



October 23, 2015

BURNCO AGGREGATE PROJECT

Marine Mammal Baseline Report

Submitted to:
BURNCO Rock Products Ltd.
BC Aggregate
1A - 2670 Emerson Street
Abbotsford, BC
V2T 3J6

REPORT



Report Number: 11-1422-0046-542-R-Rev1-4300

Distribution:

2 Copies - Burnco

2 Copies - Golder Associates Ltd.





EXECUTIVE SUMMARY

BURNCO Rock Products Ltd. (BURNCO) proposes to construct and operate a sand and gravel mine within the lower McNab Valley on Thornbrough Channel of Howe Sound, British Columbia (the Project). The Project is located approximately 22 kilometres (km) west-southwest of Squamish and 35 km northwest of Vancouver. The land-based activities for the Project are entirely contained within land that has been privately owned since 2008. The proposed marine infrastructure consists of barge loading facilities with a loading conveyor, barge loader foundation, berthing dolphins and connecting catwalks that will be supported by piles. Proposed barge routes (33 km) would occur from the Project area along Thornbrough Channel, Ramillies Channel and Queen Charlotte Channel and join the existing shipping navigational channel in southeast Strait of Georgia to either the north or south arm of the Fraser River to New Westminster and Langley, respectively.

Golder Associates Ltd. (Golder) conducted a baseline marine mammal desktop literature review from primary sources and publically accessible databases to understand marine mammal distribution, seasonal occurrence and critical habitat within the Project area and proposed barge routes. At least 11 species of marine mammals are known to occur in the southern Strait of Georgia and protected waters of Howe Sound. Five of the identified species are protected 'at risk' species and listed in Schedule 1 of the *Species at Risk Act (SARA)*, they are resident killer whale (*Orcinus orca*), harbour porpoise (*Phocoena phocoena*), humpback whale (*Megaptera novaeangliae*), grey whale (*Eschrichtius robustus*), and Steller sea lion (*Eumetopias jubatus*).

The proposed barging routes in Howe Sound do not overlap with 'critical habitat' areas for marine mammals. Existing shipping navigation routes in the Strait of Georgia and in Johnstone Strait (between Campbell River and Port McNeill) overlap with Southern resident killer whale 'critical habitat' and Northern resident killer whale 'critical habitat' respectively.

Based on the current literature, marine mammals are acoustically diverse, with wide variations in ear anatomy, frequency range, and amplitude sensitivity. An animal's sensitivity to sound varies with frequency. Audible frequencies for toothed whales range from 80 Hz to 150 kHz; some species are considered 'mid-frequency cetaceans' (i.e., killer whales), whereas others are classified as 'high-frequency cetacean' (i.e., harbour porpoise and Dall's porpoise). Baleen whales emit low-frequency sounds and have been shown to react to frequencies below 1 kHz and are classified within the 'low-frequency cetaceans' functional marine mammal hearing group. Underwater hearing sensitivity in seals and sea lions falls in between that of baleen and toothed whales with an estimated auditory bandwidth between 75 Hz to 75 kHz.



Table of Contents

1.0 INTRODUCTION.....	1
1.1 Background	1
2.0 BASELINE METHODS	3
2.1 Information Sources.....	3
2.2 Regulatory Environment	3
3.0 RESULTS	4
3.1 Literature Review- Marine Mammals in Southern BC Waters.....	4
3.2 Toothed Whales (Odontocetes).....	7
3.2.1 Killer Whale (<i>Orcinus orca</i>)	7
3.2.2 Pacific White-sided Dolphin (<i>Lagenorhynchus obliquidens</i>).....	10
3.2.3 False Killer Whale (<i>Pseudorca crassidens</i>).....	10
3.2.4 Harbour Porpoise (<i>Phocoena phocoena</i>).....	10
3.2.5 Dall’s Porpoise (<i>Phocoenoides dalli</i>).....	11
3.3 Baleen Whales (Mysticeti)	11
3.3.1 Humpback Whale (<i>Megaptera novaeangliae</i>).....	11
3.3.2 Grey Whale (<i>Eschrichtius robustus</i>).....	12
3.3.3 Minke Whale (<i>Balaenoptera acutorostrata scammonii</i>).....	12
3.4 Seals and Sea Lions (Pinnipedia).....	13
3.4.1 Steller Sea Lion (<i>Eumetopias jubatus</i>).....	13
3.4.2 California Sea Lion (<i>Zalophus californianus</i>).....	13
3.4.3 Harbour Seal (<i>Phoca vitulina</i>)	13
3.5 Hearing Abilities and Anthropogenic Noise.....	16
3.5.1 Toothed Whales	16
3.5.2 Baleen Whales	17
3.5.3 Seals and Sea Lions	17
4.0 SUMMARY.....	19
5.0 CLOSING.....	20
6.0 LITERATURE CITED.....	21



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

TABLES

There are 11 species of marine mammals have the potential to be occur in the southern Strait of Georgia and protected waters of Howe Sound, southeast Vancouver Island (BCCSN 2013; Keple 2002) (Table 1). Each of these species varies in their seasonal occurrence and habitat use within the Project area as outlined in 4

Table 1: Marine mammal species in southern Strait of Georgia and Howe Sound, British Columbia 4

Table 2: Marine mammal seasonal occurrence by species in southern Strait of Georgia and Howe Sound, BC..... 6

FIGURES

Figure 1: Proposed and Existing Barge Shipping Routes 2

Figure 2: Resident Killer Whale Critical Habitat..... 9

Figure 3: Public Cetacean Sightings and Important Areas for Marine Mammals 15

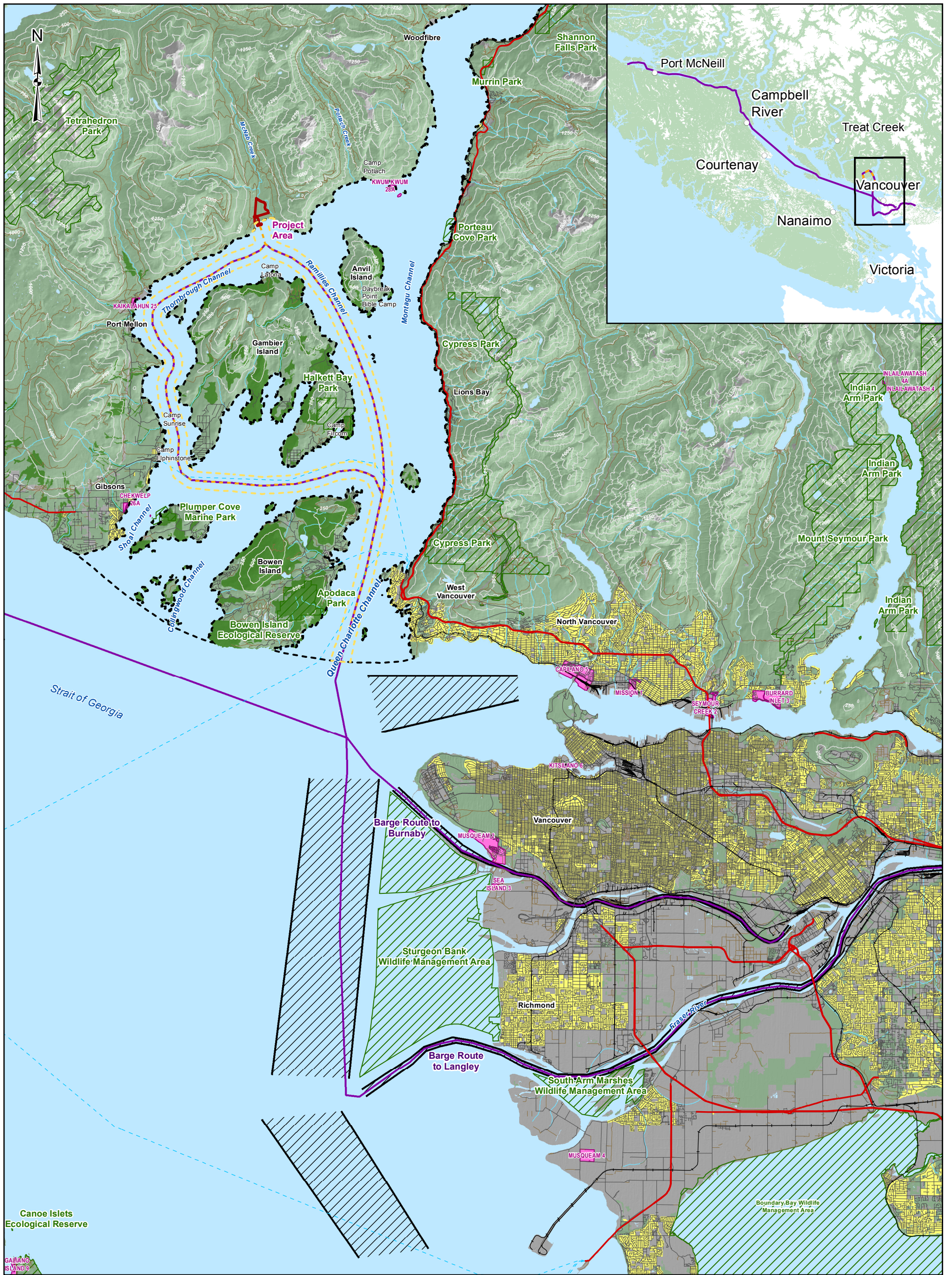


1.0 INTRODUCTION

1.1 Background

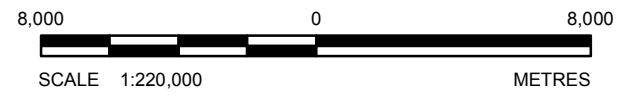
BURNCO Rock Products Ltd. (BURNCO) has proposed to construct and operate a sand and gravel mine within the lower McNab Valley on Thornbrough Channel of Howe Sound, British Columbia (the Project). The Project is located approximately 22 kilometres (km) west-southwest of Squamish and 35 km northwest of Vancouver (Figure 1). The land based activities for the Project are entirely contained within land that has been privately owned since 2008. However, the proposed marine infrastructure consists of barge loading facilities, including a loading conveyor, barge loader foundation, berthing dolphins and connecting catwalks that will be supported by piles. The marine facilities will be located in the subtidal zone contained within privately held water lot leases at the western side of the McNab Valley foreshore. Proposed barge routes (33 km) would connect the Project site to existing barging routes in Thornbrough Channel, Ramillies Channel and Queen Charlotte Channel and join the existing shipping navigational channel in southeast Strait of Georgia to either the north or south arm of the Fraser River to New Westminster and Langley, respectively (Figure 1).

