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TECHNICAL REVIEW OF THE M/V *MARATHASSA* FUEL SPILL ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Context

Starting April 8, 2015, an estimated 2800L of intermediate fuel oil (Bunker C) was discharged by the *M/V Marathassa* into English Bay, and subsequently spread over areas of inner Vancouver Harbour, both of which form part of Burrard Inlet, British Columbia. An on-water recovery and clean-up operation was immediately commenced by the Canadian Coast Guard (CCG), lasting a total of 16 days. The polluting vessel was boomed in the early morning on April 9, skimming of the oil was conducted and completed on April 12, and shoreline clean-up continued until April 23, 2015.

Upon completion of the initial response operations, a Project Management Office (PMO) was set up to continue the collaborative working relationship with parties that had participated in the Unified Command. The scope of the PMO was to oversee the continued sharing of information; coordinate the completion of specific project activities; and foster a longer term relationship in response activities between the parties. In addition to the CCG, the Project Management Office is comprised of partners from Environment and Climate Change Canada, Fisheries and Oceans Canada, Transport Canada, B.C. Ministry of Environment, Tsleil-Waututh First Nation, Squamish Nation, City of Vancouver, City of North Vancouver, and the City and District of West Vancouver.

The CCG requested that the Marathassa Shipping Corporation (the “Polluter”) conduct an environmental impact assessment (EIA) of the spill. An EIA was prepared by Hemmera Envirochem Inc. and provided to CCG by the Marathassa Shipping Corporation on September 18, 2015. The purpose of the EIA was “to assess the potential environmental effects from the *M/V Marathassa* oil spill event and determine whether there are any residual environmental effects that need to be addressed in addition to oil spill cleanup efforts and/or through natural attenuation processes” (Hemmera Envirochem Inc. 2015).

To scope oil distribution, extent of exposure and efficacy of clean-up efforts, post-spill monitoring efforts were undertaken from overflights, shoreline assessments and boat surveys. To detect potential ecological effects from the oil spill, environmental sampling was done to study Intermediate Components (ICs) and biological Valued Components (VCs). Regarding fish and fish habitat specifically, the post-spill monitoring efforts, associated observations, and conclusions in the EIA are generated from the following:

- aerial surveys;
- Shoreline Cleanup and Assessment Technique (SCAT) and seafloor sorbent drag surveys;
- the collection and sampling of weathered product (i.e tar balls);
- the collection and sampling of water, intertidal sediment and smelt embryos;
- the collection and sampling of tissue from mussels, crabs, flounders and prawns;

- intertidal habitat surveys; and
- information on marine mammals.

To continue its improvement of post-incident elements of a response, the CCG requested that Fisheries and Oceans Canada (DFO) Science Branch review the document titled "*M/V Marathassa Fuel Spill Environmental Impact Assessment*" and provide advice regarding: the adequacy of the reported monitoring and sampling efforts undertaken; the adequacy of substantiating claims and conclusions; and recommendations for future assessments.

This review focuses on components of the EIA within DFO Science (Pacific Region) expertise; namely, those related to fish and fish habitat, species ecology and ecological survey design. Note that information outside of the scope of this Science Response relates to the fate, analysis, detection, and toxicity of contaminants; potential effects of human and bird exposure to contamination; and the intent, selection or applicability of endpoint criteria. While information gaps, uncertainties and recommendations were sought from this Canadian Science Advisory Secretariat (CSAS) Science Response (SR), there is no recommendation to undertake any new impact assessment relating to this incident. Rather, advice arising from this review will help inform CCG and other agencies in the development of future post-spill monitoring programs and impact assessments.

This Science Response Report results from the Science Response Process of October 2016 on the Technical review of the M/V Marathassa Fuel Spill Environmental Impact Assessment Report.

Analysis and Response

Objectives

The main objectives of this Science Response are to provide technical comments and advice on information contained in the pertinent sections and subsections of the *M/V Marathassa* Fuel Spill Environmental Impact Assessment, prepared by Hemmera Envirochem Inc. for Marathassa Shipping Corporation, at the request of the Canadian Coast Guard.

