Comments on the Pacific NorthWest LNG Draft Environmental Assessment Report

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(supported by the Prince Rupert Environmental Society, the T. Buck Suzuki Foundation, and the United Fishermen and Allied Workers Union - UNIFOR)

Author's Note: *Although it is generally accepted stylistic practice to write objective scientific critiques in the third person, I am taking the liberty of using the first person in this critique when referring to my own work, and in explaining the rationale and significance of that work.*

To avoid confusion, references to citations and figures have been removed from material quoted directly from the proponents reports. All figure and citation references in this critique refer to information provided in this critique, and not that provided by the proponent.

1. General Comments

Many of the comments in this critique relate to breach of accepted standards for the practice of science. As a research scientist and a professional biologist, I believe that good science can only be generated if the scientists involved follow approved scientific practices, including proper referencing and citation of others' work, keeping abreast of the most recent work carried out by other scientists in the field of interest, and having the ability to provide appropriate and reasonable responses to others' work that does not support the hypothesis being presented. "Cherry picking" statements from out-dated papers which have been superseded by more current research in order to support a particular viewpoint or outcome is not good science. Furthermore professional biologists who are members of the College of Applied Biology (CAB) are bound to follow a code of ethics which states that they must "*provide objective, science-based, unfettered, forthright and intellectually-honest opinion, advice and reports*" and to "*uphold the principles of stewardship of aquatic and terrestrial ecosystems and biological resources*". While not all biologists involved in the creation of the PNW LNG EIS and Draft EA report are members of the CAB, many of the consultants involved in the environmental assessment for the PNW LNG are registered professional biologists with the CAB and therefore bound to follow the CAB code of ethics and other accepted standards. In spite of this, the whole environmental assessment process has been rampant with examples of poor science (many of which are described in detail below) and practices which, for the reasons set out below fail, in my opinion, to follow or comply with accepted standards of professional ethics. Typical of this type of poor scientific practice, the proponent released a pair of publications "*Predicted Project Effects on Fish and Fish Habitat*" and "Appendix D Report on Fish and Fish Habitat - Baseline Characterization of the Fish and Fish Habitats on Flora Bank and Adjacent Habitats". These documents received serious scientific criticisms, and have since been withdrawn by the proponent, but provide an excellent example of the type of bad science which has plagued the EA process. Not only does bad science increase the likelihood of serious environmental harm from a project, the credibility and reputation of all scientists can be affected negatively.

2. Flora Bank Eelgrass

2.1. Eelgrass Data Inadequate

The Draft EA Report states:

> *Flora Bank, immediately west of Lelu Island, is a large, flat, intertidal area of fine to medium sands with eelgrass beds that cover 10-15% of the 325 ha area seasonally.* (Draft EA Report, pg. 27).

Therefore, based on this statement, the proponent is claiming that the amount of eelgrass on Flora Bank is at best 0.49 km^2 (15% of 325 ha = 48.75 ha = 0.4875 km^2). This number is derived from the Marine Resources Sections of the EIS and the Addendum to the EIS. The original "*Section 13 - Marine Resources*" has been replaced by a new Section 13 chapter that is included in "*Appendix A*" of the EIS Addendum. However, "*Appendix M: Technical Data Report - Marine Resources*" remains unchanged.

In Appendix A, the proponent notes that:

> *Owing to the importance of Flora Bank as salmon rearing habitat, several methods were used to estimate, triangulate and ground-truth eelgrass extent and composition across this area during field surveys in May 2013. The extent of eelgrass was estimated by circumnavigating the bank with a hand-held GPS unit. These surveys were supplemented by assessing conditions on transects running perpendicular to the slope of the bank, from subtidal to intertidal zones, along which the first (i.e., deepest) observation of eelgrass was noted. In addition, eelgrass shoot percent cover and canopy height were estimated in 0.5 m x 0.5 m quadrats distributed across the Bank in a stratified random manner. These field surveys were supplemented by analysis of satellite imagery acquired in 2011 to further estimate the distribution of eelgrass across the Bank. These estimated distributions were compared to previous remote-sensing estimates to obtain insight into interannual variability in the extent of this important eelgrass area.* (EIS Addendum, Appendix A - Marine Resources, pg. 13-14)

Although the proponent has changed the wording in the new Appendix A chapter, this is still the same data that was presented in the original version of the EIS. The collection of that data was subject to significant technical difficulties, and the quality and reliability of eelgrass coverage estimates was severely affected by these difficulties. I covered this issue in detail in my submission to the Canadian Environmental Assessment Agency, titled "*Comments on the Pacific NorthWest LNG Environmental Impact Statement and Environmental Assessment Certificate Application*" (Faggetter 2014a). I have included the relevant sections of that critique in Appendix 1 of this report.

Reading further in Appendix A, the following comment is found:

> *Additional eelgrass field studies were conducted in September 2014 to supplement existing information. A complete summary of the 2014 findings are presented in the Eelgrass Survey Report (Appendix G.22).* (EIS Addendum, Appendix A - Marine Resources, pg. 13-22

As it turns out, there are two documents titled Appendix G.22. The first, published on December 12, 2014, and titled "*Eelgrass Survey Report*", states the following:

> *The objective of this report is to provide a summary of the data collected during the September 8 and 9, 2014 eelgrass surveys at the locations of the pioneer dock and the material offloading facility (MOF). Surveys were completed to describe intertidal beds of eelgrass. Beds were delineated, and percent cover and number of shoots were estimated within quadrats. Twentyfive eelgrass beds or patches were delineated at the MOF site. Both species of eelgrass were found at the site, with Z. japonica found higher and Z. marina found at or below the low tide line. In 2014, the total area of eelgrass recorded at both sites combined was approximately 1,832* m^2. (EIS Addendum, Appendix G.22 - Eelgrass Survey Report, pg. iii)

This document contains no information regarding eelgrass distribution on Flora Bank.

The second document, published on July 5, 2015, and titled "*Pacific NorthWest LNG Project Eelgrass Interim Data Report*", has the following objectives:

> *To address the objectives of the program, four field surveys (three transect surveys and one focused on installation of light loggers) will be conducted during the growing season (June through September) including maximum mid-summer distribution and spatial extent. … The first transect survey started during the low tide series in early June, 2015 to capture eelgrass*

> *characteristics and spatial extent early in the growing season. The installation of light loggers occurred during a mid-June low tide. The second and third transect surveys will be completed during the July low tide and the late-August low tide, respectively. The late-August survey is intentionally scheduled at the end of the month to capture eelgrass characteristics following peak growth.* (EIS Addendum, Appendix G.22 - Pacific NorthWest LNG Project Eelgrass Interim Data Report, pg. 1.1)

It seems that the proponent is attempting to address the issues around seasonal variability in eelgrass coverage and the importance of measuring eelgrass abundance at peak growth, which occurs in August. However, if you read further in this document, you find that there is only data for the June 4 to 7, 2015 survey. The summary section of the document states:

> *This interim data report describes the eelgrass survey methods and survey records completed on Flora Bank during Survey 1 (June 4 – 7, 2015), and of the light logger placement on June 18 – 19, 2015. To date, four semi-permanent survey sites have been established on Flora Bank, and 12 transects over four sites have been surveyed for eelgrass density and morphological characteristics. Surveys were based on international methods adopted from SeagrassNet.*
>
> *Ten light loggers were installed across Flora Bank in June, and an additional 20 light loggers will be placed across Flora Bank in early July. Light loggers will collect and store data until they are retrieved during the August/September survey. Two additional eelgrass morphological surveys are scheduled to occur in July and August of 2015.* (EIS Addendum, Appendix G.22 - Pacific NorthWest LNG Project Eelgrass Interim Data Report, pg. 6.18)

Although it appears that the proponent intended to carry out surveys in July and August, no further information on these surveys has been provided to the public, and it is unknown whether or not these surveys did in fact take place, or what their outcomes might have been.

Figure 1 in Appendix G.22 (EIS Addendum, Appendix G.22 - Pacific NorthWest LNG Project Eelgrass Interim Data Report, pg. 2.4) shows the locations of the transects for the June, 2015 eelgrass survey. It is interesting to note that none of the transects are near or under the proposed bridge, the area of greatest concern for impact on eelgrass. Thus, this survey does not allow the proponent to verify either the presence or absence of eelgrass in this critical location.

In summary, the proponent continues to use inadequate data as a basis for their estimation of eelgrass abundance. The original, unreliable data from the EIS are still being used, and the new data from 2015 were not collected during the time of peak eelgrass growth and do not cover the area of greatest impact. As a result, the total amount of eelgrass on Flora Bank is most likely underestimated by the proponent, and thus the impacts of the project to eelgrass could be considerably greater than the proponent is claiming.

2.2. Relevant Studies by Other Researchers Not Addressed

The proponent is claiming that the amount of eelgrass on Flora Bank is at best 0.49 km^2. However, several studies, including relatively recent surveys, have shown that the amount of eelgrass on Flora Bank is somewhere between 0.8 km^2 and 1.0 km^2. I covered this issue in detail in my submission to the Canadian Environmental Assessment Agency, titled "*Comments on the Pacific NorthWest LNG Environmental Impact Statement and Environmental Assessment Certificate Application*" (Faggetter 2014b). I have included the relevant sections of that critique in Appendix 2 of this report. The proponent has made no attempt to address the discrepancy between these results, and has simply assumed that their survey results are correct. This is, at best, poor science. Large discrepancies between results from different researchers studying the same phenomenon merit further study. If the total amount of eelgrass on Flora Bank has been underestimated by the proponent, the impacts of the project to eelgrass could be considerably greater than the proponent is claiming.

The proponent has not paid attention to situations where recent studies have superseded older research. For example, the proponent has referenced a study that I did in 2009 (Faggetter 2009b), stating "*Eelgrass beds are restricted to the intertidal areas of Flora Bank because the high TSS influence of the Skeena River limits the photic zone, impairing subtidal plant growth*" (EIS Addendum, Appendix A - Marine

Resources, pg. 13-22). This survey was carried out during May, and I assumed (possibly incorrectly) that the relative paucity of subtidal eelgrass was due to light limitation resulting from high turbidity. However, in a study that I carried out in 2011 (Faggetter 2011c), wherein a single bed of eelgrass was surveyed several times throughout a year, I was able to show that eelgrass did not reach its maximum biomass until sometime after July. Thus, the low abundance of subtidal eelgrass seen in my 2009 study was more likely a result of the time of the survey, rather than high turbidity. On July 26th, 2013, I again surveyed Flora Bank (Faggetter 2013). This time, a subtidal eelgrass bed was observed, with medium to tall eelgrass (e.g., ecotype *latifolia*) at a depth of 1.8 m and with an average percentage cover of 71%. Quite clearly, subtidal eelgrass does exist at Flora Bank. The proponent, however, has only referred to my oldest study, and has not addressed my more recent work. Again, the presence of subtidal eelgrass on Flora Bank provides further substantiation that the areal extent of eelgrass on Flora Bank is greater than the proponent is claiming, and the statement "*any changes to sediment erosion and/or deposition patterns would occur outside of the spatial limits of eelgrass beds on Flora Bank*" (Draft EA Report, pg. 57) is unfounded.

3. Juvenile Salmon Habitat

3.1. Eelgrass Habitat Loss on Flora Bank Underestimated

Eelgrass is high value nursery habitat for juvenile salmon. Flora Bank supports 50-60% of the eelgrass in the Skeena Estuary (Fisheries Services 1972 cited by Hoos 1975), and was ranked second only to Inverness Passage as habitat of critical importance for the rearing of juvenile salmon (Higgins and Schouwenburg 1973). Recently, I carried out a study on the Skeena River Estuary juvenile salmon habitat (Faggetter 2014b; a summary of the study is given in Appendix 3). Of the 377 million juvenile salmon entering the Skeena estuary region each year, 376 million come from the Skeena River watershed. Based on surveys of juvenile salmon done in 2007 (Gottesfeld *et al*. 2008) and 2013 (Carr-Harris & Moore 2013), it was estimated that the vast majority of these Skeena watershed juveniles (88% or 331 million) turn north into Inverness Passage, and ultimately pass over Flora Bank (Faggetter 2014b). Studies during the 2014 outmigration of juvenile salmon from the Skeena River (Eriksson *et al*. 2014) supported this estimate, showing that 91% of the juvenile salmon traveled north through Inverness Passage, and only 9% entered Telegraph Passage before turning north. Eriksson *et al*. (2014) reported:

> … the vast majority of migrating young salmon we observed turned off the main-stem of the Skeena and traveled northwest through Inverness Passage. On glassy calm days this could be observed as thousands of little dimples from one end of the channel to the other. On the flood tide these fish would move into the back eddies along the shore line and in particular work their way to the large back eddy formed by Lelu Island at the entrance to Stapleton Passage. Fish that did not turn at Inverness, but instead kept going down the main-stem, were observed dispersed and only in small numbers despite a good deal of effort spent looking in this part of the estuary. No significant concentration of smolts either in the main-stem or out front in the main plume and shore lines of De Horsey, Kennedy or Smith Island were observed.

