Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
Offshore Wind – Exploration, Construction, Operations & Maintenance, Decommissioning	Marine Mammals/Sea Turtles	The greatest risk to marine mammals and sea turtles from offshore wind (OSW) development and marine industrial activity in general, is the risk for injury or mortality from collisions with ships and infrastructure, e.g., entanglement in fishing gear, and underwater sound generated from industrial activities. Sound exposure above certain frequencies may result in behavioral changes in some species by masking sounds that mammals use for communication; mammals and sea turtles may avoid areas altogether, either permanently or temporarily. The increase of vessel activity during the construction and operation of OSW farms will create an additional pathway for potential for vessel strikes, in concert with vessel activity occurring for other industries, i.e., will increase the total number of vessels moving through an area. The introduction of OSW farms and the associated underwater sounds generated from construction and operation, will contribute to the overall soundscape of the marine environment and add a source of sound to those already occurring from natural and man-made processes. Increased activity and future projects, in addition to OSW activities, will increase the cumulative noise levels and pose increased risk for injury, mortality, or the avoidance of areas by marine mammals and sea turtles. If the areas avoided are those used for important life-cycle stages like feeding, breeding and/or nursing, there could be larger population-level impacts on species.	Bailey, Brookes, K. L., & Thompson, P. M. (2014). Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. Aquatic Biosystems, 10(1), 8–8. https://doi.org/10.1186/2046-9063-10-8 CSA Ocean Sciences Inc. (2021). Technical Report: Assessment of Impacts to Marine Mammals, Sea Turtles, and ESA-Listed Fish Species, Revolution Wind Offshore Wind Farm. Prepared for Revolution Wind, LLC. March 2021. 125 pp. Nehls, G., Rose, A., Diederichs, A., Bellmann, M., & Pehlke, H. (2016). Noise Mitigation During Pile Driving Efficiently Reduces Disturbance of Marine Mammals. Advances in Experimental Medicine and Biology, 875, 755–762. https://doi.org/10.1007/978-1-4939-2981-8_92 Nowacek, D.P., Thorne, L.H., Johnston, D.W., and P.L. Tyack (2007). Responses of cetaceans to anthropogenic noise. Mammal Rev., 37: 81-115.

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
	Fish and Fish Habitat	Potential cumulative impacts to fish and fish habitat would include direct impacts from marine activities generating underwater noise and from those activities that come into direct contact with the seafloor. For benthic habitat, such as corals and sponges or eelgrass, repeated disturbance to the seabed from marine industrial activities could have direct impacts to those species through their destruction or smothering from sediment. Other activities, such as commercial fishing and/or marine research activities that use bottom-contact gear, such as trawls, also contribute to the disturbance of fish habitat. Underwater sound produced by multiple activities in proximity could influence fish species that may be sensitive to such disturbances. In addition to OSW activities, these sources include fishing activities, commercial shipping, military exercises that may include active firing or subsea exercises, and marine research. Fish species have varying levels of tolerance to underwater sound; those species with swim bladders are more susceptible to physical injury and mortality from underwater sound sources. While some species may be able to tolerate underwater sound generated by OSW development, having other sound sources in proximity may push species tolerance to a point where they exhibit avoidance behavior or sustain injury or mortality. The different life stages of a species could also influence susceptibility to effects and impacts from underwater sound. There is evidence from jurisdictions with OSW development, and from other industries such as the oil and gas sector, that wherever large structures, or associated subsea infrastructure, are placed in the marine environment, a reef effect can be created providing refuge for some species. While that needs to be validated within a Nova Scotian context, there could potentially be a positive cumulative impact if it is shown that OSW farms may provide a refuge for certain species. This could support stock recovery and the overall health of certain species, particularly if they also are less exposed to fishing. This in turn could improve commercial fisheries. Potential cumulative impacts on fish species could have greater repercussions on those species considered at risk, commercially important, or whose stock health may be poor. Climate change is and will further change the dynamics of fish populations and their	Bat, L., Sezgin, M., & Sahin, F. (2013). Impacts of OWF installations on fisheries: A Literature Review. Journal of Coastal Life Medicine, 1(3), 241-252. https://oaji.net/articles/2015/2154-1435735819.pdf Bureau of Ocean Energy Management (BOEM). 2020. National Environmental Policy Act Documentation for Impact-Producing Factors in the Offshore Wind Cumulative Impacts Scenario on the South Atlantic Continental Shelf. US Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Sterling, VA. OCS Study 2021-043. Caine, C.A. (2020). The Race to the Water for Offshore Renewable Energy: Assessing Cumulative and In-combination Impacts for Offshore Renewable Energy Developments. Journal of Environmental Law, 32(1), 83–109. https://doi.org/10.1093/jel/eqz031 Causon, P.D. & Gill, A. B. (2018). Linking ecosystem services with epibenthic biodiversity change following installation of offshore wind farms. Environmental Science & Policy, 89, 340–347. https://doi.org/10.1016/j.envsci.2018.08.013