In support of improving post-spill monitoring programs impact assessments, this Science Response will address the following objectives as they pertain to fish and fish habitat, species biology and ecology, ecological survey design, and information related to post-spill monitoring efforts:

1. Evaluate the adequacy of the monitoring and sampling efforts undertaken to characterize potential effects to fish and fish habitat.
2. Evaluate the adequacy of the approach used by the Responsible Party (Polluter) to determine the assessment area as the area most likely affected.
3. Evaluate whether statements and conclusions made in the EIA are adequately substantiated.
4. Identify key uncertainties and information gaps that were missed, and describe consequences associated with those uncertainties where possible.
5. Provide recommendations to guide the development of future oil spill impact assessments.

Environmental Impact Assessment Sections Reviewed

To prepare this response, the following sections of Hemmera Envirochem Inc. (2015) were reviewed:

Section	Title
	Executive Summary
Section 3	Geographical and Environmental Setting
Section 6	Characterisation of Oil Spill Extent and Exposure
Section 7	Effects Assessment Methods
Section 8	Biophysical Effects Assessment
Section 11	Conclusions and Recommendations
Appendix B	Data Collection and Raw Data
Appendix D	Field Study Summary Report
Appendix E	Shoreline Cleanup Assessment Technique

Unless otherwise stated, all reported observation and collection dates reported herein represent the year 2015 and all references to sections, tables and figures correspond to those reported in the EIA.

Aerial Surveys

The EIA reports that aerial surveys (overflights) by the Canadian National Aerial Surveillance Program (NASP) collected six sets of observations taken during morning and afternoon periods over three days (i.e. Figure 9). It is reported that each set of observations was based on both naked eye observations from an altitude of 1000-1500 feet and from using remote sensing technology from 5000-10000 feet. There is not enough information in the EIA to characterize or evaluate the detection efficiency of the aerial surveys. For example, the type of remote sensing technology that was used, and information on flight patterns and environmental conditions (such as cloud coverage and height, sea state and solar glare) are not reported.

Shoreline Cleanup and Assessment Technique (SCAT) Surveys

Surveys conducted using the Shoreline Cleanup and Assessment Technique (SCAT) were undertaken to collect and document macroscopic observations of oil and to direct cleanup efforts and to inform sampling plans. Section 8.3.6 states "*The distance of shoreline that experienced some level of oiling within the assessment area was 14.5 kilometers, which was 17% of the shoreline within the assessment areas. Of this, only 0.2 kilometers (0.4%) were categorized by the SCAT survey team as "Light oiling". The remainder was "very light" (3.3km, 3.8%) or "trace"(11.0 km, 12.8% oiling).*" There is not enough information in the EIA to characterize or evaluate the detection efficiency of the SCAT surveys in terms of quantifying potential shoreline affected, given the uncertainties associated with the constraints of the SCAT surveys noted in Appendix E.

Assessment Area

Additional information on the assessment area would have been beneficial, especially in terms of relating information to the applied sampling designs of the ecological components that were monitored. The only map that clearly marked where the *M/V Marathassa* was positioned during the oil spill is in Appendix B (Figure 1 of the smelt embryo mortality report). Furthermore, the map is of relatively poor quality, and the source of the information used to develop the map, or what specifically the map represents, is unclear. A bathymetric contour map of the region to relate to selected VC and ICs, their spatial distributions and ecological associations, and/or the selection of survey sites and sampling efforts would have been informative.

Tar Balls and Other Weathered Petroleum Product

Associated with the SCAT surveys and cleanup efforts, Section 6.5 (“Tar balls and Surface Staining”) states that one tar ball collected during cleanup efforts from Second Beach was chemically analyzed to compare its polycyclic aromatic hydrocarbon (PAH) profile with that of the spilled oil from the *M/V Marathassa*. Section 6.9.6 (“Weathered Petroleum Product”) describes the collection of weathered petroleum product (which includes tar balls) at fourteen sites shown in Figure 20, and the selection of only one sample from a site south of Second Beach for PAH analysis. It is unclear if these sections represent editorial redundancy or different collection efforts. Furthermore, the ongoing collection of weathered product after the SCAT team sign off dates suggests that signs of oiling persisted after the area was deemed “clean”. The discrepancy between product collection and SCAT team sign off dates is not discussed in the EIA in terms of assumptions, uncertainty or limitations to cleanup efforts and additional information to clarify these points would have been beneficial.

