IN THE MATTER OF
ENBRIDGE NORTHERN GATEWAY PROJECT JOINT REVIEW PANEL

WRITTEN EVIDENCE OF RAINCOAST CONSERVATION FOUNDATION

Part 4: Marine Impacts - Salmonids

December 21, 2011

Date Submitted

Signature

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1.0 Introduction

1. The Raincoast Conservation Foundation submits its written evidence in the matter of the Enbridge Northern Gateway Project Joint Review Panel in seven parts:

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Part 2:	Marine Impacts – Marine Mammals
Part 3:	Marine Impacts – Marine Birds
Part 4:	Marine Impacts – Salmonids
Part 5:	Marine Impacts – Herring
Part 6:	Marine Impacts – Eulachon
Part 7:	Tanker Risks

2. The Raincoast Conservation Foundation hereby submits the following documents as Part 4 – Salmonids as its written evidence, in part, in the matter of the Enbridge Northern Gateway Project Joint Review Panel:

(a) the written evidence of Misty MacDuffee;

(b) the written evidence of Christopher Darimont; and

(c) the written evidence of Paul Paquet.

3. The Raincoast Conservation Foundation proposes to present the following individuals as a panel at the hearing:

Name	**Topics**
Paul Paquet	All topics
Christopher Darimont	Terrestrial and Cumulative Impacts, Pipeline Risks, Natural Hazards and Climate Change Marine Impacts - Salmonids
Misty MacDuffee	Marine Impacts – Marine Mammals Marine Impacts – Salmonids Tanker Risks
Andrew Rosenberger	Marine Impacts – Marine Mammals Tanker Risks
Michael Jasny	Marine acoustic impacts
Caroline Fox	Marine Impacts – Marine Birds Marine Impacts – Herring
John Kelson	Marine Impacts – Eulachon
Brian Falconer	Tanker Risks

2.0 Written Evidence of Misty MacDuffee, Christopher Darimont and Paul Paquet

Please state your name and business address

4. Misty MacDuffee
2621 Chart Drive
Pender Island, BC V0N 2M1

Dr. Christopher Darimont
Environmental Studies Department. 405 ISB
1156 High Street
University of California
Santa Cruz, CA, USA 95064

Paul Paquet
Box 150
Meacham, SK S0K 2V0

Please provide your background and work history.

5. The resume of Misty MacDuffee is filed as Attachment "A" to Part 2 of the Raincoast Conservation Foundation written evidence. The resume of Dr. Christopher Darimont is filed as Attachment "A" to Part 1 of the Raincoast Conservation Foundation written evidence. The resume of Paul Paquet is filed as Attachment "B" to Part 1 of the Raincoast Conservation Foundation written evidence.

Have you previously testified before the National Energy Board?

6. No, for all of us.

Do you submit the contents of this written submission, Part 4 – Marine Impacts – Salmonids, as your written evidence and was the submission prepared by you or under your direction?

7. Yes. Part 4 – Marine Impacts – Salmonids of this Raincoast Conservation Foundation written evidence was prepared by or under the direction of Misty MacDuffee, Christopher Darimont and Paul Paquet.

3.0 Salmonids

Scope of Part 4

8. This section focuses on salmonids, primarily the threat posed to their marine feeding, rearing and migratory habitat and intertidal spawning habitat from the marine transport and terminal component of the proposed Enbridge Northern Gateway project. We present evidence concerning the inadequacy of the Enbridge ESA and a more realistic depiction of risks posed by the proposed project to salmonid species.

Is Enbridge's baseline survey and associated ESA adequate?

9. No. Specifically we identified the following reasons why the survey and associated ESA are considered inadequate:

- No adequate baseline survey for the presence of juvenile salmon through the marine PEAA and into the upper sections of the Kitimat estuary was conducted;
- No empirical data were collected on salmon use within the marine PEAA;
- The impact assessment was based on a literature review;
- Literature review of juvenile salmon use of the marine PEAA and CCAA was cursory and superficial at best with notable omissions of:
  - Identification of salmon streams draining into Kitimat Arm;
  - The diversity and abundance of spawning populations within CCAA and the marine PEAA;
  - The presence of distinct, evolutionarily significant populations (Conservation Units) of chum salmon and Coho salmon in the Douglas Channel/Kitimat Arm/Gardiner Canal; and
  - Presence of at least five unique Conservations Units of sockeye salmon within, or on the border of, the CCAA.
- No attempt was made to identify intertidal spawning habitat, holding areas or

important wildlife streams where key species such as grizzlies rely on salmon;

- History of land use in lower river and estuary suggests sediment contamination is a problem;
- Enbridge's sediment study in Kitimat Arm begins erroneously with a baseline of no existing sedimentation problems;
- The CCAA does not include large areas adjacent to Douglas Channel such as Verney Passage, Whale Channel, and a large proportion of Wright Sound;
- Although the marine PEAA may be appropriate for considering localized construction and operational impacts of the marine terminal, it is inadequate for a broader assessment of project impacts such as: wake impacts of tankers on essential salmon habitat and juvenile salmonids; potential tanker incidents; and, cumulative impacts that may affect fish and fish habitat throughout the broader area including the CCAA and adjacent areas.

What empirical data were collected by Enbridge for salmonids?

10. None. No adequate baseline survey was undertaken and no empirical data were collected on salmonids.

11. The Fish and Fish Habitat TDR notes that near shore fish surveys, "involved the use of beach seines, gillnets, and long lines to determine the fish species present in near shore environments of the PEAA" (Enbridge 2010[1]). These studies were conducted in August and September 2005. Because gillnets and long lines are inappropriate methods to capture juvenile salmon, beach seining would be the only suitable method. July beach seine sets were limited to one small segment of lower Kitimat Arm. This sampling cannot adequately represent use by juvenile salmon species in the estuary throughout the year. At best, this survey provides an indication of potential fish presence at one location

[1] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-25 – B9-39 – Gateway Application – Fish and Fish Habitat TDR (Part 1-15 of 15) – A1V5U9-A1V5W3.

at a time of year when several species would likely not be present.

12. There is also inconsistency between Enbridge's claims in the summary volumes and the supporting technical data reports. Although Enbridge's Volume 6B (Marine terminal ESA) notes that the purpose of the surveys (referencing the Marine Fish and Fish Habitat TDR) was "to determine presence and relative abundance of fish species in the near shore environment" (Enbridge 2010[2]), the survey objectives in the cited Fish and Fish Habitat TDR state the purpose "was to compile a species inventory and characterize baseline conditions at …habitats within the PEAA" (Enbridge 2010[3]). This is indicative of Enbridge distorting their impact assessment. According to the TDR objectives, the consultants were to identify species presence ("species inventory") in a restricted location, far less comprehensive than determining 'relative abundance'. Despite the misrepresentation, Enbridge and consultants failed to undertake a proper survey and their study was very limited in scope and rigour. Simply, their assessment of salmonid distribution and abundance amounted to a cursory literature review.

13. A proper study to determine the temporal and spatial extent of estuary use by out-migrating smolts would have included the entire (i.e. lower and upper) estuary, have started in the spring, been undertaken once a week until salmon were no longer present, and included preliminary reconnaissance to determine the timing of the first outmigration wave. This information cannot be gathered from beach seine sets conducted during one week in July. Yet, such information is critical to determining the impacts to salmon populations in the Kitimat River and the 15 other salmon streams known to drain into Kitimat Arm.

14. Because the beach seine sets (or gill nets and long lines) did not recover any salmonid species and no empirical data were collected on estuary use, the 'results' section of the

[2] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – Section 10.4.1 - Pg 10-11 - A1T0G2-A1T0G5.

[3] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-25 – B9-39 – Gateway Application – Fish and Fish Habitat TDR (Part 1-15 of 15) – Section 2.3 – Pg 2-5 - A1V5U9-A1V5W3.

Marine Fish and Fish Habitat TDR instead provided a perfunctory literature review of the five commercial salmon species of BC. Accordingly, we find the work deficient and not designed to report on the criteria Enbridge purports were the study objectives in Volume 6B of the Enbridge Northern Gateway project ESA.

15. Although no baseline information was collected on juvenile salmon use/reliance on the estuary, no additional (yet necessary) assessments were undertaken on; intertidal spawning habitat, holding areas for returning adults, or the ecological importance of salmon and their relationship to other species present in the area. Even a superficial attempt to demonstrate the spatial distribution of salmon streams would have at least provided some indication of potential impact from the project. As such, the Marine Fish and Fish Habitat TDR does not provide a baseline against which anything other than relatively meaningless qualitative impacts can be assessed. The words, "uncertainty" and "error" each only appear once in Marine Fish and Fish Habitat TDR, a report of over 450 pages and neither topic is discussed with regard to their potential impact on the actual results.

Was the Enbridge literature review for salmonids adequate?

16. The literature review in Enbridge's Marine Fish and Fish Habitat TDR did not identify salmon streams draining into or adjacent to Kitimat Arm /PEAA. The Marine Fish and Fish Habitat report notes that, "Numerous rivers and associated channels branching off from Douglas Channel and Gardner Channel provide spawning habitat for salmon", (Enbridge 2010[4]). However, no further information is provided. We find the term "numerous" wanting, given that this information is readily available. In fact, our queries in the Fisheries Inventory Summary System (FISS), maintained by the British Columbia Ministry of Environment identified 15 salmon-bearing streams with eight species of salmonids in 68 spawning populations that drain into the PEAA. Moreover, more than

[4] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-25 – B9-39 – Gateway Application – Fish and Fish Habitat TDR (Part 1-15 of 15) –Pg 3-2 - A1V5U9-A1V5W3.

400 spawning populations are within the CEAA. In addition, this region contains some the highest spawning densities of salmon on the BC coast.

17. The literature review of juvenile salmon use of the PEAA and CEAA was hasty and superficial. Although a general discussion of salmon is provided, little information is provided specific to the PDA, the PEAA, or the CCAA. Specifically, only two DFO reports, one dating from 2001, are used to provide information on abundance and population trends relating to relevant fisheries management units. We find little evidence of effort to reference scientific literature regarding juvenile use of the estuary, adult holding areas in bays, migration patterns, or other essential habitats. Without this information, field studies should have been undertaken.

Table 1. Summary of salmonid populations draining into the PEAA, likely containing intertidal spawning grounds and /or using estuarine and near shore habitat in Kitimat Arm (BC Ministry of the Environment 2011[5]).

Stream Name	Coho	Chum	Pink	Chinook	Sockeye	Steelhead	Cutthroat	Dolly Varden
Big Tilhorn Creek	X	X	X	X				
Bish Creek	X	X	X	X		X		
Cordella Creek	X		X					
Dala River	X	X	X	X		X		X
Eagle Bay Creek	X	X	X					X
Emsley Creek	X	X	X				X	X
Falls River	X	X	X			X	X	
Fosh River	X	X	X	X	X	X	X	
Hugh Creek	X	X	X		X			
Kildalla River	X	X	X	X			X	X
Kihess Creek	X	X	X					
Kitimat River	X	X	X	X	X	X	X	X
Minette Bay Creek	X		X					
Pike Creek	X	X	X		X			
Wathl Creek	X	X	X		X			
Wathlsto Creek		X	X					

[5] BC Ministry of the Environment. Internet source. Available online: http://www.env.gov.bc.ca/fish/fiss/index.html. Accessed 30 November 2011

Are chum salmon an appropriate indicator to represent all salmon species?

18. No. Enbridge selected Chum salmon as a key indicator because the species has "the broadest distribution of all salmon and a life cycle that is representative of other salmon" (Enbridge 2010[6]).

19. This is a broad generalization that does not capture the diverse run timings or more extensive use of estuarine habitats that other salmonids can require.[7] On the spectrum of salmon life strategies, chum salmon are relatively simple, moving into the marine environment at a consistent life stage, remaining there for weeks to a few months in preparation for their ocean migration, and returning generally after 3-5 years (but can exhibit up to five age classes). By contrast, Chinook salmon (*O. tshawytscha*) have at least 16 age categories, reflecting the high variability in length of freshwater, estuarine, and oceanic residency.[8] Ocean-type Chinook have short, highly variable freshwater residency (from a few days to 1 year), extensive estuarine residency (6 months to a year), enter freshwater at a more advanced state of maturity, and spawn within a few weeks of freshwater entry in the lower portions of the watershed. More extensive rearing periods in estuarine habitats can also be typical of ocean-type and nomadic coho (*O. kisutch*), and river type sockeye (*O. nerka*), which exploit the higher productivity of the estuarine environment by migrating to the ocean at age zero.

20. Nomadic coho fry rely on the stream estuary ecotone for more than a year. As fry, nomadic coho acclimate to brackish water, survive, and grow in the stream-estuary ecotone. Instead of migrating farther to the ocean, they return upstream into freshwater to overwinter before migrating to sea as smolts the following year.[9] This unique use of

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[6] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – Pg 259 - A1T0G2-A1T0G5.
[7] NOAA. April 2005. Appendix F.5 Essential Fish Habitat Assessment Report for Salmon Fisheries in the EEZ off the Coast of Alaska. Final EIS. NMFS Alaska Region Juneau, AK
[8] *Ibid.*
[9] Koski, K. V. 2009. The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. Ecology and Society **14**(1): 4 http://www.ecologyandsociety.org/vol14/iss1/art4/.

overwintering and estuarine habitats has enabled Coho to develop a life strategy that promotes their resilience. The loss or decline of these nomads affects adversely the diversity and abundance of Coho populations. Healthy estuarine habitats are essential for the persistence and recovery of depressed Coho populations, such as those found in the Kitimat River and in other watersheds in Kitimat Arm.

21. The decision to select a species with potentially less estuary dependence has important implications for impacts from proposed project construction and operations. Specifically, no evidence supports their presumed absence over the summer, fall, and winter. In fact, they are likely present and simply failed to be detected. The surveys that Enbridge carried out were limited in duration, scope, and methods. One week of beach seine studies undertaken in the PDA in July is inadequate to assess the presence, abundance, distribution, and use of the area by juvenile salmonids. Moreover, their purpose was only to identify species presence, not distribution, or abundance. No specific strategy was employed to detect salmon in the broader PEAA and no discussion was provided as to how the timing and location of surveys would affect the species encountered.

22. To determine an appropriate indicator species, a proper study was needed to assess whether the temporal and spatial use of the estuary by out-migrating smolts would have included the whole (i.e. lower and upper) estuary. Such sampling should have started in the spring, and been undertaken weekly until the outmigration was complete.

23. The implication from the inadequate surveys is that Enbridge has identified mitigation strategies based on salmon being absent from certain locations during certain times of year, which is clearly inappropriate. This assertion is not supported, even if chum were an suitable indicator. Although most fry leave the streams during April and May, outmigration for Chinook can begin as early as February.

