SCOPING COMMENTS OF FRIENDS OF THE SAN JUANS ON PROPOSED GATEWAY PACIFIC TERMINAL EIS

=========

SUMMARY ITEMIZATION OF ANALYSES NEEDED TO ASSESS AND EVALUATE CONCERNS

Attachment to Accompany Letter from Friends of the San Juans, January 18, 2013

The following need to be discussed, as appropriate, for all the operational areas required by proposed Gateway Pacific Terminal (GPT) including for:

- Surface transportation into GPT (hereinafter "Facility"): Rail and truck;
- Facility operational area including storage yard, pier and trestle;
- Marine transportation to and from Facility: Capesize/Panamax ships, barges other vessels.

AREAS OF CONCERN:

1. **<u>Land use and public infrastructure</u>** requirements and alterations including new roads or bridges/overpasses necessary to decrease disruption of current traffic flow. [See Crosscut article on coal train impacts]

2. **<u>Cultural, historical and archeological</u>**:
   - Native American Issues [See Scoping Memorandum on Treaty Rights at Risk Paper]:
     - Treaty fishing rights/loss of usual and accustomed fishing sites;
     - Public's perception of negative effect on PNW totemic species: Salmon, Orca and Eagle.

3. **<u>Power used to operate Port Facility</u>** – amount and source.

4. **<u>Wetlands</u>** – loss from fill; stormwater runoff pollution including from rain or spray of water on coal piles at site and on loaded and empty cars; and mitigation. [See Olivia Edwards Comment]

5. **<u>Water Resources:</u>**
   - Fresh water, both surface and groundwater – for use at Facility, define source and amount; normal/permitted pollution from discharges, stormwater runoff, from petroleum products and solvents and other industrial fluids and substances; from heavy metals from brakes; and from accidents;

   - Salt water– normal/permitted pollution from discharges including sewage/ballast/bilge/stormwater/petroleum products and solvents and other industrial fluids and substances; from accidents and from introduction of invasive species. [See

Aquatic Invasive Species: A Guide to Least Wanted – Washington; Aquatic Nuisance Species Committee Report to the 2012 Legislature; Al Gillespie Scoping Memorandum on Aquatic Invasive Species

- Special attention to aquatic areas defined as "critical" under relevant Critical Areas Ordinances and to the Cherry Point Aquatic Reserve within which dock and trestle will be located. [See Washington State's Cherry Point Aquatic Reserve]

6. **Physical oceanography and coastal processes** including alteration of littoral drift.

7. **Coastal and nearshore ecosystem** changes due to shading from docks and lingering boats, both as to vegetative and animal habitat issues.[See Scoping Memorandum Cumulative Effects on Shoreline Armoring Report]

8. **Human Health** impacts especially from increased industrial-type pollution and from coal dust.

9. **Animal and plant species** [See Scoping Memoradum ARC report on the Marine Environment of the San Juans; Individual Comment by Joseph Gaydos; Seadoc Species of Concern; Scoping Memorandum of Federal and State Protected Lands]

    - impacts on the following including identification of abundance status (e.g., there are over 100 species in the San Juans determined either federally or state endangered or threatened, state sensitive or candidates for protection status or federal species of concern). Discussion should include impacts from any alteration in landform or physical oceanographic change/habitat change (e.g., changes in nearshore currents); light changes (on land or at water, light pollution at night, changes in ability of light to penetrate water columns and to reach bottom such as shading from dock/lingering ships); noise pollution from operation of Port Facility or from vessels; from other pollution, both permitted and accidental (e.g., coal dust [See Al Gillespie Scoping Memorandum on Coal Dust; Johnson and Bustin Scoping Memorandum on Coal Dust], oil spills, ballast and bilge water or storm water discharges); and implications of expected changes in species composition, distribution and absolute numbers as a result of the above, including introduction of invasive species from hull fouling and ballast water discharge,[See Aquatic Nuisance Species Committee Report to the 2012 WA Legislature; Al Gillespie Scoping Memorandum on Aquatic Invasive Species] with special attention being paid to species in areas defined as "critical" under relevant Critical Area Ordinances:
        - Terrestrial Mammals, especially Columbian Black-tailed Deer, Townsend's Long-eared Bat, Keen's Long-eared Bat and roosting concentrations of Big Brown Bats, Myotis Bats, and Pallid Bats;
        - Terrestrial and fresh and salt water plants including Aspen groves, old-growth trees, wetland species, eelgrass and phytoplankton species;

- Birds [See SeaDoc Society's Birds and Mammals that Depend on the Salish Sea: A Compilation], especially Brandt's Cormorant, Cassin's Auklet, Common Murre, Marbled Murrelet, Short-tailed Albatross, Tufted Puffin, Western Grebe, Great Blue Heron, Harlequin Duck, Trumpeter Swan, Bald Eagle, Golden Eagle, Peregrine Falcon, Osprey, Sooty Grouse, Band-tailed Pigeon, Yellow-billed Cuckoo, Vaux's Swift, Pileated Woodpecker, Oregon Vesper Sparrow and Purple Martin;
- Terrestrial invertebrates, especially Great Arctic, Island Marble, Sand-verbena Moth, Taylor's Checkerspot and Valley Silverspot;
- Amphibians, especially the Western Toad;
- Reptiles, especially the Sharptail Snake
- Fish [See Scoping Memorandum on Juvenile Salmon and Forage Fish], especially Pacific Herring [See Crosscut article on Pacific Herring], Pacific Sand Lance [See Scoping Memorandum Gary Greene comment], Longfin Smelt, Surfsmelt [See Scoping Memorandum Forage Fish Final Report], Bull Trout/Dolly Varden, Coastal Res./Searun Cutthroat, Kokanee, Salmon (Chinook, Chum, Coho, Pink, Sockeye), Rainbow Trout/Steelhead/Inland Redband Trout, Pacific Cod, Pacific Hake, Walleye Pollock, Rockfish (Black, Brown, Canary, China, Copper, Greenstriped, Quillback, Redstripe, Tiger, Widow, Yelloweye, Yellowtail), Spotted Ratfish, English Sole and Rock Sole;
- Marine Mammals, especially Orcas [See Al Gillespie Scoping Memorandum on Vessel Impacts and Al Gillespie Scoping Memorandum on Vessel Noise], Dall's Porpoise, Gray Whale, Harbor Seal, Pacific Harbor Porpoise and Steller Sea Lion;
- Marine Invertebrates including Pinto Abalone, Geoduck, Clams (Butter, Native Littleneck, Manila), Olympia Oyster, Pacific Oyster, Dungeness Crab, Pandalid shrimp, Pteropods (especially "sea butterfly"[See Scoping Memorandum Peter Knutson testimony]) and Zooplankton.

10. **Hazardous materials** to be present at Facility, used or generated with disposal protocols and accident prevention and remediation measures in place.

11. **Rail traffic** analysis given current state of infrastructure; discuss percentage rail infrastructure is fully utilized pre-Facility, accident likelihood and recent experiences [See Scoping Memorandum on Coal Train Derailments], impacts response capability and remediation.[See Whatcom Watch article on rail traffic; Al Gillespie Scoping Memorandum on Freight; Nicole Brown article in Whatcom Watch on rail traffic; Coal Train Facts]

12. **Road and highway infrastructure and traffic** changes due to interruption by rail or trucks that are project-associated, increased likelihood of accidents as well as need for additional roadside armoring indicated by climate change-induced sea level rise.[See The News Tribune Article on the effects of rail traffic; City of Seattle's Coal Train Traffic Impact Study]

13. **Vessel traffic** [See Al Gillespie Scoping Memorandum on Vessel Impacts; Scoping Memorandum of Cumulative Effects of Coal Shipping] in the Salish Sea and the Straits of Juan de Fuca including pre-Facility status, that to be generated from GPT (both phases) and that which could accompany expansions of other current vessel users:

- List flag state of vessels to be used and first language of crew;
- Details of Panamax vessels as to age and structural and electronic components;
- Detail normal/permitted pollution impacts:
  - Of air and water including from fuels, engine exhausts, coal, ballast or bilge water, noise and direct physical interactions or caused avoidance behavior;
- Pollution due to accidents by fuels, coal, etc.:
  - History of single and multi-ship accidents of any nature and consequences for such vessels, current risk analysis and the prevention and remediation measures proposed including discussion of needed updates of Puget Sound Harbor Safety and Geographic Response Plans and any need for/who pays cost for/what time period needed to implement as to new deployment strategies and associated response equipment in San Juans in spatial relation to shipping lanes;[See Vancouver Sun article on Westshore accident]

- Interference by these vessels with other necessary ocean transportation uses both commercial including Washington State Ferry System, fishers, and as well as with recreational and tribal users;

- Interference by these vessels with marine mammal social structure and health including physical interaction through striking;[See Al Gillespie Scoping Memorandum on Vessel Impacts; Al Gillespie Scoping Memorandum on Vessel Noise]

- Identification of location of anchorages for delayed/backed up vessels that cannot be at Facility dock. [See San Olsen Scoping Memorandum on Anchoring]

14. **Puget Sound Harbor Safety/ Geographic Response Plans** [See Puget Sound Harbor Safety Plan]

15. **Air quality:** [See Al Gillespie Scoping Memorandum on Air Pollution; Scientific American article on oil sands; Scoping Memorandum on Cumulative Effects of Coal Shipping]

- From operation of Port Facility machinery;
- Due to associated train, truck, ship engine pollution;
- From fugitive dust from coal from all aspects of operation including from rail transport, off-loading, storage, vessel loading and shipping – extent and impact to human health and to other creatures in natural environment, both terrestrial

and fresh and salt water.[See Sightline Daily post on coal dust; Venett Individual Comment]

16. **Noise and vibration:** [See Al Gillespie Scoping Memorandum on Freight and on Al Gillespie Scoping Memorandum on Vessel Noise; Seattle Times article on vessel noise]

- From operation of the Port Facility machinery;
- From increased train, truck and vessel traffic:
  - Assessment of potential for increased land/mudslides and derailment due to more and longer trains and the associated increase in train vibration;
- Impacts on marine life from significant increase in underwater noise associated with increase in vessels.