Seafloor Sorbent Drag Surveys

Ocean bottom (seafloor) surveys to search for traces of sunken oil were conducted at a total of five sites over 2 days by dragging sorbent pads across the seafloor then bringing up to the surface and inspecting for signs of oil (Figure 14). There is not enough information in the EIA to characterize or evaluate the detection efficiency of the sorbent drag surveys. It is common practice to describe seafloor sampling by dimensions and mass of survey equipment, bottom depth, type of bottom substrate, length of tow cable, and tow speed while sampling, but this information was not reported in the EIA. Each of these variables may influence the effectiveness of seafloor sampling and potential detectability of oil. It would also have been beneficial for the report to include information on site selection criteria, sample distances and the rationale for why no seafloor sampling was done in areas where “light oiling” had been observed (i.e. east of Lions Gate Bridge). Furthermore, the uncertainty associated with the seafloor sorbent drag methods and observations of “no oiling” at any of the sampling locations was not discussed.

Surface Water sampling

PAH analyses were conducted on water samples collected from six or seven sites from intertidal or foreshore waters of English Bay and Burrard Inlet, excluding the inner Harbour of Vancouver (Figure 16). Samples were collected via two sampling protocols: off the side of a boat or by wading from shore. It is reported that a total of 13 water samples were collected and chemically analyzed from four collection dates. One of the samples collected by wading on May 11 was split to create duplicates, but since a duplicate from a split is not a true replicate, the total number of water samples that were collected is 12 not 13. Repeated sampling over time was reportedly conducted at three sites. One site was sampled by both protocols on different days and two sites were sampled three different days by the wading protocol only. No replicate sampling by site and date was conducted. Sampling efforts and results as presented in the EIA were generally difficult to interpret due to inconsistencies in reporting for both of the two sampling protocols (i.e. Tables 14, 15 and Appendix B, Teranis Ltd. report). Figure 16 marks six water sampling sites, but does not have a mark for the Ambleside Beach site (reported in Table 15) so it is unclear if Ambleside Beach and John Lawson Beach were considered one or two sites (therefore it is unclear if six or seven sites were sampled).

A sample size of 1 per collection event provides no information on possible variability within a site. If oil residues have patchy distributions in water, sample sizes would need to be sufficient to represent the variability in space (within and between sites) and time (sampling dates). Because the marine environment is highly dynamic, consistent and rigorous sampling efforts at individual sites and across sites are recommended.

The assumptions made in association with sample collection, the interpretation of water sample results and the uncertainty of basing conclusions on a limited number of samples to represent the assessment area were not adequately described in the EIA. For example, it was unclear why none of the sample sites were located in the inner portion of Vancouver Harbour. Furthermore, it would have been beneficial to have some discussion on the possible effects of site-specific factors; such as exposure to current, tidal exchange, and water circulation. As a conclusion point, Section 11 states "*The majority of water samples collected shortly after the oil spill showed no evidence of detectable levels of PAHs. In a minority of samples collected near West Vancouver beaches, elevated levels of naphthalene and a few other PAHs were detected May 1, 2015, but given the duration, the source was unlikely the* M/V Marathassa. *Water quality 33 days post-spill returned to conditions existing before the spill or below applicable guidelines at all locations sampled."* However, only two sites (and two water samples) were sampled 33 days post-spill, which is an insufficient sample size to adequately represent the assessment area, or support the above statement.

Intertidal Sediment Sampling

PAH analyses were conducted on intertidal sediment samples from eleven sites varying in orientation and proximity from the oil spill site (Figure 17). Sample collection occurred over two collection periods, 7 and 8 days in length, with two sites sampled during both periods. The number of individual replicates analyzed per site, and time period (in days), ranged from 1-7. All samples were examined for sediment type, grain size, and visual or olfactory evidence of hydrocarbon impacts. It was reported that a standard grid sampling protocol was used for all sites but one (Jericho Beach). The rationale given for the deviation in sampling design at Jericho Beach was "*due to the large size of the beach and that no hydrocarbon staining was identified (during SCAT surveys)*". However, sediment samples collected from Jericho Beach were omitted from the PAH analyses (i.e. not included in Table 12), which is confusing: the EIA describes the modified sampling method associated with this site, implying that the samples collected via this method would have been analyzed similarly to the other samples.

Descriptions of, and the rationale for, the sampling designs and variability in sampling intensities would have been informative. For example, it is unclear what the vertical spacing of the grids was; what the rationale for varying the horizontal spacing was; and if, why or how subsampling was done. Additional relevant information that could have been provided includes: estimates of each site's area to relate to sampling intensity, and the criteria for selecting a subset of samples collected in the field for compositional analysis.