24. In summary, Enbridge conducted extremely cursory field surveys for fish. The assertions that chum were an suitable indicator species cannot be supported. Accordingly, Enbridge's ability to assess the presence, distribution, and use of the estuary by salmonids in general was greatly constrained and inadequate for a project of this scale.

Are the spatial extents of the CCAA and marine PEAA adequate?

25. No. The CCAA does not include large areas adjacent to Douglas Channel such as Verney Passage, Whale Channel, and a large proportion of Wright Sound. Further, the PEAA appears to have truncated the upper section of the estuary, not including the full extent of tidal influence in the Kitimat River.

26. Whereas the marine PEAA may be appropriate for considering localized construction and operational impacts of the marine terminal, it is inadequate for a broader assessment of project impacts such as wake affect of tankers, chronic oiling, potential tanker incidents, and cumulative impacts that may affect fish and fish habitat throughout a much broader area, including salmonids.

What concerns do you have regarding the release of contaminants in the PEAA?

27. Concern about the release of contaminated sediments to Kitimat Arm and their effect on marine species, has been dismissed by Enbridge as not being significant (Enbridge 2010[10]). This is based on outputs from a sediment and circulation model that is mostly data deficient, based on simple and often broad assumptions, and was designed to give a very general picture of sediment dispersal at a time when dredging and disposal might not actually occur .[11] Although some of the restrictions in the models might be logical ways to simplify a complex process, many will likely not be accurate. Because of this

[10] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – Section 7.8 - Pg 7-42- A1T0G2-A1T0G5,

[11] Since the studies were completed, Enbridge has revised its stated plans for marine disposal, yet these appear uncertain.

uncertainty, the resulting output can only be considered a best guess. Yet this level of uncertainty is not highlighted anywhere in the report, as is usual in other scientific and environmental assessment work. This oversimplification or neglect of often key considerations, data inputs, and assumptions is embedded in a narrative that gives extensive model detail. Although implying technical merit, the fundamental flaws of the report are evident.

28. The contaminant analysis and study are good examples of this misleading approach, having many inconsistencies with important procedural steps that are unreferenced and discretionary. Not considered, for example, is the re-suspension of contaminated sediments caused by dredging, despite acknowledgement that this would occur (Enbridge 2010[12]). The concern for re-suspension of contaminated sediments from disturbance to the seabed in Kitimat Arm has surfaced in the past and decisions (made in consultation with Alcan) have been to incur additional expenses rather than disturb contaminated bottom sediments in Kitimat Arm (J. Kelson, personal communication[13]).

29. There is broad recognition of contamination in the Kitimat Arm sediments, yet the consultant's findings of existing PAH concentrations are inconsistent with previously collected data. Table D1-5 of the Marine Risk Assessment TDR shows polycyclic aromatic hydrocarbon (PAH) concentrations of less than 1.0 mg/kg (Enbridge 2010[14]). However, previous work in this area (Simpson et al. 1998[15]) found concentrations of individual PAHs up to 450 mg/kg and 350 mg/kg dry weight. Further Enbridge states, "Although dredging related to the Project will resuspend contaminants, it will not release new contaminants" (Enbridge 2010[16]). This is simply incorrect and demonstrates a

[12] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – Section 7.8 – Pg 7-42 - A1T0G2-A1T0G5.
[13] J. Kelson pers.com, November, 2011.
[14] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-19 to B9-24 – Gateway Application – Marine Ecological Risk Assessment - Kitimat Terminal (Part 1-6 of 6) – A1V5U3 - A1V5U8.
[15] Simpson, C.D., Harrington, C.F., Cullen, W.R., Bright, D.A., and Reimer, K.J. 1998. Polycyclic aromatic hydrocarbon contamination in marine sediments near Kitimat, British Columbia. Environ. Sci. Technol. 32: 3266-3272
[16] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – A1T0G2-A1T0G5, pages 7-42.

fundamental ignorance of chemistry. The Canadian sediment quality guidelines specifically state that, "The fate and behaviour of PAHs in aquatic systems is influenced by a number of physical, chemical, and biological processes. Although some of these processes, such as photooxidation, hydrolysis, biotransformation, biodegradation, and mineralization, result in the transformation of PAHs into other substances. Other physical processes, such as adsorption, desorption, solubilisation, volatilization, resuspension, and bioaccumulation, are responsible for the cycling of these substances throughout the aquatic environment".[17]

30. There were other serious flaws and omissions in Enbridge's analysis. For example, only two of the 19 PAHs considered were alkyl PAHs. In petroleum products, alkyl PAHs generally account for the greatest percentage and they may be more toxic[18] to fish and bioaccumulate more than parent compounds.[19] The decision to exclude compounds below 1 mg/g (Enbridge 2010[20]) is also not justified. Environmental concentrations are considered relevant in the ng/g (ppb) range and many laboratories that conduct these assays have detection limits in the very low ng/g range. Indeed, the U.S. Environmental Protection Agency (EPA) narcosis model for benthic organisms in PAH contaminated sediments requires the measurement of 18 parent PAHs and 16 groups of alkyl PAHs ("34" PAHs) in pore water with desired detection limits as low as nanograms per liter.[21] The decision to define "negligible" as a concentration that falls below the "routine

[17] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, Polycyclic Aromatic Hydrocarbons, Canadian Environmental Quality Guidelines Canadian Council of Ministers of the Environment, 1999.
[18] Turcotte, D., P. Akhtar, M. Bowerman, Y. Kiparissis, S. Brown and P.V. Hodson. 2011. Measuring the toxicity of alkyl-phenanthrenes to early life stages of medaka (*Oryzias latipes)* using partition-controlled delivery. Environmental toxicology and chemistry. Vol:30-2, pp 487–495
[19] Barron, M.G., Carls, M.G., Heintz, R.A., and Rice, S.D. 2004. Evaluation of fish early life-stage toxicity models of chronic embryonic exposures to complex PAH mixtures. Toxicol. Sci. 78: 60-67.; Barron, M.G. and Holder, E. 2003. Are exposure and ecological risks of PAHs underestimated at petroleum contaminated sites? Human and Ecological Risk Assessment 9: 1533-1545; Soliman, Y.S. and Wade, T.L. 2008. Estimates of PAH burdens in a population of ampeliscid amphipods at the head of the Mississippi Canyon (N. Gulf of Mexico). Deep-Sea Research II 55: 2577-2584.
[20] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-19 to B9-24 – Gateway Application – Marine Ecological Risk Assessment - Kitimat Terminal (Part 1-6 of 6) – A1V5U3 - A1V5U8. pg 3-19
[21] Steven B. Hawthorne, Carol B. Grabanski, David J. Miller, and Joseph P. Kreitinger. Solid-Phase Microextraction Measurement of Parent and Alkyl Polycyclic Aromatic Hydrocarbons in Milliliter Sediment Pore Water Samples and Determination of K_{DOC} Values. *Environ. Sci. Technol.*, 2005, *39* (8), pp 2795–2803DOI: 10.1021/es0405171. Publication Date (Web): March 18, 2005

analytical limits of detection" (Enbridge 2010[22]) is an unreferenced, arbitrary decision that ignores widely known limits of ecotoxicological measurement. In summary, because Enbridge chose to measure and report concentrations of chemicals only detectable in ppm and not at the ppb, as well as measure PAHs as a class of chemicals and not their individual compound concentrations, they have used flawed methods that dismissed compounds and concentrations of potential concern.

31. Given that one of the largest contaminant concerns with the proposed Kitimat terminal is PAHs from chronic and catastrophic oiling, the minimum one would expect from an industrial proposal of this scale is that Enbridge would be rigorous and thorough in their treatment of PAH compounds, their detection limits, and potential of uptake by relevant biota. Without proper surveys to determine the presence, distribution, and use of the area by juvenile salmonids, and the use of only two marine invertebrates for toxicity tests, this exercise is of little utility, raising more concerns than it actually addresses.

What is your assessment of the baseline conditions of salmonid habitat and environmental conditions in the project?

32. The Kitimat River estuary is recognized as one of the nine most important estuaries in BC and is key rearing habitat for eight species of salmonids. Unfortunately, the combined stressors of forestry, urbanization, and heavy industry have cumulatively degraded the estuary since the 1950s. Chemical contamination from these industries, including emission of polycyclic aromatic hydrocarbons (PAHs), fluorides and sulphur dioxide, metals (i.e. copper, lead, zinc, cadmium, mercury, aluminum and iron) (Enbridge 2010[23]) and potentially chlorophenols (Enbridge 2010[24]) from Alcan, Eurocan and the adjacent sawmill, ocean dumping of dredgeate, alteration of runoff characteristics from logging or

[22] Enbridge Northern Gateway Pipelines. 2010. Exhibit B9-19 to B9-24 – Gateway Application – Marine Ecological Risk Assessment - Kitimat Terminal (Part 1-6 of 6) – A1V5U3 - A1V5U8. pg 5-20

[23] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – A1T0G2-A1T0G5; Warrington 1987, 1993, as cited in Norecol Dames & Moore Inc. 1997.

[24] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – A1T0G2-A1T0G5; Warrington 1987, 1993, as cited in Norecol Dames & Moore Inc. 1997.

land clearing, and the discharge of treated municipal sewage[25] into the intertidal and subtidal portions of the estuary has exposed juvenile salmon to a suite of pollutants through the consumption of contaminated prey organisms.[26]

33. These activities have changed physical, chemical and biological properties, features and processes within the lower Kitimat River and delta impairing the ability of the estuary to support healthy populations of salmon, among other species, particularly eulachon.[27] Over the years Alcan, Eurocan and Ocelot undertook extensive alterations to the lower river and northwest side of the estuary establishing a heavily armoured shoreline that has changed historical flow and circulation patterns and removed productive shoreline habitat. The Kitimat Salmon hatchery has also armoured the eastern bank and built a weir that is impassable to eulachon.

34. Juvenile salmon from the Alcan Harbour and Hospital Beach sites in Kitimat Arm showed PAH concentrations in bile and stomach contents that were comparable to concentrations found in juvenile salmon in Puget Sound where reduced disease resistance has been observed in wild populations.[28] Although a full suite of biological impacts was not tested in juvenile salmon, PAHs are having some effects on the health of flatfish in Kitimat Arm. English sole *(Parophrys vetulus)* from sites within Kitimat Arm showed increases in DNA damage, typically caused by mutagenic PAHs, as compared with sole from reference sites outside Kitimat Arm. In addition, 10–20% of English sole and 5–10% of yellowfin sole from sites within Kitimat Arm had some type of PAH-associated liver disease. These conditions were not generally found in sole from reference sites

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[25] Macdonald, R.W., 1983. Proceedings of a Workshop on the Kitimat Marine Environment. Can. Tech. Rep. Hydrogr. Ocean Sci. 18, 1-218.

[26] Johnson, L.L., G.M. Ylitalo, M.S. Myers, B.F. Anulacion, J. Buzitis, W.L. Reichert, and T.K. Collier. 2009. Polycyclic aromatic hydrocarbons and fish health indicators in the marine ecosystem in Kitimat, British Columbia. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-98, 123 p.

[27] Karanka, E.J. 1993. Cumulative effects of forest harvesting on the Kitimat River. Can. Man. Rep. Fish. Aqua. Sci. 2218: 67 p; Manzon, C.I. and D.E. Marshall. 1981.Catalogue of salmon stream and salmon escapements of statistical Area 6 North (Kitimat Arm). Can. Data Rep. Fish. Aquat. Sci. 300. xv + 173 pp.

[28] Johnson, L.L., G.M. Ylitalo, M.S. Myers, B.F. Anulacion, J. Buzitis, W.L. Reichert, and T.K. Collier. 2009. Polycyclic aromatic hydrocarbons and fish health indicators in the marine ecosystem in Kitimat, British Columbia. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-98, 123 p.

outside Kitimat Arm. Comparatively, salmon did not show DNA damage, possibly due to their short residence time in Kitimat Arm.[29]

35. Altered bedload and excessive sediment has also been delivered to the estuary from upstream logging. Between 1953 and 1985, the delta of the Kitimat River advanced 300 metres further into the estuary because of upstream river material scoured from logging related flooding.[30] Dyking has also affected the deposition of fine sediments within the estuary itself. These fine sediments are important as substrate for incubation of several fish species, especially eulachon (Kelson, personal communication 2011[31]). The District of Kitimat sewage treatment plant, Alcan, Eurocan, and Methanex have also contributed to TSS loading in Kitimat Arm (Enbridge 2010[32]). Logging, habitat loss, and overfishing were the cited cause of the decline in salmon populations within the watershed that facilitated the construction of the Kitimat River hatchery in 1977.[33]

36. Most of the Kitimat River salmon populations (Chinook, chum, Coho, steelhead and cutthroat) are now enhanced by the hatchery. The chum gillnet fishery in Kitimat Arm along with the recreational fisheries on Coho and Chinook in the CCAA are heavily dependent upon hatchery supplementation. Under the current and projected funding cutbacks to DFO, it is highly possible the Kitimat Hatchery will no longer receive federal funding. Indeed, funding has been provisional in recent years. If funding is cut, wild salmon populations in the Kitimat River will need to recover from extremely low levels of abundance. Because the Kitimat estuary is critical for the recovery of these populations and species, further declines in its health and ability to support rearing

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[29] Johnson, L.L., G.M. Ylitalo, M.S. Myers, B.F. Anulacion, J. Buzitis, W.L. Reichert, and T.K. Collier. 2009. Polycyclic aromatic hydrocarbons and fish health indicators in the marine ecosystem in Kitimat, British Columbia. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-98, 123 p.
[30] Gottesfield (1985) in Karanka, E.J. 1993. Cumulative effects of forest harvesting on the Kitimat River. Can. Man. Rep. Fish. Aqua. Sci. 2218: 67 p
[31] Kelson, John pers. comm. Dec 2011
[32] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-12 & B3-15– Vol 6B – Gateway Application – Marine Terminal ESA - (Part 1-4 of 4) – A1T0G2-A1T0G5, Warrington 1987, 1993, as cited in Norecol Dames & Moore Inc. 1997.
[33] Karanka, E.J. 1993. Cumulative effects of forest harvesting on the Kitimat River. Can. Man. Rep. Fish. Aqua. Sci. 2218: 67 p; DFO, http://www.pac.dfo-mpo.gc.ca/sep-pmvs/projects-projets/kitimat/bg-rb-eng.htm accessed Dec 2 2011

juveniles might conspire to facilitate the complete loss of wild salmon from this area.

