Evaluation of impacts on Pacific herring and other forage fish from proposed Trans Mountain Pipeline Expansion Project

Prepared for the National Energy Board (NEB) hearings reviewing Kinder Morgan's proposed Trans Mountain Expansion project

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1. Introduction

This report consists of a review and critique of Trans Mountain Pipeline ULC's Application, herein also referred to as the "Application", for the Trans Mountain Expansion Project as it relates to Pacific herring and other forage fish. This report should not be considered exhaustive in its coverage of all project-related impacts to Pacific herring, other forage fishes and their habitats. With constraints of time, a focus is given to information deficiencies, methodological deficiencies, and potential project-related impacts to Pacific herring and their habitats within the Marine Regional Study Area (RSA).

The evidence in this section was prepared by Dr. Caroline Fox. Dr. C. Fox is an expert on Marine Biology, Marine Ecology, and Conservation Biology, including Pacific herring and assessments of anthropogenic threats. Dr. C. Fox has over 10 years of experience working in academic and non-governmental organizations. Currently, Dr. C. Fox is a Postdoctoral Fellow in the Department of Geography, University of Victoria and Raincoast Conservation Foundation. Her PhD research related to Pacific herring spawn events and the various ecological interactions with marine, intertidal and terrestrial ecosystems. She also sits as an alternate member on the Department of Fisheries and Oceans' Integrated Herring Harvest Planning Committee (IHHPC).

1.1 Pacific Herring and and Other Forage Fishes

Forage fishes are crucial components of coastal marine ecosystems. Situated in the mid trophic levels, forage fishes represent a vital link between the bottom and the top of the foodweb (Pikitch *et al.* 2012). As a major prey species, a key ecological function of forage fishes is to support upper level predators, including marine birds, mammals, and fishes, such as salmon. In the Salish Sea, including the Marine RSA, the forage fish guild is made up of a number of species, including eulachon (Fraser River population; Endangered, COSEWIC 2011), surf smelt, Pacific sand lance and Pacific herring. Pacific herring, selected by the proponent and its consultants as an indicator species, are a highly interactive or "foundation" species (Soulé *et al.* 2003) and the dominant forage fish not just in the Salish Sea, but also throughout BC's coastal waters (Schweigert *et al.* 2010). As such, they make substantial contributions to the diets of upper trophic level marine predators in coastal BC (Schweigert *et al.* 2010).

1.2 Application Consideration of Pacific Herring and Other Forage Fishes

Given the relatively poor information base regarding Pacific herring and other forage fishes that inhabit the Marine RSA, it was not unexpected that the proponent's Application similarly suffered from poor baseline information regarding these fishes. In turn, this relative lack of information impacted the proponent and its consultants' abilities to effectively use Pacific herring as an indicator species and to adequately assess project-related effects on Pacific herring. Further, even when existing information was available (e.g., Exxon Valdez Oil Spill (EVOS) related publications), the proponent and its consultants' inclusion of this information was typically limited. Significantly, errors of omission were common throughout the Application, with the proponent and its consultants either failing completely or failing to adequately incorporate all existing habitat disturbances and potential project-related effects on Pacific herring. Collectively, these flaws tended to obscure, underestimate, or ignore potential project-related effects on Pacific herring and other forage fishes.

2. Pacific Herring: Indicator Species for Marine Fish and Habitat

Pacific herring was selected as one of six indicator species or habitats to represent the "potential effects from Project-related increased marine vessel traffic on marine fish and fish habitat" (A3S4X8). These indicators were selected based on a number of criteria, including the species having an established baseline information on biology, distribution and abundance along the shipping lanes and adjacent waters, their ecological and socio-economic importance, and others.

2.1 Information Limitations and Deficiencies

One of the criteria used by the proponent and its consultant Stantec to select indicator species was the species had "an established baseline information in biology, population abundance and distribution" (A3S4J5). The rationale provided for the selection of Pacific herring included five criteria; an established baseline of information in biology, population abundance and distribution was not listed as a rationale for selection (A3S4J5). However, the proponent and its consultant provided baseline information regarding Pacific herring and habitats that was selective and served to inaccurately portray the health of herring populations in the Marine RSA.

