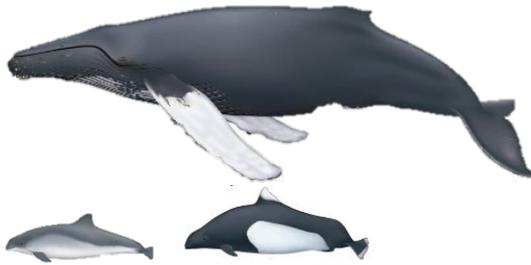




SEASONAL SPATIAL DENSITIES OF CETACEANS IN THE SOUTHERN SALISH SEA AND ON SWIFTSURE BANK



Clockwise from top: humpback whale, Dall's porpoise, harbour porpoise (not to scale, illustrations by Uko Gorter).



Figure 1. Study area for systematic cetacean line-transect surveys conducted between August 2020 and August 2024 (orange) and locations of the inbound and outbound shipping lanes (traffic separation scheme; grey). Salish Sea shown in inset (purple).

CONTEXT

The Canada Energy Regulator (CER) recommended that the Governor in Council develop an Offset Program in response to the increased underwater noise and vessel strike risk posed to species at risk by marine shipping related to the Trans Mountain Expansion Project (TMX). In particular, Recommendation 6 (d) asked for the identification of specific foraging, congregation and migration areas of federally listed marine species at risk and consideration of mitigations in those areas (including Swiftsure Bank; National Energy Board 2019). To respond to this recommendation, regular year-round boat-based surveys documenting cetacean presence in the southern Salish Sea and on Swiftsure Bank were initiated in 2020. The goal of these surveys was to collect seasonal abundance, density and distribution data using a systematic line-transect survey design.

This Science Advisory Report is from the regional peer review meeting of February 25-27, 2025 on the Seasonal Distribution, Density, and Abundance of Cetacean Species in the Southern Salish Sea and on Swiftsure Bank. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

SUMMARY

- Knowledge of seasonal density and distribution of cetaceans in the TMX marine shipping area was identified as a data gap by the Canada Energy Regulator.
- 29 systematic repeated boat-based surveys were conducted across all seasons from August 2020 to August 2024, covering the southern Salish Sea and Swiftsure Bank.
- Surveys were designed to detect multiple cetacean species. Eight different cetacean species were detected. There were sufficient sightings of humpback whales, harbour porpoises, and Dall's porpoises to inform density and abundance estimation, accounting for the detectability of each species.
- Spatial modelling was used to produce effort-corrected, season-specific density maps throughout the Canadian portions of the TMX marine shipping area. All three species showed distinct seasonal and spatial density patterns.
- Highest abundance of humpback whales occurred in fall. Areas of highest density for humpback whales included Swiftsure Bank in all seasons, and central and western Juan de Fuca Strait in summer and fall.
- Harbour porpoises were the most frequently sighted species in all seasons. Areas of highest density of harbour porpoises included Haro Strait, Boundary Pass, and eastern Juan de Fuca Strait year-round. There were also high-density areas in the southern Strait of Georgia in winter, spring, and fall.
- Dall's porpoise abundance was highest in winter. Dall's porpoise density was highest in the southern Strait of Georgia in fall and winter, and in western Juan de Fuca Strait in spring and summer.
- This multi-year study provides the first year-round spatially-explicit estimates of the seasonal distribution and abundance of humpback whales, harbour porpoises and Dall's porpoises in the southern Salish Sea and on Swiftsure Bank. These results are intended to inform a subsequent planned assessment of vessel strike risk.
- The seasonal density layers can inform ecosystem studies, recovery planning, environmental response planning, and impact assessments of threats, such as entanglement in fishing gear and underwater noise.
- The temporal variability observed in cetacean distributions within the TMX marine shipping area underscores the need for management strategies that are aligned with seasonal density patterns rather than relying on data from a single season or year.