Golder Associates Ltd. (Golder) conducted a comprehensive literature review to characterize baseline conditions for marine mammals in the Project area, including information on distribution, seasonal occurrence, habitat use, sensitive habitat areas, and hearing abilities.



LEGEND	
	Project Area
	Marine Local Study Area
	Marine Regional Study Area
	Park / Protected Area
	Sensitive Environmental Area
	Vegetation
	Residential Area
	Indian Reserve
	Existing Shipping Navigational Channel
	Proposed Barging Route
	Existing Barging Route
	Highway
	Road
	Resource Road
	Railway
	Ferry
	Contour (250m)
	Camp

REFERENCE
 Parks/protected areas and sensitive areas from BC LRDW. Elevation and indian reserves from Geobase. Base data from CanVec.
 Projection: UTM Zone 10 Datum: NAD 83



PROJECT	BURNCO ROCK PRODUCTS LTD. BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.			
TITLE	PROPOSED AND EXISTING BARGE SHIPPING ROUTES			
	PROJECT NO.	11-1422-0046	PHASE No.	
	DESIGN	MD	02 Nov. 2012	SCALE AS SHOWN
	GIS	DL	22 Oct. 2015	REV. 1
	CHECK	KZ	16 Mar. 2015	
REVIEW	PR	16 Mar. 2015		
				FIGURE 1

Path: X:\Project Data\BC\Burnco\Figures\MXD\Wildlife\Baseline\BURNCO_MARINE_WILDLIFE_Figure_01_Proposed_and_Existing_Barge_Shipping_Routes.mxd



2.0 BASELINE METHODS

2.1 Information Sources

Information provided in this report is based on a review of existing scientific literature, reports and publically accessible databases available at the time of preparation (August 2014), including the following sources:

- Relevant peer-reviewed scientific literature and government/academic/industry data reports;
- British Columbia Conservation Data Centre (CDC) *Species and Ecosystems Explorer* (2014);
- *Species At Risk Act* (SARA) Public Registry (Environment Canada 2014);
- SARA Recovery Strategy Series Reports for listed marine mammal species at risk (SAR);
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports for listed marine mammal species;
- British Columbia Cetacean Sighting Network (BCCSN)¹; and
- British Columbia Marine Conservation Analysis (MCA) atlas and public database (2011).

2.2 Regulatory Environment

The *Fisheries Act* is federal legislature that offers protection of fish², including marine mammals (Government of Canada 1985). Under section 35 of this Act, no one may undertake activities that result in harm, permanent alteration or destruction of fish or fish habitat that are part of a commercial, recreational or Aboriginal fishery (CRA), or to fish that support such a fishery, unless authorized by the Minister of Fisheries and Oceans Canada (DFO) (Government of Canada 1985). Under the *Fisheries Act*, the *Marine Mammal Regulations* were enacted in 1993 and state that it is an offence to kill, harm, disturb or harass marine mammals, except when fishing for marine mammals under the authority of these *Regulations* (Government of Canada 1993).

The federal *Species at Risk Act* (SARA) protects Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, provides for the recovery of endangered or threatened species, and encourages the management of other species to prevent them from becoming at-risk. This is achieved by promoting and securing necessary actions for recovery through legal protection (Government of Canada 2012). To kill, harm, harass, capture or take an individual of a species listed as Extirpated, Endangered or Threatened is prohibited under Section 32 of SARA. To damage or destroy the residence of individuals of a species listed as Extirpated, Endangered or Threatened is prohibited under Section 33 of SARA.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is a scientific advisory panel that assesses the national status of wild species, subspecies, varieties, or other designable units that are considered to be at risk in Canada. Designations regarding conservation concern (i.e., extinct, extirpated, endangered, threatened, special concern, not at risk, or data deficient) are made on native species including marine mammals. Based on the most current research available, COSEWIC makes recommendations to SARA to protect those “at risk” species.

¹ Data obtained from the BCCSN (2013) were collected opportunistically with limited knowledge of the temporal or special distribution of observed effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

² Under the *Fisheries Act*, ‘fish’ is defined as shellfish, crustaceans, marine animals and any part of the life history of the animal, including eggs, sperm, spat, larvae and juvenile stages.



3.0 RESULTS

3.1 Literature Review- Marine Mammals in Southern BC Waters

The west coast of Canada is a rich and diverse network of marine habitats including sheltered coastal shores, deep fjords, outer continental shelves, and submarine canyons (Ford et al. 2010). These areas provide marine mammals with valuable habitat for foraging, mating and rearing young. A documented 25 species of cetacean (whales, dolphins and porpoises), five species of pinnipeds (seals and sea lions), and one species of sea otter occur in BC seasonally or year-round depending on their life history strategies (Heise et al. 2007).

There are 11 species of marine mammals have the potential to be occur in the southern Strait of Georgia and protected waters of Howe Sound, southeast Vancouver Island (BCCSN 2013; Keple 2002) (Table 1). Each of these species varies in their seasonal occurrence and habitat use within the Project area as outlined in

- a) Table 2. ‘Critical habitat’ for resident killer whales is identified in (Figure 2 and inset) (DFO 2011). Cetacean sightings reported in the Project area between 1990 and 2014, as disclosed by the BC Cetacean Sightings Network (public sightings database), are shown in Figure 3. An overview of the biology of each marine mammal species potentially present in the Project area is provided in Sections 3.2, 3.3 and 3.4.

Table 1: Marine mammal species in southern Strait of Georgia and Howe Sound, British Columbia

Common Name (Scientific Name)	Seasonal Occurrence in Howe Sound / Habitat Use ^(a)	Preferred food ^(a)	Estimated Population Size ^(a)	SARA ^(b)	COSEWIC ^(b)	CDC ^(b)
Killer whale (<i>Orcinus orca</i>) – Southern Resident	Occur year round (peak May to October) in the Strait of Georgia. Forage and breed in this area. Critical habitat identified in the Southern Strait of Georgia including at the mouth of Fraser River, Haro Strait, Boundary Pass, and the eastern portion of the Strait of Juan de Fuca. Occasional occurrence in Howe Sound (sightings have increased since 2009).	Fishes (primarily Chinook, and other salmon species).	80	EN/Sc1	Endangered	red
Killer whale (<i>Orcinus orca</i>) – Northern Resident	Rare visitor in the Strait of Georgia; do not forage or breed in Proposed Project area. Critical habitat identified in southeastern Queen Charlotte Strait and Johnstone Strait east of Port McNeill to north of Campbell River.	Fishes (primarily Chinook, and other salmon species).	261	TH/Sc1	Threatened	red
Killer whale (<i>Orcinus orca</i>) – Transient	Occur year round in the Strait of Georgia. Forage in this area. Occasional occurrence in Howe Sound (sightings have increased since 2009 with evidence of hunting prey observed).	Seals, sea lions, dolphin and porpoise.	220	TH/Sc1	Threatened	red



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

Common Name (Scientific Name)	Seasonal Occurrence in Howe Sound / Habitat Use ^(a)	Preferred food ^(a)	Estimated Population Size ^(a)	SARA ^(b)	COSEWIC ^(b)	CDC ^(b)
Killer whale (<i>Orcinus orca</i>) – Offshore	Occur on continental shelf off outer coast of BC; occasionally observed along inside waters. Rarely observed in Strait of Georgia or Howe Sound area.	Fishes (including elasmobranchs).	288	TH/Sc1	Threatened	red
Pacific white-sided dolphin (<i>Lagenorhynchus obliquidens</i>)	Extirpated historically from Strait of Georgia – numbers have since increased. Occasionally occur in Howe Sound area (sightings have increased since 2010).	Fishes (e.g., Pacific herring, salmon, schooling fishes), shrimp and cephalopods.	Unknown but 26,860 in central North Pacific	Not at Risk	Not at Risk	yellow
False killer whale (<i>Pseudorca crassidens</i>)	Rarely occur in the Strait of Georgia or Howe Sound. Reported sightings likely represent multiple observations of a vagrant individual.	Fishes and cephalopods.	Unknown	No Status	Not at Risk	yellow
Dall's porpoise (<i>Phocoenoides dalli</i>)	Occur year round in the Strait of Georgia and forage in this area. Occasionally occur in Howe Sound area.	Fishes (e.g., Pacific herring, schooling fishes.	Unknown but 83,400 in Alaska (AK), 75,915 in CA/OR/WA	No Status	Not at Risk	yellow
Harbour porpoise (<i>Phocoena phocoena</i>)	Occur year round in the Strait of Georgia; common in shallow (<200 m) nearshore areas; higher density in northern Strait of Georgia and Johnstone Strait. Occasionally occur to Howe Sound area.	Fishes (e.g., Pacific herring) and cephalopods.	Unknown but 28,967 in WA/OR, 37,450 in southeast AK	SC/Sc1	Special Concern	blue
Humpback whale (<i>Megaptera novaeangliae</i>)	Extirpated from Strait of Georgia in early 1900s. Population has since recovered. Presently forage and migrate through area during the summer, winter and fall.	Pelagic crustaceans (e.g., krill, mysids) and schooling fish.	2,145 in BC; 6,500 in eastern North Pacific	TH/Sc1 ^(c)	Special Concern	blue
Grey whale (<i>Eschrichtius robustus</i>)	Summer resident populations may forage in the Strait of Georgia in the spring and summer. Other individuals from the eastern Pacific population migrate through on their way to foraging grounds in Northern BC and Alaska. ... Rare visitor to Howe Sound, although sightings have increased in recent years.	Mysid and ghost shrimp, benthic crustaceans, herring eggs.	20,000 individuals in the eastern Pacific. A sub-population of 'summer-residents' exists in BC (referred to as the 'Pacific Coast Feeding Aggregation) numbering in the low 100s.	SC/Sc1	Special Concern	blue