Many of these juvenile salmon traveling north along Inverness Passage (over 80%) are epibenthic, or bottom, feeders that depend heavily on shallow, nearshore nursery habitats (Faggetter 2014b). Flora Bank is one of the best quality habitats for epibenthic juvenile salmon, providing both food and shelter from predators (Faggetter 2014b). Therefore, both location and habitat quality make Flora Bank an extremely important juvenile salmon rearing area.

In the most recent version of the EIS, the proponent states the following:

> *The primary activity associated with construction of the suspension bridge, trestle and LNG carrier berth is the installation of piles (including tower/anchor platforms and scour protection) and removal/infilling of marine riparian areas. In addition to the primary construction activities, propeller scour associated with LNG vessels and changes to depositional patterns associated with constructed marine infrastructure may contribute to increased sediment deposition and TSS*

concentrations on Flora Bank. The primary activities will result in a change in fish habitat of 69,968 m^2, including:

- *1,572 m^2 of marine riparian vegetation*
- *54,000 m^2 of eelgrass habitat on Flora Bank associated with changes to depositional patterns from marine infrastructure, used by juvenile salmonids and other CRA and forage fish*
- *10,254 m^2 of subtidal soft substrate habitat associated with the southwest tower and anchor platforms and marine vessel berthing platform, primarily used by Dungeness crab and local flatfish species*
- *4,142 m^2 of intertidal and subtidal soft substrate habitat associated with pile installation and scour protection, primarily used by Dungeness crab and local flatfish species.*

(EIS Addendum, Appendix A - Marine Resources, pg. 13-49)

Using the proponents claim that the amount of eelgrass on Flora Bank is at best 0.49 km^2, then 54,000 m^2 of eelgrass habitat impacted would be approximately 11% of the total. However, the EA Report now states that:

> *The footprint of the suspension bridge, marine trestle, marine terminal berths, and associated scour protection would affect a total of 21 505 m^2 of habitat on Agnew Bank, an open water, subtidal, soft silt-clay habitat used by crabs and flatfish. Of this, the proponent identified the infrastructure footprint (8760 m^2) as permanent loss of habitat, meeting the serious harm definition of the Fisheries Act. The scour protection footprint (12 745 m^2) may also meet the serious harm definition, to be determined based on final engineering designs. Three- dimensional modelling examined changes to local hydrodynamics and morphology at Agnew Bank and the adjacent Flora Bank, an intertidal, sand habitat used by eelgrass and a wide range of fish. The model results indicated that: any seabed changes on Agnew Bank would reach equilibrium over time and not significantly affect resident fish; any changes to sediment erosion and/or deposition patterns would occur outside of the spatial limits of eelgrass beds on Flora Bank; water current speeds around the infrastructure would be unlikely to increase in a manner that would affect fish; and Flora Bank would be robust and stable following construction of the proposed structures with no evidence of divergent or run-away effects.* (Draft EA Report, pg. 57)

These new results are based on data given in the Pacific NorthWest LNG - Supplemental Modelling Report, pg. L-1. It seems that the situation has gone from a potential of 54,000 m^2 of impacted eelgrass on Flora Bank to no impacts on Flora Bank and 21,505 m^2 of direct impacts on Agnew Bank (as compared to 14,396 m^2 from the EIS). While the data used in the second supplemental modelling exercise was greatly improved over the previous modelling attempt, suggesting that the second model may be more accurate, the entire modelling approach presents more issues than it resolves:

- The two modelling attempts used different models. The first study used two models developed by the U.S. Army Corps of Engineers [USACE] - the CMS-Flow Model (a model which predicts the coastal system hydrodynamics, including tidal flows and winds) and the Particle Tracking Model (PTM) (a model which determines the fate of the sediments mobilized by the currents). The second study used Delft3D (a model which simulates wave growth and transformation, and 3D hydrodynamics, salinity transport, sediment transport, and morphological change) and MORPHO (a coastal processes modelling system that simulates hydrodynamics, sediment transport and morphological change). Therefore, it is unclear whether the difference in results between the two studies is due to improved data or the inherent differences between the models used. Clearly the Canadian Environmental Assessment Agency is not completely convinced that the model results are accurate, since they identified the following key mitigation measure which the proponent will need to implement:

  Conduct modelling of the final construction ready designs for the south-west tower and anchor block to confirm that erosion and deposition levels are at least the same or less than the levels predicted in the environmental assessment. The modelling would include high resolution modelling of the south-west tower and anchor block as well as regional three-dimensional modelling of the areas potentially affected by the Project. Include the presence of two LNG carriers at the berth in the models. Calibrate the models using measured field data of waves, currents, and total suspended sediment concentrations over Flora Bank.

Provide the results of the modelling, including detailed inputs, methodologies, and outputs, to the Agency and to Aboriginal groups. The detailed final designs used in the modelling should consider outcomes of a second year of one-hour wave-flow coupling time series run modelling. (Draft EA Report, pg. 66)

- Due to the inadequacy of the proponent's eelgrass surveys (see section 3.1 above), the total amount of eelgrass on Flora Bank has been underestimated by the proponent. As a result, even if their modelling studies are accurate, the total amount of impacted eelgrass that is calculated using these models will be underestimated.
- The boundaries of Flora Bank, and the break point between Flora Bank and Agnew Bank are very subjective. The proponent has the "edge" of Flora Bank aligning with their trestle/bridge structures. However, the "edge" may well extend into deeper water, as eelgrass has been observed below the bridge/trestle (see Appendix 2). The location of this boundary will determine how much of the modelled impacts will affect Flora Bank, and how much will affect Agnew Bank. Changes in this boundary location may be responsible for some of the differences observed between the two modelling exercises.
- There are large discrepancies between the results of the modelling carried out by the proponent and studies done by other researchers. For example, the proponent's most recent modelling study concludes "*The erosion, deposition and morphology changes due to the proposed structures are not predicted to affect the eelgrass habitat on Flora Bank*" (Pacific NorthWest LNG - Supplemental Modelling Report, pg. 178), However, recent work carried out by McLaren (McLaren 2016) states the following:

  Based on the interpretation provided by the STA, it is predicted that sand will be lost from Flora Bank (the Great Escape) following construction of the trestle portion of the terminal jetty. Because the energy of the processes affecting Flora Bank will be reduced between the start of the trestle and Kitson Island (the shadow zone), inequality of the energy between the two sides of the bank will allow sand waves to advance, causing a seaward loss of sand …

  Such diametrically opposed outcomes merit further study. Indeed, McLaren (2016) recognizes the seriousness of this issue, stating:

  Clearly the two approaches have produced exactly opposite assessments of the fate of Flora Bank. The discrepancy has serious economic, social, and environmental implications that encompass the First Nations, local communities, and ''environmentalists'' on the one hand, and the LNG developers and the British Columbia provincial and Canadian federal governments on the other.

  The opposing conclusions produced by the STA and numerical modeling emphasize the paradoxical nature of Flora Bank, which remains, at least in detail, unexplained. … Future collaboration is a possibility in order to more accurately determine the risk of placing the marine docking structures so close to Flora Bank.

3.2. Shoreline Infilling, Hardening, and Straightening in Porpoise Channel Not Adequately Mitigated

Shoreline infilling, hardening, and straightening result in adverse impacts to shoreline ecological functions and habitat degradation such as

- reduction of refugia for young salmonids.
- decreased habitat for estuarine fishes.
- restriction of native riparian vegetation to small pockets scattered along the shoreline, which results in the isolation of the intertidal flats from inputs of sediment, nutrients, and organic matter (i.e., woody debris) from upland riparian vegetation zones. This isolation degrades the habitat quality of these flats.
- starvation and/or impoundment of beach sediment which diminishes longshore sediment transport.
- exacerbation of erosion.

Shoreline complexity provides a diversity of habitats for marine organisms and promotes high marine biodiversity. Fish moving along the shore use the eddies created by shoreline complexity as resting places when they are travelling against the tide. This is particularly important for juvenile salmon, whose swimming speed is frequently less than the velocity of the region's tides. Maintaining shoreline complexity is essential to their survival, and ultimately, return as adults.

Results from my Skeena River Estuary juvenile salmon habitat study (Faggetter 2014b) showed that Porpoise Channel was particularly good habitat for juvenile sockeye and Coho salmon. This study was further confirmed by direct observations in 2014 (Eriksson *et al*. 2014):

> *As out migrating smolts move farther from the river they concentrate in large numbers along the drop off line on the north west edge of Flora Bank through into Porpoise Channel and Port Edward. This area consistently had the highest abundance of all salmon species as well as large schools of herring and smelt of several different life stages. Several little points and bays on both sides of Porpoise Channel provided excellent back eddy habitats for feeding smolts, herring and smelt. The drop off line of Flora bank near the outlet of Porpoise Channel had the largest coho and chinook smolts within our sample area as well as the only place we caught very large old growth herring along with large smelt. Our experience would lead us to believe these coho and chinook are spending considerable time in this general area, probably months, feeding on young smelt, pink, and chum.*

The construction of the proposed MOF could have significant deleterious impacts on juvenile salmon in this area:

> *Construction of the Materials Offloading Facility in Porpoise Channel would permanently destroy 31 569 m^2 of intertidal soft bottom habitat, 19 825 m^2 of riparian habitat, 1830 m^2 of eelgrass habitat, and 6800 m^2 of rock habitat. Of these, the proponent identified effects to the eelgrass habitat and rock habitat as serious harm given their use by marine plants (e.g. eelgrass and kelp), juvenile salmonids, herring, surf smelt, sandlance, and crab. The construction of the Lelu Island access bridge and the pioneer dock would affect 3859 m^2 of riparian and 16 m^2 of intertidal soft bottom habitat at Lelu Slough; the proponent did not identify these changes as serious harm.* (Draft EA Report, pg. 57)

This habitat loss is further elaborated in the EIS Addendum:

> *The primary activities associated with MOF construction are dredging, blasting, pile installation and removal/infilling of marine riparian areas. These activities will result in a change in fish habitat of 60,075 m^2, including:*
>
> - *1,830 m^2 of eelgrass potentially used by juvenile salmon, eulachon juveniles and larvae, Pacific herring juveniles and flatfish species*
> - *19,825 m^2 of marine riparian vegetation removal*
> - *38,420 m^2 of intertidal and subtidal rocky and soft substrate habitat potentially used by juvenile salmon, eulachon juveniles and larvae, Pacific herring juveniles, Dungeness crab and local flatfish species. Destruction/alteration of this habitat is associated with dredging and pile installation.*
>
> (EIS Addendum, Appendix A - Marine Resources, pg. 13-51)

As a result of the construction of the proposed MOF, the entire shoreline at the location of the MOF will be hardened and straightened. The MOF is located in a region of critical habitat used by juvenile salmon outmigrating from the Skeena River. The small bay where the MOF is proposed to be constructed provides an important resting and feeding habitat for juveniles on their outward migration to Flora Bank. Construction of the MOF will reduce the habitat quality of this site by up to 30% (Faggetter 2014c).

The Draft EA states that "*To mitigate effects to marine fish habitat including marine plants, the proponent committed to develop and implement a habitat offsetting plan to the satisfaction of Fisheries and Oceans Canada to offset any serious harm as required by the Fisheries Act.*" (Draft EA Report, pg. 58) The report then goes on to describe this potential habitat offsetting in more detail:

The proponent identified 90 000 m^2 of lower productivity habitats within five potential offsetting sites that could be modified to increase the productivity of fisheries. The potential enhancements to these habitats include the creation of eelgrass habitats, intertidal and subtidal reefs, and intertidal gravel and cobble benches. The enhanced habitats are expected to benefit a range of fish and marine plants including juvenile salmon, flatfish, forage fish, invertebrates, eelgrass, and kelp. (Draft EA Report, pg. 58)

Further details of this habitat offsetting are found in the EIS Addendum, Appendix G.10. This document informs us that the habitat offsets include "*Five sites located around Lelu Island with an approximate total area of 24,080 m^2*" (EIS Addendum, Appendix G.10 - Habitat Offsetting Plans, pg. 8-18). Figure 7 of Appendix G.10 shows us the locations of the five sites. Only one (site A) is in Porpoise Channel, and it is 5,189 m^2 in size, approximately 1/3, or about 1,730 m^2, will be planted in eelgrass. This is the only site of the five that is comparable in both structure and function (recognizing that the juvenile salmon have specific outmigration routes and do not travel randomly around Lelu Island) to the habitat that will be lost at the MOF location. Assuming that there is 100% survival of the planted eelgrass (which is highly unlikely, as eelgrass has proven to be quite difficult to transplant), this will create a new habitat which is smaller than the habitat lost (1,830 m^2). The other four habitat offset sites may well provide valuable habitat, but will not perform the same ecosystem function for juvenile Coho, Chinook, and sockeye.