17. **Light pollution at night from Facility and vessels.**

18. **Socioeconomic:**

- Human health affects:
  - Reduced employee productivity;
  - Increased health care costs;
- Fisheries, especially for Salmon;
- Agriculture;
- Tourism [See Dean Runyan Scoping Memorandum on Tourism; Deborah Hopkins Buchanen Scoping Memorandum on Tourism];
- Potential for change in values of property affected by increased rail, road or vessel traffic, or by other Port Facility related alteration of environment such as air, light and noise pollution.[See Sightline Daily Post on Property Value Impacts]

19. **Ecological damage from a severe natural disaster** such as an earthquake or tsunami – discuss mitigation planned to prevent massive pollution.

20. **Cumulative Impacts**, **relative to coal**: if GPT is fully built out all proposed west coast coal export ports come on line (including the Oregon Gateway Terminal at the Port of Coos Bay, Oregon; the Coyote Island Terminal site at the Port of Morrow, Oregon; at the Millennium Bulk Logistics site in Longview, Washington; two separate facilities at the Port of St. Helens, Oregon [Ambre Energy and Kinder Morgan]) there could be a projected total annual potential western coal export of hundreds of metric tons - and there are upwards of 70 mmt that may be exported from Canadian ports; relative to vessel traffic: all of the above export vessels will use Salish Sea and, in addition, further expansion of Kinder Morgan's pipeline and the subsequent increase in tanker traffic in and out of the Port of Vancouver must be considered. [See Vancouver Sun article on the Kinder Morgan Terminal Expansion]

21. **Visual and aesthetic considerations.**

Finally, These Global Issues Must Be Addressed

22. **Increased presence of mercury** in environment due to increased use of coal.[See UNEP report on mercury]

23. **Increased ocean acidification** from burning more coal. [See San Olson's Scoping Memorandum on Ocean Acidification; Washington State's Department of Ecology's report on Ocean Acidification; NOAA Ocean Acidification; NAS Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean]

24. **Climate change:** Impacts such as sea level rise and greater erosion from more, more intense storms on the planet, and especially implications for island states and communities such as San Juan County, comprised entirely of islands. [See Al Gillespie Scoping Memorandum on Climatic Change; San Olsen's Scoping Memorandum on Pollution from Asia; IPCC Special Report on Climate Change]

25. **Option of not building the GPT**. [See Communitywise Bellingham's report on coal traffic to Canada]

26. **Discussion of leaving the coal in the earth and of domestic fuel security issues.**

San Juan County Council

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District 2, Rich Peterson
District 3, Howard Rosenfeld
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27 November 2012

Proposed Gateway Pacific Terminal/Custer Spur EIS
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RE: Comments on Proposed Gateway Pacific Terminal EIS Scoping

Dear CH2M HILL, Mr. Perry, Mr. Schroeder, and Ms. Kelly,

San Juan County Resolution No. 36-2012, "Regarding Legislative Priorities for the 2013 Legislative Session," includes the following legislative priority:

> Secure endorsements from Washington State Representatives and the Governor for the Council's position to oppose the proposed Gateway Pacific Terminal project unless a scoping meeting is held in San Juan County and all project related concerns (including increased vessel traffic and the increased risk of a major oil spill) are considered and addressed in the EIS, and all identified project related impacts are guaranteed to be mitigated.

Thank you for holding the November 3rd, 2012 scoping meeting in Friday Harbor and meeting our first threshold for support of the proposed Gateway Pacific Terminal project. It was very important to us that our constituents had the opportunity to provide their comments at a scoping meeting here in San Juan County.

The following comments identify significant adverse impacts to San Juan County that would only occur if the proposed Gateway Pacific Terminal project is approved. It is our understanding that you must address all of our comments in the EIS by in-depth analysis with reasonable alternatives identified including mitigation measures, and that if any comment is considered not to be significant, you will provide a thorough explanation.

San Juan County's residents and visitors depend upon marine-based public and private transportation. Washington State Ferries are our marine highways. Our air, water, fish, and fowl migrate over long distances on our planet. Thousands of species spend all or part of their life cycle in San Juan County, with 113 Salish Sea species listed as threatened, endangered, of concern, or candidates for listing. Their health directly affects our quality of our life in San Juan County. The impacts from the proposed Gateway Pacific Terminal do not exist in an isolated bubble that can be drawn only around the location of the proposed terminal. A terminal-specific or site-specific EIS will not adequately consider the cumulative impact of the transportation, storage, shipment, and use of coal on the environment and the jobs that directly and indirectly depend upon a healthy Salish Sea ecosystem or upon the health of our citizens and visitors, and the local economy.

San Juan County's economy is inextricably connected to the beauty of its environment and the health of its ecosystems. Many islanders depend upon a healthy and sustainable salmon fishery and Orca population. Jobs are directly tied to commercial and recreational fishing and shellfish farming. The tourist industry is the engine that runs our economy. People come to the San Juan Islands from all over the world to enjoy the beautiful environment and to see birds and sea life.

The transport of coal through Haro and Rosario straits and the Strait of Juan de Fuca, with their narrow channels and strong currents, especially in fog-bound and storm-tossed sea lanes, increases the risk of an oil and/or coal spill. What is the increased risk of an oil and/or coal spill as a result of the increased vessel traffic associated with the proposed Gateway Pacific Terminal project according to the George Washington University's updated Vessel Traffic Risk Assessment? What is the risk of an oil and/or coal spill from a collision, allision, or grounding involving the single-hull bulk carriers? How wide-spread would the damage be? How many species and commercial and recreational fisheries would be impacted and how would it affect the sustainability of those species? How many local jobs and businesses would be adversely impacted and/or lost? What would be the impacts to property values? What would be the impacts to desalinization systems? What would be the impacts to Washington State Ferries in the event of an oil spill? What would be the costs associated with a spill of a bulk carrier's propulsion fuel? What would be the costs associated with a coal spill? What would be the costs associated with a grounding, allision, or collision involving a bulk carrier that leads to an oil spill from another vessel, including any spills of Alberta Tar Sands products such as diluted bitumen?

San Juan County is the home of and a primary destination for many commercial and recreational fishing vessels and pleasure boats. What would be the impacts, and the associated costs of these impacts, to vessel traffic, including Washington State Ferries traffic, in the waters of San Juan County given the proposed increased bulk carrier traffic? What is the increased risk of an oil and/or coal spill, and what are the associated costs, from a grounding, allision, or collision caused by a bulk carrier and a small vessel such as the November 20, 2012 grounding of a container ship in Prince Rupert Harbour?

The shipment of coal by bulk carrier requires large engine propulsion. What would be the health risks to people and to our waters and marine-dependent species and to our soil, pastures, and locally produced foods, from the increase in particulate matter from the propulsion fuel used in bulk carrier engines? How would the increased particulate matter impact our residents and visitors who already suffer from conditions such as Chronic Obstructive Pulmonary Disease, asthma, and emphysema? What would be the impacts of the vessel noise on the listed as endangered Southern Resident Orcas and other marine-dependent species, and in particular the vessel noise associated with any required queuing? What would be the impacts of the vessel noise on property values, and in particular the vessel noise associated with any required queuing? What would be the costs associated with the impacts from bulk carrier vessel noise and propulsion fuel particulate matter?

Severe weather could require vessels approaching the proposed Gateway Pacific Terminal for the purpose of transporting coal to discharge ballast water into San Juan County or neighboring waters, thus contaminating the waters of San Juan County. How would ballast from foreign waters containing non-native, invasive aquatic species affect the ecosystem of our waters? Can the impacts from foreign invasive species upon our marine-dependent species be mitigated? What would be the cost of restoration should non-native, invasive aquatic species impact our marine ecosystem?

