al. 1999). Consistent with previous studies in the lower Fraser River (ECL 1992, RL&L Environmental Services 1994), a recent acoustic-tagging study produced no direct evidence for marine excursions of white sturgeon. Between April and September (peaking in July and August), individual fish make forays to the Fraser River mouth and may also venture into the Strait of Georgia (and potentially into estuarine waters in the Project's LAA); however, such marine excursions are for short periods and not far from the river mouth (Robichaud et al. 2017). It is likely that migration to marine waters is not a common life history behaviour for the Lower Fraser population of white sturgeon (Veinott et al. 1999).

Status and Management Practices

The COSEWIC designation of white sturgeon (Lower Fraser population) was downgraded in 2012 to Threatened, from the 2003 designation of Endangered (COSEWIC 2003*a*). They are not listed under *SARA* Schedule 1, but they are provincially Red-listed (B.C. CDC 2017).

Since 1994, commercial and Aboriginal (economic opportunity and for food, social, and ceremonial purposes) fisheries are not permitted to take sturgeon. Aboriginal groups are also discouraged from retaining sturgeon caught incidentally unless the fish died in their nets (Fraser River White Sturgeon Working Group 2009). Also since 1994, sturgeon caught recreationally in the tidal and non-tidal waters of the lower Fraser River must be released (Fraser River White Sturgeon Working Group 2009).

Recent population estimates suggest a decline in abundance over the last three generations of over 50% (COSEWIC 2003*a*). Aboriginal groups have relayed historic declines in white sturgeon numbers in the lower Fraser River. In the past 15 years within the lower Fraser River, white sturgeon abundance (size classes: 40-279 cm FL) has fluctuated between 40,000 to 60,000 individuals (Nelson et al. 2016). As of January 2015, the mean abundance estimate was 47,166 (±8.8%) individuals (Nelson et al. 2016). Some apparent reductions have occurred in smaller size groups (40-99 cm FL), suggesting reduced levels of juvenile recruitment into the population (at those sizes). However, increases in abundance have been noted for most size categories above 140 cm FL, suggesting survival and growth of individual sturgeon into larger size classes, increased potential of larger females to reach sexual maturity, as well as the possibility of increased recruitment in future years (Nelson et al. 2016). Musqueam have also observed an increase in sturgeon by-catch, possibly indicative of an increase in larger size classes of sturgeon (see EIS Section 32.2.4.2). These abundance trends are suspected to be a response to closure of the upriver gill net fishery in the mid-1990s (Walters et al. 2005). With natural mortality levels ranging from 0.05 to 0.08 and an

estimated fishing mortality of 0.04, the population is predicted to increase within the next four decades (Walters et al. 2005). Since the closure of the upriver gill net fishery, fishing mortality has been reduced to a residual fishing mortality of <0.01 attributed to injury during recreational catch and release fishing (Walters et al. 2005).

The Fraser River Sturgeon Conservation Society was founded in 1997, which initiated, with assistance from the B.C. Government, the Lower Fraser River White Sturgeon Monitoring and Assessment Program. This program established standardised data collection and population monitoring protocols. Since 2004, status reports have been published on an annual or bi-annual basis and data continues to be collected (Nelson et al. 2016). These annual reports provide biological information, population age structure, and time series of population estimates to inform management efforts targeting the Lower Fraser population.

As described above, with the support of the VFPA, a provincial ten-year long acoustic telemetry study is underway to determine sturgeon movements and migration in the lower Fraser River upstream of the river mouth. The study aims to identify critical habitat and assess fidelity of habitat use to inform management of development activities that may affect white sturgeon in the lower Fraser River (Stoddard 2017).

Green Sturgeon

Life History Requirements

Green sturgeon (*Acipenser medirostris*) are found along the entire B.C. coastline, primarily in salt water (Scott and Crossman 1973). Green sturgeon are rarely encountered in fresh water in Canada, but will inhabit brackish waters at the mouth of large rivers, such as the Fraser River. Since 1985, there have only been 15 to 20 reports of green sturgeon in the lower Fraser River, from the river mouth to 90 km upstream. Habitat requirements in brackish environments are thought to resemble those of white sturgeon (COSEWIC 2004). Spawning is known to occur in only three rivers in North America: in the Rogue River in Oregon, and the Klamath and Sacramento rivers in California; there is no evidence that spawning has ever occurred in Canadian rivers (COSEWIC 2004).

Green sturgeon move among estuaries, marine waters, and natal rivers and exploit resources far from their natal spawning grounds (Lindley et al. 2008). Migration cycles appear to be complex, but are relatively regular and predictable along defined routes (Huff et al. 2012). During the marine phase of their life cycle, adult and subadult green sturgeon aggregate in non-natal estuaries and coastal bays for periods of up to several months; however, the reason for this aggregation is unclear. Non-spawning aggregations have been documented in Willapa Bay and the Columbia River estuary in Washington, but not in B.C. waters (Lindley et al. 2008).

Habitat modelling using oceanographic and migration behaviour information indicates that green sturgeon presence in the Fraser River estuary and the Strait of Georgia is of low to moderate probability (Huff et al. 2012). Individual green sturgeon have been caught incidentally in large bottom-trawl hauls in the Strait of Georgia, and in salmon gill nets at the Fraser River mouth (COSEWIC 2004). Tagged individual green sturgeon have also been

recorded from Juan de Fuca Strait and the west coast of Vancouver Island (Lindley et al. 2008). It is therefore unlikely that adults or juveniles occur in the waters of the Fraser River estuary (including Roberts Bank) in large numbers.

Green sturgeon overwinter primarily off the west coast of Vancouver Island, in sheltered, rocky, high-relief areas less than 200 m deep, characterised by high seafloor complexity and rich benthic communities (Huff et al. 2011, 2012).

Status and Management Practices

Little is known about the size of Canada's green sturgeon population or population trends. At the federal level, COSEWIC re-assessed the status of green sturgeon in 2013 and maintained its designation as species of Special Concern (COSEWIC 2004). Green sturgeon is listed as of Special Concern under *SARA* Schedule 1 (Government of Canada 2006), and is provincially Red-listed (B.C. CDC 2017). No information on targeted green sturgeon fisheries in the lower Fraser River was located; however, green sturgeon have been caught incidentally in large bottom-trawl hauls in the Strait of Georgia, and in salmon gill nets at the mouth of the Fraser River (COSEWIC 2004). Incidental catch information, which is largely anecdotal prior to 1996, indicates that the green sturgeon population has suffered a decline over the past few decades (COSEWIC 2014).

Cultus Lake Sockeye

Life History Requirements

Cultus Lake sockeye (*Oncorhynchus nerka* pop. 7) are a genetically distinct population of sockeye that inhabit Cultus Lake, located in the coastal lowland portion of the Fraser River watershed in B.C., approximately 112 km upstream of the Fraser River mouth. Cultus Lake sockeye have many adaptations for survival in their local lake environment, further distinguishing them from other sockeye within their range (DFO 2003). Based on the timing of adult return for upriver migration, Cultus Lake sockeye are classified within the late run group along with stocks such as the Late Shuswap (including Adams River), Portage, Weaver, Birkenhead, and other miscellaneous (non-Shuswap) stocks (Gable and Cox-Rogers 1993).

Cultus Lake sockeye mature predominantly in their fourth year of life, after about two years in fresh water, and about two years in the ocean. Their four-year abundance cycle is characterised by a dominant year, a sub-dominant year, and two numerically weak years. Maturing adults migrate from the open ocean to the Strait of Georgia in August where they hold or mill in schools for up to eight weeks (DFO 2003). During their delay, it appears that the late-run fish spend their time within a distinct brackish layer or plume, formed from Fraser River discharge mixing with the saline waters of the Strait of Georgia, and the Fraser River estuary (Gilhousen 1960). This milling pattern can extend as far north as Gibsons Landing, as far west and south as the Gulf Islands (stretching from Gabriola Island near Nanaimo to Saturna Island at Boundary Passage), and as far east at Point Roberts area (Gilhousen 1960, Johannes et al. 2011, Johannessen and Ross 2002). Late-run sockeye also do not feed during holding in the Strait of Georgia (Cooke et al 2004). Normally, they resume their migration into the Fraser River and Cultus Lake in September, when sockeye congregate closer to the

river mouth, at first moving in on the tidal flats of the estuary and then into the river channel entrances on ebb tides (Gilhousen 1960). Upriver migration continues into the lake until December (DFO 2003).

However, since 1995, many late-run stocks have arrived in the estuary at the normal time but entered the Fraser River with little or no holding, sometimes up to six weeks earlier than historically recorded (Lapointe et al. 2003, Cooke et al. 2004, English et al. 2005). Associated with this abnormal migratory behaviour has been an extraordinarily high en-route and pre-spawning mortality rate (Cooke et al. 2004). This earlier shift in migration behaviour of late-run stocks is poorly understood and there are many competing hypotheses, including energetics, osmoregulatory dysfunction, oceanic conditions, and parasites, with limited causal evidence (Cooke et al. 2004).

Cultus Lake sockeye spawn exclusively in the lake from late November through December and are the latest population to spawn in the Fraser River watershed (DFO 2003). Fry emerge from the gravel in spring, form schools, and move into deeper water, where they reside for one or sometimes two years. From late March to June, smolts migrate downriver in fast flowing, mid-channel areas of the river, and exhibit rapid directional movement with swimming speeds that average 15 to 30 km/day, with little evidence of milling (Welch et al. 2009). Smolts leave the estuary rapidly within four to six days (Welch et al. 2009). Juveniles rear in nearshore areas of the Strait of Georgia for an average of 25 to 34 days (Welch et al. 2009). Cultus Lake sockeye juveniles migrate to offshore waters primarily northward, generally close to the mainland coast, and through the Johnstone and Queen Charlotte straits towards the North Pacific Ocean (Groot and Cooke 1987, DFO 2003, Welch et al. 2009).

Both historic and more recent studies indicate that juvenile sockeye salmon do not use Roberts Bank in high abundance, relative to other juvenile salmon species; most past studies did not catch any juvenile sockeye salmon (Greer et al. 1980, Conlin et al. 1982, Gordon and Levings 1984, MacDonald 1984, Levings 1985, Triton 2004, Martel 2009). Also, during field studies conducted for the Project in 2012 and 2013, no sockeye juveniles were caught (see TDR MF-3 in Appendix AIR10-C of CEAR Document #388[1]).

Status and Management Practices

The population of sockeye salmon returning to Cultus Lake has been subject to monitoring since the 1920s (Bradford et al. 2011). Abundance of returning adults began to decline in the 1970s (probably because of fishing that exceeded sustainable levels); the decline accelerated in the late 1990s. Between 1991 and 2002, the adult spawner population had decreased by 36% (St-Hilaire et al. 2001), likely because of poor smolt survival and increased mortality rates of adults prior to spawning in the lake (Bradford et al. 2011).

These declines prompted a review of the status of the Cultus Lake sockeye population, which was designated by COSEWIC in 2003 as Endangered (COSEWIC 2003*b*). A recovery team was

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

formed in 2004 and a conservation strategy was drafted in 2009 (CSRT 2009). Sockeye salmon is not federally or provincially listed.

Since the last assessment in 2002, the abundance of Cultus Lake sockeye has continued to decrease. By 2003, the generational average number of spawners was down to 4,800 individuals (St-Hilaire et al. 2001), and by 2009, it was fluctuating around 1,000 spawners (Bradford et al. 2011).

To support the recovery of the Cultus Lake sockeye population, management practices employed by DFO have included a captive brood program, management of harvest rates, and predator reduction (Bradford et al. 2011).

The objectives of the captive brood program have been to produce 500 captive spawners annually, preserve the genetic diversity of the Cultus Lake sockeye stock in the event of catastrophic losses in the wild population, and supplement fry and smolt to the outmigration. The captive brood program reared fish from brood years 2000 to 2009, at which time the program was phased out; the last progeny of captive brood fish was released in October 2014 (DFO 2017*c*). The stock continues to be supplemented by hatchery-produced smolts but releases are reduced to about 30% of levels achieved by the captive brood program (DFO 2017*c*).

To aid stock recovery, fisheries harvest rates of late-run sockeye have been reduced to an average of 17% (2003-2009) from an average of 67% (1952-1972) (Bradford et al. 2011). Cultus Lake sockeye can be harvested along the full extent of their migration route from offshore waters until their entry into Cultus Lake, with a significant proportion of the catch occurring in the lower Fraser River. The 1974-2001 average annual catch was 13,700 Cultus Lake fish (DFO 2003). Aboriginal fisheries also target Cultus Lake sockeye primarily in set and drift gill net fisheries in the lower Fraser River (DFO 2003). Due to particularly low (relative to historic averages) sockeye returns in the past three years, commercial fisheries with the potential to impact Cultus Lake sockeye remain closed (DFO 2017*c*). Restrictions to Aboriginal fisheries in the lower Fraser River are also in effect; however, limited harvest opportunities for food, social, and ceremonial purposes are identified and prioritised on an annual basis depending on return size (DFO 2017*c*). Recreational fisheries for Cultus Lake sockeye are typically non-retention fisheries (DFO 2017*c*).

Predator reduction initiatives include the removal between 2004 and 2010 of 59,000 northern pikeminnow (*Ptychocheilus oregonensis*) from Cultus Lake. A northern pikeminnow fishing derby is held annually to reduce predation on sockeye fry (Bradford et al. 2011).

Interior Fraser Coho Salmon

Life History Requirements

Interior Fraser coho salmon (*Oncorhynchus kisutch*) are genetically differentiated and reproductively isolated from other coho populations in the Fraser River watershed. They are widespread throughout the Thompson River system; however, their distribution outside the Thompson River system is not well known.

Coho salmon typically return to fresh water to spawn as three-year old adults; some male coho (known as jacks) will mature earlier and return to freshwater after only six months in the ocean. Discrete seasonal runs generally do not exist (Holtby and Ciruna 2008, Decker and Irvine 2013). Spawning occurs in the fall and early winter, with spawning activity peaking in mid-January, and extending into late-January (Decker and Irvine 2013). Fry emerge from the gravel mid-March to late June and typically remain in the spawning stream for a year (Fraser et al. 1982, Sandercock 1991, Decker and Irvine 2013). Outmigration of Interior Fraser coho smolts typically occurs from mid-April to mid-June, with a peak in mid-May (Fraser et al. 1982). Coho smolts remain for a few weeks in rearing habitats on Sturgeon and Roberts banks while adapting to higher salinity conditions; many also appear to spend their first summer in the Strait of Georgia (Beamish et al. 2010). They are scarce in brackish marshes and tidal channels of the lower Fraser River (Fraser et al. 1982). Juveniles migrate to offshore oceanic waters in October/November (Chittenden et al. 2009).

Coho salmon are known to occur at Roberts Bank and are anticipated to occur within the Project's LAA. Purse seining and tow netting conducted off Roberts and Sturgeon banks (Goodman 1975) produced a considerable number of rearing coho smolts (1+) from mid-May to the end of August. This study did not indicate, however, whether these coho smolts were part of the interior Fraser coho population.

Interior Fraser coho spend 18 months at sea as maturing adults. Most of their oceanic residence is usually spent in coastal waters of the southern B.C., primarily off the west coast of Vancouver Island and in the Strait of Georgia (Decker and Irvine 2013). In freshwater, coho fry feed on insects. Smolts feed primarily on decapod larvae and euphausiids, while the dietary contribution of decapod larvae and gammarid amphipods increases as coho juveniles grow (Bollens et al. 2010). Coho salmon are typically less piscivorous than Chinook salmon of the same size, and the proportion of fish prey in coho salmon diets generally increases with body size. Fish in the diet of smaller coho include juvenile rockfish, while forage fish (northern anchovy, clupeids, osmerids) dominate the fish component of the diet of larger coho (Daly et al. 2009).

Status and Management Practices

Coho salmon is not federally or provincially listed; however, the Interior Fraser population was designated in 2002 as Endangered (COSEWIC 2002). In November 2016, it was re-assessed by COSEWIC and its designation was downgraded to Threatened (Government of Canada 2017). It is currently being considered for listing under *SARA* Schedule 1 (Government of Canada 2017).

Between 1975 and 1988, escapements of the Interior Fraser coho averaged approximately 60,000 individuals. In 1996, the population was registering a low of 9,000 escapements, and the decline rate was approximately 72% between 1975 and 2011. Abundance estimates from 2009 to 2012 averaged 27,000 to 36,000 wild spawners, suggesting a population increase since 1996, but exhibiting no clear trend (IFCRT 2006, Decker and Irvine 2013, DFO 2014). Population declines have been attributed largely to overharvesting, as well as habitat degradation and poor ocean productivity due to climate change; DFO 2012).

Fishing restrictions (e.g., closures of fisheries, including Aboriginal group directed coho fisheries; limiting the exploitation rate to 3% or less; DFO 2012) were introduced by DFO in 1997 and fully implemented in 1998 to conserve declining coho populations, including the Interior Fraser. Implementation of these restrictions, which remain in effect, have reduced average exploitation from 66% to 10% (Decker and Irvine 2013). Since 1999, Aboriginal groups have been allowed to retain coho salmon incidental mortalities during gill net and set net fisheries for pink salmon authorised during the Interior Fraser River coho migration period. All live wild coho salmon are to be released unharmed. During non-pink years, the coho salmon migration window closure is in place from early September to mid-October (Decker et al. 2014).

Following the 2002 COSEWIC designation of Endangered, a conservation strategy for the Interior Fraser coho was developed in 2006 (IFCRT 2006). The goal of the recovery strategy is to achieve viable sub-populations of 20,000 to 25,000 wild spawning adults in the short term, and to secure a viable, naturally spawning coho population (of 40,000 spawning adults; DFO 2014) within the Interior Fraser River watershed in the long term (IFCRT 2006). Several fish hatcheries also contribute to the stock; however, hatchery fish are marked, monitored and minimised to reduce potential genetic and competition-related effects (IFCRT 2006).

Steelhead Trout

Life History Requirements

Steelhead trout (*Oncorhynchus mykiss*) is the sea-run form of rainbow trout. Steelhead are found along the entire coast of B.C. in larger streams with steep gradients that empty directly into the ocean, and in larger rivers, including the Fraser River (Hartman and Gill 1968). Life histories of steelhead are highly variable. Steelhead ascending streams between November and April are classed as winter steelhead. All winter-run fish have well-developed gonads in preparation for spawning by May (Withler 1966). Steelhead ascending streams from May to August are grouped as summer steelhead. Summer-run fish have only slightly developed gonads at the time of stream entry, as spawning does not take place until early the following spring, between late March and early May (Withler 1966).

Spawning occurs over shallow gravel riffles of a river mainstem or a suitable clear water stream (Barnhart 1986). Eggs hatch within approximately three to four weeks. Fry emerge from the gravel by mid-summer and rear in fresh water for up to five years before smolting and migrating to the ocean (Barnhart 1986, Levings 2004).

Steelhead smolts migrate rapidly to salt water from late April to mid-June (Melnychuk et al. 2007), and typically during high river flows when turbidity is high. Such outmigration behaviour likely decreases predation mortality and increases smolt survival (Gregory and Levings 1998, Romer et al. 2013). Estuarine residence time of steelhead smolts is likely very short (recorded as less than one day in two estuaries in Oregon State; Romer et al. 2013). Use by juvenile steelhead of the low intertidal and shallow subtidal waters at Roberts Bank has never been documented.

Smolts are thought to stay close to the continental shelf in shallower water, but gradually venture further out to sea as they grow. A few steelhead juveniles were caught during sampling conducted in 1989 in the deeper sections of the outer Fraser River estuary (seaward of the proposed terminal), using a midwater trawl (St. John et al. 1992). Outmigration to offshore areas appears to be rapid, reducing the temporal window of vulnerability in rivers and inshore waters of the Strait of Georgia where predation risk is typically higher than in offshore areas (Melnychuk et al. 2007). Offshore, steelhead are solitary and may roam a long distance into the open ocean during their one to four years of ocean life (Melnychuk et al. 2007, Levy and Parkinson 2014). Upon maturity, steelhead return to their natal streams to spawn, and spawning may occur more than once (Levy and Parkinson 2014). Spent spawners migrate to the ocean to feed and may return to their spawning grounds within the same year, or skip a year before spawning again (Levy and Parkinson 2014).

Steelhead trout are primarily carnivorous, though their diet varies by life history stage. Fry feed on small prey, particularly aquatic macroinvertebrate drift (Thompson and Beauchamp 2016). In the ocean, juvenile, immature, and adult steelhead feed primarily on fish and squid, followed by euphausiids, copepods, amphipods (Atcheson et al. 2012).

Status and Management Practices

Steelhead trout are not provincially or federally listed. However, wild steelhead stocks in the lower Fraser River have declined to 30% of estimated carrying capacity since the early 1990s, largely due to reduced ocean survival and impaired freshwater habitat quality (Lill 2002). Fisheries restrictions and area closures have led to a reduction of angling pressure. Fishing tends to be restricted to recreational fisheries, as well as limited and localised Aboriginal harvesting (Beacham et al. 2004). Steelhead are also incidentally caught in salmon fisheries (Beacham et al. 2004).

In the early 2000s, the Greater Georgia Basin Steelhead Recovery Action Plan was initiated with the primary objective to stabilise and restore wild steelhead stocks and habitats within the lower Fraser River (Lill 2002). Initiatives within the action plan include habitat protection and restoration, stream enrichment, as well as research, including stock assessment (Lill 2002).

Provide a biological effects assessment of the proposed Project on the above listed fish species or populations and fish habitat. For Eulachon larvae and adults, evaluate the effects of underwater noise during construction and operation of the Project, including container ship and support vessel-related underwater noise, on Eulachon behavior. If the analysis concludes there are adverse effects of the Project, provide proposed measures to mitigate the adverse effects.

Potential Project-related effects on the at-risk marine fish species/populations posed in this information request have already been considered through assessing potential Project-related changes in productivity of representative species (see EIS Section 13.6). A review of issues/comments provided by Aboriginal groups post-EIS submission to the present did not yield any information on Project-related effects and species-specific mitigation measures in addition to that already presented in EIS Section 13.0. The VFPA continues to consult and

engage with Aboriginal groups on understanding issues and concerns, proposed mitigation, and monitoring through the Project's review phase.

Further, Table IR5-15-A1 in **Appendix IR5-15-A** provides additional rationale as to how eulachon was assessed via use of both Pacific herring and surf smelt (as representative species) and highlights similarities between the species as they pertain to existing conditions (e.g., life history and habitat requirements), the mechanisms through which the Project may affect them, as well as the effectiveness of mitigation. Table IR5-15-A1 in **Appendix IR5-15-A** also provides links to appropriate EIS sections specific to the assessment of Project-related effects on representative forage fish species, as well as applicable mitigation measures. Because eulachon do not have a swim bladder (Phleger 1998, Bone and Moore 2008), they are considered less sensitive to underwater noise than Pacific herring. Therefore, the assessment of underwater noise-related effects on Pacific herring is considered conservative, and implementation of an Underwater Noise Management Plan appropriate to mitigate potential effects to eulachon from Project-related changes in the acoustic environment.

Similarly, Table IR5-15-A1 in **Appendix IR5-15-A** provides additional rationale as to how sturgeon, salmon, and trout species/populations were assessed via use Chinook and chum salmon (as representative species) and highlights similarities between the species as they pertain to existing conditions (e.g., life history and habitat requirements), the mechanisms through which the Project may affect them, as well as the effectiveness of mitigation. Table IR5-15-A1 in **Appendix IR5-15-A** also provides links to appropriate EIS sections specific to the assessment of Project-related effects on representative Pacific salmon species, as well as applicable mitigation measures.

In summary, assessment conclusions and mitigation measures for representative species also apply to eulachon, white sturgeon (Lower Fraser population), green sturgeon, Cultus Lake sockeye, interior Fraser coho salmon, and steelhead trout, and remain unchanged.

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Appendices

Appendix IR5-15-A Supporting Table

APPENDIX IR5-15-A
SUPPORTING TABLE

Table IR5-15-A1 Summary of Representative Species Selection Rationale and Update to the Effects Assessment for At-risk Populations of Marine Fish Species (Including Eulachon)

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
Eulachon (Fraser River population)	Eulachon are represented by surf smelt and Pacific herring for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like surf smelt, eulachon is a pelagic smelt species exhibiting schooling behaviour. Difference is noted in spawning habitat requirements; unlike surf smelt that spawn on intertidal beaches (in the local assessment area (LAA)), eulachon spawn in freshwater in the lower Fraser River (beyond LAA boundaries). • Mechanisms affecting eulachon productivity (i.e., injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability), and eulachon response to Project-related effects, are the same as those for surf smelt and/or Pacific herring. • The use of surf smelt as a representative species (for Eulachon) to assess Project-related effects is considered appropriate, as surf smelt are more likely to interact with the Project due to higher local abundance and dependence on intertidal spawning habitats within the LAA. Eulachon are relatively rare in the LAA, found most of their lives in waters off the west coast of Vancouver Island. Adults may transit through the deeper sections of the Project's LAA during their spawning migration. Larvae are flushed rapidly to the Strait of Georgia immediately after hatching and rear in waters off the Gulf Islands, near the Fraser River plume. • The use of Pacific herring (hearing specialist) as a representative species to assess effects from changes in the acoustic environment is considered appropriate (and conservative). Eulachon do not have a swim bladder (Phleger 1998, Bone and Moore 2008), and are considered hearing generalists (i.e., less sensitive to underwater noise than Pacific herring).	Potential Project-related effects on eulachon have been assessed through the use of representative forage fish species (see EIS Sections 13.6.2.1 and 13.6.3.3). Details are provided below: • Potential effects on forage fish from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-84, and 13-86 to 13-89) are assessed as negligible. Assessment result is the same for eulachon as the maximum concentration of total suspended solids (TSS) resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on forage fish from changes in sedimentation and coastal processed (EIS Section 13.6.3.3, pages 13-108 to 13-109) are assessed as minor. However, assessment result is driven by the loss of burying habitat for Pacific sand lance, which is not a representative species for eulachon. This mechanism is not anticipated to result in changes to eulachon productivity, as eulachon are not habitat-limited within the LAA and spawning occurs in freshwater beyond LAA boundaries. • Potential effects on forage fish from injury/direct mortality (EIS Section 13.6.3.3, pages 13-107), and changes in the acoustic and light environment (see EIS Section 13.6.3.3, pages 13-107 to 13-109) are assessed as minor. Assessment result is the same for eulachon due to the low potential of adults to interact with the Project during terminal construction, assuming they transit through the LAA en route to spawning grounds in the lower Fraser River. Eggs and larvae are not at risk of entrainment as eulachon spawn beyond LAA boundaries and hatched larvae rear in the Strait of Georgia off the Gulf Islands. • Potential effects on forage fish from changes in habitat availability (EIS Section 13.6.3.3, pages 13-109 to 13-111) are assessed as minor. However, assessment result is driven by the loss of burying habitat for Pacific sand lance, which is not a representative species for eulachon. Changes in habitat availability for eulachon are likely of lesser magnitude largely due to the loss (from terminal placement) of wetted area adults may transit through en route to spawning grounds in the lower Fraser River. Adult eulachon are not habitat-limited and no spawning occurs within the LAA. Hatched larvae rear in the Strait of Georgia off the Gulf Islands.	Mitigation measures proposed for Pacific herring and surf smelt will also benefit eulachon. • A Dungeness crab fisheries-sensitive window (deeper than -5.0 m chart datum (CD)) from October 15 to March 30 will be adhered to, to minimise injury and direct mortality to fish and crab (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5).
White sturgeon (Lower Fraser population)	White sturgeon are represented by Chinook and chum salmon for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like Chinook and chum salmon, white sturgeon of the lower Fraser River are anadromous. Spawning occurs in the RAA (beyond LAA boundaries), in the Fraser River mainstem upstream of the Sumas River confluence to the Coquihalla River. There is some evidence for the use of marine habitats by larger juveniles and adults; however, marine excursions are likely rare and highly variable in duration. Smaller juveniles are less tolerant of higher salinities and therefore not present at Roberts Bank. • Mechanisms affecting white sturgeon productivity (i.e., injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability) and white sturgeon response to Project-related effects are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on white sturgeon is considered appropriate, as Chinook	Potential Project-related effects on white sturgeon have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86) are assessed as negligible. Assessment result is the same for white sturgeon, as the maximum TSS concentration resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Chinook and chum salmon from changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for white sturgeon, given their rarity in the LAA, and spawning occurring beyond LAA boundaries. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. However, assessment result is driven by the risk of juvenile salmon entrainment during dredging. This risk is practically eliminated for white sturgeon, as smaller juveniles (i.e., <10 cm fork length), which are less likely to escape the dredge flow field (Clausner and Jones 2004)), are not present in high salinity waters, such as those at Roberts Bank. Larger juveniles and adults are able to avoid the dredge flow field	Mitigation measures proposed for Chinook and chum salmon will also benefit white sturgeon. • A juvenile salmon fisheries-sensitive window (shallower than -5.0 m CD) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4).

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
	and chum salmon are more likely to interact with the Project due to higher local abundance and dependence on juvenile rearing habitats within the Project's LAA. White sturgeon are rare in the LAA as they do not require the marine environment as part of their life cycle.	and escape entrainment (Boysen and Hoover 2009). Eggs are not at risk of entrainment as white sturgeon spawn beyond LAA boundaries. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. The effect is greatly reduced for white sturgeon given their rarity in the LAA. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. However, assessment result is driven by loss of wetted habitat for returning salmon adults and increase in linear travel for outmigrating salmon juveniles. The effect is greatly reduced for white sturgeon, as marine excursions are rare, variable in duration and distance, and are not associated with specific habitats at Roberts Bank. No spawning and juvenile rearing of white sturgeon occur in the LAA.	
Green sturgeon	Green sturgeon are represented by Chinook and chum salmon for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like Chinook and chum salmon, green sturgeon are anadromous. Spawning/rearing do not occur in the Fraser River, but individual green sturgeon have been recorded in the Fraser River mouth. Habitat requirements in estuarine environments are thought to resemble those of white sturgeon. • Mechanisms affecting green sturgeon productivity (i.e., injury/ direct mortality, changes in the acoustic and light environment, and changes in habitat availability), and green sturgeon response to Project-related effects, are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on green sturgeon is considered appropriate, as Chinook and chum salmon are more likely to interact with the Project due to higher local abundance and dependence on juvenile rearing habitats within the LAA. Green sturgeon are rare in the Project's LAA. During marine migration from natal rivers in Oregon and California, adults and subadults are more likely to transit through deeper waters of the Strait of Georgia. Overwintering occurs primarily off the west coast of Vancouver Island.	Potential Project-related effects on green sturgeon have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86), and changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for green sturgeon, given their rarity in the LAA. No spawning and juvenile rearing of green sturgeon occur in the LAA. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. However, assessment result is driven by the risk of juvenile salmon entrainment during dredging. This risk is practically eliminated for green sturgeon, as larger individuals that may be encountered in the LAA are able to avoid the dredge flow field and escape entrainment. Eggs and smaller juveniles are not at risk of entrainment as green sturgeon do not spawn or rear within the LAA. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100), and changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101), are assessed as minor. The effects are greatly reduced for green sturgeon given their rarity in the LAA. No spawning and juvenile rearing of green sturgeon occur in the LAA.	Mitigation measures proposed for Chinook and chum salmon will also benefit green sturgeon. • A Dungeness crab fisheries-sensitive window (deeper than -5.0 m CD) from October 15 to March 30 and a juvenile salmon fisheries-sensitive window (shallower than -5.0 m CD) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4).
Sockeye salmon (Cultus Lake population)	Sockeye salmon are represented by Chinook and chum salmon for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like Chinook and chum salmon, sockeye is one of five Pacific salmon species that are anadromous, and rely on freshwater habitats within the Fraser River watershed for spawning and rearing. • Mechanisms affecting Cultus Lake sockeye productivity (i.e., injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability) and sockeye response to Project-related effects are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on Cultus Lake sockeye is considered appropriate, as Chinook and chum salmon are more likely to interact with the Project due to higher local abundance and dependence on juvenile rearing habitats within the LAA. Adult sockeye pass	Potential Project-related effects on Cultus Lake sockeye salmon have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86), and changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for Cultus Lake sockeye, given their similarities in physiological adaptation and habitat requirements with Chinook and chum salmon. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. Assessment result is the same for Cultus Lake sockeye; however, effect is likely reduced as sockeye juveniles are likely at Roberts Bank at low numbers, and occupy near surface waters away from the source of disturbance (e.g., dredging at depth). • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. Assessment result is the same for Cultus Lake sockeye; however, effect is	Mitigation measures proposed for Chinook and chum salmon will also benefit Cultus Lake sockeye. • A juvenile salmon fisheries-sensitive window (shallower than -5.0 m CD) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5).

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
	through the estuary (some through the Project's LAA) en route to Fraser River spawning locations (beyond LAA boundaries). Since 1995, upriver migration of this late-run group has occurred with no holding at the river mouth; there is no evidence that waters at or near Roberts Bank represent holding areas for Cultus Lake sockeye. Relative to other salmon species, Cultus Lake sockeye juveniles do not use Roberts Bank in high abundance, and primarily rear in nearshore areas of the Strait of Georgia and off the Gulf Islands.	likely reduced as adult sockeye transit through the LAA quickly (within days), limiting interaction with the Project. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. However, assessment result is driven by loss of wetted habitat for returning Chinook and chum adults and increase in linear travel for outmigrating juveniles. The effect is reduced for Cultus Lake sockeye, given rapid outmigration of juveniles into rearing habitats of the Strait of Georgia, and limited to no holding behaviour during spawning migration of adults.	• A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4).
Coho salmon (Interior Fraser population) on Cultus Lake sockeye	Coho salmon are represented by Chinook and chum salmon for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like Chinook and chum salmon, coho is one of five Pacific salmon species that are anadromous, and rely on freshwater habitats within the Fraser River watershed for spawning and rearing. • Mechanisms affecting Interior Fraser coho productivity (i.e., injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability) and coho response to Project-related effects are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on Cultus Lake sockeye is considered appropriate, as Chinook and chum salmon are likely to interact with the Project due to high local abundance and dependence on juvenile rearing habitats within the LAA. Similar to Chinook and chum, adult coho pass through the estuary (and likely through the Project's LAA) en route to Fraser River spawning locations (beyond LAA boundaries). Coho juveniles rear in habitats on Sturgeon and Roberts banks; many also rear in the Strait of Georgia.	Potential Project-related effects on Interior Fraser coho salmon have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86), and changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for Interior Fraser coho, given their similarities in physiological adaptation and habitat requirements with Chinook and chum salmon. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. Assessment result is the same for Interior Fraser coho, given similarities with Chinook and chum salmon in the use of intertidal rearing habitats in the LAA. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. Assessment result is the same for Interior Fraser coho, given potential interaction with the Project during return migration of adult coho, and similarities with Chinook and chum salmon in the use of intertidal rearing habitats in the LAA. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. Assessment result is the same for Interior Fraser coho, driven by loss of wetted habitat for returning adults and increase in linear travel for outmigrating juveniles.	Mitigation measures proposed for Chinook and chum salmon will also benefit Interior Fraser coho. • A juvenile salmon fisheries-sensitive window (shallower than -5.0 m CD) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4). • Offsetting measures, including onsite native eelgrass transplants, are expected to enhance salmon productivity by providing suitable rearing habitat for juveniles.
Rainbow/Steelhead trout	Steelhead trout are represented by Chinook and chum salmon for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR 12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 2): • Like Chinook and chum salmon, steelhead trout are anadromous salmonids that rely on freshwater habitats within the Fraser River watershed for spawning and rearing. • Mechanisms affecting steelhead trout productivity (i.e., injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability), and steelhead response to Project-related effects, are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on steelhead trout is considered appropriate, as Chinook and chum salmon are more likely to interact with the Project due to higher local abundance and dependence on juvenile rearing habitats within the LAA. Larger juveniles, maturing adults, and spent steelhead spawners inhabit offshore ocean habitats (beyond LAA boundaries). Outmigrating smolts rear in	Potential Project-related effects on steelhead trout have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86), and changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for steelhead trout, given their similarities in physiological adaptation and habitat requirements with Chinook and chum salmon. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. Assessment result is the same for steelhead trout; however, effect is likely reduced as steelhead juveniles are likely at Roberts Bank at low numbers and for a short period of time (i.e., likely a few days), occupying deeper waters of the outer Fraser River estuary. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. Assessment result is the same for steelhead trout, given potential interaction with the Project during outmigration of smolts to rearing habitats in the outer Fraser River estuary, and during return of adult steelhead to natal spawning	Mitigation measures proposed for Chinook and chum salmon will also benefit steelhead trout. • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4).

Species (Population)	Representative Species Rationale	Effects Assessment	Mitigation
	the deeper sections of the outer Fraser River estuary (estuarine residence time is likely a few days).	streams. However, effect is likely reduced given the low number of steelhead using habitats within the LAA and for a short period of time. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. However, assessment result is driven by the loss of wetted habitat for returning Chinook and chum adults and increase in linear travel for outmigrating juveniles. Effect on steelhead trout is likely reduced given the low number of steelhead using habitats within the LAA and for a short period of time.	

IR5-16 Marine Fish – Dolly Varden Char and Bull Trout Baseline

Information Source(s)

EIS Volume 3: Section 10.2.1, Table 10.2-2

Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): Table IR9-2

CEAR Doc#673

Context

According to the British Columbia Ministry of Forest, Land and Natural Resource Operations, sea run Dolly Varden Char and sea run Bull Trout are likely to use the Fraser estuary between April and July. Both of these fish species are blue-listed species that are of conservation concern in British Columbia.

There is no mention of Dolly Varden Char or Bull Trout in the tables and no information included elsewhere in the EIS.

Information Request

Provide information on the biology; abundance; migration behavior; habitat utilization in the local assessment area and regional assessment area for the proposed Project; management practices; and ongoing recovery activities of the following fish populations:

- Bull Trout; and
- Dolly Varden Char.

Assess the potential effects of the Project on Dolly Varden Char and Bull Trout occurring within the local assessment area and regional assessment area.

VFPA Response

Provide information on the biology; abundance; migration behavior; habitat utilization in the local assessment area and regional assessment area for the proposed Project; management practices; and ongoing recovery activities of the following fish populations: Bull Trout; and Dolly Varden Char.

Information on the biology, abundance, migration behaviour, habitat utilisation in the local assessment area (LAA) and regional assessment area, as well as management practices, and ongoing recovery activities is provided below for bull trout (*Salvelinus confluentus*) and Dolly Varden (*S. malma*). The response will also demonstrate that each of these species were adequately represented by Pacific salmon (Chinook and chum) in the assessment of effects of the Project and that the assessment findings do not change.

Bull Trout

Life History Requirements

Bull trout are endemic to the Pacific Northwest. In B.C., they are primarily confined to interior drainages, but are also found in major coastal watersheds that penetrate into the interior. Some bull trout populations also reach the Pacific coast (i.e., Fraser and Squamish River populations) (McPhail 2007, COSEWIC 2012).

Bull trout are notably a cold water species generally found in waters below 18°C and most commonly in temperatures less than 12°C (Dunham et al. 2003). They exhibit variable life histories, including stream resident, lake-run (adfluvial), river-run (fluvial), and sea-run (McPhail and Baxter 1996, McPhail 2007).

Stream resident bull trout are typically associated with high gradient, headwater streams in mountainous regions. They are non-migratory, usually separated from other populations by barriers (e.g., falls, velocity barriers, high temperature) (McPhail and Baxter 1996, McPhail 2007). Lake-run bull trout are also non-migratory, but move between lakes where they feed/rear and tributary rivers/streams where they spawn (McPhail and Baxter 1996). River-run bull trout live in cooler areas of large tributary rivers, and often move to smaller rivers or streams to spawn. Some river-run bull trout populations are anadromous, and spend part of their life at sea (McPhail and Baxter 1996, McPhail 2007).

Sea-run bull trout populations occur in the Squamish and lower Fraser rivers (Taylor and Costello 2006, McPhail 2007). Bull trout from coastal drainages make short forays to sea (Taylor and Costello 2006), but may also roam greater distances. One char[1] tagged in the Squamish River was recaptured in the Skagit River, after a journey of about 150 km through the Strait of Georgia (McPhail and Baxter 1996). Also, tagged bull trout in the Pitt River above Pitt Lake were recaptured in the Fraser River estuary (Taylor and Costello 2006). A review of the literature yielded no information on presence of bull trout specifically at Roberts Bank.

Bull trout spawn in shallow, slow-flowing, low gradient streams, over small gravel, and under cover (e.g., cut banks, log jams, pools, overhanging vegetation) (McPhail and Baxter 1996). Spawning occurs in the fall, when water temperatures drop below 9°C (McPhail and Baxter 1996). Eggs incubate during the winter, and fry emerge from the gravel in early spring (mid-April to mid-May) (McPhail and Baxter 1996). Fry rear within shallow edges of rivers and streams, especially in areas of large, loose gravel with interstitial habitat used for cover (McPhail and Baxter 1996).

Juvenile bull trout rear in spawning streams for at least two years before migrating to the larger rivers, or the ocean, depending on the form (Pratt 1992, McPhail and Baxter 1996). In fresh water, juvenile bull trout tend to shift to deeper, slower-flowing water in the fall, where they stay in contact with coarse substrates and remain closer to cover, which provides ice-free refuge throughout winter (COSEWIC 2012). They forage near the substrate and in the

[1] Unidentified bull trout or Dolly Varden.

water column, but not at the surface (McPhail and Baxter 1996). As they grow, juveniles shift their diet from benthic organisms and drift to small fish, such as sculpins, mountain whitefish, and trout fry (Pratt 1992).

Migration to suitable feeding and overwintering habitats in nearshore coastal areas is protracted and probably occurs during multiple time periods in a year. In coastal drainages of Puget Sound, migration of bull trout to marine waters has been noted to occur from September to December (Brenkman and Corbett 2005), as well as from April to July (Hayes et al. 2011). Bull trout in the marine environment are found in shallow (less than 4 m deep), nearshore habitats, characterised by mixed fines or mixed coarse gravel substrates, often in association with eelgrass beds (preliminary information from the Skagit River estuary; Hayes et al. 2011). Marine residence time in the Skagit River estuary has been recorded to range from 36 to 133 days (Hayes et al. 2011).

The lower Fraser River is likely used as a migratory corridor by bull trout, due to its proximity to nearshore estuarine and coastal feeding and overwintering grounds (COSEWIC 2012). Bull trout caught in recreational fisheries in the Main Arm of the Fraser River (upstream of the LAA) are predominantly sea-run fish from the Pitt River drainage, and to a lesser extent from the upper Lillooet (and tributaries) and Chilliwack rivers (Taylor and Costello 2006). Historic and recent studies undertaken at Roberts Bank (Greer et al. 1980, Conlin et al. 1982, Gordon and Levings 1984, MacDonald 1984, Levings 1985, Triton 2004, Martel 2009), as well as field studies conducted for the Project in 2012 and 2013, did not catch any bull trout.

Status and Management Practices

Bull trout are provincially Blue-listed and were designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2012 as of Special Concern (B.C. CDC 2017). Abundance of bull trout populations found in the south coast region of B.C. is estimated to range from 1,000 to 2,500 spawners (Hagen and Decker 2011). These populations are being considered for listing as of Special Concern under the *Species at Risk Act* (*SARA*) (DFO 2014).

In B.C., bull trout populations are thought to be diminishing (Hammond 2004). Limiting factors include habitat fragmentation resulting from development associated with resource extraction and logging activities, as well as degradation of habitat quality such as through obstruction to movement, stream channel instability, sedimentations, lack of cover, or increasing water temperatures (Hammond 2004). Furthermore, increasing angling effort may pose additional pressure to declining bull trout populations, as new roads allow access to streams that were previously remote (Hammond 2004).

In 1995, bull trout was identified as a priority species under the 'Strategic Plan for the Conservation and Management of Char in British Columbia' (B.C. MOE 1994, COSEWIC 2012). Under this plan, recovery efforts for the species include ongoing provincial inventory, assessment, and research efforts towards a better understanding of the species' general distribution, patterns of genetic diversity, seasonal movements, critical habitat, and interspecific interactions (Pollard and Down 2001).

Dolly Varden

Life History Requirements

Dolly Varden are found in coastal areas of the Pacific Ocean from Washington to Southeast Alaska. In B.C., Dolly Varden can be found in most coastal drainages, and are associated with cool-body watersheds (McPhail 2007). They are largely a coastal and anadromous species entering the ocean regularly, with distribution of this species not typically extending far inland (i.e., past Hope, within the Fraser River system) (McPhail 2007). Dolly Varden are commonly smaller than bull trout, inhabit small streams and feed primarily on drift. In contrast, bull trout are typically larger, piscivorous, inhabiting cool waters throughout the interior, and generally absent from shorter coastal rivers (McPhail 2007). Where distributions overlap, Dolly Varden and bull trout coexist, without extensive hybridisation (McPhail and Baxter 1996, Taylor and Costello 2006). Within B.C., their geographic ranges overlap in northern and western-central Coast Mountain drainages, and in the lower Fraser Valley (McPhail and Baxter 1996).

Dolly Varden occur in three life-history forms: a sea-run form that migrates between freshwater streams and the ocean, a stream-resident form that remains in rivers and streams for most of its life, and a lake-run form that remains within a single freshwater body and spawns in adjacent streams (McPhail 2007). Spawning can occur over multiple years, but does not necessarily occur in successive years (Mochnacz et al. 2010).

Dolly Varden spawn in the fall within headwaters of small streams. Fry emerge from the gravel in spring (April/May), and juveniles remain in the stream for two to four years (Armstrong 1970). Juveniles use a variety of habitats, including areas of still or moving water, with gravel or muddy substrates and dense instream vegetation, or open water with little or no instream complexity (Armstrong and Morrow 1980). Large rivers are important as overwintering habitats for larger juveniles, as well as sub-adult anadromous Dolly Varden. The lower Fraser River is likely used as a migratory corridor by Dolly Varden, due to its proximity to nearshore estuarine and coastal feeding and overwintering grounds. However, both historic and recent studies at Roberts Bank (Greer et al. 1980, Conlin et al. 1982, Gordon and Levings 1984, MacDonald 1984, Levings 1985, Triton 2004, Martel 2009), as well as field studies conducted for the Project in 2012 and 2013, did not catch any Dolly Varden.

Dolly Varden smolts migrate to marine and estuarine habitats in spring and may remain for only two to four months before returning to fresh water (Armstrong and Morrow 1980). Alternatively, Dolly Varden may remain in marine waters well into the fall months, returning only to spawn or overwinter in freshwater habitats (Bond and Quinn 2013). Generally, they are thought to remain in proximity to the shoreline near their natal rivers (Quinn and Myers 2004, Bond and Quinn 2013), but long movements to offshore habitats by some individuals indicate that this is not always the case (Quinn and Myers 2004, Courtney et al. 2016). Dolly Varden movement patterns are complex and often influenced by age, size, or maturational state, and the relative abundance of resources in marine and freshwater. Local environmental conditions influence the relative benefit of each habitat, and Dolly Varden may respond with flexibility in the timing of movements among habitats (Bond and Quinn 2013).

The diet of Dolly Varden varies with life history stages, and is also apparently influenced by the presence of competing fish species. The stream-resident form tends to feed near the bottom of creeks on nymphs and larvae of aquatic insects, with diet shifting to larger prey as fish grow (McPhail 2007). The lake-run form feeds on zooplankton, shifting to benthos found on the lake floor when trout are present (McPhail 2007). Sea-run Dolly Varden feed on macroinvertebrates, juvenile salmon, and other species of fish (Armstrong 1965).

Status and Management Practices

Limited information was located regarding management initiatives. Dolly Varden are not provincially or federally listed (BC CDC 2017). Although population sizes within the Fraser River basin are largely unknown, Dolly Varden are thought to be susceptible to disturbance (e.g., logging, resource extraction, urban development, stream channelisation), particularly when it degrades habitat quality and reduces availability of suitable spawning and rearing habitat (COSEWIC 2010).

Assess the potential effects of the Project on Dolly Varden Char and Bull Trout occurring within the local assessment area and regional assessment area.

Potential Project-related effects on bull trout and Dolly Varden have been considered through the assessment of potential Project-related changes in Pacific salmon productivity (as representative species; see EIS Section 13.6). Further, Table IR5-16-A1 in **Appendix IR5-16-A** provides additional rationale for why bull trout and Dolly Varden are adequately represented by Pacific salmon, and highlights similarities between char and salmon species as they pertain to existing conditions (e.g., life history and habitat requirements), the mechanisms through which the Project may affect them, as well as the effectiveness of mitigation. Table IR5-16-A1 in **Appendix IR5-16-A** also provides links to appropriate EIS sections specific to the assessment of Project-related effects on Pacific salmon, as well as applicable mitigation measures.

In summary, assessment conclusions and mitigation measures for Pacific salmon (as representative species) also apply to bull trout and Dolly Varden and remain unchanged.

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Appendices

Appendix IR5-16-A Supporting Table

APPENDIX IR5-16-A
SUPPORTING TABLE

Table IR5-16-A1 Effects Assessment of Bull Trout and Dolly Varden

Species	Representative Species Rationale	Effects Assessment	Mitigation
Bull trout	Bull trout are represented by Chinook and chum salmon for the following reasons: • Like Chinook and chum salmon, some bull trout populations in the lower Fraser River drainage are anadromous, and rely on freshwater habitats for spawning and rearing. Sea-run bull trout migrate to suitable feeding and overwintering habitats in nearshore coastal areas in the Strait of Georgia. • Mechanisms affecting bull trout productivity (which include injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability), and bull trout response to Project-related effects, are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on bull trout is considered appropriate, as Chinook and chum salmon are more likely to interact with the Project due to higher local abundance and dependence on juvenile rearing habitats within the local assessment area (LAA). Sea-run bull trout are known from the Main Arm of the Fraser River, but have not been caught at Roberts Bank. Very low numbers of larger juvenile, and adult bull trout may inhabit shallow, nearshore habitats during feeding and overwintering, and may often associate with eelgrass beds. Juvenile rearing occurs in freshwater.	Potential Project-related effects on bull trout have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86) are assessed as negligible. Assessment result is the same for bull trout, as the maximum concentration of total suspended solids (TSS) resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Chinook and chum salmon from changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for bull trout. Like Pacific salmon, bull trout are not directly associated with the sea bed, and scour and deposition are not likely to disrupt bull trout feeding. Juvenile bull trout occurs in freshwater (beyond LAA boundaries). Also, changes in salinity are unlikely to result in any effect, as bull trout, given their fast movement between fresh and salt water, can tolerate more rapid and frequent changes in salinity than Pacific salmon (Quinn and Myers 2004). • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. Assessment result is the same for bull trout; however, effect is likely reduced as bull trout in the LAA has not been documented, but may be present in very low numbers. Bull trout assumed to use nearshore estuarine habitats are adults able to escape dredge flow fields. Spawning and juvenile rearing do not occur in the LAA. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. Assessment result is the same for bull trout, assuming potential interaction with the Project if feeding and overwintering in nearshore estuarine habitats in the LAA. The effect is likely reduced given the low number of bull trout potentially present in the LAA. Spawning and juvenile rearing do not occur in the LAA. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. However, assessment result is driven by the loss of wetted habitat for returning Chinook and chum adults and increase in linear travel for outmigrating juveniles. Effect on bull trout is likely reduced given the low number of bull trout potentially present in the LAA. Also, bull trout are likely not habitat-limited in the LAA, and spawning and juvenile rearing occur beyond LAA boundaries.	Mitigation measures proposed for Chinook and chum salmon are also beneficial for bull trout. • A juvenile salmon fisheries-sensitive window (shallower than -5.0 m chart datum (CD)) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects from changes in water quality (see EIS Section 13.7.4). • Offsetting measures, including onsite native eelgrass transplants, are expected to enhance productivity of salmonids by providing increased feeding opportunities for bull trout (though bull trout presence at Roberts Bank has not been documented).
Dolly Varden	Dolly Varden are represented by Chinook and chum salmon for the following reasons: • Like Chinook and chum salmon, some Dolly Varden populations in the lower Fraser River drainage are anadromous, and rely on freshwater habitats for spawning and rearing. Sea-run Dolly Varden migrate to suitable feeding habitats in marine waters for a short time period before returning to freshwater to spawn or overwinter. • Mechanisms affecting Dolly Varden productivity (which include injury/direct mortality, changes in the acoustic and light environment, and changes in habitat availability), and Dolly Varden response to Project-related effects, are the same as those for Chinook and chum salmon. • The use of Chinook and chum salmon to assess Project-related effects on Dolly Varden is considered appropriate, as Chinook and chum salmon are more likely to interact with the Project	Potential Project-related effects on Dolly Varden have been assessed in the EIS through the use of representative Pacific salmon species (see EIS Sections 13.6.2.1, 13.6.2.2, and 13.6.3.1). Details are provided below: • Potential effects on Chinook and chum salmon from changes in water quality (EIS Section 13.6.2.1, pages 13-83 to 13-86) are assessed as negligible. Assessment result is the same for Dolly Varden, as the maximum TSS concentration resulting from dredging is not likely to exceed the existing, naturally occurring, maximum levels associated with estuarine circulation. • Potential effects on Chinook and chum salmon from changes in sedimentation and coastal processes (EIS Section 13.6.2.2, pages 13-89 to 13-90) are assessed as negligible. Assessment result is the same for Dolly Varden. Like Pacific salmon, Dolly Varden are not directly associated with the sea bed, and scour and deposition are not likely to disrupt Dolly Varden feeding. Also, changes in salinity are unlikely to result in any effect, as Dolly Varden, given their fast movement between fresh and salt water, can tolerate more rapid and frequent changes in salinity than Pacific salmon (Quinn and Myers 2004). Spawning does not occur in the LAA. • Potential effects on Chinook and chum salmon from injury/direct mortality (EIS Section 13.6.3.1, pages 13-97 to 13-98) are assessed as minor. Assessment result is the same for Dolly Varden; however, effect is likely reduced as Dolly Varden in the LAA has not been documented, but very low numbers of juveniles may be present during feeding in spring. Spawning does not occur in the LAA. • Potential effects on Chinook and chum salmon from changes in the acoustic and light environment (EIS Section 13.6.3.1, pages 13-98 to 13-100) are assessed as minor. Assessment result is the same for Dolly	Mitigation measures proposed for Chinook and chum salmon are also beneficial for Dolly Varden. • A juvenile salmon fisheries-sensitive window (shallower than -5.0 m CD) from March 1 to August 15 will be adhered to, to minimise injury and direct mortality (see EIS Section 13.7.1.2). • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Light Management Plan will be implemented to mitigate potential effects from changes in the light environment (see EIS Section 13.7.5). • A Construction Compliance Monitoring Plan will be implemented to mitigate

Species	Representative Species Rationale	Effects Assessment	Mitigation
	due to higher local abundance and dependence on juvenile rearing habitats within the LAA. Very low numbers of juvenile Dolly Varden may make use of nearshore habitats for feeding, however, their presence at Roberts Bank has not been documented.	Varden, assuming potential interaction with the Project if feeding in nearshore estuarine habitats in the LAA. The effect is likely reduced given the low number of Dolly Varden potentially present in the LAA. Spawning does not occur in the LAA. • Potential effects on Chinook and chum salmon from changes in habitat availability (EIS Section 13.6.3.1, pages 13-100 to 13-101) are assessed as minor. However, assessment result is driven by the loss of wetted habitat for returning Chinook and chum adults and increase in linear travel for outmigrating juveniles. Effect on Dolly Varden is likely reduced given the low number of Dolly Varden potentially present in the LAA. Also, Dolly Varden are likely not habitat-limited in the LAA, and spawning occurs beyond LAA boundaries.	potential effects from changes in water quality (see EIS Section 13.7.4). • Offsetting measures, including onsite native eelgrass transplants, are expected to enhance productivity of salmonids by providing increased feeding opportunities for Dolly Varden (though Dolly Varden presence at Roberts Bank has not been documented).

IR5-17 Marine Fish – Juvenile Chinook Salmon Baseline

Information Source(s)

EIS Volume 3: Section 13.0

TDR MF-3: Juvenile Salmon Surveys, Appendix AIR 10-C (CEAR Doc#388)

TDR MF-7: Marine Fish Eelgrass Fish Community Survey, Appendix AIR 10-C (CEAR Doc#388)

CEAR Doc#647

Context

The Proponent, in Appendix 10-C of TDR MF-3, presented information from the following three juvenile salmon surveys:

- a juvenile salmon beach seine survey, which documented the seasonal presence, distribution, and abundance of juvenile salmon over a one-year period (spring 2012 to winter 2012/2013) in different habitat types in shore-tied and intertidal nearshore locations;
- a directional seine survey in the spring and summer of 2012, which documented the net movement of juvenile salmon at one site; and,
- a juvenile salmon distribution survey in spring and summer 2013, which documented the seasonal, diel and tidal presence, distribution, and abundance of juvenile salmon in different habitat types in intertidal shore-tied, intertidal nearshore, and subtidal locations.

As reported, the juvenile salmon beach seine survey used a beach seine to collect data on salmon species in the daytime during flood tides at shore-tied and intertidal nearshore sites, and the juvenile salmon distribution survey used two types of fishing gear: a beach seine and a purse seine net, to collect data on salmon species at intertidal shore-tied sites, intertidal nearshore sites, and subtidal sites on different tides and diel periods.

The Proponent in Appendix 10-C of Marine Fish Eelgrass Fish Community Survey Report, presented information about the eelgrass fish community at Roberts Bank. Fish sampling was conducted at five sites with a beach seine at the intertidal sandflat north-northwest of Roberts Bank terminals. The samples were conducted seasonally over a one-year period (spring, summer and fall of 2012 and winter of 2013). The Marine Fish Eelgrass Fish Community Survey Report also considered information from the juvenile salmon distribution survey described above.

According to the Raincoast Conservation Foundation's submission to the Review Panel:

- Roberts Bank is difficult to sample due to extremely low gradients;
- previous juvenile Chinook Salmon studies at Roberts Bank have relied upon various sampling methods, including modified beach seine methods;

- the study conducted by the Proponent relied upon beach seine sets in shallow waters deployed from a boat, a method that has limited effectiveness compared to purse seine sampling;
- the studies failed to make comparison between years which could generate more accurate estimates of abundance and detect any changes in juvenile Chinook use of Roberts Bank over time; and
- although the Juvenile Salmon Surveys were designed to complement the Eelgrass Community Survey, a different methodology with a larger net was used and thus the results were not directly comparable across years.

Additional information is required to justify the seasonal juvenile Chinook Salmon sampling schedule adopted by the Proponent in relation to the period of juvenile Chinook Salmon occupancy in the local assessment area and to justify the number and timing of sampling episodes.

Information Request

Provide justification for the duration, intensity and sampling methods used in the Juvenile Salmon Surveys and Marine Fish Eelgrass Fish Community Survey Reports in relation to fish habitat utilization and juvenile Chinook and Chum Salmon migration timing.

Describe how the number and timing of sampling events were determined and the implications of any mismatches between the actual sampling timing in relation to the period of juvenile salmon habitat occupation of the local assessment area for the proposed Project.

VFPA Response

Provide justification for the duration, intensity and sampling methods used in the Juvenile Salmon Surveys and Marine Fish Eelgrass Fish Community Survey Reports in relation to fish habitat utilization and juvenile Chinook and Chum Salmon migration timing.

The justification for the duration, intensity, and sampling methods employed during the VFPA's 2012-2013 Juvenile Salmon and Eelgrass Fish Community surveys is twofold: (i) to coincide with the time juvenile salmon are known to be present at Roberts Bank (as informed by the literature and past field surveys), and (ii) to maintain consistency in survey methods employed at Roberts Bank in the past (e.g., Martel 2009) and add to the years of comparable baseline data. Further rationale is provided below.

Duration and intensity of RBT2 field surveys are justified to document habitat use during juvenile salmon outmigration and seasonal variation of fish species composition within eelgrass beds at Roberts Bank. Specifically, juvenile salmon sampling was undertaken seasonally, during sampling time periods defined in the literature based on seasonal variation in presence and abundance of different juvenile salmon species (see Section 3.3 in TDRs MF-3 and MF-7 of CEAR Document #388[1]). For example, samples in spring were taken in April to capture peak emergence of juvenile chum and pink salmon (Salo 1991, Heard 1991; EIS

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

Table 13-5), while summer beach seining was conducted in June to coincide with peak outmigration of Chinook smolts (Levings 1985, Cope 2012; EIS Table 13-5). Although outside peak outmigration periods, fall and winter samples were also taken to determine juvenile salmon presence and abundance during these seasons (see Table 1 in TDR MF-3 of CEAR Document #388). Seasonal sampling of eelgrass fish communities is also justified as literature shows seasonal variation in fish presence within eelgrass beds at Roberts Bank (Conlin et al. 1982, Gordon and Levings 1984).

Sampling methods employed during RBT2 field surveys are justified and appropriate for sampling in shallow intertidal, wadable waters (Conlin and Tutty 1979, Hahn et al. 2007), and have been shown in the literature to be effective in capturing juvenile salmon in the Fraser River estuary. Specifically, fish sampling for the Project was done predominantly using beach seining techniques (i.e., from the shore on foot, by boat, or combination, depending on flood tide and weather conditions, as well as site accessibility). These beach seining techniques are consistent with those used at Roberts Bank historically (e.g., Greer et al. 1980, Conlin et al. 1982, Levings 1982, Levy and Northcote 1982, MacDonald 1984, Levings et al. 1991), more recently during studies conducted for the Deltaport Third Berth Environmental Assessment (Triton 2004), as well as during environmental baseline monitoring studies for RBT2 (Martel 2009). These beach seining techniques continue to be used in the present by Raincoast Conservation Foundation to capture juvenile salmon as part of their Fraser River Estuary Juvenile Salmon project (Raincoast Conservation Foundation 2016).

A 6-mm mesh size used to sample juvenile salmon at Roberts Bank for the Project is justified and within the size range considered appropriate for salmon fry and smolt sampling (i.e., 3 mm to 6 mm; BC MELP 1997). Both 3 mm and 6 mm mesh sizes have been deployed historically in the Fraser River estuary, including Roberts Bank (e.g., Greer et al. 1980, Conlin et al. 1982, Levy and Northcote 1982, Levings 1982, MacDonald 1984, Levings et al. 1991). A qualitative comparison of body lengths of juvenile chum caught at Roberts Bank using nets with 3 mm and 6 mm mesh size shows that the use of larger nets does not preclude capture of smaller (<40 mm fork length) individuals (see Table IR5-22-1 in response to IR5-22).

A 3-mm mesh size used to sample eelgrass fish communities at Roberts Bank for the Project is consistent with that used by Martel (2009). This allowed to add to the years of comparable baseline data, and to perform statistical analyses that investigated potential differences over time in seasonal fish abundance, and species richness in eelgrass fish community assemblages at Roberts Bank (see Section 4.1.6. in TDR MF-7 of CEAR Document #388).

Describe how the number and timing of sampling events were determined and the implications of any mismatches between the actual sampling timing in relation to the period of juvenile salmon habitat occupation of the local assessment area for the proposed Project.

As stated in the first part of this response, fish sampling was undertaken seasonally during known periods of juvenile salmon outmigration (as defined in the literature) in attempts to capture seasonal variation in fish presence, abundance, species composition, and spatial distribution. Spring sampling coincided with outmigration of chum and pink salmon, while summer sampling coincided with outmigration of Chinook. Number and timing of sampling

events were also influenced by logistics, including coordination and availability of field crews, boat, as well as weather and tide conditions.

No mismatches are identified between the actual sampling timing in relation to the period of juvenile salmon habitat occupation in the Project's local assessment area. Beach seines deployed for the Project using techniques and timing in a manner explained earlier in the response actually captured juvenile salmon. Therefore, field survey objectives (i.e., determination of seasonal abundance, distribution, and use by juvenile salmon of habitats, including eelgrass beds, in the local assessment area) were effectively achieved, and meet the overall need of informing the Project's effects assessment.

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IR5-18 Marine Fish – Juvenile Chinook and Chum Salmon

Information Source(s)

EIS Volume 3: Section 13, Table 13-8

Context

The Proponent, Table 13-8 of the EIS, identified that the following project works or activities have potential to affect juvenile salmon migration behaviour and/or shifts in predator-prey interactions:

- construction of permanent dykes around terminal east and west basins;
- construction of the containment dyke along the western portion of causeway; and
- construction of the containment dyke along eastern portion of causeway.

The Proponent, in Section 13.6.3.1 of the EIS, reported that mechanisms that could alter migration patterns and increase time spent in deeper waters could increase exposure to predators. The Proponent also identified that data gaps related to biological effects from in-water infrastructure and stock-specific juvenile Chinook and Chum Salmon outmigration patterns reduce certainty in predictions of potential Project effects.

The Proponent, in Section 13.6.3.1 of the EIS, concluded that minor decreases in Pacific salmon productivity during construction were due to the following:

- direct mortality from entrainment;
- changes in the acoustic environment during the construction phase; and
- changes in the light environment during the construction phase.

The Proponent stated that during operations, the following were predicted to have an adverse effect on Pacific salmon productivity:

- changes in the light environment;
- changes in the acoustic environment; and
- disruption of juvenile migration due to terminal placement.

Using multiple lines of evidence, the Proponent, in Section 13.6.3.1 of the EIS, predicted that there would be a minor adverse effect on juvenile Chinook and Chum Salmon during operations.

Additional rationale is required for classifying potential construction and operational effects as minor, and the uncertainty in the confidence of these predictions.

Information Request

Provide further rationale for the prediction that the temporary and permanent effects of the proposed Project on the migratory behaviour of juvenile Chinook and Chum Salmon will have a minor effect on productivity.

Provide an estimate of the potential loss of juvenile Chinook and Chum Salmon productivity associated with the following Project construction activities:

- construction of permanent dykes around terminal east and west basins;
- construction of the containment dyke along the western portion of causeway; and
- construction of the containment dyke along eastern portion of causeway.

VFPA Response

Provide further rationale for the prediction that the temporary and permanent effects of the proposed Project on the migratory behaviour of juvenile Chinook and Chum Salmon will have a minor effect on productivity.

Project-related changes in productivity of juvenile Chinook and chum salmon that may result from changes in salmon migration behaviour were assessed as stemming from two effects mechanisms: (i) changes in the light environment (during Project operation), and (ii) changes in habitat from marine terminal placement (also during Project operation). Pre-mitigation, migration-related changes in juvenile salmon productivity were rated as minor. With mitigation, including onsite offsetting in the form of native eelgrass transplants, migration-related changes in juvenile salmon productivity were assessed as negligible, with no residual effect. The discussion below expands on the rationale (provided in EIS Section 13.6.3.1) for the minor ranking of migration-related changes in juvenile salmon productivity, prior to implementation of mitigation.

Changes in the Light Environment

The majority of Project construction activities are scheduled to occur during daytime. For those construction activities anticipated to occur during the night, the effect of lighting is considered negligible, given the temporary nature of the disturbance and the relatively small area of the effect. Dredging will be occurring at night (i.e., 24 hours, 7 days per week); however, the area of any lighting effect is expected to be limited to the immediate vicinity of the dredge equipment. In addition, dredging will occur in the deeper sections of the local assessment area (LAA) such that spatial overlap with juvenile salmon rearing in intertidal habitats will be reduced.

During Project operation, changes in the light environment may affect migrating juvenile salmon as a result of shading from marine structures during the day or artificial lighting (e.g., lighting of marine infrastructure, lighting of moored vessels) at night. At Roberts Bank, juvenile salmon distribution surveys conducted for the Project revealed that juvenile chum salmon are more abundant at shore-tied locations during the day than during the night. In contrast, juvenile Chinook, although not as shore-tied as juvenile chum, use nearshore

habitats predominantly at dusk and at night (see TDR MF-3 in Appendix AIR10-C of CEAR Document #388[1]).

Within shore-tied environments, shading from marine structures during the day may alter the migratory path of juvenile chum (Williams et al. 2003, Ono et al. 2010, Ono and Simenstad 2014). In shallow nearshore waters, juvenile chum are reported in the literature to migrate along the light side of overwater structures, but do not penetrate underneath it in waters that are shaded. Juvenile chum have also been observed deviating from their typical shore-tied path and entering deeper waters to contour and avoid shaded areas before continuing their movement along the shoreline (Gayaldo and Nelson 2006, Toft et al. 2007, Ono and Simenstad 2014). Behaviours associated with shading effects have been shown to delay ocean entry time of juvenile chum by one to two days (Prinslow et al. 1979, Ono and Simenstad 2014). The response to shading effects appears to be dependent upon schooling behaviour. For example, juvenile chum, which tend to migrate in large directed schools, tend to scatter more easily upon encountering shading than juvenile Chinook, which typically form less dense and less directed schools and are not preferentially found in shore-tied environments (Simenstad et al. 1999).

During the night, artificial lighting of marine structures has also been associated with changes in migration behaviour of juvenile salmon. For example, acoustic tracking studies conducted in Lake Washington and associated shipping canal revealed that juvenile Chinook outmigrate through the lake and shipping canal to coastal rearing habitats in Puget Sound during daytime; outmigration occurs about 45 minutes before sunrise until about 20 minutes before sunset (Celedonia and Tabor 2015). Attraction of juvenile Chinook to nighttime lighting may delay the onset of active migration in the morning by up to 25 minutes (Celedonia and Tabor 2015). In the evening, active migration appears to cease before sunset, and therefore, artificial lights would not have much effect (Celedonia and Tabor 2015).

Several authors have hypothesised, but have not successfully demonstrated (Ono et al. 2010), that marine infrastructure may also increase predation risk of juvenile salmon. Literature suggests that some juvenile salmon may be exposed to predators when deviating into deeper waters to avoid shaded areas (Heiser and Finn 1970, Salo et al. 1980, Williams et al. 2003), while predators may be attracted by nighttime lighting to areas where some juvenile salmon may congregate (Prinslow et al. 1979, Salo et al. 1980, Yurk and Trites 2000). However, the response to nighttime artificial lighting of predators targeting juvenile salmon is highly variable among species (for review of pertinent literature see response to IR5-25). Also, artificial lighting may be manipulated to help reduce predation mortality on juvenile salmon. For example, Petersen and Gadomski (1994) showed that increasing the intensity of light during nighttime caused northern pikeminnow to capture significantly fewer Chinook salmon. Yurk and Trites (2000) demonstrated that turning off structural lighting may

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review – Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

temporarily reduce seal predation on juvenile salmon; however, seals eventually habituate to the lighting change.

In summary, available literature from Puget Sound indicates that changes in the light environment have the potential to result in delays to outmigrating salmon, which may range from a few hours to a few days. If the results found in the literature were to be applied to juvenile chum salmon at Roberts Bank, whose residence time has been reported to span 15 to 25 days (MacDonald 1984), the time delay would range between <1% to about 8% of the time juvenile chum spend rearing in estuarine habitats. Similarly, for juvenile Chinook, potential lighting-related delays would range from <1% to about 5% of the time juvenile Chinook spend rearing in the estuary (considering residence time of juvenile Chinook in the LAA spans three to six weeks (DFO 2011)).

The information provided above supports the conclusions, presented in EIS Section 13.6.3.1, that potential changes in juvenile salmon productivity are predicted to be minor pre-mitigation. Placement of the terminal within the subtidal zone will minimise the influence of lighting on intertidal habitats, including eelgrass beds, which represent optimal rearing habitats for outmigrating juvenile salmon, by reducing spatial overlap between juvenile salmon distribution and areas of artificial light. Additional measures to mitigate negative effects on juvenile salmon productivity from changes in the light environment are discussed in EIS Section 13.7.5 and summarised below.

Changes in Habitat Availability

Marine terminal placement was assumed to potentially affect migration of juvenile Chinook and chum salmon and associated changes in juvenile salmon productivity were assessed as minor pre-mitigation (see EIS Section 13.6.3.1). Migration disruption due to marine terminal placement was based on the underlying assumption that juvenile salmon migrate in a linear fashion, hugging the shoreline as they move. Based on this assumption, terminal placement may encumber migration by increasing linear distance travelled and time spent in deeper waters, thereby increasing exposure and susceptibility to predators (e.g., Nightingale and Simenstad 2001, Ono et al. 2010). It would also potentially impede access to rearing habitats in the inter-causeway area. The assumption on linear movement is conservative based on available information on salmon migration behaviours described in more detail below.

Although a review of the literature yielded no evidence to suggest a causal link between causeway/terminal construction and fitness or predation consequences for juvenile salmon, because of the paucity of data on juvenile salmon movement patterns and residency in the LAA, the assessment conservatively concluded that migration disruption produced a minor adverse effect on productivity pre-mitigation. Chum salmon were assumed to be more susceptible to migration disruption than Chinook salmon, given their preference for shore-tied habitats and tendency to move along perimeters of structures (Levings 1985, Nightingale and Simenstad 2001, Ono and Simenstad 2014). Further rationale on the minor ranking of the disruption to juvenile salmon migration pre-mitigation is provided below.

Shore-tied linear movement patterns may be exhibited by some salmon; however, overall behavioural migration strategies used by juvenile salmon to move through and use estuarine

and marine environments are diverse across species, rearing histories, and habitats, as well as within individual populations (e.g., Melnychuk et al. 2010). For example, Celedonia et al. (2008) identified five distinct migration behaviours during a two-year acoustic tracking study of Chinook smolts in Lake Washington and associated shipping canal. These are summarised in **Table IR5-18-1**.

Table IR5-18-1 Migration Behaviours Exhibited by Juvenile Chinook Salmon

Migration Behaviour	Description
Active migration	High swim velocities, short residence times, and generally direct (i.e., linear) movement towards the marine environment.
Holding	Slow swim velocities, long residence times, and no apparent general direction of travel, suggesting fish are temporarily paused in their migration.
Roaming	Faster swim velocities (comparable to active migration), but movement pathways and residence times similar to holding.
Casual migration	Residence times and movement pathways similar to active migration but lacking the faster swim velocity (similar to holding).
Cycling	Looping movement pathways, often resulting in several passes through a site.

Source: Caledonia et al. 2008.

The literature suggests that linear travel is reflective of actively migrating fish that are moving quickly through the estuary (e.g., sockeye salmon; Welch et al. 2009, Rechisky et al. 2015, Freshwater et al. 2016), but it may not accurately represent the movements of fish that have paused their outmigration to take up residency in the estuary to rear and complete smoltification (e.g., Chinook salmon with residence time ranging three to six weeks (DFO 2011); chum salmon with residence time ranging 15 to 25 days (MacDonald 1984)).

For juvenile salmon that rear in estuarine habitats (such as Chinook and chum), behaviour and movement patterns are predominantly influenced by environmental and habitat conditions (e.g., turbidity, tidal currents, available prey), as well as by the presence and activity of predators (e.g., Gregory 1993, Gregory and Levings 1998). For example, turbid waters may act as refuge from visual predators and allow juvenile salmon to use open water areas with presumably better foraging opportunities; in contrast, higher water clarity may force salmon juveniles closer to shore (e.g., Gregory 1993, Gregory and Levings 1998).

Additionally, rearing fish are likely using a succession of interconnected habitats over a tidal cycle, occupying low-, mid-, and high-intertidal areas sequentially as the tide rises (Levings 2016). At Roberts Bank, juvenile salmon have been shown to occupy multiple habitats, including eelgrass (MacDonald 1984), brackish marsh (Levy and Northcote 1981, 1982), and sandflat (Levings 1982) (also see TDR MF-3 and MF-7 in Appendix AIR10-C of CEAR Document #388), and access the intertidal zone aided by the tides (see TDR MF-3 in Appendix AIR10-C of CEAR Document #388). Similar findings are reported for the Salmon River estuary in Oregon where movements generally follow the direction of tidal currents and salmon actively remain in intertidal habitats until late in the tidal cycle (Hering et al. 2010).

Collectively, these data suggest that the expression of migratory behaviours is highly variable in space and time, and driven by variable abiotic and biotic conditions. Results from the Project's 2012 and 2013 field studies indicate that juvenile salmon are actively remaining in shore-tied intertidal habitats and that outmigration may not be as linear as previously hypothesised (see EIS TDR MF-3 in Appendix AIR10-C of CEAR Document #388). Such observations are incongruent with a paradigm of solely linear migration.

As indicated in EIS Section 13.6.3.1, data gaps remain around the nature and quantification of migration effects from existing marine infrastructure at Roberts Bank (for discussion, see IR5-22). Empirical information on juvenile salmon movement patterns and residency pre-dating causeway construction in the 1960s does not exist; therefore, the degree to which the existing causeway altered (if at all) migration behaviour of juvenile salmon at Roberts Bank cannot be quantified. Studies conducted in the mid- to late 1970s, and early 1980s showed that low tide use of intertidal rearing habitats in the inter-causeway area by juvenile pink, chum, and Chinook salmon was extensive (MacDonald 1984, Levings 1985 (and Goodman 1975, Archibald 1983, Archibald and Bocking 1983 therein)). Levings (1985) suggested that construction associated with Westshore Terminals coal port expansion apparently did not divert fish from the inter-causeway area.

Between 2008 and 2015[2], the VFPA undertook a multi-year habitat compensation monitoring program for the Deltaport Third Berth project. Results indicate that juvenile pink, chum, and Chinook continue to access intertidal rearing habitats in the inter-causeway area (Archipelago and GL Williams 2016). No statistically significant changes to fish communities (i.e., species richness, species diversity, community composition) among sampling years are reported within constructed habitats south of the causeway. Results are also comparable with reference sites along the BC Ferries causeway (Archipelago and GL Williams 2016).

With mitigation, changes in juvenile salmon productivity as a result of the Project were assessed as negligible (EIS Section 13.8.1). Measures to mitigate potential losses in juvenile salmon productivity associated with changes in migration behaviour include (i) implementation of a light management plan to minimise artificial lighting from the Project, including directing light away from the marine environment (see EIS Section 13.7.3); and (ii) offsetting in the form of onsite native eelgrass transplants to increase rearing habitat, and reconstructed tidal marsh habitat north of the widened causeway to increase food supply and provide refuge for juvenile salmon moving along the causeway perimeter (see EIS Section 13.7.6).

Provide an estimate of the potential loss of juvenile Chinook and Chum Salmon productivity associated with the following Project construction activities: construction of permanent dykes around terminal east and west basins; construction of the containment dyke along the western portion of causeway; and construction of the containment dyke along eastern portion of causeway.

Pre-mitigation, multiple lines of evidence suggest a minor loss in juvenile salmon productivity associated with construction of containment dykes around the marine terminal and causeway

[2] Sampling was undertaken in 2008, 2009, 2011, 2012, and 2015 (Archipelago and GL Williams 2016).

(see EIS Table 13-8, and EIS Sections 13.6.2.1 and 13.6.3.1). This assessment, which is conservative in nature, is explained further below.

Containment dykes define the perimeter of (and are included within) the terminal and causeway footprints, which were incorporated in the Roberts Bank ecosystem model. As one of multiple lines of evidence, the Roberts Bank ecosystem model forecasted minor terminal and causeway footprint-related increases in juvenile salmon productivity.

Other lines of evidence (particularly those that account for mechanisms associated with construction activities not captured in the Roberts Bank ecosystem model) suggest a minor decrease in juvenile salmon productivity. For example, changes in the light environment (not considered in the Roberts Bank ecosystem model) were assessed and predicted minor productivity losses due to potential delays in outmigration timing of juvenile salmon (discussed earlier in the response). Other effect mechanisms associated with terminal and causeway containment dyke construction that have the potential to result in changes in juvenile salmon productivity are summarised in **Table IR5-18-2** (and described in EIS Section 13.6, including EIS Table 13-8). **Table IR5-18-2** also provides rationale on the nature of the effect, and links to pertinent mitigation measures (described in EIS Section 13.7).

Therefore, considering all lines of evidence summarised in **Table IR5-18-2**, including increases in juvenile salmon productivity forecasted by the Roberts Bank ecosystem model, it was determined that containment dyke construction would result in a minor decrease in juvenile salmon productivity, pre-mitigation.

With mitigation (including terminal placement in subtidal areas, away from intertidal rearing habitats; adherence to juvenile salmon fisheries-sensitive window; implementation of environmental management plans (listed in **Table IR5-18-2** and described in EIS Section 13.7); offsetting in the form of onsite native eelgrass transplants and reconstructed tidal marsh habitat north of the widened causeway), changes in juvenile salmon productivity are assessed as negligible, with no residual effect.

Table IR5-18-2 Summary Assessment of Juvenile Chinook and Chum Salmon Productivity Changes Associated with Construction of Containment Dykes Around Terminal and Causeway and Pertinent Mitigation

Effects Mechanism	Nature of Effect and Rationale		Mitigation Measure
	Construction of Permanent Dykes around Terminal East and West Basins	**Construction of Containment Dykes along Western and Eastern Portion of Causeway**	
Injury and Direct Mortality	Minor productivity loss (EIS Section 13.6.3.1 and EIS Table 13-8): • No spatial overlap with rearing juvenile salmon in intertidal habitats north of the causeway • Potential to interact with juvenile salmon accessing rearing habitats in the inter-causeway area and outmigrating to the Strait of Georgia • Predicted incremental Project-induced mortality minor relative to the scale of what occurs naturally (i.e., early natural mortality generally exceeds 90% to 95%; Bradford 1995, Trudel and Hertz 2013)	Minor productivity loss (EIS Section 13.6.3.1 and EIS Table 13-8): • Potential to lower juvenile salmon productivity through burial • Spatial overlap with rearing juvenile salmon in intertidal habitats north of the causeway	Terminal: • Placement in the subtidal zone to avoid overlap with sensitive intertidal habitats (EIS Section 13.7.1.1) • Marine Species Salvage Plan to remove marine fish prior to infilling of all containment dykes (EIS Section 13.7.2) Causeway: • Adherence to juvenile salmon fisheries-sensitive window (no temporal overlap, construction to be undertaken when juvenile salmon have transitioned to coastal, non-estuarine rearing areas) (EIS Section 13.7.1.2) • Marine Species Salvage Plan (see above)

Effects Mechanism	Nature of Effect and Rationale		Mitigation Measure
	Construction of Permanent Dykes around Terminal East and West Basins	**Construction of Containment Dykes along Western and Eastern Portion of Causeway**	
Changes in Water Quality	Negligible productivity change (EIS Section 13.6.2.1 and EIS Table 13-8): • Project-induced increase in total suspended solids (TSS) beyond the localised area of disturbance predicted to be within the ambient range (ambient TSS concentration up to 60 mg/L in subtidal waters, and up to 260 mg/L in intertidal waters during the spring freshet) • Juvenile salmon adapted to naturally high levels of TSS that can range between 500 and 1,000 mg/L during freshet, from 100 to 200 mg/L in late summer and fall, and from 50 to 100 mg/L during low flow in the winter • Changes in salinity negligible and within the range juvenile salmon are adapted to during the smoltification process and transition from brackish to higher salinity waters • Sediments that may be re-suspended during dyke construction not contaminated; thus, changes in contaminant concentrations bioavailable to the food chain not anticipated		Terminal and causeway: • Construction Compliance Monitoring Plan to monitor during construction parameters for the protection of aquatic life from TSS and turbidity (and other physical, chemical, or biological parameters) (EIS Section 13.7.4)
Changes in the Light Environment	Minor productivity loss (EIS Section 13.6.1.5 and EIS Table 13-8): • Most Project construction activities scheduled to occur during daytime • For nighttime Project construction activities, lighting effect considered temporary in nature, and spatially confined to the area of the disturbance		Terminal and causeway: • Light Management Plan to minimise excess artificial lighting from the Project, including directing light away from the marine environment (EIS Section 13.7.5) Causeway: • Adherence to juvenile salmon fisheries-sensitive window (see above description) (EIS Section 13.7.1.2)

Effects Mechanism	Nature of Effect and Rationale		Mitigation Measure
	Construction of Permanent Dykes around Terminal East and West Basins	**Construction of Containment Dykes along Western and Eastern Portion of Causeway**	
Changes in Habitat Availability	Minor productivity loss (EIS Section 13.6.3.1 and EIS Table 13-8): • Increase in linear distance travelled (increase in energy expenditure) and time spent in deeper waters (increase in predator exposure) by outmigrating juvenile salmon (see discussion in the first part of this response) • Changes in outmigration behaviour and shifts in predator/prey interactions	Minor productivity loss (EIS Section 13.6.3.1 and EIS Table 13-8): • Intertidal areas enclosed by dykes will no longer be available to rearing juvenile salmon • Changes in outmigration behaviour	Terminal: • None applicable Causeway: • Offsetting in the form of onsite native eelgrass transplants to increase rearing habitat, and reconstructed tidal marsh habitat north of the widened causeway to increase food supply and provide refuge for juvenile salmon moving along the causeway perimeter (see EIS Section 13.7.6)
Biotic Interactions	Minor productivity gain (EIS Section 13.6.3.1 and EIS Table 13-8): • Containment dykes define the perimeter of (and are included within) the proposed terminal and causeway footprints incorporated in the Roberts Bank ecosystem model that provided quantitative predictions on footprint-related juvenile salmon productivity changes • The Roberts Bank ecosystem model forecasted minor increases in juvenile Chinook (+16%) and chum (+14%) salmon productivity, due to prey increases • Sensitivity analysis results indicate that these values are robust, but the magnitude of increase in productivity is likely overestimated by 6% for juvenile Chinook and by 4% for juvenile chum salmon		Terminal and causeway: • None required

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IR5-19 Marine Fish – Chinook Salmon Baseline

Information Source(s)

EIS Volume 3: Section 13.5.1, Appendix 13-A, Appendix 13-B

Context

In Section 13.5.1 of the EIS the Proponent stated that genetic analyses will be carried out on juvenile Chinook Salmon samples to provide information on stock-specific distribution across the banks. Results of this genetic analysis are not reported in the EIS.

This information would identify the different Fraser River Chinook Salmon stocks utilizing the Roberts Bank area. Coupled with the time series information about Chinook Salmon stock status (Appendix 13-A: Fraser River Chinook Salmon Stock Nomenclature and Stock Status) and abundance (Appendix 13-B: Chinook Salmon Abundance Index), the potential effects of the proposed Project on specific Chinook Salmon stocks can be better understood.

Information Request

Provide an analysis of the juvenile Chinook Salmon stock identification results for different areas on Roberts Bank based on genetic analyses. Update Appendix 13-B to include information from 1979 to present and evaluate Chinook Salmon stock-specific utilization of Roberts Bank.

VFPA Response

Provide an analysis of the juvenile Chinook Salmon stock identification results for different areas on Roberts Bank based on genetic analyses.

Summary

Genetic analysis of juvenile Chinook salmon samples collected in the Fraser River estuary (including Roberts Bank) in 2013 and 2014 was carried out by the VFPA. The analysis was undertaken following the signing of a memorandum of understanding between the VFPA and Fisheries and Oceans Canada (DFO) (after EIS submission), thus results are reported here for the first time. Results revealed that the majority of Chinook juveniles sampled at Roberts Bank were from the Fraser Late aggregate (71%; **Table IR5-19-1**), followed by South and

Lower Thompson summer run (Summer 4_1[1]) fish (23%; **Table IR5-19-1**). These groups exhibit an ocean-type life history[2].

Genetic analysis results support the primary literature as presented in EIS Section 13.5.1.2 by highlighting that ocean-type Chinook, rather than the stream type, are primary users of Roberts Bank. Best available information[3] indicates that the Fraser Late and Summer 4_1 stock aggregates are either increasing or showing no discernible trend. Genetic analysis results are also in agreement with preliminary genetics analysis undertaken by Raincoast Conservation Foundation, which revealed that Chinook stocks using intertidal rearing habitats at Roberts Bank are primarily ocean-type (Scott 2017).

Updated information on Chinook stock-specific timing and presence at Roberts Bank, as well as trend analysis of Chinook total returns to the Fraser River from 1979 to the present are provided below; results presented in this response do not change conclusions made in the EIS as they pertain to the assessment of effects on Pacific salmon (including Chinook).

Method

In 2015, genetic analysis was conducted on 404 juvenile salmon fin clip samples, including the following:

- 68 samples collected by the VFPA from the local assessment area in 2013 as part of the juvenile salmon distribution survey conducted for the Project; and
- 336 samples collected by DFO during surface trawl surveys undertaken in 2014 off Roberts and Sturgeon banks.

Information on sampling gear, methods, timing, and location of sampling stations specific to the juvenile salmon distribution survey is provided in Section 3.0 of TDR MF-3 in Appendix AIR10-C of CEAR Document #388[4]. Surface trawl surveys undertaken by DFO in the Fraser River estuary are summarised in EIS Section 13.5.1.

Genetic analysis of juvenile Chinook samples was performed by Dr. Terry Beacham of DFO's molecular genetics laboratory, Pacific Biological Station, Nanaimo, B.C.

Results

Table IR5-19-1 presents results of the genetic analysis carried out on juvenile Chinook samples collected from the Fraser River estuary (including Roberts Bank). Results are

[1] Chinook age and life history type are expressed as a group of numbers. In the Gilbert and Rich (G-R) format (e.g., 4_1), the large number (i.e., '4') represents the age of the salmon on its next birthday. The subscript number represents the year in which the fish migrated to the ocean (i.e., it migrated as a 1-year old in its second year of life).
[2] Ocean-type Chinook outmigrate to sea during their first year of life while stream-type Chinook spend one or more years in freshwater before outmigrating to the ocean.
[3] Time series of Chinook salmon total returns were provided to the VFPA by DFO (2017a,b).
[4] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

reported by Chinook stock and corresponding aggregate (determined by English et al. (2007)), as well as month of sampling.

Table IR5-19-1 Total Number of Genetic Samples of Juvenile Chinook Salmon by Stock, Stock Aggregate, and Month of Sampling in the Fraser River Estuary (Including Roberts Bank)

Stock ID	Stock Aggregate[a]	May	June	July	September	Total
COWICHAN	n/a	0	1	0	0	1
GREEN@KENDAL_F	n/a	0	2	0	0	2
Nooksack_SP@Ke	n/a	0	3	0	0	3
PUNTLEDGE_F	n/a	0	1	0	0	1
Skagit_Su	n/a	0	2	0	0	2
SOOS_CR_H	n/a	0	1	0	0	1
WESTROAD	n/a	2	0	0	0	2
U_COLDWAT_SP	Spring 4_2	2	0	0	0	2
COTTONWOOD	Spring 5_2	3	1	0	0	4
SLIM_C	Spring 5_2	3	0	0	0	3
CLEARWATER	Summer 5_2	1	1	0	0	2
STUART	Summer 5_2	1	0	0	0	1
L_SHUSWAP	Summer 4_1	0	0	1	0	1
L_THOMPSON	Summer 4_1	0	0	6	1	7
LITTLE	Summer 4_1	0	2	12	3	17
MARIA_SLOUGH	Summer 4_1	0	1	0	0	1
SOUTH_THOM	Summer 4_1	3	3	30	26	62
CHILLIWAC@STAV	Fraser Late	75	41	3	0	119
CHILLIWACK_F	Fraser Late	52	27	3	0	82
HARRISON	Fraser Late	32	43	1	0	76
Total		**174**	**129**	**56**	**30**	**389**

Notes:

a. Stock aggregate names are taken from English et al. (2007).

- No genetic sampling was undertaken in August.
- Stocks denoted with 'n/a' are Fraser River Chinook stocks for which no stock aggregate is determined by English et al. (2007).

Overall, Chinook stock origin was determined for 389 out of 404 juvenile Chinook salmon samples analysed. Forty-six percent (46%) of samples (179 out of 389) were taken from Roberts Bank and 43% of samples (166 out of 389) from Sturgeon Bank. The remaining Chinook were from areas within the lower Fraser River and estuary, other than Sturgeon and Roberts banks. For 15 samples, Chinook stock origin could not be determined.

The majority of juvenile Chinook samples in the Fraser River estuary (including Roberts Bank) were from the Fraser Late stock aggregate (277 out of 389 samples analysed; 71%;

Table IR5-19-1), followed by Summer 4_1 fish largely of South and Lower Thompson origin (88 out of 389 samples analysed; 23%; **Table IR5-19-1**). Fraser Late Chinook dominated the catch in spring (May/June), while Summer 4_1 fish followed later in the season (primarily in July, and then in September). Both these stock aggregates comprise ocean-type Chinook, whose abundance has been increasing or showing no discernible trend (see Figure 13-B in EIS Appendix 13-B, and updated **Figure IR5-19-1** in the second part of this response).

Specifically, abundance for the Summer 4_1 stock aggregate have been increasing over the last decade (except for 2012 and 2016—the progeny of the 2012 brood year). This stock aggregate is considered healthy and abundant (Pacific Salmon Commission 2017).

Abundance for the Fraser Late stock aggregate have fluctuated substantially with no apparent trend in the time series (Pacific Salmon Commission 2017). Estimated spawning escapements[5] in the Harrison River consistently exceeded the escapement goal range from 1984 to 2011, and in 2015. However, escapements during the past four out of five years (i.e., 2012-2014 and 2016) have been low relative to the escapement goal (Pacific Salmon Commission 2017).

Genetic analysis results presented in this response support the primary literature presented in EIS Section 13.5.1.2 by confirming that ocean-type Chinook, rather than the stream type, are primary users of rearing intertidal habitats at Roberts Bank. It is the stream-type Chinook stocks that exhibited notable declines over the past decade (Pacific Salmon Commission 2017), and very few of these fish (12 out of 389 individuals; 3%; **Table IR5-19-1**) were caught at Roberts Bank during genetic sampling (consistent with what is known about their life history; see EIS Section 13.5.1.2). Synchronous declines have occurred in the productivity of many Chinook salmon stocks throughout their range along the Pacific coast, and are most likely attributable to changing ocean conditions (Dorner et al. 2017).

Genetic analysis results are also in agreement with preliminary results of a similar genetic study conducted by Raincoast Conservation Foundation in 2016 in the Fraser River estuary. Raincoast Conservation Foundation report that ocean-type juvenile Chinook from the Harrison River are abundant in early spring, transitioning to ocean-type stocks from Chilliwack and Thompson rivers as the season progresses; few fish from some Middle and Upper Fraser stocks (stream-type) are also present at Roberts Bank in the summer (Scott 2017).

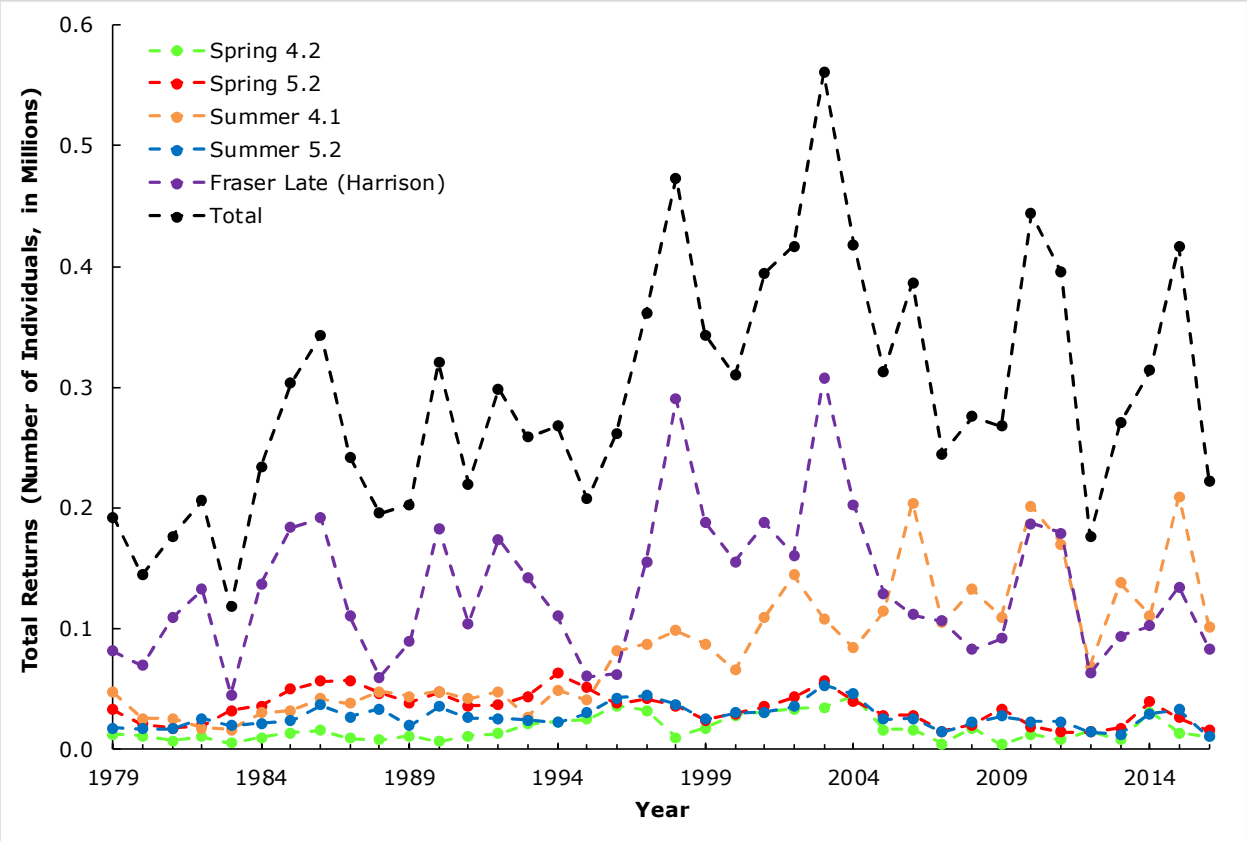
Update Appendix 13-B to include information from 1979 to present and evaluate Chinook Salmon stock-specific utilization of Roberts Bank.

Figure IR5-19-1 presents time series of Chinook abundance ranging from 1979 to 2016[6]. Abundance is expressed using Chinook total returns to the Fraser River, calculated as the sum of Chinook fisheries catches, escapements, and hatchery removals. **Figure IR5-19-1**

[5] Escapement is the number of salmon arriving at their natal river or stream to spawn (or the number of salmon that have escaped fisheries and are available to spawn).
[6] At the time of writing this response, 2016 was the most recent year with Chinook abundance information available from DFO.

updates EIS Appendix 13-B by providing total returns by Chinook stock aggregate for the years 2013 to 2016.

Figure IR5-19-1 1979-2016 Time Series of Chinook Salmon Total Returns (Number of Individuals, in Millions) to the Fraser River by Stock Aggregate



Source: DFO 2017a,b

Estimates of Chinook salmon total returns to the Fraser River continue to show considerable year-to-year variation (**Figure IR5-19-1**), reflecting primarily variation in the strength of different brood years, as well as variation in ocean conditions (Riddell et al. 2013, Dorner et al. 2017). Most stock aggregates have showed an increase up to the early 2000s; since then, declines have been observed for many stocks, particularly of stream type Chinook (Riddell et al. 2013). Abundance for ocean-type stock aggregates has been increasing (i.e., Summer 4_1; **Figure IR5-19-1**) or showing no obvious trend (i.e., Fraser Late; **Figure IR5-19-1**).

From 2012 to 2016, total returns of stream-type Chinook ranged between (DFO 2017*b*):

- 8,259 (in 2013) and 31,136 (in 2014) individuals (mean: 15,862 (±8,963)) for Spring 4_2;
- 14,197 (in 2012) and 39,664 (in 2014) individuals (mean: 22,704 (±10,510)) for Spring 5_2; and
- 10,818 (in 2016) and 33,048 (in 2015) individuals (mean: 20,121 (±10,304)) for Summer 5_2.

For the same period, total returns of ocean-type Chinook ranged between (DFO 2017*b*):

- 69,001 (in 2012) and 209,155 (in 2015) individuals (mean: 125,662 (±52,735)) for Summer 4_1; and
- 63,015 (in 2012) and 134,881 (in 2015) individuals (mean: 95,672 (±26,480)) for Fraser Late.

As discussed in the first part of this response, Fraser Late run Chinook dominate the catch at Roberts Bank in spring, with Summer 4_1 fish following later in the season. Both these stock aggregates comprise ocean-type Chinook, whose abundance has been increasing or showing no discernible trend (**Figure IR5-19-1**).

As indicated above, genetic analysis information on Chinook stock-specific timing and presence at Roberts Bank, as well as trend analysis of Chinook total returns to the Fraser River from 1979 to the present, support the primary literature presented in EIS Section 13.5.1.2. Conclusions made in the EIS as they pertain to the assessment of negligible effects on Pacific salmon (including Chinook) remain unchanged.

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IR5-20 Marine Fish – Forage Fish Residual Effects, Frequency Criteria

Information Source(s)

EIS Volume 3: Section 13.6.3.3, Table 13-11, Table 13-15, Appendix 12-A

CEAR Doc#577

Context

In Section 13.6.3.3 of the EIS the Proponent reported that Pacific Sand Lance is particularly sensitive to alterations or losses in subtidal sand habitat, on which they rely for burying. Terminal placement would result in:

- permanent loss of subtidal sand habitat;
- sediment grain size within the entire berth pocket will be rendered unsuitable for Pacific Sand Lance burying following construction activities; and,
- based on subtidal habitat suitability modelling for Pacific Sand Lance, a total of 125 ha of moderately suitable and 3.6 ha of highly suitable burying habitat will be permanently lost to terminal placement and dredge basin creation.

The Proponent, in Table 13-11 of the EIS, reported that approximately 130.1 ha of suitable subtidal burying habitat, or 9.4% of moderate and high suitable subtidal burying habitat, will be lost with the construction of the terminal, tug basin and dredge basin (not including the 33.1 ha from the intermediate transfer pit).

The Proponent, in Table 13-15 of the EIS, in characterizing the criteria for frequency of residual effect from productivity loss, identified the rating criteria for productivity losses to marine fish. The rationale provided for the infrequent to frequent rating criteria was that while changes in geomorphic process and habitat availability from the proposed Project placement are permanent, productivity effects are not, and they are expected to recover naturally and through mitigation within one or two generations.

Additional information to determine whether productivity for Pacific Sand Lance will recover following Project construction is needed to assess whether the conclusions are consistent with the frequency rating of infrequent to frequent.

Information Request

For Pacific Sand Lance, provide further rationale for the criterion rating of infrequent to frequent that are applied to predict productivity losses in relation to the proposed Project. This should be done in terms of changes to habitat availability and sensitivities to alterations or losses in subtidal sand habitat.

VFPA Response

Additional rationale on the frequency criterion[1] of infrequent to frequent residual loss in forage fish productivity is provided below to clarify the approach taken in EIS Section 13.8.1. Residual loss in productivity of the forage fish sub-component is predicted to result from reduction in suitable subtidal burying habitat for Pacific sand lance, as well as residual behavioural disturbance from underwater noise on Pacific herring (see EIS Section 13.8).

A frequent rating of the residual effect applies to Pacific herring indicating that behavioural disturbance from underwater noise may occur intermittently during Project construction activities (e.g., dredging) and frequently during Project operation (e.g., vessel manoeuvring and berthing).

An infrequent rating of the residual effect applies to Pacific sand lance. Although placement of the proposed RBT2 terminal is permanent, the infrequent rating applies to the associated loss in Pacific sand lance *productivity.* Further explanation is provided below.

Following terminal placement, Pacific sand lance productivity is expected to recover naturally in the local assessment area (LAA) for the following reasons. Based on the amount of habitat suitable for Pacific sand lance burying that will remain in the LAA following terminal placement, Pacific sand lance were not considered in the EIS to be habitat limited in the LAA. Specifically, subtidal habitat that will be lost from terminal placement amounts to about 7% of soft sediments in the LAA. Of the soft substrate predicted suitable for Pacific sand lance burying in the LAA (using habitat suitability modelling), 99% of the highly suitable and 86% of the moderately suitable substrate is predicted to occur outside the terminal footprint, and will thus remain available to Pacific sand lance for burying. Additional suitable burying habitat also occurs outside the LAA within the southern Strait of Georgia (e.g., Robinson et al. 2013).