INTRODUCTION

The Salish Sea is a biologically rich region that supports diverse marine mammal populations and is increasingly affected by human activities, including shipping and industrial development. Previous published knowledge of cetacean occurrence in the Salish Sea has largely been based on presence-only data from opportunistic platforms (e.g., Hauser et al. 2007, Olson et al. 2018), which are not always suitable for quantifying abundance and density due to spatial and effort-related biases. While some earlier studies employed systematic survey designs and spatial modelling (e.g. Best et al. 2015, Nichol et al. 2017, Wright et al. 2021), they were often

restricted to a single season, relied on small sample sizes, or are now outdated. These limitations have made it difficult to assess seasonal variation in cetacean distribution and to estimate densities at relevant scales – information that is essential for spatially explicit risk assessment and threat mitigation. The present study addresses these gaps through year-round systematic surveys and density surface modelling, providing updated and seasonally resolved estimates of cetacean density in areas affected by TMX-related shipping.

ASSESSMENT

Surveys and modelling

The study area was delineated using a 6 km buffer around the commercial shipping lanes in the southern Salish Sea between Vancouver and Swiftsure Bank, excluding U.S. waters (Figure 1). Surveys were conducted on a monthly basis when possible in 2020-2022, and every other month in 2023-2024, for a total of 29 surveys encompassing 7,370 km of effort. The 12.8 m research vessel traveled along systematic transect lines that were spaced 18 km apart and oriented perpendicular to the shoreline and depth gradients. Data were collected using standard distance sampling protocols with one observer positioned on either side of the vessel's bow and a data recorder positioned inside the wheelhouse.

The surveys yielded 2,306 sightings of eight cetacean species, all made by the same three observers throughout the entire study period. The most frequently detected cetaceans were humpback whales, harbour porpoises, and Dall's porpoises. Density surface models (DSMs) were created for each of these three species and for each season (defined as winter: January - March, spring: April - June, summer: July - September, and fall: October – December). The first step of the analysis was to model how the detectability of each species was affected by distance from the transect line and by environmental conditions. The second step was to model the number of animals counted in each 2 km survey segment, adjusted for detectability, to predict how density varies throughout the study area in each season as a consequence of habitat covariates (e.g., slope, depth, sea surface temperature), plotted on a 2 km x 2 km grid.

The spatial modelling yielded effort-corrected, season-specific density maps throughout the Canadian portions of the TMX marine shipping area (National Energy Board 2019). All three species showed distinct seasonal and spatial density patterns. Highest abundance of humpback whales occurred in fall. Areas of highest density for humpback whales included Swiftsure Bank in all seasons, and central and western Juan de Fuca Strait in summer and fall (Figure 2). Harbour porpoises were the most frequently sighted species in all seasons. Areas of highest density of harbour porpoises included Haro Strait, Boundary Pass, and eastern Juan de Fuca Strait year-round (Figure 3). There were also high-density areas in the southern Strait of Georgia in winter, spring, and fall. Dall's porpoise abundance was highest in winter. Dall's porpoise density was highest in the southern Strait of Georgia in fall and winter, and in western Juan de Fuca Strait in spring and summer (Figure 4).