How will the coal dust, and its constituent parts, associated with the transport, storage, and loading of coal impact the Cherry Point herring and the environment necessary for them to spawn and maintain a sustainable population necessary to feed the marine-dependent species in San Juan County, including the federally listed as endangered Chinook salmon, which, in turn, are the primary food source of the federally listed as endangered Southern Resident Orcas? What would be the costs associated with the restoration of the Cherry Point herring spawning area?

Given San Juan County's proximity to the proposed terminal location and given storm events with significant winds, what amount of coal dust, and its constituent parts, would reach San Juan County from the proposed Gateway Pacific Terminal? What would be the impacts from the terminal's coal dust, and its constituent parts, to human health, crops produced for home and commercial purposes, ground water quality, desalinization water quality, and the near-shore marine ecosystem and species? What would be the costs associated with any of these impacts?

The burning of coal releases carbon dioxide into our oceans and contributes to ocean acidification. Based on the tonnage of coal proposed to be exported and subsequently burned, what would be the impacts of increased ocean acidification in the waters of San Juan County? What would be the costs of the increased ocean acidification's impacts on recreational and commercial shellfish? What would be the impacts to the spawning of shellfish for recreational and commercial harvest? What would be the impacts to the wildlife who feed on shellfish? What would be the impacts to the pteropods that comprise much of the diet of juvenile salmon? What would be the costs associated with the increased ocean acidification?

The burning of coal releases carbon dioxide that contributes to global warming. Based on the tonnage of coal proposed to be exported and subsequently burned, what would be the impacts of increased global warming to San Juan County? What would be the costs from associated increased storm winds, ocean surges, and precipitation? What would be the impacts due to sea level rise? What would be the costs associated with sea level rise?

The burning of coal releases mercury. Based on the tonnage of coal proposed to be exported and subsequently burned, what amount of mercury will be released and what amount of that mercury will increase the mercury content of San Juan County seafood and the people and wildlife that feed upon that seafood? What would be the impacts of the increased mercury pollution? How would the increased mercury pollution impact fish consumption rates? What would be the costs associated with the increased mercury pollution?

We look forward to the draft EIS that addresses all of our comments with in-depth analysis and with reasonable alternatives identified including mitigation measures. Thank you for this opportunity to comment on the scoping for the proposed Gateway Pacific Terminal EIS and to secure the San Juan County Council's standing in the EIS process.

Sincerely,

COUNTY COUNCIL
SAN JUAN COUNTY, WASHINGTON

Lovel Pratt
Lovel Pratt, Member
District No. 1

Richard Peterson
Richard Peterson, Member
District No. 2

Howard Rosenfeld
Howard Rosenfeld, Member
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R D Fralick
Richard Fralick, Member
District No. 4

Patty Miller
Patty Miller, Chair
District No. 5

Jamie Stephens
Jamie Stephens, Vice-Chair
District No. 6

Cc. The Honorable Maria Cantwell, US Senator
The Honorable Patty Murray, US Senator
The Honorable Rick Larsen, US Representative
The Honorable Christine Gregoire, Governor of the State of Washington
The Honorable Jay Inslee, Governor-Elect of the State of Washington
The Honorable Kevin Ranker, Washington State Senator
The Honorable Jeff Morris, Washington State Representative
The Honorable Kristine Lytton, Washington State Representative
The Honorable Billy Frank, Chairman, Northwest Indian Fisheries Commission
The Honorable Cliff Cultee, Chair, Lummi Nation
The Honorable Melvin R. Sheldon, Jr., Chair, Tulalip Tribes
The Honorable Brian Cladoosby, Chair, Swinomish Indian Tribal Community
The Honorable Micah McCarty, Chairman, Makah Tribe
The Honorable W. Ron Allen, Chair, Jamestown S'Klallam Tribe
The Honorable Frances Charles, Chair, Lower Elwha Klallam Tribe
The Honorable Robert (Bob) Kelly, Chairman, Nooksack Tribe
The Honorable Jeromy Sullivan, Chair, Port Gamble S'Klallam Tribe
The Honorable Leonard Forsman, Chair, Suquamish Tribe

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Accidents Associated with Vessel Traffic (Impacts)

Prepared By: Alexander Gillespie

January 5, 2013

1. The base problem and the need for a cumulative view

Each year, around 11,000 large vessels and oil barges transit to and from the San Juan Islands Figure 1). This figure includes over 1,322 oil tankers, each of which carries an average of 30 to 40 million gallons of crude oil. Around 4,300 of these large vessels are destined for United States' ports in Puget Sound. The other 6,250 make for Canadian ports. This level of shipping traffic already comes with a certain inherent level of risk. For example, between 1995 and 2005, there were 1,462 accidents and 1,159 incidents reported.[1]

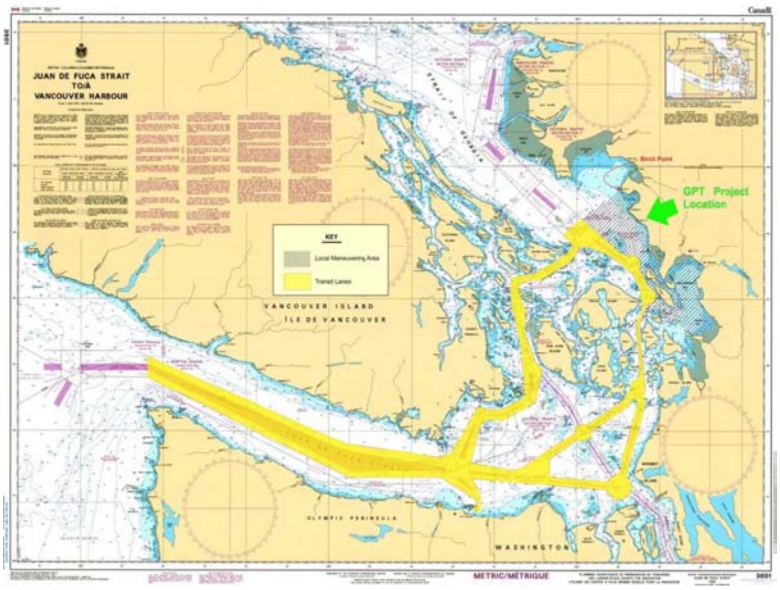

Figure 1. *Main shipping routes of Northern or Greater Puget Sound*[2]

The proposed Gateway Pacific Terminal (GPT) will add approximately 440 ship transits per year, equating to a 4% increase to the 2011 traffic once it becomes operational. After it becomes fully operational, the GPT is projected to generate an additional increase of about 950 transits per year, or an increase of 9%, within 15 years.[3] This increase will be over and above other future expansion in other shipping operations. Impacts from the specific increase in shipping from the development of the GPT needs to be understood and modeled.By using

[1]Hass, T. (2012).*The Vessel Traffic Risk Assessment for BP Cherry Point and Maritime Risk Management in Puget Sound*. (Puget Sound Partnership). 5.van Dorp, J.(2008). *Assessment of Oil Spill Risk due to Potential Increased Vessel Traffic at Cherry Point, Washington*. (Final Report - Submitted to BP : 8/31/2008).
[2]ibid
[3] Pacific International Terminals, Inc. (2011). *Project Information Document, Gateway Pacific Terminal*, Whatcom County, Washington. 304 p. Also, *Vessel Entries and Transits: 2011* WDOE Publication 12-08-003 April 2012

vessel traffic risk assessments, such as that conducted in 2008, and including updated projections of ship traffic for the GPT project, it will be possible to quantify the increased risk of accident from the extra transits.[4] It is important for the risk assessment to be updated to account for the additional transits projected for the GPT, to be in accordance with legal precedent.[5] However, the impact assessment must also evaluate the cumulative risks of all existing and projected (e.g., including vessels over 400 tons and/or carrying a dangerous cargo) transits through this area, as onlythis type of evaluation will reveal the true extent of the significant risk at hand. A cumulative assessment is required and essential as it will reveal risks that, while perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework, may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk to the greater Puget Sound area.[6]

In addition to the past, present and the currently proposed 8% increases in shipping traffic for the GPT development, the cumulative assessment should also scope the likely, further future additional expansions of vessel traffic in this area (even if they are not yet formal or approved proposals). This requirement is especially important when dealing with inter-related projects that will all utilize the same limited resource, in this case, shipping routes. That is, a forward projected assessment should also include data in the cumulative equation on traffic increases that can reasonably be foreseenincluding general increases in vessel traffic from other sources and also vessel traffic projections for other proposed major developments (including in Canada) that will need to use the same shipping route. This will greatly assist the authorities in providing the necessary information to achieve meaningful regional planning at a reasonable cost, in which uncertainties can be evaluated and effective, appropriate, and sustainable (in economic, social and environmental) choices can be made.[7]

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[4] Montewka, J. (2012). ‘Determination of Collision Criteria and Causation Factors Appropriate to a Model for Estimating the Probability of Maritime Accidents’. *Ocean Engineering* 40: 50–61.