Pacific sand lance preference and use of sediments for burying varies among years, presumably due to their specific sediment size requirements (e.g., Haynes and Robinson 2011). Sediment distribution and characteristics in the LAA are driven by coastal geomorphic processes, including wave action, tidal currents, freshet, and influx of Fraser River sediment. As these abiotic processes are predicted to remain largely unchanged with the Project (see EIS Section 9.5), they are also expected to continue to govern sediment distribution and in turn Pacific sand lance habitat preferences in the LAA.

[1] The frequency criterion refers to how often the residual effect occurs within a given time period, and is usually related to how frequently a physical work or activity is causing the residual effect (see IR5-09 in CEAR Document #1116). Ratings of the frequency criterion are defined in EIS Table 13-14 as follows:

- Infrequent – Effect(s) occur once;
- Frequent – Effect(s) occur repeatedly during Project construction or operation; and
- Continuous – Effect(s) occur continuously throughout the Project phases.

Moreover, the Roberts Bank ecosystem model, which incorporates potential coastal geomorphic changes in the LAA with the Project, forecasts a negligible change[2] in Pacific sand lance productivity.

Lastly, offsetting in the form of sand and gravel beach creation along the north side of the causeway will increase Pacific sand lance spawning habitat in the LAA, and is anticipated to enhance Pacific sand lance productivity. Similar compensation habitat (i.e., sand and gravel beaches) was created along the south side of the causeway as part of habitat compensation for the Deltaport Third Berth project (DP3). Winter sampling in 2013 and 2015 as part of habitat compensation monitoring for DP3 found Pacific sand lance eggs in various stages of development that were deposited on created beach habitat (Archipelago and GL Williams 2016). The presence of Pacific sand lance eggs at habitat compensation sites south of the causeway may be the first documentation in southern B.C. of a beach spawning event by forage fish on created habitat (Archipelago and GL Williams 2016).

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[2] The Roberts Bank ecosystem model forecasts a minor increase (i.e., 6%; see Section 3.7.7 in EIS Appendix 10-C) in Pacific sand lance productivity; this is likely overestimated by 3%, based on sensitivity analyses (see Figure 3-18 in EIS Appendix 10-D).

IR5-21 Marine Fish – Forage Fish Residual Effects, Magnitude Criteria

Information Source(s)

EIS Volume 2: Section 9.5, Table 9.5-35

EIS Volume 3: Section 13.6.3.3, Table 13-15

CEAR Doc#577

Context

The Proponent reported that the proposed Project will result in a minor reduction in forage fish productivity because of the following:

- reductions in habitat availability are expected to have a minor negative influence on forage fish productivity within the local assessment area;
- terminal placement will result in permanent loss of subtidal sand habitat, and sediment grain size within the entire berth pocket will be rendered unsuitable for Pacific Sand Lance burying following construction activities;
- habitat suitability modelling (Table 13-11) indicates that the Project footprint will permanently remove 130.1 ha or 9.4% of suitable (moderately and highly suitable) burying habitat within the local assessment area; and,
- alteration of bottom habitats through sedimentation from dredging and terminal placement is expected to result in a minor decrease in forage fish productivity, specifically for Pacific Sand Lance.

As reported in Table 13-15 of the EIS, the Proponent identified the magnitude criteria rating for productivity losses to forage fish and flatfish as low because the Project is unlikely to result in changes in productivity outside the range of natural variability experienced by representative species within the local assessment area for the Project.

As reported by the Proponent that uncertainties in environmental effects assessment for forage fish included:

- the degree to which Pacific Sand Lance use the local assessment area as spawning or burying habitat;
- movements of Pacific Sand Lance and Pacific Herring in relation to the spatial and temporal overlap with construction activities; and
- terminal placement anticipated to result in increased deposition of silt on the tidal flats north of the causeway (Zone 7, Fig 9.5-35 of the EIS).

According to Fisheries and Oceans Canada, uncertainties in the baseline data for forage fish and in the interaction of the Project activities with forage fish may influence the effects assessment. Although the area of suitable Pacific Sand Lance burying habitat is identified, the area of reduced suitability for other forage fish is not quantified.

Further information is required about the uncertainties in the effects prediction for forage fish species including Pacific Sand Lance, Surf Smelt, Pacific Herring and Shiner Perch and how they influence the magnitude criteria for forage fish.

Information Request

Given the uncertainties presented in the marine fish assessment regarding potential proposed Project effects on forage fish and, in particular Pacific Sand Lance, provide a discussion and rationale explaining how uncertainties were considered in the assessment of the magnitude criterion rating of low in Table 13-15 of the EIS.

Quantify the loss of suitable forage fish habitat, including Pacific Sand Lance, Surf Smelt, Pacific Herring and Shiner Perch habitat, caused by the Project.

VFPA Response

Given the uncertainties presented in the marine fish assessment regarding potential proposed Project effects on forage fish and, in particular Pacific Sand Lance, provide a discussion and rationale explaining how uncertainties were considered in the assessment of the magnitude criterion rating of low in Table 13-15 of the EIS.

Uncertainty in forage fish baseline information (identified in EIS Section 13.5.3 and indicated by DFO in the context to this information request (above)) was integrated and managed in the assessment of Project-related effects on forage fish, including characterisation of a predicted residual effect. Given gaps in baseline data for certain representative species such as Pacific sand lance, confidence in predictions made in the EIS remains moderate (for discussion, see EIS Section 13.9.2).

In summary, uncertainty in baseline data for Pacific sand lance was integrated into the effects assessment by assuming that the Project would interact with, and therefore potentially affect, Pacific sand lance productivity, despite lack of empirical evidence (based on field studies undertaken by the VFPA) of Pacific sand lance spawning or burying within the local assessment area (LAA).

Uncertainties in baseline data, identified in the context to this information request, are associated with the following:

1. The degree to which Pacific sand lance use the LAA as
    a. spawning or
    b. burying habitat;
2. Movements of
    a. Pacific sand lance and
    b. Pacific herring in relation to the spatial and temporal overlap with construction activities; and
3. Terminal placement anticipated to result in increased deposition of silt on the tidal flats north of the causeway (Zone 7 on EIS Figure 9.5-35).

Uncertainties 1 and 2 comprise two parts each (i.e., *a* and *b*); hence, the response below explains how each of the five uncertainties identified in the context to this information request

were addressed in the assessment of potential effects on forage fish. The response also provides rationale on how uncertainties were considered, where appropriate, in rating 'low'[1] the magnitude of the residual loss in forage fish productivity. The discussion also clarifies where uncertainties identified in the above context did not influence the residual effect characterisation.

1a: Pacific Sand Lance Use of the Local Assessment Area for Spawning

Uncertainty has been identified in the EIS (Pacific sand lance existing conditions; see EIS Section 13.5.3.1) relating to Pacific sand lance use of the LAA (specifically the north side of the causeway) for spawning. Suitable beach spawning habitat was identified north of the causeway during field surveys conducted for the Deltaport Third Berth project (DP3; 2003-2004; Triton 2004) and for RBT2 (2012-2013; see TDR MF-4 in Appendix AIR10-C of CEAR Document #388[2]). However, during the same surveys, Pacific sand lance eggs were not found; thus, spawning north of the causeway could not be confirmed.

Despite this uncertainty, the assessment assumed that Pacific sand lance do spawn north of the causeway, and disruption of suitable beach spawning habitat during causeway widening was considered to result in the loss of Pacific sand lance productivity, pre-mitigation. Hence, the assessment is conservative in nature, given that empirical evidence suggests Pacific sand lance do not spawn north of the causeway, and thus would not interact with the Project.

Uncertainty was further addressed through proposed onsite offsetting to promote Pacific sand lance productivity. Specifically, the creation of sandy gravel beaches (see EIS Section 17.3.2) for Pacific sand lance spawning is expected to mitigate potential losses in Pacific sand lance productivity associated with habitat disruption, such that no residual productivity loss is anticipated from this effect mechanism. Similar onsite compensation for DP3 south of the causeway has proven effective for Pacific sand lance, as eggs were documented on created beach habitat on two occasions in January 2013 and January 2015, during the VFPA's 5-year post-construction habitat monitoring program for DP3 (Archipelago and GL Williams 2016).

Uncertainty regarding the use by Pacific sand lance of the LAA for spawning did not influence the residual effect characterisation or assessment conclusion. As indicated above, with mitigation, no residual loss in forage fish productivity is anticipated from disruption of Pacific sand lance spawning habitat.

[1] Low magnitude indicates that potential residual loss in forage fish productivity would be measurable, but within the range of natural variability of the population, and would not affect population integrity (see EIS Section 13.8.1). This rating was derived by considering multiple lines of evidence, including results from empirical studies (field surveys), the Roberts Bank ecosystem model, other models (such as habitat suitability modelling for Pacific sand lance), published literature, information on mitigation measures, and proposed onsite habitat offsetting.

[2] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review – Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

1b: Pacific Sand Lance Use of the Local Assessment Area for Burying

Uncertainty has been identified in the EIS (Pacific sand lance existing conditions; see EIS Section 13.5.3.1) relating to the use by Pacific sand lance of the LAA for burying. Pacific sand lance burying at Roberts Bank has not been confirmed historically[3] or during sediment grab sampling conducted in 2012 to 2013 for the Project.

In the absence of empirical evidence demonstrating Pacific sand lance burying in the LAA, uncertainty was addressed by developing a habitat suitability model to predict the extent of suitable burying habitat for Pacific sand lance in the LAA. Based on model results, terminal placement (not causeway expansion, as causeway footprint does not overlap with subtidal habitat predicted to be suitable for Pacific sand lance burying; see Section 6 of EIS Appendix 12-A) will remove about 9% of available soft substrate predicted to be suitable for Pacific sand lance burying.

In the absence of empirical evidence, the assessment also conservatively assumed that Pacific sand lance do bury in the LAA within habitat predicted to be suitable by the model. Pre-mitigation, interaction between burying Pacific sand lance and Project construction activities was assumed to result in physical injury and direct mortality.

Uncertainty was addressed further through implementation of mitigation measures. Specifically, adherence to the fisheries-sensitive timing window for Dungeness crab[4] will prevent mortality of Pacific sand lance that may bury in sediments within the terminal footprint during the winter months. However, because Pacific sand lance bury in coarse sand substrates throughout the year when they do not feed (Haynes et al. 2007), interaction with Project construction activities outside the fisheries-sensitive window has been assessed to result in a residual loss in Pacific sand lance productivity.

Despite the lack of empirical evidence regarding Pacific sand lance burying in the LAA, the magnitude of the residual effect was rated low for the following reasons (for discussion see response to IR5-20 of CEAR Document #1134[5]):

- Pacific sand lance are not considered habitat-limited in the LAA;
- With the Project, characteristics and distribution of sediment patches suitable for Pacific sand lance burying will continue to be driven in the LAA by coastal geomorphic processes; and
- Potential productivity losses that may occur outside the fisheries-sensitive window are expected to be counter-balanced over a relatively short time period through natural

[3] To date, targeted studies on Pacific sand lance at Roberts Bank have focused on spawning (Triton 2004, TDR MF-4 in Appendix AIR10-C of CEAR Document #388) and not burying (also see Section 6 of EIS Appendix 12-A).
[4] The fisheries-sensitive timing window for Dungeness crab prevents activities occurring below –5.0 m chart datum (CD) from October 15 to March 30.
[5] CEAR Document #1134 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR5-20, IR5-30, IR5-31, IR6-13, IR7-12, IR7-37 & IR7-41. (See Reference Documents #975, #991, & #1000).

recovery (i.e., recruitment, immigration), given high fecundity, early maturation, and short generation time, characteristic of Pacific sand lance.

2a: Movements of Pacific Sand Lance in Relation to the Spatial and Temporal Overlap with Construction Activities

Pacific sand lance movements referred to in the context to this information request were considered in the assessment relating to Pacific sand lance spawning, burying, and rearing within suitable habitats in the LAA. As explained earlier in this response, uncertainty is identified in the EIS (Pacific sand lance existing conditions; see EIS Section 13.5.3.1) relating to Pacific sand lance spawning and burying. The spatial and temporal overlap between movements of Pacific sand lance spawning and burying and Project construction activities is presented in Table IR4-18-5 of CEAR Document #1051[6]. Information provided earlier in this response explains how uncertainty regarding Pacific sand lance spawning and burying was addressed in the assessment of potential effects of the Project on forage fish.

No uncertainty relating to movements of rearing Pacific sand lance in the LAA has been identified in the EIS. Pacific sand lance rearing in the LAA is described in EIS Section 13.5.3.1 based on information from the literature and the Project's 2012 to 2013 field surveys. Specifically, Pacific sand lance rear within intertidal eelgrass beds at Roberts Bank with high abundances recorded in spring, summer, and early fall (Greer et al. 1980, Conlin et al. 1982, Gordon and Levings 1984). During 2012 to 2013 field surveys conducted for the Project, Pacific sand lance were caught in spring, summer, and winter, in numerous habitats, including eelgrass north of the causeway (TDRs MF-3, MF-6, and MF-7 in Appendix AIR10-C of CEAR Document #388[7]).

The spatial and temporal overlap between movements of rearing Pacific sand lance and Project construction activities is presented in Table IR4-18-5 of CEAR Document #1051. With mitigation, including terminal placement in subtidal areas to avoid optimal intertidal rearing habitats (e.g., eelgrass), adherence to the fisheries-sensitive timing window for juvenile salmon[8], and onsite offsetting in the form of eelgrass transplants, no residual loss in the productivity of rearing Pacific sand lance is anticipated.

2b: Movements of Pacific Herring in Relation to the Spatial and Temporal Overlap with Construction Activities

Pacific herring movements referred to in the context to this information request relate to Pacific herring spawning and rearing within suitable habitats in the LAA (discussed respectively below).

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[6] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document # 946).
[7] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review – Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.
[8] The fisheries-sensitive timing window for juvenile salmon prevents activities occurring above –5.0 m CD from March 1 to August 15.

Uncertainty is identified in the EIS (Pacific herring existing conditions; see EIS Section 13.5.3.3) regarding the degree the LAA is used by Pacific herring for spawning. The literature indicates that there is less herring spawning at Roberts Bank than on the east side of Vancouver Island (e.g., Gordon and Levings 1984, Hay and McCarter 2013). Historic records of herring spawning in the LAA include one from 1992 just north of the BC Ferries causeway (Hay and McCarter 2013), as well as observations by Tsawwassen First Nation of herring spawn on crab traps (see EIS Section 32.2.4.1). During field surveys conducted for DP3 (2003-2004; Triton 2004) and RBT2 (2012-2013), herring spawn was not documented, until a recent field survey conducted by the VFPA in April 2017 (see response to IR4-18 of CEAR Document #1051). Results from the 2017 field survey are consistent with existing conditions (described in EIS Section 13.5.3.3) that the LAA is not a major spawning area for herring.

Despite the lack of evidence of herring spawning in the Project's LAA at the time the EIS was being written (2014, prior to documenting herring spawn in the LAA in 2017; see response to IR4-18 of CEAR Document #1051), the assessment of potential effects of the Project on forage fish assumed herring spawn to overlap spatially and temporally and interact with Project construction activities, resulting in minor loss of Pacific herring productivity (see EIS Section 13.6.3.3). Uncertainty is managed through implementation of proposed mitigation measures, including onsite offsetting in the form of eelgrass transplants, adherence to the fisheries-sensitive timing window for juvenile salmon, and implementation of environmental management plans. However, because Pacific herring spawning may occur as early as February (based on nearby records from Point Roberts and Boundary Bay; Hay and McCarter 2013), interaction with Project construction activities outside the fisheries-sensitive timing window (i.e., March 1 to August 15, above –5.0 m CD) has been assessed to result in residual loss in Pacific herring productivity (associated with behavioural disturbance from underwater noise). The magnitude of the residual effect was rated low for the following reasons:

- The LAA is not an important herring spawning area (based on literature (Gordon and Levings 1984, Hay and McCarter 2013, DFO 2016), observations from Aboriginal groups, and field studies undertaken at Roberts Bank by the VFPA during the last two decades);
- The assessment of underwater noise effects on Pacific herring is conservative as it assumes behavioural effects to result from underwater noise generated during impact pile driving. Overall, pile driving for the Project will be limited in duration, and vibratory pile driving will be preferably used where practical (see EIS Section 13.6.1.2 and response to IR4-15 of CEAR Document #1051); and
- Potential productivity losses that may occur outside the fisheries-sensitive window are expected to be counter-balanced over a relatively short time period through natural recovery (i.e., recruitment, immigration), given high fecundity, early maturation, and short generation time, characteristic of Pacific herring.

Movements of Pacific herring rearing in the LAA are described in EIS Section 13.5.3.3 based on literature (Greer et al. 1980, Conlin et al. 1982, Gordon and Levings 1984) and the Project's 2012 to 2013 field surveys; no uncertainty has been identified that is associated with such movements. Specifically, Pacific herring juveniles rear in eelgrass beds in the

Project's LAA during the summer months, and have the potential to overlap spatially and temporally with Project construction activities (also see Table IR4-18-5 of CEAR Document #1051). Implementation of mitigation measures described above for Pacific sand lance is anticipated to also offset potential loss in productivity of rearing Pacific herring, resulting in no residual effect.

3: Terminal Placement Anticipated to Result in Increased Deposition of Silt on the Tidal Flats North of the Causeway (Zone 7, EIS Figure 9.5-35)

To clarify, Zone 7 in EIS Figure 9.5-35 represents the area of increased turbidity (not silt deposition) where wave energy and salinity are predicted to be altered by the Project. The proposed terminal is expected to interrupt the landward movement of seawater during rising tides, causing the saline water to be deflected further to the northwest, and resulting in an increased residence time of turbid lower-salinity Fraser River water along the western end of the widened causeway (see EIS Section 9.5.10). Fine sediment (mainly silt) is also expected to be deposited at the western end of the causeway in Zone 7 over time; however, this deposition is expected to be at a slower rate compared to silt deposition predicted in zones 2 and 4 in EIS Figure 9.5-35. Nonetheless, sedimentation rates with the Project are expected to be low overall, given that there is limited annual natural sediment supply (see EIS Section 9.5.6.1).

Coastal geomorphic changes predicted to result from terminal placement in Zone 7 (EIS Figure 9.5-35) are not regarded as uncertainty in the assessment. Rather, coastal geomorphic change predictions were incorporated in the Roberts Bank ecosystem model as abiotic factors to investigate changes in biotic interactions with the Project, and determine Project-related changes in productivity of marine fish, including forage fish. For a discussion on how coastal geomorphic changes were incorporated in the Roberts Bank ecosystem model, see Sections 2.2 and 2.12 of EIS Appendix 10-C, as well as the response to IR3-02 of CEAR Document #984[9]. For a discussion on how uncertainty in abiotic factors was addressed in the Roberts Bank ecosystem model, see Section 2.2 of EIS Appendix 10-D.

In summary, the Roberts Bank ecosystem model forecasted a minor (i.e., 6%) increase in Pacific sand lance productivity with the Project, which was likely overestimated by 3% based on sensitivity analysis (see Figure 3-18 in EIS Appendix 10-D). Roberts Bank ecosystem model forecasts were one of several lines of evidence considered in the assessment of potential Project effects on forage fish, including Pacific sand lance. No residual effect on Pacific sand lance was identified to result from changes in biotic interactions with the Project. Moreover, anticipated Project-related changes to coastal geomorphic conditions were considered in the design of onsite offsetting concepts (described above for Pacific sand lance) (see EIS Section 17.3.2.2).

[9] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document #928).

Quantify the loss of suitable forage fish habitat, including Pacific Sand Lance, Surf Smelt, Pacific Herring and Shiner Perch habitat, caused by the Project.

The effects of the Project were assessed based on a productivity approach (as per advice by the Productive Capacity Technical Advisory Group). The results of the assessment of potential effects of the Project are presented as changes to productivity for marine fish sub-components, including forage fish, based on weight of evidence, and not as changes to the areal extent of suitable forage fish habitat. This ecosystem and productivity approach is consistent with federal policy goals and objectives (see Preamble in support of Responses to IR3-01 to IR3-24 – Roberts Bank Ecosystem Model of CEAR Document #984 for further discussion).

Notwithstanding the above, the loss of suitable Pacific sand lance burying habitat was quantified (see EIS Section 13.6.3.3, including Table 13-11) to manage uncertainty regarding lack of empirical evidence on Pacific sand lance burying in the LAA as described in the first part of the response.

Implementation of mitigation, including avoidance measures and onsite offsetting, are anticipated to result in no net loss in suitable habitat for Pacific sand lance (spawning), surf smelt, Pacific herring, and shiner perch. Specifically:

- Locating the terminal primarily in the subtidal zone will avoid overlap with sensitive intertidal habitats (i.e., including those habitats, such as eelgrass beds, upon which surf smelt, Pacific herring, and shiner perch depend for multiple life processes);
- Onsite offsetting is anticipated to result[10] in an increase of sandy gravel beach habitat suitable for surf smelt and Pacific sand lance spawning, as well as native eelgrass areas that may be used for deposition of Pacific herring spawn, as well as by surf smelt and shiner perch for rearing; and
- The Project will also provide additional rocky substrate (i.e., rip-rap) along portions of the proposed terminal and expanded causeway, benefitting shiner perch which associate with a variety of habitats (and not a single one preferred), including hard substrates along anthropogenic structures.

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[10] The VFPA will implement a follow-up monitoring program to confirm that all mitigation measures, including onsite offsetting, meet intended objectives (as outlined in EIS Section 33.5).

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IR5-22 Marine Fish – Juvenile Salmon Effects Assessment

Information Source(s)

EIS Volume 3: Section 13.6.3.1; Section 13.6.1.6; Section 13.8.1

TDR MF-3: Juvenile Salmon Surveys, Appendix AIR10-C (CEAR Doc#388)

CEAR Doc#647

Context

In Section 13.8.1 of the EIS, the Proponent indicated that the proposed Project may affect juvenile salmon migration and identified that quantification of the effect is not available as the Project would have to be in place in order to evaluate the potential change in juvenile salmon migration.

According to Raincoast Conservation Foundation, there is insufficient baseline to adequately compare and predict the effects of the widened causeway on juvenile salmon.

As indicated in Appendix 10-C of the Juvenile Salmon Surveys Report, field surveys were undertaken by Archipelago in 2012 and 2013, and by other investigators historically. For example, the Proponent reported that detailed work on juvenile salmon relevant to the proposed Project area was conducted for the Deltaport Third Berth Environmental Assessment in 2004 and previous baseline studies were conducted in 2009. These data, if combined with other historical juvenile salmon studies, could provide a basis for comparing juvenile salmon utilization of habitats to the north and south of the causeway. Such observations could inform predictions of the effects of the expanded terminal and causeway on juvenile salmon displacement from the inter-causeway area.

Information Request

Synthesize the existing data, including historical studies and data identified in Section 2.2 of the Juvenile Salmon Surveys Report and provide a statistical analysis and interpretation of differences in juvenile salmon utilization of habitats to the north and south of the existing terminal and the terminal causeway.

Report on displacement of juvenile salmon from the existing terminal and causeway as well as access to the inter-causeway area.

Predict the effect of any displacement of juvenile salmon by the expanded causeway and new terminal structure, including the effect of exposure to predators and change in access to intertidal habitats in the inter-causeway area.

VFPA Response

Synthesize the existing data, including historical studies and data identified in Section 2.2 of the Juvenile Salmon Surveys Report and provide a statistical analysis and interpretation of differences in juvenile salmon utilization of habitats to the north and south of the existing terminal and the terminal causeway.

To clarify, existing data referred to in the information request comprise data collected (a) historically in the 1970s and 1980s (i.e., Goodman 1975, Greer et al. 1980, Conlin et al. 1982, Levings et al. 1983, Gordon and Levings 1984, MacDonald 1984, Levings 1985; referred to here as 'historical' data), and (b) recently in the 2000s (i.e., Triton 2004, Martel 2009, the VFPA's 2008-2015 habitat compensation monitoring program associated with the Deltaport Third Berth (DP3) project, 2012-2013 field surveys conducted for the Project; referred to here as 'recent' data).

Data identified in the previous paragraph were synthesised qualitatively in the EIS (see TDRs MF-3 and MF-7 in Appendix AIR10-C of CEAR Document #388[1]) and were considered in the assessment of Project-related effects on juvenile salmon. However, a statistical analysis of historical and recent Roberts Bank data (to identify and interpret differences in juvenile salmon utilisation of habitats to the north and south of the existing causeway and terminal) was not undertaken as it is not technically feasible. This is primarily because varying methodologies have been deployed to survey across estuarine environments at Roberts Bank since the 1970s that reflect differences in the spatial extent and timing of sampling, as well as the types of sampling gear deployed, and data collected. Additional rationale for not undertaking a statistical analysis of these incompatible data sets is provided below.

Differences in Spatial Extent of Sampling

The ability to perform comparative statistical analyses and investigate potential changes in the patterns of juvenile salmon habitat use north and south of the causeway is hampered by marked differences in the spatial coverage of sampling conducted at Roberts Bank in the 1970s and early 1980s. Differences are noted in the size of study areas and location of sampling stations during past surveys in an effort to meet a wide range of objectives (summarised in Table 2 of TDR MF-3 in Appendix AIR10-C of CEAR Document #388).

Specifically, studies carried out in the 1970s (i.e., Goodman 1975, Greer et al. 1980, Conlin et al. 1982) were part of a Fisheries and Oceans Canada (DFO) sampling program aimed at developing an inventory of fish species presence and abundance in the entire Fraser River estuary. For this purpose, sampling stations were selected such that sampling effort was distributed across the entire estuary (including Sturgeon Bank and the river mouth at Steveston) to represent a variety of environments.

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review – Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

At Roberts Bank, intertidal environments were represented by samples taken from the tidal flats off Westham Island (outside the Project's local assessment area (LAA)), while subtidal waters were sampled off Westshore Terminals, and at the edge of the borrow pit in the inter-causeway area. Sampling in intertidal habitats north and south of the causeway (that would overlap and could potentially be compared with sampling conducted post-2000s) was not undertaken as part of DFO's inventory.

Gordon and Levings (1984) and Levings (1985) analysed data from the inventory estuary-wide and for the inter-causeway area, respectively, but did not conduct additional sampling.

Sampling in the early 1980s by Levings et al. (1983) and MacDonald (1984) focused on habitats in the inter-causeway area in response to the (proposed at the time) expansion of the Roberts Bank coal port facility. Sampling was also conducted within shore-tied environments south of the causeway for the first time. However, a number of intertidal habitats in the inter-causeway area that were sampled pre-2000s were either removed or modified following coal port expansion in the early 1980s (Levings 1985), posing challenges in comparative statistical analysis and interpretation of potential differences between historic and recent habitat use by juvenile salmon south of the causeway.

Post-2000s, sampling was undertaken within intertidal habitats north and south of the causeway and within subtidal waters off the terminal to aid in describing existing conditions and assessing potential effects associated with DP3 (Triton 2004) and RBT2 (Martel 2009; TDR MF-3 in Appendix AIR10-C of CEAR Document #388). Stations north and south of the causeway were selected by Martel (2009) to overlap with those sampled by Triton (2004) and allow among year comparisons. Also, the RBT2 2012-2013 field program built on that of Martel (2009) to add to the years of comparable baseline data. However, the small number of juvenile salmon caught in 2008 (seven individuals; Martel 2009), compared to 2004 (204 individuals; Triton 2004), as well as the use of different sampling gear (e.g., beam trawl (Triton 2004); beach seine (Martel 2009); for discussion on gear differences, see below), hinder the ability to undertake comparative statistical analysis and investigate potential differences in juvenile salmon habitat use over time.

Between 2008 and 2015, the VFPA undertook five years of habitat compensation monitoring associated with DP3, which focused on evaluating the use by juvenile salmon of created shore-tied habitats south of the causeway. Data collected in 2008, 2009, 2011, and 2012 were statistically compared, and no significant inter-annual differences were detected in the abundance of juvenile chum and Chinook caught south of the causeway (see Section 4.1.7 of TDR MF-3 in Appendix AIR10-C of CEAR Document #388). Juvenile salmon abundance data collected during the VFPA's habitat compensation monitoring for DP3 are not directly comparable with data collected during the Project's 2012-2013 field surveys due to differences in sampling timing and gear used (see Sections 5.1.1 and 5.1.2 of TDR MF-3 in Appendix AIR10-C of CEAR Document #388).

In summary, comparative statistical analysis of historic and recent juvenile salmon data is not feasible due to inconsistent sampling design across studies, lack of continuity and overlap of sampling stations, as well as differences in sampling timing and gear used (see below for details).

Differences in Sampling Timing

Differences in sampling timing during studies undertaken to date at Roberts Bank preclude the ability to conduct rigorous statistical analyses comparing historical data. Sampling timing (e.g., day or night, during ebb or flood tide) and frequency (e.g., biweekly, monthly, seasonally, etc.) may influence data collection and analysis results, especially if sampling is infrequent and does not coincide with the time juvenile salmon are present in the estuary. Migration of juvenile salmon to rearing habitats at Roberts Bank is transient and occurs in pulses, depending on species, life histories, and water discharge (Beamish et al. 2013). Depending on time of year, time of day, and tidal state, juvenile salmon may be found using different areas at Roberts Bank. Also, inconsistencies in sampling timing and frequency among various sampling programs may introduce bias in comparative statistical analyses when data are pooled.

Historically, much effort was invested in sampling the estuary during spring and summer to document relative abundance and estuarine habitat use of juvenile salmon during peak outmigration (Gordon and Levings 1984, MacDonald 1984). Sampling timing was inconsistent, however; for example, MacDonald (1984) reported that sampling in 1981 began in mid-June, thus most of the year's chum migration was missed and only the latter part of the Chinook migration was observed. In the 2000s, Triton (2004) sampled seasonally for a year, whereas samples were taken by Martel (2009) on two occasions in May and June 2008, resulting in a small number of juvenile salmon caught in 2008 (Martel 2009).

Sampling to date at Roberts Bank has also been undertaken during different tidal stages. Juvenile salmon likely use a succession of interconnected habitats for short periods over a tidal cycle, occupying low, mid, and high intertidal zones sequentially as the tide rises (Levings 2016). Thus, sampling during different tidal stages likely influences fish species composition and catch size. For example, sampling by Levings et al. (1983) at a variety of tide levels in the inter-causeway area showed that juvenile chum were more abundant during flood tides. Thus, low-tide sampling by Greer et al. (1980) and Conlin et al. (1982) underestimated juvenile chum abundance (Gordon and Levings 1984).

Post 2000s, sampling during day and night allowed for the investigation of diel patterns in the use of intertidal and nearshore habitats at Roberts Bank by juvenile salmon. As historic sampling was undertaken during the day only, annual trends in in diel habitat use at Roberts Bank by juvenile salmon cannot be reliably inferred from existing information.

Differences in Sampling Gear and Data Analysis

Across studies, a variety of gear has been used to sample different environments at Roberts Bank. For example, trawl nets and purse seines were deployed in subtidal waters off the existing terminal. Intertidal areas were sampled predominantly with beach seines; however, pole nets and minnow traps were also occasionally used.

Different sampling gear are selective for different size classes or species behaviour, depending on gear dimensions and deployment method. For example, mesh size of beach seines used at Roberts Bank to date has been variable, equal to 3 mm, 6 mm, and 6.35 mm (stretched).

A 3 mm to 6 mm range is generally considered appropriate for juvenile salmon sampling in the estuary (B.C. MELP 1997); however, smaller fish size classes tend to be underrepresented in the catch of larger (i.e., >6 mm) mesh sizes, resulting in biased estimates of abundance and population size structure (e.g., Beamesderfer and Rieman 1988).

Across studies, variability is also noted regarding the types of data collected. Specifically, studies have consistently reported on numbers of fish caught by date and sampling station; however, catch per unit of effort by species was not always estimated. Primary data on body lengths of juvenile salmon caught are also not available, and description of habitat types (e.g., sand flat, eelgrass, etc.) sampled at Roberts Bank has been scant.

Because of differences in sampling methods and available data described above, as well as year-to-year variability in catch abundances (influenced by complex salmon movements and factors (e.g., large-scale environmental forcing) external to the LAA), comparative statistical analysis and interpretation of trends over time are not feasible.

Report on displacement of juvenile salmon from the existing terminal and causeway as well as access to the inter-causeway area.

Empirical information that pre-dates causeway construction in the 1960s does not exist to inform pre-causeway use by juvenile salmon of intertidal rearing habitats, as well as movement patterns and estuarine residency at Roberts Bank. Therefore, the degree to which the existing causeway may have contributed to the displacement of juvenile salmon from rearing habitats at Roberts Bank, or may have hindered access to rearing habitats in the inter-causeway area, cannot be quantified. Post-causeway construction, there is no empirical evidence to suggest that juvenile salmon use of rearing habitats in the inter-causeway area has been impeded. Additional rationale is provided below.

As described earlier in the response, a statistical analysis to investigate differences in the use of rearing habitats north and south of the causeway is not feasible, given data limitations coupled with natural year-to-year variability in juvenile salmon abundance. Instead, historical data were synthesised (see Section 2.2 of TDR MF-3 in Appendix AIR10-C of CEAR Document #388) and qualitatively compared with results from the Project's 2012-2013 field surveys (for discussion, see Section 5.1 of TDR MF-3 and Section 4.1.7 of TDR MF-7 in Appendix AIR10-C of CEAR Document #388).

Studies conducted in the 1970s and 1980s showed that low tide use of intertidal rearing habitats in the inter-causeway area by juvenile chum and Chinook salmon was extensive (Goodman 1975, MacDonald 1984, Levings 1985). Levings (1985) suggested that construction associated with Westshore Terminals coal port expansion apparently did not divert juvenile salmon from the inter-causeway area. More recently, habitat compensation monitoring for DP3 and results from the Project's 2012-2013 field surveys revealed that habitats in the inter-causeway area continue to support rearing juvenile chum and Chinook salmon.

Table IR5-22-1 summarises body lengths of juvenile chum caught during spring (April) sampling in the inter-causeway area in early 1980s and early 2010s, as well as north of the

causeway in early 2010s. Body lengths for chum were extracted from the literature (sources identified in **Table IR5-22-1**), and are presented here for the first time (body lengths for Chinook were not available in the literature). A qualitative comparison of data snapshots from the 1980s and 2010s suggests that small (and presumably more vulnerable) size classes (i.e., < 45 mm fork length (FL)[2]) of juvenile chum salmon are present north and south of the causeway during the same time (e.g., during April sampling; **Table IR5-22-1**), and access to rearing habitats in the inter-causeway area does not appear to be impeded. As discussed earlier, due to the paucity of primary data on body lengths of juvenile chum and Chinook caught at Roberts Bank, a qualitative comparison is limited to juvenile chum and cannot be undertaken for juvenile Chinook.

Table IR5-22-1 Fork Length (Mean and Range, in mm) of Chum Salmon Rearing North of the Causeway and in the Inter-Causeway Area in the 1980s and 2010s

Location	Date	Mesh Size (mm)	Fork Length (mm)			Source
			Mean	Min	Max	
North of causeway	April 2012	6	42	33	69	1
	April 2013	6	43	31	79	1
Inter-causeway area	April 1980	3	41	37	45	2
	April 2011	6	50	38	61	3
	April 2012	6	38	35	57	3

Sources: 1: TDR MF-3 in Appendix AIR10-C of CEAR Document #388; 2: Gordon and Levings (1984); 3: 2008-2015 Deltaport Third Berth Habitat Compensation Monitoring Program.

Predict the effect of any displacement of juvenile salmon by the expanded causeway and new terminal structure, including the effect of exposure to predators and change in access to intertidal habitats in the inter-causeway area.

The potential effect on the migration behaviour of juvenile salmon from terminal placement and causeway widening was assessed qualitatively (see EIS Section 13.6.3.1). Two effects mechanisms—changes in the light environment and changes in habitat availability—were considered to have the potential to influence migration behaviour of juvenile salmon and result in a minor decrease of juvenile salmon productivity pre-mitigation. With implementation of mitigation measures, including adherence to juvenile salmon fisheries-sensitive window, implementation of a light management plan, as well as offsetting in the form of onsite native eelgrass transplants and reconstructed tidal marsh habitats north of the widened causeway, migration-related changes in juvenile salmon productivity were assessed as negligible. A summary regarding the effects on juvenile salmon migration from changes in the light environment and changes in habitat availability (included in EIS Section 13.6.3.1) is supplemented with additional information extracted from the literature in the response to IR5-18.

[2] Fork length equal or greater than 45 mm has been identified as the body size over which juvenile chum typically leave very shallow nearshore habitat for more open pelagic habitat (Healey 1980, 1982).

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IR5-23 Marine Fish – Juvenile Chinook Salmon Effects Assessment

Information Source(s)

EIS Volume 3: Section 13, Table 13-8

Context

The Proponent, in Table 13-8 of the EIS, identified that the placement of sand in the Intermediate Transfer Pit (ITP) has the potential to decrease marine fish productivity through:

- direct mortality (burial);
- acoustic disturbance from continuous noise from transport vessels;
- changes in water quality (increases in TSS);
- changes in sediment (contaminant re-suspension); and
- changes in habitat availability (shift from mud to sand).

These effects are predicted to have only limited interaction with environmental components because they will be temporary and localised, and highly mobile species are expected to relocate.

It is unclear whether indirect effects associated with juvenile Chinook and Chum Salmon displacement from the ITP area will increase their vulnerability to predators thereby reducing their survival and productivity.

Additional information about the indirect effects of habitat displacement of juvenile Chinook and Chum Salmon associated with sand placement in the ITP is required.

Information Request

Analyse the potential effects of the ITP on:

- juvenile salmon habitat quantity and quality;
- temporal (seasonal) overlap between sand deposition and juvenile salmon occurrence in the vicinity of the ITP;
- displacement of juvenile salmon;
- susceptibility of juvenile salmon to predation associated with habitat-related displacement; and
- changes in juvenile Chinook and Chum Salmon productivity associated with habitat-related displacement.

VFPA Response

The VFPA has revised the Project's construction plan to eliminate temporary storage of Fraser River sand in the intermediate transfer pit (ITP). As such, predicted effects to valued components from this activity will not be realised. For more information concerning the elimination of the ITP from the Project's construction plan, please see *Information Request*

Package 3 Preamble in Support of Responses to IR3-25 to IR3-40 – General and Disposal at Sea-related Project Construction Update in Part 2 of CEAR Document #984[1]. The Panel has requested the VFPA provide an updated project description and a revised effects assessment to account for these changes to the construction plan (see CEAR Document #995[2], #1054[3], and #1069[4]). The VFPA is currently preparing this document and will provide it to the Panel once it is complete.

[1] CEAR Document #894 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document #928).
[2] CEAR Document #995 From the Review Panel to the Vancouver Fraser Port Authority re: Requirements for information pertaining to changes to the Roberts Bank Terminal 2 Project.
[3] CEAR Document #1054 From the Vancouver Fraser Port Authority to the Review Panel re: Schedule for providing information regarding the revised Roberts Bank Terminal 2 Project description.
[4] CEAR Document #1069 From the Review Panel to the Vancouver Fraser Port Authority re: Response to the Vancouver Fraser Port Authority's plan for the presentation of the revised information (See Reference Document # 1054).

IR5-24 Marine Fish – Marine Fish Sub-components and Represented Marine Fish

Information Source(s)

Marine Shipping Addendum: Section 8.1.1, Table 8.1-1, Table 8.1-4

Appendix 8.0-A, Table 8.0-A1

Context

The Proponent, in Table 8.1-1 of the Marine Shipping Addendum, identified Pacific Herring and Pacific salmon as marine fish sub-components which are representative of forage fish and anadromous salmonids, respectively, in the marine shipping area. The Proponent stated that the descriptions of potential effects on Pacific salmon and Pacific Herring are sufficient to characterise the effects for other species, despite differences in life histories and habitat use identified in the rationale for selection of sub-components.

In Table 8.0-A1 of Appendix 8.0-A of the Marine Shipping Addendum, federally and provincially listed species at risk and species of conservation concern considered in the marine shipping area assessment were identified in relation to the represented species or subcomponents and rationale for the selection. For example, some fish species/populations identified included Okanagan Chinook Salmon; Fraser Coho Salmon; Cultus and Sakinaw Sockeye Salmon; and Eulachon.

Additional information about the marine fish species represented by the selected marine fish subcomponents in the effects assessment for the marine shipping area is required.

Information Request

Provide a table which summarizes the complete list of all represented pelagic marine fish species of the two selected sub-components of marine fish used in the marine shipping area effects assessment. Include descriptions of the primary habitat use, ecological attributes and, if relevant, the conservation status, of each represented species in the marine shipping area.

VFPA Response

Table IR5-24-A1 in **Appendix IR5-24-A** summarises baseline information for represented pelagic marine fish species in the marine shipping area, including descriptions of the primary habitat use, ecological attributes, and conservation status (where relevant).

The assessment completed in the Marine Shipping Addendum identified that the potential effect pathways for marine fish are vessel wake and underwater noise from passing vessels, and concluded that both potential effects are negligible for any marine fish species (see Section 8.1.6.1 of the Marine Shipping Addendum).

Appendices

Appendix IR5-24-A Supporting Table

APPENDIX IR5-24-A
SUPPORTING TABLE

Table IR5-24-A1 Represented Pelagic Marine Fish Species

English Name	Scientific Name	Listing Status*			Primary Habitat Use	Ecological Attributes	Marine Shipping Sub-component or Representative Species	Data Sources
		B.C. List	*SARA*	COSEWIC				
Bull trout	*Salvelinus confluentus*	Blue	No status	SC (2012)	Benthopelagic, freshwater, brackish, marine; in Squamish and lower Fraser rivers, annual seasonal peaks suggest anadromy; spawn in shallow, slow-flowing, low gradient streams, over small gravel, and under cover; spawning occurs in fall and eggs incubate during winter, fry emerge from the gravel in early spring; juveniles rear in spawning streams for at least 2 years before migrating to larger rivers or ocean; migration to nearshore coastal areas is protracted and probably occurs during multiple time periods in a year.	Anadromous; iteroparous; foraging occurs near substrate and in water column, but not at the surface; as they grow, juveniles shift their diet from benthic organisms and drift to small fish, such as sculpins, mountain whitefish, and trout fry.	Pacific salmon	1, 2
Chinook salmon	*Oncorhynchus tshawytscha*	Yellow	No status	T	Benthopelagic, 0 to 375 m depth; spawn in many tributary systems throughout the Fraser River watershed; spawning habitat requires gravel substrate with intra-gravel water flow; stream type Chinook spend 1+ years rearing in freshwater and complete extensive offshore migrations; ocean type Chinook spend 2 to 5 months rearing in freshwater and estuaries (most estuarine dependent off all Pacific salmon species) and spend most ocean life in coastal waters.	Anadromous; semelparous; diet includes fishes, crustaceans, and invertebrates (particularly harpacticoid copepods).	Pacific salmon	3, 5, 6, 7, 23, 24
Chinook salmon (Okanagan population)	*Oncorhynchus tshawytscha*	Yellow	No status	T (2006)	Migration and spawning occur outside marine shipping area in Columbia River Basin and Okanagan Lake, but marine shipping area may be part of marine distribution of smolts or adults migrating northward along the coast to the Gulf of Alaska.	Anadromous; semelparous; diet includes fishes, crustaceans, and invertebrates (particularly harpacticoid copepods).	Pacific salmon	8, 9
Chum salmon	*Oncorhynchus keta*	Yellow	No status	No Status	Benthopelagic, 0 to 250 m depth; spawn in several tributaries of the lower Fraser River, including Harrison/Chehalis/Weaver, Chilliwack/Vedder, and Stave watersheds; typically rear in estuaries in large schools for several weeks.	Anadromous; semelparous; juveniles and adults feed mainly on copepods, tunicates, and euphausiids but also on pteropods, squid, and small fishes; adults cease feeding in freshwater.	Pacific salmon	3, 5, 6, 10, 23, 24
Coho salmon	*Oncorhynchus kisutch*	Yellow	No status	E	Benthopelagic, 0 to 250 m depth; spawn throughout the Fraser River watershed; spawn on gravel substrate; most spend first year in freshwater; estuary residence time is unknown; oceanic residence typically 18 months in coastal waters.	Anadromous; semelparous; diet includes crustaceans, jellyfish, squids and fishes.	Pacific salmon	3, 5, 6, 11, 23, 24
Coho salmon (Interior Fraser population)	*Oncorhynchus kisutch*	Yellow	No status	E (2002)	Detected in marine shipping area: similar distribution to many other southern B.C. coho salmon populations, migrates through Fraser River to the ocean, documented in fisheries both inside (Strait of Georgia) and outside (west coast Vancouver Island).	Anadromous; semelparous; diet includes crustaceans, jellyfish, squids and fishes.	Pacific salmon	11
Cutthroat trout	*Oncorhynchus clarkii*	Blue	No status	No Status	Benthopelagic, 0 to 200 m depth; inhabit low elevation streams, sloughs, ponds, and lakes; spawn on gravel substrate; residence time in the ocean or estuary is usually less than a year.	Anadromous; iteroparous; diet includes small fishes (e.g., northern anchovy, greenling, rockfish), invertebrates (e.g., amphipods, shrimp, isopods), and insects.	Pacific salmon	3, 5, 6, 12

English Name	Scientific Name	Listing Status*			Primary Habitat Use	Ecological Attributes	Marine Shipping Sub-component or Representative Species	Data Sources
		B.C. List	*SARA*	COSEWIC				
Dolly varden	*Salvelinus malma*	No status	1-SC	SC (2010)	Benthopelagic, freshwater, brackish, marine; found in coastal drainages, associated with cool-body watersheds; lower Fraser River is likely used as a migratory corridor due to its proximity to nearshore estuarine, coastal feeding, overwintering grounds; enters the ocean regularly, with distribution not typically extending far inland; spawning can occur over multiple years, not necessarily in successive years; spawns in the fall within headwaters of small streams; fry emerge from the gravel in spring, smolts migrate to marine and estuarine habitats in spring and may remain for only 2 to 4 months before returning to fresh water; juveniles remain in the stream for 2 to 4 years.	Anadromous; diet varies with life history stages, influenced by presence of competing fish species; primarily includes drift, sea-run feed on macroinvertebrates, juvenile salmon, and other species of fish, while stream-resident form tends to feed near bottoms of creeks on nymphs and larvae of aquatic insects, with diet shifting to larger prey as fish grow.	Pacific salmon	13
Green sturgeon	*Acipenser medirostris*	Red	1-SC	SC (2013)	Demersal, 0 to 80 m depth; highly migratory; spawning occurs primarily in three rivers in the U.S.A.; juveniles rear in estuaries for several years; overwintering habitat off northwest coast of Vancouver Island.	Anadromous; spawning occurs every 2 to 5 years; diet includes zooplankton and zoobenthos (including clams, mollusks, and amphipods).	Pacific salmon	21, 22
Pink salmon	*Oncorhynchus gorbuscha*	Yellow	No status	No status	Benthopelagic, 0 to 250 m depth; major spawning habitat in mainstem Fraser River and tributaries in lower river, close to the sea; juvenile residence times in estuaries vary from a few weeks to a few months; offshore oceanic migrations often extensive.	Anadromous; semelparous; strict two-year life cycle, return to the Fraser River in odd years; diet includes a variety of invertebrates (including copepods, amphipods, euphausiids, and small fishes).	Pacific salmon	3, 5, 6, 17, 23, 24
Steelhead	*Oncorhynchus mykiss*	Yellow	No status	No status	Benthopelagic, 0 to 200 m depth; rear in freshwater for 1 to 3 years before migrating to ocean, sometimes spend a few weeks or months in estuaries; present in most coastal streams and in all the larger drainages of the Salish Sea.	Anadromous; iteroparous; diet includes a variety of aquatic and terrestrial invertebrates, fishes, and cephalopods.	Pacific salmon	3, 5, 20
Sockeye salmon	*Oncorhynchus nerka*	Yellow	No status	E	Benthopelagic, 0 to 250 m depth; key spawning and rearing habitat includes Harrison, Chilliwack, and Pitt Lake watersheds; lower Fraser River and estuary typically used as migratory pathway for smolts and adults with a residence period often less than 7 to 10 days (i.e., smolts do not use the Fraser River estuary as nursery habitat); most smolts tend to migrate north out of the Fraser River and enter ocean via Johnstone Strait.	Anadromous; semelparous; most fry spend 1 or 2 years in a lake before migrating; diet includes zooplankton (e.g., crab larvae), euphausiids, amphipods, copepods, and small fishes (e.g., Pacific sand lance) - less piscivorous than other salmon species.	Pacific salmon	3, 5, 6, 18, 19, 23, 24
Sockeye salmon (Cultus population)	*Oncorhynchus nerka*	Yellow	No status	E (2003)	Detected in marine shipping area: sockeye smolts typically outmigrate northward through Johnstone Strait upon emerging from the Fraser River (hence avoid the marine shipping area), but returning adults can take either the northern or southern route around Vancouver Island and hence may be present in the marine shipping area in abundance.	Anadromous; semelparous; most fry spend 1 or 2 years in a lake before migrating; diet includes zooplankton (e.g., crab larvae), euphausiids, amphipods, copepods, and small fishes (e.g., Pacific sand lance) - less piscivorous than other salmon species.	Pacific salmon	9
Sockeye salmon (Sakinaw population)	*Oncorhynchus nerka*	Yellow	No status	E (2006)	Detected in marine shipping area: sockeye smolts typically outmigrate northward through Johnstone Strait upon emerging from the Fraser River (hence avoid the marine shipping area), but returning adults can take either the northern or southern route around Vancouver Island and hence may be present in the marine shipping area in abundance.	Anadromous; semelparous; most fry spend 1 or 2 years in a lake before migrating; diet includes zooplankton (e.g., crab larvae), euphausiids, amphipods, copepods, and small fishes (e.g., Pacific sand lance) - less piscivorous than other salmon species.	Pacific salmon	9

English Name	Scientific Name	Listing Status*			Primary Habitat Use	Ecological Attributes	Marine Shipping Sub-component or Representative Species	Data Sources
		B.C. List	*SARA*	COSEWIC				
White sturgeon (Lower Fraser River population)	*Acipenser transmontanus*	Red	No status	T (2012)	Demersal, 1 to 122 m depth; spawning habitat exists in side channels of large rivers and requires deep, swift water and coarse substrates; juvenile habitat mainly lower reaches of tributaries, large backwaters, side channels, and sloughs; adults prefer deep nearshore areas adjacent to heavy flows.	Anadromous; slow growing and long-lived with delayed onset of sexual maturity; iteroparous; diet includes benthic invertebrates (such as crayfish, shrimp, and clams) and fish (such as lamprey, salmon, eulachon, and smelt), also scavengers.	Pacific salmon	21
Pacific herring	*Clupea pallasii*	No status	No status	No status	Marine; pelagic; coastal and offshore, to 250 m depth; spawn in estuaries on substrate/vegetation such as kelp or eelgrass; larvae and juveniles remain nearshore for first year; oceanic deepwater phase for next 2 to 3 years.	Schooling; oviparous; spawns from January to May in Salish Sea; diet consists of zooplankton, crustaceans, and small fishes.	Pacific herring	3, 4, 5, 23, 24
Eulachon (Fraser River population)	*Thaleichthys pacificus*	Blue	No status	E (2011)	Pelagic-neritic, from 0 to 300 m depth, most common between 50 to 200 m; occupy near-benthic habitats in open marine waters, spends 95% of its life in the marine environment; spawn in lower reaches of rivers with spring freshet.	Anadromous; semelparous; spawning in Fraser River occurs in April and May; planktonic larvae; feeds on plankton.	Pacific herring	25
Longfin smelt	*Spirinchus thaleichthys*	Yellow	No status	No status	Anadromous, benthopelagic; found close to shore to 137 m depth in bays and estuaries; spawns in coastal streams.	Schooling; oviparous; form spawning aggregations and lay eggs over sand in low velocity river habitats; diet primarily small crustaceans, including shrimp and copepods.	Pacific herring	3, 5, 23, 26
Northern anchovy	*Engraulis mordax*	No status	No status	No status	Pelagic-neritic, 0 to 310 m depth; marine; typically in coastal waters within about 30 km from shore.	Schooling; oviparous; batch spawner in inlets or offshore, throughout the year; intermittent fluctuations in abundance in the Salish Sea, largely related to changes in ocean temperature; diet includes euphausiids, copepods, and decapod larvae.	Pacific herring	4, 5, 23
Pacific hake	*Merluccius productus*	No status	No status	No status	Pelagic, oceanic, and coastal species; broad vertical distribution from surface to depths exceeding 900 m.	Schooling; oviparous; form spawning schools between 130 to 500 m along continental shelf; diet includes euphausiids, Pacific herring, and Pacific sand lance.	Pacific herring	27
Pacific sand lance	*Ammodytes personatus*	No status	No status	No status	Marine, to 172 m depth; epipelagic; migratory; buries in sand or gravel substrate in between periods of feeding activity.	Schooling; oviparous - deposit eggs on sand grains; planktonic larvae; feeds on zooplankton, particularly copepods.	Pacific herring	3, 5, 23, 24, 26, 28, 29, 30
Pacific tomcod	*Microgadus proximus*	No status	No status	No status	Marine, 0 to 275 m depth; may stray into brackish waters; demersal; sandy bottoms; young move into shallow waters in summer and fall, whereas adults usually stay in deeper waters.	Schooling; oviparous; noise sensitive (i.e., low hearing threshold); diet includes shrimps, amphipods, isopods, gastropods, mussels, and fishes.	Pacific herring	3, 5, 23
Pile perch	*Rhacochilus vacca*	No status	No status	No status	Marine, typically 0 to 90 m depth but reported to 210 m; demersal; usually found along rocky and sandy shores, often around pilings and in kelp beds.	Breeding involves courtship and mating; slow to mature; viviparous - give birth to highly developed young; found in loose schools or aggregations; diet includes various small crustaceans, mollusks, and algae.	Pacific herring	3, 5, 23
Shiner perch	*Cymatogaster aggregata*	No status	No status	No status	Marine, brackish, and freshwater, 1 to 146 m depth; non-migratory; seasonal onshore-offshore movements; typically in shallow waters, around eelgrass beds, piers and pilings.	Breeding involves courtship and mating; slow to mature; viviparous - give birth to highly developed young; found in loose schools or aggregations; diet includes various small crustaceans, mollusks, and algae.	Pacific herring	3, 5, 23, 24, 26, 28, 29, 31

English Name	Scientific Name	Listing Status*			Primary Habitat Use	Ecological Attributes	Marine Shipping Sub-component or Representative Species	Data Sources
		B.C. List	*SARA*	COSEWIC				
Striped perch	*Embiotoca lateralis*	No status	No status	No status	Marine, to 50 m depth; demersal; adults occur in rocky coasts and kelp beds, occasionally in sandy surf near rocks, around piers and beneath docks.	Breeding involves courtship and mating; slow to mature; viviparous - give birth to highly developed young; found in loose schools or aggregations; diet includes various small crustaceans, mollusks, and algae.	Pacific herring	3, 5, 28
Surf smelt	*Hypomesus pretiosus*	No status	No status	No status	Marine; brackish; benthopelagic; may ascend rivers, presumably returning to the sea shortly after; young believed to move offshore and reappear inshore as mature adults.	Schooling; oviparous; demersal eggs are laid on beaches with heavy surf action; diet includes small crustaceans, worms, jellyfish, and larval fishes.	Pacific herring	3, 5, 23, 24, 26, 30
Walleye pollock	*Gadus chalcogrammus*	No status	No status	No status	Marine, 0 to 1,280 m depth; semi-pelagic; perform diurnal vertical migrations; congregate in dense schools to spawn (usually at 50 to 250 m).	Schooling; oviparous, pelagic eggs; noise sensitive (i.e., low hearing threshold); diet is mainly copepods and krill (euphausiids) but also eat small fishes.	Pacific herring	3, 5, 24, 26

Note: * Listing Status:

- B.C. List = B.C. Conservation Data Centre: Red – Includes ecological communities, indigenous species, or subspecies that are extirpated, endangered, or threatened in B.C.; Blue – Includes ecological communities, and indigenous species and subspecies considered of special concern (formerly Vulnerable) in B.C.; Yellow – Includes ecological communities, and indigenous species that are not at risk in B.C. See B.C. Conservation Data Centre website for more details (http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/red-blue-yellow-lists).
- *SARA* = *Species at Risk Act*: 1-SC = Schedule 1: Special Concern – A species of special concern because of characteristics that make it is particularly sensitive to human activities or natural events.
- COSEWIC = Committee on the Status of Endangered Wildlife in Canada: E = Endangered - A species facing imminent extirpation or extinction; T = Threatened – A species that is likely to become endangered if limiting factors are not reversed; SC = Special Concern – A species of special concern because of characteristics that make it is particularly sensitive to human activities or natural events. Year in brackets indicates when the designation was made. See COSEWIC website for more details (http://www.cosepac.gc.ca/default.asp?lang=En&n=A9DD45B7-1).

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30 TDR MF-4 Forage fish beach spawn survey in Appendix AIR10-C (CEAR Document #388).
31 TDR MI-3 Orange Sea Pens (Ptilosarcus gurneyi) in Appendix AIR10-C (CEAR Document #388).

IR5-25 Marine Fish – Effects of Light on Juvenile Salmon

Information Source(s)

EIS Volume 3: Section 13.6.3.1, Table 13-9

CEAR Doc#647

Context

The Proponent, in Table 13-9 of the EIS, reported that changes to the light environment (artificial lighting) from the marine terminal during the operations phase can decrease marine fish productivity. Sections 13.6.3.1 and 13.6.3.3 of the EIS identified that Project-related changes in the light environment due to construction and operation are anticipated to have a minor negative effect on forage fish and Pacific salmon productivity.

According to Raincoast Conservation Foundation, the role of artificial lights in facilitating excessive predation by seals on juvenile salmon has been documented in British Columbia. Lighting and shading have the potential to negatively affect juvenile Chinook and Chum Salmon, but the magnitude of this effect was not quantified.

Additional information and rationale is needed to justify the Proponent's rating of minor for this potential effect.

Information Request

Identify the potential negative effects of lighting and shading on juvenile Chinook and Chum Salmon and all life stages of herring and Eulachon in the local assessment area for the proposed Project. Provide an evaluation of the magnitude and consequences of habitat displacement due to the effects of the proposed Project light increases during construction and operations.

Provide further rationale for the prediction that changes in the light environment will have a minor effect on juvenile Chinook and Chum Salmon and forage fish productivity.

VFPA Response

Identify the potential negative effects of lighting and shading on juvenile Chinook and Chum Salmon and all life stages of herring and Eulachon in the local assessment area for the proposed Project.

The response below expands on negative effects of lighting and shading that have the potential to occur during Project operation[1] on juvenile Chinook and chum salmon (identified

[1] Changes in the light environment anticipated to occur during Project construction are assessed as negligible, given the temporary nature of the disturbance, and the relatively small area of the effect.

in EIS Section 13.6.3.1), all life stages of herring (identified in EIS Section 13.6.3.3), and eulachon (represented by herring; see the VFPA's response to IR5-15 of CEAR Document #1078[2]). The assessment also considered potential positive effects on fish from structural lighting and shading. The response below also summarises literature findings that highlight positive influences on marine fish behaviour associated with Project-related changes in the light environment.

In summary, the assessment of potential effects of the Project predicted a minor decrease in juvenile salmon and herring productivity pre-mitigation that could result from lighting and shading associated with Project marine infrastructure. With mitigation, including implementation of a light management plan, effects on fish productivity from Project-related changes in the light environment will be negligible, with no residual effect. Additional information is provided below.

Juvenile Chinook and Chum Salmon

Changes in the light environment associated with lighting or shading from Project marine infrastructure may affect Pacific salmon productivity in the local assessment area (LAA) both positively and negatively (see EIS Section 13.6.3.1) due to (i) behavioural responses that may delay migration, (ii) reduced foraging success due to shading in the day, or increased foraging opportunities due to illumination at night, and (iii) increased predation risk (Nightingale and Simenstad 2001, Nightingale et al. 2006). These three elements are described further below.

Migration

A summary of lighting and shading effects on juvenile salmon migration, included in EIS Section 13.6.3.1, is supplemented with additional information extracted from the literature in the response to IR5-18. In summary, potential delays to outmigrating salmon from Project-related changes in the light environment in the LAA may range from a few hours to a couple of days (Prinslow et al. 1980, Ono and Simenstad 2014). This range represents a fraction of the time juvenile salmon spend rearing in the estuary. For juvenile chum, this time range represents <1% to about 8% of their residence time at Roberts Bank (reported to span 15 to 25 days (MacDonald 1984)), while for juvenile Chinook, this time range represents <1% to about 5% of their residence time at Roberts Bank (reported to span three to six weeks (DFO 2011)).

Also, construction activities will occur primarily during the day. Dredging will occur at night (i.e., 24 hours, 7 days per week), and the area of effect is expected to be limited to the immediate vicinity of the dredge equipment (see EIS Section 13.6.1.5).

[2] CEAR Document #1078 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR4-33, IR5-01, IR5-12, IR5-15, IR5-16, IR5-23, IR5-24, IR5-32, IR5-33, IR5-34, IR5-35, IR5-36, IR6-26, IR7-03, and IR7-05 (See Reference Documents #946, #975, #991, and #1000).

Foraging Opportunities

Daytime shading from overwater structures (e.g., docks, piers, marinas, ferry terminals) has been linked with reduced foraging success of juvenile Chinook and chum salmon (Ono et al. 2010), which depend on light for prey capture and schooling (Nightingale and Simenstad 2001, Nightingale et al. 2006). Studies conducted in Puget Sound show that juvenile salmon avoid structural shading and tend to move along the light side of the shadow's edge (Williams et al. 2003, Ono et al. 2010). Structural shading may limit plant growth and reproduction, as well as availability of juvenile salmon prey associated with marine vegetation, thereby reducing refugia and foraging opportunities for juvenile salmon (Nightingale and Simenstad 2001, Nightingale et al. 2006).

Artificial lighting associated with overwater structures along the shoreline has been shown to influence nighttime foraging behaviour of juvenile salmon. Nighttime observations in nearshore areas of Puget Sound indicate that, in the absence of artificial lighting, juvenile salmon are typically inactive, rest close to the substrate, and are not closely associated with each other (Tiffan et al. 2010; Tabor et al. 2011). Sudden exposure to high or intermediate light may cause temporary blindness in juvenile salmon and temporarily reduce foraging success (Ono et al. 2010). However, once adjusted to lit conditions (typically within 30 minutes from light exposure; Ali 1959), foraging success of juvenile salmon increases as juvenile salmon have been observed to behave more like they do during the day; they are active, often schooling and feeding at the surface on zooplankton and insects that have concentrated in the light field (Prinslow et al. 1980, Nightingale and Simenstad 2001, Tabor et al. 2017).

Predation Risk

Increased foraging success at nighttime due to artificial lighting (described above) may be counterbalanced by an increase in the risk of juvenile salmon predation. Predators may be attracted by nighttime lighting to areas where some juvenile salmon may congregate (Ginetz and Larkin 1976, Martel and Dill 1995, Yurk and Trites 2000, Nightingale et al. 2006, Ono et al. 2010). For example, Martel and Dill (1995) found that, under laboratory conditions, common mergansers took advantage of increased foraging activity higher in the water column under artificially lit conditions to prey on juvenile coho salmon. In the Puntledge River in B.C., harbour seals entered the river at dusk and appeared to use artificial nighttime lighting of overwater structures to prey heavily on migrating juvenile salmon (Yurk and Trites 2000). Several authors have hypothesised, but have not successfully demonstrated (Ono et al. 2010), that some juvenile salmon may be exposed to predators when deviating into deeper waters to avoid shaded areas (Heiser and Finn 1970, Salo et al. 1980, Williams et al. 2003).

The response to nighttime artificial lighting of predators targeting juvenile salmon is highly variable among species. For example, Prinslow et al. (1980) found that spiny dogfish, preying on juvenile chum in Hood Canal, Washington, were attracted to artificial lights where juvenile chum also congregated; however, five other predator species (i.e., hake, dogfish, sculpin, large Chinook, and coho) were not (Prinslow et al. 1980). Moreover, stomach content analysis of spiny dogfish did not demonstrate heavy chum consumption under artificially lit conditions (Prinslow et al. 1980). Petersen and Gadomski (1994) also showed that increasing the

intensity of light during nighttime caused northern pikeminnow to capture significantly fewer Chinook salmon, suggesting that artificial lighting may be manipulated to help reduce predation mortality on juvenile salmon. Conversely, Yurk and Trites (2000) demonstrated that turning off lights from overwater structures may temporarily reduce predation on juvenile salmon by harbour seals; however, seals eventually habituate to the lighting change.

In summary, effects of lighting and shading on juvenile salmon can be positive and negative and are highly variable and dependent on species. Lighting or shading may negatively affect movement patterns and migration timing of juvenile salmon. Changes in the light environment may also influence foraging success (i.e., increase foraging opportunities under lit conditions, or reduce prey availability due to shading), and risk to predation (although predatory response to changes in the light environment varies depending on species). Positive and negative influences on juvenile salmon behaviour were considered in the assessment of effects from Project-related changes in the light environment, and assessment conclusions are summarised below.

Assessment Summary

In the Project's LAA, changes in the light environment are predicted to occur during Project operation in the subtidal zone due to marine terminal placement (and associated lighting infrastructure). In contrast, the light environment in the intertidal zone is not predicted to differ from existing conditions following causeway widening (see EIS Section 9.4.8.2). Thus, the results of the assessment of Project effects concluded a minor loss in juvenile salmon productivity pre-mitigation (see EIS Section 13.6.3.1), attributed partially to potential lighting-related effects on migration of those salmon species that are shore-tied (such as chum), and may preferentially swim along the shoreline during their outmigration to estuarine rearing habitats (see response to IR5-18), and presumed increase in predation risk (e.g., by seals). As marine terminal placement is proposed to occur in the subtidal zone away from habitats optimal for juvenile salmon rearing, lighting-related effects on juvenile salmon foraging behaviour in the intertidal zone are not anticipated. During Project construction, lighting-related effects at nighttime will be temporary in nature and localised within a relatively small area of disturbance; also, most construction activities are scheduled to occur during the day.

Mitigation measures proposed will result in no residual effects on juvenile salmon from Project-related changes in the light environment. Project effects are avoided through placement of the terminal in the subtidal zone which will minimise the influence of lighting on intertidal habitats, including eelgrass beds, which represent optimal rearing habitats for outmigrating juvenile salmon. Onsite offsetting in the form of native eelgrass transplants and tidal marsh creation, will increase food supply and provide additional refuge for juvenile salmon moving along the causeway perimeter (see EIS Section 13.7.6). Lastly, implementation of a light management plan will further mitigate potential changes in the light environment, such that no residual change in Pacific salmon productivity is anticipated. Effectiveness of the light management plan will be maximised as follows:

- Described in EIS Section 13.7.5 for marine fish:
    - Orient light downward and away from the marine environment; and

    - Limit the use of lights to active work areas; and
- Described in Table IR12-A (Appendix IR12-A of CEAR Document #314[3]) for coastal birds, but expected to also benefit marine fish:
    - Use shielding to minimise light trespass; and
    - Where possible, use fixtures that emit light at specific wavelengths (that are not visible or disruptive to marine fish).

All Life Stages of Herring

Changes in the light environment with the Project have the potential to positively and negatively influence productivity of Pacific herring (adult and juvenile life stages) in the LAA, due to, respectively, (i) increased foraging success from prey illumination at night and (ii) increased risk of predation on herring foraging under artificial lighting at night (see EIS Section 13.6.3.3).

A review of the literature regarding lighting-related effects on herring spawning and spawn deposited on marine vegetation yielded no information. The Project is not expected to influence these life stages, as placement of the marine terminal in the subtidal zone will reduce spatial overlap with eelgrass beds that support some spawn in the LAA (see response to IR4-18 of CEAR Document #1051[4]). Based on literature (Gordon and Levings 1984, Hay and McCarter 2013, DFO 2016) and field studies undertaken at Roberts Bank by the VFPA from the early 2000s to the present, the LAA does not appear to be an important herring spawning area (see response to IR4-18 of CEAR Document #1051).

Adult and juvenile Pacific herring are visual predators and rely on light availability to detect prey (Batty 1987, Batty et al. 1990). At night, herring move up in the water column and make use of ambient lighting to prey on zooplankton that have come to the surface under cover of darkness; during the day, herring move deeper to reduce risk of predation (Blaxter and Parrish 1965, Batty 1987, Batty et al. 1990).

Artificial lighting during a dark night can illuminate zooplankton prey and may increase foraging opportunities for herring. For example, McConnell et al. (2010) found that artificial lighting associated with aquaculture pens resulted in increased aggregations of invertebrates and Pacific herring. Herring were observed feeding and schooling under the light where prey was more visible (McConnell et al. 2010).

Predators can also benefit from artificial lighting in finding and consuming herring. For example, herring aggregating under lit aquaculture pens were identified in the stomachs of farmed Chinook salmon (Black et al. 1992). Increased herring predation by spiny dogfish has

[3] CEAR Document #314 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review – Responses to Additional Information Requirements (See Reference Document #271) for the Environmental Impact Statement.
[4] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).

also been linked with artificial lighting from overwater structures in the Hood Canal, Washington (Prinslow et al. 1980).

As a result of the Project, and based on the review of existing information, gains in herring productivity through increased foraging efficiency are only likely to occur during cases where artificial lighting is introduced to the marine environment suddenly (e.g., during the Project construction phase). Increased predation may occur during Project operation, with minor consequences for herring productivity. As described above for juvenile Chinook and chum salmon, spatial overlap between the Project and eelgrass beds that support rearing Pacific herring will be minimised by placing the marine terminal in the subtidal zone. Moreover, implementation of proposed measures (including light management plan, and onsite offsetting in the form of native eelgrass transplants) is anticipated to mitigate potential lighting-related losses in herring productivity, such that no residual effect is anticipated.

All Life Stages of Eulachon

A review of the scientific literature on the effects of artificial lighting and structural shading on all life stages of eulachon yielded no information. In general, very little scientific information is available about the role of light on eulachon ecology. Spangler (2002) investigated the role of light intensity in the run timing of eulachon in Twentymile River, Alaska, and reported that spawning migration and larval downstream drift occur at night, likely due to a behavioural adaptation to escape predation (Spangler 2002). Eulachon spawning is also presumed to occur at night (Cambria Gordon Ltd. 2006).

As described in EIS Section 13.2.1 and in the response to IR5-15 (in CEAR Document #1078), eulachon was assessed via Pacific herring as a representative species, under the assumption that eulachon may interact with the Project and may be affected via mechanisms similar to herring. However, given differences in the life history and habitat requirements between eulachon and herring (described in response to IR5-15 of CEAR Document #1078), Project-related effects on eulachon from changes in the light environment are anticipated to be negligible.

Specifically, eulachon spawn in the lower Fraser River outside LAA boundaries (see response to IR5-15 of CEAR Document #1078), and are unlikely to interact with and be affected by Project-related infrastructure lighting during spawning. Anecdotal evidence[5] suggests that, during spawning migration, adult eulachon may transit through the deeper sections of the LAA; however, eulachon swim close to the seafloor (see response to IR5-15 of CEAR Document #1078), minimising the likelihood of interacting with marine infrastructure lighting, which will be located at the surface. Immediately after hatching, larvae are flushed into the

[5] As described in IR5-15 of CEAR Document #1078, there is anecdotal evidence that eulachon hold at Canoe Passage prior to upstream passage. Also, limited harvesting of eulachon for food, social, and ceremonial purposes occurs in Canoe Passage, Ladner Reach, and in waters around the Woodward Island complex (for details see EIS Sections 32.2.4.1 and 32.2.4.2, and references therein, specifically Blakley et al. (2011, 2012, 2013), Woolman (2014)).

Strait of Georgia rapidly by spring freshet, and rearing occurs in near-surface waters off the Gulf Islands (outside LAA boundaries) (see response to IR5-15 of CEAR Document #1078).

Provide an evaluation of the magnitude and consequences of habitat displacement due to the effects of the proposed Project light increases during construction and operations. Provide further rationale for the prediction that changes in the light environment will have a minor effect on juvenile Chinook and Chum Salmon and forage fish productivity.

As explained in the first part of this response, the assessment predicted a minor loss, pre-mitigation, in the productivity of juvenile Chinook and chum salmon and forage fish from Project-related changes in the light environment (in the form of artificial lighting or structural shading). Rationale for the minor effect prediction, outlined in EIS Sections 13.6.3.1 and 13.6.3.3, is detailed further in the first part of this response, and summarised below.

- Potential delays to outmigration of juvenile salmon (especially those salmon species that are shore-tied and may preferentially swim along the shoreline during their outmigration to estuarine rearing habitats) may range from a few hours to a couple of days, representing up to 8% of the time juvenile salmon spend rearing in the estuary.
- Lighting-related effects on forage fish migration are not anticipated for the following reasons:
    - Placement of the marine terminal (and associated lighting infrastructure) in the subtidal zone will minimise spatial overlap with habitats (e.g., eelgrass beds) optimal for Pacific herring spawning and rearing; and
    - Eulachon that may transit through the subtidal sections of the LAA are not anticipated to interact with Project lighting infrastructure, as they swim near the seafloor. No other eulachon life stages are using habitats in the LAA to undertake sensitive life history processes.
- Foraging behaviour and success of juvenile salmon and forage fish may be affected both negatively and positively:
    - Structural shading may reduce juvenile salmon foraging opportunities directly by affecting juvenile salmon foraging behaviour as they tend to avoid shaded areas, and indirectly by limiting plant growth, and availability of prey associated with marine vegetation; and
    - Artificial lighting may increase efficiency of juvenile salmon and forage fish feeding on prey concentrated in the light field.
- Artificial lighting may increase the risk of predation on juvenile salmon and forage fish; however, predator response to lighting is variable among species. Also, artificial lighting may be manipulated to help reduce predation mortality on juvenile salmon, in particular.

As described above, implementation of mitigation (including placement of the marine terminal in the subtidal zone, light management plan, and onsite offsetting in the form of native eelgrass transplants and tidal marsh creation), will mitigate potential adverse effects on juvenile salmon and forage fish productivity, such that no residual effect from changes in the light environment is anticipated. Consequently, a residual effect characterisation (including evaluation and rating of magnitude) is not applicable.

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IR5-26 Marine Fish – Effects of Underwater Noise on Juvenile Salmon

Information Source(s)

EIS Volume 3: Section 13.6.1.2; Section 13.6.3; Appendix 9.8-A, Appendix B, Table B-24 and B-25; Appendix 9.8-A, Appendix A, Figures A-47 to A-49

Context

As identified in Appendix 9.8-A of the EIS, the Proponent modelled the effects of underwater noise from construction and terminal activities on marine mammals and marine fish. The model used audiograms for Atlantic Salmon; Atlantic Herring; and a composite of Common Dab and Marbled Sole. The study considered the effects of underwater noise from 15 scenarios (impact and vibratory piling, vibro-densification, dredging, and berthing and approach of an E-class container ship with tug assistance) on salmon. For herring or flatfish, only audiogram-weighting for continuous sound activities was modeled for vibratory piling. Vibro-densification, dredging, tug assisted container ship berthing and tug assisted containership approach were not modelled for herring or flatfish.

The Proponent, in Section 13.6.1.2 of the EIS, identified that there are established injury criteria for impact pile driving (impulsive noise) that vary with fish size and that there are no fish harm guidelines for continuous noise from vibro-densification or dredging or behavioural threshold criteria or guidelines for marine fish, mainly due to a lack of scientific data on harmful exposures especially on a species-by-species basis. In the absence of an accepted quantitative threshold, the Proponent used a 90 dBht (species) standard as an indicator for potential behavioural effects. Further justification in the use of the 90 dBht standard in the assessment is required.

Additional information about the underwater noise effects from vibro-densification, dredging, tug assisted container ship berthing and tug assisted containership approach for herring and flatfish is required.

Information Request

Provide further justification for the use of the 90 dBht standard in the assessment of behavioural effects of underwater noise on juvenile Chinook and Chum Salmon, and all life stages of Pacific Herring and Eulachon.

Provide herring and flatfish audiogram weighted maps for the following activities:

- vibro-densification;
- dredging,
- berthing of tug assisted E-Class container ship; and,
- approach of tug assisted E-Class container ship.

Include a description of the findings and present the results in figures and tables, similar to those used in Figures A-47 to A-49 of Appendix A of Appendix 9.8-A, and in Tables B-24 and 25 of Appendix B of Appendix 9.8-A of the EIS.

VFPA Response

Provide further justification for the use of the 90 dBht standard in the assessment of behavioural effects of underwater noise on juvenile Chinook and Chum Salmon, and all life stages of Pacific Herring and Eulachon.

Effects on marine fish from Project-related changes in the acoustic environment are assessed in EIS Section 13.6.3 using underwater noise criteria described in EIS Table 13-2. Established criteria for assessing marine fish injury and mortality that may result from impulsive underwater sound[1] exist and were used in the EIS (see Table 13-2). However, no regulatory criteria or guidelines exist that can be applied to assess behavioural changes in marine fish that may result from non-impulsive (continuous) sound[2]. In the absence of universally accepted criteria or guidelines, the 90 dB_{ht} metric, proposed by Nedwell et al. (2007), was used in the assessment of potential behavioural effects from underwater noise on marine fish, as explained further below.

The dB_{ht} metric (also referred to in the literature as a species' behavioural threshold) represents the level of underwater noise above a species' hearing threshold (the 'ht' in the dB_{ht}) that results in a behavioural effect (Nedwell et al. 2007).

The hearing threshold of a fish species, considered in the dB_{ht} metric, is defined as the average sound level (measured in decibels (dB)) that is just audible to a fish species under quiet conditions (Nedwell et al. 2007, Hawkins et al. 2013).

Because fish species differ in terms of their sensitivity to underwater sound, hearing thresholds vary among species. For example, the hearing threshold of Atlantic salmon is 95 dB (Hawkins and Johnstone 1978), meaning that underwater sound must be 95 dB louder than quiet conditions to be just audible to the species. In contrast, the hearing of Atlantic herring is more sensitive and sound becomes audible at 75 dB above quiet conditions (Enger 1967).

The 90 dB_{ht} metric reflects the premise that behavioural effects occur when underwater noise (i) is loud enough to be uncomfortable or painful to fish, and (ii) will cause fish to instinctively react to protect their hearing (Nedwell et al. 2007). Fish with sensitive hearing (such as herring) may perceive a given noise level to be loud enough and react by swimming away; however, fish with poor hearing (such as salmon) may perceive the same noise level to be low and not react (Nedwell et al. 2007). Nedwell et al. (2007) also hypothesised that instinctive reaction to noise has evolved to occur at the upper end of the

[1] Impulsive sound is high in intensity, and of short duration (i.e., less than several seconds), generated from activities such as impact pile driving.
[2] Continuous sound is less intense but longer lasting than impulsive sound, and is generated from activities such as vessel movement, vibratory piling, and dredging.

species' loudness range to prevent a species being in a perpetual state of panic or avoidance. Therefore, fish behavioural effects are suggested to occur when underwater noise exceeds this upper end of the species' loudness range (Nedwell et al. 2007).

During a laboratory experiment using 15 fish species (including Atlantic salmon, Atlantic herring, and dab), Nedwell et al. (2007) determined that, across species, strong avoidance response by virtually all individuals starts at a level approximately 90 dB above a species' hearing threshold (study findings are summarised in **Table IR5-26-1**). For example, in Atlantic salmon, underwater noise would have to exceed 185 dB (i.e., 90 dB above the species' hearing threshold of 95 dB) to elicit a behavioural reaction. Similarly, Atlantic herring would react to underwater noise that exceeds 165 dB (i.e., 90 dB above the species' hearing threshold of 75 dB). Thus, 90 dB_{ht} was determined to be the loudness level above which behavioural effects would manifest regardless of species, and was deemed to be an appropriate universal metric to assess underwater noise-related behavioural effects on marine fish in general (Nedwell et al. 2007).

Table IR5-26-1 Reaction of Individual Fish to Varied Sound Levels Above a Species' Hearing Threshold (Expressed in dB_{ht})

dB_{ht}	Effect
<0	None
0–50	Mild reaction in minority of individuals, probably not sustained
50–90	Stronger reaction by majority of individuals, but habituation may limit duration of effect. At 75 dB_{ht}, approximately 85% of individuals will react to the noise
>90	Strong avoidance reaction by virtually all individuals

Source: Nedwell et al. 2007

There is some precedence in applying the dB_{ht} metric to assess behavioural effects on marine fish from underwater noise associated with offshore development in the United Kingdom (UK) (Hawkins and Popper 2016). In the U.S.A., the National Marine Fisheries Service has used 150 dB re 1 µPa rms[3] as a criterion for behavioural effects on protected marine fish species, but no data or literature have been put forward to support this choice (Hawkins and Popper 2016).

Establishment of the 90 dB_{ht} metric and its applicability in assessing noise-related behavioural effects on fish have been criticized in the literature (see response to IR5-27). However, no regulatory criteria or guidelines exist, in Canada or anywhere else in the world, that can be applied to assess noise-related behavioural effects on fish. During the panel review process of the Trans Mountain Expansion project, Fisheries and Oceans Canada (2015) acknowledged that detailed assessment on behavioural responses of marine fish to underwater noise is difficult given the lack of established Canadian standards or thresholds and limited species-specific information on noise sensitivity. Hence, in the absence of

[3] rms = root-mean-square

universally accepted criteria or guidelines, the 90 dB_{ht} metric was used in the environmental assessment for the Trans Mountain Expansion project.

There is no site-specific information on the hearing sensitivity of juvenile Chinook and chum, and all life stages of Pacific herring and eulachon. As such, the assessment assumed that hearing thresholds of Atlantic salmon (i.e., 95 dB[4]) and Atlantic herring (i.e., 75 dB) were representative of Pacific salmon and Pacific herring, respectively (see Section 2.2.1 of EIS Appendix 9.8-A), supposing similarities in their physiology, and the structure and function of their auditory systems. Eulachon was considered in the assessment via the use of Pacific herring as a representative species (see response to IR5-15 in CEAR Document #1078[5]). The 90 dB_{ht} metric was then applied to the above-listed hearing thresholds to determine the zone within which noise-related behavioural effects to salmon, and herring (also eulachon) would have the potential to occur. Appendices A and B of EIS Appendix 9.8-A also show the distance from the sound source underwater sound at levels 10 dB_{ht} and 50 dB_{ht} would be audible to salmon and herring, but would not result in behavioural effects.

Although represented by herring, eulachon lack a swim bladder (Phleger 1998, Bone and Moore 2008), and are likely not as sensitive to underwater noise as herring. However, information from Musqueam First Nation and the literature suggests that eulachon are skittish, and schools could stray if disturbed (Pickard and Marmorek 2007, Schweigert et al. 2012). Thus, the assessment of underwater noise-related effects on herring is considered conservative and appropriate for eulachon (see response to IR5-15 in CEAR Document #1078).

[4] A hearing threshold of 88 dB was determined for juvenile Chinook salmon from the lower Columbia River (Halvorsen et al. 2009). This value is similar to the hearing threshold of flatfish (i.e., 90 dB) used in the assessment (see EIS Appendix 9.8-A and EIS Section 13.6.3.4). However, because of limitations in their experiment, Halvorsen et al. (2009) caution that the hearing threshold determined for juvenile Chinook cannot be considered to represent the hearing sensitivity of Pacific salmon. Therefore, the approach used in the assessment to consider the hearing sensitivity of Pacific salmon similar to, and thus represented by Atlantic salmon, remains valid.

[5] CEAR Document #1078 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR4-33, IR5-01, IR5-12, IR5-15, IR5-16, IR5-23, IR5-24, IR5-32, IR5-33, IR5-34, IR5-35, IR5-36, IR6-26, IR7-03, and IR7-05 (See Reference Documents #946, #975, #991, and #1000).

Provide herring and flatfish audiogram weighted maps for the following activities: vibro-densification; dredging; berthing of tug assisted E-Class container ship; and, approach of tug assisted E-Class container ship.

To clarify, EIS Appendix 9.8-A presents underwater noise modelling results for piling (impact and vibratory), and continuous non-piling scenarios (i.e., vibro-densification[6], dredging, berthing, and approach of a tug-assisted E-class container ship) for salmon, while for herring and flatfish, results are presented for impact and vibratory piling only. As indicated in EIS Section 9.8 (including EIS Tables 9.8-4 to 9.8-6), impact and vibratory piling were determined to be the loudest when compared to other Project construction and operation activities; thus, consideration of these two activities in the assessment of behavioural effects to marine fish is considered a conservative approach.

To answer this information request, underwater noise modelling of continuous non-piling scenarios was undertaken for herring (but not for flatfish; see below for rationale), and modelling results are presented below in tables and figures. In summary, based on additional modelling undertaken for this information request, behavioural effects to fish from continuous non-piling activities do not change conclusions made in the EIS, as distances from the sound source underwater noise may result in behavioural effects to fish remain small (i.e., <20 m).

Consistent with Appendices A and B of EIS Appendix 9.8-A, **Tables IR5-26-2** to **IR5-26-4** present the 95th percentile and maximum sound pressure level radii, and zone of audibility, of herring for the above-listed continuous non-piling scenarios. Herring audiogram-weighted maps for the same scenarios are included in **Figures IR5-26-1** to **IR5-26-4**.

Tables IR5-26-2 and **IR5-26-3** show the distance from the sound source sound pressure levels of 10 dB_{ht}, and 50 dB_{ht} are audible to herring, but would not result in a behavioural effect. Underwater noise modelling results for herring and flatfish are discussed in the third part of the response.

Audiogram-weighted maps, and tables describing zone of audibility and sound pressure level radii for continuous non-piling scenarios have not been developed for flatfish. Flatfish have a higher hearing threshold (i.e., 90 dB; composite of dab (Chapman and Sand 1974) and sole (Zhang et al. 1998)) than herring (i.e., 75 dB), and hence are not as sensitive to underwater noise as herring. Hence, results for piling and other continuous non-piling scenarios presented in Appendices A and B of EIS Appendix 9.8-A for salmon (all piling and continuous non-piling activities were modelled already in the EIS for salmon) are expected to be comparable to those for flatfish.

[6] Vibro-replacement is a subsoil improvement technique that uses special depth vibrators to replace finer material (e.g., clay, sand) with coarser material. Vibro-densification also uses depth vibrators to densify in situ material and is not considered a material replacement technique. Vibro-replacement activities are no longer required to improve the seismic response of soils below the base of the dredge basin (as described in the Preamble to Information Request Package 3 in Support of Responses to IR3-25 to IR3-40; CEAR Document #984); thus, vibro-replacement was not modelled for this response.

In summary, based on modelling results for Pacific salmon (see Tables B-24 and B-25 of EIS Appendix 9.8-A), behavioural effects to flatfish from changes in the acoustic environment are expected to be negligible. Specifically, for Pacific salmon and expected for flatfish, underwater noise is not likely to reach the 90 dB_{ht} metric during Project construction activities generating continuous noise (i.e., vibro-densification, dredging) or during operation (i.e., vessel berthing and approaching).

Table IR5-26-2 Herring Zone of Audibility and Range ($R_{95\%}$) to Sound Pressure Levels for Continuous Non-piling Scenarios

SPL (dB re HT)	S11 Vibro-densification at Dredge Basin (m)	S12 Dredging at Dredge Basin (m)	S14 Berthing (m)	S15 Approaching (m)
ZOA	39,490	43,260	67,290	98,260
10	43,550	46,160	67,810	70,220
50	800	550	6,880	2,040
90	<10	<10	20	10

Notes: $R_{95\%}$ = radii (in m) underwater sound propagates at the 95th percentile sound pressure level, SPL = sound pressure level, ZOA = zone of audibility

Table IR5-26-3 Herring Zone of Audibility and Range (R_{max}) to Sound Pressure Levels for Continuous Non-piling Scenarios

SPL (dB re HT)	S11 Vibro-densification at Dredge Basin (m)	S12 Dredging at Dredge Basin (m)	S14 Berthing (m)	S15 Approaching (m)
ZOA	61,740	68,420	118,270	119,720
10	61,710	63,930	85,850	85,470
50	870	630	7,750	2,430
90	<10	<10	20	10

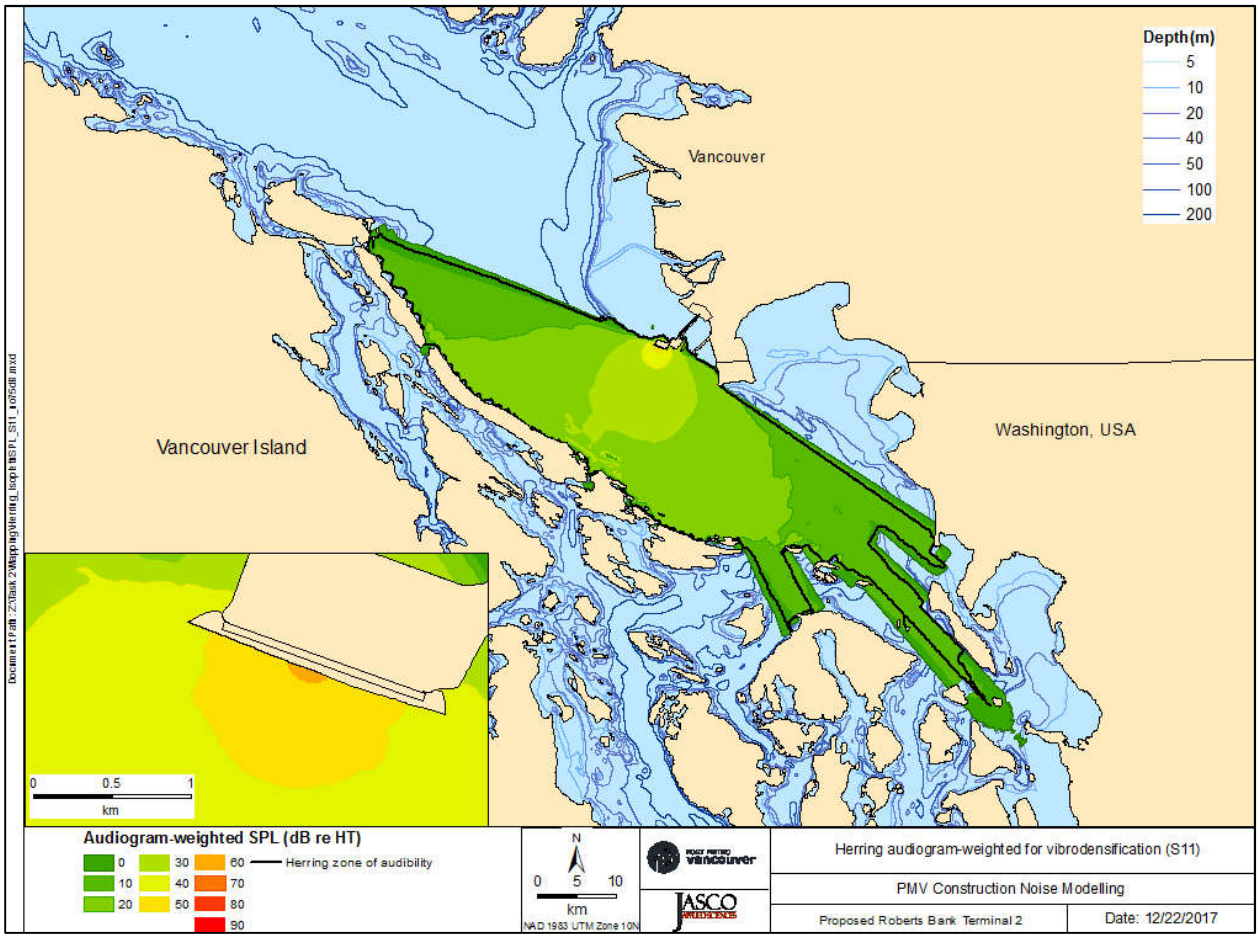
Notes: R_{max} = radii (in m) underwater sound propagates at the maximum sound pressure level, SPL = sound pressure level, ZOA = zone of audibility

Table IR5-26-4 Area of Ensonification for Herring Zone of Audibility for Continuous Non-piling Scenarios ($R_{95\%}$)

SPL (dB re HT)	S11 Vibro-densification at Dredge Basin (m)	S12 Dredging at Dredge Basin (m)	S14 Berthing (m)	S15 Approaching (m)
ZOA	112,040	120,230	159,260	201,440

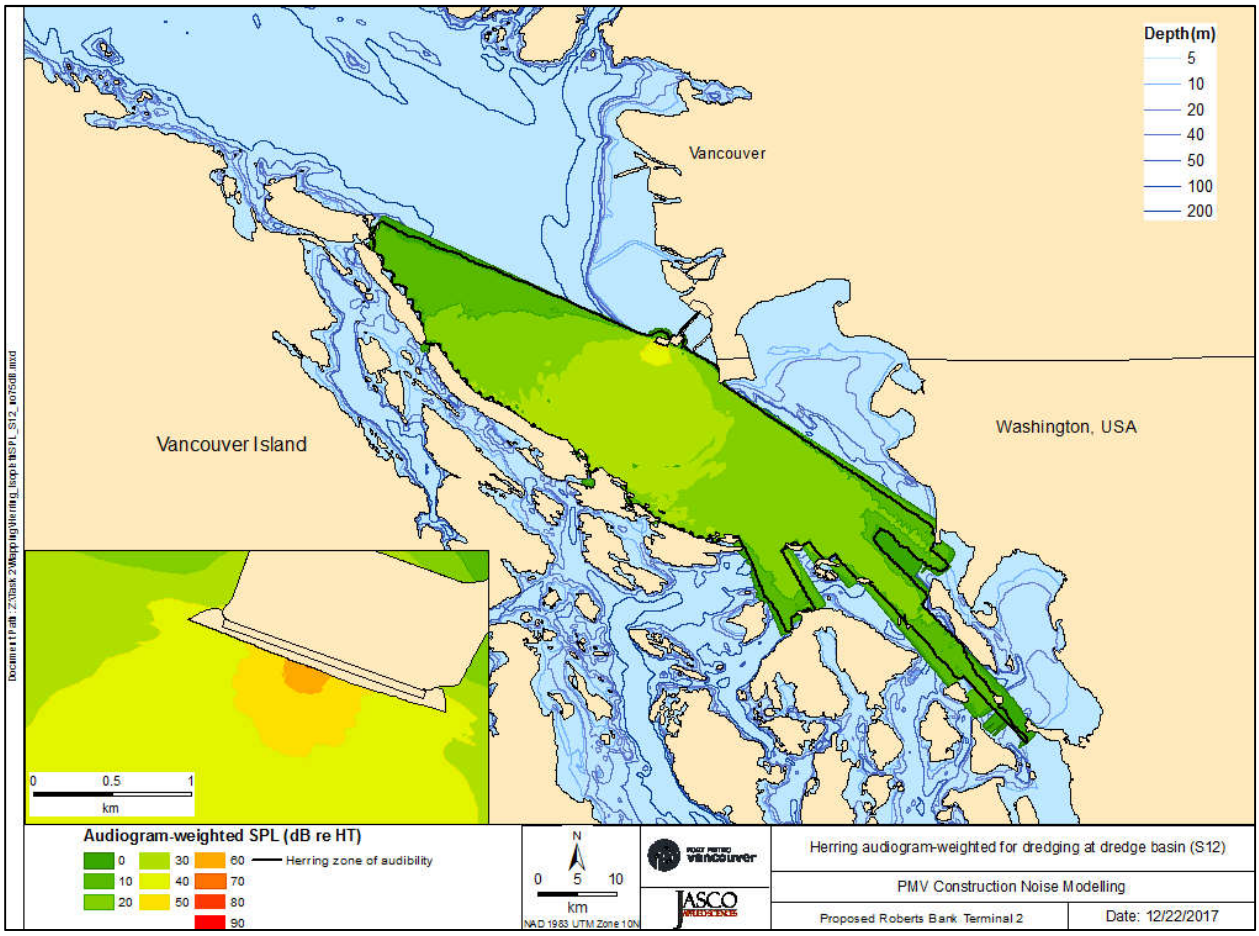
Notes: Area of ensonification = area affected by a sound source, SPL = sound pressure level, ZOA = zone of audibility

Figure IR5-26-1 Herring Audiogram-weighted Map for Vibro-densification at the Dredge Basin (S11)



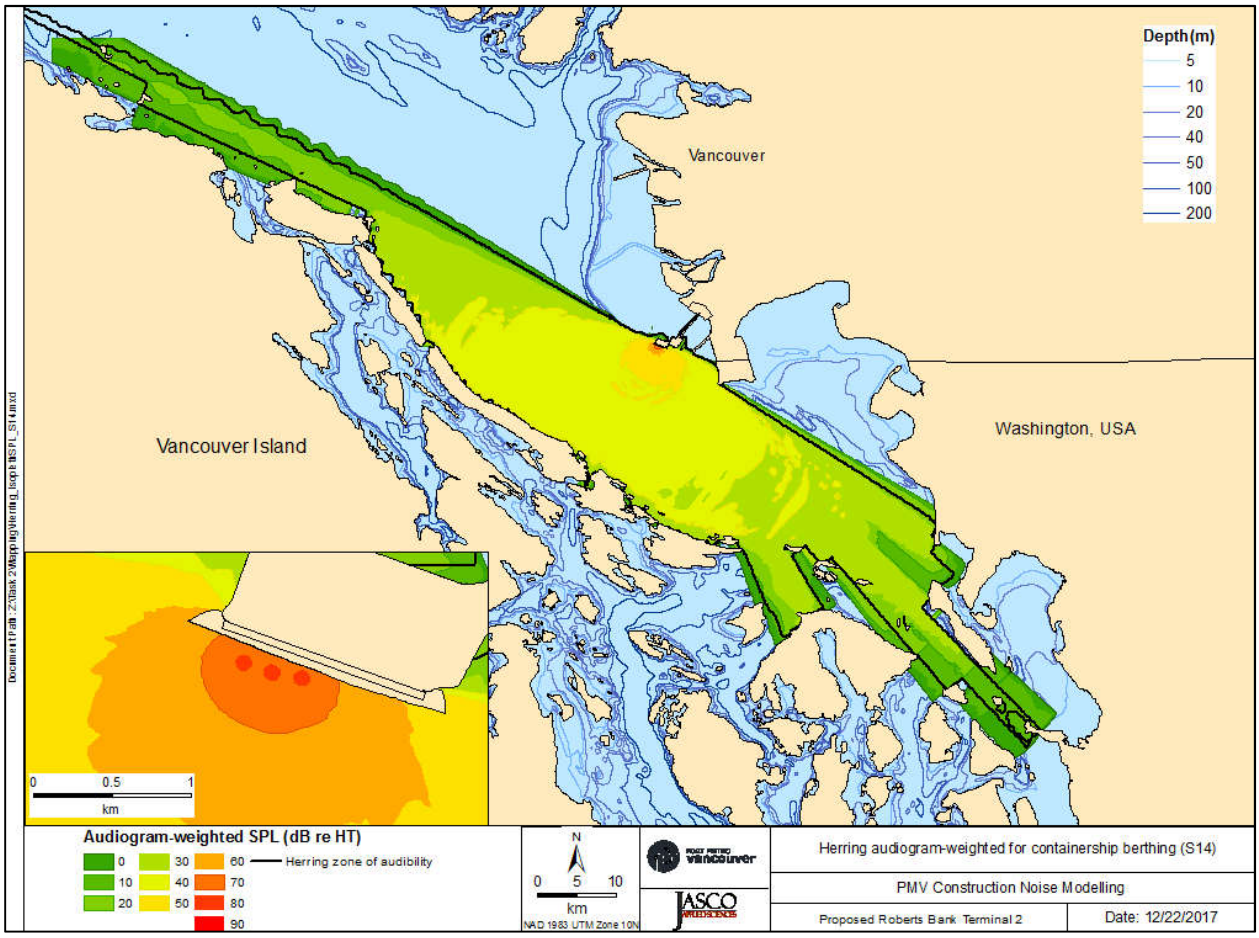
Note: SPL = sound pressure level.

Figure IR5-26-2 Herring Audiogram-weighted Map for Dredging at the Dredge Basin (S12)



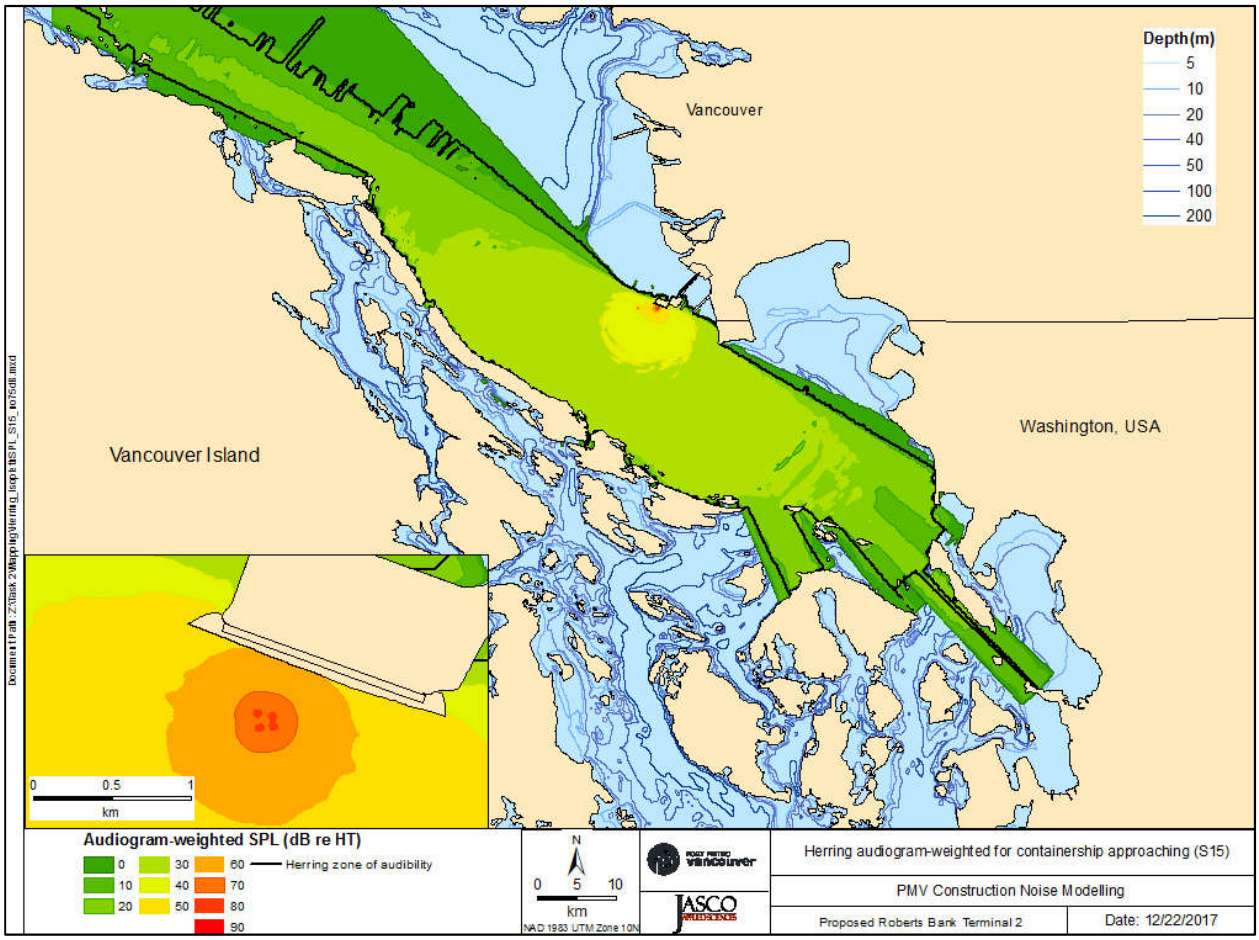
Note: SPL = sound pressure level.