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
		distribution; as waters warm and the ocean becomes more acidic, species with preferences for colder water will move further north, and warmer water species may move into the region.	Degraer, S., Z.L. Hutchison, C. LoBue, K.A. Williams, J. Gulka, and E. Jenkins. (2021). Benthos Workgroup Report, State of the Science Workshop on Wildlife and Offshore Wind Energy 2020: Cumulative Impacts. Report to the New York State Energy Research and Development Authority (NYSERDA). Albany, NY. 45 pp. Farr, H., Ruttenberg, B., Walter, R. K., Wang, Y.-H., & White, C. (2021). Potential environmental effects of deepwater floating offshore wind energy facilities. Ocean & Coastal Management, 207, 105611–. https://doi.org/10.1016/j.ocecoaman.2021.105611 Gill, E.; Hein, C. (2022). IEA Wind White Paper Cumulative Effects Analysis for Wind Energy Development: Current Practices, Challenges, and Opportunities. Report by National Renewable Energy Laboratory (NREL). Report for International Energy Agency (IEA). ICF (ICF Incorporated, LLC). (2020). Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations. U.S. Department of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2020-041. 42 pp.

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
			Kaldellis, J.K., Apostolou, D., Kapsali M., and E. Kondili. (2016). Environmental and social footprint of offshore wind energy. Comparison with onshore counterpart. Renewable Energy, 92, 543-556. https://doi.org/10.1016/j.renene.2016.02.018. Kikuchi, R. (2010). Risk formulation for the sonic effects of offshore wind farms on fish in the EU region. Marine Pollution Bulletin, 60(2), 172–177. https://doi.org/10.1016/j.marpolbul.2009.09.023 Maxwell, S.M., Kershaw, F., Locke, C. C., Conners, M. G., Dawson, C., Aylesworth, S., Loomis, R., & Johnson, A. F. (2022). Potential impacts of floating wind turbine technology for marine species and habitats. Journal of Environmental Management, 307, 114577–114577. https://doi.org/10.1016/j.jenvman.2022.114577 Normandeau Associates Inc. (Normandeau), Exponent Inc., Tricas, T., and A. Gill. (2011). Effects of EMFs from Undersea Power Cables on Elasmobranch and Other Marine Species. Camarillo, CA: U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation,

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
			and Enforcement, Pacific OCS Region. OCS Study BOEMRE 2011-09. pp. NYSERDA (New York State Energy Research and Development Authority). (2017a). New York State Offshore Wind Master Plan: Consideration of Potential Cumulative Effects (NYSERDA Report 17- 25g). Prepared by Ecology and Environment, Inc. Smyth, K., Christie, N., Burdon, D., Atkins, J. P., Barnes, R., & Elliott, M. (2015). Renewables-to-reefs? – Decommissioning options for the offshore wind power industry. Marine Pollution Bulletin, 90(1-2), 247–258. https://doi.org/10.1016/j.marpolbul.2014.10.045 Stenberg, C., J. G. Stottrup, M. van Deurs, C. W. Berg, G.E. Dinesen, H. Mosegaard, T. M. Grome, and S. B. Leonard. (2015). Long-term effects of an offshore wind farm in the North Sea on fish communities. Mar. Ecol. Prog. Ser.528: 257–265. doi:10.3354/meps11261. Svendsen, J. C., Ibanez-Erquiaga, B., Savina, E., & Wilms, T. (2022). Effects of operational offshore wind farms on fishes and fisheries. Review report. DTU Aqua. DTU Aqua-rapport No. 411-2022