[5]See Ocean Advocates v. United States Army Corps of Engineers**.**402 F.3d 846 (9th Cir. 2005). Also, Anon (2004), ‘Corps Fail to Take ‘Hard Look’ Required by NEPA Before Issuing FONSI and Permitting Extension of Oil Refinery Dock’. *Planning and Environmental Law* 56(5): 17.

[6] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002) (quoting Churchill County v. Norton, 276 F.3d 1060, 1072 (9th Cir. 2001).

[7] Zhao, M. (2012). ‘Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States’. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). ‘Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment’. *Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). ‘Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management’. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). ‘Conceptual and Methodological Challenges to Cumulative Effects Assessment’. *Environmental Impact Assessment Review.* 31: 154-160. Therivel, R. (2007). ‘Cumulative Effects Assessment: Does Scale Matter ?’ *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). ‘Facilitating Cumulative Impact Assessment in the EIA Process’. *International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). ‘Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National

It is essential to evaluate the cumulative impacts on vessel safety from the various port expansion projects through the Salish Sea including at minimum the twinning of the Trans Mountain pipeline and associated tanker traffic, expansion of the Delta Port container terminal as well as the Westshore Coal Terminal. However, it is also critical for the Corps to recognize the fact that if all five of the proposed coal terminals are built in the Pacific Northwest it would result in approximately an additional 2000 bulk carriers transiting through Unimak Pass in Alaska. This would approximately double the volume of traffic that currently ply through these biologically rich and vulnerable waters.

2. The reasonably foreseeable accident

Substantive shipping accidents, despite being of a low probability, carry with them the possibility of catastrophic consequences. Precedent tells us that these accidents are reasonably foreseeable. For example, since the *Exxon Valdez* accident in 1990, a succession of large spills have occurred including the *Nakhodka* spill of Japan in 1997, the *Prestige* spill off France in 1999, the *Erika* spill off Spain in 2003 and the *HebeiSpirit* spill off South Korea in 2007. Many spills occurring regularly around the world, and while other spills may be smaller, their impacts are far from negligible.[8]

Since the 1960s, the waters of the Salish sea (and especially the Juan de Fuca Strait and Puget Sound)have not only been exposed to the risk of oil pollution, they have also had to deal with actual oil spills and pollution. Since the 1980s, there have been six significant spills.[9] These larger spills have been in addition to dozens, if not hundreds (depending on how the counting is undertaken), of lesser spills. These lesser spills have still cost hundreds

Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673.http://www.aleutiansriskassessment.com/passing.htm

[8] For the most recent significant oil spill from a vessel, see Ministry for the Environment (2011). *Rena: Long-term Environmental Recovery Plan* (MFE, Wellington). 4-7. Note also,
Ramseur, J. (2010). Oil Spills in US Coastal Waters: Background and Governance. Congressional Research Service 7-5700.

[9] Ross, W. (1973). *Oil Pollution as an International Problem: A Study of Puget Sound and the Strait of Georgia*. (University of Victoria Press, Canada). Vagners, J. (1972). *Oil on Troubled Waters* (University of Washington Press, Seattle). The recent examples include the *Arco Anchorage* which, in 1985,spilled 239,000 gallons of crude oil off the Strait of Juan de Fuca. This incident was followed:, in 1988, by the barge *Nestucca* whichspilled 231,000 gallons of crude oil in the outer coast near Grays Harbor; in 1991, the cargo ship *Tuo Hai* which collided with the fishing vessel *Tenyo Maru* spilling 400,000 gallons of heavy oil outside the entrance of the Strait of Juan de Fuca; in 1999, the explosion at Olympic Pipeline, killing 3 and spilling 277,000 gallons of gasoline into Whatcom Creek in Bellingham; in 2003, the Foss barge spill at Point Wells spilled approximately 4,700 gallons of heavy fuel during a transfer in Snohomish County; and, in 2004, the Conoco Phillips oil tanker *Polar Texas* spilled 7,200 gallons of ANS Crude oil while the ship attempted to introduce ballast water into its oil tanks. See Department of Ecology/Puget Sound Partnership (2011). *Improving Oil Spill Prevention and Response in Washington State: Lessons Learned From the BP Deepwater Horizon Oil Spill*. (DoE, Publication Number: 11-08-002). 7.

of thousands, if not millions of dollars, once the costs of the cleanup, restoration and fines are totaled.[10]

3. Indicators of significant risk

In order to be approved, the GPT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies, all of which address issues of potential significant risk. A summary of some of the more relevant standards are provided below:

- The Antiquities Act
- The Endangered Species Act
- The National Historic Preservation Act
- The Migratory Bird Treaty Act
- The Bald and Golden Eagle Protection Act
- The Marine Mammal Protection Act
- Executive Order 13158: Marine Protected Areas
- The Coastal Zone Management Act
- The Fish And Wildlife Coordination Act
- The Exchange of Notes between Canada and the United States Constituting an Agreement on Vessel Traffic Management for the Juan de Fuca
- The British Columbia/Washington Environmental Cooperation Council Agreement and Memorandum of Understanding
- The Magnus-Stevens Fishery Conservation and Management Act-Essential Fish Habitat
- The Pacific Salmon Treaty
- The International Convention on the Regulation of Whaling and,
- The World Heritage Convention

[10] US Fed New Service (2007). 'Oil Cleanup Continues in Puget Sound'. 28 Feb. DiBenedetto, B. (2006). 'Polar Tankers to pay $540,000 fine for Puget Sound spill'. Journal of Commerce 16 Oct: 1. Note also, US Fed News Service. (2009). 'Tug Company Fined For Puget Sound Oil Spill'. 19 Nov. Ramasamy, E. (2006). 'ConocoPhillips to Pay $2.31 Million for Puget Sound Crude Spill'. *Platts Oilgram News*. October 18.

4. The significant risk of extinction and/or declining conservation status

(i). Birdlife

There are over 100 species of marine bird which rely on the Puget Sound as habitat. Some protected wetlands on the San Juan Islands are known to hold most, if not all, of these bird populations at key times.[11] Many of the species in the area are migratory and, at certain times of the year, populations can expand five-fold, to number in the tens of thousands. A number of these species, while not threatened at the species level, are known to be declining at the regional level (e.g., scoters, bugglehead, goldeneyes, long-tailed duck, common loon, and the western grebe).[12]

A number of species which frequent Puget Sound, which forms part of the Pacific Flyway, are listed as protected under the Migratory Bird Treaty Act (MBTA).[13] Therefore these species require special conservation attention (both for the birds themselves and their habitats) as part of international treaty obligations of the United States. Species requiring conservation attention include the great blue heron, (American)-black oystercatcher, peregrine falcons, trumpeter swans, northern harriers, rhinoceros auklet, the pigeon guillemots, the barred, and spotted owl, the brown pelican and the (American)-white pelican.

Some species listed under the MBTA have specific management plans, such as snow geese and Canadian geese, and therefore they also require special conservation attention. In addition, the marbled murrelet, although not subject to a specific management plan under the Pacific Flyway Council (the administrative body that forges cooperation among public wildlife agencies for the purpose of protecting and conserving migratory birds in western North America), is actually listed as being threatened with extinction under the Endangered Species Act (in both the United States and Canada) with the risk of oil spills being one of the catalysts for its listing. Finally, the bald eagle, also listed under the MBTA, must have its conservation needs considered. Given that the San Juan Islands may host the greatest concentration of bald eagles in the continental United States, the obligations to protect this

[11] Domico, T (2007). *Natural Areas of the San Juan Islands*. (Turtleback, Washington). 59-64, 81, 158. Johnson, C & J (2011). *Birds and Habitats of the Puget Sound Area* (Orange Spot, Seattle). Downing, J. (1983). *The Coast of Puget Sound,* (University of Washington Press, Seattle).

[12] Washington Department of Fish and Wildlife Program (2009). *Status and Trends of Marine Birds in Washington's Southern Puget Sound*. (WDFW, Seattle). 7-8. Washington Department of Fish and Wildlife (2006). *Nearshore Birds in Puget Sound* (Washington Department of Fish and Wildlife Technical Report 2006-05, Seattle).

[13] 16 U.S.C. 703. Note also the *North American Waterfowl Management Plan between Canada and the United States.*

species under both international and domestic law (i.e., the 1940 Bald and Golden Eagle Protection Act)[14] are clear and mandated. Under the 1940 legislation, although bald eagles are not actually endangered, due to their high cultural value, these eagles remain protected from acts including disturbance (as elaborated in the Act's associated Guidelines and conservation recommendations). An estimated 247 bald eagles were killed in Prince William Sound as a consequence of the Exxon Valdez spill in 1989.

