Exploring the issue of cumulative shipping impacts in the Salish Sea though a systematic focal species assessment framework

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ABSTRACT

The cumulative impacts of shipping on the Salish Sea ecosystem have been an issue of concern in recent years, exacerbated by a number of project proposals that could substantially increase the already high levels of ship traffic. Potential threats from ship traffic include chronic and catastrophic oil spills, acoustic and physical disturbance, ship strikes, and wake wave disturbance. These primarily incremental and cumulative impacts are going largely unheeded by project-level cumulative effects assessments (CEAs), which are poorly-placed to address cumulative impacts. Determining which indicator or focal species to evaluate impacts against is a key part of environmental assessments, particularly CEAs, however there is a need to improve how species are selected. This project explores the need for a regional assessment of the cumulative effects of shipping in the Salish Sea, as well as the need to ensure proper selection and evaluation of species used in such assessments. A systematic focal species assessment framework is tested in this context, by evaluating 94 marine species that are at-risk, ecologically important, and/or culturally important against the framework. The results provide a suite of potential focal species that could be assessed in a regional cumulative effects assessment of shipping in the Salish Sea, as well as recommendations for furthering the focal species tool. Recommendations for addressing the issue of cumulative shipping effects in the Salish Sea are provided based on the broad issues explored within this research as well as specifically the results of the assessment and the test of the framework.

Keywords: *Salish Sea, cumulative effects, environmental assessment, shipping, focal species, indicator species*

ABBREVIATIONS

CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Agency
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada (Department of Fisheries and Oceans)
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
ESA	Endangered Species Act
ESU	Ecologically Significant Unit
EVOS	Exon Valdez Oil Spill
IA	Impact Assessment
MPA	Marine Protected Area
NEB	National Energy Board
NOAA	National Oceanic and Atmospheric Association
NRKW	Northern Resident Killer Whale population
REA	Regional Environmental Assessment
R-SEA	Regional Strategic Environmental Assessment
SARA	Species At Risk Act
SRKW	Southern Resident Killer Whale population
US EPA	United States Environmental Protection Agency
VEC	Valued Ecosystem Component
WDFW	Washington Department of Fish and Wildlife

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INTRODUCTION & BACKGROUND

THE SALISH SEA

Straddling the border between Canada and the United States on the Pacific Northwest coast, three interconnected waterbodies — the Strait of Georgia, Puget Sound, and Juan de Fuca Strait — collectively form an inland sea known as the Salish Sea (Figure 1). The region is composed of island archipelagos and high relief underwater topography that forms deep and narrow channels; it is subject to intense mixing from strong currents and upwellings; and it is intricately connected to the larger Salish Sea watershed — and the surrounding productive coastal temperature rainforest — via an extensive estuarine system. As a result of this complexity the Salish Sea is known as one of the most ecologically rich regions in the world, supporting over 3500 marine species. As a highly populated area (currently at 7-8 million people live in the region) and a heavily used waterway, the Salish Sea is also subject to an array of anthropogenic impacts; indeed, Parks Canada considers the Strait of Georgia "the most at-risk natural environment in Canada" (DFO, 2007). Concerns over anthropogenic impacts have marked the Salish Sea as a key area of conservation concern: Parks Canada has a National Marine Conservation Area proposed for the Strait of Georgia, and in 2005 the tri-national Baja California to the Bering Sea initiative identified the Salish Sea (then called the 'Puget Sound/Georgia Basin Region') as a priority conservation area (Tsao, Morgan, & Maxwell, 2005).

As it spans the Canada-US border, the region is also a complex network of overlapping and interconnected jurisdictions between the two federal governments, the Province of British Columbia, the State of Washington, Coast Salish Indigenous governments, and local municipal governments. Despite these jurisdictional divisions, the name 'Salish Sea' speaks to the need to treat the region as a single entity. Drawing on the rich and long history of the Coast Salish peoples who have long inhabited the region, and officially adopted in 2009, the name was born out of marine biologist Bert Webber's desire to have the three connected bodies of water viewed as a single regional sea in order to address growing cross-boundary environmental issues.

Figure 1. Map of the Salish Sea & Surrounding Basin. Copyright Stefan Freelan, WWU, 2009. Image from https://www.epa.gov/salish-sea.

While the numerous jurisdictions complicate attempts at maintaining a regional perspective on the trajectory of resource use and development in the Salish Sea, the idea of managing it as a regional sea has gained traction in recent years; for example, a 2000 Joint Statement of Understanding between the United States Environmental Protection Agency (EPA) and Environment and Climate Change Canada (ECCC) established the Health of the Salish Sea Ecosystem Report and an annual Salish Sea Ecosystem Conference (US EPA & ECCC, 2017). Yet the growing population in the region and increased development on both sides of the Canada-US border are having a number of adverse impacts on the region's high ecological diversity. Indeed, in a 2008 global assessment of cumulative human impacts on marine ecosystems the Salish Sea was found to be among the regions most heavily impacted by anthropogenic drivers; notably it also contains rocky reefs and seagrass beds, which were identified as two of the most impacted ecosystems (Halpern et al., 2008). Of the ten broad-scale ecosystem quality measurements tracked by the EPA-ECCC Health of the Salish Sea Ecosystem Reports, half continue to deteriorate, including marine species at risk, the endangered southern resident killer whale (SRKW) population, Chinook salmon, and marine water quality (US EPA & ECCC, 2017). These and other declines in ecological integrity have been linked to a variety of adverse anthropogenic stressors, including but not limited to habitat loss from development (both industrial and otherwise), overfishing, climate change, and pollution (Halpern et al., 2008; US EPA & ECCC, 2017); commercial shipping has been identified as one sector that contributes such adverse impacts (e.g. Erbe et al., 2012; Gaydos et al., 2015; Bain et al., 2017).

SHIPPING IN THE SALISH SEA: Current state & proposed increases

Increasing commercial ship traffic[1] in the region has been an issue of particular concern in recent years, due to a number of project proposals that add substantially to the already high levels of ship traffic in the region, including the high profile and contentious Kinder Morgan Trans Mountain Pipeline Expansion (Trans Mountain). As of late 2016 there were 20 new, recently approved, or proposed projects within the Salish Sea, which would

[1] Ship traffic that carries commercial goods; other vessel traffic such as military, research, passenger ferries, and recreational boats are not included in the scope of this paper.

in total increase the number of large commercial vessels transiting the region annually by 37% if all are approved — an increase of more than 4000 ships per year, from 11,580 per year in 2015 (Friends of the San Juans, 2016). These additional vessels will mostly carry coal, oil products, liquefied natural gas, and other cargo, while a relatively small number will be cruise ships (Friends of the San Juans, 2016). The Trans Mountain project alone will add an additional 780 oil tanker transits per year, increasing the number calling at its terminal per month from 5 to approximately 34. Another development, the Roberts Bank Terminal 2 project (Roberts Bank) will add an additional 260 container ships per year.

Concerns have been raised by scientists, environmental groups, and First Nations about the impact of the current and proposed levels of shipping on the region's marine environment. Shipping poses a number of ecological threats, including increased risk of catastrophic and chronic oil spills (van Dorp & Merrick, 2014), chronic acoustic and physical disturbance (e.g. Erbe et al., 2012; Codarin et al., 2009), increased risk of ship strikes on cetaceans (e.g. Williams & O'Hara, 2010), and shoreline disturbance from waves generated by ship wake (e.g. Parnell & Kofoed-Hansen, 2001). Notably, the current level of impact from vessel traffic in the region — both shipping and non-shipping — is already a substantial concern in some regards: for example, a recent open letter from twenty marine scientists to federal ministers called for the federal government to take action to reduce "the already excessive levels of underwater noise pollution in the Salish Sea" in order to facilitate the recovery of the critically endangered southern resident killer whale population (Bain et al., 2017). Oil spills, physical and acoustic disturbance, ship strikes, and wake waves have been identified as the key threats of concern posed by ship traffic in the Salish Sea[2] (National Energy Board, 2016; P. Paquet & C. Fox, personal communication). A brief summary of each of these threats is provided below.

[2] Even within just the shipping industry there are a number of impacts to be considered when examining cumulative effects. This report is limited to some of the main threats posed by the transit of ships through the Salish Sea, however it should be noted that the increase in shipping goes hand-in-hand with port expansions, which have their own associated environmental impacts including loss of shoreline habitat. Two other threats from ship traffic that have been discussed in relation to the Trans Mountain project are not explicitly explored in this report; these are the impacts of ship lights on marine birds, and the impact of emissions on marine mammals (BC Nature & Nature Canada, 2014; C. Fox, personal communication).

Chronic acoustic disturbance

The level of chronic anthropogenic noise in the underwater marine environment has increased substantially in the Pacific Northwest in recent decades (e.g. McDonald et al., 2006; Slabbekoorn et al., 2010) — in some low frequency ranges this increase has been identified as up to 10-12 decibels since the 1960s (Andrew et al., 2002; McDonald et al., 2006). The Salish Sea has been identified as an area with particularly high levels of chronic acoustic disturbance: a 2012 study of the region's acoustic environment found that a large portion of the Salish Sea exceeds the "good conservation status" chronic noise level limits set by the EU Marine Strategy Framework Directive[3] (Erbe et al., 2012). While the noise level is the cumulative result of all vessels transiting the waterway as well as other sources, noise from commercial shipping has been identified as a key contributing factor (e.g. Andrew et al., 2002; McDonald et al., 2006; Erbe et al., 2012; Williams et al., 2014). Chronic underwater noise pollution can have long-term population-level impacts on marine animals that rely on noise for vital processes like communication and predation (e.g. Slabbekoorn et al., 2010; Williams et al., 2014). Notably, at this point most academic and management interest in the impacts of chronic acoustic disturbance has been focused on marine mammals, though there is recent interest in the impacts on fish (e.g. Slabbekoorn et al., 2010; Peng et al., 2015). In the Salish Sea the southern resident killer whale population has become a flagship species for discussions surrounding the impacts of vessel noise.

Physical disturbance

Species that are sensitive to physical disturbance or that are found within shipping corridors may be also be physically displaced or show behavioural changes in response to ship traffic. For example, birds respond to ship traffic by flushing at varying distances from traffic (BC Nature & Nature Canada, 2014). Such physical disturbance may cause increase in energy use, displacement from key habitats, or physiological stress (e.g. Williams et al., 2006; Williams et al., 2009; COSEWIC, 2008b).

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[3] The EU strategy was chosen for the study because Canada has not set a chronic noise limit or threshold, even though sound has been identified as a key element of critical habitat for some at-risk species (Erbe et al., 2012).

Oil spills

Large catastrophic oil spills can cause significant immediate damage to marine ecosystems. For instance, floating oil from the immediate aftermath of the Exxon Valdez Oil Spill (EVOS) killed an estimated 100,000 to 300,000 marine birds from 90 species (Piatt et al., 1990), as well as thousands of marine mammals (cetaceans and pinnipeds), and countless invertebrates and algae on oiled shorelines[4] (Peterson et al., 2003). Furthermore, oil from EVOS has persisted in subsurface sediment in the ecosystem, resulting in chronic oil exposure to species associated with these sediments for foraging or egg laying; this has had long-term impacts on populations of fish (including herring and salmon), sea otters, and seabirds, and has had a number of substantial long-term indirect effects on species as varied as rockweed and killer whales (Peterson et al., 2003). Chronic exposure to smaller amounts of oil (e.g. chronic oil spills smaller than 1000L), can also have a significant impact on marine life: the magnitude of their ecological impacts in the marine environment may be similar or greater than that of catastrophic spills, and they are a particular concern for marine birds (e.g. Burger, 1993; Wiese & Robertson, 2004; BC Nature & Nature Canada, 2016 and sources therein).

Ship strikes

Ship strikes are a key threat to multiple large whale species found along the west coast of North America, as important feeding grounds and migratory routes often coincide with shipping lanes (DFO 2016b). While all types and sizes of vessels may hit whales, ships over 80 m long and/or travelling at or faster than 14 knots cause the worst or most lethal injuries (Laist et al., 2001). Grey, humpback, fin, minke, and killer whales may be vulnerable to ship strikes within the inland waters of Salish Sea (Douglas et al., 2008, Williams & O'Hara, 2010), and ship strikes appear to be a particular threat to fin, grey, and humpback whales (Douglas et al., 2008; DFO 2016b). The number of known fatalities from ship strikes is relatively low, however the frequency of fatalities is under

[4] Note that while such spills are relatively rare and are not routine shipping effects, they are included in the scope of effects considered here due to the potential for significant immediate population-level adverse impacts, as well as the potential for them to lead to chronic exposure through oil persistence in the ecosystem (e.g. Peterson et al., 2003), as discussed above. In addition, an increase in traffic can lead to an increased risk of such spills (van Dorp & Merrick, 2014).

reported as often strikes go unnoticed and whale carcasses sink before drifting to shore (Douglas et al., 2008; Williams & O'Hara, 2010). The increased ship traffic in the Salish Sea is expected to increase the risk of ship strikes (Williams & O'Hara, 2010); furthermore, as populations recover from historic whaling they may begin to return to historic feeding grounds within the Salish Sea (as has been observed in grey and humpback whales in recent years), further increasing the risk of collisions with large ships (Douglas et al., 2008).

Wake waves

Wake waves produced by vessels of all types have the potential to impact shoreline environments over the long-term by altering processes such as erosion and sediment transport (e.g. Castillo et al., 2000; Parnell & Kofoed-Hansen, 2001; Bauer et al., 2002). While wake waves add to the cumulative wave energy hitting shorelines, their interaction with shorelines substantively differs from wind waves (Parnell & Kofoed-Hansen, 2001; Houser, 2010). Wake waves can increase sediment resuspension, cause shoreline instability, alter beach slope and sediment composition, and damage vegetation (e.g. Asplund & Cook, 1997; Castillo et al., 2000; Parnell & Kofoed-Hansen, 2001). As these properties inform shoreline ecology both above and below water, the introduction of or increase in wake waves has the potential to alter species composition in shoreline habitats (Parnell & Kofoed-Hansen, 2001). The impacts of vessel wake waves are expected to be more substantial on more protected shorelines and in narrower and shallower channels where wake energy has less space to dissipate (e.g. Parnell & Kofoed-Hansen, 2001, Bilkovic et al., 2017). Management attention to this issue is largely focused on the wake wave impacts of higher speed passenger ferries, which when introduced resulted in "new and significant adverse effects" on shorelines (Parnell et al., 2007); while commercial ships may have lesser impacts than passenger ferries, the potential for such impact is considered here because of the site-specific and cumulative nature of wake wave effects.

Cumulative nature of shipping impacts

Other than catastrophic oil spills, the impacts from these threats tend to be cumulative in nature: ship traffic from individual projects or activities may not be identified as contributing significant levels of adverse impacts, but in total the incremental impacts from many projects could be substantial, both directly via first-order impacts as well as indirectly (Clark Murray et al., 2014). An example of this is smaller-scale but more frequent chronic oil spills, which are given less attention than large catastrophic spills yet the magnitude of their impact on the marine environment can be similar or greater than that of catastrophic spills (e.g. Burger, 1993; Wiese & Robertson, 2004).

The incremental impacts of shipping provide a sector-specific example of cumulative effects, defined by the Canadian Environmental Assessment Agency (CEAA) as "changes to the environment that are caused by an action in combination with other past, present and future human actions" (CEAA, 2016a). This refers specifically to single-project assessments; the definition provided by the Canadian Council of Ministers of the Environment (CCME) — "change in the environment caused by multiple interactions among human activities and natural processes that accumulate across space and time" (CCME, 2014) — takes a more regional perspective. In general, cumulative effects are the result of multiple activities in a region producing multiple stressors, which directly and indirectly impact various interconnected aspects of an ecosystem (Clark Murray et al., 2014). Individually these impacts may appear insignificant, but when viewed cumulatively they can substantially degrade an ecosystem.

Currently the cumulative effects of increased ship traffic from development projects are only assessed on a project-by-project basis as a relatively small component of a project's environmental impact assessment, and led by the project proponent. There are number of issues with this approach which are further discussed below, and which mean that throughout Canada as well as elsewhere, project-level cumulative effects assessments by and large tend to be ineffective and of poor quality (e.g. Baxter et al., 2001; Duinker & Greig, 2006). Furthermore, in the Salish Sea project-related shipping appears to be viewed by project proponents as a somewhat tangential concern given that shipping regulations and mitigation are largely outside the proponents' jurisdictional power (Port Metro Vancouver, 2015; National Energy Board, 2016). As a result, the cumulative adverse impacts of shipping in the Salish Sea may not be adequately addressed, even though development projects that increase shipping continue to be proposed and approved.

CUMLATIVE EFFECTS ASSESSMENTS

Cumulative Effects Assessment (CEA) has been a part of environmental assessment (EA) practice in both Canada and internationally for decades, and as of 1995 it became a mandatory part of environmental assessments under the Canadian Environmental Assessment Act, yet there is broad agreement in the impact assessment literature that current CEA practice in Canada is largely ineffective (e.g. Baxter et al., 2001; Duinker & Greig, 2006; Harriman & Noble, 2008; CCME, 2009; Olagunju & Gunn, 2015; Sinclair et al., 2016). In an evaluation of CEA in Canada, Duinker and Greig state that "the promise and the practice of CEA are so far apart that continuing the kinds and qualities of CEA currently undertaken in Canada is doing more damage than good" (2006, p. 153). A number of reasons have been cited for this failure, however looming large among these issues are that cumulative effects in Canada are largely only assessed within the context of project EAs — yet by their nature project EAs are inherently not well suited to addressing cumulative impacts (Duinker & Greig, 2006). A few of the key reasons for this are examined here.

Characterization of project effects

When assessing cumulative effects project proponents are required to accurately characterize the effects of their own project, those of ongoing and reasonably foreseeable projects, and how the effects of all the projects may interact. Duinker and Greig note that this is may be difficult for proponents to do adequately, since "even if plans exist or are well underway for some future projects . . . they may be poorly specified with respect to implementation details, or, if specified to some degree, kept confidential by the plan owners" (2006, p. 155). Even without these barriers, it is unrealistic and unreasonable to ask project proponents to account for impacts outside the scope of their own project; for instance, to do so adequately within the Salish Sea would require proponents to undertake a scoping exercise to identify which of a myriad of ongoing and potential development projects on both sides of the border would have impacts likely to interact with their own.

Setting baseline conditions

Adequate assessment of cumulative effects should also require establishing a baseline of environmental conditions against which to compare current and potential impacts (Gunn & Noble, 2009a; Clarke Murray et al., 2014; Expert Panel, 2017). However, the baseline used for project-level assessments tends to be conditions prior to that particular project, which means that this baseline is continuously re-set with each new project (Clarke Murray et al., 2014). This results in 'shifting baselines' whereby any change that occurs gets measured against an already degraded ecosystem, and so incremental changes (such as those that result from cumulative effects) may not be detected (Pauly, 1995). This issue is further exacerbated in a region such as the Salish Sea that has a history of heavy use and subsequent ecosystem degradation (e.g. Bain et al., 2017; US EPA & ECCC, 2017). For example, in their independent assessment of Trans Mountain the Tsleil-Waututh Nation described the historical abundance of marine resources in their territory in the Salish Sea, noting that increased urban, commercial, and industrial development throughout the 20th century gradually decreased their ability to use the region's resources. In particular, they note that, "by 1972, cumulative effects [from development] had exceeded what is allowable under Tsleil-Waututh law as indicated by the devastation of [their] subsistence economy" (Tsleil-Waututh Nation, 2015, p. 3).