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
			Taormina B., Quillien, N., Lejart, M., Carlier, A., Desroy, N., Laurans, M., D'Eu, J. F., Reynaud, M., Perignon, Y., Erussard, H., Derrien-Courtel, S., Le Gal, A., Derrien, R., Jolivet, A., Chauvaud, S., Degret, V., Saffroy, D., Pagot, J. P., and A. Barillier. (2020). Characterisation of the potential impacts of subsea power cables associated with offshore renewable energy projects. Plouzané: France Energies Marines Editions, 74 pages
	Fisheries	Potential effects of OSW development on fisheries and other ocean users are related to a potential loss of access to fishing grounds or traditional travel corridors and potential interactions between fishing gear and infrastructure, resulting in lost catch due to damage or loss of equipment. Likewise, impacts on commercially important species, including injury, mortality, or behavioural changes such as avoidance may result in lower catch numbers due to less species present in traditional fishing locations.	Bat, L., Sezgin, M., & Sahin, F. (2013). Impacts of OWF installations on fisheries: A Literature Review. Journal of Coastal Life Medicine, 1(3), 241-252. https://oaji.net/articles/2015/2154-1435735819.pdf Lüdeke, J. (2017). Offshore Wind Energy: Good Practice in Impact Assessment, Mitigation and Compensation. Journal of Environmental Assessment Policy and Management, 19(31). 10.1142/S1464333217500053. Mooney, T.A., Andersson, M. H., & Stanley, J. (2020). Acoustic impacts of offshore wind energy on fishery resources: An Evolving Source and Varied Effects Across a Wind Farm's Lifetime. *Oceanography (Washington, D.C.)*, *33*(4), 82–95.

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
			https://doi.org/10.5670/oceanog.2020.408 Raoux, A., Dambacher, J. M., Pezy, J.-P., Mazé, C., Dauvin, J.-C., & Niquil, N. (2018). Assessing cumulative socio-ecological impacts of offshore wind farm development in the Bay of Seine (English Channel). Marine Policy, 89, 11–20. https://doi.org/10.1016/j.marpol.2017.12.007 Svendsen, J. C., Ibanez-Erquiaga, B., Savina, E., & Wilms, T. (2022). Effects of operational offshore wind farms on fishes and fisheries. Review report. DTU Aqua. DTU Aqua-rapport No. 411-2022
	Indigenous Communities and Activities	The degree to which Indigenous individuals and communities experience cumulative effects associated with OSW development, in conjunction with past, present and reasonably foreseeable future marine activities, will depend largely on the anticipated cumulative impacts on those species considered traditionally important, whether for food, ceremonial or cultural reasons. Projects that take place farther offshore may not directly interfere with many of the traditional activities undertaken by Indigenous communities and individuals, but it must be noted that today indigenous communities' fish throughout the study area. Potential impacts to those species, including marine and migratory birds, salmon and eel that are valued and harvested by Indigenous people could indirectly affect their ability to undertake traditional harvesting activities and perform ceremonies. If, for example, Atlantic salmon or American eel are affected by OSW development, along with other marine industrial activities, to the point where their population levels are adversely impacted, the change could affect the ability of Indigenous communities to carry out traditional harvesting activities and reduce their overall harvest. This could impact the mental health of communities, particularly if they	

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
		feel that they cannot successfully undertake traditional activities in a manner that provides value to their culture.	
	Communities and Economy	The introduction of major new projects to the region, including multiple OSW projects, could result in scenarios that include positive and/or adverse cumulative impacts. The potential for these scenarios to become positive or adverse is largely dependent on the availability, or absence, of the necessary physical and social infrastructure together with the supply chains and workforce necessary to support such projects.	Connolly, K. (2020). The regional economic impacts of offshore wind energy developments in Scotland. Renewable Energy, 160, 148–159. https://doi.org/10.1016/j.renene.2020.06.065 Cooper, L. M., and Sheate, W. R. (2004). Integrating cumulative effects assessment into UK strategic planning: implications of the European Union SEA Directive. Impact Assessment and Project Appraisal, 22(1), 5-16. Copping, A.E. and L.G. Hemery (eds.). (2020). OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES). 327 pp. Durning, B., & Broderick, M. (2019). Development of cumulative impact assessment guidelines for offshore wind farms and evaluation of use in project making. Impact Assessment and Project Appraisal, 37(2), 124–138. https://doi.org/10.1080/14615517.2018.1498186