(ii). Southern Resident killer whales

Puget Sound is frequented by a number of marine mammal species including, *inter alia*, harbor seals, river otters, Steller sea lions, common minke whales and Dall's porpoise. Although many of these are of conservation concern, one sub-species in particular, the resident pods of Killer whales around the San Juan Islands known as the Southern Resident killer whale community (SRKW), are of a very high concern. The SRKW represent the smallest of four resident sub-species of Killer Whale within the eastern North Pacific Ocean. The SRKW comprises three pods (termed J, K and L). The SRKW population has fluctuated considerably over the 30 years that it has been studied. All three southern resident pods were reduced in number between 1965 and 1975 because of captures for marine parks. In 1974, the group comprised 71 whales and it peaked at 97 animals in 1996, before falling to 86 as of the end of 2010.[15] Numbers may have fallen since then, as there were estimated to be fewer Killer Whale in the middle of 2012 than there were in the 2010 baseline year (N=83).[16]

[14] 16 U.S.C. 668-668c.
[15] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle).
[16] Puget Sound Partnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24. NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). 2, 56-58.

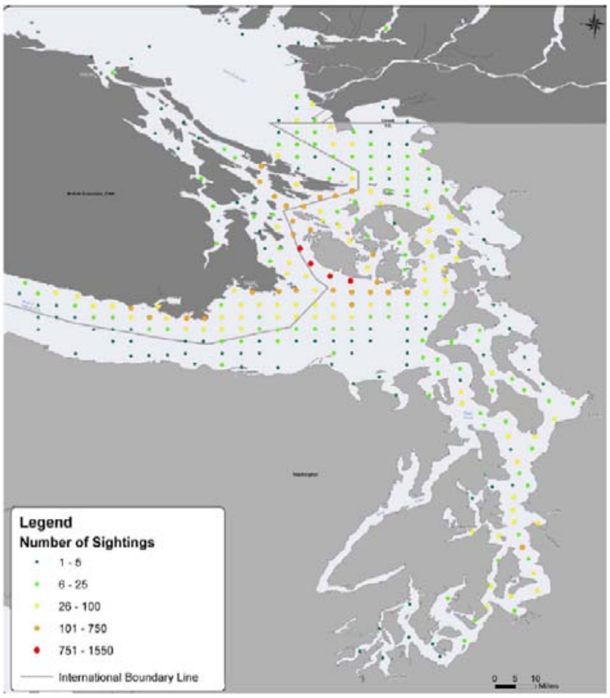

Figure 2. Distribution of Southern Resident killer whale sightings from 1990-2005.[17]

Due to being a distinct and significant population of very limited numbers, with a slow growth rate and low productivity,[18] after prolonged scientific and legal consideration,[19] the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration decided that SRKWs constituted a 'distinct population segment' that was endangered due to being 'threatened' with extinction, as per the 1973 Endangered Species Act (ESA).[20] This categorization was supplemental to their status as depleted (i.e., below its optimum sustainable population) under the Marine Mammal Protection Act (MMPA).[21] The national obligations upon authorities to conserve these species successfully are multiplied through both regional[22] and international conservation instruments, the latter through the International Convention for the Regulation of Whaling.[23]

The obligations imposed by all of these pieces of legislation mean that it is critical to protect the most important habitat on which a threatened/depleted species depends (Figure 2). This

[17]Source: NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). Figure 5. p. II-27. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]

[18] There is a limited number of reproductive-age Southern Resident males and several females of reproductive age are not having calves. This is a particular concern with the largest pod (L) with only three surviving females producing surviving female offspring in recent years.

[19] Center for Biological Diversity v. Lohn, 296 F. Supp. 2d. 1223 (W.D. Wash. 2003).

[20]Department of Commerce, NOAA, *Endangered Status for Southern Resident Killer Whales*. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

[21] 68 FR 31980; May 29, 2003.

[22] The Canadians concur that the SRKW are endangered.

[23] See Gillespie, A. (2006). *Whaling Diplomacy*. (Edward Elgar, London). Chapter 6.

obligation is required under both the MMPA[24] and the ESA.[25] The designation of critical habitat[26] under the ESA is specifically focused upon the need to conserve habitat which is directly linked to the survival of the species. This designated habitat, which must not be destroyed or adversely modified, is well defined for the SRKW. Specifically, all pods use Haro Strait (i.e., west side of San Juan Island), particularly for transit. The southwest portion of San Juan Island is important for foraging and the southwest of Lopez Island is important for resting (as well as the south and west of Henry Island), although one pod (L) alone appears to frequent the area in the Strait of Juan de Fuca south of Vancouver Island.[27] In 2006, the NMFS designated critical habitat for SRKW to include all the waters of the inland sea other than military facilities (which overall compromises approximately 2,560 square miles of marine habitat).[28]. The Summer Core Area includes the waters in Haro Strait and the waters around the San Juan Islands This critical habitat is shown in Figure 3.

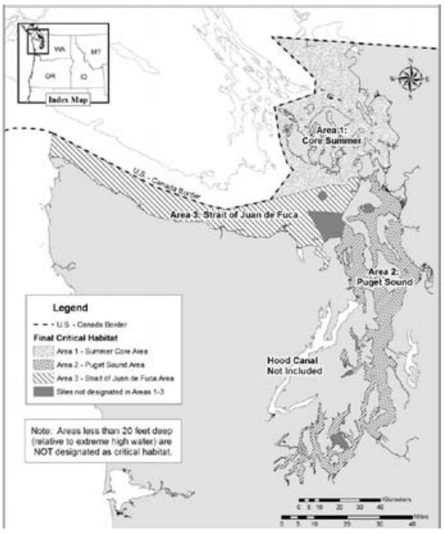

Figure 3. Designated critical habitat for Southern Resident killer whales under the Endangered Species Act[29]

[24] ‘In particular, efforts should be made to protect essential habitats, including the rookeries, mating grounds, and areas of similar significance for each species of marine mammal from the adverse effect of man's actions’. See Section 2 (2). *Findings and Declaration of Policy* 16 U.S.C. 1361.

[25] *The 1973 Endangered Species Act*. Public Law 93–205, Approved Dec. 28, 1973, 87 Stat. 884; as Amended Through Public Law 107–136, Jan. 24, 2002. See section 4(2).

[26] The term ‘‘critical habitat’’ for a threatened or endangered species means the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of the ESA which are found as physical or biological features essential to the conservation of the species and which may require special management considerations or protection.

[27] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 5.

[28] NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). II-67, 76-78.

[29] Source: NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). Figure 7. p. II-38. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]

(iii). Chinook salmon

Although the risk and impact of an oil spill to the survival of the SRKW is clear, perhaps the foremost threat to their survival is a further reduction in the quantity or quality of their prey. Although the SRKW will consume other species, their preferred prey is Chinook salmon. As such, Chinook salmon is a critical food resource for SRKW (as well as for multiple other species). Mortality rates and rates of population increase for SRKW have shown statistical correlations with some indices of Chinook salmon abundance.[30]

The difficulty in ensuring the continuation of this critical food resource for the SRKW is that many (27) salmon populations are endangered.Puget Sound Chinook are currently estimated to be between 1 and 10% of their pre-exploitation numbers and they are already facing a clear risk of extinction as their overall abundance remains very low and many populations are in decline. For example, only one of 22 local to Puget Sound populations increased in the past five years and this small increase was in stark contrast to the overall trend in Puget Sound, of which the total number declined between 2006 and 2010.[31]

The Chinook salmon of Puget Sound (including the Straits of Juan De Fuca) is explicitly recognized as threatened with extinction and it is listed under the ESA.[32] The Chinook is also subject to further conservation considerations under Fish and Wildlife Coordination Act, the Magnus-Stevens Fishery Conservation and Management Act-Essential Fish Habitat,[33] and international conservation efforts under the 1985 Pacific Salmon Treaty.[34] When this treaty was updated in 2008, new fishing regimes came to encompass, *inter alia*, Chinook Salmon and included responsibilities which sought to preserve the biological diversity of the Chinook resource and contribute to the restoration of currently depressed stocks by improving their abundance, productivity, genetic diversity and spatial structure over time.[35]

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[30] National Marine Fisheries Services (2012). *The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel.* (NOAA, Seattle). 3-4. National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 6.
[31] PugetSoundPartnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound.* (PSP, Seattle). 22, 24.
[32] See NOAA, *Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead.* 50448 Federal Register / Vol. 76, No. 157 / Monday, August 15, 2011 / Proposed Rules.
[33] Public Law 94-265.
[34] *The Treaty Between the Government of Canada and the Government of the United States of America Concerning Pacific Salmon*. See in particular, article 3.
[35] See chapter 3 of Annex IV of the Treaty.