Separation of project and cumulative effects

Cumulative effects are by and large not assessed separately from project-specific impacts, and instead are only analysed within the context of project-specific impacts: project-level impacts are identified, and then the cumulative effects of those impacts are assessed (Baxter et al., 2001; Sinclair et al., 2016). This is a concern when on their own individual projects often contribute relatively small and insignificant impacts to each VEC (Duinker & Greig, 2006). This was illustrated in a review of 12 project-level cumulative effects assessments in Canada, which noted that in many cases "project impacts were determined to be insignificant and, based on that, it appeared that the cumulative effects were left unexamined" (Baxter et al., 2001, p. 225). Even when cumulative effects are examined, they may only be based on the impacts of a project that were found to be significant, meaning the smaller impacts that may be considered negligible and which incrementally add up between projects slip through the cracks (Baxter et al., 2001; Duinker & Greig, 2006). In addition, cumulative effects may be assessed within a geographical scope set in the context of project level impacts rather than a larger region, meaning that impacts from other projects outside the boundary are not accounted for (Baxter et al., 2001; Clarke Murray et al., 2014).

Project approval

A final issue is that in practice environmental assessments can be more about gaining project approval rather than ensuring environmental protection (Duinker & Greig, 2006; Sinclair et al., 2016). Whether intentional or not, because cumulative effects are difficult to characterize adequately and because projects may face tight timelines or monetary constraints, efforts towards addressing cumulative effects may be minimized in the attempt to get a project approved (Duinker & Greig, 2006).

While there are a number of other issues associated with current CEA practice in Canada (e.g. see Duinker & Greig, 2006 and Sinclair et al., 2016 for more detailed examinations), the above issues provide context for why cumulative effects cannot be adequately captured by project-level environmental assessments. Examples of these issues are evident in the environmental assessments for the marine shipping components of Trans Mountain and Roberts Bank. Throughout both there are multiple instances where project-related impacts were stated as 'insignificant' or 'negligible/low' and therefore adverse cumulative effects from current and future shipping were either listed as not expected, or cumulative effects were not even assessed (Port Metro Vancouver, 2015; National Energy Board, 2016). The Trans Mountain assessment reasoned on multiple occasions that cumulative effects were not significant because species that were potentially impacted by an incremental sub-lethal stressor were already adapted to the current levels of shipping, and that the project's additional shipping would not significantly add to the stressor (National Energy Board, 2016). Furthermore, neither assessment fully considered the impacts of other projects when assessing cumulative effects: in instances where project-level impacts are described as potentially adverse, the interaction of these effects with the incremental impacts of multiple ships from current and future shipping were not acknowledged (Port Metro Vancouver, 2015; National Energy Board, 2016). This failure to acknowledge the additional impacts of other shipping-related projects runs counter to the purpose of cumulative effects assessment.

REGIONAL CUMULATIVE EFFECTS ASSESSMENTS

In recent years environmental assessment practitioners and academics in Canada have advocated for switching to a system whereby cumulative effects take the central focus in more regional assessments, variously termed regional environmental assessments (REAs), strategic environmental assessments (SEAs), and regional strategic environmental assessments (R-SEAs) (e.g. CCME, 2009; Gunn & Noble, 2009b; Sinclair et al., 2016). These assessment types are given various meanings in different sources; however the definitions applied by a recent federal environmental assessment review are likely to be the most relevant to EA processes in Canada going forward: REA is focused on assessing baseline conditions and cumulative effects of existing and proposed regional development and activities, while SEA is focused on evaluating the effects of existing and proposed government plans, policies, and programs on a regional or national scale (Expert Panel, 2017).[5] Such regional EAs go beyond individual projects to take a regional, planning-based approach to past, current, and future environmental assessments of human development and activities. They are regarded as the most effective way to address the issues that have prevailed in cumulative effects assessments under the largely project-level focus of Canadian EAs (e.g. Duinker &Greig, 2006; Noble, 2008; CCME, 2009; Gunn & Noble, 2009a; Murray et al., 2014; Sinclair et al., 2016). Regional EAs are better placed to assess cumulative effects for a number of reasons; two key reasons are highlighted here.

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[5] There seems to be a lack of consistency and clarity in the terminology used to describe environmental assessments beyond the basic project EA. SEA and REA are used differently in different publications, while the Canadian Council of Ministers of the Environment advocates for combining the two into R-SEA (CCME, 2009). While these distinctions have purpose, and different circumstances may be better suited to one type of assessment over the other, they all have two major points of commonality: 1) they take a regional, planning-based approach to environmental assessment of human development and activities, and 2) they include cumulative effects assessment as a central feature. Furthermore 'impact assessment' is used when factors beyond environmental are included in assessments; 'regional environmental assessment' (regional EA) therefore becomes a component of regional impact assessment (regional IA), and the same for strategic (Expert Panel, 2017). For clarity, this document will mostly use regional EA and strategic EA.

Alternative scenarios

First, REAs provide a future-focused assessment of alternative scenarios. Rather than just determining the impacts of past and present human activities, the regional approach also considers the impacts of reasonably foreseeable development and potential future trends, thus allowing proactive decisions to be made based on what the region could look like in the future under multiple different scenarios. For instance, Noble (2008) recommends REAs consider a minimum of three scenarios: retaining the status quo (no new development), increased conservation, and enhanced development. Considering a range of different scenarios for balancing development and conservation within a region is regarded as a central feature of effective cumulative effects assessments (e.g. Duinker & Greig, 2006; Noble, 2008; CCME 2009; Gunn & Noble, 2009b; Clogg et al., 2017).

Regional vision

Second, the REA process provides a platform for decision-makers and other involved parties to establish a regional vision. The CCME (2014) states that "cumulative effects management is driven by defined outcomes or objectives for the desired quality or state of air, water, land, and biodiversity now and in the future." Setting these objectives requires a regional vision to bring focus to the ecological issues and trends that are significant on a regional rather project scale, and to develop thresholds for development and impacts in the region (Duinker & Greig, 2006; Gunn & Noble, 2009b; Clogg et al., 2017). The regional vision then becomes a reference point against which the outcomes of alternative development scenarios may be judged (Gunn & Noble, 2009a; CCME, 2009).

EA Expert Panel Report

The need to address cumulative effects through regional environmental assessments was a key finding in a recent Expert Panel report on Canada's environmental assessment processes. This report, released on April 5th, 2017 and titled *Building Common Ground: A new vision for impact assessment in Canada*, provides guidance for improving and advancing Canada's EA processes based on a review that included input from stakeholders across the country. The panel recommended that a regional impact assessment should be required by legislation where cumulative impacts currently exist or could occur in areas of federal jurisdiction (i.e. on federal lands or marine areas) (Expert Panel, 2017). This is based on the panel's recognition that "while project-specific assessments have an important role to play to ensure new activities contribute to sustainability, many sustainability questions cannot be properly assessed at the scale of project IA [Impact Assessment]" (Expert Panel, 2017, p. 6). As a marine area that is experiencing high levels of anthropogenic impacts from multiple sources, perhaps nowhere else is the Expert Panel's recommendation better suited or more relevant than the Salish Sea. While an assessment of all anthropogenic impacts would be ideal (and would be most reflective of the purpose of an effective cumulative effects assessment), there is interest among environmental organizations within the region for an assessment of cumulative effects of shipping in particular (Ross Dixon, personal communication).

SCOPING IN ENVIRONMENTAL ASSESSMENTS

Scoping happens early on in the environmental assessment process and involves determining the geographic region, temporal scale, key impacts or issues, and ecological components against which to assess impacts. Good scoping is widely regarded as a central feature in effective environmental assessments (e.g. EAO, 2013; Bérubé, 2007; Sinclair et al., 2016), yet it tends to be a major point of failure in CEA practice (Baxter et al. 2001, Duinker & Greig 2006). Reasons for this are varied, and include poorly-chosen ecological components (valued ecological components (VECs) and their associated indicators); not expanding the geographic scope of the assessment past the area of direct and substantial project impacts; not adequately considering historical ecological conditions or trends in the assessment; and weak representation of the activities and impacts of other projects in the region (Baxter et al., 2001, Bérubé, 2007, Clark Murray et al., 2014; Olagunju & Gunn, 2015). While some of these scoping issues also occur in Canadian environmental assessments in general, they are inherently exacerbated by the project-level nature of CEA practice (e.g. Duinker & Greig, 2006).

Valued Ecosystem Components

A key aspect of scoping is determining what components of an ecosystem should be used to assess development impacts. These valued ecosystem components (VECs) are commonly defined as "components of the environment (biophysical and human) that are identified as important ecologically, socially, or economically and are the focus of attention in environmental assessment" (CCME, 2014). The concept of using VECs to focus environmental assessments has been central to EA practice in Canada for decades; similar practices exist elsewhere including Europe and the U.K. The use of VECs was developed as an alternative to the previous inefficient and ineffective approach whereby environmental assessment practitioners tried to assess the impacts of development on an entire ecosystem (Beanlands & Duinker, 1983). It was also intended to encourage "a more holistic view of ecological health and integrity" (Olagunju & Gunn, 2015, p. 207). The conditions of VECs are typically measured using indicators, which are also determined during scoping; for biological VECs these could be individual species or populations, depending on the scope of the analysis and the chosen VEC; for more broadly-defined VECs such as 'marine mammals' individual species may be chosen as indicators for that component.

There are trade-offs to this approach: while formerly more of the ecosystem was assessed less effectively, the VEC approach assesses fewer elements but more thoroughly (Olagunju & Gunn, 2015). Since this approach inherently means some ecosystem components must be disregarded, however, choosing the right VECs and indicators for the assessment — those that can be adequately represent the state of an ecosystem's integrity in addition to its vulnerabilities — therefore becomes vital to success of the assessment in properly capturing the past and current states of the ecosystem, as well as trends and potential future trajectories under alternate scenarios. Evaluations of CEA case studies emphasize that proper VEC selection is vital to good scoping, and subsequently is a major determinant of the quality and utility of an assessment (both EA and CEA) (Bérubé, 2007; Olagunju & Gunn, 2015). This is highlighted in best practice guidelines outlined by both the BC Environmental Assessment Office and the Canadian Council of Ministers of the Environment (CCME, 2009; EAO, 2013).

Despite the vital role of VEC selection, research indicates there is a need to improve how they are selected (e.g. Bérubé, 2007; Ball et al., 2013; Olagunju & Gunn, 2015). There is limited guidance in this process, even for the more well-established practice of project environmental assessment, and VEC selection for CEAs is often not well differentiated from those selected for project-level EAs (Olagunju & Gunn, 2015). There is also relatively limited research into how or why VECs are currently selected in practice (Olagunju & Gunn, 2015). A study on VEC selection in Canadian road construction projects found there is a substantial lack of both general and sector-specific guidelines for how to select VECs for CEAs (Olagunju & Gunn, 2015). It also revealed a number of issues and potentially problematic practices in how VECs are chosen: selection may be based on previous projects, specific issues or species, the mandates of stakeholder organizations, or liability issues.[6] Overall the process can be based on subjective values rather than scientific evidence or the context of the project: respondents to the study noted that "the ecosystem approach is being circumvented by just focusing on certain parts of the environment" and that the process involved much "speculation or judgement calls" (Olagunju & Gunn, 2015, p. 210). Other studies have also raised concerns about the limited guidance and the high degree of subjectivity in VEC selection (e.g. Bérubé, 2007; Ball et al., 2012).

Species are also commonly used to assess and monitor ecological integrity in other applications outside of environmental impact assessments (Siddig et al., 2016). For instance, the Puget Sound Partnership and Puget Sound Science Review are working to develop a set of indicators, including species, for monitoring the ecosystem health and recovery of Puget Sound (Kershner et al., 2011; Levin et al., 2011). Species used in these contexts tend to be called focal or indicator species, though it should be noted that there is considerable inconsistency in how these terms are applied (these terms will be discussed in a following section). As with VECs, subjectivity can play a role in choosing focal or indicator species: according to a review of all papers published in the journal *Ecological Indicators*, almost one-fifth of studies did not justify their choice of indicator species, suggesting that subjectivity was likely a factor (Siddig et al., 2016).

[6] For example, since there is a legal requirement to compensate project effects on fish and fish habitat, by choosing that as a VEC "you could consider for example that there will not be any residual effects of the project [on that VEC] because it would have been compensated" (Olagunju & Gunn, 2015, p. 210).

An example of questionable indicator species selection comes from Trans Mountain's assessment of project-related shipping impacts on marine birds. The project proponent failed to include in its assessment some of the more at-risk species commonly found in the Salish Sea that could be highly impacted by oil spills, and apparently put little weight on the provincial, national, or international conservation status of bird species in its selection of indicator species in order to ensure the most at-risk species were assessed (BC Nature & Nature Canada, 2014). This example and others from Trans Mountain will be explored further in the discussion section of this report.

Despite these issues, the use of VECs and their associated indicators appears to be widely accepted as the best way to provide focus to environmental assessments. Indeed, in a framework developed with the input of over 30 EA practitioners and academics and in conjunction with the CCME, centring assessments on VECs is highlighted as a "core methodological principle" for ensuring cumulative effects take priority (Gunn & Noble, 2009a). The authors of the framework provide guidance for adapting VEC selection to a regional scale, noting that an assessment must consider multiple scales of VECs by assessing the types of VECs traditionally used in project EAs, such as species, as well as VECs that can be "broader indicators of regional environmental change or ecosystem sustainability" (Gunn & Noble, 2009a, p. 263). Examples of the latter include biodiversity, ecosystem services, habitat connectivity, and sensitive habitats or areas (Gunn & Noble, 2009a). For the purposes of this project, however, the focus is on selection of species as VECs or VEC indicators.

RESEARCH OBJECTIVES

The broader issue explored in this project is the clear need for a regional assessment of the cumulative effects of shipping in the Salish Sea, and the need to ensure species selected as VECs or VEC indicators are suitable and are properly evaluated. In light of these issues, combined with the importance of VEC/indicator species selection for environmental assessments and the need to address subjectivity in selection, the goal of this project was to explore the impact of cumulative effects of shipping on species in the Salish Sea through 1) identifying key issues with how shipping is addressed in CEA practice in the region and providing potential management solutions, 2) identifying potential focal species that could be included in a regional cumulative effects assessment of shipping, and 3) assessing the utility of a previously-developed systematic qualitative focal species selection framework in this context. This framework was developed by King & Beazley (2005), originally with the purpose of selecting a suite of focal species for marine protected area (MPA) planning in the Scotia-Fundy region of Atlantic Canada. The results of the assessment are considered within the context of the Trans Mountain and Roberts Bank projects, two of the more high-profile projects that will contribute to the regional increase in shipping. Recommendations for addressing the issue of cumulative shipping effects in the Salish Sea are provided based on the broad issues explored within this research as well as specifically the results of the assessment and the test of the framework.

FOCAL SPECIES ASSESSMENT

INTRODUCTION: The focal species concept

Focal species are those that are thought to be particularly valuable for directing conservation and ecosystem management practices, whether for ecological reasons or socio-cultural (Zacharias & Roff, 2001). While a number of definitions for focal species exist, and various types of focal species have been proposed, King and Beazley note that "focal species have been most consistently described as those that warrant conservation attention because they possess characteristics that identify them as keystone or functionally important, umbrella, indicator, flagship, vulnerable and/or sensitive" (2005. p. 368). These species are thus used as surrogates for the rest of the ecosystem, whereby their conservation confers protection on other elements of the ecosystem or helps uphold ecological integrity. There also appears to be some confusion in the application of the term 'focal species' compared to 'indicator species', with the two sometimes treated interchangeably; for the purpose of this report indicator species will be treated as a type of focal species (in keeping with the practice of King and Beazley (2005) as well as Zacharias and Roff (2001)).

The value of the focal species concept as a whole, as well as the various proposed types of focal species, has been debated and criticized for a number of reasons. The main critiques are centred on the lack of agreement and clarity in how the various types of focal species are defined, the lack of standards for their application in management, the legitimacy of the ecological theory behind using such surrogate species to confer wider protection, and the scientific rationale (including lack of data to guide selection) for their use in management decisions (Simberloff, 1998; Lindenmayer et al., 2002; Zacharias & Roff, 2001). Regardless of such critiques, some of the key focal species types — keystone, umbrella, indicator, and flagship — have been repeatedly reviewed over the years and are still thought to be valuable in management and conservation (e.g. Power et al., 1996; Simberloff, 1998; Zacharias & Roff, 2001; King & Beazley, 2005; Mittelbach, 2012) A notable point stressed by many reviewers is the need to not see focal species as a panacea for conservation, but rather that they are one tool of many that should be applied to conservation-based management (e.g. Simberloff, 1998; Zacharias & Roff, 2001; King & Beazley, 2005).

Explicit application of focal species is more common in terrestrial rather than marine management, though the potential value of focal species to marine conservation has also been raised (e.g. Zacharias & Roff, 2001; King & Beazley, 2005). Additionally, though focal species are seen as those that warrant particular attention in conservation and management practices in general, the focal species approach appears to be more explicitly applied to protected area planning or restoration, rather than to assessing ecological impacts of development projects. While the limitations of the focal species approach must be kept in mind, criticism and debate seems more focused on the former use and may be less relevant to its application in VEC and VEC indicator selection. In particular, the critique of using species to act as surrogates for an ecosystem is less relevant in this context, as this is already accepted as a necessary part of environmental assessment practice as discussed previously (i.e. VECs). Indeed, the focal species approach as defined by King and Beazley is essentially already in use in EA practice, just not in a methodical manner: species may be chosen as VECs or VEC indicators because they are of conservation concern, they are thought to act as proxies for a habitat type or group of similar species, or they are economic or sociocultural importance (e.g. Carignan & Villard, 2002; Olagunju & Gunn, 2015). However, without a systematic method of reviewing all potential focal species, a species may be chosen for one of these reasons out of context and over others that may be more appropriate or that may be more vulnerable to the environmental impacts of a project (project-level assessments) or impacts within a region (e.g. cumulative effects of sector specific impacts of shipping, or of all major anthropogenic impacts).

The focal species framework developed by King and Beazley therefore provides one potential systematic method by which to guide the selection of focal species to act as VECs or VEC indicators for environmental assessments. This framework applies key qualitative characteristics that are commonly used to identify species that play a key ecological role, have particular habitat associations or requirements, are especially vulnerable or sensitive to human disturbance, and/or are culturally or economically important. A key benefit of this framework is that it uses characteristics from multiple focal species types, thus allowing the identification of species that may fulfil multiple focal species roles. In this way, the framework side-steps deciding which focal species type is preferable, an issue which is discussed in reviews of focal species value (e.g. Power et al., 1996; Simberloff, 1998; Zacharias and Roff, 2001). It is also adaptable for different regions, cultural values, and anthropogenic impacts, and once complete it can be adapted for multiple conservation purposes. Furthermore, as it is a ranking system it provides for the identification of a number of focal species, organized by taxa; this is particularly important as the use of focal species as surrogates is believed to be more valuable when multiple species from various taxa and life histories are used (e.g. Roberge & Anglestam, 2004; Siddig et al., 2016). King and Beazley caution that the framework is limited by its qualitative nature, however, and it should be paired with field research and thorough quantitative assessments to identify knowledge and data gaps that may impact a potential species' utility (2005).

While various types of focal species have been proposed and definitions have been debated (e.g. Zacharias & Roff, 2001), by and large those applied by King and Beazley are most relevant for this project. A short summary of each focal species in the context of this project is provided below. Further detail on the varying definitions, critiques, and benefits of focal species type can be found in King and Beazley (2005), Zacharias and Roff (2001), Power et al. (1996) (keystone), Simberloff (1998) (umbrella, flagship, keystone), Roberge and Angelstam (2004) (umbrella), and more.