Figure IR5-26-3 Herring Audiogram-Weighted Map for Berthing of a Tug-assisted E-Class Container Ship (S14)



Note: SPL = sound pressure level

Figure IR5-26-4 Herring Audiogram-weighted Map for Approach of a Tug-assisted E-Class Container Ship (S15)



Note: SPL = sound pressure level.

Include a description of the findings and present the results in figures and tables, similar to those used in Figures A-47 to A-49 of Appendix A of Appendix 9.8-A, and in Tables B-24 and 25 of Appendix B of Appendix 9.8-A of the EIS.

In summary, modelling results for herring presented in this response indicate that continuous underwater noise from non-piling scenarios is likely to reach 90 dB_{ht} for herring within the immediate vicinity of the sound source; if 90 dB_{ht} for herring are exceeded, behavioural effects to herring are expected to be localised. Details are provided below. As indicated earlier in the response, modelling of continuous non-piling scenarios was not undertaken for flatfish, as results presented in the EIS for salmon are anticipated to be similar for flatfish due to similarities in noise sensitivity.

Modelling results for herring presented in this response are comparable to those in the EIS for vibratory piling (see Tables B-30 and B-31 of EIS Appendix 9.8-A), and of lesser scale compared to those in the EIS for impact piling (see Tables B-27 and B-28 of EIS Appendix 9.8-A), which produces impulsive sound of higher intensity than continuous piling and non-piling construction activities. As the EIS conservatively assessed minor noise-

related behavioural effects on herring from impact piling activities, modelling results presented here do not influence conclusions made in the EIS.

Specifically, during vibro-densification and dredging at the dredge basin (Project construction phase), underwater noise may reach 90 dB_{ht} for herring within 10 m from the sound source (**Tables IR5-26-2** and **IR5-26-3**; red contours in **Figures IR5-26-1** and **IR5-26-2**). In comparison, during vibratory and impact piling, 90 dB_{ht} for herring may be reached within 20 m and 150 m (with mitigation) from the sound source, respectively (see Tables B-27 and B-28 of EIS Appendix 9.8-A).

During berthing and approach of a tug-assisted E-class container ship (Project operation phase), 90 dB_{ht} for herring may be reached within approximately 10 m to 20 m from the sound source (**Tables IR5-26-2** and **IR5-26-3**; red contours in **Figures IR5-26-3** and **IR5-26-4**). As indicated in Undertaking #1 of CEAR Document #667[7] and in responses to IR4-11 and IR4-13 of CEAR Document #1051[8], however, it is highly unlikely that E-class container ships (i.e., ships greater than 15,000 twenty-foot equivalent units (TEUs)) will call on RBT2 before 2035, and may likely never enter the trans-Pacific service. Instead, vessel size representative of the Project is considered to be approximately 9,365 TEUs (see CEAR Document #667). Therefore, associated underwater noise that will be generated during vessel berthing and approach is anticipated to be of lesser scale (see responses to IR4-11 and IR4-13 of CEAR Document #1051), and unlikely to result in a behavioural effect on herring.

As indicated in EIS Sections 13.6.3.1 and 13.6.3.4 for salmon and flatfish, respectively, behavioural effects from underwater noise are expected to be negligible, as 90 dB_{ht} may be reached within 30 m from the sound source during impact piling activities only; the metric is not reached during any of the construction and operation activities that produce continuous underwater noise (also see Tables B-18 to B-23 (salmon) and Tables B-33 to B-38 (flatfish) of EIS Appendix 9.8-A). As indicated in the first part of the response, eulachon, although represented in the EIS by herring, are likely not as sensitive to underwater noise as herring; thus, the assessment of underwater noise-related effects on herring is considered conservative and appropriate for eulachon.

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[7] CEAR Document #667 From the Vancouver Fraser Port Authority to the Review Panel re: Orientation Session #2 Undertaking #1: Estimate of the number of ultra-large ships that would call on Roberts Bank Terminal 2.
[8] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).

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IR5-27 Marine Fish – Effects of Underwater Noise on Pacific Salmon

Information Source(s)

Marine Shipping Addendum: Section 8.1.6.1, Appendix 7.6-A

CEAR Doc#363

CEAR Doc#647

Context

In Appendix 7.6-A of the Marine Shipping Addendum, the Proponent identified that the acoustic impact criteria for assessing the effects of underwater noise from container ships on Pacific Herring and Pacific salmon is based on a 90 dB re HT SPL (which is an audiogram weighted dB above a species' hearing threshold behavioural response threshold) for salmon and herring. The audiogram-weighted sound levels were calculated based on estimated hearing thresholds for marine mammals and fish, as described in the EIS Appendix 9.8-A, Construction and Terminal Activity Underwater Noise Modelling Study Technical Report, which relied upon audiograms for Atlantic Salmon and Atlantic Herring.

According to Raincoast Conservation Foundation, the standard which the Proponent chose to use is inappropriate as it is based on a report which looked at the effect of pile driving noise (associated with the construction of wind farms) which creates a very different noise spectrum than container ship operations. The use of the 90 dB standard also provides no information on the minimum level of noise at which effects begin to occur, but instead is the level at which all individuals exhibit a strong response.

According to Ecojustice, the 90 bBht behavioural threshold for salmon is based on a reference to a study conducted in a laboratory setting with only two adult Atlantic Salmon.

There is uncertainty in the prediction of the effects of underwater noise on juvenile and adult Pacific salmon and Pacific Herring behavior.

Information Request

Based on literature information, analyse the uncertainty regarding underwater noise effects on juvenile and adult salmon.

Assess the potential behavioural effects of underwater noise on juvenile and adult Pacific salmon, Pacific Herring and Eulachon in the local assessment area of the Marine Shipping Addendum.

VFPA Response

Based on literature information, analyse the uncertainty regarding underwater noise effects on juvenile and adult salmon.

As per the context to this information request, the response below analyses uncertainty regarding the prediction of behavioural effects from Project-related shipping noise on juvenile and adult salmon. Such uncertainty, linked primarily with the scarcity of methods to assess behavioural effects that are generic and applicable across fish species, is reviewed extensively in the literature (e.g., Popper et al. 2014, Hawkins et al. 2015, Hawkins and Popper 2016a,b, Carroll et al. 2017), and is acknowledged in EIS Section 13.6.1.2 and Marine Shipping Addendum (MSA) Section 8.1.6.1. The response below also describes how uncertainty was managed in the assessment. Despite uncertainty, the 90 dB_{ht} metric (proposed by Nedwell et al. 2007) applied in the assessment of behavioural effects on salmon and herring from Project-related shipping noise, is the only method backed by empirical observations (see response to IR5-26). Thus, in the absence of universally accepted criteria or established regulatory thresholds, the dB_{ht} approach represents the best available method at the time of EIS and MSA preparation, and currently.

Behavioural effects from underwater noise on fish (including salmon) are described in the literature (and are summarised in EIS Section 13.6.1.2 and MSA Section 8.1.6.1). However, it has been deemed challenging in the literature to develop methods that evaluate conditions under which underwater noise may elicit fish behavioural responses, for reasons provided below (Hawkins and Popper 2016a,b, Carroll et al. 2017).

It is not realistic to assume that virtually all extant fish species respond to underwater noise in a similar manner; it is also overly simplistic to apply the same response criteria to multiple species with divergent sensitivities to noise (Hawkins et al. 2013, Hawkins and Popper 2016a,b, Carroll et al. 2017). Data on hearing sensitivity exist for only about 100 of the more than 33,000 recorded fish species (Hawkins and Popper 2016b). Also, fish behavioural responses are influenced by a number of factors, including variability among species in the structure and function of auditory systems (e.g., perception of particle motion as opposed to sound pressure), ambient noise conditions, degree of habituation, and an individual's motivation (e.g., whether a fish is feeding, mating, etc.) at the time of sound exposure (Hawkins and Popper 2016a,b, Carroll et al. 2017). Hearing sensitivity and response to sound may also vary among different life history stages of the same fish species, due to changes in the auditory system that occur with growth and age (Carroll et al. 2017).

Establishing criteria (such as the 90 dB_{ht} metric used in the Project's effects assessment) to assess behavioural effects on fish (including salmon) from underwater noise is debated in the literature (Hawkins et al. 2013, Hawkins 2016a,b, Carroll et al. 2017). This is because metrics are generally derived using data on the hearing sensitivity of fish acquired primarily using experimental cages or tanks in a laboratory environment. It is argued that the sound field in a laboratory setting is often complex and unlike that encountered by fish in the natural environment, as sound reflects off tank walls cause interference, also affecting levels and direction of particle motion. Fish in a tank are unable to escape the sound source, which may

influence their behavioural response and its interpretation (Hawkins et al. 2013, Hawkins 2016a,b, Carroll et al. 2017).

As described in EIS Section 13.6.1.2 and MSA Section 8.1.6.1, and given the uncertainty described above, there is no formal consensus regarding measurement and evaluation of behavioural effects on fish from underwater noise (Hawkins et al. 2013, Hawkins and Popper 2016a,b, Carroll et al. 2017). Also, no regulatory criteria or guidelines exist, in Canada or anywhere else in the world, that can be applied to assess noise-related behavioural effects on fish (including salmon). There is some precedence in applying the 90 dB_{ht} metric to assess behavioural effects on marine fish from underwater noise associated with offshore development in the United Kingdom (Hawkins and Popper 2016b). During the panel review process of the Trans Mountain Expansion project, Fisheries and Oceans Canada (2015) acknowledged that detailed assessment on behavioural responses of marine fish to underwater noise is difficult given the lack of established Canadian standards or thresholds and limited species-specific information on noise sensitivity.

In the absence of universally accepted criteria or guidelines, the 90 dB_{ht} metric was considered to be the best available information at the time of EIS and MSA preparation, and currently. The metric was considered universal in that Nedwell et al. (2007) accounted for the hearing threshold of every species considered in the experiment (including salmon), and all species in the experiment were recorded to perceive sound and respond to loudness levels in a similar manner (also see response to IR5-26). Also, as described in the response to IR5-26, the dB_{ht} metric was determined during a laboratory experiment, and supplemented with field observations of fish behavioural responses to continuous noise generated during operation of a fish avoidance system at a nuclear power station, and of a fish guidance system in shallow hatchery raceways (Nedwell et al. 2007). It was not conducted during pile driving of windfarm construction as stated in the context to this information request. It was deemed appropriate to use in the MSA, as marine shipping noise is also continuous.

Uncertainty described above was managed in the assessment by adopting a conservative approach and assessing potential behavioural effects from underwater noise not only on Pacific salmon, but also on Pacific herring, which is considered a more sensitive species to underwater noise than Pacific salmon (see EIS Section 13.6.3.3 and MSA Section 8.1.6.1). For both assessments (EIS and MSA), the hearing sensitivity of Pacific salmon[1] was considered to be similar to, and thus represented by, Atlantic salmon, given similarities in their physiology, and the structure and function of their auditory systems (based on information on the inner ear anatomy of the following salmonids: lake whitefish (Popper 1976, 1977),

[1] A hearing threshold of 88 dB was determined for juvenile Chinook salmon from the lower Columbia River (Halvorsen et al. 2009). If this value, which is similar to the hearing threshold of flatfish (i.e., 90 dB) used in the EIS, were to be applied in the assessment of behavioural effects on salmon from continuous underwater noise, modelling results would be similar to flatfish and assessment predictions for salmon presented in the EIS would not change (see EIS Appendix 9.8-A and EIS Section 13.6.3.4). However, because of limitations in their experiment, Halvorsen et al. (2009) caution that the 88 dB hearing threshold determined for juvenile Chinook cannot be considered to represent the hearing sensitivity of Pacific salmon. Therefore, the approach taken in the EIS to consider the hearing sensitivity of Pacific salmon similar to, and represented by Atlantic salmon, remains valid.

Atlantic salmon (Popper 1976, 1977), and rainbow trout (Popper et al. 2007)). The same approach was applied to Pacific herring, which was assumed to respond to underwater noise in a manner similar to Atlantic herring (e.g., Wilson et al. 2003). Based on this approach, behavioural effects from Project-related marine shipping generated underwater noise on juvenile and adult Pacific salmon, as well as the noise sensitive herring, were assessed to be negligible (EIS Section 13.6.3.1 and MSA Section 8.1.6.1).

Assess the potential behavioural effects of underwater noise on juvenile and adult Pacific salmon, Pacific Herring and Eulachon in the local assessment area of the Marine Shipping Addendum.

As indicated above, behavioural effects from Project-related shipping noise on juvenile and adult Pacific salmon and Pacific herring (and eulachon represented by herring; see response to IR5-15 of CEAR Document #1078[2]) were assessed as negligible (see MSA Section 8.1.6.1); the approach is summarised below.

As described earlier in the response, in the absence of universally accepted metrics or guidelines, the 90 dB_{ht} metric (Nedwell et al. 2007) was used in the MSA to assess behavioural effects from Project-related shipping noise on marine fish. In the absence of site- and species-specific information, the assessment considered literature on the hearing sensitivity of Atlantic salmon, and assumed that their response to underwater noise would be similar to, and thus representative of, Pacific salmon, given similarities in their physiology, and the structure and function of their auditory systems. The same approach was applied to Pacific herring, which was assumed to respond to underwater noise in a manner similar to Atlantic herring (e.g., Wilson et al. 2003).

There is no literature information on the hearing sensitivity of eulachon. Although represented by herring, eulachon lack a swim bladder (Phleger 1998, Bone and Moore 2008), and are likely not as sensitive to underwater noise as herring. Because eulachon are found primarily off the west coast of Vancouver Island (see response to IR5-15 of CEAR Document #1078), interaction with ships calling at RBT2 has the potential to only temporarily occur in the MSA local assessment area during migration of adults spawning in the Fraser River and migration of juveniles to habitats off the west coast of Vancouver Island. This potential for eulachon to interact with Project-associated shipping is similar to that anticipated for migratory populations of Pacific herring, but of lesser scale when compared to non-migratory herring populations found in the Salish Sea year-round (see MSA Section 8.1.5.5). Moreover, given information provided by Musqueam First Nation and the literature that suggests eulachon are skittish, and schools could stray if disturbed (Pickard and Marmorek 2007, Schweigert et al. 2012), eulachon were conservatively represented in the effects assessment by the noise sensitive herring. Thus, behavioural effects from Project-related shipping noise on eulachon are assessed as negligible.

[2] CEAR Document #1078 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR4-33, IR5-01, IR5-12, IR5-15, IR5-16, IR5-23, IR5-24, IR5-32, IR5-33, IR5-34, IR5-35, IR5-36, IR6-26, IR7-03, and IR7-05 (See Reference Documents #946, #975, #991, and #1000).

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IR5-28 Marine Fish – Chinook and Chum Salmon

Information Source(s)

EIS Volume 3: Section 10.3.1

CEAR Doc#647

Context

According to Raincoast Conservation Foundation, the developers of EcoPath with Ecosim concluded that a useful assessment tactic for EcoSim may be to work back and forth between Ecosim and single-species assessment models, using each to check and improve the other.

Further lines of evidence are needed to verify and provide confidence in the EwE model predictions of Project effects on juvenile Chinook and Chum Salmon.

Information Request

Provide single-species models to evaluate the effects of the Project on juvenile Chinook and Chum Salmon with model boundaries identical to the EwE model. The models should address migration, seasonality, spatial distribution, exposure to predators and survival in the local assessment area for the Project including the inter causeway area.

Compare the predictions from the single-species models with the EwE model outputs for juvenile Chinook and Chum Salmon.

VFPA Response

In summary, single-species models to evaluate the effects of the Project on juvenile Chinook and chum salmon have not been developed for the following reasons:

- There are no single-species models that are able to depict distribution of juvenile salmon in the local assessment area (LAA), incorporate migration, seasonality, exposure to predators and survival, and also determine habitat-related changes (with the Project) in the productive potential of juvenile salmon;
- The Productive Capacity Technical Advisory Group (PC TAG) recommended an ecosystem based approach (and not a single-species based approach);
- The Roberts Bank ecosystem model accounts for seasonality, migration, exposure to predators, and survival of juvenile salmon in the LAA;
- Sensitivity analyses of the Roberts Bank ecosystem model show that model predictions are robust in forecasting changes in juvenile salmon productivity with and without Project;
- Multiple lines of evidence (not only the Roberts Bank ecosystem model) were used to assess Project-related effects on juvenile salmon;

- Several conservative assumptions were included in the assessment that provide confidence in the assessment conclusions for juvenile salmon;
- The assessment includes mitigation measures (e.g., fisheries sensitive timing windows; onsite offsetting) that will benefit juvenile salmon; and
- Comments from the developers of Ecopath with Ecosim and Ecospace (EwE) on 'working back and forth between Ecosim and single-species assessment models' reflect past applications of these tools to fisheries management, and not environmental assessment.

Each of these elements is discussed in more detail below.

Single-species Models

There are no single-species models that are able to predict the distribution of juvenile salmon on a spatial scale that is appropriate for the LAA. Development and validation of such models would require the use of LAA-wide multi-year data sets on related model variables; however, such data sets are not available for the LAA. In addition, single-species distribution models are not able to determine habitat-related changes (with the Project) in the productive potential of juvenile salmon at Roberts Bank. They also generally fail to incorporate seasonality and migration, and do not consider predator-prey interactions and food web dynamics (Robinson et al. 2011, Christensen et al. 2014); these elements are better handled by EwE (Christensen et al. 2014). Instead, the habitat capacity model of EwE (the preferred tool selected by the PC TAG (see below)) was used in the assessment to forecast productivity changes of juvenile salmon with the Project. The habitat capacity model of EwE was developed by Christensen et al. (2014) to bridge the gap between single-species distribution and food web modelling (Christensen et al. 2014).

Productive Capacity Technical Advisory Group Advice on Ecosystem-based Approach

To best assess the potential effects on the productive capacity of Roberts Bank from RBT2, the VFPA sought expert advice (see PC TAG summary report in Appendix IR3-A of CEAR Document #984[1]). Species-specific models were discussed as a potential option by the PC TAG (see Section 3.2 of the PC TAG summary report (Appendix IR3-A of CEAR Document #984) relating to habitat suitability models) but were rejected in favour of an ecosystem-based approach given limitations described above. Seasonality, migration, predator-prey interactions, and food web dynamics were modelling requirements that were considered key criteria by the PC TAG in their selection of EwE as the preferred tool/model.

Seasonality, Migration, and Predator-Prey Interactions

The Roberts Bank ecosystem model explicitly addresses spatial distribution of production, exposure to predators and survival of juvenile salmon in the LAA for the Project including the inter-causeway area (see EIS Figure 10.3-1 showing the Roberts Bank ecosystem model study area, which includes the inter-causeway area), and implicitly incorporates migration and

[1] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document #928).

seasonality. Information on how these elements were integrated into the Roberts Bank ecosystem model can be found in the following VFPA submissions:

- *Migration*: question 2.1 in CEAR Document #547[2], IR3-05 and IR3-14 in CEAR Document #984;
- *Seasonality*: question 2.1 in CEAR Document #547, IR3-05 and IR3-13 in CEAR Document #984;
- *Spatial distribution (Ecospace foraging habitat capacity model)*: EIS Appendix 10-C, IR-7.31.15-6 in CEAR Document #314[3], question 2.2 in CEAR Document #547, IR3-13 in CEAR Document #984; and
- *Predator-prey interactions (including vulnerabilities)*: EIS Appendices 10-B and 10-C, IR3-23 in CEAR Document #984.

Sensitivity Analyses

Confidence in the Roberts Bank ecosystem model outputs (including those related to juvenile salmon) was demonstrated during validation and accuracy studies undertaken by the VFPA to evaluate model performance[4]. In summary, performance of the Roberts Bank ecosystem model was thoroughly evaluated using methodologies described in previous VFPA submissions (i.e., Section 3.4 in EIS Appendix 10-C, and responses to IR-7.31.15-06 of CEAR Document #314, question 2.15 of CEAR Document #547, and IR3-21 of CEAR Document #984).

Sensitivity analyses were also conducted to evaluate how potential uncertainty in input parameters may affect model results[5]. Analyses indicate that the Roberts Bank ecosystem model is robust to uncertainty in input parameters and provides generally consistent forecasts of changes in productivity at Roberts Bank as a result of terminal and causeway footprints. Robustness of the Roberts Bank ecosystem model, as well as its utility as a framework to organise information pertinent to Roberts Bank and derive estimates of how the system may respond to perturbation, are also acknowledged by DFO in CEAR Document #900[6].

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[2] CEAR Document #547 From the Vancouver Fraser Port Authority to the Review Panel re: Answers to preliminary technical questions submitted during the completeness phase from Fisheries and Oceans Canada, Natural Resources Canada, and Environment and Climate Change Canada, concerning the ecosystem modelling to support the Roberts Bank Terminal 2 Project environmental review (NOTE: Updated September 28th, 2016).

[3] CEAR Document #314 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements (See reference document #271) for the Environmental Impact Statement.

[4] Model performance studies included visual validation of model forecasts (see EIS Appendix 10-C), percent correct classification accuracy statistics (see CEAR Document #547), and additional validation studies (see IR3-19 to IR3-21 of CEAR Document #948).

[5] Sensitivity analyses are initially described in EIS Appendix 10-D. Additional sensitivity analyses were undertaken in response to preliminary technical questions concerning the Roberts Bank ecosystem model and subsequent information requests, and are presented in questions 2.7 and 2.13 of CEAR Document #547, as well as in IR3-09 and IR3-23 of CEAR Document #984.

[6] CEAR Document #900 From the Review Panel Secretariat to the Review Panel re: Technical Review of Roberts Bank Terminal 2 Environmental Assessment: Section 10.3 - Assessing Ecosystem Productivity - by Fisheries and Oceans Canada.

Multiple Lines of Evidence

Multiple lines of evidence (and not only the Roberts Bank ecosystem model) were used to assess potential effects to juvenile Chinook and chum salmon, as described in EIS Section 13.6.3.1 and summarised here. The Roberts Bank ecosystem model (along with results from sensitivity analyses), used as one line of evidence, forecasted minor increases in juvenile salmon productivity from terminal and causeway footprints. Other lines of evidence, particularly those that relate to effect mechanisms not captured in the Roberts Bank ecosystem model (i.e., underwater noise, changes in the light environment, migration-related effects), predicted a minor decrease in juvenile salmon productivity. After collectively considering all lines of evidence, a minor decrease in juvenile salmon productivity with the Project was conservatively assessed, based on a weight of evidence approach (outlined in EIS Table 13-12). The framework used to combine and apply predictions from multiple lines of evidence to support assessment conclusions regarding productivity changes associated with the Project is described in detail in the response to IR5-29. Therefore, as indicated in the context to this information request, multiple lines of evidence (and not only the Roberts Bank ecosystem model) were used in the assessment of juvenile salmon.

Conservative Assumptions

A number of conservative assumptions, described in EIS Section 13.6.3.1 and summarised here, were included in the assessment of potential Project-related changes in juvenile salmon productivity.

Based on a weight of evidence approach (described below), a minor decrease in juvenile salmon productivity was conservatively predicted. This assessment result was reached after considering outputs of the Roberts Bank ecosystem model that suggested minor increases in juvenile salmon productivity, alongside assessment predictions of minor decreases in juvenile salmon productivity based on other lines of evidence.

The prediction of minor decreases in juvenile salmon productivity from changes in the acoustic environment considered the use of impact pile driving during Project construction, which is the loudest of Project construction activities. This assessment prediction is conservative as the preferred method planned during Project construction is vibratory piling, which generates underwater sound at levels unlikely to cause physical harm to juvenile salmon (see EIS Section 13.6.3.1). If impact piling is required, it will be of limited duration.

Minor decreases in juvenile salmon productivity were also predicted to have the potential to result from migration disruption and habitat displacement associated with terminal placement. This assessment prediction is based on the assumption that all juvenile salmon at Roberts Bank swim in a linear fashion hugging the shoreline as they outmigrate to estuarine rearing habitats. This approach is conservative as results from field surveys conducted for the Project, as well as the literature, suggest that movement patterns of juvenile salmon at Roberts Bank are complex, swimming within and between intertidal rearing habitats aided by the tides, and

actively remaining in shore-tied intertidal habitats as the tide ebbs (for discussion see responses to IR5-18 and IR5-22 of CEAR Document #1153[7]).

Therefore, inclusion of these conservative assumptions provides additional confidence in assessment predictions on potential effects to juvenile salmon.

Mitigation and Offsetting for Juvenile Salmon

As indicated above, the EIS presented a conservative assessment of minor losses in juvenile salmon productivity associated with the Project, pre-mitigation. With implementation of mitigation measures, changes in juvenile salmon productivity were assessed as negligible. Mitigation measures that will benefit juvenile salmon include the following:

- Terminal placement in subtidal areas, away from intertidal rearing habitats (such as eelgrass beds);
- Undertaking of Project construction activities in the intertidal zone outside the juvenile salmon fisheries-sensitive window;
- Implementation of environmental management plans (including marine fish salvage plan, underwater noise and light management plans, construction compliance monitoring plan); and
- Offsetting in the form of onsite native eelgrass transplants and reconstructed tidal marsh habitat north of the widened causeway, which will potentially provide refuge and increase food availability for juvenile salmon.

Comments from EwE Developers on Single-species Models

The applicability of comparing single-species models with Ecosim outputs (referred to in the context to this information request) was suggested by the developers of EwE within the framework of fisheries management and not environmental assessment. This suggestion, referred to in the context to this information request by Raincoast Conservation Foundation, was made in Christensen and Walters (2004) when EwE was used predominantly in fisheries management applications to answer questions regarding ecosystem-level effects of fishing that single-species models cannot address (Christensen and Walters 2004, Colléter et al. 2015). Since then, EwE has expanded from its original fisheries scope; EwE's spatial module, Ecospace (which was used in the EIS, and not Ecosim as indicated in the context to this information request) has evolved to allow for an assessment on a spatial scale of ecosystem-wide changes in productivity of functional groups (including juvenile salmon) that may result from land/project development (e.g., Alexander et al. 2016, de Mutsert et al. 2012, 2016), such as RBT2.

[7] CEAR Document #1153 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR5-02, IR5-11, IR5-13, IR5-17, IR5-18, IR5-22, IR5-25, IR5-26, IR5-27, IR5-43, and IR5-44 (See Reference Document # 975).

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IR5-29 Marine Vegetation, Marine Invertebrate and Marine Fish – Lines of Evidence for Productivity Assessment

Information Source(s)

EIS Volume 3: Section 11, Table 11-21; Section 12, Table 12-11; Section 13, Table 13-12.

Context

The Proponent in Tables 11-21, 12-11, and 13-12 of the EIS, summarized the weight of evidence from multiple information sources to derive predictions of productivity changes, prior to mitigation, associated with the proposed Project construction and operations.

The method applied by the Proponent for integration of predictions from multiple lines of evidence into an overall conclusion for each environmental sub-component and component requires clarification.

Information Request

Provide a summary of the different sources of evidence used to evaluate productivity changes for environmental components and sub-components of marine vegetation, marine invertebrates, and marine fish. Provide a clear explanation as to how expert opinion was considered in the effects assessments.

Describe the process that was used to combine and apply predictions from multiple lines of evidence (such as EwE model and other model predictions, Aboriginal Traditional Knowledge, expert opinion, field work, desk analysis) to support the overall conclusions regarding predicted productivity changes associated with the Project.

Describe how qualitative information was combined with quantitative predictions (such as EwE model output) to derive effects assessment conclusions.

VFPA Response

Provide a summary of the different sources of evidence used to evaluate productivity changes for environmental components and sub-components of marine vegetation, marine invertebrates, and marine fish.

Different sources of evidence used to evaluate productivity changes for valued components (VCs) and sub-components of marine vegetation, marine invertebrates, and marine fish are listed in EIS Sections 11.4, 12.4, and 13.4, respectively[1]. In addition, the flowcharts in Appendix IR3-01-A of CEAR Document #984[2] have been updated to pair with tables

[1] Note that this approach applies to other valued components as well, such as coastal birds.
[2] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).

summarising the different sources of evidence used to evaluate potential productivity changes (see **Appendix IR5-29-A** and Tables IR5-29-A1, IR5-29-A2, and IR5-29-A3 therein).

In general, there were six categories of evidence used in the marine vegetation, marine invertebrate, and marine fish assessments:

1. Model evidence: this includes results from models undertaken to support the RBT2 effects assessment; depending on the sub-component, one or several models were developed to inform potential effects of the Project.
2. Empirical evidence: typically, this is site-specific, quantitative data collected via field studies at Roberts Bank.
3. Literature evidence: this includes available information, including peer-reviewed journal articles and literature published by government or industry.
4. Previous environmental assessments: this includes information collected as part of previous development at Roberts Bank (e.g., coal port expansion, Deltaport Third Berth).
5. Aboriginal traditional knowledge (ATK): this includes knowledge that is held by, and unique to, Aboriginal peoples about the natural environment; ATK in the EIS refers to information provided by Aboriginal groups specifically about an intermediate component (IC) or VC.
6. Expert opinion: this includes knowledge and experience that trained professionals have accumulated over time in a specific technical discipline.

Provide a clear explanation as to how expert opinion was considered in the effects assessments.

The expert opinion of multiple professionals—including regulators, academics, and Project scientists—was incorporated into all effects assessment elements for the marine vegetation, marine invertebrate, and marine fish VCs. Each expert, but particularly those bound by professional designations provided objective, science-based opinions. Some examples are summarised below:

- During the initial scoping phase, interdisciplinary planning workshops[3] were held to evaluate the optimal location for the RBT2 terminal, which ultimately resulted in the terminal being sited in the current subtidal configuration and away from more sensitive and productive intertidal habitat (see EIS Section 5.0);
- During baseline data collection, four 'technical advisory group' processes were conducted, which were designed to solicit best available local, regional, national, and international expert opinion on study approach and design, models, and appropriate

[3] These workshops elucidated expert opinion from regulatory agencies (i.e., DFO and Canadian Wildlife Service), engineering, economic, and environmental professionals, as well as the VFPA's senior management team (see EIS Section 5.4).

effect pathways to examine; opinions of up to 50+ experts were integrated by this means[4];

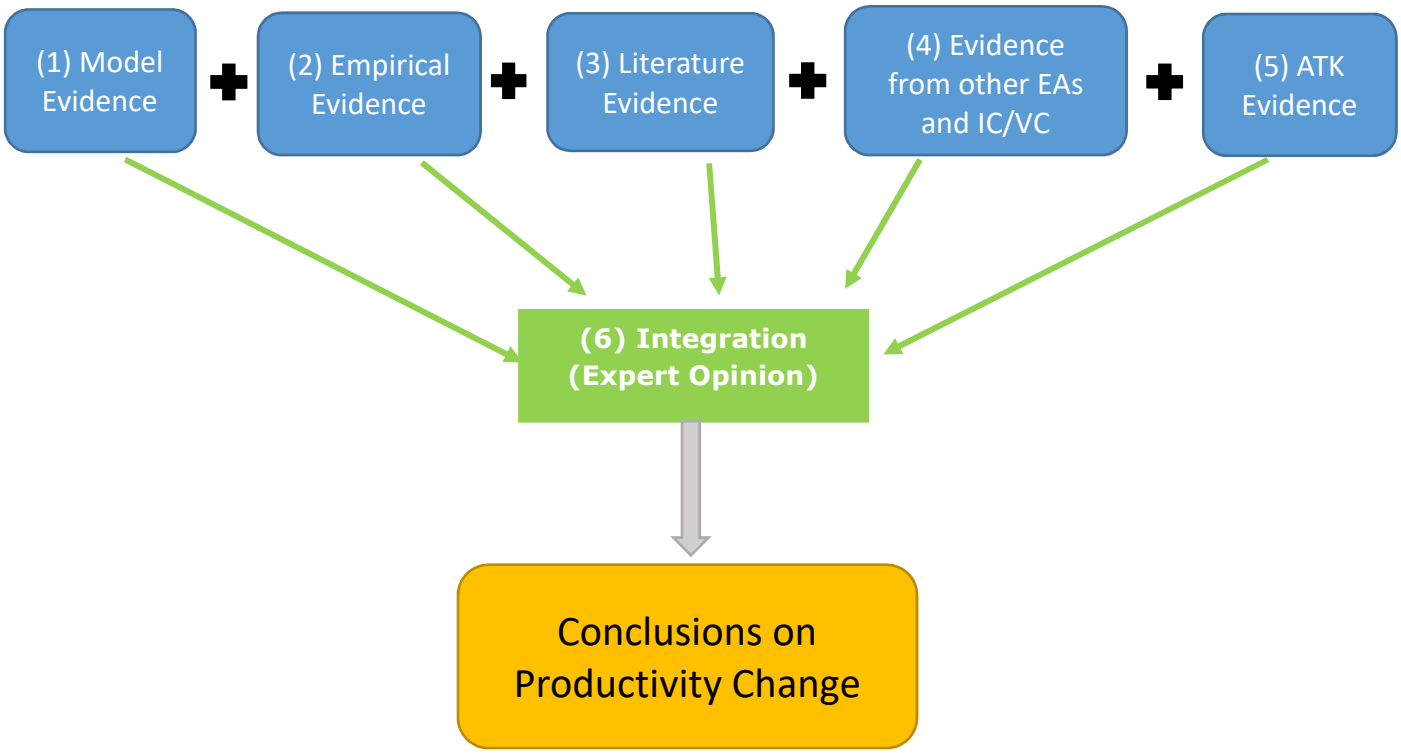
- During the description of existing and expected conditions, in addition to undertaking site- and species-specific field studies, all available information was collected, synthesised, and evaluated (i.e., past environmental assessments, technical studies, ATK, peer-reviewed literature; references provided at the end of each EIS section) as it relates to each sub-component / representative species, thereby utilising a broad, collective body of knowledge;
- During the 'Future with the Project' phase, conclusions from ICs informed the assessment of marine biophysical VCs; extensive dialogue occurred between the geomorphology, sediment and water quality, light, underwater noise, and biophysical experts to ensure IC results were presented in a useable format and appropriately interpreted (please refer to the Authorship and Professional Credentials sections of EIS Sections 9.0 through 15.0 for more details); and
- During the 'Future with the Project' phase, Roberts Bank ecosystem model (RB model) conclusions were tested via robust sensitivity analyses and all materials associated with the model were reviewed by third party experts, including Dr. Carl Walters (Professor Emeritus, UBC Institite for the Oceans and Fisheries) and Dr. Dave Preikshot (Senior Fisheries Scientist, Madrone Environmental Services).

Describe the process that was used to combine and apply predictions from multiple lines of evidence (such as EwE model and other model predictions, Aboriginal Traditional Knowledge, expert opinion, field work, desk analysis) to support the overall conclusions regarding predicted productivity changes associated with the Project.

The general process that was used to combine and apply predictions from multiple lines of evidence to support the overall conclusions regarding predicted productivity changes associated with the Project is depicted in **Figure IR5-29-1** (this process was employed using expert opinion of the technical authors and is not described in the EIS). Expert opinion was used to collect and synthesise information, as well as to evaluate the merit of each line of evidence. This process is described below using Dungeness crabs as an example.

[4] See Appendix IR2-A of CEAR Document #961, Appendix IR3-A of CEAR Document #984, **Appendix IR5-29-B**, and **Appendix IR5-29-C** for the Coastal Geomorphology, Productive Capacity, Biofilm & Shorebirds, and Southern Resident Killer Whales Technical Advisory Group Summary Reports, respectively.

Figure IR5-29-1 General Process used to Integrate Multiple Lines of Evidence for Predicting Changes to Productivity for Each Sub-component



Notes: EA = environmental assessment

(1) MODEL EVIDENCE

a. Roberts Bank Ecosystem Model (RB Model)

i. Roberts Bank Ecosystem Model Key Run

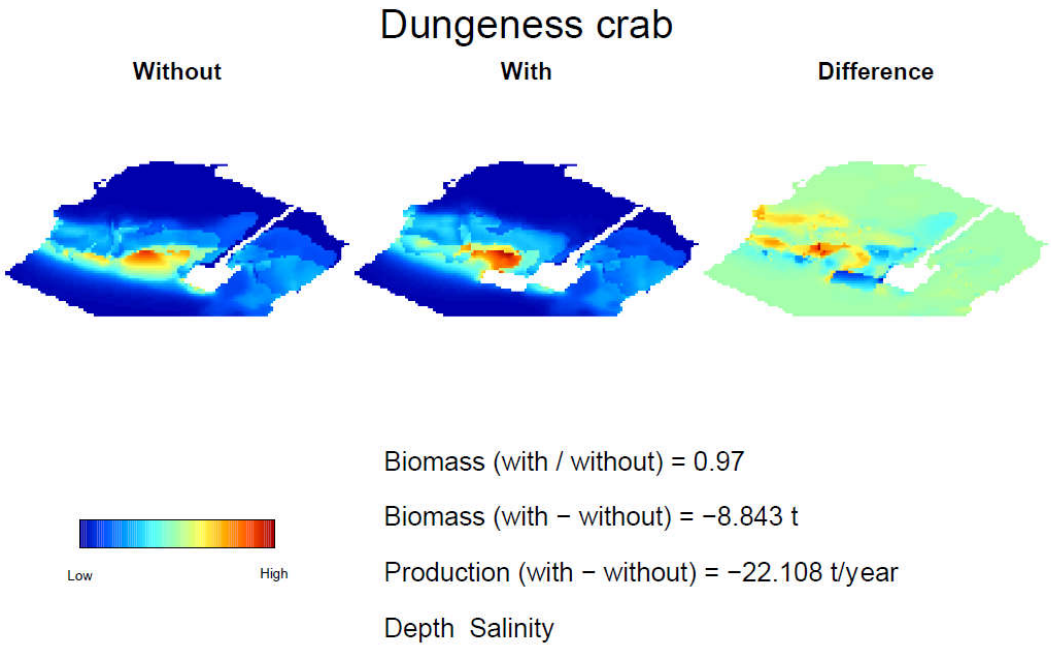
The RB model (Ecopath with Ecosim and Ecospace (EwE)) key run outputs were used as a quantitative reference point to begin the evaluation of potential effects; specifically, these outputs were used to understand the direction and relative magnitude of effects for each sub-component.

For Dungeness crab, the key run productivity change is estimated to be -3% (8.8 t/y; see **Figure IR5-29-2**), driven primarily by footprint losses of subtidal sand habitat and declines in infaunal bivalves, a primary food source. Independent of any other lines of evidence (see below for how other lines of evidence were integrated), this result is considered 'negligible' as per the classification system categories of negligible, minor, moderate, and high[5] outlined

[5] Productivity change was characterised according to the following categories: Negligible = 0% to 5% change; Minor = 6% to 30% change; Moderate = 31% to 60% change; High = 61% to 100% change.

in EIS Section 12.6.3 and described further in the response to IR-7.31.15-07 of CEAR Document #314[6]).

Figure IR5-29-2 Roberts Bank EwE RB Model Key Run Results with and without Project



ii. Roberts Bank Ecosystem Model Sensitivity Analyses

When integrating the RB model key run results with other lines of evidence to determine Project conclusions, an important step in the process was to ensure the robustness of the model outputs. This was achieved through a number of sensitivity analyses[7], which were used to evaluate the accuracy of productivity changes predicted by the key run. Results from RB model sensitivity analyses were considered and evaluated by multiple modelling and biological experts and showed that, overall, the model forecasts are robust to uncertainty in various input data (see IR-7.31.15-06 of CEAR Document #314, responses to Information

[6] CEAR Document #314 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements (See reference document # 271) for the Environmental Impact Statement.

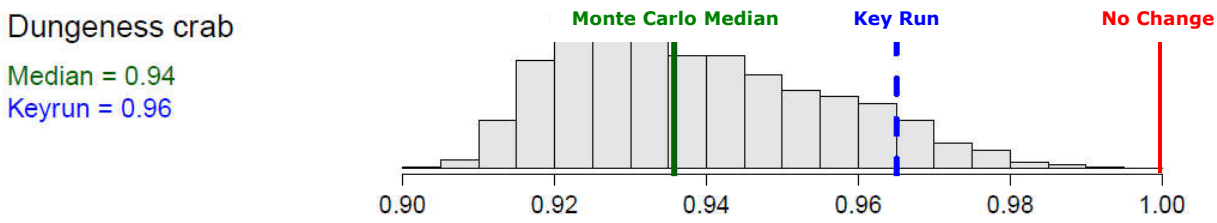
[7] As discussed in the *Preamble in Support of Responses to IR3-01 to IR3-24* (CEAR Document #984), sensitivity analyses were designed to evaluate how potential uncertainty within input variables may affect model results. Four sensitivity analyses were conducted—sensitivity to vulnerability setting, sensitivity to inclusion of abiotic factors, sensitivity to abiotic factor over/underestimate, and sensitivity to input assumptions—and all are described in EIS Appendix 10-D.

Request Package 3 of CEAR Document #984, and CEAR Document #547[8] for further information on sensitivity analyses completed).

This sub-step focused predominantly on the analysis of input assumptions using a Monte Carlo approach to indicate whether key run predictions for each sub-component might be over- or underestimated. **Figure IR5-29-3** below presents the results of 4,000 Monte Carlo runs, in the form of a frequency distribution, where input parameters were randomly modified (for more information on the Monte Carlo approach, refer to EIS Appendix 10-D). A value of 1.00 (depicted by the red line) reflects no change in productivity, while the blue and green lines reflect the key run value and the median of the Monte Carlo runs, respectively. The entire distribution falls to the left of the red line, indicating that all 4,000 Monte Carlo runs predict that the direction of change for Dungeness crab will be negative (i.e., less productivity with the Project compared to without). A comparison between the key run and the Monte Carlo median shows the results are well aligned and robust (i.e., within a few percent of each other) but that the key run result may be underestimated by about 3%.

Overall, results of this sensitivity analysis suggest there will be a measurable (i.e., not negligible as predicted by the key run) reduction in Dungeness crab productivity as a result of the Project and, hence, a change in category from 'negligible' to 'minor' was warranted (in the context of the common classification system referred to above).

Figure IR5-29-3 Monte Carlo Sensitivity Analysis Results for Dungeness Crab



iii. Accounting for Mechanisms Not Considered in Roberts Bank Ecosystem Model

When integrating the RB model key run results with other lines of evidence to determine Project conclusions, another important step in the process involved accounting for the contribution of Project effect mechanisms that were not considered within the context of the RB model[9]. This was achieved through qualitative evaluation, based on expert opinion, of the potential for each mechanism to change the direction (i.e., an increase or decrease in productivity) or magnitude of the result for each species/group modelled as well as the productivity category rating (i.e., from negligible to minor, or minor to moderate). The

[8] CEAR Document #547 From the Vancouver Fraser Port Authority to the Review Panel re: Answers to preliminary technical questions submitted during the completeness phase from Fisheries and Oceans Canada, Natural Resources Canada, and Environment and Climate Change Canada, concerning the ecosystem modelling to support the Roberts Bank Terminal 2 Project environmental review (NOTE: Updated September 28th, 2016).
[9] The RB model included terminal and causeway footprint related changes to productivity only.

influence of these other mechanisms on predicted productivity change for each sub-component were each considered qualitatively even if they were studied quantitatively. This is because quantitative information from other studies on such mechanisms were not always described in a productivity based metric or unit; for example, results of total suspended solids (TSS) dispersion modelling were presented via several units, including square kilometres (spatial extent) and millimetres (maximum deposition), while results changes in the acoustic environment were reported in units of dB re 1 µPa.

Specific mechanisms were selected for consideration based on their relevance related to each species group in question; for Dungeness crab, this includes (a) direct mortality from construction activities and changes in water quality from (b) TSS and (c) contaminant re-suspension (described below) but for marine fish, this step also included changes in the acoustic environment, light environment, and migration disruption (Pacific salmon).

Direct Mortality

Direct mortality is expected for all life stages of Dungeness crab during the construction phase, particularly as a result of entrainment from dredging activities in the terminal dredge basin and tug basin. Mortality of crab under the terminal and causeway footprints was accounted for in the RB model, but this was not the case for the dredge and tug basin footprints; mortality in these areas will thus increase the magnitude of the productivity decrease predicted by the RB model. However, mitigation in the form of crab salvages and adherence to DFO's fisheries sensitive timing window is anticipated to effectively limit construction-associated mortality in these areas. Though mortality from construction will increase the magnitude of predicted productivity loss, this is expected to be reduced through mitigation (including offsetting) and therefore is not anticipated to change the category rating for Dungeness crab, which remains minor (i.e., 6% to 30% change; based on sub-steps i and ii above).

Total Suspended Solids

As outlined in EIS Section 12.6.2.1, Project-related TSS is considered to have a negligible effect on Dungeness crab productivity because maximum Project-related concentrations are not expected to reach harm-inducing levels; reported concentrations of harm are orders of magnitude higher than those expected for the Project. Behavioural avoidance of areas where TSS plumes are most concentrated (i.e., the end of the discharge pipe) is possible, as Dungeness crabs are mobile and capable of moving away from areas of activity, reducing the potential for exposure. Therefore, TSS is not expected to influence the productivity category for Dungeness crab, which remains minor (i.e., 6% to 30% change; based on sub-steps i and ii above).

Re-suspension of Contaminated Sediments

Also discussed in EIS Section 12.6.2.1, contaminant re-suspension is not considered to affect Dungeness crab productivity because (i) there are no Project-related inputs of contaminants in the local assessment area; (ii) no appreciable sediment contamination was observed in areas of Project activities; and (iii) where contaminants are present, concentrations are either

below interim sediment quality guidelines or probable effects level thresholds in sediments or below consumption thresholds in Dungeness crab tissue based on rigorous human health risk assessment (EIS Sections 12.5.2.5 and 12.5.3.5 and EIS Appendix 27-C). Project-related contamination is therefore unlikely to occur. Thus, contaminant re-suspension is not expected to influence the productivity category for Dungeness crab, which remains minor (i.e., 6% to 30% change; based on sub-steps i and ii above).

b. Statistical or Predictive Modelling

For some sub-components, additional statistical and/or predictive models were generated and used as lines of evidence in the effects assessment, as shown in the figures comprising **Appendix IR5-29-A.** These models were developed for varying objectives, including to bridge data gaps (e.g., Pacific Sand Lance Habitat Suitability Model), explore specific issues at high resolution (e.g., the Shorebird Foraging Opportunity Model), and/or better understand important ecological dynamics (e.g., Dungeness Crab Productivity Model). Detailed examples of modelling evidence, and how it informed the process of assessing productivity change, are described for Dungeness crab below.

i. Dungeness Crab Habitat Suitability Model

A habitat suitability model was developed to quantify the amount of optimal Dungeness crab habitat in the local assessment area, by life stage, and compare it to the footprints of various Project components (i.e., terminal, berth pocket, causeway, and tug basin). This is relevant to the assessment because, while similar to the spatial outputs produced by the RB model (which is essentially a series of habitat capacity models, as discussed in IR3-13 of CEAR Document #984), this habitat suitability model is focused specifically on Dungeness crab, providing additional detail and context to the crab assessment.

Model results indicate permanent displacement from highly suitable sand habitat for each life stage, which is linked to productivity loss. However, while each life stage will experience a reduction of suitable habitat, substantial amounts of highly and moderately suitable habitat will remain available to crabs outside Project component footprints. Further, planned onsite offsetting in the form of native eelgrass transplants will provide habitat for both adult and juvenile crabs, partially mitigating predicted productivity loss. This aligns with the RB model result and supports the conclusion of a minor adverse effect on productivity. Thus, the productivity category rating for Dungeness crab remains minor (i.e., 6% to 30% change).

ii. Dungeness Crab Productivity Model

The Dungeness crab productivity model was developed to estimate trends in population parameters (e.g., biomass, recruitment, production) over time rather than inform predictions of change; hence, this study was not used to determine the amount of productivity change from the Project, and no change in the productivity category was made in response to this work. Results confirm that Roberts Bank is a highly productive area for Dungeness crab, but that this productivity fluctuates over time and space. This is relevant to the assessment because it helped characterise existing conditions and contextualise Project effects relative to natural variability and fishing pressure. For example, as described in IR5-11 of CEAR

Document #1153[10], mean annual percent change in Dungeness crab fisheries landings (as a proxy for natural variability) was calculated as 26.5%. The measurable change from the Project on Dungeness crabs was determined to be 3% (~9 tonnes) by the RB model key run, and 5% (~15 tonnes) based on sensitivity analyses. Overall, productivity change due to the Project was characterised as minor, especially given the context of a highly variable natural system where average year-over-year changes are 26.5% (and up to 52.1% when counting standard deviation), and given the effect will not change population integrity or function.

(2) EMPIRICAL EVIDENCE

Numerous field studies were conducted at Roberts Bank to provide updated, site-specific information on the VCs to support the assessment (e.g., juvenile salmon surveys, intertidal marsh surveys, orange sea pen underwater video surveys). Additionally, in some cases, sampling extended beyond the local assessment area to provide a broader context for the assessment of Project-related effects (e.g., infaunal and epifaunal invertebrate sampling across entire Fraser River estuary, including Sturgeon Bank and Boundary Bay; dunlin genetics study with samples spanning Pacific coast, including Mexico and California). Results contributed to the scientific knowledge and ecological understanding of Roberts Bank, and enabled potential effects to be rigorously assessed and appropriately contextualised. Again, detailed examples using Dungeness crab are illustrated below.

a. Juvenile Crab Surveys

Surveys of juvenile Dungeness crabs showed that Roberts Bank is used as settlement and nursery habitat, but that settlement is patchy in both time and space. As discussed in EIS Section 5.0, the terminal was intentionally placed in deeper subtidal waters to avoid overlap with highly productive and sensitive intertidal habitats, including the eelgrass and *Ulva* that supports rearing Dungeness crabs. This is relevant to the assessment because it confirms there is very little direct impact in areas of settlement and rearing (i.e., intertidal zone) and thus will not change the productivity category for Dungeness crab, which remains minor (i.e., 6% to 30% change).

b. Gravid Female Crab Surveys

SCUBA surveys were conducted to determine whether the terminal footprint was being used as a brooding location by gravid (i.e., egg-bearing) female Dungeness crabs. Over the course of five days of surveys in January, the middle of brooding season, only four gravid females were reported; however, multiple factors limited the ability to detect gravid females, including their propensity to bury themselves in the sand, and these are discussed further in IR4-23 of CEAR Document #1051[11]. This is relevant to the assessment because it suggests the location under the proposed terminal may not be highly valuable rearing habitat; in the absence of

[10] CEAR Document #1153 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Requests IR5-02, IR5-11, IR5-13, IR5-17, IR5-18, IR5-22, IR5-25, IR5-26, IR5-27, IR5-43, and IR5-44 (See Reference Document # 975).
[11] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).

unequivocal evidence, however, brooding in these areas was assumed as a conservative measure (see IR4-23 of CEAR Document #1051), which would indicate the potential for a greater magnitude of productivity loss. However, mitigation in the form of adherence to DFO's fisheries sensitive timing window is anticipated to effectively limit construction-associated mortality on gravid female crabs; thus, the category for Dungeness crab productivity change remains minor (i.e., 6% to 30% change).

(3) LITERATURE EVIDENCE

Both peer-reviewed scientific literature and government or industry reports were used as a line of evidence in the assessment to inform and/or support predictions for all marine VCs. In all cases, literature was incorporated into both the existing conditions section as well as predictions of future conditions with the Project, as illustrated by the Dungeness crab example below.

In most cases, results of modelling or field studies were compared to the literature for validation and context. For example, juvenile Dungeness crab surveys at Roberts Bank documented ontogenetic shifts in habitat use, where densities of recently settled crabs were higher in areas of *Ulva* than in eelgrass beds; this was corroborated by the literature, with several studies reporting similar patterns (e.g., Armstrong et al. 1989, McMillan et al. 1995). Hence, literature was collated, evaluated for relevance, and integrated into the assessment using expert opinion, to substantiate field study and/or modelling results. In these instances, literature was not used to determine the amount of productivity change from the Project, and no change in the productivity category was made in response.

However, experts also used literature to support the characterisation of potential effects. For example, the rating of Project-related TSS as negligible (see EIS Section 12.6.2) was partly based on evidence from a study that reported mortality rates among adult crabs ranged between 5% to 50% after eight days of exposure to fine suspended sediments that ranged between 9,200 mg/L TSS and 32,000 mg/L TSS, respectively (McFarland and Peddicord 1980). Since these reported concentrations are much higher than those expected for the Project, and since Dungeness crabs are highly mobile, effects of TSS on Dungeness crab were characterised as negligible.

(4) EVIDENCE FROM PREVIOUS ENVIRONMENTAL ASSESSMENTS and other IC/VC CONCLUSIONS

Another line of evidence that contributed to the evaluation of productivity change of sub-components includes information gathered and lessons learned from previous environmental assessments at Roberts Bank, specifically the Deltaport Third Berth Project. The ability to draw from past Project experience provides site-specific evidence as to how the Roberts Bank ecosystem responds to development and, in some cases, establishes a robust time-series which strengthens predictions.

Additionally, the RBT2 assessment was highly integrative such that data generated and conclusions drawn within a particular IC or VC section informed subsequent VC sections. For example, as discussed in greater detail below, the Dungeness crab assessment heavily relied

on data from the coastal geomorphology, surficial sediment and geology, marine water quality, and marine vegetation assessments.

a. Deltaport Third Berth

The Deltaport Third Berth (DP3) environmental assessment was submitted in 2005 to support construction of a third ship berth at the existing Deltaport container terminal. Dungeness crab was assessed as a VC, and field studies were conducted to support baseline conditions for both juvenile and adult life stages. Effects to both life stages were identified as loss of intertidal mudflat habitat and nursery habitat, respectively, but characterised as not significant after the application of mitigation measures, which included timing windows and salvages.

These studies and assessment are relevant to the RBT2 assessment because they provide relatively recent empirical data and literature review of Dungeness crab ecology at Roberts Bank; as discussed above, this enables trends in densities and habitat use to be qualitatively tracked over time. Further, the lessons learned from mitigation (e.g., salvages, timing windows) for DP3 set precedent, and helped inform the effectiveness and implementation of RBT2's mitigation measures. Additionally, the DP3 experience helped inform the overall conclusion of 'minor' since Roberts Bank continues to support productive Dungeness crab habitat and intensive commercial and food, social, and ceremonial crab fisheries; in fact, onboard logbook data from 2006 to 2009 (which overlap with the DP3 construction period of 2007 to 2010) indicate that commercial fisheries landings in Areas 29-6 and Areas 29-7 were the highest on record in a 21-year time-series.

b. Adaptive Management Strategy

The adaptive management strategy (AMS) was an eight-year study (2007 to 2014) focused on the Roberts Bank inter-causeway ecosystem, and was designed to provide an early warning system, so that steps can be taken to mitigate risks well before valued ecosystem components are affected. While not part of the core AMS program, juvenile crab habitat monitoring was completed to fulfill the VFPA's commitments under the Owner's Table of Commitments and Assurance for the DP3 Project to determine whether nursery habitat re-establishes itself along the newly created foreshore (Hemmera et al. 2015).

A juvenile crab monitoring survey was conducted over a nine-week period from July 7 to September 5, 2014. Eight survey locations on the west side of the inter-causeway area were repeatedly surveyed to quantify juvenile Dungeness crab density and size. The density and distribution of *Ulva* mat and hummocks, as important juvenile habitat, was also quantified. Study results demonstrate that juvenile Dungeness crabs and *Ulva* re-established on the mudflat adjacent to the DP3 footprint (Hemmera et al. 2015). Hence, no further work was recommended to assess the re-establishment.

This study provides empirical evidence of natural recovery of juvenile crab nursery habitat, which not only informed predictions for the RBT2 assessment, but also helped increase confidence in the assessment conclusion of 'minor' by providing empirical evidence of natural recovery occurring at Roberts Bank post-DP3.

c. Other IC/VC Effects Assessment Conclusions

Conclusions of the coastal geomorphology assessment were incorporated into the VC effects assessments as a mechanism of potential productivity change. Specifically, the mechanism 'changes in sedimentation and coastal processes' evaluated how predicted changes in sediment scour and deposition, turbidity, and wave energy might, in turn, affect marine vegetation, invertebrate, and fish sub-components (see EIS Sections 11.6, 12.6, and 13.6, respectively). Overall, results of the coastal geomorphology assessment indicated that, while the Project is expected to cause changes in coastal processes, not only are such changes fairly localised but also minor in the context of natural dynamics (i.e., the tidal flats and delta foreslope exist in a dynamic environment where ongoing change is expected). Because geomorphic changes are localised, and Dungeness crabs are highly mobile (hence able to move to more suitable areas) and already adapted to fluctuating estuarine conditions, effects resulting from changes in sedimentation and coastal processes were deemed to be negligible. Thus, no change in the productivity category was made in response to this line of evidence.

Conclusions of the surficial geology and marine sediment assessment were integrated in the VC effects assessments as a mechanism of potential productivity change, specifically contaminant re-suspension. For Dungeness crab, potential effects associated with contamination were characterised as negligible (see EIS Sections 12.6.2.1) based on the work presented in EIS Section 9.6.8, which demonstrated that while contaminants are present at Roberts Bank, they are closely associated with fine sediment and have thus largely accumulated in locations outside those that will be disturbed by Project activities, such as the upper intertidal zone north of the causeway, near Brunswick Point. No appreciable sediment contamination was observed in Project areas. Because sediments that will be re-suspended and deposited as a result of construction-phase activities are not contaminated, or have trace levels of contaminants that are below accepted thresholds, changes in contaminant concentrations bioavailable to the food chain are not anticipated. This was supported by laboratory analyses of contaminants in Dungeness crab muscle tissue, which indicated that there were no detectable polycyclic aromatic hydrocarbons despite the use of sensitive analytical techniques with extremely low detection limits (see EIS Appendix 27-C). Thus, no change in the productivity category was made in response to this line of evidence.

Conclusions of the marine water quality assessment were incorporated into the VC effects assessments as a mechanism of potential productivity change. Specifically, the mechanism 'changes in water quality' evaluated how predicted changes in TSS and salinity might, in turn, affect marine vegetation, invertebrate, and fish sub-components (see EIS Sections 11.6, 12.6, and 13.6, respectively). For Dungeness crab, no effects were expected to stem from changes in water quality. This is because there is little spatial overlap between areas of predicted salinity change (predominantly high-mid intertidal) and Dungeness crab distribution (predominantly low intertidal – subtidal). Thus, no change in the productivity category was made in response to this line of evidence.

Lastly, conclusions of the marine vegetation assessment were incorporated into the effects assessments of higher trophic levels. For example, as outlined in EIS Section 12.6.2.2 sedimentation may cause portions of the area north of the terminal to become unsuitable for native eelgrass, considered high-value habitat for adult Dungeness crabs; a worst-case

scenario estimates 12 tonnes of eelgrass may be affected, discussed in EIS Section 11.6.3. In contrast, a decrease in wave energy predicted within Zone 5 is anticipated to increase native eelgrass biomass by an estimated 4 to 8 tonnes (see EIS Section 11.6.3). Overall, changes in productive potential of native eelgrass were concluded to be negligible and, in turn, were deemed to have a negligible influence on Dungeness crab productivity. Thus, no change in the productivity category was made in response to this line of evidence.

(5) ABORIGINAL TRADITIONAL KNOWLEDGE

The overall approach taken for collection and integration of ATK is described in EIS Section 7.2.1.7 and IR-7.31.15-08 of CEAR Document #314. All relevant ATK that was available was incorporated into the effects assessment to inform existing conditions. Specifically, for Dungeness crab, ATK informed the description of population characteristics in terms of historical abundance and observed declines (EIS Sections 12.5.3.3 and 12.5.3.6) as well as the description of key habitat features of Dungeness crabs, in terms of location, abundance, and seasonality (EIS Section 12.5.3.4).

In addition, other types of Aboriginal information, including Current Use information and issues and interests raised, were also incorporated into the assessment. For example, Aboriginal concerns around potential contamination from re-suspension of sediments prompted this mechanism to be added to the assessment (see EIS Appendix 27-C). Concerns about existing (and possible Project-related increases in) contamination from coal in Dungeness crabs resulted in two additional studies to understand the cause of black material under the shells of crabs, and to test for levels of coal-related contaminants (see Appendix IR4-34-A of CEAR Document #1051 for the summary of these two studies). Aboriginal groups were engaged in the study, in the sampling of crabs for analysis.

(6) INTEGRATION

The last step of the process (Step 6) was to synthesise all information identified in Steps 1 through 5 and evaluate which productivity category rating was best represented by the evidence using expert opinion; this is summarised in **Table IR5-29-1** below.

Table IR5-29-1 Integration and Qualitative Results of Dungeness Crab Lines of Evidence

Line of Evidence	Conclusion Supported by Line of Evidence
Model Evidence	
RB Model Key Run	Negligible
Sensitivity Analysis	Minor
Mechanisms not considered in RB model: Direct Mortality TSS Contamination	 Minor Negligible Negligible
Crab Productivity Model	Minor
Habitat Suitability Model	Minor
Empirical Evidence	
Juvenile Crab Surveys	Minor
Gravid Female Crab Surveys	Minor
Literature Evidence	
Literature	Minor
Evidence from Previous EAs and Other IC/VC Conclusions	
Previous EAs	Minor
Other IC/VC conclusions	Negligible
Aboriginal Traditional Knowledge (ATK) Evidence	
ATK	Used to help characterise existing conditions not inform predictions of change.

Overall, quantitative and qualitative information from multiple lines of evidence was evaluated using the conceptual approach outlined above, and indicates a minor adverse effect on Dungeness crab (i.e., 6% to 30% change in productivity). This process was replicated for all VCs.

Describe how qualitative information was combined with quantitative predictions (such as EwE model output) to derive effects assessment conclusions.

This information is described in the response to IR-7.31.15-07 of CEAR Document #314.

In summary, both qualitative and quantitative information from different lines of evidence was integrated under one defined framework using a common classification system (of negligible, minor, moderate, or high). Common classification systems are standard tools in environmental assessment and are typically determined using expert opinion.

The common classification system was based on the following categories:

- Negligible: changes that are so small that they are not detectable or measurable and are not anticipated to influence the short-term or long-term viability of the VC or sub-components (between 0% and 5%);
- Minor: a measurable change but within the range of natural variability that will not affect population integrity or function (between 6% and 30%);
- Moderate: a measurable change outside natural variability that may affect population integrity OR function, but not both (between 31% and 60%); and
- High: a measurable change that exceeds the limits of natural variability and may affect long-term population integrity and function (between 61% and 100%).

Deriving assessment conclusions (i.e., designating a category of change) was based on the process outlined above, where all available lines of evidence were synthesised and integrated into the common classification system using expert opinion. Once all available lines of evidence were considered, the conclusions of productivity change for each sub-component or representative species may have differed from the results indicated by the RB model key run. For example, the overall conclusion for Dungeness crab was 'minor', despite the key run indicating a negligible result.

References

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Hemmera, Northwest Hydraulic Conslutants, and Precision Identification. 2015. Adaptive Management Strategy 2014 Annual Report: Deltaport Third Berth, Delta, B.C. Prepared for Vancouver Fraser Port Authority. 523 pp. Available at https://www.portvancouver.com/wp-content/uploads/2015/10/AMS-2014-Final-Annual-Report1.pdf. Accessed March 2018.

McFarland, V. and R. Peddicord. 1980. Lethality of a Suspended Clay to a Diverse Selection of Marine and Estuarine Macrofauna. Archives of Environmental Contamination and Toxicology 9:733–741.

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Appendices

Appendix IR5-29-A Updated Flowcharts and Corresponding Tables

Appendix IR5-29-B Biofilm & Shorebirds Technical Advisory Group Summary Report

Appendix IR5-29-C Southern Resident Killer Whales Technical Advisory Group Final Report

APPENDIX IR5-29-A

UPDATED FLOWCHARTS AND CORRESPONDING TABLES

EIS Marine Vegetation Flow Chart

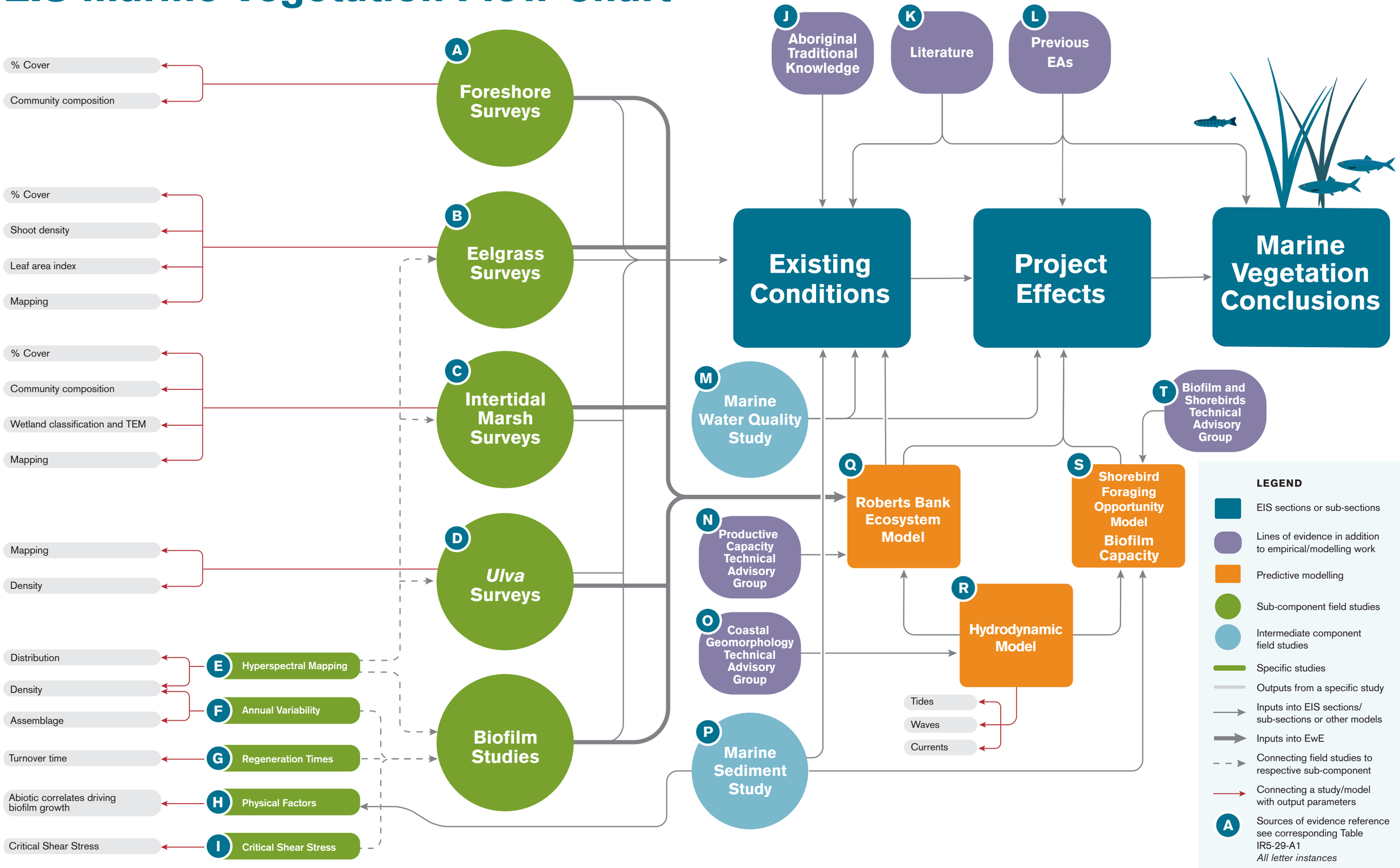


Table IR5-29-A1 Summary of Sources of Evidence used to Evaluate Productivity Changes for Sub-components of Marine Vegetation

Flow Chart Reference	Report Code	URL / Notes
A – Foreshore Surveys	RBT2 TDR MVB-1 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107589E.pdf
B – Eelgrass Surveys	RBT2 TDR MVB-1 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107589E.pdf
C – Intertidal Marsh Surveys	RBT2 TDR MVB-1 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107589E.pdf
D – Ulva Surveys	RBT2 TDR MVB-1 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107589E.pdf
E – Biofilm Community at Roberts Bank - Analyses to Support Hyperspectral Mapping	RBT2 TDR MVB-5	http://www.robertsbankterminal2.com/environmental-assessment/technical-data-reports/
F – Biofilm Annual Variability Study	RBT2 TDR MVB-6	http://www.robertsbankterminal2.com/environmental-assessment/technical-data-reports/
G – Biofilm Regeneration Study	RBT2 TDR MVB-2	http://www.robertsbankterminal2.com/environmental-assessment/technical-data-reports/
H – Biofilm Physical Factors Study	RBT2 TDR MVB-4	http://www.robertsbankterminal2.com/wp-content/uploads/RBT2-Biofilm-Physical-Factors-TDR1.pdf
I – Biofilm Critical Shear Stress Study	RBT2 TDR MVB-3	http://www.robertsbankterminal2.com/environmental-assessment/technical-data-reports/
J – Aboriginal Traditional Knowledge	IR-7.31.15-08 (CEAR Document #314)	https://www.ceaa-acee.gc.ca/050/documents/p80054/103668E.pdf
K – Literature	n/a	See EIS Section 11.13; see 'References' sections in RBT2 TDRs MVB-1 to MVB-6, respectively.
L – Previous Environmental Assessments	n/a	See EIS Sections 11.4, 11.5.1, 11.5.3, 11.5.4, 11.5.5, 11.7.2, and 11.9.2 and RBT2 TDR MVB-1.
M – Marine Water Quality Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf

Flow Chart Reference	Report Code	URL / Notes
N – Productive Capacity Technical Advisory Group	Appendix IR3-A (CEAR Document #984)	http://www.ceaa-acee.gc.ca/050/documents/p80054/119369E.pdf
O – Coastal Geomorphology Technical Advisory Group	Appendix IR2-A (CEAR Document #961)	http://www.ceaa-acee.gc.ca/050/documents/p80054/118950E.pdf
P – Marine Sediment Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf
Q – Roberts Bank Ecosystem Model	RBT2 EIS Appendix 10-B RBT2 EIS Appendix 10-C RBT2 EIS Appendix 10-D (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101363E.pdf
R – Coastal Geomorphology Study	RBT2 EIS Appendix 9.5-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101370E.pdf
S – Shorebird Foraging Opportunity during Migration	RBT2 EIS Appendix 15-B (CEAR Document #181)	https://www.ceaa-acee.gc.ca/050/documents/p80054/101358E.pdf
T – Biofilm and Shorebirds Technical Advisory Group	Appendix IR5-29-B	Appended to this response.

EIS Marine Invertebrate Flow Chart

LEGEND

- EIS sections or sub-sections
- Lines of evidence in addition to empirical/modelling work
- Predictive modelling
- Sub-component field studies
- Intermediate component field studies
- Specific studies
- Outputs from a specific study
- Inputs into EIS sections/ sub-sections or other models
- Inputs into EwE
- Connecting field studies to respective sub-component
- Connecting a study/model with output parameters
- (A) Sources of evidence reference see corresponding Table IR5-29-A2 *All letter instances*

(A) Infauna and Epifaunal Invertebrate Surveys
- Biomass
- Abundance
- Community composition

(B) Bivalve Shellfish Studies
- Density

(C) Orange Sea Pen Studies
- Mapping
- Density
- Community associations
- Underwater Video Surveys
- SCUBA Surveys

Section 27 Human Health
- (D) Contamination Studies
- Contaminant Concentrations

Dungeness Crab Studies
- Density
- Habitat Preferences
- (E) Juvenile Crab Surveys
- (F) Gravid female SCUBA surveys

(G) Biofilm and Shorebirds Technical Advisory Group

(H) Aboriginal Traditional Knowledge

(I) Literature

(J) Previous EAs

(K) Project Effect (Marine Vegetation/ Biofilm)

Existing Conditions

Project Effects



Marine Invertebrate Conclusions

(L) Productive Capacity Technical Advisory Group

(M) Roberts Bank Ecosystem Model

(Q) Hydrodynamic Model

(R) Shorebird Foraging Opportunity Model Infaunal Capacity

(T) Marine Sediment Study

(J) Marine Water Quality Study

(N) Species Distribution Model
- Tides
- Waves
- Currents
- Probability of Occurrence

(S) Coastal Geomorphology Technical Advisory Group

(O) Bayesian Population Dynamics Model
- Biomass
- Production
- Recruitment

(G) Biofilm and Shorebirds Technical Advisory Group

(P) Habitat Suitability Model
- Area of Suitable Habitat

Table IR5-29-A2 Summary of Sources of Evidence used to Evaluate Productivity Changes for Sub-components of Marine Invertebrates

Flow Chart Reference	Report Code	URL / Notes
A – Infaunal and Epifaunal Invertebrate Study	RBT2 TDR MI-1 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107610E.pdf
B – Shellfish Harvesting Potential and Contaminant-Related Consumption Risks at Roberts Bank	RBT2 EIS Appendix 27-C (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101347E.pdf
C – Orange Sea Pen Study	RBT2 TDR MI-3 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107607E.pdf
D – Dungeness Crab Contamination Study	RBT2 EIS Appendix 27-C	http://www.ceaa-acee.gc.ca/050/documents/p80054/101347E.pdf
E – Juvenile Dungeness Crab Survey	RBT2 TDR MI-2 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107609E.pdf
F – Gravid Female Dungeness Crab SCUBA Survey	RBT2 TDR MF-2 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107617E.pdf
G – Biofilm and Shorebirds Technical Advisory Group	n/a	Appended to this response.
H – Aboriginal Traditional Knowledge	IR-7.31.15-08 (CEAR Document #314)	https://www.ceaa-acee.gc.ca/050/documents/p80054/103668E.pdf
I – Literature	n/a	See EIS Section 12.13; see 'References' sections in RBT2 TDRs MI-1 to MI-4, respectively; see 'References' in EIS Appendix 12-A and Appendix 27-C, respectively.
J – Previous Environmental Assessments	n/a	See EIS Sections 12.4, 12.5.1, 12.5.2, 12.5.3, 12.5.4, 12.6.1, 12.6.3, 12.7.2, 12.7.4, and 12.9.2 and RBT2 TDRs MI-1 to MI-3.
K – Marine Vegetation Conclusions	RBT2 EIS Section 11.0 (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101365E.pdf
L – Productive Capacity Technical Advisory Group	Appendix IR3-A of CEAR Document #984	http://www.ceaa-acee.gc.ca/050/documents/p80054/119369E.pdf
M – Roberts Bank Ecosystem Model	RBT2 EIS Appendix 10-B RBT2 EIS Appendix 10-C RBT2 EIS Appendix 10-D	http://www.ceaa-acee.gc.ca/050/documents/p80054/101363E.pdf

Flow Chart Reference	Report Code	URL / Notes
	(CEAR Document #181)	
N – Orange Sea Pen Species Distribution Model	RBT2 EIS Appendix 12-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101361E.pdf
O – Dungeness Crab Productivity Study	RBT2 TDR MI-4 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107604E.pdf
P – Dungeness Crab Habitat Suitability Model	RBT2 EIS Appendix 12-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101361E.pdf
Q – Coastal Geomorphology Study	RBT2 EIS Appendix 9.5-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101370E.pdf
R – Shorebird Foraging Opportunity during Migration	RBT2 EIS Appendix 15-B (CEAR Document #181)	https://www.ceaa-acee.gc.ca/050/documents/p80054/101358E.pdf
S – Coastal Geomorphology Technical Advisory Group	Appendix IR2-A (CEAR Document #961)	http://www.ceaa-acee.gc.ca/050/documents/p80054/118950E.pdf
T – Marine Sediment Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf
U – Marine Water Quality Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf

EIS Marine Fish Flow Chart

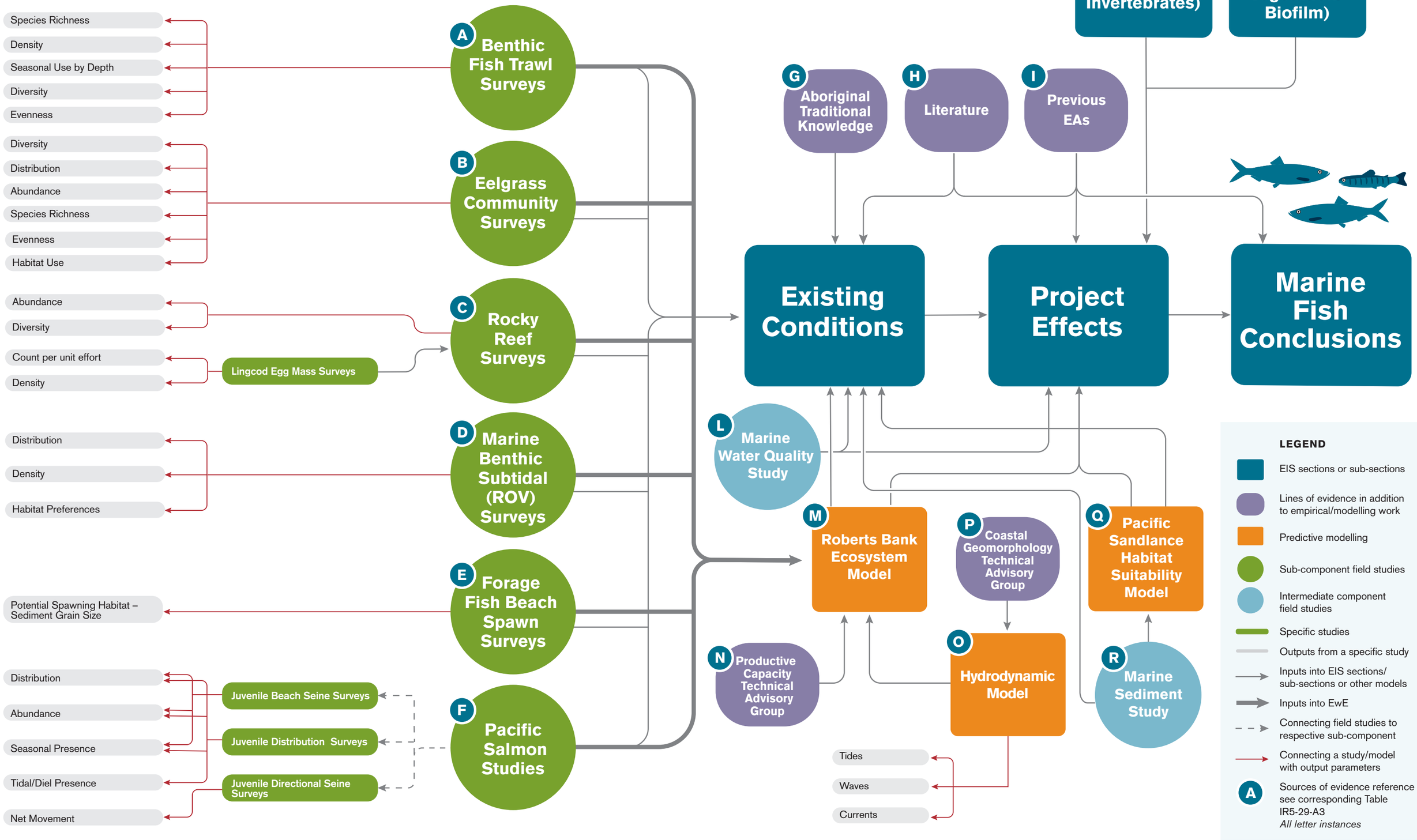


Table IR5-29-A3 Summary of Sources of Evidence used to Evaluate Productivity Changes for Sub-components of Marine Fish

Flow Chart Reference	Report Code	URL / Notes
A – Benthic Fish Trawl Surveys	RBT2 TDR MF-6 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107612E.pdf
B – Eelgrass Community Surveys	RBT2 TDR MF-7 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107611E.pdf
C – Reef Fish Surveys	RBT2 TDR MF-5 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107613E.pdf
D – Marine Benthic Subtidal Study	RBT2 TDR MF-2 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107617E.pdf
E – Forage Fish Beach Spawn Surveys	RBT2 TDR MF-4 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107614E.pdf
F – Pacific Salmon Studies	RBT2 TDR MF-3 (CEAR Document #388)	http://www.ceaa-acee.gc.ca/050/documents/p80054/107615E.pdf
G – Aboriginal Traditional Knowledge	IR-7.31.15-08 (CEAR Document #314)	https://www.ceaa-acee.gc.ca/050/documents/p80054/103668E.pdf
H – Literature	n/a	See EIS Section 13.13; see 'References' sections in RBT2 TDRs MF-1 to MF-7, respectively; see 'References' in EIS Appendix 12-A.
I – Previous Environmental Assessments	n/a	See EIS Sections 13.4, 13.5.1, 13.5.2, 13.5.3, 13.5.4, 13.5.5, 13.6.2, 13.6.3, 13.7.1, 13.7.2, 13.7.6, and 13.9.2 and RBT2 TDRs MF-1 to MF-7.
J – Marine Invertebrate Conclusions	RBT2 EIS Section 12.0 (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101365E.pdf
K – Marine Vegetation/Biofilm Conclusions	RBT2 EIS Section 11.0 (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101365E.pdf
L – Marine Water Quality Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf
M – Roberts Bank Ecosystem Model	RBT2 EIS Appendix 10-B RBT2 EIS Appendix 10-C RBT2 EIS Appendix 10-D (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101363E.pdf

Flow Chart Reference	Report Code	URL / Notes
N – Productive Capacity Technical Advisory Group	Appendix IR3-A of CEAR Document #984	http://www.ceaa-acee.gc.ca/050/documents/p80054/119369E.pdf
O – Coastal Geomorphology Study	RBT2 EIS Appendix 9.5-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101370E.pdf
P – Coastal Geomorphology Technical Advisory Group	Appendix IR2-A (CEAR Document #961)	http://www.ceaa-acee.gc.ca/050/documents/p80054/118950E.pdf
Q – Pacific Sandlance Habitat Suitability Model	EIS Appendix 12-A, Section 6.0 (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101361E.pdf
R – Marine Sediment Study	RBT2 EIS Appendix 9.6-A (CEAR Document #181)	http://www.ceaa-acee.gc.ca/050/documents/p80054/101369E.pdf

APPENDIX IR5-29-B

BIOFILM & SHOREBIRDS TECHNICAL ADVISORY GROUP SUMMARY REPORT

Roberts Bank Terminal 2

Technical Advisory Group (TAG) Process Report

Biofilm & Shorebirds Final

Prepared for

Port Metro Vancouver

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Acronyms

BACI	Before/After Control Impact
B&S	Biofilm and Shorebirds
CEAA	Canadian Environmental Assessment Act
CCIP	Container Capacity Improvement Program
Compass	Compass Resource Management
EA	Environmental EPS Assessment
EPS	Extracellular Polymeric Substance
FRE	Fraser River Estuary
HPLC	High-Protein, Low-Carbohydrate
FRE	Fraser River Estuary
IPCC	Intergovernmental Panel on Climate Change
NHC	Northwest Hydraulics Consultants
POE	Pathways of Effects
PC	Productive Capacity
PMV	Port Metro Vancouver
POC	Particulate Organic Carbon
RB	Roberts Bank
RBT2	Roberts Bank Terminal 2
SRKW	Southern Resident Killer Whales
TAG	Technical Advisory Group
TEU	Twenty-Foot Equivalent Unit
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
VEC	Valued Ecosystem Component
WESA	Western Sandpiper

1 Introduction

1.1 Purpose and Background

The Roberts Bank Terminal 2 (RBT2) project is a proposed new three-berth container terminal in Delta, BC that would expand existing port facilities by 2.4 million twenty-foot equivalent units (TEUs) of container capacity. The project is part of Port Metro Vancouver's (PMV) Container Capacity Improvement Program (CCIP), a long-term strategy to meet anticipated growth in demand for container capacity. The proposed RBT2 project entails the construction of a new three-berth marine terminal and associated road and rail infrastructure alongside the existing Westshore and Deltaport terminals at Roberts Bank. PMV has a mandate to support the growth of Canadian trade with other countries, and current demand forecasts anticipate container traffic to triple by 2030. Subject to regulatory approvals, the RBT2 project could be operational by the mid-2020s. Further information on the proposed RBT2 project can be found on the project's website, www.robertsbankterminal.com.

Figure 1.1 Artist's rendering of the proposed RBT2.



Image courtesy of PMV.

The proposed RBT2 project is subject to environmental assessment (EA) under federal and BC provincial laws. EA is a process whereby the potential effects of proposed projects on the environment are examined through a public process. While the scope and nature of the EA for RBT2 has not yet been determined by regulators, PMV expects the EA to be some form of joint review process. The proposed RBT2 project could potentially cause a variety of environmental effects, some of which are reasonably well understood, and some of which are less well understood due to their complexity and based on the current state of scientific knowledge.

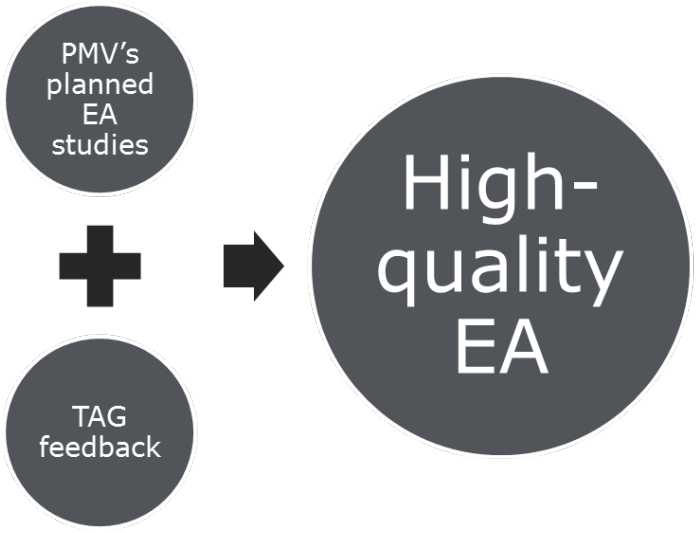
PMV has contracted Hemmera, a consulting firm specializing in EA, to conduct the EA studies for the proposed RBT2 project. Some of these studies, such as baseline studies that characterize the environment pre-construction, are currently underway. As part of its pre-EA work, PMV initiated a Technical Advisory Group (TAG) process to gather input from outside experts on four separate topics.

This report is written by Compass on behalf of the Biofilm & Shorebirds TAG and summarizes the proceedings and recommendations of that TAG.

1.2 Overview of the Technical Advisory Group Process

The purpose of the TAG process was to pro-actively gather input from scientific and technical experts prior to the formal initiation of the EA for RBT2 so as to enhance the relevance, quality, and rigour of EA studies for the project (Figure 1.2). Experts were invited from regulatory agencies, academia, First Nations and key non-government organizations based on their ability to contribute to technical discussions pertaining to the EA studies.

Figure 1.2. Role of TAG process in ensuring high-quality EA of the proposed RBT2 project.



The TAG process involved four separate TAGs:

1. Biofilm and Shorebirds;
2. Southern Resident Killer Whales (SRKW);
3. Coastal Geomorphology; and
4. Productive Capacity of Roberts Bank habitat.

The four TAGs each addressed topics that were considered by PMV and its consultants to require additional preliminary scoping in order to satisfy EA requirements.

The initial intention of the Biofilm and Shorebirds TAG was to inform the relationship between biofilm and shorebirds. However, given the importance of infauna as a food source for shorebirds, the TAG decided to include infauna in the discussion. The focus of the Biofilm and Shorebirds TAG therefore gave equal attention to biofilm, infauna, and shorebirds, despite infauna being absent from the title.

Biofilm, shorebirds, and SRKW are likely to be recognized in the forthcoming EA as topics of particular importance to stakeholders and thus of the forthcoming EA process. These topics are discussed in this report, and within a companion report on the SRKW TAG.

Coastal geomorphology—the physical features and processes in the vicinity of the proposed project area at Roberts Bank—was chosen because project-related geomorphic and physical oceanographic changes are expected to be a primary driver for marine biological and ecological changes. RBT2 infrastructure may cause changes to tidal currents and water movement associated with wind-generated waves, which could affect sediment settling and re-suspension, which in turn could cause changes to local marine habitats, such as biofilm and eelgrass beds. This topic is explored in a companion report on the Coastal Geomorphology TAG.

Similarly, the ability of habitat to support species of particular interest to stakeholders is critical to the health of those species. PMV sees merit in entering into technical dialogue on how the productive capacity of habitat is most appropriately defined at Roberts Bank. This topic is explored in a companion report on the Productive Capacity TAG.

Despite the different topics of each of the four TAGs, all four had a similar set of objectives:

- build a common understanding of the potential effects of RBT2 based on the best available information;
- provide input on appropriate methods for assessing potential adverse effects and their significance;
- identify priority information needs and related studies; and
- Identify opportunities for collaboration.

Each TAG met face to face three or four times between November 2012 and May 2013. Meetings were held in Vancouver over full day periods. Each individual TAG was designed and led by Compass, who acted as an external facilitator. In each meeting Compass and PMV consultants led discussions with TAG members. In addition, for all TAGs except Coastal Geomorphology, focus groups were created to investigate particular topics in greater depth with an additional set of experts relevant to each field.

1.3 Participants and Roles in the TAG Process

There were five main parties identified as potential participants in the TAG process: technical experts from government agencies, academia, non-governmental organizations, PMV and PMV consultants, and First Nations. First Nations did not participate in the TAG process, however PMV has committed to share TAG information and obtain input through a separate process.

TAG members were tasked with:

- providing input on current and planned EA studies;
- providing input on potential effects of the project on the environment;
- providing input on impact assessment methods;
- helping prioritize and scope key issues; and
- providing input from their organization.

PMV consultants, Hemmera, were tasked with:

- preparing material for TAG meetings, such as pre-reading packages, presentation slides, and discussion materials;
- managing schedules, scope, and budget for the TAG process;
- explaining current study plans to the TAGs;
- ensuring integration of people and discussions across TAGs where relevant;
- organizing meeting logistics; and
- where relevant, having representatives participate as TAG members in TAG meeting discussions.

PMV was tasked with:

- providing resources and meeting logistics;
- providing communications with TAG participants and the public;
- providing information about the proposed RBT2 project; and
- observing TAG meetings and considering input from each TAG.

The TAG process was *advisory* in nature, and so PMV sought to gather advice through the process in terms of how best it and its consultants should conduct the EA studies for RBT2.

Compass was tasked with:

- designing the TAG process and advising on implementation;
- facilitating TAG meetings;
- advising on how discussions and outputs of individual TAGs might be used by other TAGs;
- summarizing input, including areas of agreement and disagreement, in meeting notes; and
- producing a record of the process in this summary report.

1.4 About This Report

This report reviews the discussions and outputs of the Biofilm & Shorebirds TAG. This report does not attempt to follow the chronological order in which items were discussed during the meetings, but rather provides a thematically-organized synthesis of discussions that occurred over the course of the TAG meetings.

The next section provides more background information on the Biofilm & Shorebirds TAG in terms of what meetings were held, who was involved, and what specific topics were explored. Sections 3 and 4 examine methods for assessing effects on shorebirds, and on biofilm and benthic macrofaunal and meiofaunal invertebrates (infauna) respectively, and form the bulk of the report. Section 5 examines several related issues that were less prominent in the TAG process. The reader is encouraged to review the reports for the other three TAGs to have a complete understanding of the RBT2 TAG process.

2 Background on Biofilm and Shorebirds TAG

2.1 Introduction

The proposed Roberts Bank Terminal 2 (RBT2) project will introduce changes to the biotic and abiotic environment that may affect shorebirds using the Fraser River Estuary. It will be necessary in the EA context to determine whether the RBT2 project is likely to result in changes to food sources (biofilm and infaunal invertebrates) and to site safety in the Roberts Bank area, thereby causing a significant adverse effect (as defined by the Canadian Environmental Assessment Act - CEAA) on shorebird populations. Of particular interest is the utilization of biofilm as a food source for migrating shorebirds, for which very little is known.

The Biofilm and Shorebirds (B&S) TAG was convened to solicit input on suitable methods that are scientifically defensible, relevant to the regulatory process and relevant to the Roberts Bank area for modelling change to biofilm, infauna and shorebirds, and for assessing and reporting biofilm, infauna and shorebirds response to such change. The B&S TAG discussed how the RBT2 project might affect B&S at Roberts Bank, how PMV and its consultants might assess these effects (using suitable assessment methodologies), and how any effects might be mitigated. This report summarizes the input provided by the B&S TAG and Focus Group in a thematically-organized synthesis of discussions over the course of four TAG meetings.

2.1.1 TAG Meeting Summary

The B&S TAG met four times between November 2012 and March 2013 to discuss a number of topics (Table 2.1).

Table 2.1 Dates and key topics of B&S TAG meetings

Meeting Date	Key Topics Covered
November 29, 2012	• TAG process • RBT2 project overview • Overview of biofilm and shorebird issues at Roberts Bank • Pathways of Effects diagram intended for use as an organizing framework to structure B&S TAG discussion about effects, uncertainties, and studies (see Figure 2.1 Pathways of effects on Biofilm, Infauna, and Shorebirds) • Current research: methods, preliminary results and future planned studies • Priorities and work plan for B&S TAG
January 25, 2013	• Review of anticipated geomorphological changes due to RBT2 • Discussion on assessing significance in environmental assessments • Review of preliminary data collected from biofilm, infauna, and shorebird studies across the Fraser River Estuary (FRE) • Review of proposed method for modelling effects on shorebird abundance (based on food availability and site safety) • Decision to convene Focus Group to provide input on possible factors affecting biofilm and infaunal invertebrate distribution, composition, and abundance (i.e., pathways of effects), development of studies • Work plan and next steps
March 14, 2013	• Review of biofilm and infauna Focus Group results • Review of potential effects of geomorphological changes on biofilm and infauna • Detailed presentation of biofilm and infauna studies, review of assumptions, assessment of potential data gaps or methodological challenges, and identification of additional studies or modifications to existing studies to fill gaps • Assessing effects to infauna and biofilm and identification of potential mitigation options • Review of proposed model for assessing affects to shorebirds
March 15, 2013	• Continued discussion concerning shorebird model structure • Detailed presentation of shorebird studies and methods • Assessment of potential data gaps or methodological challenges, review of assumptions, and identification of additional studies or modifications to existing studies to fill gaps • Assessing significance of effects • Discussion of mitigation options and post-implementation monitoring • TAG wrap-up and key messages

2.1.2 TAG Participants

In total, twelve TAG members participated in the B&S TAG discussions, and nine observers attended without active participation. Table 2.2 presents participants of the B&S TAG.

Table 2.2 Participants in the Biofilm & Shorebirds TAG

Name	Affiliation	Role	Participation
Juergen Baumann	*Baumann Environmental Services Ltd.*	TAG member	Meetings 1, 2 , 3, 4
Christian Beaudrie	*Compass*	Facilitator	Meetings 1, 2
David Angus	*Compass*	Support	Meetings 3, 4
Lee Failing	*Compass*	Facilitator	Meetings 1, 2, 3, 4
Andrew Robinson	*Environment Canada*	Observer	Meetings 2, 3, 4
Mark Drever	*Environment Canada*	TAG member	Meetings 2, 3, 4
Terri Sutherland	*Fisheries and Oceans Canada*	TAG member	
Ben Wheeler	*Hemmera*	Observer	Meetings 1, 2, 3, 4
Carson Keever	*Hemmera*	TAG member	Meetings 1, 2, 3, 4
Doug Bright	*Hemmera*	Observer	Meetings 1
Eriko Arai	*Hemmera*	Observer	Meetings 1, 2, 3, 4
Jay Rourke	*Hemmera*	TAG member	Meetings 1, 2, 3, 4
Marina Winterbottom	*Hemmera*	Observer/Presenter	Meetings 1, 2, 3, 4
Tobin Seagel	*Hemmera*	Presenter	Meeting 2
Matthew Fields	*Montana State University*	TAG member	Meetings 1, 2, 3
Derek Ray	*Northwest Hydraulic Consultants*	Presenter	Meeting 2, 3
Rob Butler	*Pacific Wildlife Foundation*	TAG member	Meetings 1, 2, 3, 4
Tomohiro Kuwae	*Port and Airport Research Institute*	TAG member	Meetings 2, 3, 4
Jody Addah	*Port Metro Vancouver*	Observer	Meetings 2, 3, 4
John Parker-Jervis	*Port Metro Vancouver*	Observer	Meetings 1
Kyle Robertson	*Port Metro Vancouver*	Observer	Meetings 1
Rhona Hunter	*Port Metro Vancouver*	Observer	Meetings 1
David Lank	*Simon Fraser University*	TAG member	Meetings 1, 3, 4
Ron Ydenberg	*Simon Fraser University*	TAG member	Meetings 1,2 , 3, 4
Maycira Costa	*University of Victoria*	TAG member	Meetings 1, 2, 3, 4
John Takekawa	*USGS Western Ecological Research Center*	TAG member	Meetings 1, 2, 3, 4
Chris Martin	*WorleyParsons*	Presenter	Meeting 2, 3, 4
Mary-Lou Lauria	*WorleyParsons*	TAG member	Meetings 1, 2, 3, 4

2.1.3 Focus Group Participants

Given the expertise required to inform specific questions raised by the Biofilm & Shorebirds TAG, a Focus Group was convened consisting of individuals with expertise in biofilm and infaunal invertebrates. Focus Group members were engaged through a series of structured interviews to create additional detailed pathway of effects diagrams relating RBT2 to effects on biofilm and infauna. Three experts participated in the Focus Group from government bodies (Environment Canada, Port and Airport Research Institute (Japan)), and one US academic institution (Montana State University).

2.1.4 Initial Selection of TAG Topics

At the onset of the TAG process, PMV consultants identified a number of key areas for guidance, and tasked the TAG members with providing input on several key questions:

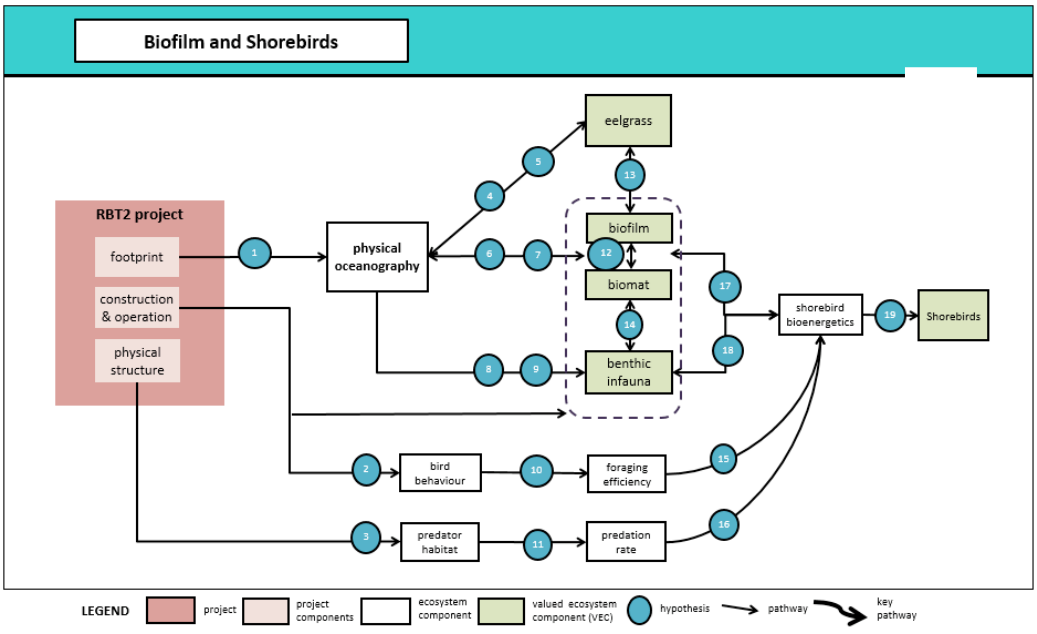
- What are the pathways of potential effects linking the proposed RBT2 project to biofilm, infauna, and shorebirds?

- What are the key uncertainties (i.e., knowledge gaps), and how do they affect the ability to assess the effects of the project?
- What are appropriate methods and metrics for assessing the potential effects of the RBT2 project on biofilm, infauna, and shorebirds?
- What should be considered when assessing what would constitute a significant adverse effect on biofilm, infauna, or shorebirds?
- What additional studies are needed to understand how RBT2 may affect biofilm, infauna, and shorebirds?

These topics served to guide the development of agendas for four Biofilm & Shorebirds TAG meetings.

As a starting point, the B&S TAG reviewed potential pathways of effects between the proposed RBT2 project and biofilm, infauna, and shorebirds in the Roberts Bank area (Figure 2.1). This pathway of effects diagram was initially prepared to facilitate discussion, and while revisions proposed by the TAG are incorporated, no attempt was made to seek formal TAG approval. It was not intended for use in quantitative modelling or analysis, but rather as an organizing framework to structure TAG discussion about effects, uncertainties, and studies.

Figure 2.1 Pathways of effects on Biofilm, Infauna, and Shorebirds



The possible cause-effect relationships (or hypotheses) summarized in Figure 2.1 were as follows:

1. The proposed RBT2 project footprint may affect physical oceanography (sedimentation, grain size, turbidity, wave/water velocity, salinity, etc.).
2. The presence of terminal construction and operation may affect how shorebirds use the Project area.

3. Infrastructures may affect how predators (raptors) use the Project area which could affect shorebird behaviour and use.

4. Changes in seabed morphology may affect changes in eelgrass, and conversely, changes in eelgrass may affect seabed morphology.

5. Changes in physical oceanography may affect eelgrass distribution.

6. Changes in coastal geomorphology can affect abiotic factors related to biofilm growth, e.g. increases in sediment load in water column could lead to smothering of biofilm/biomat through deposition, and changes in water quality characteristics (turbidity) could make it easier or harder for biofilm/biomat to grow.

7. Changes to biofilm may affect seabed morphology (through stabilization in the event of biofilm growth, or through loss of stabilization in the event of biofilm decline).

8. Changes to seabed morphology may affect benthos.

9. Changes in physical oceanography may affect abiotic factors related to infaunal invertebrate growth.

10. Changes in bird behaviour may have bioenergetic costs (e.g. shifting habitat use, reduced foraging efficiency).

11. Changes in predator use may alter the current rate of predation on shorebirds (e.g. an increase in predator use of area may lead to increased predation rate on shorebirds).

12. Changes in biomat may affect biofilm distribution and abundance, and vice versa.

13. Biofilm and eelgrass may interact competitively.

14. Changes in benthos may affect biofilm/biomat as benthos graze on biofilm/biomat Conversely, changes in biofilm/biomat may affect benthos.

15. Changes in bird foraging behaviour could have bioenergetic effects.

16. Changes in predation pressure may lead to changes in alternation in use of habitat.

17. Potential changes in biofilm abundance and distribution at Roberts Banks may potentially affect individual shorebird feeding at Roberts Bank and across the FRE.

18. Potential changes in benthic infauna abundance and distribution at Roberts Banks may potentially affect individual shorebird feeding at Roberts Bank and across the FRE.