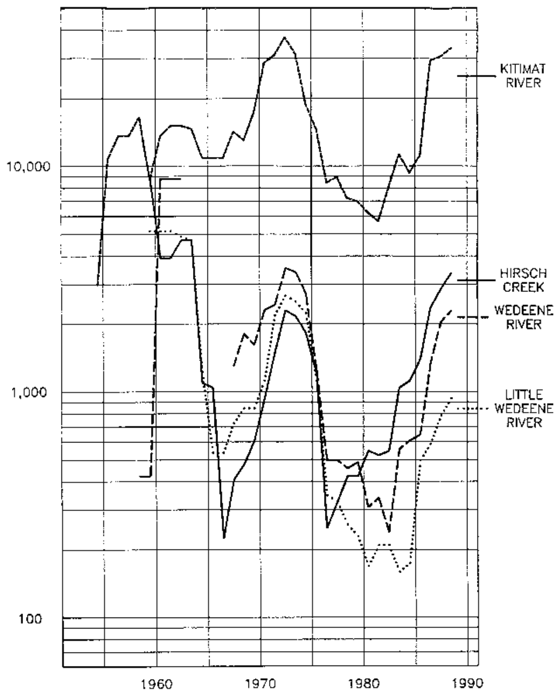

Figure 1. Trend in chum salmon mean abundance in the Kitimat River and its tributaries from 1950 -1990. Hatchery supplementation began modestly in 1977 (arrow), with a focus on Chinook, but built up to include annual releases of 1.5 million chum, 0.5 million coho, and 2 million Chinook by 2010, in addition to steelhead and cutthroat trout. Habitat loss, degradation and fisheries pressure were the cited reasons for hatchery construction and hence artificial rearing to feed fry and smolt life stages (Karanka 1993).

What is the status of salmonids in the CCAA and the OWA?

37. Thirteen Fisheries Management Areas (FMAs) drain to the waters of the CEAA and OWA, all within the Queen Charlotte Basin. The CEAA lies within Fisheries and Oceans Canada Areas 5 and 6, and the OWA crosses or is adjacent to Areas 1-4 (Haida Gwaii and the north coast), 7-12 and 27 (Central coast and northern Vancouver Island-mainland).

38. The salmon bearing watersheds the Queen Charlotte Basin ("QCB") are an increasingly rare phenomenon. Remnants of North America's last large ecosystems, many of these watersheds remain relatively free from human activities that have undermined the

survival of salmon elsewhere. Salmon populations here provide the primary link between the vast Pacific Ocean and terrestrial wildlife - processes that capitalize on salmon-derived nutrients. Beyond migratory birds, this ocean-salmon-bear-ancient forest linkage stands as one of the most wide reaching wildlife ecosystems in the world.[34]

Presence of evolutionarily distinct Conservation Unit

39. The QCB is partitioned into 249 salmon Conservation Units, which are delineated by a given area's ability to support geographically, ecologically, or genetically distinct populations of salmon.[35] These Conservation Units contain 26 unique Chinook populations, 153 unique sockeye populations, 23 unique Coho populations, 23 unique pink populations and 24 unique chum populations within their hundreds of tributaries.

40. The Douglas Channel/Kitimat Arm/Gardiner Canal region is the site of unique CUs for chum salmon and Coho salmon.[36] These are recognized as units that, if lost, would not be replaced by other salmon populations within human-life times scales. In addition, there are at least five unique Conservations Units of sockeye that drain to the CCAA. The PEAA also hosts a high percentage of the runs in the Central-North Coast early-timing Chinook Conservation Unit.

41. The 249 Conservation Units of the QCB constitute more than 5,000 spawning populations of five salmon species within 1,000 different primary watersheds. These fish represent 58% of all anadromous salmon populations originating from Canada's west coast.[37] These spawning populations contribute to more than 3,000 runs of salmon

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[34] Reimchen, T.E., Mathewson D., Hocking M.D., Moran J., Harris D. 2003. Isotopic evidence for enrichment of salmon-derived nutrients in vegetation, soil and insects in riparian zones in coastal British Columbia. American Fishery Society Symposium 34: 59–69; Darimont, C.T, Bryan, H.M., Carlson, S.M., Hocking, M.D., MacDuffee, M., Paquet, P.C., Price, M.H.H., Reimchen, T.E., Reynolds, J.D. and C.C. Wilmers. 2010. Salmon for terrestrial protected areas. Conservation Letters 00: 1–11.

(extrapolated[38]) that play key roles in natural ecosystems, providing food and nutrients to a complex web of interconnected species (Figures 2-8).[39]

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[35] Holtby, L.B. and Ciruna, K.A. 2007. Conservation Units for Pacific salmon under the Wild Salmon Policy. CSAS Research Document 2007/070: 367p

[36] Holtby, L.B. and K. A. Ciruna. 2007. Conservation Units for Pacific Salmon under the Wild Salmon Policy. Canadian Science Advisory Secretariat. Research document 2007/070. Fisheries and Ocean Canada available at http://www.dfo-mpo.gc.ca/csas/

[37] Hyatt, K., Johannes, M.S., and Stockwell, M. 2007. Appendix I: Pacific Salmon. In Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Edited by Lucas, B.G., Verrin, S., and Brown, R. Can. Tech. Rep. Fish. Aquat. Sci. 2667: vi + 55 p.

[38]Hyatt et al., supra note 37; M. H.H. Price, C. T. Darimont, N. F. Temple, S. M. MacDuffee, Raincoast Conservation Foundation, Sidney, BC Ghost runs: management and status assessment of Pacific salmon (Oncorhynchus spp.) returning to British Columbia's central and north coasts, *Canadian Journal of Fisheries and Aquatic Sciences*, 2008, 65:(12) 2712-2718.

[39] Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palm- isano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. Pacific salmon and wildlife–ecological contexts, relationships, and implications for management. Special Edition Technical Report, prepared for D. H. Johnson and T. A. O'Neil. Wildlife-habitat relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia, Washington; Piccolo, John J., Milo D. Adkison & Frank Rue,2009. Linking Alaskan Salmon Fisheries Management with Ecosystem-based Escapement Goals: A Review and Prospectus. Fisheries Vol 34-3; Hocking, M. D. and J.D. Reynolds. 2011. Impacts of Salmon on Riparian Plant Diversity**.** Science 25: 1609-1612.

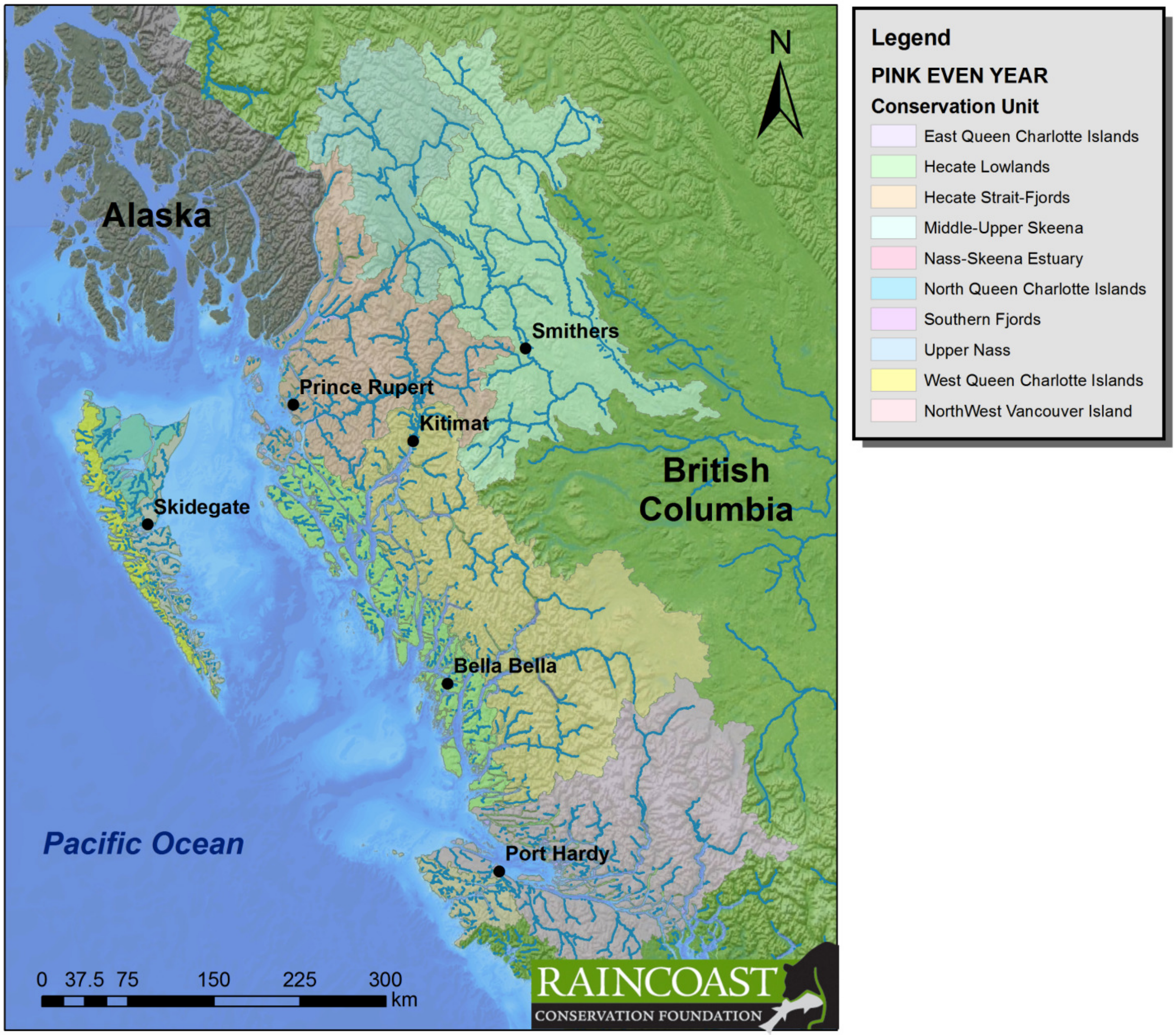

Figure 2. Geographic location of 10 distinct even year Conservation Units for Pink salmon lineages in BC. Raincoast 2011.

42. Pink salmon Conservation Units have been delineated based on life-history types, run-timing, marine adaptive zones, and genetic uniqueness within more than 1,000 watersheds and tributaries that drain into Queen Charlotte Basin.

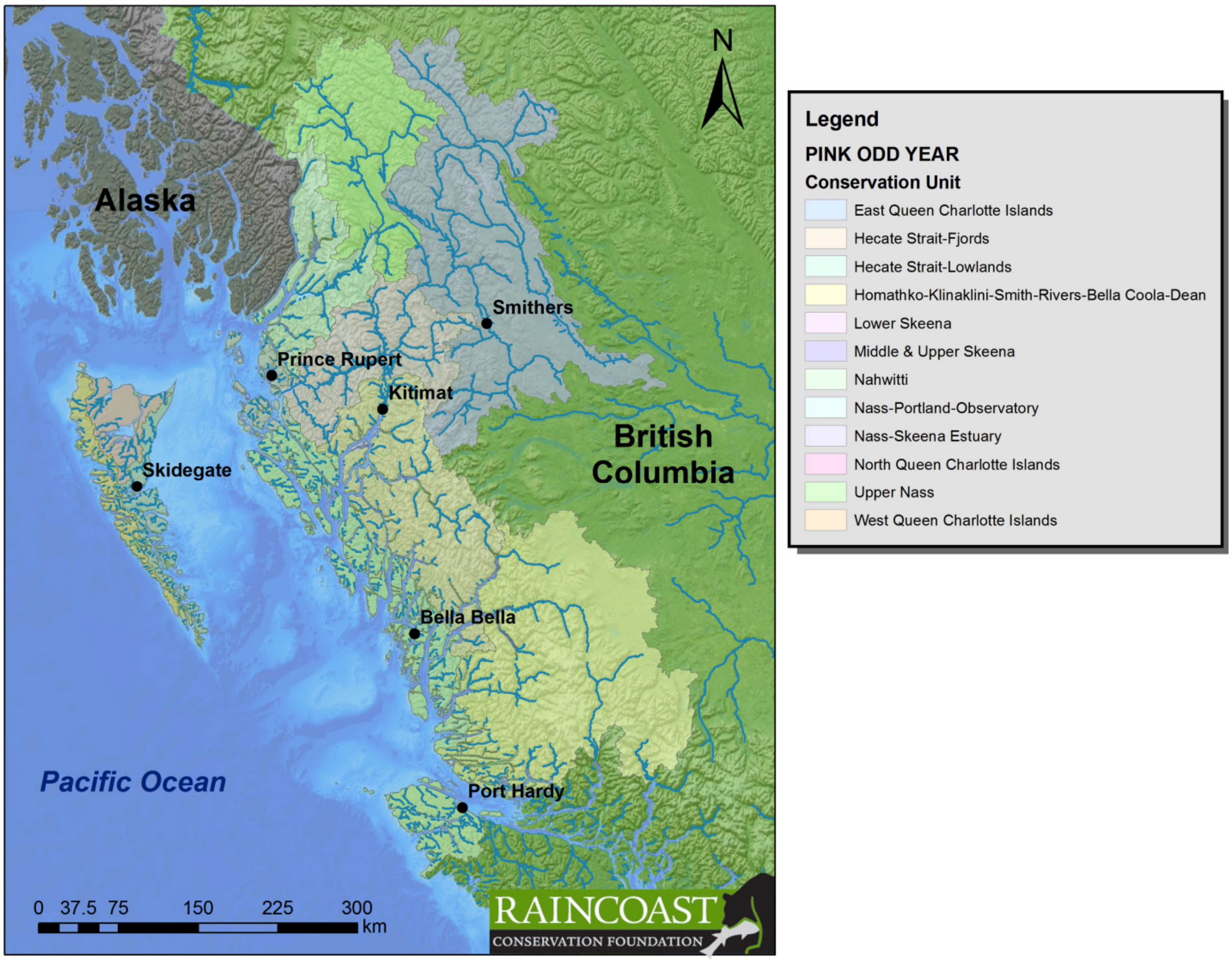

Figure 3. Geographic location of 13 distinct odd year Conservation Units for Pink salmon lineages in BC. Raincoast 2011.