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

Common Name (Scientific Name)	Seasonal Occurrence in Howe Sound / Habitat Use ^(a)	Preferred food ^(a)	Estimated Population Size ^(a)	SARA ^(b)	COSEWIC ^(b)	CDC ^(b)
Minke whale (<i>Balaenoptera acutorostrata</i>)	Likely year round resident in the Strait of Georgia; most frequently found in nearshore waters. Rare visitor in Howe Sound.	Krill, copepods, schooling fishes and cephalopods.	Unknown, but not abundant; <600 in CA/OR/WA	No Status	Not at Risk	yellow
Steller sea lion (<i>Eumetopias jubatus</i>)	Occasional visitor to Howe Sound throughout the year. Foraging and migratory movements in RSA, but no breeding sites.	Fishes (e.g., rockfish, flatfish, salmon) and cephalopods.	18,400 to 19,700 in BC	SC/Sc1	Special Concern	red
California sea lion (<i>Zalophus californicanus</i>)	Occasional visitor to Howe Sound throughout the year. Foraging and migratory movements in RSA, but no breeding sites.	Fishes and cephalopods.	1,500 to 3,000 in BC	No Status	Not at Risk	yellow
Harbour seal (<i>Phoca vitulina</i>)	Year round resident; forage, mate and rear young in region.	Fishes.	108,000 in BC	No Status	Not at Risk	yellow

- a) Johannessen et al. 2005; Heise et al. 2007; Golder 2012; Keple 2002; COSEWIC 2004; Environment Canada 2014 DFO 2009a, 2009b, 2009c, 2011b; BCMCA 2011, Ellis et al. 2011, CWR 2015; Rugh et al. 2005; and Calambokidis et al. 2002)
- b) COSEWIC=Committee on the Status of Endangered Wildlife in Canada; Sc1=Schedule 1 of *Species at Risk Act* (SARA); CDC=BC Conservation Data Center. *EN* = *Endangered*, *TH* = *Threatened*, *SC* = *Special Concern*, *No Status* = *Not assessed*, *Sc1*=*Schedule 1 of SARA*; *Red* = *Extirpated, Endangered or Threatened*; *Blue* = *Vulnerable*; *Yellow* = *Not at Risk*;
- c) The Minister of the Environment, on the advice of the Minister of Fisheries and Oceans Canada, has recommended that the Governor in Council make a regulatory amendment to Schedule 1 of SARA in order to change the status of the species from threatened to a species of special concern. A notice in April of 2014 was given that the Governor in Council, pursuant to subsection 27(1) of the SARA, proposes to make the annexed Order Amending Schedule 1 to the Species at Risk Act (Government of Canada 2014).

Table 2: Marine mammal seasonal occurrence by species in southern Strait of Georgia and Howe Sound, BC

Common Name (Scientific Name)	Seasonal Occurrence			
	Spring	Summer	Fall	Winter
Resident Killer Whale (<i>O. orca</i>)*	x	x	x	x
Pacific White-Sided Dolphin (<i>L. obliquidens</i>)	x	x	x	x
False Killer Whale (<i>P. crassidens</i>)	x	x	x	x
Dall's Porpoise (<i>P. dalli</i>)	x	x	x	x
Harbour Porpoise (<i>P. phocoena</i>)*	x	x	x	x
Humpback Whale (<i>M. novaeangliae</i>)*		x	x	x
Grey Whale (<i>E. robustus</i>) *	x	x		
Minke Whale (<i>B. acutorostrata</i>)	x	x		
Steller Sea Lion (<i>E. jubatus</i>)*	x	x	x	x
California Sea Lion (<i>Z. californianus</i>)	x	x	x	x
Harbour Seal (<i>P. vitulina</i>)	x	x	x	x

Notes: Seasonal occurrence is based on sightings data from BCCSN (2013), DFO (2009a), and Keple (2002) and does not indicate number of individuals per sighting or the number of sightings per season. Species with asterisk (*) denotes listed species under Schedule 1 of SARA.



3.2 Toothed Whales (Odontocetes)

3.2.1 Killer Whale (*Orcinus orca*)

Three killer whale ecotypes are known to occur in coastal waters of British Columbia: resident, transient, and offshores (DFO 2011; Jefferson et al. 2008). Sightings of all ecotypes have occurred in the Strait of Georgia and Gulf Islands areas (DFO 2009a; Keple 2002; Figure 3). The three populations are socially isolated from one another, and vary considerably in terms of distribution/movement patterns, behaviour, prey preference, genetics and morphology (Baird 2001).

Resident killer whales are acoustically active and highly social animals, preying primarily on fish and cephalopods, and traveling in small matrilineal groups known as 'pods', each consisting of 10 or more individuals. Seasonal occurrence of resident killer whales correlates strongly to the migratory movements of their preferred prey, including chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*) and coho salmon (*O. kisutch*). Each pod has a distinct dialect, offering unique signature calls between members. Resident killer whales are further delineated into northern and southern sub-populations, estimated at 205 and 85 individuals, respectively. The home range of Northern residents extends from Grays Harbour, Washington to Glacier Bay, Alaska; although during summer (June to October), this sub-population primarily occurs in Johnstone Strait and Queen Charlotte Strait (DFO 2011), with 'critical habitat' identified in this area for this sub-population (PNCIMA 2011). Northern residents are considered infrequent visitors to the southern Strait of Georgia (MCA 2011).

The home range of Southern residents extends from northern BC to central California with high summer and fall occurrence along trans-boundary waters of Haro Strait, Boundary Pass, eastern Strait of Juan de Fuca, southern Strait of Georgia, and Puget Sound. Although Southern residents are periodically observed in these waters over winter and spring, their distribution and movement patterns during this period are less well understood. Most Southern resident sightings during winter/spring are reported in the Western Strait of Juan de Fuca, and off the coasts of Washington and Oregon, including the mouth of the Columbia River (NOAA Fisheries 2014). Due to high seasonal occurrence of Northern residents in southern BC waters during summer, this area has been designated as 'critical habitat' for this sub-population (DFO 2011).

Northern and Southern resident killer whales are provincially Red-listed (CDC 2014), and are federally designated as 'Threatened' and 'Endangered', respectively, under Schedule 1 of SARA (Environment Canada 2014). Resident killer whales are considered at-risk due to their low reproductive rate, small population size and susceptibility to anthropogenic impacts including pollutants, acoustic disturbance, and reduced prey that may prevent recovery. Vessel traffic contributes to increased underwater noise that may displace individuals from preferred foraging areas (DFO 2009a).

Transient killer whales prey almost exclusively upon marine mammals, including seals, sea lions, and porpoises (DFO 2007). They travel in small cooperative groups and are acoustically silent as they hunt for prey. There is an estimated 250 individuals belonging to the 'West Coast transient' community (DFO 2007). Transient killer whales are provincially Red-listed (CDC 2014), and are federally designated as 'Threatened' under Schedule 1 of SARA (Environment Canada 2014).

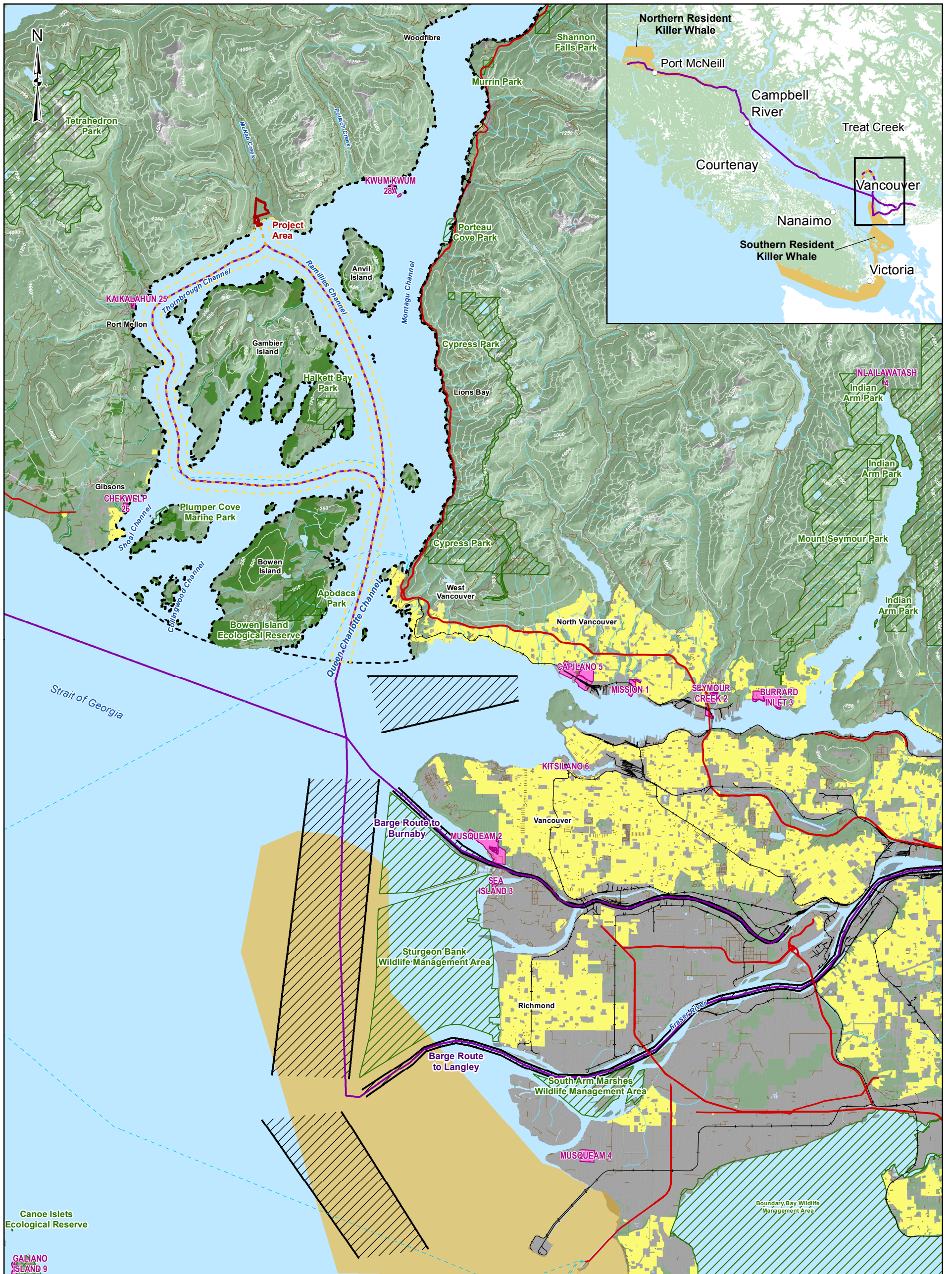
Offshore killer whales are a lesser-known community that is thought to prey predominately on fishes, including elasmobranchs (sharks and rays). They travel in large socially active groups of 20 or more individuals (DFO 2009a) and are sighted primarily on the continental shelf off the outer coast of BC. However, offshore killer whales are occasionally observed within inside protected waters (DFO 2011). Recent estimates predict there to