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
			Kaldellis, J.K., Apostolou, D., Kapsali M., and E. Kondili. (2016). Environmental and social footprint of offshore wind energy. Comparison with onshore counterpart. Renewable Energy, 92, 543-556. https://doi.org/10.1016/j.renene.2016.02.018. Ladenburg, T.M., Termansen, M., & Hasler, B. (2013). Assessing acceptability of two onshore wind power development schemes: A test of viewshed effects and the cumulative effects of wind turbines. Energy (Oxford), 54, 45–54. https://doi.org/10.1016/j.energy.2013.02.021

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Offshore Petroleum Production Projects (Existing and Proposed), Exploration (Seismic/ Geophysical and Drilling)	Marine Mammals/Sea Turtles Fish and Fish Habitat Fisheries	Oil and gas drilling and production activities, should they again occur in the region, include the drilling of wells and installation of subsea infrastructure. In addition to the disturbance of sediment, some drill muds and cuttings are discharged directly to the seabed, these discharges, dependent on their dispersion, can potentially smother benthic species and result in loss of habitat and injury or mortality to benthic habitat and fish species.	Weilgart, L. S. (2007a). The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology, 85(11), 1091-1116. Weilgart, L. S. (2007b). A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology, 20(2). CEF Consultants Ltd. (2011). Report on a Workshop on Fish Behaviour in Response to Seismic Sound held in Halifax, Nova Scotia, Canada, March 28-31, 2011, Environmental Studies Research Funds Report No. 190. Halifax, 109 p. Dalen, J. (2007). Effects of seismic surveys on fish, fish catches and sea mammals. Det Norse Veritas (DNV). Report for the Cooperation Group – Fishery Industry and Petroleum Industry Report No. 2007-0512. Day, R.D., McCauley, R.M. Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M., Institute for Marine and Antarctic Studies. (2016). Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries. University of Tasmania, Hobart, October. CC BY 3.0 Hawkins, & Popper, A. N. (2017). A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. ICES Journal of Marine

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			Science, 74(3), 635–651. https://doi.org/10.1093/icesjms/fsw205 Hudson, D.M., Krumholz, J. S., Pochtar, D. L., Dickenson, N. C., Dossot, G., Phillips, G., Baker, E. P., & Moll, T. E. (2022). Potential impacts from simulated vessel noise and sonar on commercially important invertebrates. *PeerJ (San Francisco, CA), 10, e12841–.* https://doi.org/10.7717/peerj.12841 Nowacek, D.P., Thorne, L.H., Johnston, D.W., and P.L. Tyack (2007). Responses of cetaceans to anthropogenic noise. Mammal Rev., 37: 81-115. Popper, A.N. and M.C. Hastings. (2009). The effects of human-generated sound on fish. Integrative Zoology, 4: 43-52. Ragnarsson, S.Á., Burgos, J.M., Kutti, T., van den Beld, I., Egilsdóttir, H., Arnaud-Haond, S. and A. Grehan (2017). The Impact of Anthropogenic Activity on Cold-Water Corals. Marine Animal Forests: The Ecology of Benthic Biodiversity Hotspots, 1-35. Streever, B., Raborn, S.W., Kim, K.H., Hawkins, A.D. and A.N. Popper. (2016). Changes in fish catch rates in the presence of air gun sounds in Prudoe Bay, Alaska. Arctic 69(4):346-358.

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
Fishing Activities	Marine Mammals/Sea Turtles		
	Fish and Fish Habitat	Commercial fishing and/or research activities that use bottom-contact gear, such as trawls, contribute to the disturbance to fish habitat.	Christensen, V., Coll, M., Piroddi, C., Steenbeek, J., Buszowski, J. and D. Pauly. (2015). A century of fish biomass decline in the ocean. Marine ecology progress series, 512, 155-166. Clark, M.R., Althaus, F., Schlacher, T.A., Williams, A., Bowden, D.A. and A.A. Rowden (2016). The impacts of deepsea fisheries on benthic communities: a review. ICES Journal of Marine Science 73 (Supplement 1): 151-169. Ragnarsson, S.Á., Burgos, J.M., Kutti, T., van den Beld, I., Egilsdóttir, H., Arnaud-Haond, S. and A. Grehan (2017). The Impact of Anthropogenic Activity on Cold-Water Corals. Marine Animal Forests: The Ecology of Benthic Biodiversity Hotspots, 1-35.