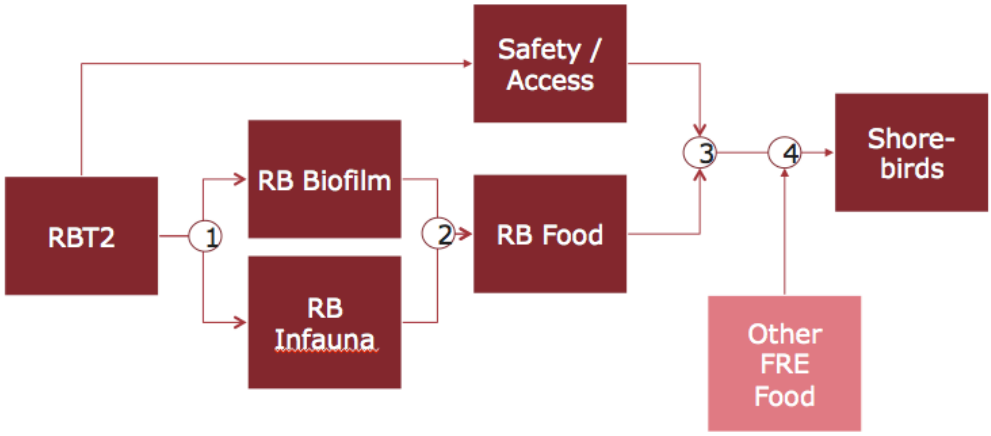
19. Changes to individual shorebird bioenergetics may translate into population level effects on shorebirds.

For each pathway, PMV consultants presented the impact hypothesis, the key uncertainties, and the studies currently underway or planned to address them and the preliminary findings to date. They identified where other TAGs or other parts of the consulting team were doing more detailed work (e.g. the pathways related to physical oceanography are addressed by the Coastal Geormorphology TAG). A summary of pathways of effects, hypotheses, uncertainties, available data, and planned studies can be found in Appendix A.

Key messages from the TAG at this stage included:

- The TAG should guard against overemphasizing the study of biofilm at the expense of infauna. The TAG views infauna as an equally important food source that may be affected by many of the same pathways as biofilm but possibly in different ways.
- Biofilm and infauna have special significance as food sources for shorebirds; they are important elements of the ecological community and have broader value than just as food sources for shorebirds. Based on the discussion, the TAG focused in on a simplified set of pathways and key questions, namely the effects of the proposed RBT2 project on the *abundance* and *availability* of shorebird food, and *site safety*, as detailed in Figure 2.2.

Figure 2.2 Simplified Pathways of effects on Biofilm, Infauna, and Shorebirds



This simplified pathway of effects diagram brings into focus four key questions addressed by the TAG (indicated by numbers 1, 2, 3, and 4 in Figure 2.2.):

1) How can we model and report the potential effects of RBT2 on biofilm and infauna?

2) a) What is the importance of biofilm as a food source for shorebirds at Roberts Bank?

   b) How substitutable are biofilm and infauna as food sources? At what point and under what conditions do birds switch from one source to another?

   c) How do biofilm and infauna differ as a food source from one location to the next?

   d) What would constitute a biologically meaningful effect on biofilm or infauna?

3) How can we model and report the effect of RBT2 on shorebirds (with respect to food sources, access to food, and site safety in the Roberts Bank area)?

4) a) What is the importance of Roberts Bank relative to other areas in the Fraser River Estuary?

   b) What would constitute a significant adverse effect on shorebird populations?

   c) What kinds of mitigation actions might be suitable, and where might they be located?

These key topics provided a basis for TAG discussion. The TAG began by developing an approach to assessing effects on shorebirds. They then looked at methods for assessing effects on biofilm and infauna. They concluded by reviewing updated list of studies and key assumptions, and provided input to guide the work of the project team.

3 Assessing Effects on Shorebirds

3.1 Assessment Methods

As noted above, the key issues discussed in relation to predicting RBT2 project-related effects on shorebirds included the following:

- How can we model and report the effect of RBT2 on shorebirds (with respect to food sources, access to food, and site safety in the Roberts Bank area)?
- What are good metrics/indicators for effects on shorebirds?
- What is the best way to assess whether projected changes at Roberts Bank cause a significant adverse effect on shorebird populations?
- How do shorebirds use the Roberts Bank area?
- What is the importance of Roberts Bank relative to other areas in the Fraser River Estuary?
- What kinds of mitigation actions might be suitable, and where might they be located?

The TAG discussed various ways of assessing impacts on migratory shorebirds, in consideration of the fact that they use multiple sites and are affected by multiple developments and activities throughout their range. While the TAG appreciated the goal of assessing the effect of the project on the overall fitness and reproductive success of shorebird populations, it was determined to be not feasible and beyond the scope of the assessment.

The TAG therefore recommended the EA focus on assessing the effect of RBT2 on changes to *shorebird foraging opportunity*[1] at this site, with the goal of avoiding or offsetting any negative effects on shorebirds and ultimately striving for no net loss of opportunity at a) the immediate Roberts Bank site; and / or b) the broader FRE. If it can be demonstrated that there is no net loss of shorebird opportunity at the site / estuary level, then potential effects resulting from the project could be deemed minimal.

In response to the TAG's feedback about the key pathways of effects (Figure 2.2), the project team developed and presented an illustrative "shorebird opportunity model". This model integrates *food availability* and *site safety* into an assessment of effects on shorebirds. The conceptual model assumes that shorebirds make a tradeoff between site safety (measured as the distance a location is from cover that predators can use to conceal themselves) and food quality and quantity when choosing whether or not to feed at a site.

[1] Shorebird opportunity was defined in the TAG as a measure of energy available to a shorebird to feed on at any one location, weighted against site safety, and considering other factors such as tidal exposure.

In overview, the model involves:

- *Assigning a food value to each spatial increment of the mudflat (e.g. every 200 m²) across the Project area, based on infaunal invertebrate and biofilm food data collected as part of the proposed RBT2 project EA.*
- *Assigning site safety scores to the same spatial increment (e.g. every 200m²).*
- *Inferring shorebird opportunity at each spatial increment.*
- *Validating shorebird opportunity inference with shorebird usage data collected as part of the proposed RBT2 project EA.*
- *Predicting shorebird opportunity post RBT2; predictions are based on data on direct impacts due to the RBT2 footprint and indirect impacts due to changes in waves, currents and water velocity.*
- *Evaluating change in shorebird opportunity as a result of RBT2.*

The resulting index score reflects the "opportunity" for shorebirds, and the change in the score reflects the loss or gain in opportunity for shorebirds at Roberts Bank as a result of RBT2.

The concept of the opportunity model evolved and developed through discussion conducted on days three and four of the TAG. TAG members agreed that the approach is conceptually sound, and provided the following feedback:

- The approach is defensible and the index score will provide useful information. However, it will be critical to validate the predicted index score with post implementation monitoring.
- In combining food quality and site safety into a single metric (shorebird opportunity), TAG members cautioned that there may be a loss of dimensionality.
- Site safety may have a logarithmic relation with distance from cover, whereas food quality may be more linear. It may be reasonable then to scale the axes, and possibly inversely weigh food quality against site safety.
- Safety and food availability are determined temporally by tides giving the birds "windows of opportunity." If the bulk of the usage occurs where there is not much of a predicted change in abiotic and biotic conditions (due to RBT2), then it stands to reason that effects could be minimal.
- Consider weighting model outcomes according to species (dunlin vs. WESA); however, be mindful that birds will adapt to changing food availability.
- Consider using a balance sheet approach to calculate caloric value of sites combined with a safety rating of the location to create a composite value that would be measured against the foraging area / opportunity time.
- Convert biofilm and infauna into energy units and look at map as an expression of opportunity.
- Complicating factors in modelling may be related to the social behavior between sandpipers and dunlin, whereas western sandpipers may be avoiding areas heavily used by dunlin when dunlin are present.

- Predator densities may also increase from increased perching opportunities.
- Grain size could be used as a surrogate for food suitability as sediment grain size seems to be correlated with infauna.
- Estimated changes in the Roberts Bank area due to climate change should be considered.
- The wintering dunlin population is one of the largest populations on the pacific coast. The FRE is an extremely important site to wintering dunlin. The current dunlin program is not designed to be able to develop an opportunity model that could be used to assess potential effect. This was identified as a gap in the winter program. It was recommended that the winter dunlin program be adjusted to include usage and food data (droppings and infauna), and that a foraging opportunity model (similar to the WESA model) be developed for dunlin.
- Modelling of opportunity changes for Western Sandpiper (WESA) and Dunlin should include the entire Fraser River Estuary (e.g. Roberts Bank, Sturgeon Bank, and Boundary Bay).
- A goal of no net loss in opportunity could be a good metric in assessing project effects on shorebirds.
- TAG members recommended that mitigation and post construction monitoring commitments be written into the terms of commitments.

3.2 Indicators of Effects

The shorebird opportunity model produces an index that can be used to summarize RBT2 effects on shorebirds. TAG members did not reach a conclusion on which metrics would be best for reporting effects on shorebirds, but recommended that the project team consider the following: bird abundance (coarser estimate than others), usage (number of droppings), shorebird usage days (derived from the opportunity model and post-construction droppings transects – similar to the existing program), fattening rate (less intensive than "length of stay" and more repeatable), length of stay (more difficult to measure as it requires radio tagging birds and measuring their length of stay at stopover sites) and flight speed (promising preliminary research indicates this could be an effective (and cost effective) method of measuring site quality).

3.3 Significance of Effects

With respect to determining the significance of effects (as per CEAA guidelines), TAG members suggested:

- That the assessment of effects based on the shorebird opportunity model be conducted across the entire FRE, as the estuary functions as a whole to support migrating and overwintering populations;
- That the absolute change and trends in shorebird abundance and diversity be monitored; and

- That the use of historical data on the natural variability of shorebird populations over time be used as a benchmark in determining whether predicted changes are significant.

3.4 Proposed Studies

Shorebird Opportunity Model

TAG members reviewed study needs in support of the proposed shorebird opportunity model and made a number of recommendations, which are captured in the proposed model methodology above, and the current study plan shown in Appendix A. Additional recommendations included:

- That results from the first year of data collection not influence the design of subsequent sampling and that the sampling locations continue to be selected using a randomize procedure;
- That the model include a measure of 'food availability'; and
- That consideration be made for using a before/after control impact (BACI) design to assess effects.

Food Quality Studies

With respect to defining a unit of food 'quality' at a given location, TAG members suggested utilizing a measure of energy density (energy available per unit area) as a metric for food quality at a particular location, calculated as the total caloric content without differentiating between the food source (biofilm versus infauna). TAG members supported this proposed approach with the following suggestions:

- That possible energy density and intake rate measures include: joules per m^2, food availability, intake rate, and bird fattening rates;
- That further study be conducted to determine the relative quality of these two food sources;
- Biofilm may comprise a high proportion of a migrating shorebird's diet; however, there is uncertainty concerning the nutritional quality of biofilm compared to infauna; and
- Biomass per unit area (e.g. G/m^2), for which data has already been collected, would be an acceptable proxy metric.

The TAG acknowledged that while this approach for assessing food quality is sound, the lab work involved is onerous.

Shorebird Usage Studies

TAG members supported the proposed methodologies, conducting droppings counts, for assessing shorebird usage in the Roberts Bank area (and the FRE), providing valuable feedback

guide the 2013 field program. This feedback has been incorporated into the study program which is summarized in (Appendix A). TAG members suggested the following:

- Avoid bias in sampling by returning to 'hotspots'; and
- Do not use results from 2012 season to influence sampling design for 2013. Transects and sampling locations should be selected independently from previous results using a random or systematic procedure.

4 Assessing Effects on Biofilm and Infauna

4.1 Assessment Methods

As noted in Section 2.1.4, key issues with respect to biofilm and infauna include:

- How can we model and report the potential effects of RBT2 on biofilm and infauna?
- What is the importance of biofilm as a food source for shorebirds at Roberts Bank?
- How substitutable are biofilm and infauna as food sources? At what point and under what conditions do birds switch from one source to another?
- How do biofilm and infauna differ as food sources from one location to the next?
- How do biofilm and infauna vary in abundance, distribution, and composition both seasonally and annually?
- What would constitute a biologically meaningful effect on biofilm or infauna?

To address these questions, TAG members reviewed preliminary data and discussed the studies planned and currently underway to understand the distribution, abundance, and composition of biofilm and infaunal invertebrates at Roberts Bank. Given the high degree of uncertainty with respect to the factors that affect biofilm and infauna growth, the TAG recommended eliciting input from a broader group of experts to identify:

- Key factors limiting biofilm and infaunal invertebrate growth; and
- Factors likely affected by changes to coastal geomorphology resulting from RBT2.

A small group of external experts was identified and interviewed to provide insight on detailed pathways of effects between RBT2 and biofilm and infauna. Given the findings of these experts, outlined below, the TAG reviewed and discussed proposed approaches for effects assessment and monitoring, and assumptions and uncertainties.

In order to understand anticipated *changes to the coastal geomorphology and the ability to predict them* as a result of RBT2, TAG members reviewed preliminary results from the Coastal Geomorphology Study being conducted Northwest Hydraulics Consultants (NHC), and which relies on numerical modelling studies as well as interpretive techniques. TAG members discussed:

- The key changes anticipated to coastal geomorphology; and

- The capabilities and limitations of the geomorphology study (in particular the numerical modelling component) and any implications for the assessment of effects on biofilm and infauna.

4.2 Biofilm and Infauna Pathways: Focus Group Results

Figure 4.1 is the detailed pathway of effects diagram developed by the Focus Group. It illustrates the main pathways by which RBT2 could affect changes in abiotic (e.g. wave energy, water flow) and biotic (e.g. nutrient) conditions in the Roberts Bank area, thereby affecting the growth of biofilm and infauna. Yellow boxes indicate the key factors identified by Focus Group participants in driving changes to biofilm and infaunal invertebrate growth. White boxes indicate factors that influence biofilm and infauna growth, but are not key factors. For example, the factor 'sediment grain size' (in yellow) is considered to be a key factor in affecting biofilm and infauna growth, while 'nutrient load' plays a relatively minor role in comparison. Figure 4.1 also shows which pathways are thought to be most critical. Red arrows on the left hand side of the diagram indicate abiotic factors directly affected by RBT2. Blue arrows on the right indicate the pathways which Focus Group participants considered most strongly influence biofilm and infauna growth.

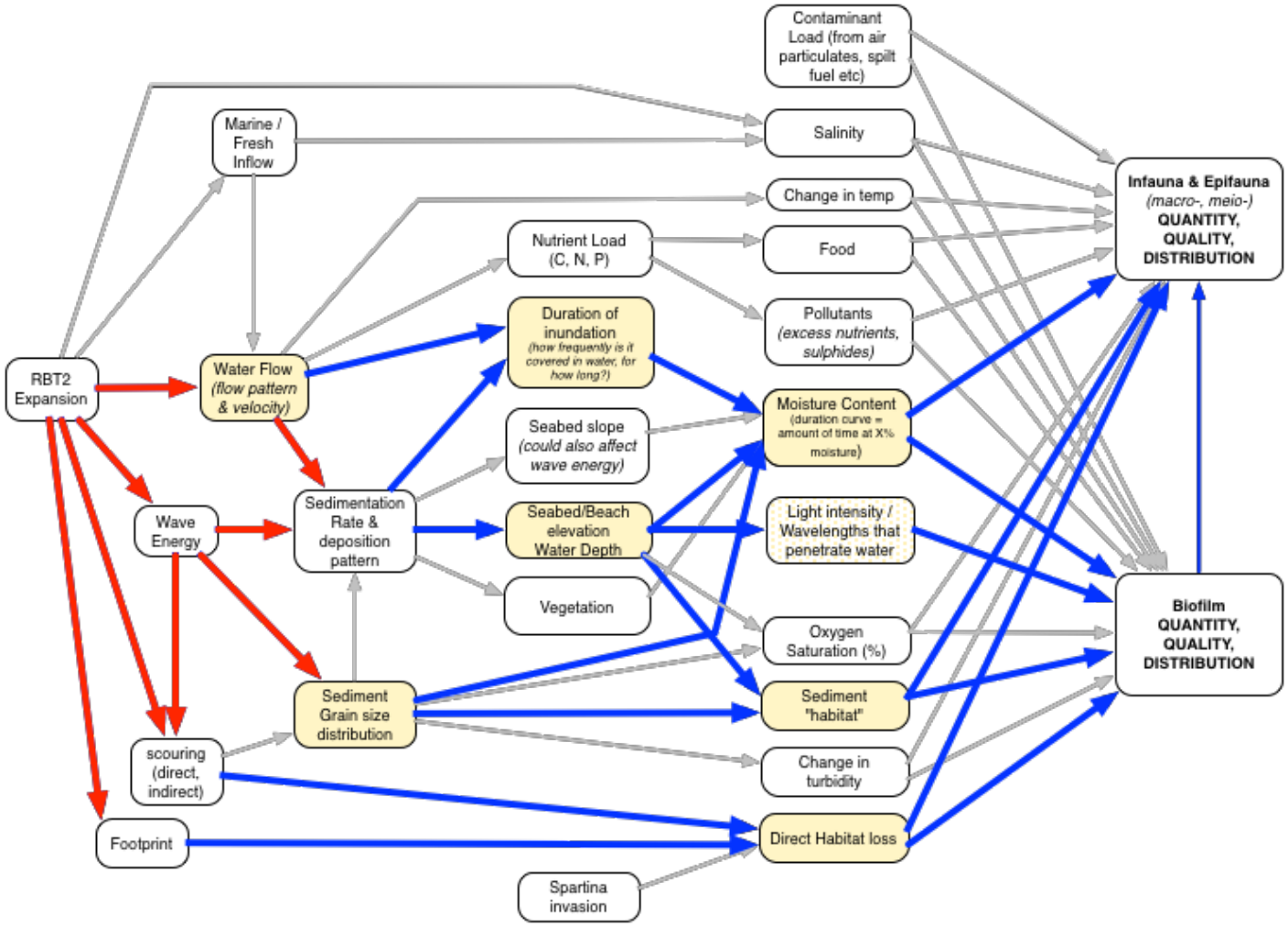
Focus Group findings are summarized in Appendix B, which contains a summary table of key uncertainties and data available for key pathways, and planned studies to evaluate effects, along with a summary of more general input. Some of the key messages from the focus group work are listed below:

- The same abiotic and biotic factors drive growth for infauna and biofilm. Similarly, the key factors that drive growth are the same for both biofilm and infauna. The only exception is that intensity of available sunlight is a key factor for biofilm only. This creates some synergies for data collection and effects modelling.

- From Figure 4.1, the TAG noted that in particular, the ability to reliably predict depth and duration of inundation and sediment grain size is critical to being able to reliably predict changes in biofilm and infauna communities (especially the composition of infaunal invertebrates).

While the pathways in Figure 4.1 can be readily identified, there are important uncertainties on some of the pathways, particularly for biofilm. One focus group member felt that there is a need to convene a major science panel, consisting of neutral international experts to study biofilm.

Figure 4.1 Key Pathways of Effects for Biofilm and Infauna



Given the results of the Focus Group, TAG members discussed what must be known about potential changes to the coastal geomorphology in the Roberts Bank area in order to predict changes to infauna and biofilm. Preliminary results from the Coastal Geomorphology Study (in particular results of preliminary hydrodynamic, morphodynamic, and wave modelling) performed by Northwest Hydraulics Consultants (NHC) were presented. TAG members reviewed these results and discussed several challenges for assessing changes to biofilm and infauna using the pathway of effects methodology, including the following:

- Based on the information presented by NHC, there are limits to the ability of numerical models to predict future change. While modelling of waves and ocean currents are thought to be quite robust, modelling of sediment transport (morphodynamics) is less certain. In particular, model predictions of fine, cohesive sediment transport is highly uncertain. NHC has adopted an approach to increase certainty in these areas by relying on interpretive and empirical techniques. This topic is explored in a companion report on the Coastal Geomorphology TAG. The residual uncertainty may have implications for assessments of biofilm and infauna. TAG members encourage close linkage between the ongoing geomorphological study efforts and the assessment of infauna/biofilm.

- The TAG noted that there is no clear precedent on which indicators are best for characterizing the effect of RBT2 on biofilm and infauna.

Despite these challenges, the TAG provided comment on studies that need to be in place to clearly understand key (limiting) factors and key pathways of effects by which RBT2 may affect biofilm and infauna. A summary of the key pathways of effects, available data, and drivers can be found in Appendix B.

4.3 Biofilm Studies

TAG members discussed key issues related to biofilm, and provided feedback on assessment methods, planned studies, assumptions, metrics, and uncertainties. Key messages included:

- TAG members concurred that biofilm is important both as a food source for shorebirds and for its role in the overall ecology in the region.

- Although the TAG did not recommend specific indicators for assessing changes to biofilm, they did propose that the indicators encompass biomass, diversity, distribution, and possibly fat and carbohydrate content. TAG members suggested including total organic carbon (TOC) and particulate organic carbon (POC).

- TAG members established that shorebird energy requirements are met through the consumption of both biofilm and infauna. The amount of biofilm consumed by shorebirds varies by species, season, and site.

- TAG members agreed that the selection and substitutability of biofilm versus infauna as food sources requires further study.

- TAG members suggested that there are two main ways to characterize the biofilm: from an energy perspective and from a diversity perspective.

- TAG members recommended that studies focus on how biofilm differs at two separate locations where biofilm is found: the area near Canoe Pass, and the known biofilm polygon from the work of Catherine Berris Associates Inc. It was discussed that the biological characteristics (e.g. species composition, biomass, etc.) of the

biofilm documented near Canoe Pass may differ from those of the existing biofilm polygon.

- TAG members recommended changes to sampling techniques: keep samples shallow (1-2mm), keep sampling randomized, and maximize spatial coverage, to minimize extrapolation of results from one area to another. Mapping of interpolated spatial data was suggested, though no specific interpolation radius was agreed to.
- TAG members debated the appropriateness of extrapolating results from one sampled area to an area which has evidence of biofilm presence and similar substrate qualities. No consensus was reached.
- TAG members endorsed the proposed methodology for assessing impacts on biofilm as sound, though suggested that the assumption of spatial homogeneity of results be tested (e.g. it may not be valid to assume that biofilm at locations other than the studied locations have the same characteristics).

TAG members supported the proposed studies, and in addition to the feedback and recommendations above, they recommended two additional studies:

- An investigation into the role of fatty acids in diet and the palatability of biofilm to understand shorebird preference for different biofilm types.
- Consideration of hyperspectral surveys or substitutes, remote sensing, unmanned drones or satellites for mapping of biofilm across the FRE. This would enable a comparison between biofilm in the project area and the surrounding FRE.

4.4 Infaunal Invertebrate Studies

TAG members discussed a number of key questions related to infaunal invertebrates, and provided feedback on study methods, metrics, and uncertainties. Key messages included:

- TAG members concurred that infauna is important both as a food source for shorebirds and for its role in the overall ecology in the region. Infauna also plays a role in aerating and modifying substrate, among other functions.
- TAG members suggested several metrics for characterizing effects on infauna, including measures of species richness, abundance, biomass, and diversity. TAG members cautioned however, that indexing these measures can be deceiving, and as a result there was no consensus on which metrics to use.
- TAG members were concerned about how changes due to RBT2 might affect infauna, and reiterated the importance of infauna in relation to biofilm.
- TAG members supported the use of a stratified sampling design of 60% of sampling occurring within 1 km from shore, or the causeway, and 40% occurring between 1-3 km. This was justified based on known WESA foraging distributions.
- TAG members cautioned that it would be difficult to differentiate between natural variation and project effects.

TAG members supported the studies proposed, and no new studies were recommended.

5 Summary of Approach

In summary, TAG members provided input on various aspects of study design and sampling, and recommended additional studies. Based on this input, the current approach for biofilm, shorebirds and infauna is to proceed with a spatial opportunity model that integrates food availability and site safety.

Food availability is assumed to be the the energy available from biofilm and infauna, and will be calculated per unit area (e.g. joules/m^2 or joules/hectare). With some minor study design modifications, the TAG endorsed the infaunal field program, which seeks to derive (i) abundance, biomass, distribution and taxonomic data from sediment cores and (ii) abiotic co-variates through co-located sediment sampling. The TAG also endorsed the biofilm field program with some minor study design recommendations. This program includes studies of (i) the distribution of biofilm at Roberts Bank from hyperspectral mapping, (ii) taxonomic composition through HPLC (High-Protein, Low-Carbohydrate) analysis of sediment cores, (iii) abiotic co-variates through co-located sediment sampling, and (iv) the carbohydrate or "EPS" (extracellular polymeric substance) composition through spectrophotometry. Taken together, these studies will lay the foundation for quantifying the amount of food available for foraging shorebirds. Details of these field programs can be found in Table 5.1.

In addition to food availability, an estimate of "opportunity" will also consider site safety, as the perception of danger affects the timing, duration, and location of shorebird foraging. It is assumed that less potential energy is available to shorebirds at sites with nearby predators, as they would decide it was too dangerous to feed at a specific location thereby reducing their foraging "opportunity". Site safety scores will be assigned through a field assessment conducted in summer 2013. Opportunity will also consider other factors such as tidal exposure (e.g. the amount of time an area of mudflat is exposed and therefore available to a foraging shorebird).

These weighted opportunity values across the FRE would then be summed to estimate the total shorebird foraging opportunity (in joules). Opportunity would be modeled against actual droppings counted on mudflats to help build and validate the overall model. The model could be rerun with the RBT2 project footprint and proposed mitigation and/or offsetting to see if the opportunity changed. The goal set by the TAG was no net change in opportunity across the FRE (and preferably at RB).

Table 5.1 TAG Endorsed Biofilm and Infauna Field Program Studies

Study	Methodology	Endorsed (Yes/NO)
Hyperspectral Mapping	Aerial surveys using a hyperspectral sensor and concurrent in situ sampling with handheld spectrophotometer & sediment cores	Yes
Biofilm Taxonomic Analysis	Field sampling of sediment cores for taxonomic validation using HPLC analysis (17 pigments) and microscopic taxonomic ID	Yes
Biofilm EPS Study	Laboratory carbohydrate measurements	Yes
Biofilm Abiotic Parameters	Multivariate analysis of abiotic covariates of biofilm	Yes
Benthic Infaunal Invertebrate Sampling	Sediment core sampling; lab analysis for abundance, biomass and taxonomic composition.	Yes
Benthic Infaunal Abiotic Parameters	Multivariate analysis of abiotic covariates of benthic infauna	Yes

6 Other Considerations

6.1 Mitigation Options

While specific mitigation measures were not the focus of discussion given the early stage of the pre-environmental assessment work, the project team proposed a high level approach to mitigation and post implementation monitoring for discussion with the TAG. TAG members provided input on the approach and on specific issues that merit further examination.

Potential mitigation options were presented and discussed for the abiotic environment (sediment, water flow and wave height, and beach elevation), biofilm and infauna (shorebird food enhancement), and shorebirds (site safety). TAG members suggested that the project follow a hierarchy of enhancements, and suggested a number of non-food related habitat enhancements, including upland food enhancements, and reducing impact from invasive species (e.g. spartina).

TAG members suggested a number of additional mitigation options for consideration. The options are highly conceptual in nature; therefore further investigation into each option is warranted:

- Consider engineered mitigations to slow water velocity in order to establish conditions suitable for biofilm growth.
- Seek like-for-like enhancements (habitat creation) at other sites, such as at the mouth of the Fraser River (however, some TAG members cautioned that the creation of artificial mudflats has proven difficult in certain cases).
- Enhance habitat for shorebirds by determining how to best manage the water output of pumping stations.
- Enhance shorebird safety by removing or altering structures that can be utilized by predators for hunting.

6.2 Other disturbances

TAG members discussed the potential effects from a number of other disturbances, and suggested the consideration of effects from new invasive species, effects on existing invasives, effects due to potential lubricant or hydrocarbon leaks from ships and potential effects related to climate change.

6.3 Linkages to Other EA Work

The modelling work proposed for assessing effects of RBT2 on biofilm, infauna, and shorebirds, is highly dependent on the results from the Geomorphology Study.

7 Conclusion and Future Opportunities

The Biofilm & Shorebirds TAG met four times over 2012 and 2013 to provide PMV and its consultants with feedback on appropriate methods to assess the potential effects of the proposed RBT2 project on biofilm, infauna, and shorebird populations at Roberts Bank. This report catalogues this TAG process and the key findings and outputs of the process. At this point, PMV and its consultants are continuing their pre-EA studies with this additional

guidance in mind. Looking forward, PMV and its consultants will complete their EA studies, engage the provincial and federal governments in the formal EA process, and continue to consult with stakeholders and First Nations.

Appendix A – Pathways of Effects Studies Planned

Table A1. Pathways of Effects and Planned Studies

This table summarizes key Pathways of Effects (POE) linkages, hypotheses, uncertainties, data available, and studies planned for each linkage in the pathway of effects diagram in Figure 2.1.

Pathway	Linkage	Hypothesis	Specific Uncertainties	Data Available	Planned Studies (Details in Table A2)
1	RBT2 - coastal geomorphology	The proposed RBT2 Project will potentially affect physical oceanography (sedimentation, grain size, turbidity, wave, water velocity salinity).	- Changes in ebb and flow tidal currents - Changes in salinity - Changes in turbidity - Changes in temperature - Changes in light penetration - Changes in sediment grain size - Changes in wave climate	- 2004 Coastal Geomorphology Study for DP3 - existing scientific literature - existing consultants and government reports - historical and recent measurements of tides/waves/winds/current - historical and recent bathymetric surveys, air photos, sediment data, etc.	Coastal geomorphology studies (NHC): 35, 38, 39, 40, 42 Abiotic parameters studies: 29, 44
2	RBT2 - bird behaviour	Presence of terminal construction and operation may affect how shorebirds use the RBT2 area.	- Spatial distribution of shorebird use across the FRE - Intensity of shorebird use across the FRE	- Shorebird dropping counts across the FRE (2012-2013) - Shorebird abundance counts across the FRE (2012-2013)	Shorebird habitat use surveys: 31 -
3	RBT2 - predator habitat	Infrastructures may affect how raptors use the RBT2 area which could affect shorebird behaviour and use.	- Whether new RBT2 infrastructure will affect raptor use/hunting within Roberts Bank	- Data to become available through planned site safety assessment	Shorebird site safety assessment: 33
4	phys oceanography - eelgrass	Changes in physical oceanography and seabed morphology may affect eelgrass AND vice versa.	- Eelgrass/biofilm interactions - Eelgrass/infauna interactions	- Scientific literature	Coastal geomorphology studies (NHC): 40,42
5					

Pathway	Linkage	Hypothesis	Specific Uncertainties	Data Available	Planned Studies (Details in Table A2)
6	phys oceanography - biofilm/biomat	Changes in coastal geomorphology can change abiotic factors related to biofilm growth, e.g. increases in sediment load in water column could lead to smothering of biofilm/biomat through deposition, and changes in water quality characteristics (turbidity) could make it easier/harder for biofilm/biomat to grow.	- Physical oceanographic correlates of biofilm and/or biomat growth and distribution - How changes in these processes may potentially affect biofilm and/or biomat at Roberts Bank - Biotic and abiotic sources of nutrients for biofilm and their origins	- NHC field data - Sediment grain size and chemistry data for FRE (2012-2013) - Biofilm isotope data -	Coastal geomorphology studies (NHC): 35, 38, 40 Biofilm abiotic parameters study: 27, 29
7	phys oceanography - biofilm/biomat	Changes to biofilm may affect seabed morphology (through stabilization in the event of biofilm growth or through loss of stabilization in the event of biofilm decline).	- Critical shear stress tolerance of biofilm - Cohesion and chemical composition of polysaccharides associated with the biofilm community - Methods to measure sediment stabilization	- Scientific literature - Biofilm EPS data - Biofilm shear stress levels - NHC hydrodynamic model	Coastal geomorphology studies (NHC): 38, 40 Biofilm critical shear stress study: 30 Biofilm recolonization study: 28 -
8	phys oceanography - benthic infauna	Changes in physical oceanography can change abiotic factors related to infuanal invertebrate growth.	- Physical oceanographic correlates of benthic infaunal growth and distribution - How changes in these processes may potentially affect benthic infaunal communities	- Sediment grain size and chemistry data for FRE (2012-2013) - NHC hydrodynamic model	Coastal geomorphology studies (NHC): 39,40 Abiotic parameters of infauna study: 44
9	bird behaviour - foraging efficiency	Changes in bird behaviour may have bioenergetic costs (e.g. shifting habitat use, reduced foraging efficiency).	- Shorebird food (infauna and biofilm) may be affected by changes in abiotic processes resulting from construction of RBT2, which could affect food availability, quality, and use by shorebirds	- Shorebird dropping counts across the FRE for northward and southward migration 2012-2013 - Distribution and biomass of biofilm and infauna for northward and southward migration 2012-2013	Shorebird habitat use study: 31 Biofilm studies: 24, 25, 26, 28, 29, 30 Benthic

Pathway	Linkage	Hypothesis	Specific Uncertainties	Data Available	Planned Studies (Details in Table A2)
					infauna studies: 43, 44 -
10	predator habitat - predation rate	Construction of RBT2 may increase the availability of structures used by predators for concealment and increase the predation rate on shorebirds.	- If and how changes in raptor use might affect shorebird use	- Assessment of changes in site safety to shorebirds resulting from RBT2 construction (summer 2013)	Shorebird site safety assessment: 33 -
11	relationship between biofilm and biomat	These studies will further characterize shorebird biofilm at Roberts Bank and the FRE.	- Composition of biofilm and/or biomat that is important to shorebirds at Roberts Bank - Difference between biofilm and biomat - Whether biomat promotes the growth of biofilm or the reciprocal - Whether shorebirds require both biofilm and biomat - Current velocities (and associated shear) withstood by biofilm and/or biomat - Recolonization potential of biofilm and/or biomat after a disturbance (removal from substrate via abiotic processes or grazing pressure)	- Scientific literature - Biofilm/biomat distribution at Roberts Bank - Taxonomic composition of biofilm - Shear stress thresholds of biofilm - Recolonization rates of biofilm -	Biofilm studies: 24, 25, 26, 27, 28, 29, 30
12	relationship between biofilm/biomat and eelgrass	Biofilm and eelgrass may interact competitively.	- Eelgrass/biofilm interactions - If eelgrass limits biofilm are the two species always found in different parts of the mudflat? - If they are found in different parts of the mudflat, how do these areas relate to abiotic parameters? - How does the distribution of eelgrass and biofilm relate to shorebird use?	- Scientific literature - Biofilm and eelgrass distributions at Roberts Bank - Sediment grain size and chemistry data for FRE (2012-2013)	Coastal geomorphology studies (NHC): 35, 40 Biofilm studies: 24, 25, 29 Shorebird habitat use study: 31
13	relationship between biofilm/biomat and benthic infauna	Changes in benthos may affect biofilm/biomat as benthos graze on biofilm/biomat OR changes in biofilm/ biomat may affect benthos.	- Do infaunal invertebrates also graze on biofilm? - Is there a geospatial relationship between the infaunal invertebrate and biofilm communities?	- Distribution and taxonomic composition of biofilm and infaunal communities	Biofilm studies 24, 25, 29 Benthic infauna studies: 43, 44
14	foraging efficiency - shorebird	Changes in bird foraging behaviour could have bioenergetic effects.	- How and whether potential changes to food abundance, quality, and distribution will affect fattening rates, length of stay and	- Scientific literature on site quality, site safety, rating rates, and usage of	Shorebird opportunity model

Pathway	Linkage	Hypothesis	Specific Uncertainties	Data Available	Planned Studies (Details in Table A2)
	energetics		other metrics associated with shorebird site quality	shorebird sites.	
15	predation rate - shorebird energetics	Changes in predation pressure may lead to changes in use of habitat.	- Changes in raptor usage and resulting shorebird behaviour may affect shorebirds use of particular foraging areas	- Scientific literature -	Shorebird site safety assessment: 33 Shorebird opportunity model
16	biofilm/biomat - shorebird energetics	Potential changes in biofilm abundance and distribution at Roberts Banks may potentially affect individual shorebird feeding across the FRE.	- Biofilm abundance and distribution across the estuary and its relative abundance at Roberts Bank - Are there different kinds of biofilm, and if so, which kinds of biofilm are important for shorebirds? - How much is bird feeding rates on biofilm affected by benthos availability? - What's the relative contribution of biofilm and biomat to shorebird diet? - What's the relative contribution of biofilm at Roberts Bank to other food sources across the FRE?	- Distribution and taxonomic composition of biofilm and infaunal communities - Shorebird isotope data - Shorebird droppings data	Biofilm studies: 24, 25, 26 Benthic infauna studies: 43 Shorebird studies: 31, 32 Shorebird opportunity model
17	benthic infauna - shorebird energetics	Potential changes in benthic infauna abundance and distribution at Roberts Banks may potentially affect individual shorebird feeding across the FRE.	- Infaunal distribution and abundance at Roberts Bank relative to the entire FRE - What is the relative importance of infaunal invertebrates (vs. biofilm) in the shorebirds annual cycle? - How does infaunal invertebrate distribution correlate with shorebird use?	- Distribution and taxonomic composition of infaunal communities - Shorebird isotope data - Shorebird droppings data	Benthic infauna studies: 43 Shorebird studies: 31, 32 Shorebird opportunity model
18	shorebird energetics - shorebird populations	Changes to individual shorebird bioenergetics may translate into population level effects on shorebirds.	- How does individual shorebird bioenergetics translate to successful migration and breeding? - How do shorebirds use the Fraser River Estuary (FRE)? - How do shorebirds use Roberts Bank in the context of the entire FRE?	- Shorebird droppings counts - Shorebird abundance counts	None – determined not to be feasible to assess and beyond the scope of the EA

Table A2. Biofilm and Infauna Study Details

Study ID	Related to Pathway # *(Details in Table A1)*	Field Study Full Title	Study Objectives	Methods/Approach
24	12, 13, 14, 17	Biofilm Hyperspectral Mapping	Delineate and map the extent of biofilm & identify main taxonomic groups which comprise biofilm community at Roberts Bank	Aerial surveys using a hyperspectral sensor and concurrent in situ sampling with handheld spectrophotometer & sediment cores
25	12, 13, 14, 17	Biofilm Taxonomic Analysis	Identify the main taxonomic groups which comprise the biofilm community; ground truthing of hyperspectral	Field sampling of sediment cores for taxonomic validation; HPLC analysis (17 pigments); microscopic taxonomic ID
26	12, 17	Biofilm EPS Study	Quantify carbohydrate composition of biofilm to determine nutritional value	Spectrophotometry to measure colloidal and non-colloidal carbohydrate content
28	7, 12	Biofilm Recolonization Study	Determine recolonization/growth rates of biofilm to assess its ability to rebound from disturbance	Laboratory and field experiments
29	1, 6, 7, 9, 12, 13	Biofilm Abiotic Parameters Study	Identify and quantify abiotic co-variates of biofilm	Multivariate correlational analysis between taxonomic and abiotic data
30	6, 7, 12	Biofilm Critical Shear Stress Study	Determine the critical shear stress of biofilm to better elucidate a) its role in sediment stabilization b) it tolerance to changes in flow	Laboratory and field experiments
31	13, 17, 19	Shorebird/WESA/Dunlin Habitat Use Study	Develop a usage map of the Fraser River Estuary (FRE) by shorebirds during north and southward migrations; determine the number and broad distribution of shorebirds across the FRE during north/south migratory periods; model usage data against other biotic and abiotic data collected to determine locations of greatest shorebird use, food availability and habitat quality	Counting dropping (fecal) densities at sampling stations along transects. Shorebird relative abundance counts across the FRE.
32	17, 19	WESA/Dunlin Stable Isotope Analysis	Determine the contribution of biofilm to WESA diet at Sturgeon Bank, Boundary Bay, and Roberts Bank during northward migration	Stable isotope analysis of bird droppings or blood
33	3, 11, 14	Site Safety Assessment	Assess to what extent RBT2 infrastructure may influence the predation danger for shorebirds from raptors at Roberts Bank	Desktop evaluation of design drawings; field visits
35	1	Study of Vertical, Lateral and Tidal Variations in Salinity & Turbidity	Understand the spatial and temporal distribution of the salt wedge and fresh water lens within Canoe Passage and the Fraser River plume over the Roberts Bank tidal flats	Sound used to collect depth profiles of the water column (turbidity, salinity, conductivity & depth measured at 1 s intervals); collection of water samples at sub-set of sites using handheld sampler; generate

Study ID	Related to Pathway # *(Details in Table A1)*	Field Study Full Title	Study Objectives	Methods/Approach
				turbidity-TSS relation
38	1	Roberts Bank Sediment & Erosion Monitoring	Gain an understanding of the existing disturbance regime at Roberts Bank	Installation of 30 DoD rods on tidal flats in groups of 10 to monitor three distinct regions (lower flats; biofilm; biomat) over 2 months; measurements of temporal variation in erosion & deposition (distance from top of rod to sediment surface and washer)
39	1	Roberts Bank Wave Heights & Periodicity Study	Collect wave height and period data to validate numerical models and help interpret erosion pin observations	Three wave recorders installed along a transect stretching from deep to shallower water (allowing for characterization of changing wave environment through transition of delta slope to mid intertidal; tidal measurements every 15 minutes as well as burst samples (4096 samples at 6 Hz)
40	1	Hydrodynamic Modelling	Define interaction of currents and waves near project site; define magnitude and spatial extent of hydrodynamic effects	Hydrodynamic model runs to determine if project effects can be minimized by optimizing its orientation; run model using adopted boundary input conditions; hydraulic information will also be used to carry out analytical calculations to estimate local scour and deposition patterns near the terminal
42	1	Biofilm Investigations	Predict potential changes to the physical environment and the wave and tidal current climate	Inputs from biofilm studies used to assess results from the model in order to predict potential changes in biofilm; models used to identify other biofilm regions as well as regions that may be engineered to foster biofilm growth
43	9, 14, 18	Benthic Infauna Sampling	Quantify the abundance, biomass, taxonomic composition, and distribution of infaunal invertebrates at Roberts Bank relative to the entire FRE	Sediment core sampling and microscopic identification
44	9, 14, 18	Benthic Infauna Abiotic Parameters Study	Identify and quantify abiotic co-variates of benthic infauna	Multivariate correlational analysis between taxonomic and abiotic data

Appendix B – Biofilm and Infauna Pathways of Effects Focus Group Results

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Biofilm & Infauna Focus Group Summary

This document summarizes the findings of the Biofilm & Infauna Focus Group, which involved structured expert interviews to explore potential effects from the proposed Port Metro Vancouver Roberts Bank Terminal 2 (RBT2) project on biofilm and infaunal invertebrates.

Overview

The Biofilm & Infauna Focus Group involved the iterative development of a 'pathways of effects' (POE) diagram, a review of key factors and pathways by which biofilm and infauna may be affected by the RBT2 project, and an assessment of key uncertainties. Three experts participated in the Focus Group from government bodies (Environment Canada, Port and Airport Research Institute (Japan)), and a US academic institution.

Overall, this process involved four main steps:

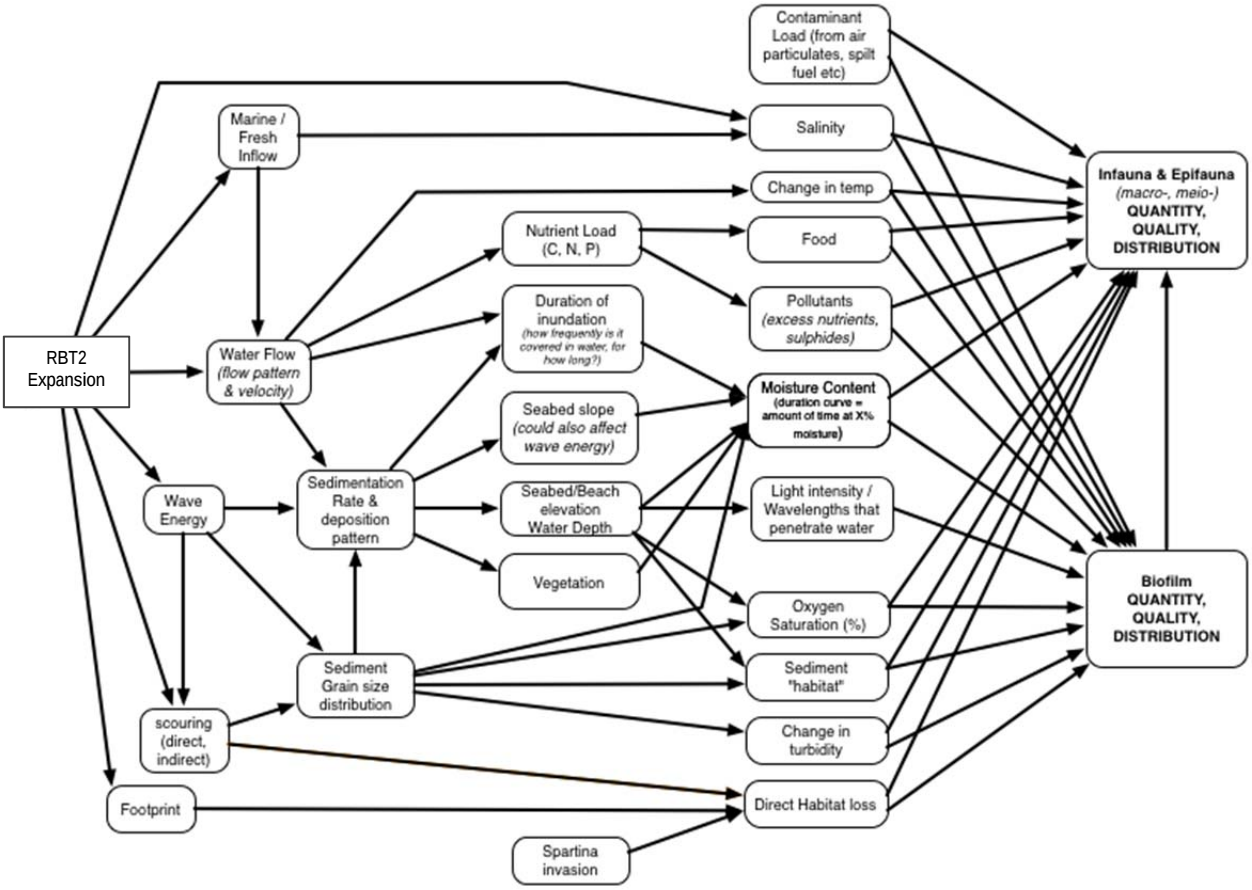
1. Develop a pathway of effects diagram relating biotic and abiotic factors with biofilm and infaunal invertebrates
2. Identify most significant pathways of effects (*i.e. which key factors, if changed by RBT2, would result in changes to biofilm and/or infauna)*
3. Identify key areas of uncertainty with respect to infauna/biofilm growth, and studies or models that can address these uncertainties
4. Identify which of these factors are expected to change as a result of RBT2

This Focus Group process was run in parallel with a Biofilm & Shorebirds Technical Advisory Group (TAG) process. The results from the Focus Group study were fed back to the Biofilm & Shorebirds TAG for further review and discussion, and to identify additional questions for the Focus Group members. The resulting findings will serve as a guide for the development of studies and approaches to assess potential effects from RBT2 on biofilm, infauna, and shorebirds, and for identifying mitigation strategies to minimize potential effects.

1) Pathways of Effects Diagram

An initial POE diagram was developed by Compass and Hemmera consultants based on a questionnaire to TAG members and in-house expertise. This diagram served as a basis for initial discussion with Focus Group experts, and was revised significantly over the course of the Focus Group interviews and TAG review. Figure 1 illustrates the detailed pathway of effects diagram developed by the Focus Group. It summarizes the main pathways by which RBT2 could affect changes in abiotic (e.g. wave energy, water flow) and biotic (e.g. nutrient) conditions in the Roberts Bank area, thereby affecting the growth of biofilm and infauna. Focus Group members suggested that the same abiotic and biotic factors drive growth for infauna and biofilm, hence one diagram can be utilized to relate RBT2 to both infauna and biofilm. Further, it was recommended that 'epifauna' be included in the study in addition to 'infauna'.

Figure 1. Pathways of Effects for Biofilm and Infauna



2) Key pathways of effects

Focus Group members were then asked the question: "Given the pathway of effects diagram for infauna and biofilm, what do you think are the most significant pathways?" In summary, the key factors that drive infauna, epifauna, and biofilm quantity, quality, and distribution were deemed to be:

- sediment moisture content
- sediment 'habitat' – including the presence, stability (considering resuspension, adsorption of sediment), and quality of habitat
- light intensity and wavelengths that penetrate water (for photosynthetic biofilm only)
- direct habitat loss

These factors are directly influenced by:

- duration of inundation - *the frequency with which sediment is covered in water will determine how moist the sediment is*
- seabed/beach elevation and water depth – *this factor will influence moisture content, the amount of sediment that is available as 'habitat', and the light that can penetrate the water*

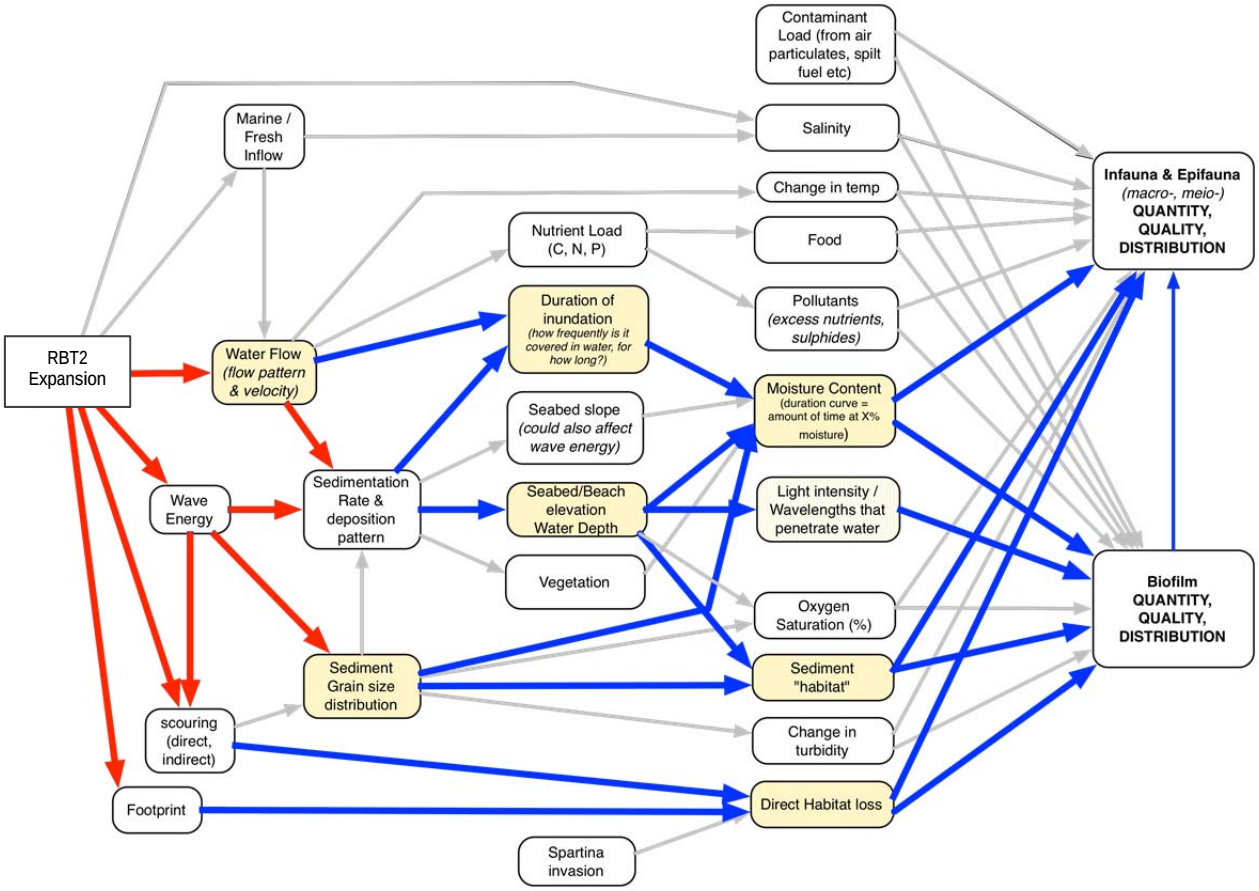
- sediment grain size – *this will affect the sediment moisture content, and the suitability of sediment 'habitat' for different organisms*
- direct habitat loss – *biofilm habitat will be directly affected by the placement of the RBT2 terminal and causeway footprint, as well as potential associated habitat loss such as scour and channel formation*
- water flow (pattern and velocity) and wave energy – *these geomorphic processes will influence seabed elevation, duration of inundation, and sediment grain size*

Other concerns raised by Focus Group members include:

- Indirect habitat loss
    - *Caused by river inflow changes, water flow patterns and velocity as a result of the RBT2 project*
    - *Caused by a system change from 'mud' to sea grass-type habitat as the result of changes to flow patterns, velocity, and sediment grain size*
- Shallow sub-surface water – *this will also play a role in the wetting of sediments (in addition to surface waters)*
- The 'availability' of food sources (primarily infauna) should be considered in modeling – migration occurs vertically in sediments to and from the surface, and so may or may not be available as food

Figure 2 illustrates they key pathways by which Focus Group members believe potential hydrological and geomorphological changes due to RBT2 may affect biofilm and infaunal and epifaunal invertebrates. Yellow boxes indicate the key factors identified by Focus Group participants in driving changes to biofilm and infaunal invertebrate growth. White boxes indicate factors that influence biofilm and infauna growth, but are not key factors. For example, 'duration of inundation' and 'moisture content' (in yellow) are considered to be key factors affecting biofilm and infauna growth, while 'nutrient load' plays a relatively minor role by comparison. This figure also shows which pathways are thought to be most critical. Red arrows on the left hand side of the diagram indicate critical abiotic factors directly affected by RBT2. The hydrological and geomorphological processes that determine sedimentation patterns and sediment grain size (for example) were discussed in detail in the Coastal Geomorphology TAG and were not reviewed in detail by Focus Group members. Blue arrows on the right indicate the pathways which Focus Group participants considered most strongly influence biofilm and infauna/epifauna growth. The key factors that drive growth are the same for both biofilm and infauna. The only exception is that intensity of available sunlight is a key factor for biofilm only.

Figure 2. Key Pathways of Effects for Biofilm and Infauna



3) Key Uncertainties

Key Uncertainties raised by Focus Group members for further examination include:

- What is the specific composition of bacteria, extracellular polysaccharides (EPS), diatoms that compose the biofilm present in Roberts Bank? How does this differ spatially across the area?
- What biofilm compositions are preferred by shorebirds (i.e. which composition is considered a 'high quality' food source)? How might changes to biofilm composition affect the palatability? How might changes to biofilm composition affect shorebird energetics?
- What factors/processes support the development of this 'high quality' biofilm versus lower quality biofilm?
- What factors are involved in shorebirds' selection of whether to eat biofilm or infauna? When would they switch from one food source to another? Is biofilm a necessary component of their diet?

- Does biofilm serve as more than just a food source? Does it contain biochemical components that are necessary for functions such as assisting in breeding, testosterone, providing beta carotene for plumage?

- What are the dynamics in terms of seasonal and daily changes? What are expected changes in water flow and current patterns?

One focus group member indicated concern with taking an approach that looks too closely at the details of effects, and suggested taking a 'big picture' approach to understanding RBT2 effects on biofilm. This would involve looking at what could be affected if biofilm was degraded or diminished (e.g. shorebirds), how those organisms could be affected, and whether or not it should be a concern. Additionally, they noted that biofilm is not very well understood and it is necessary to understand the composition of biofilm and how it works before it is possible to assess potential effects on it. Further, biofilm at Roberts Bank may be unique (different than in other places of the Fraser River Estuary) since biofilm exists elsewhere but is not fed upon in those other locations. It is also a primary source of food consumed in the Roberts Bank area by some birds. Therefore, the Focus Group member suggested that further study of biofilm is necessary and should be a main focus given that it is not well understood.

4) Potential changes anticipated due to the RBT2 project

Focus Group members indicated a number of factors that must be understood before potential effects on biofilm and infauna can be determined. These factors involve the assessment of:

- Changes to water flow patterns and velocities
- Habitat loss
    - Direct
        - Footprint, scour, channel formation
    - Indirect
        - sediment distribution, elevation
        - sediment grain size
- Sea level changes expected due to climate change

Potential changes to the coastal geomorphology in the Roberts Bank area due to the RBT2 project are currently being investigated, given guidance received from the Coastal Geomorphology Technical Advisory Group. Details can be found in the Coastal Geomorphology TAG Final Report.

Table 1 summarizes the key pathways indicated in Figure 2, along with a summary of specific uncertainties, data available to enable assessment given these uncertainties, and studies planned to better understand the causal linkages. In addition, the table summarizes the Focus Group members' subjective assessments of the weight of evidence linking the factors, and judgments on the ability to predict changes given available information and models. It summarizes Focus Group member's judgments and is not a reflection of consensus among members. This table was developed to guide the development of studies to further understand the potential impacts of the RBT2 project on biofilm and infauna in the Roberts Bank area.

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Table 1: Summary of pathways of effects, data available, and studies planned

The table below summarizes key POE linkages, hypotheses, uncertainties, data available, and studies planned for each linkage highlighted in the pathway of effects diagram in Figure 2. The table also summarizes Focus Group assessment of evidence available characterizing the linkage, and evaluation of the ability to predict changes within each pathway. These ratings are subjective assessments taking into consideration all potential effects pathways, and information and models available.

Linkage	Hypothesis	Weight of evidence linking these factors	Ability to predict effects	Specific Uncertainties	Data available	Studies Planned
Terminal 2 effect on geomorphic processes	RBT2 will affect coastal geomorphology (e.g. water flow, wave energy), thereby affecting sedimentation rates and patterns, sediment grain size, and other factors which may affect biofilm and infauna quantity, quality, and distribution in the Roberts Bank area.	N/D	Moderate to High		Details of potential changes are outlined in the Coastal Geomorphology TAG Final report.	
RBT2 Footprint effect on direct habitat loss	The RBT2 terminal and causeway footprint will cover portions of the Roberts Bank area, resulting in direct habitat loss	High / certain	High		YES (Hemmera)	YES (Hemmera Desktop studies 2013)
Scouring effect on direct habitat loss	Different erosion rates could alter locations of established, mature biofilm/mats.	N/D	Low		YES (NHC)	YES (NHC)
Sedimentation rate & deposition pattern effect on seabed/beach elevation, water depth, and duration of inundation		N/D	Low		YES (NHC)	YES (NHC)
Sediment grain size effect on sediment 'habitat'	Changes in the distribution of particle sizes and/or particle composition will alter sedimentation rates.	Medium / some scientific evidence	Low	Do biofilms differ dependent upon particle size and/or composition? How does particle size and composition impact sedimentation that in turn affects the localization and distribution of biofilms/mats?	YES (Hemmera field studies 2012)	YES (Hemmera field & Desktop studies 2013)

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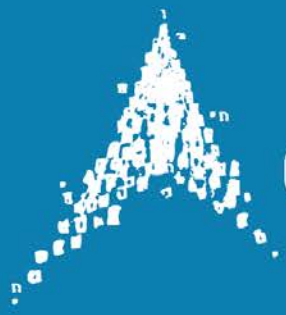
Linkage	Hypothesis	Weight of evidence linking these factors	Ability to predict effects	Specific Uncertainties	Data available	Studies Planned
Sediment grain size effect on moisture content		Medium / some scientific evidence	Low		YES (Literature, Hemmera field studies 2012)	YES (Hemmera field & Desktop studies 2013)
Duration of inundation effect on moisture content		N/D	Low	To what extent is water content/activity of the inhabited sediments dictated by surface- and/or groundwater?	NO	NO
Seabed/beach elevation, Water depth effect on light intensity and wavelengths		Medium / some scientific evidence	Low	If water depth is deep enough to limit light penetration, then it is most likely that biofilm/mats are not significant or at least for infaunal invertebrates and/or shorebirds.	YES elevation (Lidar Bathymetry data), YES some light intensity, NO water depth/standing water	NO
Seabed/beach elevation, Water depth on sediment 'habitat'		Medium / some scientific evidence	Low		YES elevation (Hemmera field studies and Lidar Bathymetry data), NO water depth/standing water	YES (Hemmera Desktop studies 2013)

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Linkage	Hypothesis	Weight of evidence linking these factors	Ability to predict effects	Specific Uncertainties	Data available	Studies Planned
Seabed/beach elevation, Water depth on moisture content	There is a preferred water depth (or degree of sediment saturation) for biofilm/mat establishment and maintenance.	Medium / some scientific evidence	Low	Is there a preferred water depth or water saturation in the sediment for biofilm quantity and/or quality?	YES elevation (Hemmera field studies and Lidar Bathymetry data), NO water depth/standing water	YES (Hemmera Desktop studies 2013)
Moisture content effect on biofilm abundance	For biofilms without significant surface water, moisture saturation will be crucial for "healthy" biofilm establishment and maintenance.	Low / uncertain	Low	Is there a preferred water depth or water saturation in the sediment for biofilm quantity and/or quality? How does water saturation impact microbial populations and functions?	YES (Literature, Hemmera field studies 2012)	WP (Desktop and Field Studies) Correlation and experimental
Moisture content effect on infauna and epifauna assemblages and abundance	Moisture content affects composition and abundance of certain infaunal and epifaunal taxa through both passive (hydrodynamic) and active (behavioural) processes	N/D	Low	How does water saturation impact microbial populations and functions?	YES (Hemmera field studies 2012)	YES (Hemmera field & Desktop studies 2013)
Light Intensity / Wavelengths effect on biofilm abundance		Medium / some scientific evidence	Low		YES (Hemmera field studies 2012)	NO
Sediment 'habitat' effect on biofilm abundance		Medium / some scientific evidence	Low		YES (Hemmera field studies 2012)	WP (Desktop and Field Studies) Correlation and experimental
Sediment 'habitat' effect on infauna and epifauna assemblages and abundance	Small-scale distribution of epifaunal invertebrates in particular, is associated with sediment topography (e.g. ripples, burrows, grass shoots)	N/D	Low		YES (Hemmera field studies 2012)	YES (Hemmera field & Desktop studies 2013)

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Linkage	Hypothesis	Weight of evidence linking these factors	Ability to predict effects	Specific Uncertainties	Data available	Studies Planned
Direct habitat loss effect on biofilm abundance		High / certain	High		YES	NO
Direct habitat loss effect on infauna and epifauna abundance		N/D	Low		NO	NO



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APPENDIX IR5-29-C

SOUTHERN RESIDENT KILLER WHALES TECHNICAL ADVISORY GROUP FINAL REPORT

Roberts Bank Terminal 2

Technical Advisory Group (TAG) Process Report

Southern Resident Killer Whales – Final Report

Prepared for

Port Metro Vancouver

Prepared by

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Date

November 27, 2013

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Acronyms

AIS	automatic information system
BRS	behavioural response study
CCIP	Container Capacity Improvement Program
Compass	Compass Resource Management
DTAG	Digital Acoustic Recording Tag for Measuring the Response of Wild Marine Mammals to Sound
EA	environmental assessment
FRE	Fraser River Estuary
IPCC	Intergovernmental Panel on Climate Change
KW	killer whale
NHC	Northwest Hydraulics Consultants
NMFS	National Marine Fisheries Service (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
PBR	Potential Biological Removal
PC	productive capacity
PCB	polychlorinated biphenyl
PCOD	Population Consequence of Acoustic Disturbance
PMV	Port Metro Vancouver
POE	pathway of effects
PVA	Population Viability Analysis
RBT2	Roberts Bank Terminal 2
SARA	Species at Risk Act
SECR	spatially explicit capture-recapture
SEL	Sound Exposure Level
SNR	Signal-to-noise ratios
SPL	Sound Pressure Level
SRKW	Southern Resident Killer Whales
TAG	technical advisory group

TEU	twenty-foot equivalent units
VEC	valued ecosystem component
ZMRG	Zero Mortality Rate Goal

1 Introduction

1.1 Purpose and Background

The Roberts Bank Terminal 2 (RBT2) project is a proposed new three-berth container terminal in Delta, BC that would expand existing port facilities by 2.4 million twenty-foot equivalent units (TEUs) of container capacity. The project is part of Port Metro Vancouver's (PMV) Container Capacity Improvement Program (CCIP), a long-term strategy to meet anticipated growth in demand for container capacity. The proposed RBT2 project entails the construction of a new three-berth marine terminal and associated road and rail infrastructure alongside the existing Westshore and Deltaport terminals at Roberts Bank. PMV has a mandate to support the growth of Canadian trade with other countries, and current demand forecasts anticipate container traffic to double in the next 10-15 years and nearly triple by 2030. Subject to regulatory approvals, the RBT2 project could be operational by the mid-2020s. Further information on the proposed RBT2 project can be found on the project's website, www.robertsbankterminal.com.

Figure 1-1 Artist's rendering of the proposed RBT2.



Image courtesy of PMV.

The proposed RBT2 project is subject to environmental assessment (EA) under federal and BC provincial laws. EA is a process whereby the potential effects of proposed projects on the environment are examined through a public process. While the scope and nature of the EA for RBT2 has not yet been determined by regulators, PMV expects the EA to be some form of joint review process. The proposed RBT2 project could potentially cause a variety of environmental effects, some of which are reasonably well understood, and some of which are less well understood due to their complexity and based on the current state of scientific knowledge.

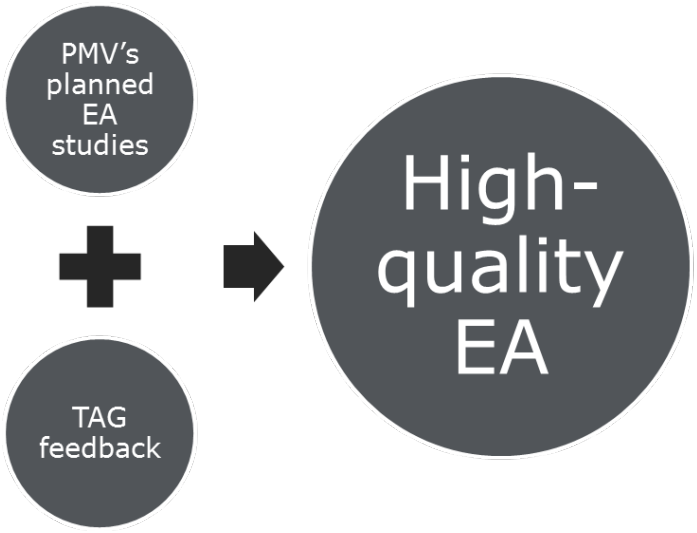
PMV has contracted Hemmera, a consulting firm specializing in EA, to conduct the EA studies for the proposed RBT2 project. Some of these studies, such as baseline studies that characterize the environment pre-construction, are currently underway. As part of its pre-EA work, PMV initiated a Technical Advisory Group (TAG) process to gather input from outside experts on four separate topics.

This report is written by Compass on behalf of the Southern Resident Killer Whales (SRKW) TAG, and summarizes the proceedings and recommendations of that TAG.

1.2 Overview of the Technical Advisory Group Process

The purpose of the TAG process was to pro-actively gather input from scientific and technical experts prior to the formal initiation of the EA for RBT2 so as to enhance the relevance, quality, and rigour of EA studies for the project (Figure 1-2). Experts were invited from regulatory agencies, academia, First Nations, and key non-government organizations based on their ability to contribute to technical discussions pertaining to the identified EA studies.

Figure 1-2. Role of TAG process in ensuring high-quality EA of the proposed RBT2 project.



The TAG process involved four separate TAGs:

1. Biofilm and Shorebirds;
2. Southern Resident Killer Whales (SRKW);
3. Coastal Geomorphology; and
4. Productive Capacity of Roberts Bank habitat.

The four TAGs each addressed topics that were considered by PMV and its consultants as requiring additional preliminary scoping in order to satisfy EA requirements.

Biofilm, shorebirds, and SRKW are likely to be recognized in the forthcoming EA as topics of particular importance to stakeholders and thus of the forthcoming EA process. The topic of SRKW is discussed in this report and the topics of biofilm and shorebirds are discussed in a companion report on the Biofilm and Shorebirds TAG.

Coastal geomorphology—the physical features and processes in the vicinity of the proposed project area at Roberts Bank—was chosen because any project-related geomorphic and physical oceanographic changes are expected to be the primary driver for marine biological and ecological changes. RBT2 infrastructure may cause changes to tidal currents and water movement associated with wind-generated waves, which could affect sediment settling and re-suspension, and which in turn could cause changes to local marine habitats such as biofilm and eelgrass beds. This topic is explored in a companion report on the Coastal geomorphology TAG.

The ability of habitat to support species of particular interest to stakeholders is critical to the health of those species. PMV saw merit in entering into technical dialogue on how the productive capacity of habitat is most appropriately defined at Roberts Bank. This topic is explored in a companion report on the Productive Capacity TAG.

Despite the different topic matter of each of the four TAGs, all four had a similar set of objectives:

- build a common understanding of the potential effects of RBT2 based on the best available information;
- provide input on appropriate methods for assessing potential adverse effects and their significance;
- identify priority information needs and related studies; and
- identify opportunities for collaboration.

Each TAG met face to face three or four times between November 2012 and May 2013. Meetings were held in Vancouver over full-day periods. Each individual TAG process was designed and led by Compass, who acted as an external facilitator. In each meeting Compass and PMV consultants led discussions with TAG members. In addition, for all TAGs except Coastal Geomorphology, focus groups were created to investigate particular topics in greater depth with an additional set of experts relevant to each field.

1.3 Participants and Roles in the TAG Process

There were five main parties identified as potential participants in the TAG process: technical experts from government agencies, academia, non-governmental organizations, PMV and PMV consultants, and First Nations. First Nations did not participate in the TAG process, however PMV has committed to share TAG information and obtain input through a separate process.

TAG members were tasked with:

- providing input on current and planned EA studies;
- providing input on potential effects of the project on the environment;
- providing input on impact assessment methods;
- helping prioritize and scope key issues; and
- providing input from their organization.

PMV consultants, Hemmera, were tasked with:

- preparing material for TAG meetings, such as pre-reading packages, presentation slides, and discussion materials;
- managing schedules, scope, and budget for the TAG process;
- explaining current study plans to the TAGs;
- ensuring integration of people and discussions across TAGs where relevant;
- organizing meeting logistics; and
- where relevant, having representatives participate as TAG members in TAG meeting discussions.

PMV was tasked with:

- providing resources and meeting logistics;
- providing communications with TAG participants and the public;

- providing information about the proposed RBT2 project; and
- observing TAG meetings and considering input from each TAG.

The TAG process was *advisory* in nature, and so PMV sought to gather advice through the process in terms of how best to conduct specific EA studies for RBT2.

Compass was tasked with:

- designing the TAG process and advising on implementation;
- facilitating TAG meetings;
- advising on how discussions and outputs of individual TAGs might be used by other TAGs;
- summarizing input, including areas of agreement and disagreement, in meeting notes; and
- producing a record of the process in this summary report.

1.4 About This Report

This report reviews the discussions and outputs of the SRKW TAG. This report does not attempt to follow the chronological order in which items were discussed during the meetings, but rather provides a thematically-organized synthesis of discussions that occurred over the course of the TAG meetings.

The next section provides more background information in terms of what meetings were held, who was involved, and what specific topics were explored. Section 3 examines methods for assessing noise effects on SRKW. Section 4 examines assessment of magnitude and significance of noise effects on SRKW population and Section 5 examines several SRKW assessment related issues that were less prominent in the TAG process. The reader is encouraged to review the reports for the other three TAGs to have a complete understanding of the RBT2 TAG process.

2 Background on SRKW TAG

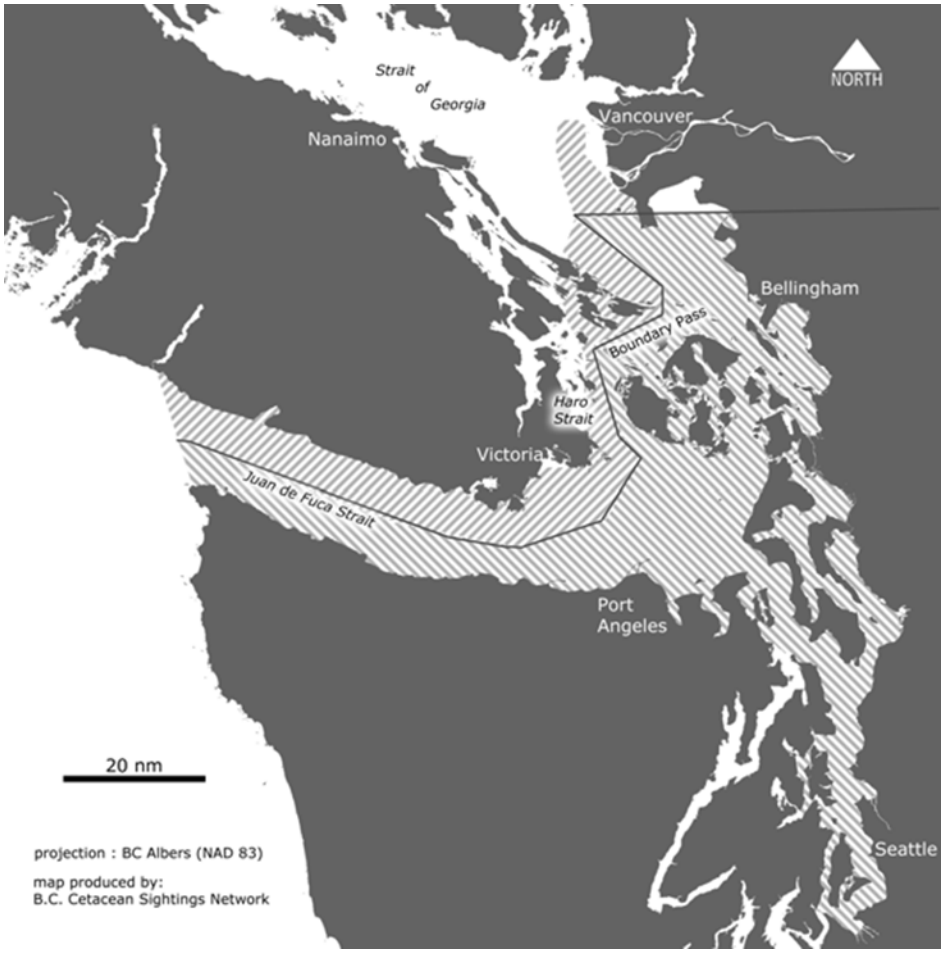
2.1 Introduction

SRKWs are endangered under the *Species at Risk Act* (SARA). A recovery strategy for this species was developed in 2008 and subsequently amended in August 2011 (Fisheries and Oceans Canada, 2011).

During the summer and fall, SRKW can primarily be found in the trans boundary waters of Haro Strait, Boundary Pass and the eastern portion of the Strait of Juan de Fuca, and the southern portion of the Strait of Georgia. A map of SRKW critical habitat is shown in Figure 2-1. Critical habitat is defined under the Species at Risk Act as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". The proposed RBT2 project is located within SRKW critical habitat.

The construction and ongoing operations of the proposed RBT2 project will introduce noise and other disturbances, which could in turn have effects on SRKW, and these will need to be assessed and evaluated as a component of the EA.

Figure 2-1: SRKW Critical Habitat



For the purposes of the EA, it will be important to determine whether noise, due to both the construction of RBT2 and associated with the increase in ship traffic, poses increased risk to SRKW.

Additionally, it will be necessary to determine the potential for accidents or malfunctions such as potential spills and strikes of SRKW, and whether re-suspended sediments may affect the SRKW population, and if so, what the importance or significance of the potential effects may be. Of particular interest during the TAG process were discussions on appropriate studies and methodologies for carrying out a noise effects assessment in relation to increased shipping traffic and any resulting effects on SRKW (e.g. behavioural disturbances and masking of prey finding and communication sounds).

In general, the SRKW TAG discussed how the RBT2 project might affect SRKW, how PMV's consultants might assess these effects (using suitable assessment methodologies), and how any effects might be mitigated. This report summarizes the input provided by the SRKW TAG and SRKW Focus Group in a thematically-organized synthesis of discussions over the course of four TAG meetings.

2.1.1 TAG Meeting Summary

The SRKW TAG met four times between November 2012, and April 2013 to discuss a number of topics, as outlined in Table 2-1.

Table 2-1: Dates and key topics of SRKW TAG meetings.

Meeting Date	Key Topics Covered
November 8, 2012	• TAG process • RBT2 project overview • Context for Assessing Effects on SRKWs • Pathway of effects • Current field studies and planned methods of EA • Significance of effects and key questions for TAG • Priorities and work plan for TAG
December 18, 2012	• Discussion of changes to study plan based on TAG input • Noise-SRKW overlap modelling • PCOD model • Alternatives to modelling, including the use of mitigation • Proposed noise effects assessment approach • Noise effects Focus Group • Significance thresholds • Work plan and next steps
March 4, 2013	• Noise effects Focus Group results • Update and review of population effects modelling • Characterizing adverse effects and determining significance • Mitigation options • Work plan and next steps
April 12, 2013	• Update on study plan and effects assessment o Noise-SRKW overlap model o PCOD model o Masking model o SRKW noise thresholds • Significance of effects (magnitude and duration) • Transient killer whales • Relative importance of project effects to SRKW (ranking) • Review of mitigation options and level of effort required • TAG wrap-up and key messages

2.1.2 TAG Participants

In total, six TAG members participated in the SRKW TAG discussions, and ten observers attended without active participation. Table 2-2 presents participants of the SRKW TAG.

Table 2-2: Participants in the SRKW TAG.

Name	Affiliation	Role	Participation
Dr. Rob Williams	University of St. Andrews	TAG member	Meetings 1, 2, 3, and 4
Dr. John Ford	Department of Fisheries and Oceans	TAG member	Meetings 1, 2, 3, and 4
Dr. Harald Yurk	SMRU Ltd.	TAG member	Meetings 1, 2, 3, and 4
Dr. Lance Barrett-Lennard	Vancouver Aquarium	TAG member	Meetings 1, 2, and 3
Marianne Gilbert	Hemmera	TAG	Meetings 1, 2, 3, and 4

Name	Affiliation	Role	Participation
		member	
Dr. Dominic Tollit	SMRU Ltd.	TAG member	Meetings 1, 2, 3, and 4
Dr. Louise Blight	WWF Canada	Observer	Meeting 2
Hussein Alidina	WWF Canada	Observer	Meeting 1
Kyle Robertson	PMV	Observer	Meetings 2 and 3
John Parker-Jervis	PMV	Observer	Meeting 1
Rhona Hunter	PMV	Observer	Meetings 1 and 4
Kim Keskinen	PMV	Observer	Meetings 1 and 4
Marina Winterbottom	Hemmera	Observer	Meetings 1, 2, 3, and 4
Malcolm Smith	Hemmera	Observer	Meeting 2 (morning)
Ben Wheeler	Hemmera	Observer	Meetings 1, 2, 3 and 4
Eriko Arai	Hemmera	Observer	Meetings 1, 2, 3, and 4 (afternoon)
Michael Harstone	Compass	Facilitator	Meetings 1, 2, 3, and 4
Christian Beaudrie	Compass	Facilitator	Meetings 1, 2, 3, and 4

2.1.3 Focus Group Participants

Given the specialised background required to inform specific questions raised by the SRKW TAG, a Focus Group consisting of individuals with expertise in assessing noise effects on marine mammals was convened (Table 2-3). Members of the Focus Group were engaged through a web-based survey.

Table 2-3 Participating Experts in the SRKW Focus Group

Name	Affiliation
Dr. Whitlow Au	University of Hawaii
Dr. Volker Deecke	University of Cumbria
Dr. John Harwood	SMRU Ltd.
Dr. Marla Holt	NOAA
Dr. Ronald Kastelein	SEMARCO
Dr. Veronique Lesage	Fisheries and Oceans Canada
Dr. Brandon Southall	Southall Environmental Associates Inc.
Dr. Harald Yurk	SMRU Ltd.
6 experts in their field that wished to remain anonymous	Various

14 experts participated in the Focus Group survey in total, representing academic institutions, government, and private consulting firms.

2.1.4 Initial Selection of TAG Topics

At the onset of the TAG process, PMV consultants identified a number of key discussion topics, and tasked the TAG members with providing input on the following key questions:

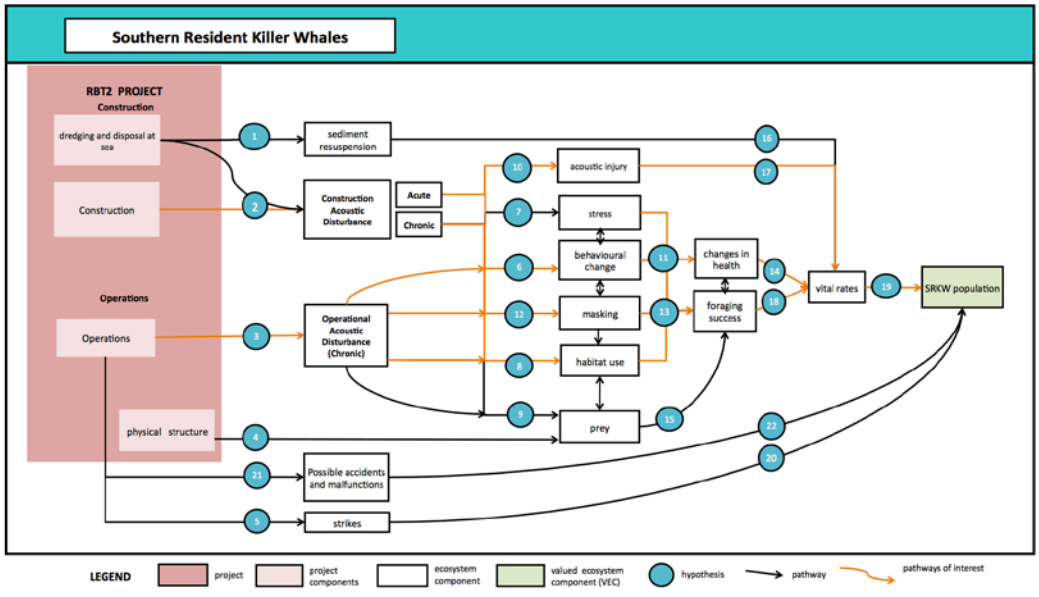
- What are the pathways of potential effects linking the proposed RBT2 project to SRKW, and which of them have the potential to result in significant adverse effects on SRKW?
- What assessment approaches, data, and studies are most relevant and reliable for assessing effects on SRKW?

- What constitutes a significant adverse effect on SRKWs, and how could that be assessed:
    - In consideration of the proposed RBT2 project alone; and
    - In consideration of cumulative effects?
- How should the consequences of underwater sound on SRKW population recovery be assessed, specifically:
    - Can we define appropriate disturbance thresholds for sound exposure?
    - What methods or models should be considered for evaluating noise effects on SRKW?
    - What are the strengths and weaknesses of utilizing a Population Consequence of Disturbance (PCOD) approach to evaluate the significance of population-level effects?
- What mitigation and monitoring measures exist, or may exist in the future, to potentially avoid or minimize effects relating to underwater noise and SRKWs?

These topics served to guide the development of agendas for four SRKW TAG meetings.

As a starting point, the SRKW TAG reviewed potential pathways of effects (POE) between the proposed RBT2 project and SRKW. The POE diagram served as a framework for summarizing possible project effects and their relationship to one another. The diagram was used to facilitate TAG discussion and was repeatedly revised during the TAG process. The final POE is shown in Figure 2-2. The diagram was also used to highlight focus areas of TAG discussion (indicated in the orange lines and arrows).

Figure 2-2: Final pathway of effects diagram identified by the project team and SRKW TAG members



The possible cause-effect relationships (or hypotheses) summarized in Figure 2-2 are captured as follows:

1) Dredging/disposal at sea activities will disturb bottom sediments and any associated contaminants, causing them to re-suspend and possibly persist in the water column.
2) In-water construction activities will temporarily increase underwater noise in the marine environment.
3) Increase in shipping may lead to increase in chronic noise[1].
4) Physical structure of RBT2 may affect SRKW prey.
5) Increased shipping may lead to an increase in the risk of a ship striking a marine mammal.
6) Chronic noise from construction and operations may change behaviour/movement patterns (e.g. habitat avoidance/exclusion/attraction).
7) Chronic underwater noise from construction and/or operations may increase physiological stress of SRKW.
8) Chronic underwater noise from construction and/or operations may result in temporary or permanent changes in SRKW habitat use.
9) Chronic underwater noise from construction and/or operations may impact species that SRKW prey upon.
10) Acute construction noise[2] (e.g. pile driving) may cause permanent or temporary threshold shift (deafness), and injuries, mortality, disturbance or area avoidance of SRKW prey (salmon) in RBT2 area.
11) Effects of chronic underwater noise on SRKW (stress, masking, changes in behaviour and movement patterns and habitat use) may act individually or cumulatively to impair foraging success.
12) Chronic underwater noise from construction and operations may mask SRKW communication or echolocation.
13) Underwater noise from construction may result in temporary or permanent changes in habitat use.
14) Changes in habitat use may affect foraging success and health.
15) Given the dependence of SRKW on salmon (particularly Chinook), effects on prey may affect killer whale vital rates[3].
16) Re-suspended sediments may make contaminants bioavailable in the food chain.
17) Acoustic injury may affect SRKW vital rates.
18) Effects on behaviour, masking and habitat use may lead to changes in vital rates.

[1] continuous sound with little interruption
[2] sound of high intensity that occurs suddenly or over a short period of time
[3] Vital rates include birth, fertility, and death, which indicate the nature and possible changes in a population.

19) These changes could influence survival of individuals and lead to population level effects.

20) Injuries and mortality from ship strikes may affect SRKW population.

21) Shipping operations may lead to possible accidents and malfunctions such as spills of contaminants from fuel tanks or containerised cargo.

22) Possible accidents and malfunctions could affect SRKW population

Of the potential effects identified in the POE diagram, the RBT2 team and TAG members selected three potential effects to SRKW that require the most input to fill data gaps. These include:

- Acoustic (noise) disturbances and masking;
- Changes in prey availability; and
- Increased risk of exposure to contaminants.

2.1.5 Approach to Assessing Noise Effects

TAG discussion was based primarily on the assessment of noise effects from RBT2 on SRKW. Underwater noise levels have been increasing steadily over time globally, largely as a result of increased shipping. SRKW use areas throughout their range and within their critical habitat where noise levels are expected to continue to increase from shipping traffic (compared to current levels). During RBT2 project construction and operation phases, they may be subject to noise of various frequencies and intensities, varying over time and space. With the aim of better understanding noise-related effects on SRKW, TAG members discussed the need to establish thresholds above which noise may cause injury or behavioural disturbance, or mask 'clicks' produced by the whales to locate prey. TAG members also discussed options for developing models to evaluate the magnitude of noise effects on killer whale pods, and the potential significance of effects on the SRKW population.

PMV consultants outlined their approach for assessing noise effects on SRKW, as follows:

1. Determine appropriate **noise threshold criteria** for SRKW.

2. Calculate **zones of influence,** including zones of injury, behavioural disturbance, and 'click' and 'call' masking, based on these thresholds.

3. Select an appropriate **frequency weighting** methodology to account for SRKW hearing sensitivity:

    - A frequency weighting methodology should be used that accounts for the varying hearing sensitivities of killer whales to noise across the audible frequency range, as established by hearing studies.

    - Killer whales are considered to have mid-frequency hearing sensitivity (reasonable hearing of sounds between 800 Hz and 80 kHz), and while the highest amplitudes of noise from vessels, dredging and vibro-densification operations is considered low frequency (source level peaks <100 Hz and medium levels up to 5 kHz), there is some overlap between the frequencies of noise produced and SRKW hearing sensitivity. Harmonic noise components and sound pulses can also influence hearing in higher frequencies.

4. Determine the **overlap** between noise produced and SRKW habitat usage (i.e., potential exposure):

    - Compare SRKW habitat usage patterns calculated as a spatial SRKW population density estimate with estimates of noise levels caused by ship traffic and the RBT2 construction and operation activities.

5. Estimate **proportion of time noise thresholds are exceeded where there is overlap:**

    - Estimate potential time-dose thresholds in areas of overlap for injury, behavioural disturbances, and masking, using a cumulative probability approach.

6. **Compare relative changes** (in health, foraging success), **and determine the significance of effects** due to project-related noise.

7. Assess **mitigation requirements** and the **efficacy of various mitigation** measures:

    1. Propose and compare efficacy of different mitigation efforts.

    2. Look at different proposed ideas; make sure they are practical and effective.

TAG members provided feedback on the appropriateness and comprehensiveness of the proposed study plan.The TAG agreed in concept with the proposed approach for assessing noise effects, recognizing the overlap between some of the steps. The following sections summarize the proposed methodologies, discussions, and recommendations made by TAG members to address key questions when assessing the potential effects of RBT2 on SRKW.

3 Assessing Noise Effects on SRKW – Disturbance and Masking

3.1 Overview and Key Issues

Assessing the effect of noise on SRKW is complicated due to important data gaps, the presence of numerous noise sources at various frequencies and intensities, and poor understanding of the direct and indirect relationship between chronic noise and cumulative effects on survival. This section summarizes the main discussions by the TAG with respect to the following questions:

- *What are **sources** of noise and their characteristics?*
- *What are appropriate **noise thresholds** for injury, behavioural disturbance, and masking?*
- *What **methods** are most appropriate for assessing injury, disturbance, and masking?*

3.2 Sound Sources and Zones of Influence

Sound Source Characteristics

The characteristics of noise sources during the construction and operational phases of the RBT2 project were reviewed to provide context for selection of appropriate noise effects assessment methodologies and thresholds. Noise sources, as they are understood for RBT2 at the time (and hence are subject to change), were summarized as follows:

a. Construction Noise
    i. High intensity pulsed sources (Acute - temporary in nature) e.g. pile driving. Little, if any, impact pile driving (high level pulsed acute sound) is planned.
    ii. Moderate intensity non-pulsed sources (Chronic – relatively continuous in nature throughout construction) e.g. dredging, vibro-densification, berthing activities, vessel movement.

b. Operational Noise
    i. Temporary / acute at short ranges (e.g., potentially tug operations during berthing).
    ii. Chronic (e.g. berthing, vessel movements at port and in shipping lanes).

Overall, the RBT2 sound sources with the greatest potential for effects on SRKW (including both construction and operations) were considered by the TAG to be mainly moderate level non-pulsed chronic.

Zones of Influence

As a basis for evaluating noise effects on SRKW, PMV consultants proposed that noise effects be partitioned into 'zones of influence' that allow for the assessment of different types of effects based on noise intensity and frequency bandwidth (Erbe 2002). These zones include:

- *Zone of Acoustic Injury* – where sound levels above a certain threshold may result in injury to SRKW.
- *Zone of Behavioural Disturbance* – where sound levels above a certain threshold may result in behavioural changes in SRKW.
- *Zone of Masking* – where sound levels above a certain threshold and within certain bandwidths may mask the sound of 'clicks' and 'calls', affecting SRKW's ability to communicate or find food.

TAG members discussed the use of these three zones and agreed in concept that this is an appropriate approach for assessing noise effects on SRKW. However, it was noted that effects associated with these zones also overlap, and that there are various ways to define where the transitions are. Additionally, it was recognized that acoustic injury is only likely to occur in close proximity to a sound source, while masking and behavioural disturbance effects may occur at greater distances and span a greater range of possible effects. Key points from the discussion include the following:

- It is important to determine appropriate (biologically meaningful) noise threshold criteria to describe potential zones of *injury*, *behavioural disturbance,* and *'click' and 'call' masking*.
- TAG members agreed that there is an increasing understanding that acoustic masking effects can be important and should be considered in noise effect assessments.
- There are no official noise injury or disturbance threshold criteria used by regulators in Canada. Thresholds are a key source of uncertainty, especially for behavioural effects.
- Other jurisdictions have used the National Marine Fisheries Service (NMFS) criteria, but there are weaknesses in the approach, including use of thresholds based largely on reactions of baleen whales. NMFS is presently developing new

guidelines for assessing the effects of noise on marine mammals which are currently under review.
- Advice from noise Focus Group and new data analyses are likely required to determine appropriate threshold criteria.

Based on this discussion and on focus group input, TAG members reviewed a number of methods and proposed approaches for assessing noise effects on SRKW based on zones of injury, behavioural disturbance, and masking. TAG members provided input on the most appropriate methods to use, as summarized below.

3.3 Estimating Zone of Acoustic Injury

PMV Consultants proposed a dual approach for the assessment of injury from noise sources, using Southall et al. (2007) Sound Pressure Level (SPL) (peak) criteria; and modified Southall et al. (2007) M-weighted Sound Exposure Level (SEL) criteria developed by Wood et al. (2012). Southall et al. (2007) SEL approach is becoming widely adopted in Canadian and European Environmental Assessments. M-weighting is considered a precautionary form of frequency weighting. The modifications by Wood et al. (2012) include up-to-date scientific auditory effects information applicable for other cetaceans that will be assessed.

In discussing the potential for injury and the proposed methodology for assessing injury effects, TAG members concluded:

- Risk of *injury* due to high intensity noises from pulsed (pile-driving) and non-pulsed sources are minimal relative to other noise effects.
- Southall et al (2007) injury criteria, used in three out of four recent BC EAs, may be suitable for this study as well.
- It will be necessary to model pile driving sound to set an appropriate safety zone.

TAG members agreed that a modified Southall et al (2007) approach is appropriate for assessing potential for injury, and support the SEL, M-weighting approach for assessing injury.

3.4 Estimating Zone of Behavioural Disturbances

For the assessment of behavioural disturbances, TAG members discussed the following topics:

1) Selection of an appropriate sound measurement method (noise metric);
2) SRKW hearing sensitivity and selection of an appropriate frequency weighting; and
3) Selection of an appropriate noise threshold (in dB).

With respect to the selection of appropriate measurement method and frequency weighting options, TAG members discussed the use of either: Sound Pressure Levels (SPL), SEL, or sensation levels, and one of four frequency weighting options that would take into account SRKW hearing sensitivity when modelling effects. These include:

- Flat (no) weightings;
- M-weightings;
- Equal-weightings; and

- Reverse audiogram weightings.

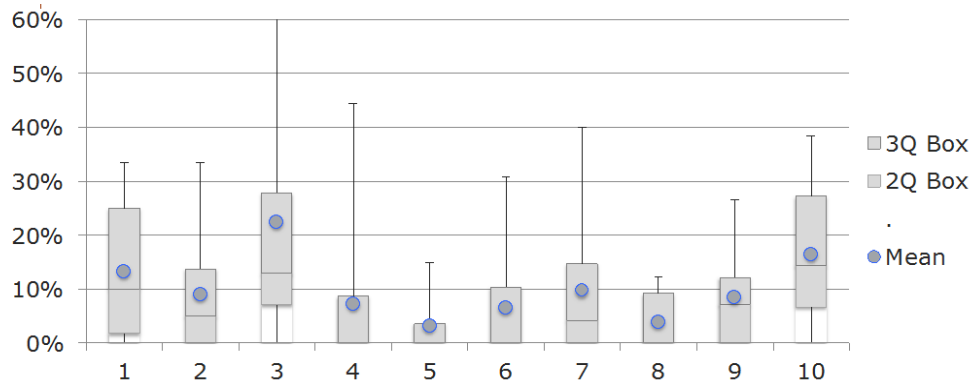
With respect to the selection of an appropriate noise threshold value for behavioural disturbances, the TAG discussed the appropriateness of the NMFS received SPL threshold value (120 dB re 1 u Pa) for assessing noise effects.

Overall, the TAG summarized that there is a great deal of uncertainty on the most appropriate combination of measurement method, threshold criteria, and frequency weighting options. A Focus Group of scientists and regulators with expertise in acoustic noise disturbances and masking for marine mammals was asked to provide additional feedback on the suitability of different metrics and threshold criteria.

With regard to behavioural disturbance effects, Focus Group participants were first asked to rate the appropriateness of a number of measurement method and frequency weighting options. Out of ten possible combinations of measurement method (see Figure 3-1 for list of 10 measurement options) and frequency weighting for assessing the level of chronic acoustic behavioural disturbance in SRKW, the one with the greatest support from Focus Group participants is 'Sound Pressure Level (SPL) with killer whale specific reverse audiogram weighting'.

The use of 'sensation levels and narrow frequency bands' also scored well on the survey. Results and a description of all ten methods and weighting combinations can be found in Figure 3-1. This figure is presented as a box-whisker plot to illustrate collective opinion across all ten options (expressed as mean scores), and the range in expert opinion for each option, expressed as 25 and 75 percentiles (grey boxes) and extremes (whiskers, or 'error-bars'). Full Focus Group results can be found in Appendix A.

Figure 3-1 Appropriateness of 'measurement method' and 'frequency weighting' combinations



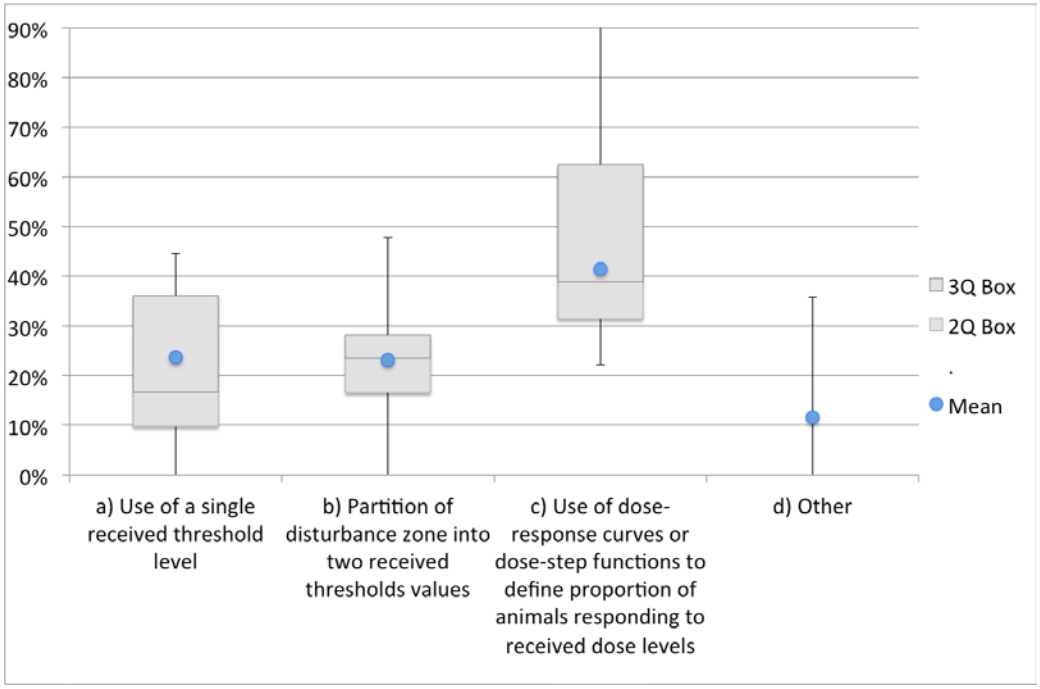
1) Sound Pressure Level (Root Mean Square) with no frequency weighting
2) Sound Pressure Level (Root Mean Square) with M-frequency weighting
3) Sound Pressure Level (Root Mean Square) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)
4) Sound Pressure Level (Root Mean Square) with US Navy Type II frequency weighting
5) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with no frequency weighting
6) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with M frequency weighting
7) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)
8) Sound Energy Level (24 hour cumulative, sensu Southall et al. 2007) with US Navy Type II frequency weighting
9) Maximum Sensation Level within frequency band from 0.5-5 kHz
10) Maximum Sensation Level within narrow frequency bands

Focus Group participants raised concerns about the reliability of using the audiogram in the lower frequency range (i.e. due to lack of data at low frequencies and the need to extrapolate data) for options using reverse audiogram weighting. To address these concerns, a follow-up

Focus Group survey question was sent and found greater support for the use of SPL with a more precautionary audiogram (removing reduced-sensitivity undulations from most sensitive audiogram), followed by a precautionary buffer of 12 dB.

Focus Group participants were next asked to assess the appropriateness of four different methods for assessing anthropogenic noise disturbances around a point source. Focus Group participants most strongly supported the use of dose-response curves or dose-step functions to define proportion of animals responding to received dose levels. Results and a description of the four assessed options can be found in Figure 3-2.

Figure 3-2 Appropriateness ratings for noise disturbance effects assessment methods



Nearly half of the focus group participants thought the NMFS received SPL threshold value of 120 dB re 1 u Pa for behavioural disturbance is inappropriate as a general threshold for all cetaceans. The remainder of focus group members were uncertain about the appropriateness of the threshold value. A follow-up survey with Focus Group members did not provide clarification on whether the appropriate threshold should be higher or lower than 120 dB.

Based on the findings from the Focus Group, TAG members concluded the following:

- The use of selected comparative approaches (e.g. frequency weightings, species specific) to assess disturbances was appropriate.
- Further assessment of KW-specific sensation levels is warranted, but data are limited.
- Development of precautionary KW audiogram for species-specific frequency weighting was supported by TAG. TAG members generally supported the proposed modified audiogram presented by the project team. (an example precautionary KW audiogram reviewed by TAG members can be found in Appendix B)
- Dose or step function is an optimal approach to assess noise disturbance effects. However, there are challenges with this in practice, and more analysis of existing data or new research is needed.

- Analysis of existing datasets to assess disturbance criteria was recommended as an appropriate measure to fill data gaps rather than conducting invasive new tagging or behavioural field studies as originally proposed by PMV consultants. TAG members agreed that existing datasets would potentially be sufficient for use in predicting behavioural effects.
- All TAG members expressed support for the development of new threshold criteria in place of the default NMFS criteria. The TAG as a whole agreed that work carried out on developing new noise thresholds has the potential to help the government in its regulatory framework as well.
- Information on SRKW behaviour is scarce for the northern portion of critical habitat, including the area around RBT2. Focal follow studies may be needed to better determine potential effects on SRKW behaviour (e.g. on foraging) in these areas. Given additional data on presence and behaviour, critical habitat boundaries could potentially be changed in the future (critical habitat definition is an iterative process).
- TAG members also noted that there is increasing evidence that physiological stress is a potential effect that should be considered in noise effects assessments.

3.5 Estimating Zone of 'Click' and 'Call' Masking

TAG members identified that masking is an important effect to consider primarily because of its potential to interfere with the whales' ability to find food. SRKWs come to this region in summer and fall to feed on energetically rich Chinook salmon. There could be consequences to the health of the SRKW population if a) there are not enough salmon for SRKWs to feed on; or b) if SRKWs are not able to catch the salmon because they are not able to locate them (through echolocation clicks).

The consequences of call masking are less clear, but it could affect the whales' ability to communicate and receive important information about their environment. Whales may expend more energy to compensate for the increased noise, and this could potentially affect their health and survival over the long term. It is difficult to determine how much masking of important signals occurs at any given time due to variation in several factors (e.g., noise propagation, orientation of animal, environmental conditions). Therefore, it is also difficult to estimate the absolute size of the zone of masking that is important for whales to communicate and to be able to find and catch prey effectively. Masking has not traditionally been a main focus of environmental assessments. There is no established standard or threshold for masking noise for marine mammals to guide the RBT2 effects assessment. The RBT2 project team proposes to develop a method (model) to determine the critical zone(s) where masking has the greatest impact on killer whales' feeding and communication, as it has the most direct potential effect on their health and survival. The goal of the masking model is to provide realistic estimates of the size of the critical zones and durations for which masking by project noise can affect foraging. For the assessment of noise masking effects, TAG members discussed the following topics:

1) Methods and uncertainties in assessing masking effects;
2) Call masking: Selection of critical bandwidth (most important sound frequency range for 'calls'), appropriate number of signal peaks (most important frequencies); and
3) Click-Masking: Selection of critical ratio (how much louder the 'click' signal must be above the noise to be audible), frequency.