Keystone (and other functionally important, e.g. dominant, foundation, and ecosystem engineer)

While this term was originally intended to describe species with relatively low abundance or biomass that have a disproportionate effect on the ecosystem (Paine 1969), it has since been adapted to include other species that play key functional roles (Power et al., 1996; Zacharias & Roff 2001). It has also been applied to common species or those that occur at high densities, which are alternatively called 'dominant' or 'foundation'. Definitions aside, the key feature of these species is that their removal will cause substantial change in ecosystem or community structure. This framework therefore groups together "functionally important species that fulfil unique and essential roles within an ecosystem" under the term keystone for ease of discussion (King & Beazley, 2005, p. 369). Two important caveats, particularly for the traditional keystone species, are that the strength and role of a species' functional importance (e.g. 'keystoneness') can vary between ecosystems and regions, and can be difficult to know *a priori* (Power et al., 1996).[7]

Umbrella

These are species that require large areas or that range over large distances, and therefore their conservation is thought to confer protection to co-occurring species with smaller habitat requirements (King & Beazley, 2005; Roberge & Angelstam 2004). As these species may have key habitat associations, such as important migration stopover points or feeding grounds (King & Beazley, 2005), focusing on these habitat associations may be the most valuable aspect of the umbrella species concept in the context of environmental assessments.

Indicator

Definitions of indicator species — and what they are intended to indicate — vary widely, and 'indicator' is sometimes used as a blanket term for other focal species types (Zacharias & Roff, 2001). The most applicable definition to environmental assessments is what Zacharias and Roff (2001) term 'condition indicator', also known as 'bioindicator' and 'sentinel species'. These species are particularly sensitive to ecosystem change or disturbance either through specific or general forms of habitat degradation or management practices, and require relatively high-quality or undisturbed habitat (King & Beazley, 2005). These habitat requirements make such species particularly useful to monitor for adverse anthropogenic impacts.

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[7] For example, in some habitats or regions sea otters have been identified as keystone species and their removal causes kelp forests to transition to urchin barrens; however the strength or existence of this role varies in different context (e.g. Soule et al., 2003).

Vulnerable and sensitive

Vulnerable and sensitive are two similar but differing categories. The first refers to species that are at risk of extinction or extirpation and are therefore vulnerable to regional anthropogenic impacts. Sensitive species may have intrinsic biological or ecological traits that make them particularly sensitive to anthropogenic disturbance or natural stochastic events (details in Table 1), but are not presently at risk of extinction or extirpation (King & Beazley, 2005). These traits may have been a factor in the at-risk state of vulnerable species. For this project a specific vulnerability to shipping impacts is considered.

Flagship

These species are commonly defined as those that are considered charismatic and have public appeal, particularly large vertebrates. This includes those that hold public interest because they are commercially or recreationally harvested. For this project species that are culturally important to the Coast Salish are grouped into this focal species type.

METHODS

Assessment methods were adapted from King and Beazley (2005), in which the authors reviewed qualitative characteristics commonly used in the identification of terrestrial focal species and chose a subset of 20 characteristics to use in the selection of focal species for MPA network design. These 20 characteristics identify species that are vulnerable or sensitive, those that are particularly ecologically important, and those that, when adequately protected, are thought to confer further protection to other species or habitats. For this project the set of 20 characteristics used in King & Beazley was adapted to include the vulnerability of species to the impacts of ship traffic, the importance of species to Coast Salish culture, and to be specific to the Salish Sea region; this resulted in a set of 22 focal species characteristics against which species were assessed (Table 1).

Table 1. Characteristics used in focal species assessment, organized by focal species type

Focal Species Type	Characteristics
Keystone (Functionally important)	• Presence is critical to maintaining community organization and diversity (e.g. identified as having keystone, dominant, and foundation characteristics). • Functionally important predator, prey, plant, link, or modifier (e.g. ecosystem engineer).
Umbrella	• Require large amounts of habitat or several specific habitat types within the Salish Sea. • Established habitat association within the Salish Sea. Species display high fidelity to a specific geographic location (e.g. feeding, foraging, or nesting grounds have been identified), community or habitat type, or ephemeral event (e.g. herring spawn) within the region, or individuals display high site fidelity (e.g. many rockfish have 'home rocks'). In order to uphold an ecosystem-based perspective, species that have an established habitat association within the watershed of the Salish Sea were considered to display this characteristic (e.g. the great blue heron and the marbled murrelet have high nesting site fidelity and their reproductive success is thought to be linked to adequate foraging areas near nest sites).
Sentinel (Indicator)	• Sensitive or vulnerable to other human activities anywhere within the species' range. A species was considered to display this characteristic if an anthropogenic threat not related to shipping was identified expressly for that species (e.g. habitat degradation). While climate change is likely to be a threat to most if not all species, it was only considered a threat if it was explicitly identified as a particular concern for that species. • Presence implies pristine or undisturbed habitat; decline or loss indicates habitat degradation (e.g. condition indicator or sentinel species)
Vulnerable	• Vulnerable to impacts or threats of shipping within the Salish Sea. These threats are specific to traffic, and include chronic and catastrophic oil spills, physical and acoustic disturbance, ship strikes, and shoreline impacts from wake waves. This is the only attribute for which there were two levels of positive response: yes [✓] and maybe [E]. A species was considered to display this characteristic if a threat is identified in the literature as posing a significant risk to the species at the population level. A species was considered to be possibly impacted (E) if there is some preliminary or correlated evidence in the literature that a shipping could potentially pose a substantial threat to a species or group of species (i.e. research gaps exist but there are indications shipping could be a key threat). • Listed as endangered, threatened, or sensitive/of special concern by one or more federal, provincial, or state jurisdiction (BC, Washington State, Canada, United States). • Reduced or declining populations size. This characteristic was considered specifically in the context of the Salish Sea (i.e. an identified population in the region is declining) or at a larger scale (national or global population). In order to take a conservative or precautionary approach, a species was considered to display this characteristic if there are indications that a population is reduced or declining even if this is not officially confirmed.

Sensitive	• Low genetic variation. • Poor dispersal ability. This attribute includes species or regional populations that the literature identifies as having little or no possibility of being impacted by the rescue effect. • Low productivity through low fecundity, recruitment, or survivorship. (Note: this was expanded from King & Beazley's original 'low fecundity' because a species may have high fecundity but low recruitment, ultimately leading to the same issue of actual low reproduction or low reproductive potential) • Dependent on patchy, unpredictable, limited, declining, or threatened resources within the Salish Sea. • Congregate in large groups when present in the Salish Sea (e.g. at staging or feeding grounds during migration). • Long-distance migrations • Long-lived • Large-bodied • Breeds within the Salish Sea. Species that undergo a stage of reproduction and/or raising of young within the Salish Sea watershed, including nesting, spawning, calving, and pupping. This was only applied to fish, birds, mammals, and reptiles — i.e. highly mobile species. • Other. This category is to account for any other trait identified in the literature that makes the Salish Sea especially important to that species, or that makes the species particularly sensitive. For example, if a significant part of the regional or global population congregates in a migratory or wintering area, if a species is particularly late maturing compared to taxonomically similar counterparts (e.g. most rockfish are late maturing, but some are especially so), if a species exhibits very variable recruitment, if the species is endemic to the region, or if the population is not reduced but is naturally small.
Charismatic & Cultural	• Charismatic species • Commercially or recreationally harvested. A species is ranked positive for this characteristic if species was historically harvested but is no longer due to conservation concerns. • High level of significance to the Coast Salish (important economic or subsistence harvest species, culturally or spiritually significant, or historically integral to the Coast Salish way of life)

Source: Modified from King and Beazley (2005).

Selecting species for assessment

A subset of marine-reliant Salish Sea species was compiled from the literature to be assessed against the 22 focal species characteristics[8]. Species, subspecies, or ecologically significant populations (hereafter referred to as species) were included in an initial list to be considered for assessment if they rely substantially on the marine environment of the Salish Sea and meet at least one of the following criteria:

1. Currently listed as a species of concern by one or more of the Province of British Columbia (BC Red or Blue List), the State of Washington (via the Washington Department of Fish and Wildlife (WDFW), the Government of Canada (Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and/or the Species At Risk Act (SARA)), or the Government of the United States (US Endangered Species Act (ESA)).
2. Identified as particularly important or of concern to the Coast Salish indigenous peoples of the region.
3. Identified as particularly ecologically important in the Salish Sea ecosystem.

Federally, provincially, or state listed species of concern were sourced from Zier and Gaydos (2016), which identified all species that use the marine ecosystem, have occurred in the Salish Sea, and are listed or are candidates for listing by one or more jurisdiction. The species listing process differs between these jurisdictions. Two aspects of these processes are especially pertinent to this study. First, during the federal listing process for both Canada and the U.S., 'candidate' status is temporarily given to species that are proposed for listing but have not yet been assessed. The WDFW also keeps a list of candidate species for review, however according to state law marine invertebrates and fish are only permitted candidate status within the state's listing system; candidate status for these species is thus permanent even after review, unless the species is de-listed (Zier

[8] For a complete and comprehensive assessment King & Beazley (2005) recommend compiling a list of all native marine species in the region to assess against selection characteristics. The Salish Sea is home to a current count of over 3,500 species, the majority of which are invertebrates, and such an assessment would require the involvement of several regional experts and broad taxonomic coverage.

& Gaydos, 2016). For the purposes of this project marine invertebrates and fish listed as candidates are therefore included, however candidate species under either federal listing process are not. Second, not all species given an at-risk status (endangered, threatened, or special concern) by COSEWIC are subsequently listed by SARA, as the latter is a political decision made by the Canadian federal government; therefore species identified as endangered, threatened, or of special concern by only COSEWIC are included as well as those listed by SARA.

Jurisdictions may list at-risk subspecies and other ecologically significant units (ESUs, e.g. stocks or populations) individually without listing the species as a whole. For this project subspecies distinctions were retained, while ESU designations were not and only the species was included. The one exception to this was the four killer whale (*Orcinus orca*) populations, which are sufficiently distinct and well-studied to warrant separate assessments.

Coast Salish species were sourced from Gaydos et al. (2015), which identified 50 marine species that are of particular importance or concern to the Coast Salish for cultural, spiritual, economic, subsistence, or historical reasons. Species were identified and prioritized for this list by members of Coast Salish communities as well as scholars of Coast Salish traditional resource use, and the final list was approved by members of the Coast Salish Gathering, which is a cross-border engagement platform for Tribal and First Nations leaders and non-indigenous governing agencies. While the list was limited to 50 species, the authors note that prioritizing species was challenging for participants because "Coast Salish traditions identify all species as important and connected" (Gaydos et al., 2015, p. 3).

A literature search was conducted to identify species that are considered particularly ecologically important, either specifically within the Salish Sea or more broadly in the marine environment of the Pacific Northwest. Species were included if they were identified in the literature as playing a substantial ecological role in the ecosystem or a specific community or habitat. This includes species identified — either explicitly or implied — as exhibiting the characteristics of focal species, including but not limited to keystone, foundation, umbrella, or sentinel species, or ecosystem engineers.

This initial list of vulnerable, culturally important, and/or ecologically important species was reduced to exclude species that are uncommon in the Salish Sea specifically or have a low use of the marine environment in general (i.e. species that use but are not dependent on marine resources) relative to their taxon (e.g. birds, mammals, fish). Birds and mammals were excluded based on the results of an abundance and dependence ranking conducted by Gaydos and Pearson (2011): species ranked with low or medium dependence on the marine environment (dependence on marine or intertidal habitat and marine-derived food were both considered) were excluded, as were those with rare or low abundance in the Salish Sea through the majority of the year (three of four seasons). Birds and mammals with high dependence but low abundance, and those with medium dependence but high abundance, were judged on an individual basis using information from species databases and conservation reports. For example, whether a species is resident or transient in the region was taken into consideration, with resident more likely to be included. The prevalence or abundance of fish and reptile species within the Salish Sea were also checked using species databases and conservation reports, and species that were found to be uncommon, rare, or vagrants to the region were excluded. Species databases and conservation reports consulted include the BC Conservation Data Centre, COSEWIC, NOAA, and WDFW reports, the BC Breeding Bird Atlas, and E-Fauna BC. All invertebrate, seaweed, and seagrass species were retained for assessment. Two non-marine invertebrates, Edward's beach moth (*Anarta edwardsii*) and sand-verbena moth (*Copablepharon fuscum*), were included in assessment due to the key role that intertidal processes (e.g. sediment transport, accretion, and erosion) have on the sensitive sandy dune habitats these species require (COSEWIC, 2003; COSEWIC, 2009a).

Each of the remaining final species was assessed against the set of 22 characteristics using available information from jurisdictional conservation reports, species databases, and other relevant literature. If the species was found to display the characteristic it received a check mark [✓]. As this process is subjective, judgement was used when it was unclear whether a species exhibited a certain characteristic, and where relevant a more precautionary or conservative approach was used (e.g. if there was some evidence for a characteristic but the evidence is not yet conclusive). The number of characteristics displayed by each species were added up and the highest scoring species overall were identified, as were the highest scoring within each taxonomic group of birds, fish, invertebrates, seaweeds and seagrasses[9], mammals, and reptiles. High-scoring species representing a range of focal species types from each major taxonomic group were selected for a suite of candidate focal species.

RESULTS

High scoring species

The final list for assessment consisted of 94 vulnerable, ecologically important, and/or culturally important species, subspecies, or ecologically significant units that depend on the Salish Sea (see Appendix A). This included 32 birds, 29 fish, 13 invertebrates, 11 mammals, 1 reptile, and 8 seaweeds and seagrasses. Species with the highest scores overall were exclusively birds, fish, and mammals, as follows (see Tables 2 and 3):

- Southern and northern resident killer whales (16 and 14 respectively)
- All Pacific salmon (Chinook salmon at 14+, chum, sockeye, coho, coastal cutthroat trout, and steelhead trout at 13+, and pink salmon at 12+)
- Marbled murrelet (12), Pacific herring (12)
- North Pacific spiny dogfish (12)
- Sea otter (12)
- Humpback whale (12)
- Grey whale (12)

Species with the highest scores in their taxonomic group are the marbled murrelet, Chinook salmon, Olympia oyster, the southern resident killer whale population, leatherback sea turtle (by default as the only reptile assessed), and eelgrass (see Tables 2 and 3). The fish, mammals, and birds had the largest number of highly-ranked species, with 10 fish (of 29), 6 mammals (of 11), and 5 birds (of 32) displaying at least half (11) of the assessment characteristics (see Appendix A).

[9] Despite being taxonomically dissimilar, seaweeds and seagrasses were grouped together due to similar function and growth form.

Table 2. Part one of a sample focal species assessment framework, with a selection of species that scored high overall and within each taxonomic group (✓ = species displays characteristic; E = there is some evidence for shipping impacts on that species). Modified from King and Beazley (2005).

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Impacted by other anthropogenic threats	Presence implies pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish species	Listed (federal, provincial, or state)	Reduced or declining population	Low genetic variation
Birds														
Great blue heron	*Ardea herodias fannini*				✓		✓		✓		✓	✓	✓	
Marbled murrelet	*Brachyramphus marmoratus*				✓	✓	✓	✓	✓			✓	✓	
Brant	*Branta bernicla*				✓		✓	✓	✓			✓	✓	
Peregrine falcon (Peale's and Anatum subspecies)	*Falco peregrinus ssp pealei & anatum*				✓	✓	✓		✓	✓		✓	✓	✓
Tufted puffin	*Fratercula cirrhata*					✓	✓	✓	✓	✓		✓	✓	
Black oystercatcher	*Haematopus bachmanii*	✓			✓	✓	✓	✓	✓					
Harlequin duck	*Histrionicus histrionicus*				✓	✓	✓			✓	✓			
Surf scoter	*Melanitta perspicillata*					✓	✓			✓	✓	✓	✓	
Fish														
Pacific herring	*Clupea pallasi*	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	✓	✓	✓	✓	E	✓		✓	✓		✓	✓	
Pink salmon	*Oncorhynchus gorbuscha*	✓	✓	✓	✓	E	✓		✓	✓	✓		✓	
Chum salmon	*Oncorhynchus keta*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓	
Coho salmon	*Oncorhynchus kisutch*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓	
Steelhead trout	*Oncorhynchus mykiss*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓	

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Impacted by other anthropogenic threats	Presence implies pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish species	Listed (federal, provincial, or state)	Reduced or declining population	Low genetic variation
Sockeye salmon	*Oncorhynchus nerka*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓	
Chinook salmon	*Oncorhynchus tshawtscha*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓	
Bocaccio rockfish	*Sebastes paucispinis*				✓	✓	✓			✓		✓	✓	
Yelloweye rockfish	*Sebastes ruberrimus*		✓		✓	E	✓			✓		✓	✓	
North Pacific spiny dogfish	*Squalus suckleyi*		✓	✓			✓			✓		✓		✓
Seaweeds & Seagrasses														
Giant kelp	*Macrocystis pyrifera*	✓	✓			✓	✓			✓			✓	
Bull kelp	*Nereocystis luetkeana*	✓	✓			✓	✓			✓	✓		✓	
Eelgrass	*Zostera marina*	✓	✓		✓	✓	✓	✓			✓		✓	
Invertebrates														
Sand-verbena moth	*Copablepharon fuscum*				✓	E	✓	✓				✓	✓	
Northern (pinto) abalone	*Haliotis kamtschatkana*				✓		✓		✓	✓	✓	✓	✓	
Olympia oyster	*Ostrea conchaphila*		✓		✓	E	✓			✓	✓	✓	✓	
Geoduck clam	*Panopea generosa*					E	✓			✓	✓		✓	
Mammals														
Sea otter (northern)	*Enhydra lutris kenyoni*	✓			✓	✓	✓		✓			✓	✓	✓
Grey whale	*Eschrichtius robustus*			✓	✓	✓	✓		✓		✓	✓	✓	
Steller sea lion	*Eumetopias jubatus*			✓	✓	✓	✓	✓	✓			✓		

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Impacted by other anthropogenic threats	Presence implies pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish species	Listed (federal, provincial, or state)	Reduced or declining population	Low genetic variation
Humpback whale (North Pacific)	*Megaptera novaeangliae*			✓	✓	✓	✓		✓			✓	✓	
Killer whale (SRKW)	*Orcinus orca*			✓	✓	✓	✓		✓		✓	✓	✓	✓
Killer whale (NRKW)	*Orcinus orca*			✓	✓	✓	✓		✓		✓	✓		✓
Killer whale (Transient)	*Orcinus orca*			✓		✓	✓		✓		✓	✓		✓
Killer whale (Offshore)	*Orcinus orca*			✓		✓	✓		✓		✓	✓		✓
Reptiles														
Leatherback sea turtle	*Dermochelys coriacea*					✓	✓		✓			✓	✓	✓

Sources: see Appendix C

Table 3. Part two of a sample focal species assessment framework, with a selection of species that scored high overall and within each taxonomic group (✓ = species displays characteristic; E = there is some evidence for shipping impacts on that species. Modified from King & Beazley.