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
Other Marine Vessel Traffic	Marine Mammals/Sea Turtles Fish and Fish Habitat Fisheries		Weilgart, L. S. (2007a). The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology, 85(11), 1091-1116. Weilgart, L. S. (2007b). A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology, 20(2). DFO (Fisheries and Oceans Canada). (2019). Vessel Shipping Density: DFO Human Use Atlas. Shape file provided by DFO Oceans Branch January, 2019. Hudson, D.M., Krumholz, J. S., Pochtar, D. L., Dickenson, N. C., Dossot, G., Phillips, G., Baker, E. P., & Moll, T. E. (2022). Potential impacts from simulated vessel noise and sonar on commercially important invertebrates. *PeerJ (San Francisco, CA), 10, e12841–.* https://doi.org/10.7717/peerj.12841
Military Exercises	Marine Environment (e.g., Marine Mammals, Fish and Fish Habitat, Fisheries)	The Department of National Defense and the Canadian Coast Guard carry out military training exercises within the offshore region; this includes areas that are designated as live firing areas. Coordination with DND for future OSW development will be required by developers of any project to avoid potential use conflict.	

Table 2: Cumulative Effects and Offshore Wind Background

Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
		Most of the Scotian shelf is identified as a potential area for training exercises, but only small portions have been identified as live firing areas.	
Climate Change related Environmental shifts (e.g., Declining Sea Ice, Atmospheric Emissions)	Marine Mammals and Sea Turtles	While some species such as harp seals have been negatively affected by declining sea ice, others, such as the endangered blue whale, have benefited from this environmental change as fewer numbers are being trapped in heavy ice near shore (Bernier et al., 2018). Distributions of highly mobile pinnipeds and cetaceans have also changed due to the loss of sea ice extent and the northward shift of prey. The frequency of visits from killer whales in the northern regions of the Atlantic has increased and pupping of grey seals now primarily occurs on land rather than on pack ice in the Gulf of St. Lawrence due to declines in sea ice (Bernier et al., 2018). Atmospheric emissions in the Study Area come from a number of sources, but mainly stem from vessels transiting through the area. While the atmospheric environment offshore can likely be considered good, cumulative impacts from an increase in vessel traffic would incrementally add to the sources of emissions. Potential emissions from other sources, such as offshore substations, or oil and gas platforms would add to the mix. The spatial and temporal nature of future projects would influence the level of cumulative emissions, but it could be expected that local air quality in the vicinity of multiple projects, plus increased vessel activity, could both contribute to a decline in localized air quality, as well as contribute to overall GHG emissions from industrial activity in Canada.	DFO (Fisheries and Oceans Canada). (2023). Oceanographic Conditions in the Atlantic Zone in 2022. Canadian Science Advisory Secretariat Science Advisory Report. Available at: https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2023/2023_019-eng.pdf Morato, T., González-Irusta, J. M., Dominguez-Carrió, C., Wei, C. L., Davies, A., Sweetman, A. K., ... & Laffargue, P. (2020). Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology.

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Interacting Activity/Factor	VCs Effected	Understanding of the Issue	Literature
Special Areas (MPAs, Marine Refuges/OECMs)	Marine Mammals/Sea Turtles	Special areas are identified and designated in recognition of their ecological importance, to protect important or sensitive environmental components, or to identify areas that may be used by species for important life-stages. In certain cases, this is based on the objective of conserving the present nature of these areas or to otherwise ensure that important ecological processes and features are recognized and remain intact, e, g., Ecologically and Biologically Significant Areas. In other cases, their designation is intended to help prevent further damage to already affected and sensitive environmental features and components and to facilitate recovery of both the ecological and socioeconomic functions of the marine space, e.g., Fisheries Closure Areas. In terms of potential cumulative effects from OSW development, and other ongoing, or foreseeable future projects and activities, the degree to which special areas will be influenced will be largely determined by the impacts on species within the areas or impacts on the areas' valued physical or ecological characteristics. These areas have been identified, or designated, because several species are either present in them, e.g., Significant Benthic Areas, or use them for a number of different reasons such as feeding, spawning or nursing. If impacts from projects that may occur, in addition to OSW developments, cause a reduction in species through injury or mortality, or behavioural changes that cause species to avoid these identified areas, it will inherently impact the overall ecological importance / integrity of these areas. It will reduce the rationale for why these areas were identified as special or sensitive in the first place.	
	Fish and Fish Habitat		
	Fisheries		