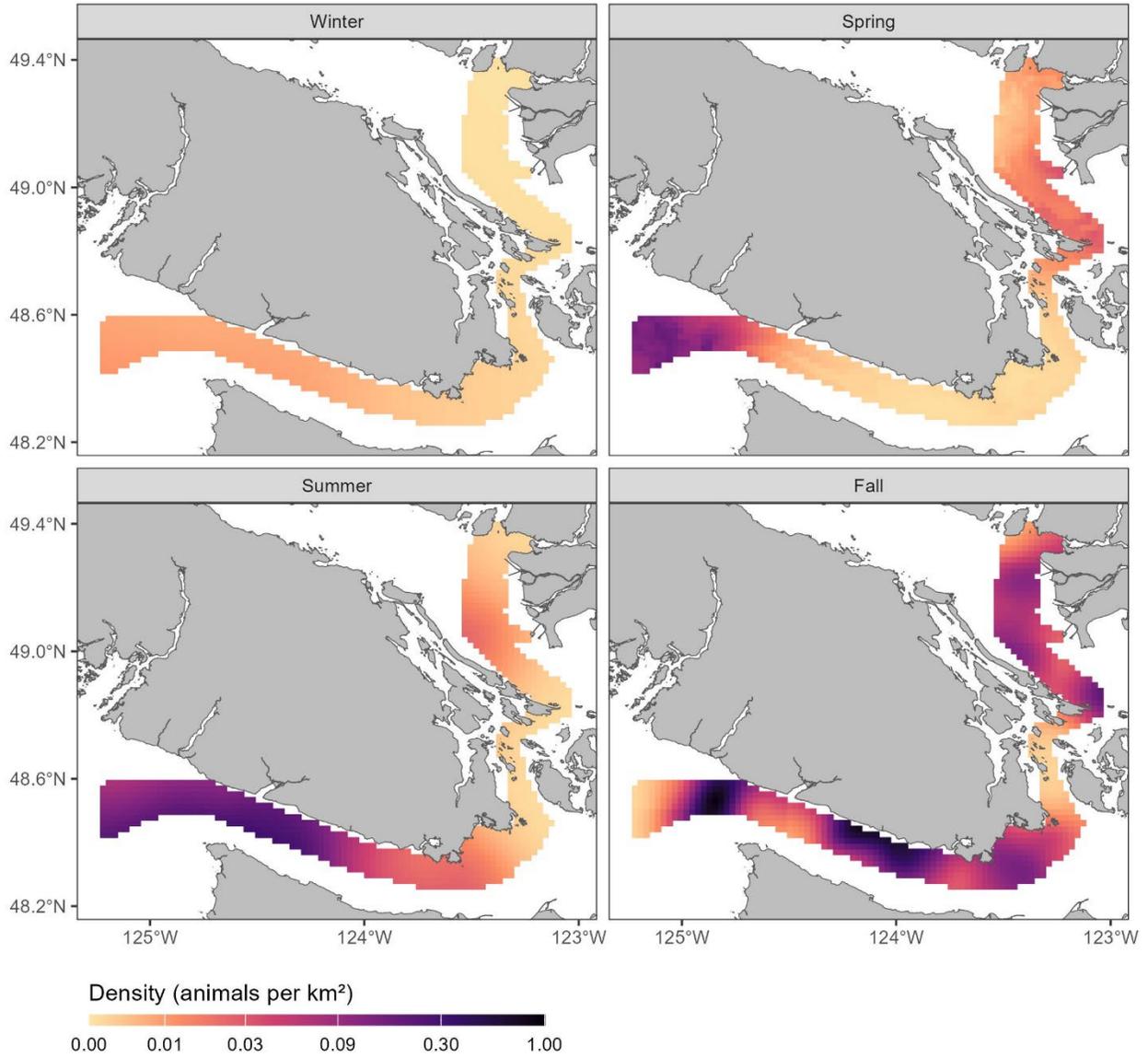


Figure 2. Predicted humpback whale density (animals per km²) during each season. Winter: January to through March; Spring: April through June; Summer: July through September; Fall: October through December.