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

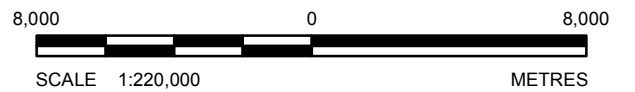
be at least 288 individuals in this community (DFO 2009a). Recent sightings of offshore killer whale in the lower Strait of Georgia indicate that coastal habitat may be more important than in the past. Significant threats to this population include prey availability through regime shifts and fisheries competition, chronic and acute pollutants, and noise disturbance. Transient killer whales are provincially Blue-listed (CDC 2014), and are federally designated as 'Threatened' under Schedule 1 of SARA (Environment Canada 2014).

The auditory range of killer whales is 75 Hz to over 100 kHz (DFO 2011; Szymanski et al. 1999); with peak hearing sensitivity occurring around 20 kHz. Killer whales are classified within the 'mid-frequency cetacean' functional marine mammal hearing group (150 Hz-160 kHz) (Southall et al. 2007).



LEGEND	
	Project Area
	Marine Local Study Area
	Marine Regional Study Area
	Park / Protected Area
	Sensitive Environmental Area
	Vegetation
	Residential Area
	Indian Reserve
	Critical Habitat - Resident Killer Whale
	Existing Shipping Navigational Channel
	Proposed Barging Route
	Existing Barging Route
	Highway
	Road
	Resource Road
	Railway
	Ferry
	Contour (250m)
	Camp

REFERENCE
 Parks/protected areas and sensitive areas from BC LRDW. Elevation and indian reserves from Geobase. Base data from CanVec.
 Critical Habitat - Resident Killer Whale obtained from BCMCA.
 Projection: UTM Zone 10 Datum: NAD 83



PROJECT		BURNCO ROCK PRODUCTS LTD. BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.	
TITLE		CRITICAL HABITAT - RESIDENT KILLER WHALE	
PROJECT NO. 11-1422-0046		PHASE No.	
DESIGN	MD	02 Nov. 2012	SCALE AS SHOWN
GIS	DL	22 Oct. 2015	REV. 1
CHECK	KZ	16 Mar. 2015	FIGURE 2
REVIEW	PR	16 Mar. 2015	





3.2.2 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

After a decades-long absence, this species recently returned to BC's inshore waters and is considered the most abundant cetacean in the region (Heise 1997; Ford et al. 2010). They are found in North Pacific temperate waters as far north as the Aleutian Islands of Alaska and are considered a year-round resident of inshore BC waters including southeast Strait of Georgia and Howe Sound (BCCSN 2013; Keple 2002). The population size is estimated at 29,724 individuals in Queen Charlotte Basin and the mainland inlets (Best and Halpin 2009). Information is limited on preferred habitat conditions for this species in Pacific Northwest waters. They are generally more common in coastal areas during the fall/winter and tend to move to offshore areas in the spring/summer in response to prey distribution and abundance (LGL 2004). The Pacific white-sided dolphin is known to feed on a variety of fish and squid species (Klinkenberg 2012). Pacific white-sided dolphins are provincially Yellow-listed and federally designated as 'Not at Risk' (CDC 2014).

An auditory study of the Pacific white-sided dolphin by Tremel et al. (1998) identified underwater hearing sensitivity between 2 to 128 kHz. Similar to other toothed whale species, the Pacific white-sided dolphin is classified within the 'mid-frequency cetacean' functional marine mammal hearing group.

3.2.3 False Killer Whale (*Pseudorca crassidens*)

The false killer whale is extremely social and is often observed in groups of 20 to 100 individuals (Reeves et al. 2002). Although this species has been observed in temperate and tropical waters throughout the world, very little is known about its life history strategy. BC coastal waters appear to be at the northernmost extent of the false killer whale home range as sightings of this species in BC are quite rare (Ford et al. 2010). This species is described as being an opportunistic feeder as its prey items include squid and a variety of fish species (Madsen et al. 2004). The false killer whale is federally designated as 'Not at Risk' in Canadian Pacific waters (CDC 2014).

Optimal hearing sensitivity in false killer whales occurs between 16 kHz and 24 kHz, with peak sensitivity occurring at 20 kHz (Yuen et al. 2005). This species is classified within the 'mid-frequency cetacean' functional marine mammal hearing group.

3.2.4 Harbour Porpoise (*Phocoena phocoena*)

The harbour porpoise typically travels in small groups of one to eight individuals (COSEWIC 2003b); however, they may aggregate in larger groups for movement between forage localities (Jefferson et al. 2008; COSEWIC 2003b), preying upon fishes and cephalopods (COSEWIC 2003b). Harbour porpoises are coastally distributed throughout the temperate and subarctic waters of the northern hemisphere, with several records in Canadian Arctic waters (Gaskin 1992). On the Pacific coast of Canada, harbour porpoises are found year-round throughout coastal waters (Baird and Guenther 1995), excluding some deep-water fjords and inlets. Surveys conducted in 1996 along the inshore portion of BC recorded approximately 3000 individuals (COSEWIC 2003b). This species occurs in southeast Strait of Georgia (BCCSN 2013). The Pacific population of harbour porpoise is provincially Blue-listed (CDC 2014) and federally designated as 'Special Concern' under Schedule 1 of SARA. The primary source of mortality in harbour porpoise is via incidental catch in the fishing industry (COSEWIC 2003b).



An auditory study of harbour porpoise by Kastelein et al. (2002) reported hearing sensitivity between 2 kHz and 180 kHz; therefore, the harbour porpoise is classified within the 'high-frequency cetacean' functional marine mammal hearing group (200 Hz-180 kHz) (Southall et al. 2007).

3.2.5 Dall's Porpoise (*Phocoenoides dalli*)

The Dall's porpoise are likely the most common small cetacean in the Pacific Ocean. This species can be observed year-round in coastal and offshore waters in BC, including localities with deep underwater channels and canyons. This species travels in small groups and is common throughout the Strait of Georgia (Keple 2002), Juan de Fuca Strait, Johnstone Strait, and Queen Charlotte Strait (Klinkenberg 2012). The Dall's porpoise is provincially Yellow-listed and federally designated as 'Not at Risk' (CDC 2014).

Porpoises are classified within the 'high-frequency cetacean' functional marine mammal hearing group (200 Hz to 180 kHz) (Southall et al. 2007).

3.3 Baleen Whales (Mysticeti)

3.3.1 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is a larger cetacean found in tropical, temperate and sub-polar waters around the world. In the Pacific Ocean, their range extends from breeding areas in Hawaii, Mexico and Central America to feeding grounds throughout BC coastal and offshore waters, southeast Alaska, the Bering Sea, and southern Chukchi Sea. BC waters are primarily used for foraging; however, some non-breeding individuals have remained in high latitude areas throughout the year (COSEWIC 2003a). Humpback whales are known to feed primarily on euphausiids (i.e., krill), copepods and small schooling fishes (DFO 2013; Jefferson et al. 2008). Humpback whales have unique foraging behaviours (i.e., bubble nets, bubble clouds, flickering their flukes) and have developed cooperative feeding behaviours (Leighton et al. 2007).

Threats to humpback whales include entanglement in fishing gear, collisions with vessels, acoustic disturbance, exposure to acute pollutants, and habitat degradation (COSEWIC 2003a, DFO 2013). Baleen whales are more likely to be struck by vessels than other maneuverable marine mammals (i.e., toothed whales and pinnipeds) as they are slow moving and spend time at the surface feeding and traveling. It is not known how many humpback whales have died as a result of vessel strikes; it is thought that a high proportion of struck humpback whales have been juveniles or calves (DFO 2013). According to Vanderlaan and Taggart (2006), the probability of lethal injuries in baleen whale is positively correlated with speed of vessel movement. This study highlights the importance of reducing vessel speeds in areas where baleen whales are known to occur.

In 2003, the North Pacific humpback whale population was federally listed as 'Threatened' under Schedule 1 of SARA. The humpback whale is provincially Blue-listed (CDC 2014).

Humpback vocalizations are complex, ranging from low-frequency sounds from 0.04 to 5 kHz to mid to high frequency sounds from 2 kHz to 14 kHz (Winn and Reichley 1985). Humpback whales are classified within the 'low-frequency cetacean' functional marine mammal hearing group (7 Hz to 22 kHz) (Southall et al. 2007).