Common name	Scientific name	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments)	Total number of affirmative responses	Comments
Birds												
Great blue heron	*Ardea herodias fannini*			✓	✓		✓	✓	✓		**11**	
Marbled murrelet	*Brachyramphus marmoratus*	✓	✓	✓			✓		✓		**12**	
Brant	*Branta bernicla*			✓	✓	✓	✓			✓	**11**	Other = grey-bellied variant (not recognized as official Ecologically Significant Unit) has a small population and is of particular concern
Peregrine falcon (Peale's and Anatum subspecies)	*Falco peregrinus ssp pealei & anatum*		✓	✓					✓		**11**	
Tufted puffin	*Fratercula cirrhata*		✓	✓			✓		✓		**11**	
Black oystercatcher	*Haematopus bachmanii*		✓		✓		✓		✓	✓	**11**	Other = small (but apparently not reduced) population size and restricted range
Harlequin duck	*Histrionicus histrionicus*	✓		✓	✓		✓		✓	✓	**11**	Other = Salish Sea provides major wintering habitat; a major moulting concentration occurs in the north of the region
Surf scoter	*Melanitta perspicillata*			✓	✓		✓			✓	**10**	Other = Salish Sea provides major wintering habitat.
Fish												
Pacific herring	*Clupea pallasi*				✓				✓		**12**	
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	✓			✓	✓		✓			**13E**	
Pink salmon	*Oncorhynchus gorbuscha*				✓	✓		✓			**12E**	
Chum salmon	*Oncorhynchus keta*				✓	✓		✓			**13E**	

Common name	Scientific name	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments)	Total number of affirmative responses	Comments
Coho salmon	*Oncorhynchus kisutch*				✓	✓		✓			**13E**	
Steelhead trout	*Oncorhynchus mykiss*				✓	✓		✓			**13E**	
Sockeye salmon	*Oncorhynchus nerka*				✓	✓		✓			**13E**	
Chinook salmon	*Oncorhynchus tshawtscha*				✓	✓		✓		✓	**14E**	Other = primary prey for southern resident killer whales; some remain resident in Salish Sea ('blackmouth feeders').
Bocaccio rockfish	*Sebastes paucispinis*		✓				✓	✓	✓		**10**	
Yelloweye rockfish	*Sebastes ruberrimus*		✓				✓	✓	✓	✓	**11E**	Other = particularly late-maturing
North Pacific spiny dogfish	*Squalus suckleyi*	✓	✓		✓		✓	✓	✓		**12**	
Seaweeds & Seagrasses												
Giant kelp	*Macrocystis pyrifera*				✓			✓			**8**	
Bull kelp	*Nereocystis luetkeana*				✓			✓			**9**	
Eelgrass	*Zostera marina*				✓						**9**	
Invertebrates												
Sand-verbena moth	*Copablepharon fuscum*	✓		✓						✓	**8E**	Other = endemic to Salish Sea and West Vancouver Island
Northern (pinto) abalone	*Haliotis kamtschatkana*		✓								**8**	
Olympia oyster	*Ostrea conchaphila*	✓			✓						**9E**	
Geoduck clam	*Panopea generosa*				✓		✓	✓		✓	**8E**	Other = highly variable recruitment
Mammals												
Sea otter (northern)	*Enhydra lutris kenyoni*	✓	✓		✓			✓			**12**	

Common name	Scientific name	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments)	Total number of affirmative responses	Comments
Gray whale	*Eschrichtius robustus*		✓			✓	✓	✓			**12**	
Steller sea lion	*Eumetopias jubatus*				✓			✓		✓	**10**	Other = major winter haul-out sites are in the Salish Sea
Humpback whale (North Pacific)	*Megaptera novaeangliae*		✓		✓	✓	✓	✓			**12**	
Killer whale (SRKW)	*Orcinus orca*	✓	✓	✓	✓		✓	✓	✓	✓	**17**	Other = Salish Sea is identified as critical habitat
Killer whale (NRKW)	*Orcinus orca*	✓	✓	✓	✓		✓	✓			**14**	
Killer whale (Transient)	*Orcinus orca*		✓				✓	✓			**10**	
Killer whale (Offshore)	*Orcinus orca*		✓		✓		✓	✓			**11**	
Reptiles												
Leatherback sea turtle	*Dermochelys coriacea*		✓			✓	✓	✓			**10**	

Sources: see Appendix C

Focal species suite

Because the selection of focal species entails a discussion of high-scoring species, the suite of selected species is identified and explained in the discussion section.

Shipping impacted species

Results also show that one or more of the impacts of shipping focused on in this report (oiling exposure via chronic and catastrophic spills, ship strikes, physical disturbance, acoustic disturbance, and wake wave impacts on shorelines) has been identified in the reviewed literature as being a substantial threat to 44 of the 94 species assessed (47%). The majority of these shipping-threatened species are birds (23 of 32 species) and mammals (10 of 11 species). Oil is the primary shipping-related threat for these birds, while for mammals ship strikes, acoustic and physical disturbance, and oil spills are all identified threats to varying degrees.

There is also is some evidence that shipping impacts could potentially pose a threat to an additional 38 assessed species (40%), though these impacts are not at this point identified as key threats, either because the evidence is preliminary or the impacts have not been confirmed specifically for the species in this assessment. The majority of these species are fish (25 species): shipping is identified as a potential threat in the results because the literature indicates that sound is thought to be important to communication for many fish, however research on whether acoustic disturbance from boats may adversely impact fish is in its early stages, and relatively few species have been studied in depth (e.g. Slabbekoorn et al., 2010).

Key habitats & functional groups

A notable result of the assessment is that while seaweeds and eelgrass were not high-scoring species overall, during the literature review for the assessment kelp and eelgrass beds were noted as important habitat for a number of assessed species — either directly as foraging or nursery habitat, or indirectly as habitat for key prey (i.e. forage fish). Forage fish (especially Pacific herring) were also identified as a key functional group upon which many assessed species rely. The details of these associations can be found in Table 4).

Table 4. Species for which kelp beds, eelgrass beds, and/or forage fish provide important habitat or resources.

Common name	Scientific name	Reliance on habitat or functional group
Great blue heron (Pacific)	*Ardea herodias fannini*	Reproductive success is associated with adequate foraging habitat, which includes eelgrass and kelp beds; nests near eelgrass meadows
Brant	*Branta bernicla*	Highly reliant on eelgrass as foraging habitat
Brandt's cormorant	*Phalacrocorax penicillatus*	Foraging frequently associated with kelp beds
Harlequin duck	*Histrionicus histrionicus*	Highly dependent on herring during annual spawn events
Surf scoter	*Melanitta perspicillata*	Highly dependent on herring eggs during annual spawn events; decline in Salish Sea thought to be associated with collapse of a key spawn event in Washington State
Tufted puffin	*Fratercula cirrhata*	Breeding success has been linked with forage fish abundance
Glaucous-winged gull	*Larus glaucescens*	Forage fish are the preferred food; declines in forage fish linked with declines in gull productivity
Western grebe	*Aechmorphus occidentalis*	Thought to be reliant on forage fish, and herring in particular in parts of the Salish Sea; declines in herring spawn/spawning areas may be a cause of western grebe decline or redistribution in winter range.
Ancient murrelet	*Synthliboramphus antiquus*	Appears to be dependent on herring and krill (forage fish)
Marbled murrelet	*Brachyramphus marmoratus*	Forage fish (sand lance and herring) are primary prey; potentially prey limited
Pacific salmon	*Oncorhynchus spp.*	Eelgrass and kelp provide key nursery habitat
Pacific herring	*Clupea pallasi*	Herring deposit their eggs on benthic marine macro-vegetation; in Puget Sound eelgrass is the primary species, and elsewhere kelp is important
North Pacific spiny dogfish	*Squalus suckleyi*	Use of eelgrass habitat is newly identified; degree of importance to life history not yet known
Pacific cod	*Gadus macrocephalus*	Eelgrass and kelp beds provide nursery habitat for juveniles
Dungeness crab	*Metacarcinus magister*	Eelgrass and kelp provide nursery habitat for juveniles
Red urchin	*Strongylocentrotus fraciscanus*	Graze on young and adult seaweeds, including the large kelp species that form kelp beds
Northern abalone	*Haliotis kamtschatkana*	Feed on macroalgae, especially kelp
Sea otter (northern)	*Enhydra lutris kenyoni*	Kelp bed provide important foraging habitat
Gray whale	*Eschrichtius robustus*	Opportunistic and generalist feeder, however grey whale arrival in the region during northward migration is associated with herring spawn events

Sources: see Appendix C

DISCUSSION

A number of key themes can be drawn from the results of the focal species framework assessment, as well as the use of the framework for identifying focal species for environmental assessment purposes. First, however, a discussion of some of the higher scoring species is required to set the context for these themes, and for which species were selected for the suite of candidate focal species and why. Where there were notable agreements or disagreements with the project-related marine shipping assessments conducted by Trans Mountain and Roberts Bank these differences are discussed.

HIGH SCORING SPECIES

This assessment resulted in high scoring species that were both expected and unexpected. The expected species were those that are already commonly identified as key focal species for the region as they are charismatic and are widely recognized as being of high conservation concern. The highest ranked species overall and the highest ranked in each taxonomic group — other than eelgrass — are all listed as at risk by one or more jurisdiction. This is not surprising, as the characteristics that identify vulnerable or sensitive species in this assessment — such as reduced or declining population, long-lived, low productivity, and dependence on limited resources or specific habitats — are factors that lead to official at-risk listing. For instance, species may be put on the BC blue list or designated special concern under COSEWIC/SARA because of such inherent biological characteristics that make them particularly susceptible to anthropogenic threats or natural stochastic disturbance events. While some of these species have been identified as focal or indicator species in other regional conservation work (e.g. Kershner et al., 2011; Levin et al., 2012; US EPA & ECCC, 2017) and were used in the Trans Mountain and/or Roberts Bank marine shipping-related assessments, others were not. Other species scored high and are listed at risk by at least one jurisdiction, but are less commonly used as focal species for marine conservation efforts in the Salish Sea. Some of the key species in both contexts are discussed here.

Killer whales

The southern resident killer whale population, which received the highest score, is listed under the most at-risk category by all four jurisdictions included in this project (red-listed in BC, endangered in Washington State, Canada, and the US) and is currently the marine species of greatest conservation concern with regards to shipping impacts in the region (e.g. Lacy et al., 2017; US EPA & ECCC, 2017). The endangered state of the SRKWs is widely known by the public, so much so that births, deaths, and the whales' annual summer-fall appearance in the Salish Sea are closely monitored and publically reported on in the news (US EPA & ECCC, 2017). A recent population viability analysis found that under current conditions of key stressors — limited prey availability and noise from commercial and recreational ships — the population, which is at a 30-year low of 78 individuals, has a 25% chance of extinction in the next century (Lacy et al., 2017). Notably this was the one indicator species which both Roberts Bank and Trans Mountain acknowledged would be significantly impacted by both project-level and cumulative shipping impacts (Port Metro Vancouver, 2015; National Energy Board, 2016). While the northern resident killer whale population is currently considered in better condition and is less reliant on high quality habitat in the Salish Sea than the southern residents, the population is still considered threatened and is adversely impacted by shipping-related stressors (COSEWIC 2009b).

Baleen whales

The high focal species scores for the humpback whale and the grey whale are also to be expected. They have biological characteristics that make them inherently vulnerable; as 'charismatic megafauna' they tend to be considered flagship species in conservation efforts; and they are susceptible to multiple shipping-related threats as well as other anthropogenic stressors (COSEWIC 2004b; Douglas et al., 2008; Williams & O'Hara, 2010; COSEWIC 2011b). While neither species is present in the Salish Sea year-round, the region contains important feeding grounds for populations of both species (COSEWIC 2004b; COSEWIC 2011b). Humpback whales were chosen by both Trans Mountain and Roberts Bank to represent baleen whales, including grey whales (Port

Metro Vancouver, 2015; National Energy Board, 2016). The high score of both supports their continued use as key focal species against which to assess shipping impacts.

Sea otter

Another predictably high-ranking species is the sea otter, which is commonly used as a flagship species for marine conservation concerns in areas of the Pacific Northwest, particularly because of their vulnerability to oil spills and their well-established keystone role in the maintenance of healthy and productive kelp forest habitat (COSEWIC, 2007e). After being extirpated from much of their range in the early to mid-1900s, sea otters were successfully reintroduced to Salish Sea along part of the Olympic Peninsula coastline in Washington State (Lance, Richardson, & Allen, 2004). While the population has increased and isolated sightings have occurred throughout the Salish Sea, their resident range in the region is still relatively restricted (MacDuffee et al., 2016; Lance, Richardson, & Allen, 2004); since they are not as ubiquitous throughout the Salish Sea as they are elsewhere along the Pacific Northwest coastline, nor as common as other at-risk species in the Salish Sea, they would not necessarily be immediately thought of as a focal species for the region — particularly on the Canadian side of the border where they have not yet established a resident population. Their high score in this assessment suggests that despite currently having a restricted range they may be an important species to include in a regional assessment of shipping impacts, for a few key reasons: they historically occupied more of the Salish Sea, they could play a role in maintaining kelp forest habitat in the region, and they are particularly vulnerable to oil spills (COSEWIC, 2007e). Notably the potential impacts of project-related shipping on sea otters appear to not have been considered by Trans Mountain and Roberts Bank in any detail; Trans Mountain noted that catastrophic oil spills such as EVOS could have population level impacts, while Roberts Bank noted that sea otters are not currently present in their assessment area (Port Metro Vancouver, 2015; National Energy Board, 2016)

Marbled murrelet

The highest-scoring bird, the marbled murrelet, is the only assessed bird listed as at-risk under all four jurisdictions. While its high score is unsurprising, it notably is more commonly used as a terrestrial focal species (as a condition indicator or umbrella species) for the coastal old growth rainforest habitat upon which it depends for nesting (COSEWIC, 2012b). Yet the species also depends on forage fish — specifically herring and sand lance — and requires adequate marine foraging habitat within 30-50 km of its nesting habitat; it is also one of the species most vulnerable to impacts from chronic and catastrophic oil spills (COSEWIC, 2012b). The murrelet's high assessment score indicates it could play an important role as a marine focal species as well as terrestrial. This is supported by written evidence submitted by BC Nature and Nature Canada for the National Energy Board review of Trans Mountain, which argued that the species should be considered in such an assessment since chronic and catastrophic oil spills are listed as threats under SARA, noting that breeding population on the east coast of Vancouver Island currently only numbers 1000-2000 birds (BC Nature & Nature Canada, 2014). Notably Trans Mountain largely excluded the marbled murrelet from its assessment (which prompted that response in the written evidence), while Roberts Bank used the species as one of the representative species for pelagic and piscivorous diving birds (Port Metro Vancouver, 2015; National Energy Board, 2016).

Salmon and herring

The high rank of Pacific salmon (*Oncorhynchus* species, including trout) and Pacific herring in this assessment is to be expected given the key role they play ecologically, socially, and culturally in the region. Salmon are an iconic cultural symbol of the Pacific Northwest and are well-known as keystone species that link the marine and terrestrial ecosystems due to their anadromous lifecycle: when salmon return to their natal streams to spawn then die they deposit a pulse of marine-derived nutrients throughout the watershed (e.g. Cederholm et al., 2000; Schindler et al., 2003; Hocking & Reynolds, 2011). Herring is recognized as an important foundation species in nearshore and intertidal ecosystems because of its role as a key forage fish for a number of predators, including salmon and other commercially important fish (e.g. Schweigert et al., 2010; McKechnie et al., 2014 and sources therein). In addition, when herring spawn in spring the eggs they deposit provide an ephemeral pulse of nutrients on shorelines along the coast; the ecological role of herring spawn is still being uncovered, however research suggests it may be substantial, as eggs are consumed by black bears, wolves, birds, and small mammals feeding in the intertidal (e.g. Fox et al., 2015). Similar to the southern resident killer whale, conservation concerns and management of both salmon and herring has been controversial and highly publicized in recent years in part due to declining and/or fluctuating annual spawning returns (e.g. Fox et al., 2016; Price et al., 2017). Pacific salmon (as a group) and Pacific herring were used as representative fish species in the Trans Mountain and Roberts Bank project assessments, though they were not considered in the CEAs for these projects (Port Metro Vancouver, 2015; National Energy Board, 2016; Trans Mountain Pipeline ULC, 2013).

Olympia oyster

The highest scoring invertebrate, the Olympia oyster, is the only native oyster currently found in the region, is listed and legally protected as endangered within Canada, and is found in relatively high densities in the Salish Sea (COSEWIC, 2011d) — yet it tends to gain less public conservation focus than the next high scoring invertebrate, the endangered Northern abalone. The oyster's high assessment score suggests it is an important species to consider for a regional CEA of shipping, particularly given its role as an ecosystem engineer and the possibility of it being impacted by shipping through oil spills and the potential effects of wake waves on sedimentation and wave regimes (COSEWIC, 2011d). While both the Trans Mountain and Roberts Bank assessments addressed the potential impacts of wake waves on intertidal habitat, both stated that because the wake waves produced the shipping associated with their individual projects would largely be within the range of natural variation, their contributions to total cumulative effects from all shipping would be low (Port Metro Vancouver, 2015; National Energy Board, 2016).

North Pacific spiny dogfish

While the North Pacific spiny dogfish is listed as at-risk has in the past been considered a pest by the commercial fishing industry due to its predation on and competition with commercially targeted species, and as a result was the subject of eradication programs; it also has been harvested for a variety of purposes (COSEWIC, 2011c). Despite its inherent vulnerability to anthropogenic impacts, the COSEWIC report notes that "the reputation of the Spiny Dogfish is partly responsible for the lack of proper management worldwide" which gives an indication of why it is not commonly used as a conservation focal species (COSEWIC p. 39). While shipping is not currently considered a significant threat to the two populations found in the Salish Sea (Strait of Georgia and Puget Sound), it was identified in the focal species assessment as threat to the species' primary prey (herring), and to and eelgrass, which only recently identified as a habitat used by dogfish within the Salish Sea (Penaluna & Bodensteiner, 2015).

Peregrine falcon

There are thought to be two peregrine falcon subspecies present in the Salish Sea; subspecies *pealei* makes up the majority of the birds found, though subspecies *antum* and hybrids of the two also appear to be present in the region (COSEWIC, 2007c). While the peregrine falcon may not commonly be considered a marine bird, the *pealei* subspecies preys primarily on seabirds and thus the availability of its seabird prey base is considered its key limiting factor (COSEWIC, 2007c). Furthermore, the species is known to be susceptible to negative population-level impacts via oil-contaminated prey (Zuberogoitia et al., 2006). The peregrine falcon therefore has the potential to be substantially but indirectly impacted by oil spills; this combined with its high focal species score suggests it could be a valuable focal species for shipping, yet it was not considered by neither Trans Mountain nor Roberts Bank in this context. The former used the bald eagle to represent falcons (National Energy Board, 2016), while the latter stated that "no interactions were identified between raptors . . . and Project-associated marine shipping" (Port Metro Vancouver, 2015). The use of the peregrine falcon in shipping assessments was supported in the BC Nature and Nature Canada submission for the Trans Mountain project (BC Nature & Nature Canada, 2014).