Given the amount of available information regarding Pacific herring populations and their trends in the Salish Sea, which includes information regarding herring life-histories (e.g., Hay 1985), annual adult biomass estimates, population trends (e.g., DFO 2014) and archaeological evidence (e.g., McKechnie et al. 2014), the baseline information provided by the proponent was selective. The proponent stated that Pacific herring abundance reached a "historical high in 2003" (A3S4X9) but failed to explain that the baseline for this information is relatively short-term (since ~1950s), that herring biomass estimates are often highly uncertain with large confidence intervals (e.g., DFO 2014), and that deep-time baselines and oral history both suggest that Pacific herring abundance in BC, including the Salish Sea, were greater before the onset of commercial harvesting (McKechnie et al. 2014). This selective provision of information provided an inaccurate description of the health of herring populations in the Canadian portion of the Salish Sea that lies within the Marine RSA. As acknowledged in a different section however, several US Pacific herring stocks in the Marine RSA were depressed, in severe decline, critical condition and/or disappeared, in addition to several being considered healthy (A3S4X9).

Herring was selected as an indicator species based on five stated criteria, one of which was that "DFO Important Areas for Pacific herring overlap with the shipping lanes" (A3S4J5). This information regarding important areas for Pacific herring is incomplete for the region; no important areas in the US were mapped and no equivalent information was available for US waters. This information was also provided without explanation or description of its source, other than a reference. In addition to being spatially limited, the 'DFO Important Areas' for Pacific herring were generated by four DFO employees or former employees who drew on paper maps, which were subsequently digitized (DFO 2012). Although this information indeed reflects "expert opinion" and is considered by the proponent to be "best-available information" (A3Y3C0), it is overall reflective of the limited knowledge base regarding Pacific herring distribution and important habitats, with exception to spawning grounds.

2.2 Deficiencies in Methodology: Measurement Endpoints

The proponent's consultant Stantec used measurement endpoints that were intended to "facilitate quantitative or qualitative measurement of potential residual and cumulative effects, and provide a means to determine the level or amount of change to an indicator" (A3S4J5). Measurement endpoints are essentially certain factors, such as length of shoreline impacted or potential for fish mortality, that allow qualitative or quantitative measurement of potential project-related effects to a given indicator. The proponent's consultant stated that "the key issue for marine fish and fish habitat is the potential for wake waves generated by Project-related tankers and tugs to disturb intertidal habitats and potentially injure or kill" marine fish, including Pacific herring. In terms of potential environmental effects and measurement endpoints, the proponent's consultants identified (1) disturbance to marine fish due to vessel wake (indicator = intertidal habitat), (2) injury or mortality of marine fish due to vessel wake (indicator species = Pacific herring and Pacific salmon) and (3) auditory injury or sensory disturbance to marine mammals due to underwater noise (indicator species = three marine mammals; A3S4J5).

The potential for underwater noise impacts on marine fish was excluded from the proponent's measurement endpoints framework. Although there is relatively limited information available in the scientific literature on this topic, underwater noise has been documented to affect fish (e.g., avoidance response in Pacific herring; Schwarz and Greer 1984). Citing the lack of knowledge in the area, the proponent excluded any meaningful evaluation of potential residual and cumulative effects arising from project-related underwater noise on Pacific herring and salmon. By excluding this potential effect, the proponent has not accounted for all pathways of potential environmental effects. Further, by not accounting for all pathways of potential environmental effects, the proponent's assessment of risks is incomplete and may serve to minimize potential project-related effects. More on the issue of underwater noise is included elsewhere in this document (Section 3.1).

In addition to underwater noise being excluded as a potential project-related environmental effect, small, more frequently occurring discharges of oil (i.e., chronic oil spills) were also excluded as a potential project-related effect. More on the issue of chronic oil spill is included elsewhere in this document (Section 3.2), but in terms of potential environmental effects to the selected indicator species Pacific herring, chronic oil spills should have been included as it poses potential for injury and mortality. Further, the exclusion of chronic oil as a potential environmental effect, in terms of Pacific herring and qualitative measurement endpoints, is another example of the proponent's failure to account for all potential avenues of potential harm. As described here, the failure to incorporate chronic oil spills with regard to potential environmental effects and measurement endpoints with regard to Pacific herring may serve to minimize potential project effects.

2.3 Deficiencies in Methodology: Biological Sensitivity Factors and the Assumption of Habitat Exposure

In Stantec's Preliminary Quantitative Ecological Risk Assessment (PQERA), the Biological Sensitivity Factors (BSF) for marine fish and habitats were based on several statements and assumptions. First, the consultant identified two major mechanisms of toxicity to fish: non-polar narcosis and blue sac disease. Although the consultant acknowledged that the marine fish community is comprised of a diversity of species and that each species has its own sensitivity to hydrocarbon exposure, for the non-polar narcosis mode of action the consultant stated that, "it is usual to consider the toxicity of hydrocarbons to a sensitive species, defined as representing the 5th percentile on a species sensitivity distribution". Assuming the "synthetic sensitive species is the same regardless of the specific habitat under consideration, the sensitivity of the community becomes a function of the degree of exposure of the particular habitat to dissolved hydrocarbons" (A3S4K7).