Methods and Uncertainties

TAG members noted that a number of key considerations, including the following, must be taken into account when assessing masking effects:

- Signal-to-noise ratios (SNR) which depend on noise spectrum and may vary across different frequency bands;
- Signals typically have directional components; and
- SRKW use a range of frequency bands and some overlap with frequencies from shipping traffic (most importantly <3 kHz band).

It was suggested that Clark et al's (2009) 'masking metric', which represents the ratio of how far a signal is audible in quiet versus noisy conditions, be considered further in modelling of masking effects. Further, TAG members identified a number of areas of uncertainty, suggesting that more information is needed on the range of clicks and call frequencies. In general, TAG members suggested that modelling should focus on meaningful biological assessment (i.e., what really matters for the whales to be able to feed and be healthy).

Click and Call-Masking

A number of questions were posed to the Focus Group to inform the selection of critical bandwidth and number of signal peaks for assessing 'call masking', as well as the selection of a critical ratio and frequency for assessing 'click masking'. With respect to 'call masking' the Focus Group study found a high degree of uncertainty over the appropriate critical bandwidth and number of signal peaks, with the majority of participants unsure of the best approach. There was marginal support for the use of 1/12 octaves and constant Q; however the number of signal peaks for recognition is unknown.

With respect to 'click-masking', participants were largely uncertain on the selection of appropriate critical ratio, but 20 kHz and 50 kHz were identified as optimal frequencies.

Given the uncertainty in the Focus Group results, the TAG concluded that masking model sensitivity analyses are required to determine how important critical ratio and critical bandwidth selection is to the model. It was generally agreed that a range of variables and the use of scenario testing need be used for defining a critical bandwidth for killer whale call masking. TAG members suggested that appropriate masking signal peaks could be related to what the animal needs to know, and there may be two areas of interest: one at high frequencies for click masking and one at low frequencies for call masking.

In general, TAG members agreed that masking effects should be assessed despite uncertainties and felt that there were opportunities to improve on recent work in this area. The RBT2 team has considered this input in developing further studies to help determine an appropriate methodology and threshold to assess potential masking effects.

4 Assessing Magnitude and Significance of Noise Effects on SRKW Population

Assessment of the magnitude and significance of noise effects builds upon the analyses discussed in the previous section, and aims to address two central questions:

1) What proportion of the SRKW population might be injured, disturbed, or has calls or clicks masked as a result of shipping activities and RBT2 construction and operation?

2) What does this effect on individual killer whales mean to the larger SRKW population, and is the effect significant?

Key issues discussed in assessing the magnitude and significance of noise effects on SRKW include:

- How to define **magnitude of chronic noise effects** to SRKW population?
- What constitutes a **significant adverse environmental effect**?
    - How to define a significant adverse environmental effect? And on what basis?
    - What is an *appropriate threshold* above which population level effects would be considered significant?
    - How to *assess significance* of noise effects for SRKW population?
- How to assess **cumulative effects** of noise on SRKW population?
- How to include **other natural and anthropogenic effects** in a SRKW population model?

To address the first two questions on the *magnitude* and *significance* of noise effects, TAG members reviewed and discussed the studies planned and currently underway, providing feedback to refine the proposed approach. PMV consultants proposed a 'dual-approach' to assessing *magnitude* and *significance* of noise effects on SRKW, as follows:

1) Assess the **overlap in time and space** between SRKW space use and project-related noise to determine magnitude of effects.

2) Undertake population consequences **of disturbance (PCOD)** model to assess population effects and significance of effects.

Discussions on these two topics are summarized in Sections 4.1 and 4.2. Discussions related to the assessment of cumulative effects and effects from other natural and anthropogenic sources are summarized in Sections 5.3 through 5.7.

4.1 Noise-SRKW Overlap

The TAG reviewed and discussed a proposed *Noise-SRKW overlap model* approach to assessing the magnitude of noise effects on SRKW populations. In this model, noise from ship traffic and construction activities is overlapped with SRKW population density estimates to evaluate the extent to which SRKW are subject to noise levels within injury, disturbance and masking zones. This approach allows for a comparison of relative change due to project-related noise (and a determination of the magnitude of construction and operational noise effects), and assessment of the efficacy of various mitigation measures.

The proposed method for determining the spatial extent of noise from construction and ship traffic includes:

- Standard modelling of construction noise activities;
- Summarizing ship traffic information using data from the automatic information system (AIS) on board vessels; and

- Modelling noise from vessel sound sources by ship category using existing data from the literature, new data collected for this project and by other researchers.

With respect to quantifying noise effects to SRKW, the TAG reviewed, suggested and discussed a number of alternative approaches:

- Conducting a behavioural response study (BRS) involving focal animal or digital acoustic recording tag (DTAG) as a means of assessing noise effects on SRKW. However, TAG members were concerned about the invasive nature and potential risks in relation to the information gained. Further, TAG members expressed concern over the small sample size that could likely be obtained.

- Analysing existing datasets collected for this project and those collected by government agencies and other researchers (DTAG, theodolite tracks and acoustic data) over undertaking new invasive field work.

- Using spatially explicit capture-recapture (SECR) modelling to estimate usage density of SRKW and quantify exposure using sightings and potentially acoustic data. Some members expressed concerns with the limitations of the available data, small population size, and spatial interpolation using the sightings data in order to provide a meaningful assessment.

- Alternative methods using pod level travel routes and photo ID data were suggested. However, TAG members noted significant challenges with these approaches (e.g. seasonal and inter-annual variability).

- A suggestion was made that field work (e.g. DTAG study) may still be needed or warranted if existing datasets are unable to answer the study questions (it was noted however that a multiyear study would likely be required to get useful information).

TAG members agreed that the best approach for estimating SRKW density and space use depends on the quality of the available data.

Based on TAG feedback, a revised Noise-SRKW overlap approach was proposed, with the following features:

1) Kernel density approach based on synthesis of Canadian and US sightings databases with consideration of sightings effort analyses.

2) Noise modelling using synthesis of one year of AIS data with 200m grid cell size, 24 hour resolution, improved resolution of vessel category vessel sound spectra and transmission loss estimates in 3 key areas.

3) Overlap SRKW space use with appropriate SEL and SPL threshold criteria for noise modelled.

TAG members support the approach and recommend proceeding as the data quality from the sightings databases is appropriate for this approach.

4.2 Population Modelling

With respect to assessing significance of effects, TAG members discussed the need to both establish a threshold above which population level effects would be considered significant, and identify appropriate approaches for evaluating significance of effects to the SRKW population.

TAG members reviewed a number of potential approaches for establishing a significance threshold, including:

- Taking guidance from the Species at Risk Act (SARA);
- The use of Potential Biological Removal (PBR; how many animals can be removed without causing the population to decline) as a comparative metric for significance assessment;
- Energetics or Population Viability Analysis (PVA; how the population trend is predicted to change over time) models;
- Zero Mortality Rate Goal (ZMRG); and
- Net zero noise increase goal (precautionary approach).

SARA provides some guidance in determining when an activity constitutes destruction of critical habitat, but does not provide guidance on whether population level effects are significant. TAG members suggested that PVA models were not considered useful for noise effects assessments, though the use of PBR was supported generally as a comparative metric (i.e., TAG members supported the use of a population level based definition). It was noted that, given its population trend and risk of extinction, and their endangered classification under SARA, PBR for SRKW is close to or essentially zero (i.e., any animal removed from the population due to the project would be considered a significant effect). Therefore, focus should be on minimizing effects on individuals.

A PCOD modelling approach was proposed as one input into the assessment of possible population level effects. TAG members noted several concerns over using a PCOD model for assessing the significance of effects on SRKW. These include:

- The PCOD model is a relatively new approach that is not well understood yet or used in an EA context.
- Data on numerous input variables is lacking and so a PCOD model would need to rely on assumptions. The model output may therefore not reflect risk to the population accurately.
- The complexity of the PCOD model and small SRKW population size would result in low confidence in model output.
- The population effects from incremental increase in shipping traffic will likely be difficult to detect.
- The uncertainty of foraging efficiency and limited understanding of the relationship with Chinook salmon.

With respect to the concept of population modelling, TAG members did not agree whether or not it is strictly necessary to model population level effects for the purpose of an EA. It was noted that relevant regulation in Canada is primarily focused on significant effects on SRKW critical habitat, not population, and therefore it might not be necessary to establish population level effects. However, since it was agreed that the most appropriate definition of biological significance would be one based on effects to population recovery, population modeling is considered a useful tool for the assessment. One TAG member suggested that deciding to put resources into studying population effects when it is not clear that the results would be helpful could unnecessarily hold up or divert resources from finding effective mitigation measures. An

approach that would look at a no net increase in noise ("net zero") was suggested as a potentially more appropriate measure to consider. Both methods were noted as not necessarily mutually exclusive.

Overall, TAG members did not disagree on the development of a PCOD model as a worthwhile endeavor, but the confidence in the results was questioned. A conference call to specifically discuss value and options for a population model approach in support of the effects assessment took place among TAG members. After discussing various options and weaknesses of a PCOD approach as originally proposed, a number of changes to improve the model's usefulness and confidence in the results for SRKW were discussed. It was agreed that a simpler PCOD focusing on foraging and energetic costs associated with disturbance and masking would be more appropriate than the original PCOD model proposed. The other modelling approaches suggested and discussed that could also be helpful in a significance assessment or as alternatives to PCOD, included:

1) A carrying capacity model approach proposed by Dr. David Bain;
2) New foraging efficiency models developed by Dr. Rob Williams; and
3) New PVA assessment and approaches.

Given this TAG feedback, PMV consultants proposed a revised study plan, which included:

- A simpler PCOD focused on foraging efficiency of SRKW feeding on salmon incorporating potential reductions due to the project and associated energetic cost and scenario testing; and
- Recognition of confidence limitations.

It was generally conceded that this population modelling effort was associated with a low degree of confidence for making quantitative predictions but was useful for testing and comparing various scenarios of future vessel forecasts and application of potential implementation of mitigation measures. It will be used as one component in assessing population effects and making a judgement on the overall significance of possible project level effects.

Based on discussions on the limitations of population modelling options and data, TAG members identified two additional options for moving forward:

1) Suggest a level of mitigation that is precautionary:
    a. Assuming that there is a project effect, focus on mitigation rather than developing a model with low confidence in estimates. Mitigation is possible; some forms can be done cheaply, may have the effect of reducing noise at or below current levels ("*net zero noise*" goal was discussed as a strategy).
    b. Will still require an assessment approach to evaluate if there is an effect and what level of mitigation is required to offset any effects from RBT2. A goal of net zero increase in noise levels was proposed, and ways this could be achieved were discussed.
2) Employ an adaptive approach to assessment and mitigation:

a. Conduct the best effects assessment possible with available data, recognizing the high level of uncertainty.

b. Improve the assessment and mitigation efforts when new information becomes available through future through monitoring activities.

Population modelling effort would be important in informing possible mitigation measures and helping to identify which are the driving (sensitive) factors affecting SRKW. TAG recommendations are summarized as follows:

- Focus PCOD model on foraging and energetic costs. Compare model results using different scenarios (pre RBT2, post RBT2, post RBT2 + cumulative) to evaluate the difference in magnitude of these increases on lost foraging opportunities (i.e., number of salmon not available for SRKW to feed on due to noise) and resulting population trend.
- Model must assume uncertainties remain similar between scenarios tested and compare relative change in selected metrics, rather than absolute values.
- Explore use of PBR and reduction in foraging efficiency as metrics to assess effects.
- Influence of Chinook salmon seasonal and intra and inter-annual availability is a key factor for year-to-year survival of SRKW as identified in the SRKW recovery strategy. During years where chinook salmon are available in moderate to high abundance, the effects of other stressors such as noise may be less important. However, during years with low chinook availability, these stressors may have larger effects on the survival of individuals. Assessment of effects and reduction of effects through mitigation should focus on years of low chinook availability.
- A large noise assessment area is required for PCOD model to be useful.
- SRKW presence and activity budget in vicinity of RBT2 throughout the year is an important consideration.
- Recognition of relatively low confidence in absolute model predictions due to uncertainty in key linkages but still useful for comparing scenarios.

It was also recommended that consideration be given to the selection of baseline conditions for assessing effects, such as whether the baseline will be the current conditions, or pre-industrial (quieter) conditions, to avoid a shifting baseline. PMV and PMV consultants will determine what an adequate baseline (existing conditions) is in the context of the environmental assessment for the PCOD scenarios.

4.3 Significance Assessment

In addition to discussion on methods for assessing noise effects on SRKW, TAG members evaluated the relative importance of a number of potential effects on SRKW based on the pathways of effects diagram in Figure 2-2. TAG members discussed certainty, scale, duration, frequency, and probability of effects, as well as the effectiveness of mitigation and overall concern level for nine areas of potential effects:

- Habitat loss at the terminal;
- Accidents & Malfunctions (e.g. toxic spill);

- Construction noise – acute;
- Construction noise – chronic;
- Operational noise – local area;
- Operational noise – regional area;
- Potential contaminant release (e.g. PCBs released from sediments during dredging);
- Indirect prey effects; and
- Ship strikes.

TAG members noted that their relative level of concern for Accidents & Malfunctions (e.g. a toxic spill) is high (due to the potentially high negative effects on this small population). However, the probability of occurrence is deemed very low (see Appendix C). Relatively, the level of concern for regional operational noise (i.e. ship noise) is moderate to high (due to uncertainties in potential cumulative effects). A concern level for contaminant release (e.g. PCBs) could not be established as more information on the project effects on sediment and levels of contaminant present is needed to assess the overall concern. Variation in the potential level of concern of some effects related to uncertainty in measures that will be put forward to mitigate effects or the effectiveness of such measures.

TAG members agreed that strike risk to SRKW is very low for container vessels and is not high enough to be a concern and warrant a quantitative risk analysis. There are 30 to 40 years of data to show that while strike risk is not zero, strikes are very rare. There would be no value in conducting a quantitative ship strike analysis since it would provide a large range of answers due to uncertainty. It was suggested that resources would be better focussed on providing support for organizations aimed at treating and studying injured animals. TAG members agreed that supporting a program such as this would be a good use of resources. If mitigation measures are required to mitigate potential strike effects, this suggestion will be considered as part of the mitigation options for the project.

A summary table of TAG assessments of these nine areas of potential effects is available in Appendix C.

5 Consideration of Other Effects

5.1 Mitigation Options

TAG members discussed mitigation measures to identify possible options for further consideration, and to flag key issues that should be considered in discussions following the conclusion of the TAG meetings. Mitigation options spanning a wide range of level of effort and potential benefit were put forward (as concepts for PMV consideration) and discussed to obtain a comprehensive list of options to investigate further. These options included:

- Education *(e.g. PMV skipper marine mammal awareness program, for noise and strikes)*
- Construction Management *(E.g. utilize work windows during times of low SRKW use to limit noise impacts)*
- Construction Monitoring *(e.g. use of an observer network for presence of SRKWs at or near Roberts Bank)*

- On-site vessels *(e.g. tug speed monitoring and reduction on site to limit noise)*
- Container vessels *(e.g. incentives for quieter vessels, speed management to limit noise)*
- Strike Mitigation *(e.g. speed restrictions or avoidance of hotspots)*
- Habitat and prey *(e.g. use of work windows to limit impacts on SRKW prey in the area)*
- Contaminant release *(e.g. development of comprehensive contingency plans)*

A complete list of mitigation options discussed can be found in Appendix D. It was noted that until the relevant studies were undertaken it was premature for PMV to select the appropriate mitigation measure.

The consultants proposed an assessment of noise characteristics from all classes of ships in the region to provide insight on the mitigation efforts that would be most effective. For example, a small percentage of the ships may generate a large fraction of the noise.

TAG members support a '*net zero noise*' approach to the environmental assessment and mitigation strategy, and suggested the use of real-time detection systems for the presence of SRKWs, and the use of vessel slow-downs and minimal thruster use in the presence of killer whales. However, it was recognized that PMV may not have the jurisdiction to require vessel slowdowns outside of the immediate area of the proposed RBT2 facility. TAG members pointed to other ports potentially regulating the types of ships that use their port as examples to evaluate.

PMV may be limited in terms of the mitigation programs they can feasibly carry out within and outside of their jurisdiction, and will potentially need to identify opportunities for collaboration on SRKW mitigation at a regional level, if required.

With respect to measures to enhance SRKW prey availability, TAG participants reviewed the mitigation and offsetting options Port Metro Vancouver is considering. These include a variety of projects in the Fraser River Estuary and potentially further afield that may provide benefits to salmon and thus to SRKW. TAG members were supportive of initiatives that improved salmon habitat and population numbers to offset for the loss of feeding opportunities potentially caused by the project.

5.2 Cumulative Effects

The topic of cumulative effects (effects from multiple anthropogenic activities) was flagged as a topic for further discussion following the conclusion of the TAG meetings if opportunities allowed. TAG members noted that it is also important to analyze the effect of all stressors on SRKW considered together to understand their cumulative effect, rather than a typical stressor-by-stressor analysis.

5.3 Accident and Malfunctions – chemical release

On the topic of accidental releases of fuel, oil, or other chemicals into the environment, TAG members agreed that they do not possess the appropriate expertise to address these questions, and suggested that this topic be explored further with a group of relevant experts.

5.4 Contaminant exposure

The potential release of contaminants such as PCBs through resuspension of sediments during dredging and infilling was only briefly discussed in the TAG meetings. Details on the dredging activity and the potential for SRKW exposure to contaminants were uncertain at the time of the TAG meetings, and an informed discussion was not possible. It was noted that a large portion of the PCB levels in SRKW comes from offshore food sources (taken up by salmon while salmon are feeding at sea). A TAG member, however, pointed out that some Chinook salmon spend more time in nearshore waters where they may be more prone to exposure to local sources of PCBs. Depending on timing of these runs and prey availability, SRKW could be exposed to salmon with locally acquired PCBs. PMV consultants are looking at whether PCB exposure is likely to occur from the project.

TAG members agreed that they do not possess the appropriate expertise to address these questions, and suggested that this topic be explored further with a group of relevant experts.

5.5 Transient Killer Whales

TAG members engaged in a brief discussion on the possible effects of the RBT2 project on transient killer whales, whether SRKW could be viewed as a proxy for transients, and what factors should be considered in assessing effects on transients.

- Possible physiological effects related to hearing should be similar, but there are enough differences in ecology of these two ecotypes to suggest that they would be affected differently. Hearing sensitivity is unknown, but may be more sensitive at lower frequencies.
- Transient killer whales use passive acoustics (listening) rather than active acoustics (echolocation) to detect their main prey (other marine mammals). Therefore, they may be more prone to masking as they have a lesser ability to compensate by increasing vocalizations source level (volume of their calls)
- Proposed critical habitat for transient killer whales overlaps with the RBT2 project area and may have implications for the project
- Sightings data for transients do not appear to show that transients use the area near the RBT2 frequently, compared to SRKW.

6 Conclusions and Future Opportunities

The SRKW TAG met four times over 2012 and 2013 to provide PMV and its consultants with feedback on appropriate methods to assess the potential noise effects of the proposed RBT2 project and associated ship traffic on SRKW. This report catalogues this TAG process and the key findings and outputs of the process. At this point, PMV and its consultants are continuing their pre-EA studies with this additional guidance in mind. Looking forward, PMV and its consultants will complete their EA studies, engage the provincial and federal governments in the formal EA process, and continue to consult with stakeholders and First Nations.

While the SRKW TAG process has drawn to a close, the consultants and PMV noted the potential for involvement of TAG members in further discussions on data analysis, interpretation, mitigation, and monitoring.

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APPENDIX A – SRKW Noise Effects Focus Group Summary

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SRKW Noise Effects Focus Group Summary

This document summarizes the findings of the SRKW Focus Group, which involved a web-based survey to explore approaches to assessing potential noise effects from the proposed Port Metro Vancouver Roberts Bank Terminal 2 (RBT2) project and associated ship traffic on SRKWs.

Overview

To compliment SRKW Technical Advisory Group discussions and expand expert input on appropriate approaches for assessing noise effects, a focus group was created to investigate a number of topics in greater depth with an additional set of experts relevant to each field.

The expert survey was designed to answer key questions related to acoustic noise disturbance and masking for SRKW. Survey questions were organized into two key categories:

Section A: Acoustic Disturbance

1. Measurement Method & Frequency Weighting options;

2. Methods for assessing anthropogenic noise disturbances around a point source & follow-up questions; and

3. NMFS received SPL threshold value.

Section B: Acoustic Masking

1. Call-Masking: critical bandwidth, appropriate number of signal peaks; and

2. Click-Masking: critical ratio, frequency.

After an initial round of input, the results were compiled and circulated to the participating experts for further input and revision of estimates given comments raised. Findings from this survey of experts will help inform the noise effects assessment methodologies used for the proposed Port Metro Vancouver Roberts Bank Terminal 2 (RBT2) Project.

A total of 35 experts with experience in acoustic noise disturbances and masking for marine mammals were invited to participate in the expert survey, and 14 experts representing academic institutions, government (NOAA, Department of Fisheries and Oceans), and private consulting firms participated (Table 1).

Table 1 Participating Experts in the SRKW Focus Group

Dr. Whitlow Au	University of Hawaii
Dr. Volker Deecke	University of Cumbria
Dr. John Harwood	SMRU Ltd.
Maria Holt	
Dr. Ronald Kastelein	SEMARCO
Dr. Veronique Lesage	Fisheries and Oceans Canada
Dr. Brandon Southall	Southall Environmental Associates Inc.
Dr. Harald Yurk	SMRU Ltd.
6 anonymous participants	Various

Figures 1 and 2 provide a breakdown of responding experts' employment affiliation and years of experience in their field.

Figure 1 Employment Affiliation

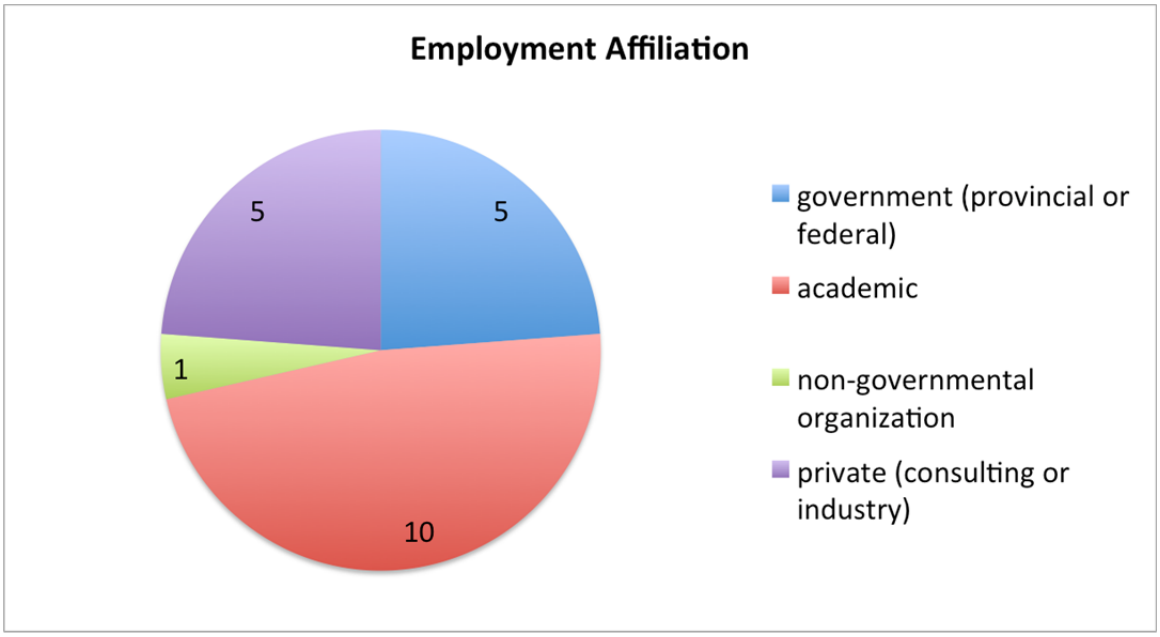
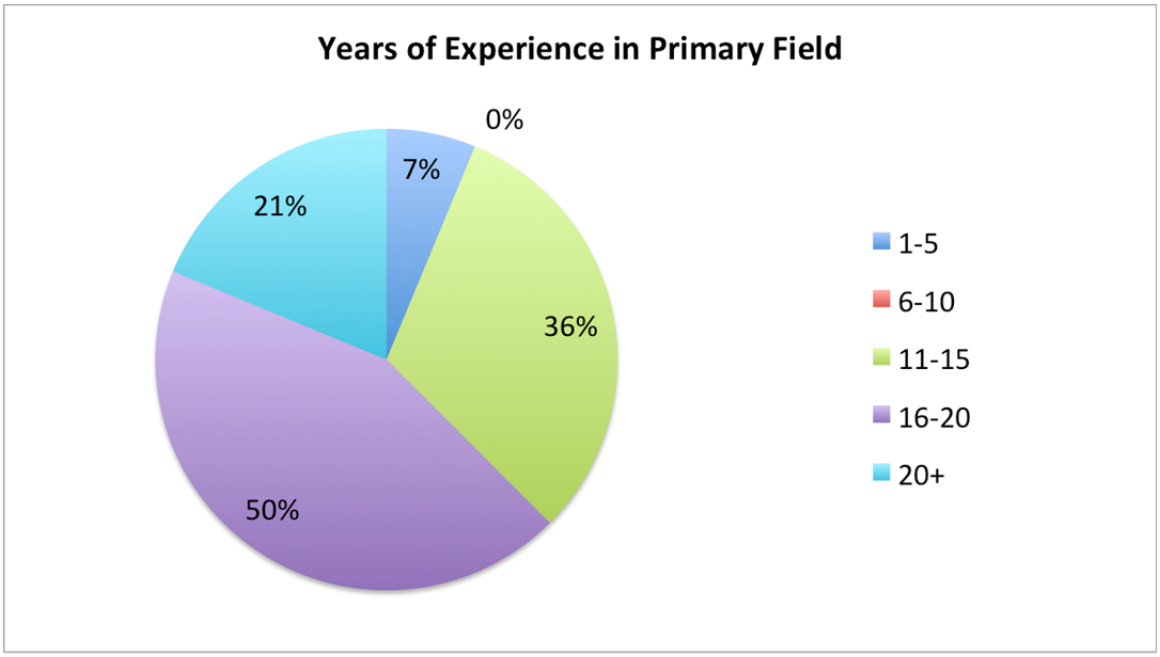


Figure 2 Years of Experience



Of the 16 experts participating in the exercise, 14 responded to the 'Acoustic Disturbances' question set, while 10 replied to the 'Acoustic Masking' set. Participants who self-rated their level of expertise below 50 points (on a scale of 0 to 100) were omitted from the analysis.

SECTION A) ACOUSTIC DISTURBANCE

A1) Measurement Method & Frequency Weighting options

For this section of the focus group survey, participants were asked the following question:

> *"Of the following ten (10) combinations of MEASUREMENT METHOD and FREQUENCY WEIGHTING, please weight at least three (3) options (by assigning between 0 and 100 points) to indicate how appropriate it is for assessing the behavioural disturbance effects of non-pulsed (continuous) low frequency sounds on killer whales.*
>
> *100 points – the most appropriate combination(s)*
>
> *50 – half as appropriate your top choice(s)*
>
> *0 (or blank) – not appropriate in this context*
>
> *You may assign up to 100 points for EACH of the following combinations"*

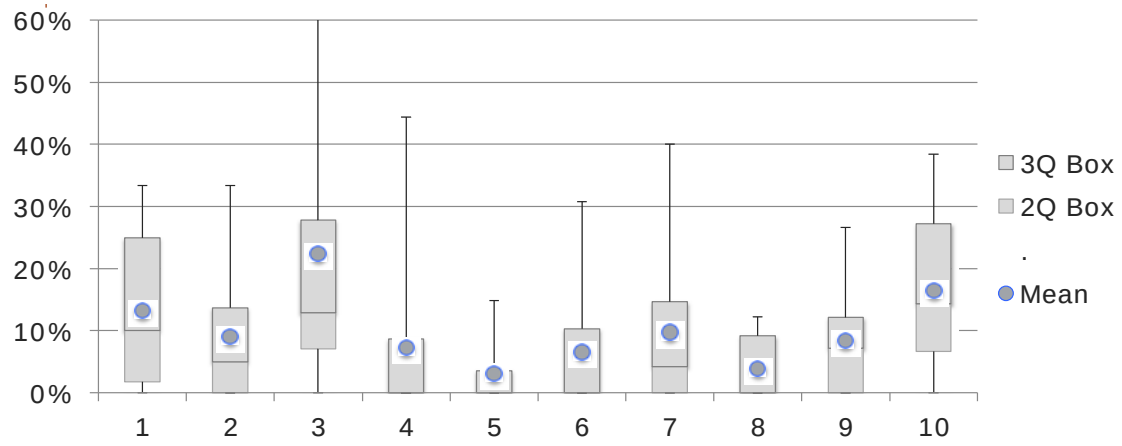
Since each expert was able to assign up to 100 points for each of the options, it was necessary to normalize responses to enable comparison. All scores were divided by the total number of points assigned by a respondent to normalize responses between 0 and 1. Table 2 shows normalized responses for each expert expressed as a percentage of total points assigned.

Table 2 Appropriateness of 'Measurement method' and 'frequency weighting' combinations

	Expert B	Expert D	Expert E	Expert F	Expert G	Expert J	Expert K	Expert L	Expert M	Expert N	Expert O
a) Sound Pressure Level (Root Mean Square) with no frequency weighting	31%	20%	0%	13%	5%	10%	33%	0%	4%	0%	30%
b) Sound Pressure Level (Root Mean Square) with M-frequency weighting	0%	0%	5%	8%	5%	20%	17%	33%	11%	0%	0%
c) Sound Pressure Level (Root Mean Square) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)	0%	10%	12%	4%	60%	33%	17%	22%	13%	75%	0%
d) Sound Pressure Level (Root Mean Square) with US Navy Type II frequency weighting	0%	0%	5%	13%	0%	7%	0%	44%	11%	0%	0%
e) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with no frequency weighting	0%	15%	0%	13%	0%	0%	0%	0%	7%	0%	0%
f) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with M frequency weighting	31%	10%	12%	8%	0%	0%	0%	0%	11%	0%	0%
g) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)	0%	10%	24%	4%	0%	0%	0%	0%	14%	15%	40%
h) Sound Energy Level (24 hour cumulative, sensu Southall et al. 2007) with US Navy Type II frequency weighting	0%	10%	12%	8%	0%	0%	0%	0%	12%	0%	0%
i) Maximum Sensation Level within frequency band from 0.5-5 kHz	0%	10%	5%	14%	20%	27%	0%	0%	7%	10%	0%
j) Maximum Sensation Level within narrow frequency bands	38%	16%	24%	14%	10%	3%	33%	0%	11%	0%	30%

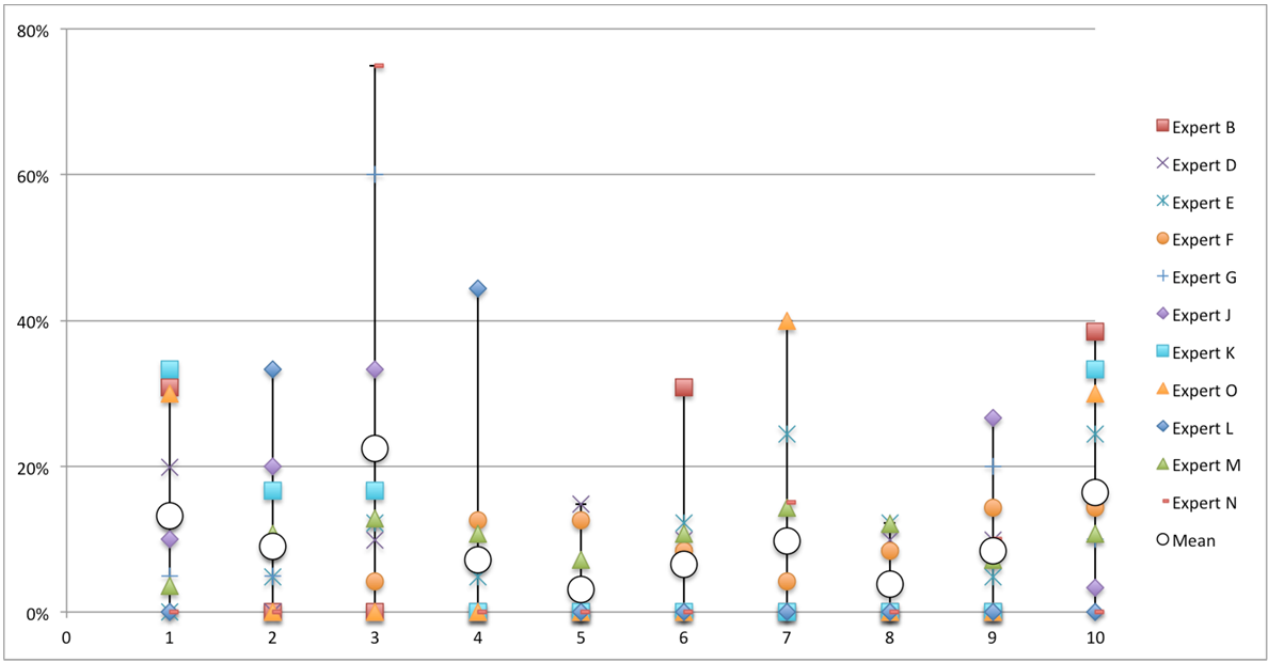
The results from Table 2 are presented as a box-whisker plot in Figure 3 to illustrate collective opinion across the 10 options (expressed as mean scores), and the range in expert opinion for each option, expressed as 25 and 75 percentiles (grey boxes) and extremes (whiskers, or 'error-bars'). Figure 4 overlays the scores from each individual expert for each of the 10 options, and again indicates the mean score across experts for each option (white circles), and extreme scores (indicated with 'error bars').

Figure 3 Appropriateness of 'measurement method' and 'frequency weighting' combinations



1) Sound Pressure Level (Root Mean Square) with no frequency weighting
2) Sound Pressure Level (Root Mean Square) with M-frequency weighting
3) Sound Pressure Level (Root Mean Square) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)
4) Sound Pressure Level (Root Mean Square) with US Navy Type II frequency weighting
5) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with no frequency weighting
6) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with M frequency weighting
7) Sound Exposure Level (24 hour cumulative, sensu Southall et al. 2007) with Killer Whale-specific reverse audiogram frequency weighting (with or without slope adaptations for 1-5kHz band due to use of captive animal data)
8) Sound Energy Level (24 hour cumulative, sensu Southall et al. 2007) with US Navy Type II frequency weighting
9) Maximum Sensation Level within frequency band from 0.5-5 kHz
10) Maximum Sensation Level within narrow frequency bands

Figure 4 Individual rating of 'measurement method' and 'frequency weighting' combinations



From these two figures we see that option #3 Sound Pressure Level with KW specific reverse audiogram frequency weighting is the top scoring option, while option #10 maximum sensation level with narrow frequency bands has the second highest average score. The overall range of scores in most cases span approximately +/- 10 to 20 points indicating a moderate degree of agreement across experts, while option #3 indicates much stronger than average support from several experts.

To provide additional background on the conditionalizing assumptions that influenced their choice of weighting, experts were asked to summarize their justifications for rating each item. These comments are outlined in Table 3 below.

Table 3 Conditionalizing assumptions for the 'measurement method' and 'frequency weighting' exercise

Please comment here to justify your weightings for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice of weightings.	
Expert B	Audiograms from captive animals are often unreliable. An animal's frequencies of highest sensitivity may be the ones most robust from damage. Maybe the frequencies of poorer sensitivity may also hold some importance for animals and be most prone to damage. So many assumptions are made based on audiograms from captive animals. There have been too many surprises of animals reacting when one wouldn't have expected it based on their audiograms. Also, the loudest sounds are damaging even independent of frequency or audiogram, i.e. The damage curve is fairly flat across frequencies when the noise is loud enough.
Expert D	Frequency weighting for marine mammals are at best only guesstimates and may not be applicable at all. I rather see results in an unweighted format and then I can decide what kind of weighting to use if any.
Expert E	Weightings are important, as hearing differs between different species. Weightings should be as specific to the study species (i.e. Killer whale as possible) to be realistic. Killer whale audiogram data are based on a large enough sample size so as to be reasonably robust. Therefore killer whale-specific weighting would be desirable. Whether cumulative or non-cumulative measures should be used depends on the type of sound (persistent vs. Episodic), but in most cases cumulative metrics would be preferable.

Please comment here to justify your weightings for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice of weightings.	
Expert F	Unweighted RMS levels are important to obtain for comparison with other studies and that give an overall way of assessing exposure without the filter of filters we have made with limited data. Using these filters is important as well and should be done in combination - my view is the M-weightings are still relevant because the others, especially inverse audiogram are too prescriptive and narrow and based on limited data. Using sensation level is a good idea as well. There should be multiple metrics and using 1/3rd octave levels is probably a good approximation.
Expert G	
Expert J	SEL is not appropriate for behavioral responses, but is appropriate for TTS en PTS estimates. US Navy type II weighting is based on bottlenose dolphins, therefore the reversed Killer whale audiogram is the presently best option.
Expert K	There is no data on how m-weighted values correlate with behavioral disturbance.
Expert L	SEL is more relevant to injury effects than to behavioural response. What triggers disturbance is more the characteristic of the sound in term of initial output (so SPL), plus familiarity of the sound and behavioural context. Duration of exposure might play a role, but likely more secondary. Using no frequency weighting is likely to greatly overestimate effects even more than M-weighting, so M-weighting seems more appropriate than no weighting. However, there is little data to assess the drop off of the perception curve outside of the optimal hearing range for a given group of animals (e.g. Mid-frequency cetaceans). The US Navy Type II approach is based on the single study where an experimental weighting function was developed for mid-frequency odontocetes and so seems the most appropriate to describe the hearing sensitivity of killer whales. The second most relevant would be SPL with M-weighting, and third best approach would be one that simply uses the reversed audiogram without equal-loudness curves for correcting for sensitivity. I am not sure what MSL criteria are so did not comment.

Respondents were then asked to describe any alternative method/frequency-weighting combinations that were not provided as an option (Table 4), and to gauge how their choice of combination would change when used for other marine mammals (Table 7).

Table 4 Alternative method / frequency weighting combinations

Can you describe any alternate method/frequency-weighting combinations that you would weight higher than any of those described in Question 8?	
Expert B	I would build a lot of conservativeness into the process, as we have been wrong so many times before and animals are irreparably damaged as a result.
Expert D	I can't suggest anything at this point in time. I think that considerably more research need to be done before assuming any type of weighting would be applicable. Perhaps no weighting might be the best approach to use.
Expert E	None.
Expert F	
Expert G	
Expert J	Yes, equal-loudness curves specially for killer whales.
Expert K	sound pressure level within the hearing range of killer whales (based on published audiograms), unweighted.
Expert L	

How would you change your choice of weighting for the combinations in Question 8 if you were asked to consider acoustic disturbance in the following marine mammal species groupings? Please describe how your weightings would change, and whether or not a different method/frequency-weighting combination(s) would become your top choice.a) low frequency cetaceans:	
a) low frequency cetaceans:	
Expert B	We need to be even more conservative in our assumptions as there aren't even audiograms from captive animals.
Expert D	I prefer not to use any weighting at this time.
Expert E	Species-specific weighting, if available. If not MIf weighting of Southall (2007) should be applied. Exposure should be assessed in a cumulative fashion.
Expert F	M-weighting still the most appropriate - we have and will never have the relevant direct data for these species.
Expert G	With the lack of a LF species audiogram we have used audiograms based on vocal frequency and anatomy to produce a modelled LF audiogram. M weighted SPL may be alternative.
Expert J	I would use the US navy weighting.
Expert K	Not different.
Expert L	Use SPL with M-frequency weighting given that data to better characterize drop off of sensitivity outside of optimal hearing range does not exist.
b) high frequency cetaceans:	
Expert B	I have a problem with these groupings as even animals with similar audiograms (high frequency cetaceans) have sometimes remarkably different sensitivities and behavioral reactions (e.g. Dall's and harbor porpoises).
Expert D	I prefer not to use any weighting at this time.
Expert E	Species-specific weighting, if available. If not Mhf weighting of Southall (2007) should be applied. Exposure should be assessed in a cumulative fashion.
Expert F	Can see something narrower making sense -- like the Navy current approach better than inverse audiogram.
Expert G	Use of relevant HF species inverse audiogram would appear most appropriate.
Expert J	At this moment I would use the reverse audiogram, but the equal loudness curves for harbor porpoises are close to being submitted to a journal.
Expert K	Not different.
Expert L	Use SPL with M-frequency weighting given that data to better characterize drop off of sensitivity outside of optimal hearing range does not exist.
c) pinnipeds	
Expert B	These are at least easier to study and, generally, more plentiful and faster reproducing, so I wouldn't reserve my highest conservative treatment for these animals. However, the unexplained and unexpected PTS in a harbor seal is disconcerting.
Expert D	I prefer not to use any weighting at this time.
Expert E	Species-specific weighting, if available. If not Mpw weighting of Southall (2007) should be applied. Exposure should be assessed in a cumulative fashion.
Expert F	Limited data in some species of course, but clear indication need to split phocids and otariids.
Expert G	Use of relevant pinniped species inverse (underwater) audiogram would appear most appropriate.
Expert J	I would use the reverse audiogram for specific species (if it exists for that species), as there are 45 pinniped species and they are difficult to put in one hearing group (also, hearing of only a few species has been measured). By lack of data for a species, use the M-weighting. For the harbor porpoise, a few equal loudness curves exist (near threshold).
Expert K	Not different.
Expert L	Use SPL with M-frequency weighting given that data to better characterize drop off of sensitivity outside of optimal hearing range does not exist.

Measurement Method & Frequency Weighting Follow-Up Questions

Based on the overall preference for option #3 - Sound Pressure Level with KW specific reverse audiogram frequency weighting is the top scoring option (Table 2), several follow-up questions were presented to focus group participants as follows:

> *"In evaluating the most appropriate method to assess the level of chronic acoustic **behavioural disturbance** in SRKW, the use of received Sound Pressure Level (SPL) with an audiogram-based frequency weighting was ranked highly by participants in the focus group (see attached box-whisker plot – Method and Weighting Combinations.pdf). However, a number of respondents raised concerns over using the lower frequency range audiogram data based on small numbers of long-term captive animals. To address these concerns, a precautionary audiogram with the two following modifications could be used:*
>
> - *keeping the audiogram flat across the zone of very sensitive hearing (presently considered 10-60 kHz for killer whales), similar to the approach of M-weighting.*
> - *compensating for possible effects due to experimental biases, animal age and noise exposure history. This second stage would involve (for less sensitive hearing frequencies <10 kHz and > 60 kHz) smoothing a composite killer whale audiogram by removing reduced sensitivity undulations from the most sensitive existing audiogram, followed by the addition of a precautionary 12 dB buffer.*
>
> ***Part a:** Would the use of received SPL with such a precautionary audiogram weighting (similar to the one described) increase your rating of how appropriate this methodology is for assessing acoustic behavioural disturbance in killer whales (compared to the SPL / audiogram frequency weighting methodology without the proposed modifications)?*
>
> ***Part b:** If, yes, would your rating increase a small, moderate or a large amount, and do you have further recommendations? If no, please provide comments"*

Responses to follow-up question #1 indicate a mix of support and feedback on the proposed approach, as summarized in Table 5 below.

Table 5 Follow-up question responses for 'measurement method' and 'frequency weighting' selection

Respondent	Response: Part a	Comments: Part a	Response: Part b
Respondent A	No	My original comment on this issue questions the appropriateness of using weighting functions for behavior in the first place (if the sound is completely outside the hearing range of the species, then I agree with some type of filtering, like a boxcar filter, is appropriate). How an audiogram or whatever weighting is chosen drops off may reflect how a species *hears* a sound but it does necessarily offer an accurate predictor of how an animal *perceives* the sound and then decides how to behaviorally *respond* (or not respond). There have been multiple studies showing animals responding strongly to sounds on the edge of their hearing range (where if you use some weighting method you would predict a minimal response) because for example it was associated with food (something of high motivation). Thus, the reaction had nothing to do with how well the animal heard the sound.	Moderate
Respondent B	Yes	----	----

Respondent	Response: Part a	Comments: Part a	Response: Part b
Respondent C	Yes	I agree that the fact the audiogram data is based on such a small sample size of long-term captive animals is a problem. The precautionary approach would be better, but there are still large uncertainties.	A small amount
Respondent D	Yes	Yes, certainly the modifications help, but may not be sufficient. Behavioural disturbance can happen even over parts of the audiogram that aren't very sensitive. Note the recent research on blue whales responding strongly and at low received levels to mid-frequency sonar--frequencies to which they should not be sensitive. Beaked whales also shouldn't be very sensitive to the frequencies of mid-frequency sonar, yet they also respond strongly.	Small amount. I don't believe audiograms are necessarily all that relevant to behavioral disturbance. The animal would have to hear OR sense (not necessarily by ear) the sound, of course, but beyond that, I think an animal can be disturbed even in parts of the audiogram that aren't the most sensitive. There are so many examples where we would expect animals not to be disturbed based on their audiograms, yet we are wrong time after time
Respondent E	Yes	----	Moderate
Respondent F	No	In the harbor porpoise we found a hearing insensitivity at 64 kHz. At first we thought this was an abnormal animal, but we found the exact phenomenon in the second animal that we tested 10 year later. So, irregularities could be a characteristic of the species. With the small sample size with killer whales and the different hearing test techniques used, it is difficult to decide which audiogram is the most representative for the majority of animals of the species.	
Respondent G	No	No because weighting functions used in the context of behavioural disturbance is not based on any rigorous scientific studies supportive of its use in killer whales or other odontocetes that I am aware of (e.g. that using weighted received SPL better explains behavioural responses to noise exposure vs. using unweighted received SPL). Furthermore, the use of weighting functions for addressing occupation safety criteria in the work place for humans is not based on audiogram data. They are based on equal-loudness contours, which do not follow audiogram shape. Rather, they flatten as noise exposure level increases. Using this type of data (i.e. equal loudness data) is more predictive of the potential for hearing loss and also how humans would rate noise annoyance (the latter which I suppose is more applicable to behavioural disturbance).	

An additional follow-up question was asked to gauge preference for Received Sound Pressure Level versus Sound Exposure Level as follows:

> ***"Q2.*** *In evaluating the most appropriate method to assess the level of chronic acoustic* ***behavioural disturbance*** *in SRKW, if you had a choice of using either Received Sound Pressure Level or Sound Exposure Level - which would you choose, and why?"*

Participant responses are summarized in Table 6 below.

Table 6 Received Sound Pressure Level versus Sound Exposure Level

Respondent	Response: Part a
Respondent A	My first question would be how you define "chronic," but I will assume you mean a sound that lasts from multiple days or longer. Based on this assumption, a metric that accumulates sound would be preferred (e.g., cSEL) to provide either a daily, weekly, monthly, etc. exposure level. Of course, accumulating sound is easier to do when considering the source vs. the receiver in real world situations (i.e., there would need to be some basic assumptions made up front). Apologies, I can't remember the sources of concern for in this particular situation.
Respondent B	I would stick with SPL because behavioural reactions to sound exposure occur primarily as a result of noise physical characteristics, irrespective of period of exposure (Ellison et al. 2012, Götz and Janik 2011). In these cases, a metric more directly linked to instantaneous received SPL might be more appropriate. However, environmental, operational and biological factors are likely to play a significant role in determining the probability and severity of the invoked reaction, particularly at low SPL (Southall et al. 2007; Ellison et al. 2012), and so taking into account the context of exposure in addition to SPL might be a better way to go.
Respondent C	Sound exposure level - many studies have shown that effects are summative and the duration of sound exposure matters.
Respondent D	Definitely Received SPL as SEL breaks down over longer time periods--it is no longer meaningful or backed by research, so is totally inappropriate for chronic disturbance.
Respondent E	If I had to make a choice between RL and SEL, I would choose RL because of the essentially arbitrary nature of SEL, which depends on the time interval over which sound exposure is integrated. However, I see no reason why such a choice is necessary, especially for the kinds of noise to which SRKW are likely to be exposed.
Respondent F	Received SPL. A longer period of exposure time will not increase the effect, it will only make the effect last longer, or make the animal habituate. For TTS you should use received cumulative SEL. For behavior you should use received SPL.
Respondent G	I would choose received sound pressure level (SPL) over sound exposure level (SEL) for two reasons. One is based on scientific evidence, or lack thereof, in that there is no scientific evidence that SEL should be used for behavioral disturbance (whereas SEL has scientific basis in the delphinid literature for temporary hearing loss). Furthermore, behavioral disturbance is also context dependent so even using received SPL is likely not fully protective; the second reason is practical – for truly chronic disturbance, how would one define what duration of sound exposure over which to integrate SEL?

A2) Methods for assessing anthropogenic noise disturbances around a point source

For the second set of questions, participants were asked the following question:

> *"Noise effects assessments often define a received noise level threshold to estimate a 'zone of disturbance'. For example, the US National Marine Fisheries Service (NMFS) presently uses a single received SPL threshold level of 120 dB re 1 µ Pa root mean square (and no frequency weighting) to define the zone of disturbance around 'continuous' noise sources. Alternative methods exist for determining the scale and magnitude of disturbance.*
>
> *For the following list of methods/options available for assessing how anthropogenic noise might disturb marine mammals around a point sound source, please indicate how appropriate you consider them to be by assigning between 0 and 100 points for each option."*

Normalized scores for each expert are summarized in Table 7.

Table 7 Appropriateness ratings for noise disturbance effects assessment methods

CODE NAME	Expert B	Expert D	Expert E	Expert F	Expert G	Expert J	Expert K	Expert L	Expert M	Expert N	Expert O
a) Use of a single received threshold level	54%	28%	8%	0%	10%	15%	17%	50%	9%	44%	25%
b) Partition of disturbance zone into two received thresholds values, with the aim of distinguishing between Southall et al. (2007) strong severity behavioural response index scores (>4-5) and weak severity behavioural response index scores (<4)	15%	28%	25%	22%	20%	8%	50%	0%	28%	33%	25%
c) Use of dose-response curves or dose-step functions to define proportion of animals responding to received dose levels	31%	44%	67%	33%	70%	77%	33%	50%	28%	22%	0%
d) Other method: (please specify in the 'comments' box below)	0%	0%	0%	44%	0%	0%	0%	0%	34%	0%	50%

Figure 5 Appropriateness ratings for noise disturbance effects assessment methods

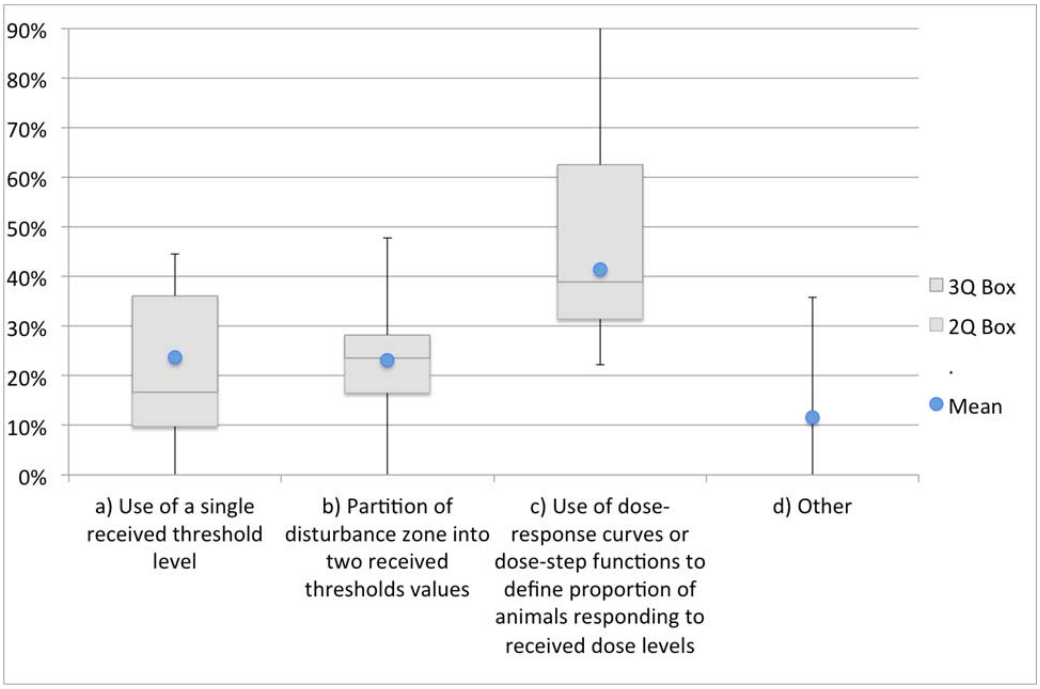
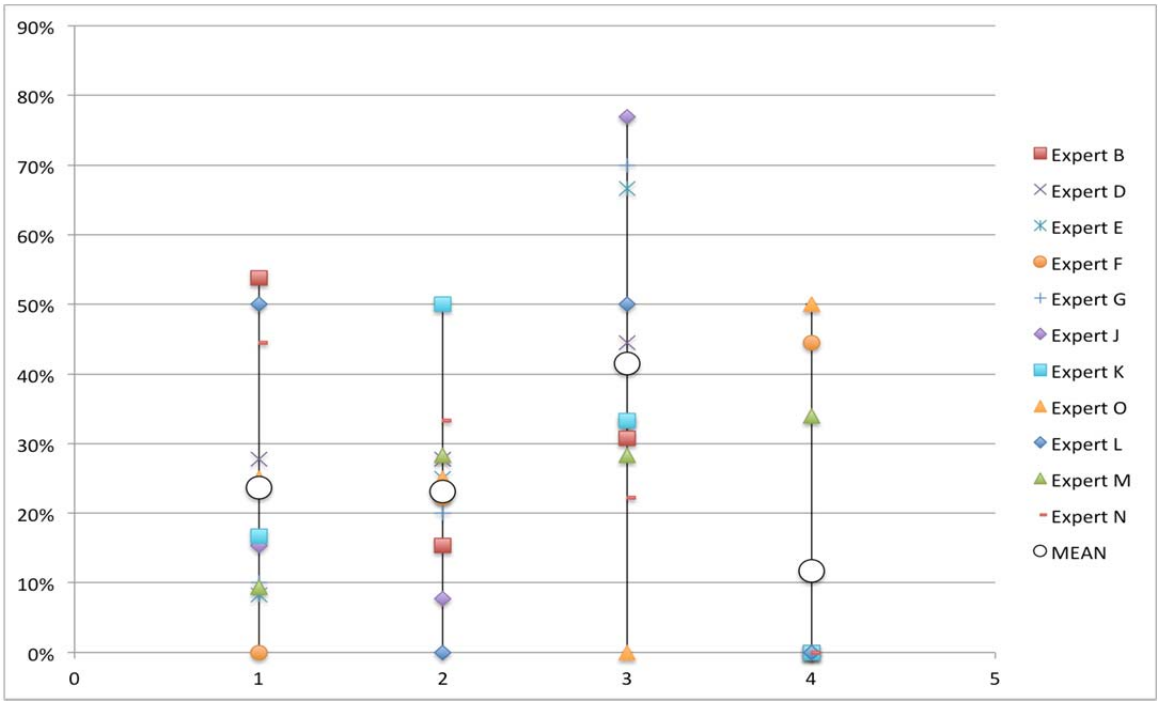


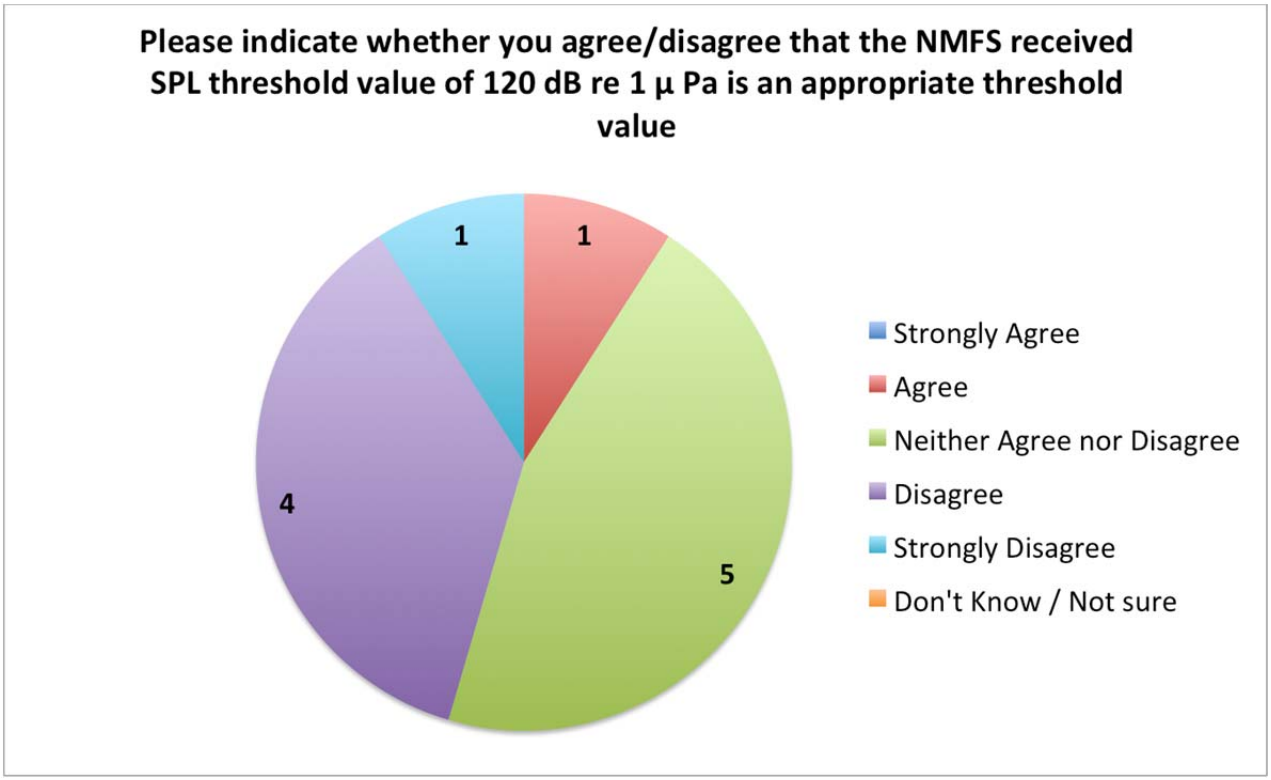
Figure 6 Individual rating of noise disturbance effects assessment methods



A3) NMFS received SPL threshold value

For the third set of questions, participants were asked to indicate whether they agree that the NMFS received SPL threshold value of 120 dB re 1 u Pa is appropriate for noise disturbance effects. Response options included 'strongly disagree', 'disagree', 'neither agree nor disagree', 'agree', 'strongly agree', 'don't know / not sure'. Results shown in Figure 7 indicate both high level of disagreement with the appropriateness of the threshold, yet also many expressing a neutral opinion.

Figure 7 Selection of appropriate NMFS received threshold value for noise disturbance effects



Summary of findings

Overall, the findings for the 'Acoustic Disturbance' section of the focus group survey are summarized as follows:

1. Measurement Method & Frequency Weighting

- *Mixed Results – appears to be a fair amount of scientific uncertainty, hedging;*
- *Received level and Sensation level rate higher overall;*
- *Received level + reverse audiogram ranks #1; and*
- *Follow-up question rating alternative M-weighting scheme scored better than original options.*

2. Methods for assessing anthropogenic noise disturbances around a point source

- *Dose response or step-response clearly ranks #1; and*
- *Comments highlight difficulty in assessing correct form of any dose-response probability curve.*

3. NMFS received SPL threshold value of 120 dB

- *Only marginal support for this level and approach; and*
- *Additional alternate value question for follow up received too few responses to analyze further.*

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SECTION B) ACOUSTIC MASKING

B1) Call-Masking

For this section of the focus group survey, participants were asked a number of questions related to the selection of appropriate parameters for an SRKW call-masking model. In the first question, participants were asked to choose what they thought was the most appropriate 'critical bandwidth' to use. Results are shown in Figure 8, with conditionalizing substances listed in Table 8.

Figure 8 Selection of appropriate critical bandwidth for an SRKW call-masking model

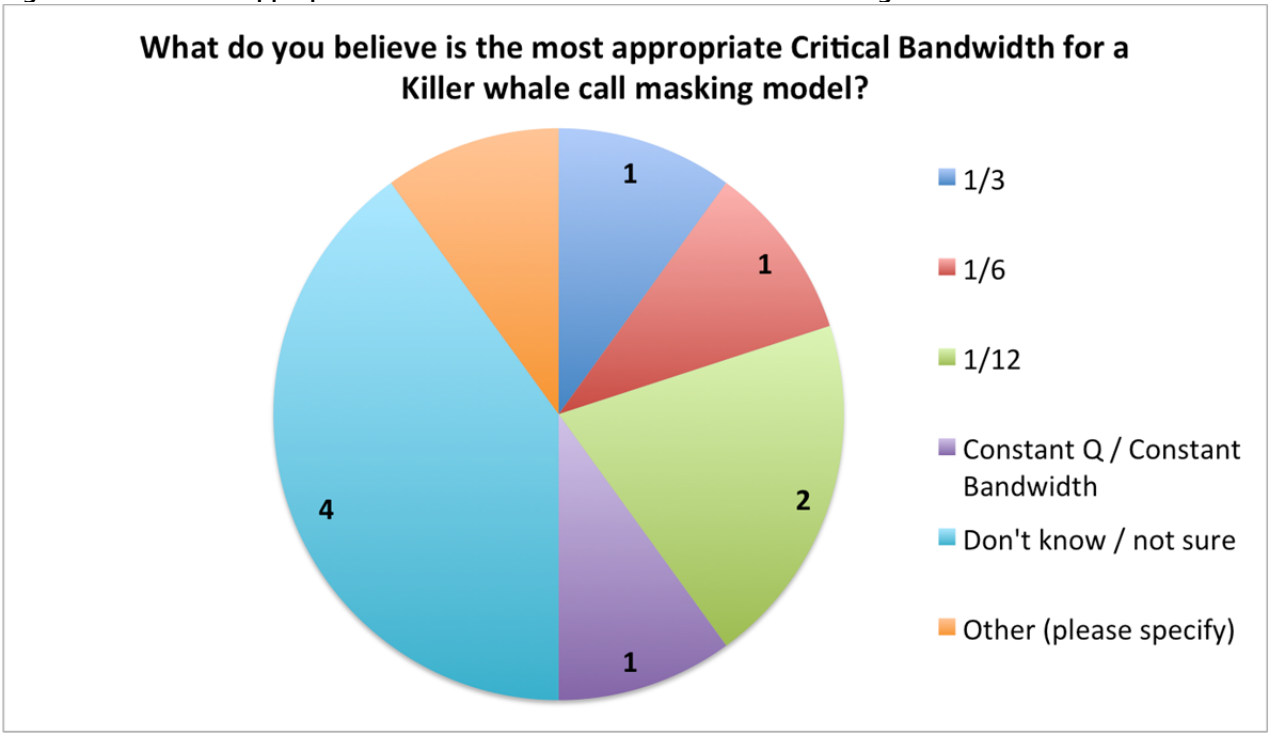


Table 8 Conditionalizing assumptions for the selection of appropriate call-masking critical bandwidth

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
Expert AA	Out of the choices above, I used 1/12th octaves; CB are not of constant-Q but change w frequency, which would be an improvement to my model, just a touch more laborious to implement.
Expert BB	I don't think we know enough, thus must proceed with greatest caution and least assumptions as to an animal's adaptability. Thus, we must assume even noise well outside an animal's frequency of calls can still mask it.
Expert CC	I don't think we have enough information to determine this in scientifically valid way (for killer whales or any marine mammal species).
Expert EE	The auditory system of marine mammals can be most accurately modeled as a bank of constant-Q filters.

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
Expert FF	I assume the fractions (1/3, 1/6, 1/12) refer to OCTAVE BANDS. Frequency perception is logarithmic, so an octave model is more realistic than one based on constant frequency bands. In my opinion, 1/6 octave provides a good compromise between resolution and generality
Expert GG	From what we know about all mammals and limited masking data on marine mammals this appears to be a conservative (maybe slightly broad which is good) model that fits.
Expert HH	Not sure because no CB measurements are available in killer whales. If I had to choose, I would either choose 1/6 or constant Q/constant BW based on empirical measurements in other odontocetes.

In the second question, participants were asked to choose the most appropriate number of signal peaks to use in an SRKW call-masking model. Results are shown in Figure 9, with conditionalizing substances listed in Table 9. Feedback on additional parameters and alternative models to consider are found in Table 10 and Table 11.

Figure 9 Appropriateness of number of signal peaks for an SRKW call-masking model

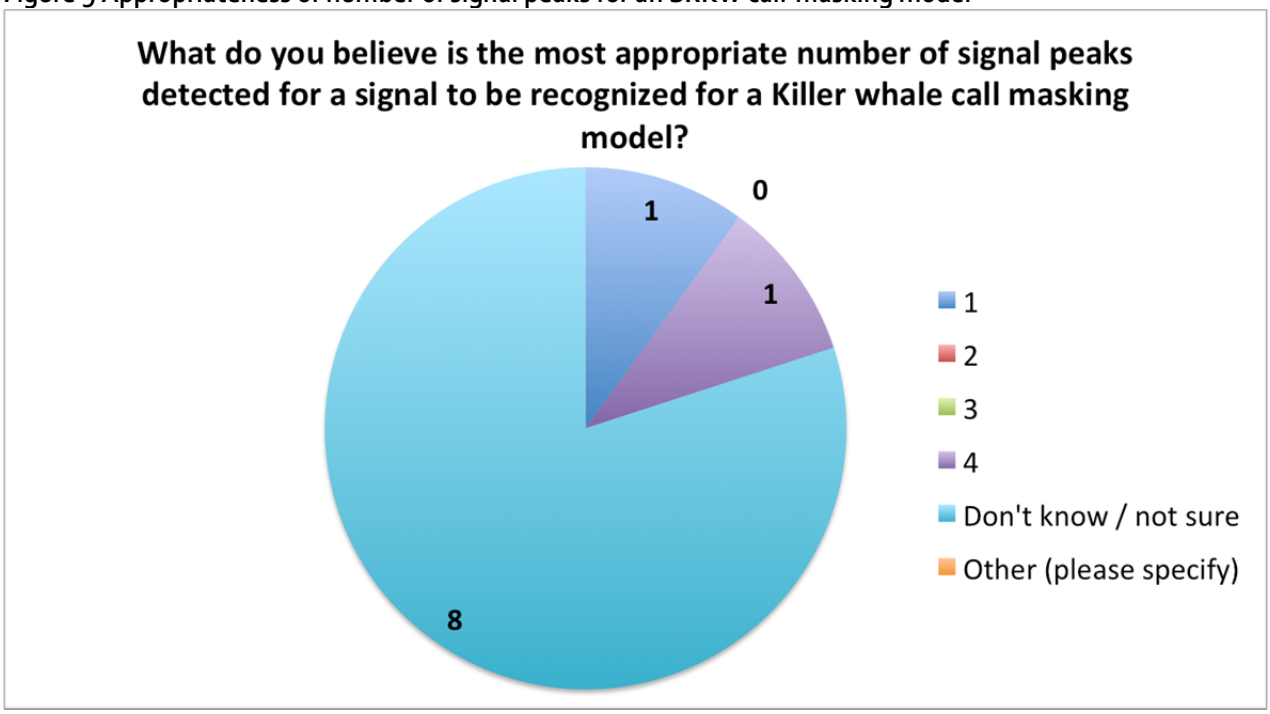


Table 9 Conditionalizing assumptions for the selection of appropriate number of signal peaks

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
Expert AA	We don't have the data to answer this; for pure detection, 1 should suffice; for call recognition, you might want more, yet don't know which ones or how many and FOR HOW LONG !! Masking is not just a frequency business.
Expert BB	It is not enough for a killer whale to detect a call as being from another killer whale. It must have all the information inherent in it without the masking. We do not know what that information is, so can't say how much of the signal is enough to detect. Again, we must proceed with precaution in the face of ignorance.
Expert CC	Again, I don't think we have enough information to determine this in scientifically valid way (for killer whales or any marine mammal species).
Expert EE	At this point in time, we can only guess at the answer to this question because we just don't know enough on how killer receive and perceive sounds.
Expert FF	Masking noise from several industrial processes can be rather complex in its spectral composition. A realistic assessment on masking effects therefore requires a model considering as many signal peaks as possible. In most situations, a model considering 4 spectral peaks would seems to present a good compromise between resolution and computing intensity.
Expert GG	Don't think we know enough about how they attend to information to be explicit about this. Certainly more than 1.
Expert HH	One good one would probably be enough considering how important calls on for acoustic communication in killer whales.

Table 10 Additional variables to include in a whale call and whistle masking model

	What other key variables should be included in a whale call and whistle masking model? Please list and/or describe these here.
Expert AA	Temporal structure of call and noise, see Erbe, C. (2008) “Critical ratios of beluga whales (Delphinapterus leucas) and masked signal duration”, Journal of the Acoustical Society of America 124(4): 2216-2223.
Expert BB	It is hard to tell what features are important to killer whales, but they could be duration, directivity, repetition rate, etc.
Expert CC	Actual data on the sound type of interest rather than relying on tonal data.
Expert EE	The duration of sounds, the amplitude modulation, the frequency modulation, and the frequency range of sounds are some of the key variables.
Expert FF	Frequency content must be assessed with the species' hearing abilities in mind (i.e. Killer whale-specific weighting or sensation levels) Environmental noise from sources other than the source in question must be considered as well, as masking is cumulative.
Expert GG	Time-variance in masking noise, which is challenging but important.
Expert HH	Temporal fluctuations in noise levels.

Table 11 Alternative call-masking models to consider

	Do you think a different masking model for killer whale calls and whistles would be more appropriate? If so, which one?
Expert AA	Again, there is NO data on masking of complex calls by real noise for killer whales the study conducted at Vancouver Aquarium in 1994 w beluga whales is still the only one, 20 years later... Though similar work w dolphins in San Diego is underway now, and w pinnipeds in Santa Cruz.
Expert BB	If calls and whistles are differentially detected by whales within shipping noise, then yes. Perhaps playbacks to wild animals could elucidate this.
Expert CC	
Expert EE	I don't know.
Expert FF	
Expert GG	The above describes energetic masking, as occurs within the cochlea. This is important, but a communication masking model that accounts in some way for the context of exposure and behavioral context/state would be relevant.
Expert HH	No.

B2) Click-Masking

For this section of the focus group survey, participants were asked a number of questions related to the selection of appropriate parameters for an SRKW click-masking model. In the first question, participants were asked to choose what they thought was the most appropriate 'critical ratio' to use. Results are shown in Figure 8, with conditionalizing substances listed in Figure 10 and Table 12.

Figure 10 Selection of appropriate critical ratio for SRKW click-masking model

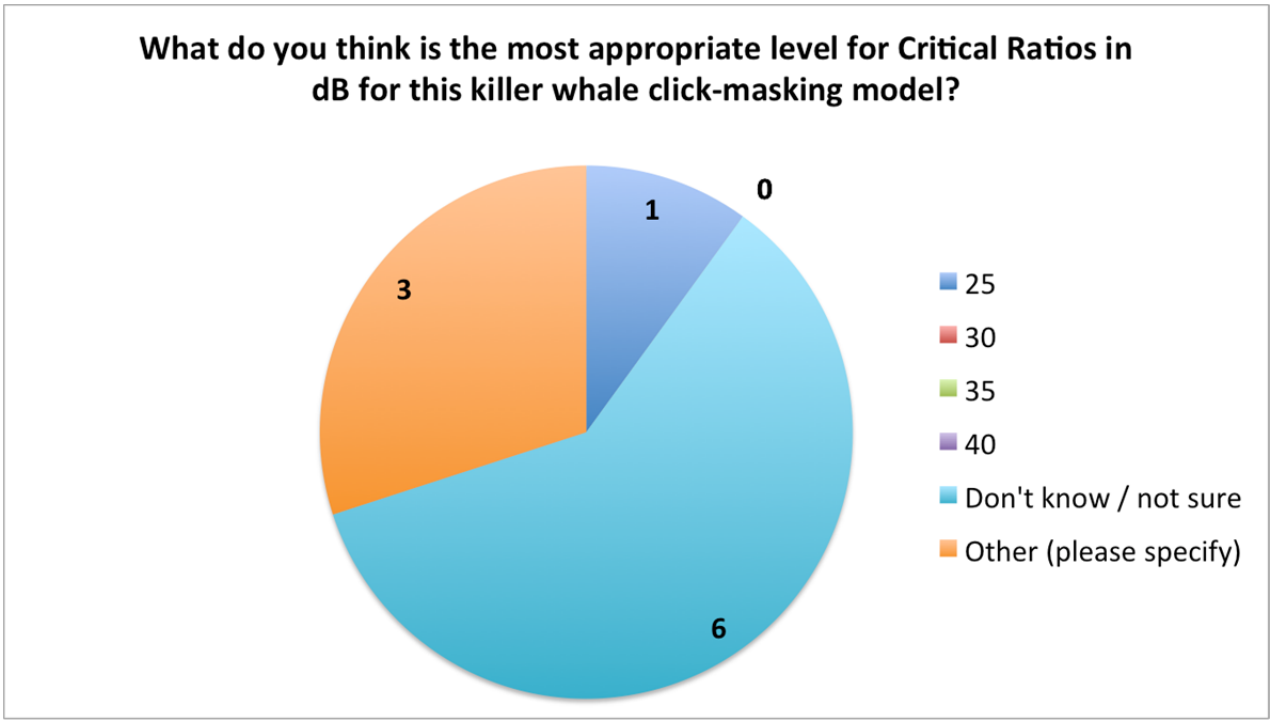


Table 12 Conditionalizing assumptions for the selection of appropriate critical ratio

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
Expert AA	In the absence of killer whale measurements, you would likely go with Fletcher as a first approximation, i.e. equal intensity of tone in noise.
Expert BB	As before, I think we need to proceed with precaution as I don't think we know which parts of a click are most important to a whale in all circumstances.
Expert CC	Not enough data to determine this.
Expert EE	We only have some masking data for killer whale at best and probably only for one animal. I wouldn't base anything on data from only one animal.
Expert FF	Given our current knowledge, I feel that it is impossible to assign a single critical ratio. Killer whale echolocation is extremely variable and the appropriate critical ratio very much depends on the echolocation task at hand (e.g. Orientation vs. Prey detection). The important part to consider is that it is NOT the click that the whale needs to be able to detect, but its echo. The appropriate critical ratio therefore depends to a large degree on the distance to the target.
Expert GG	This is on the lower end by some indications but given comments above about communication masking may be more appropriate and also more likely if more and well-trained animals tested directly.
Expert HH	No empirical data to draw from, especially given that clicks are broadband signals and critical ratios are defined from studies measuring the detection of pure tones in band limited white noise.

In the second question, participants were asked to choose the most appropriate frequency at which to model SRKW click-masking. Results are shown in Figure 11, with conditionalizing substances listed in Table 13. Feedback on alternative models to consider are found in Table 14.

Figure 11 Selection of appropriate frequency to model killer whale click-masking

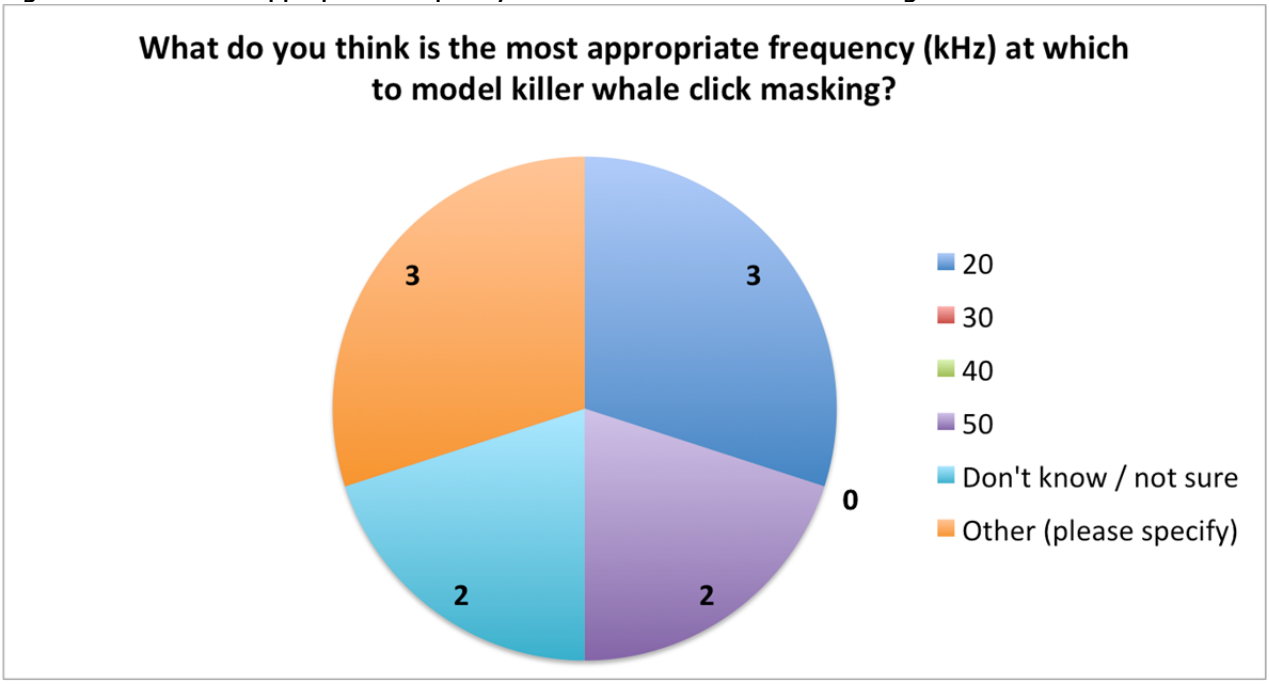


Table 13 Conditionalizing assumptions for the selection of appropriate frequency

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
Expert AA	Depends on your environment, over what ranges are clicks important to the animal? Then use the source spectrum, propagate it for the specific environment, see how the spectrum changes, au & ford measured and modelled this for SRKW; you'd likely want to pick a few frequencies of max returned echo energy.
Expert BB	As above.
Expert CC	Clicks are fairly broadband, why would you focus just on one frequency. Plus, even though one frequency might contain the most energy, do we know enough about the characteristics of these clicks to understand what all the features are being used for?
Expert EE	Killer whales tend to produce clicks that peak between 40-60 khz so I figure 50 khz would be a good choice.
Expert FF	Because killer whale echolocation is extremely variable it is inappropriate to model masking on a single frequency. Frequency content of clicks and more importantly of echoes depends on the echolocation task at hand (e.g. Orientation vs. Prey detection). Therefore masking in the entire frequency range of killer whale echolocation must be considered.
Expert GG	Lower end but where more noise is and likely to travel further. Could make a case for even lower

	Please comment here to justify your selection for the above question, or to highlight conditionalizing assumptions that you feel are important and which influenced your choice.
	actually.
Expert HH	50 khz is the peak frequency.

Table 14 Alternative models for SRKW click-masking

	Do you think a different masking model for killer whale clicks would be more appropriate? If so, which one?
Expert AA	see 25
Expert BB	Don't know.
Expert CC	
Expert EE	I don't think so.
Expert FF	
Expert GG	
Expert HH	If there is data on peak echo level (peak frequency of an echo off of a Chinook) from free-ranging animals, then this would be a better assumption of what the most appropriate frequency should be to model killer whale click masking.

Summary of findings

Overall, the findings for the 'Acoustic Masking' section of the focus group survey are summarized as follows:

1. Call-Masking: critical bandwidth, # of signal peaks

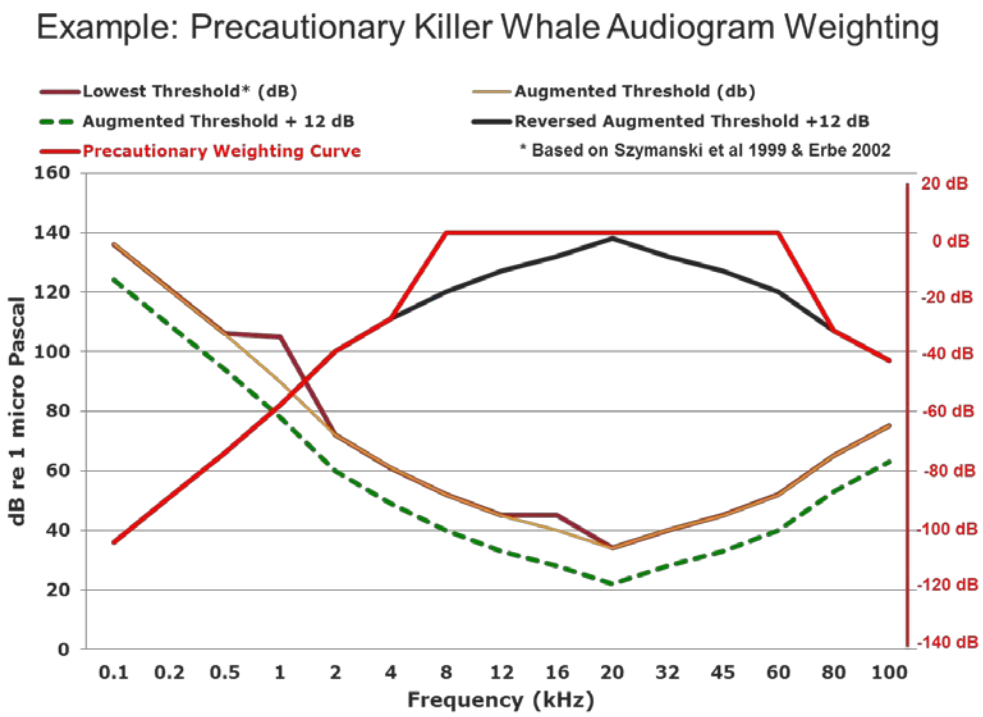
- *General uncertainty on Critical bandwidth*
- *Marginal support for 1/12 octaves and constant Q*
- *Number of signal peaks for recognition not known*

2. Click-Masking: critical ratio, frequency selection

- *High uncertainty on choice of critical ratio*
- *20 and 50 kHz selected as optimal frequencies*

APPENDIX B – Example Draft Precautionary Killer Whale Audiogram Weighting

The following audiogram weighting scheme was discussed during the TAG meetings, and was considered to be more appropriate than existing published audiograms. See section 3.4 for details.



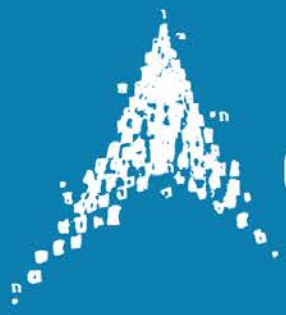
APPENDIX C – Preliminary Rating of Potential Project Effects and TAG Members' Relative Level of Concern

Effect	**Habitat Loss**	**A + M** **(Toxic Spill)**	**Construction** **Noise** **Acute**	**Construction** **Noise** **Chronic**	**Operational** **Noise** **Local**	**Operational** **Noise** **Regional**	**Contaminant Release**	**Indirect Prey**	**Strike** **Large Ships**
Effect Certainty	Sara Effect Unknown	Demonstrated	Demonstrated	Plausible	Plausible	Fairly Certain	Plausible	Plausible/Unknown	Unknown
Scale	Local	Local to regional	Local	Local	Local	Regional	Local	Local	Regional
Duration.	Long	Short-Med	Short	Med-Long	Long	Long	Med- Long	Med-Long	Long
Freq.	Continuous	Isolated	Intermittent	Continuous	Intermittent to continuous	Intermittent to continuous	Continuous	Continuous	Isolated
Mitigation Effectiveness	Unknown at This Stage	Low-Moderate	High	Moderate	Moderate	Low-high (depending on mitigation).	Mod-High	Low- Moderate	Low
Probability	V. High	V. Low	Low (Mitigation)	High	High	High	Low	High	V. Low
Concern Level	**Low**	**High**	**Low - Mod**	**Low- High**	**Low - high (depending on mitigation)**	**Mod - High**	**More Info Needed**	**Low-Mod** **Dependent on productive capacity losses and associated offsetting**	**Low**
	Depends on local fish concentration		(with effective mitigation)	Depends on mitigation	Depends on mitigation	Given cumulative effects and existing noise levels	Depends contaminants and mitigation	Given cumulative effects and existing stock status	No quantitative strike risk analysis was deemed necessary given the low likelihood of strike

*Relative level of concern assumes at least some mitigation will be in place to reduce potential effects but no specific mitigation measures were put forward at this point.

APPENDIX D – Potential Mitigation Options

Mitigation Type	Mitigation Measure
Education (noise and strike)	• PMV skipper marine mammal awareness program • All skippers and pilots marine mammal awareness program • Radio broadcast of whale presence • Sending noise signature information of vessels to owners to encourage improvement/maintenance
Construction Management (noise)	• Use of vibratory methods, ramp up of pile driving or vibratory activities • Use of (winter) work windows (low SRKW use) • Acoustic restrictions, DFO guidelines • Duration and intensity management • Piling caps (to reduce noise from impact pile driving) • Bubble curtains
Construction Monitoring (noise)	• Use of SRKW observer network for presence at or near Roberts Bank • Use of marine mammal observers for monitoring of exclusion zones and shut-downs • Monitoring of construction noise and pager alarm system at RBT2 for noise levels exceeding set threshold • Use of acoustic monitoring and real-time SRKW detections for construction ramp-downs or shut-downs • Real-time cameras, infrared monitors for SRKW detections at RBT2 • Real-time hydrophone network for RBT2 SRKW detection and ramp-down
On site Vessels (noise)	• Optimize operational procedures when whales are present • Speed monitoring and reductions • Tug and thruster use management • Incentives for propeller/hull maintenance • Vessel noise levels provided to Transport Canada to meet new standards • Retrofit of tug using quietening technology • Use of newer quieter tugs/vessels
Container Vessels (noise)	• Restrictions in use of unnecessary onboard equipment • Thruster use management • Incentives for quieter vessels, voluntary slow-downs • Incentives for propeller/hull maintenance • Improvements to onboard machinery and mountings • Speed restrictions or route changes (interagency) Traffic light system • Retrofit using quietening tech. (caps, maskers, new props)
Strike	• Vessel management of high risk areas • Marine mammal observer use in hotspot areas • Route changes if hotspots overlap • Speed monitoring & restrictions • Hotspot monitoring •
Habitat and prey	• Use of work Windows • Habitat offsetting • Prey Compensation • Assess/support increased protection of Hotspots
Contaminant Release	• Develop comprehensive contingency plan • Harassment devices availability (Koizumi/Pingers) for displacement • Improve vessel substance release monitoring • Provide clean-up equipment at key locations • Disposal at sea site and method selection to minimize effects to SRKWs



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IR5-30 Marine Fish – Effects Assessment

Information Source(s)

EIS Volume 3: Table 13-8

Context

In Table 13-8 of the EIS, the Proponent identified the Project components and Project activities and their interactions with environmental components, the effects rating and nature of interactions with environmental components and rationale for the effect ratings.

Information about the nature of interaction and effect and rationale for effects rating for the proposed Project activity to add toe and scour protection rock to the berth pocket is missing from Table 13-8 of the EIS.

Information Request

Evaluate the potential effects on marine fish from the addition of toe and scour protection rock in the berth pocket. Update Table 13-8 of the EIS with a potential effects rating and the rationale for the preliminary effects rating.

If the Project effect rating is determined to be other than negligible, conduct an effects assessment of adding toe and scour protection rock in the berth pocket on Pacific salmon, reef fish, forage fish, flatfish, and demersal fish.

VFPA Response

The VFPA would like to clarify that the potential effect rating and rationale for the Project activity "addition of toe and scour protection rock in berth pocket" are provided in EIS Table 13-8; however, a table formatting issue makes this information appear as though it is omitted. Clarification is provided below.

In EIS Table 13-8, the Project activity "addition of toe and scour protection rock in the berth pocket" was merged with the Project activity listed in the row above (i.e., placing caissons, ballast, berm, and berm filter rock in wharf area, and installing keys to lock structure together), as the potential effect rating and associated rationale for the Project activities were the same. The two merged rows were split across two pages such that rating and rationale of the former Project activity appear to have been missed. Formatting of EIS Table 13-8 has been corrected and the corrected portion is shown as **Table IR5-30-1** below. This table formatting issue has no bearing on the effects assessment and conclusions made in the EIS.

Table IR5-30-1 Partial EIS Table 13-8 with Corrected Formatting

Project Component	Project Works and Activities	Potential Effect Rating	Nature of Interaction and Effect, and Rationale for Effects Rating
Marine Terminal	Place caissons, ballast, berm, and berm filter rock in wharf area, and install keys to lock structure together	Negligible	While these activities have the potential to decrease productivity, the area will have been already dredged and disturbed (therefore unlikely to cause direct mortality/injury), and elevated TSS [total suspended solids] levels will be temporary and localised.
	Add toe and scour protection rock in berth pocket		

IR5-31 Marine Fish – Effects of Ship Collisions on Basking Shark

Information Source(s)

Marine Shipping Addendum: Section 8.1.5.2

Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): Appendix IR11-A

Context

In Section 8.1.5.2 of the Marine Shipping Addendum, Basking Shark was identified by the Proponent as an endangered aquatic species at risk, listed under Schedule 1 of the Species at Risk Act. In Appendix IR 1-A of its response to information requirement #11 from the Canadian Environmental Assessment Agency (CEAR Doc#314) the Proponent identified that Basking Shark occurrence was recently documented in the regional assessment area but not the local assessment area. Further, this species does not fall under a sub-component of marine fish.

Information about the potential effects of marine shipping associated with the Project on Basking Shark is required.

Information Request

Provide an assessment of the potential environmental effects from marine shipping associated with the proposed Project on Basking Shark. Include consideration of the frequency, effects and probability of ship collisions with Basking Sharks in the marine shipping area.

If adverse effects are identified, describe mitigation measures that could be adopted to reduce ship collisions with Basking Sharks.

VFPA Response

Provide an assessment of the potential environmental effects from marine shipping associated with the proposed Project on Basking Shark. Include consideration of the frequency, effects and probability of ship collisions with Basking Sharks in the marine shipping area.

An assessment of the potential environmental effects from marine shipping associated with the proposed Project on basking sharks was completed, using humpback whales as a representative species[1] (refer to Marine Shipping Addendum (MSA) Section 8.2.6.3). In summary, adverse effects to basking sharks from marine shipping associated with the Project are not anticipated because of the rarity of basking sharks combined with the very low

[1] As described in Table AIR9-3 of Additional Information Request #9 (AIR-12.04.15-9 of CEAR Document #388), basking sharks are represented by humpback whales (*Megaptera novaeagliae*).

likelihood of collision with a ship. This response will provide additional information on basking sharks, as well as a discussion of potential effects, particularly ship collisions, from marine shipping associated with the Project.

Humpback whale is considered an appropriate proxy to characterise existing conditions and assess potential effects of marine shipping associated with the Project (i.e., vessel collisions, underwater noise) on basking shark. The two species share a number of ecological similarities, including large body size, prey and habitat preferences, and foraging behaviour; for example, basking sharks are often associated with both historic and current distribution of humpback whales (Wallace and Gisborne 2006) and, like humpback whales, spend considerable time resting and feeding at the surface and travelling at relatively slow speeds (DFO 2011). Therefore, basking sharks and humpback whales are likely to interact with the Project in analogous ways. Further, in B.C., humpback whales are the most common species of cetacean struck by vessels, and humpback whales are more likely to be hit within shipping lanes (Laist et al. 2001, Williams and O'Hara 2010, DFO 2013, Nichol et al. 2017) such that their use as a proxy species represents a conservative approach to the assessment.

Canada's Pacific population of basking shark has virtually disappeared (DFO 2016). The early historic and scientific record for basking sharks off the coast of B.C. is limited, but consistently describes the Pacific population as abundant and widely spread, with a minimum pre-exploitation population of 750 individuals (COSEWIC 2007, McFarlane et al. 2009, DFO 2016). The dramatic reduction in abundance and lack of recovery is attributed to directed fisheries for liver oil (1941-1947) and a Canadian government-sponsored eradication program (until 1970) that killed hundreds, perhaps thousands of individuals (DFO 2011). The current eastern North Pacific population size is estimated at 300 to 500 individuals, or approximately 10% of pre-harvest levels (McFarlane et al. 2009 in NOAA 2010); however, these numbers are highly uncertain (DFO 2011).

Since 2010, the Pacific population of basking shark has been listed as Endangered under the *Species at Risk Act* (*SARA*) and the threat of vessel strikes is considered a medium level of concern (DFO 2011). Similarly, in 2010, the U.S. National Marine Fisheries Service under the National Oceanic and Atmospheric Administration (NOAA) identified the Pacific population of basking shark as a 'species of concern' (NOAA 2010). Basking sharks rarely occur in Canadian Pacific waters with only 35 confirmed sightings between 1996 and 2017 (DFO 2016, 2017), six of which occurred in the local assessment area for marine shipping. Since 2008, DFO has conducted annual surveys focusing on basking sharks within Canadian Pacific waters—including vessel-based and aerial surveys—with no observations of basking shark recorded (DFO 2011, 2016; Surry and King 2015, Nichol et al. 2017).

As basking sharks are rarely sighted in B.C. or in the marine shipping area, it is not possible to quantify the frequency, effects, and probability of ship collisions from marine shipping associated with the Project. The current extent and population consequence of vessel collisions in Canadian Pacific waters or elsewhere is unknown (DFO 2011). Based on the rarity of this species (see above text) and the very low likelihood of collision with a ship that could lead to death, a residual effect from the Project or marine shipping associated with the Project is not anticipated.

If adverse effects are identified, describe mitigation measures that could be adopted to reduce ship collisions with Basking Sharks.

As indicated above, adverse residual effects to basking sharks from marine shipping associated with the Project are not anticipated.

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IR5-32 Marine Mammals – Transient Killer Whales

Information Source(s)

EIS Volume 3: Section 14

Marine Shipping Addendum: Section 8.2, Table 8.2-3

Context

As stated by the Proponent in Section 14 of the EIS, Fisheries and Oceans Canada is proposing to designate critical habitat for the Northeast Pacific Transient (Bigg's) Killer Whale (hereafter referred to as Transient Killer Whales) within approximately 5.5 kilometres of shore for all of British Columbia. Table 8.2-3 of the Marine Shipping Addendum described the Transient Killer Whale as occurring within the local assessment area. According to Section 8.2 of the Marine Shipping Addendum, the marine mammals that were considered in the effects assessment either feed exclusively on fish, such as the Southern Resident Killer Whale (SRKW) or a combination of fish and invertebrates, such as the Humpback Whale and the Steller Sea Lion. However, this statement does not address Transient Killer Whales which feed on marine mammals.

Although SRKW is meant to represent all other toothed whales, the use of SRKW as a proxy may lead to an inadequate characterization of the potential effects of the Project and marine shipping associated with the Project on Transient Killer Whales.

Information Request

Provide an evaluation of the predicted effects of the proposed Project and marine shipping associated with the Project on the ability of Transient Killer Whales to forage efficiently and profitably on marine mammal prey within the marine mammal local assessment area as denoted in Figure ~~8.1-2~~8.2-1[1] of the Marine Shipping Addendum.

VFPA Response

Southern resident killer whale (SRKW) was selected as a representative species for all toothed whales due to overall similarities in life history, prey preferences, and hearing sensitivities (see EIS Table 14-3), in addition to having the greatest conservation status (i.e., Endangered). An evaluation of the predicted effects of the Project and marine shipping associated with the Project on transient killer whales was undertaken using SRKW as a

[1] The original information request as posted (CEAR Document #975) referred to Figure 8.1-2. This was assumed to be a typographical error, and the correct reference is assumed to be Figure 8.2-1.

representative species.[2] While there are some differences between the biological attributes of the resident and transient whale ecotypes[3], they are classified as the same species *Orcinus orca* (DFO 2007), and the nature of their interaction with the Project and marine shipping associated with the Project, potential effects, proposed mitigation measures, residual effects, effects characterisations, conclusions, and proposed follow-up monitoring, are analogous. Furthermore, use of SRKW as the representative species for transient killer whales provides a more conservative assessment as transient killer whales occur less frequently than SRKW in the local assessment area shown in Figure 8.2-1 in the Marine Shipping Addendum (MSA); predictions of potential effects to SRKW are likely an overestimate for the effects to transient killer whales.

The EIS and MSA stated that marine mammals considered in this assessment either feed exclusively on fish (i.e., SRKW) or a combination of fish and invertebrates (i.e., humpback whale, Steller sea lion). While this statement applies to representative species assessed in the EIS, it does not apply explicitly to transient killer whales. This response will provide an evaluation of the predicted effects of the Project and marine shipping associated with the Project on the ability of transient killer whales to forage efficiently and profitably on their marine mammal prey.

Provide an evaluation of the predicted effects of the proposed Project and marine shipping associated with the Project on the ability of Transient Killer Whales to forage efficiently and profitably on marine mammal prey within the marine mammal local assessment area as denoted in Figure 8.2-1 of the Marine Shipping Addendum.

The pathway of potential effects of the Project and marine shipping associated with the Project on transient killer whales includes the following:

- Changes in transient killer whale prey habitat quantity and quality; and
- Changes in the acoustic environment.

Further discussion is provided below evaluating each of these predicted effects of the proposed Project and marine shipping associated with the Project that could potentially affect the ability of transient killer whales to forage efficiently and profitably on marine mammal prey within the marine shipping local assessment area.

Availability of Prey

Transient killer whales require an adequate and accessible supply of marine mammal prey to forage efficiently and profitably. As described in EIS Section 16.6.4 and MSA Sections 8.2.6.2 and 8.2.6.3, the Project and marine shipping associated with the Project will not change the

[2] In previous responses posted to the Canadian Environmental Assessment Agency registry, the VFPA provided information on the biology and existing conditions of transient killer whales, including the following: Additional Information Request #9 (AIR-12.04.15-9 of CEAR Document #388): Appendix AIR9-A Table 3 and Appendix AIR9-B Figure AIR9-3; Additional Information Request #11 (AIR-12.04.15-11 of CEAR Document #388) Table AIR11-1; Marine Shipping Addendum Information Request #5 (MSA IR-02.24.16-5 of CEAR Document #391).

[3] Three forms, or ecotypes, of killer whale occur in B.C.: residents (northern and southern) that feed on fish, west coast transients (also called Bigg's) that feed on marine mammals, and offshores that are thought to feed on fish, such as shark.

availability (i.e. quantity, quality or distribution) of Steller sea lions representing transient killer whale prey (e.g. seals, sea lions) in the marine shipping local assessment area (MSA Figure 8.2-1).

Furthermore, since active programs in the 1970s to cull harbour seals and Steller sea lions in B.C. were concluded, harbour seal numbers have rebounded to their pre-cull abundance (Olesiuk 1999) and Steller sea lion numbers have also doubled (DFO 2003). These recovering prey populations have likely had a significant positive effect on the population of transient killer whales and there appears to be no limitations in the availability of marine mammal prey and unlike SRKW, the transient population of killer whales appears to be stable and growing (Ford and Ellis 1999, DFO 2007).

Therefore, as no changes to the quantity, quality, or distribution of transient marine mammal prey are anticipated, no adverse effects on the ability of transient killer whales to forage efficiently and profitably on their prey are predicted.

Changes to the Acoustic Environment

Underwater noise from the Project and marine shipping associated with the Project have the potential to increase underwater noise levels in the acoustic environment and affect the foraging ability of killer whales. While biological differences do exist between how transient killer whales and SRKW detect their different prey (i.e., SRKW feed on fish and transients feed on marine mammals), the pathway of potential effects to all killer whales from the Project and marine shipping associated with the Project is similar.

When compared to existing conditions of the acoustic environment, underwater noise levels predicted to potentially result in potential effects to killer whales during Project construction and operation were comparable to levels currently measured at Roberts Bank (EIS Section 9.8.7). Furthermore, existing underwater noise conditions in the marine mammal marine shipping local assessment area (MSA Figure 8.2-1) are already considered high due to existing levels of vessel traffic (see MSA Section 7.6.4).

Proposed mitigation measures during Project construction (see EIS section 14.7.1.1) will effectively reduce underwater noise resulting in no predicted residual effects to marine mammals during the construction period, including transient killer whales. The incremental contribution of underwater noise from Project operation and marine shipping associated with the Project is small compared to existing underwater noise levels (see EIS Section 9.8.7 and MSA Section 7.6.5). Individual killer whales may experience residual behavioural effects or reduced ability to detect their prey due to the incremental contribution of underwater noise from Project operation or marine shipping associated with the Project. However, these predicted effects are not substantially different from existing conditions and are not expected to affect the ability of killer whales (both SRKW and transients) to forage efficiently and profitably on their prey (see EIS Section 14.8.1.1 and MSA Section 8.2.8).

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IR5-33 Marine Mammals - River Otters

Information Source(s)

TDR MM-1 Marine Habitat Use Studies

Marine Shipping Addendum: Section 9.5

Context

At stated by the Proponent in TDR MM-1, two sightings of otters were recorded during the marine mammal observation study carried out at the existing Roberts Bank terminals. The Proponent indicated that based on current Sea Otter range, these sightings were likely of River Otters but that River Otters were not included under the valued component of marine mammals. As described in Section 9.5 of the Marine Shipping Addendum, River Otters were also listed as land mammals that have been or continue to be harvested by Pacheedaht First Nation. Although the Proponent did not include River Otters as a marine mammal and given that they occur in the marine environment, further information is required to determine the potential effects of the proposed Project and marine shipping associated with the Project on River Otters.

Information Request

Provide an estimate of the abundance and distribution of River Otters in the local and regional assessment areas for the proposed Project, and the local assessment area for marine shipping associated with the Project.

Identify, describe and map the River Otter habitat in the local assessment area for the Project including the rip rap habitat along the existing causeway, terminal and tug basin.

Describe the potential effects of construction and operation of the Project and marine shipping associated with the Project on River Otters.

VFPA Response

This response will provide the following:

- Additional information describing the biology and life history of river otters;
- Additional information regarding the abundance and distribution of river otters in the local and regional assessment areas (LAA and RAA) for the proposed Project, and the LAA for marine shipping associated with the Project; and
- A description of how the Steller sea lion assessment represents the assessment of river otters.