Black oystercatcher, harlequin duck, and geoduck clam

Less expected were the high scoring species that are not considered at-risk under any of the four jurisdictions, particularly the black oystercatcher, the harlequin duck, and the geoduck clam. The black oystercatcher was included in the assessment because it is referred to as a particularly sensitive indicator (condition indicator or sentinel species) of the health of shorelines in the Pacific Northwest, as well as a keystone species in the rocky intertidal because of its preferential predation on large limpets (e.g. Tessler et al., 2007; Tessler et al., 2014; Weinstein et al., 2014). The harlequin duck and the geoduck clam were included because of their cultural importance to the Coast Salish (Gaydos, Thixton, & Donatuto, 2015). As identified during the assessment (see Tables 2 and 3), while the populations of these species in the Salish Sea are not known to be reduced or in decline, all three species have characteristics that could make their populations inherently more susceptible to declines and slower to recover from perturbations. The black oystercatcher has a small population size, a restricted range, is highly reliant on the rocky intertidal, and it nests in on shorelines in the Salish Sea (e.g. Tessler et al., 2007; Golumbia et al., 2009; Weinstein et al., 2014). The harlequin duck forms major wintering and moulting concentrations in the Salish Sea, and at least part of the population relies heavily on the annual pulse of spawning herring along the Strait of Georgia (Rodway et al., 2015; BC Conservation Data Centre, 2017). The geoduck is extremely long lived, can form large aggregations, and has highly variable recruitment (Dethier, 2006). These species' high assessment scores combined with their definite (black oystercatcher and harlequin duck) or probable (geoduck) vulnerability to shipping stressors (see Tables 2 and 3) suggests that species not currently listed as at-risk could still be valuable focal species. The high score of the oystercatcher and the geoduck is particularly notable as population levels or trends are currently not well known for these species (Dethier, 2006; Golumbia et al., 2009).

Eelgrass and kelp

Long-term distribution trends and/or current distribution in some regions are not well known for these species, however anecdotal evidence indicates that they are decreasing in at least some regions (Mumford, 2007). Eelgrass, bull kelp, and giant perennial kelp scored the highest in their taxonomic group; while this group did not score highly overall in the assessment, the important role that kelp and eelgrass beds play in the lifecycles of numerous assessed —and many high-scoring — species indicates the need to thoroughly assess the cumulative effects of shipping on these habitats (see Table 4). This is to be expected, as eelgrass and kelp — particularly bull kelp and giant perennial kelp — are commonly known as dominant or foundation species that structure intertidal and nearshore communities (e.g. Mumford, 2007; Essington et al., 2011). Furthermore, detached pieces of vegetation play key roles in nutrient cycling, both in the nearshore subtidal and in the intertidal (e.g. Birtwell et al, 2013 and sources therein). Given such critical functional importance, assessments should address the direct impacts of cumulative shipping activities on these species.

FOCAL SPECIES SUITE

Based on the results of the assessment high-scoring species were selected from each major taxonomic group to form a suite of candidate focal species, with an emphasis on those that are most at-risk and most likely to be significantly impacted by shipping stressors (Table 5). A total of 19 species were selected: 6 birds, 4 fish, 4 mammals, 3 seaweeds and seagrass, and 2 invertebrates. A number of factors were considered in the selection of these species alongside the assessment scores. The larger number of birds, fish, and mammals in the suite reflects the larger number of high-scoring species in those groups, a result which suggests that those groups are particularly vulnerable or important ecologically or culturally. Eelgrass and the two high-scoring kelp species were chosen because of the direct and indirect importance of kelp and eelgrass habitats to many of the species in the assessment; Pacific herring was also included for this reason, despite only being listed in Washington State (as a candidate). Another major factor in the selection was whether a species is listed as at-risk, by how many jurisdictions, and whether it was listed as endangered, threatened, or special concern. Most of the selected species are therefore listed as at-risk by at least one jurisdiction. Shipping is a threat to the majority of the selected species, to varying degrees: for example, some are particularly vulnerable to just oil (e.g. the marbled murrelet), while others are vulnerable to oil, ship strikes, and acoustic and physical disturbance (e.g. humpback whale).

The selected species — in particular the birds, mammals, and fish — also represent a wide variety of life history types (e.g. different feeding strategies and trophic levels, birds from multiple ecological guilds) and habitat requirements (e.g. benthic, pelagic, intertidal, estuarine; some that require multiple habitat types and some with high habitat or site fidelity). Another element of consideration was if the Salish Sea region is known to be of particular importance to an element of a species' life history. For example, it is a key wintering region for the surf scoter and harlequin duck; it is part of the peregrine falcon subspecies' limited breeding range; the Olympia oyster is found at relatively high densities in the region; and it comprises the majority of the southern resident killer whale population's identified critical habitat. The selected species also fulfil multiple focal species roles, and at least 10 are important to Coast Salish culture.[10]

[10] "At least" because, as was noted in the methods, prioritizing species was difficult given the ecosystem-based view that the Coast Salish culture has of species importance (Gaydos et al., 2015).

Table 5. Suite of potential focal species for a cumulative effects assessment of shipping in the Salish Sea

Common name	Scientific name	Score	At risk status	Rationale for inclusion in suite (e.g. threats, limiting factors, Salish Sea association)
Great blue heron (Pacific)	*Ardea herodias fannini*	11	Blue List (BC), Special Concern (COSEWIC & SARA)	Species of conservation concern for shorebirds and waders. Not impacted directly by shipping however eelgrass (which is vulnerable to shipping impacts) provides key foraging habitat, and population size has been correlated with availability of local foraging habitat near nesting sites;
Marbled murrelet	*Brachyramphus marmoratus*	12	Blue List (BC), Threatened (Washington), Threatened (COSEWIC & SARA), Threatened (USA)	Species of conservation concern for alcids. Oil is listed as a primary threat. Nests in Salish Sea, and adequate foraging near nesting location is a key habitat requirement; herring (vulnerable to shipping impacts) is a key prey species.
Peregrine falcon (Peale's and Anatum/Anatum hybrid)	*Falco peregrinus*	11	ssp. *anatum*: Red List, ssp. *pealei*: Blue List (BC), Special Concern (COSEWIC & SARA)	Species of conservation concern for falcons. Not impacted directly by shipping however is highly reliant on declining seabird prey (which is vulnerable to oil and potentially other shipping impacts). Breeds within the Salish Sea; ingestion of oil via seabird prey can impact reproduction.
Harlequin duck	*Histrionicus histrionicus*	11	Not listed	Oil is a threat (catastrophic and chronic oiling identified as keys threats to the COSEWIC-listed East Coast population). Displays high site fidelity; Salish Sea provides major wintering habitat and a major moulting concentration occurs in the north of the region. Herring (vulnerable to shipping impacts) is a key ephemeral food source.
Black oystercatcher	*Haematopus bachmanii*	11	Not listed	Sensitivity to oil spills and wake wash at nest sites combined with high nesting site specificity on rocky intertidal shorelines makes species vulnerable to shoreline impacts of shipping. Small population size and restricted range adds to vulnerability. Plays a keystone role in structuring rocky intertidal through selective predation on limpets.
Surf scoter	*Melanitta perspicillata*	10	Blue List (BC)	Species of conservation concern for the diving ducks, to compliment the harlequin duck (diving duck, not currently listed). Oil is a key threat. Salish Sea provides major wintering habitat; winter in large concentrations. Herring spawn (vulnerable to shipping impacts) is a key ephemeral food source.

Common name	Scientific name	Score	At risk status	Rationale for inclusion in suite (e.g. threats, limiting factors, Salish Sea association)
Pacific herring	*Clupea pallasi*	12	Candidate (Washington)	Oil (chronic and catastrophic) is an identified threat, and disturbance from ships (including noise) is a potential impact. Is a foundational species — is a key food source for numerous other species (including assessed, e.g. see Table 4). Returns to the same core areas to spawn in Salish Sea; spawning returns are decreasing; evidence suggests returns are experiencing larger and more extreme fluctuations.
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	13E	Blue list (BC),	Potentially impacted by ship noise. Limiting factors include low fecundity compared to steelhead and salmon, small size of populations, and limited short-term rescue effect. The Georgia Basin (i.e., Salish Sea) populations are particularly at risk. Remain in estuaries and nearshore environments instead of migrating further offshore, therefore may remain in closer proximity to ship traffic.
Chinook salmon	*Oncorhynchus tshawtscha*	14E	Candidate (Washington), Endangered (COSEWIC, Okanagan population), Threatened (USA)	Potentially impacted by ship noise. Particularly large declines occurring the Salish Sea. Is the primary prey for southern and northern resident killer whales. Some remain resident in Salish Sea ('blackmouth feeders').
Yelloweye rockfish	*Sebastes ruberrimus*	11E	Candidate (Washington), Special Concern (COSEWIC),	Potentially impacted by ship noise. One of the largest and longest-lived rockfish, and is particularly late maturing. Habitat specialist with a small home range and high site fidelity. Occurs in benthic habitats, and likely plays a role in structuring nearshore rocky ecosystems. Higher scoring than other rockfish; is of particular conservation concern, is important to commercial, recreational, and First Nations fisheries.
Giant kelp	*Macrocystis pyrifera*	8	Not listed	Oil can cause tissue death/damage, and reduced photosynthesis and respiration. Potentially impacted by changes to sedimentation regimes that may arise from wake waves. Dominant macrophyte in the intertidal and subtidal that provides habitat for communities (foundation species).

Common name	Scientific name	Score	At risk status	Rationale for inclusion in suite (e.g. threats, limiting factors, Salish Sea association)
Bull kelp	*Nereocystis luetkeana*	9	Not listed	Oil can cause tissue death/damage, and reduced photosynthesis and respiration. Potentially impacted by changes to sedimentation regimes that may arise from wake waves. Dominant macrophyte in the intertidal and subtidal that provides habitat for communities (foundation species).
Eelgrass	*Zostera marina*	9	Not listed	Oil can cause tissue death/damage, and reduced photosynthesis and respiration. Potentially impacted by changes to sedimentation regimes that may arise from wake waves (likely more so than kelp); also susceptible to mechanical damage from high energy waves. Dominant macrophyte in intertidal and subtidal that provides habitat for communities (foundation species) and modifies the substrate and water column (ecosystem engineer).
Olympia oyster	*Ostrea conchaphila*	9E	Blue List (BC), Candidate (Washington)	Species of conservation concern for invertebrates. Potentially impacted by changes in the sediment/wave regime (e.g. from ship traffic); pollution is a threat, indicating that oiling could be a concern. Has been recorded at relatively high densities in the Salish Sea, and is the only oyster species native to BC.
Geoduck clam	*Panopea generosa*	8E	Not listed	Potentially impacted by oil; aggregates in dense beds, meaning entire beds could be impacted. Large, long-lived invertebrate with highly variable recruitment suggests potential for population recovery is uncertain. Not listed as a species of concern however there are indications that the Puget Sound population has decreased in the past century. Supports the largest and most valuable commercial native clam fishery.
Sea otter (northern)	*Enhydra lutris kenyoni*	12	Blue List (BC), Endangered (Washington), Special concern (COSEWIC & SARA), Species of Concern (US)	Highly vulnerable to oil spills. Has recolonized parts of the Salish Sea after decades of extirpation, displays high site fidelity, and has a small home range. Kelp beds (which may be impacted by shipping) are important foraging habitat.

Common name	Scientific name	Score	At risk status	Rationale for inclusion in suite (e.g. threats, limiting factors, Salish Sea association)
Steller sea lion	*Eumetopias jubatus*	10	Blue List (BC), Special Concern (COSEWIC & SARA)	Species of conservation concern for pinnipeds. Sensitive to displacement and disturbance from human activity and in general are habitat specialists. Vulnerable to oil spills; major winter haul-out sites occur in the Salish Sea, and oil spills near these sites could have population-level consequences.
Humpback whale (North Pacific population)	*Megaptera novaeangliae*	12	Blue List (BC), Endangered (Washington), Threatened (COSEWIC & SARA), Endangered (US)	Sighted in the region more frequently than grey whale. Has returned to historic feeding grounds in the region, feeds in relatively large groups, and exhibits high site fidelity to feeding grounds. Directly impacted by shipping via acoustic disturbance, ship strikes, and likely oil.
Killer whale (SRKW)	*Orcinus orca*	17	Red list (BC), Endangered (Washington; COSEWIC & SARA; US)	Directly impacted by shipping via acoustic disturbance. Oil spills and ship strikes are also threats. Critical habitat (which includes acoustic habitat quality) is in the Salish Sea. Limited by small population and minimal dispersal. Population viability is linked with availability of Chinook, which are the primary prey and are also reduced and declining; could therefore also be indirectly impacted by shipping impacts on Chinook (potentially impacted by ship noise and oil).

Sources: see Appendix C

The aim of this project was to identify a suite of candidate focal species that would be particularly valuable for a cumulative effects assessment of shipping in the Salish Sea. Nevertheless, as noted by King and Beazley (2005), since 94 Salish Sea species assessed with the focal species framework are all considered at-risk, ecologically important, and/or culturally important to varying degrees, an argument could be made for including each in a potential suite of focal species. While the 19 species selected stood out in the assessment results as particularly important focal species with regards to shipping in the region, that number is somewhat arbitrary, and more species could be justified to include in this suite; the species selected for the suite are recommendations rather than an exhaustive list of all species that should be included in a regional CEA of shipping. A number of other species from the assessment could also be proposed, either as additions to a larger, expanded suite, or even as 'alternates' to the current identified species. For example, Chinook and coastal cutthroat trout were picked from amongst the seven Pacific salmon species because Chinook is the primary prey for the southern resident killer whale population, because aspects of the coastal cutthroat trout's life history make it particularly vulnerable, and because populations of both remain as residents within the Salish Sea (Cederholm et al., 2000; Costello, 2008; US EPA & ECCC, 2017) — yet similar species-specific arguments could be made for including the other five Pacific salmon in the focal species suite. Ideally all seven species would be used in a CEA of shipping due to their critical importance as a keystone species on the BC coast. A list of potential alternate species is therefore provided below (see Table 6).

Table 6. Alternative species that could be considered in a focal species suite for a CEA of shipping in the Salish Sea

Common name	Scientific name	Score	Species at risk listing	Rationale for consideration as focal species (e.g. threats, limiting factors, Salish Sea association)
Brant	*Branta bernicla*	11	blue list BC	Not directly impacted by shipping, however high reliance on and fidelity to eelgrass habitat during winter, and on herring roe during migration, indicates it could be indirectly impacted. The population level of the grey-bellied variant is small and of particular concern but not currently recognized as a distinct ESU.
Tufted puffin	*Fratercula cirrhata*	11	blue list BC; endangered Washington	Vulnerable to oil spills. Breeding success has been linked with forage fish abundance, including herring. A handful of breeding sites are active in the Salish Sea, though it historically bred throughout more of the region.
Brandt's cormorant	*Phalacrocorax penicillatus*	9	red list BC; candidate Washington	Highly sensitive to oiling. Has small breeding colonies within the Salish Sea. Forages in association with kelp beds, therefore may be also be indirectly impacted.
Western grebe		8	red list BC; candidate Washington, special concern COSEWIC	Large flocks in winter are vulnerable to large and small oil spills, and populations in the Salish Sea are experiencing significant declines. Is dependent on forage fish, including herring.
Common murre	*Uria aalge*	9	red list BC; candidate Washington	Vulnerable to chronic and catastrophic oiling (is the most commonly oiled bird along BC and Washington coasts). Salish Sea provides major wintering habitat; forms large rafts in winter.
Pacific cod	*Gadus macrocephalus*	9E	candidate Washington, species of concern USA	Potentially impacted by ship noise. Spawn in the Salish Sea, and may be indirectly impacted due to reliance on eelgrass and kelp beds for nursery habitat. Salish Sea population has declined an estimated 80-90% since the 1970s.
Pink salmon	*Oncorhynchus gorbuscha*	12E	Not listed	Potentially impacted by ship noise. May spawn in intertidal (not confirmed for the Salish Sea), and intertidal egg exposure to oil could cause population-level impacts.
Chum salmon	*Oncorhynchus keta*	13E	candidate Washington, candidate COSEWIC, threatened USA	Potentially impacted by ship noise. Is primarily associated with eelgrass habitat when in estuarine habitats.

Common name	Scientific name	Score	Species at risk listing	Rationale for consideration as focal species (e.g. threats, limiting factors, Salish Sea association)
Coho salmon	*Oncorhynchus kisutch*	13E	endangered COSEWIC	Potentially impacted by ship noise. Is experiencing particularly large population declines in the Salish Sea.
Steelhead trout	*Oncorhynchus mykiss*	13E	candidate COSEWIC, threatened USA	Potentially impacted by ship noise. Is experiencing particularly large population declines in the Salish Sea.
Sockeye salmon	*Oncorhynchus nerka*	13E	endangered COSEWIC	Potentially impacted by ship noise. Is particularly commercially important.
North Pacific spiny dogfish	*Squalus suckleyi*	12	special concern COSEWIC	Not directly impacted by shipping threats, however may be impacted indirectly via impacts on herring (primary prey) or eelgrass habitat, which has only recently been examined. Late maturation, long generation time, and long gestation period indicates population would be slow to recover if impacted. Potentially plays a keystone species role in ecosystem.
Bocaccio rockfish	*Sebastes paucispinis*	10	candidate Washington, endangered COSEWIC, endangered USA	Oil spills are a major threat. Displays high site fidelity, and areas of the Salish Sea have been identified as critical habitat by NOAA. Is one of the top ten intrinsically vulnerable rockfish species.
Northern (pinto) abalone	*Haliotis kamtschatkana*	8	BC red list; candidate Washington; endangered COSEWIC & SARA	Habitat requirements include macroalgae (especially kelp) for food; therefore may be indirectly impacted by shipping via impacts to kelp.
Gray whale	*Eschrichtius robustus*	12	blue list BC; sensitive Washington, special concern COSEWIC & SARA	Threats include ship strikes and noise disturbance. Summer-resident population feeding grounds include areas of the Salish Sea (especially eelgrass beds); high site fidelity to feeding grounds.
Leatherback sea turtle	*Dermochelys coriacea*	10	red list BC; endangered Washington, endangered COSEWIC & SARA, endangered USA	Highly sensitive to oil spills and is vulnerable to ship strikes. Not included in focal species suite because is sighted so infrequently in the Salish Sea.

Sources: see Appendix C

MULTI-SPECIES ECOSYSTEM-BASED APPROACH

A theme that emerged from the results and the literature review conducted for the assessment was that this focal species framework supports the need for a multi-species, ecosystem-based approach to the selection of focal species for the cumulative effects of shipping. First, species from all taxa are vulnerable or potentially vulnerable to the impacts of shipping. Second, while birds, fish, and mammals scored highest overall, within each taxonomic group there were a number of species that received high scores for that group, indicating that within each taxa multiple focal species could be employed. Third, while the indirect impacts of shipping on species were largely outside of the scope of this project, nevertheless some indirect impacts became clear. For instance, shipping-related stressors are not identified as key threats to the great blue heron, peregrine falcon, brant, spiny dogfish, northern abalone, and sand-verbena moth, all of which are listed as at-risk and are among the high-scoring species in their respective taxonomic class; yet all have the potential to be indirectly affected through habitat degradation caused by shipping.

SHIPPING IMPACTS & CUMULATIVE EFFECTS

Aside from the identification of potential focal species, this assessment highlights the considerable number of at-risk, ecologically important, and culturally important species that could be detrimentally impacted by shipping. Oil (chronic oiling and catastrophic spills), ship strikes, physical disturbance, acoustic disturbance, and/or wake wave impacts on shorelines poses a substantial threat to nearly half of the assessed species (44 of 94), most of which are mammals and birds. Notably these are all species for which one or more of these stressors has been identified in the literature as a key population-level threat, rather than simply a threat to individuals within a population.