3.3.2 Grey Whale (*Eschrichtius robustus*)

Two populations of grey whale occur in the North Pacific, namely the western North Pacific population and eastern North Pacific population. The eastern North Pacific population migrates from wintering localities in Baja California, Mexico to summer feeding grounds in arctic waters of the Bering, Chukchi, and Beaufort seas. However, small groupings migrate only as far as the productive waters of northern California and coastal waters of BC to forage and rear their young (COSEWIC 2004). Grey whales forage in multiple localities, including kelp beds, eelgrass beds and in soft sediments, providing a varied diet of herring eggs, planktonic larvae, mysid shrimp, ghost shrimp and amphipods. Grey whales are able to feed on benthic crustaceans by dragging their baleen along soft mud and sand substrates, expelling sediments through their baleen and trapping organisms. They are also able to feed mid-water and at the waters' surface when mysid shrimp and other planktonic organisms are plentiful. Grey whales are considered keystone species as their bottom foraging behavior recirculates nutrients into the water column to be used by other marine organisms (COSEWIC 2004).

Grey whales occur throughout BC waters and are considered summer seasonal residents in Boundary Bay, Strait of Georgia, and Haro Strait (DFO 2010). Threats to the grey whales include noise disturbance, industrial development in shallow marine areas and loss of habitat and forage areas (COSEWIC 2004; DFO 2010). The eastern North Pacific population of grey whale is provincially Blue-listed (CDC 2014) and federally designated as 'Special Concern' under Schedule 1 of SARA.

Grey whale vocalizations are from 0.04 to 5 kHz to higher frequency sound range 2 to 14 kHz (Winn and Reichley 1985). Like other baleen whales, grey whales are classified within the 'low-frequency cetacean' functional marine mammal hearing group (7 Hz-22 kHz) (Southall et al. 2007).

3.3.3 Minke Whale (*Balaenoptera acutorostrata scammonii*)

The minke whale is the smallest of the baleen whales and forages on krill, copepods, squid and small schooling fishes (Dorsey 1983). The North Pacific minke whale population usually migrate from less productive birthing areas such as California, Baja California, Gulf of California and Hawaii to more productive feeding areas as far north as the Bering Sea, Chukchi Sea and Gulf of Alaska (Reilly et al. 2008).

Most minke whale sightings in BC are in coastal areas north of Vancouver Island and in Hecate Strait (Ford et al. 2010). Minke whales are thought to be a rare sighting in southern Strait of Georgia with only a few sightings documented in the past decade (Keple 2002; MCA 2011). Three important forage areas are documented in the San Juan Islands (south of Vancouver Island); however, these areas tend to fluctuate and are largely influenced by prey distribution and movement (Dorsey 1983). The minke whale is provincially Yellow-listed (CDC 2014) and has not been federally assessed by COSEWIC in Canadian waters.

Minke whale vocalizations range from 0.06 to 20 kHz with source levels as high as 165 dB re 1 μ Pa at 1 m (Richardson et al. 1995). Minke whales are classified within the 'low-frequency cetacean' functional marine mammal hearing group (7 Hz-22 kHz) (Southall et al. 2007).



3.4 Seals and Sea Lions (Pinnipedia)

3.4.1 Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion occurs along the coastal rim of the North Pacific Ocean, from California to the Bering Sea and Kurile Islands. The species tends to remain within 45 km of shore, but occasionally occurs as far as 130 km offshore (Klinkenberg 2012). Steller sea lions occur along coastal BC and reside year-round where they gather on rookeries to breed during summer months. Steller sea lion rookeries in BC are situated at Cape St. James, Bank Island and Scott Islands (Klinkenberg 2012). Seasonal distribution of the Steller sea lion is influenced by one of its most important prey species, Pacific herring (Edgell and Demarchi 2012). Historical winter haul out sites exist in the Strait of Georgia at Plumper Sound, Porlier Pass, Sand Heads, Ada Island and Trail Island (Bigg 1985). Steller Sea Lions are provincially Blue-listed (CDC 2014) and federally listed as ‘Special Concern’ under Schedule 1 of SARA.

Southall et al. (2007) classified pinnipeds within separate functional marine mammal hearing groups (“pinnipeds in water” [75 Hz-75 kHz] and “pinnipeds in air” [75 Hz-30 kHz]), since they communicate acoustically in air and water and have significantly different hearing capabilities in the two media. Most of these sites are far from the Project area, with the exception of Trail Island that neighbours the mouth of Howe Sound.

3.4.2 California Sea Lion (*Zalophus californianus*)

California sea lions occur along the west coast of North America from Baja California, Mexico to BC. Although they do not breed north of California, adult males and sub-adults travel into Canadian and Alaskan waters (Edgell and Demarchi 2012), following the movement of prey fishes, including salmonids, Pacific herring, eulachon (Edgell and Demarchi 2012), dogfish and hake (MCA 2011), in addition to foraging on octopods and squid (MCA 2011). Over the past few decades, an increase in abundance of California sea lions has been observed at Race Rocks, a rocky archipelago in southern Vancouver Island. Race Rocks is thought to act as a staging area for individuals moving northward and throughout the Strait of Georgia to foraging localities. California sea lions travel into the Strait of Georgia during the nonbreeding season in search of prey and, according to Edgell and Demarchi (2012), are not year-round residents. However, California sea lions are observed year round in the Strait of Georgia indicating this to be an important foraging and migratory corridor (Keple 2002). Historical haul out and rafting sites exist in the Strait of Georgia at Plumper Sound, Porlier Pass, Sand Heads, Ada Island and in the Fraser River (Bigg 1985). These sites are not in the project area, with the exception of the Fraser River site where the existing barge routes occur. California sea lions are provincially Yellow-listed (CDC 2014) and are federally designated as ‘Not at Risk’ by COSEWIC (2013).

The auditory range of the California sea lion is 0.4 to 32 kHz (Reichmuth 2012). Southall et al. (2007) classified pinnipeds within separate functional marine mammal hearing groups (“pinnipeds in water” [75 Hz-75 kHz] and “pinnipeds in air” [75 Hz-30 kHz]), since they communicate acoustically in air and water and have significantly different hearing capabilities in the two media.

3.4.3 Harbour Seal (*Phoca vitulina*)

The harbour seal is widely distributed on both west and east coasts of Canada. In western Canada, the harbour seal is known to enter rivers and lakes to forage on fishes (Baird 2001). Harbour seals haul out on land and rest on a variety of structures, including rocky shores, mud flats, sandbars, and man-made structures (i.e., floats and

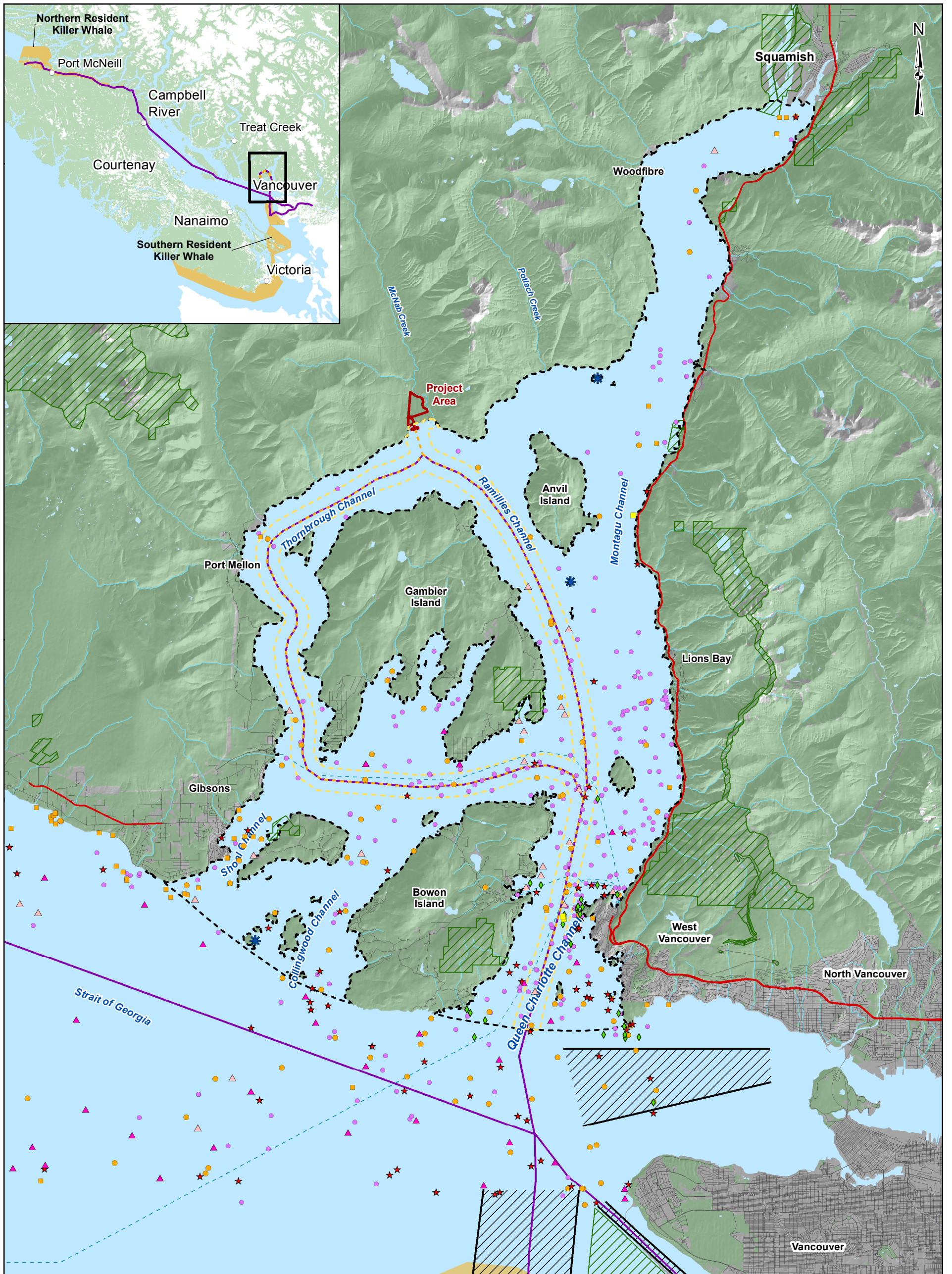


BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

docks) (Hoover-Miller et al. 2013). Unlike other pinnipeds, harbour seals do not congregate on rookeries but breed throughout most of their range. In southern BC, births occur on haul out structures in July and August and pups are able to swim immediately after birth. Although local movements associated with breeding and foraging may occur, harbour seals are otherwise non-migratory and show strong site fidelity (Baird 2001).