Seasonal Spatial Densities of Cetaceans in the Southern Salish Sea

Pacific Region

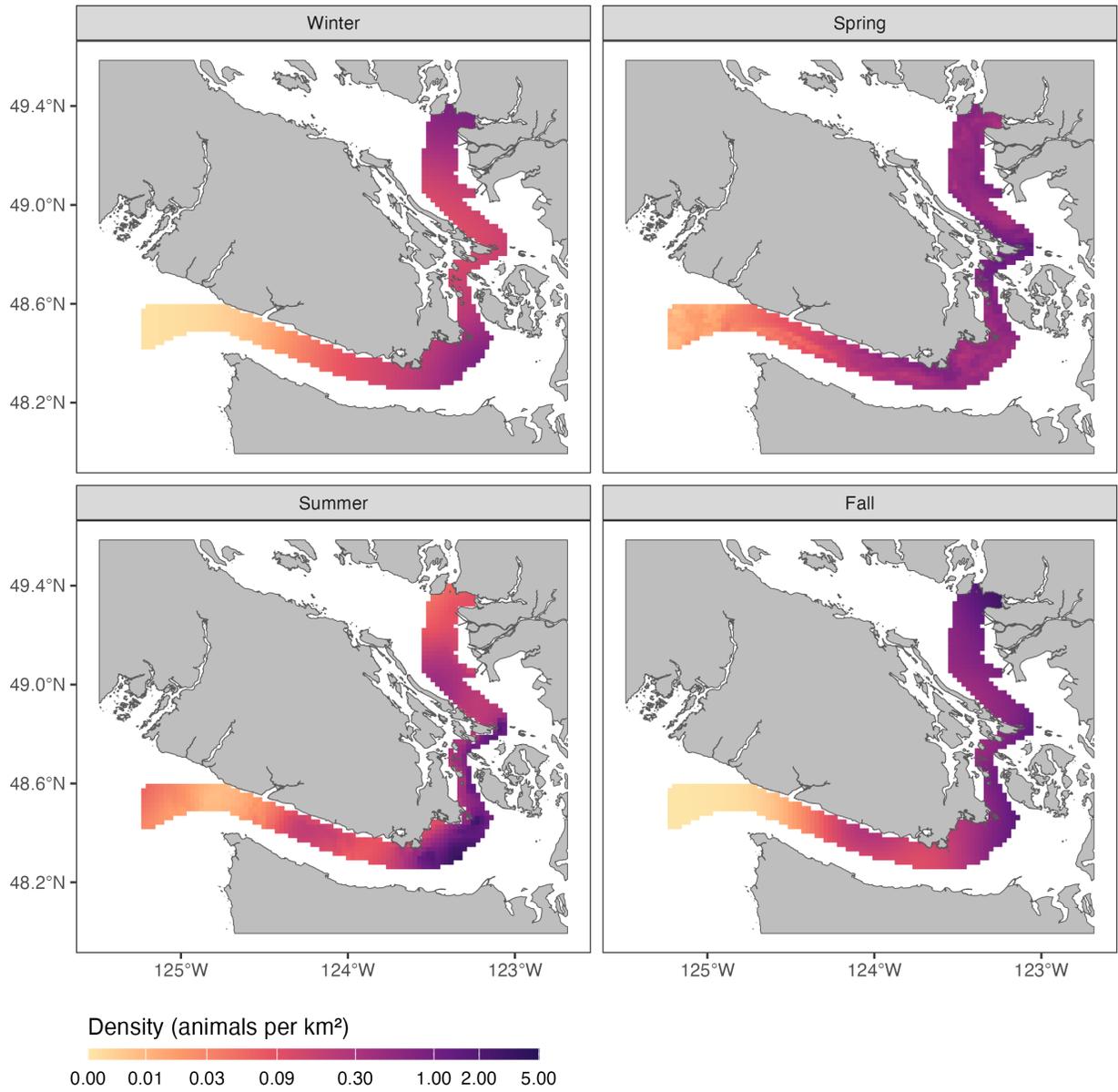


Figure 3. Predicted harbour porpoise density (animals per km²) during each season. Winter: January to through March; Spring: April through June; Summer: July through September; Fall: October through December.