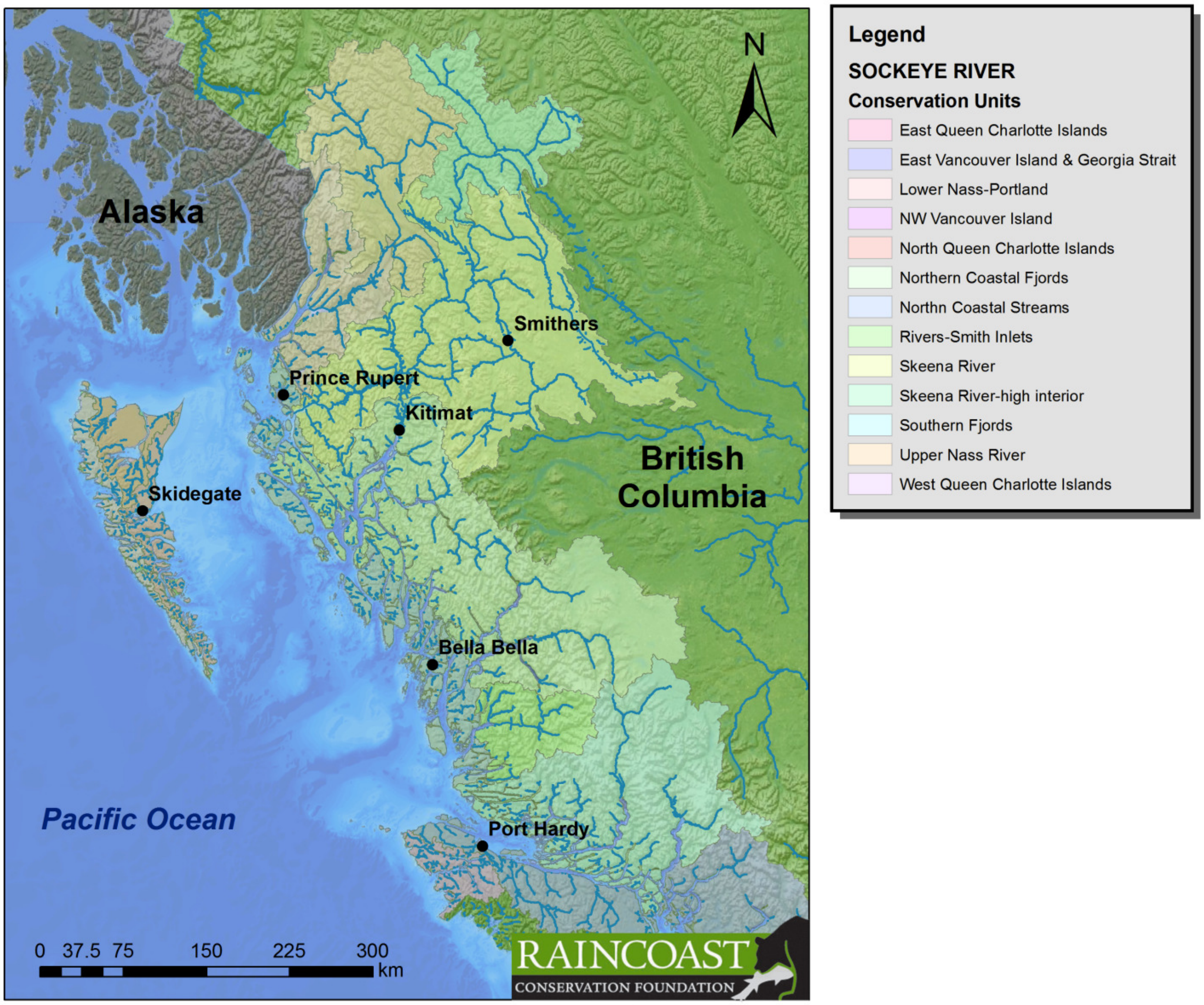

Figure 4. The 11 Conservation Units of River-type sockeye salmon in BC. River-type sockeye are different from Lake-type based on their short residence time in freshwater, and their greater reliance on estuaries for rearing. Raincoast 2011.

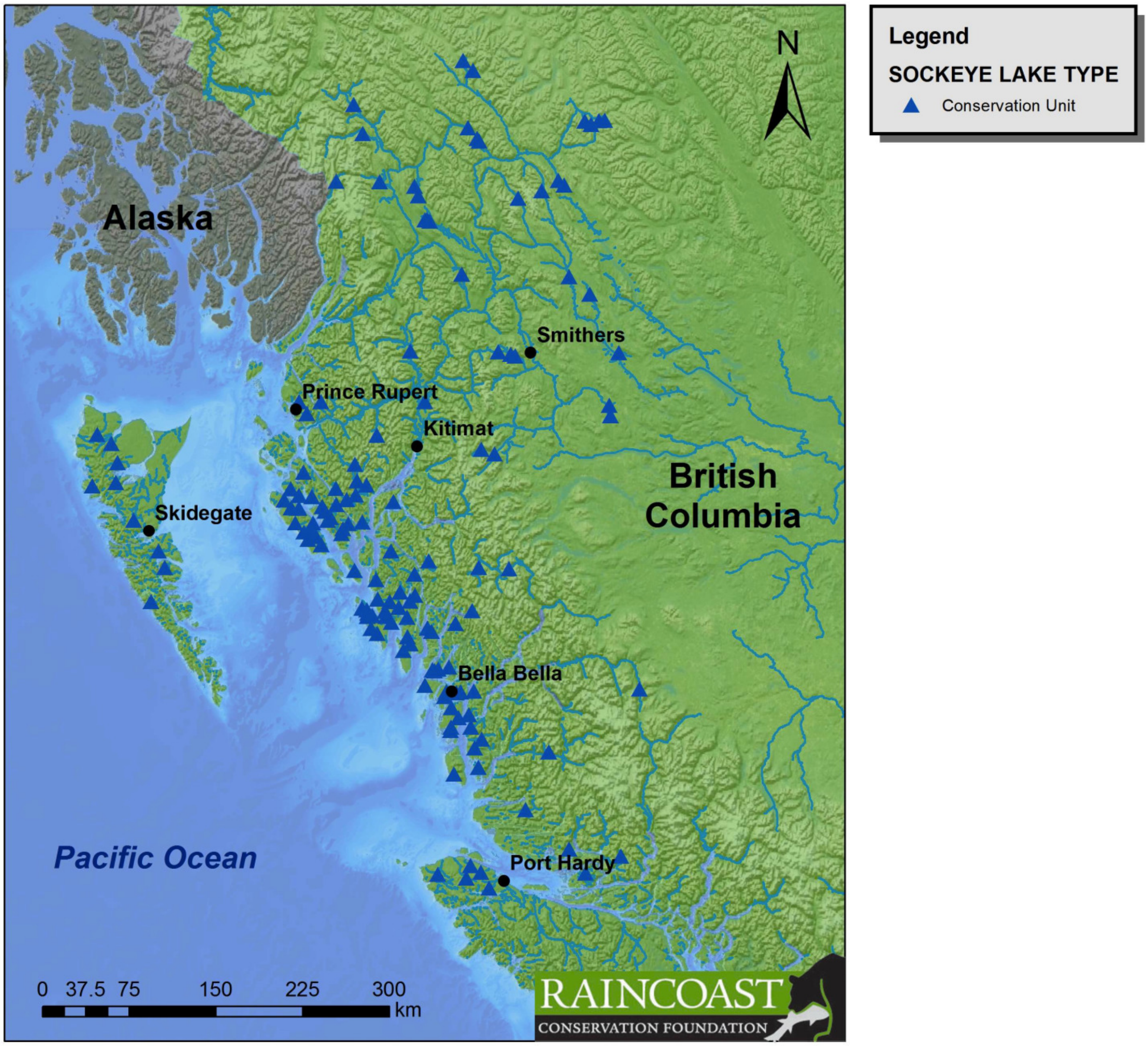

Figure 5. The lake locations for 142 Conservation Units of Lake-type sockeye in BC. These populations are genetically and reproductively isolated from other sockeye lake populations, and differ from River-type sockeye by spending up to two years rearing in freshwater lakes. Raincoast 2011.

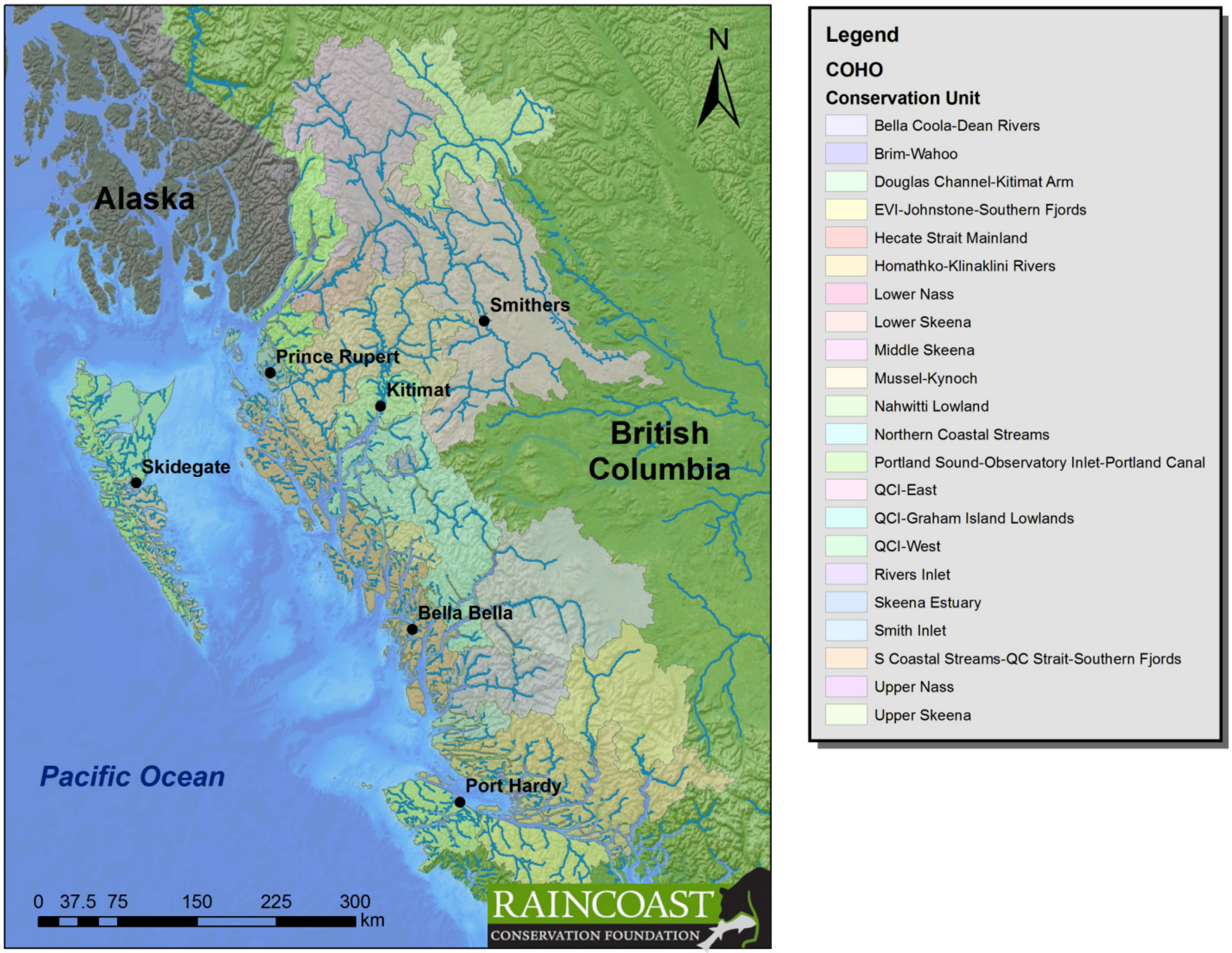

Figure 6. The 23 unique Conservation Units of coho salmon in Queen Charlotte Basin. These populations are based on life-history, running times, different uses of freshwater and marine habitats, and genetic uniqueness.

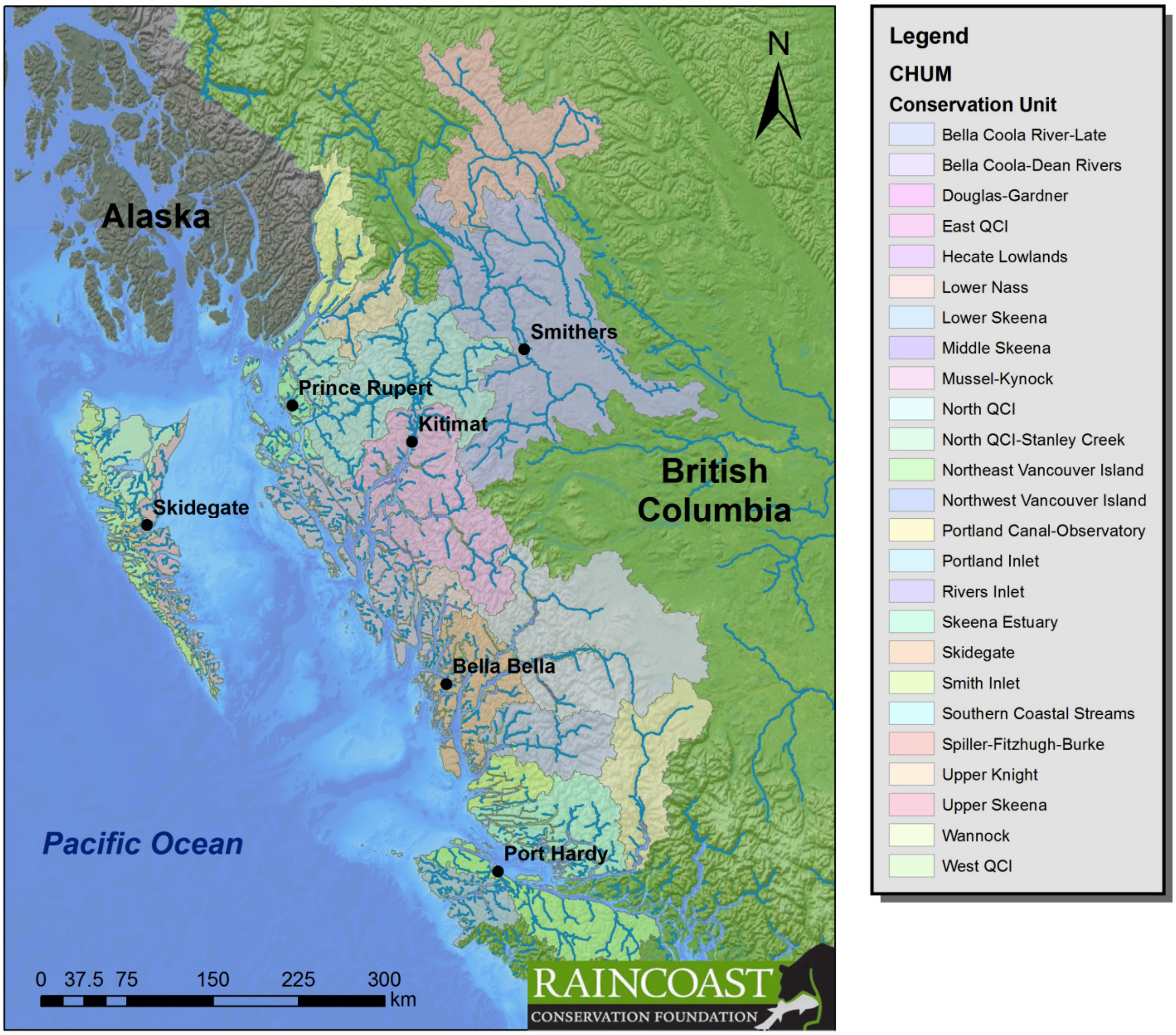

Figure 7. The 24 distinct Conservation Units of chum salmon that spawn in more than 1,000 streams in the Queen Charlotte Basin. Chum CUs are delineated based on run-timing, use of marine habitats, and genetic uniqueness.