When asked in an Information Request (IR) to provide supporting scientific evidence for the assumption and subsequent determination that the sensitivity of marine fish and associated habitat is a function of the degree of exposure of the particular habitat to dissolved hydrocarbons (IR1.15b, A3W7J7), the proponent simply referred back to the application, stated that in the absence of exposure a toxicological response will not be induced, and reiterated their marine habitat classification scheme regarding BSF values (Response to IR1.15b, A3Y3C0).

The scientific evidence provided by the proponent and its consultant to justify their assumption that the sensitivity of marine fish and associated habitat is a function of the degree of exposure of the particular habitat to dissolved hydrocarbons was limited in the application and absent from their follow-up response to the IR (A3Y3C0), which is concerning. In the absence of a detailed explanation, it appears that the proponent and its consultant borrowed their approach from a single scientific source relevant to non-polar narcosis and we note that blue sac disease was not addressed.

In our view, little scientific evidence exists to support the proponent and its consultant's assumption regarding the sensitivity of the community being a function of the degree of exposure of a given habitat. Such an assumption is overly simplistic and not established in the scientific literature. The consultant itself acknowledged that "[t]he marine fish community is assumed to comprise a wide variety of species, each of which has its own sensitivity to hydrocarbon exposure" (A3S4K7). Examples in the scientific literature have also clearly demonstrated that species and communities have varying sensitivities to oil (e.g., Rice et al. 1977). Therefore, the reliance on this assumption in the PQERA may act to minimize and/or inaccurately estimate potential project-related effects on species and their habitats.

2.4 Deficiencies in Methodology: Failure to Assess Subsurface Oil

Subsurface oil and its potential environmental impacts on relevant wildlife receptors, including Pacific herring, were largely excluded from the PQERA, with amount of dissolved oil only granted "limited use" (A3S4K7). This omission of subsurface oil from the PQERA is concerning because without explicit inclusion and modeling of subsurface oil fates, not all potential mechanisms for oil exposure have been evaluated. As noted by French-McCay (2004), in addition to surface oil, subsurface oil and dissolved hydrocarbons must be simulated in oil fates models in order to assess exposure of marine wildlife to oil hydrocarbons. As an example, the *North Cape* oil spill resulted in most of the oil being "entrained into the water column by heavy surf, resulting in high concentrations of dissolved components in shallow water that killed millions of water column and benthic organisms" (McCay 2003).

3. Pathways for Potential Environmental Effects

The proponent and its consultants outlined existing habitat disturbances and considered several potential project-related environmental effects with respect to Pacific herring and other forage fish. Several, such as underwater noise, were only minimally considered with respect to marine fish in the project area. Others, such as chronic oil spills, were not considered an existing habitat disturbance nor were chronic oil spills considered a potential pathway for environmental effects to marine fishes. Lastly, in terms of larger spills, the proponent and its consultants make the unsupported claim that, following a worst-case oil spill scenario, Pacific herring would recover within 1-2 years.

3.1 Underwater Noise

Although the much of the attention regarding the impacts of human-generated underwater noise on marine wildlife has focused on marine mammals, similar concerns have been raised about the effects of underwater noise on fish. The proponent identified potential effects of anthropogenic noise on fish as including physical injury, mortality, and behavioural responses (A3S4Y3). However, proponent wrote that "[e]xisting information indicates that noise levels from vessel traffic are not likely to cause physical injury or mortality to marine fish" (Popper and Hastings 2009), "therefore, physical injury and mortality were not considered further in this assessment. Underwater noise from vessel traffic could, however, potentially trigger behavioural responses by marine fish. Consequently, this potential effect was considered for inclusion in the assessment" (A3S4Y3).

The proponent's inclusion of this potential effect with respect to marine fish in the Marine RSA was restricted to referencing a single study relating to Pacific herring responses to vessels (Schwarz and Greer 1984) and the statement regarding the lack of evidence regarding vessel traffic resulting in large-scale displacement of fish. The proponent also cited the existing overlap between fish (salmon and herring) migration areas and areas of high shipping activity as evidence that large-scale displacements had not occurred. For these reasons and "according to the judgment of the assessment team, behavioural disturbance to marine fish and invertebrates due to underwater noise from vessel traffic was not considered further in this assessment" (A3S4Y3).