Elevated PAH levels were detected in some of the replicates from the two sites and collection periods that showed the most variability in sediment composition and total organic content (TOC; Table 12, i.e., Capilano I.R. No 5 and New Brighton). Each of those sample collections was represented by at least 5 replicates per collection date (Tables 13), which are relatively large sample sizes compared to other sets of sediment results. The report concludes that because sample replicates from those two sites showed decreases in PAHs between sampling periods, that this was indicative of decreases in PAH levels over time for the entire local environment near the oil spill.

The uncertainty associated with the constraints of the sampling design and results was not adequately discussed. Because residual oil would be expected to have patchy distributions, sample sizes and spatial coverage would need to be sufficient to represent the variability in PAH levels by sediment composition, space (within and between sites) and time (sampling dates). Due to the variability in sample sizes and possible confounding effects of variability in substrate composition and other site features (such as slope and aspect) between sample collections, the reason for the observed variability in PAH levels between sites and time periods cannot be clearly explained.

To address heterogeneity of samples from a site, and to allow for statistical comparison within and among sites, Environment Canada (2010, 2012) published guidelines for sampling sediment in association with effects monitoring that could be adapted to oil spill responses. Stratified sampling designs are also recommended to take into account variability in physical characteristics of a site, such as differences in substrate composition and intertidal zones (Robinson et al. 1996).

Mussel, Crab, Starry Flounder and Spot Prawn Sampling

PAH analyses were conducted on tissue from mussels (*Mytilus sp)* collected over a week period at ten sites varying in proximity and orientation to the oil spill site (i.e. ranging from Whytecliff Park to inside Burrard Inlet). For each of the 10 sites, soft body tissue from 40-60 mussels (described as similar mid-range size) were combined to prepare composite tissue samples for chemical analysis. The results showed variability in PAH concentrations within and between sites with the highest levels found near New Brighton and English Bay beaches.

PAH analyses were conducted on crab hepatopancreas and muscle tissues from individual crabs collected over three days at three sites in English Bay, and at one site near Deep Cove (Cates Park), where the latter site was said to be a reference site. For each of the English Bay sites, tissue from 3-5 Dungeness Crabs (*Metacarcinus magister)* was analyzed. For the Cates Park reference site, one Red Rock Crab (*Cancer productus*) was collected and sampled. There is a discrepancy in the EIA with respect to the number of Dungeness Crabs that were sampled (i.e. section 8.4.5.1 reports 12, Appendix B reports 11). Bottom depths where the traps were placed are not reported. For each site and trap date, comparable hepatopancreas and muscle tissue samples from the same crabs were analyzed to measure PAH levels. The results showed considerable variability in PAH concentrations between tissue types of individual crabs, and from crabs within a site and between sites; particularly large ranges in PAH concentrations were detected from hepatopancreas tissue.

PAH analyses were conducted on Starry Flounder (*Platichthys stellatus*) muscle tissue, from flounders collected over three days, at two sites in English Bay. From one site, composite samples (each from three fish) were analyzed and from the other site, no composite samples were used; instead two muscle samples were analyzed from two separate fish. Fish lengths were reported and sizes ranged from 96-231 mm. Sex of the fish was not reported. The results showed some variability in PAH concentrations within and between sites. There was no reference site identified for the Starry Flounder sampling protocol.

PAH analyses were conducted on Spot Prawn (*Pandulus platyceros*) head and tail muscle tissue from prawns collected over two days, at two sites in the assessment area, and one site near Whytecliff Park, referred to as a reference site. Numbers of composite samples prepared for each tissue type varied by site (i.e. three composite samples were prepared for each of the assessment sites and two composite samples were prepared for the reference site). It was reported that each composite sample of either muscle or head tissue was represented by 15-20 prawns from the same trap but the exact number of prawns per composite sample was not reported. The EIA reports that prawns ranged in size, but larger prawns were selected over smaller ones. The length and sex of individual prawns in the samples were not reported. Results showed some variability in PAH concentration between head and tail samples for comparable trap groups. An inconsistency in the laboratory method used to analyze the chemical composition of prawn tissue compared to the method used to analyze tissue from other species was reported; this appears to have partly compromised the comparability between sets of results.

