Evaluating the Viability of the Salish Sea as a Cetacean Sanctuary at Present

Geographic Information Sciences Final Project
GEOB 270

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Abstract

There is currently a movement to turn the Salish Sea into a Cetacean sanctuary to support the recovery of the Southern Resident Orca Whale (SROW) populations. The K, J, and L pods whose primary summer habitat is the Salish Sea have seen a 20 percent population decline since the late 1990s, in their most recent count in 2014 revealed only 78 Orcas remained (NOAA Fisheries, 2015). The SROW are facing facing intense habitat disruption: constant aquatic noise pollution from daily ferry, tanker, and cruise ship traffic (Ramanujan, 2010), dramatically lower than forecasted returns of the Fraser salmon fishery (Pynn, 2017), and the presence of a number of industrial sites on the coast(NOAA Fisheries, 2015).This analysis will look into the current state of the Salish Sea and the areas incongruent with the needs of the SROW in order to better understand the steps that need to be taken to create a viable cetacean sanctuary. Our findings show that at present, the Canadian portion of the Salish Sea is extremely far from being a livable habitat for the SROW or a viable Cetacean sanctuary.

Description of Project, Study Area, and Data

This project focuses on the state of the Salish Sea as an appropriate habitat for the SROW and the possibility of demarcating the area a cetacean sanctuary at present. The area in study is the Canadian portion of the Salish Sea where the SROW habitat exists which includes the Juan de Fuca Strait, the Georgia Strait and the Johnstone Strait. We split our analysis into three major influences on the health of the SROW and the Salish Sea: aquatic noise pollution, industrial areas

impacting the bodily health of the SROW, and finally industry harmful to the SROW food supply.

The majority of the data used in this analysis is from Data BC, which should be a largely unbiased and reliable source of information. The base layer to which we clipped the rest of our data was the BC killer whale habitat layer. To this layer we overlaid and clipped the routes of BC ferries, barges, water taxis and cruise ships. This data allowed us to study the extent to which these routes affect the SROW. We obtained layers that located coastal industry and ports which can be a source of chemical contaminants that affect the bodily health of the SROW. Finally, we acquired data on the locations of dammed rivers and marine fish farms both of which are seriously detrimental to the health and reproduction of wild salmon. Wild salmon, namely Chinook Salmon is the main food source of the SROW.

Methodology of Analysis

This analysis looked into a number of factors that negatively impact the SROW and combines them to provide a holistic look at the extent to which these factors occur in the Salish Sea. Aquatic noise is known to disrupt the echolocation of Orcas which is used to communicate with their pods and while hunting. Noise pollution from tankers and ferries is intolerable for SROW 19 kilometers from the source of the noise (BC Cetacean Sightings Network, n.d.). To illustrate which areas are uninhabitable due to noise pollution, we initially buffered the cruise, ferry routes, locations of ports and harbors, and gave each of these lines and points a 19-kilometer buffer. Upon applying this buffer, the map became completely obscured because the noise pollution was so extensive. In order to maintain the reader's comprehension, we decided to simply overlay and clip these points and areas to the BC killer whale habitat layer.

In addition to the disruption of communication, there is serious threat to the bodily health of the SROW and the health of their food supply from toxins that can be released from industrial sites and ports. To demonstrate how persistent the threat of these industrial sites we gathered spatial information on all the coastal industry, ports and harbor sites clipped and overlaid to the base BC killer whale habitat layer. The sheer number of these sites located on the coast illustrates how much of the Salish Sea is potentially chemically hazardous to the SROW.

To complete the holistic analysis of the viability of the Salish Sea as a Cetacean sanctuary at present, we also looked into the state of the SROW's food source. SROW feed primarily on Chinook salmon, the largest and fattiest species of Pacific. The final map shows threats not directly to the SROW but to their food supply. In this map, we highlighted dammed rivers and saltwater fish farms. Dammed rivers are a physical barrier to spawning salmon. By damming these rivers, fewer fish return and fewer fry are produced resulting in a decline in overall population. Marine fish farms, specifically Atlantic salmon fish farms host a number of viral and parasitic diseases that are endemic to Atlantic salmon and potentially detrimental to Wild Salmon. By overlaying and clipping the saltwater fish farms with the BC killer whale habitat we can see the difficulties facing the health of the SROW food supply.