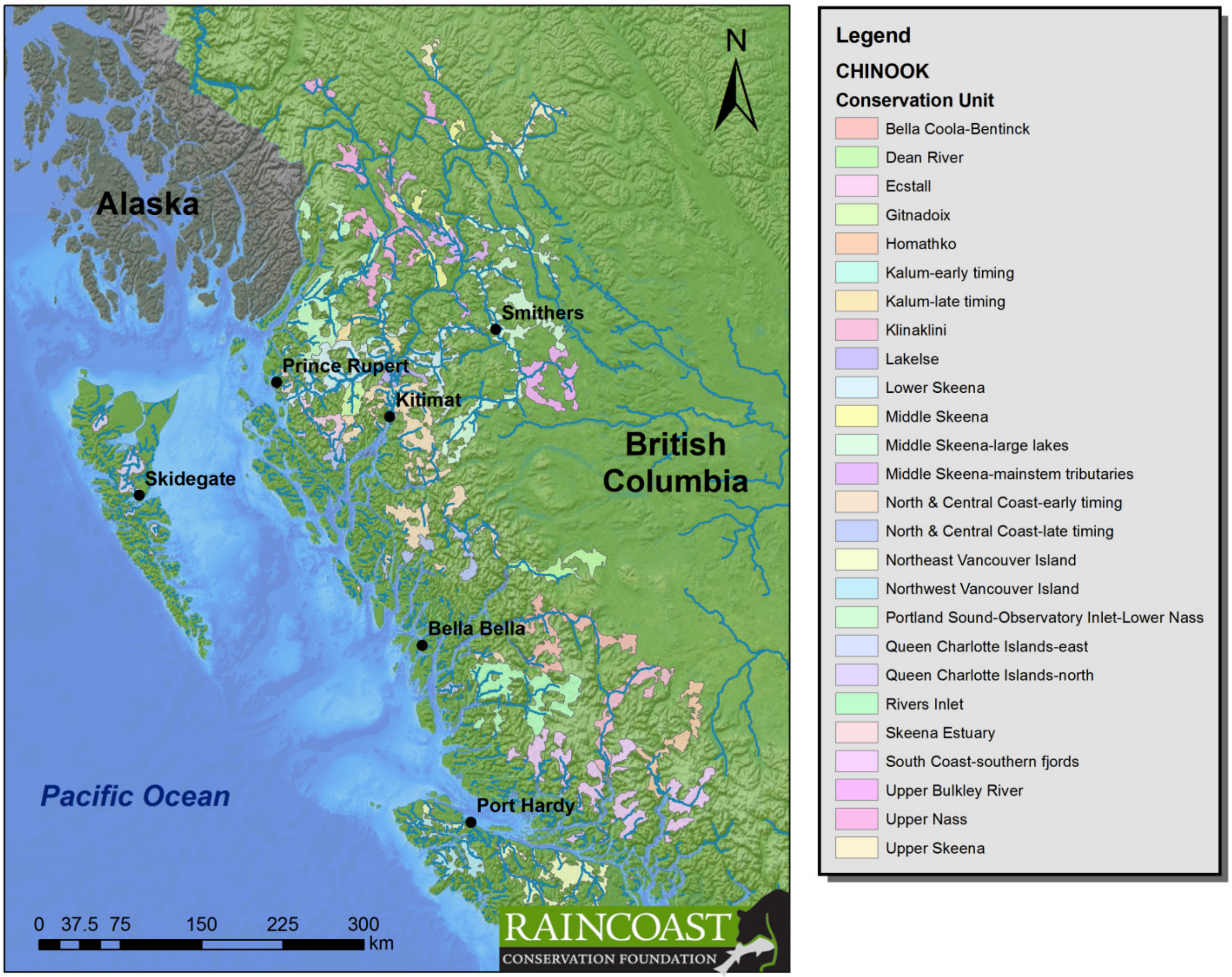

Figure 8. The 26 unique Conservation Units of chinook salmon that have been assessed based on Stream-type and Ocean-type populations, run timings, life history, and genetic uniqueness.

43. On average, 25-30 million adult salmon return each year to these watersheds. Annual fluctuations are large, however, ranging from 12 to 48 million adults.[40]

44. Major populations of the region's salmon were first assessed in the 1960s.[41] Fisheries scientists ranked salmon runs in order of their average spawning abundance. Major

[40] Hyatt, K., Johannes, M.S., and Stockwell, M. 2007. Appendix I: Pacific Salmon. In Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA). Edited by Lucas, B.G., Verrin, S., and Brown, R. Can. Tech. Rep. Fish. Aquat. Sci. 2667: vi + 55 p

populations were defined as those with spawners that met a set value for each species. These were >5000 for sockeye; >20,000 for pinks; >10,000 for chums; >2000 Coho; and >500 Chinook salmon. Their results suggested the Queen Charlotte Basin hosts approximately 383 major populations of the five commercial species including: 131 pink (58 odd-year, 64 even-year), 94 Coho, 67 chum, 55 sockeye, and 36 Chinook populations.[42] In addition to these major stocks, more than 4,000 additional populations of smaller, less productive runs that form the foundation for the remarkable genetic diversity and biological complexity of salmon populations occur within this region.[43]

What is the status of Salmon in the project area?

45. Salmon watersheds in Area 6 (adjacent to and within the CCAA) contain some of the highest spawner densities in the province (Figure 9). These densities have been an important factor in the densities of grizzlies within this region, as well as the presence of black bears, wolves, eagles, and many other salmon dependent species found throughout this area. However, at least three known species of concern occur within the PEAA and the CEAA.

46. Chum salmon, the indicator selected by Enbridge, are of greatest concern. Low abundance of chum salmon has implications not just for salmon conservation but also for salmon dependent species such as grizzlies, black bears, wolves, eagles, and many more mammals, birds and invertebrates.

47. Low abundance of sockeye and even-year pink salmon is also a concern. Data on Chinook and Coho in recent years have been gathered extremely sparsely so it is hard to assess their abundance on spawning streams.

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[41] Aro, K. V., and M. P. Shepard. 1967. Pacific salmon in Canada. Pages 225–327 *in* Salmon of the North Pacific Ocean, part 4. International North Pacific Anadromous Fisheries Committee Bulletin 23.
[42] Hyatt, *supra* note 40.
[43] 2600 streams were identified in Areas 3-10 by Price et al. 2008.
[43] Thomson and MacDuffee, 2002, Death by a thousand cuts: the importance of small streams on the North and Central Coasts of British Columbia, Raincoast Conservation Foundation, Sidney, BC.

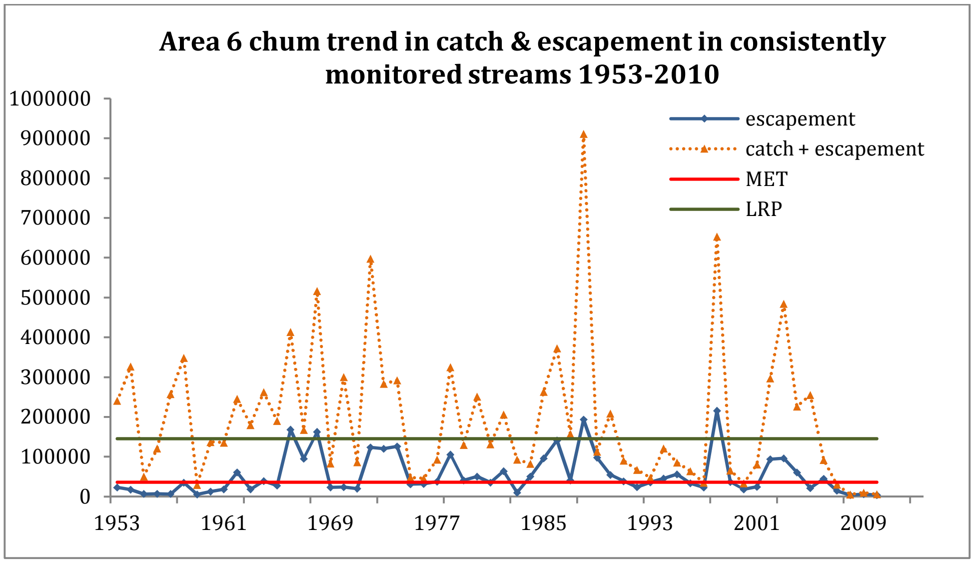


Figure 9. Trend in chum spawners and total abundance within Area 6. Total abundance is the sum of catch and escapement. 'Escapement' is defined as the number of salmon that "escape" the fishing nets and return to the rivers to spawn. These streams are considered indicators for all of Area 6 including streams in the CEAA and the PEAA. Spawner escapement targets (green line), set by Fisheries and Oceans Canada (DFO), have been met only once in the last 20 years and have recently fallen below their limit reference point (red line). Chum runs in Area 6 have been recognized by DFO as stocks of conservation concern. Concerted efforts, including reduced fishing pressure (from non-directed fisheries) and habitat protection in freshwater spawning and marine phases rearing are required for chum to recover. The depressed state of chum salmon in Area 6 is a conservation concern for salmon and wildlife, as well as a fisheries concern.

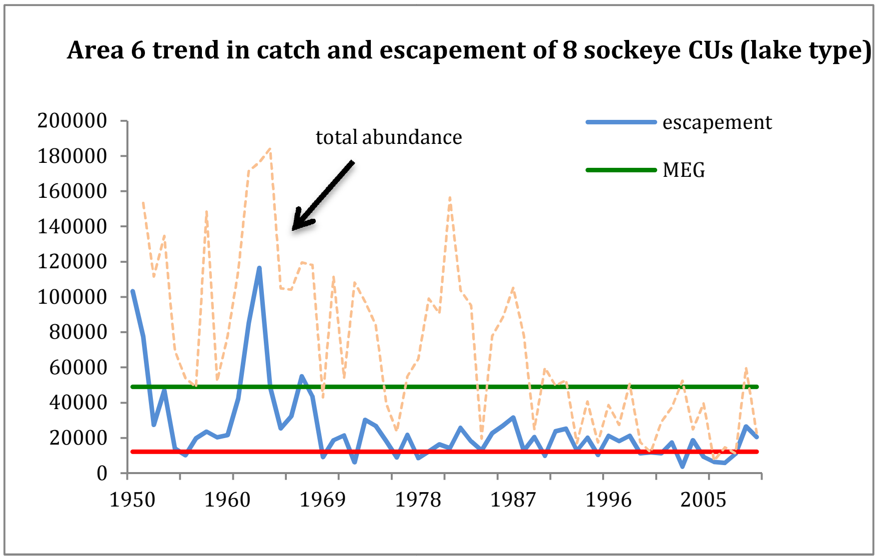


Figure 10. Trend in eight Area 6 sockeye Conservation Units, including two sockeye units that drain to the CCAA (Kitlope and Kitkiata). Total abundance has been declining since the 1960s and target escapements have been rarely met in decades. The trend and status of sockeye in Area 6 is a conservation concern.

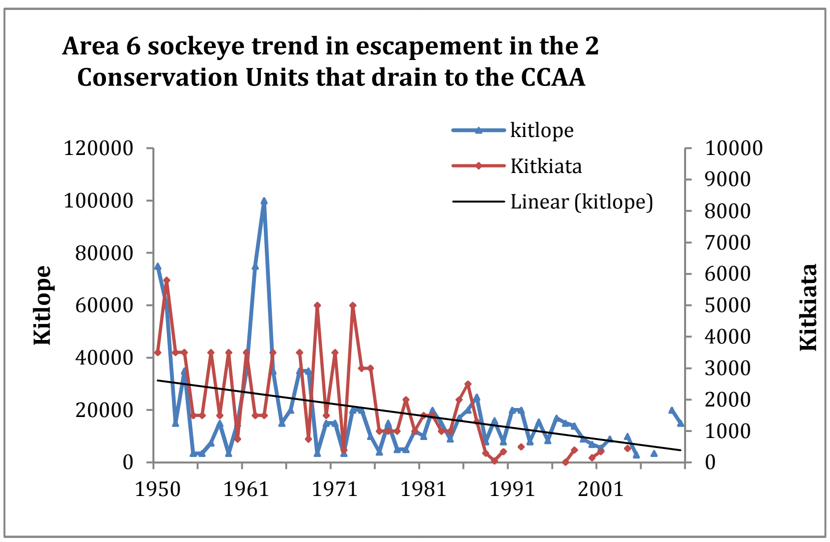


Figure 11. Trend in the two sockeye Conservation Units that drain to the CCAA. Total abundance has been declining since the 1960s. In 2010, the Kitlope CU did meet its target escapement.

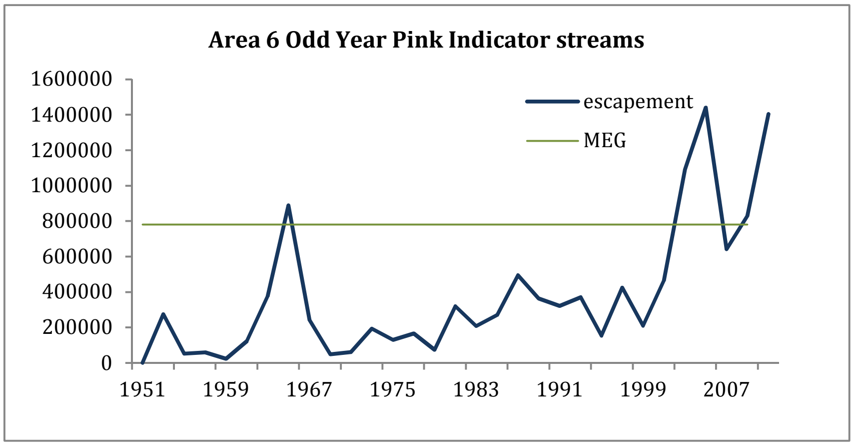


Figure 12. The trend in spawner abundance of ten Area 6 odd year pink salmon indicator streams. The increasing abundance of odd year pink salmon in recent years has been contributing to the highly productive Gil Island commercial fishery. These fish also support many salmon dependent species in the watersheds of the Great Bear Rainforest in Area 6. This trend is considered indicative of spawner trends within the PEAA and CEAA and contains streams within these regions.