Section 11 states "*Sampling of biological tissues provided evidence of PAH uptake in intertidal mussels and Dungeness crabs from the study area. However, with the information provided it was difficult to determine if measured concentrations were a result of the* Marathassa *spill. Other anthropogenic long-term inputs are locally present, directly comparable reference data were not readily available in many cases, and follow-up sampling was not conducted after the approximately two week period following the spill to monitor change over time. Without this information, differentiating one-time inputs from the spill with other chronic inputs and secondary sources of PAHs and allied contaminates to Vancouver Harbour was difficult*." This conclusion exemplifies that overall sampling efforts were insufficient to characterize variability between samples and sites and track potential changes over time to relate to possible effects from the fuel spill.

When sampling a population where variability in the metric of interest can be affected by a range of factors, larger sample sizes and more rigorous protocols to control for extraneous effects are necessary to effectively characterize the extent and variability of the metric (e.g. PAH levels). Inconsistent sampling methods (such as changing the basic observational unit—i.e. pooling tissues at some sites, then not pooling tissues at other sites) are especially problematic because it confounds variability of the sampling units, making them incomparable. Furthermore, this uncertainty needs to be clearly stated, as was the uncertainty due to sampling two different species of crab.

In keeping with recommendations from Environment Canada's environmental effects monitoring guidance documents (2010, 2012), sampling protocols should include detailed sampling requirements; such as minimum samples size, and morphometric measurements to be taken, prior to implementation. Environment Canada (2010) reports that the use of a single composite sample has been eliminated from their protocols of tracing chemicals in order to provide a better statistical basis for data evaluation and decision making. Environment Canada (2010) states that sampling should include multiple individual samples or multiple pooled (composite) samples and advises on the use of power analyses to establish sample sizes to detect potential minimum effects.

The EIA lacks rationale describing why mussel, crab, Starry Flounder, and Spot Prawn were targeted for sample collection compared to other species occurring in the area. A monthly beach seining study conducted for a full year at three sites in West Vancouver area (Macdonald and

Chang 1993) identified the following species as having the highest prevalence or catch densities from March to June: Pacific Sandlance (*Ammodytes hexapterus)*; juvenile Chum and Chinook Salmon (*Oncorhynchus keta and O. tshawytscha, respectively)*; Three-Spine Stickleback (*Gasterosteus aculeatus)*; English Sole (*Parophrys vetulus)*; Speckled Sanddab (*Citharichthys stigmaeus*); Bay Pipefish (*Syngnathus leptorhyncus*), and several species of sculpin (Scorpaeniformes). In relation to the acquisition of reasonable sample sizes and controls, some of these species may be worth considering as indicators of VCs for future EIAs.

It is concluded in section 11 that "*Measureable and observable effects from the spill on biota populations, including invertebrates, fish, birds or marine mammals, are determined to be unlikely."* This alone is a reasonable statement, but the reasons for a lack of observations and the associated uncertainty associated with potential effects were not clearly discussed in the EIA. It would have been appropriate to acknowledge the difficulty (or impossibility) of detecting acute or delayed mortality in the marine environment due to the cryptic nature of many species and their ecological interactions. In addition, behavioural responses, such as avoidance following irritation, or changing of forage habitats as a result of impacts to prey species, would also be expected to go undetected.

Surf Smelt Embryo Surveys

Surf smelt (*Hypomesus pretiosus)* embryo surveys were conducted from seven sites within the assessment area of English Bay and Burrard Inlet, and two reference sites outside of this area "*to quantify potential effects of the* Marathassa *oil spill on spawning beaches within the assessment area; assess the geographical extent and duration of mortality, and assess combined PAH toxicity and temperature on mortality rates and hatching success likelihood based on embryological state*". Field survey methods were described as following the protocols outlined in Moulton and Pentilla (2001); including a protocol for collecting embryos from a bulk sample of sand from a 35m transect in the upper third of the intertidal zone. Laboratory analysis to categorize embryos and estimate the proportion dead, and based on living embryos, to estimate the proportions of 9 development stages were described as following methods of Middaugh et al. (1987). Information from similar surveys conducted in 2002 (Lee and Levings 2007) was included for comparative purposes.

There was a lack of information on the sampling intensity and variability of observations by transect and/or site. It is unclear how many transects were done by site and date, and how the subsamples of embryos were collected and grouped, to derive averages. Additional information may have provided insight into possible biases related to sample collection and potential effects of varying sample sizes, especially related to small sample sizes. The number of embryos collected by site and sampling period for estimating mortality and embryo development varied considerably (i.e. zero to 601).