When viewed side by side, these maps will illustrate the numerous, often disparate factors affecting the viability of the Salish Sea as a Cetacean Sanctuary.
These three maps will help to illustrate the current state of the Salish Sea
and how much work needs to be done if a Cetacean sanctuary were to be constructed.

Discussion of Results

In our first map, the *Sources of Noise Pollution in Southern Resident Killer Whale Habitat,* we found that there are no areas within the Salish Sea that are free of aquatic noise pollution. When we applied the ferry route and cruise ship route layer, we then applied a 19-kilometer buffer around each of these routes as vessel noise travels 19 kilometers from the original source (BC Cetacean Sightings Network, n.d.). Once this 19-kilometer buffer was applied, the map was illegible as the buffers were too large to see any of the underlying map beneath it. With the buffers in place, we could see that there were no areas in the Salish Sea that the noise did not reach and therefore there are no areas that the SROWs could live without being constantly disrupted by vessel noise.

The pernicious effects of noise pollution on cetaceans has been well documented. L.S. Weilgart notes that anthropogenically induced noise pollution has devastating implications on the wellbeing of whale populations, including stranding's and deaths (Weilgart, 2007). Additionally, Weilgart ascertained that the noise levels in the events of mortalities weren't deafeningly loud; in fact, they are "not high enough to cause hearing damage." (Weilgart, 2007) This means that relatively small amounts of noise pollution are significant enough to induce significant, even catastrophic levels of harm to the Southern Residents. Furthermore, it was found that even isolated instances of acoustic disturbances can "have prolonged and serious population impacts." (Weilgart, 2007) In sum, Weilgart's research exemplifies the extreme noise sensitivity cetaceans possess.

Our first map demonstrates the high number of noise sources present in the Salish Sea. Ferry and cruise ship routes and terminals are span the entire extent of the map, which are a major contributor of noise pollution. Additionally, sound travels a significantly further distance

in water than in air due to the water's physical properties. As such, this indicates that a majority of the Salish Sea has significant levels of noise pollution, which as elucidated in the paragraph above, renders significant suffering upon the Southern Residents. In fact, as the map shows, it's only in isolated regions in the middle of Salish Sea where there appear to be low densities of noise pollution, in locations far from the shipping terminals and ferry/cruise ship routes. Thus, it's only in these regions where we can assume that there is a low density of shipping traffic where the Southern Residents would be the most protected from high levels of noise pollution. But even there, due to the acoustic properties of the water, the noise pollution levels would still most likely be too detrimental to the safety and prosperity of the Southern Residents. Therefore, our first map cogently demonstrates the unviability of the Salish Sea as a cetacean sanctuary at present, considering the extreme levels of noise pollution created by the shipping terminals and routes.

It's worth also highlighting some limitations of this assessment. For one, we couldn't conclusively find how far noise pollution travelled in the water from the incident source. This is due to the fact that different ships produce highly variable levels of noise, which thereby affects the distribution of the sound pollution in space. It was also difficult to designate a noise threshold that the Southern Residents could safely live in. Weilgart notes that noise responses are highly variable across different species of cetaceans (Weilgart, 2007). Thus, it's exceedingly difficult to what level of noise pollution would be considered harmful to the Southern Residents.

In our second map, *Threats to Bodily Health for Southern Killer Whales,* we see that there are many coastal industry sites along the coasts of the Johnstone Strait which can potentially release toxic industrial waste into the waters. Bioaccumulation, the buildup of chemicals within organisms through the food chain (Michigan Government, n.d.), takes place

when toxins from the industrial sites are leaked into the water. The ecological laws of biomagnification position the SROW as most susceptible to the buildup of toxins due to their position at the top of the food chain (*NOAA, n.d.).* The pollutants that are being excreted into the waters can cause diseases, genetic mutations, birth defects, reproductive difficulties and death in many marine organisms (*NOAA, n.d.).* The toxins settle on the bottom of the sea and are then eaten by smaller organisms but because these toxins are not digestible, they accumulate within the animals that digest them and become more concentrated as these animals are consumed further up the food chain (*NOAA, n.d.).* Therefore, the SROWs will build up more concentrated and higher amounts of the toxins than the organisms on the lower part of the food chain.