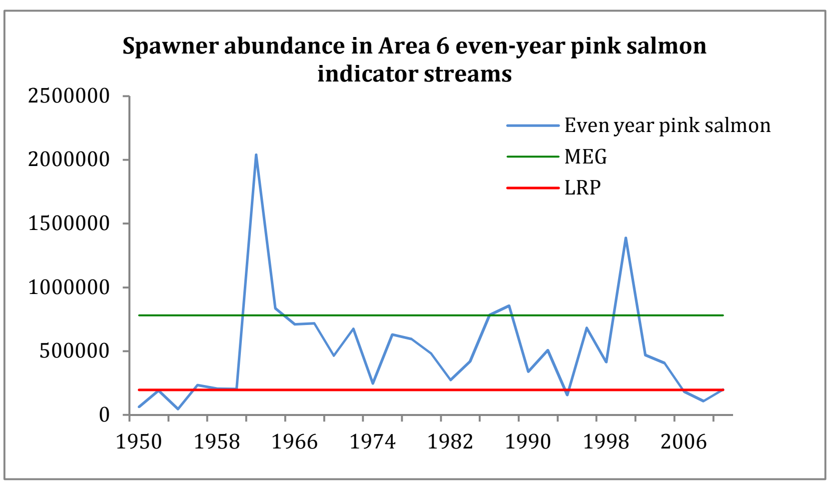


Figure 13. Trends in ten even-year pink salmon indicator streams in Area 6. These even year runs generally follow a different pattern than odd-year pink salmon in Areas 3-10. Although fluctuations can be high, these runs are much lower in abundance and have fallen below their target escapements (MEG) in recent years. Low abundances of pink and chum salmon in Areas 5 and 6 are a significant concern for wildlife species (e.g. bears, wolves and eagles) that rely on these fish.

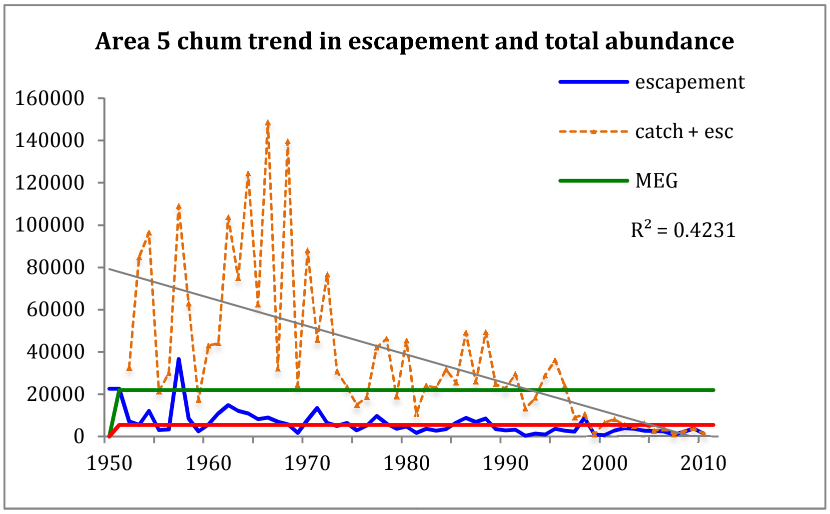


Figure 14. Area 5 chum salmon show a pronounced downward trend in total abundance and consistently low escapement. These Area 5 indicator streams lie throughout the CCEAA. The status of chum in Area 5 is a severe conservation concern. Chum runs in Area 5 have been recognized by DFO as stocks of conservation concern (DFO 2011[44]). Concerted efforts, including reduced fishing pressure (from non-directed fisheries) and habitat protection in freshwater spawning and marine phases rearing, are required for chum to recover. This decline in abundance adversely affects wildlife as well as fisheries. Further risks to abundance from reductions in spawning and rearing habitat or fisheries pressure would make these populations even more vulnerable to further declines.

What is the status of salmon in the Open Water Area?

48. Many BC salmon populations have declined over the last century. Analysis undertaken on more than 2,400 salmon runs in Fisheries Management Areas 1-10 on BC's north and central coasts showed that only 6% had reliable information on trends in abundance by 2006.[45] Of the 135 streams with reliable information, 44% were not at risk, 20% were depressed relative to their escapement targets, and 35% were at moderate to high levels of concern. Threats that have been identified to salmon abundance on the BC coast include

[44] DFO, Integrated Fisheries Management Plan 2011
[45] Price, M.H.H., C.T. Darimont, N.F. Temple, and S.M. MacDuffee. 2008. Ghost Runs: Management and status assessment of Pacific salmon returning to British Columbia's central and north coasts. Canadian Journal of Fisheries and Aquatic Sciences 65:2712-2718

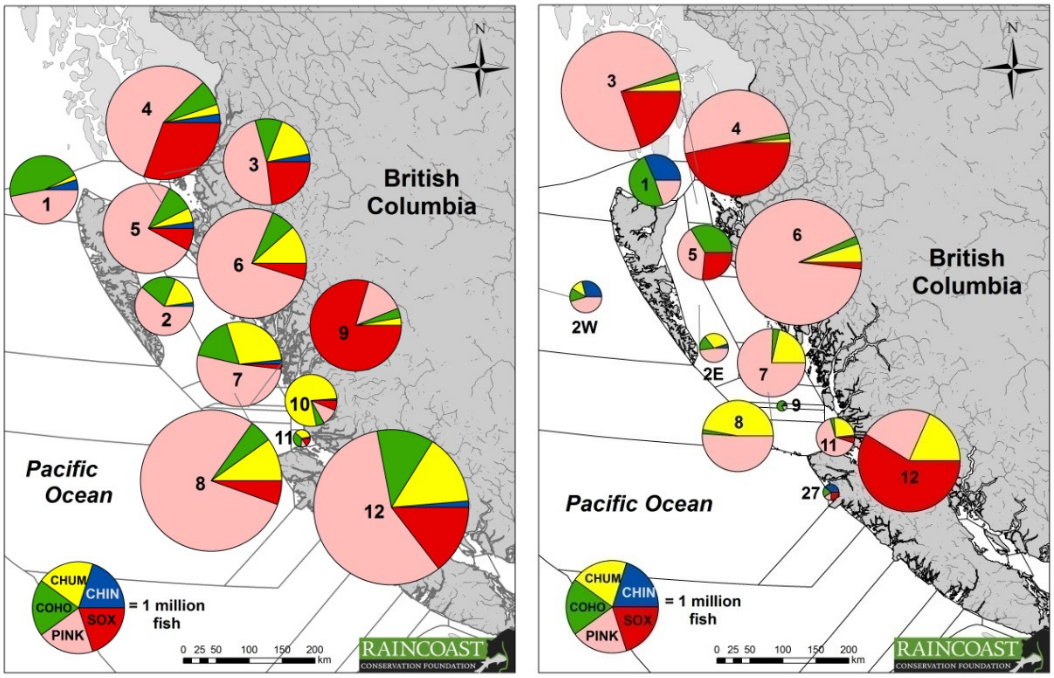
fisheries, ocean productivity and climate change, freshwater and marine habitat loss, enhancement activities, and salmon aquaculture and associated disease transmission.

49. Commercial catches in BC have also declined. The period from 2000-2010 hosted the lowest catches on record[46] and most salmon escapements to coastal streams did not meet their escapement targets. Accompanying the decline in abundance, the number of stocks contributing to the catch has also declined, shifting over the decades from many diverse (wild) runs to fewer large, and often enhanced, runs.[47]

50. Regardless of the inability to document long term trends in a large percentage of salmon populations, the abundance of many coastal runs of wild chum, coho, sockeye, Chinook and even-year pink salmon reached record lows in the past decade. Only odd-year pink salmon were stable or increasing.

51. Wild terminal fisheries in Areas 7-12 are primarily closed and the presence of depressed to severely depressed wild sockeye, wild chum, wild coho and steelhead stocks throughout Areas 1-12 is constraining fisheries on other, often enhanced, stocks.[48]

[46] DFO http://www.pac.dfo-mpo.gc.ca/stats/comm/index-eng.htm Accessed November 13, 2010.
[47] Wood, C.C. 2001. Managing biodiversity in Pacific salmon: The evolution of the Skeena River sockeye salmon fishery in British Columbia. Blue Millennium: Managing Global Fisheries for Biodiversity, Victoria, British Columbia, Canada, pp. 1-34. Proceedings of the Blue Millennium International Workshop, June 25-27, 2001, Victoria, BC, Canada. available at http://www.worldfish.org/bluem-reports.htm
[48] DFO 2011 Integrated Fisheries Management Plan, Salmon



Figures 15a and **15b.** Distribution of average catch and shift in catch composition and relative abundance among salmon species, 1952-1962 (a) 2000-2010 (b) for Fisheries Management Areas 1-12 and 27 in Pacific Canadian waters. Pie chart sizes are scaled to the catch size. Catch from 1952- 1962 was collected by DFO from sales. Catch statistics from 2000 -2010 consist of commercial and recreational statistics. The exception to the trend of declining abundance is odd-year pink salmon, which have increased in their importance to the catch, especially in Area 6 within the CCAA. The period from 2000-2010 contains the largest pink catches on record for areas 1-12.

What risk and impacts does the Enbridge Northern Gateway project present to Salmonid species?

52. We review several elements of risk and impacts below. In general, the most important to wild salmon come from acute, chronic, sub-lethal, delayed, or indirect effects from exposure to hydrocarbons in the marine environment.[49] The severity of these impacts on

[49] Peterson, C. H. Stanley D. Rice, Jeffrey W. Short, Daniel Esler, James L. Bodkin, Brenda E. Ballachey, David B. Irons. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science Vol 203; Stanley D. Rice, Robert E. Thomas Mark G. Carls Ronald A. Heintz, Alex C. Wertheimera Michael L. Murphya Jeffrey W. Short & Adam Moles. 2001. Impacts to Pink

the BC coast are magnified by the persistence of crude oil in cold-water habitats, the role of strong winds, tides, and freshwater to disperse oil over large distances.

53. The most vulnerable periods for exposure are the embryonic[50] and juvenile life stages. In the embryonic stage, chum[51] and pink salmon are the most susceptible species because of their tendency to spawn in the lower reaches of freshwater streams, [52][53] where residue from a marine spill would accumulate. In the juvenile life stages, all species and life history types are vulnerable because of their reliance on estuarine, saltmarsh, and shallow near shore waters for food, protection from predators, and migration. However chum, ocean-type Chinook, nomadic and ocean-type coho, river-type sockeye and pink salmon could be considered the most vulnerable because of their longer residence times in these environments.[54] Ingestion of contaminated food sources, reduced food supply and lowered survival from loss of critical kelp and eelgrass beds in near and foreshore habitats are the broad primary routes for impacts to juvenile salmon.[55],[56]

54. Even low levels of exposure (ppb) to surface and subsurface toxic and persistent PAHs are known to cause lethal and sub-lethal effects to salmon through a variety of food web

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Salmon Following the Exxon Valdez Oil Spill: Persistence, Toxicity, Sensitivity, and Controversy. Review in Fishery Science. Vol 9:3; M.G Carlsa, M.M Babcockb, P.M Harrisa, G.V Irvinec, J.A Cusickd, S.D Ricea 2001. Persistence of oiling in mussel beds after the Exxon Valdez oil spill. Marine Environmental Research.Vol 51-2

[50] Peterson, C. H. S.D. Rice, J.W. Short, D. Esler,. J.L. Bodkin, B.E. Ballachey, D.B. Irons. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science Vol 203

[51] Wertheimer, A. C., A. G. Celewycz, M. G. Carls, and M.V. Sturdevant. 1994. Impact of the Oil Spill on Juvenile Pink and Chum Salmon and Their Prieny Critical Near shore Habitats. Exxon Valdez oil spill state/federal natural resource damage assessment final report, (Fish/Shellfish Study Num4b,e NrM FS Component),National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska.

[52] Heintz, R.A., J.W. Short, S.D. Rice. 1999. Sensitivity of fish embryos to weathered crude oil. Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. Environ Toxic Chem 18(3):494–503

[53] Heintz, R.A., Rice, S.D., Wertheimer, A.C. Bradshaw, R.F., Thrower, F.P., Joyce, J.E. and J.W. Short. 2000. Delayed effects on growth and marine survival of pink salmon *Oncorhynchus gorbuscha* after exposure to crude oil during embryonic development. Marine Ecology Progress Series 208:205-216.

[54] Koski, K. V 2004. The Fate of coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. Ecology and Society **14**(1): 4

[55] Semmens, B.X. 2008. Acoustically derived fine-scale behaviours of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) associated with intertidal benthic habitats in an estuary. CJFAS 65:2053-2062.

[56] Bravender, B.A., Anderson, S.S. and J. Van Tine. 1999. Distribution and abundance of juvenile salmon in Discovery Harbour marina and surrounding area, Campbell River, B.C., during 1996. Canadian Technical Reports Fish and Aquatic Science 2292: 45 p.

and exposure pathways.[57] Indirect habitat effects from oil contamination to supporting ecosystems include oxygen depletion and impacts to key ecosystem components. These indirect effects from trophic interactions and cascades result in impacts at the ecosystem level.[58]

55. There are threats to salmon even in the absence of a marine oil spill. Specifically, the presence of tankers in confined channels has the potential to degrade and destroy essential habitat features such as eelgrass beds and other sensitive vegetation from wake action.[59] Wakes and subsequent beach run-up from large ships in confined channels have also been shown to strand (i.e. kill) juvenile salmon in the near shore environment, with sub yearling Chinook being particularly vulnerable.[60]

56. Another effect, and contributing to cumulative effects, relates to increased suspended sediments in Kitimat Arm and estuary that are associated with terminal operation and maintenance. These have the potential to further adversely affect habitat and food supply for juvenile salmonids and lead to direct mortality via smothering.