Harbour seals are sensitive to disturbances and will often flee from resting areas into water to avoid interaction, thus reducing valuable resting times and increasing stress. With continued disturbance, harbour seals may abandon haul out sites. This is particularly problematic during birthing and nursing when pups may become separated from their mother and risk abandonment and subsequent starvation (Hoover-Miller et al. 2013). Harbour seals are a common occurrence year round in southeast Strait of Georgia (Keple 2002) with low to medium densities (an estimated 0 to 6 seals per square kilometre) in Howe Sound (MCA 2011). The BC harbour seal population is estimated at 108,000 individuals. Harbour seals are yellow-listed in BC (CDC 2014) and are federally designated as 'Not at Risk' (COSEWIC 2013).

The auditory range of harbour seals is generally from <1 to 150 kHz (Richardson et al. 1995). Southall et al. (2007) classified pinnipeds within separate functional marine mammal hearing groups ("pinnipeds in water" [75 Hz- 75 kHz] and "pinnipeds in air" [75 Hz- 30 kHz]), since they communicate acoustically in air and water and have significantly different hearing capabilities in the two media.



LEGEND

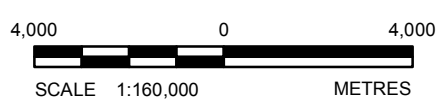
- Project Area
- Marine Local Study Area
- Marine Regional Study Area
- Existing Shipping Navigational Channel
- Critical Habitat - Resident Killer Whale
- Park / Protected Area
- Proposed Barging Route
- Existing Barging Route
- Highway
- Road
- Ferry
- ✳ Harbour Seal Haul-out

BCCSN Marine Mammal Sightings (Howe Sound Data)

- ▲ Dall's Porpoise
- ◆ Pacific White-sided Dolphin
- ◇ False Killer Whale
- Gray Whale
- ★ Harbour Porpoise
- ▲ Humpback Whale
- Killer Whale
- Minke Whale

REFERENCE

British Columbia Cetacean Sighting Network (BCCSN). 2013. Marine Mammal Howe Sound Sighting Data 1990- 2013. Letter from Vancouver Aquarium Marine Science Centre to Golder Associates Ltd., E-mail dated March 1, 2013. Sightings data supplied by the BC Cetacean Sightings Network. Sightings are opportunistic and not corrected effort. Critical Habitat - Resident Killer Whale obtained from BCMCA. Harbour Seal Haul-out from Biggs M., Pers. Comm. 1980 in Peatt and Knight 1980. Projection: UTM Zone 10 Datum: NAD 83



PROJECT		BURNCO ROCK PRODUCTS LTD. BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.	
TITLE		BCCSN SIGHTINGS AND IMPORTANT AREAS FOR MARINE MAMMALS	
	PROJECT NO.	11-1422-0046	PHASE No.
	DESIGN	AK 21 May 2014	SCALE AS SHOWN
	GIS	RH 22 Oct. 2015	REV. 1
	CHECK	KZ 08 Apr. 2015	
REVIEW	PR 08 Apr. 2015		
FIGURE 3			



3.5 Hearing Abilities and Anthropogenic Noise

Marine mammals are acoustically diverse, with wide variations in ear anatomy, frequency range, and amplitude sensitivity (Ketten 1991). An animal's sensitivity to sound varies with frequency. Response to sound likely depends strongly on the presence of and level of sounds in the frequency bands or range of frequencies to which the animal is most sensitive (Richardson et al. 1995). The general trend is that larger species, such as humpback and grey whale are better able to hear at lower frequency ranges than smaller species, such as Dall's porpoise. Hearing abilities are generally only well understood in certain captive species where audiograms (plots of hearing threshold at different sound frequencies) have been developed based on behavioural response studies (reactions to sound) and electrophysiological experiments (measuring auditory evoked potentials) (Erbe 2002).

Anthropogenic noise has gained recognition as an important stressor for marine life, and in particular for marine mammals because of their reliance on underwater hearing for a variety of biologically critical functions (Ketten 1998; Richardson et al. 1995). The potential impacts of underwater sound to marine mammals depend, to a degree, on the type of marine mammal involved as well as the characteristics of the sound emitted. The potential zone of impact of anthropogenic sound is also influenced strongly by the properties of ambient sound present in the area of exposure (Richardson et al. 1995) and local sound transmission properties which are determined by site-specific environmental factors such as seafloor bathymetry, substrate composition and water column characteristics. Impacts of underwater sound on marine mammals are generally measured through observations of behavior responses to sounds (McCauley 1994, Richardson et al. 1995). These impacts are measured through observations of behavioural responses to sounds and used as a surrogate measure for sensitivity or susceptibility.

3.5.1 Toothed Whales

Audible frequencies for toothed whales range from 80 Hz to 150 kHz, but they are most sensitive to sounds in the frequency range of 8 to 90 kHz (Richardson et al. 1995). Killer whales are considered 'mid-frequency cetaceans' (Southall et al. 2007); meaning their most sensitive hearing range occurs in the mid-frequency range. This species has been shown to detect sounds as low as 15 kHz based on signal of 30 dB re 1 μ Pa. Using sound for foraging, navigation and social purposes, killer whales are a highly vocal species with call types consisting of pulsed sounds and whistles used to communicate. Echolocation clicks are produced in the 0.5 to 25 kHz with dominant frequencies from 1 to 6 kHz range, with source levels reported at 160 dB re 1 μ Pa at 1 m. Non-echolocation calls (e.g., whistles) are centered on frequencies below 12 kHz, but attain frequencies up to 18 kHz (Richardson et al. 1995), with dominant frequencies ranging between 6 kHz to 12 kHz. Killer whales use complex pulsed sounds (0.5 to 25 kHz) with pulse repetition rates of up to 5,000 per second. However, echolocation clicks differ in pulse repetition rate with between six to 18 clicks per second. Dall's porpoise communicate with low-frequency clicks emitted between 0.04 and 12 Hz with source levels reported at 120 to 148 dB re 1 μ Pa at 1 m. Harbour porpoise emit clicks at approximately 2 Hz with source levels reported at 100 dB re 1 μ Pa at 1 m (Richardson et al. 1995).

Toothed whales are sensitive to sound in both the low-frequency and mid-frequency range. Movement and presence of marine vessels emits low-frequency sound that may mask or limit audible communication between conspecifics during hunting, breeding and rearing young. Toothed whales and baleen whales show varying levels of sensitivity to mid-frequency pulsive noise sources (i.e., active sonar, pile driving), with observed



responses ranging from displacement (Maybaum 1993), avoidance behavior (animals moving rapidly away from the source) (Watkins et al. 1993; Hatakeyama et al. 1995), decreased vocal activity, and disruption in foraging patterns (Goldbogen et al. 2013). In certain conditions, mid-frequency (1-10 kHz) military sonars have been linked to mass marine mammal strandings (Balcolm and Claridge 2001; Cox et al. 2006; D'Amico et al. 2009; Jepson et al. 2003; Parsons et al. 2008), although these events are typically more coincident with deep-diving mammal species such as beaked whales, and usually in areas of complex, steep-bottom bathymetry. An increase in underwater noise may lead to abandonment of forage areas or habituation to vessels. This is particularly problematic for southern resident killer whales that are an 'endangered' species and frequent areas that have become established vessel routes. Toothed whales are less likely to be struck by vessels due to their speed and agility (Richardson et al. 1995); however, there have been documented occurrences with some types of ships (Van Waerebeek et al. 2007; Wells and Scott 1997).

3.5.2 Baleen Whales

The baleen whale auditory system does not appear to be as specialized as that of toothed whales (Ketten 1997). However, audiograms are generally not available for baleen whales due to the difficulties of implementing controlled behavioural or electrophysiological hearing studies on large animals under a captive experimental setting. Hearing thresholds and frequency sensitivities in baleen whales are thus inferred from anatomical ear structure, vocalizations, and behavioural studies in the wild (Richardson et al. 1995). In general, most baleen whale species emit low-frequency sounds and have been shown to react to frequencies below 1 kHz (Richardson et al. 1995). They have an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007).

Because baleen whales are most sensitive to sounds in the low frequency range, they often react to low frequency vessel and shipping noise (5 to 500 Hz). Observed behaviour to underwater noise include site avoidance and movement away from the sound source, interruption of feeding and foraging, and change in dive patterns (DFO 2013). Studies indicate that maritime activity may have adverse effects on marine mammals due to ship strikes (Moore and Clarke 2002; Laist et al. 2001). Baleen whales are more susceptible than other marine mammals due to their large size, slower travel and maneuvering speeds, and lower avoidance capability (Laist et al. 2001). Vessel speed and size are an important factor for determining the probability and severity of ship strikes involving marine mammals. Lethal and severe injuries are caused by ships 80 m or longer travelling at speeds greater than 13 to 15 knots. These speeds are considered to be a critical threshold, below which ship strikes and mortality are less likely to occur (Jensen and Silber 2003).

3.5.3 Seals and Sea Lions

Underwater hearing sensitivity in seals and sea lions falls in between that of baleen and toothed whales with an estimated auditory bandwidth between 75 Hz and 75 kHz. Phocinid seals, such as the harbour seal, have underwater hearing thresholds between 60 and 85 dB re 1 μ Pa, with flat audiograms between 1 kHz and 30 to 50 kHz (Mohl 1968; Terhune and Ronald 1972, 1975; Terhune 1981). Some phocinids are able to detect high frequency sounds up to 180 kHz, although, their sensitivity to sounds above 60 kHz is poor and frequencies cannot be discriminated (Mohl 1968).