River Otter Life History

While not technically classified as a marine mammal, river otters are mustelids (e.g., otters, weasels) that are both terrestrial and aquatic. They occur in streams, lakes, ponds, swamps, marshes, estuaries, and along the exposed outer coast in habitats that provide otters with escape cover, den sites, and resting sites (Hill 2001). River otters are opportunistic predators that eat fish, shellfish, invertebrates, birds, and small mammals and den in hollow logs, burrows dug by other animals, beaver lodges, or dense thickets (Hill 2001). The current distribution in Canada is coast-to-coast, with areas of no or low occurrence in the southern prairies (Hill 2001, Hatler et al. 2003). In B.C., the species occurs broadly, including on all offshore islands, and the distribution is not known to have changed from historic times (Hatler et al. 2003). The best estimate for abundance is between 15,000 and 30,000 individuals for the entire B.C. coast (Mos et al. 2003). They are commonly seen throughout coastal B.C. though little is understood about their movement patterns or breeding. River otters are not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under the *Species at Risk Act*, but are Yellow-listed in B.C. River otters were historically hunted in B.C. by Aboriginal hunters largely for their dense, warm fur. The river otter is officially designated as a furbearer in B.C. and, as such, can be legally harvested by licensed trappers. In 2001, approximately 400 river otters were harvested in B.C. (MOE 2008).

River otter distribution and densities are seldom reported in the literature due to the varied nature of their habitat (i.e., terrestrial, marine, aquatic, riparian) and few estimates of population size and density have been quantified in environmental assessments (Boyle 2006). River otter densities range from approximately one otter per kilometre of shoreline in coastal Alaska and Louisiana, to one otter per four to 17 kilometres along a freshwater system in Idaho (Melquist and Hornocker 1983, Shirley et al. 1988). River otters reach their highest densities in food-rich coastal habitats and lower stream reaches, with coastal densities reported to be two to three times higher than for interior populations (Boyle 2006). The number of river otters present in an area is related to the amount and quality of aquatic and terrestrial habitat present, and to the abundance of food in those habitats (Boyle 2006). When prey supply decreases, or other prey becomes available, otters either opportunistically transfer to a new location or switch to the most adequate prey (Melquist and Hornocker 1983).

Provide an estimate of the abundance and distribution of River Otters in the local and regional assessment areas for the proposed Project, and the local assessment area for marine shipping associated with the Project.

As stated in the Panel's context, two river otters were observed during marine mammal surveys conducted at Roberts Bank in 2012 and 2013 (see TDR MM-1 in Appendix AIR10-C of Additional Information Request #10 (AIR-12.04.15-10 of CEAR Document #388)) and have been previously observed in the Project area (Langer 2014, VFPA 2004). While river otters occur throughout the Georgia Basin (Osborne et al. 1988), they are uncommon in the Boundary Bay watershed (Murray 2009).[1] Interviews conducted to inform the Deltaport Third Berth environmental assessment indicated that out of 22 interviewees, only two reported

[1] Recorded from Alaksen, Boundary Bay, Westham Island, White Rock, Blackie Spit, Point Roberts (Lily Point), and Drayton Harbour.

sporadically observing river otters at Roberts Bank (VFPA 2004). The B.C. Ministry of the Environment database (BCCDC 2017) had no reported sightings of river otters in the LAA and RAA for the Project, and the LAA for marine shipping associated with the Project. River otters can occur opportunistically throughout the coastal environment in the assessment areas, but are infrequent, occasional visitors in the LAA and RAA.

Identify, describe and map the River Otter habitat in the local assessment area for the Project including the rip rap habitat along the existing causeway, terminal and tug basin.

There is inadequate information to map river otter habitat in the LAA for the Project, including the rip-rap habitat along the existing causeway, terminal, and tug basin. River otter habitat use is poorly studied worldwide, but river otter populations are healthy and individuals can occur opportunistically in the marine and terrestrial coastal habitat throughout their range. Based on information collected during the environmental assessment for the Deltaport Third Berth and during surveys conducted to inform the RBT2 environmental assessment, river otters are infrequent visitors in the Project area along the existing causeway, terminal, and tug basin. As stated above, river otters may occur opportunistically in the LAA for the Project, but are likely infrequent, occasional visitors in the rip-rap habitat along the existing causeway, terminal, and tug basin.

Describe the potential effects of construction and operation of the Project and marine shipping associated with the Project on River Otters.

Potential effects of the Project and marine shipping associated with the Project on river otters have been considered through the assessment of potential effects on Steller sea lions (as representative species; see Section 14.6 of EIS and Section 8.2.6 of the Marine Shipping Addendum). Further, Table IR5-33-A1 in **Appendix IR5-33-A** provides additional rationale why river otters are adequately represented by Steller sea lion, and highlights similarities between river otter and Steller sea lion as they pertain to existing conditions (e.g., life history and habitat requirements) and the mechanisms through which the Project may affect them. Table IR5-33-A1 in **Appendix IR5-33-A** also refers the reader to EIS sections specific to the assessment of Project-related effects and effects of marine shipping associated with the Project on Steller sea lion, as well as applicable mitigation measures.

In summary, while there are some differences between the biology, life history, and habitat use of Steller sea lions and river otters, the nature of their interaction with the Project and marine shipping associated with the Project, potential effects, proposed mitigation measures, residual effects, effects characterisations, conclusions, and proposed follow-up monitoring are the same. Therefore, the assessment of Steller sea lion presented in the EIS is an appropriate and conservative assessment for river otters.[2]

[2] The environmental assessment for Deltaport Third Berth concluded that there were no predicted significant adverse effects from the construction and operation of that terminal, as river otters (represented by Steller sea lion) are not believed to be at risk from ship collisions and have auditory systems that are less likely to be affected by low frequency sound produced by ship traffic (Richardson et al. 1995, VFPA 2004).

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Appendices

Appendix IR5-33-A Supporting Table

APPENDIX IR5-33-A
SUPPORTING TABLE

Table IR5-33-A1 Effects Assessment of River Otters

Species	Representative Species Rationale	Effects Assessment	Mitigation
River Otter	River otters are represented by Steller sea lions for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 3): • Steller sea lions occur more predictably in the local and regional assessment areas than river otters. • Mechanisms potentially affecting river otters and Steller sea lions in water and on land (i.e., changes in the acoustic environment) and potential responses to effects from the Project and marine shipping associated with the Project are similar. • Steller sea lions have a greater conservation status (i.e., Threatened) than river otters (i.e., not listed under the *Species at Risk Act*), resulting in a more conservative magnitude rating of potential effects. • The use of Steller sea lions to assess effects on river otters from changes in the acoustic environment from the Project and marine shipping associated with the Project is considered appropriate as they share similar hearing anatomy and ability and expected behavioural responses to underwater and in-air noise.[a]	Potential effects from the Project and marine shipping associated with the Project on river otters have been assessed in the EIS through the use of representative species. Details are provided below: • Potential effects on river otters from changes to in-air noise (EIS Section 14.6.1.1, Marine Shipping Addendum Section 8.2.6.1) are assessed as negligible. Assessment result is the same for Steller sea lions as they share similar hearing anatomy and expected behavioural responses to in-air noise. • Potential effects to Steller sea lions from changes in environmental contamination from air pollution from the Project and marine shipping associated with the Project (EIS Section 14.6.1.2, Marine Shipping Addendum Section 8.2.6.1) are assessed as negligible. Assessment result is the same for river otters as they share similar physiology and expected responses to environmental contamination. • Potential effects on Steller sea lions from changes in the availability of prey from changes in fish habitat quality and quantity due to the Project (EIS Section 14.6.1.3) are assessed as negligible as productivity losses of prey (e.g., fish) are considered minor. Potential effects to river otters from changes in the availability of prey from changes in fish habitat quality and quantity due to the Project (EIS Section 14.6.1.3) are also assessed as negligible as effects to river otter prey (e.g., fish, invertebrates) due to productivity losses are considered minor. • Potential effects on Steller sea lions and river otters from changes in water and sediment quality (EIS Section 14.6.1.4) due to the Project resulting in adverse health effects from potential re-distribution of contaminants (i.e., polychlorinated biphenyls (PCBs)) in sediments are assessed as negligible as construction activities will not increase sediment concentrations of contaminants. • Potential effects on Steller sea lions and river otters from changes to the existing underwater acoustic environment from the incremental contribution of the Project and marine shipping associated with the Project, resulting in injury, behavioural disturbance, or acoustic masking (EIS Section 14.6.3.1, Marine Shipping Addendum Section 8.2.6.2) are assessed as moderate. Assessment result is the same for both Steller sea lions and river otters due to similar hearing ability / expected behavioural responses to established thresholds.	Mitigation measures propose to reduce or eliminate potential residual effects of the Project on Steller sea lions are also beneficial for river otters. • An Underwater Noise Management Plan will be implemented during construction to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3).

Notes: a. The estimated in-air auditory bandwidth of seals and sea lions (~75 hertz (Hz) to 30 kilohertz (kHz)) is similar to measured levels for river otters (125 Hz to 32 kHz) (Southall et al. 2007, Ghoul and Reichmuth 2014).

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IR5-34 Marine Mammals – Eastern Pacific Grey Whale and Fin Whale Baseline

Information Source(s)

EIS Volume 3: Section 14.8, Table 14-2

Proponent Response to Information Requirements of July 31, 2015 (CEAR Doc#314): Appendix IR11-A, Table IR9-3

Proponent Response to Follow-up Information Requirements of July 31, 2015 (CEAR Doc#388): AIR11-1

Marine Shipping Addendum: Appendix 5-B, Section 9.5

Management Plan for the Eastern Pacific Grey Whale in Canada (CEAR Doc#964)

Recovery Strategy for Blue, Fin, and Sei Whales in Pacific Canadian Waters (CEAR Doc#965)

Context

As stated by the Proponent in Section 14.8 of the EIS, the North Pacific Humpback Whale was selected as the representative species for other baleen whales within the regional assessment area for the Project and marine shipping associated with the Project.

Eastern Pacific Grey Whale is of interest to numerous indigenous groups including Lake Cowichan, Pacheedaht, Ditidaht, Maa-Nulth, Semiahmoo and Lyackson First Nations. Further, this species is blue-listed by the British Columbia Conservation Data Centre and is a species of special concern under the *Species at Risk Act*. As part of the species at risk listing process, a management plan for Eastern Pacific Grey Whale was prepared by the COSEWIC to summarize international management approaches for this species. Among the identified threats in the management plan, boat strikes were rated as unknown. The Proponent's response to information requirement #11 from the Canadian Environmental Assessment Agency (CEAR Doc#314) indicated that Eastern Pacific Grey Whale is periodically observed in the local and regional assessment areas for the Project and fairly common but not generally abundant in the local assessment area for marine shipping associated with the Project.

Fin Whale is red-listed by the British Columbia Conservation Data Centre and is listed as threatened under the *Species at Risk Act*. As part of the species at risk listing process, there is a combined recovery strategy for Blue, Fin, and Sei Whales. While the historical distribution and preferred habitat of Fin Whale is primarily offshore, the whales may occasionally use the western portion of the local assessment area for the Project for foraging (Table 14-2 of EIS) and are known to occur at Roberts Bank (response to information requirement #9 from the Canadian Environmental Assessment Agency, Table IR9-3: CEAR Doc#314).

Although in Table AIR11-1 of its response to follow-up information requirement #11 from the Canadian Environmental Assessment Agency (CEAR Doc#388), the Proponent provided a rationale for why North Pacific Humpback Whale is considered an appropriate proxy for

Eastern Pacific Grey Whale and Fin Whale, further information is required to determine the adequacy of the representativeness and any differences in the potential effects of marine shipping associated with the Project on these species.

Information Request

Provide a comparison of life history traits, distribution, and migrations of Eastern Pacific Grey Whale, Fin Whale and North Pacific Humpback Whale.

Provide information on Eastern Pacific Grey Whale and Fin Whale vessel strikes within the regional assessment area for marine shipping associated with the Project including annual vessel strike frequency.

VFPA Response

This response will provide further information regarding grey and fin whale life history (including distribution and migrations), and how the environmental assessment of the Project and marine shipping associated with the Project on humpback whale represents grey and fin whales (see **Appendix IR5-36-A**). The response will also provide information on grey and fin whale vessel strikes within the regional assessment area for marine shipping associated with the Project.

Provide a comparison of life history traits, distribution, and migrations of Eastern Pacific Grey Whale, Fin Whale and North Pacific Humpback Whale.

Information on the life history traits, distribution, and migrations of humpback whales was previously presented in EIS Section 14.5.2 and Marine Shipping Addendum Section 8.2.5.4. As described in EIS Section 14.2.1, humpback whales were selected as the representative species for all baleen whales that could occur in the local and regional assessment areas for the Project and marine shipping associated with the Project, including grey and fin whales. A comparison of life history traits of baleen whales occurring in the assessment areas, and more information on how the humpback whale assessment represents grey and fin whales in the environmental assessment of the Project and marine shipping associated with the Project is provided in Table IR5-36-A1 in **Appendix IR5-36-A**.

Eastern North Pacific Grey Whale

The North Atlantic population of grey whales was extirpated in the 18th century (Mead and Mitchell 1984, Lindquist 2000) and two populations of grey whales currently only occur in the North Pacific: the critically endangered western North Pacific population numbering approximately 140 individuals (migrates between winter breeding grounds off southern China to summer feeding grounds in the Sea of Okhotsk) and the Eastern North Pacific (ENP) grey whale population numbering approximately 21,000 individuals (winters in breeding lagoons along the west coast of Baja Mexico and summers in temperate waters from northern California to the Arctic) (Rice et al. 1981, Moore et al. 2007, Stafford et al. 2007, Tyurneva et al. 2010, Durban et al. 2013) (**Figure IR5-34-1**). While the two populations are genetically distinct (LeDuc et al. 2002, Lang et al. 2011, Weller et al. 2013), recent studies have shown individuals from the western population migrating to ENP grey whale breeding lagoon in Mexico, or ENP grey whales sighted in western grey whale feeding areas (Lang 2010, Mate et

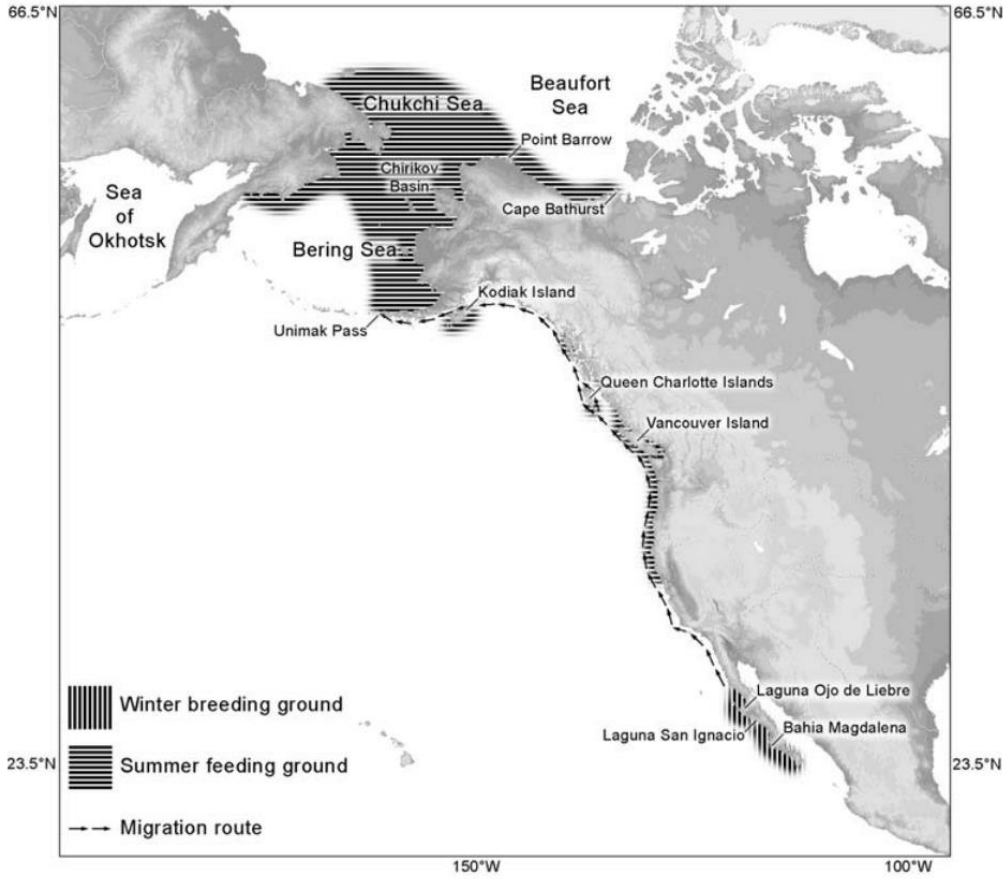
al. 2011, Weller et al. 2012, Cooke et al. 2013, Urbán et al. 2013, Mate et al. 2015), and it is currently unknown if interbreeding sometimes occurs (NOAA 2015).

Both populations were commercially hunted from the mid-1800s until 1937, when grey whales were internationally protected from harvest. By the late 19th century, commercial whaling had reduced the ENP population to less than 2,000 individuals (Rice et al. 1984). The population increased by 2.5% per year following the cessation of whaling and peaked, within the range of pre-exploitation estimates, at approximately 27,000 animals in 1998 (DFO 2010). The best estimate for the current size of the ENP grey whale population is approximately 21,000 individuals (Durban et al. 2013). This is within the range of the estimated current carrying capacity for this population between 20,000 to 30,000 animals (Rugh et al. 2005, NOAA 2015).

In 1994, the ENP stock of grey whales was removed from the U.S. List of Endangered and Threatened Wildlife, as it was no longer considered endangered or threatened under the U.S. Endangered Species Act (NMFS 1994). ENP grey whales experienced an unusual mortality event (UME) in 1999 and 2000, when large numbers of emaciated animals stranded along the west coast of North America (Moore et al. 2001, Gulland et al. 2005). Several factors following this UME suggest that the high mortality rate observed was a short-term, acute event and the population has recovered to levels seen prior to the UME of 1999 to 2000 (NOAA 2015). In 2004, the ENP population was listed as Special Concern under the Canadian *Species at Risk Act* (*SARA*) (DFO 2010). The current estimated potential biological removal level (number of mortalities that can occur per year without threatening the viability of the population) is 624 individuals per year (NOAA 2015).

From early January to mid-February, breeding and calving occurs in shallow lagoons and bays in warm, protected lagoons along the west coast at Baja-California, Mexico. From mid-February to May, the grey whales migrate northward along the west coast of the U.S.A. and generally arrive in B.C. waters west of Carmanah Point on Vancouver Island and follow the island's west coast north to Cape Scott (Darling 1984). The migration route north of Vancouver Island remains poorly understood, but some studies have suggested that part of the population migrates in waters between the B.C. central coast and the east coast of Haida Gwaii (Ford et al. 2013). The majority of the grey whale population then crosses Dixon Entrance and continues their migration to the Bering, Beaufort, and Chukchi seas. During the northward migration, individuals stop to opportunistically feed inshore in shallow B.C. coastal waters (Pike 1962, Sund 1975, Darling 1984). The southbound migration likely follows a similar route, although the animals tend to travel farther offshore and feed less (Pike 1962, Darling 1984). Once at the arctic feeding grounds, grey whales are almost exclusively benthic feeders (e.g., amphipods) and are found in shallow (less than 60 m) soft bottom habitats (Moore and Ljungblad 1984, Moore and DeMaster 1997, Moore et al. 2000).

Figure IR5-34-1 Eastern North Pacific Grey Whale Range, Including Winter Breeding Ground, Summer Feeding Grounds and Migration Route



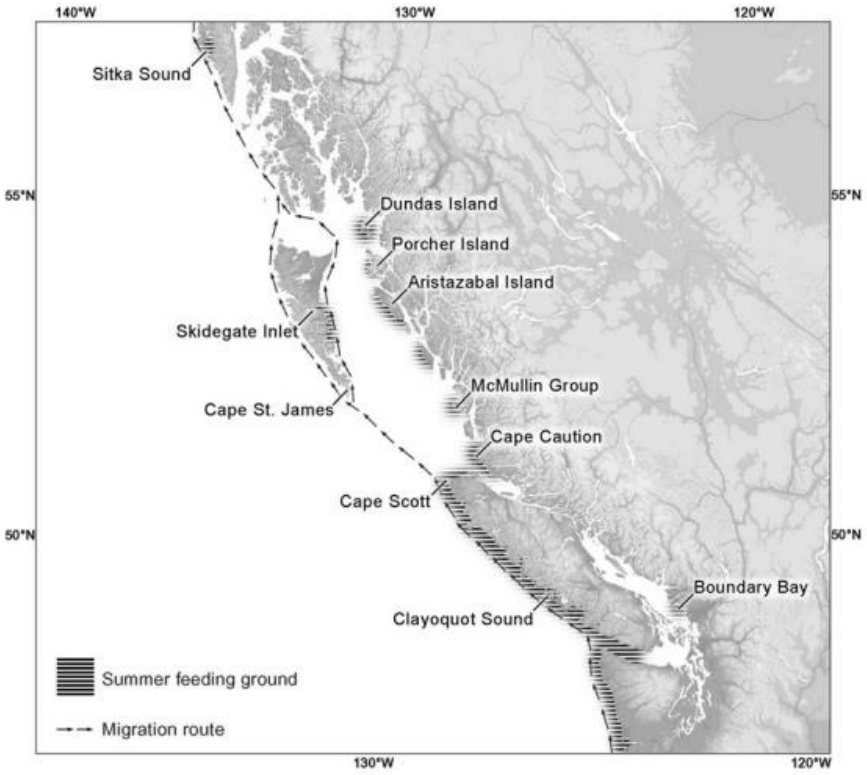
Source: DFO 2010.

A small part of the population (approximately 200 individuals) spends the summer feeding in nearshore waters ranging from northern California to southeastern Alaska (**Figure IR5-34-2**) (Calambokidis et al. 1994, 2012, 2014; Gosho et al. 2011, Mate et al. 2010; Ford et al. 2012). Individuals belonging to this sub-group of the population are termed either seasonal or summer-residents, or more formally the Pacific Coast Feeding Aggregation (Calambokidis et al. 2012, IWC 2012). Photo identification studies indicate that grey whales in this sub-group move widely within and between areas on the Pacific coast, are not always observed in the same area each year, and may have several year gaps between re-sightings in studied areas (Calambokidis and Quan 1999, Quan 2000, Calambokidis et al. 2002, IWC 2012). Summer-resident grey whales have also been observed in the inside waterways of B.C., primarily in Boundary Bay (Deecke 1996), as well as occasionally in Haro Strait and the Strait of Georgia (Calambokidis and Baird 1994, Malcolm 1999). Grey whales are frequently observed travelling alone or in small, unstable groups, although large aggregations may be seen where localised concentration of prey occur (Meier et al. 2007). Site fidelity of summer resident grey whales appears to be primarily driven by epibenthic (e.g., mysids) and benthic (e.g., amphipod) prey availability, and thus may also be somewhat variable within and between years depending on prey distribution and abundance (Dunham and Duffus 2001, 2002; Nelson et al. 2008;

Calambokidis et al. 2012; Feyrer and Duffus 2014; Burnham and Duffus 2016). Documented sightings of grey whales in B.C. from the B.C. Cetacean Sightings Network (1982 to 2013) are shown in Figure MSA IR5-4 in Appendix MSA IR5-A in MSA IR-02.24.16-5 of CEAR Document #391[1].

Subsistence hunters in Russia, Canada, and the U.S.A. have traditionally harvested eastern grey whales, although only the Russian hunt has persisted in recent years (Huelsbeck 1988, Reeves 2002). In 2005, the Makah Indian Tribe requested authorisation from the U.S. National Oceanic and Atmospheric Association (NOAA) / National Marine Fisheries Service (NMFS), under the *Marine Mammal Protection Act* and the *Whaling Convention Act*, to resume limited hunting of grey whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed fishing grounds off Washington State (NMFS 2008). In 2012, the International Whaling Commission (IWC) approved a 6-year quota (2013-2018) of 744 ENP grey whales, with an annual cap of 140, for Russian and U.S. (Makah Indian Tribe) aboriginals, based on the joint request and needs statements submitted by the U.S. and Russian federation (NOAA 2015).

Figure IR5-34-2 Eastern North Pacific Grey Whale Pacific Coast Feeding Aggregation Summer Feeding Ground and Migration Route



Source: DFO 2010.

[1] CEAR Document #391 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Marine Shipping Addendum Completeness Review - Responses to Additional Information Requirements (See Reference Document #386).

Fin Whale

Fin whales are found in all oceans in both coastal and offshore waters, but are more abundant in temperate and polar latitudes (Leatherwood et al. 1988, Jefferson et al. 1993, Reeves et al. 2002). Fin whales are thought to undertake seasonal migrations from low-latitude winter breeding areas to high-latitude summer feeding grounds. Conception and calving are believed to occur in low latitudes during winter, but no specific breeding grounds have yet been identified (Mizroch et al. 1984 in DFO 2005). The known winter range extends from Korea to Taiwan, the Hawaiian Islands, and to the Baja California peninsula, although the distribution is believed to be primarily offshore (Leatherwood et al. 1988). Payne (2004) suggested that the long-distance communication abilities of the species may allow mating to occur without the need for breeding grounds or aggregations. Fin whales reach sexual maturity between five to 15 years with females calving every two to three years following an 11 to 12 month gestation period. The life span of fin whales is thought to be around 80 years.

Fin whales summer at various locations along the eastern North Pacific coast, and are known to occupy some regions (e.g., Gulf of California and south/central California) year-round. Summer aggregations have been documented in Oregon, and summer-fall groups have been observed in the Shelikof Strait / Gulf of Alaska region (Carretta et al. 2003). Acoustic detection occurs year-round off northern California, Oregon, and Washington, with a concentration of activity between September and February (Moore et al. 1998, Ford et al. 2010).

In B.C., fin whales were historically observed in exposed coastal seas (e.g., Hecate Strait and Queen Charlotte Sound) and occasionally in the more protected waters (e.g., Queen Charlotte Strait and the Strait of Georgia) (Gregr and Trites 2001). Contemporary sightings of fin whales in Pacific Canadian waters are predominantly from the west coast of Vancouver Island, and the inland waters of Hecate Strait and Queen Charlotte Sound, and occur in both summer and winter (COSEWIC 2004, DFO 2005). Fin whale sightings in B.C. have been primarily located in deep water beyond the continental shelf break (Ford 2014). However, from spring to fall, fin whales are regularly observed in nearshore waters and channels of Caamano Sound and waters around Gil Island (Pilkington et al. 2011). Fin whales are not sighted in the local assessment area for the Project and rare sightings have occurred in the regional assessment area in western portion of Juan de Fuca Strait (Ford 2014, Chamberlain 2015, Nichol et al. 2017, DFO 2017).

Fin whales forage on a variety of species including small invertebrates, schooling fishes and squids. In the North Pacific, fin whale diet is dominated by euphausiid zooplankton (70%), followed by copepods (25%) with some fish and squid (Kawamura 1980). Flinn et al. (2002) examined records of stomach contents for fin whales taken in B.C. and found similar results. Feeding habitat is selected for areas of dense prey concentrations correlated with specific physical features (e.g., water temperature, bathymetry, oceanic fronts) (Hain et al. 1992, Woodley and Gaskin 1996).

Between 1905 and 1967, commercial whaling removed at least 7,600 animals from the population, and thousands of additional animals were taken by pelagic whalers through the 1970s until their protection in 1976 by the IWC (Mizroch et al. 1984 in DFO 2005). Shore-based stations operating in B.C. from the early 1900s through 1967 killed at least 7,605 fin

whales, though the annual catch declined rapidly as the population was depleted (Gregr et al. 2000). Based on the severe depletion and lack of sufficient time for recovery, it is thought that the current population is below 50% of its level 60 to 90 years ago (2005). The DFO Recovery Strategy states that current threats to fin whales are acute and chronic underwater noise, ship strikes, and entanglement in fishing gear and listed fin whales as Threatened under *SARA* (DFO 2005, COSEWIC 2005). Subsistence hunting sporadically occurs, but is not considered a threat to the fin whale population (DFO 2005). No critical habitat has been designated under *SARA*; however, Gregr and Trites (2001) proposed regions in B.C. that could be suitable habitat for large whale species (DFO 2005). Designating critical habitat may be problematic due to the ephemeral nature of oceanographic conditions supporting fin whale prey (DFO 2005).

Documented sightings of fin whales from the B.C. Cetacean Sightings Network (1982 to 2013) in the local and regional assessment areas for the Project and marine shipping associated with the Project, are shown in Figure MSA IR5-3 in Appendix MSA IR5-A of CEAR Document #391. Fin whales are rarely observed in the local or regional assessment areas and only four fin whales were observed in the marine shipping area during the period from 1983 to 2013, three of which were in Juan de Fuca Strait and one in the Strait of Georgia.

Provide information on Eastern Pacific Grey Whale and Fin Whale vessel strikes within the regional assessment area for marine shipping associated with the Project including annual vessel strike frequency.

Information on baleen whale vessel strikes (e.g., represented by humpback whales) within the regional assessment area for marine shipping associated with the Project was presented in EIS Section 14.6.3.2 and Marine Shipping Addendum Section 8.2.6.3. Additional information on represented grey and fin whales within the regional assessment area for marine shipping associated with the Project is presented below.

Grey Whale

The annual vessel strike frequency of grey whales in this area is not currently unavailable.[2] There is currently insufficient information to determine the annual vessel strike frequency, nor can the risk or frequency of strikes be quantified with the available information. A recent analysis by DFO of vessel strike to baleen whales from shipping traffic off the west coast of Vancouver Island and the entrance to Juan de Fuca Strait did not include grey whales (Nichol et al. 2017). Furthermore, DFO has stated that quantitative assessment of vessel strike risk is currently not possible due to limited available data on baleen whale distribution and abundance in the assessment area for marine shipping associated with the Project (DFO 2017).

Despite growing rates of shipping traffic throughout its coastal range from Mexico to the Arctic, the grey whale population has fully recovered and is currently near its estimated carrying capacity. Jensen and Silber (2003) compiled a database of global ship strikes for

[2] A request for historical information of vessel strikes of grey whales in the local assessment area for marine shipping has been requested from DFO and will be submitted to the Panel upon receipt.

large whales and found that grey whales were the fifth most commonly struck whale, less than both fin and humpback whales. Of a total 292 recorded ship strikes between 1975 and 2002, 24 (~8%) were of grey whales. Between 1985 and 2005, six grey whales with scarring evidence of ship strike were observed along the Washington state coast (Douglas et al. 2008). From 2008 to 2012, the total serious injury and mortality of grey whales attributed to ship strikes along the U.S. Pacific coast was 9.8 animals (including 7 deaths, 2 serious injuries, and 0.8 prorated serious injuries), or 2.0 whales per year (Carretta et al. 2013, Carretta et al. 2014b). The total ship strike serious injury and mortality of grey whales of the Pacific Coast Feeding Aggregation during this same period was 0.52 animals, or 0.1 whales per year, and did not exceed the potential biological removal level of 3.1 whales for this sub-population (NOAA 2015). Laist et al. (2001) stated that grey whales are commonly struck by boats off the coast of California, and some individuals identified off B.C. have been observed with large propeller scars (Deecke 2003, Calambokis et al. 2012).

Fin Whale

Globally, fin whales are the most common whale species struck by vessels; however, in B.C., reports of fin whale vessel strikes are lower than the number reported for humpback whales (Laist et al. 2001). Shipping lanes within the entrance to Juan de Fuca Strait have high volumes of vessel traffic and higher than average speeds (e.g., 20 knots) and, despite rare occurrence in the marine shipping area, the western portion of Juan de Fuca Strait is a relatively high-risk area for collisions of vessel traffic with fin whales if they were to enter the strait (Nichol et al. 2017). However, as only four fin whales have been reported in the marine shipping area from 1983 to 2013 (three in western Juan de Fuca Strait and one in the Strait of Georgia), the frequency of vessel strike is currently unknown and presumably of low risk in the local assessment area for marine shipping associated with the Project.[3]

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[3] In DFO's response to DFO IR-05 from the Review Panel (CEAR Document #988), DFO stated that there was a low likelihood of fin whale presence within the assessment area of the Project or marine shipping associated with the Project.

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Appendices

Appendix IR5-34-A Supporting Table

APPENDIX IR5-34-A
SUPPORTING TABLE

Table IR5-34-A1 Effects Assessment of Grey and Fin Whales

Species	Representative Species Rationale	Effects Assessment	Mitigation
Eastern Pacific Grey Whale and Fin Whale	Grey and fin whales are represented by humpback whales for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 3). Like humpback whales: • Grey and fin whales migrate to B.C. waters during summer months, occur usually as solitary individuals in coastal environments, and feed on zooplankton with baleen plates. • Mechanisms potentially affecting grey and fin whales (i.e., changes in the acoustic environment, physical disturbance from vessel strikes) and potential grey and fin whale responses to effects from the Project and marine shipping associated with the Project are similar as those for humpback whales. • Grey and fin whales could interact with marine shipping associated with the Project, but humpback whales are more likely to interact with Project-associated marine shipping due to higher local abundance within the marine shipping local assessment area. • Grey and fin whales, like all baleen whales, are at risk of vessel strikes due to extended time at the surface and slow swim speeds; however, humpback whales are more commonly struck.	Potential effects from the Project and marine shipping associated with the Project on grey and fin whales have been assessed in the EIS through the use of the representative species, humpback whale. Details are provided below: • Potential effects on grey and fin whales (represented by humpback whales) from changes in in-air noise (EIS Section 14.6.1.1, Marine Shipping Addendum Section 8.2.6.1) are assessed as negligible. Assessment result is the same for grey and fin whales as baleen whales share similar hearing anatomy and expected behavioural responses to in-air noise. • Potential effects on grey and fin whales (represented by humpback whales) from changes in environmental contamination from air pollution from the Project and marine shipping associated with the Project (EIS Section 14.6.1.2, Marine Shipping Addendum Section 8.2.6.1) are assessed as negligible. Assessment result is the same as baleen whales share similar physiology and expected responses to environmental contamination. • Potential effects on grey and fin whales (represented by humpback whales) from changes in the availability of prey from changes in fish habitat quality and quantity due to the Project (EIS Section 14.6.1.3) are assessed as negligible as productivity losses of baleen whale prey (e.g., invertebrates and fish) are considered minor. • Potential effects on grey and fin whales (represented by humpback whales) from changes in water and sediment quality (EIS Section 14.6.1.4) due to the Project resulting in adverse health effects from potential re-distribution of contaminants (i.e., polychlorinated biphenyls (PCBs)) in sediments are assessed as negligible as construction activities will not increase sediment concentrations of contaminants. • Potential effects on grey and fin whales from changes to the acoustic environment from the Project and marine shipping associated with the Project, resulting in injury, behavioural disturbance, or acoustic masking (EIS Section 14.6.3.1, Marine Shipping Addendum Section 8.2.6.2) are assessed as moderate. Assessment result is the same for all baleen whales (e.g., humpback, grey, and fin whales). • Potential effects on grey and fin whales from physical disturbance from vessel strikes due to marine shipping associated with the Project (EIS Section 14.6.3.2, Marine Shipping Addendum Section 8.2.6.3) are assessed as moderate as vessel strikes of baleen whales are globally common. However, injury or mortality of humpback, grey, or fin whales are not expected to result in population-level effects.	Mitigation measures proposed to reduce or eliminate potential residual effects of the Project on humpback whales are also beneficial for grey and fin whales. • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3).

IR5-35 Marine Mammals - Harbour Porpoise Effects Assessment, Criteria Ratings

Information Source(s)

EIS Volume 2: Section 8

EIS Volume 3: Table 14-23

Marine Shipping Addendum: Table 8.2-11

Proponent Response to Follow-up Information Requirements of July 31, 2015 (CEAR Doc#388): Appendix AIR9-A, Table 3; IR11

Context

In Section 8 of the EIS, the Proponent indicated that sub-component species were chosen for their ability to represent other species that are similar in nature, occupy comparable types of habits, serve similar ecological roles, or could otherwise be affected by the Project in an analogous way. In the response to follow-up information requirement #11 from the Canadian Environmental Assessment Agency (CEAR Doc#388), the Proponent indicated that one of the reasons SRKW is an appropriate proxy for Harbour Porpoise is because killer whales have the highest sensitivity to underwater noise recorded for any marine mammal, and therefore the analyses of underwater noise effects on killer whales would provide a conservative estimate of effects. As stated by the Proponent in Appendix AIR9-A Table 3, the hearing threshold for Harbour Porpoise is indicated to be approximately 39-55 dB re 1 µPa from 8-90 kHz. However, the hearing threshold for Harbour Porpoise is different than the hearing threshold specified for SRKW, which is approximately 30 dB re 1 µPa at 15 kHz.

In Table 14-23 of the EIS, the Proponent summarized the criteria ratings for acoustic disturbance from operational noise associated with the proposed Project. In Table 8.2-11 of the Marine Shipping Addendum, the Proponent summarized the criteria ratings for behavioral and acoustic masking effects from marine shipping associated with the Project on marine mammals.

Further information is required to determine whether any of the criteria ratings identified in Table 14-23 and Table 8.2-11 would be different for Harbour Porpoise, given the differences in biology and acoustic sensitivity between Harbour Porpoise and SRKW.

Information Request

Describe whether any of the criteria ratings identified in Table 14-23 of the EIS and Table 8.2-11 of the Marine Shipping Addendum would be different for Harbour Porpoise as a result of differences in biology and acoustic sensitivity between Harbour Porpoise and SRKW.

VFPA Response

This response will provide further information regarding harbour porpoise life history and biology and will also provide information on whether any of the criteria ratings identified in Table 14-23 of the EIS and Table 8.2-11 of the Marine Shipping Addendum would be different for harbour porpoise as a result of differences in biology and acoustic sensitivity between harbour porpoise and southern resident killer whale (SRKW).

Criteria Ratings for Harbour Porpoise

The criteria ratings for SRKW identified in Table 14-23 of the EIS and Table 8.2-11 of the Marine Shipping Addendum (i.e., magnitude, extent, duration, frequency, reversibility) are the same for harbour porpoise (see **Tables IR5-35-1** and **IR5-35-2**).

As stated in the Panel's context, hearing threshold for harbour porpoise is approximately 39 dB re 1 µPa to 55 dB re 1 µPa from 8 kilohertz (kHz) to 90 kHz and the hearing threshold specified for SRKW is approximately 30 dB re 1 µPa at 15 kHz. Like SRKW, harbour porpoise could be potentially affected by changes to the acoustic environment from the Project and marine shipping associated with the Project. These potential effects include acoustic injury (e.g., unmitigated impact pile driving), behavioural effects (e.g., increased swim speed, change in dive time), and acoustic masking of communication calls or prey detection. Like SRKW, harbour porpoise may be exposed to underwater noise levels that exceed underwater noise from the existing conditions at a given moment in time that could result in short-term, reversible behavioural effects. However, because harbour porpoises generate narrow band, high frequency clicks at approximately 130 kHz, there is little overlap between container ship noise (typically in the 0.1-10.0 kHz range; Veirs et al. 2016) and porpoise clicks and therefore, little opportunities for acoustic masking to occur. Therefore, the assessment of underwater noise effects to SRKW from the Project and marine shipping from the Project considered both behavioural effects and acoustic masking of vocalisations. The SRKW assessment was a more conservative assessment for harbour porpoise, as harbour porpoise are not expected to experience acoustic masking effects (i.e., reduced prey availability due to underwater noise, masking of vocalisations).

As harbour porpoise are not predicted to experience acoustic masking from underwater noise during operation, the residual effects and criteria ratings for SRKW are more conservative and likely overestimate the potential effects to harbour porpoise.

In summary, effects assessment conclusions determined for the SRKW representative species also apply to harbour porpoises.

Table IR5-35-1 Summary of Criteria Ratings for Acoustic Disturbance from Project Operation for SRKW and Harbour Porpoise

Criteria	Criteria Rating[a]	Rationale for Criteria Rating	
		SRKW	Harbour Porpoise
Magnitude	Moderate[b]	A measurable change within or beyond the range of natural variability including low- and moderate-severity behavioural responses to continuous noise unlikely to affect SRKW life functions or critical habitat features.[c]	A measurable change within or beyond the range of natural variability including low- and moderate-severity behavioural responses to continuous noise unlikely to affect population viability.
Extent	Regional[d]	Area where Project operation could result in behavioural effect or acoustic masking.	Area where Project operation could result in behavioural effect.[e]
Duration	Short-term[f]	Duration of behavioural effects is less than 25 minutes.	Duration of behavioural effects is less than 25 minutes.
Frequency	Frequent[g]	Behavioural effects to individuals could occur repeatedly during approach/departure and berthing/unberthing of container ships and use of associated support vessels.	Behavioural effects to individuals could occur repeatedly during approach/departure and berthing/unberthing of container ships and use of associated support vessels.
Reversibility	Fully Reversible[h]	Behaviour of individuals from increased underwater noise return to expected conditions after effects from berthing/unberthing and/or approach/departure cease.	Behaviour of individuals from increased underwater noise return to expected conditions after effects from berthing/unberthing and/or approach/departure cease.

Notes: a. All criteria definitions can be found in EIS Section 14.22.
b. Corresponds to measurable change beyond the range of natural variability that includes behavioural responses to continuous noise.
c. Unlike harbour porpoise, rationale for the magnitude rating of SRKW includes features and attributes of its federally designated critical habitat under the *Species at Risk Act*.
d. Effects within the local assessment area.
e. Harbour porpoises generate narrow band, high frequency clicks at approximately 130 kHz, there is little overlap between container ship noise (typically in the 0.1-10.0 kHz range) and acoustic masking of clicks is not expected to occur.
f. Confined to a period of minutes up to a day.
g. Effect(s) occur repeatedly during Project operation.
h. Indicator(s) will return to existing conditions after Project effects cease.

Table IR5-35-2 Summary of Criteria Ratings for Acoustic Disturbance from Marine Shipping Associated with the Project for SRKW and Harbour Porpoise

Criteria	Criteria Rating[a]	Rationale for Criteria Rating	
		SRKW	Harbour Porpoise
Magnitude	Moderate[b]	The local assessment area includes the designated critical habitat of this endangered species, and underwater noise from marine shipping associated with the Project will result in a measurable change, including low- and moderate-severity behavioural responses and acoustic masking from continuous noise. These changes are unlikely to affect individual life functions, critical habitat features[c], population viability, or recovery. While effects of the Project-associated shipping in combination with existing conditions are not predicted to be substantially different from existing conditions, the magnitude is conservatively rated as moderate due to the conservation status of SRKW (Endangered) and the possibility of chronic physiological and/or behavioural changes to individuals.	Underwater noise from marine shipping associated with the Project will result in a measurable change including low- and moderate-severity behavioural responses[d] from continuous noise. These changes are unlikely to affect individual life functions or population viability. While effects of Project-associated shipping in combination with existing conditions are not predicted to be substantially different from existing conditions, the magnitude is conservatively rated as moderate due to the conservation status of harbour porpoise (Special Concern) and the possibility of chronic physiological and/or behavioural changes to individuals.
Extent	Local[e]	Residual effects of behavioural disturbance and acoustic masking of marine mammals will be concentrated along the shipping lanes in the local assessment area and will decrease with distance from the transiting container ship.	Residual effects of behavioural disturbance and acoustic masking of marine mammals will be concentrated along the shipping lanes in the local assessment area and will decrease with distance from the transiting container ship.
Duration	Long-term[f]	Underwater noise from marine shipping associated with the Project will extend for the life of the Project; therefore, the behavioural and acoustic masking effects are also expected to be long-term.	Underwater noise from marine shipping associated with the Project will extend for the life of the Project; therefore, the behavioural and acoustic masking effects are also expected to be long-term.

Criteria	Criteria Rating[a]	Rationale for Criteria Rating	
		SRKW	Harbour Porpoise
Frequency	Frequent[g]	Marine shipping associated with the Project will include 520 additional vessel movements through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait, and 780 movements in the waters south of Victoria (Segment C). It will take RBT2-associated marine vessels approximately 7.0 hours to complete one transit of the local assessment area, and there are approximately three vessel movements every two days. In the case of some pods of SRKW, the residual effect will be frequent when they are seasonally present in the local assessment area.	Marine shipping associated with the Project will include 520 additional vessel movements through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait, and 780 movements in the waters south of Victoria (Segment C). It will take RBT2-associated marine vessels approximately 7.0 hours to complete one transit of the local assessment area, and there are approximately three vessel movements every two days. In the case of harbour porpoise, the residual effect will be frequent when present in the local assessment area.
Reversibility	Fully Reversible[h]	Behaviour of individuals from increased underwater noise return to existing conditions with increasing distance from the transiting container ship.	Behaviour of individuals from increased underwater noise return to existing conditions with increasing distance from the transiting container ship.

Notes: a. All criteria definitions can be found in Marina Shipping Addendum Section 8.2.10.
b. Corresponds to measurable change beyond the range of natural variability that includes moderate-severity behavioural responses to continuous noise, and is unlikely to affect population viability or recovery (including life functions or critical habitat features of SRKW).
c. Unlike harbour porpoise, rationale for magnitude rating of SRKW includes features and attributes of its federally designated critical habitat under the *Species at Risk Act*.
d. Harbour porpoises generate narrow band, high frequency clicks at approximately 130 kHz, there is little overlap between container ship noise (typically in the 0.1-10.0 kHz range) and acoustic masking of clicks is not expected to occur.
e. Effects within the local assessment area.
f. Confined to a period of months or years.
g. Effect occurs regularly, possibly unpredictably, not on an annual or seasonal basis.
h. Indicator(s) will return to existing conditions after effects cease.

References

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IR5-36 Marine Mammals – Seals and Sea Lions Representative Species, Baseline

Information Source(s)

EIS Volume 3: Section 8

Proponent Response to Follow-up Information Requirements of July 31, 2015 (CEAR Doc#388): Appendix AIR9-A; Table 3

Context

In Section 8 of the EIS, the Proponent indicated that sub-component species were chosen for their ability to represent other species that are similar in nature, occupy comparable types of habits, serve similar ecological roles, or could otherwise be affected by the proposed Project in an analogous way. In Appendix AIR9-A Table 3 of its response to Canadian Environmental Assessment Agency follow-up information requirement #9 (CEAR Doc#388), the Proponent summarized the existing conditions and mechanisms of potential Project effects for marine mammal species in the local and regional assessment area of the Project.

Further information is required to determine the validity of relying on Stellar Sea Lion as the appropriate representative species for California Sea Lion, Harbour Seal, and Northern Fur Seal.

Information Request

Provide further rationale for why Stellar Sea Lion is an appropriate representative species for California Sea Lion, Harbour Seal, and Northern Fur Seal. In the response, include a comparison of the following:

- life history traits;
- diet/prey;
- habitat distribution;
- migration behavior;
- potential to be affected by the proposed Project and marine shipping associated with the Project; and
- summary of differences in the five bullets above between Stellar Sea Lion, California Sea Lion, Harbour Seal, and Northern Fur Seal.

VFPA Response

This response will provide the following:

- Additional information regarding California sea lion, harbour seal, and fur seal life history, prey preferences, distribution, and migrations;
- A comparison of these traits; and

- Additional information on how the environmental assessment of the Project and marine shipping associated with the Project of Steller sea lions represents California sea lions, harbour seals, and northern fur seal.

Additional Information

California Sea Lion

California sea lion (*Zalophus californianus*) is one of two species of sea lions found in B.C. and are often found together with Steller sea lions. Slightly smaller than Steller sea lions, California sea lions are darker brown or black in colour and have a large bump extending from their forehead. California sea lions feed mostly on squid, anchovies, mackerel, rockfish, and sardines (Carretta et al. 2017). They are social animals that congregate with other individuals and are fast, agile swimmers (Carretta et al. 2017). California sea lions are sexually dimorphic with males reaching average lengths of 2.25 metres and weighing about 315 kilograms (kg). Females are much smaller, reaching average lengths of two metres and weighing approximately 110 kg. They have a lifespan of 20 to 30 years (Carretta et al. 2017). There are three populations of California sea lions globally: the largest population breeds off the coast of California and Mexico; a second population breeds off the Galapagos Islands; and a small population breeds off Japan (Olesiuk and Bigg 1984).

The California breeding population resides along the Eastern North Pacific Ocean in shallow coastal and estuarine waters, ranging from the Pacific coast of Central Mexico north to B.C. (Carretta et al. 2017). From May to August, most California sea lions congregate at rookeries off the coast of California (Channel Islands) to Central Mexico to pup and mate (NOAA 2011, 2017). After the mating season, adult and subadult males migrate north to feeding areas as far as Washington State (Puget Sound), B.C., and Alaska (Lowry et al. 1992, Carretta et al. 2015).

In B.C., California sea lions are found at haulouts (often with Steller sea lions) (see Figure AIR9-4 in Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388[1])). In B.C. waters, male California sea lions have been observed hauled out on the intertidal rocks and reefs along the west coast of Vancouver Island (e.g., Race Rocks, Sombrio Point) and on the end of the jetty near Sand Heads at the mouth of the Fraser River (Jeffries et al. 2000, Stantec 2015), with multiple haulout sites scattered throughout the local and regional assessment area (LAA and RAA) for the Project and marine shipping associated with the Project (Figure IR5-36-A1 in **Appendix IR5-36-A**). These winter haulouts consist of adult and subadult males as the females and juveniles remain in California and Mexico after the breeding season (Carretta et al. 2015). No rookeries (i.e., breeding colonies) are located in the LAA and RAA for the Project or marine shipping associated with the Project.

California sea lions are abundant, widely distributed, and experiencing population increase through most of their range, with a total global population estimate of around

[1] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document #345) including 22 Technical Data Reports.

355,000 individuals (Aurioles and Trillmich 2008). The minimum population estimate of the stock in California is approximately 297,000 individuals, growing at an average rate of 5.4% per year with a maximum rate of 12% (Carretta et al. 2017). As a result of the large numbers of sea lion strandings in 2013, the U.S. National Oceanographic and Atmospheric Administration (NOAA) declared an 'unusual mortality event'. Although the exact causes of this unusual mortality event are unknown, two hypotheses meriting further study include nutritional stress of pups resulting from a lack of forage fish available to lactating mothers and unknown disease agents during that time period.

Historic exploitation of California sea lions include harvest for food by Aboriginal groups along the U.S. and B.C. coasts (Stewart et al. 1993) and for oil and hides in the mid-1800s (Scammon 1874). There are few historical records to document the effects of such exploitation on sea lion abundance (Lowry et al. 1992). Current threats and/or causes of mortality include interactions with commercial fisheries (e.g., entanglement and hook and line fisheries), recreational hook and line fisheries, entanglement in marine debris, bioaccumulation of pollutants through the marine food chain, shootings, direct removals (culls), disease, harmful algal blooms, subsistence hunting, and entrainment in power plants (Aurioles and Trillmich 2008, Carretta et al. 2017). During El Niño events, prey availability is greatly reduced, and large numbers of pups born during these periods can die of starvation, as can weaker animals from all age classes (Aurioles and Trillmich 2008). The U.S. NOAA has authorised and is currently lethally removing California sea lions from rivers where they feed on salmon and steelhead listed as endangered under the U.S. Endangered Species Act.

Recent estimates of the B.C. winter population in the Strait of Georgia from survey counts show an increase from less than 100 individuals in 1975 to an average of over 1,600 individuals between the mid-1980s to 2010 (Olesiuk et al. 2011). California sea lions are frequently sighted inside the provincially designated Roberts Bank Wildlife Management Area (MFLNRO 2017).

California sea lions are listed as Least Concern by the International Union for Conservation of Nature, are considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be Not at Risk with no status under the *Species at Risk Act* (*SARA*) (Aurioles and Trillmich 2008, Government of Canada 2017), and are not listed under the U.S. Endangered Species Act (NOAA 2017). They do not have a Provincial conservation status in B.C. The potential biological removal[2] for this stock is 9,200 sea lions per year (Carretta et al. 2017).

Harbour Seal

Pacific harbour seal is an abundant and common resident, with multiple haulout sites scattered throughout the LAA and RAA for the Project and marine shipping associated with the Project (Figure IR5-36-A2 in **Appendix IR5-36-A**). The harbour seal (*Phoca vitulina*) is the most

[2] The term 'potential biological removal' level refers to the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

widely distributed and abundant marine mammal in B.C. (DFO 2010), with over 1,000 haulout sites along the coast. The only true seal that resides year-round and breeds off the west coast of Canada (DFO 2010), they are commonly seen around marinas and harbours staying relatively close to shore or hauled out on small islets, rocks, tidal reefs, and sandbars. A non-migratory species, harbour seals exhibit a high degree of site fidelity, often returning to the same haulout site year after year (DFO 2010).

Harbour seals inhabit temperate and subarctic coastal waters throughout much of the northern hemisphere, with five geographically separated subspecies recognised (Thompson and Harkonen 2008, DFO 2010). The eastern Pacific subspecies inhabits coastal and estuarine waters off Baja California, north along the western coasts of the continental U.S.A., B.C., and southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands (Carretta et al. 2017). A total of 300,000 to 500,000 individuals are estimated worldwide (Thompson and Harkonen 2008), with approximately 360,000 seals inhabiting the Northeast Pacific Ocean, as a documented recovery of the population is occurring throughout B.C., California, Washington, and parts of southwest Alaska (DFO 2010, Carretta et al. 2017).

Harbour seals are opportunistic predators feeding on prey that are locally and seasonally abundant or accessible. Preferred prey include small to medium size schooling fished such as herring, hake, sandlance, salmon, eulachon, and sardines, with bottom fish (flounder, sole, or skate), and squid or octopus also documented in their diet in B.C. (Olesiuk 1999, DFO 2010). Detailed diet studies in the Strait of Georgia indicated that hake and herring made up about 75% of the harbour seal's total diet, with herring predominating the diet during the winter, when herring stocks move inshore in preparation of spawning, and hake during the summer when herring stocks move offshore (DFO 2010, Olesiuk et al. 2011). Salmon were found to only make up 4% of the total diet, and were usually taken in rivers and estuaries when adult salmon were returning to spawn (DFO 2010).

Based on observations of pupping times, and genetic analyses, harbour seals in southern B.C. are considered to be a distinct population from those in northern B.C. and southeast Alaska (Burg et al. 1999). An estimated 39,000 harbour seals inhabit the Strait of Georgia (13.1 seals per kilometre of shoreline), which accounts for only 11% of the coastline but supports 37% of the seal population (DFO 2010). Outside the Strait of Georgia, densities average about 2.6 seals per kilometre of shoreline. This average density has been applied to areas of unsurveyed coastline to come up with an estimate of approximately 66,000 seals throughout the remainder of the B.C. coast (DFO 2010).

Harbour seals are non-migratory species that move locally with time of day, tides, weather, season, food availability, and for finding mates (Bigg 1969, Frost et al. 1997, Thompson and Harkonen 2008, DFO 2010). Unlike sea lions, harbour seals do not congregate on a few large rookeries, but breed in smaller groups along shorelines throughout most of their range. Harbour seals can travel significant distances (up to 525 km) to forage or disperse when seal densities get too high; however, adults typically remain close to their haulout (within 35 km) suggesting strong site fidelity, typically foraging within 10 to 20 km of haulout sites (Frost et al. 1997, Thompson and Harkonen 2008, DFO 2010). Some individuals have been documented as far as 100 km offshore (DFO 2010). They will also enter rivers and lakes in

pursuit of their prey and have travelled as far as 250 km up the Skeena River and 500 km up the Fraser River (DFO 2010).

The pupping season varies by latitude, with pups born from mid-May to early-July in northern B.C., and from early-July to mid-August in southern B.C. (DFO 2010). The average life span for most male harbour seals is 20 years versus females, which can live past 30 years. Both males and females become sexually mature at three to five years of age, with adult females giving birth to a single pup each year (Thompson and Harkonen 2008, DFO 2010). Harbour seal pups are highly precocial at birth, and are reared in the water as well as on land (Riedman 1990). The mother and pup remain together until weaning occurs three to six weeks after birth (Bigg 1969). Moulting occurs from late-June to October, during which time seals are typically hauled out on shore, glacial ice, or other substrates (LGL Limited et al. 2009). During late autumn and winter, seals can be at sea continuously for several weeks to feed and regain weight lost during the mating and moulting seasons (DFO 2010).

Between 1879 and 1968 an estimated 0.5 million seals were killed in B.C., with the largest kills occurring during two periods of commercial harvesting (DFO 2010). After being protected in 1970, the B.C. population grew exponentially during the 1970s and 1980s at an estimated 11.5% per year. Growth rates slowed in the 1990s and the population now appears to have stabilised at pre-exploitation levels (Thompson and Harkonen 2008, DFO 2010, Carretta et al. 2017). In 2008, it was estimated that about 105,000 harbour seals inhabited the waters of B.C., with approximately 82% of the coastline surveyed and nearly 1,400 haulout sites identified (DFO 2010). It is estimated that abundance levels were on the order of 10,000 seals when the first surveys were conducted in the 1970s.

Identified current threats include entanglement and by-catch in fisheries, limited prey as a result of over-fishing, oceanographic regime shifts and climate change, bioaccumulation of pollutants through the marine food chain, shootings, direct removals (culls), disease, subsistence hunting, and both acute and chronic oil spills and discharges, which can cause direct mortality and have long term impacts on harbour seal health and their environment (Thompson and Harkonen 2008).

Harbour seals are considered by COSEWIC to be Not at Risk with no status under *SARA* (Thompson and Harkonen 2008, Government of Canada 2017). They do not have a Provincial conservation status in B.C. The recovery of harbour seal populations in B.C. to pre-exploitation levels has renewed concern over conflicts between fisheries and the impact seals have on fish stocks (DFO 2010). Recognised as an ecologically significant species in B.C., they are considered an important prey species for transient killer whales. The number of transient killer whales in an area may be directly correlated with the abundance of harbour seals, and as a result they may be used as a general indicator of the status of food webs in the North Pacific as we see a shift towards ecosystem-based management (DFO 2010).

Northern Fur Seal

Northern fur seals are uncommon in the LAA and RAA for the Project and marine shipping associated with the Project. Historically, their habitat range has extended to the western portion the RAA. Due to their rare and incidental occurrence in the LAA and RAA for the Project

and marine shipping associated with the Project, adverse effects to northern fur seals are unlikely to occur.

Northern fur seals (*Callorhinus ursinus*) are endemic to the North Pacific Ocean and occur from northern Baja, Mexico north to the Bering Sea and west to the Okhotsk Sea and the Sea of Japan (Gelatt and Lowry 2008). They are considered one of the most pelagic pinniped species, spending most of the year at sea rarely returning to land (Gelatt and Lowry 2008). On average per year, males and females only spend 45 and 35 days respectively ashore. The highest concentrations of northern fur seals in the open ocean are associated with oceanographic frontal features such as canyons and sea mounts along the continental shelf (COSEWIC 2010).

Two stocks are recognised: Eastern Pacific and San Miguel Island (California). Most of the Eastern Pacific stock that winter in Canadian waters breed at four islands from the Pribilof Islands and Bogoslof Island in the Bering Sea (summer range) to the Channel Islands in southern California (winter range) (Gelatt and Lowry 2008). During the breeding season (June–September), approximately 74% of the world's population inhabits the Pribilof Islands (Lander and Kajimura 1982).

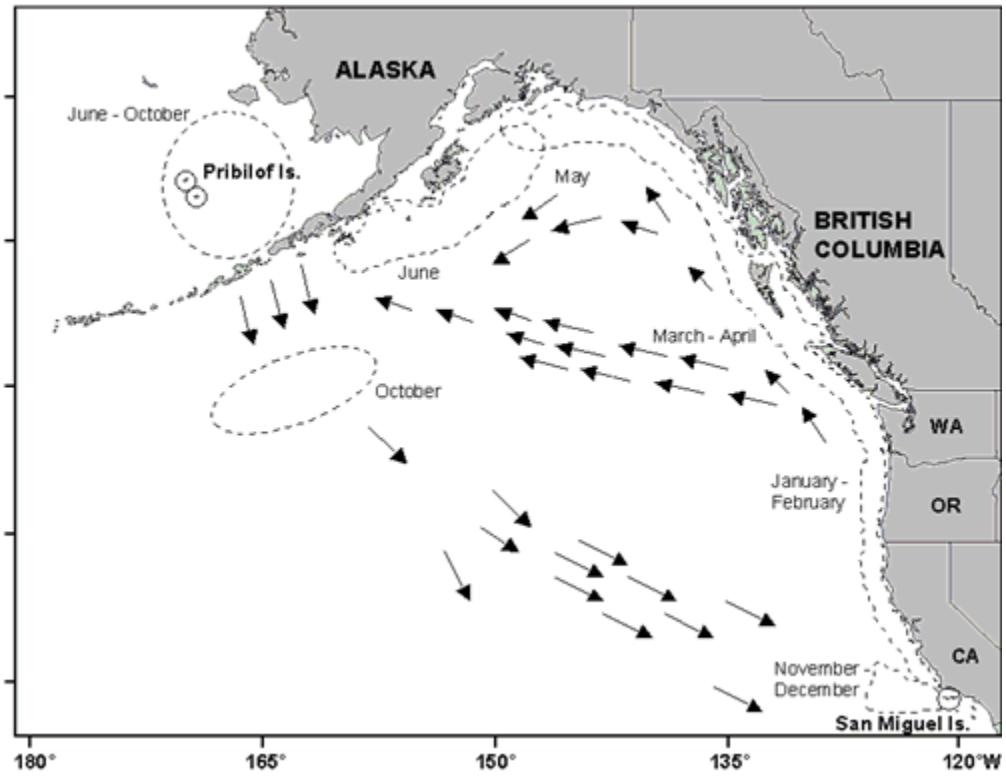
Northern fur seals leave Alaskan rookeries in October and November and remain offshore, remaining solitary and returning to shore intermittently to haulout until March to June (LGL Limited et al. 2009). Subadult males can be found from Alaska to California in the winter, whereas adult males tend to stay in the North Pacific. Adult females migrate down the North American coast from southeast Alaska to California and in some cases to the Hawaiian Islands (LGL Limited et al. 2009). Females breed in late June through August (depending on the rookery they use), giving birth to single pups (Gelatt and Lowry 2008). A highly polygynous species, the males arrive at rookeries up to one month ahead of the females to establish territories. No breeding areas are located in Canada.

Pup production at the two largest breeding colonies, both in the Pribilof Islands, which presently account for 90% of all fur seals in the eastern Pacific, has been declining for the last 45 years and pup numbers at these colonies have declined by 38% over the last 30 years (three generations) (COSEWIC 2011). Numbers of pups have been increasing in the much smaller colony at Bogoslof Island. Taken together, these trends in pup production mean it is likely that numbers of mature individuals will continue to decline. In 2008, there were approximately 650,000 fur seals in the eastern Pacific compared with more than two million in the 1950s (COSEWIC 2011). The causes of the declines are unknown and the immediate cause appears to be low survival of young seals.

Waters off B.C. are important habitat for migrating and overwintering northern fur seals that breed on islands in the eastern North Pacific (see **Figure IR5-36-1**). In waters off B.C., the largest numbers of fur seals occur from January through June about 20 to 150 km offshore (Baird and Hanson 1997, Heise et al. 2003, COSEWIC 2010). Most adult females, and a few juveniles, pass southward through B.C. waters in early winter and northward in late spring. Approximately 500,000 northern fur seals may travel offshore of B.C. each year, to and from wintering grounds (A. Trites, University of British Columbia, pers. comm. in Heise et al. 2003), most closely to west Vancouver Island and Haida Gwaii (Heise et al. 2003). Based on harvest

and sampling records the area of LaPerouse Bank off southwest Vancouver Island appears to be particularly important for migrating and wintering animals, although juveniles appear also to use nearshore areas (COSEWIC 2010). There have been no recent attempts to locate fur seals on their annual migration through Canadian waters, although they have been observed during cetacean surveys of offshore waters conducted by DFO (J. Ford pers. comm. 2010 in COSEWIC 2010). Incidental sightings of northern fur seals have been documented in inshore waters at winter and spring sea lion haulouts (e.g., Race Rocks off southern Vancouver Island) (Baird and Hanson 1997).

Figure IR5-36-1 Approximate Migratory Pattern of Northern Fur Seals from the Eastern Pacific Populations



Source: COSEWIC (2010).

The northern fur seals diet varies by location and season and is made up of a variety of schooling and non-schooling fish and squid. In California and Washington, this includes anchovy, hake, saury, several species of squid and rockfish, and salmon (Gelatt and Lowry 2008). In B.C., fur seals have been documented feeding on herring, gadids and sablefish, squid, and salmon (Heise et al. 2003). Pacific herring is the predominant prey in inshore waters from February through June, whereas in oceanic waters the seals prey almost exclusively on onychoteuthid squids and salmonids (COSEWIC 2010). Although the diets of both California and Steller sea lions overlap with northern fur seals, fur seals prey more on forage fish and the juvenile stages of larger fish species, whereas sea lions tend to prey on larger species and older life stages. Additionally, sea lions forage in nearshore areas whereas most fur seals forage on the outer continental shelf and the shelf break (Gentry 1998 in COSEWIC 2010). Despite these spatial differences, fur seals and sea lions feed on many of

the same migratory prey species in different portions of their ranges (e.g., Pacific herring and salmon). Similarly, harbour seals prey on many of these same migratory fish species as fur seals, as the fish return to coastal areas to spawn (Olesiuk 2007 in COSEWIC 2010). Despite this potential for competition, little is known about how this overlap in diet affects pinniped populations.

Exploitation of northern fur seals occurred between the discovery of the main breeding colonies in the late 18th century through until 1984 (Gelatt and Lowry 2008). It is estimated that the population in the 1950s numbered around 2.5 million animals. In Canada, northern fur seals were hunted by Europeans and Russians off the west coast of Vancouver Island and around Haida Gwaii, perhaps as early as 1866 (Scheffer et al. 1984). The commercial hunt was for their pelts, which, when the guard hairs have been removed, produces a luxurious fur. Aboriginal peoples throughout the Aleutian Islands, coastal Alaska, B.C., Washington, and Oregon have also hunted northern fur seals for several millennia (Gustafson 1968, Huelsbeck 1983, Savinetsky et al. 2004, Newsome et al. 2007). Fur seals were identified as an important resource by the Haida, Heiltsuk, and Namgis (Brown and Brown 2009 in COSEWIC 2010).

Continuing and potential threats include entanglement in marine debris, discarded fishing gear, interactions with commercial fisheries, changes in prey abundance, climate change, oil spills, and contaminants (COSEWIC 2010). Killer whale predation may have contributed to the decline and could be a limiting factor in the recovery of fur seals in some areas (Jefferson et al. 1991, Matkin et al. 2007, COSEWIC 2010). Hunting of northern fur seals in Canadian waters is not permitted except by Aboriginal people, who must obtain a licence, issued at the discretion of the Minister of Fisheries and Oceans and valid for one year (COSEWIC 2010). The subsistence harvest in the U.S.A. is currently limited to a 47-day season targeting subadult males from 23 June to 8 August (NMFS 2004), with a mean annual take from 1997 to 2001 of 1,132 animals (Angliss and Lodge 2003). Fur seals are not protected while at sea outside the exclusive economic zones of Canada and the U.S.A. (Baird and Hanson 1997) because attempts to establish a new fur seal treaty have been unsuccessful (COSEWIC 2010).

The species was classified by COSEWIC in 1996 as Not at Risk. It was reassessed in 2006 and COSEWIC recommended a Threatened status due to declines in pup production on the Pribilof Islands. This recommendation was referred back to COSEWIC by the Governor in Council for reconsideration due to the overall abundance of the entire population and northern fur seal are not currently listed under *SARA* (Government of Canada 2009). They are currently classified by COSEWIC as Threatened (COSEWIC 2010) and are Red-listed in B.C. (BCCDC 2017). In the U.S.A., northern fur seals are protected by the Marine Mammal Protection Act, under which the eastern North Pacific population, specified as consisting of seals from the Pribilof Islands and Bogoslof Island colonies, is designated as 'depleted' (COSEWIC 2010). The overall abundance of northern fur seals makes it unlikely that they will become extirpated from B.C. waters in the foreseeable future. Providing the populations at Bogoslof and San Miguel islands remain stable, the seals from those colonies, as well as individuals from the stable or growing breeding colonies in the western Pacific, ensure the presence of fur seals in Canadian waters, even if the decline in numbers at the Pribilof Islands continues (COSEWIC 2010).

Comparison of Represented and Representative Species

A comparison of life history traits of Steller sea lion, California sea lions, and harbour seals that occur in the LAA and RAA, and additional rationale for why they are adequately represented by Steller sea lions is provided in Table IR5-36-B1 in **Appendix IR5-36-B**.

Steller sea lion are more frequently and regularly observed in the assessment areas compared to California sea lion e.g., hauled out individuals at Sand Heads at the northernmost extent of their range (see Figure IR5-36-A1 in **Appendix IR5-36-A**). Harbour seals are abundant in B.C. and are observed throughout the assessment area (Figure IR5-36-A2 in **Appendix IR5-36-A**). These species all experienced historical decreases in their population during the last century due to overhunting and have recovered to varying extents. Northern fur seals are considered a pelagic species in B.C., and are unlikely to occur in the assessment areas, and it is highly unlikely that they will interact with or be adversely affected by the Project or marine shipping associated with the Project, and will not be discussed further.

Steller sea lions, California sea lions, and harbour seals all potentially occur in the LAA and RAA for the Project and marine shipping associated with the Project, share similar anatomy, prey and habitat preferences, physical characteristics, and life history traits. Steller sea lions, California sea lions, and harbour seals are coastal species that forage on fish and invertebrates, haul out on land for a portion of the day, and are frequently observed together at haulout sites. Mechanisms potentially affecting California sea lion and harbour seal (i.e., changes in the acoustic environment) and potential responses to effects from the Project and marine shipping associated with the Project are similar as those for Steller sea lion.

Steller and California sea lions and harbour seals have poor underwater hearing sensitivity below 1,000 hertz (Kastelein et al. 2005), and most underwater noise from the Project and marine shipping associated with the Project will not be audible to them. Furthermore, sea lions and harbour seals are expected for the most part to be habituated to regular traffic movements along the shipping lanes and have typically been shown to tolerate noisy environments even congregating around vessels (Richardson et al. 1995, Demarchi 2010, SMRU 2014). Like Steller sea lion, if behavioural responses of California sea lions and harbour seals occur, they will likely be of low magnitude, short-term, of short duration, and reversible. No rookeries or major haulouts occur in the LAA, and the Project is unlikely to result in residual effects to the population of Steller sea lion, California sea lion, or harbour seal.

In conclusion, Steller sea lion are the only pinniped that is listed under *SARA* in the assessment areas and use of this species to represent other pinnipeds (i.e., seals and sea lions) resulted in the most conservative assessment of the potential effects of underwater noise from the Project and marine shipping associated with the Project. Potential effects of the Project and marine shipping associated with the Project on California sea lion and harbour seal will be equal to or lesser than those predicted for Steller sea lion.

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Appendices

Appendix IR5-36-A Supporting Figures

Appendix IR5-36-B Supporting Table

APPENDIX IR5-36-A
SUPPORTING FIGURES

Path: O:\1200\1246\EIS_INFORMATION_REQUEST\IR5_36\map\IR5_36_A1_CaliforniaSealionHaulouts_171013.mxd

PROJECT AREA

British Columbia

Washington

Vancouver Island

Vancouver Island
Île de Vancouver

Saltspring Island

UNITED STATES

UNITED STATES

Strait of Georgia

Strait of Juan de Fuca

Juan de Fuca Strait
Détroit de Juan de Fuca

Roberts Bank

Boundary Bay

Howe Sound

Malaspina Strait

Vancouver

Burnaby

Coquitlam

New Westminster

Maple Ridge

Richmond

Surrey

White Rock

Langley

Abbotsford

Mission

Chilliwack

Agassiz

Hope

Yale

Harrison Lake

Sunshine Valley

Nanaimo

Ladysmith

Duncan

Lake Cowichan

Victoria

Saanich

Colwood

Sooke

Port Renfrew

Sidney

Shawnigan Lake

Tofino

Ucluelet

Barkley Sound

Bamfield

Parksville

Qualicum Beach

Port Alberni

Courtenay

Campbell River

Sechelt

Gibsons

Horseshoe Bay

Union Bay

Cumberland

Texada Island

Garden Bay

Madeira Park

Tetrahedron Provincial Park

Indian Arm Provincial Park

Pinecone Burke Provincial Park

Golden Ears Provincial Park

Strathcona Provincial Park

Flores Island

Vargas Island Provincial Park

Pacific Rim National Park Reserve
Réserve de parc national Pacific Rim

Cherry Point

Bellingham

Oak Harbor

Mt Vernon

Port Angeles

Everett

Tulalip Reservation

Lummi Reservation

Makah Indian Reservation

San Juan Islands National Monument

Olympic National Forest

OLYMPIC MOUNTAINS

SKAGIT RANGE

Mt. Baker National Forest

North Cascades National Park

Skagit

Whatcom

Baker Lake

Ross Lake Recreation Area

Chilliwack Lake Provincial Park

Skagit Valley Provincial Park

Pacific Rim National Park Reserve
Réserve de parc national Pacific Rim

Cumanah Walbran Provincial Park

Ozette Lake

Lake Crescent

Clallam

1035m

1504m

2557m

3623 ft

3497 ft

6027 ft

5020 ft

10762 ft

Legend

- BOUNDARY OF PROJECT AREA
- STELLER SEA LION (SEAL AND SEA LION) LOCAL ASSESSMENT AREA
- STELLER SEA LION (SEAL AND SEA LION) REGIONAL ASSESSMENT AREA
- MARINE SHIPPING AREA
- CALIFORNIA SEA LION HAULOUT
- VFPA NAVIGATIONAL JURISDICTION AREA
- U.S.A.-CANADA BORDER

California Sea Lion Haulouts data acquired from Ministry of Forests, Lands and Natural Resource Operations - GeoBC. Data downloaded on August 18, 2017.

0 20 40
Kilometres

1:900,000

NAD 1983 UTM Zone 10N

N

PORT of vancouver

ROBERTS BANK TERMINAL 2

CALIFORNIA SEA LION HAULOUTS

DATE: 10/16/2017

FIG No. IR5-36-A1

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Path: O:\1200\1246\EIS_INFORMATION_REQUESTS\IR5_36\map\IR5_36_A2_Harbour_Seal_171013.mxd

PROJECT AREA

British Columbia

Vancouver Island

Washington

Legend

- BOUNDARY OF PROJECT AREA
- STELLER SEA LION (SEAL AND SEA LION) LOCAL ASSESSMENT AREA
- STELLER SEA LION (SEAL AND SEA LION) REGIONAL ASSESSSMENT AREA
- MARINE SHIPPING AREA
- HARBOUR SEAL HAULOUT
- VFPA NAVIGATIONAL JURISDICTION AREA
- U.S.A.-CANADA BORDER

Harbour Seal Haulouts data acquired from Ministry of Forests, Lands and Natural Resource Operations - GeoBC. Data downloaded on August 14, 2017.

0 20 40
Kilometres
1:900,000
NAD 1983 UTM Zone 10N

N

PORT of vancouver

ROBERTS BANK TERMINAL 2

HARBOUR SEAL HAULOUTS

DATE: 10/16/2017

FIG No. IR5-36-A2

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

APPENDIX IR5-36-B
SUPPORTING TABLE

Table IR5-36-B1 Effects Assessment of California Sea Lion and Harbour Seal

Species	Representative Species Rationale	Effects Assessment	Mitigation
California Sea Lion and Harbour Seal[a]	California sea lion and harbour seal are represented by Steller sea lions for the following reasons (additional rationale is provided in Additional Information Request #9 (AIR-12.04.15-09 of CEAR Document #388), including Appendix AIR9-A Table 3). Like Steller sea lions: • California sea lions and harbour seals are social animals that congregate with other individuals in coastal environments, often together hauled out on land, and feed on fish. • California sea lions and harbour seals occur in the local and regional assessment areas. • The mechanisms potentially affecting California sea lions and harbour seals (i.e., changes in the acoustic environment, and changes in habitat availability), and response of California sea lions and harbour seal to potential effects are the same. • California sea lions and harbour seals share similar hearing anatomy and ability; they all have poor hearing below 1,000 hertz and most underwater noise from vessel movements will not be audible.	Potential Project-related effects on California sea lions and harbour seal have been assessed in the EIS through the use of the representative species (Steller seal lion). Details are provided below: • Potential effects on Steller sea lion from changes in in-air noise (EIS Section 14.6.1.1, Marine Shipping Addendum Section 8.2.7) are assessed as negligible. Assessment result is the same for California sea lion and harbour seals as they share similar hearing anatomy and expected behavioural responses to in-air noise. • Potential effects on Steller sea lion from changes in environmental contamination from air pollution (EIS Section 13.6.1.2) are assessed as negligible. Assessment result is the same for California sea lion and harbour seal as they share similar physiology and expected responses to environmental contamination. • Potential effects on Steller sea lion from changes in the availability of prey from changes in fish habitat quality and quantity (EIS Section 14.6.1.3) are assessed as negligible as productivity losses of sea lion prey (e.g., invertebrates and fish) are considered minor. Assessment result is the same for California sea lion and harbour seal as productivity losses of California sea lion and harbour seal prey (e.g., invertebrates and fish) are considered minor. • Potential effects on Steller sea lion from physical disturbance from vessel strikes (EIS Section 14.6.4.2) are assessed as negligible as vessel strikes of seals and sea lions (including California sea lion and harbour seal) are uncommon. • Potential effects on Steller sea lion from changes in water and sediment quality (EIS Section 14.6.1.4) resulting in adverse health effects from potential re-distribution of contaminants (i.e., polychlorinated biphenyls (PCBs)) in sediments are assessed as negligible as construction activities will not increase sediment concentrations of contaminants. Assessment result is the same for California sea lion and harbour seal as construction activities will not increase sediment concentrations of contaminants. • Potential effects on Steller sea lion from changes to the acoustic environment resulting in injury, behavioural disturbance, or acoustic masking (EIS Section 14.6.4.1) are assessed as moderate. Assessment result is the same for California sea lion and harbour seal due to habituation to existing levels of underwater noise and similar hearing ability / expected behavioural responses to established thresholds.	Mitigation measures proposed to reduce or eliminate potential residual effects of the Project on Steller sea lion are also beneficial for California sea lion and harbour seal. • An Underwater Noise Management Plan will be implemented to mitigate potential effects from changes in the acoustic environment (see EIS Section 13.7.3). • A Construction Compliance Monitoring Plan will be implemented to mitigate potential effects to prey from changes in water quality (see EIS Section 13.7.4).

Notes: a. Northern fur seals are considered a pelagic species in B.C., and are unlikely to occur in the assessment areas, and it is highly unlikely that they will interact with or be adversely affected by the Project or marine shipping associated with the Project, and will not be discussed further.

IR5-37 Marine Mammals – Contaminant Uptake

Information Source(s)

Recovery Strategy for the Northern and Southern Resident Killer Whales in Canada (Attachment to CEAR Doc#263): Table 1.

EIS Volume 2: Appendix 9.6-A, Appendix 9.6-B

EIS Volume 3: Section 14, Appendix 14-D

Context

The recovery strategy for SRKW identified environmental contaminants as a current threat to SRKW. Table 1 of the recovery strategy provided a list of persistent organic pollutants that may pose a risk to resident killer whales. As stated in the EIS guidelines, the Proponent was required to carry out a characterization of the contaminant loading in fish species and aquatic species at risk and the pathways of bio-accumulation, for those species whose contaminant loadings may be affected by the proposed Project.

In Section 14 of the EIS, the Proponent stated that while SRKW and Steller Sea Lion are vulnerable to accumulating a wide range of persistent, lipophilic organic contaminants, including chlorinated pesticides such as chlordane, dichlorodiphenyltrichloroethane (DDT) and polybrominated diphenyl ethers (PBDEs), no substance other than polychlorinated biphenyls (PCBs) appear to approach or exceed thresholds resulting in toxicological effects. Although there is information presented in Appendix 9.6-A, Appendix 9.6-B and Appendix 14-D of the EIS on some of the persistent organic pollutants specified in Table 1 of the recovery strategy (such as PCBs and PAHs) it is unclear how the Proponent came to the conclusion that no substance other than PCBs approached or exceeded thresholds for toxicological effects. Further information is required to determine whether there is the potential for contaminants other than PCBs to result in adverse effects to marine mammals.

Information Request

For all pollutants identified in Table 1 of the recovery strategy for the SRKW, provide the following:

- concentrations in sediment likely to be mobilized through dredging in the Fraser River, tug basin and dredge basin;
- comparison with Canadian Council for Ministers of the Environment (CCME) interim sediment quality guidelines or other applicable guidelines; and
- potential for the pollutant to result in toxicological effects on SRKW and Stellar Sea Lion.

VFPA Response

The information provided below supports the conclusion that no measurable changes in existing concentrations of pollutants listed in Table 1 of the southern resident killer whale (SRKW) Recovery Strategy (DFO 2011) are anticipated to result from Project construction activities. Project construction will result in a negligible change to existing surface sediment concentrations of these pollutants and no toxicological effects to SRKW or Steller sea lion from pollutants listed in Table 1 are expected (EIS Appendix 9.6-B).

Background and Context

Sediment samples at and adjacent to the proposed Project site were sampled and analysed for various parameters by the VFPA to inform the EIS, including the potential contaminants polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals, and coal content (EIS Appendix 9.8-A, EIS Appendix 9.6-B, IR3-25 of CEAR Document #984[1], Hemmera 2017). Sediment quality was assessed by comparing concentrations of regulated substances to federal sediment quality guidelines as set by the Canadian Council of Ministers of the Environment (CCME 1999)[2] (EIS Appendix 9.6-B; Table IR3-25-1, Appendix IR3-27-A of CEAR Document #984).

However, the CCME sediment concentration guidelines do not account for exposures of higher predators, such as marine mammals, to pollutants based on biomagnification through food webs, and there are no other sediment guidelines or thresholds to compare the concentrations of pollutants listed in Table 1 (**Appendix IR5-37-A**) of the SRKW Recovery Strategy (DFO 2011). It is currently not possible to determine the absolute or comparative risks of pollutants, including those listed in Table 1, to resident killer whales or other marine mammals through the direct evaluation of these sediment contaminant concentrations. Thus, information on the concentrations of various individual Table 1 pollutants in sediment is not useful for managing risks to SRKW in their critical habitat unless accompanied by both estimates of SRKW exposure levels based on biomagnification through the food web and relevant toxicological thresholds.

The VFPA conducted studies to inform the EIS that focused on PCBs as they are an appropriate proxy for the potential toxicological risks to SRKW from other pollutants listed in Table 1 of the Recovery Strategy, as these substances have similar physical and chemical properties (e.g., hydrophobic) and distribution mechanisms (see IR3-29 of CEAR Document #984). The SRKW Recovery Strategy does not provide information regarding potential toxicological thresholds of the pollutants listed in Table 1 and the concentrations and potential toxicological effects of PCBs to marine mammals have been the focus of both DFO and the U.S. National Oceanic and Atmospheric Administration (NOAA) (Ross et al. 2011, Lachmuth et al. 2010, Alava et al. 2012, NOAA 2016, West et al. 2017). Overall, the available scientific knowledge, including guidance from DFO described above, suggests that potential health risks to predatory marine mammals

[1] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).
[2] CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, including the Interim Marine Sediment Quality Guidelines (ISQGs) and the Probable Effects Levels (PELs).

using PCBs as a surrogate for other contaminants should lead to similar conclusions about their risk potential.

Additional sampling of sediment and a high-resolution PCB congener[3] analysis was conducted by the VFPA to characterise dredging and disposal at sea[4] activities and to address transfer of PCBs through a food web-based ecological risk assessment model (EIS Appendix 9.6-B, EIS Appendix 14-D)[5]. A PCB food web bioaccumulation model[6] was adapted for the effects assessment from an earlier DFO model developed for resident killer whale food webs (Lachmuth et al. 2010, Alava et al. 2012) to determine if historical sediment-bound contaminants, if re-suspended, may be ingested and magnified through the food chain, ultimately adversely affecting the health of fish-eating killer whales.

Concentrations in Sediment Likely to be Mobilised Through Dredging

Sediment samples were collected from the lower Fraser River navigational channel, tug basin, and the dredge basin and were analysed for PCB congeners and total organic carbon[7] as a conservative proxy for the contaminants listed in Table 1 of the SRKW Recovery Strategy.

No collected samples exceeded the CCME criteria for total PCBs in the tug and dredge basins or the Fraser River maintenance dredging sites (EIS Appendix 9.6-B; Table IR3-25-1, Appendix IR3-27-A of CEAR Document #984). Furthermore, total PCB congeners in the receiving environment will not increase as a result of Project construction. PCB concentrations in the dredge basin, tug basin expansion area, and Fraser River sands are lower than surficial sediment samples from the broader Strait of Georgia. PCB concentrations of suspended sediments during construction are the same as concentrations in the existing environment, when expressed on the basis of normalised organic carbon or normalised percent fines concentrations (EIS Appendix 14-D; see IR3-29 of CEAR Document #984). Overall, existing sediment concentration

[3] The concentrations, fate, and effects of PCBs, analysed and interpreted based on high resolution gas chromatography (HRGC) – high resolution mass spectrometry (HRMS) (i.e., a congener-based analytical method (e.g., EPA method 1668). A congener is a unique, well-defined chemical compound in PCBs out of a total of 209 congeners.

[4] The discharge area for decant water from the containment dykes during infilling is no longer referred to as the Roberts Bank candidate disposal at sea area for reasons explained in the *Preamble in Support of Responses to IR3-25 to IR3-40* (CEAR Document #984).

[5] "In order to ensure that excavation of sediments from sites within or adjacent to Resident Killer Whale critical habitat do not increase exposure of Resident Killer Whales to PCBs, DFO recommends that Proponents perform high resolution PCB congener analysis of sediments proposed for excavation, and the sampling results against thresholds identified by Ross et al. 2011." (CEAR Document #988).

[6] The model provides conservative predictions of PCB concentrations in SRKW tissues relative to observed or predicted levels in surface sediments within critical habitat. The model assumes equilibrium partitioning from sediment to water and sediment-associated biota that do not account for reduced bioavailability as a result of contaminant aging in sediments, nor stronger sorption in the sediment matrix to other substances (such as soot carbon). In addition, the predictions of PCB levels in higher trophic consumers relative to concentrations in prey items will generally predict concentration within an order of magnitude accuracy, with model parameterisation over-predicting (as opposed to under-predicting) the overall magnitude of trophic transfers.

[7] Persistent organic pollutants preferentially adsorb to organic carbon and finer textured sediments; detectable PCBs are primarily found in areas of finer-textured organic-rich sediments (EIS Appendix 9.6-B).

of pollutants listed in Table 1, including PCBs, are not predicted to change as a result of re-suspension of sediments during Project construction.

Comparison with Canadian Council for Ministers of the Environment Interim Sediment Quality Guidelines or Other Applicable Guidelines

As stated above, there are no regulated CCME sediment quality guidelines for contaminants listed in Table 1 of the Recovery Strategy, other than PCBs and PAHs. The CCME guidelines for PCBs do not account for exposures to pollutants of higher predators such as marine mammals based on food web-mediated biomagnification. As stated above, no other sediment guidelines or thresholds related to potential toxicological effects on marine mammals exist for pollutants listed in Table 1 of the SRKW Recovery Strategy (DFO 2011).

Potential for Contaminants to Result in Toxicological Effects to SRKW and Steller Sea Lion

Based on the distribution of PCBs in sediments, the water column, and biota, the food web-based risk assessment model predicted that PCB concentrations in SRKWs from the re-distribution of sediments during Project construction were negligible compared to levels in SRKW predicted during existing conditions (EIS Section 14.6.1.4, EIS Appendix 14-D; see IR3-29 of CEAR Document #984). As stated above, because no measurable changes in existing concentrations of PCBs as a persistent pollutant are anticipated to result from Project construction activities, no toxicological effects to SRKW or Steller sea lion are expected (EIS Appendix 9.6-B). Therefore, there is also likely a negligible potential for contaminants listed in Table 1 to result in adverse health effects to SRKW and Steller sea lions due to Project construction.

The DFO SRKW Action Plan (DFO 2017) recommends a number of recovery actions to further quantify and understand the existing risks associated with all potential contaminants and the potential for toxicological effects affecting the recovery of SRKW. To help meet these recovery actions, the VFPA's Enhancing Cetacean Habitat and Observation (ECHO) Program (see response to IR4-10 of CEAR Document #1051[8]) is supporting initiatives to better understand and manage these risks.

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Appendices

Appendix IR5-37-A Pollutants Listed in Table 1 of the Recovery Strategy for SRKW (DFO 2011)

APPENDIX IR5-37-A
POLLUTANTS LISTED IN TABLE 1 OF THE RECOVERY STRATEGY FOR SRKW (DFO 2011)

Appendix IR5-37-A: Pollutants Listed in Table 1 of the Recovery Strategy for SRKW (DFO 2011)

- DDT – dichlorodiphenyltrichloroethane;
- PCBs – polychlorinated biphenyls;
- Dioxins and Furans (PCDD/Fs) – polychlorinated dibenzo-p-dioxins / polychlorinated dibenzofurans;
- PAHs – polycyclic aromatic hydrocarbons;
- Flame retardants: polybrominated biphenyls (PBBs) and PBDEs – polybrominated diphenyl ethers;
- PFOs – perfluoroctane sulfonate;
- TBT, DBT – tributyltin, dibutyltin;
- PCPs – polychlorinated paraffins;
- PCNs – polychlorinated naphthalenes;
- APEs – alkyl-phenol ethoxylates; and
- PCTs – polychlorinated terphenyls.

IR5-38 Marine Mammals – Air Pollution

Information Source(s)

EIS Volume 3: Section 14

Marine Shipping Addendum: Section 8.2

CEAR Doc#581

Context

In Section 8.2 of the Marine Shipping Addendum, the Proponent indicated that there is the potential for synergistic, additive, and/or antagonistic interactions between the individual components in fuel exhaust and current persistent organic pollutants. However, the Proponent does not elaborate on the potential effects of inhalation of these pollutants by marine mammals.

In both Section 14 of the EIS and Section 8.2 of the Marine Shipping Addendum, the Proponent concluded that the potential effect of air pollution on marine mammals is negligible. In Section 8.2 of the Marine Shipping Addendum, the Proponent stated that the North American Emission Control Area (ECA) was implemented with the intention of reducing overall SO_2 emissions from marine vessels by 96% with full implementation in 2015. The Proponent indicated that implementation of the ECA will also reduce emissions of NO_x and $PM_{2.5}$. According to Environment and Climate Change Canada, the ECA came into effect on January 1, 2015. Further information is required to determine the potential effects of inhalation of pollutants by marine mammals, and to determine whether the implementation of the ECA may result in a reduction in the effects of pollutant inhalation by marine mammals.

Information Request

Provide information on the potential effects of the inhalation of the following pollutants on marine mammals:

- CO;
- NO_x;
- SO_2;
- $PM_{2.5}$; and
- Hydrocarbons.

Describe how the implementation of the North American Emission Control Area may result in a reduction of the potential effects of pollutant inhalation by marine mammals in the local assessment area for marine shipping associated with the proposed Project.

VFPA Response

Potential health effects to marine mammals from air pollution in the local assessment area (LAA) due to the incremental contribution of marine shipping associated with the Project are not anticipated; therefore, this potential effect was determined to be negligible in the Marine Shipping Addendum (MSA) (Section 8.2.6.1). The following response will provide information on the existing potential effects of inhaled pollutants on marine mammals and how the implementation of the North American Emission Control Area (ECA) may result in a reduction of these potential effects to marine mammals in the LAA.

Provide information on the potential effects of the inhalation of the following pollutants on marine mammals: CO; NO_x; SO_2; $PM_{2.5}$; and Hydrocarbons.

Studies have been conducted examining the effects of engine exhaust (including exhaust components CO (carbon monoxide), NO_x (nitrogen oxide), SO_2 (sulphur dioxide), and $PM_{2.5}$ (respirable particulate matter; particulate matter of 2.5 microns or less in diameter)) on humans, which are assumed to be similar in all mammals, including marine mammals. No direct studies of the effects of inhalation of fuel exhaust and air pollution have been conducted on marine mammals, largely due to the challenges of data collection; for example, mounted passive monitors are not a feasible tool due to swimming and surfacing behaviour of marine mammals.

The effects of hydrocarbons during oil spills on cetaceans have been evaluated in a number of studies (e.g., Geraci and St. Aubin 1980, 1985, Geraci 1990, Loughlin 1994a,b, Moore and Clark 2002, Matkin et al. 1994, 2008). Inhalation could result in inflammation of mucous membranes, congested lungs, pneumonia, or damaged airways. For more information on the potential effects of a hydrocarbon spill, see MSA Section 10.5.7.

Documented health effects to humans of acute and chronic exposure to engine exhaust via inhalation are varied as they depend on exposure concentrations and duration of exposure (Lachmuth et al. 2011). Several long-term exposure studies examining the toxicological effects of diesel and gasoline exhaust containing pollutants, including CO, NO_2, SO_2, and $PM_{2.5,}$ have been conducted on humans and laboratory animals (Edling and Axelson 1984, Gamble et al. 1987, Purdham et al. 1987, van Vliet et al. 1997, Heinrich et al. 1986, 1995, Mauderly et al. 1996, Nikula et al. 1995, Parent et al. 2006, Reed et al. 2008). Effects can include aggravation of asthma, changes in pulmonary function, inflammation, oxidative stress, and arterial vasoconstriction (Koenig 2000, Pope and Dockery 2006). Effects from chronic exposure include lung growth or decline, lung inflammation, and atherosclerosis (Koenig 2000, Pope and Dockery 2006).

Due to the implementation of the ECA described below, air contaminant emissions and predicted ambient air concentrations during Project operation are expected to be lower than for existing conditions, and similar or slightly higher in over-water locations immediately adjacent to Roberts Bank compared to expected conditions without the Project (see EIS Section 9.2.10). Potential health effects to marine mammals from air pollution in the LAA due to the incremental contribution of marine shipping associated with the Project are therefore

not anticipated; therefore, this potential effect was determined to be negligible in the MSA (Section 8.2.6.1).

Describe how the implementation of the North American Emission Control Area may result in a reduction of the potential effects of pollutant inhalation by marine mammals in the local assessment area for marine shipping associated with the proposed Project.

Implementation of the ECA in Canadian waters may result in a reduction of the potential effects of pollutant inhalation by marine mammals in the LAA from incremental marine shipping associated with the Project through the adoption of strict controls to progressively reduce emissions of pollutants (i.e., NO_x, SO_2, and $PM_{2.5}$). As stated in MSA Section 7.1.8, ECA implementation will reduce large vessel-related emissions of NO_x, SO_2, and $PM_{2.5}$ such that estimated concentrations of these criteria air contaminants are predicted to be lower in 2030 than in 2012, with or without the contribution of RBT2-associated container ship emissions. Therefore, potential health effects to marine mammals from air pollution in the LAA are anticipated to be reduced in the future.

In October 2008, based on technological improvements and implementation experience, the member states of the International Maritime Organization (IMO) agreed to amend MARPOL Annex VI[1], adopting new controls to progressively reduce global shipping emissions. On March 26, 2010, the IMO designated specific portions of U.S., Canadian, and French waters as ECAs, in which stringent international emission standards would apply to ships to reduce their air emissions of NO_x, SO_2, and $PM_{2.5}$[2]. For the North American ECA, the first-phase fuel sulphur standard began in 2012, the second phase began in 2015, and stringent NO_x engine standards began in 2016. This meant that starting after August 1, 2012, the allowable level of sulphur content in marine fuels was decreased by more than 75% and was further reduced by 90% (from Phase 1 level allowable content) on January 1, 2015 (Metro Vancouver 2017). As of January 1, 2015, implementation of the North American ECA is expected to result in a 96% reduction of SO_2 emissions (plus associated particulate matter reductions) (GOC 2017) and as of January 1, 2016, an 80% reduction in NO_x emissions from newly built Tier III ships (compared to Tier 1 ships) (Transport Canada 2015). In Canada, the ECA was implemented in 2013 through amendments to the *Vessel Pollution and Dangerous Chemicals Regulations* and Environment Canada's *Sulphur in Diesel Fuel Regulations.*

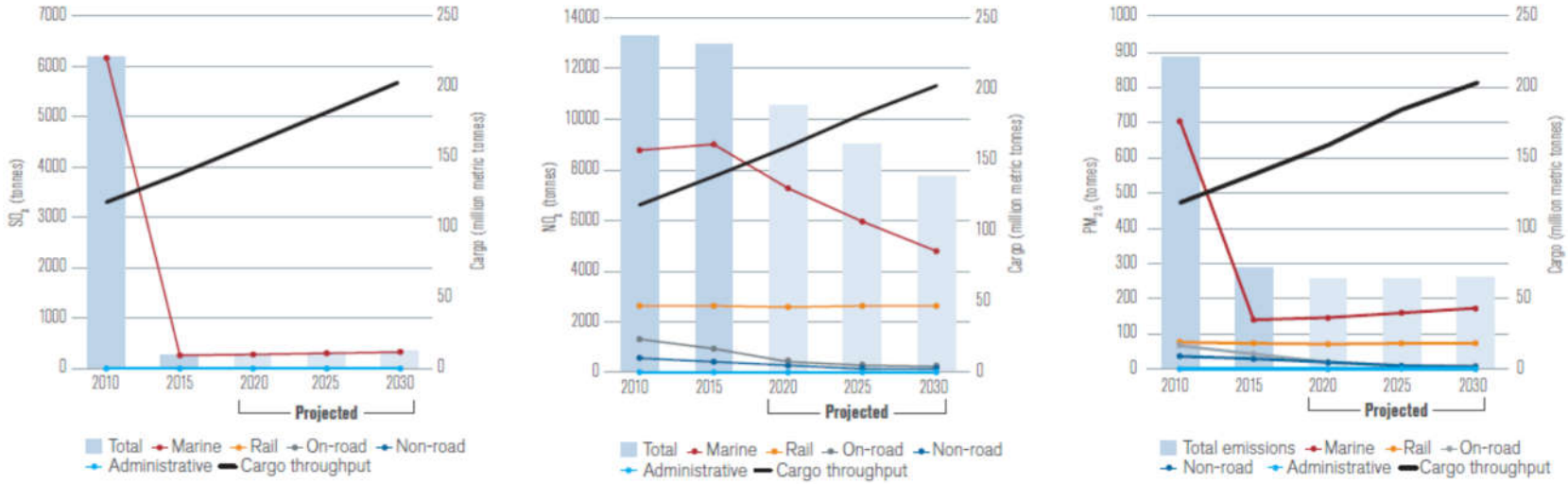
To determine the level of air quality improvements occurring after the implementation of the ECA, Metro Vancouver and the VFPA developed a monitoring program for the Burrard Inlet area (Metro Vancouver 2017, VFPA 2017). This monitoring shows an overall 36% reduction in air pollutants from 2010 to 2015 and continued predicted declines by 2030 (see SO_2, NO_x, $PM_{2.5}$ emission levels in **Figure IR5-38-1**). The VFPA continues to strive towards reducing emissions from marine shipping, including supporting regulations, such as the ECA, providing incentives for positive environmental practices through the EcoAction Program, and

[1] The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI was first adopted in 1997, limiting some air pollutants in ship exhaust.

[2] https://www.epa.gov/regulations-emissions-vehicles-and-engines/designation-north-american-emission-control-area-marine

supporting the use of shore power and cleaner fuels. The VFPA will continue to collaborate with government and industry stakeholders to undertake port emission inventories and enhance air quality monitoring.

Figure IR5-38-1 SO_x, NO_x, and $PM_{2.5}$ Emissions and Cargo Throughput, 2010-2030



Source: VFPA 2017

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IR5-37 Marine Mammals – Contaminant Uptake

Information Source(s)

Recovery Strategy for the Northern and Southern Resident Killer Whales in Canada (Attachment to CEAR Doc#263): Table 1.

EIS Volume 2: Appendix 9.6-A, Appendix 9.6-B

EIS Volume 3: Section 14, Appendix 14-D

Context

The recovery strategy for SRKW identified environmental contaminants as a current threat to SRKW. Table 1 of the recovery strategy provided a list of persistent organic pollutants that may pose a risk to resident killer whales. As stated in the EIS guidelines, the Proponent was required to carry out a characterization of the contaminant loading in fish species and aquatic species at risk and the pathways of bio-accumulation, for those species whose contaminant loadings may be affected by the proposed Project.

In Section 14 of the EIS, the Proponent stated that while SRKW and Steller Sea Lion are vulnerable to accumulating a wide range of persistent, lipophilic organic contaminants, including chlorinated pesticides such as chlordane, dichlorodiphenyltrichloroethane (DDT) and polybrominated diphenyl ethers (PBDEs), no substance other than polychlorinated biphenyls (PCBs) appear to approach or exceed thresholds resulting in toxicological effects. Although there is information presented in Appendix 9.6-A, Appendix 9.6-B and Appendix 14-D of the EIS on some of the persistent organic pollutants specified in Table 1 of the recovery strategy (such as PCBs and PAHs) it is unclear how the Proponent came to the conclusion that no substance other than PCBs approached or exceeded thresholds for toxicological effects. Further information is required to determine whether there is the potential for contaminants other than PCBs to result in adverse effects to marine mammals.

Information Request

For all pollutants identified in Table 1 of the recovery strategy for the SRKW, provide the following:

- concentrations in sediment likely to be mobilized through dredging in the Fraser River, tug basin and dredge basin;
- comparison with Canadian Council for Ministers of the Environment (CCME) interim sediment quality guidelines or other applicable guidelines; and
- potential for the pollutant to result in toxicological effects on SRKW and Stellar Sea Lion.

VFPA Response

The information provided below supports the conclusion that no measurable changes in existing concentrations of pollutants listed in Table 1 of the southern resident killer whale (SRKW) Recovery Strategy (DFO 2011) are anticipated to result from Project construction activities. Project construction will result in a negligible change to existing surface sediment concentrations of these pollutants and no toxicological effects to SRKW or Steller sea lion from pollutants listed in Table 1 are expected (EIS Appendix 9.6-B).

Background and Context

Sediment samples at and adjacent to the proposed Project site were sampled and analysed for various parameters by the VFPA to inform the EIS, including the potential contaminants polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), metals, and coal content (EIS Appendix 9.8-A, EIS Appendix 9.6-B, IR3-25 of CEAR Document #984[1], Hemmera 2017). Sediment quality was assessed by comparing concentrations of regulated substances to federal sediment quality guidelines as set by the Canadian Council of Ministers of the Environment (CCME 1999)[2] (EIS Appendix 9.6-B; Table IR3-25-1, Appendix IR3-27-A of CEAR Document #984).

However, the CCME sediment concentration guidelines do not account for exposures of higher predators, such as marine mammals, to pollutants based on biomagnification through food webs, and there are no other sediment guidelines or thresholds to compare the concentrations of pollutants listed in Table 1 (**Appendix IR5-37-A**) of the SRKW Recovery Strategy (DFO 2011). It is currently not possible to determine the absolute or comparative risks of pollutants, including those listed in Table 1, to resident killer whales or other marine mammals through the direct evaluation of these sediment contaminant concentrations. Thus, information on the concentrations of various individual Table 1 pollutants in sediment is not useful for managing risks to SRKW in their critical habitat unless accompanied by both estimates of SRKW exposure levels based on biomagnification through the food web and relevant toxicological thresholds.