The toxin that is the main environmental concern for cetaceans in British Columbia is the persistent organic pollutant (POP) and that includes PCBs, PBDE's and dioxins (BC Cetacean Sightings Network, n.d.). The PCBs that are within the pollutant can increase the susceptibility rate to infectious diseases and cancers. Recent studies have shown that SROWs are some of the most contaminated marine organisms in the world and have accumulated four times the amount of toxins than the Northern whale's due to the salmon that they depend residing in urbanized areas and thus having higher concentrations of toxins in their bodies (BC Cetacean Sightings Network, n.d.). The pollutants can also be passed from the female to calf during the gestation period and nursing as the toxins are transferred through the milk that is produced from the mother (BC Cetacean Sightings Network, n.d.). Through lactation alone, the amount of toxins within an adult female whale is around 30% lower than the amount in adult males.

The second map demonstrate how pervasive industry is in the Salish Sea which as earlier explained can cause the food sources of the SROW to become highly toxic. The large amount of industry directly demonstrates that the Salish Sea is not a viable cetacean sanctuary at present.

In our third map, *Threats to Food Supplies in Southern Killer Whale Habitat,* we can see that there are a lot of dams that reside in surrounding rivers as well as many saltwater fish farms in the Johnstone Strait. The fish farms and dams cause damages to the food supply for the SROW. The dams block access for spawning wild salmon thus resulting in fewer salmon being born and returning to the rivers and the Salish Sea. The third map shows an extremely high number of dams blocking the rivers feeding into the Salish Sea. These dams directly impact and destabilize the food supply of the SROW.

Furthermore, Parasitic Sea Lice is endemic to Atlantic salmon populations, especially in populations in very close proximity to each other. Sea lice attack the scales of the fish. Healthy, adult salmon are able to resist the sea lice but juvenile salmon are quite susceptible. Sea lice is known to affect wild salmon as well as farmed Atlantic salmon. (Bateman, 2016). A research article published in 2016 has said that up to 40% of juvenile wild salmon have been killed from fish farms as poorly timed treatments of the sea lice and warmer environmental conditions have caused a larger outbreak of the disease (Bateman, 2016). The warmer conditions also mean that more salmon return to the Salish Sea via the Johnstone strait (Washington University, n.d.) which our map shows as having a very high concentration of fish farms.

Beyond just fish farms, the fish packaging plants that harvest the farmed Atlantic salmon have been dumping the remains and blood of the Atlantic salmon into the ocean. This biohazardous waste can contain a number of other viral infections that are endemic to Atlantic salmon excretion of the blood water of the fish remains into the sea which could allow viral infections that are endemic to the Atlantic Salmon (Marley et al, 2017).

The large presence of dams blocking wild salmon from reaching their spawning grounds coupled with the threat of diseases being spread through the fish farms located on the migratory

routes of the salmon demonstrates that the food supply of the SROW. If these dams and fish farms continue to operate in the Salish Sea, the Viability of this area as a cetacean sanctuary is very low.

These maps work in accordance with the research performed by outside sources to highlight the complicated environmental needs of the SROW. From our spatial analysis, we have demonstrated that at present the Salish Sea is not a viable habitat for the SROW. The actions needed to transform the area into a cetacean sanctuary would be dramatic reduction of aquatic noise, strict controls on coastal industry, and banning fish farms in the migratory routes of wild salmon.

Error and Uncertainty

Despite our analysis demonstrating the unviability of the Salish Sea as a livable habitat for the Southern Resident Orcas, there are still notable limitations. We noticed that the data we obtained included internal uncertainty. For one, when we acquired the land cover layer from DataBC, there was an error as there was an island in the Strait of Georgia that was represented as a peninsula connected to Vancouver Island. The nodes of this island and Vancouver Island were incorrectly recorded.