57. Another potential adverse influence, also contributing to cumulative effects, is damage to sensitive eelgrasss habitat for salmon. Because eelgrass grows in low energy (i.e. low wave) shore zones, it is also sensitive to mechanical impacts from the wake of tankers, which can damage the beds. Added to this is the increased disturbance from wave action and climate change impacts. Eelgrass can also accumulate high levels of heavy metals that can then be further passed through the food chain to waterfowl and marine invertebrates.[61] Eelgrass is also highly sensitive to sedimentation[62]; even settlement of

[57] Carls, M. G. and J. P. Meador. 2009. A Perspective on the Toxicity of Petrogenic PAHs to Developing Fish Embryos Related to Environmental Chemistry. 15(6):1084-1098.
[58] Peterson, C. H. S.D. Rice, J.W. Short, D. Esler, J. L. Bodkin, B.E. Ballachey, D. B. Irons. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 203: 282-286
[59] Short, F.T. and H.A. Neckles. 1999. The effects of global climate change on seagrasses. Aquatic Botany 63:169-196.
[60] Pearson, W. H. and J. R. Skalski. 2011. Factors affecting stranding of juvenile salmonids by wakes from ship passage in the Lower Columbia River. River Research and Applications Vol. 27:7, pp 926–936
[61] Govindasamy C, Arulpriya M, Ruban P, Francisca Jenifer L, Ilayaraja. 2011. A Concentration of heavy metals in Seagrasses tissue of the Palk Strait, Bay of Bengal. International Journal of Environmental Sciences Vol 2(1)

particles on leaves can lead to mortality from decreased photosynthesis.[63],[64]

58. In summary, the risks and impacts in specific spatial and temporal environments include:

59. Embryos:

-Risks from spills and corresponding PAH exposure of pink and chum salmon embryos in spawning gravels within the OWA, CEAA and PEAA causing acute mortality,

-Risk from spills and corresponding PAH exposure of pink and chum salmon embryos in spawning gravels within the OWA, CEAA and PEAA causing reduced survival and fitness in the initial and subsequent generations of salmon,

-Risk to pink and chum embryos in the PEAA from suffocation associated with increased sedimentation on the spawning grounds from terminal activities of dredging and marine disposal of sediments.

60. Juveniles:

-Impacts from disease, toxicity and mortality caused by acute spills and subsequent ingestion of PAH-contaminated prey for juvenile pink, chum, Chinook, coho, and sockeye salmon feeding and rearing in estuarine and near shore habitats within the OWA, CEAA and the PEAA

-Impacts from disease, toxicity, and mortality caused by chronic oiling and ingestion of PAH-contaminated prey for juvenile pink, chum, Chinook, coho, and

[62] Wright, N; (2002) Eelgrass conservation for the B.C coast. *B.C Coastal Eelgrass Stewardship Project.*
[63] S. Cabaço, R. Santos, C.M. Duarte The impact of sediment burial and erosion on seagrasses: A review, Estuarine, Coastal and Shelf Science, Volume 79, Issue 3, 10 September 2008, Pages 354-366.
[64] H. Tamaki, M. Tokuoka, W. Nishijima, T. Terawaki, M. Okada, Deterioration of eelgrass, *Zostera marina* L., meadows by water pollution in Seto Inland Sea, Japan, Marine Pollution Bulletin Volume 44, Issue 11, November 2002, Pages 1253-1258.

sockeye salmon feeding and rearing in estuarine and near shore habitats within the PEAA

-Impacts to juveniles through physical (gill) injury caused increased suspended sediments associated with dredging, marine disposal of sediment, and run-off from proposed terminal construction and operation activities in the PEAA

-Impacts to juveniles from reduced feeding caused by vision impairment in waters with increased suspended sediments associated with dredging and marine disposal of sediment, and proposed terminal construction in the PEAA.

61. Adults:

-Risks from physical injury (gills) to returning adult spawners from increased suspended sediment in holding areas of PEAA

-Potential food chain impacts from consumption of toxic prey sources at lower trophic levels

62. Indirect ecosystem impacts:

-Indirect effects on supporting ecosystems including oxygen depletion and impacts to key ecosystem components from spills within the CCAA and PEAA

-Impacts from tanker wakes on the survival of juvenile salmon in the CCAA and PEAA

-Increased risks to juveniles from predation associated with loss of near shore and estuarine structural habitat (such as eel grass) due to chronic oiling, sedimentation, wave action and climate change in the CCAA and PEAA

-Impact from the introduction of competitive invasive species from ballast water exchange in the OWA, CCAA and PEAA

How do cumulative impacts, including climate change, affect salmonids and is the overall impact significant?

63. Cumulative impacts, including those from climate change, have clear and as-of-yet unknown impacts that are likely significant. Below we identify these, but begin with a clear explanation of cumulative impacts.

64. The concept of cumulative impacts has been examined and used in environmental policy for decades.[65] Cumulative impacts can emerge from activities occurring at a spatial or temporal frequency high enough to make the individual events of an activity no longer independent. Similarly, they can emerge from multiple activities acting in synergy. Notably, their combined effects on species and/or ecological processes are often greater than that predicted from the sum of their parts.

65. Large changes are occurring in marine ecosystems that are already affecting the diversity and abundance of wild Pacific salmon. Part of the ongoing debate about salmon population viability considers the potential resilience of salmon ecosystems in the face of large-scale shifts in marine and freshwater productivity. These issues have not been accounted for by past or present management practices.[66] In addition to changing ocean processes, factors such as disease, overfishing, aquaculture, habitat loss in marine and freshwater, acoustic disturbance, higher stream temperatures, lower stream flows, sea level change and declining marine biomass – and their potential interaction – all conspire against salmon.

[65] H. Spaling and B. Smit. 1993. Cumulative environmental change – conceptual frameworks, evaluation approaches, and institutional perspectives. *Environmental Management*, **17**: 587–600
[66] Bottom, D. L., K. K. Jones, C. A. Simenstad, and C. L. Smith. 2009. Reconnecting social and ecological resilience in salmon ecosystems. *Ecology and Society* 14(1): 5. [online] URL: http://www. ecologyandsociety.org/vol14/iss1/art5/

66. Emerging diseases might be especially relevant to salmon of coastal British Columbia (BC). The identification of Infectious Salmon Anaemia virus (ISAv) in salmon from BC's central coast, Fraser River and potentially other locations could have dire consequences for all species of salmon and potentially other fish like herring. ISAv, along with other diseases and parasites that have been concentrated and intensified by salmon farming, present a serious threat to wild salmon abundance and diversity.[67]

67. Acoustic disturbance by development and marine traffic are among the myriad risks to salmon. Generally, little is known about the effects of anthropogenic sound on fish and even less is known about the impacts to developing eggs and embryo.[68] It is becoming clear, however, that sound can be important and that artificial underwater noise may be harmful.[69] Although the harm caused by short-term intense sounds like sonar, pile driving and explosions have attracted the most attention, the greater impact on fish will be from less intense sounds that are of longer duration and that can potentially affect whole ecosystems.[70],[71] Sublethal physiological responses to underwater noise generated by vessel traffic such as increased heart rate[72] increased metabolism and motility[73] and the secretion of stress hormones[74] are all documented responses in fish exposed to noise.

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[67] M.H.H. Price, A. Morton, and J.D. Reynolds. 2010. Evidence of farm-induced parasite infestations on wild juvenile salmon in multiple regions of coastal British Columbia, Canada. Can. J. Fish. Aquat. Sci. 67: 1925–1932
[68] Popper. Arthur N. 2003. Effects of Anthropogenic Sounds on Fishes. Fisheries, Vol 28 (3)
[69] Slabbekoorn et al. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. Trends in Ecology and Evolution 25(7):419–427.
[70] Popper, A. N. and Hastings, M. C. 2009. The effects on fish of human-generated (anthropogenic) sound. Integrative Zoology 75, 455–48
[71] Slabbekoorn et al. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. Trends in Ecology and Evolution 25(7):419–427.
[72] Graham A. L and S. J. Cooke. 2008 The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (Micropterus salmoides) Aquatic Conser*v*: Mar. Freshw. Ecosyst. 18: 1315–1324
[73] Assenza, Anna, Francesco Fazio, Giovanni Caola and Salvatore Mazzola. 2010. Impact of an acoustic stimulus on the motility and blood parameters of European sea bass (*Dicentrarchus labrax L.)* and gilthead sea bream (*Sparus aurata L.).*
Marine Environmental Research 69: 136–14
[74] Slabbekoom, *supra* note 71.

Cumulative Impacts within the PEAA

68. Construction of an oil storage tank and marine shipping terminal in Kitimat Arm will adversely affect local salmon populations and their habitat in the short and long terms. These impacts represent steady cumulative stressors to the Kitimat River's salmon populations already affected by degraded marine and freshwater habitat, climate change, hatchery enhancement activities and fishing pressure. Habitat conditions in the estuary will very likely be further eroded by the dredging, construction, and operation of the LNG terminal in Kitimat Arm.

69. At minimum, chronic oiling, remobilization of contaminated sediments and increased suspended solids that will accompany the proposed hydrocarbon activities in Kitimat Arm add more stress to the processes and structures that create key rearing habitat for salmonids, eulachon and other forage fish. Given the impaired quality of the estuary, activities that accompany construction and operation of an oil-shipping terminal, they impose additional stress on all these fish populations and their associated ecosystem beneficiaries.

Did Enbridge adequately assess the risk of marine transportation to salmonids?

70. No. Although Enbridge's Quantitative Risk Analysis calculates the probability of a spill occurring, an appropriate risk assessment includes the *consequences* of an event, not just the occurrence. Accordingly, oil spill risk is defined as the likelihood (i.e. probability) of spills occurring multiplied by the consequences (impacts) of those incidents.[75] Enbridge simply quantified the probability of oil, bunker fuel, or condensate spills occurring during marine transport. They did not assess the consequences of these hypothetical spills, either qualitatively or quantitatively.

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[75] French-McCkay, D., Beegle-Krause, C.J., Etkin, D.S. 2009. Oil Spill Risk Assessment – Relative Impact Indices by Oil Type and Location. In Proceedings of the 32nd AMOP Technical Seminar on Environmental Contamination and Response, Emergencies Science Division, Environment Canada, Ottawa, ON, Canada, pp. 655-681. Available online at <http://www.asascience.com/about/publications/publications09.shtml>, Accessed December 11, 2011.

Assessment of Risk for Salmonids in Queen Charlotte Basin

71. Tools from the field of ecological risk assessment can be used in combination with GIS to produce relative risk maps of large geographic areas that integrate risk to habitat quality, communities of indicator taxa, and cultural resources.[76],[77],[78] Lacking an assessment of risk by Enbridge, Raincoast carried out a brief quantitative risk assessment that evaluated the impact of marine tanker spills to anadromous salmon in the QCB. In general, we assumed that natural variability in density and distribution of salmon was a proxy for consequence. Combined with probability of a spill, salmon density and distribution provided a method for quantifying risk.[79]

72. The geographic scope of the watershed risk assessment was determined by several factors, beginning with identification of at-risk salmon species and populations in the QCB.

73. Vulnerability of the streams and populations reflected a potential zone of impact from a catastrophic marine spill along the proposed tanker route. The at-risk polygon was based on the 28,500 km^2 area affected by the Exxon Valdez Spill (EVOS) in Alaska.[80] Although Alaska's worst hit area was Prince William Sound, crude oil spread more than 750 km to the southwest along the Kenai Peninsula, Kodiak archipelago, and the Alaskan Peninsula, contaminating 1,990 km of pristine shoreline.[81]

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[76] Kapustka, L.A., Landis W.G. 2010. Environmental Risk Assessment and Management from a Landscape Perspective. John Wiley & Sons, Inc. New York

[77] Landis, W.G., Wiegers, J.K. 2007. Ten years of the relative risk model and regional scale ecological risk assessment. Human and Ecological Risk Assessment.13:25-38.

[78] Hull, R. N., Swanson, S. 2006. Sequential analysis of lines of evidence—An advanced weight-of-evidence approach for ecological risk assessment. Integrated Environmental Assessment and Management 2:302–311.

[79] French-McCay, D. 2011. Oil Spill Modeling for Ecological Risk and Natural Resource Damage Assessment. 2011 International Oil Spill Conference. Available online at <http://www.asascience.com/about/publications/publications11.shtml>, Accessed December 11, 2011.

[80] Belanger, M., Tan, L., Askin, N., Wittnich, C. 2010. Chronological effects of the Deepwater Horizon Gulf of Mexico oil spill on regional seabird casualties. Journal of Marine Animals and Their Ecology 3:10-14.

[81] Peterson, C.H., Rice, S.D, Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., Irons, D.B. 2003. Long-term ecosystem response to the Exxon Valdez oil spill. Science 302:2082-2086.

74. We limited the southern extent of our risk area to watersheds draining into Queen Charlotte Strait. We do not assume, however, that this would be the limit of potential oiling on areas further south. Similarly, tanker spills might adversely affect watersheds south of Brooks Peninsula on the West Coast of Vancouver Island. The northern extent of our risk area was limited to those watersheds that drain into Canadian waters of QCB, which abut the British Columbia-Alaska border. Upper watersheds included those that drain into the QCB, such as the Upper Nass and Upper Skeena. Coincidentally, this area of at-risk watersheds generally aligns with boundaries of the Pacific North Coast Integrated Marine Planning Area for the Queen Charlotte Basin. Therefore, ecological, economic, and social profiles of the PNCIMA region can broadly apply.

75. The consequence portion of our assessment comprises two factors; vulnerability of habitat used by salmon and the density of salmon in an individual watershed. The vulnerability of a watershed to an oil spill was assigned high consequence for watersheds where spawning and rearing habitat for anadromous salmonids would be affected by an oil spill, and medium for watersheds where only rearing habitat would be affected (Figure 16a). Watersheds adjacent only to marine waters at the end of long inlets (i.e. Klinaklini, Kitlope and the Lower Dean watersheds) were also assigned medium consequence because it is less likely that major oil contamination would reach spawning habitat.

76. The density of salmon in a watershed was determined using the relative salmon biomass of only consistently enumerated streams from Fisheries and Oceans Canada nuSEDS database.[82] Salmon escapement from 1960-2009 was averaged and then summed for each watershed to provide a density value on a watershed basis.[83] Some watersheds included in this assessment were not enumerated frequently enough over the last 50 years to have an average salmon density calculated. These later watersheds were ranked based on available data in the nuSEDS database and known distribution and spawning sites for salmonids. All data were then quartile ranked (Figure 16b.)

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[82] DFO website, online at <http://www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm>, accessed on December 10, 2011.
[83] Raincoast Conservation Foundation, unpublished data.