This assessment also underscored the need to revisit how cumulative effects are currently being addressed in environmental assessments. While some of the assessed species are at risk from large-scale or lethal impacts (i.e. sea otters are most vulnerable to catastrophic oil spills while baleen whales are particularly impacted by ship strikes), many are at risk from the sub-lethal or smaller-scale impacts that CEAs are intended to address. While the chronic oiling, physical and acoustic disturbance, and wake wave effects of individual ships or even individual projects (e.g. the shipping increase that will be attributable to Trans Mountain) may not cause significant population-level impacts to these vulnerable species, when added together the current and projected high level of shipping has the potential to have substantial adverse impacts.

This is exemplified by the southern resident killer whale population, for which the cumulative underwater noise of all vessel traffic in the region is identified as a primary threat (e.g. COSEWIC, 2008b; Lacy et al., 2017) This example embodies the adage of 'death by a thousand cuts,' whereby the gradual increase in shipping in the region over decades has led to an underwater soundscape that is currently unsustainable for the population (Lacy et al., 2017). The impact of underwater noise on the southern resident killer whale population has been a central point in emerging discussions regarding cumulative shipping effects — however it appears to be the only cumulative effect on the region's biota considered to be of significance by the two project proponents examined in this report, and even then the proponents reasoned that this should have no bearing on their projects as cumulative effects are already substantial. For example, in the NEB hearing "Trans Mountain argued that the shipping lanes will continue to host marine vessel traffic with or without the Project, and that the impacts to the Southern resident killer whales will continue to exist with or without the Project" (National Energy Board, 2016, p. 334). Similarly, Roberts Bank asserts that there is no "statistically significant difference in survival, fecundity . . . or population growth of [southern resident killer whales] between existing and future conditions with the Project and future certain and reasonably foreseeable projects and activities" (Port Metro Vancouver, 2015, p.8.2-52) Notably underwater acoustic disturbance is also an identified threat to other cetaceans in this assessment (see Tables 2 and 3, and Appendix B).

Meanwhile, the project-level effects of shoreline disturbance from wake waves and physical disturbance by ships were considered insignificant, and therefore the cumulative effects were too. Both Trans Mountain and Roberts Bank contend that their project-related wake waves would be well within the range of natural variation seen by shorelines in the region, and therefore intertidal habitats and the species they support would be adapted to those conditions (Port Metro Vancouver, 2015; National Energy Board, 2016). However, the impacts of wake generated waves can differ from those of natural wind-generated waves (Gourlay, 2011)[11], and the cumulative wake waves from all shipping activities were not considered. This is particularly relevant for eelgrass, as sedimentation regimes can impact eelgrass beds (Mumford, 2007); indeed, the Tsawout First Nation[12] submitted evidence to the NEB Trans Mountain hearing that wake waves are causing a loss of eelgrass in their traditional territory due to a build-up of sediment in shallow waters (National Energy Board, 2016). Given the importance of eelgrass to many of the high-scoring species in this assessment along with numerous others, simply comparing project-related wake height with natural wave conditions should be considered insufficient to determine whether either the project-level or cumulative effects of increased wake wave action will have a significant impact on shorelines.

Similarly, the project-level impacts of physical disturbance, which can cause behavioural alteration and displace animals from habitat, were found by the proponents to be insignificant since potentially impacted species have habituated to the current level of shipping in the region, and project-associated shipping would not add significantly to those impacts (Port Metro Vancouver, 2015; National Energy Board, 2016). The examples from Trans Mountain and Roberts Bank examples demonstrate how cumulative effects can be dismissed by proponents when project-level effects are considered negligible and/or when a proper regional baseline against which to measure project effects is not established (Clark Murray et al., 2014), thus providing for arguments about project-level effects being inconsequential in the context of current shipping impacts.

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[11] How wake-generated waves impact shorelines relative to natural wind waves depends on a number of variables, including shoreline exposure, wind conditions, currents, bathymetry, and ship size and speed. Determining the magnitude of impact vessel wake may have on shorelines is therefore site- and situation-specific, and difficult to accurately characterize without undertaking some level of field study (Gourlay, 2011). Simply comparing wake height with natural wave conditions is therefore insufficient to determine whether either the project-level or cumulative effects of increased wake wave action will have a significant impact on shorelines.

[12] The Tsawout Nation is located on the Saanich Peninsula on Vancouver Island.

Chronic oiling, on the other hand, was largely unconsidered by either proponent even though cumulatively it can have substantial adverse impacts on bird populations. Oil is identified as a threat to 23 of the 32 bird species assessed in this project, and chronic oil spills are thought to be potentially more lethal to marine birds than larger catastrophic spills such as the notorious Exxon Valdez Oil Spill (Wiese & Robertson, 2004). Yet the impacts of chronic spills are much more cryptic than large catastrophic spills: they tend to go undetected or are not reported, making them difficult to quantify (e.g. O'Hara and Morgan 2006, BC Nature & Nature Canada, 2014). Despite being a threat on par with catastrophic spills, and the inclusion of catastrophic spills in both the Trans Mountain and Roberts Bank assessments, chronic spills and their cumulative impacts were not included by either proponent as either an existing habitat impact or a project-related impact (BC Nature & Nature Canada, 2014; Port Metro Vancouver, 2015; National Energy Board, 2016). This is of particular concern as the Salish Sea provides important nesting, migratory, and wintering region for numerous marine bird species, and is a region of global or continental importance for many of these (Bower, 2009; Crewe et al., 2012); notably many of the region's listed and non-listed marine bird populations are declining, reduced, or otherwise facing ecological limitations (Bower, 2009; Crewe et al. 2012; BC Nature & Nature Canada, 2014).

This assessment also highlights the multiple shipping stressors that could impact species, particularly mammals. The Trans Mountain and Roberts Bank assessments examined stressors on species one by one, rather than considering the cumulative effects of multiple stressors that on their own or from one project could be considered negligible, but with multiple stressors coming from all current and proposed shipping may be substantial (Port Metro Vancouver, 2015; National Energy Board, 2016). Furthermore, it is important to consider that this project and assessment only takes direct impacts of ship traffic into account; ideally a regional cumulative effects assessment would take into account at minimum all direct and indirect shipping-related impacts, if not other sources of habitat degradation in the region and contribute to the 'death by a thousand cuts' of impacted species.

KNOWLEDGE & MANAGEMENT GAPS

This assessment served as a broad literature review of key ecological concerns for the assessed species, and a striking theme that arose during this process was the substantial knowledge gaps that currently exist for many of the species, both for the Salish Sea region specifically and in general. These knowledge gaps undoubtedly impacted the assessment results: as noted by King and Beazley, "a lack of affirmative response does not necessarily indicate that the species does not display the characteristic" (2005, p. 379). While the somewhat subjective nature of the assessment has bearing on the results, as does the use of published species accounts, databases, and other literature rather than expert opinions in conducting the assessment (these limitations are discussed in a later section), the assessment made clear that there were substantial gaps in the study and understanding of many species; such gaps could in turn have bearing on the ability of CEAs to effectively address shipping impacts on these species.

Chronic underwater noise and fish

The knowledge gap that was most evident from the assessment is to what degree fish are impacted by the underwater noise pollution created by vessels. Most research on chronic acoustic disturbance globally has focused on marine mammals, however concerns have recently been raised about the impact of underwater anthropogenic noise on fish, as sound is vital to the lives of many fish species: it facilitates functions such as communication, the detection of prey, predator avoidance, and understanding surroundings (Slabbekoorn et al., 2010). In a 2010 review, Slabbekoorn et al. noted that "all fish studied to date are able to hear sounds" and that "over 800 species from 109 families are known to produce sounds, while many more are suspected to do so" (2010, pp. 421-422). Research on the impacts of chronic noise on fish is limited — multiple reviews call for increased investigation into the topic to address this (e.g. Popper et al., 2003; Slabbekoorn et al., 2010; Peng et al., 2015) — and is complicated by the fact that there is a wide amount of variation across existing species in both the anatomy of fish ears and the process by which fish hear (Popper & Fay, 2011; Slabbekoorn et al., 2010). What research has been conducted, however, indicates that vessel noise could have a wide array of impacts on fish, including masking communication sounds (Codarin et al., 2009; Slabbekoorn et al., 2010), decreasing schooling ability, increasing stress levels, and altering behaviour (Popper et al., 2003; Slabbekoorn et al., 2010). Such impacts could be of consequence to feeding, predator-prey interactions, and overall fitness (Slabbekoorn et al., 2010).

This gap in knowledge means that whether the levels of chronic underwater noise from current and projected shipping traffic in the Salish Sea may have adverse impacts on the region's fish, including those assessed for this project, is currently unknown. There are 400 known fish species in British Columbia's waters (approximately 250 of which are found in the Salish Sea), and at present 22 are known to produces sounds; this includes rockfish and herring, which are known to communicate using sound to communicate[13] (Owens, 2017). Research on the impacts of chronic anthropogenic noise on fish are currently underway in the region, however there are early indications that species found in the Salish Sea may be detrimentally impacted by boat noise. A 2015 pilot study in a region just north of the Salish Sea found that boats can influence Pacific herring and juvenile salmon behaviour, though it was unclear whether this was due to the boat noise specifically or simply the boat's presence and movement through the water (van der Knapp, 2015). Research elsewhere has found that Atlantic herring and cod — taxonomically similar to their Pacific counterparts — show behavioural responses to boat noise (Slabbekoorn et al., 2010; Peng et al., 2015). A study conducted by the University of Victoria in coordination with the Department of Fisheries and Oceans is set to begin in 2018, with a focus on the impacts of underwater anthropogenic sound on Pacific salmon species.

This knowledge gap is important to highlight because, despite the uncertainty regarding how and to what degree fish are impacted by ship noise, the environmental impact assessments for at least two development proposals in the Salish Sea state that noise from the project-associated shipping would have no significant effects on fish

[13] In a recent article about fish communication in BC waters, a University of Victoria PhD student discussing the number of fish known to make sounds noted that "there are probably a lot more we don't know about" (Owens, 2017).

species in the region. The Roberts Bank assessment found the potential for project-related ship noise to cause injury and behavioural changes to be negligible, while the possibility of ship noise masking communication or increasing stress levels was not addressed:

> *"Potential effects of underwater noise were . . . considered to be negligible because noise associated with Project-associated marine vessel activity and future cumulative shipping activities would not exceed injury thresholds for fish species or the Pacific salmon species behavioural threshold. Further, while noise-induced behavioural changes are possible for Pacific herring, potential effects would be localized to within 20 metres of a container ship and of short duration (as the ship passes by) and are therefore not anticipated to affect the integrity of populations within the local assessment area" (Port Metro Vancouver, 2015, p. 11).*

Particularly notable is the assertion that behavioural effects would only occur while a ship passes within 20 meters of herring; conversely, the pilot project mentioned above found that the behavioural impact on Pacific herring lasted after exposure to boats, suggesting that the impact could be longer-term. Furthermore, while the Roberts Bank statement mentions cumulative shipping activities, the proponent did not actually carry out a cumulative effects assessment of ship noise on fish.

The Trans Mountain assessment was similarly limited, only addressing the potential for behavioural changes and noting the lack of data on the subject. Like the Roberts Bank assessment, Trans Mountain did not address the potential for increased stress levels and communication masking. The company's approach is summarized by the National Energy Board's report:

> *"Trans Mountain . . . did not conduct a detailed effects assessment on the potential impact of underwater noise produced by Project-related marine vessels on marine fish as there are no standard criteria or thresholds to assess these effects against and there is a lack of data and knowledge surrounding the effects of underwater noise on marine fish.*

Trans Mountain did acknowledge that underwater noise from Project-related marine vessels could potentially trigger behavioural responses by marine fish ranging from small temporary movements to large scale change displacements. However, Trans Mountain further stated that there is no evidence in the literature that vessel traffic will result in the large-scale displacement of fish or invertebrate populations from foraging, spawning, rearing or migrations areas, or will otherwise affect their distribution or abundance" (National Energy Board, 2016, p.339).

While both proponents acknowledged that short-term behavioural changes were possible, notably neither discussed the cumulative nature of these impacts, particularly when the total numbers of current and proposed ships navigating the region are taken into account. A marine biologist acting as an intervener in the Trans Mountain hearings noted that "although [large-scale] displacement has not occurred, short-term behavioural changes may accumulate, leading to long-term significant consequences" as gradual noise increases could lead to gradual and eventual large-scale changes in feeding and spawning locations over the long-term (National Energy Board, 2016).

While the statements can be critiqued in more detail (indeed, in the case of Trans Mountain they were by multiple interveners (see National Energy Board, 2016)), the key point to address is that the scarcity of research on the subject is either ignored (in the case of Roberts Bank), or this lack of information is presented as there being no evidence for significant negative effects.[14]

Population trends and structure

The assessment also highlighted how information is lacking on population status, trends, and structure for many of the assessed species, both specifically within the Salish Sea and in general; while there were numerous knowledge gaps of this sort across all taxa, a few key ones are highlighted here. First, the lack of information on population trends in the

[14] Thus 'absence of evidence' is being equated to 'evidence of absence' with regards to studies of chronic noise impacts on fish.

Salish Sea was particularly evident for assessed birds, including some that are listed as at-risk. This issue is highlighted in a study of marine bird abundance in the Salish Sea, noting that though population declines have become evident in marine birds globally, "relatively few investigations of marine bird populations have been conducted in the Salish Sea" despite it being an area of particular importance for nesting, migration, and wintering for numerous marine bird species (Bower, 2009, p. 9); therefore declines in location populations may not be detected. While this is an issue for species that are known to be of conservation concern already, such as the short-billed dowitcher, the red-breasted merganser, the pink-footed shearwater, and the red-necked phalarope, it is also troubling for species like the black oystercatcher that have a small population size and may be impacted by shipping and other anthropogenic threats, particularly if they play a key ecological role (like the black oystercatcher), or if the region hosts a globally or continentally significant population.

Population structure (e.g. the presence of multiple discrete stocks) and/or trends are also not well known for a number of the assessed species in at least part of the Salish Sea,[15] including those that are commercially or recreationally harvested, such as some rockfish (COSEWIC, 2007d; COSEWIC, 2008d; Essington et al., 2011; COSEWIC, 2013a), walleye Pollock (Gustavson et al, 2000, Essington et al., 2011), some salmon populations (Price et al, 2017), and some shellfish (Dethier, 2006). In some cases population information is only gleaned through fisheries landings; for species in this assessment this is particularly the case for commercially harvested invertebrates in Washington State, where fisheries-independent population trends and statuses are largely lacking for highly commercially valuable species like the geoduck clam and the Dungeness crab (Dethier, 2006). As harvest rates can vary based on harvest effort, stable or increasing harvests do not necessarily indicate stable populations. Trends in abundance and distribution of kelp (particularly giant kelp and bull kelp) and eelgrass beds throughout the Salish Sea are also not well known (Mumford, 2007; Essington et al., 2011). There is anecdotal evidence of substantial declines in some regions, and there are now ongoing efforts throughout the region to survey and map kelp and eelgrass

[15] This variability reflects differences in management between jurisdictions and management areas.

abundance, however with limited long-term data to provide adequate baselines against which to compare present-day distribution understanding long-term trends is challenging (Mumford, 2007; Essington et al., 2011).

Ecological importance

This focal species assessment also highlighted how the ecological roles — and thus ecological importance — of many of the assessed species are currently not well understood. Examples include the bluntnose sixgill shark (COSEWIC, 2007a), the North Pacific spiny dogfish (COSEWIC, 2011c), the harbour porpoise (COSEWIC, 2016b), the geoduck clam, and the California sea cucumber (Dethier, 2006). For some of these species a level of ecological importance is suspected or starting to be unravelled: the bluntnose sixgill shark is thought to be the top predator in continental shelf ecosystems globally (COSEWIC, 2007a), and the yelloweye rockfish is thought to play a key role in structuring nearshore rocky ecosystems (COSEWIC, 2008c), while a recent study of top-down and bottom-up trophic control in Puget Sound found that the spiny dogfish shows some keystone predator characteristics by exerting strong top-down trophic control in the Puget Sound marine food web (Harvey et al., 2012). The challenge is identifying these strongly interacting species before they are lost from a system: it is much easier to identify species as keystones once they are lost from a system than it is to identify them *a priori* (e.g. Power et al., 1996; Mittelbach, 2012). A key species that needs to be further investigated in this regard is the Pacific herring, which is known to be a key ephemeral resource for birds (and many other species) (e.g. Schweigert et al., 2010), however the degree to which populations rely on this pulse of nutrients has not been fully elucidated (e.g. Rodway et al., 2003) particularly for species that live in the transitional zone between marine and terrestrial systems (Fox et al., 2015).

Thresholds and critical habitat

A critical management gap is the lack of established species-specific thresholds for acceptable levels of disturbance or impact; a striking example is the lack of chronic underwater noise thresholds set in regulations or policies to limit impacts on marine mammals. While the EU's Marine Strategy Framework Directive has set "good conservation status" limits for ambient underwater noise, Canada has not yet established formal thresholds or acceptable limits of change, despite "stat[ing] qualitatively that critical habitats of acoustically sensitive species should incorporate acoustic attributes" (Erbe, et al., 2012). Species with critical habitat in the Salish Sea and for which chronic underwater noise is a known threat include the southern resident killer whales and North Pacific humpback whales (COSEWIC, 2008b; COSEWIC, 2011b). While more difficult to establish due to research gaps and uncertainty, behavioural impact thresholds have also not been established for fish species; Roberts Bank and Trans Mountain responded to this differently, with the former setting a threshold for all fish species based on one study (Port Metro Vancouver, 2015), while the latter simply stated that setting a threshold was not currently possible (National Energy Board, 2016).

Additionally, critical habitat has not yet been established for some of the species of conservation concern. Lengthy delays in establishing critical habitat is a particular issue for species listed in Canada under SARA (as opposed to those listed in the US under the Endangered Species Act): as of 2014 critical habitat had been identified for only 56 of 221 COSEWIC-listed species that required it (i.e. those listed as endangered or threatened) (Favaro et al., 2014). As critical habitat once defined must be protected, and actions that degrade or destroy critical habitat should be avoided (DFO, 2016a), delays in critical habitat designation for a species impacted by shipping in a region with proposed shipping increases represents a key management gap. For instance, when the marine critical habitat of the marbled murrelet is defined it will probably include part of the Salish Sea (BC Nature & Nature Canada, 2015).

FRAMEWORK: Lessons & limitations

The original intent of King and Beazley's framework was to identify focal species to be used in the design of MPA networks, however they recognized that it may be more broadly applicable, noting that it is "of potential utility for other marine management considerations" (2005, p. 374). A secondary objective of this project was therefore to test the utility of this framework in the context of focal species for a regional cumulative effects assessment. The goal in both cases is similar: to identify key vulnerable and ecologically important (and in the case of this project also culturally important) species in a region that should gain additional conservation attention. For the original framework, conservation would be in the form of MPA networks that protect the identified species, while for this project conservation would come from assessing the impacts of shipping on the identified species with the goal of ensuring cumulative effects do not exceed an acceptable level. Similar to its original use in King and Beazley, in the context of this project the framework is limited but it does show promise in helping to guide or structure the selection of focal species, in particular for fish, birds, and mammals. It provides a level of methodical guidance in species selection that may be missing in current project-level EA practice (e.g. Bérubé, 2007; Ball et al., 2012; Olagunju & Gunn, 2015), and it provides a systematic template of some key qualitative characteristics that would help justify and be valuable to consider in the selection of focal species.