We also had some difficulty acquiring data from the BC government and Canadian government. Data on the salmon run and killer whale sightings were restricted. When we requested this data, we were denied. There was information on Salmon runs in the Skeena river but not for the Fraser river despite there being media reports on the low Fraser salmon returns (Pynn, 2017). The lack of transparency to provide this data on the part of the DFO and the provincial government is concerning.

In terms of our own analysis, due to difficulties acquiring quality data we had to generalize some of our findings. First, the locations of fish farms were produced as small polygons, which, at the scale we were working were not visible when mapped. To solve this, we applied a very large outline to these farms which generalized the location and size of the polygons. This impacted the accuracy of the points and created error. Second, we included all the dammed rivers in the Salish Sea watershed; however, we did not interrogate certain variables about the reliability of these dams as a measure of food supply health. The dammed streams were not necessarily salmon bearing to begin with, and if they were they were not necessarily Chinook bearing streams. Chinook being the main source of food for the SROW. Chinook bearing streams would also have been on too small of a scale in order for it to be accurately presentable in the scale of this project. Looking at the habitat of the Killer Whales thus proved difficult since extremely localized influences can carry significant consequences, yet might be hard to identify and record in a data-set in the first place, let alone represent on a map with a scale similar to the ones we produced.

Along those same lines, we included the location of coastal industry without interrogating what constituted the category industry or if it was indeed detrimental to the health of the SROW. We also didn't look into which industrial sites were leaching chemicals or waste into the water. That said, information on improper disposal of industrial waste is not often recorded. For example, the recent expose on salmon packing plants dumping the waste of Atlantic salmon that is potential toxic to wild salmon was only just revealed (Marley et al, 2017). The lack of identifiable components to the different types of industry, and thus the consequential lack of understanding with regard to the impact that is enacted unto the project area leaves the analysis

without a fully comprehensive understanding of the sincerity of the situation. This in turn could arguably lead to a dramatized view of the situation.

Further Research and Recommendations

After completing our research and analyzing the causes that are impacting the SROWs, if the impacts continue at their current rate then the Salish Sea will not be able to turn into a cetacean sanctuary. Further research should be done on what needs to happen realistically in order for the Salish Sea to be a viable place for cetaceans to live. Based on our analysis, we recommend that the Sea is not a place for the whales to live and that they will continue to die off if they do not move to another habitat or changes are made in the Salish Sea to preserve their populations.

Additional research can be conducted on specific changes on the emittance of aquatic noise, the amount of sea vessel traffic and the impact of salmon fishing. If one were to conduct further research on these topics, one could look at policies that could be implemented to make sure that there is a true reduction in impacts on the whales.

Research could also look at proposed projects such as the Kinder Morgan Trans Mountain Pipeline Expansion and the Squamish LNG Plant project and how these projects might further impact the SROWs on top of the current aggravations they are facing. Proper Environmental Impact Assessments need to be done on these proposed projects before they are approved in order to prevent further degradation of the SROW population. For example, the Kinder Morgan expansion will result in a seven-fold increase in tanker traffic through the (Kinder Morgan, n.d.). Salish Sea which will only further harm the cetaceans. Lastly, research could be completed on the type of incentives that could be given to those who use smaller shipping vessels, which have produce far less aquatic noise pollution.