The fact that the proponent has chosen to focus on large-scale displacement of fish as the only possible negative effect of underwater vessel noise is problematic, as there exist other documented behavioural responses to underwater noise. Although the proponent is correct in stating that there is a lack of evidence in the literature showing that vessel traffic will result in large-scale displacement of fish populations, the proponent has failed to include other scientific evidence that demonstrates that underwater noise may cause behavioural changes, such as avoidance responses, and/or sublethal consequences to fish, such as cardiovascular disturbances (e.g., Engås et al. 1995, Graham and Cooke 2008, and reviewed by Slabbekoorn et al. 2010, Whitfield and Becker 2014). It should also be noted that avoidance behaviours might not result in large-scale displacement of fish populations. The lack of inclusion of relevant information regarding fish responses to underwater noise caused by the project is troubling and in this example, may have served to minimize potential project-related effects.

3.2 Chronic Oil Spills

Chronic oil spills, also referred to as chronic oil discharges, are smaller (here defined as <1000L), more frequently occurring releases of oil in the environment. Cumulatively, these chronic small discharges of oil contribute more oil to marine environments than the larger, catastrophic oils spills (National Research Council 2003). Still poorly documented in terms of specific impacts to Pacific herring and other forage fish, chronic oil spills have been demonstrated to have greater cumulative impacts on marine wildlife than the larger, less frequent oil spills (e.g., marine birds; Wiese and Robertson, 2004). Due to the documented responses of Pacific herring and other fishes to chronic exposures of oil, with examples including malformations, genetic damage, and mortality in larval pacific herring following exposure of eggs to weathered crude oil (Carls et al. 1999) and increased levels of polyaromatic hydrocarbon concentrations in Atlantic cod chronically exposed to oil (Aas et al. 2000), even relatively small discharges of oil pose a substantial risk to Pacific herring, other forage fish and marine ecosystems in the Marine RSA.

Although the proponent claimed that they were unable to "provide a comprehensive description of oil spill conditions in the Marine RSA" (Response to IR1.10b, A3Y3C0), relatively detailed evidence was available to the proponent and its consultants regarding the distribution and frequency of numerous chronic oil spills (<1000L) in the Marine RSA and surrounding waters (e.g., Serras-Sogas et al. 2008, O'Hara et al. 2009). Oiled bird carcasses and oiled beaches documented by O'Hara et al. (2009) also clearly indicate that marine wildlife and intertidal habitat, very likely including habitats used by forage fish, are impacted by chronic oil spills in the Marine RSA and surrounding waters.

The proponent's failure to include chronic oil spills as an existing habitat disturbance to marine wildlife in the Marine RSA represents a substantial omission and serves to minimize the existing hazards that negatively impact wildlife and their habitats in the Marine RSA. Further, harm to Pacific herring and other forage fish via project-associated chronic oil spills was not identified by the proponent as a potential project-related effect, which represents another substantial omission and may serve to minimize potential project-related effects.

When asked to justify why the ecological effects of small discharges of oil likely to occur with Project-related marine traffic was not included in the submission, the proponent stated that "[c]umulative ecological effects of small discharges of oil (< 15 mg/L hydrocarbon) were not considered as a residual effect because effective compliance monitoring and enforcement of existing legislation (which is designed to protect the marine environment) should prevent cumulative effects" (Response to IR1.10a, A3Y3C0). This response is misleading and represents an unsubstantiated opinion not supported by scientific evidence. First, the small oil discharges reported in the Marine RSA and surrounding waters by Serras-Sogas et al. (2008) were considered illegal and we note that chronic oil spills may be legal or illegal and intentional or accidental. Second, the statement that small, legal (<15mg/L) discharges of oil will not cause residual effects because compliance monitoring and enforcement of existing legislation "should" prevent cumulative effects is an unsubstantiated opinion.

3.3 Recovery from Oil Spills

In the PQERA, the proponent's consultant Stantec relied on the EVOS, as it was a good example of the effects of a large crude oil spill on various aspects of the marine environment and was particularly relevant to the proponent's project area. Concerns with the consultant's review of the EVOS and its implications for the proponent's project included: (1) their reliance on only four EVOS-focused scientific publications to evaluate the recovery potential of marine fish and habitats, (2) problematic interpretation of Pacific herring recovery, and (3) a focus on population-level impacts to marine fish.