Toothed whales and pinnipeds are fast and maneuverable in the water, and have sensitive underwater hearing, enabling them to avoid being struck by approaching vessels (Laist et al. 2001; Jensen and Silber 2003).



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

However, there are a few documented cases of seal mortality as a result of a vessel strike (Richardson et al. 1995). This may be due to the considerable amount of time that seals and sea lions spend at or near the surface that increases their risk of vessel interactions. In this case, they are physically in the path of approaching vessels and research has shown that sound levels are lower near the surface and at the bow of the approaching vessel (Richardson et al. 1995).



4.0 SUMMARY

At least 11 species of marine mammal are known to occur in the southern Strait of Georgia and protected waters of Howe Sound. Five of these species are listed under Schedule 1 of SARA, including killer whale (*Orcinus orca*), harbour porpoise (*Phocoena phocoena*), humpback whale (*Megaptera novaeangliae*), grey whale (*Eschrichtius robustus*), and Steller sea lion (*Eumetopias jubatus*).

The proposed barging routes in Howe Sound do not overlap with 'critical habitat' areas for marine mammals (Figure 2). Existing shipping navigation routes in the Strait of Georgia and in Johnstone Strait (between Campbell River and Port McNeill) overlap with Southern resident killer whale 'critical habitat' and Northern resident killer whale 'critical habitat' respectively (Figure 2 inset).

Marine mammals are acoustically diverse, with wide variations in ear anatomy, frequency range, and amplitude sensitivity (Ketten 1991). An animal's sensitivity to sound varies with frequency. Audible frequencies for toothed whales range from 80 Hz to 150 kHz, but they are most sensitive to sounds in the frequency range of 8 to 90 kHz (Richardson et al. 1995). Killer whales are considered 'mid-frequency cetaceans' (Southall et al. 2007); meaning their most sensitive hearing range occurs in the mid-frequency range. However, other toothed whales such as harbour porpoise and Dall's porpoise are classified within the 'high-frequency cetacean' functional marine mammal hearing group (200 Hz to 180 kHz) (Southall et al. 2007). Baleen whale species emit low-frequency sounds and have been shown to react to frequencies below 1 kHz (Richardson et al. 1995). They have an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007) and are classified within the 'low-frequency cetaceans' functional marine mammal hearing group. Underwater hearing sensitivity in seals and sea lions falls in between that of baleen and toothed whales with an estimated auditory bandwidth between 75 Hz to 75 kHz.



5.0 CLOSING

We trust that this baseline report is sufficient to characterize existing baseline conditions for marine mammals in the Project area. For any queries on the contents of this report, please do not hesitate to contact the undersigned at 250-881-7372.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Erika Grebeldinger, B.Sc.
Marine Biologist

ORIGINAL SIGNED

Phil Rouget, M.Sc., R.P.Bio.
Senior Marine Biologist

Reviewed by:

ORIGINAL SIGNED

Dave Munday, B.Sc., MBA, R.P.Bio.
Senior Environmental Specialist
Consultant to Golder Associates Ltd.

EG/PR/DM/asd

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

o:\final\2011\1422\11-1422-0046\114220046-542-r-rev1-4300\114220046-542-r-rev1-4300 marine mammal baseline 23oct15.docx



6.0 LITERATURE CITED

- Baird, R.W. 2001. Status of Harbour Seals, *Phoca vitulina*, in Canada. Canadian field-naturalist 115(4): 663-675.
- Baird, R.W., and T.J. Guenther. 1995. Account of Harbour Porpoise (*Phocoena phocoena*) Strandings and Bycatches Along the Coast of British Columbia. Reports of the International Whaling Commission Special Issue. 16:159-168.
- Balcolm, K.C., and D.E. Claridge. 2001. Mass Stranding's of Cetaceans in the Bahamas Caused by Navy Sonar. Bahamas Journal of Science. 8:2001:2-12.
- BCCSN (British Columbia Cetacean Sighting Network). 2013. *Marine Mammal Howe Sound Sighting Data 1990 - 2013*. Letter from Vancouver Aquarium Marine Science Centre to Golder Associates Ltd., e-mail dated March 1, 2013.
- Best, B. and P. Halpin. 2009. Predictive Marine Mammal Modeling for Queen Charlotte Basin, British Columbia. Raincoast Conservation Foundation, 120p.
- Bigg, M.A. 1985. Status of the Steller Sea Lion (*Eumetopias jubatus*) and California Sea Lion (*Zalophus californianus*) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77: 20 p.
- Calambokidis, J., J. D. Darling, V. Deeke, P. Gearin, M. Gosho, W. Megill, C. M. Tombach, D. Goley, C. Toropova and B. Gisbourne. 2002. Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California and southeastern Alaska in 1998. J. Cetacean Res. Manage. 4(3):267-276.
- CDC (British Columbia Conservation Data Centre). 2014. BC Species and Ecosystems Explorer. BC Ministry of Environment. Victoria, BC. Available at: <http://a100.gov.bc.ca/pub/eswp>. Accessed on: February 2014.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2003a. COSEWIC assessment and update status report on the harbour porpoise *Phocoena phocoena* (Pacific Ocean population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 22 pp. Available at: <http://www.sararegistry.gc.ca>. Accessed: February 2014.
- COSEWIC. 2003b. COSEWIC assessment and update status report on the Steller sea lion *Eumetopias jubatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 47 pp. Available at: <http://www.sararegistry.gc.ca>. Accessed: February 2014.
- COSEWIC. 2004. COSEWIC assessment and update status report on the grey whale (Eastern North Pacific population) *Eschrichtius robustus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa vii + 31 pp. Available at: <http://www.sararegistry.gc.ca>. Accessed: February 2014.
- COSEWIC. 2013. Wildlife species search. Available at: http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm. Accessed: February 2014.
- Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford and L. Crum. 2006. Understanding the Impacts of Anthropogenic Sound on Beaked Whales. Journal of Cetacean Res. Manag. 7: 177-187.



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

- CWR (Centre for Whale Research). 2015. Another New Calf - L12, February 25, 2015 Available at: <http://www.whaleresearch.com/>. Accessed March 2015.
- D'Amico, A., Gisiner, R.C., Ketten, D.R., Hammock, J.A., Johnson, C., Tyack, P.L. and J. Mead. 2009. Beaked Whale Strandings and Naval Exercises. *Aquatic Mammals* 35: 452-472.
- DFO (Fisheries and Oceans Canada). 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 + 46pp.
- DFO. 2009a. Management Plan for the Offshore Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Nanaimo. v + 49pp.
- DFO. 2009b. Recovery Potential Assessment of Humpback Whales, Pacific Population. DFO Canadian Science Advisory Secretariat Science Advisory Report. No. 2009/048. 10 pp.
- DFO. 2010. Management Plan for the Eastern Pacific Grey Whale (*Eschrichtius robustus*) in Canada [Final]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Nanaimo. v + 60pp.
- DFO. 2011. Recovery Strategy for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa, ix + 80 pp.
- 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. 67 pp.
- Dorsey, E.M. 1983. Exclusive Adjoining Ranges in Individually Identified Minke Whales (*Balaenoptera acutorostrata*) in Washington State. *Can. J. Zoo.* 61: 174-181.
- Edgell, T.C. and M.W. Demarchi. 2012. California and Steller Sea Lion Use of a Major Winter Haulout in the Salish Sea Over 45 Years. *Mar Ecol Prog Ser.* 467: 253-262.
- Ellis, G.M., J.R. Towers, and J.K.B. Ford. 2011. Northern Resident Killer Whales of British Columbia: Photo-Identification Catalogue and Population Status to 2010. *Can. Tech. Rep. Fish. Aquat. Sci.* 2942:v + 71 p.
- Environment Canada. 2014. Species at Risk Act (SARA) Registry. Available at: http://www.sararegistry.gc.ca/default_e.cfm. Accessed on: February 2014
- Erbe, C. 2002. Hearing Abilities of Baleen Whales. Prepared for Defence Research and Development Canada – Atlantic. 40 p.
- Ford, J.K.B., G.M. Ellis and K.C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington. Second Edition. UBC Press. Vancouver, British Columbia. 104pp.
- Ford, J.K.B., R.M. Abernethy, A.V. Phillips, J. Calambokidis, G.M. Ellis and L.M. Nichol. 2010. Distribution and Relative Abundance of Cetaceans in Western Canadian Waters from Ship Surveys, 2002-2008. *Can. Tech. Rep. Fish. Aquat. Sci.* 2913: v + 51 p.
- Gaskin, D.E. 1992. Status of the Harbour Porpoise, *Phocoena phocoena*, in Canada. *Canadian Field-Naturalist.* 106:36-54.