As a species listed under the ESA, like the SRKW, the Chinook salmon also has defined critical habitat that must be protected (Figure 4).[36] In this regard, the Puget Sound Salmon Recovery Plan[37] has placed a considerable emphasis upon the restoration of the most important habitats of the Chinook salmon in this region, including, amongst others, estuaries, floodplains, riparian areas and particularly important near shore (i.e., shoreline and marine) areas. Considerable success has already been made with this issue with approximately 2,350 acres of habitat restoration projects being completed from 2007 to 2011 in the 16 major river delta estuaries.[38] The restoration of the Elwha River that empties into Juan de Fuca Strait is the single largest salmon restoration project in the Nation. Although this habitat restoration work is to be commended, the risks of a substantial vessel accident upon all of these critical habitats remain significant and must be assessed.[39]

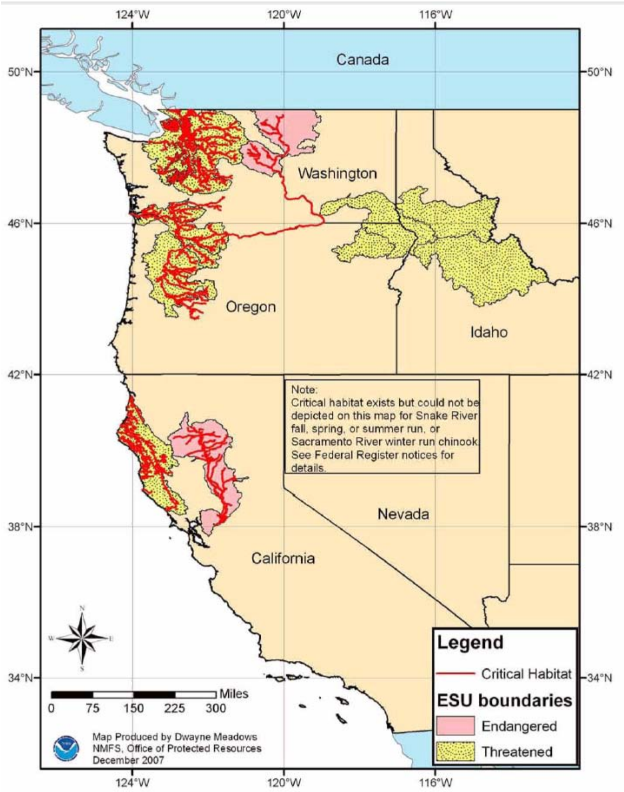

Figure 4. Designated critical habitat for Chinook salmon under the Endangered Species Act[40]

5. The significant risk of damaging listed protected areas

[36]*See http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/chinooksalmon.pdf*
[37] National Marine Fisheries Service (2007). *Puget Sound Salmon Recovery Plan* (NOAA, Washington).
[38] PugetSoundPartnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24.
[39] Ibid.
[40] Source: NOAA (2007). *See http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/chinooksalmon.pdf*

(i). The areas at risk and associated obligations

Legal obligations already exist to conserve protected areas in this region. Beyond the federal governments Trust Obligations to the Treaty Tribes of the Salish Sea, the foremost obligation in this area exists at the international level through the World Heritage Convention,[41] which includes the Olympic National Park which can be reached from the southern side of the Strait of Juan de Fuca and along the Olympic Coast. This World Heritage area is internationally renowned for the diversity of its ecosystems. Glacier-clad peaks interspersed with extensive alpine meadows are surrounded by an extensive old growth forest, among which is the best example of intact and protected temperate rainforest in the Pacific Northwest. Eleven major river systems drain the Olympic Mountains offering some of the best habitat for anadromous fish species in the country. The park is rich in native and endemic animal and plant species, including critical populations of the endangered northern spotted owl, marbled murrelet and bull trout. The coastal strip of the Park is the longest Wilderness beach in the continental United States.[42]

In addition to its aesthetic value, this park has been recognized by the international community due to its varied topography, from seashore to glacier, which includes habitats of unmatched diversity on the Pacific coast. The coastal Olympic rainforest reaches its maximum pristine growth within the park confines and has a living standing biomass which may be unsurpassed anywhere else in the world. The park also includes more than 60 miles of wilderness coastline, the longest undeveloped coast in the contiguous United States. This coastline is characterized by rocky headlands, log-strewn beaches, and a wealth of intertidal life; rocky islets along the coast are remnants of a continuously receding, changing coastline and the arches, caves and buttresses are evidence of the continuous battering of the waves. Tide pools are filled with hundreds of species of invertebrate life and seals, sea lions, sea otters and several species of whale are often seen in the waves and around the offshore Islands.[43] Due to such overt importance, the Olympic Coast National Marine Sanctuary was promulgated under the National Marine Sanctuaries Act, and this was the basis for the International Maritime Organisation (IMO) to recognise, in 1991, this location as an Area to be Avoided. The core of this measure is a request for operators of vessels carrying

[41] See article 4 of the *World Heritage Convention*. Also, Gillespie, A. (2012). *Conservation, Biodiversity and International Law*. (Edward Elgar, London). Chapter 7.
[42] McNulty, T. (2009). *The Olympic National Park: A Natural History*. (University of Washington Press, Seattle). 249-250.
[43] Ibid. 151-215.

petroleum and/or hazardous materials to maintain a 25-mile buffer from the coast.[44] Despite the value of this measure, its application, in terms of geographical coverage, ends at the beginning of the Juan de Fuca strait.

At the national level, obligations also exist to conserve particular sites of significance within these high value areas, such as the San Juan Islands, and including the American and English camps. These two coastal sites are listed under the 1966 National Historic Preservation Act which requires that potential impacts on the listed sites must be considered and 'taken into account'.[45] In addition, Executive Order 13158 on Marine Protected Areas (MPA) requires federal agencies to identify actions that affect natural or cultural resources that are within a marine protected area. It further requires federal agencies, in taking such actions, to avoid harm to the natural and cultural resources protected by an MPA. Finally, the 1972 Coastal Zone Protection Act requires that federal actions that will have reasonably foreseeable effects on the land or water uses or natural resources of a state's coastal zone must be consistent with federally approved State Coastal Management Practices.[46]

Within this context, there is a complicated mix of 54 protected areas, which fall under multiple ownership and management regimes (including public, private and non-governmental ownership)[47] and all must have their conservation needs taken into account. Although none of these areas extend beyond the tidal zone, they are complemented by a myriad of MPAs. As it stands, Washington State is currently home to 127 MPAs managed by 11 federal, state and local agencies. These sites occur primarily in Puget Sound and associated coasts and cover approximately 644,000 acres and over 6 million feet of shoreline. The greater San Juan Islands area (San Juan archipelago) has responsibility for the most MPAs. Of note, in 2004, the San Juan County Board of Commissioners designated the entire marine waters of the county as a Marine Stewardship Area and, in 2007, the San Juan County Council enacted a local ordinance to prevent boaters from harassing SRKW that frequent County waters.[48] Cumulatively, between 1 to 5% of Puget Sound and coastal regions is covered by MPAs which have been recognized as possessing local, regional and global

[44]An ATBA is, 'a routeing measure comprising an areawithin defined limits in which either navigation is particularly hazardous or it is exceptionallyimportant to avoid casualties and which should be avoided by all ships, or certain classes ofships'. For the actual designation, see Department of Commerce/NOAA (2000). *Olympic Coast National Marine Sanctuary: Area to be Avoided*. (Marine Sanctuaries Conservation Series MSD-00-1).
[45] 16 U.S.C. 470. See sections 106 and 110.
[46] 16 U.S.C. 1451.
[47] Domico, T (2007). *Natural Areas of the San Juan Islands.* (Turtleback, Washington).
[48] No. 35-2007.

importance.[49] The waters surrounding the proposed Gateway Marine Terminal have been designated as a State Aquatic Reserve by the Department of Natural Resources for the primary purpose of recovering the genetically unique, spring spawning Cherry Point Herring stock. The stock has declined dramatically since the construction of the Delta Port Coal Dock in Point Robert and the Arco/BP refinery dock at Cherry Point.

(ii). The loss of integrity

All of the listed protected areas are at risk of losing their integrity (as in, the reasons for which their protected status was originally granted, such as being important habitats for species, special ecosystems, aesthetic beauty, etc), and thus their status, if a substantial vessel accident impacts upon them.[50]

(iii). The potential economic loss

The first estimates of the all-in cost to British Petroleum (BP) for the *Deepwater Horizon* spill in the Gulf of Mexico were below $5 billion (USD).[51] These original estimates, like all of those prior to the *Deepwater Horizon* spill, were based on the earlier cost-estimation methodologies used to quantify costs of the *Exxon Valdez* spill. These estimates were quickly eclipsed as the scale of the oil leaking out became apparent. By the end of 2012, the direct costs of the clean-up, compensation/damages for lost economic activity (collectively about $21 billion) and fines (based on the amount of oil spilt, by barrel, at around $17 billion) had taken the total closer to $38 billion.[52] However, these figures could climb even higher as while the cost of fines and compensation are relatively quantifiable and negotiable, the costs for restoration of the damaged environment (assuming this is possible and species are not made extinct) are proving much more difficult to conclude.