Uncertainty generated by potential confounding factors associated with embryo mortality and development was not adequately reported in the EIA. Given that the spring of 2015 was relatively warm, the number of embryos encountered on each sampling date may have been affected by accelerated hatching. Uncertainties regarding the assumption of a 14-day incubation period are not clearly discussed. Additional variables (including correlates) of water quality and temperature would be expected to have effects on surf smelt embryo mortality and development. Examples of differences between sites that could confound results include: beach aspect and exposure to sunlight; wind and rain patterns; proximity to freshwater run-off sources; and substrate types.

Information from the surf smelt surveys is inconclusive because

a) there are many confounding factors between sites not controlled for that are not related to the oil spill, including local temperature effects,

b) many small embryo sample sizes representing different sites and collection dates from both which mortality and proportions of developmental stages were estimated, and

c) the narrow ranges in mortality estimates between sites and dates (since embryo mortality was consistently very high at all sites).

Intertidal Habitat Surveys

The EIA states that "*intertidal habitat was selected as a valued component because it provides fish habitat at various species-specific life stages. Intertidal habitat was also one of the ecological components that was directly affected as fuel was deposited on the shore due to currents and tidal action."* The intertidal habitat surveys were done approximately three months after the oil spill to:

1. determine whether oil was visibly present;
2. characterize the intertidal habitat and community composition; and,
3. assess whether intertidal habitat appeared to differ between sites where oiling was observed during SCAT surveys and another site in Burrard Inlet where no visible oil observations were previously made (referred to as a reference site).

It was also reported that water, sediment and mussel samples were collected during initial oil responses at the four sites where oil was seen during SCAT surveys. The EIA describes the application of a modified survey protocol from DFO (2004, Marine Foreshore Environmental Assessment Procedures), whereby within each quadrat, observations were recorded to depict

1. substrate type and % composition;
2. marine vegetation by species group and % cover;
3. intertidal macrobenthic invertebrate community composition (to identify and quantify exposed animals); and,
4. the presence or absence and oiling category of macroscopically-visible oil.

There are notable uncertainties and information gaps related to the intertidal habitat sampling design and associated assumptions that were not reported. For example, the subjectivity of the modified transect sampling design of placing transects "*where substrate was suitable for colonization of invertebrates and seaweed*" and not applying a systematic or random design across the assessment area or within individual sites, would have introduced bias to the observations. Transect length, spacing, and quadrat size were not explicitly reported in the EIA but a reference was made to DFO (2004); this suggests transect lengths of 75m with transect spacing of at least 25m may have been applied. It was reported that, due to sampling constraints such as incoming tides, not all intertidal zones were sampled for all transects; thereby potentially further compromising the comparability of inter-site observations (Appendix D of the EIA report). Slope, exposure to tides and current, geography, fetch, geology, and signs of past and present habitat alterations would be expected to contribute variability to the observed presence of oil within and between sites; irrespective of the actual volume of oil at any given site. Substrate type, a driver of intertidal biota, was considerably rockier at the Brockton Point "reference" site than it was at the previously oiled sites that were surveyed. Therefore, conclusions drawn from any comparison of previously oiled sites to the reference site are especially questionable. Contrary to protocols described in DFO (2004), local site conditions were not reported in terms of explaining variability between and within sites. In addition, the methods used to aggregate quadrat observations by site within and between transects and intertidal zones was not described in the EIA. Therefore, it was not clear what the average and standard deviation measurements reported actually represent.

Section 11 states that "*Although robust baseline data does not exist to measure the effects from the spill on intertidal habitat, the lines of evidence suggest that there was likely a very minimal effect to intertidal habitat that was short in duration*." However, the EIA does not adequately discuss the uncertainty associated with the constraints of the study design in terms of its ability to detect potential effects of the oil spill three months after it occurred, based on the selected habitat sites, transect placement, and the methods of observing organisms within quadrats. Information on the criteria used for the selection (or omission) of sites may have been informative. It was not clear if and how information related to Figures 1, 3 and 10 was used to plan the sample design (for example, a reason was not provided for excluding the site east of the Lions Gate Bridge which had the highest level of oiling ("light") during the initial April SCAT surveys). The report also claims that species observations (indicator values) were within normal ranges, with respect to information in two referenced consultant reports. However, no comparable data are presented in order to evaluate this statement.