Clearly the habitat at the MOF site is extremely important to juvenile salmon, not only because of habitat quality and type, but also as a result of location. Attempting to replace habitat destroyed in this area by creating habitat offsetting at other sites will not be successful, as it is unlikely that those offsetting locations will provide the same ecosystem services to the same fish species. Thus, these habitat offsetting measures cannot ensure no net loss in productivity.

3.3. Importance of Lelu Island Upland Habitat to Juvenile Salmon Not Recognized

In my study on the Skeena River Estuary juvenile salmon habitat (Faggetter 2014b}, I commented on the importance of subestuaries and riparian zones as foraging areas for juvenile salmon.

Subestuaries:

- Both terrestrial and aquatic based prey are important within subestuaries
- Subestuaries are important "stop-over" feeding areas for salmon fry migrating along the nearshore shoreline.
- Prey availability within subestuaries is related to riparian conditions within the subestuary and the lower portion of the adjoining freshwater system and to adjacent wetlands, marshes, and mudflats.
- Land uses within and adjoining subestuaries that result in diking or disconnecting wetlands, sloughs, and secondary channels from main channels will reduce amounts of prey.
- Subestuaries that have high forage availability will hold fry longer and promote rapid growth and facilitate transition to salt water.

Riparian zones:

- The riparian zone of the shoreline can be an important source of prey.
- Land uses that remove riparian vegetation will reduce inputs of prey to the nearshore environment.
- Chinook and sockeye juveniles feed more on adult insects than other juvenile salmonids.

The proponent's marine fish survey confirms the importance of terrestrially derived prey in the diet of juvenile salmon. They report "*Terrestrial insects comprised a high proportion of contents in stomachs of chum and coho salmon, and were found frequently in stomachs of all four salmon species.*" (Pacific NorthWest LNG Project Marine Fish and Fish Habitat Survey Results December 2014 to August 2015 Interim Data Report, pg. 5.56). Their data shows that insects/arachnids make up 88% (by number) of the food items in chum stomachs, and 41% in Coho stomachs (Pacific NorthWest LNG Project Marine Fish and Fish Habitat Survey Results December 2014 to August 2015 Interim Data Report, pg. 5.57).

In both subestuaries and riparian zones, activities which impact the terrestrial uplands can significantly alter the foraging opportunities for juvenile salmon. The Draft EA states:

> *The Project would remove approximately 162 hectares of vegetation in the local assessment area. This represents 64 percent of the local assessment area, which covers 254 hectares.* (Draft EA Report, pg. 39)
>
> *A total of 119.2 hectares of wetland out of the 154.3 hectares found in the local assessment area would be lost … This area represents 77 percent of the wetlands found in the local assessment area* (Draft EA Report, pg. 40)

The Draft EA goes on to list a variety of functions provided by wetlands, but does not include the production of prey items which provide forage for juvenile salmon. Since this function has not been recognized, the proponent's proposed implementation of a wetland compensation plan by restoring off-site coastal bog habitat and creating new off-site wetland habitat will do nothing to mitigate the impact of this habitat loss on juvenile salmon foraging around Lelu Island.

4. Marine Country Foods

4.1. Full Human Health Risk Assessment for Country Foods Has Not Been Completed

According to the Draft EA:

> *… dredging marine sediment at the Materials Offloading Facility in Porpoise Channel during Project construction could disturb sediments containing historically deposited dioxins and furans. Although the concentration of dioxins and furans in sediments would not increase from dredging activities, the resulting sediment plume would increase total suspended solids in the water column. This could temporarily increase exposure to dioxins and furans through the gills of species of marine country foods. There is some risk that humans who regularly consume these organisms could be exposed to increased concentrations of dioxins and furans through this pathway.* (Draft EA Report, pg. 87)

A human health risk assessment (HHRA) is normally carried out to estimate the risk of potential adverse health effects on an individual, community or population that could arise from changes in environmental quality due to the proposed project alone and combined with the cumulative impact from other existing and planned projects, as well as inclusion of ambient or background conditions in the region (AWH 2011). HHRAs try to assess the following (Kindzierski *et al.* 2011):

1) *what the contaminants of concern for potential human health impact are – **chemicals***
2) *how and where they are released into the environment, and what pathways they are in (e.g., air, water, food, or soil) – **exposure pathways***
3) *who may be exposed to them – **people***

In addition to the assessment of potential health risks to members of the population in general, consideration must be given to individuals within a population who may be at greater risk. Critical subgroups are considered to be those whose lifestyle and behavioural characteristics may contribute to greater chemical exposures than the general public. This would include children or individuals consuming greater than average proportions of country foods and other natural foods (e.g., Aboriginal peoples and residents subsisting predominantly on locally grown produce, and traditional foods such as plants, wild game and fish) (AWH 2011).

Typically, an HHRA would involve detailed surveys of local diets to get information on both the types of foods eaten as well as the quantities of each type. This would then be followed up by a food chain analysis to determine potential pathways of exposure. Instead, the proponents report the following:

> *A baseline survey of marine country foods was conducted due to concerns from First Nations and local residents about the potential for adverse chemical effects to marine*

biota (i.e., clams, crabs and prawns) and subsequent effects to humans consuming these tissues. (EIS, Section 19 - Human and Ecological Health, pg. 19-15)

Although there have been a number of changes to the project since the original EIS, the proponent states:

> *The baseline environmental conditions regarding human and ecological health are described in Chapter 19 of the EIS and the Technical Memorandum: Human Health Risk Assessment submitted in June 2014. Baseline data includes laboratory results for concentrations of chemicals in the environment (i.e., drinking water, soil, marine sediment, and marine country foods), air quality and levels of light and noise.*
>
> *The project changes do not affect the baseline environmental data, which quantifies the quality of air, soil, drinking water, and marine country foods and also levels of noise and light.* (EIS Addendum, Section 19 - Human and Ecological Health, pg. 19-2)

Therefore, the proponent's conclusions about the exposure to dioxins and furans through country foods is still based on this baseline survey. This survey involved the following:

> *In September 2013, samples of crab (Metacapus magister), clam (Macoma sp., Mya arenaria) and prawn (Pandalus hypsinotus) were collected within 3 km of the MOF based on the anticipated sediment plume distribution and the southern end of Lelu Island where the proposed natural gas feed pipeline would enter the facility. Samples were analyzed for all congener classes of PCDD/F. These samples include 16 crab muscle, 16 composites mixtures of Macoma sp. and Mya arenaria, and 8 prawn samples.* (EIS, Section 19 - Human and Ecological Health, pg. 19-16)

The proponents do not identify which critical subgroups ingest each of these organisms, nor do they identify the exposure route for each of these organisms (it is assumed to be dermal exposure and/or ingestion, but this should be examined in more detail). Crabs and prawns are generally harvested for commercial resale, and probably only represent a small percentage of the diet of First Nations and local residents. *Macoma* and soft-shell (*Mya* sp.) clams are small, mud-dwelling clams than are not typically eaten by any local human consumers. However, several species commonly eaten by local residents (e.g., butter clams, cockles, salmon, and *Porphyra*) were not tested. The exposure routes of the sampled organisms are also likely to be different, since crabs and shrimp are detritus feeders, whereas bivalves are filter feeders. Additionally, it would have been useful to observe values from secondary consumers, such as salmon, to determine levels of bioaccumulation.

In light of the limited number of samples analyzed, and the fact that many of the organisms sampled do not represent the most significant pathways of exposure to First Nations and local residents, there is reason for concern that the proponent's baseline survey does not adequately reflect the human health risk potential of their proposed project.

5. Effects of Sound from Terminal Construction and Operation on Fish

5.1. Noise Threshold for Fish Set Too High

Anthropogenic noise can affect marine organisms in a variety of ways, including (Stocker 2002):

1) Tissue damage in extreme cases (e.g., very loud sounds).
2) Interference with normal sound production and reception, resulting in impacts on feeding, breeding, community bonding, schooling synchronization, and other acoustically-mediated behavior.
3) False triggering of behavioral responses causing an animal to expend energy unnecessarily. Large expenditures of energy that do not produce any positive benefits for an organism can make that organism unfit and less likely to survive.
4) Producing stress. Responses to stress can weaken organisms or damage community interactions.

Although the proponents have described at some length the effects of sound from terminal construction and operation on marine mammals (EIS Addendum, Appendix A - Marine Resources and EIS, Appendix N - Modelling of Underwater Noise for Pacific NorthWest LNG Marine Construction and Shipping Scenarios), their discussion on the effects of sound on other organisms, particularly juvenile fish, is relatively limited. With respect to direct injury, the proponents state the following:

> *In fish with swim bladders (e.g., salmon, herring, rockfish), pressure waves created by concussive impacts (e.g., pile driving) can rupture the swim bladder and/or damage other internal organs and tissue. Vulnerability to and the potential implications of such injuries, depend on the type of swim bladder a species possesses. Beyond this effect, auditory effects of underwater noise on fish are poorly understood.* (EIS Addendum, Appendix A - Marine Resources, pg. 13-62)
>
> *Despite the lack of information on auditory effects (injury) on fish, interim guidance criteria have been developed and adopted by the Fisheries Hydroacoustic Working Group for exposure to noise generated by pile driving:* SPL_{peak} *of 206 dB re: 1 μPa; and* SEL_{cum} *of 187 dB re: 1* $\mu Pa^2 s$*. This assessment considers exceeding these criteria to constitute a high potential for injury or mortality to fish.* (EIS Addendum, Appendix A - Marine Resources, pg. 13-64 - 13-65)

The proponents go on to describe behavioural responses as follows:

> *Potential behavioural responses of fish to underwater noise include change in behavior, small temporary movements for the duration of the sound, large movements that displace fish from their normal locations, and large-scale changes in migration routes. Construction noise is expected to trigger behavioural changes in fish that are close to construction activities. Behavioural changes in fish from non-pulse noises have not been well-studied but are likely to be greater in hearing specialists (e.g., herring) than generalists (e.g., salmon). Fish hearing specialists rely on auditory signals for communication, foraging and schooling; they have greater hearing sensitivity and perceive sounds over wider bandwidths than generalists.*
>
> *The most common reaction for all fish species is expected to be a short-lived startle response by fish near the onset of pulse noises (e.g., in close proximity to a pile during impact driving); however, normal behaviour is likely to resume within seconds. It is expected that juvenile fish (e.g., those that use the Flora Bank eelgrass bed as rearing habitat) will exhibit similar startle responses, but may be more sensitive at this life cycle stage.* (EIS Addendum, Appendix A - Marine Resources, pg. 13-77 - 13-78)

Since Flora Bank is a highly productive nursery area for juvenile fish, and since both the construction and terminal operation activities are in very close proximity to Flora Bank, there is a legitimate concern regarding the impacts of sound on juvenile fish utilizing this nursery habitat. Impacts which would cause juvenile fish to leave the nursery habitat prematurely, thus resulting in lost feeding opportunities and potential starvation, or which caused juvenile fish to develop behavioral responses (e.g., sound acclimatization) which could make them more susceptible to predation would be especially concerning. Based on the known range of salmonid hearing, sounds generated during pile driving activities are likely heard by fish within a radius of 600 meters from the source (Feist 1991). Feist (1991) determined that sounds generated during pile driving activities influenced both fish behavior and distribution of schooling salmonids in the vicinity of the site. On non-pile driving days the number of schooling salmonids drastically increased as compared to pile driving days. A study by Vagle (2003) discovered that juvenile Chinook salmon and chum salmon became disoriented after exposure to sounds ranging between 40 (186 dB SPL) and 50 kPa (188 dB SPL), and that mortality occurred with sounds in the range of 150 kPa (198 dB SPL). Juvenile Chinook salmon displayed both flight and avoidance responses to sounds in the 10 Hz range (Knudsen *et al.* 1997).

Based on the few specific studies available to date, the Fisheries Hydroacoustic Working Group's interim guidance criteria are too high to provide adequate protection for species such as salmon. Further research is needed to determine if sound generated by normal terminal operation will affect the foraging behavior of juvenile fish on Flora Bank. The Canadian Environmental Assessment Agency also appears to have some concerns, since they state:

> *With additional mitigation measures, there may still be residual effects … to fish behaviour that could affect life processes (e.g. herring spawning on Flora Bank affected by underwater noise).* (Draft EA Report, pg. 65)

6. Impacts on Harbour Porpoise

6.1. Adverse Effects on Harbour Porpoise Cannot Be Mitigated

Marine mammals are frequently, and affectionately, referred to as "charismatic megafauna" because they are easily viewed marine animals which capture the imagination and concern of the public. As mammals, they serve as "canaries", sensitive organisms which can provide an early warning of potentially dangerous threats to other organisms, particularly mammals such as ourselves. Threats to cetaceans are of particular concern because many species are at risk or have been at risk in the recent past.