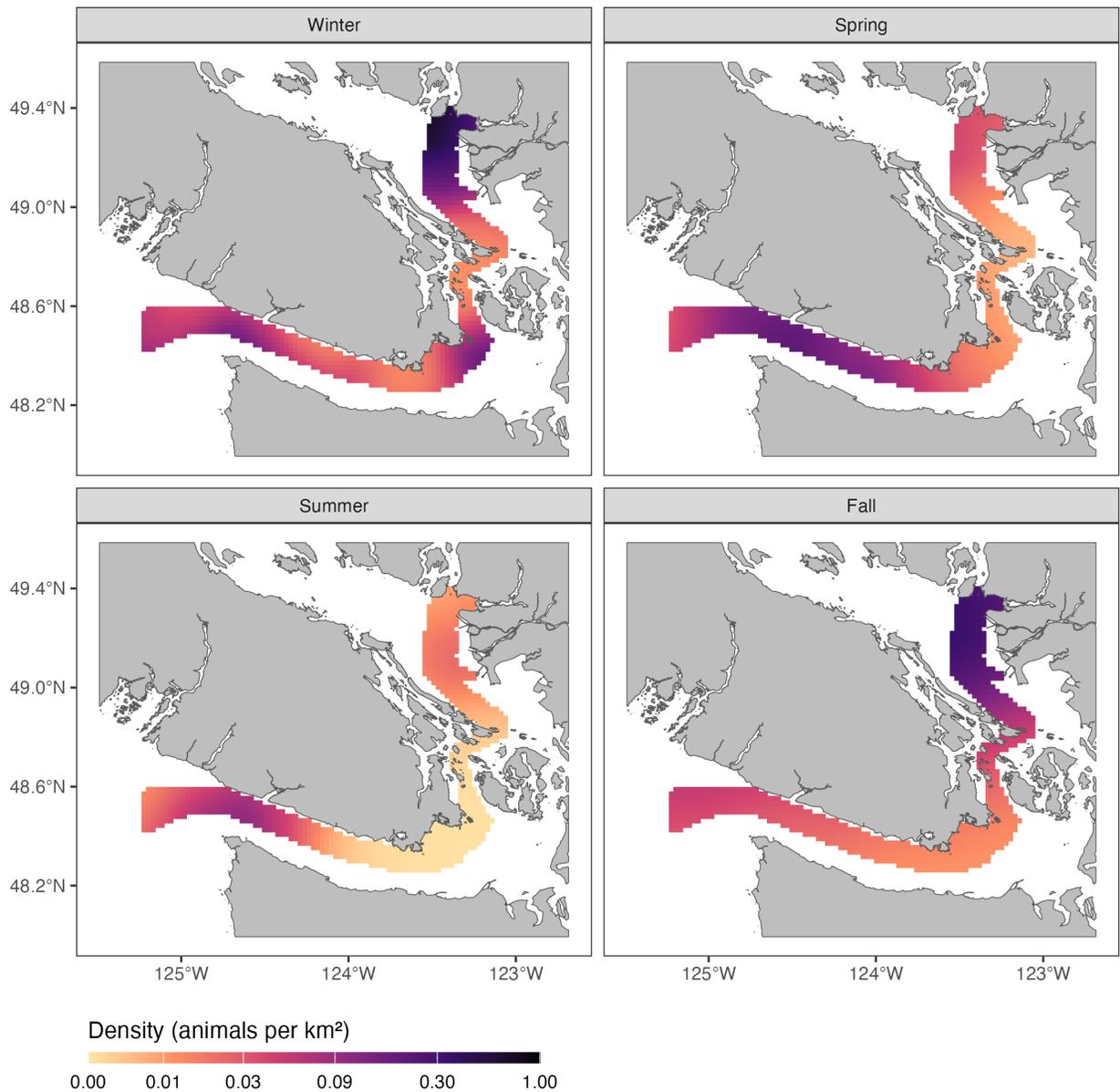


Figure 4. Predicted Dall's porpoise density (animals per km²) during each season. Winter: January to through March; Spring: April through June; Summer: July through September; Fall: October through December.

Sources of Uncertainty

Distance sampling techniques assume that all animals on the survey trackline are detected. Violations of this assumption occur when observers miss animals that are underwater (availability bias) or miss animals close to the trackline even when they are available at the surface (perception bias). Both biases can result in an underestimation of true abundance. The magnitude of these biases is expected to be low due to the short dive times of the species in the area, the slow speed of the survey platform, and the experience of the survey team. However, the validity of the modelled density patterns could be affected if these biases vary in space and

time (e.g., if detectability differs in certain seasons or areas due to variability in diving behaviour or effects of weather conditions that could not be accounted for in the models). In particular, harbour porpoises are likely harder to detect in the more exposed and often rough waters of Swiftsure Bank than in more sheltered waters of the inner Salish Sea, due to their small size and low profile.

In many cases, the best-fitting spatial models were not improved by the inclusion of any environmental variables (i.e., predicted density was based on effort-corrected spatial data only). This suggests that some of the environmental predictors being considered were not appropriate proxies for the actual mechanisms underlying habitat selection by cetaceans within the study area. Although the goal of this study was not to explain the function of preferred habitat, the lack of strong inferred environmental relationships precludes extrapolation of observed patterns outside of the surveyed area or under changing future conditions.

Despite considerable seasonal survey effort over multiple years, the natural variability in the distribution patterns of cetaceans creates some uncertainty around the density estimates, especially in areas or seasons with lower effort or challenging weather conditions. Therefore, this variability was quantified, and maps of uncertainty were created (to be published in the associated Research Document) to inform users about the precision of density estimates and to identify gaps in space and time where additional effort could increase confidence.