DFO (2004) outlines field survey protocols for the collection of fish habitat information for use in assessing the potential effects of a development project, including the rationale for use of standardized survey methods repeated over time and space. Similarly, the use of standardized methods with fixed transects and/or quadrats to provide observations capable of detecting change over time at individual sites is also advised by Robinson et al. (1996) and Environment Canada (2010, 2012). In addition to a sampling design that stratifies by intertidal zone, other stratification schemes may have been appropriate given the reported variability in substrate type, marine vegetation, and macroscopic invertebrate species within intertidal zones of individual sites.

Marine Mammals and Species at Risk

Killer Whales (*Orcinus orca*), Grey Whales (*Eschrichtius robustus*) and Harbour Seals (*Phoca vitulina)* were identified as representing toothed whales, baleen whales and pinniped marine mammal sub-components, respectively; each having unique life histories and prey preferences. Under the Section "Characterization of Residual Effects and Context", the report has sub-sections aimed at discussing these species in terms of observed and potential effects from past oil spills. Marine mammal information in the EIA is based on opportunistic sightings, historical sighting reports for the Burrard Inlet (1985-2015) and other existing sources of information such as scientific literature, previous environmental assessments and supporting documents (i.e. Exxon Valdez Oil Spill, Kinder Morgan Westridge Terminal Hydrocarbon Accidental Releases). The EIA reported that no indicators of potential effects from exposure to oil (such as visible oiling, beach stranding, behavioural stress or visible health effects) were observed or are expected in relation to the *M/V Marathassa* spill.

There are notable uncertainties and information gaps that could have been discussed further on the potential oil spill effects and habitat use by marine fish species with conservation concerns and marine mammals in the assessment area. During post-spill cleanup and monitoring efforts, it appears that no dedicated surveys or sampling efforts were conducted to collect information on species of fish, invertebrates, or marine mammals with conservation concerns; as listed in sections 8.1 and 8.5.4. Other than Killer Whales, no data on counts and sighting locations are provided in association with possible *M/V Marathassa* oil exposure on marine mammals. The report acknowledges that Harbour Seals are the most abundant marine mammal in Burrard Inlet, and that adverse effects from the oil spill may have affected some of them, but states that "…no rookeries or major haulouts occur in Burrard Inlet". This assertion may be misleading because Harbour Seals do not congregate in large rookeries to mate (as do other pinnipeds), but breed in small, scattered groups throughout their range (DFO 2010, Capital Regional District of Victoria 2016). There is the possibility that small porpoises, such as Harbour Porpoise (*Phocoena phocoena*) and Dall's Porpoise (*Phocoenoides dalli)*, were exposed to the spilled oil but were not sighted because they are relatively small, and generally occur in small groups; and thus often go undetected.

Salmonids

The EIA does not accurately characterize habitat utilization by salmonids in the assessment area. In Section 8.4.2.1, the EIA states that "*The migratory nature of salmon implies a limited seasonal presence and given the timing of the spill in early April, it is likely that some Fraser River sockeye smolts were already out in the Strait of Georgia, but it is unknown what proportion would be using the Burrard Inlet/ English Bay area. Some Chum and Chinook smolts may also have been using the area around the time of the oil spill but the proportion is unknown."* Similarly, Section 8.4.6 also states that *"the migratory nature of species such as salmon imply a limited seasonal presence with less potential for temporal and spatial overlap with a spill".* However, in contrast to what is reported in the EIA, there is considerable information available in the published literature that shows juvenile Chum and Chinook Salmon are the most abundant salmonids in the nearshore areas of Burrard Inlet from early spring to fall; with Coho, Sockeye, Pink and Steelhead salmon (*Oncorhynchus kisutch, O. nerka, O. gorbuscha and O. mykiss, respectively)* also present, but in fewer numbers (Macdonald and Chang 1993; Nato and Hwang 2000; Haggarty 2001). Juvenile Chum Salmon are found with the greatest abundance in nearshore areas of the Inlet in April; exactly when the spill occurred. Juvenile Chum Salmon would have been especially vulnerable to oil exposure as they primarily inhabit surface waters (i.e. top 10 cm, Haggarty 2001), where interactions with spilled oil would have been most likely to occur. Therefore, there was considerable potential for salmonids to be adversely affected by the spill. In addition to these trends being well documented from field studies, the Regional Mark Processing Centre (the body responsible for reporting annual fry and smolt releases for salmon enhancement efforts throughout the Canadian and United States Pacific region), reports over one million juvenile salmon were released from stock enhancement facilities into Burrard Inlet between April and May 2015. A majority of these fish would have entered the ocean in the vicinity of the spill. Dates and numbers of releases by species for individual release events are available from the Regional Mark Processing Centre website. The EIA's failure to appropriately assess the potential impacts of the oil spill on salmonids in light of this information demonstrates a lack of due diligence.