The Draft EA notes the following with respect to harbour porpoise (Draft EA Report, pg. 68-72):

- harbour porpoise are listed as special concern under the Species at Risk Act
- harbour porpoise are present in the assessment area throughout the year
- high densities of harbour porpoise are found in the shallow waters around Prince Rupert and throughout the southern portion of Chatham Sound
- harbour porpoise are particularly sensitive to underwater noise, and have shown a higher degree of behavioral response to similar disturbances when compared to other marine mammals
- acoustic disturbance is a threat of medium to high concern for harbour porpoise

Clearly, impacts to harbour porpoise are an issue with respect to the proponent's proposed project. Using a "*characterization of the potential residual effects on marine mammals with respect to the magnitude, duration, frequency, and reversibility of effects, as well as the resilience of marine mammal populations in the area*" (Draft EA Report, pg. 78), the Canadian Environmental Assessment Agency makes the following statement about the adverse effects of the proponent's project on harbour porpoise:

> *… the Agency concludes that the Project is likely to cause significant adverse environmental effects to harbour porpoise, given its susceptibility to behavioural effects from underwater noise, its current at risk status, its extensive use of the Project area year-round, and the uncertainty of suitable alternative habitat.* (Draft EA Report, pg. 79)

and again:

> *… the Agency concludes that the Project is likely to result in significant adverse cumulative environmental effects to harbour porpoise, given its susceptibility to behavioural effects from underwater noise, its current at risk status, its extensive use of the project area year-round, and the uncertainty of suitable alternative habitat.* (Draft EA Report, pg. 143)

Note that the Agency says they are "*taking into account the implementation of mitigation measures and a follow-up program, as well as the marine mammal management program initiated by the Prince Rupert Port Authority that would help manage these effects*" (Draft EA Report, pg. 143) when making the statement that adverse effects are likely. Therefore, they are, in essence, saying that the impacts on harbour porpoise cannot be mitigated.

The question here is not whether or not adverse effects on harbour porpoise are likely, but rather, why are we allowing adverse effects on a species of special concern which cannot be mitigated? To me this is clearly a "show stopper". Projects with serious unmitigatable impacts should not be allowed to proceed. There are many other locations on the BC coast where this project could take place and not cause unmitigatable adverse effects. Are we siting this project based on sound science or politics?

7. Effects of Overwater Structures

7.1. Shading Impacts on Eelgrass Underestimated

Shading from overwater structures can greatly reduce eelgrass photosynthesis, and thus affect the productivity of impacted eelgrass beds. The proponent claims that there will be no shading impacts on eelgrass from their overwater structures (EIS Addendum, Appendix A - Marine Resources, Figure 13-10). However the proponent has significantly underestimated the amount of eelgrass present on Flora Bank as a result of the inadequacy of their surveys (see section 2.1). Recent surveys by other researchers have shown that there is eelgrass present below their bridge/trestle structure, and this eelgrass will experience significant shading impacts.

7.2. Effects of Overwater Structures on Juvenile Fish Behaviour Not Mitigated

Overwater structures have been documented to pose the following potential risks for increasing mortality of juvenile fish utilizing shallow estuarine and nearshore marine environments (Nightingale & Simenstad 2001; Toft *et al*. 2007):

1) "Behavioral barriers" that can deflect or delay migration (including juvenile salmonids avoidance of swimming beneath overwater structures – shading effect).
2) Prey resource production and availability (e.g., "carrying capacity") limitations.

Piers reduce the presence and feeding of juvenile salmon, indicating that areas under piers provide less-valuable habitat to salmon species (Munsch *et al*. 2014). When shoreline-oriented juvenile salmonids encounter an overwater structure or deep riprap, they either swim under the structure or move into deeper water. When juvenile salmon schools are forced into deeper water by overwater structures, they change their behavior. This may have implications for within-species competition, feeding behavior, and susceptibility to predation (Toft *et al*. 2007).

The proponent does not discuss, or suggest mitigation options for, issues relating to deflection or delaying of migration and altered predator-prey relationships associated with the effects of overwater structures.

7.3. Effects of Night Time Lighting Not Adequately Mitigated

Night time artificial lighting on dock structures can change fish species assemblages and pose increased risk of predation by subsequent changes in night time migration, activity, and location of predators (Nightingale & Simenstad 2001). For example, pink and chum salmon tend to congregate below security lights, and at high light intensities, chum salmon may be attracted and their out-migration delayed (Prinslow *et al.* 1979).

The proponent has proposed as a mitigation measure to "*Shield lights and direct light onto deck structures to prevent light spillage onto water*" (Draft EA Report, pg. 196). There are no discussions or details on how or where this might be achieved. Nor do they suggest that night time lighting will be altered at all of their other overwater structures (e.g., they only state that the deck lighting on the bridge will be shielded). It is not clear at this time how significant the reduction in night time lighting will be from this mitigation, since some light will still spill into the water, both from the bridge and trestle to a limited extent, and from the marine berth, where no mitigations have been suggested.

8. Acid Deposition

8.1. Effects of Ocean Acidification Not Evaluated or Mitigated

Ocean "acidification" occurs when chemical compounds such as carbon dioxide, sulfur, or nitrogen mix with seawater, a process which lowers the pH and reduces the storage of carbon. Ocean acidification decreases the ability of marine organisms - such as sea urchins, starfish, brittle stars, shellfish, corals, fish, and certain types of plankton - to use calcium carbonate for making hard outer shells or "exoskeletons", or for maintaining their internal body chemistry. These organisms provide essential food and habitat to other species, so decreases in their populations could affect entire ocean ecosystems (WHOI 2014).

While increased atmospheric CO_2 has generally been considered the culprit behind the current increase in ocean acidification, acid deposition also has the capacity to affect the ocean. This effect is most pronounced near the coasts, which are already some of the most heavily affected and vulnerable parts of the ocean due to pollution, over-fishing, and climate change. In addition to acidification, excess nitrogen inputs from the atmosphere promote increased growth of phytoplankton and other marine plants which, in turn, may cause more frequent harmful algal blooms and eutrophication (excess algal growth which can create oxygen-depleted "dead zones") in some parts of the ocean (Doney *et al.* 2007, WHOI 2014).

Emissions of air pollutants from the proponent's proposed facility are estimated to be as high as 0.47 tpd of SO_2, 11.44 tpd of NO_X, and 14,019 tpd of CO_2 (tpd = metric tons per day) (EIS Addendum, Section 6 - Air Quality, pg. 6-4). Unfortunately, studies on the impact of a coastal LNG facility on ocean acidification have not yet been done, thus the magnitude of the impact that acid deposition from the proponent's facility could have on the marine environment is not known. However, given the serious concerns that the BC shellfish industry has regarding ocean acidification and its relationship to the recent die-offs of oysters and scallops, coastal areas in BC may already be at risk. Increased ocean acidification can impact juvenile salmon by causing declines in the organisms on which they feed. For example small ocean snails called pteropods, which may make up more than 50% of the juvenile pink salmon diet, are already being affected by the acidification of the ocean.

9. Greenhouse Gas Emissions

9.1. Adverse Environmental Effects As a Result of Greenhouse Gas Emissions Unmitigatable

The environmental effects of global warming as a result of greenhouse gas emissions are no longer deniable. The UN Intergovernmental Panel on Climate Change (IPCC) states:

> *Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.* (IPCC 2014)

In response to the imminent need to limit climate change, Canada, as a signatory to the Paris Agreement, has agreed to

> *Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change* (Paris Agreement 2015).

If the proposed Pacific Northwest LNG project proceeds, it will be amongst the largest single point sources of greenhouse gas emissions in the country (Draft EA Report, pg. 36), resulting in "*5.28 million tonnes CO_2e per year (0.27 tonnes of CO_2e per tonne of LNG), a marked increase of greenhouse gas emissions both at the provincial (8.5 percent increase) and national (0.75 percent increase) level. Upstream greenhouse gas emissions associated with the Project of 6.5 - 8.7 million tonnes CO_2e per year would represent 10 - 14 percent of provincial emissions and 0.90 – 1.2 percent of national emissions…* (Draft EA Report, pg. 38)

The Canadian Environmental Assessment Agency clearly recognizes the immensity of the greenhouse gas emissions from this project, and states:

> *The Agency concludes that the Project is likely to cause significant adverse environmental effects as a result of greenhouse gas emissions after taking into consideration the implementation of*

> *best achievable technology and management practices and compliance with the B.C. Greenhouse Gas Industrial Reporting and Control Act.* (Draft EA Report, pg. 39)

Given the clearly observable impacts of global climate change that have already occurred and the urgent need to limit our greenhouse gas emissions, why are we allowing a project with massive GHG emissions to go ahead?

10. Cumulative Impacts on Salmon Habitat

10.1. Cumulative Impacts Resulting in Loss of Salmon Habitat Not Evaluated or Mitigated

Although the proponent recognizes the potential for cumulative impacts on marine fish and fish habitat, such as changes in sediment and water quality, direct mortality or physical injury, and behavioural changes resulting in underwater noise, they have not considered the cumulative impacts of habitat loss (Draft EA Report, pg. 136-137).

Recently, I completed a study on the cumulative effects on juvenile salmon habitat by Canpotex, Prince Rupert LNG, Pacific Northwest LNG, the Westcoast Connector pipeline, and the Prince Rupert Gas pipeline based on the public information provided by the various proponents. While I recognize that not all of these projects may go ahead, others which were not included in this model have since entered the field. Therefore, I feel that the conclusions drawn by this study are valuable in bringing to light the degree of cumulative habitat loss that may take place, and the impacts this could have on juvenile salmon (Faggetter 2014c).

Marine habitat offsetting proposals were not included in the model used in this study because:

- Location of habitat is key. Offsetting plans at other locations do not provide the same ecosystem services to the same organisms.
- Many of the proposed offsetting plans have not been adequately modeled, scoped, or reviewed, and several seem likely candidates for failure.
- Habitat compensation is not always successful. Good design, proper follow-up, appropriate governmental oversight and compliance monitoring, and often good luck, are all important ingredients for success.

The model showed that in the Ridley Island-Lelu Island-Flora Bank region, there is approximately 32.6 km of shoreline that is utilized by salmon out- migrating from the Skeena River. About 18.5 km, or 57%, of this shoreline will be impacted at some level by the proposed industrial developments. Considering the habitat value of the impacted shoreline, the loss of valued habitat to juvenile salmon will be 29%, or over ¼ of the currently existing habitat.

Total habitat loss as a result of multiple projects has not been addressed in the Draft EA or in any of the EIS documents. The potential amount of habitat loss is very significant, and could result in an unexpected collapse of Skeena River salmon stocks.

11. Appendix 1

The proponent carried out a number of eelgrass surveys on Flora Bank in an attempt to determine the areal extent of the eelgrass bed:

> *Owing to the importance of Flora Bank as salmon rearing habitat, several methods were used to estimate, triangulate and ground-truth eelgrass extent and composition across this area. The extent of eelgrass was estimated by circumnavigating the bank with a hand-held GPS unit. These surveys were supplemented by assessing conditions on transects running perpendicular to the slope of the bank, from subtidal to intertidal zones, along which the first (i.e., deepest) observation of eelgrass was noted. In addition, eelgrass shoot percent cover and canopy height were estimated in 0.5 m x 0.5 m quadrats distributed across the Bank in a stratified random manner. These field surveys were supplemented by analysis of satellite imagery acquired in 2011 to further estimate the distribution of eelgrass across the Bank. These estimated distributions were compared to previous remote-sensing estimates to obtain insight into interannual variability in the extent of this important eelgrass area.* (EIS, Section 13 - Marine Resources, pg. 13-13)

Each of these surveys is described in further detail in Appendix M1 of the EIS. Initially, a subtidal delineation was done during May 29-31, 2013, as follows:

> *Between May 29 and 31, 2013 a towed video survey was conducted from a small aluminum skiff (6.67 m in length) with a shallow draft.*
>
> *Twenty underwater video transects haphazardly spaced along the circumference of Flora Bank were surveyed using an underwater camera (Deep Blue Pro Splash Cam, Ocean Systems Inc., Everett, WA, USA) mounted on a polyvinyl chloride (PVC) frame attached to a 0.5 m x 0.5 m quadrat.*
>
> *To visualize eelgrass in the highly turbid water, the camera frame was tipped onto its side and towed rear-facing to ensure imagery would be collected from within the eelgrass canopy. Transects began in subtidal depths adjacent to Flora Bank in water depths assumed to be beyond eelgrass depth distribution limits. Attempts were made to collect transect data every 250 m along the circumference of Flora Bank; however, this was not possible due to the water current velocity laterally displacing the research vessel and poor underwater visibility due to high water column turbidity. The camera was towed towards Flora Bank (perpendicular to the hypothesized eelgrass bed edge) at a constant speed (not exceeding 4.5 km/h, speed over ground). Transects were halted and a GPS waypoint recorded upon visual confirmation of suspected eelgrass shoots on the video monitor. All video imagery collected during the survey was reviewed by a Stantec marine scientist with extensive eelgrass experience to verify field determinations of eelgrass presence/absence. Depth data were not recorded during the survey due to a chart plotter malfunction. All references to depth in this report are taken from Canadian Hydrographic Service (CHS) chart soundings.* (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 64-65)
>
> *While reductions in water clarity were anticipated, it was not expected that the turbidity levels would preclude the ability to visualize the quadrat frame on the drop camera. Multiple unsuccessful attempts were made to collect downward-viewing images of the substrate at varying locations during all tidal stages throughout the survey. As a result, the sampling method was amended as described.* (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 69)