[49]Washington Department of Fish and Wildlife (2009) *Marine Protected Areas in Washington*. (WDFW, Washington). 2.Don, C. (2002). 'Could the San Juan Islands National Wildlife Refuge Serve to Protect Marine Areas ?' *Coastal Management*. 30: 421-426. Tuya, F. et al. (2000). 'An Assessment of the Effectiveness of Marine Protected Areas in the San Juan Islands'. *ICES Journal of Marine Science*. 57: 1218-12226.
[50] See Gillespie, A. (2008). *Protected Areas and International Law*. (Brill, The Netherlands). Chapter 8.
[51] Note, all figures are USD unless indicated otherwise.
[52]Goldenberg, S. (2012). 'BP adds $847m to Deepwater Horizon Costs'. *The Guardian*. July 31. A6. Goldenberg, S. (2012). 'Deepwater Horizon Aftermath: How Much is a Dolphin worth?'. *The Guardian*. April 12. A7. Anon (2010). 'The Oil Well and the Damage Done: BP Counts the Political and Financial cost of Deepwater Horizon'. *Economist.* June 17. 54-56.

The base difficulty in the *Deepwater Horizon* incident is that the long-term ecological impacts appear to be much larger than originally predicted as most of the damage is beyond what is visually apparent (i.e., oil soaked birds, mammals or fish). For example, although the 700 dolphin carcasses that washed up were most likely killed by the spill, the true death toll is unknown but is probably closer to many multiples of this with the majority dying at sea and never washing up ashore.[53] Similarly, with all of the associated ecosystems which are not immediately visible, such as those beneath the surface and especially on the ocean floor, the impacts are likely to considerably exceed predictions.[54]

A 2004 Report concluded that a major oil spill could cost Washington's economy $10.8 billion and impact 165,000 jobs.[55] This predicted figure is problematic both because of its age but also because it is likely to be an underestimate. Even relatively small oil spills – in high value areas – are proving increasingly difficult and expensive to clean up. For example, the most recent spill of note involved some 360 tons of bunker oil which escaped when the container ship *Rena* grounded off the east coast of New Zealand. This spill has already cost approximately $30 million in clean-up but the expectations are that it could cost as much as $110 million. Regrettably, the vast majority of this cost will fall upon the New Zealand taxpayer as the legal cap for the ship owners had been set at $29 million.[56]

The most obvious manifestation of direct economic risk from a large vessel accident is its impact upon tourism. Tourism is one of the economic powerhouses of the modern global economy. In 2011, the total for international tourist arrivals declined by 4.2% to 880 million due to the recession. These 880 million people spent some $852 billion on their travel. It is expected that this number will grow in the future to an estimated 1.6 billion international tourist arrivals by 2020. This growth in numbers is particularly noticeable with nature and eco-tourism and it is estimated that somewhere between 20-40% of all tourists are interested

[53] Williams et al (2011). Underestimating the Damage: interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. *Conservation Letters*. 4: 228–233.
[54] Whitehead, A. (2012). 'Genomic and Physiological Footprint of the Deepwater Horizon Oil Spill on Resident Marsh Fishes'.*Proceedings of the National Academy of Sciences*. doi:10.1073/pnas.1109545108. Helen K. White (2012). 'Impact of the Deepwater Horizon Oil Spill on a Deep-water Coral Community in the Gulf of Mexico'. PNAS 2012. doi:10.1073/pnas.1118029109.
[55] Department of Ecology/Puget Sound Partnership (2011). Improving Oil Spill Prevention and Response in Washington State: Lessons Learned From the BP Deepwater Horizon Oil Spill. (DoE, Publication Number: 11-08-002). 7, quoting an earlier 2004 study.
[56] Ministry for the Environment (2011). *Rena: Long-term Environmental Recovery Plan* (MFE, Wellington). 4-7.

in some form of wildlife watching.[57]This figure is broadly comparable with the United States as 82 million, or 39% of all Americans, participate in some kind of non-consumptive wildlife-related recreation, with an annual economic impact of $110 billion, or 1.1 % of the Gross Domestic Product.[58]

Areas which are already inscribed as protected and valued are generating large amounts of revenue. At the end of the 20th century, 63 million people were visiting 116 natural World Heritage sites annually. Fifteen sites recorded over one million visitors per year (eight of these being in the United States) with the Great Smokey Mountains having the highest number with 9,265,667 visitors. Even in areas which are not World Heritage, the revenue streams are impressive. For example, in the mid-1990s, nature tourism and visits to national parks in Costa Rica were estimated to generate over $600 million per annum. By 2001, this figure was over 1 billion dollars and had trebled to 3 billion by 2004.Australia's top eight national parks were estimated to be bringing in more than $2 billion per year with about a quarter of this sum coming from the Great Barrier Reef alone. In terms of the highest economic worth of an individual site, Yosemite in the United States generates approximately $1.3 billion per year.[59]

All of these figures have a direct applicability to the situation in Puget Sound. Protected areas can produce vast amounts of money. For example, the San Juan Islands have developed a particularly enviable position, commonly scoring in the top five places to visit on the planet. This popularity is reflected in visits to state parks on the Islands, which are in the range of 1.3 to 1.6 million people per year. In turn, this is believed to feed into an outdoor industry in the San Juan County worth $117 million per year, buttressed by 669 dependent jobs. This industry is understood to be a subset of the larger outdoor industry, with a value of $8.5 billion per year to the Washington State, buttressed by 115,000 dependent jobs.[60]

57 World Tourist Organisation (2012) *World Tourism Barometer* (NYC, WTO) 3-4; Convention on Migratory Species (2006) *Wildlife Watching and Tourism* (Bonn, CMS). 12-14; IUCN (2003) 'Protected Areas as Engines for Development.' *Parks* 13 (3), 1-71.

58 Dolesh, R. (2011). 'Assessing the Value of Feathered Workers: Birds Perform a Multitude of Services that Contribute to Our Well-Being'. *Birder's World* 25(4): 12-20.

59 Maldonado, P (2008) 'Rumble in the Jungle' *Economist* (April 12) 50-51; Toepfer, K (2004) 'Protected Areas.' *Our Planet* 14(2): 1; IUCN (2002) *Sustainable Tourism in Protected Areas: Guidelines for Planning and Management* (Gland, IUCN) 24-25.

60 For the popularity see, for example, the New York Times, The 41 Places to Go in 2011; National Geographic Traveller, The Best Trips for Summer 2011; Lonely Planet: US Islands That Won't Break the Bank. For the figures, see Dean Runyan Associates (2009). *The Economic Impacts to Visitors of Washington State Parks.*

Many of these jobs are based directly, or indirectly, around high-value eco-tourism such as whale-watching or bird-watching. Birding, the most accessible form of wildlife watching, continues to be the fastest growing outdoor recreational activity in the United States.[61]In addition to the indirect values that these birds bring, from controlling pests to performing key roles in ecosystems, they often have a direct economic value related to tourism.[62] On average, a day tripper focused on bird-watching will spend somewhere between $32 and $142 per day in a local community. However, this figure may be higher depending on the type of bird, its conservation status and the time of year.[63] Similar economic values come from whale-watching, which is now a rapidly growing industry active in over in 65 countries which is attracting more than 9 million participants per year and which brings in $2.1 billion per year.[64]

6. Alternatives

The most obvious alternative available in attempting to reduce the impact of increased shipping traffic and the risk of oil spill is the selection of routes which do not threaten either endangered species and/or protected areas. In this regard, alternate shipping routes which avoid designated critical, sensitive and protected areas should be investigated.

7. Mitigation

Mitigation actions should, ideally, render potentially significant impacts insignificant. This is not possible in this situation. What is possible, however, is reducing the magnitude of the

[61]Baicich, R (2003). Parks and Birders: A Natural Pair. *Parks & Recreation* 38. 2 (Feb 2003): 48-56.

[62]Dolesh, R. (2011). 'Assessing the Value of Feathered Workers: Birds Perform a Multitude of Services that Contribute to Our Well-Being'. Birder's World 25(4): 12-20.

[63] Edwards, P. (2011). 'The Economic Value of Viewing Migratory Shorebirds on the Delaware Bay: An Application of the Single Site Travel Cost Model Using On-Site Data'. Human Dimensions of Wildlife, 16:435–444. Lee, C. K. et al.. (2009). Assessing the Economic Value of a Public Birdwatching Interpretive Service Using a Contingent Valuation Method. International Journal of Tourism Research, 11, 583–593. Glowinski, S. L. (2008). 'Bird-Watching, Ecotourism, and Economic Development: A Review of the Evidence'. Applied Research in Economic Development, 5(3), 65–77. Eubanks, T. L., Stoll, J. R., & Ditton, B. (2004). Understanding the Diversity of Eight Birder Sub-Populations: Sociodemographic Characteristics, Motivations, Expenditures and Net Benefits. Journal of Ecotourism. 3: 151–172. MacMillan, D., (2004). Costs and Benefits of Wild Goose Conservation in Scotland. Biological Conservation, 119: 475–485.

[64]Pain, S (2009) 'You'll Miss Me When I'm Gone'. *New Scientist* (July 25) 34, 36-37. Anon (2009) 'Preservation Pays' *New Scientist* (July 4) 4; Hoyt, E (2008) *The State of Whalewatching in Latin America* (Washington, IFAW) 3; IFAW (2005) *The Growth of the New Zealand Whale Watching Industry* (Melbourne, IFAW) 4-5. Newsome, D (2007) *Wildlife Tourism* (Boston, Thomson) 122-127. Anon (2008) 'A Trophy for Conservation' *SPECIES* 49: 35; Barnett, R (2005) *Sport Hunting in the Southern African Development Community Region* (Cambridge, TRAFFIC) 3.

scale, and likelihood, of the significant risks.[65] This reduction of risk, but not its elimination, may be found in three areas: advanced preparedness, enhanced vessel controls, and an increased protection status for the most valuable regions.