Appendices

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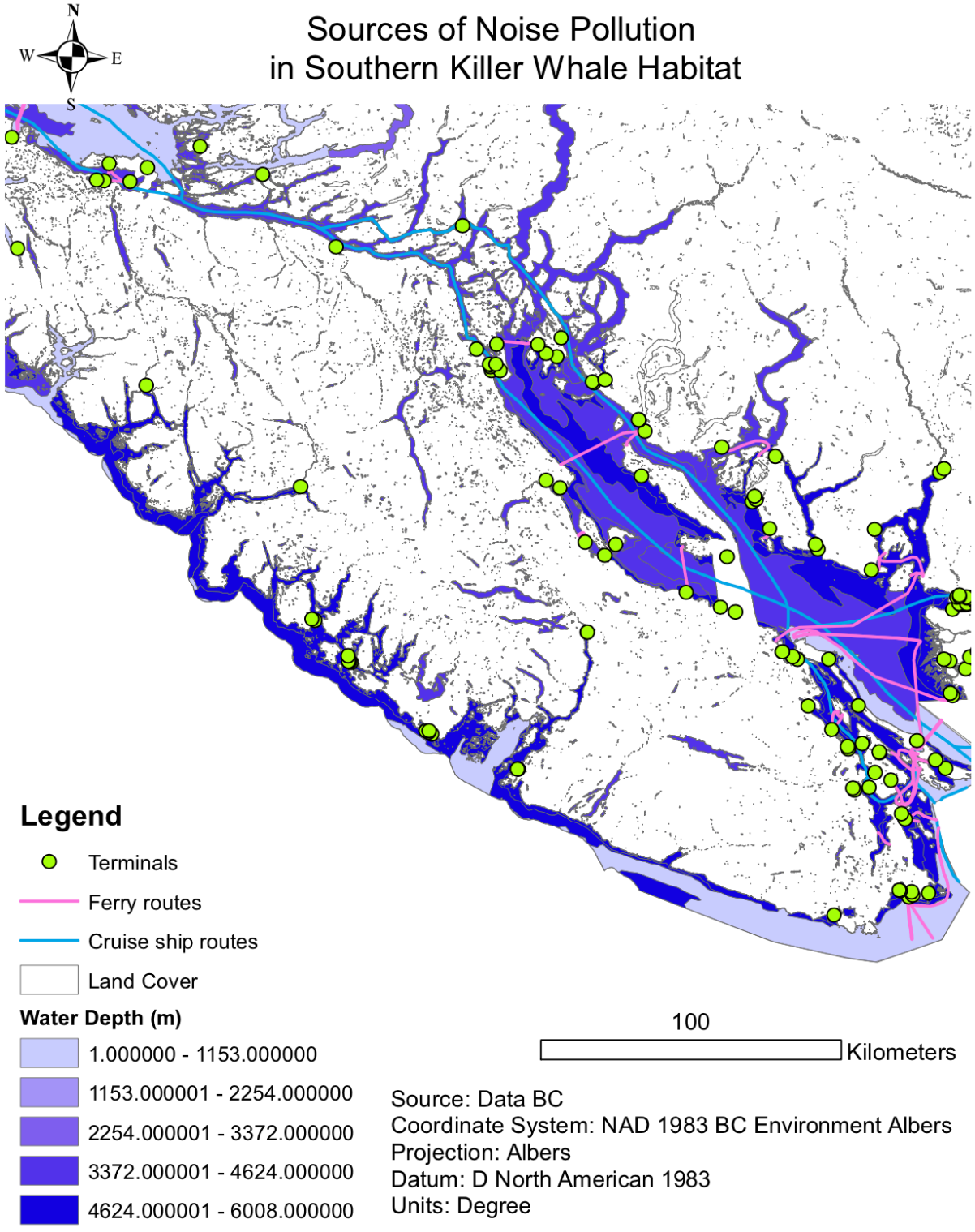
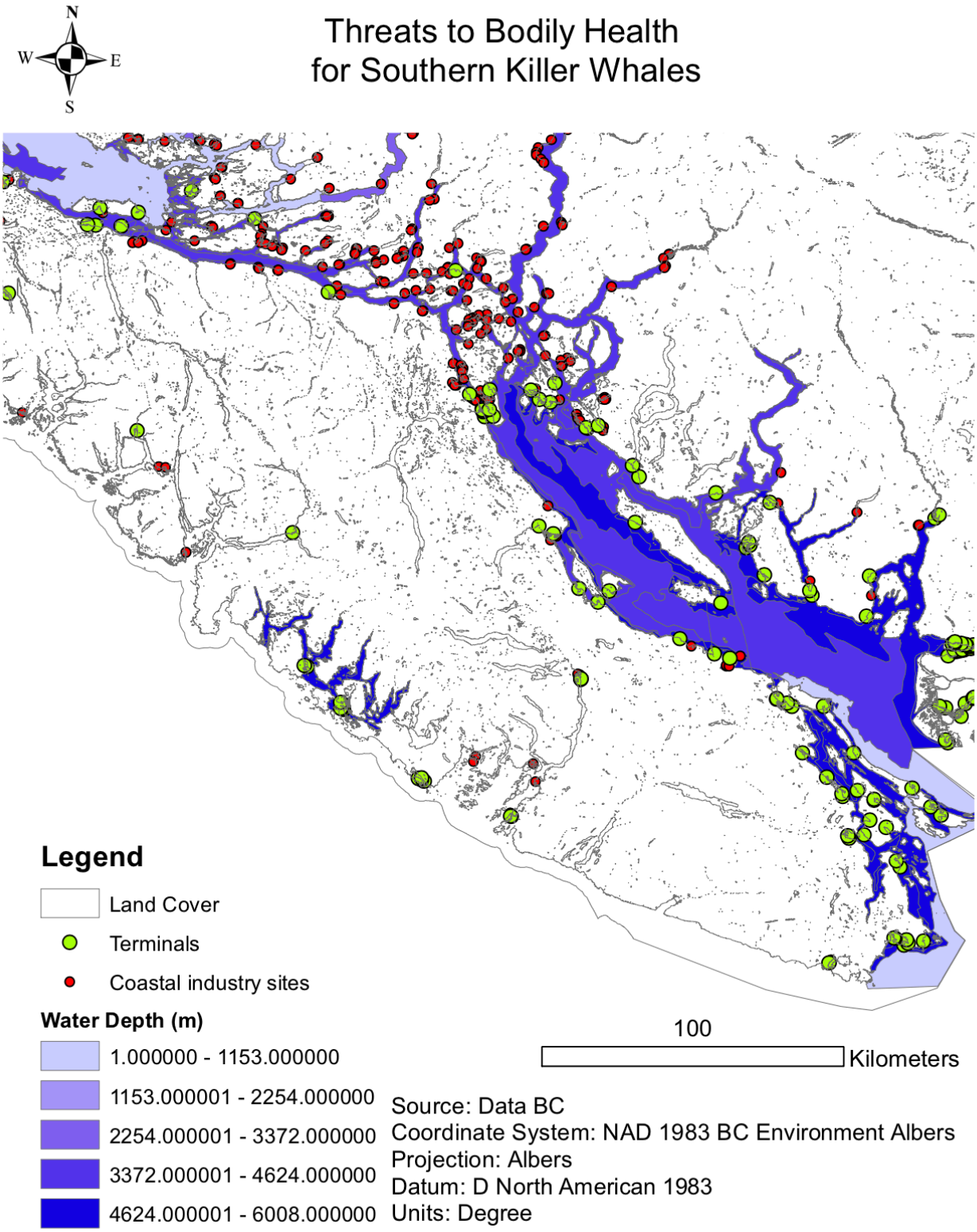
Maps and Figures