Clearly, this was a very difficult survey for the proponent, with issues such as high water column turbidity, high water current velocity, and chart plotter malfunction all mentioned as contributing factors. The sampling method amendment of towing the camera frame sideways to collect rear-facing imagery is a particularly unusual technique. Not only does it involve dragging the camera frame through the eelgrass bed, a very damaging procedure and one generally avoided by most scientists working in the field, but it also precludes accurate field of view measurements, and thus density calculations, since the reference frame is now at an angle to viewed eelgrass. Since it has been well reported that visibility conditions within the Skeena River plume (including Flora Bank) often require camera towing altitudes of less than1 m above the bottom (Faggetter 2009a, 2009b, 2011a), it is very surprising that the proponent attempted the subtidal survey with a camera mounted on 1 m tall frame. Based on this survey, the proponent estimated the areal coverage of eelgrass on Flora Bank at 2.00 km^2 (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 72)

On May 30, 2013, an intertidal delineation of eelgrass on Flora Bank was carried out as follows:

> *On May 30, 2013 the intertidal extent of Flora Bank was surveyed during low tide. Two field biologists equipped with dry suits disembarked the research vessel on the eastern edge of Flora Bank approximately 30 minutes before low tide. With GPS units on tracking, each biologist walked in separate directions along the perimeter of Flora Bank. Efforts were made to walk along the seaward edge of the deepest visible eelgrass shoots encountered.* (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 65)

Again, it appeared that this survey was not completely successful, as the field biologists were unable to travel the complete circumference of Flora Bank (see EIS, Appendix M2 - Technical Data Report - Marine Resources Maps), leaving a large gap on the northwest side of Flora Bank. Since this is the region of the eelgrass bed which is closest to the proposed trestle, this data gap contributes to a lack of sufficient information on which to make informed decisions on eelgrass impact. However, the proponent estimates the areal coverage of eelgrass on Flora Bank based on this survey at 1.74 km^2 (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 72).

Finally, the proponent attempted to use satellite data to determine the areal extent of the eelgrass on Flora Bank as follows:

> *To obtain satellite imagery of Flora Bank, multiple options were explored to provide the best data interpretation possible given the dynamic environment of Chatham Sound. Prior to commencing field surveys, a WorldView-2 satellite test image (collected on June 7, 2011) was acquired through the DigitalGlobe image archive to assess whether satellite imagery would be useful for eelgrass classification in this region. Although the image coverage did not extend south beyond the Kitson Islet just north of Kitson Island, the image coincided with a low tide and all of Flora Bank was exposed.*
>
> *Coinciding with the 2013 field surveys, both the WorldView-2 and Pléiades satellites were commissioned through BlackBridge Geomatics to increase the probability of obtaining useful satellite imagery of Flora Bank ... During the study period, two WorldView-2 satellite passes were possible on May 24 and 26, 2013 at low tides of 0.4 m and 0.2 m, respectively. Three Pléiades satellite passes were made at low tides on the May 24, 26 and 28 of, 2013, at predicted tidal heights of 0.4, 0.2 and 0.4 m respectively. Due to adverse weather conditions on these days (i.e., the cloud cover was greater than 70%) and no usable satellite imagery from either satellite was acquired. However, BlackBridge Geomatics continued to collect Pléiades imagery for the Project after these dates. Although the low tide was higher than preferred (1.5 m), a cloud free image was acquired on June 1, 2013, and one day after the field surveys were completed.* (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 66)

Presence/absence of eelgrass in the satellite images was determined by applying both supervised (WorldView-2 satellite image) and unsupervised (Pléiades satellite image) maximum likelihood classification (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 67, 74-75). The Pléiades satellite image suffered from "*high turbidity*" and had "*large areas for which there was little information due to the suspended sediment*" (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 74). Based on these two satellite images, the proponent estimated the areal coverage of eelgrass on Flora Bank at 0.33 km^2 from the Pléiades image (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 74) and 0.64 km^2 from the WorldView-2 image (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 75). The proponent goes on to say that "*direct comparison of both* *satellite images demonstrated a 64.7% overlap of areas*" and that "*both images delineated large eelgrass patches in the northern and eastern regions of Flora Bank*" (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 75). Furthermore, they conclude "*Based on this level of agreement between images, it was assumed the 2013 field data would provide a reasonable approximation of the extent and structure of Flora Bank eelgrass described by the 2011 WorldView-2 imagery*" (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 75).

In summary, the proponent has used a range of survey methods to estimate the areal extent of eelgrass on Flora Bank, generating values ranging from 0.33 km^2 to 2.00 km^2. There is a wide degree of variation between the results of their different survey methods, and all of the survey methods used during the field season of 2013 were subject to significant technical difficulties, as described above. Ultimately, the proponent settled on a value of 0.64 km^2 derived from a WorldView-2 satellite test image collected on June 7, 2011, rather than on data collected during 2013. Using this data, the proponent then goes on to estimate the amount of eelgrass that will be destroyed by the marine terminal and breakwaters at 935 m^2 (EIS, Section 13 - Marine Resources, pg. 13-36). The issues associated with the proponents survey methods, and the variability of their data, suggests that the accuracy of their estimate of eelgrass impacted by the project is also likely to be poor. The proponent explains their data variability as follows:

> *Borstad Associates Ltd. completed a compact airborne spectrographic imager (CASI) survey of the greater Prince Rupert Harbour, including Flora Bank. Their August 1997 survey estimated the areal coverage of Flora Bank eelgrass to be 0.8 km^2. This value is comparable to our 0.64 km^2 estimate based on June 2011 imagery. While both values are very similar in magnitude, this 21% difference in areal estimates may be the result of multiple factors including: comparison of differing methodologies (airborne CASI vs. WorldView-2 satellite); intra-annual variation; and/or interannual variation.*
>
> *Eelgrass above-ground biomass and spatial distribution follows a strong seasonal pattern with minimal growth rates found during periods of low light and temperature in fall and winter with subsequently increasing growth rates during spring progressing to maximum distributional extent and above-ground biomass levels in early to mid-summer periods. As the Borstad Associates Ltd. CASI survey was collected during August, as opposed to our WorldView-2 survey in early June, it is possible our data do not accurately reflect the maximum intra-annual spatial distribution of Flora Bank eelgrass.*
>
> *Substantial inter-annual variation in eelgrass bed coverage has been observed in multiple studies at various locations throughout North America. … Given the magnitude of inter-annual variation recorded from eelgrass, our observed 21% difference from the results of Borstad Associates Ltd. is not likely to be of biological relevance. Further, the agreement of total areal extent values combined with the observed similarity in the distributional pattern of eelgrass between our survey and the Borstad Associates Ltd. survey 14 years prior suggests that the distribution of Flora Bank eelgrass has been relatively stable over this time period. In terms of the specific distributional pattern, two contrasting areas were apparent upon visual comparison of both surveys. First, a large patch of eelgrass present to the northeast of Kitson Island in 1997 no longer exists. Alternatively, the 2011 satellite imagery showed a bed of eelgrass along the southwestern aspect of Lelu Island near Leer Point which was not detected in the Borstad Associates Ltd. survey. These distributional shifts highlight the dynamic nature of submerged aquatic vegetation distributions in coastal environments.* (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 76-77)

While it is true that eelgrass has significant inter- and intra-annual variations, this is not justification to conclude that "*our observed 21% difference from the results of Borstad Associates Ltd. is not likely to be of biological relevance*" (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 77), nor is it justification to imply that no eelgrass is present underneath the proposed trestle simply because it was not seen on the 2011 WorldView-2 satellite. In fact, the highly variable nature of the eelgrass extent, particularly the intra-annual variation, is a good reason to suspect that the proponents did not observe eelgrass growing at the edge of Flora Bank simply because they were looking at the wrong time of the year. Seasonal studies at nearby Lucy Islands (Faggetter 2011c) showed that eelgrass areal extent was greatest in mid-July. A study on the growth and nitrogen uptake by eelgrass in a homogeneous bed located in the Oresund approximately 10 km north of Copenhagen (latitude 55° 40' N) showed that maximum eelgrass biomass was reached in August and minimum biomass was found in April (Pedersen and Borum, 1993). Although this study took place in the Atlantic, it was at a similar latitude to Prince Rupert (54° 19' N), and thus probably reflects the seasonal patterns observed here. Even though the proponents recognize the seasonal issues in their statement "*As the Borstad Associates Ltd. CASI survey was collected during August, as opposed to our WorldView-2 survey in early June, it is possible our data do not accurately reflect the maximum intra-annual spatial distribution of Flora Bank eelgrass.*" (EIS, Appendix M1 - Technical Data Report - Marine Resources, pg. 77), they do not recognize that their low estimate of impacted eelgrass may in fact be the result of this seasonal variation, and that if they had, in fact, surveyed in August, there may well have been eelgrass present below the trestle.

12. Appendix 2

A further examination of previous surveys of Flora Bank is merited. Figure 1 shows an overlay of the data from the Borstad Associates Ltd. CASI survey done in 1997 (Borstad Associates Ltd. 1996, Forsyth *et al.* 1998) on the proponents' data. The total areal extent of the eelgrass from this survey, as calculated by myself (Faggetter 2009b), was 0.8 km^2. Of particular note are the eelgrass patches that extend along and under the proposed trestle. These patches do not appear in the proponents' data. In 2009, I surveyed eelgrass on Flora Bank (Faggetter 2009b). This data is shown in Figure 2 overlaid on the proponents' data. As with the proponents' surveys, this data was collected during May, and does not represent the annual maximum extent of eelgrass for the area. However, while this survey was quite limited in nature, it illustrates two important factors: (1) using a methodology designed to be effective under low visibility, high current situations, eelgrass was observed subtidally, in several cases beyond the perimeter defined by the proponents' subtidal delineation; and (2) eelgrass was observed below the proposed trestle location.

On June 24, 2013, an independent group of scientists and technicians, myself included, performed a low altitude aerial survey of Flora Bank. The date was specifically chosen to coincide with a 0 m low tide (unlike the June 7, 2011 WorldView-2 satellite image, which was taken on a 1.3 m low tide). A 0 m low tide ensured maximum eelgrass bed exposure for aerial photography. Photographs from this flight were rectified, georeferenced, and mosaiced to form a complete image of Flora Bank (see Figure 3). Due to the variation in the angle of lighting as a result of photographs taken from multiple positions and altitudes, it was not possible to carry out a maximum likelihood classification. However, as a person with significant experience in both eelgrass surveys and remote sensing technology, I was readily able to identify the eelgrass based on color and texture, and hand digitized the patches (see Figure 4). No attempt was made to differentiate the eelgrass patches based on density. It was clear from the photo that eelgrass on the outer edges of Flora Bank had not yet reached its maximum growth for the season (e.g., the eelgrass was still short and "shrubby", rather than forming long, flat-laying swaths). This is not unexpected, as the eelgrass on the outer edges occurs at greater depths and receives less total sunlight annually, thus reaches its maximum growth later than eelgrass at the center of the bank. Based on this data, I estimated the total areal extent of the Flora Bank eelgrass bed at 1.0 km^2. As with the proponents' data, this estimate does not likely represent the maximum extent, which would occur later in August. However, it is still significantly larger (56%) than the amount (0.64 km^2) used by the proponent in their report (see Figure 5). The extent of the eelgrass seen in this survey also agrees well with the Borstad Associates Ltd. CASI survey done in 1997 (Borstad Associates Ltd. 1996, Forsyth *et al.* 1998; see Figure 6). Of particular note, the large patch of eelgrass present to the northeast of Kitson Island in 1997, which did not appear in the 2011 WorldView-2 satellite image, is present in the 2013 aerial survey. However, the 2013 aerial survey was not able to confirm the presence of the bed of eelgrass along the southwestern aspect of Lelu Island near Leer Point, which was detected in 2011 WorldView-2 satellite image, due to lack of coverage at this location. Finally, it is important to note that there is eelgrass present under the proposed trestle based on the data from the 2013 aerial survey (see Figure 7). The amount of this impacted eelgrass is 14,295 m^2 - approximately 15 times more than the proponents' estimated 935 m^2.