Conclusions

Monitoring and sampling efforts undertaken to characterize potential effects to fish and fish habitat.

- The sampling and monitoring efforts undertaken were insufficient to characterize potential effects to fish and fish habitat.

- Rationale provided for site selection and spatial and temporal coverage was unclear and inconsistent between types of sample collections within the assessment area and in association with reference sites.
- There was a lack of replicate measurements over space and time to adequately capture inherent sample variability and potential change over time.
- Surf smelt and intertidal habitat survey designs did not adequately address potentially confounding environmental factors, and provided no direct link between observations and reported results; aside from reporting a lack of oil observed during surveys.
- There was a lack of discussion describing: the rationale for, and the methods undertaken in, the sampling designs; assumptions, sampling constraints, confounding factors, and uncertainties associated with monitoring efforts and observations.

Approaches used to determine the assessment area as the area most likely affected.

- There was insufficient information provided on the methods, survey designs or survey constraints to properly assess the adequacy of the approaches used to determine the assessment area as the area most likely affected by the oil spill.
- Additional information describing the methods, and detection efficiencies of the aerial surveys (and associated remote sensing methods), the SCAT surveys, and the sorbent bottom drags would have improved understanding of how the assessment area was delineated. The inclusion of such information in a marine oil spill EIA is recommended.
- There was insufficient information describing the local marine environment to relate it to the assessment area outlined in Figure 21; the selection of VCs and ICs; or to the applied sampling designs. The inclusion of bathymetric maps in a marine oil spill EIA to relate to fish and fish habitat is recommended.

Statements and conclusions, uncertainty and information gaps

- The EIA does not sufficiently assess potential effects of the oil spill on many marine ecological components, including, but not limited to, the species studied as part of the EIA. This is largely due to inadequate sampling designs and information gaps associated with monitoring potential responses.
- The EIA does not discuss the uncertainties associated with conclusions drawn. In particular, the conclusions that were based on a limited number of samples that may not be sufficiently representative of the affected area. In addition, there was a lack of statistical validation and analysis of the observations, including insufficient characterization of sample variance (e.g. tissue samples, surf smelt embryo surveys, intertidal habitat surveys).
- The EIA does not accurately characterize habitat utilization by salmonids in the assessment area and**,** as a result**,** poorly assesses the potential impact of the oil spill on them.
- Many information gaps associated with the EIA are noted in this DFO Science Response. Due to the time lag since the spill, opportunities to apply more effective sampling designs or collect additional information to better understand potential effects from the *M/V Marathassa* fuel spill have now passed. However, information from this Science Response may be used to evaluate the overall effectiveness of the EIA to detect and assess potential effects from the fuel spill.

Recommendations to guide the development of future oil spill impact assessments

- To ensure efficient and timely responses to future oil spills, the development of a framework with guidelines and protocols for planning and implementing EIAs for marine oil spill incidents is recommended. Recommended components of such a framework include:
  - clear descriptions of sampling efforts needed to adequately assess environmental impacts based on established sampling design principles;
  - clear definitions of the roles and responsibilities of the Polluter in ensuring the thorough collection of representative information for assessing potential effects, and
  - alignment with the framework and guidelines of other national initiatives, such as Area Response Planning under the World Class Tanker Safety System, the Coastal Strategy, and the Centre for Offshore Oil, Gas and Energy Research (COOGER), to ensure systematic and comprehensive identification of ecologically important or sensitive components and the application of suitable methods to characterize potential effects.
- Information related to oil spill EIAs in other jurisdictions (both within and outside of Canada) could prove valuable in assisting the development of components of an oil spill response framework; such as those developed for monitoring environmental impacts from effluent discharges related to the pulp and paper and mining industries in Canada. The use of published literature to inform survey design choices and interpret results is also recommended.
- The development of guidelines or standards on EIA documentation and reporting structure is recommended to improve clarity and understanding of the information and efforts undertaken in an EIA. A format which caters to providing clear and consistent explanations of the objectives, assumptions, methods, results, and uncertainties for each type of monitoring or sampling effort would reduce redundancy and improve clarity. The use of summary tables and figures to give a clear overview of all realized sampling efforts, and to assist in cross-referencing information on sampling methods, sites, dates and observed results, is recommended.

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