There are limitations to the framework, however, some of which were pointed out by King and Beazley. Though the framework is systematic, the qualitative nature of the assessment means a level of subjectivity comes into play when determining whether or not a species displays each characteristic. This is especially the case for characteristics such as long-distance migrations, long-lived, large-bodied, and charismatic which require judging species relative to each other more so than characteristics such as reduced or declining population and commercially or recreationally harvested. For this project gauging species relative to others within their taxonomic group partially minimized this problem: for instance, large-bodied has a different meaning for invertebrates than for mammals. Focusing on gathering species information from conservation reports and databases also helped to minimize subjectivity as these sources have a similar structure (e.g. COSEWIC reports tend to have a template of what information is included) and because these sources are essentially reviews they are inclined to contain information that has become widely accepted by researchers in that field. As noted by King and Beazley, this subjectivity would be decreased by having several experts in the regional ecology of the Salish Sea provide input into the assessment: "ideally, several experts would independently complete the [framework], and the determination of whether certain species display the characteristics would subsequently be made on the basis of combined wisdom" (2005, p. 374). This limitation could also be addressed through a numerical ranking system when suitable: for example, if a species is a highly valuable commercially harvested species it would ranked higher for that characteristic than a species that is subject to a small or limited commercial fishery. This concept was put to use in this project for the characteristic "sensitive to disturbance or stress from threats posed by shipping with in the Salish Sea," as it quickly became clear in the process of the assessment that whether and how some aspects of shipping adversely impact species or taxonomic groups has not been sufficiently studied. Most notable is the issue of vessel noise impacts on fish, as discussed previously. A ranking system would also be able to account for differences in how vulnerable species are to the range of shipping-related stressors. For instance, oil spills, ship strikes, and noise were identified in the assessment as key threats to humpback whales, while oil spills, while oil was identified as the primary shipping-related threat to many marine birds.

Qualitative characteristics

The authors also note that the 20 characteristics they used when presenting and testing the framework (which were the basis for the ones used in this project) were drawn from over 30 qualitative characteristics commonly used in the identification of terrestrial focal species, and that which characteristics were selected was somewhat subjective and could impact the results. Since using a larger number of characteristics would make it less manageable, they chose to narrow the list to 20 characteristics, and in the process excluded some that were less relevant to MPA network creation but may be relevant to the cumulative effects of shipping. For a first test of the framework in the context of shipping in the Salish Sea it was useful to remain close to the suite of characteristics established by King and Beazley, so that their example assessment could serve as a guide — however this meant not including characteristics that may have been valuable for this project, such as species' susceptibility to pollution or ability to bioaccumulate pollution (King & Beazley, 2005). Revisiting these excluded factors could be beneficial in making the assessment framework more effective for this project's objectives. The authors also note how the way in which characteristics are organized could have bearing on the assessment results. For instance, they grouped related keystone characteristics proposed in the literature — such as ecosystem engineer and keystone predator or prey — into two main categories of 'critical to maintaining community organization and diversity' and 'functionally important predator, prey, plank, link or modifier' (King & Beazley, 2005, p. 373). Not grouping these characteristics together could potentially impact some of the results; for example, Chinook salmon are the primary prey of the southern resident killer whales and are also a key link in the transfer of marine nutrients to coastal terrestrial habitats due to their anadromous life cycle and post-spawning death (e.g. Cederholm et al., 2000; Lacy et al., 2017), yet these roles are grouped into one characteristic.

King and Beazley recommended that their set of characteristics and other alternative sets "should be reviewed by marine experts, applied experimentally, and compared and rigorously assessed to identify the most effective subset(s) of characteristics for selecting focal species . . . for particular regions" (2005, p. 373). The test of the framework for this project contributes to that objective, as it showed how the set of characteristics could be tweaked to better account for specific considerations or issues within a region. For example, 'long distance migrations,' an attribute of sensitive species, is more effective in this context if the Salish Sea is also identified as an important stopover point during migration, at which point the species may be more vulnerable to shipping impacts than non-migratory species due to the energetic demands of migration (King & Beazley, 2005). Additionally, the set of characteristics could be altered to give the assessment a more ecosystem-based approach by accounting for potential indirect impacts of shipping, such as impacts on habitat and prey. While the assessment accounted for species' reliance on specific habitats and resources (through 'habitat association' and 'dependent on limited resources'), only direct shipping impacts on a species were included unless an indirect impact was explicitly stated in the literature — for example, oil spills and chronic oiling indirectly impact peregrine falcons by decreasing the availability of seabirds, their key prey (Zuberogoitia et al, 2006; COSEWIC, 2007c; BC Nature & Nature Canada, 2014). Without taking indirect impacts into account, impacts on upper trophic levels such as bioaccumulation of hydrocarbons, loss of prey, and loss of juvenile habitat may not be captured in the assessment.

Taxonomic bias

Another limitation of this framework in its current form is that it is more applicable to animals than to seaweeds and seagrasses. To complete the assessment for this project some characteristics were not applicable (such as 'long-distance migrations') while others needed to be reinterpreted to be more applicable to marine vegetation: for example, 'congregates in large groups' was checked off for species that form large patches in which they are the dominant species (e.g. eelgrass beds); 'low fecundity' meant slow-growing species; and 'reduced or declining population' meant that the extent of shoreline coverage by these species was reduced or declining. The framework could be altered to include characteristics that would be more applicable for seaweeds and seagrasses; this could include differentiating between opportunistic species and equilibrium species, and identifying species that are susceptible to water quality degradation.

Excluded species

It is also important to note that the 94 species used in this assessment were narrowed down from a substantially larger list. While limiting the list was necessary, it meant that the assessment largely focused on species that are already listed as at-risk or known to be of ecological importance, and therefore are relatively more well-studied. Consequently, a number of species that may also be vulnerable to shipping impacts were excluded because they are currently candidate species for at-risk assessment, or because they do not rely as heavily or directly on the marine environment in the Salish Sea. This latter point is especially important as species do not necessarily need to be highly dependent on the marine environment or region to be adversely impacted by shipping; for instance fin whales are only rarely sighted within the region, however the Pacific population is thought to be below 50% of historic levels, and ship strikes and acoustic disturbance are key threats (Douglas et al., 2008; Laist et al. 2001; Williams & O'Hara, 2010), indicating that impacts from shipping in the Salish Sea could still be significant.[16] Species that are

[16] One exception to this is grizzly bears, which on the Pacific Coast are highly reliant on salmon taken from streams during spawning season, so much so that salmon availability has been linked to grizzly bear productivity (e.g. Cederholm et al., 2000; COSEWIC, 2012c). Grizzlies were excluded from the assessment because of this close association as impacts on grizzlies from shipping would be indirect via impacts on salmon.

reduced or declining but are not yet listed were also not captured in this assessment, unless they were otherwise identified as ecologically or culturally important.

MANAGEMENT PRIORITIES AND RECOMMENDATIONS

The failure of proponent-led, project-level environmental assessments to adequately address cumulative effects of development projects has been examined and critiqued by academics and practitioners for a number of years (e.g. Baxter et al., 2001; Duinker & Greig, 2006; Harriman & Noble, 2008; Sinclair et al., 2016), and the recent EA Review Panel provided a platform to advance these discussions and produce concrete policy recommendations; accordingly, addressing cumulative effects at a regional level is a key feature of the subsequent EA Review Panel Report (Expert Panel, 2017). At the same time, the high-profile Trans Mountain project has raised the issue of how shipping from this and other development projects may adversely impact the Salish Sea ecosystem, thus sparking local interest in how to adequately address the impacts all commercial shipping in the region cumulatively (Friends of the San Juans, 2016; Woodsworth, 2016; Ross Dixon, personal communication). A major concern in the current process of project-level EA and CEA is the need to improve the selection and evaluation of species used as VECs or VEC indicators in assessments: the issues with the current system are illustrated by the Trans Mountain NEB review, where the assessment choices of the proponent (via contractors) were questioned and critiqued in detail by numerous government, non-government, and academic experts (BC Nature & Nature Canada, 2014; National Energy Board, 2016).

This research sought to explore how a systematic focal species framework could help address this issue, and guide an improved assessment of cumulative shipping effects; more broadly, it also explored the issue of cumulative shipping effects in the Salish Sea in general, and how key species for conservation, ecosystem function, and Coast Salish culture may be impacted by the cumulative effects of shipping. The results of the assessment indicated that shipping activities in the Salish Sea have the potential to directly impact numerous species that are of conservation concern, ecological importance, and/or cultural importance, from a variety of taxa, and that a number of relevant research gaps exist, thus supporting the overarching need to better address the cumulative shipping impacts. Therefore, while testing the focal species framework and developing a suite of focal species was a key objective of this research, the following recommendations relate to both the results of the focal species assessment and the broader issue of cumulative shipping effects explored throughout this research. Addressing the broader issue is especially important as improving VEC and indicator scoping is of limited value if cumulative effects continue to only be addressed at the project-level rather than regionally.

USE A FOCAL SPECIES APPROACH TO GUIDE AN ECOSYSTEM-BASED ASSESSMENT

The focal species assessment provided suggestions of key species that could be considered in a cumulative effects assessment of shipping in the Salish Sea. Furthermore, the numerous high-ranking species (overall and within taxonomic groups), the key habitats, and the indirect impacts that emerged from the assessment highlighted the importance of also taking an ecosystem-based approach to assessments. While the framework adapted from King and Beazley (2005) could be further modified and improved to be more relevant to the region and the issue, this test suggests that it has utility in structuring the selection of focal species by focusing an assessment on the key ecological, cultural, and most vulnerable elements of an ecosystem. It is limited, however, and needs to be combined with more rigorous approaches that use quantitative and field-based data. Nevertheless, using a methodical, multi-taxa focal species identification tool such as this could help structure an ecosystem approach to assessing the cumulative impacts of shipping on VECs and VEC indicators, while still utilizing the surrogate species approach that is seen as necessary to focus environmental assessments. Once key species are identified, assessments should examine how direct and indirect effects on that species could have cascading impacts in the ecosystem. This echoes an article by Simberloff, "Is single-species management passé in the landscape era?" in which he asserted that management that merges surrogate species and ecosystem management could benefit from the best of both approaches (1998).

FORM A CEA PANEL FOR SHIPPING IN THE SALISH SEA

This research highlighted the need to involve independent (i.e. not proponent-contracted) regional experts in the scoping stage for cumulative effects assessments, including the selection of species as VECs and indicators. While simply giving independent experts a role in scoping would be an improvement upon the current system, it would be more effective and efficient if this was undertaken as part of a full regional cumulative effects assessment of shipping. Notably this echoes the recommendations of the EA Review Panel; however even if the EA Review Panel's recommendations are fully implemented in an updated Canadian Environmental Assessment Act they will only legally apply to areas of federal jurisdiction in Canada (Expert Panel, 2017).[17] A panel that involves all jurisdictions within both Canada and the United States, including Indigenous governments, would therefore be necessary in order to properly address cumulative shipping impacts. This panel could collectively conduct a regional CEA of shipping independently of any particular project; in doing so it would lay the groundwork for project-level assessments, therefore streamlining the process for project proponents while leading to a more thorough review of a project's shipping impacts within the regional context.

This panel would be facilitated by an overall regional impact assessment driven by the EA Panel's recommendations (if implemented) —and in turn the regional assessment would benefit from the panel's findings regarding shipping — however the creation of this panel would not be dependent on this, as current federal EA legislation allows for regional assessments (though this option has not been utilized under the current Canadian Environmental Assessment Act) (Expert Panel, 2017). While the international nature of the region and the issue provide an additional challenge, cross-border CEA is not unprecedented. An example of effective multi-jurisdictional cooperation between Canada and the United States in conducting a regional CEA comes from The Crown of the Continent ecosystem — an area of the Rockies divided by the borders between BC, Alberta, and Montana, and composed of federal, provincial, state,

[17] Notably, the Panel did emphasize the importance of cooperating with other jurisdictions within a region in order to increase the effectiveness of the assessment (Expert Panel, 2017).

Indigenous, private, and municipal lands and protected areas — provides an example of effective multi-jurisdictional cooperation between Canada and the US in conducting a regional CEA. Management cooperation in the region was specifically driven by concerns about the cumulative effects that were being observed by land managers in BC, Alberta, and Montana (Gunn & Noble, 2009b). The result of this cooperation is the Transboundary Crown of the Continent Managers Partnership, which guides more than 20 government agencies and has been active since 2001. This partnership could provide a template for a similar shipping-specific partnership in the Salish Sea. Furthermore, Canada is a signatory to the UN Espoo Convention on Environmental Impact Assessment in a Transboundary Context, which provides guidance on conducting strategic environmental assessments across international borders (Woodsworth, 2016). Existing cross-border cooperation on ecological matters in the Salish Sea could help facilitate this CEA panel, including the collaborative agreement between the EPA and Environment and Climate Change Canada on addressing ecological issues within the region (US EPA & ECCC, 2017).

ADDRESS CRITICAL KNOWLEDGE GAPS

While "more research is needed" could likely be said about all aspects of the Salish Sea ecosystem — knowledge gaps even exist for the southern resident killer whales, known as the most well-studied orcas in the world — there are key research gaps that should be addressed in order to gain a better understanding of the cumulative effects of shipping in the region. The regional shipping CEA panel would provide a platform from which knowledge and management gaps are identified, and from that regional research priorities could be set.

This project highlighted some of the gaps that should be addressed. First, the impacts of shipping on fish populations must be investigated; while recent and upcoming research programs are examining the impact on some species, the fact that it has been identified as a research gap of global concern indicates that it deserves greater research attention, particularly in busy shipping regions (e.g. Slabbekoorn et al., 2010).

Second, uncertainty regarding population trends of key species should be addressed so that population declines are caught before a species is imperilled enough to require at-risk listing, to ensure that timely conservation action is taken. This is particularly important in light of a recent study which found that at-risk listing under SARA is not associated with recovery (Favaro et al., 2014). Furthermore, any existing research gaps in population structure should also be addressed, in order to understand the vulnerability of discrete and potentially isolated populations and whether the rescue effect could play a role in the recovery of impacted populations (e.g. in the event of a catastrophic oil spill). For example, distinct populations of some species in the Salish Sea have only recently been identified, and there are indications that these populations are relatively isolated.

Third, identifying and understanding the ecological roles played by species, particularly those already at-risk, should be considered a priority in order to ensure that populations of species that play significant roles in structuring ecosystems do not decline to the point where their loss could have cascading impacts on the ecosystem. This is especially salient as scientists are increasingly recognizing the need to preserve functional diversity as well as species diversity in order to fully maintain ecological integrity and ecosystem services (Cadotte, Carscadden, & Mirotchnick, 2011). Focusing research on ecological roles and interactions can help identify key species or functional groups a priori: for example, a food web model developed for Puget Sound identified a number of species and guilds that potentially play keystone roles in Central Puget Sound through direct and indirect effects (Harvey et al., 2012). The study also examined the food web effects of direct and indirect fishing impacts; potentially a similar study could be conducted with shipping impacts as the anthropogenic stressor.

IMPLEMENT THE PRECAUTIONARY APPROACH

Incomplete knowledge of how human activities interact with ecosystems and each other to cause cumulative impacts means cumulative effects assessments will include some level of uncertainty. This uncertainty should be addressed using the precautionary principle, which in resource management calls for caution "when scientific information is uncertain, unreliable or inadequate" (DFO, 2009), as well as not letting the lack of scientific certainty or evidence be a reason for delay in taking action when there is potential for serious or irreversible environmental degradation (ECCC, 2017). Applying the precautionary approach to cumulative effects management includes establishing conservative or low-risk thresholds particularly where uncertainty exists (Duinker & Greig, 2006); assessing a range of alternative future development scenarios (already an integral part of regional CEAs); and erring on the side of caution where uncertainty exists regarding the magnitude of impacts, a species' or VEC's response to impacts, or the current state of a species or VEC (Clarke Murray et al., 2014).

Given the critical knowledge gaps and scientific uncertainty regarding shipping impacts on key species — such as those assessed here that are of conservation concern and ecologically and/or culturally important — the precautionary principle should be a central guiding policy for the cumulative shipping effects panel, as well as subsequent project-level assessments (Westwood et al., 2017). Approval of projects that increase the current level of shipping, such as the Trans Mountain project, when there are relevant critical knowledge gaps runs counter to the precautionary principle; issues of particular importance in this regard include uncertainty in how fish are impacted by chronic underwater noise, and population trends, distribution, and baseline conditions of key focal species. Clear procedures for the application of the precautionary principle should also be established where management gaps exist, including a lack of established thresholds and critical habitat. While these gaps may exist in part due to research gaps or scientific uncertainty, in some cases conservative measures based on current research or best practices could be implemented while uncertainty is addressed (e.g. applying the EU's "good conservation status" limits). Notably both Canada and the United States are committed to implementing the precautionary principle in resource management in international agreements as well as national policies, including in marine environments. Furthermore, the precautionary principle is listed by the Canadian Environmental Assessment Agency as a guiding principle for assessing the impacts of projects on biodiversity (CEAA, 2016b), however previously discussed examples from the Trans Mountain and Roberts Bank assessments indicate that it is not actually being applied.

CONCLUSION

Project-level, proponent-led environmental assessments are not well-placed to sufficiently address the ongoing and potential future cumulative impacts of shipping in the Salish Sea, in particular the incremental impacts that are considered negligible at the project level. A regional cumulative effects assessment is therefore necessary to fully understand and subsequently mitigate the current and potential adverse ecological impacts of shipping in the region, especially given the large increase in ship traffic that would result if all proposed shipping-associated development projects are approved. This could be accomplished through a cross-boundary, multi-jurisdictional panel responsible for assessing the cumulative effects of shipping in the region; in the process of doing so, it would lay the groundwork for future project-level environmental assessments, thus improving the effectiveness and efficiency of these assessments (Expert Panel, 2017). This panel would also provide a platform to identify and address critical knowledge and management gaps relevant to regional shipping, and to ensure that the precautionary principle is applied accordingly. Furthermore, such a panel would be well-placed to address the need for improvement in the selection and evaluation of species as VECs and VEC indicators, potentially by utilizing a more systematic approach to species selection. While limited by its qualitative nature, the focal species framework tested in this project provides suggestions of potential candidate species for a regional CEA of shipping, and demonstrates how such a tool could be useful in structuring the selection of species around an ecosystem-based approach.

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APPENDICES

Appendix A: Complete results from the focal species assessment

The following tables contain the full results of the focal species assessment. Due to the large size of the tables, they are split into two parts: the first (Table 7) contains twelve focal species characteristics (for keystone/functionally important, umbrella, sentinel/indicator, charismatic/cultural, and vulnerable), and the second (Table 8) contains ten characteristics (for sensitive species) and the total score for each species. Sources for the assessment are listed in Appendix C.

Table 7. Part one of the focal species assessment framework for all 94 assessed species. (✓ = species displays characteristic; E = there is some evidence for shipping impacts on that species). Modified from King and Beazley (2005).