It is clear that the proponent has chosen to use an areal extent for the Flora Bank eelgrass bed that significantly underestimates the amount of eelgrass present as compared to other surveys of the region. This is of importance to evaluating the overall impact of the proposed project for several reasons:

1) Significant patches of eelgrass growing in the area of the proposed trestle were missed by the proponents' surveys. This eelgrass will be severely impacted by the project and needs to be included in the discussion on impacts and mitigation.
2) According to the proponent:

   "*The final HOP* [habitat offsetting plan] *will include detailed design drawings and construction plans for habitat offsetting measures. Once the final offsetting features have been selected, offsetting ratios will be developed in consultation with DFO. These ratios will reflect both the ecological value of affected habitats and the type of permanent alteration or destruction of fish habitat incurred. Specifically, ratios will be higher for habitats that have high ecological value and* *productivity and lower for habitats that have lesser value as fish habitat*." (EIS, Appendix K - Conceptual Fish Habitat Offsetting Strategy, pg. iii)

Thus, for the purpose of making decisions on how much new eelgrass habitat must be created as part of a habitat offsetting plan, it is important to have an accurate estimate of the current extent of impacted eelgrass, as well as a clear understanding of the ecological value of the habitat provided by that eelgrass. Compensation ratios for eelgrass habitat generally range from 2:1 to 4:1, depending on the ecological value of the destroyed habitat and the degree of uncertainty in the viability of the offsetting plan (Pearson *et al.* 2005, Sikumiut Environmental Management Ltd. 2011). Due to the importance of eelgrass habitat, DFO recommends a compensation ratio of at least 3:1 (DFO 2006).

3) Given the marked intra-annual variations of eelgrass (Faggetter 2011c), the precautionary principle, which guides Canada's environmental policy, should be followed. In this case, that would imply using the maximum recently recorded bed size (e.g., the Borstad data backed up with recent supportive aerial photos) to estimate amount of eelgrass impacted by the proposed project.

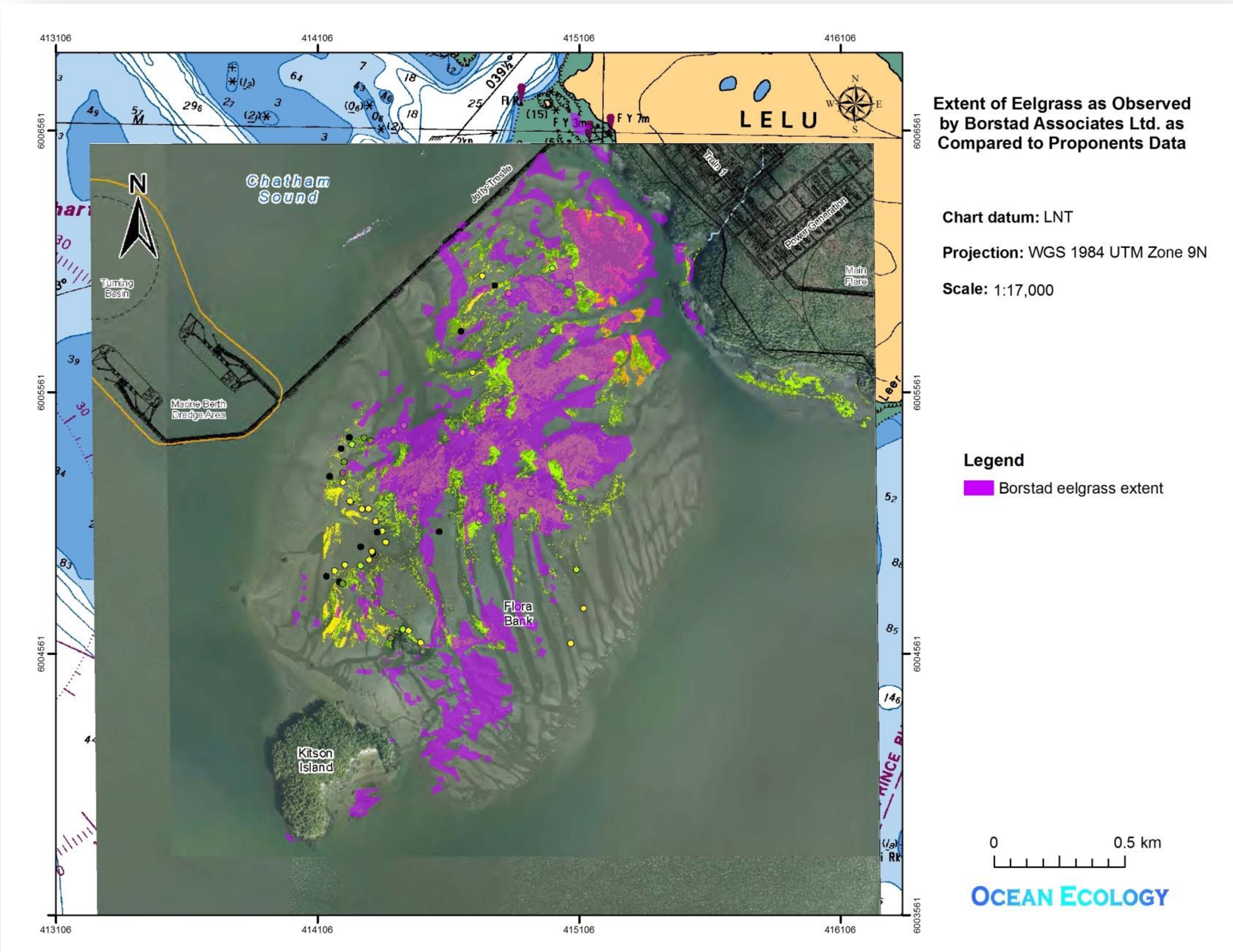

Figure 1. Extent of eelgrass as observed by Borstad Associates Ltd. as compared to the proponents' data.

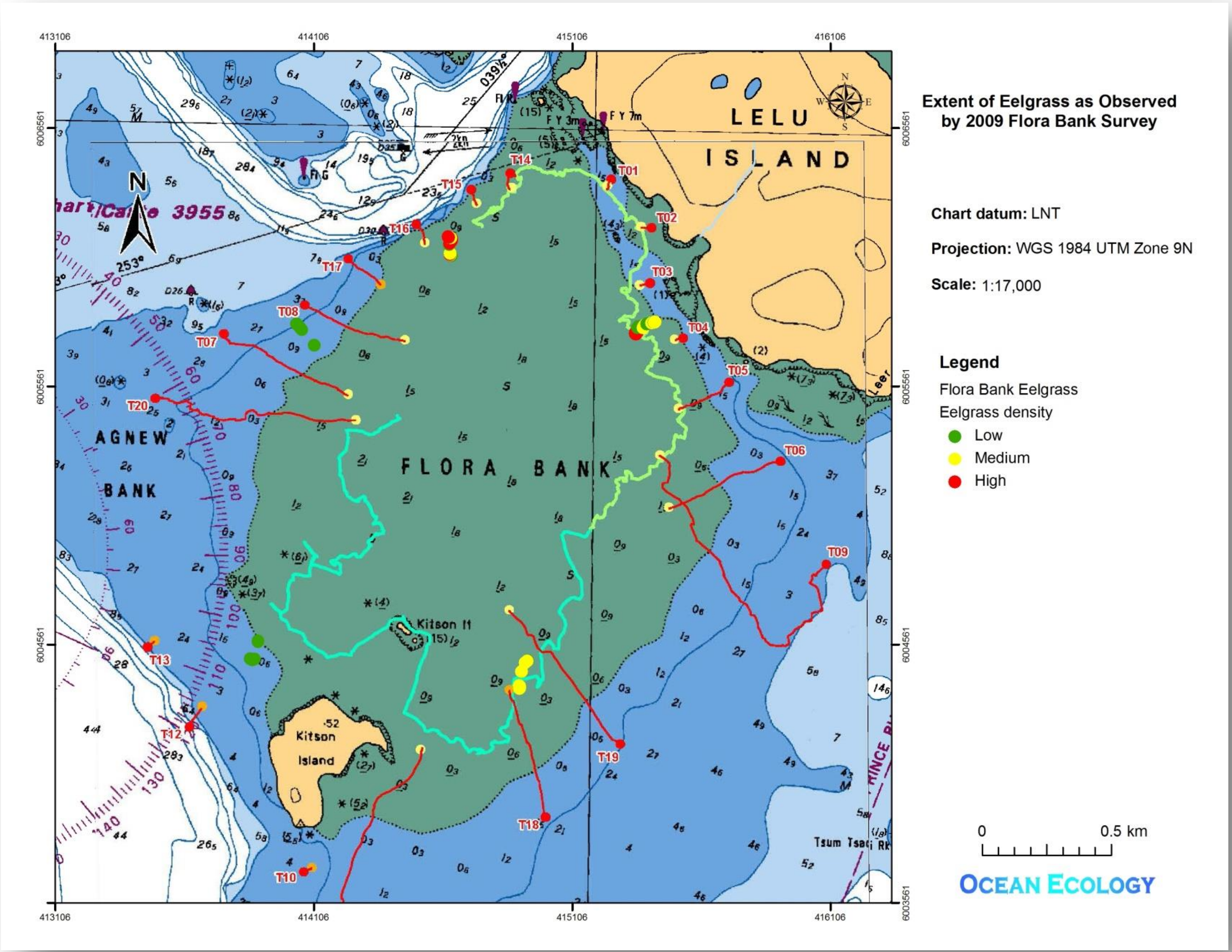

Figure 2. Extent of eelgrass as observed by the 2009 Flora Bank survey as compared to the proponents' data.

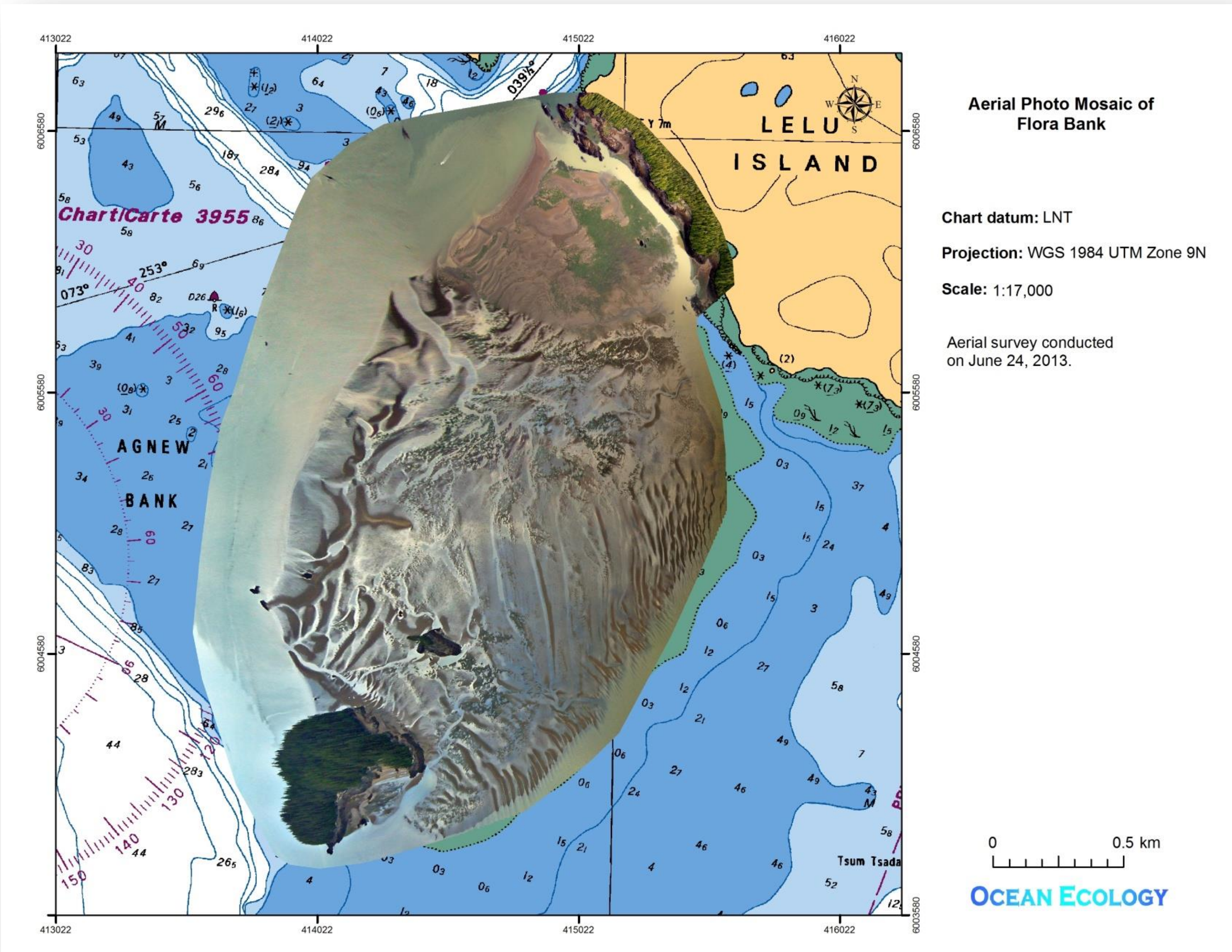

Figure 3. Aerial photo mosaic of Flora Bank from aerial survey conducted on June 24, 2013.