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

- Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack. 2013. Blue Whales Respond to Simulated Mid-Frequency Military Sonar. *Pro. R. Soc. B.* 280(1765):1-8.
- Golder Associates Ltd. (Golder). 2012. Marine Mammal Surveys in Upper Kitimat Channel- Spring 2012. Report prepared for LNG Canada. Submitted October 2012.
- Government of Canada. 1985. Fisheries Act R.S.C., 1985, c. F-14 Section 35. Minister of Justice. Available at: <http://laws-lois.justice.gc.ca/eng/acts/F-14/>. Accessed on: February 2014.
- Government of Canada. 1993. Fisheries Act: Marine Mammal Regulations. Available at: <http://laws-lois.justice.gc.ca/eng/regulations/SOR-93-56/index.html>. Accessed: June 2013.
- Government of Canada. 2012. Species at Risk Act: Background. Available at: http://www.sararegistry.gc.ca/approach/strategy/background/default_e.cfm. Accessed: January 2014.
- Government of Canada. 2014. Order Amending Schedule 1 to the *Species at Risk Act*. ARCHIVED — Vol. 148, No. 16 — April 19, 2014. Available: <http://canadagazette.gc.ca/rp-pr/p1/2014/2014-04-19/html/reg1-eng.php#archived>. Accessed March 2015.
- Hatakeyama, Y., K. Ishii, H. Akamatsu, T. Soeda, T. Shimamura and T. Kojima. 1995. A Review of Studies on Attempts to Reduce the Entanglement of the Dall's Porpoise, *Phocoenoides dalli*, in the Japanese Salmon Gillnet Fishery. Report of the International Whaling Commission (Special Issue) 15: 549-563.
- Heise, K., J. Ford., and P. Olesiuk. 2007. Appendix J: Marine mammals and turtles. In Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Edited by Lucas, B.G., S. Verrin., and R. Brown. Canadian Technical Report on Fisheries and Aquatic Sciences. 2667:iv. 35 pp.
- Hoover-Miller, A., A. Bishop, J. Prewitt, S. Conlon, C. Jezierski, and P. Armato. 2013. Efficacy of Voluntary Mitigation in Reducing Harbor Seal Disturbance. *Journal of Wildlife Management* 77(4): 689-700.
- Jefferson, T.A., M.A. Webber., and R.L. Pitman. 2008. *Marine Mammals of the World: A Comprehensive Guide to Their Identification*. Amsterdam: Elsevier. 573 pp.
- Jensen, A.S., and G.K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-ORP. 37 p.
- Jepson, P.D., M. Arbelo, R. Deaville, L.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herraiez, A.M. Pocknell, F. Rodriguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham and A. Fernandez. 2003. Gas – Bubble Lesions in Stranded Cetaceans. *Nature* 425: 575-576.
- Johannessen, D.I., S.M. Verrin, P. Winchell, K. Truman, R. Birch., and S. Lindstrom. 2005. Biophysical overview report for the Pacific North Coast Integrated Management Area Parts A, B, and C: draft for expert review. Fisheries and Oceans Canada, Pacific Region, Science Branch.
- Kastelein, R.A., P. Bunskoek, M. Hagedoorn, W.W.L. Au, and D. Haan. 2002. Audio-gram of a Harbor Porpoise (*Phocoena phocoena*) Measured with Narrow-band Frequency Modulated Signals. *Journal of the Acoustical Society of America*. 112:334–344.



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

- Keple, A.R. 2002. Seasonal Abundance and Distribution of Marine Mammals in the Southern Strait of Georgia, British Columbia. M.Sc. Thesis. University of British Columbia, Vancouver, BC. 94 pp.
- Ketten, D.R. 1991. The Marine Mammal Ear: Specializations for Aquatic Audition and Echolocation. In: Webster D, Fay R, Popper A, editors. The Biology of Hearing. Berlin: Springer-Verlag. p. 717-750.
- Ketten, D.R. 1997. Structure and Function in Whale Ears. *Bioacoustics*. 8:103-135.
- Ketten, D.R. 1998. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts. NOAA Tech Memo NMFS: NOAA-TM-NMFS-SWFSC-256.
- Klinkenberg, B. (ed.) 2012. E-Fauna BC: Electronic Atlas of the Fauna of British Columbia. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. Available at: <http://www.efauna.bc.ca>. Accessed: January 2013.
- Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet and M. Podesta. 2001. Collisions Between Ships and Whales. *Marine Mammal Science* 17(1):35-75.
- Leighton, T.G., D. Finfer, E. Grover., and P.R. White. 2007. An Acoustical Hypothesis for the Spiral Bubble Nets of Humpback Whales and the Implications for Whale Feeding. *Acoustics Bulletin*. 22:17-21.
- LGL Limited Environmental Research Associates (LGL). 2004. A Review of the State of Knowledge of Marine and Shoreline Areas in the Queen Charlotte Basin. University of Northern British Columbia's Northern Land Use Institute. Prince George, BC. In Stantec. 2010 Technical Data Report Marine Mammals. Enbridge Northern Gateway Project. Stantec Consulting Ltd. Burnaby, British Columbia. B. Wheeler, MSc., RPBio, A. Rambeau, MSc.
- Madsen, P.T., I. Kerr, and R. Payne. 2004. Echolocation Clicks of Two Free-Ranging, Oceanic Delphinids with Different Food Preferences: False Killer Whales *Pseudorca crassidens* and Risso's Dolphins *Grampus griseus*. *J Exp Biol* 207: 1811-1823.
- Maybaum, H.L. 1993. Responses of Humpback Whales to Sonar Sounds. *Journal of the Acoustical Society of America* 94(3, Pt.2): 1848-1849.
- MCA (British Columbia Marine Conservation Analysis Project Team). 2011. Marine Atlas of Pacific Canada: A Product of the British Columbia Marine Conservation Analysis. Available at: www.bcmca.ca. Accessed: February 2014.
- McCauley, R.D. 1994. Seismic Surveys. In Environmental Implications of offshore oil and gas development in Australia – The findings of an independent scientific review, edited by J.M. Swan, J.M. Neff and P.C. Young. pp. 19-122.
- Mohl, B. 1968. Auditory Sensitivity of the Common Seal in Air and Water. *J. Aud. Res.* 8(1):27-38.
- Moore, S.E. and J.T. Clarke. 2002. Potential Impact of Offshore Human Activities on Gray Whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):19-25.
- NOAA Fisheries. 2014. Southern resident killer whale tagging. Northwest Fisheries Science Center. Available at: http://www.nwfsc.noaa.gov/research/divisions/cb/ecosystem/marinemammal/satellite_tagging/. Accessed: August 2014.



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

- Parsons, E.C.M., S.J. Dolman, A.J. Wright, N.A. Rose, and W.C.G. Burns. 2008. Navy Sonar and Cetaceans: Just How Much Does the Gun Need to Smoke Before We Act? *Marine Pollution Bulletin* 56: 1248-1257.
- PNCIMA (Pacific North Coast Integrated Management Area). 2011. Killer Whale Important Areas and Critical Habitat. Available at: <http://www.pncima.org/site/atlas.html>. Accessed on: February 2014.
- Reeves, R. R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. National Audubon Society Guide to Marine Mammals of the World. Chanticleer Press Inc., New York, USA.
- Reichmuth, C. 2012. Underwater Hearing in California Sea Lion (*Zalophus californianus*): Expansion and interpretation of existing data. *Marine Mammal Science* 28(2): 358-363.
- Reilly, S.B., J.L. Bannister, P.B. Best, M. Brown, R.L. Brownell Jr., D.S. Butterworth, P.J. Clapham, J. Cooke, G.P. Donovan, J. Urbán, and A.N. Zerbini. 2008. *Balaenoptera acutorostrata*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. Available at: www.iucnredlist.org. Accessed: April 2014.
- Richardson, J., C.R. Greene Jr, C. Malme, and D. Thomson. 1995. Marine Mammals and Noise. Academic Press. San Diego.
- Rugh D. J., Hobbs R. C., Lerczak J. A., Breiwick J. M. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) 1997–2002. *Journal of Cetacean Research and Management* 7:1–12.
- Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas. and P.L. Tyack. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals*. 33(4):411-521.
- Szymanski, M.D., D.E. Bain, K. Kiehl, S. Pennington, S. Wong., and K.R. Henry. 1999. Killer whale (*Orcinus orca*) Hearing: Auditory Brainstem Response and Behavioral Audiograms. *Journal of the Acoustical Society of America*. 106(2):1134-1141.
- Terhune, J.M. 1981. Influence of Loud vessel Noises on Marine Mammal Hearing and Vocal Communication. In: Peterson NM, editor. The question of sound from icebreaker operations: The proceedings of a workshop. Arctic Pilot Proj., Petro-Canada, Calgary, Alb. p. 270-286.
- Terhune, J.M. and K. Ronald. 1972. The Harp Seal, *Pagophilus groenlandicus* (Erleben, 1777). III. The underwater audiogram. *Can. J. Zool.* 50(5):565-569.
- Terhune, J.M. and K. Ronald. 1975. Underwater Hearing Sensitivity of Two Ringed Seals (*Pusa hispida*). *Can. J. Zool.* 53(3):227-231.
- Tremel, D. P., J.A. Thomas, K.T. Ramirez, G.S. Dye, W.A. Bachman, A.N. Orban, and K.K. Grimm. 1998. Underwater Hearing Sensitivity of a Pacific White-Sided Dolphin, *Lagenorhynchus obliquidens*. *Aquatic Mammals*, 24: 63-70.
- Van Waerebeek, K., Baker, A., Felix, F., Gedamke, J., Iniguez, M., Sanino, G.P., Secchi, E., Sutaria, D., van Helden, A. and Y. Wang. 2007. Vessel Collisions with Small Cetaceans Worldwide and with Large Whales in the Southern Hemisphere, an Initial Assessment. *LAJAM*. 6(1): 43-49.



BURNCO AGGREGATE PROJECT- MARINE MAMMAL BASELINE REPORT

- Vanderlaan, A.S.M. and C.T. Taggart. 2006. Vessel Collisions with Whales: the Probability of Lethal Injury Based on Vessel Speed. *Marine Mammal Science* 23(1):144-156.
- Watkins, W.A., M.A. Daher, K.M. Fristrup, T.J. Howald, and G. Notarbartolo di Sciara. 1993. Sperm Whales Tagged With Transponders and Tracked Underwater by Sonar. *Marine Mammal Science* 9(1): 55-67.
- Wells, R.S. and M.D. Scott. 1997. Seasonal Incidence of Boat Strikes on Bottlenose Dolphins Near Sarasota, Florida. *Mar. Mamm. Sci.* 3:475-480.
- Winn, H.E., and N.E. Reichley. 1985. Humpback Whale – *Megaptera novaeangliae* (Borowski, 1781), pp. 241-73. In: Ridgway, S.H., and R. Harrison. (eds). *Handbook of Marine Mammals, Vol. 3: The Sirenians and Baleen Whales*. London and Orlando: Academic Press.
- Yuen, M.M.L., P. Nachtigall, M. Breese and A. Supin. 2005. Behavioral and auditory evoked potential audiograms of a false killer whale (*Pseudorca crassidens*). *Journal of Acoustical Society of America*. 118 (4), October 2005.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
2nd floor, 3795 Carey Road
Victoria, British Columbia, V8Z 6T8
Canada
T: +1 (250) 881 7372