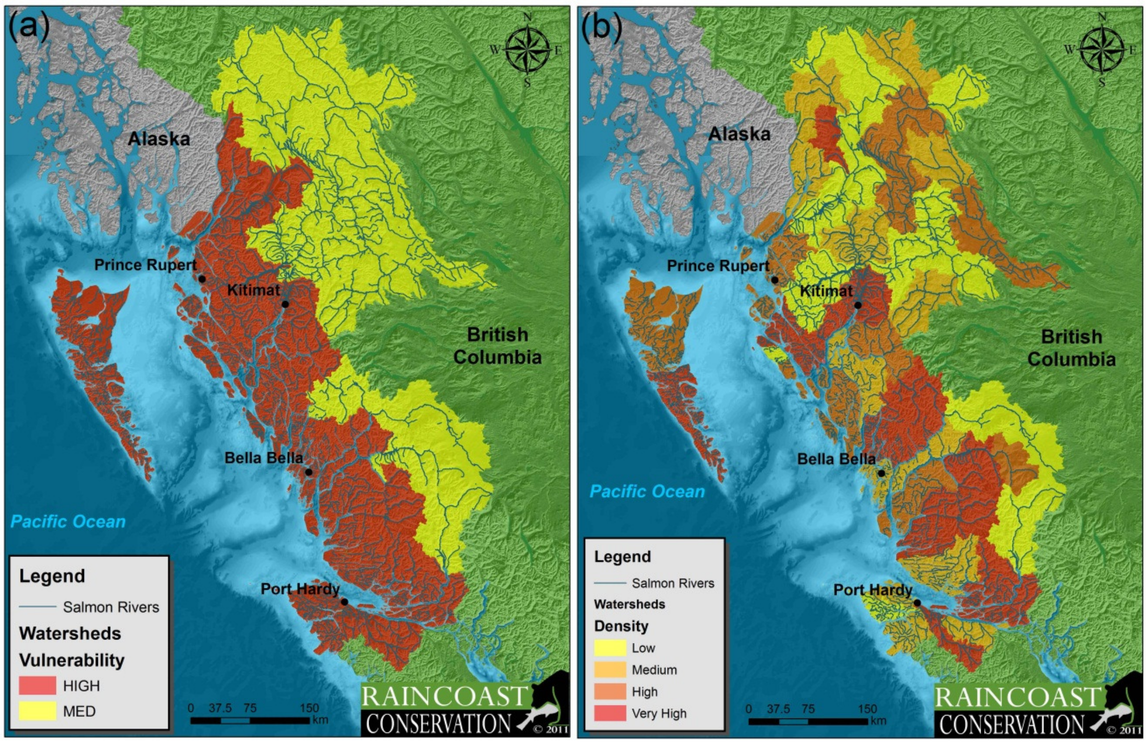

Figure 16a. Vulnerability of salmon watersheds based on potential impact of an oil spill on spawning and rearing habitat or rearing habitat only, and **Figure 16b.** ranked density of salmon.

77. We quantified the probability of a spill occurring within a particular watershed by assigning the segments taken from Figure 3-1 of Volume 8C,[84] spill probability numbers from Table 8-2 of the Marine Shipping Quantitative Risk Analysis Technical Data Report.[85] In ArcGIS, the segment probability was extended outwards from the intersection point between segments using a geo-referenced shipping line to create polygons. These were assigned the probability value (Figure 17). This layer was joined to the 5-km^2 grid used in the density surface modelling. Although we use Enbridge's probabilities in our assessment of risk, our usage is not an endorsement, as explained elsewhere in our submission.

[84] Enbridge Northern Gateway Pipelines. 2010. Exhibit B3-37 to B3-42 – Vol 8C - Gateway Application – Risk Assessment and Management of Spills – Marine Transportation - pg.3-3.

[85] Enbridge Northern Gateway Pipelines. 2010. Exhibit B23-34 - Gateway Application – TERMPOL TDR Marine Shipping QRA - pg.8-122.

78. Where multiple segments were adjacent to a watershed, the one with a higher probability was used. In a tanker spill, oil can disperse over long distances; hence the closest segment is not necessarily the origin of the spill. The assignment of a given spill probability is used as a means of quantifying relative risk. Secondary and other upper watersheds were assigned the probability of the segment adjacent to the lower river mouth. For example, the Nass River watershed was assigned the probability of segment 4b, as were all upper watersheds that drain into the Nass River.

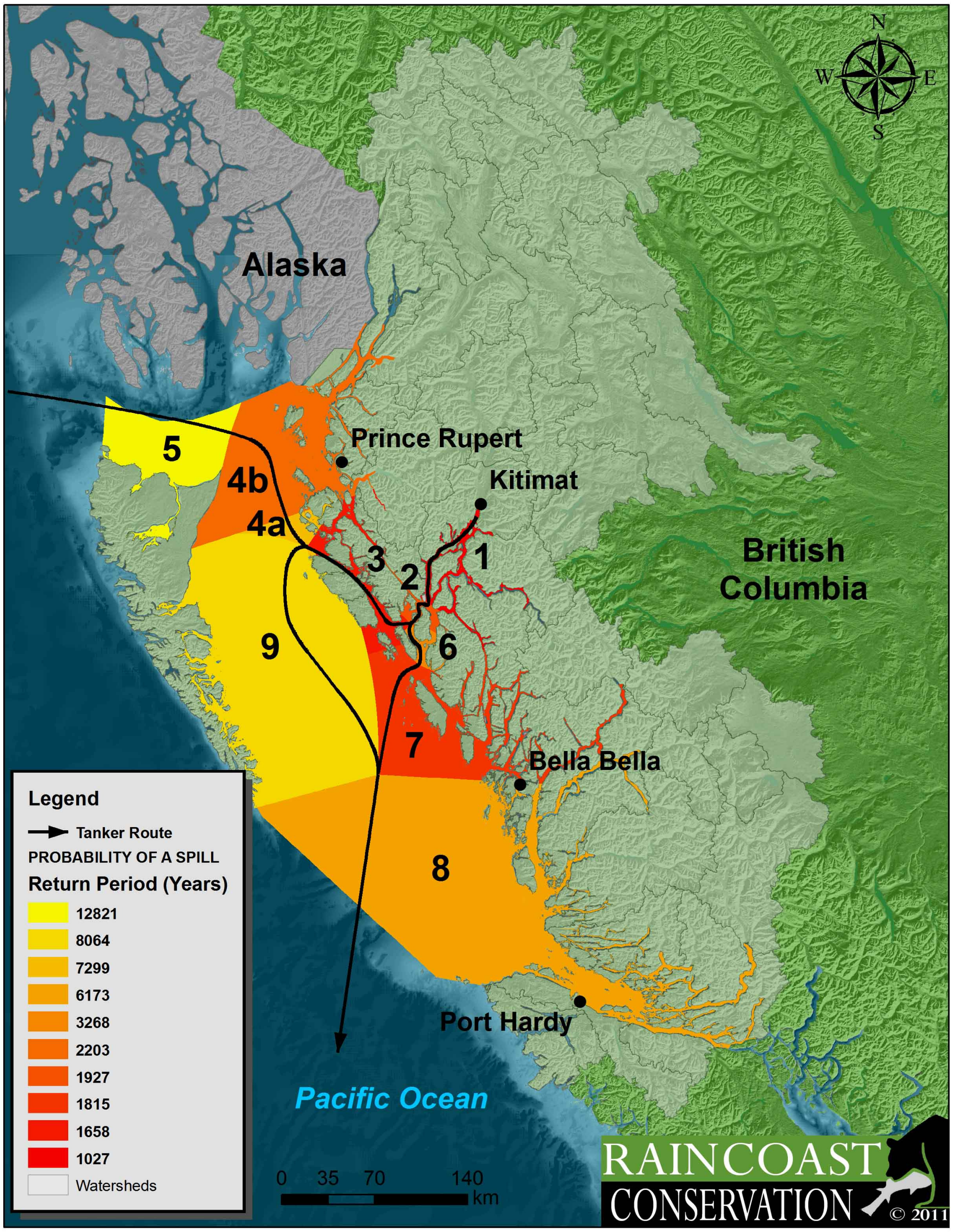

Figure 17. Probability of an oil spill for each segment of the marine transportation routes to the Kitimat Marine Terminal. Polygons were extended outwards from the intersection points of adjacent segments to provide a guideline for the spatial extent of that probability to marine waters and watersheds.

79. Habitat vulnerability (high or medium) and ranked salmon density (suspected, low, medium, high and very high) were then normalized (to give equal weight) and combined additively to provide a composite map of consequence, emphasizing watersheds where there was high vulnerability of habitat and high salmon density (Figure 18a).

80. To quantify the risk to salmon in these watersheds, the composite of habitat vulnerability and density was then multiplied by the probability of an oil spill in that watershed (Figure 18).

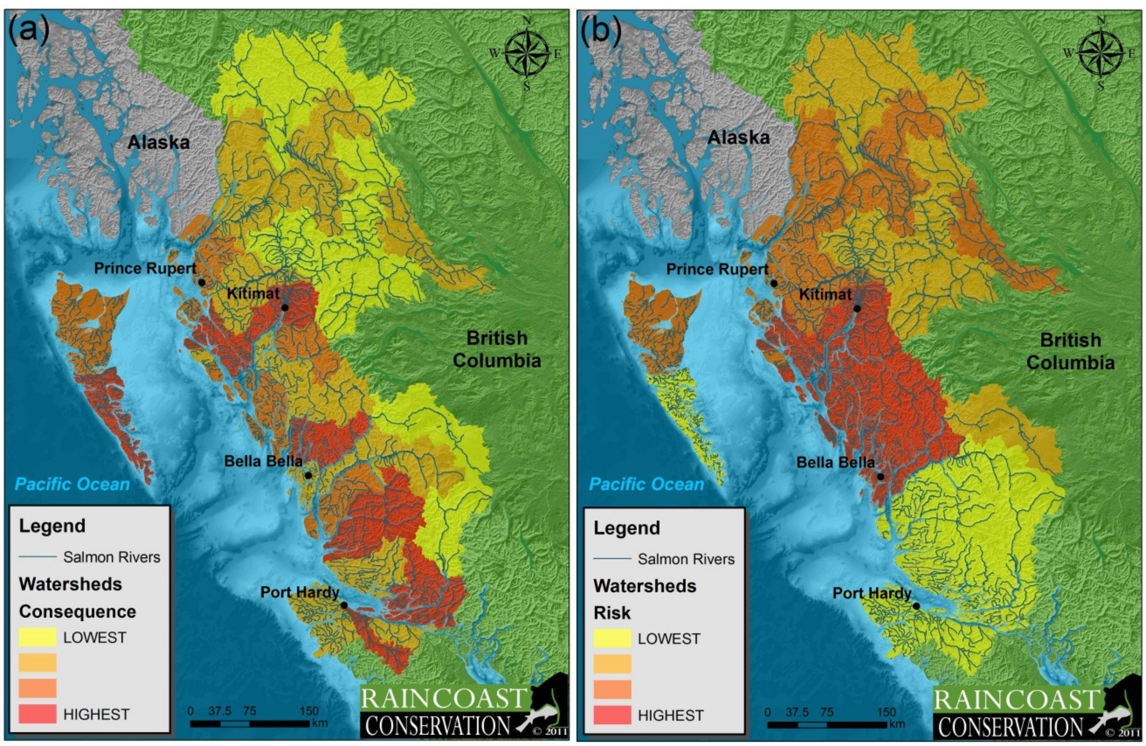

Figure 18a. Consequence – composite map of watershed salmon habitat vulnerability combined with salmon density, and **Figure 18b** risk – watershed salmon composite multiplied by the probability of an oil spill.

81. The highest risk areas include those watersheds that surround the CCAA, and those segments that have the highest probability of an oil spill associated with them (Figure 18b). Notably, upper watersheds that have high densities of salmon can have elevated

risks and could be severely affected depending on the timing and season of a spill. Low and medium density watersheds can also have high risk associated with them in this type of analysis, based on high habitat vulnerability and high probability of an oil spill. When comparing solely the probability of an oil spill with the risk (Figure 19), it is also critical to note that watersheds with high consequence (salmon density and habitat vulnerability) can be elevated to higher risk than they would be based on probability alone.

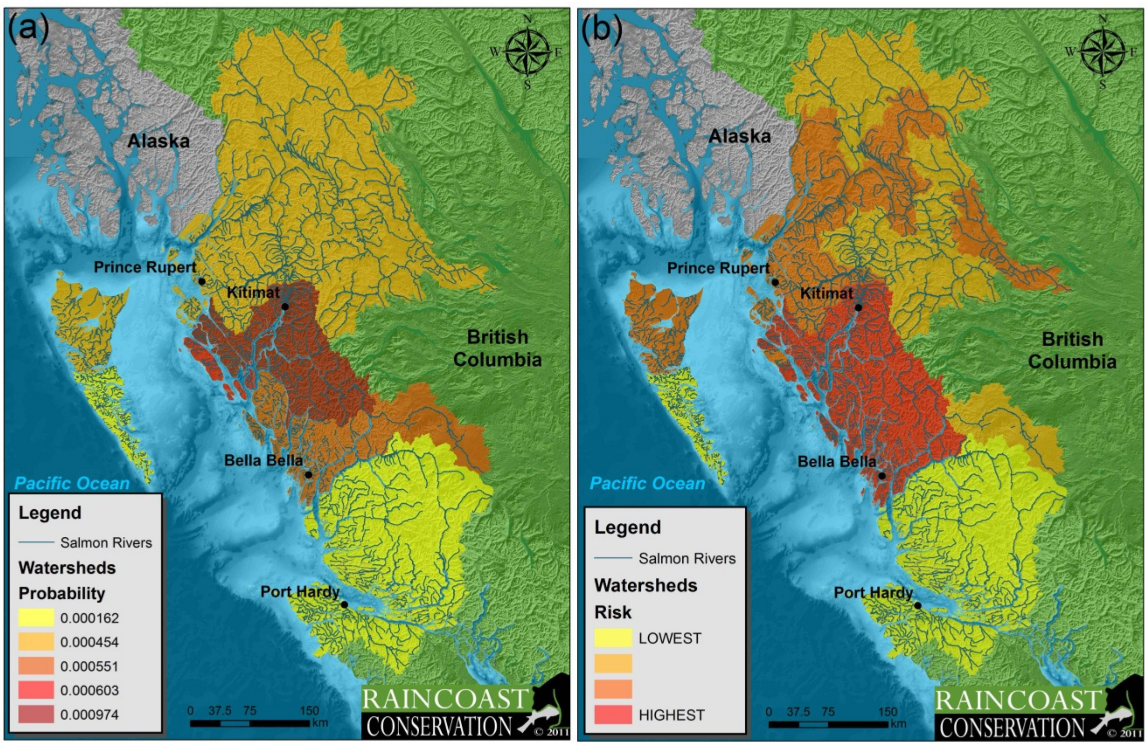

Figure 19b. Map of watersheds based on their assigned probability and **Figure 19b** map of risk – watershed salmon composite multiplied by the probability of an oil spill.

82. This characteristic of risk assessment makes it a crucial component for large projects with enormous potential negative environmental impacts. Raincoast's risk assessment used only two indices of impacts/consequence to salmon at a large scale (watershed). A comprehensive assessment of risk would address other components of consequence (e.g. salmon diversity, conservation units, terrestrial animals, cultural and economic values, seasonality etc.) and other components of spill probability (i.e. seasonality of weather

conditions and marine traffic etc.). Enbridge's failure to complete a comprehensive assessment of risk is a serious shortcoming of their ESA.