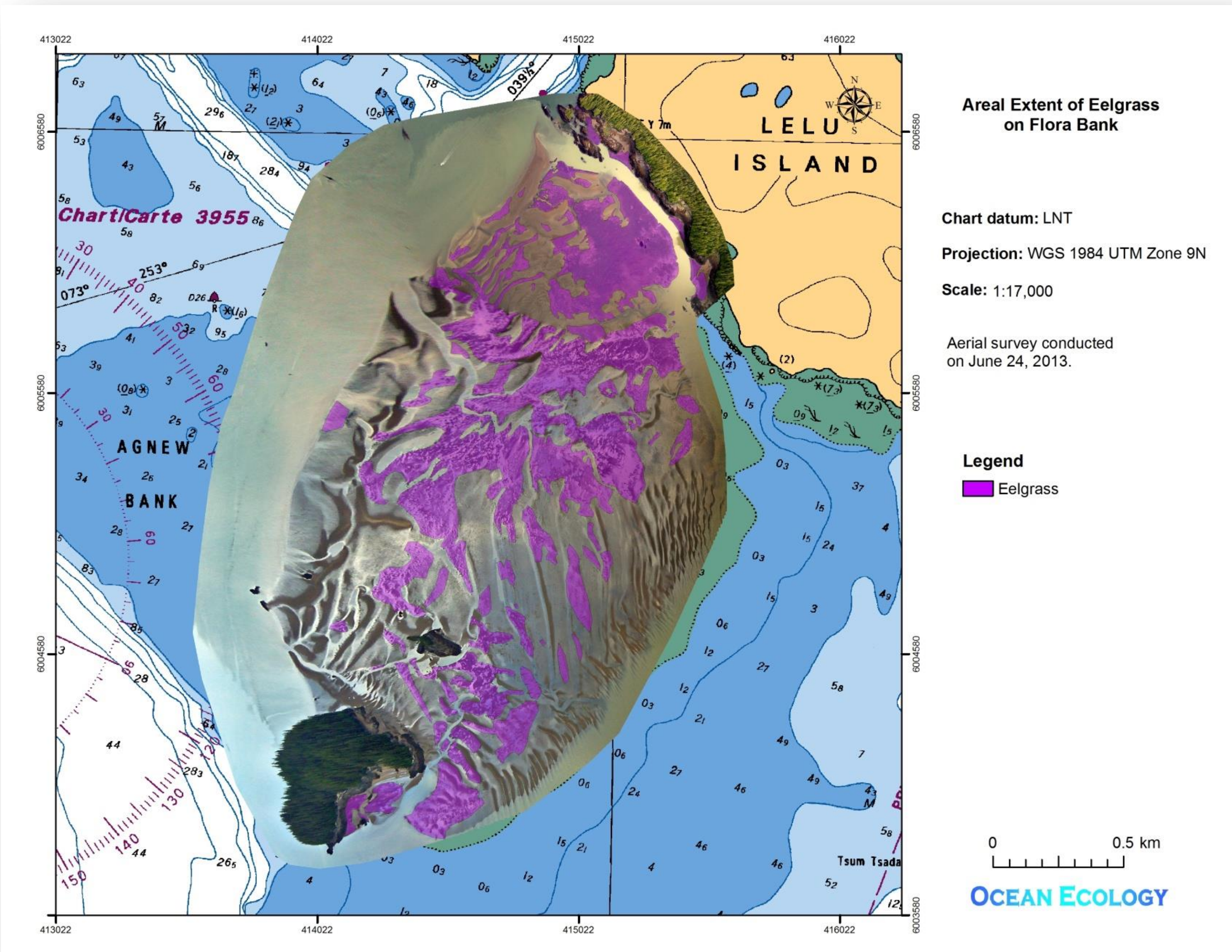

Figure 4. Areal extent of eelgrass on Flora Bank based on the aerial survey conducted on June 24, 2013.

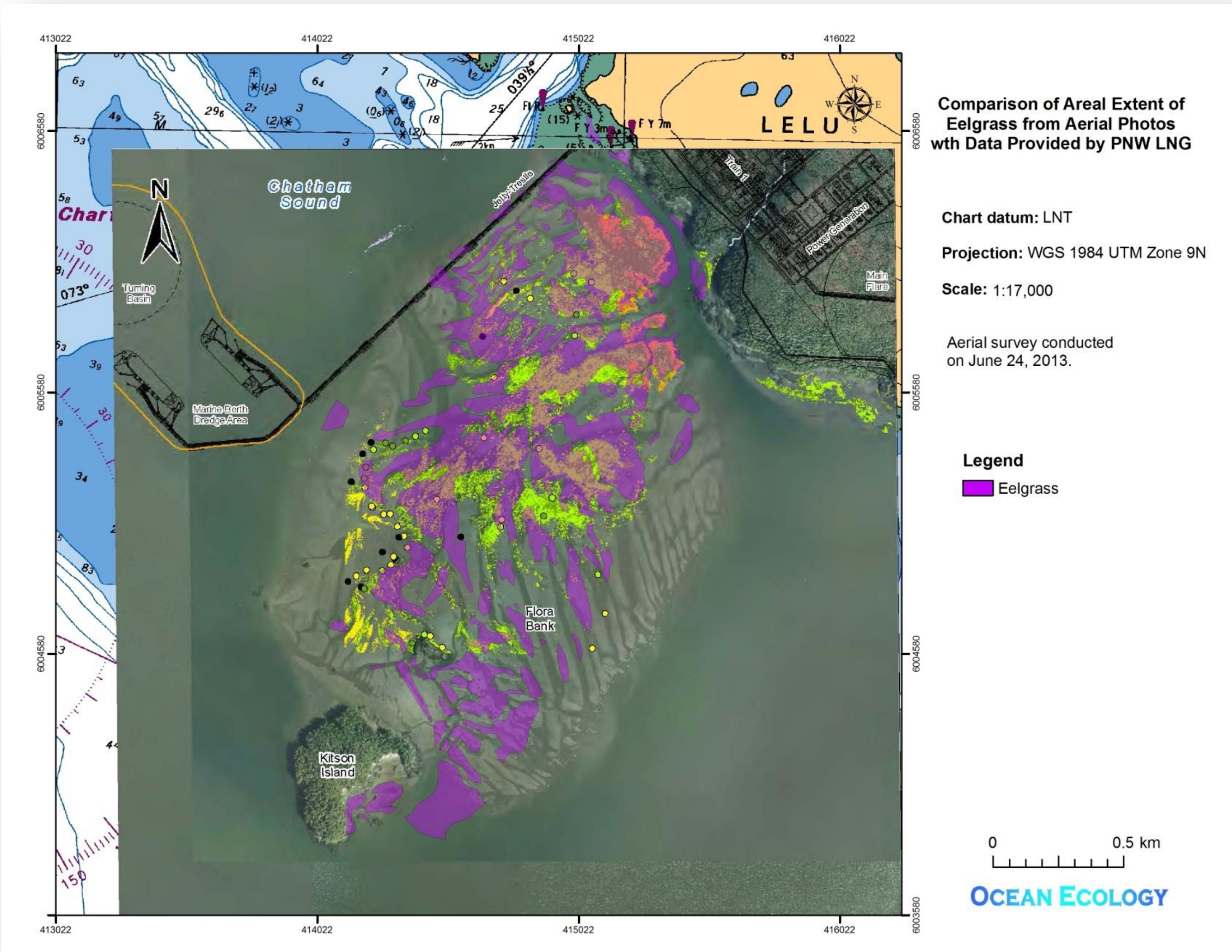

Figure 5. Comparison of the areal extent of eelgrass on Flora Bank based on the 2013 aerial survey with the proponents' data.

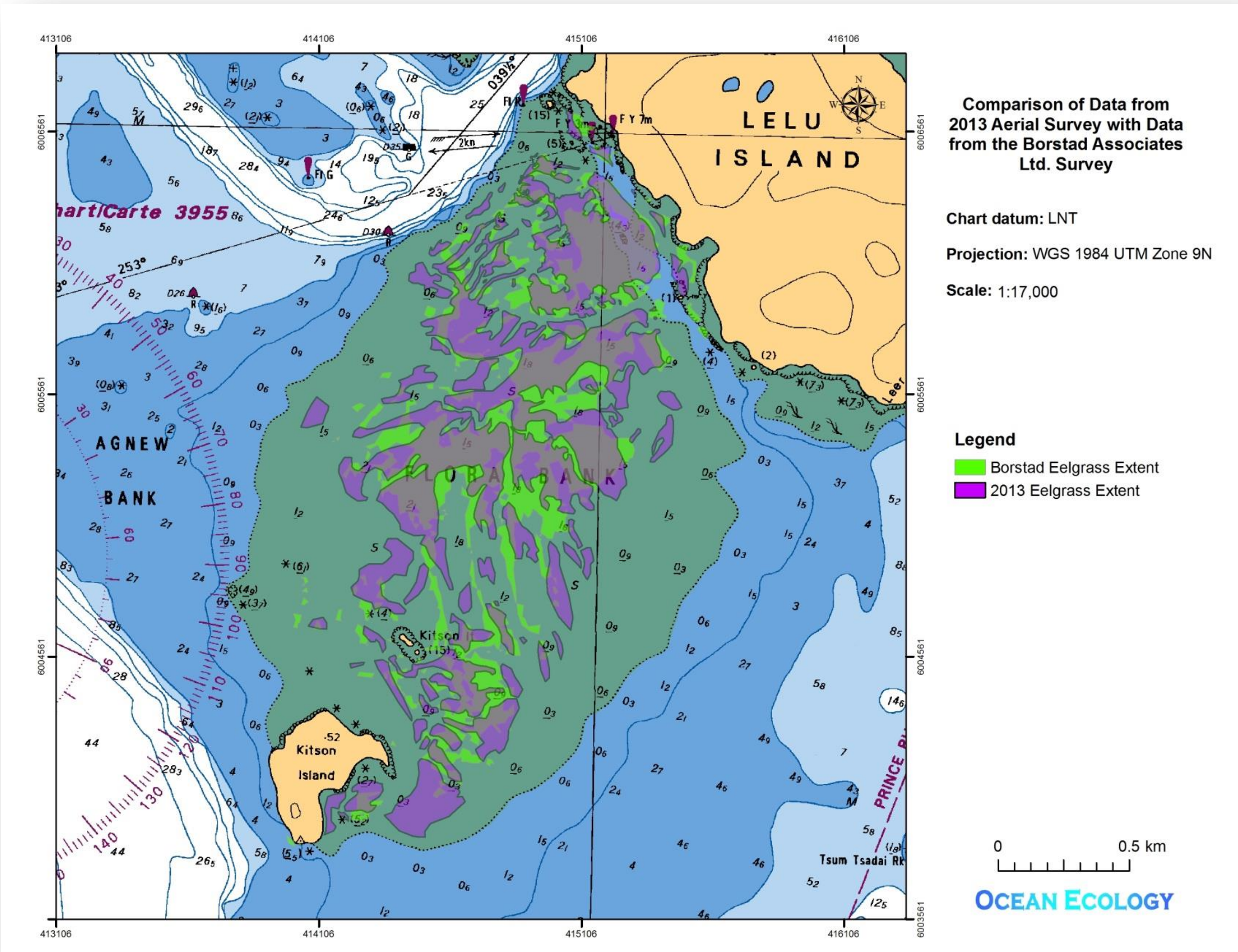

Figure 6. Comparison of areal extents of eelgrass on Flora Bank based on the 2013 aerial survey and the Borstad Associates Ltd. survey.