Future work

Additional data collection and analyses are underway to produce spatio-temporal predictions of vessel strike risk to cetaceans in the TMX project area. The density layers from the current analysis will be combined with information from data-logging tags and additional boat-based survey efforts to address some of the sources of uncertainty identified herein. Specifically, these data will: 1) provide additional insight into habitat use of cetaceans, particularly in areas where more challenging weather conditions have contributed to higher uncertainty in density estimates; 2) allow incorporation of behavioural factors, specifically humpback whale dive behaviour, into the vessel strike risk analysis; and 3) potentially allow for inclusion of additional areas (e.g., the U.S. portions of the southern Salish Sea and Swiftsure Bank) and species (e.g., killer whales) into the vessel strike risk assessment.

CONCLUSIONS

The results of this study provide temporally and spatially-varying density estimates for humpback whales, harbour porpoises, and Dall's porpoises with the objective of informing effective management of anthropogenic activities in and around the shipping lanes between Swiftsure Bank and Vancouver. The seasonal shifts in distribution of all three species underscore the importance of repeated, year-round monitoring to quantify their density patterns and inform threat mitigation.

OTHER CONSIDERATIONS

Other cetacean species (fin whales, grey whales, multiple killer whale populations) were also documented in the survey area, but there were not enough sightings to estimate their densities. The low number of detections during survey efforts does not necessarily reflect a lack of importance of the area to these species, and may instead result from the limitations of distance sampling as an approach for studying small populations or cryptic species. Systematic surveys are not the only method available to assess the use of an area by a species or whether it will be impacted by increases in shipping traffic. For instance, other sources of information and science

advice are available for Southern Resident killer whales and grey whales (e.g., Darling et al. 1998, Thornton et al. 2022).

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SOURCES OF INFORMATION

- Best, B.D., Fox, C.H., Williams, R.W., Halpin, P.N. and Paquet, P.C. 2015. [Updated marine mammal distribution and abundance estimates in British Columbia](#). J. Cetacean Res. Manage. 15: 9-26.
- Darling, J.D., Keogh, K.E., and Steeves, T.E. 1998. [Gray whale \(*Eschrichtius robustus*\) habitat utilization and prey species off Vancouver Island, B.C.](#) Mar. Mam. Sci. 14: 692-720.
- Hauser, D.D.w., Logsdon, M.G., Holmes, E.E., VanBlaricom, G.R., and Osborne, R.W. 2007. [Summer distribution patterns of southern resident killer whales *Orcinus orca*: core areas and spatial segregation of social groups](#). Mar. Ecol.-Prog. Ser. 351: 301-310.
- National Energy Board. 2019. [Reconsideration Report - Trans Mountain Pipeline ULC - MH-052-2018](#).
- Nichol, L.M., Wright, B.M., O'Hara, P., and Ford, J.K.B. 2017. [Assessing the risk of lethal ship strikes to humpback \(*Megaptera novaeangliae*\) and fin \(*Balaenoptera physalus*\) whales off the west coast of Vancouver Island, Canada](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2017/007. vii + 33 p
- Olson, J.K., Wood, J., Osborne, R.W., Barrett-Lennard, L., and Larson, S. 2018. [Sightings of southern resident killer whales in the Salish Sea 1976–2014: the importance of a long-term opportunistic dataset](#). Endang Species Res 37:105-118
- Thornton, S.J., Toews, S., Stredulinsky, E., Gavrilchuk, K., Konrad, C., Burnham, R., Noren, D. P., Holt, M.M., and Vagle, S. 2022. [Southern Resident Killer Whale \(*Orcinus orca*\) summer distribution and habitat use in the southern Salish Sea and the Swiftsure Bank area \(2009 to 2020\)](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2022/037. v + 56 p.
- Wright, B.M., Nichol, L.M., Doniol-Valcroze, T. 2021. [Spatial density models of cetaceans in the Canadian Pacific estimated from 2018 ship-based surveys](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2021/049. viii + 46 p. (Erratum: March 2022).

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