The VFPA conducted studies to inform the EIS that focused on PCBs as they are an appropriate proxy for the potential toxicological risks to SRKW from other pollutants listed in Table 1 of the Recovery Strategy, as these substances have similar physical and chemical properties (e.g., hydrophobic) and distribution mechanisms (see IR3-29 of CEAR Document #984). The SRKW Recovery Strategy does not provide information regarding potential toxicological thresholds of the pollutants listed in Table 1 and the concentrations and potential toxicological effects of PCBs to marine mammals have been the focus of both DFO and the U.S. National Oceanic and Atmospheric Administration (NOAA) (Ross et al. 2011, Lachmuth et al. 2010, Alava et al. 2012, NOAA 2016, West et al. 2017). Overall, the available scientific knowledge, including guidance from DFO described above, suggests that potential health risks to predatory marine mammals

[1] CEAR Document #984 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 3 (See Reference Document # 928).
[2] CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, including the Interim Marine Sediment Quality Guidelines (ISQGs) and the Probable Effects Levels (PELs).

using PCBs as a surrogate for other contaminants should lead to similar conclusions about their risk potential.

Additional sampling of sediment and a high-resolution PCB congener[3] analysis was conducted by the VFPA to characterise dredging and disposal at sea[4] activities and to address transfer of PCBs through a food web-based ecological risk assessment model (EIS Appendix 9.6-B, EIS Appendix 14-D)[5]. A PCB food web bioaccumulation model[6] was adapted for the effects assessment from an earlier DFO model developed for resident killer whale food webs (Lachmuth et al. 2010, Alava et al. 2012) to determine if historical sediment-bound contaminants, if re-suspended, may be ingested and magnified through the food chain, ultimately adversely affecting the health of fish-eating killer whales.

Concentrations in Sediment Likely to be Mobilised Through Dredging

Sediment samples were collected from the lower Fraser River navigational channel, tug basin, and the dredge basin and were analysed for PCB congeners and total organic carbon[7] as a conservative proxy for the contaminants listed in Table 1 of the SRKW Recovery Strategy.

No collected samples exceeded the CCME criteria for total PCBs in the tug and dredge basins or the Fraser River maintenance dredging sites (EIS Appendix 9.6-B; Table IR3-25-1, Appendix IR3-27-A of CEAR Document #984). Furthermore, total PCB congeners in the receiving environment will not increase as a result of Project construction. PCB concentrations in the dredge basin, tug basin expansion area, and Fraser River sands are lower than surficial sediment samples from the broader Strait of Georgia. PCB concentrations of suspended sediments during construction are the same as concentrations in the existing environment, when expressed on the basis of normalised organic carbon or normalised percent fines concentrations (EIS Appendix 14-D; see IR3-29 of CEAR Document #984). Overall, existing sediment concentration

[3] The concentrations, fate, and effects of PCBs, analysed and interpreted based on high resolution gas chromatography (HRGC) – high resolution mass spectrometry (HRMS) (i.e., a congener-based analytical method (e.g., EPA method 1668). A congener is a unique, well-defined chemical compound in PCBs out of a total of 209 congeners.

[4] The discharge area for decant water from the containment dykes during infilling is no longer referred to as the Roberts Bank candidate disposal at sea area for reasons explained in the *Preamble in Support of Responses to IR3-25 to IR3-40* (CEAR Document #984).

[5] "In order to ensure that excavation of sediments from sites within or adjacent to Resident Killer Whale critical habitat do not increase exposure of Resident Killer Whales to PCBs, DFO recommends that Proponents perform high resolution PCB congener analysis of sediments proposed for excavation, and the sampling results against thresholds identified by Ross et al. 2011." (CEAR Document #988).

[6] The model provides conservative predictions of PCB concentrations in SRKW tissues relative to observed or predicted levels in surface sediments within critical habitat. The model assumes equilibrium partitioning from sediment to water and sediment-associated biota that do not account for reduced bioavailability as a result of contaminant aging in sediments, nor stronger sorption in the sediment matrix to other substances (such as soot carbon). In addition, the predictions of PCB levels in higher trophic consumers relative to concentrations in prey items will generally predict concentration within an order of magnitude accuracy, with model parameterisation over-predicting (as opposed to under-predicting) the overall magnitude of trophic transfers.

[7] Persistent organic pollutants preferentially adsorb to organic carbon and finer textured sediments; detectable PCBs are primarily found in areas of finer-textured organic-rich sediments (EIS Appendix 9.6-B).

of pollutants listed in Table 1, including PCBs, are not predicted to change as a result of re-suspension of sediments during Project construction.

Comparison with Canadian Council for Ministers of the Environment Interim Sediment Quality Guidelines or Other Applicable Guidelines

As stated above, there are no regulated CCME sediment quality guidelines for contaminants listed in Table 1 of the Recovery Strategy, other than PCBs and PAHs. The CCME guidelines for PCBs do not account for exposures to pollutants of higher predators such as marine mammals based on food web-mediated biomagnification. As stated above, no other sediment guidelines or thresholds related to potential toxicological effects on marine mammals exist for pollutants listed in Table 1 of the SRKW Recovery Strategy (DFO 2011).

Potential for Contaminants to Result in Toxicological Effects to SRKW and Steller Sea Lion

Based on the distribution of PCBs in sediments, the water column, and biota, the food web-based risk assessment model predicted that PCB concentrations in SRKWs from the re-distribution of sediments during Project construction were negligible compared to levels in SRKW predicted during existing conditions (EIS Section 14.6.1.4, EIS Appendix 14-D; see IR3-29 of CEAR Document #984). As stated above, because no measurable changes in existing concentrations of PCBs as a persistent pollutant are anticipated to result from Project construction activities, no toxicological effects to SRKW or Steller sea lion are expected (EIS Appendix 9.6-B). Therefore, there is also likely a negligible potential for contaminants listed in Table 1 to result in adverse health effects to SRKW and Steller sea lions due to Project construction.

The DFO SRKW Action Plan (DFO 2017) recommends a number of recovery actions to further quantify and understand the existing risks associated with all potential contaminants and the potential for toxicological effects affecting the recovery of SRKW. To help meet these recovery actions, the VFPA's Enhancing Cetacean Habitat and Observation (ECHO) Program (see response to IR4-10 of CEAR Document #1051[8]) is supporting initiatives to better understand and manage these risks.

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Appendices

Appendix IR5-37-A Pollutants Listed in Table 1 of the Recovery Strategy for SRKW (DFO 2011)

APPENDIX IR5-37-A
POLLUTANTS LISTED IN TABLE 1 OF THE RECOVERY STRATEGY FOR SRKW (DFO 2011)

Appendix IR5-37-A: Pollutants Listed in Table 1 of the Recovery Strategy for SRKW (DFO 2011)

- DDT – dichlorodiphenyltrichloroethane;
- PCBs – polychlorinated biphenyls;
- Dioxins and Furans (PCDD/Fs) – polychlorinated dibenzo-p-dioxins / polychlorinated dibenzofurans;
- PAHs – polycyclic aromatic hydrocarbons;
- Flame retardants: polybrominated biphenyls (PBBs) and PBDEs – polybrominated diphenyl ethers;
- PFOs – perfluoroctane sulfonate;
- TBT, DBT – tributyltin, dibutyltin;
- PCPs – polychlorinated paraffins;
- PCNs – polychlorinated naphthalenes;
- APEs – alkyl-phenol ethoxylates; and
- PCTs – polychlorinated terphenyls.

IR5-39 Marine Mammals – Light

Information Source(s)

EIS Volume 2: Appendix 8-B

EIS Volume 3: Section 14, Table 14-9

Context

In Appendix 8-B of the EIS, the Proponent indicated that there is an interaction between overpass lighting and rail switch lighting and the marine mammals valued component. However, in Table 14-9 of the EIS, there is no entry in the table describing this Project activity and its corresponding potential effect rating or the nature of the potential interaction and effect. Further information is required to determine the potential effects of overpass lighting and rail switch lighting on marine mammals in the local assessment area for the proposed Project.

Information Request

Complete Table 14-9 to include overpass lighting and rail switch lighting.

VFPA Response

The interaction between overpass lighting and rail switch lighting and the marine mammals valued component indicated in Appendix 8-B of the EIS was in error. There is no anticipated interaction. Light from the Project is not anticipated to extend into the water, and known marine mammal haulouts in the local assessment area for the Project are located at Sand Heads, approximately 16 kilometres from overpass lighting and rail switch lighting, where light will not reach (Marine Shipping Addendum Figure 8.2-3).

IR5-40 Marine Mammals – Stress-Related Immune Suppression

Information Source(s)

EIS Volume 2: Section 8

EIS Volume 3: Section 14

Context

In Section 8 of the EIS, the Proponent indicated that there may be technical limitations (such as unavoidable gaps or model limitations) to the assessment of potential effects of the proposed Project, and that the nature of those limitations and their implications on the effects assessment would be described.

Further, in Section 14 of the EIS, the Proponent stated that some potential effects from underwater noise on marine mammals could not be predicted using injury and behavioral effects thresholds. The Proponent stated that another potential effect from underwater noise is stress-related immune suppression, but that it was not included in the assessment of potential effects on marine mammals. However, the Proponent did not provide a rationale for why stress-related immune suppression was not included in the assessment, and did not describe the implications of this effect not being considered further. Additional information is required to determine why stress-related immune suppression was not included in the effects assessment for marine mammals, and to determine the implications of this lack of inclusion.

Information Request

Provide a rationale for why stress-related immune suppression was not considered in the assessment of effects of underwater noise on marine mammals.

Describe the implications of not including stress-related immune suppression as a factor in the prediction of the effects of underwater noise on marine mammals.

VFPA Response

Provide a rationale for why stress-related immune suppression was not considered in the assessment of effects of underwater noise on marine mammals.

Potential effects of stress-related immune suppression in marine mammals due to underwater noise from the Project, marine shipping associated with the Project, or cumulative effects of commercial shipping traffic were not measured or predicted in this assessment. Data on this subject matter are lacking, and the southern resident killer whale (SRKW) Technical Advisory Group (TAG) advised against including stress-related immune suppression in the assessment of effects of underwater noise on endangered SRKW due to the invasive nature of data collection required to quantify potential effects (i.e., vessel noise, physical disturbance). Furthermore, the SRKW TAG questioned the ability of results to meaningfully reduce

uncertainty as it is not possible to distinguish between the many factors that may induce or influence the stress response of an individual, such as sex, age, prey, body condition, or distinguish immune suppression effects from various stressors (Compass 2013). There remains high uncertainty and gaps in knowledge as to the health consequences of stress-related responses and potential immune suppression to marine mammal individuals and populations (NRC 2005, NAC 2017). It is unknown whether these responses to underwater noise result in biologically significant effects that may have long-term consequences for individuals or populations (NRC 2005, NAC 2017).

Describe the implications of not including stress-related immune suppression as a factor in the prediction of the effects of underwater noise on marine mammals.

There are no implications of not including stress-related immune suppression as a factor in the prediction of the effects of underwater noise on marine mammals; in particular, its exclusion does not change the conclusions described in the EIS.

Potential effects of underwater noise on marine mammal behavioural responses, acoustic masking, and availability of prey were assessed using conservative assumptions such that potential effects are likely overpredicted; therefore, any potential stress-related immune suppression effects are indirectly captured in the assessment. Further, because the predicted difference in Project-related underwater noise between existing conditions and the operation phase is so small, individual marine mammals are unlikely to experience stress-related health effects that compromise their ability to survive or reproduce or result in population-level effects. For these reasons, the omission of this effect pathway will not change the conclusions described in the EIS.

References

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IR5-41 Marine Mammals – Vessel Strikes

Information Source(s)

Marine Shipping Addendum: Section 8.2.6.3

Context

In Section 8.2.6.3 of the Marine Shipping Addendum, the Proponent presented information on potential physical disturbance that could result from vessel strikes. The Proponent highlighted a previous quantitative analysis of vessel strike risk that was carried out by Stantec for the Trans Mountain Expansion Project environmental assessment. This model assumed 348 Aframax class tanker vessel calls per year. However, the Proponent also indicated that the representative container ships associated with the proposed Project travels at an average of 20 knots, which is approximately double the speed of the Aframax class tankers used in the Stantec model. The Proponent indicated that this could increase the rate of encounter and/or likelihood of strike in some areas of the local assessment area for the marine shipping associated with the Project, depending on vessel speed.

The Proponent stated that despite the differences between container and tanker traffic, the quantitative analysis carried out by Stantec provided a reasonable estimation of the potential vessel-whale encounter risk and a proxy for strike risk. However, the Proponent indicated that vessel speed has been correlated with both the probability and severity of vessel strikes, and highlighted that vessels travelling at speeds of more than 14 knots provide the greatest threat of collisions with cetaceans. The Proponent stated that the likelihood of a vessel strike causing serious or fatal injury to a marine mammal depends on the probability of encounter, the probability of a strike occurring, and the probability that the strike results in severe or fatal injuries.

Further information is required to determine how the Proponent used the Stantec study in combination with other lines of evidence to make its conclusions regarding the effects of vessel strikes on marine mammals. Further information is also required to determine whether the Stantec study provides a reasonable estimation of vessel strike risk for the proposed Project.

Information Request

Describe how the Stantec study was used in combination with other lines of evidence to make conclusions regarding the frequency and effects of vessel strikes on marine mammals in the marine shipping area.

In consideration of criteria including but not limited to vessel speed and size, provide a comparison of the marine shipping associated with the proposed Project with that of the marine shipping associated with the Trans Mountain Expansion Project to determine the differences in:

- probability of encounter;

- probability of a strike occurring; and
- the probability that the strike results in severe or fatal injuries to marine mammals.

Based on this comparison, highlight whether any of the criteria ratings or significance determinations presented in Table 8.2-12 or Table 8.2-13 would change.

VFPA Response

This response focuses on baleen whales (represented by humpback whales) as it is unlikely that container ships associated with the Project would strike a toothed whale (represented by southern resident killer whale (SRKW)) or a pinniped (represented by Steller sea lion), resulting in injury or mortality (Marine Shipping Addendum (MSA) Section 8.2.6.3). As stated in the MSA, smaller marine mammals are less vulnerable to collisions with large vessels than larger baleen whales given that their greater overall manoeuvrability, echolocation capabilities (for toothed whales), and social behaviour (groups of individuals travelling together may enhance vessel detection and escape (Lawson and Lesage 2013)). Furthermore, vessel strikes were not identified as a potential threat in the DFO Management Plan for Steller sea lions or the SRKW Recovery Strategy. This approach was supported by DFO's Canadian Science Advisory Secretariat (CSAS), which, in its review of the MSA, stated that the "conclusion that ships pose a very low risk of causing injury or mortality to SRKWs and Steller Sea Lions through collisions is reasonable" (CEAR Document #919[1]).

This response will describe how the Stantec (2015) study (the 'Stantec study') was used in combination with other lines of evidence to make conclusions regarding the potential effects of vessel strikes to humpback whales from the incremental contribution of marine shipping associated with the Project to potential effects occurring during existing conditions.

Describe how the Stantec study was used in combination with other lines of evidence to make conclusions regarding the frequency and effects of vessel strikes on marine mammals in the marine shipping area.

As it is not possible to undertake a quantitative strike risk analysis (see DFO's response to DFO IR-12 of CEAR Document #988[2]), it is not possible to predict the risk of a strike during existing conditions or from the incremental contribution of RBT2-associated vessel traffic, or any project with associated shipping. In the absence of this information, a qualitative approach was taken in the MSA using multiple lines of evidence regarding the frequency and potential effects of vessel strikes from RBT2-associated container ship traffic on humpback whales in the marine shipping area. These multiple lines of evidence included the following:

- Cetacean encounter study completed to inform the assessment of tanker traffic associated with the Trans Mountain Expansion Project (Stantec 2015; i.e., the 'Stantec study');

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.
[2] CEAR Document #988 From Fisheries and Oceans Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on May 18, 2017 (See Reference Document # 969).

- Current status and population growth rate of humpback whales in B.C.; and
- Current state of knowledge regarding vessel strikes of humpback whales in B.C.

Each of these lines of evidence are further described below.

Trans Mountain Vessel Strike Study (the 'Stantec Study')

The Stantec study was used to inform the existing conditions within the marine shipping area relating to the current probabilities of existing vessel traffic encountering (sharing the same physical space at the same time, not striking) humpback whales. This existing information was then used in the assessment of marine shipping associated with the Project to qualitatively predict the anticipated probability of encountering whales with the incremental contribution of RBT2-associated shipping.

The MSA (as reflected in the context to this information request above) did acknowledge the speed differences between the Aframax carriers and RBT2-associated container ships and did not equate the two as being the same, nor did the assessment of marine shipping associated with the Project rely on Aframax-related carrier encounter risks to inform potential effects from RBT2-associated traffic.

Population Status of Humpback Whales in B.C.

As a result of substantive increases in the population since being listed as a Threatened species under the *Species at Risk Act* (*SARA*) in 2005, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reassessed the North Pacific population of humpback whales in 2011; this resulted in its status being downgraded from Threatened to Special Concern (COSEWIC 2011, 2014). In 2017, the humpback whale was reclassified from Threatened to Special Concern under *SARA* (GOC 2017), despite existing levels of marine shipping traffic in B.C.

Under existing conditions (2012; IR4-04 of CEAR Document #1051[3]), there are 16,820 vessel movements in Juan de Fuca Strait per year, where strike risk to humpbacks is considered greatest (Nichol et al. 2017). While effects of vessel strikes on individual humpback whales can be severe, current population growth trends in B.C. (approximately five percent annually) indicate that vessel strikes are not affecting overall population viability under existing conditions (DFO 2013). The risk to the humpback population in B.C. in 2030 due to vessel strikes from the addition of 520 incremental Project-associated shipping traffic movements per year to existing conditions (IR4-04 of CEAR Document #1051) was qualitatively determined to be low (MSA Section 8.2.8). DFO CSAS agreed with this conclusion and stated that the abundance of humpback whales is growing in B.C. and mortality due to ship strikes

[3] CEAR Document#1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).

due to vessels associated with the Project would not result in population-level effects (CEAR Document #919)[4].

State of Knowledge of Vessel Strike Risk in B.C.

The VFPA recently financially contributed to the first spatially explicit analysis estimating the relative risk of lethal collisions between commercial vessels and whales off the west coast of Vancouver Island, conducted by DFO (CEAR Document #1102[5], Nichol et al. 2017). This analysis identified areas with high probabilities of interaction between ships and humpback whales, including an area of high relative risk near the entrance to Juan de Fuca Strait and over Swiftsure Bank, where high densities of humpback whales occur. As stated above, DFO CSAS agreed with this conclusion and stated that the abundance of humpback whales is growing in B.C. and mortality due to ship strikes due to vessels occurring during existing conditions (DFO 2013) and vessels associated with the Project would not result in population-level effects (CEAR Document #919)[4]. Despite these efforts, DFO acknowledges that there currently remains a lack of spatial and temporal distribution and abundance data for humpback whales in the marine shipping area to quantify strike risk (CEAR Document #919).

Conclusions Regarding the Frequency and Effects of Potential Project-associated Vessel Strikes

In summary, it was concluded that incremental effects of vessel strikes from RBT2-associated vessel traffic would be moderate in magnitude[6] and occur infrequently above and beyond strikes occurring during existing conditions, and were determined to be not significant. These predictions were based on the multiple lines of evidence described above, including the following:

- Probability of encounter information from recent vessel strike risk models in B.C. (i.e., 'Stantec study');
- The observed growth of the humpback whale population in B.C, despite existing volumes of shipping traffic;
- Reclassification of humpback whales under *SARA* from Threatened to Special Concern;
- DFO analyses indicating that vessel strikes under existing conditions are not affecting overall population viability of humpback whales at this time[4] (DFO 2013); and
- The relatively small number of RBT2-associated container ships compared to all other marine vessel traffic (i.e., 520 incremental RBT2-associated movements out of

[4] In CEAR Document #919, DFO CSAS stated, "Although the abundance of Humpback Whales is growing in British Columbia and mortality due to ship strikes and other anthropogenic causes may be minor at the population level, due to high levels of site fidelity by individual Humpback Whales to feeding grounds, shipping associated with the Project could potentially result in local increased lethal encounters in the future (due to both increased whale and ship densities)."

[5] CEAR Document #1102 From Fisheries and Oceans Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on September 27, 2017 (See Reference Document #1062).

[6] Moderate magnitude was defined in MSA Table 8.2-12 as ranging from minor, reversible injuries that do not affect the survival of an individual to severe injuries resulting in mortality to an individual, but not affecting population recovery or viability in B.C.

21,695 movements of commercial vessels in Juan de Fuca Strait in 2030; IR4-10 of CEAR Document #1051).

In consideration of criteria including but not limited to vessel speed and size, provide a comparison of the marine shipping associated with the proposed Project with that of the marine shipping associated with the Trans Mountain Expansion Project to determine the differences in: probability of encounter; probability of a strike occurring; and the probability that the strike results in severe or fatal injuries to marine mammals.

The following response will provide a comparison of the marine shipping associated with the proposed Project with that of the marine shipping associated with the Trans Mountain Expansion Project, including probability of encounter, probability of a strike occurring, and the probability that the strike results in severe or fatal injuries to marine mammals.

Probability of Encounter

There will be 520 additional vessel movements associated with the Project per year through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait (see MSA Figure 1.1), while the Trans Mountain Expansion Project will result in 696 additional vessel movements per year through the same area. However, by 2050, the number of container ship movements associated with RBT2 is predicted to decrease from 520 to approximately 312 movements (IR4-02 of CEAR Document #1051), thereby reducing the probability of encountering humpback whales. The probability of a vessel encountering humpback whales is considered less for RBT2 than Trans Mountain, because there will be relatively fewer RBT2-associated vessel movements along shipping lanes through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait. It is important to note that container ships will likely travel slower than present day container ships (**Table IR5-41-1**), thus reducing strike risk (Laist et al. 2001, Jensen and Silber 2003, Vanderlaan and Taggart 2007).

Table IR5-41-1 Comparison between Trans Mountain Expansion Project and RBT2-associated Vessel Movements, Sizes, and Speeds in the Marine Shipping Area

Vessel Information	Trans Mountain Expansion	RBT2 2030	
		Marine Shipping Addendum	IR4-02[a]
Number of Vessel Movements through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait	696	520	520
Vessel Length (metres)	244	398	338
Vessel Speed (knots)	8.0 – 14.5[b]	16.0[c]	8.0 – 23.0[d]

Notes: a. IR4-02 of CEAR Document #1051.
b. See Stantec (2015).
c. Vessel speed ranges for a Triple-E class container ship are unavailable. Average cruising speed estimated as 16 knots.
d. See MSA Table 4-5.

Probability of a Strike Occurring and Probability of Severe or Fatal Injuries

Given it is not possible to undertake a quantitative strike risk analysis (see DFO's response to DFO IR-12 of CEAR Document #988), neither the Stantec study, nor the MSA included a prediction on the probability of a strike occurring and resulting in severe or fatal injuries to humpback whales.

Since 2015, the VFPA's Enhancing Cetacean Habitat and Observation (ECHO) Program has been supporting DFO in a project to evaluate the distribution and habitat of large baleen whales, and the potential for vessel strikes along shipping lanes off the west coast of Vancouver Island. In 2017, DFO published a preliminary report that detailed the use of whale distribution data obtained through aerial surveys in a modelling exercise to assess the risk of lethal ship strikes to humpback and fin whales off the west coast of Vancouver Island. The ECHO Program continues to support the DFO-led project through funding of aerial surveys and satellite tagging (see IR4-10 of CEAR Document #1051, DFO Evaluation of VFPA Response to IR4-10 of CEAR Document #1102).

Based on this comparison, highlight whether any of the criteria ratings or significance determinations presented in Table 8.2-12 or Table 8.2-13 would change.

The incremental contribution of approximately three vessel movements every two days over existing conditions is not predicted to result in population-level effects to the population of humpback whales in B.C. as the population is growing at a rate of approximately five percent (DFO 2013). In its recent review of the MSA (CEAR Document #919), DFO CSAS stated that recent increases in humpback whale abundance and site fidelity by individual humpback whales could potentially result in local increases in mortality to individuals from shipping associated with the Project in the future but not affect overall population viability[4].

Based on this comparison, no criteria ratings or significance determinations presented in MSA Table 8.2-12 or MSA Table 8.2-13 would change.

References

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IR5-42 Marine Mammals – Underwater Noise from Support Vessels

Information Source(s)

EIS Volume 2: Appendix 9.8-A

EIS Volume 3: Section 14, Table 14-8

Context

In Table 14-8 of the EIS, the Proponent indicated that potential changes to the acoustic environment from support vessels resulting in behavioral disturbance and/or acoustic masking on marine mammals ranged from negligible to moderate. In Appendix 9.8-A, the Proponent modelled several scenarios, some of which involved dredges and tugs. However, it is unclear how the Proponent defines support vessels, and how support vessels other than dredges and tugs (such as vessels used to transport construction materials or Fraser River sands) were included in the assessment of underwater noise and applied in the marine mammal effects assessment. Further information is required to determine the potential effects of underwater noise from support vessels on marine mammals.

Information Request

Provide a list of the types and sizes of support vessels that would be used during construction and operation of the proposed Project.

Describe if and how support vessels, such as vessels delivering construction materials, were included in the effects assessment of underwater noise on marine mammals.

If these types of vessels were not included, provide an assessment of the potential effects of underwater noise during construction on marine mammals from support vessels alone and in combination with vessels calling on the existing Roberts Bank terminals.

VFPA Response

Provide a list of the types and sizes of support vessels that would be used during construction and operation of the proposed Project.

Construction

Support vessels during the construction period are defined here as barges with associated tugs delivering materials (e.g., terminal fill, riprap).[1]

[1] Dredging vessels were not considered a support vessel in the assessment, and potential effects to marine mammals during dredging activities (by dredging vessels) were assessed in EIS Section 14.6.

Barges have no self-propelling ability and depend on tugs to transport and position them. Barges and tugs are not expected to differ from those currently transporting material in the region. Barges will range from 5,000 to 8,000 tonne capacities, between 60 to 85 metres long, and 15 to 25 metres wide. During the construction period, the tugs that will operate in VFPA jurisdiction are expected to range between 20 and 25 metres in length, with either single or twin propulsion engines.

Operation

Support vessels during Project operation are defined as tugs and line boats assisting the container ship approaching and leaving the terminal within VFPA jurisdiction. The Project will have the capacity to accommodate two tug operation contractors at the extended tug basin, each with moorage for three 30-metre, 80-tonne berthing and escort tugs, two 18-metre line handling tugs, and two six-metre small craft (EIS Section 4.2.3). Underwater noise from these support vessels and their potential effects to marine mammals during Project operation were described and assessed in the EIS Section 14.6.2.1.

Describe if and how support vessels, such as vessels delivering construction materials, were included in the effects assessment of underwater noise on marine mammals.

The potential effects of underwater noise generated by support vessels (i.e., tugs and barges) during construction were included in the effects assessment of underwater noise on marine mammals. Potential effects from support vessels were described in EIS Section 4.4.1 and were assessed qualitatively as minor[2] in EIS Table 14-8. Underwater noise from tug activity during construction is not anticipated to differ from underwater noise from existing vessel movements, including tug activity currently transporting material in the region. It is important to note that Project construction will occur within an established, urban marine port and adjacent waters are used extensively by marine traffic (i.e., 20,592 vessel movements in 2012 in Segment A, see Figure IR4-04-A1 of CEAR Document #1051[3], including existing tug traffic) with existing contributions of underwater noise to the acoustic environment and potential effects to marine mammals.

Furthermore, measurements of underwater noise from the harbour tug *Seaspan Resolution* were conducted at multiple transit speeds at Roberts Bank to inform the assessment (see Mouy et al. 2012 and *RBT2 Technical Data Report – Underwater Noise, Ship Sound Signature Analysis Study* (CEAR Document #936[4])). Based on these measurements, underwater noise produced from tug activity in VFPA jurisdiction during construction is not expected to change existing levels of underwater noise.

[2] A minor potential effect rating was considered to be of low consequence or severity in Table 14-8.
[3] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).
[4] CEAR Document #936 From the Review Panel Secretariat to the Review Panel re: Roberts Bank Terminal 2 Technical Data Report for Underwater Noise - Ship Sound Signature Analysis Study.

If these types of vessels were not included, provide an assessment of the potential effects of underwater noise during construction on marine mammals from support vessels alone and in combination with vessels calling on the existing Roberts Bank terminals.

As indicated above, the contributions of support vessels to underwater noise—and associated effects to marine mammals—were included and assessed qualitatively in the effects assessment as minor. Overall, underwater noise from support vessels is expected to be comparable to levels of underwater noise from existing marine vessel, including traffic tug activity currently transporting material in the region.

As described in EIS Section 14.7.1.1, the Underwater Noise Management Plan will outline measures to reduce construction noise, including that equipment and vessel propellers and hulls will be properly cleaned and maintained to minimise vibration and underwater noise. With the implementation of these mitigation measures, no detectable or measurable residual adverse effects from support vessels during construction are predicted for marine mammals.

References

Mouy, X., A. MacGillivray, J. Vallarta, B. Martin, and J. Delarue. 2012. Ambient Noise and Killer Whale Monitoring near Port Metro Vancouver's Proposed Terminal 2 Expansion Site: July–September 2012. Technical report prepared by JASCO Applied Sciences for Hemmera.

IR5-43 Marine Mammals – Underwater Noise from Decommissioning of Temporary Infrastructure

Information Source(s)

EIS Volume 2: Appendix 9.8-A

EIS Volume 3: Section 14, Table 14-8

Context

In Table 14-8 of the EIS, the Proponent indicated that the potential changes to the acoustic environment resulting in behavioral disturbance or masking on marine mammals from the removal of temporary piles was rated as moderate. However, in Appendix 9.8-A, decommissioning of temporary infrastructure, such as the removal of temporary piles, is not included in the list of modelled scenarios. Further information is required to determine the effects of underwater noise from the decommissioning of temporary infrastructure on marine mammals.

Information Request

Provide an assessment of the potential effects of underwater noise from the decommissioning and removal of temporary infrastructure on marine mammals.

VFPA Response

Underwater noise generated from the decommissioning and removal of temporary infrastructure is not predicted to result in residual effects to marine mammals.

Temporary infrastructure, including barge ramps and submarine discharge pipes, installed during construction of the terminal, will be removed and decommissioned at the end of the construction period (EIS Section 4.4.1.19). Specifically, decommissioning of the temporary barge ramps will include extraction and offsite disposal of all driven piles, demolition of any onshore pivot ramp abutments, and removal of any navigation markers or tie-up buoys. Decommissioning of submarine discharge pipes connecting the terminal and the discharge location involves their removal once all dredging activities have been completed.

The method to remove these items will be determined by the Infrastructure Developer. Options to remove navigation markers or tie-up buoys, and submarine discharge pipes would be by a barge-fixed crane. Options to decommission piles include removal from the ocean substrate by vibrohammer on a barge-fixed crane, or cutting the piles at their base using divers. While there is little information on the levels of underwater noise produced during pile removal, noise levels produced by removal of temporary barge ramp piles with a vibrohammer is anticipated to be similar to levels produced during installation. Removal using a crane barge is expected to generate similar noise levels as produced from a clamshell dredge, but less

than by using vibrohammer methods (A. MacGillivray (JASCO), personal communication, January 2018). Noise levels generated by removal by cutting are expected to be similar to those produced by a diamond wire cutter at less than 130 dB re uPa, which is less than levels produced by vibrohammer or crane barge (Pangerc et al. 2016).

Thus, underwater noise modelling of vibratory piling during the construction period is considered a representative worst-case estimation of underwater noise that may be produced during decommissioning and removal of temporary infrastructure (see EIS Appendix 9.8-A, Figure A-26). With the implementation of appropriate mitigation measures (as described in EIS Sections 14.7.11 and 33.3 for vibratory piling as an example, including underwater noise thresholds prescribed by DFO), no detectable or measurable residual adverse effects from underwater noise during decommissioning and removal of temporary infrastructure at the end of the construction period are predicted for marine mammals.

References

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Pangerc, T., S. Robinson, and P. Theobald. 2016. Underwater Sound Measurement Data During Diamond Wire Cutting: First Description of Radiated Noise. Fourth International Conference of the Effects of Noise on Aquatic Life. Dublin, Ireland, 10-16 July. Acoustical Society of America.

IR5-44 Marine Mammals – Factors Influencing Response to Underwater Noise

Information Source(s)

EIS Volume 3: Appendix 14-B

Context

In Appendix 14-B of the EIS, the Proponent indicated that many factors can influence the response of individual marine mammals to underwater noise, including sound characteristics, the physical and behavioral state of the animal, population demographics and the ecological context in which the animal encounters the sound.

Additional information is required to determine how different SRKW, North Pacific Humpback Whale and Stellar Sea Lion age classes would be affected by underwater noise originating from construction and operation of the proposed Project, and marine shipping associated with the Project.

Information Request

Describe how different SRKW, North Pacific Humpback Whale and Stellar Sea Lion age classes would be affected by underwater noise originating from construction or operation of the proposed Project, or marine shipping associated with the Project.

VFPA Response

This response will clarify how the assessment incorporated uncertainty regarding how different age classes of marine mammals are potentially affected by underwater noise from the Project and marine shipping associated with the Project. This response will also describe what is known about how different marine mammal age classes are potentially affected by underwater noise.

Background

In general, there are differences in how individual marine mammals respond to underwater noise based on multiple factors, as described in EIS Appendix 14-B and in the context to this information request. Age may be one of these many factors, though there is no evidence to suggest it is predictive. Overall, due to challenges in data collection and analytical methods in the field of marine mammal science, there is a lack of information available to distinguish how different marine mammal age classes, including southern resident killer whale (SRKW), North Pacific humpback whale, and Steller sea lion, would be affected by underwater noise originating from the construction or operation of any Project.

To account for some of this uncertainty, modelling conducted to predict Project-related underwater noise to inform the assessment included multiple conservative assumptions (EIS

Appendices 9.8-A and 9.8-B). This approach was supported by both the SRKW Technical Advisory Group (TAG) convened to inform the assessment (Compass 2013) and DFO's assessment of the EIS (CEAR Document #919[1]).[2] Modelling predicting underwater noise during construction used worst-case activity scenarios using colder, winter water profiles that result in larger predictions of underwater noise than warmer, summer profiles. Similarly, modelling predicting underwater noise during Project operation assumed a conservative scenario that all vessels (260 calls) during operation in 2030 would be Triple-E class (18,000 TEU (twenty-foot equivalent unit)) vessels assisted by four tugs. A more representative vessel size expected to call at RBT2 is 9,600 TEU assisted by two tugs (IR4-02 of CEAR Document #1051[3]).

Furthermore, resident killer whale-specific behavioural response criteria did include measured behavioural responses of different age classes (Williams et al. 2002a,b, Williams and Noren 2009, Williams et al. 2014, CEAR Document #938[4]), developed from three distinct datasets to inform the assessment (i.e., digital acoustic tags, shore-based theodolite, and passive acoustic monitoring; EIS Section 14.4.4.1).[5] Given these studies included a range of ages, it is reasonable to assume that the dose response behavioural thresholds developed for SRKW account for some of the variability and uncertainty in the responses of individuals and uncertainty in different age classes. In the shore-based study (Williams et al. 2014), animal age was specifically considered as one of the candidate covariates; however, empirical evidence suggests that a killer whale's response to the passage of a ship, on average, was best explained by its sex (with males less likely to respond than females), number of small vessels, and received noise level (with an increasing probability of response as received noise level increased)—not by age. Behavioural responses of killer whales to whale-watching boats was also previously shown to vary by sex (Williams et al. 2002a,b), with females again showing more responsiveness than males.

Overall, while an animal's age may play a role in a behavioural response to underwater noise, the relationship is not established well enough to be able to reliably describe effects by age

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.
[2] DFO Canadian Science Advisory Secretariat (CSAS) stated in CEAR Document #919 that, "A state-of-the-art numerical model was used to characterize the potential effects of underwater noise by pile driving and local vessel traffic on the Roberts Bank ecosystem. The assessment used estimates of underwater noise that were based on modeling of sound levels and propagation during construction and operation phases of the project. This model appears well developed using the best information as inputs, and its output seems reasonable. Of particular note is the Proponent's development of killer whale-specific thresholds for behavioural disturbance due to exposure to underwater noise, rather than using generic and somewhat obsolete thresholds commonly applied elsewhere."
[3] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).
[4] CEAR Document #938 From the Review Panel Secretariat to the Review Panel re: Roberts Bank Terminal 2 Technical Data Report for Marine Mammals - Determination of Behavioral Effect Noise Thresholds for Southern Resident Killer Whales.
[5] The behavioural disturbance criteria applied to humpback whales and Steller sea lions (i.e., regulatory criteria applied by the U.S. National Oceanic and Atmospheric Administration (NOAA) (see EIS Section 14.6.2.1) do not incorporate specific age-class information.

class. Causal factors of behavioural responses of marine mammals to underwater noise are variable and dependent on an unknown combination of internal and external factors that have not been thoroughly studied to date.

Describe how different SRKW, North Pacific Humpback Whale and Stellar Sea Lion age classes would be affected by underwater noise originating from construction or operation of the proposed Project, or marine shipping associated with the Project.

The following is a summary of what is known about age classes and hearing sensitivity in marine mammals.

Some studies have shown that the age of a marine mammal can influence its response to underwater noise. For example, mother-calf grey whale pairs were found to experience more behavioural disturbance from the presence of whale-watching boats compared to solitary adults (Tilt 1985). Humpback whale groups containing at least one calf were more responsive to approaches by small boats based on behavioural measures of respiration, diving, swimming, and aerial behaviors, compared to groups without a calf (Bauer et al. 1993). The measured responses in these studies were likely due to underwater noise, the physical presence of the whale watch vessels, or a combination of both. The variability of how individuals and populations respond to underwater noise is not fully understood and is dependent on internal and external factors. These factors include characteristics of the noise source, physical condition and health of the individual, and population demographic factors, including age (described in greater detail in EIS Appendix 14-B; NRC 2000, 2003, 2005, 2017; Williams et al. 2002a,b; Williams and Noren 2009).

It is likely that hearing sensitivity in all marine mammals decreases with age. For example, Houser and Finneran (2006) measured hearing thresholds in 42 bottlenose dolphins (28 male, 14 female), ranging in age from four to 47 years. Variations in hearing sensitivity with age and sex followed patterns seen in humans and terrestrial mammals: generally, within the population there was a progressive loss of high frequency hearing with age and an earlier onset of hearing loss in males than in females. Hearing loss generally occurred between the ages of 20 and 30, and all animals over the age of 27 had some degree of hearing loss.

References

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IR5-45 Marine Mammals – Southern Resident Killer Whale Response to Underwater Noise

Information Source(s)

TDR Marine Mammals - Determination of Behavioral Effect Noise Thresholds for Southern Resident Killer Whales (CEAR Doc#938)

Context

In CEAR Doc#938, the Proponent presented the results of a digital acoustic tag (DTAG) study of killer whale responses to ship traffic. This study was among 3 studies that were used by the Proponent to determine acoustic thresholds for killer whale behavioral responses to continuous noise from passing ships. The Proponent indicated that because of the lack of information on SRKW behavioral responses to ships, and the potentially invasive nature of any additional studies, the SRKW Technical Advisory Group suggested using existing data on SRKW, and if that was not available, using data collected on Northern Resident Killer Whale as a proxy for SRKW. The Proponent further indicated that data from an ongoing DTAG study on SRKW would not have been available in time for this proposed Project; therefore, data from a DTAG study on Northern Resident Killer Whales was used.

Further information is required to determine whether the data from the DTAG study on SRKW referred to by the Proponent is currently available. If the data is available, information is required to determine whether its inclusion would change the acoustic thresholds for killer whale behavioral responses that were estimated by the Proponent, and its subsequent use in the assessment of acoustic disturbance on SRKW.

Information Request

Indicate whether the DTAG study on SRKW has concluded and whether its data, results and conclusions are presently available for use by the Proponent.

If these data are available, describe whether the inclusion of these data would change the determination of behavioral effect noise thresholds for SRKW, and its subsequent use in determining noise exposure, acoustic masking, and the population consequences of disturbance model.

If these data are available, provide a comparison of the results before and after the inclusion of the SRKW DTAG data, and describe whether any of the ratings for the characterization of residual effects, or the determination of significance would change.

VFPA Response

Indicate whether the DTAG study on SRKW has concluded and whether its data, results and conclusions are presently available for use by the Proponent.

The DTAG (acoustic 3D tag) study on southern resident killer whales (SRKW), conducted by researchers from the U.S. National Oceanic and Atmospheric Administration, Cascadia Research Collective, University of Washington, and University of California, Davis, has concluded. The data, results, and conclusions of this study are therefore available for use by the VFPA.

If these data are available, describe whether the inclusion of these data would change the determination of behavioral effect noise thresholds for SRKW, and its subsequent use in determining noise exposure, acoustic masking, and the population consequences of disturbance model.

The SRKW DTAG dataset was examined to determine if it contained pertinent information regarding SRKW behavioural responses to large, commercial vessels that could supplement the findings of the assessment of potential effects of the Project on SRKW. The objective of this recent DTAG study was to examine the potential effects of small, whale-watching vessel traffic, and not large marine shipping traffic. It was determined that the data would not further inform the assessment because no data were collected on transits of large commercial vessels without small whale-watching vessels also being present, such that the data are not useful in documenting the behavioural responses of SRKW in the presence of large vessel traffic only.

If these data are available, provide a comparison of the results before and after the inclusion of the SRKW DTAG data, and describe whether any of the ratings for the characterization of residual effects, or the determination of significance would change.

Although the SRKW DTAG dataset was available to the VFPA, it was determined not to be relevant to the assessment and, for the reasons outlined above, a comparison of the results before and after inclusion is not provided. The ratings for the characterisation of residual effects, or the determination of significance, will not change.

IR5-46 Marine Mammals – Southern Resident Killer Whale, Time Interval for Behavioural Responses to Underwater Noise

Information Source(s)

EIS Volume 3: Section 14, Appendix 14-B, Appendix 14-C

Context

In Section 14 of the EIS, the Proponent indicated that low-severity behavioural responses to underwater noise have been predicted to last 5 minutes and are considered relatively minor and brief, and moderate-severity behavioural responses have been predicted to last 25 minutes and have a higher likelihood of affecting foraging, reproduction, and subsequent long-term vital rates of individual whales. However, the Proponent also stated that 5 minutes may not have been a suitable time window to capture a good estimate of a behavior (see page 10 of Appendix B of Appendix 14-C of the EIS).

Further information is required to determine the implications of using different time intervals to capture estimates of behavioral response to underwater noise and determine how it would change the duration of low and moderate severity responses and acoustic masking experienced by SRKW.

Information Request

Provide a discussion of how the use of both shorter and longer time intervals to capture behavioral response to underwater noise would change the duration of low and moderate severity responses and acoustic masking experienced by SRKW.

VFPA Response

The use of shorter and longer time intervals to capture behavioural response to underwater noise would affect the precision of estimates of duration of low and moderate severity responses[1] and acoustic masking experienced by southern resident killer whales (SRKW). If smaller increments of time (one minute) were used, estimated duration of low and moderate severity responses would be more precise (e.g., individual estimates could have been in increments of one minute instead of five minutes). However, as demonstrated by analyses of data collected from acoustic tagging (i.e., DTAGs) of northern resident killer whales, the use of smaller time intervals would not have resulted in a material change in the estimate of duration (see Appendix B of CEAR Document #938[2]). Specifically, northern resident killer

[1] Low-severity behavioural responses are relatively brief and minor; moderate-severity behavioural responses have a higher potential to affect foraging, reproduction, or survival (EIS Section 14.6.2).
[2] CEAR Document #938 From the Review Panel Secretariat to the Review Panel re: Roberts Bank Terminal 2 Technical Data Report for Marine Mammals - Determination of Behavioral Effect Noise Thresholds for Southern Resident Killer Whales.

whale DTAG data were subject to both a 'randomisation test' and a 'B-spline regression analysis' based on five-minute and one-minute increments, respectively, and both approaches yielded the same result, concluding that moderate-severity behavioural responses last, on average, 25 minutes.

In contrast, integrating the behavioural data over longer periods of time (e.g., 10 or 15 minutes) would decrease the precision of estimates and may result in an underestimate of the duration of moderate-severity behavioural response. As the duration over which a behaviour is averaged increases, the more the behavioural response may be diluted. For example, if a SRKW calling rate[3] is calculated over one- or five-minute intervals, the calling rate returning to 'normal' after 25 minutes can be detected. However, if a 10-minute interval is used instead, the first two 10-minute intervals would show an elevated calling rate, while the final 10-minute interval would represent a blend of both elevated and 'normal' calling rates. This could lead researchers to conclude that the estimate of behavioural response is 20 minutes, rather than 25 minutes, hence underestimating its duration.

[3] The rate of vocalisations used to maintain contact between group members.

IR5-47 Marine Mammals – Southern Resident Killer Whale Usage of Swiftsure Bank

Information Source(s)

CEAR Doc#919

Marine Shipping Addendum: Section 8.2, Appendix 8.2-A

CEAR Doc#966

Context

In its Technical Review of the EIS and Marine Shipping Addendum (CEAR Doc#919), Fisheries and Oceans Canada reported that recent passive acoustic monitoring at Swiftsure Bank indicated that SRKW were present on 24% of days over a two-year study period, which is equivalent to an average of 88 days per year. According to Fisheries and Oceans Canada, this area is under consideration for critical habitat designation under the *Species at Risk Act*, and is used year-round by the SRKW pods K and L, which seldom enter the SRKW regional assessment area during winter and early spring. Although Swiftsure Bank is included in the extended region described in Section 8.2 and Appendix 8.2-A of the Marine Shipping Addendum, its importance to SRKW in terms of annual usage is underestimated as the information obtained by Fisheries and Oceans Canada was unavailable to the Proponent. Fisheries and Oceans Canada has recently released a report on the Identification of Habitats of Special Importance to Resident Killer Whales (CEAR Doc#966), which reaffirms the importance of Swiftsure Bank to SRKW. Thus, the magnitude of SRKW exposure to the disturbance and masking effects of Project-related shipping could be greater than described in the EIS and the Marine Shipping Addendum.

Information Request

Revise the killer whale behavioural response analysis for western Juan de Fuca Strait in Appendix 8.2-A of the Marine Addendum using new information on SRKW use around Swiftsure Bank and provide a discussion of any predicted changes in behavioral response to marine shipping associated with the proposed Project. Consultation with Fisheries and Oceans Canada is suggested to obtain this information.

Update Table 8.2-7 of the EIS to reflect any changes in the number of behavioral responses and hours of behavioral disturbance in the local assessment area, as denoted by Figure 8.2-1 of the Marine Shipping Addendum.

Describe whether any of the criteria ratings in Table 8.2-11 of the Marine Shipping Addendum would change as a result of the inclusion of this information.

VFPA Response

Revise the killer whale behavioural response analysis for western Juan de Fuca Strait in Appendix 8.2-A of the Marine Addendum using new information on SRKW use around Swiftsure Bank and provide a discussion of any predicted changes in behavioral response to marine shipping associated with the proposed Project. Consultation with Fisheries and Oceans Canada is suggested to obtain this information.

The Marine Shipping Addendum (MSA) described the assessment of the potential behavioural and acoustic masking effects from Project-associated shipping to southern resident killer whale (SRKW) in the Focused Model Area and the Extended Region, two subsets of the marine shipping local assessment area (LAA) (MSA Figure 8.2-5; also see EIS Appendix 14-B).[1]

The VFPA would like to clarify that the first year of DFO's acoustic monitoring data collected at Swiftsure Bank was available and acquired during the writing of the MSA; these data were subsequently used in the SRKW behavioural response analysis in the Extended Region (western Juan de Fuca Strait) (MSA Appendix 8.2-A). The second year of acoustic monitoring data were not available at the time of writing the MSA, but are now available, and are included and summarised in this response.

The SRKW behavioural response analysis for western Juan de Fuca Strait region (described in MSA Section 8.2 and MSA Appendix 8.2-A) was revised to incorporate the second year of passive acoustic monitoring data at Swiftsure Bank, as well new information regarding the mean monthly sightings of SRKW between 2001 and 2011. This new data was provided to the VFPA by DFO in response to this information request.

The annual occurrence of SRKW in the Extended Region was calculated using not only DFO's acoustic monitoring data and voluntary sightings data, but also satellite telemetry data from the U.S. National Oceanic and Atmospheric Administration (NOAA). A conservative approach was adopted by utilising the highest monthly occurrence derived from either of these datasets.

A comparison with the original analysis is presented in **Table IR5-47-1** and shows that, with the addition of this new passive acoustic monitoring data and sighting data, estimated SRKW occurrence within the Extended Region increased by approximately 10%, or 17 days (i.e., increase from 162 days to 179 days per year). A discussion of predicted changes in behavioural response to marine shipping associated with the proposed Project, based on this new data, is provided in the section below.

[1] Underwater noise modelling assumed a conservative scenario that all vessels (260 calls) during operation in 2030 would be Triple-E class (18,000 TEU (twenty-foot equivalent unit)) vessels assisted by four tugs. A more representative vessel size expected to call at RBT2 is 9,600 TEU assisted by two tugs (IR4-02 of CEAR Document #1051).

Table IR5-47-1 Estimated Days of SRKW Pod Occurrence Within the Extended Region

Analysis	Days of J Pod	Days of K Pod	Days of L Pod	Total Days of All Pods
MSA Appendix 8.2-A	57.08	60.39	44.94	162.41
MSA Appendix 8.2-A with New DFO Data	61.85	63.76	53.23	178.84
Percent increase (%)	8.4	5.6	18.4	10.1[a]

Note: Data in the table above based on calculations in MSA Appendix 8.2-A and using new DFO data (CEAR Document #966[2]).

a. Percent increase for all Pods uses difference in Total Days between MSA Appendix 8.2-A and Total Days with New DFO data, not simply a weighted average of the three pods.

Update Table 8.2-7 of the EIS to reflect any changes in the number of behavioral responses and hours of behavioral disturbance in the local assessment area, as denoted by Figure 8.2 1 of the Marine Shipping Addendum.

EIS Table 8.2-7 has been updated to reflect changes in the number of behavioural responses and hours of behavioural disturbance in the LAA (due to the addition of the second year of SRKW data in the Extended Region) and is presented below as **Table IR5-47-2**.

[2] CEAR Document #966 From the Review Panel Secretariat to the Review Panel re: Identification of Habitats of Special Importance to Resident Killer Whales off the West Coast of Canada.

Table IR5-47-2 Median Low- and Moderate-severity Behavioural Responses per Whale per Year in the Marine Shipping Local Assessment Area, including New DFO Swiftsure Bank Data (Updated EIS Table 8.2-7)

Assessment Area	Model Area	Predicted Behavioural Responses	Behavioural Severity Response					
			Low			Moderate		
			Existing	Existing + Shipping Associated with RBT2	Contribution of RBT2-associated Shipping	Existing	Existing + Shipping Associated with RBT2	Contribution of RBT2-associated Shipping
Local Assessment Area	Focused Model Area	Median number of responses per whale per year	1,482	1,556	74	624	650	26
		Predicted hours of disturbance per whale per year	123.50	129.67	6.17	260.00	270.83	10.83
	Extended Region	Median number of responses per whale per year	859 (+79)	872 (+80)	13 (+1)	242 (+22)	248 (+23)	6 (+1)
		Predicted hours of disturbance per whale per year	71.58 (+6.58)	72.67 (+6.67)	1.09 (+0.09)	100.83 (+9.16)	103.33 (+9.58)	2.5 (+0.42)
	Entire Local Assessment Area	Median number of responses per whale per year	2,341 (+79)	2,428 (+159)	87 (+1)	866 (+22)	898 (+23)	32 (+1)
		Median predicted hours of disturbance per whale per year	195.08 (+6.58)	202.33 (+6.66)	7.25 (+0.08)	360.83 (+9.16)	374.17 (+9.59)	13.33 (+0.42)
		Median predicted days of disturbance per whale per year	8.13 (+0.28)	8.43 (+0.28)	0.30 (+0.00)	15.03 (+0.38)	15.59 (+0.40)	0.56 (+0.02)

Note: Numbers in brackets indicate difference from values reported in EIS Table 8.2-7.

Low- and moderate-severity behavioural responses per SRKW per year in the Extended Region were re-calculated by applying the all pod average of 10.1% in the occurrence of SRKW in this area, based on the conservative annual SRKW occurrence estimated for the region (179 days) recalculated using the second year of DFO's passive acoustic monitoring data at Swiftsure Bank. As a consequence, under existing conditions, the total number of behavioural responses within the Extended Region increased by 79 low-severity and 22 moderate-severity behavioural responses, respectively. The inclusion of marine shipping associated with Project resulted in an increase of 80 low-severity and 23 moderate-severity behavioural responses. Thus, the resulting incremental contribution of marine shipping associated with the Project to SRKW behavioural effects in the marine shipping LAA increased by one low-severity behavioural response and one moderate-severity behavioural response per whale per year (**Table IR5-47-2**). The SRKW behavioural response model is a multi-stage probabilistic approach that incorporates uncertainty in acoustic dose-response thresholds, pod monthly occurrence, and pod location to define 95% confidence intervals in estimated behavioural responses. The incremental effects described in this response are very small and considered not discernible when viewed within the context of previous model results and associated wide 95% confidence intervals described in MSA Table 8.2-7.

Describe whether any of the criteria ratings in Table 8.2-11 of the Marine Shipping Addendum would change as a result of the inclusion of this information.

Criteria ratings in MSA Table 8.2-11[3] would not change as a result of the inclusion of this information. This is because, as stated above, the calculated increase in the number of low- and moderate-severity behavioral responses in the LAA is not discernable from those already described in the MSA and the incremental contribution of marine shipping to existing conditions associated with the Project does not change.

[3] Magnitude: The LAA includes the designated critical habitat of this endangered species, and underwater noise from marine shipping associated with the Project will result in a measurable change including low- and moderate-severity behavioural responses and acoustic masking from continuous noise. These changes are unlikely to affect SRKW life functions, critical habitat features, population viability, or recovery. While effects of Project-associated shipping in combination with existing conditions are not predicted to be substantially different from existing conditions, the magnitude is conservatively rated as moderate due to the conservation status of SRKW and the possibility of chronic physiological and/or behavioural changes.
Extent: Residual effects of behavioural disturbance and acoustic masking of marine mammals will be concentrated along the shipping lanes in the LAA and will decrease with distance from the transiting container ship.
Duration: Underwater noise from marine shipping associated with the Project will extend for the life of the Project; therefore, the behavioural and acoustic masking effects are also expected to be long-term.
Frequency: Marine shipping associated with the Project will include 260 additional vessel calls through the Strait of Georgia, Haro Strait, and Juan de Fuca Strait, and 390 calls in the waters south of Victoria (Segment C). It will take RBT2-associated marine vessels approximately 7.0 hours to complete one transit of the LAA, and there are approximately 1.5 vessel calls every two days. In the case of some pods of SRKW, the residual effect will be frequent during the times of the year that species are seasonally present in the LAA.

IR5-48 Marine Mammals – Southern Resident Killer Whale, Destruction of Critical Habitat

Information Source(s)

EIS Volume 3: Section 14

CEAR Doc#919

Context

As presented in Figure 14-1 of the EIS, the proposed Project and marine shipping associated with the Project would be located in SRKW critical habitat. The Proponent defined the destruction of critical habitat as resulting if part of the critical habitat is degraded, either permanently or temporarily, such that its biophysical features would not be available when needed by SRKWs for foraging, mating, resting, or socializing. In Section 14.9.2.1 of the EIS, the Proponent concluded that all three of the critical habitat features (acoustic environment, availability of prey, and water and sediment quality) will not be affected by the Project when needed by individuals for their life functions of foraging, mating, resting, or socializing, and that destruction of critical habitat is therefore not anticipated.

The Proponent undertook an assessment of changes to the acoustic environment and characterized the residual effects for acoustic disturbance from operational noise. Predictions were provided for the occurrence of low and moderate severity behavioral responses to shipping noise, and although these were characterized by the Proponent as short-term, this could be considered as a temporary loss of function of critical habitat. Further information is required to determine the absolute area of critical habitat that would be temporarily or permanently degraded by the construction and operation of the Project and marine shipping associated with the Project.

Information Request

Provide an estimate of the absolute area and proportion of total area of SRKW critical habitat that will be temporarily or permanently degraded by acoustic and physical disturbance caused by construction and operation of the proposed Project and marine shipping associated with the Project.

VFPA Response

The following response provides information, where possible, regarding the absolute area and proportion of total area of southern resident killer whale (SRKW) critical habitat[1] that will be

[1] Definitions of critical habitat and critical habitat destruction used in the EIS, as defined in consultation with DFO, can be found in EIS Section 14.1.

affected by potential physical and acoustic effects from the Project and marine shipping associated with the Project.

Project Construction and Operation

Physical Disturbance

The only absolute area that can be provided in this response is in relation to the physical disturbance from the footprint of the Project that overlaps with SRKW critical habitat. The total area of critical habitat for SRKW is 247,844 ha (2,478.44 km^2) under the Critical Habitat Order of 2009[2]. The combined total marine footprint of the terminal and dredged berth pocket will be approximately 179.9 hectares (ha) (1.80 km^2, EIS Section 4.2.1 and EIS Figure 4-24) representing 0.07% of the Critical Habitat Order area (247,844 ha) and 0.02% of all U.S. and Canadian trans-boundary critical habitat (939,280 ha).

As stated in EIS Section 14.6.1.3, after the implementation of proposed mitigation and offsetting measures, no adverse effects to the availability of SRKW prey[3] (i.e., Chinook and chum salmon) are predicted as a result of physical disturbance associated with the Project footprint. Furthermore, changes to the critical habitat feature, water and sediment quality, during construction of the terminal are predicted to result in negligible effects to SRKW (EIS Section 14.6.1.4, EIS Appendix 14-D).

Construction – Acoustic Disturbance

To inform the assessment, underwater noise for in-water construction activities (i.e., vibro-densification, dredging, and pile driving[4]) were modelled and noise footprints of these activities were presented as sound contour maps and areas of potential behavioural effects to SRKW (EIS Section 9.8.7, EIS Appendix 9.8-A). These contour maps are estimates of areas ensonified by underwater noise from construction activities as a snapshot in a moment of time. During construction, both activities producing underwater noise and the potential effects to SRKW due to acoustic disturbance are not static and individual SRKW will move in space and time[5]. Potential effects are dependent on the probability of a SRKW being present and 'needing' features and attributes of critical habitat at that location at that time; thus, calculation of an absolute area is not technically possible.

During construction, mitigation measures will be implemented as outlined in EIS Section 14.7.1.1 and the response to IR5-49 (environmental management plans and subplans

[2] http://www.sararegistry.gc.ca/virtual_sara/files/ch_killer_whale_nthn_sthn_res_pops_0209_e.pdf.
[3] The biophysical features of SRKW critical habitat that support life functions, as identified in the Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada (Recovery Strategy; DFO 2011) and developed in consultation with DFO, are acoustic environment, availability of prey, and water and sediment quality (EIS Table 14-1).
[4] While both vibratory and impact pile driving were modelled and presented in the EIS, these activities will only occur for a short period of time during the installation of the temporary barge ramps and will only occur during daylight hours when detection of marine mammals in the defined buffer zone by trained marine mammal observers is likely.
[5] A description of the duration and frequency of Project construction activities can be found in EIS Appendix 4-E.

described in EIS Section 33.3, including the Environmental Training Plan (EIS Section 33.3.2), the Underwater Noise Management Plan (EIS Section 33.3.7), and the Marine Mammal Observation Plan (EIS Section 33.3.8)). These mitigation measures include the presence of trained marine mammal observers during construction and shut-down of pertinent construction activities when SRKW enter a prescribed buffer zone. With the implementation of mitigation measures during construction, no detectable or measurable residual adverse effects from underwater noise are predicted for SRKW. Thus, due to the implementation of effective mitigation measures during construction, no additional acoustic disturbance to SRKW or its critical habitat is predicted, exceeding those occurring during existing conditions.

Operation – Acoustic Disturbance

Underwater noise during Project operation (i.e., approach/departure and berthing/unberthing within VFPA jurisdiction) was modelled and noise footprints of these activities were presented as sound contour maps and areas of potential behavioural effects to SRKW (EIS Appendix 9.8-A, Figures A-44 and A-45). As stated above, these contour maps are estimates of areas ensonified by underwater noise during Project operation as a snapshot in a moment of time and do not consider established levels of underwater noise currently present during existing conditions. During operation, Project-related underwater noise will move in space and time; thus, calculation of an absolute area is not technically possible.

It is important to note that the Project will occur within an established, urban marine port and adjacent waters are used extensively by marine traffic (i.e., 20,592 vessel movements in 2012 in Segment A, see Figure IR4-04-A1 of CEAR Document #1051[6]) with existing contributions of underwater noise to the acoustic environment and potential effects to SRKW critical habitat. Underwater noise levels during operation of the Project may at times exceed current existing levels (EIS Section 9.8) but are generally comparable and will only exceed existing conditions for a small portion of the year; these predicted increases are based on highly conservative assumptions and are overestimated[7]. Approximately 260 Project-related container ships (i.e., 520 movements out of 25,315 marine vessel movements in Segment A in 2030, see IR4-04 of CEAR Document #1051) will call on RBT2 per year (see Figure IR4-04-A1 of CEAR Document #1051). Consequently, overall, the primary contributor of underwater noise in SRKW critical habitat will be from other marine vessel traffic.

[6] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).

[7] Underwater noise modelling assumed a highly conservative, worst-case scenario that all vessels (260 calls), during operation in 2030 would be Triple-E class (18,000 TEU (twenty-foot equivalent unit)) vessels assisted by four tugs. Given larger vessels can carry more TEU containers, fewer than 260 vessel calls at RBT2 would actually occur if all calls to RBT2 were made by Triple-E container ships. A more realistic vessel size expected to call at RBT2 in 2030 is 9,600 TEU assisted by two tugs (IR4-02 of CEAR Document #1051). The VFPA is currently conducting additional modelling studies to predict underwater noise produced during this more realistic operational scenario, to be submitted at a later date to the Review Panel.

Recent initiatives led by the VFPA through the Enhancing Cetacean Habitat and Observation (ECHO) Program and the Government of Canada to explore the effectiveness of mitigation measures to reduce shipping-related noise levels are described further below.

Marine Shipping Associated with the Project

Acoustic Disturbance

The Marine Shipping Addendum (MSA) provides detailed information[8] regarding the potential underwater noise levels and behavioural and acoustic masking effects to SRKW within its critical habitat during existing conditions and marine shipping associated with the Project (MSA Section 8.6, MSA Appendix 7.6-A, MSA Appendix 7.6-B, MSA Appendix 8.2-A, EIS Appendix 14-B, EIS Appendix 14-C). As stated above, estimates of the absolute area and proportion of total area of SRKW critical habitat that will be temporarily[9] degraded by acoustic disturbance caused by marine shipping associated with the Project are not technically possible or meaningful. Both shipping noise and the potential effects to SRKW due to acoustic disturbance are not static, moving in space and time, and are dependent on the probability of a SRKW being present and 'needing' features and attributes of critical habitat at that location at that time.

It is important to note that marine shipping associated with the Project will occur within established international shipping lanes used extensively by marine traffic for decades with existing contributions of underwater noise to the acoustic environment and potential effects to SRKW critical habitat (Figure IR4-04-A1 of CEAR Document #1051). Accordingly, there will be no change in the absolute area of the international shipping lane due to Project-associated shipping. Furthermore, the incremental contribution of Project-associated shipping to underwater noise levels within established lanes through critical habitat is small compared to those occurring from existing shipping traffic (MSA Figure 7.6-3; MSA Appendix 7.6-B, Table 7.6-B2).

Recent Initiatives

While estimates of absolute areas of potential effects to SRKW critical habitat from existing marine vessel traffic and RBT2 (and its associated shipping) are not technically possible, multiple initiatives are underway to try to understand and reduce potential effects associated with shipping noise to SRKW and its critical habitat.

As described in IR4-10 (CEAR Document #1051), through its EcoAction Program, the VFPA has provided incentives since January 2017 to vessels calling at RBT2 that reduce their

[8] The models used to inform the MSA regarding potential acoustic disturbance to SRKW and its critical habitat were recommended by the SRKW Technical Advisory Group and use the best science available (DFO technical review, CEAR Document #919). It is important to note that these models are intended to only be used as a relative comparison of existing and future acoustic environments to inform the assessment of potential effects of the Project on SRKW. Thus, these models are not intended to be interpreted as absolute predictions of the proportion of critical habitat potentially affected.

[9] SRKW critical habitat will not be permanently degraded by acoustic disturbance during marine shipping associated with the Project.

underwater noise. In addition, since 2014, the VFPA-led ECHO Program has worked collaboratively with marine shipping stakeholders to better understand and manage the impact of shipping activities on at-risk whales in southern B.C. waters, with a focus on SRKW and its critical habitat.[10] In its recent review of the Recovery Strategy for SRKW, DFO (2017a) stated that the VFPA's ECHO projects are addressing numerous recovery objectives outlined in the recent DFO SRKW Action Plan (DFO 2017b). As a result of the development of the Government of Canada's Oceans Protection Plan, Transport Canada is currently working with DFO and marine shipping stakeholders to explore mitigation measures to better understand and address the cumulative effects of shipping on SRKW and its critical habitat (CEAR Document #954[11], CEAR Document #1133[12]). Technically and economically feasible tools and strategies to mitigate the potential effects of marine vessel activities are expected to be implemented by Transport Canada by 2021 to 2022 (CEAR Document #954).

References

Fisheries and Oceans Canada (DFO). 2011. Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries & Oceans Canada, Ottawa, ix + 80 pp.

Fisheries and Oceans Canada (DFO). 2017a. Action Plan for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 33 pp.

Fisheries and Oceans Canada (DFO). 2017b. Evaluation of the Scientific Evidence to Inform the Probability of Effectiveness of Mitigation Measures in Reducing Shipping-Related Noise Levels Received by Southern Resident Killer Whales. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/041.

[10] An overview of the EcoAction and ECHO programs is provided in the response to IR4-10 (CEAR Document #1051).
[11] CEAR Document #954 From Transport Canada to the Review Panel re: Overview of the Government of Canada's Oceans Protection Plan.
[12] CEAR Document #1133 From Transport Canada to the Review Panel re: Additional information regarding the Government of Canada's Ocean Protection Plan (See Reference Document #954).

IR5-49 Marine Mammals – Mitigation of Underwater Noise During Construction

Information Source(s)

EIS Volume 3: Section 14

CEAR Doc#919

TDR MM-1 Marine Habitat Use Studies

Context

In Section 14 of the EIS, the Proponent indicated that with the implementation of mitigation measures during construction, no detectable or measurable residual adverse effects from the proposed Project-generated underwater noise are predicted for marine mammals.

However, in CEAR Doc#919, Fisheries and Oceans Canada indicated that if construction activities are undertaken when the buffer distance (or safety zone) is not visible to marine mammal observers due to darkness or fog, hydrophone detection cannot be relied upon with complete certainty as a means to determine if SRKWs are in the area and potentially exposed to high noise levels. Fisheries and Oceans Canada stated that resident killer whales frequently travel in silence, so passive acoustic monitoring would be an ineffective detection method at such times. Although in TDR MM-1, the Proponent estimated that SRKW were silent only 3% of the time, it is unclear whether the use of hydrophone detection would be an effective mitigation measure.

Further information is required to determine whether other measures could be used to mitigate the potential effects of underwater noise on marine mammals during construction of the proposed Project, and to characterize the residual effects if residual effects of underwater noise during construction are predicted to occur.

Information Request

Describe additional mitigation measures that could be used to avoid and/or reduce the potential effects of underwater noise on marine mammals during construction of the proposed Project.

Describe whether any contingency plans or additional mitigation measures would be developed and then be employed in the event that a transiting pod of SRKW is traveling in silence at nighttime, or under conditions of fog.

Quantify how all the proposed mitigation measures, including any additional measures identified in response to the above, would reduce the potential effects on marine mammals.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures.

If there is a residual effect predicted, provide a characterization of residual effects and determine the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

VFPA Response

As stated in the context to this information request, the VFPA concluded that with the implementation of proposed mitigation measures during construction, no detectable or measurable residual adverse effects from Project-generated underwater noise are predicted for marine mammals.

In its review of the EIS, DFO stated that "The noise mitigation measures proposed for the Project terminal construction area are standard approaches for such projects and are appropriate." (CEAR Document #919[1]). However, DFO also acknowledged some uncertainty that, "if construction activities are undertaken when the buffer distance (or safety zone) is not visible to marine mammal observers due to darkness or fog, hydrophone detection cannot be relied upon with complete certainty as a means to determine if SRKWs [southern resident killer whales] are in the area and potentially exposed to high noise levels." (CEAR Document #919).

As stated in EIS Section 14.7.1, there are no formal regulations in Canada regarding underwater noise mitigation and marine mammals; however, guidelines for standard industry practices have evolved in Canada and internationally. Guidance was initially developed for the mitigation of underwater noise effects from geophysical seismic surveys (Weir and Dolman 2007; DFO 2004, 2010). These guidelines have been successfully used in the Port of Vancouver (i.e., construction of Deltaport Third Berth (DP3))[2] and extensively throughout the world for decades to successfully mitigate the effects of underwater noise on marine mammals from seismic surveys and a range of marine activities, including marine construction (see Weir and Dolman 2007, DFO 2010, and Martin et al. 2014 for a review of mitigation use and effectiveness).

After reviewing existing guidelines and recommendations, and other relevant scientific literature (i.e., Johnson et al. 2007; DFO 2010; JNCC 2010a,b,c, 2017; Nowacek and Southall 2016), a series of industry-best mitigation measures were proposed in the EIS for implementation during Project construction (EIS Section 14.7.1.1), including the following:

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.

[2] It is important to note that no SRKW were observed by marine mammal observers in the prescribed buffer zone during construction of the adjacent DP3 terminal. In the low likelihood that a SRKW occurred in the buffer zone at nighttime or during fog conditions, there is a high probability (97% of the time; see TDR MM-1 in Appendix AIR10-C of CEAR Document #388) that they would be detected acoustically.

- Reduction of construction noise, including gradual start-up of noise producing activity, maintenance of equipment, and noise reduction and dampening methods (e.g., bubble curtains during impact pile driving[3]);
- Establishment and monitoring of buffer distances by trained marine mammal observers and shutdown of relevant construction activities when marine mammals enter prescribed buffer zones; and
- During periods of darkness and fog, hydrophones will be used to detect vocalising marine mammals and monitor underwater noise to inform when noise-producing construction activities should be shut down.

Describe additional mitigation measures that could be used to avoid and/or reduce the potential effects of underwater noise on marine mammals during construction of the proposed Project.

Additional mitigation measures were identified by DFO (CEAR Documents #919 and #988[4]), which the VFPA has considered. As recommended by DFO, the VFPA will require the marine mammal observers to coordinate with existing whale sighting networks to receive advance warning of SRKW approaching the construction area to facilitate mitigation (CEAR Document #919). In addition, if any killer whale is observed in distress within the prescribed buffer zone, construction activities producing underwater noise will be suspended immediately and notification provided to DFO (see DFO IR-07 response in CEAR Document #988). Details will be provided in the Environmental Management Plans to be implemented during construction and will be discussed with DFO pursuant to the *Fisheries Act* Authorization.

Additional methods to detect marine mammals during periods of low visibility include radio detection and ranging (RADAR), active sonar, and thermal infrared (IR). These technologies have undergone preliminary testing, but few have been implemented in industry settings and there is little information and high uncertainty regarding the effectiveness of these methods (see Zitterbart et al. 2013, Verfuss et al. 2018)[5]. Due to the uncertainty in these emerging technologies in detecting marine mammals during periods of darkness or fog, the VFPA does not propose to implement any of these methods at this time but will continue to monitor their developments to determine their future applicability to avoid and/or reduce the potential effects of underwater noise during periods of low visibility (i.e., darkness or fog) during the construction period.

[3] Both vibratory and/or impact pile driving during installation of the temporary barge ramps will only be conducted during daylight hours. Impact pile driving is the only activity that could potentially result in hearing injury to marine mammals if not mitigated.

[4] CEAR Document #988 From Fisheries and Oceans Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on May 18, 2017 (See Reference Document # 969).

[5] In RADAR, radio or microwaves are emitted into the air and echoes from the animal's body, its exhalation, or from disturbance on the sea surface are picked up by an array of receivers. Active acoustic monitoring (active sonar) is a method where sound pulses are emitted into the water and acoustic reflections from an animal are received by hydrophones. Thermal IR uses an electro-optical imaging sensor to detect temperature differences between the body or the exhalation of the warm blooded marine mammal and that of the surrounding environment.

Describe whether any contingency plans or additional mitigation measures would be developed and then be employed in the event that a transiting pod of SRKW is traveling in silence at nighttime, or under conditions of fog.

No additional mitigation measures are being proposed in the event that a transiting pod of SRKW is travelling in silence at nighttime, or under conditions of fog. The mitigation measures proposed in the EIS are industry-best standards and have been successfully implemented for decades worldwide to mitigate potential effects to marine mammals from underwater noise. Furthermore, these measures should be considered conservative as they are the measures currently recommended during acute noise sources, such as seismic surveys, both by DFO (DFO 2010), by regulators worldwide (Martin et al. 2014), and were recommended and supported by DFO for RBT2 construction (CEAR Document #988). As described above, the VFPA is monitoring developments in the emerging technologies (RADAR, active sonar, and thermal IR) that could potentially be used in the future, if feasible.

Quantify how all the proposed mitigation measures, including any additional measures identified in response to the above, would reduce the potential effects on marine mammals.

Conclusions regarding the effectiveness of the mitigation measures proposed in the EIS are qualitatively based on their successful implementation during other projects reducing or eliminating potential effects to marine mammals worldwide for decades (Richardson et al. 1995; Johnson et al. 2007; DFO 2010; Stantec 2010; Weir and Dolman 2007; JNCC 2010a,b,c, 2017; Nowacek and Southall 2016). It is important to note that underwater noise levels that could potentially result in effects to marine mammals during construction are comparable to levels currently measured at Roberts Bank (EIS Section 14.6.2.1, EIS Section 9.8.7.1). Furthermore, coordination with existing whale sighting networks to receive advance warning of SRKW approaching the construction area will further facilitate effective detection of individuals and mitigation of potential effects. Project construction will occur adjacent to multiple terminals (i.e., Deltaport, BC Ferries) within an established urban port used extensively by marine traffic for decades (i.e., 20,592 vessel movements in Segment A in 2012, IR4-04 of CEAR Document #1051[6]) with existing contributions of underwater noise to the acoustic environment and potential effects to marine mammals.

Previous mitigation and monitoring of potential effects to marine mammals during construction of DP3 did not detect any measurable effects to marine mammals due to construction noise (Stantec 2010). In the unlikely event that a SRKW occurred in the buffer zone at nighttime or during fog conditions, there is a high probability (97% of the time; see TDR MM-1 in Appendix AIR10-C of CEAR Document #388[7]) that they would be detected acoustically with hydrophones. Hydrophone studies of SRKW conducted by the VFPA for over three years at Roberts Bank suggest that SRKW occurred less at night (64% of detections

[6] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).
[7] CEAR Document #388 From Port Metro Vancouver to the Canadian Environmental Assessment Agency re: Completeness Review - Responses to Additional Information Requirements Follow-Up (See Reference Document # 345) including 22 Technical Data Reports.

during daylight hours, 36% detections at night) compared to daylight hours, thus potentially reducing the probability of SRKW not being detected during nighttime hours. Furthermore, habitat use studies conducted by the VFPA indicate that SRKW are only occasionally present (i.e., 16 hydrophone detections at Roberts Bank compared to 62 detections in Haro Strait from August to December 2013) in VFPA jurisdiction and would occur primarily during the summer to fall period (TDR MM-1 in Appendix AIR10-C of CEAR Document #388). It is important to note that no SRKW were observed by marine mammal observers in the prescribed buffer zone during construction of the adjacent DP3 terminal (Stantec 2010). With the effective implementation of proposed mitigation measures described above, no detectable behavioural effects are anticipated from the incremental contribution of Project construction from those potentially occurring during existing conditions.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures. If there is a residual effect predicted, provide a characterization of residual effects and determine the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

With the implementation of mitigation measures during construction proposed in the EIS and additional measures proposed in this response, no detectable or measurable residual adverse effects of the Project from underwater noise over and beyond existing conditions are predicted for marine mammals. In summary, this conclusion is based on the following:

- Known occurrence of marine mammals within VFPA jurisdiction;
- Known effectiveness of proposed mitigation measures in reducing effects to marine mammals worldwide for decades;
- Coordination with local whale-watching fleet and whale sighting networks during the construction period; and
- Limitation of the loudest construction activities (i.e., vibratory and impact pile driving) to only daylight hours when certainty of marine mammal detection is greatest.

Additional measures proposed by DFO during the construction period will be incorporated into the mitigation planning as described above to improve the certainty of mitigation effectiveness (i.e., coordination with whale-watching fleet observations, reporting of distressed SRKW).

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IR5-50 Marine Mammals – Mitigation of Underwater Noise During Operation

Information Source(s)

EIS Volume 3: Section 14

Proponent Response to IR1-01 (CEAR Doc#897): Appendix IR1-01-A

CEAR Doc#919

Potential Acoustic Impacts of Vessel Traffic from the Trans Mountain Expansion Project on Southern Resident Killer Whales (Attachment to CEAR Doc#263)

Context

In Section 14 of the EIS, the Proponent stated that no specific mitigation measures are proposed to reduce underwater noise during the proposed Project operation and the resultant behavioural or acoustic masking effects for marine mammals.

In Appendix IR1-01-A of the response to Review Panel information request IR1-01, the Proponent provided a Port Information Guide that detailed how it asserts its authority on vessels that intend to enter or are within the waters controlled by the Port Authority. The purpose of this guide was stated to be the promotion of safe and efficient navigation within the local waters of the port and the protection of the marine environment.

In CEAR Doc#919, Fisheries and Oceans Canada highlighted that the SRKW Technical Advisory Group discussed a number of potential mitigation measures that could be considered to maintain underwater noise at or near existing levels despite increasing shipping associated with the proposed Project. For example, a range of quieting technologies and measures are possible such as, ship hull and propeller design and maintenance, management of thruster use, improvements to onboard machinery and mounting, and speed restrictions. However, none of these potential mitigation measures are discussed or proposed in the EIS or the Marine Shipping Addendum.

Information is required to determine the mitigation measures that are or could be employed by the Proponent to reduce underwater noise during operation of the Project.

Information Request

Describe the measures that are or could be used within the Proponent's control to mitigate the potential effects of underwater noise on marine mammals during the proposed Project operation, such as the measures included in the EcoAction/Blue Circle Award.

Quantify how the mitigation measures described above would reduce the potential effect on marine mammals.

Describe the technical and economic feasibility of these mitigation measures and provide a rationale for why such measures may or may not be implemented.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures.

If there is a residual effect predicted, provide a characterization of residual effects and predict the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

VFPA Response

Describe the measures that are or could be used within the Proponent's control to mitigate the potential effects of underwater noise on marine mammals during the proposed Project operation, such as the measures included in the EcoAction/Blue Circle Award.

As discussed in the context to this information request, the Southern Resident Killer Whale Technical Advisory Group (SRKW TAG) discussed potential mitigation measures for both the Project and marine shipping associated with the Project. The following sections will describe these potential mitigation measures and the rationale for their exclusion from the assessment.

Management of Container Ship

Potential mitigation measures during Project operation suggested by the SRKW TAG included reductions of container ship speeds and management of thruster use. The typical service speed of a container ship in this region is between 18 to 20 knots. By the time they enter VFPA jurisdiction, container ships have already slowed considerably to approximately 10 knots and this speed is reduced to approximately six to eight knots once the tugs have tethered to the vessel. Speeds of both the container ship and associated tugs are reduced further as the container ship is manoeuvred into its berth at the terminal. The use of container ship thrusters and tugs to assist the ship into its berth is under the care and control of the Canadian marine pilot to ensure safe and efficient operation of the ship. Thus, management of vessel speed and thruster use of container ships is under the care and control of the marine pilot, not the VFPA, and thus was not proposed as a feasible mitigation measure during Project operation.

The VFPA-led Enhancing Cetacean Habitat and Observation (ECHO) Program is currently engaging with tug operators to explore and understand the contribution of underwater noise from a range of tugs under different speeds and operating conditions. It is hoped that this work will help inform what future vessel noise reduction options might be available to tugs operating within the port and within the wider region.

Container Ship Design and Maintenance

As stated in the context to this information request, the SRKW TAG proposed potential mitigation measures to reduce underwater noise, including vessel quietening technologies such as ship hull and propeller design and maintenance, and improvements to onboard machinery and mounting. The design and maintenance of foreign vessels calling at the Port of Vancouver is not under the care and control of the VFPA.

However, as described in IR4-10 (CEAR Document #1051[1]), the VFPA recognised that to adequately address and understand the potential cumulative threats posed by underwater noise from all commercial vessel traffic in the region, a larger, regional-scale approach was required. In 2014, the VFPA-led ECHO Program was developed as a voluntary, collaborative initiative aimed at better understanding and managing the cumulative impact of existing shipping activities on at-risk whales throughout the southern coast of B.C. Scientists, shipping industries, conservation groups, Aboriginal individuals, and government agencies are participating in this program to explore a range of voluntary options to reduce underwater noise levels (see IR4-10 of CEAR Document #1051 and Hemmera 2016 for more information).

The technical and economic feasibility of potential mitigation measures to reduce underwater noise from shipping in the region is currently being explored as part of the VFPA-led ECHO Program and by the Government of Canada as part of its *Oceans Protection Plan* (OPP; CEAR Document #954[2], DFO 2018). For example, as described in IR4-10 (CEAR Document #1051), during summer 2017 the ECHO Program conducted a voluntary vessel slowdown trial in Haro Strait with the goal of studying the relationship between slower vessel speeds, underwater noise levels, and effects to SRKW. The ECHO Program completed a financial analysis prior to the voluntary slowdown trial to make intended participants aware of the potential costs of slowing vessels down for the trial. Interim trial results indicate that it was feasible for 60% (578) piloted vessels to participate in the two-month voluntary trial (VFPA 2018). The ECHO Program anticipates releasing a final report in April/May 2018 that will include all data and summarise all results.

The VFPA has also updated its EcoAction incentive program, offering discounted harbour due rates to vessels voluntarily implementing underwater noise reduction technologies (see IR4-10 of CEAR Document #1051). Effective January 1, 2017, the EcoAction Program includes new incentive criteria to provide harbour due rate discounts for quieter ships (i.e., ship classification society quiet vessel notations, cavitation/wake flow reduction technologies), making Canada the first country in the world, and Port of Vancouver the first port, with a marine underwater noise reduction incentive[3].

Quantify how the mitigation measures described above would reduce the potential effect on marine mammals.

As described above, the VFPA was the first port in the world to offer financial incentives to encourage the voluntary use of quieter vessel technologies. The EcoAction incentive program is reviewed annually and measures can be added as new and additional quiet technologies become available. As the dataset of qualifying vessels builds, the ECHO Program intends to

[1] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).
[2] CEAR Document #954 From Transport Canada to the Review Panel re: Overview of the Government of Canada's Oceans Protection Plan.
[3] To date, 38 vessel calls from 30 separate vessels have received an EcoAction incentive for underwater noise criterion, reducing their harbour fees by 23%.

compare the measured source levels of qualifying vessels to quantify how much quieter they typically are compared to non-qualifying vessels.

Container ships are already transiting at slow speeds in VFPA jurisdiction. The marine pilot has care and control of the movement of both the container ship and its associated tugs to ensure the safe and efficient transit of the vessel to its berth. As such, no additional technically feasible mitigation measures are currently available to reduce underwater noise during Project operation within VFPA jurisdiction.

Voluntary mitigation and management options, informed by the ECHO Program's collaborative work with shipping stakeholders and upcoming measures from the Government of Canada's OPP, that are ultimately implemented in the region (e.g., the VFPA's incentives for quieter vessels, potential future vessel slowdown areas) would also indirectly reduce potential effects to marine mammals from the proposed Project and marine shipping associated with the Project. While these measures are not mandatory, any vessels meeting the VFPA's EcoAction vessel noise reduction criteria will qualify for incentives and help reduce underwater noise in the region. Container ships calling on RBT2 that qualify under the EcoAction Program by meeting incentive criteria for reducing underwater noise levels will reduce potential effects to marine mammals. These reductions in underwater noise would occur in the regional study area due to both marine shipping associated with the Project along shipping lanes, and within VFPA jurisdiction when container ships are calling at RBT2.

Describe the technical and economic feasibility of these mitigation measures and provide a rationale for why such measures may or may not be implemented.

Project-associated vessels within VFPA jurisdiction are already operating at reduced speed under the care and control of the Canadian marine pilot, and further reductions in vessel speed are not under the care and control of the VFPA. Similarly, the use of the container ship's thrusters is at the marine pilot's discretion and is not under the care and control of the VFPA. Thus, implementation of reduced vessel speeds and thruster use management were not proposed in the EIS as a mitigation measure to reduce underwater noise during operations.

The technical and economic feasibility of other potential mitigation measures to reduce effects of marine shipping on marine mammals in the region will continue to be explored by the ECHO Program with its participating stakeholders and by the Government of Canada's OPP initiative.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures.

There are currently no technically feasible mitigation measures under the care and control of the VFPA that can be implemented during Project operation. Therefore, there is no change to the characterisation of residual effects as described in EIS Section 14.8.1.[4]

If there is a residual effect predicted, provide a characterization of residual effects and predict the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

Increased underwater noise produced from the incremental contribution of the Project during operational activities by container ships and support tugs, including approach and departure, as well as berthing and unberthing, could result in a residual effect to marine mammals. As described above, no technically or economically feasible mitigation measures were identified to reduce or eliminate this residual effect. However, initiatives by the VFPA-led ECHO Program and the Government of Canada's OPP may result in future measures that reduce underwater noise from marine shipping in the region and would also reduce underwater noise associated with the Project and container ships calling at RBT2.

Ratings for criteria and supporting rationale for the criteria rating for this residual effect were summarised in EIS Table 14-23 and do not change. Marine mammals may experience short-term, reversible residual behavioural effects, but these effects are not substantially different from those occurring during existing conditions. Effects from the Project on SRKW (toothed whales), baleen whales (North Pacific humpback whale), and pinnipeds (Steller sea lion) are therefore considered to be not significant.

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[4] It is important to note that multiple conservative assumptions were applied to underwater noise modelling that overestimate the amount of underwater noise produced during Project operation and the adverse residual effect. Underwater noise modelling, as presented in the EIS, assumed that all 260 vessel calls to RBT2 will be made by Triple-E container ships (18,000 twenty-foot equivalent units (TEUs)). Current fleet forecasts (see IR4-01 of CEAR Document #1051) show this to be a conservative assumption because vessels of >15,000 TEUs may not call on RBT2 until after 2030 (and therefore 9,600 TEU vessels are more realistic vessel size calling on RBT2 during Project operation). The VFPA is currently conducting additional modelling studies to predict underwater noise produced during this more realistic operational scenario, to be submitted at a later date to the Review Panel. Secondly, given larger vessels can carry more TEU containers, fewer than 260 vessel calls at RBT2 would actually occur if all calls to RBT2 were made by Triple-E container ships.

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IR5-51 Marine Mammals – Mitigation of Vessel Strikes

Information Source(s)

EIS Volume 3: Section 14.7.2

Marine Shipping Addendum: Section 8.2.7.2

Proponent Response to Information Requirements of July 31, 2015 (CEAR Doc#314): Appendix IR12-A

Context

In Section 14.7.2 of the EIS, the Proponent stated that mitigation of the physical disturbance from vessel strikes on marine mammals during construction and operation activities included the following measures:

- implementation of a Construction Compliance Monitoring Plan;
- implementation of an Environmental Training Plan; and
- distribution of a marine mammal awareness pamphlet (Marine Mammals of the Roberts Bank Area).

Although no mitigation measures were proposed in the local assessment area for the marine shipping associated with the proposed Project (Section 8.2.7.2 of the Marine Shipping Addendum), the Proponent stated that the awareness pamphlet could improve education and awareness of pilots and therefore reduce vessel strike risk in areas outside of the Proponent's jurisdiction.

The Proponent predicted that with the implementation of the above measures, there would be no detectable or measurable residual adverse effects from vessel strikes predicted for marine mammals due to Project operation and construction. However, the mitigation measures described within the plans as presented in Appendix IR12-A of CEAR Doc#314 do not support the Proponent's conclusion that there would be no residual effects from vessel strikes on marine mammals. For example, the anticipated effectiveness of the specified measures for vessel strikes as indicated by the Proponent in Appendix IR12-A of CEAR Doc#314 is listed as unknown, partially effective and effective. Although in Section 14 of the EIS, the Proponent stated that vessel speed has been correlated with both the probability of vessel strikes, vessel speed is not mentioned as a measure that could be used to reduce the potential residual effects.

Further information is required to determine what specific measures would and/or could be implemented by the Proponent to mitigate the potential effects of vessel strikes on marine mammals.

Information Request

Provide a list of the existing and proposed marine mammal awareness pamphlets described in Section 14.7.2 of the EIS and Section 8.2.7.2 of the Marine Shipping Addendum. For those that have been developed, provide a copy of the pamphlet.

Describe all potential measures that could be used within the Proponent's jurisdiction to mitigate the potential effects of vessel strikes on marine mammals.

Quantify how the mitigation measures described above would reduce the potential effect.

Describe the technical and economic feasibility of these mitigation measures and provide a rationale for why such measures may or may not be implemented.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures.

If there is a residual effect predicted, provide a characterization of residual effects and predict the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

VFPA Response

Vessel strikes from Project-associated vessels in the marine shipping area were assessed for baleen whales only, represented by North Pacific humpback whales, because they are large and slow-moving, increasing the risk of being struck compared to smaller marine mammals (see EIS Section 14.6.3.2). While more common in VFPA jurisdiction, it is unlikely that Project container ships would strike a southern resident killer whale (SRKW, representing toothed whales) or Steller sea lion (representing seals and sea lions) due to their agility and speed (see Marine Shipping Addendum (MSA) Section 8.2.6.3). DFO Canadian Science Advisory Secretariat (CEAR Document #919[1]) stated that, "The conclusion that ships pose a very low risk of causing injury or mortality to SRKWs and Steller sea lions through collisions is reasonable." Hence, the remainder of this response primarily focuses on North Pacific humpback whales.

Provide a list of the existing and proposed marine mammal awareness pamphlets described in Section 14.7.2 of the EIS and Section 8.2.7.2 of the Marine Shipping Addendum. For those that have been developed, provide a copy of the pamphlet.

There are three existing VFPA marine mammal awareness pamphlets and information sources described in Section 14.7.2 of the EIS and Section 8.2.7.2 of the MSA:

- The marine mammal awareness pamphlet *Marine Mammals of the Roberts Bank Area*;
- The marine mammal mariner's guide *Mariner's Guide to Whales, Dolphins, Porpoises of Western Canada*; and

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.

- The VFPA Port Information Guide.

Each of these education materials are described in greater detail below.

Since the development of the Deltaport Third Berth Expansion Project (DP3) at Roberts Bank, the VFPA has distributed a marine mammal awareness pamphlet—*Marine Mammals of the Roberts Bank Area*—to local pilots (**Appendix IR5-51-A**, Section 14.7.2 of the EIS, and Section 8.2.7.2 of the MSA). This pamphlet describes actions that could be implemented by mariners, including marine pilots of commercial vessels at Roberts Bank and in the marine shipping area, to reduce potential effects from underwater noise and physical disturbance from vessel strikes.

In 2017, the VFPA's Enhancing Cetacean and Observation (ECHO) Program, in collaboration with the Vancouver Aquarium's Coastal Ocean Research Institute and the Prince Rupert Port Authority, developed the *Mariner's Guide to Whales, Dolphins, Porpoises of Western Canada* (appended to IR4-10 as Appendix IR4-10-E of CEAR Document #1051[2]). The purpose of the guide is to raise awareness among large vessel mariners and provide information that will help mitigate vessel impacts on cetaceans along the B.C. coast. The guide has been distributed to commercial vessel captains, coastal pilots, BC Ferries, and other professional mariners, and will also be distributed to pilots and commercial vessel captains calling on the RBT2 terminal.

Lastly, the VFPA Port Information Guide[3] (appended to IR1-01 as Appendix IR1-01-A of CEAR Document #897[4]) includes information for commercial and recreational mariners operating within its navigational jurisdiction on marine mammals, including species at risk and their critical habitat, the VFPA-led Enhancing Cetacean Habitat and Observation (ECHO) Program (see IR4-10 of CEAR Document #1051), and protocols for reporting of vessel strikes to the B.C. Marine Mammal Response Network.

Describe all potential measures that could be used within the Proponent's jurisdiction to mitigate the potential effects of vessel strikes on marine mammals.

Movements of foreign container ships that would call at the VFPA during operation would be under the care and control of a Canadian marine pilot, as legislated by the *Pilotage Act* as part of the larger *Canada Marine Act*. The pilot has legislated authority over the movement of both the container ships, and associated tugs tethered to the container ship, within VFPA jurisdiction to determine the appropriate safe and efficient movement and berthing. Container

[2] CEAR Document #1051 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 4 (See Reference Document #946).
[3] The Port Information Guide was created pursuant to Section 56 of the *Canada Marine Act* and aligned with the standards of the International Harbour Masters Association. It contains a set of localised practices and procedures designed to promote safe and efficient navigation within the waters of the port and support efforts to protect the marine environment. The practices and procedures contained in the manual apply to all vessels in VFPA jurisdiction, including pleasure craft and recreational vessels, as well as other users of the port.
[4] CEAR Document #897 From the Vancouver Fraser Port Authority to the Review Panel re: Responses to Information Request Package 1 (See Reference Document #559).

ships enter VFPA jurisdiction at approximately 10 knots, and this speed is reduced to approximately six to eight knots once the tugs have tethered to the vessel. Speeds of both the container ship and tugs are reduced further as the container ship is manoeuvred into its berth at the terminal (R. Armstrong, personal communication, May 31, 2017).

The potential for RBT2-related vessel strikes to all marine mammals in VFPA jurisdiction is considered very low (see EIS Section 14.6.3.2), primarily as vessel speeds are, by necessity, low (and below the speed reported in the literature for strike risk to baleen whales; see Laist et al. 2001, Jensen and Silber 2003, Vanderlaan and Taggart 2007, Silber et al. 2012). As the marine pilot has care and control of container ship movements within VFPA jurisdiction, educational materials described above are VFPA initiatives intended to increase awareness of marine pilots to avoid vessel strikes regionally when safe and practicable to do so. The distribution of educational materials to mariners by the VFPA was not taken into consideration in the determination of the residual effect of vessel strikes on humpback whales, and therefore did not factor into the determination of a residual effect.[5] The VFPA is unaware of other potential technically and economically feasible measures that could be used within VFPA jurisdiction to mitigate the potential effects of vessel strikes on marine mammals.

Quantify how the mitigation measures described above would reduce the potential effect. Describe the technical and economic feasibility of these mitigation measures and provide a rationale for why such measures may or may not be implemented.

No mitigation measures, other than the VFPA's educational awareness of marine pilots, is proposed. As stated above, the distribution of awareness materials to marine pilots are VFPA initiatives to reduce potential effects of marine shipping to marine mammals throughout the region and were not taken into consideration in the determination of no residual effect of strikes on humpback whales from Project-related vessels. As stated above, the VFPA is unaware of other potential technically and economically feasible measures that could be used within VFPA jurisdiction to mitigate the potential effects of vessel strikes on humpback whales.

Describe whether there would be an adverse residual effect after the implementation of the above mitigation measures. If there is a residual effect predicted, provide a characterization of residual effects and predict the significance of those residual adverse effects on marine mammals and the likelihood that the effects would occur.

As stated in EIS Section 14.7.2, due to the low occurrence of baleen whales in VFPA jurisdiction and the slow speeds of Project-related vessels, no detectable or measurable residual effect to humpback whales or the humpback whale population are anticipated. Furthermore, the current population in B.C. is growing at approximately five percent annually

[5] As stated in the Panel's context to this information request, in Appendix IR12-A of CEAR Document #314, the anticipated effectiveness of some specified measures for vessel strikes (i.e., Environmental Training Plan, Education and Awareness materials) were described as unknown or partially effective. However, Appendix IR12-A also stated that as effectiveness of proposed marine mammal awareness pamphlets and educational measures is difficult to measure, that the application of this measure was not taken into consideration in the determination of the residual effect of vessel strikes, and therefore, if it is ineffective, there would be no change to the determination of no adverse residual effects.

and was recently relisted from Threatened under the *Species at Risk Act*, to Special Concern. Current increases in the population indicate that existing marine shipping is not affecting overall population viability (DFO 2013).[6] In the highly unlikely event that a humpback whale was struck by a Project-related vessel, the loss of an individual would not affect the viability of the population in B.C.

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Appendices

Appendix IR5-51-A Pamphlet: Marine Mammals of the Roberts Bank Area *(Note that this is a print-ready PDF of a folded pamphlet. As such, some of the images and text will appear upside down.)*

[6] In 2017, the humpback whale was officially reclassified from Threatened to Special Concern under the *Species at Risk Act* (GOC 2017; included in the response to IR5-53 as Appendix IR5-53-A (CEAR Document #1159)).

APPENDIX IR5-51-A
PAMPHLET: MARINE MAMMALS OF THE ROBERTS BANK AREA

COMMON MARINE MAMMALS OF THE STRAIT OF GEORGIA

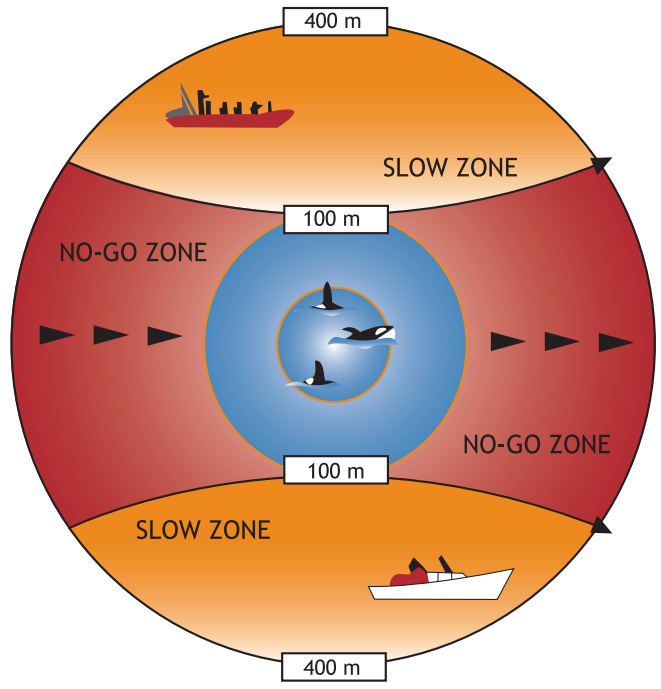
Even if you cannot see them, a wide variety of marine mammals use the waters near Roberts Bank at various times of the year. Responsible boating behaviour can help reduce human induced impacts on marine mammals.

WHAT CAN YOU DO?

Responsible Boating Behavior

The following guidelines apply to all boats including pleasure craft, kayaks and commercial boats:

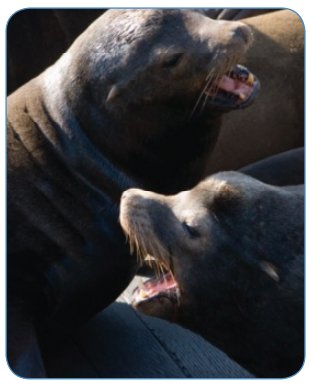
- Be cautious and courteous in areas where marine mammals are known to be found.
- Slow down to seven knots when within 400m of any marine mammal.
- Keep clear of the path the mammal is taking.

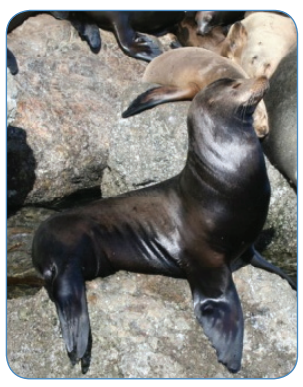


Fisheries and Oceans Canada

- Do not approach from the front or back, only the side parallel to direction of travel of the mammal.
- Keep back 100 m (football field). If unable to do so, put boat in neutral and wait for mammal to pass.
- Stay on the offshore side of the mammal when they travel close to shore.

SEALS AND SEA LIONS





California Sea Lion

(Not at risk[1]) Seen year-round, but only males from the U.S. stock migrate north to Canada.



Stellar (Northern) Sea Lion

(Special Concern[1]) Present year-round.



Pacific Harbour Seal

(Not at risk[1]) Most common marine mammal in the Roberts Bank region and present year-round.

WHALES



Grey Whale

(Special Concern[1]) A small group frequents the Strait of Georgia waters from March to May. These whales feed on small organisms present in soft sediments.



Minke Whale

(Not at risk[1]) Smallest of baleen whales, mostly present in the summer, but also observed year-round.

If you see a marine mammal, report your sighting!

Your sightings help scientists understand where marine mammals are found and identify areas important to protect.

In Canada:
B.C. Cetacean Sightings Network:
1-866 I SAW ONE
or online at: http://www.wildwhales.org

In the U.S.:
The Whale Hotline:
1-800-562-8832 (Whale Museum)

[1]Species at Risk Act (SARA)

In Canada, species at risk are protected by SARA. The status of wildlife species is assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) which recommends a classification for the legal protection of species. The species are listed according to the level of risk of becoming extinct using specific criteria (from most risk to least):

- *Extinct*
- *Extirpated*
- *Endangered*
- *Threatened*
- *Special Concern*
- *Not at Risk*

For more information, visit: http://www.sararegistry.gc.ca

DOLPHINS AND PORPOISES



Dall's Porpoise

(Not at risk[1]) Stocky black-bodied cetacean, present year-round.



Harbour Porpoise

(Special Concern[1]) B.C.'s smallest cetacean, present year-round.



Fisheries and Oceans Canada



Jacques Whitford AXYS

Killer Whales (Orcas)

(Endangered[1]) Southern Resident Population, (Threatened[1]) West Coast Transient Population: Most commonly seen near Roberts Bank in summer and fall, present year-round.

Marine Mammals of the Roberts Bank Area



PORT METRO vancouver

Roberts Bank is home to two of the Port Metro Vancouver's (PMV) largest marine terminals—Deltaport container terminal and Westshore coal terminal. These facilities are located in the municipality of Delta approximately 40 kilometers south of Vancouver and two kilometers northwest of the Tsawwassen ferry terminal.

PMV strives to mitigate port growth with innovative solutions to ensure the long-term preservation of marine life. This brochure provides an overview of the marine mammals found near Roberts Bank, particularly killer whales, and provides information on what the PMV is doing to help ensure their long-term survival.

What is the PMV doing for Marine Mammals?

PMV has developed a **Marine Mammal Monitoring Program** as part of the Deltaport Third Berth Expansion Project (DP3) and is committed to implementing actions that will reduce the potential for harmful effects to killer whales and other marine mammals through:

1. Determining a "zone of influence" within which killer whales are likely to be affected by noise from construction activities. If killer whales are sighted within this zone of influence, the Environmental Monitor will stop all marine construction work until the killer whales have moved outside this zone.



Birds of a Feather

2. Scheduling noisy in-water construction outside peak marine mammal use of the area.
3. Notifying contractors and vessel operators of the possible presence of marine mammals and providing guidelines for safe construction practices around marine mammals.
4. Using regular, predefined shipping routes for construction vessels.
5. Slowly starting noisy equipment to avoid startling marine mammals, and to give them time to leave the work area.
6. Shutting down noisy equipment while it is being relocated to minimize underwater noise.
7. Ensuring all propellers are properly and regularly maintained to minimize vibration and underwater noise.