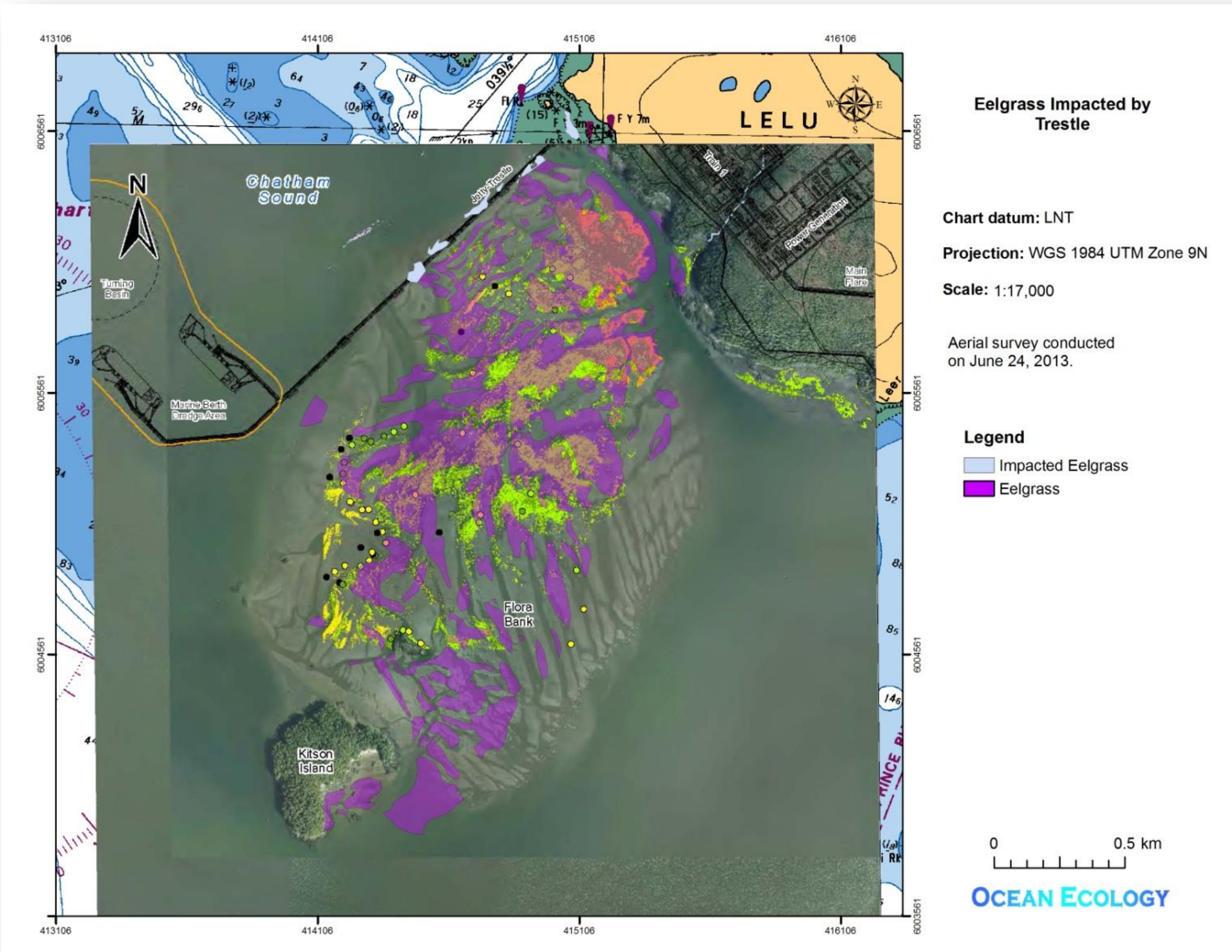

Figure 7. Eelgrass impacted by the proposed trestle based on the 2013 aerial survey.

13. Appendix 3

Recently, I carried out a study on the juvenile salmonid habitat in the Skeena River estuary region (Faggetter 2014b). This research involved looking at 39 factors affecting habitat quality for juvenile salmonids, including factors such as shoreline morphology,currents, subtidal, intertidal, and riparian vegetation, anthropogenic shoreline modifications, predators, food resources, shelter, access to freshwater, dissolved oxygen in the water, sediment and water column pollutants, and water temperature. Shoreline segments were defined based on the morphological characteristics of the shore, and each shoreline segment was assigned a "habitat suitability index (HSI)" for each species of juvenile salmonid by applying species-specific habitat rules to the habitat factors. The HSI value was normalized to have a range between 1 and 10, with 1 being poor quality habitat ad 10 being good quality habitat (see Figure 8 as an example of the HSI values calculated for a single species).

Juvenile salmonids can be loosely grouped into two feeding categories. Epibenthic feeders are those species, such as chum, chinook, and pink, which spend the early part of their marine life in shallow water environments (e.g., eelgrass beds and sheltered subestuaries), feeding on organisms such as harpacticoid copepods and epiphytic crustaceans. Neritic feeders are those species, such as sockeye, coho, and steelhead, which spend the early part of their marine life in deep water environments (e.g., the estuarine plume), feeding on organisms such as neritic zooplankton and small fish. Flora Bank is a more important habitat for epibenthic juveniles (HSI of 8) than for neritic juveniles (HSI of 6). Flora Bank is still considered important for neritic juveniles, but they only spend a short period of time feeding in this habitat as they pass through it on their way to deeper water, whereas epibenthic juveniles spend weeks to months feeding in the shallow water areas until they are large enough to forage successfully in the neritic environment. Degraded epibenthic habitats force juveniles of these species into the neritic environment while they are still very small, leading to starvation and increased predation.

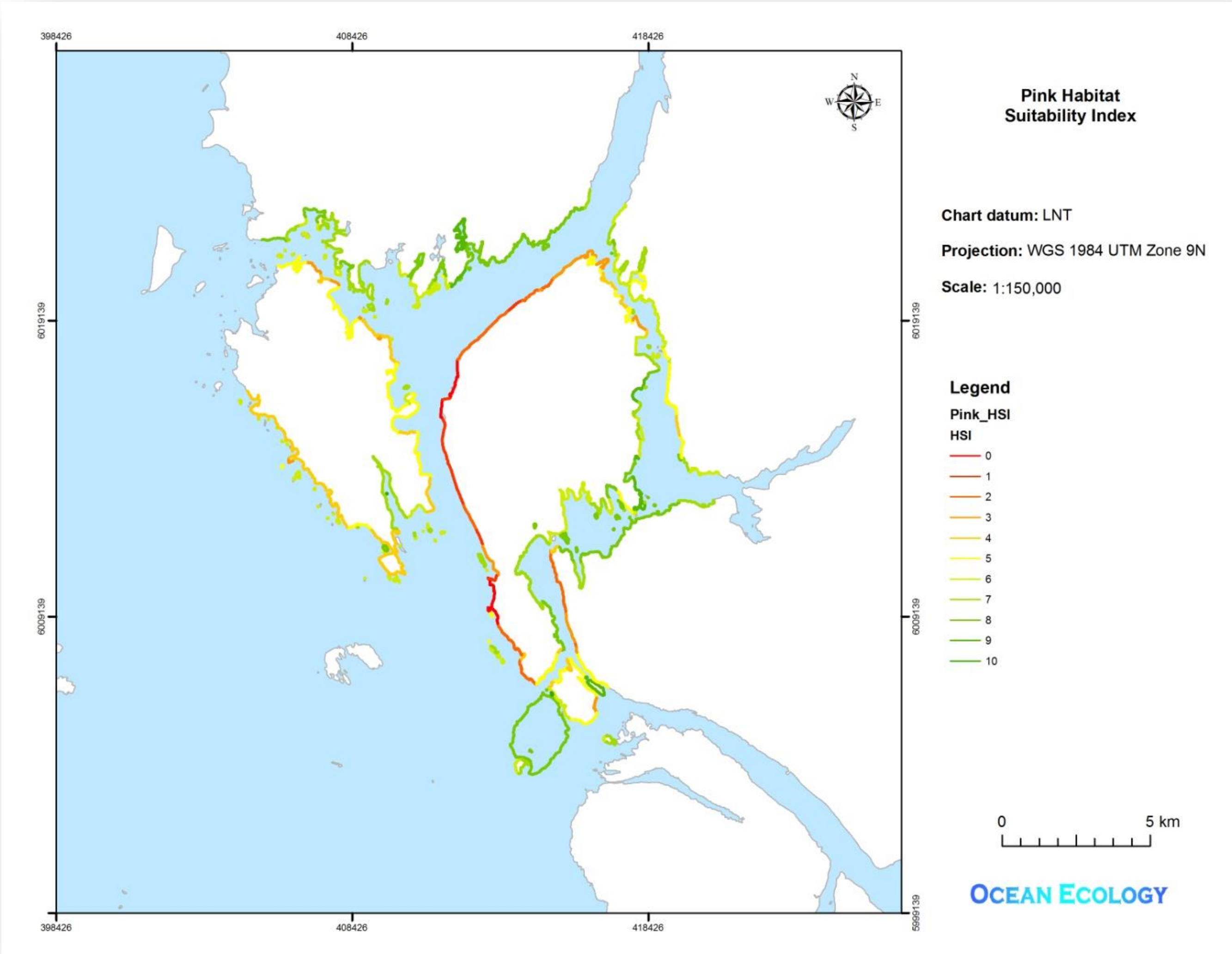

Figure 8. Habitat suitability index calculated for juvenile pink salmon (an epibenthic species).

To fully understand the importance of an HSI value of 8, it is necessary to consider the HSI values assigned to other nearby locations. Porpoise Channel has an HSI value of 4-5, the nearby Ridley Island shoreline has an HSI value of 2, and the Lelu Island shoreline has HSI values ranging from 3 to 6. Therefore, locally, in the area around Inverness Passage, Lelu Island, Porpoise Channel, and southern Ridley Island, Flora Bank has the highest HSI value, and is the best juvenile salmonid habitat in this region. In the entire study area for this research, a region which included all of Prince Rupert Harbour and the northern reaches of the Skeena River estuary, there were very few other shoreline segments which had HSI values equal to or exceeding that of Flora Bank, and these few segments were in the basins on the east side of Kaien Island and on the southern tip of the Tsimpsean Peninsula.

The HSI value that I calculated in this research was specific to the habitat requirements of juvenile salmonids. By comparison, my research on eelgrass beds throughout Chatham Sound (Faggetter 2013) was looking specifically at factors which contributed to the health of the eelgrass (turbidity, local freshwater, salinity, current velocity, wave exposure, sedimentation, cumulative sewage impact, average substrate particle size, and bottom slope). Although it may seem counter-intuitive, factors which promote a healthy eelgrass bed do not necessary ensure a high quality salmonid habitat. To illustrate this, it is useful to look at turbidity, a particularly important factor that contributes to eelgrass health. As turbidity increases, light penetration into the water column decreases, thus resulting in reduced photosynthesis and decreased eelgrass health. However, from the perspective of juvenile salmonid habitat, high levels of turbidity help to reduce predation on juvenile salmon, and thus increase the quality of the habitat. While this type of trend reversal between eelgrass health and quality of juvenile salmonid habitat is not true for all factors, it is significant enough that the relationship between eelgrass health and quality of juvenile salmonid habitat is not a simple linear one.

In addition to habitat quality, habitat location is vitally important to out-migrating juvenile salmonids, particularly those species which are epibenthic feeders. Species which require epibenthic food cannot travel far before they must find the right type of habitat for foraging. If they must travel any significant distance in open water, they will either starve or become food for predators. Thus, epibenthic juveniles out-migrating from the Skeena River would be unable to cross Chatham Sound to reach healthy eelgrass beds on Porcher Island. Therefore, it is erroneous for the proponents to believe that the various healthy eelgrass beds scattered throughout Chatham Sound will provide the same ecosystem functions with respect to Skeena River juvenile salmon survival that Flora Bank does.

Over 99% of the juvenile salmon in the study area for my research come from the Skeena River out-migration. The remaining juvenile salmon (less than 1%) come from small natal creeks and rivers in the region (e.g., Hays, Oldfield, Silver, McNichol, and Diana Creeks, and Kloiya River). Each year, approximately 377 million juvenile salmon swim out of the mouth of the Skeena River. The composition of this outmigration is roughly 72% pink, 21% sockeye, 3% coho, 2% chinook, 1% chum, and 1% steelhead (Faggetter 2014). Juvenile Pacific salmon migrating along the British Columbian coast instinctively turn northward as they exit their natal rivers and begin their migration along the coast to the Gulf of Alaska. Some individuals make this northward turn a little earlier than others during their out-migration. Based on beach seine and trawl catches of juvenile salmon in Chatham Sound (Carr-Harris & Moore 2013; Gottesfeld *et al.* 2008), we can estimate that approximately 88% of the juvenile salmon out-migrating from the Skeena River turn north into Inverness Passage. The remaining 12% travel through Telegraph Passage before turning north. Those juveniles traveling through Inverness Passage will pass over Flora Bank or around the shores of Lelu and Ridley Islands. Juveniles of species which forage in epibenthic habitats will remain in these areas until they are large enough to feed in the neritic environment. Thus, not only is Flora Bank a high quality habitat for juvenile salmon, it is in the direct path of approximately 331 million juvenile salmon, of which about 279 million are epibenthic feeders.

Other areas of high quality salmonid habitat in the study area, such as those shoreline segments in the basins on the east side of Kaien Island and on the southern tip of the Tsimpsean Peninsula, do provide habitat for salmon, but not those out-migrating from the Skeena River. Rather, these areas provide important rearing habitats for salmon out-migrating from the local natal streams. While these populations are small, they are important to the overall health and diversity of salmon in the region.

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