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Sensitive to other anthropogenic impacts	Presence = pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish Species	Listed (federal, provincial, or state)	Reduced or declining population
Birds													
Western grebe	*Aechmorphus occidentalis*					✓	✓		✓			✓	✓
Great blue heron	*Ardea herodias fannini*				✓		✓		✓		✓	✓	✓
Lesser scaup	*Aythya affinis*						✓			✓			✓
Greater scaup	*Aythya marila*									✓			✓
Marbled murrelet	*Brachyramphus marmoratus*				✓	✓	✓	✓	✓			✓	✓
Brant	*Branta bernicla*				✓		✓	✓	✓			✓	✓
Common goldeneye	*Bucephala clangula*					✓	✓			✓	✓		✓
Barrow's goldeneye	*Bucephala islandica*					✓	✓			✓	✓		
Western sandpiper	*Calidris mauri*				✓	E	✓						
Long-tailed duck	*Clangula hyemalis*					✓				✓	✓	✓	✓
Peregrine falcon	*Falco peregrinus*				✓	✓	✓		✓	✓		✓	✓
Tufted puffin	*Fratercula cirrhata*					✓	✓	✓	✓			✓	✓
Red-throated loon	*Gavia stellata*					✓	✓	✓			✓		✓
Black oystercatcher	*Haematopus bachmanii*	✓			✓	✓	✓	✓	✓				
Bald eagle	*Haliaceetus leucocephalus*		✓				✓		✓		✓		
Harlequin duck	*Histrionicus histrionicus*				✓	✓	✓			✓	✓		
Caspian tern	*Hydroprogne caspia*					✓	✓					✓	
California gull	*Larus californicus*					E	✓					✓	✓
Glaucous-winged gull	*Larus glaucescens*					E	✓						✓
Short-billed dowitcher	*Limnodromus griseus*					✓	✓					✓	✓
Black scoter	*Melanitta nigra*					✓	✓			✓	✓	✓	✓
Surf scoter	*Melanitta perspicillata*					✓	✓			✓	✓	✓	✓
Red-breasted merganser	*Mergus serrator*					✓	✓				✓		
Brandt's cormorant	*Phalacrocorax penicillatus*				✓	✓	✓					✓	✓
Red-necked phalarope	*Phalaropus lobaus*				✓	✓	✓					✓	

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Sensitive to other anthropogenic impacts	Presence = pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish Species	Listed (federal, provincial, or state)	Reduced or declining population
Pelagic cormorant	*Phalocrocorax pelagicus subsp. pelagicus*					✓	✓					✓	✓
Horned grebe	*Podiceps auritus*					✓	✓					✓	✓
Sooty shearwater	*Puffinus griseus*					✓	✓						✓
Pink-footed shearwater	*Puffinus creatopus*					✓	✓					✓	✓
Ancient murrelet	*Synthliboramphus antiquus*		✓		✓	✓	✓		✓			✓	✓
Wandering tattler	*Tringa incana*											✓	
Common murre	*Uria aalge*					✓	✓				✓	✓	✓
Fish													
Pacific herring	*Clupea pallasi*	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Pacific cod	*Gadus macrocephalus*			✓		E	✓			✓		✓	✓
Bluntnose sixgill shark	*Hexanchus griseus*			✓	✓		✓					✓	
Pacific hake	*Merluccius productus*		✓			E	✓			✓		✓	✓
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*	✓	✓	✓	✓	E	✓		✓	✓		✓	✓
Pink salmon	*Oncorhynchus gorbuscha*	✓	✓	✓	✓	E	✓		✓	✓	✓		✓
Chum salmon	*Oncorhynchus keta*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓
Coho salmon	*Oncorhynchus kisutch*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓
Steelhead trout	*Oncorhynchus mykiss*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓
Sockeye salmon	*Oncorhynchus nerka*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓
Chinook salmon	*Oncorhynchus tshawtscha*	✓	✓	✓	✓	E	✓		✓	✓	✓	✓	✓
Rougheye rockfish	*Sebastes aleutianus*					E	✓			✓		✓	
Brown rockfish	*Sebastes auriculatus*				✓	E	✓			✓		✓	✓
Copper rockfish	*Sebastes caurinus*				✓	E	✓			✓		✓	✓
Greenstriped rockfish	*Sebastes elongatus*					E	✓			✓		✓	
Widow rockfish	*Sebastes entomelas*					E	✓			✓		✓	✓
Yellowtail rockfish	*Sebastes flavidus*					E	✓			✓		✓	✓
Quillback rockfish	*Sebastes maliger*				✓	E	✓			✓		✓	✓
Black rockfish	*Sebastes melanops*					E	✓			✓		✓	✓
China rockfish	*Sebastes nebulosus*				✓	E	✓			✓		✓	✓
Tiger rockfish	*Sebastes nigrocinctus*				✓	E	✓			✓		✓	✓

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Sensitive to other anthropogenic impacts	Presence = pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish Species	Listed (federal, provincial, or state)	Reduced or declining population
Bocaccio rockfish	*Sebastes paucispinis*				✓	✓	✓			✓		✓	✓
Canary rockfish	*Sebastes pinniger*				✓	E	✓			✓		✓	✓
Puget Sound rockfish						E	✓			✓			
Redstripe rockfish	*Sebastes proriger*					E	✓			✓		✓	
Yelloweye rockfish	*Sebastes ruberrimus*		✓		✓	E	✓			✓		✓	✓
North Pacific spiny dogfish	*Squalus suckleyi*		✓	✓			✓			✓		✓	
Eulachon	*Thaleichthys pacificus*					E	✓	✓		✓	✓	✓	✓
Walleye pollock	*Theragra chalcogramma*					E	✓			✓		✓	✓
Seaweeds & Seagrasses													
Wing kelp	*Alaria marginata*		✓			✓	✓			✓	✓		
Feather boa kelp	*Egregia menzisii*	✓	✓			✓	✓						
Rockweed	*Fucus distichus*	✓	✓			✓	✓				✓		
Giant kelp	*Macrocystis pyrifera*	✓	✓			✓	✓			✓			✓
Bull kelp	*Nereocystis luetkeana*	✓	✓			✓	✓			✓	✓		✓
Nori	*Porphyra spp.*									✓	✓		
Sea lettuce	*Ulva lactuca*									✓	✓		
Eelgrass	*Zostera marina*	✓	✓		✓	✓	✓	✓			✓		✓
Invertebrates													
Edward's beach moth	*Anarta edwardsii*				✓	E	✓	✓				✓	✓
Sand-verbena moth	*Copablepharon fuscum*				✓	E	✓	✓				✓	✓
Northern (pinto) abalone	*Haliotis kamtschatkana*				✓		✓		✓	✓	✓	✓	✓
Native littleneck clam	*Leukoma staminea*					✓	✓			✓	✓		
Dungeness crab	*Metacarcinus magister*			✓		✓	✓			✓	✓		
Mussels	*Mytilus sp.*		✓			E				✓	✓		
Olympia oyster	*Ostrea conchaphila*		✓		✓	E	✓			✓	✓	✓	✓
Spot prawn	*Pandalus platyceros*					E				✓	✓		
Geoduck clam	*Panopea generosa*					E	✓			✓	✓		✓
California sea cucumber	*Parastichopus californicus*									✓	✓		

Common name	Scientific name	Critical to community organization and diversity	Functionally important	Large amounts of habitat or several specific habitats	Established habitat association	Impacted by shipping threats in Salish Sea	Sensitive to other anthropogenic impacts	Presence = pristine or undisturbed habitat	Charismatic	Harvested commercially or recreationally	Coast Salish Species	Listed (federal, provincial, or state)	Reduced or declining population
Ochre star	*Pisaster ochraceus*	✓				E			✓				✓
Butter clam	*Saxidomus gigantea*					E				✓	✓		
Red urchin	*Strongylocentrotus fraciscanus*		✓		✓	E				✓	✓		
Mammals													
Sea otter (northern)	*Enhydra lutris kenyoni*	✓			✓	✓	✓		✓			✓	✓
Gray whale	*Eschrichtius robustus*			✓	✓	✓	✓		✓		✓	✓	✓
Steller sea lion	*Eumetopias jubatus*			✓	✓	✓	✓	✓	✓			✓	
Humpback whale	*Megaptera novaeangliae*			✓	✓	✓	✓		✓			✓	✓
Northern elephant seal	*Mirounga angustirostris*					E						✓	
Killer whale (SRKW)	*Orcinus orca*			✓	✓	✓	✓		✓		✓	✓	✓
Killer whale (NRKW)	*Orcinus orca*			✓	✓	✓	✓		✓		✓	✓	
Killer whale (transient)	*Orcinus orca*			✓		✓	✓		✓		✓	✓	
Killer whale (offshore)	*Orcinus orca*			✓		✓	✓		✓		✓	✓	
Harbour seal	*Phoca vitulina*				✓	✓	✓		✓				
Harbour porpoise	*Phocoena phocoena*				✓	✓	✓		✓			✓	
Reptiles													
Leatherback sea turtle	*Dermochelys coriacea*					✓	✓		✓			✓	✓

Table 8. Part two of the focal species assessment framework for all 94 assessed species (✓ = species displays characteristic; E = there is some evidence for shipping impacts on that species). Modified from King and Beazley (2005).

Common name	Scientific name	Low genetic variation	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments in Appendix B)	**Total number of affirmative responses**
Birds												
Western grebe	*Aechmorphus occidentalis*	✓			✓	✓						**8**
Great blue heron	*Ardea herodias fannini*				✓	✓		✓	✓	✓		**11**
Lesser scaup	*Aythya affinis*					✓		✓			✓	**6**
Greater scaup	*Aythya marila*					✓		✓				**4**
Marbled murrelet	*Brachyramphus marmoratus*		✓	✓	✓			✓		✓		**12**
Brant	*Branta bernicla*				✓	✓	✓	✓			✓	**11**
Common goldeneye	*Bucephala clangula*							✓				**6**
Barrow's goldeneye	*Bucephala islandica*							✓			✓	**6**
Western sandpiper	*Calidris mauri*				✓	✓	✓				✓	**6E**
Long-tailed duck	*Clangula hyemalis*					✓		✓				**7**
Peregrine falcon	*Falco peregrinus*	✓		✓	✓					✓		**11**
Tufted puffin	*Fratercula cirrhata*			✓	✓			✓		✓		**10**
Red-throated loon	*Gavia stellata*			✓			✓					**7**
Black oystercatcher	*Haematopus bachmanii*			✓		✓		✓		✓	✓	**11**
Bald eagle	*Haliaceetus leucocephalus*			✓				✓	✓	✓		**8**
Harlequin duck	*Histrionicus histrionicus*		✓		✓	✓		✓		✓	✓	**11**
Caspian tern	*Hydroprogne caspia*					✓		✓		✓		**6**
California gull	*Larus californicus*					✓		✓				**5E**
Glaucous-winged gull	*Larus glaucescens*					✓		✓		✓		**5E**
Short-billed dowitcher	*Limnodromus griseus*						✓					**5**
Black scoter	*Melanitta nigra*					✓		✓			✓	**9**
Surf scoter	*Melanitta perspicillata*				✓	✓		✓			✓	**10**
Red-breasted merganser	*Mergus serrator*											**3**
Brandt's cormorant	*Phalacrocorax penicillatus*					✓		✓	✓	✓		**9**
Red-necked phalarope	*Phalaropus lobaus*					✓	✓					**6**

Common name	Scientific name	Low genetic variation	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments in Appendix B)	**Total number of affirmative responses**
Pelagic cormorant	*Phalocrocorax pelagicus subsp. pelagicus*							✓	✓			**6**
Horned grebe	*Podiceps auritus*										✓	**5**
Sooty shearwater	*Puffinus griseus*			✓			✓	✓				**6**
Pink-footed shearwater	*Puffinus creatopus*			✓			✓	✓				**7**
Ancient murrelet	*Synthliboramphus antiquus*			✓	✓							**9**
Wandering tattler	*Tringa incana*						✓					**2**
Common murre	*Uria aalge*			✓		✓		✓			✓	**9**
Fish												
Pacific herring	*Clupea pallasi*					✓				✓		**12**
Pacific cod	*Gadus macrocephalus*			✓		✓			✓	✓		**9E**
Bluntnose sixgill shark	*Hexanchus griseus*							✓	✓	✓		**7**
Pacific hake (Pacific-Georgia Basin)	*Merluccius productus*			✓		✓				✓		**8E**
Coastal cutthroat trout	*Oncorhynchus clarkii clarkii*		✓			✓	✓		✓			**13E**
Pink salmon	*Oncorhynchus gorbuscha*					✓	✓		✓			**12E**
Chum salmon	*Oncorhynchus keta*					✓	✓		✓			**13E**
Coho salmon	*Oncorhynchus kisutch*					✓	✓		✓			**13E**
Steelhead trout	*Oncorhynchus mykiss*					✓	✓		✓			**13E**
Sockeye salmon	*Oncorhynchus nerka*					✓	✓		✓			**13E**
Chinook salmon	*Oncorhynchus tshawtscha*					✓	✓		✓		✓	**14E**
Rougheye rockfish	*Sebastes aleutianus*			✓				✓	✓	✓		**7E**
Brown rockfish	*Sebastes auriculatus*			✓				✓		✓		**8E**
Copper rockfish	*Sebastes caurinus*			✓				✓	✓	✓	✓	**10E**
Greenstriped rockfish	*Sebastes elongatus*			✓				✓		✓	✓	**7E**
Widow rockfish	*Sebastes entomelas*			✓				✓		✓		**7E**
Yellowtail rockfish	*Sebastes flavidus*			✓		✓		✓	✓	✓		**9E**
Quillback rockfish	*Sebastes maliger*			✓				✓	✓	✓	✓	**10E**
Black rockfish	*Sebastes melanops*			✓		✓		✓	✓	✓		**9E**
China rockfish	*Sebastes nebulosus*			✓				✓		✓		**8E**

Common name	Scientific name	Low genetic variation	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments in Appendix B)	**Total number of affirmative responses**
Tiger rockfish	*Sebastes nigrocinctus*			✓				✓	✓	✓		**9E**
Bocaccio rockfish	*Sebastes paucispinis*			✓				✓	✓	✓		**10**
Canary rockfish	*Sebastes pinniger*			✓				✓	✓	✓	✓	**10E**
Puget Sound rockfish										✓		**3E**
Redstripe rockfish	*Sebastes proriger*			✓				✓		✓		**6E**
Yelloweye rockfish	*Sebastes ruberrimus*			✓				✓	✓	✓	✓	**11E**
North Pacific spiny dogfish	*Squalus suckleyi*	✓	✓	✓		✓		✓	✓	✓		**12**
Eulachon	*Thaleichthys pacificus*					✓						**7E**
Walleye pollock	*Theragra chalcogramma*			✓		✓			✓	✓		**8E**
Seaweeds & Seagrasses												
Wing kelp	*Alaria marginata*											**5**
Feather boa kelp	*Egregia menzisii*											**4**
Rockweed	*Fucus distichus*					✓						**6**
Giant kelp	*Macrocystis pyrifera*					✓			✓			**8**
Bull kelp	*Nereocystis luetkeana*					✓			✓			**9**
Nori	*Porphyra spp.*											**2**
Sea lettuce	*Ulva lactuca*					✓						**3**
Eelgrass	*Zostera marina*					✓						**9**
Invertebrates												
Edward's beach moth	*Anarta edwardsii*		✓		✓							**7E**
Sand-verbena moth	*Copablepharon fuscum*		✓		✓						✓	**8E**
Northern (pinto) abalone	*Haliotis kamtschatkana*			✓								**8**
Native littleneck clam	*Leukoma staminea*					✓					✓	**6**
Dungeness crab	*Metacarcinus magister*											**5**
Mussels	*Mytilus sp.*					✓		✓				**5E**
Olympia oyster	*Ostrea conchaphila*		✓			✓						**9E**
Spot prawn	*Pandalus platyceros*					✓						**3E**

Common name	Scientific name	Low genetic variation	Poor dispersal ability	Low fecundity	Dependent on limited resources	Form large congregations (in Salish Sea)	Long-distance migrations	Long-lived	Large-bodied	Breeds in Salish Sea	OTHER (see comments in Appendix B)	**Total number of affirmative responses**
Geoduck clam	*Panopea generosa*					✓		✓	✓		✓	**8E**
California sea cucumber	*Parastichopus californicus*											**2**
Ochre star	*Pisaster ochraceus*											**3E**
Butter clam	*Saxidomus gigantea*											**2E**
Red urchin	*Strongylocentrotus fraciscanus*					✓		✓				**6E**
Mammals												
Sea otter (northern)	*Enhydra lutris kenyoni*	✓	✓	✓		✓			✓			**12**
Gray whale	*Eschrichtius robustus*			✓			✓	✓	✓			**12**
Steller sea lion	*Eumetopias jubatus*					✓			✓		✓	**10**
Humpback whale	*Megaptera novaeangliae*			✓		✓	✓	✓	✓			**12**
Northern elephant seal	*Mirounga angustirostris*	✓					✓		✓	✓		**5E**
Killer whale (SRKW)	*Orcinus orca*	✓	✓	✓	✓	✓		✓	✓	✓	✓	**17**
Killer whale (NRKW)	*Orcinus orca*	✓	✓	✓	✓	✓		✓	✓			**14**
Killer whale (transient)	*Orcinus orca*	✓		✓				✓	✓			**10**
Killer whale (offshore)	*Orcinus orca*	✓		✓		✓		✓	✓			**11**
Harbour seal	*Phoca vitulina*					✓			✓	✓		**7**
Harbour porpoise	*Phocoena phocoena*					✓			✓	✓		**8**
Reptiles												
Leatherback sea turtle	*Dermochelys coriacea*	✓		✓			✓	✓	✓			**10**

Appendix B: Species-specific comments from the focal species assessment

Table 9. Species-specific comments from the 'other' category of the focal species assessment.

Common name	Scientific name	Comments
Lesser scaup	*Aythya affinis*	Salish Sea is a major wintering area
Brant	*Branta bernicla*	Grey-bellied variant population is small and of particular concern (found in Puget Sound, Boundary Bay, Tsawwassen) but not officially recognized.
Barrow's goldeneye	*Bucephala islandica*	BC may support up to 60-90% of the global population
Western sandpiper	*Calidris mauri*	The entire global population appears to migrate through BC, with Brunswick Pt. in Delta used as a very important stopover location.
Black oystercatcher	*Haematopus bachmanii*	Small population size (though apparently not reduced) and restricted range.
Harlequin duck	*Histrionicus histrionicus*	Major moulting concentration at north end of Strait of Georgia; Victoria and east Vancouver Island are major wintering areas.
Black scoter	*Melanitta nigra*	Major wintering and staging areas in the Salish Sea; short-term declines are unusually large.
Surf scoter	*Melanitta perspicillata*	BC/Puget Sound has major wintering habitat.
Horned grebe	*Podiceps auritus*	Strait of Georgia, Haro Strait, Fraser River estuary are important wintering areas.
Common murre	*Uria aalge*	Salish Sea a major wintering region.
Chinook salmon	*Oncorhynchus tshawtscha*	Some ("blackmouth feeders") may remain in the Salis Sea instead of migrating further offshore; are the primary prey for the southern and northern resident killer whale populations.
Copper rockfish	*Sebastes caurinus*	Particularly late maturing.
Greenstriped rockfish	*Sebastes elongatus*	Particularly late maturing.
Quillback rockfish	*Sebastes maliger*	Particularly late maturing.
Canary rockfish	*Sebastes pinniger*	Particularly late maturing.

Common name	Scientific name	Comments
Yelloweye rockfish	*Sebastes ruberrimus*	Particularly late maturing.
Sand-verbena moth	*Copablepharon fuscum*	Endemic to the Strait of Georgia and Puget Sound (Salish Sea), and West Vancouver Island.
Native littleneck clam	*Leukoma staminea*	Highly variable recruitment.
Geoduck clam	*Panopea generosa*	Highly variable recruitment.
Steller sea lion	*Eumetopias jubatus*	Major winter haul-out sites in Salish Sea.
Killer whale (southern res)	*Orcinus orca*	Essentially the entirety of defined critical habitat is in the Salish Sea.

Sources: see Appendix C.

Appendix C: References used for the focal species assessment

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