In addition, PMV commissions marine biologists to conduct regular surveys that document marine mammal habitat use near Roberts Bank. Results are compared with pre-construction surveys and with additional marine mammal information from other sources into a comprehensive report.

Marine Mammals & Underwater Noise

Marine mammals use and produce sound underwater to navigate, communicate, and find food. Underwater noise produced by human activity can therefore affect killer whales and other mammals present in the area. Noise can travel much farther in water than it can in air. Various man-made noises may be tolerated by animals but they may also mask important natural sounds. This could lead to marine mammals avoiding an area or cause temporary or permanent hearing loss when subjected to particularly loud noises.

Studies have shown that the underwater region surrounding Roberts Bank can be a noisy environment. The main noise sources are ferries, coal carriers, conveyor systems, tug boats, container vessels, fishing boats and pleasure craft.



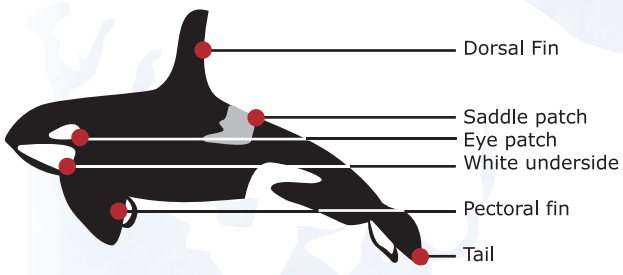
Jacques Whitford AXYS



Killer Whales (Orcas)

There are different types of killer whales that use areas of the Georgia Basin; Southern Residents and West Coast Transients Killer Whales.

Description of Killer Whale: 7-9 m toothed whale (4000-5000 kg). Dorsal fin, saddle patch and eye patch are unique to each individual and can be used for identification. Threats: Small population size, low reproductive rate, environmental contamination, reductions in prey, physical and noise disturbances (i.e., from vessels and other human activities).



Southern Resident Killer Whale (SRKW) (Endangered[1]): There are only 85 Southern Resident killer whales. Individuals from this population spend most of their time in coastal waters.

The SRKW population consists of a single clan with three pods (J, K, and L), which travel in groups of 10-25 or more. These whales are often observed near Roberts Bank. What do they eat? In summer & fall they move to the waters off the Fraser River to feed on salmon, their main prey. Their winter diet is not well known. When are they present? The J pod is the most common pod seen in the Georgia Basin and is observed year-round. The K and L pods typically leave in October or November and return in May or June.

West Coast Transient Killer Whale (Threatened[1]): There are approximately 250 West Coast Transient killer whales. Generally they spend most of their time in offshore waters but may be seen closer to shore. They travel in smaller groups than resident whales. What do they eat? Harbour seals, sea lions and porpoises. When are they present? Most frequently seen in the Southern Strait of Georgia in late summer and early fall.

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Canada

IR5-52 Marine Mammals – Vessel Strikes

Information Source(s)

Marine Shipping Addendum: Section 8.2.6.3, Table 8.2-12

Context

In Section 8.2.6.3 of the Marine Shipping Addendum, the Proponent described the potential effects of vessel strikes on marine mammals. In Table 8.2-12, the Proponent indicated that the magnitude of the residual effect resulting from vessel strikes on SRKW is low, and stated that physical disturbance is not expected to affect the survival of an individual or population viability. However, there is no supporting information for this conclusion despite the fact that the risk for the other 2 representative species selected by the Proponent (Humpback Whales and Stellar Sea Lions) was described both for the individuals, as well as the populations.

In Section 14, the Proponent quoted Fisheries and Oceans Canada as stating that the loss of one individual, in particular a breeding female, could result in population-level effects. Further information is required to determine the magnitude of the residual effect from vessel strikes on SRKW.

Information Request

Using the criteria specified in Table 8.2-10, clarify the magnitude of the effect of vessel strikes on an individual SRKW and at the population level, and provide information to support this conclusion.

VFPA Response

As stated in the context to this information request, Marine Shipping Addendum (MSA) Table 8.2-12, stated the following:

- The magnitude of the residual effect resulting from potential strikes of RBT2-associated vessel on southern resident killer whale (SRKW) is low (based on the low likelihood of the event occurring);
- Injury or mortality from vessel strikes by incremental marine shipping associated with the Project is considered unlikely due to small number of increased vessel movements and the agile nature of SRKW; and
- Physical disturbance is not expected to affect the survival of an individual or population viability.

The VFPA clarifies in this response that potential effects to SRKW from vessel strikes could range from minor injuries that do not affect the survival or reproduction of an individual (thus not affecting population recovery or viability), to severe injuries resulting in mortality to a breeding individual and adverse effects to the population. As defined in MSA Table 8.2-10,

the magnitude of the effect of a vessel strike of a SRKW could range from low to high, defined as follows:

- Low – Effects are sub-lethal, potentially leading to short-term behavioural changes or transient degradation of habitat; unlikely to affect population viability or recovery (including life functions or critical habitat features of SRKW);
- Moderate – Effects result in chronic physiological and/or behavioural changes or degradation of habitat; may have some effect on long-term population viability (including life functions and critical habitat of SRKW); or
- High – Effects are lethal or affect population viability or recovery (including life functions and critical habitat of SRKW).

The magnitude criteria rating for physical disturbance from vessel strikes to SRKW spans a range from low to high depending on the severity of the injury, if such an unlikely event were to occur. However, the likelihood of a Project-associated vessel striking a SRKW is low considering the agility of the animals, combined with the small incremental contribution of marine shipping associated with the Project (i.e., three container ship movements every two days over existing conditions). DFO has not identified vessel strikes as a primary threat to killer whales in B.C. in their Recovery Strategies nor have any injuries or mortalities to killer whales from container ships been reported (DFO 2007, 2011, 2015a,b). In its assessment of RBT2, DFO Canadian Science Advisory Secretariat (CSAS) stated that, "The conclusion that ships pose a very low risk of causing injury or mortality to SRKWs [and Steller sea lions] through collisions is reasonable" (CEAR Document #919[1]).

To reflect the range of possible outcomes of a vessel strike on SRKW as described above, the VFPA notes that, if this unlikely event were to occur, the residual effect could range from low magnitude (if only minor injuries to an individual occurs) to high magnitude (if mortality of a breeding individual occurs). When taking this range of magnitude into consideration in determining significance of the residual effect, if this unlikely event were to occur, the significance would also range from not significant (if only minor injuries occurred and the residual effect is low in magnitude) to significant (if mortality of a breeding individual occurs and the residual effect is high in magnitude). However, a residual effect, whether significant or not significant, is unlikely to occur due to the speed and agility of SRKW. Vessel strikes are not identified by DFO as a primary threat to killer whales in B.C. in their Recovery Strategies nor have any injuries or mortalities to killer whales from container ships been reported (DFO 2007, 2011, 2015a,b). The likelihood of a Project-associated vessel striking a SRKW is low considering the agility of the animals, combined with the small incremental contribution of marine shipping associated with the Project (i.e., three container ship movements every two days over existing conditions).

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.

References

Fisheries and Oceans Canada (DFO). 2007. Recovery Strategy for the Transient Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver, vi + 46 pp.

Fisheries and Oceans Canada (DFO). 2011. Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries & Oceans Canada, Ottawa, ix + 80 pp.

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Fisheries and Oceans Canada (DFO). 2015b. Report on the Progress of Recovery Strategy Implementation for the Transient Killer Whale (*Orcinus orca*) in Canada for the Period 2007-2012. Species at Risk Act Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. v + 19 pp.

IR5-53 Marine Mammals – Cumulative Effects on Humpback Whales and Steller Sea Lions

Information Source(s)

EIS Volume 3: Section 14.10, Table 14-29

Context

In Section 14.10 of the EIS, the Proponent stated that the residual effects to marine mammals that are to be evaluated in the cumulative effects assessment are behavioural effects and acoustic masking resulting from increases in underwater noise associated with the proposed Project operation. For Humpback Whales and Steller Sea Lions, it was concluded that cumulative effects could occur within the regional assessment area (Section 14.10.1.2 and 14.10.1.3). The Proponent stated that the residual effect of Project operation, including marine shipping associated with the Project is likely to combine with the effects of other projects and activities. However, the Proponent did not provide information in Section 14.10.1.2 and 14.10.1.3 of the EIS to support the criteria ratings presented in Table 14-29 of the EIS for Humpback Whales and Stellar Sea Lions. Additional information is required to support the criteria ratings presented in Table 14-29 of the EIS.

Information Request

Provide further rationale to support the criteria ratings used to characterize the residual cumulative effects to Humpback Whales and Stellar Sea Lions as presented in Table 14-29 of the EIS.

VFPA Response

Further rationale for the criteria ratings in EIS Table 14-29 describing potential Project cumulative effects to humpback whales and Steller sea lion from changes in the acoustic environment are described below and summarised in **Table IR5-53-1.**

Humpback Whale

Additional rationale for the criteria ratings describing potential cumulative effects to humpback whales from changes in the acoustic environment includes the following:

- *Uncommon occurrence of humpback whales in the local assessment area (LAA)*: Humpback whales (and other baleen whales) are uncommon in the LAA (EIS Figure 14-5); this suggests that there will be minimal spatial overlap with Project-related underwater noise (i.e., approach, berthing, unberthing, departure), thereby minimising the potential for cumulative interactions.

- *Current annual increased growth rate of population of approximately five percent, despite existing levels of marine shipping and underwater noise levels in B.C.:* Past

projects and activities that have been carried out (i.e., historical commercial whaling, see EIS Section 14.5.2) resulted in reductions of the humpback whale population. However, this trend has reversed, with current population trends in B.C. showing approximately five percent growth annually. This indicates that potential effects from existing marine shipping are not affecting overall population viability despite existing levels of underwater noise (DFO 2013).

- *Recategorization of the humpback whale population in B.C. as Special Concern, rather than Threatened:* As a result of substantial increases in the population since being listed as 'Threatened' under the *Species at Risk Act* (*SARA*) in 2005, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reassessed the North Pacific population of humpback whales in 2011 and downgraded its status to 'Special Concern' (COSEWIC 2011, 2014). In 2017, the humpback whale was officially reclassified from Threatened to Special Concern under the S*ARA* (GOC 2017, appended to this response as **Appendix IR5-53-A**).

- *Small incremental contribution of Project operation and future marine shipping to existing underwater noise levels and subsequent potential behavioural effects:* Under existing conditions in marine waters adjacent to the Roberts Bank terminals, underwater noise levels are high due to existing marine vessel traffic (see EIS Appendix 9.8-A). Noise modelling has demonstrated that future underwater noise levels in the regional assessment area (RAA) will be comparable to levels occurring during existing conditions; by extension, this implies that any potential incremental behavioural effects experienced from the Project will likely be within the range of those already occurring under existing conditions. Given that humpback whale populations are healthy and growing under existing conditions, the cumulative effect of underwater noise is not anticipated to adversely affect population recovery or viability.

Steller Sea Lion

Additional rationale for the criteria ratings describing potential cumulative effects to Steller sea lion from changes in the acoustic environment includes the following:

- *Current annual increased growth rate of population of approximately three percent, despite existing levels of marine shipping and underwater noise levels in B.C.:* Past projects and activities that have been carried out resulted in reductions of the Steller sea lion population. Between 1912 and 1968, thousands of Steller sea lions were killed in B.C. in a campaign to reduce competition for fish stocks with commercial fishers (see EIS Section 14.5.3.4). Since that time, the Steller sea lion population in B.C. has been increasing at a rate of approximately 3.2% per year, despite existing levels of marine shipping traffic and its associated underwater noise (DFO 2010).

- *Small incremental contribution of Project operation and future marine shipping to existing underwater noise levels and subsequent potential behavioural effects:* Under existing conditions in marine waters adjacent to the Roberts Bank terminals, underwater noise levels are generally relatively high due to existing marine vessel traffic (see EIS Appendix 9.8-A). Noise modelling has demonstrated that future

underwater noise levels in the RAA will be comparable to levels occurring during existing conditions; by extension, this implies that any potential incremental behavioural effects experienced from the Project will likely be within the range of those already occurring under existing conditions. Given that Steller sea lion populations are healthy and growing under existing conditions, the cumulative effect of underwater noise is not anticipated to adversely affect population recovery or viability.

- *Evidence of habituation to regularly occurring, predictable underwater noise sources.* As described in EIS Section 14.6.4, Steller sea lions are expected to habituate to some extent to existing, Project, and future cumulative underwater noise levels due to marine shipping; this is based on observations of continued use of areas that experience regular disturbance (e.g., air or vessel traffic) by seals and sea lions.

Table IR5-53-1 Summary of Criteria Ratings for the Residual Project Cumulative Effect for Humpback Whales and Steller Sea Lions (EIS Table 14-29) and Further Rationale for Criteria Ratings in EIS

Criteria	Criteria Rating	Rationale for Criteria Rating in EIS	Further Rationale Requested in IR5-53
Magnitude	Low	A measurable change, but within the range of natural variability that will not affect population recovery or viability.	• Underwater noise levels are already elevated during existing conditions in marine waters adjacent to the Roberts Bank terminals (see EIS Appendix 9.8-A). • Future underwater noise levels in the RAA are comparable to levels occurring during existing conditions (EIS Appendix 9.8-A). • Any potential incremental behavioural effects experienced from the Project are likely within the range of those occurring during existing conditions. • As both humpback whale and Steller sea lion populations are healthy and growing under existing conditions of underwater noise, this potential change is not anticipated to adversely affect population recovery or viability.
Extent	Regional	Area where residual effects from Project operation could combine with cumulative effects resulting in behavioural effect or acoustic masking.	• The estimated distance from the LAA that an individual experiencing a residual effect from Project underwater noise could travel and experience potential cumulative effects from marine vessel traffic noise (Noad and Cato 2007).
Duration[a]	Short term	Approximately 0.5 hour.	• Measured length of behavioural responses of endangered southern resident whales to marine shipping noise (0.5 hour for a moderate-severity response) was used as a conservative estimate for length of humpback whales and Steller sea lion behavioural responses (EIS Appendix 14-B).
Frequency	Frequent	Behavioural effects to individuals could occur repeatedly during transiting, berthing, and unberthing of container ships, and associated support vessels.	• Project operation (berthing/unberthing, approach/departure) would occur during approximately 260 calls each year (3% annually) and humpback whales and Steller sea lions could be exposed to underwater noise from these repeated activities if they were to occur within the LAA. • This repeated effect could then repeatedly combine with underwater noise from incremental marine vessel traffic outside VFPA jurisdiction within the RAA.

Criteria	Criteria Rating	Rationale for Criteria Rating in EIS	Further Rationale Requested in IR5-53
Reversibility[a]	Reversible	Behaviour of individuals from increased underwater noise return to existing conditions after causal activities cease.	• Behavioural responses of humpback whales and Steller sea lions are anticipated to return to those occurring during existing conditions after exposure to cumulative underwater noise (Richardson et al. 1995, Southall et al. 2007, Williamson et al. 2016, Demarchi 2010).

Note: a. DFO Canadian Science Advisory Secretariat agreed with these ratings (CEAR Document #919[1]) stating, "The conclusion in Section 14.9, that effects on Humpback Whales and Steller Sea Lions are expected to be short-term and reversible with no long-term population consequences, and the assigned high confidence level in this conclusion are reasonable for the RAA and LAA areas."

[1] CEAR Document #919 From the Review Panel Secretariat to the Review Panel re: Fisheries and Oceans Canada's Technical Review of the Roberts Bank Terminal 2 Environmental Impact Statement and Marine Shipping Supplemental Report: Effects on Marine Mammals.

References

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011. COSEWIC Assessment and Status Report on the Humpback Whale *Megaptera novaeangliae* in Canada. Ottawa. x + 32 pp.

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Fisheries and Oceans Canada (DFO). 2013. Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. x + 67 pp.

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Appendices

Appendix IR5-53-A Government of Canada Order Amending Schedule 1 to the *Species at Risk Act*

APPENDIX IR5-53-A
GOVERNMENT OF CANADA ORDER AMENDING SCHEDULE 1 TO THE *SPECIES AT RISK ACT*

Registration
SOR/2017-130 June 20, 2017

SPECIES AT RISK ACT

Order Amending Schedule 1 to the Species at Risk Act

P.C. 2017-782 June 20, 2017

His Excellency the Governor General in Council, on the recommendation of the Minister of the Environment, pursuant to subsection 27(1) of the *Species at Risk Act*[a], makes the annexed *Order Amending Schedule 1 to the Species at Risk Act*.

Order Amending Schedule 1 to the Species at Risk Act

Amendments

1 Part 3 of Schedule 1 to the *Species at Risk Act*[1] is amended by striking out the following under the heading "MAMMALS":

Whale, Humpback (*Megaptera novaeangliae*) North Pacific population

Rorqual à bosse population du Pacifique Nord

2 Part 4 of Schedule 1 to the Act is amended by adding the following in alphabetical order under the heading "MAMMALS":

Whale, Humpback (*Megaptera novaeangliae*) North Pacific population

Rorqual à bosse population du Pacifique Nord

Coming into Force

3 This Order comes into force on the day on which it is registered.

[a] S.C. 2002, c. 29
[1] S.C. 2002, c. 29

Enregistrement
DORS/2017-130 Le 20 juin 2017

LOI SUR LES ESPÈCES EN PÉRIL

Décret modifiant l'annexe 1 de la Loi sur les espèces en péril

C.P. 2017-782 Le 20 juin 2017

Sur recommandation de la ministre de l'Environnement et en vertu du paragraphe 27(1) de la *Loi sur les espèces en péril*[a], Son Excellence le Gouverneur général en conseil prend le *Décret modifiant l'annexe 1 de la Loi sur les espèces en péril*, ci-après.

Décret modifiant l'annexe 1 de la Loi sur les espèces en péril

Modifications

1 La partie 3 de l'annexe 1 de la *Loi sur les espèces en péril*[1] est modifiée par suppression, sous l'intertitre « MAMMIFÈRES », de ce qui suit :

Rorqual à bosse (*Megaptera novaeangliae*) population du Pacifique Nord

Whale, Humpback North Pacific population

2 La partie 4 de l'annexe 1 de la même loi est modifiée par adjonction, selon l'ordre alphabétique, sous l'intertitre « MAMMIFÈRES », de ce qui suit :

Rorqual à bosse (*Megaptera novaeangliae*) population du Pacifique Nord

Whale, Humpback North Pacific population

Entrée en vigueur

3 Le présent décret entre en vigueur à la date de son enregistrement.

[a] L.C. 2002, ch. 29
[1] L.C. 2002, ch. 29

REGULATORY IMPACT ANALYSIS STATEMENT

(*This statement is not part of the Order.*)

Issues

The Humpback Whale (North Pacific population) has increased in number significantly since it was first listed as a threatened species under Canada's *Species at Risk Act* (SARA) in 2005. A 2011 assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent scientific advisory body whose role under SARA is, among other things, to classify species as extinct, extirpated, endangered, threatened or species of special concern, has indicated that Humpback Whale (North Pacific population) growth rates have increased, leading to an increased abundance of the species. COSEWIC has determined that the Humpback Whale (North Pacific population) has reached a point where the species' reclassification can be amended from a threatened species to a species of special concern.

Given the reassessment by COSEWIC, and based on the considerations discussed below, the Governor in Council has put in place an Order that amends Schedule 1 of SARA. By this Order, the species is listed as a "species of special concern."

Background

Species At Risk Act and recommendations for listing aquatic species

SARA was enacted in 2002. The purposes of this Act are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened.

Under SARA, the Minister of Fisheries and Oceans is the "competent minister" for aquatic species, except with respect to individuals in or on federal lands administered by the Parks Canada Agency. Since Humpback Whales (North Pacific population) also enter the Gwaii Haanas National Marine Conservation Area Reserve and the Pacific Rim National Park Reserve of Canada, which are federal lands administered by the Parks Canada Agency, the Minister of the Environment is also a "competent minister" under SARA for those individuals of the Humpback Whale (North Pacific population) found in those areas.

RÉSUMÉ DE L'ÉTUDE D'IMPACT DE LA RÉGLEMENTATION

(*Ce résumé ne fait pas partie du Décret.*)

Enjeux

Le nombre de rorquals à bosse (population du Pacifique Nord) a considérablement augmenté depuis que cette espèce a été inscrite pour la première fois en tant qu'espèce menacée en vertu de la *Loi sur les espèces en péril* (LEP) du Canada en 2005. Selon une étude de 2011 du Comité sur la situation des espèces en péril au Canada (COSEPAC), un organisme scientifique consultatif indépendant dont le rôle en vertu de la LEP est, entre autres, de classer les espèces comme étant éteintes, disparues, en voie de disparition, menacées ou préoccupantes, les taux de croissance du rorqual à bosse (population du Pacifique Nord) ont augmenté, ce qui a entraîné une plus grande abondance de l'espèce. Le COSEPAC a déterminé que le rorqual à bosse (population du Pacifique Nord) a atteint un point où l'espèce peut être reclassée comme espèce préoccupante plutôt que menacée.

Compte tenu de la nouvelle évaluation du COSEPAC et d'après les considérations dont il est question ci-dessous, le gouverneur en conseil a adopté un décret qui modifie l'annexe 1 de la LEP. Par le présent décret, l'espèce est inscrite en tant qu'« espèce préoccupante ».

Contexte

Loi sur les espèces en péril et recommandations pour l'inscription des espèces aquatiques

La LEP a été adoptée en 2002. La présente loi vise à prévenir la disparition — de la planète ou du Canada seulement — des espèces sauvages, à permettre le rétablissement de celles qui, par suite de l'activité humaine, sont devenues des espèces disparues du pays, en voie de disparition ou menacées et à favoriser la gestion des espèces préoccupantes pour éviter qu'elles ne deviennent des espèces en voie de disparition ou menacées.

En vertu de la LEP, le ministre des Pêches et des Océans est le « ministre compétent » en ce qui a trait aux espèces aquatiques, à l'exception des espèces présentes dans les parties du territoire domanial dont la gestion relève de l'Agence Parcs Canada. Comme le rorqual à bosse (population du Pacifique Nord) fréquente aussi la réserve d'aire marine nationale de conservation Gwaii Haanas et la réserve de parc national du Canada Pacific Rim, qui sont des terres fédérales administrées par l'Agence Parcs Canada, le ministre de l'Environnement est également un « ministre compétent » pour les spécimens de rorqual à bosse trouvés dans ce secteur aux termes de la LEP (population du Pacifique Nord).

In providing advice to the Minister of the Environment in relation to making a listing recommendation to the Governor in Council for an aquatic species, the Minister of Fisheries and Oceans considers the following, as appropriate:

- the purposes of SARA;
- the species status assessment made by the COSEWIC;
- other available information regarding the status and threats to the species;
- the *Fisheries and Oceans Canada* Species at Risk Act *Listing Policy and Directive for "Do Not List" Advice*;
- results of consultations with the public, provinces and territories, appropriate Aboriginal peoples and organizations and Wildlife Management Boards and with any other person or organization that the competent minister considers appropriate;
- the socio-economic (costs and benefits), biological and corporate impacts; and
- where the Minister of the Environment is also a competent minister for the species, the advice of the Minister of the Environment and the Parks Canada Agency is sought.

En conseillant le ministre de l'Environnement en ce qui concerne la formulation de recommandations pour l'inscription d'une espèce aquatique à l'intention du gouverneur en conseil, le ministre des Pêches et des Océans considère les éléments suivants comme appropriés :

- les objectifs de la LEP;
- l'évaluation de la situation de l'espèce faite par le COSEPAC;
- les autres renseignements disponibles sur la situation de l'espèce et les menaces à sa survie;
- la *Politique en matière d'inscription sur la liste de la* Loi sur les espèces en péril *de Pêches et Océans Canada et Directive concernant les avis visant à « ne pas inscrire » une espèce sur la liste*;
- les résultats des consultations avec le public, les provinces et les territoires, les organisations et les peuples autochtones, et les conseils de gestion des ressources fauniques compétents, ainsi qu'avec toute autre personne ou organisation que le ministre compétent juge pertinente;
- les répercussions socio-économiques (coûts et avantages), biologiques et ministérielles;
- lorsque le ministre de l'Environnement est également compétent à l'égard de l'espèce, l'avis du ministre de l'Environnement et de l'Agence Parcs Canada.

SARA is a key tool in the ongoing work to protect species at risk. By providing for the protection and recovery of species at risk, SARA is one of the most important tools in the conservation of Canada's biological diversity. SARA also complements other laws and programs of Canada's federal, provincial, municipal, and territorial governments, and supports the efforts of conservation organizations and other partners working to protect Canadian wildlife and habitat. For instance, the conservation of species at risk is an important component of the Government of Canada's commitment to conserving biological diversity under the United Nations Convention on Biological Diversity (1992). The Government of Canada has also made a commitment to protect and recover species at risk through the Accord for the Protection of Species at Risk (1996).

La LEP est un outil essentiel dans le cadre des efforts continus visant à protéger les espèces en péril. En assurant la protection et le rétablissement des espèces en péril, la LEP joue un rôle primordial dans la préservation de la diversité biologique au Canada. La LEP vient aussi compléter d'autres lois et programmes des gouvernements fédéral, provinciaux, municipaux et territoriaux du Canada, et appuie les activités des organismes de conservation et d'autres partenaires œuvrant à la protection de la faune et de son habitat au Canada. Par exemple, la conservation des espèces en péril est une composante importante de l'engagement du gouvernement du Canada à préserver la diversité biologique en vertu de la Convention des Nations Unies sur la diversité biologique (1992). Enfin, le gouvernement du Canada s'est engagé à protéger et à rétablir les espèces en péril en signant l'Accord pour la protection des espèces en péril (1996).

COSEWIC reassessment of the Humpback Whale (North Pacific population)

COSEWIC is a body established, and granted specific duties and powers, under SARA. It is an independent group of expert scientists who, among other things, assess species to determine if they are at risk or not. SARA requires that COSEWIC review the classification of each species at risk at least once every 10 years to confirm the species' classification, reclassify the species or indicate that the species is no longer at risk, depending on whether its situation has improved or deteriorated.

Réévaluation du COSEPAC relative au rorqual à bosse (population du Pacifique Nord)

Le COSEPAC est un organisme établi en vertu de la LEP, qui lui confère des devoirs et des pouvoirs précis. Il s'agit d'un groupe indépendant de scientifiques experts qui évaluent notamment les espèces afin de déterminer si elles sont en péril ou non. La LEP exige du COSEPAC qu'il réévalue les espèces en péril au moins une fois tous les 10 ans afin d'en confirmer la classification, de reclasser l'espèce ou d'indiquer que l'espèce n'est plus en péril, en fonction de l'amélioration ou de la détérioration de sa situation.

In its 2003 and 2011 assessments for the Humpback Whale (North Pacific population), COSEWIC provided historical context for its findings, notably that the species' population had been heavily reduced by commercial whaling, which had continued almost without interruption until the Second World War. Commercial whaling in Canada ended in 1966. In the COSEWIC 2003 assessment the evidence at the time showed that the population had been increasing, with numbers totalling in the low hundreds. COSEWIC concluded at that time that the species was a threatened species, and the Humpback Whale (North Pacific population) was subsequently listed as a threatened species in Schedule 1 of SARA in 2005.

In its most recent 2011 assessment and status report, COSEWIC found that there had been no evidence of a population decline since the 1960s, which is around the time that commercial whaling ended. Based on a three-year international and basin-wide scientific collaboration conducted from 2004 to 2006, the North Pacific population was estimated to have increased by more than 50% over the last three generations (i.e. 64.5 years), consisting of more than 18 000 non-calf individuals. Research conducted between 2004–2006 indicated that about 2 145 whales (not including first-year calves) were present seasonally in British Columbia waters, where they were increasing at around 4% per year compared to 4.9% for the entire North Pacific population.

According to COSEWIC, while the population has increased over the last five decades, current numbers are still considerably smaller than the number that must have been historically present off the west coast of Vancouver Island before 1905. This, combined with the potential impact of residual threats, led COSEWIC to determine that the Humpback Whale (North Pacific population) is a recovering wildlife species no longer considered to be threatened, but not yet clearly secure. Therefore, COSEWIC has reclassified the Humpback Whale (North Pacific population) as a species of special concern.

For more information on the Humpback Whale (North Pacific population), please visit the Species at Risk Public Registry at www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=148.

For more information on COSEWIC's most recent assessment and status report of the Humpback Whale (North Pacific population), please visit http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=982.

Dans ses évaluations du rorqual à bosse (population du Pacifique Nord) réalisées en 2003 et en 2011, le COSEPAC présente le contexte historique appuyant ses résultats. Il mentionne notamment que la population de l'espèce a fortement diminué en raison de la chasse commerciale à la baleine, qui s'est déroulée pratiquement sans interruption jusqu'à la Deuxième Guerre mondiale. Au Canada, la chasse commerciale à la baleine a pris fin en 1966. Dans l'évaluation du COSEPAC de 2003, les données montrent qu'à cette période, la population était en hausse, comptant alors quelques centaines d'individus. À cette époque, le COSEPAC a conclu que l'espèce était menacée. Par conséquent, le rorqual à bosse (population du Pacifique Nord) a, en 2005, été inscrit comme espèce menacée à l'annexe 1 de la LEP.

Dans son évaluation et son rapport de situation les plus récents (2011), le COSEPAC indique que rien ne prouve que la population connaisse un déclin depuis les années 1960, période où la pêche commerciale à la baleine a pris fin. À partir des données des activités de collaboration scientifique menées pendant trois ans à l'échelle internationale et du bassin entre 2004 et 2006, on a déterminé que la population du Pacifique Nord aurait augmenté de plus de 50 % au cours des trois dernières générations (64,5 ans), et qu'elle compterait maintenant plus de 18 000 individus autres que des baleineaux. Des recherches menées entre 2004 et 2006 indiquent qu'environ 2 145 baleines (à l'exclusion des baleineaux de moins d'un an) étaient présentes de façon saisonnière dans les eaux de la Colombie-Britannique, où elles ont augmenté à environ 4 % par année comparé à 4,9 % pour l'ensemble de la population du Pacifique Nord.

D'après le COSEPAC, si la population a augmenté au cours des 50 dernières années, le nombre actuel est encore bien inférieur au nombre d'individus qui devaient être présents au large de la côte Ouest de l'île de Vancouver avant 1905. Cela, combiné aux incidences potentielles des menaces résiduelles, amènent le COSEPAC à déterminer que le rorqual à bosse (population du Pacifique Nord) est une espèce sauvage qui se rétablit et qui ne doit plus être considérée comme une espèce menacée, sans pour autant être totalement hors de danger. Par conséquent, le COSEPAC a fait passer le rorqual à bosse (population du Pacifique Nord) au statut d'espèce préoccupante.

Pour en savoir plus sur le rorqual à bosse (population du Pacifique Nord), veuillez consulter le Registre public des espèces en péril à l'adresse suivante : http://www.sararegistry.gc.ca/species/speciesDetails_f.cfm?sid=148.

Pour obtenir plus amples renseignements sur l'évaluation et le rapport de situation les plus récents du COSEPAC sur le rorqual à bosse (population du Pacifique Nord), veuillez consulter le site suivant : http://www.registrelep-sararegistry.gc.ca/document/default_f.cfm?documentID=982.

Species characteristics

The Humpback Whale is one of the largest cetaceans, typically reaching lengths of 13 m for males and 14 m for females and weighing 25 to 40 tonnes. The Humpback Whale is characterized by pleated grooves in the skin of the neck that allow the throat to expand with the intake of huge amounts of water during feeding.

Humpback Whales are found in tropical, temperate and sub-polar waters worldwide. In Canada, Humpback Whales are found on both the east and west coasts, and belong to separate populations. In Pacific Canadian waters, the range of Humpback Whales (North Pacific population) extends along the full length of the west coast of British Columbia and spans the inshore coastal inlets, seaward across the continental shelf and into offshore waters. They are highly migratory, moving seasonally between winter subtropical breeding areas to high latitude feeding grounds in Canada.

In Canadian waters, Humpback Whales (North Pacific population) are most frequently observed from May to October; however, they can be observed in lower numbers throughout the year. Their primary activity in Canadian waters is feeding, and some individuals use the area as a migratory corridor.

Objectives

This Order amends Schedule 1 of SARA so that the Humpback Whale (North Pacific population) will no longer be listed as a threatened species, but will be listed as a species of special concern in Schedule 1 of SARA.

The amendment

- aligns the classification of the Humpback Whale (North Pacific population) under Schedule 1 of SARA with the most up-to-date science available, including the most recent assessment by COSEWIC;
- aligns the level of protection under SARA with the classification of the species as determined by COSEWIC. That is, once a species' status has improved such that it no longer meets COSEWIC's criteria and guidelines for threatened species, but is still considered by that body as meeting its criteria for species of special concern under SARA, such species are no longer subject to the prohibitions once they are listed as a species of special concern under Schedule 1; and
- requires the preparation and implementation of a management plan, which includes measures for the conservation of the species.

Caractéristiques de l'espèce

Le rorqual à bosse est l'un des plus gros cétacés; il mesure généralement 13 mètres pour les mâles et 14 mètres pour les femelles, et pèse entre 25 et 40 tonnes. Le rorqual à bosse se caractérise par des sillons sur la peau du cou qui permettent à la gueule de se déployer lorsqu'il avale de grandes quantités d'eau pour s'alimenter.

Le rorqual à bosse est présent dans les eaux tropicales, tempérées et subpolaires du monde entier. Au Canada, ces baleines vivent le long des côtes est et ouest, et appartiennent à des populations distinctes. Dans les eaux canadiennes du Pacifique, l'aire de répartition du rorqual à bosse (population du Pacifique Nord) s'étend le long de toute la côte Ouest de la Colombie-Britannique et des bras de mer côtiers vers la mer, sur tout le plateau continental et dans les eaux de mer ouverte. Le rorqual à bosse est un grand migrateur; il se déplace de façon saisonnière entre les aires de reproduction subtropicales en hiver et les aires d'alimentation dans les hautes latitudes du Canada.

Dans les eaux canadiennes, les rorquals à bosse (population du Pacifique Nord) sont observés le plus fréquemment entre mai et octobre; toutefois, on peut les observer en petit nombre tout au long de l'année. Dans ces eaux, leur activité principale est l'alimentation, bien que certains individus utilisent cette aire comme voie de migration.

Objectifs

Ce décret modifie l'annexe 1 de la LEP, de sorte que le rorqual à bosse (population du Pacifique Nord) ne soit plus inscrit à titre d'espèce menacée, mais soit inscrit en tant qu'espèce préoccupante à l'annexe 1 de la LEP.

Cette modification :

- harmonise la classification du rorqual à bosse (population du Pacifique Nord) en vertu de l'annexe 1 de la LEP avec les données scientifiques disponibles les plus récentes, notamment l'évaluation la plus récente du COSEPAC;
- harmonise le niveau de protection en vertu de la LEP avec la classification de l'espèce déterminée par le COSEPAC. Cela signifie qu'une fois que la situation de l'espèce s'est améliorée de façon telle qu'elle ne répond plus aux critères et aux recommandations du COSEPAC relatifs aux espèces menacées, et une fois que l'espèce a été inscrite comme espèce préoccupante en vertu de l'annexe 1, cette dernière n'est plus soumise aux interdictions stipulées dans la LEP, même si le COSEPAC considère encore qu'elle répond aux critères des espèces préoccupantes;
- nécessite l'élaboration et la mise en œuvre d'un plan de gestion qui comporte des mesures de conservation de l'espèce.

Description

This Order amends Schedule 1 of SARA so that the Humpback Whale (North Pacific population) will no longer be a threatened species, but will be listed as a species of special concern.

The reclassification under Schedule 1 to a species of special concern means that the Humpback Whale (North Pacific population) is no longer subject to the general prohibitions set out in SARA, and its critical habitat is no longer required to be identified or legally protected under SARA. However, other provisions of SARA continue to apply. For example, under section 79 of SARA, a person who is required by or under an Act of Parliament to ensure that an assessment of the environmental effects of a project is conducted, and an authority who makes a determination in relation to a project on federal lands under section 67 of the *Canadian Environmental Assessment Act, 2012*, must notify the competent minister(s) if the project is likely to affect a listed species or its critical habitat, including those listed as special concern (although, as explained, there is no requirement to identify critical habitat for species listed as species of special concern). If the project is carried out, the person must ensure that measures are taken (1) to avoid or lessen any adverse effects the project may have on a listed wildlife species and its critical habitat; and (2) to monitor them. These requirements under section 79 will continue to apply to such projects that are likely to affect Humpback Whale (North Pacific population).

Furthermore, several other measures will continue to apply to the Humpback Whale (North Pacific population). For example, parties to the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES)[1] have agreed to, among other things, regulate the trade of, among many other species, Humpback Whale parts or derivatives; the *Canada National Marine Conservation Areas Act* applies to the area that has been identified as a primary feeding habitat for Humpback Whales in the Gwaii Haanas National Marine Conservation Area Reserve; among many other things, the *National Energy Board Act* prohibits the construction of a pipeline without a certificate issued by the Board, which includes terms and conditions. The *Fisheries Act* will continue to apply, in particular, the *Marine Mammals Regulations* will continue to apply to the Humpback Whale (North Pacific population). Under the *Marine Mammal Regulations,* it is an offence to disturb marine mammals except

[1] The *Convention on International Trade and Endangered Species of Wild Fauna and Flora* (CITES) has three appendices. Appendix I lists species that are threatened with extinction, which are or may be affected by trade. According to the Convention, trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances.

Description

Ce décret modifie l'annexe 1 de la LEP, de sorte que le rorqual à bosse (population du Pacifique Nord) ne soit plus inscrit à titre d'espèce menacée, mais soit inscrit en tant qu'espèce préoccupante.

La reclassification à « espèce préoccupante » en vertu de l'annexe 1 signifie que le rorqual à bosse (population du Pacifique Nord) n'est plus soumis aux interdictions générales stipulées dans la LEP et que son habitat essentiel n'a plus besoin d'être désigné et légalement protégé en vertu de la LEP. Toutefois, d'autres dispositions de la LEP continuent de s'appliquer. Par exemple, en vertu de l'article 79 de la LEP, toute personne qui est tenue, sous le régime d'une loi fédérale, de voir à l'évaluation des effets environnementaux d'un projet et toute autorité qui prend une décision au titre des alinéas 67a) ou b) de la *Loi canadienne sur l'évaluation environnementale (2012)* relativement à un projet doit aviser le ministre compétent de tout projet susceptible de toucher une espèce sauvage inscrite ou son habitat essentiel désigné, et plus particulièrement une espèce préoccupante (bien que, comme il a été indiqué, il ne soit pas nécessaire de déterminer l'habitat essentiel des espèces inscrites en tant qu'espèce préoccupante). Si le projet est réalisé, la personne doit veiller à ce que des mesures soient prises : (1) en vue d'éviter ou d'amoindrir les effets nocifs du projet sur l'espèce et sur son habitat essentiel; (2) de les contrôler. Ces exigences stipulées dans l'article 79 continueront de s'appliquer à des projets susceptibles de toucher le rorqual à bosse (population du Pacifique Nord).

En outre, plusieurs autres mesures continueront de s'appliquer au rorqual à bosse (population du Pacifique Nord). Par exemple, les parties à la *Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction* (CITES)[1] ont accepté, entre autres, de réglementer le commerce des parties ou des produits dérivés du rorqual à bosse, parmi de nombreuses autres espèces; la *Loi sur les aires marines nationales de conservation du Canada* s'applique aux aires qui ont été désignées comme habitat d'alimentation principal des rorquals à bosse dans la réserve d'aire marine nationale de conservation Gwaii Haanas, entre autres; la *Loi sur l'Office national de l'énergie* interdit la construction de pipelines sans un certificat délivré par l'Office, qui comporte des modalités et des conditions à respecter. La *Loi sur les pêches*, et en particulier le *Règlement sur les mammifères marins* connexe, continuera de s'appliquer au rorqual à bosse (population du Pacifique Nord). En vertu du

[1] La *Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction* (CITES) comporte trois annexes. L'annexe I énumère les espèces menacées d'extinction qui sont concernées par le commerce ou qui pourraient l'être. Conformément à la Convention, le commerce des spécimens de ces espèces doit faire l'objet d'une réglementation particulièrement stricte afin de ne pas compromettre davantage leur survie et doit être autorisé uniquement dans des circonstances exceptionnelles.

when fishing for them under the authority of those Regulations. It is also an offence to move, tag or mark, or attempt to tag or mark, a live marine mammal, without a licence to do so [with an exception related to the holders of licences to fish for marine mammals for experimental, scientific, educational or public display purposes issued under the *Fishery (General) Regulations*]; section 35 of the *Fisheries Act* prohibits the carrying on of any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal (CRA) fishery, or to fish that support such a fishery; section 36 of the *Fisheries Act* prohibits the deposit of deleterious substances in water frequented by fish, where such deposits may be deleterious to fish, fish habitat or the use of fish, unless authorized by regulation; and, the *Canadian Environmental Protection Act, 1999* regulates disposal at sea.

Règlement sur les mammifères marins, il est interdit de perturber les mammifères marins, sauf dans les cas prévus par le Règlement. Il est également interdit de déplacer, d'étiqueter ou de marquer, ou de tenter d'étiqueter ou de marquer, un mammifère marin vivant, sans permis [exception faite des détenteurs de permis autorisant la pêche de mammifères marins à des fins expérimentales, scientifiques, éducatives ou pour exposition au public délivrés en vertu du *Règlement de pêche (dispositions générales)*]; l'article 35 de la *Loi sur les pêches* interdit d'exploiter illégalement un ouvrage ou une entreprise ou d'exercer une activité entraînant des dommages sérieux à tout poisson visé par une pêche commerciale, récréative ou autochtone, ou à tout poisson dont dépend une telle pêche; l'article 36 de la *Loi sur les pêches* interdit d'immerger ou de rejeter une substance nocive dans des eaux où vivent des poissons si le rejet peut être nocif pour le poisson, l'habitat du poisson ou l'utilisation du poisson, sauf si cela est autorisé par un règlement; et la *Loi canadienne sur la protection de l'environnement (1999)* régit l'immersion en mer.

It should also be noted that, under SARA, a proposed management plan must be prepared for listed species of special concern within three years after listing. It must include measures for the conservation of the species that the competent minister considers appropriate. It is anticipated that the management plan's conservation measures will include measures outlined in the final Recovery Strategy,[2] prepared when the Humpback Whale (North Pacific population) was listed as a threatened species in Schedule 1 of SARA.

Il convient également de noter qu'en vertu de la LEP, une proposition de plan de gestion doit être préparée pour l'espèce inscrite comme espèce préoccupante dans les trois ans suivant l'inscription. Ce plan doit comprendre les mesures de conservation de l'espèce que le ministre compétent estime appropriées. On prévoit que les mesures de conservation du plan de gestion comprennent les mesures présentées dans le programme final de rétablissement[2], préparé lorsque le rorqual à bosse (population du Pacifique Nord) a été inscrit en tant qu'espèce menacée à l'annexe 1 de la LEP.

Recovery and management planning is an opportunity for federal, provincial and territorial governments to work together and to stimulate cooperation and collaboration among a number of other partners — including municipalities, Aboriginal peoples and organizations, and other partners — in determining the actions necessary to support the survival or recovery of listed species.

La planification du rétablissement et de la gestion est une occasion pour les gouvernements fédéral, provinciaux et territoriaux de travailler ensemble et de susciter la coopération et la collaboration parmi plusieurs autres partenaires, y compris les municipalités, les peuples et les organisations autochtones et les autres partenaires, en vue de déterminer les mesures nécessaires au soutien de la survie ou du rétablissement de l'espèce inscrite.

"One-for-One" Rule[3]

The "One-for-One" Rule does not apply to the amendments to reclassify the species from a threatened species to a species of special concern on Schedule 1 of SARA, as

Règle du « un pour un »[3]

La règle du « un pour un » ne s'applique pas aux modifications visant à reclasser l'espèce de menacée à préoccupante à l'annexe 1 de la LEP, puisque cela n'introduit pas

[2] Recovery Strategy for the Northern Pacific Humpback Whale: www.sararegistry.gc.ca/document/default_e.cfm?documentID=1344.

[3] The "One-for-One" Rule requires regulatory changes that increase administrative burden costs to be offset with equal reductions in administrative burden. In addition, ministers are required to remove at least one regulation when they introduce a new one that imposes administrative burden costs on business. More information can be found at http://www.tbs-sct.gc.ca/hgw-cgf/priorities-priorites/rtrap-parfa/ofo-upu-eng.asp.

[2] Programme de rétablissement du rorqual à bosse du Pacifique Nord : www.sararegistry.gc.ca/document/default_f.cfm?documentID=1344.

[3] La règle du « un pour un » nécessite des modifications réglementaires qui accroissent les coûts du fardeau administratif et qui doivent être compensés par des réductions équivalentes du fardeau administratif. En outre, lorsqu'ils mettent en place un nouveau règlement qui impose des coûts administratifs aux entreprises, les ministres sont tenus de supprimer au moins un règlement. De plus amples renseignements sont disponibles à l'adresse suivante : http://www.tbs-sct.gc.ca/hgw-cgf/priorities-priorites/rtrap-parfa/ofo-upu-fra.asp.

the amendments do not introduce new or incremental administrative burden costs on business.

Small business lens[4]

The amendments to Schedule 1 of the *Species at Risk Act* do not impose annual nationwide costs over $1 million, nor do they have a disproportionate impact on any small businesses. As a result, the small business lens does not apply to the amendments.

Consultation

Under SARA, the scientific assessment of a species' status by COSEWIC and the decision to add a species to Schedule 1 of SARA by the Governor in Council (or amend a species' classification on Schedule 1 on the recommendation of the Minister of the Environment) are two distinct processes. This separation ensures that the biological assessment of a species status and its risk classification are separate from the Government's decision on whether or not to list the species, which can take into account other factors including socio-economic considerations.

Consultation regarding potential change of classification under Schedule 1

Consultations were facilitated through mail-outs, consultation workbooks, and other supporting documents which were made available under the "Consultations" section of the Fisheries and Oceans Canada Pacific Region's website from November 10, 2011, to January 4, 2012. Consultations were undertaken with environmental organizations, Aboriginal peoples and organizations, industry, marine mammal environmental conservation groups, other levels of government and the public on the potential reclassification under Schedule 1 of the Humpback Whale (North Pacific population) as a species of special concern, based on the May 2011 COSEWIC reassessment.

In total, out of the 312 consultation letters that were sent out, 22 responses were received.

Five respondents (two responses from provincial ministries in British Columbia, one response from the tourism industry, one response from an environmental non-governmental organization, one response from an unknown source) were in favour of reclassifying the Humpback Whale (North Pacific population) as a species of special concern under Schedule 1. One of the reasons

[4] The objective of the small business lens is to reduce regulatory costs on small businesses without compromising the health, safety, security and environment of Canadians. More details about the small business lens can be found at http://www.tbs-sct.gc.ca/hgw-cgf/priorities-priorites/rtrap-parfa/sbl-lpe-eng.asp.

de nouveaux coûts ou de coûts supplémentaires liés au fardeau administratif.

Lentille des petites entreprises[4]

Les modifications de l'annexe 1 de la *Loi sur les espèces en péril* entraînent à l'échelle nationale des coûts annuels inférieurs à un million de dollars et n'ont pas d'incidences disproportionnées sur les petites entreprises. Par conséquent, la lentille des petites entreprises ne s'applique pas à ces modifications.

Consultation

En vertu de la LEP, l'évaluation scientifique de la situation d'une espèce par le COSEPAC et la décision d'ajouter ou non une espèce à l'annexe 1 de la LEP par le gouverneur en conseil (ou de modifier la classification d'une espèce à l'annexe 1 sur recommandation du ministre de l'Environnement) sont deux processus distincts. Cette séparation garantit que l'évaluation biologique de la situation d'une espèce et sa classification du risque ne dépendent pas de la décision du gouvernement d'inscrire ou non l'espèce, décision susceptible de prendre en compte d'autres facteurs, y compris des facteurs socio-économiques.

Consultation relative au changement potentiel de classification en vertu de l'annexe 1

Des consultations ont été menées au moyen d'envois postaux, de cahiers de consultation et d'autres documents à l'appui qui ont été mis à disposition sur le site Web des consultations dans la région du Pacifique entre le 10 novembre 2011 et le 4 janvier 2012. Des consultations ont été entreprises avec des organismes environnementaux, des organisations et des peuples autochtones, l'industrie, des groupes de conservation environnementale des mammifères marins, d'autres ordres de gouvernement et le public au sujet de la reclassification potentielle du rorqual à bosse (population du Pacifique Nord) comme espèce préoccupante, en vertu de l'annexe 1, fondée sur la réévaluation du COSEPAC datant de mai 2011.

Au total, 312 lettres de consultation ont été envoyées et 22 réponses ont été reçues.

Cinq des répondants (deux réponses des ministères provinciaux de la Colombie-Britannique; une réponse de l'industrie du tourisme; une réponse d'une organisation non gouvernementale de l'environnement et une réponse provenant d'une source inconnue) étaient pour la reclassification du rorqual à bosse (population du Pacifique Nord) en tant qu'espèce préoccupante en vertu de l'annexe 1.

[4] La lentille des petites entreprises a pour objectif de réduire les coûts réglementaires des petites entreprises sans compromettre la santé, la sécurité et l'environnement des Canadiens. De plus amples renseignements sur la lentille des petites entreprises sont disponibles à l'adresse suivante : http://www.tbs-sct.gc.ca/hgw-cgf/priorities-priorites/rtrap-parfa/sbl-lpe-fra.asp.

cited by these respondents was the positive trend in the recovery of the species. One respondent indicated that a revised listing status must not be used as a rationale to decrease efforts to manage human activities and that the management plan should be developed to proactively manage impacts to the species.

Thirteen respondents (six responses from environmental non-governmental organizations, three responses from academic institutions, two responses from the tourism industry, one response from a First Nations organization, and one response from an unknown source) were not in favour of reclassifying the Humpback Whale (North Pacific population) as a species of special concern under Schedule 1. The general concern was that the prohibitions were a deterrent against activities that would negatively affect the species and its habitat. Without the prohibitions, it was argued, deterrence would no longer be present. Some respondents indicated that the reclassification of the species under Schedule 1 could lead to increased marine activity in the waters along the British Columbia which could result in increased ship strikes, entanglements or hazardous petroleum product spills. Academia and other individual respondents cited that more research was needed to better understand the diet needs of the species, its genetic and population structure, the impacts of vessel interactions, and the impacts of ocean noise before reclassification under Schedule 1 should be considered.

Four respondents (two responses from academic institutions, one response from a First Nations organization, and one response from an unknown source) were undecided with respect to the reclassification. Reasons for being undecided included insufficient information available to discuss potential impacts of reclassification under Schedule 1, insufficient information available on the impacts of debris from Japan's tsunami, and wanting mitigation measures to continue to reduce threats to the species' population.

The Province of British Columbia has indicated support for reclassifying the Humpback Whale (North Pacific population) as a species of special concern under Schedule 1 of SARA.

While the majority of responses were against reclassification of the species under Schedule 1 as a species of special concern, Fisheries and Oceans Canada maintains that the upward trend of population growth rates and increased abundance are not expected to be significantly affected by

Une des raisons citées par ces répondants était la tendance positive du rétablissement de l'espèce. L'un des répondants a indiqué qu'une révision de la situation de l'espèce dans la liste ne doit pas être utilisée pour justifier une baisse des efforts dans la gestion des activités humaines, et que le plan de gestion devrait être élaboré de manière à pouvoir gérer de façon proactive les effets sur l'espèce.

Treize des répondants (six réponses provenant d'organisations non gouvernementales de l'environnement; trois d'établissements d'enseignement; deux de l'industrie du tourisme; une d'une organisation des Premières Nations et une provenant d'une source inconnue) étaient contre la reclassification du rorqual à bosse (population du Pacifique Nord) en tant qu'espèce préoccupante en vertu de l'annexe 1. La préoccupation générale était que les interdictions dissuadent les activités susceptibles d'avoir une incidence négative sur l'espèce et son habitat. Ces répondants ont affirmé que, sans ces interdictions, il n'y aurait plus d'effet de dissuasion. Certains répondants ont indiqué que la reclassification de l'espèce en vertu de l'annexe 1 pourrait conduire à une augmentation de l'activité maritime dans les eaux au large des côtes de la Colombie-Britannique, ce qui est susceptible d'entraîner une augmentation des collisions avec des navires, des enchevêtrements ou des rejets de produits pétroliers dangereux. Des universitaires et d'autres répondants ont indiqué que des recherches supplémentaires étaient nécessaires pour mieux comprendre les besoins alimentaires de l'espèce, la structure génétique de l'espèce et de sa population, les effets des interactions avec les navires et les effets du bruit généré dans l'océan, et qu'elles devaient être prises en compte avant la reclassification en vertu de l'annexe 1.

Quatre des répondants (deux réponses provenant des établissements d'enseignement, une réponse d'une organisation des Premières Nations et une réponse d'une source inconnue) ont indiqué qu'ils étaient indécis en ce qui concerne la reclassification. Parmi les raisons de leur indécision, ils ont mentionné l'insuffisance de renseignements disponibles pour discuter des incidences potentielles de la reclassification en vertu de l'annexe 1, l'insuffisance de renseignements disponibles sur les incidences des débris provenant du tsunami au Japon, et le souhait de la mise en place de mesures d'atténuation afin de continuer à réduire les menaces pour la population de l'espèce.

La province de la Colombie-Britannique a indiqué qu'elle appuie la reclassification du rorqual à bosse (population du Pacifique Nord) en tant qu'espèce préoccupante en vertu de l'annexe 1 de la LEP.

Bien que la plupart des répondants étaient contre la reclassification de l'espèce en tant qu'espèce préoccupante en vertu de l'annexe 1, Pêches et Océans Canada soutient que la tendance à la hausse des taux de croissance et l'augmentation de l'abondance ne devaient pas être touchées

the non-application of SARA's general prohibitions or requirement to identify and legally protect critical habitat. It is noteworthy that the *Marine Mammal Regulations* continue to apply to the Humpback Whale (North Pacific population), and that listing a species under SARA as a species of special concern requires that a management plan, which must include measures for the conservation of the species, be prepared.

During the course of consultations, a number of concerns were raised with regard to the structure of the population (or "designatable unit" or "DU") in Canada. Three respondents expressed that new scientific information could divide the Humpback Whale population into two DUs; with one DU still designated as a threatened species.

COSEWIC review of referral

In January of 2012, the Minister of the Environment recommended that the Governor in Council refer the 2011 assessment of the Humpback Whale (North Pacific population) back to COSEWIC for further information or consideration. New scientific information was sent to COSEWIC for consideration as part of an official referral, which was published in the *Canada Gazette*, Part II, on March 27, 2013 (Vol. 147, No. 7).

In response to the Governor in Council referring the 2011 assessment back to COSEWIC for further information or consideration, the Chair of COSEWIC asked that the COSEWIC Marine Mammals Specialist Subcommittee consider the evidence provided and make a recommendation. The Subcommittee determined that there was no clear evidence to support the Humpback Whale (North Pacific population) being split into two DUs. According to the Subcommittee, "the Humpback Whale population off the Canadian west coast does not meet any of the COSEWIC guidelines used to recognize multiple DUs."

COSEWIC met between November 23 and 29, 2013, and reviewed the information provided by Fisheries and Oceans Canada and the recommendation from the COSEWIC Marine Mammal Specialist Subcommittee. The Minister of the Environment received a letter from the Chair of COSEWIC on December 17, 2013, in response to the referral. The letter agreed with the Subcommittee's findings that there was currently no clear evidence to support the division of the Humpback Whale population off Canada's Pacific coast into two DUs. Therefore, COSEWIC maintained its assessment for the North Pacific population of the Humpback Whale as a single DU and as a species of special concern.

de manière significative par la non-application des interdictions générales et des exigences de la LEP visant à désigner et à protéger légalement l'habitat essentiel. Il est important de noter que le *Règlement sur les mammifères marins* continuera de s'appliquer au rorqual à bosse (population du Pacifique Nord) et que l'inscription d'une espèce en tant qu'espèce préoccupante en vertu de la LEP nécessite l'élaboration d'un plan de gestion qui devra comprendre des mesures pour la conservation de l'espèce.

Au cours des consultations, plusieurs préoccupations ont été soulevées en ce qui concerne la structure de la population (ou l'« unité désignable » [« UD »]) au Canada. Trois répondants ont affirmé que les nouvelles données scientifiques pourraient permettre la division de la population de rorqual à bosse en deux unités désignables, dont l'une serait toujours désignée comme menacée.

Examen du renvoi par le COSEPAC

En janvier 2012, le ministre de l'Environnement a recommandé au gouverneur en conseil de renvoyer l'évaluation du rorqual à bosse (population du Pacifique Nord) de 2011 au COSEPAC pour obtenir davantage de renseignements et effectuer un examen plus approfondi. De nouvelles données scientifiques ont été transmises au COSEPAC, afin qu'elles soient examinées en vertu d'un renvoi officiel publié dans la Partie II de la *Gazette du Canada* du 27 mars 2013 (vol. 147, nº 7).

À la suite du renvoi par le gouverneur en conseil de l'évaluation de 2011 au COSEPAC pour obtenir davantage de renseignements et effectuer un examen plus approfondi, le président de cet organisme a demandé au Sous-comité de spécialistes des mammifères marins du COSEPAC d'examiner les données fournies et de formuler une recommandation. Le Sous-comité a déterminé qu'il n'y a pas de données claires à l'appui de la division des rorquals à bosse (population du Pacifique Nord) en deux UD. D'après le Sous-comité, « la population de rorquals à bosse au large de la côte ouest du Canada ne répond à aucune des recommandations du COSEPAC utilisées pour reconnaître de multiples UD ».

Le COSEPAC s'est réuni du 23 au 29 novembre 2013 pour étudier les renseignements fournis par Pêches et Océans Canada et la recommandation du Sous-comité de spécialistes des mammifères marins du COSEPAC. Le ministre de l'Environnement a reçu une lettre du président du COSEPAC le 17 décembre 2013 en réponse au renvoi. Tout comme les conclusions du Sous-comité, la lettre reconnaissait qu'il n'existe actuellement aucune donnée claire à l'appui de la division de la population de rorquals à bosse au large de la côte du Pacifique canadienne en deux UD. Par conséquent, le COSEPAC a maintenu son évaluation voulant que les rorquals à bosse de la population du Pacifique Nord forment une seule UD et constituent une espèce préoccupante.

***Canada Gazette*, Part I, summary of comments**

The proposed *Order Amending Schedule 1 to the Species at Risk Act* for the Humpback whale (North Pacific population) was prepublished in the *Canada Gazette*, Part I, on April 19, 2014 (Vol. 148, No. 16), for a 30-day public comment period.

A total of 2 590 submissions were received including comments from Aboriginal groups, academics, industry, non-governmental organizations, and members of the public. The majority of these submissions (2 073 or 80%) were generated through online petitions facilitated by an environmental group (Living Oceans Petition), or individuals on the website Change.org.

Of the total submissions received, 2 448 (95%) were against the reclassification of Humpback Whale from a threatened species to a species of special concern under Schedule 1; 124 expressed concerns about the change in classification; 11 requested additional information; 3 were in support of the reclassification; and, 4 responses did not express any opinion.

The three submissions in support of the reclassification under Schedule 1 included one academic, one individual from the Canadian public, and one submission made through the online petition. The comments were all positive and praised the recovery of the Humpback Whale (North Pacific population), citing it as a success story. The submissions were also supportive of the decision by COSEWIC to reclassify the species from a threatened species to a species of special concern, and stated that the decision was based on the best available science.

The online petitions were launched shortly after the prepublication of the proposed amendment. The Living Oceans Petition generated 2 025 submissions, all against the reclassification of the Humpback Whale (North Pacific population) under Schedule 1. This petition used a generic letter that participants could copy and use as their submission to the Department to express their concern over the reclassification under Schedule 1, to reiterate that more work needed to be done to determine if there were two distinct DUs, to link the reclassification of the Humpback Whale (North Pacific population) under Schedule 1 to the approval of a major resource development project, and to request the Department to put the reclassification under Schedule 1 on hold until a more specific recovery target for the Humpback Whale (North Pacific population) could be identified. The remaining petitions were all launched by individuals on the Change.org website, and generated 54 submissions against the reclassification of the Humpback Whale (North Pacific population) under Schedule 1. Participants who signed the Change.org

Résumé des commentaires de la Partie I de la *Gazette du Canada*

La proposition de *Décret modifiant l'annexe 1 de la Loi sur les espèces en péril* (pour le rorqual à bosse, population du Pacifique Nord) a été publiée préalablement dans la Partie I de la *Gazette du Canada* le 19 avril 2014 (vol. 148, nº 16) pour une consultation publique de 30 jours.

Au total, 2 590 soumissions ont été reçues, lesquelles provenaient entre autres des groupes autochtones, des universitaires, de l'industrie, des organisations non gouvernementales et des membres du public. La plupart de ces soumissions (2 073 ou 80 %) ont été générées au moyen de pétitions en ligne préparées par un groupe environnemental (pétition Living Oceans) ou des personnes sur le site Web Change.org.

De toutes les soumissions reçues, 2 448 (95 %) étaient contre la reclassification du rorqual à bosse consistant à faire passer ce dernier d'espèce menacée à espèce préoccupante en vertu de l'annexe 1; 124 soumissions rapportaient des inquiétudes concernant le changement de classification; 11 visaient à demander des renseignements supplémentaires; 3 étaient pour la reclassification; et 4 réponses n'exprimaient aucune opinion sur la question.

Les trois soumissions pour la reclassification en vertu de l'annexe 1 provenaient d'un universitaire, d'un membre du public canadien et d'une entrée de la pétition en ligne. Les commentaires étaient tous positifs et se réjouissaient du rétablissement du rorqual à bosse (population du Pacifique Nord), le qualifiant de véritable succès. De plus, les soumissions appuyaient la recommandation du COSEPAC de reclasser l'espèce à la baisse en la faisant passer d'espèce menacée à espèce préoccupante, et indiquaient que la décision était fondée sur les meilleures données scientifiques disponibles.

Les pétitions en ligne ont été lancées peu après la publication préalable de la modification proposée. La pétition Living Oceans a généré 2 025 soumissions, toutes opposées à la reclassification du rorqual à bosse (population du Pacifique Nord) en vertu de l'annexe 1. Cette pétition consistait en une lettre générique que les participants pouvaient copier et utiliser pour leur soumission au Ministère afin d'exprimer leurs préoccupations au sujet de la reclassification en vertu de l'annexe 1, de souligner qu'il faut réaliser plus de travaux afin de déterminer s'il existe deux unités désignables distinctes, d'établir un lien entre la reclassification du rorqual à bosse (population du Pacifique Nord) en vertu de l'annexe 1 et l'approbation d'un grand projet d'exploitation des ressources, et de demander au Ministère de mettre la reclassification en vertu de l'annexe 1 en attente jusqu'à ce qu'une cible de rétablissement précise puisse être préparée pour l'espèce. Les autres pétitions ont toutes été créées par des personnes sur le site Web Change.org; elles ont généré 54 soumissions contre la reclassification du rorqual à bosse

petitions supported the following two statements: "I support the full protection of the Northern Humpback Whale's status as a species 'at risk' and 'under threat'"and "I support the full protection of the Northern Humpback Whale's habitat."

A summary of all the comments received during the 30-day comment period have been categorized into five main types:

Type 1: The Humpback Whale (North Pacific population) and its habitat still need to be protected

Members of the public, academics and environmental non-governmental organizations asked how the Humpback Whale (North Pacific population) and its critical habitat would be protected, and threats mitigated, to prevent it from becoming a threatened species again.

Response

COSEWIC reclassified the Humpback Whale (North Pacific population) as a species of special concern based on the best available information, including new information regarding the structure of the population. While the general prohibitions and the obligation to identify and protect critical habitat do not apply to species of special concern under SARA, the species will remain on the *List of Wildlife Species at Risk* (Schedule 1) [although at a different classification] and the competent minister must prepare a SARA management plan for the species and its habitat, and regular monitoring of the implementation of that plan. Additionally, as discussed above, other sections of SARA will continue to apply including, for example, section 79 (Project Review) which requires the identification of adverse effects of any proposed projects on listed species. The preparation of the management plan will draw on the existing Recovery Strategy for this species and address the threats that have been outlined in that document, including ship strikes, acoustic disturbance, prey availability and pollution, among others.

Some provisions of the *Fisheries Act* will continue to apply to the Humpback Whale (North Pacific population). For example, section 35 of the *Fisheries Act* prohibits the unauthorized carrying on of any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery. Serious harm to fish is defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat." Thus, given that "serious harm to fish" encompasses destruction of fish habitat, the

(population du Pacifique Nord) en vertu de l'annexe 1. Les participants qui ont signé les pétitions sur Change.org appuyaient les deux déclarations suivantes : « J'appuie la protection complète du statut du rorqual à bosse du Nord en tant qu'espèce "en péril" et "menacée" », et « J'appuie la protection complète de l'habitat du rorqual à bosse du Nord » [traduction].

Tous les commentaires reçus pendant la période de consultation de 30 jours ont été classés en cinq grandes catégories, selon leur type :

Type 1 : La protection du rorqual à bosse (population du Pacifique Nord) et de son habitat doit être maintenue

Des membres du public, des universitaires et des organisations non gouvernementales de l'environnement ont posé des questions relativement aux moyens qui seraient utilisés pour protéger le rorqual à bosse (population du Pacifique Nord) et son habitat essentiel, atténuer les menaces et empêcher que l'espèce redevienne une espèce menacée.

Mesure

Le COSEPAC a reclassé le rorqual à bosse (population du Pacifique Nord) en tant qu'espèce préoccupante, en se basant sur la meilleure information disponible, dont les nouvelles données sur la structure de la population. Bien que les interdictions générales et l'obligation de déterminer et de protéger l'habitat essentiel ne s'appliquent pas aux espèces préoccupantes en vertu de la LEP, l'espèce demeure sur la *Liste des espèces en péril* (annexe 1) [mais sous une classification différente] et le ministre compétent est tenu d'élaborer un plan de gestion en vertu de la LEP pour l'espèce et son habitat, et d'assurer la surveillance régulière de la mise en œuvre de ce plan. De plus, comme il a été mentionné précédemment, d'autres articles de la Loi continueront de s'appliquer, par exemple l'article 79 (examen du projet), qui exige la détermination des effets négatifs de toute proposition de projet concernant une espèce inscrite. L'élaboration du plan de gestion s'appuiera sur le programme de rétablissement existant de cette espèce et s'attaquera aux menaces répertoriées dans ce document, y compris les collisions avec les navires, les perturbations acoustiques, la disponibilité des proies et la pollution.

Certaines dispositions de la *Loi sur les pêches* continueront de s'appliquer au rorqual à bosse (population du Pacifique Nord). Par exemple, l'article 35 de la *Loi sur les pêches* stipule qu'il est interdit d'exploiter illégalement un ouvrage ou une entreprise ou d'exercer une activité entraînant des dommages sérieux à tout poisson visé par une pêche commerciale, récréative ou autochtone, ou à tout poisson dont dépend une telle pêche. La Loi considère comme des dommages sérieux « la mort de tout poisson ou la modification permanente ou la destruction de son

prohibition under section 35 contributes to the protection of habitat of the North Pacific Humpback Whale. Additionally, the *Marine Mammals Regulations* made under the *Fisheries Act* will continue to apply. Under these Regulations, it is an offence to disturb a marine mammal except when fishing for a marine mammal under the authority of the Regulations (disturbance would include noise disturbance). It is also an offence to move, tag, or mark them without a licence issued under the appropriate regulations. It is also an offence to fish for them except under the authority of a licence issued under the *Marine Mammal Regulations*, or under the *Aboriginal Communal Fishing Licences Regulations*.

Other specific threats to the Humpback Whale (North Pacific population) and its habitat will continue to be mitigated through the application of other legislation and management measures. For example, the following legislation will still apply in the habitat of the Humpback Whale (North Pacific population): the *Ballast Water Control and Management Regulations* and the *Vessel Pollution and Dangerous Chemicals Regulations* made under the *Canada Shipping Act, 2001* (which concerns certain aspects of marine pollution) as well as the *Canadian Environmental Protection Act, 1999*, which, among other things, regulates disposal at sea, and the *Fisheries Act* (section 36), which prohibits the unauthorized deposit of deleterious substances in waters frequented by fish. Additionally, other non-regulatory measures will also continue to apply, including the Marine Mammal Response Program, which responds to entangled or stranded marine mammals and works to free the animal and protects it from disturbance and noise as provided for in the Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment.

It should be noted that seven other species of whales, namely the Blue Whale (Pacific population), Fin Whale (Pacific population), Sei Whale (Pacific population), North Pacific Right Whale, Killer Whale (Northeast Pacific transient population, Northeast Pacific northern resident population, and Northeast Pacific southern resident populations) can be found in areas frequented by the Humpback Whale (North Pacific population). These other whales, for which the general prohibitions under SARA continue to apply, face similar threats as the Humpback Whale (North Pacific population). In addition, a critical habitat order is currently in force with respect to the Killer Whale (Northeast Pacific northern resident population and Northeast Pacific southern resident population). Therefore, the prohibition against the destruction of critical habitat of these two populations of Killer Whales applies to areas that are also frequented by the Humpback Whale (North Pacific population), thereby offering some protection to habitat important for this species.

habitat ». Par conséquent, étant donné que les « dommages sérieux » comprennent la destruction de l'habitat du poisson, l'interdiction en vertu de l'article 35 contribue à la protection de l'habitat essentiel du rorqual à bosse du Pacifique Nord. De plus, le *Règlement sur les mammifères marins* adopté en vertu de la *Loi sur les pêches* continuera de s'appliquer. En vertu de ce règlement, il est interdit de perturber un mammifère marin, sauf dans les cas prévus par le Règlement (les perturbations incluent les perturbations acoustiques). Il est également interdit de déplacer, d'étiqueter ou de marquer ces mammifères sans un permis délivré en vertu du règlement pertinent. De même, il est interdit de les pêcher, sauf en vertu d'un permis délivré dans le cadre du *Règlement sur les mammifères marins* ou du *Règlement sur les permis de pêche communautaires des Autochtones*.

D'autres menaces spécifiques pesant sur le rorqual à bosse (population du Pacifique Nord) et son habitat continueront d'être atténuées grâce à l'application d'autres lois et mesures de gestion. Par exemple, les lois suivantes s'appliquent toujours à l'habitat du rorqual à bosse (population du Pacifique Nord) : le *Règlement sur le contrôle et la gestion de l'eau de ballast* et le *Règlement sur la pollution par les bâtiments et sur les produits chimiques dangereux* adopté en vertu de la *Loi de 2001 sur la marine marchande du Canada* (qui concerne certains aspects de la pollution marine), ainsi que la *Loi canadienne sur la protection de l'environnement (1999)* [qui, entre autres, réglemente les activités d'immersion en mer] et la *Loi sur les pêches* (article 36) [qui interdit le rejet de substances nocives dans les eaux où vivent des poissons]. De plus, d'autres mesures non réglementaires continueront de s'appliquer, notamment le Programme d'intervention auprès des mammifères marins, qui vise les mammifères marins échoués ou empêtrés et qui vise à libérer les animaux et à les protéger des perturbations et du bruit, conformément à l'Énoncé des pratiques canadiennes d'atténuation des ondes sismiques en milieu marin.

Il convient de noter que sept autres espèces de baleine, à savoir le rorqual bleu (population du Pacifique), le rorqual commun (population du Pacifique), le rorqual boréal (population du Pacifique), la baleine noire du Pacifique Nord et l'épaulard (population migratrice du Pacifique Nord-Est, population résidente du nord du Pacifique Nord-Est et population résidente du sud du Pacifique Nord-Est) sont présentes dans les zones fréquentées par le rorqual à bosse (population du Pacifique Nord). Ces autres baleines, pour lesquelles les interdictions générales prévues par la LEP continuent de s'appliquer, sont confrontées à des menaces semblables à celles auxquelles est exposé le rorqual à bosse (population du Pacifique Nord). De plus, un arrêté en conseil visant la protection de l'habitat essentiel est actuellement en vigueur en ce qui concerne l'épaulard (population résidente du nord du Pacifique Nord-Est et population résidente du sud du Pacifique Nord-Est). Par conséquent, l'interdiction empêchant la destruction de l'habitat essentiel de ces deux

populations d'épaulards s'applique aux zones qui sont également fréquentées par le rorqual à bosse (population du Pacifique Nord), afin d'assurer la protection de l'habitat important pour cette espèce.

Type 2: Additional information requested on how a listing decision is made and how the listing process works

Members of the public, academics and environmental non-governmental organizations raised concerns about the decision-making process, the basis for decisions, and a perceived lack of notice and consultation prior to decisions being made.

Response

Fisheries and Oceans Canada consulted with stakeholders and notified the public on multiple occasions prior to prepublishing the proposed Order amending Schedule 1 of SARA. Public consultations were held from November 10, 2011, to January 4, 2012, by Fisheries and Oceans Canada on amending Schedule 1 of SARA so that the Humpback Whale (North Pacific population) would no longer be listed as a threatened species, but would be listed as a species of special concern. In addition to the online consultation, 312 consultations letters were sent out to the province of British Columbia, environmental non-government organizations, First Nations, marine mammal stakeholders, marine mammal ecological contacts and government marine mammal experts. As well, the Government of Canada referred back to COSEWIC new information for consideration based on a concern raised during consultations. This referral back to COSEWIC was formalized in the *Canada Gazette*, Part I, (Vol. 147, No. 7) on March 27, 2013. In response, COSEWIC stated that there was insufficient evidence to support the division of the species into two separate Designated Units (DU). Therefore, COSEWIC maintained its assessment for the North Pacific population of the Humpback Whale as a single DU and as a species of special concern. COSEWIC posted this information on their website on December 13, 2013, which was also posted on the Species at Risk Public Registry on February 24, 2014.

The prepublication of the Order in the *Canada Gazette,* Part I, (Vol. 148, No. 16) on April 19, 2014, was another opportunity provided to stakeholders and the public to provide comments on the proposed amendment to Schedule 1 of SARA.

Type 2 : Demande de renseignements supplémentaires sur la façon dont cette décision d'inscription est prise et le fonctionnement du processus d'inscription

Des membres du public, des universitaires et des organisations non gouvernementales de l'environnement ont soulevé des préoccupations sur le processus décisionnel, le fondement des décisions, et l'impression d'un manque de préavis et de consultation avant la prise de décisions.

Mesure

Pêches et Océans Canada a consulté les intervenants et a averti le public à plusieurs reprises avant la publication préalable du décret modifiant l'annexe 1 de la LEP proposé. Des consultations publiques ont été menées du 10 novembre 2011 au 4 janvier 2012 par Pêches et Océans Canada relativement à la modification de l'annexe 1 de la LEP, qui consiste à retirer le rorqual à bosse (population du Pacifique Nord) de la liste des espèces menacées et à l'inscrire sur la liste des espèces préoccupantes. En plus des consultations en ligne, 312 lettres de consultation ont été envoyées à la province de la Colombie-Britannique, aux organisations non gouvernementales de l'environnement, aux Premières Nations, aux intervenants en matière de mammifères marins, aux personnes-ressources du domaine de l'écologie et des mammifères marins, et aux spécialistes des mammifères marins du gouvernement. En outre, le gouvernement du Canada s'est appuyé sur les nouveaux renseignements du COSEPAC relatifs à une préoccupation soulevée au cours des consultations. Ce renvoi au COSEPAC a été officialisé dans la Partie I de la *Gazette du Canada* (vol. 147, nº 7) le 27 mars 2013. En réaction, le COSEPAC a déclaré qu'il n'existait pas assez d'éléments probants pour justifier une division de l'espèce en deux unités désignables distinctes. Par conséquent, le COSEPAC a maintenu son évaluation voulant que les rorquals à bosse de la population du Pacifique Nord forment une seule UD et constituent une espèce préoccupante. Le COSEPAC a publié cette information sur son site Web le 13 décembre 2013. L'information a également été publiée dans le Registre public des espèces en péril, le 24 février 2014.

La publication préalable du Décret dans la Partie I de la *Gazette du Canada* (vol. 148, nº 16) le 19 avril 2014 était une autre occasion offerte aux intervenants et au public de fournir des commentaires sur les changements proposés à l'annexe 1 de la LEP.

As for the information related to the listing process[5], there are a number of steps. First, COSEWIC assesses species to determine whether they are currently at risk and, if so, classifies them as extinct, extirpated, endangered, threatened or of special concern. COSEWIC's classifications are based on status reports prepared by independent experts. COSEWIC carries out its functions on the basis of the best available information on the status of the species, including scientific knowledge, community knowledge and aboriginal traditional knowledge (ATK).

Status reports are reviewed by COSEWIC's species specialist subcommittees which provide recommendations to COSEWIC. COSEWIC's decision to assign a classification to a species considers a large number of criteria, including the extent of a species' decline and its overall abundance. When COSEWIC completes its assessment, it must provide the Minister of the Environment and the Canadian Endangered Species Conservation Council with a copy of the assessment and the reason for it.

Upon receiving an assessment for an aquatic species from the Minister of the Environment, the Governor in Council will make a decision, on the recommendation of the Minister of the Environment, who must — among other things — first consult the Minister of Fisheries and Oceans (as competent minister). For a species that is not already on the List, the Governor in Council must either (1) accept the assessment and add the species to the List; (2) decide not to add the species to the List; or (3) refer the matter back to COSEWIC for further information or consideration. For species that are already on the List, the Governor in Council can either (1) accept the reassessment and reclassify the species; (2) decide not to reclassify the species; or (3) refer the matter back to COSEWIC for further information or consideration. This decision is not made in isolation; it is made after consultations with affected stakeholders and other groups, taking into account the economic and social implications that listing a species may have on Canadians' lives and livelihoods.

En ce qui concerne l'information liée au processus d'inscription[5], il y a plusieurs étapes. Dans un premier temps, le COSEPAC évalue l'espèce afin de déterminer si elle est actuellement en péril. Si tel est le cas, elle la désigne comme étant éteinte, disparue, en voie de disparition, menacée ou préoccupante. Les classifications du COSEPAC sont fondées sur les rapports de situation préparés par des experts indépendants. Le COSEPAC mène à bien ses fonctions en s'appuyant sur les meilleurs renseignements disponibles à propos de la situation de l'espèce, notamment les connaissances scientifiques, les connaissances des collectivités et les connaissances traditionnelles des peuples autochtones.

Les rapports de situation sont révisés par les sous-comités de spécialistes des espèces du COSEPAC, lesquels formulent des recommandations au COSEPAC. La décision du COSEPAC d'attribuer une classe à une espèce prend en compte un grand nombre de critères, y compris l'étendue du déclin d'une espèce et son abondance globale. Lorsque le COSEPAC termine son évaluation, il doit en fournir une copie au ministre de l'Environnement et au Conseil canadien pour la conservation des espèces en péril au Canada, en leur indiquant les raisons de la désignation.

À la réception de l'évaluation d'une espèce aquatique transmise par le ministre de l'Environnement, le gouverneur en conseil prendra une décision, sur la recommandation du ministre de l'Environnement. Ce dernier doit d'abord, entre autres, consulter Pêches et Océans Canada (en sa qualité de ministère compétent). Dans le cas des espèces qui ne figurent pas encore sur la liste, le gouverneur en conseil doit soit : (1) accepter l'évaluation et ajouter l'espèce sur la liste; (2) décider de ne pas ajouter l'espèce à la liste; ou (3) renvoyer la question au COSEPAC pour obtenir de plus amples renseignements ou pour effectuer un examen approfondi. Dans le cas des espèces déjà sur la liste, le gouverneur en conseil doit soit : (1) accepter la réévaluation et reclasser l'espèce; (2) décider de ne pas reclasser l'espèce; ou (3) renvoyer la question au COSEPAC pour obtenir de plus amples renseignements ou pour effectuer un examen approfondi. Cette décision n'est pas prise en vase clos; elle fait suite à des consultations avec les intervenants et d'autres groupes intéressés, en tenant compte des répercussions économiques et sociales que l'inscription sur une liste d'une espèce pourrait avoir sur la vie et les moyens de subsistance des Canadiens.

[5] The Humpback Whale COSEWIC reassessment information can be found at http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=982 and all Humpback Whale information can be found on the Species at Risk Public Registry at http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=148#ot18. Information regarding SARA listing can be found at http://www.sararegistry.gc.ca/sar/listing/default_e.cfm.

[5] Des renseignements sur la réévaluation du rorqual à bosse menée par le COSEPAC sont disponibles à l'adresse suivante : http://www.registrelep-sararegistry.gc.ca/document/default_f.cfm?documentID=982. Tous les renseignements sur l'espèce sont disponibles dans le Registre public des espèces en péril, à l'adresse suivante : http://www.sararegistry.gc.ca/species/speciesDetails_f.cfm?sid=148#ot18. Les renseignements relatifs à l'inscription en vertu de la LEP sont disponibles à l'adresse suivante : http://www.sararegistry.gc.ca/sar/listing/default_f.cfm.

Type 3: This decision was based on economic reasons and not on science

Members of the public, academics and environmental non-governmental organizations stated that the Governor in Council's decision to reclassify the Humpback Whale (North Pacific population) from a threatened species to a species of special concern was made based on economic reasons and was not science-based.

Response: The decision to reclassify the Humpback Whale (North Pacific population) from a threatened species to a species of special concern was based on the assessment of the species by COSEWIC. The assessment process is independent and transparent and does not consider socio-economic criteria. COSEWIC classified the Humpback Whale (North Pacific population) as a threatened species in May 2003 and reclassified it as a species of special concern in May 2011.

During the public consultation period from November 2011 to January 2012, Fisheries and Oceans Canada considered the best available information to advise the Minister of the Environment to recommend to the Governor in Council to refer COSEWIC's reclassification of the Humpback Whale (North Pacific population) as a species of special concern. In referring the matter back, the Governor in Council requested COSEWIC to reconsider information that would separate the population into two distinct DUs. COSEWIC examined this information, and determined that there was insufficient evidence to support the Humpback Whale (North Pacific population) being split into two different DUs. COSEWIC maintained its assessment for the North Pacific population of the Humpback Whale as a single DU, and as a species of special concern. This determination was based on a recommendation by the Marine Mammals Specialist Subcommittee of COSEWIC.

Type 4: Canadians and stakeholders want to be informed and involved in the next steps

Members of the public, industry, academics and environmental non-governmental organizations mentioned they would like to be informed or be part of the next steps for the Humpback Whale (North Pacific population).

Response: A management plan will be prepared in consultation with key stakeholders, and a proposed version will be posted on the Species at Risk Public Registry for a 60-day public consultation period. The management plan will be developed based on the Humpback Whale's

Type 3 : Cette décision a été prise pour des raisons économiques et n'est pas fondée sur des données scientifiques

Des membres du public, des universitaires et des organisations non gouvernementales de l'environnement ont indiqué que la décision du gouverneur en conseil de reclasser à la baisse le rorqual à bosse (population du Pacifique Nord), plus précisément de le faire passer d'espèce menacée à espèce préoccupante, a été prise pour des raisons économiques et n'est pas fondée sur des données scientifiques.

Réponse : La décision de reclasser le rorqual à bosse (population du Pacifique Nord) d'espèce menacée à espèce préoccupante se fonde sur une évaluation de l'espèce faite par le COSEPAC. Le processus d'évaluation est indépendant et transparent et il ne tient pas compte des critères socio-économiques. Le COSEPAC a classé le rorqual à bosse (population du Pacifique Nord) comme espèce menacée en mai 2003 et l'a reclassé comme espèce préoccupante en mai 2011.

Pendant la période de consultation du public de novembre 2011 à janvier 2012, Pêches et Océans Canada s'est appuyé sur les meilleures données disponibles pour conseiller le ministre de l'Environnement et recommander au gouverneur en conseil de renvoyer au COSEPAC le reclassement du rorqual à bosse (population du Pacifique Nord) d'espèce menacée à espèce préoccupante. En renvoyant la question au COSEPAC, le gouverneur en conseil a demandé à l'organisme de réexaminer les renseignements susceptibles de justifier la séparation de la population en deux unités désignables distinctes. Le COSEPAC a examiné l'information et a déterminé qu'il n'y a pas de données suffisantes à l'appui de la division des rorquals à bosse (population du Pacifique Nord) en deux unités désignables distinctes. Le COSEPAC a maintenu son évaluation voulant que les rorquals à bosse de la population du Pacifique Nord forment une seule unité désignable et constituent une espèce préoccupante. Cette détermination se fondait sur une recommandation du Sous-comité de spécialistes des mammifères marins du COSEPAC.

Type 4 : Les Canadiens et les intervenants souhaitent être informés et participer aux prochaines étapes

Des membres du public, l'industrie, des universitaires et des organisations non gouvernementales de l'environnement ont indiqué qu'ils aimeraient être mis au courant des prochaines étapes prises pour le rorqual à bosse (population du Pacifique Nord), ou y prendre part.

Réponse : Un plan de gestion sera préparé en consultation avec les principaux intervenants, et une version proposée sera publiée dans le Registre public des espèces en péril, pour une période de consultation publique de 60 jours. Le plan de gestion sera élaboré suivant le

Recovery Strategy and any new information that has arisen since that document was prepared.

The *Species at Risk Act* requires that a proposed management plan be posted within three years of a species being listed as a species of special concern. The management plan will address the identified threats and take into account existing protections afforded by other federal legislation. Following the 60-day public comment period, the proposed management plan will be revised, if considered appropriate, and its final version posted on the Species at Risk Public Registry.

programme de rétablissement du rorqual à bosse et toute nouvelle information obtenue pendant sa préparation.

En vertu de la *Loi sur les espèces en péril*, une proposition de plan de gestion doit être publiée dans les trois années suivant l'inscription d'une espèce en tant qu'espèce préoccupante. Le plan de gestion ciblera les menaces cernées et prendra en compte les protections existantes accordées par d'autres lois fédérales. Après la période de commentaires du public de 60 jours, la proposition de plan de gestion doit être révisée, si cela est approprié, et sa version définitive doit être publiée dans le Registre public des espèces en péril.

Type 5: Concerns about reclassification despite opposition from stakeholders

Members of the public, academics and environmental non-governmental organizations expressed concerns that the federal government was moving forward with the reclassification of the Humpback Whale (North Pacific population) despite the fact that a majority of the stakeholders who participated in the 2011–2012 consultations expressed opposition.

Response: In their most recent 2011 assessment and status report, COSEWIC found that there had been no evidence of a Humpback Whale population decline since the 1960s. Although no trend data are available from 1966 to the 1990s, COSEWIC determined that the North Pacific population has been increasing at about 4.9% per year since the early 1990s. Based on 2006 photo-identification data, the local British Columbia population was estimated to be 2 145 individuals.

Therefore, Schedule 1 *List of Wildlife Species at Risk* of SARA is amended so that the Humpback Whale (North Pacific population) is listed as a species of special concern. The Minister of the Environment will continue to make SARA listing recommendations to the Governor in Council following the consideration of COSEWIC assessments, consultations with the competent minister or ministers, other consultations, socio-economic considerations, and our commitment to the conservation of biological diversity.

Fisheries and Oceans Canada will also work with the Parks Canada Agency, Aboriginal peoples and organizations, industry, environmental non-governmental organizations, and Canadians to develop a management plan that will include various conservation measures for the Humpback Whale (North Pacific population).

Type 5 : Préoccupations sur le reclassement malgré l'opposition des intervenants

Des membres du public, du milieu universitaire et d'organisations non gouvernementales se sont dits inquiets du fait que le gouvernement fédéral décide de reclasser à la baisse le rorqual à bosse (population du Pacifique Nord) malgré le fait que la majorité des intervenants ayant participé aux consultations de 2011-2012 s'y soient opposés.

Réponse : Dans son évaluation et son rapport de situation les plus récents (2011), le COSEPAC indique que rien ne prouve que la population de rorquals à bosse connaît un déclin depuis les années 1960. Bien qu'il n'y ait pas de données disponibles pour la période allant de 1966 aux années 1990, le COSEPAC a déterminé que la population du Pacifique Nord a augmenté d'environ 4,9 % par an depuis le début des années 1990. D'après les données d'identification photographique de 2006, la population locale en Colombie-Britannique a été estimée à 2 145 individus.

Ainsi, la *Liste des espèces en péril* de l'annexe 1 de la LEP a été modifiée de manière à ce que le rorqual à bosse (population du Pacifique Nord) soit classé comme espèce préoccupante. Le ministère de l'Environnement continuera de formuler au gouverneur en conseil des recommandations concernant l'inscription en vertu de la LEP en fonction des évaluations du COSEPAC, des consultations avec le ou les ministres compétents, d'autres consultations, des facteurs socio-économiques, et de notre engagement à préserver la diversité biologique.

De plus, Pêches et Océans Canada travaillera avec Parcs Canada, les organisations et les peuples autochtones, l'industrie, les organisations non gouvernementales de l'environnement et les Canadiens dans le but d'élaborer un plan de gestion qui comprendra diverses mesures de conservation du rorqual à bosse (population du Pacifique Nord).

Conclusion

All relevant factors, including the best scientific information (which includes the COSEWIC assessment), socio-economic analyses, and consultations with Canadians, key stakeholders and provinces and territories, were taken into consideration prior to providing advice to the Minister of the Environment. The Minister of the Environment, after consulting the Minister of Fisheries and Oceans, has recommended to the Governor in Council to amend Schedule 1 of SARA. By this Order, the Humpback Whale (North Pacific population) is listed as a species of special concern.

Rationale

The baseline for assessing the incremental benefits and costs associated with the reclassification of the Humpback Whale (North Pacific population) as a species of special concern on Schedule 1 of SARA is the complete suite of relevant existing legislation, regulations, and other measures.

As identified by COSEWIC, Humpback Whales (North Pacific population) face a variety of threats, notably vessel strikes, entanglement in fishing gear, toxic spills, reduction in prey and acoustic disturbance. These threats are not limited to Canadian waters.

The Humpback Whale is protected under two international conventions. The *International Convention for the Regulation of Whaling* (administered by the International Whaling Commission [IWC]) banned the commercial hunting of Humpback Whales in the North Atlantic in 1955 and in the North Pacific in 1966 (Best 1993)[6]. The Humpback Whale has not been subject to commercial hunting in Canada since 1966 even though Canada withdrew from the whaling convention in 1982. Parties to the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) have agreed to, among other things, regulate the trade of, species listed in the Convention's Schedules. Humpback Whale is listed in Appendix I of the Convention.

In Canada, Fisheries and Oceans Canada is responsible for the management of Humpback Whales (North Pacific population) and other cetaceans. The *Marine Mammal Regulations*, made under the *Fisheries Act*, apply to cetaceans and other marine mammals and, among other things, make it an offence to disturb a marine mammal, except when fishing for a marine mammal under the authority of those Regulations.

[6] Best, P. B. 1993. "Increase rates in severely depleted stocks of baleen whales." *ICES Journal of Marine Science* 50(2):169–186.

Conclusion

Avant de formuler une recommandation au ministre de l'Environnement, on a tenu compte de tous les facteurs pertinents, y compris des meilleures données scientifiques disponibles (dont l'évaluation du COSEPAC), des analyses socio-économiques et des consultations avec les Canadiens, les principaux intervenants, les provinces et les territoires. Le ministre de l'Environnement, après avoir consulté le ministre des Pêches et des Océans, a recommandé au gouverneur en conseil de modifier l'annexe 1 de la LEP. Par le présent décret, le rorqual à bosse (population du Pacifique Nord) est inscrit comme espèce préoccupante.

Justification

Le niveau de référence pour l'évaluation des avantages et des coûts supplémentaires liés au reclassement du rorqual à bosse (population du Pacifique Nord) en tant qu'espèce préoccupante à l'annexe 1 de la LEP est un ensemble complet de lois, de règlements et d'autres mesures pertinents existants.

Comme l'a déterminé le COSEPAC, les rorquals à bosse (population du Pacifique Nord) sont exposés à diverses menaces, notamment les collisions avec les navires, l'enchevêtrement dans les engins de pêche, les déversements de substances toxiques, les perturbations acoustiques potentielles et la baisse éventuelle du nombre de proies. Ces menaces ne concernent pas seulement les eaux canadiennes.

Le rorqual à bosse est protégé par deux conventions internationales. La *Convention internationale pour la réglementation de la chasse à la baleine* (administrée par la Commission baleinière internationale [CBI]) a interdit la chasse commerciale au rorqual à bosse dans l'Atlantique Nord en 1955 et dans le Pacifique Nord en 1966 (Best 1993)[6]. Le rorqual à bosse n'a pas fait l'objet d'une chasse commerciale au Canada depuis 1966, même si le Canada s'est retiré de la convention en 1982. Les parties à la *Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction* (CITES) ont accepté, entre autres, de réglementer le commerce des espèces inscrites aux annexes de la Convention. Le rorqual à bosse est inscrit à l'annexe I de la Convention.

Au Canada, Pêches et Océans Canada est responsable de la gestion des rorquals à bosse (population du Pacifique Nord) et d'autres cétacés. Le *Règlement sur les mammifères marins* adopté en vertu de la *Loi sur les pêches* s'applique aux cétacés et aux autres mammifères marins. Il stipule, entre autres, que quiconque dérange un mammifère marin commet une infraction, sauf dans les cas autorisés aux termes du Règlement.

[6] Best, P. B. 1993. "Increase rates in severely depleted stocks of baleen whales." *ICES Journal of Marine Science* 50(2):169–186.

In British Columbia, Fisheries and Oceans Canada, in collaboration with many other organizations, has developed the "Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers" (DFO 2008),[7] which are voluntary measures aimed at limiting physical and acoustic disturbance.

In June 2010, Parks Canada Agency established the Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site, which covers a marine area of approximately 3 400 km^2 around the Gwaii Haanas National Park Reserve and Haida Heritage Site. This area has been identified as a primary feeding habitat for Humpback Whales in western Canadian waters (Nichol *et al.* 2010).[8]

Benefits

As a charismatic species, Humpback Whales (North Pacific population) likely have a high non-market value,[9] which is unlikely to be reduced under this action. SARA recognizes in its preamble that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons," which indicates that actions taken to conserve and recover a species hold value for Canadians.

The non-applicability of both the general prohibitions under SARA (section 32) and the requirement to identify and legally protect critical habitat (section 58) could result in negligible benefits to industry in the form of cost savings. The *Marine Mammal Regulations*, made under the *Fisheries Act*, will continue to apply to the Humpback Whale (North Pacific population). As the differences between mitigation requirements under SARA and the *Fisheries Act* are minimal, the incremental cost savings would also be negligible.

Costs

Listing a species as a species of special concern requires the preparation of a SARA management plan. The

En Colombie-Britannique, Pêches et Océans Canada, en collaboration avec de nombreux autres organismes, a élaboré le document « Respectez les baleines – Directives concernant la faune marine à l'intention des plaisanciers, des pagayeurs et des observateurs » (MPO 2008)[7], qui présente les mesures volontaires visant à limiter les perturbations physiques et acoustiques.

En juin 2010, l'Agence Parcs Canada a établi la réserve d'aire marine nationale de conservation et le site patrimonial haïda Gwaii Haanas, lesquels couvrent une aire marine d'environ 3 400 km^2 située autour de la réserve du parc national et du site patrimonial haïda Gwaii Haanas. Cette aire a été définie comme habitat d'alimentation principal des rorquals à bosse dans les eaux occidentales canadiennes (Nichol *et al.* 2010)[8].

Avantages

En tant qu'espèce charismatique, le rorqual à bosse (population du Pacifique Nord) présente vraisemblablement une valeur non marchande élevée[9], laquelle ne devrait pas diminuer dans le cadre de cette mesure. Selon le préambule de la LEP, « les espèces sauvages, sous toutes leurs formes, ont leur valeur intrinsèque et sont appréciées des Canadiens pour des raisons esthétiques, culturelles, spirituelles, récréatives, éducatives, historiques, économiques, médicales, écologiques et scientifiques », ce qui laisse entendre que les mesures prises pour la conservation et le rétablissement d'une espèce ont de la valeur aux yeux des Canadiens.

La non-application des interdictions générales en vertu de la LEP (article 32) et de l'exigence de désigner et de protéger légalement l'habitat essentiel (article 58) pourrait entraîner des avantages négligeables pour l'industrie, sous forme d'économies. Le *Règlement sur les mammifères marins* adopté en vertu de la *Loi sur les pêches* continuera de s'appliquer au rorqual à bosse (population du Pacifique Nord). Puisque les différences entre les exigences d'atténuation en vertu de la LEP et celles de la *Loi sur les pêches* sont minimes, les économies en matière de coûts différentiels seraient également négligeables.

Coûts

L'inscription d'une espèce à titre d'espèce préoccupante exige l'élaboration d'un plan de gestion en vertu de la LEP.

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[7] DFO. 2008. "Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers." Fisheries and Oceans Canada. Website [accessed September 2009].

[8] Nichol, L. M., R. Abernethy, L. Flostrand, T. S. Lee, and J. K. B. Ford. 2010. "Information relevant for the identification of Critical Habitats of North Pacific Humpback Whales (*Megaptera novaeangliae*) in British Columbia." DFO Can. Sci. Advis. Sec. Res. Doc. 2009/116, 40 pp.

[9] The amount that a person (or society) values a good or service for which there is no market where they can express that value through actual payments.

[7] MPO. 2008. « Respectez les baleines – Directives concernant la faune marine à l'intention des plaisanciers, des pagayeurs et des observateurs ». Pêches et Océans Canada. Site Web (consulté en septembre 2009).

[8] Nichol, L. M., R. Abernethy, L. Flostrand, T. S. Lee et J. K. B. Ford. 2010. "Information relevant for the identification of Critical Habitats of North Pacific Humpback Whales (*Megaptera novaeangliae*) in British Columbia." Secr. can. de consult. sci. du MPO. Doc. de rech. 2009/116, 40 p.

[9] La valeur qu'accorde une personne (ou une société) à un bien ou à un service pour lequel il n'existe pas de marché sur lequel exprimer cette valeur par des paiements réels.

management plan, developed in cooperation with other governments, Aboriginal peoples and organizations and any other person or that the Minister of Fisheries and Oceans considers appropriate, includes measures for the conservation of the species. It is anticipated that the preparation of the management plan for the Humpback Whale (North Pacific population) will draw on recovery measures established in and ongoing under the existing Recovery Strategy. Consequently, additional and incremental costs associated with the reclassification under Schedule 1 are expected to be negligible.

The *Marine Mammal Regulations*, made under the *Fisheries Act*, will continue to apply. The cost differences between mitigation and management measures that would be required under SARA and the *Fisheries Act* are negligible.

Conclusion

The Humpback Whale (North Pacific population) was reclassified by COSEWIC as a species of special concern on the basis of available scientific evidence. The Minister of the Environment, on the advice of the Minister of Fisheries and Oceans, has recommended that the Governor in Council amend Schedule 1 of SARA in order to change the classification of the species from a threatened species to a species of special concern. There are no additional administrative burden costs for business expected. As existing SARA prohibitions and critical habitat identification and legal protection requirements are no longer applicable, it is possible that costs for some businesses may be reduced as a result of the reclassification of the Humpback Whale (North Pacific population) under Schedule 1 of SARA from threatened to a species of special concern. Other applicable legislation and voluntary measures will continue to apply. These include voluntary measures outlined in guidelines to boaters, paddlers, and viewers; requirements under section 79 of SARA that have specific requirements when environmental assessments of certain specific projects are required; and the *Marine Mammal Regulations*.

Strategic environmental assessment

As required by the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals, a preliminary scan was conducted which concluded that there would be no expected important environmental effects, either positive or negative; accordingly, a strategic environmental assessment is not required.

Implementation, enforcement and service standards

As the Humpback Whale (North Pacific population) is listed as a species of special concern, the general

Le plan de gestion, élaboré en collaboration avec les autres gouvernements, les organisations et les peuples autochtones et toute autre personne ou organisation jugée compétente par le ministère des Pêches et des Océans, comprend des mesures de conservation de l'espèce. On s'attend à ce que l'élaboration du plan de gestion du rorqual à bosse (population du Pacifique Nord) s'appuie sur les mesures de rétablissement définies dans le programme de rétablissement en cours. Par conséquent, on prévoit que les coûts supplémentaires et différentiels liés au reclassement en vertu de l'annexe 1 soient négligeables.

Le *Règlement sur les mammifères marins* adopté en vertu de la *Loi sur les pêches* continuera de s'appliquer. Les différences de coût entre les mesures de gestion et d'atténuation qui pourraient être requises en vertu de la LEP et de la *Loi sur les pêches* sont négligeables.

Conclusion

Le rorqual à bosse (population du Pacifique Nord) a été reclassé comme espèce préoccupante par le COSEPAC en tenant compte des preuves scientifiques disponibles. Le ministre de l'Environnement, sur avis du ministre des Pêches et des Océans, a recommandé au gouverneur en conseil de modifier l'annexe 1 de la LEP, de manière à faire passer la situation de l'espèce, d'espèce menacée à espèce préoccupante. On ne prévoit aucun coût supplémentaire lié au fardeau administratif. Puisque les interdictions et les exigences relatives à la désignation et à la protection légale de l'habitat essentiel stipulées dans la LEP ne s'appliquent plus, il est possible que les coûts de certaines activités diminuent en raison du reclassement du rorqual à bosse (population du Pacifique Nord) d'espèce menacée à espèce préoccupante en vertu de l'annexe 1 de la LEP. D'autres lois et mesures volontaires applicables continueront de s'appliquer. Celles-ci comprennent les mesures volontaires décrites dans les lignes directrices à l'intention des plaisanciers, des pagayeurs et des observateurs, les exigences stipulées à l'article 79 de la LEP qui comportent des exigences particulières lorsque des évaluations environnementales sont requises pour des projets précis, et le *Règlement sur les mammifères marins*.

Évaluation environnementale stratégique

Comme l'exige la Directive du Cabinet sur l'évaluation environnementale des projets de politiques, de plans et de programmes, une analyse préliminaire a été effectuée et a permis de conclure qu'il n'y aurait pas d'effets environnementaux importants, tant positifs que négatifs. Par conséquent, aucune évaluation environnementale stratégique n'est requise.

Mise en œuvre, application et normes de service

Étant donné que le rorqual à bosse (population du Pacifique Nord) est inscrit comme espèce préoccupante, les

prohibitions under SARA no longer apply. Fisheries and Oceans Canada must complete a proposed management plan within three years of the species' classification being changed.

The Department is responsible for monitoring the implementation of the management plan and must report on the plan's progress every five years. As part of the monitoring, Fisheries and Oceans Canada and partners will follow population and distribution trends of the species over time. Also, the Conservation and Protection Branch of Fisheries and Oceans Canada will be involved in enforcing the *Marine Mammal Regulations* as they apply to the Humpback Whale (North Pacific population), just as it would do with all other marine mammals.

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interdictions générales de la LEP ne s'appliquent plus. Pêches et Océans Canada doit rédiger une proposition de plan de gestion dans les trois années suivant le changement de classification de l'espèce.

Le Ministère est responsable de la surveillance de la mise en œuvre du plan de gestion. Il doit également faire état de la progression du plan tous les cinq ans. Dans le cadre de la surveillance, Pêches et Océans Canada et ses partenaires surveilleront les tendances de la population et de la répartition de l'espèce au fil du temps. De plus, la Direction de la conservation et de la protection de Pêches et Océans Canada participera à la mise en application du *Règlement sur les mammifères marins* tel qu'il s'applique au rorqual à bosse, tout comme elle le ferait pour tout autre mammifère marin.

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