The proponent's consultant Stantec relied on just four EVOS-focused scientific sources to evaluate the potential for marine fish and marine fish habitat to recover from an oil spill in the Marine RSA (A3S4K7). Based on findings of the Exxon Valdez Oil Spill Trustee Council (EVOSTC, 2010), the consultant listed several species and communities injured and their recovery status following the EVOS (A3S4K7). Of these, the consultant listed two marine fish as "recovered", sediments as "recovering", rockfish and subtidal communities as "very likely recovered" and *Pacific herring as "not recovering"* (emphasis ours; A3S4K7). Although the consultant admitted that there was controversy regarding the recovery assessment of Pacific herring, and cited several studies that speculated on the underlying causes of the Prince William Sound (PWS) population collapse following the EVOS, the consultant ultimately concluded that there were "no remaining ecologically significant effects" on PWS Pacific herring (A3S4K7). No scientific evidence was provided to support the consultant's claim and no information was provided with regard to its determination of the recovery timeframe of PWS Pacific herring. Importantly, no explanation regarding the conflict between the consultants claim that there were "no remaining ecologically significant effects" on Pacific herring and the EVOSTC (2010) findings, which lists Pacific herring as "Not recovering" (EVOSTC, 2010, A3S4K7) were provided.

Following this review, the consultant stated that "due to the generally low potential for the spill scenarios to cause wide-spread mortality of fish, recovery of the marine fish community would be expected to be rapid. Even under a worst-case outcome event where localized fish kills might be observed, it is expected that natural processes would compensate for the lost biological productivity within one to two years" (A3S4K7). The proponent also stated that the "effects of the EVOS on marine fish populations … were either not significant to begin with, or recovery occurred within one or two years at most" (A3S4K7).

The consultant's interpretation of these publications and use as evidence to support their claim that "natural processes would compensate for the lost biological productivity within one to two years" (A3S4K7) potentially misrepresents and minimizes the consequences of an oil spill in the Marine RSA on Pacific herring and other forage fishes. Further, with respect to Pacific herring, the consultant's claim that in the event of a worst-case oil spill event in the Marine RSA it would be expected that "that natural processes would compensate for the lost biological productivity within one to two years" (A3S4K7) is potentially unsound and not based on the life-history of Pacific herring. Pacific herring in the Marine RSA generally recruit to the commercially valuable adult population at age three (Schweigert et al. 2009). Theoretically, if there was an oil spill that caused significant mortality to adult, juvenile and larval herring in the Marine RSA, it would take a minimum of three years for the first generation of post-spill herring to recruit to the adult population and represents the earliest possible timeframe for "recovery" following significant mortality of adult, juvenile and larval herring.

Upon asking the proponent to provide scientific evidence from other cold-water oil spills that might indicate that the marine fish community or marine fish habitat in the Marine RSA impacted for any period greater than two years, the proponent stated that "[h]arm to marine fish populations seems to be the exception, rather than the rule, following marine oil spills" and simply referenced subject matter in the Enbridge Northern Gateway hearings (Response to IR1.16h, A3Y3C0). We find this concerning for multiple reasons: (1) the proponent's statement appears to be unsupported opinion, (2) the proponent focuses on harm at the population-level and fails to mention harm to fish overall (e.g., genetic impacts on individuals), and (3) evidence from studies of oil spills on marine fish have indeed documented harm, here at the individual and population-level, lasting longer than two years (e.g., Teal et al. 1992, Short 2003), which contradicts the proponent's statement, and (4) referral to subject matter in the Enbridge Northern Gateway Hearings is inadequate, in part because it has not been subjected to scientific peer-review.

4. Conclusions

Because Pacific herring and other forage fishes represent a crucial conduit of energy and nutrients from lower trophic levels to upper level predators, such as salmon, marine birds, and mammals, it needs to be highlighted that existing threats to Pacific herring and other forage fish potentially impact other components of marine ecosystems in the Marine RSA. As such, project-related impacts to Pacific herring and other forage fishes could cause cascading effects across the foodweb, potentially including SARA-listed Marbled Murrelets and Southern Resident Killer Whales (SRKW). We also note that these pathways for impact are not restricted to population-level concerns (e.g., reduction of Pacific herring biomass affects Chinook salmon which, in turn, affects SRKW). Because certain contaminants biomagnify up the foodweb, any increased contamination of Pacific herring could potentially influence the contamination load of upper-level predators, including SRKW and other species. Lastly, because any potential project-related effects to Pacific herring and other forage fishes will occur alongside numerous anthropogenic influences (e.g. commercial extraction, climate change, pollution etc.), these potentially cascading effects need to be considered in the cumulative context in which they occur.

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