Map 1



Map 2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Threats to Bodily Health
for Southern Killer Whales
Legend
Land Cover
Terminals
Coastal industry sites
Water Depth (m)
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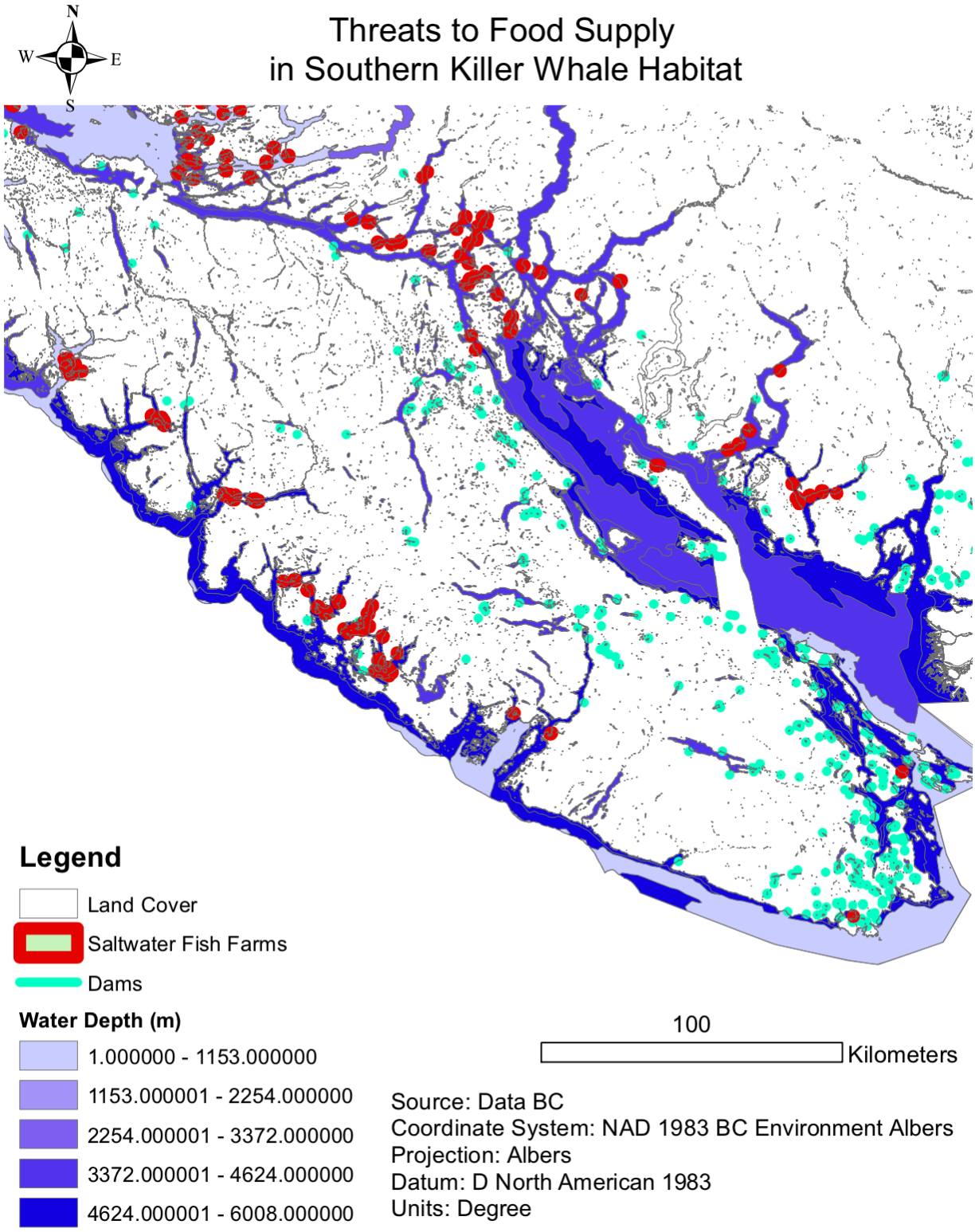
Kilometers
Source: Data BC
Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
Datum: D North American 1983
Units: Degree

Map 3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Threats to Food Supply
in Southern Killer Whale Habitat
Legend
Land Cover
Saltwater Fish Farms
Dams
Water Depth (m)
1.000000 - 1153.000000
1153.000001 - 2254.000000
2254.000001 - 3372.000000
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Coordinate System: NAD 1983 BC Environment Albers
Projection: Albers
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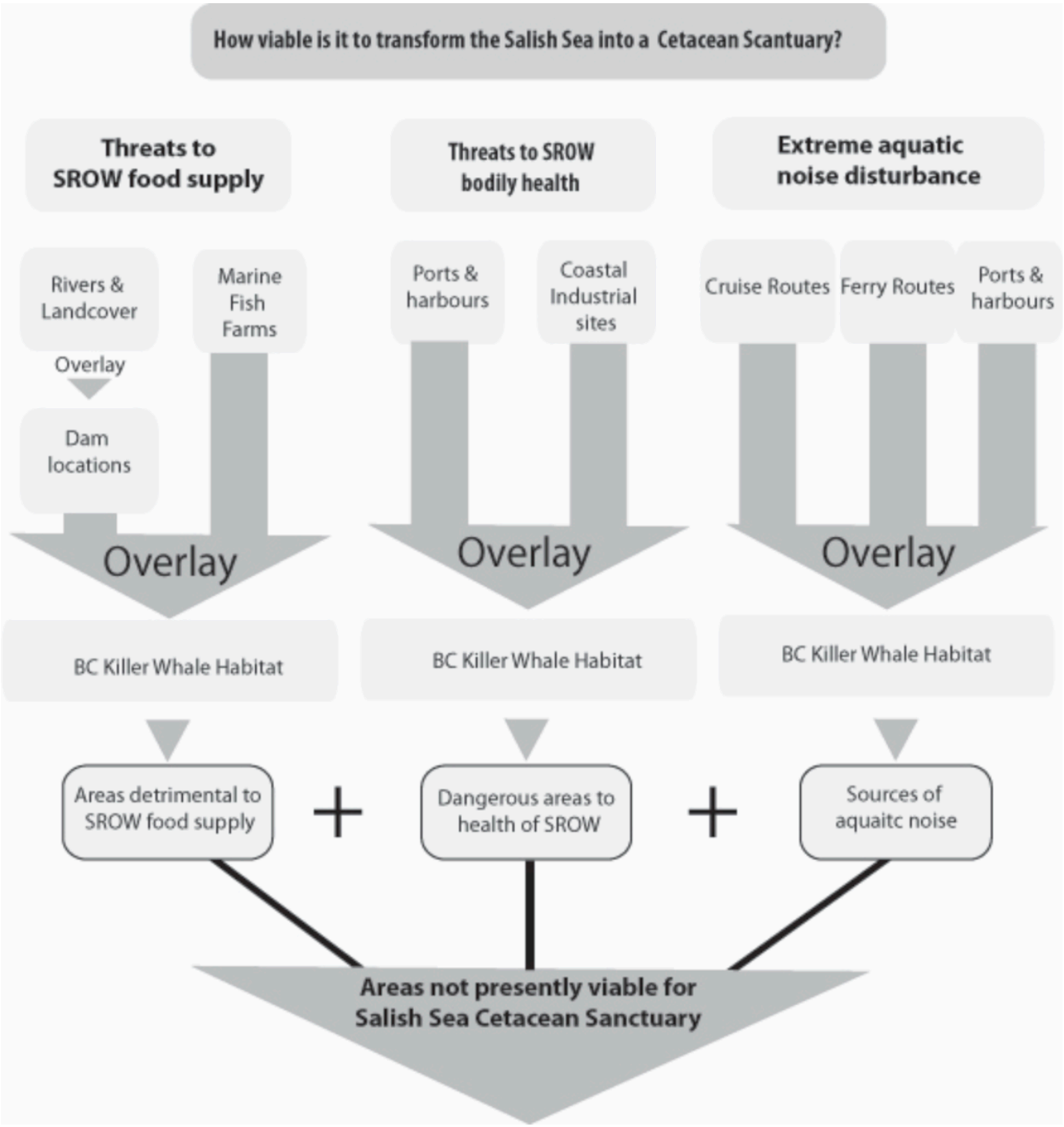
Flow Chart


How viable is it to transform the Salish Sea into a Cetacean Scantuary?
Threats to SROW food supply
Threats to SROW bodily health
Extreme aquatic noise disturbance
Rivers & Landcover
Marine Fish Farms
Overlay
Dam locations
Ports & harbours
Coastal Industrial sites
Cruise Routes
Ferry Routes
Ports & harbours
Overlay
Overlay
Overlay
BC Killer Whale Habitat
BC Killer Whale Habitat
BC Killer Whale Habitat
Areas detrimental to SROW food supply
+
Dangerous areas to health of SROW
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Sources of aquaitc noise
Areas not presently viable for Salish Sea Cetacean Sanctuary