(i). Preparedness

In the same year that the National Commission on the *Deepwater Horizon* disaster report came out in 2011, a joint review by the Department of Ecology and the Puget Sound Partnership was undertaken in response to recommendations from the National Commission, namely Improving Oil Spill Prevention and Response in Washington State.[66] The Joint Review made many sensible and robust recommendations which should form the first level of mitigation against the significant risks posed by shipping in the proposed GPT area and in the greater Puget Sound region. In particular, they identified a need to increase research and development to improve spill response, strengthen state and local involvement, developnew regulations to govern the use of dispersants and to improve oil spill response planning. All of these recommendations should be applied to the Puget Sound area and also to the consideration of the GPT proposal.[67]

(ii). Reducing the Risk of Accidents

Extension of pilotage limits

In the case of high densities of shipping traffic and associated risk around the San Juan Islands, one of the highest sources of risk has not been addressed by either the traffic separation and routing scheme[68] nor the broad precautionary measures that are required for oil tankers. As it stands, within the existing traffic control regime in this area, both the federal and state regulations require the master of oil tankers to accept both pilots and tugs. Such measures, complemented by additional requirements such as all oil tankers being double hulled, have, to date, been successful in mitigating disasters in this region of the world as less than 1 gallon of oil is spilled for every 100 million gallons transferred. The primary problem

[65] See Eccleston, C. (2012). *Preparing NEPA Environmental Assessments*. (Taylor and Francis, NYC). 47.
[66] Department of Ecology/Puget Sound Partnership (2011). *Improving Oil Spill Prevention and Response in Washington State: Lessons Learned From the BP Deepwater Horizon Oil Spill*. (DoE, Publication Number: 11-08-002).
[67] The original recommendations of the National Commission can be found in chapter 9, pages 265-269.
[68] See Traffic Separation Schemes: In the Strait of Juan de Fuca and Its Approaches; in Puget Sound and Its Approaches; and in Haro Strait, Boundary Pass, and the Strait of Georgia. Reprinted in The Federal Register (Nov 19, 2010).

here, with regards to oil tankers, is that the first 70 miles of the Strait of Juan de Fuca is *not* covered by pilots, with the starting point for pilotage only beginning at Victoria/Port Angeles, and tugboats are only mandatory for oil tankers which are laden. In addition, laden Articulated Tug/barges are not required to have tug escorts at all. Accordingly, in terms of a reduced risk, it is important to study the utility of an extension in the range of the compulsory use of pilots and tugs for both oil tankers, as well as all vessels over 400 tons and/or carrying dangerous cargo.

Revision of criteria for requiring pilotage and tug

The first standard that should be investigated to help mitigate potential risks in this area is the applicability of the requirement for a pilot and tug to all large vessels with the highest risk profile, such as those over 400 tons and/or carrying dangerous cargo. This is necessary because there is a much greater risk of accidents in this region, potentially even more so, given the projected increase in overall shipping traffic from the proposed GPT. Therefore, similar mitigation measures should be required for all large vessels and not just oil tankers. This requirement is especially important because the most common type of vessel currently involved in incidents or accidents are cargo vessels, followed by ferries, fishing vessels, and barges. The benefit for requiring the sectors with the highest risk profiles to be accompanied by tugs and guided by local pilots is potentially large given that the types of vessels most likely to be utilized in the freight of coal will be Panamax and Capesize. These vessels are up to 950 feet long and 106 feet wide. The same requirements should be implemented for barges over a certain size, especially those carrying oil. This requirement was recognized by the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling, which noted that these vessels may represent a distinct and previously invisible risk.[69]

Furthermore, while oil tankers are presently the only vessels that require pilots and tugs, it is possible that other vessels not under pilotage and escort could be responsible for a collision with a laden oil tanker, even when the oil tanker was conforming to best practice. The impacts from such an event would likely be equivalent to an incident which was the fault of the oil tanker. Due to this reasonably foreseeable scenario, it is essential to study the possible mitigation benefits of the compulsory use of pilots and tugs for all large vessels and/or those carrying potentially dangerous cargothrough the entire waterway.

[69]Commission Report (Chapter 9, page 251).

Reassessment of the definition of high risk and/or potentially dangerous cargo

With regard to the point above regarding potentially dangerous cargos, and with a view to exploring further risk mitigation, it would be useful to reassess the issue of whether other forms of cargo, including materials such as tarsands/bitumen and coal, should be classified as high risk and/or potentially dangerous and, therefore, requiring additional mitigation measures to ensure their safe transit. The definition of high risk and/or potentially dangerous should also be refined to include those cargoes that may result in significant, negative environmental, social and/or economic impact on this region. This should include both quantitative and qualitative assessment of the expected impacts from the sinking or grounding in the Puget Sound area of a fully loaded coal transport vessels of both Panamax and Capemax class.

Speed reductions

Another standard that should be investigated to help mitigate potential risks in this area is reducing the speed of all large vessels traversing this area. As it stands, the only restrictions on speed in this highly valuable and sensitive area pertain to restrictions that oil tankers should not outrun their escorts. There are no restrictions on other vessels and many of those most at risk, such as larger freighters, currently exceed 20 knots while traveling in the Salish Sea and related regions, which makes them both noisy and difficult to stop. Any enforced reduction in speed for all large vessels and/or those carrying dangerous cargos would be consistent with the broad international rules in this area, as stated in the 1972 Convention on the International Regulations for Preventing Collisions at Sea, that, ‘Every vessel shall at all times proceed at a safe speed...’[70]. With this mitigation option in mind, there is merit in examining the utility of mandating a reduced speed for all large vessels and/or those carrying high risk and/or dangerous cargo.

(iii). Enhanced Protection Status

Whilst the preferred option would be that there is no risk posed by vessel traffic in the waters which are particularly vulnerable, the existing levels of traffic alone means that it is not possible to ‘turn back the clock’. Accordingly, the best that can be achieved in this area is to

[70] Rule 6.

introduce further mitigations to reduce the risk of traffic accidents. The foremost tool to do this is rethinking the way, type and method of implementing effective protected areas around threatened or sensitive areas. This tool would not only assist goals of conservation and vessel shipping coordination in this area,[71] but it would also be consistent with regional initiatives to enhance conservation protection in the Salish sea (and especially the Juan de Fuca Strait and Puget Sound)Puget Sound area. Most importantly, it would help impose restrictions on the vessels traversing the area to Canadian (not American) destinations, as they would be obliged to work in accordance with regulations of an international basis.

The current possibilities in this area include the creation of a National Monument via the 1906 Antiquities Act through a public proclamation to protect sites of historic and scientific importance found on federally owned land. Recent notable precedents in this area are the Presidential Declaration for the PapahānaumokuākeaNational Marine Monument in the Northwestern Hawaiian Islands (2006) and the Pacific Islands National Marine Monuments (2009) which includes Rose Atoll Monument, Marianas Trench Monument, and the Pacific Remote Islands Monument.

The critical aspect of such a designation is that it could effectively be the stepping stone to reconciling an increase in vessel traffic and adequately protecting the endangered species and protected areas within it the region. That protection can be found in the designation of Puget Sound as a Particularly Sensitive Sea Area (PSSA). A PSSA is defined as, 'an area that needs special protection through action by the International Maritime Organization because of significance for recognized ecological, socioeconomic or scientific reasons and because it may be vulnerable to being damaged by international shipping activities'.[72] The PSSA is ultimately a balance between the protection of high value environments (of a coastal State) and the freedom of the high seas (as jealously guarded by flag States and the shipping communities). It is also an instrument which pulls together and synchronizes very complex, and often conflicting, domestic and international, legal and policy goals. The advantages of

[71] Washington Department of Fish and Wildlife (2009) *Marine Protected Areas in Washington*. (WDFW, Washington). 3-4.
[72]Broder, S. (2011). 'Particularly Sensitive Sea Areas-Protecting the Marine Environment in the Territorial Seas and Exclusive Economic Zones'. *Denver Journal of International Law and Policy*. 40(1): 472-300. Chalain, H. (2007). 'Fifteen Years of Particularly Sensitive Sea Areas: A Concept in Development'. *Ocean and Coastal Law Journal*. 13(1): 47-65. Ottesen, P. (1994). 'Shipping Threats and Protection of the Great Barrier Reef Marine Park: The Role of the Particularly Sensitive Sea Area'. *The International Journal of Marine and Coastal Law*. 9(4): 507-543. Gerard, P. (1994). 'Particularly Sensitive Sea Areas-A Documentary History'. *The International Journal of Marine and Coastal Law*. 9(4): 469-482. Gjerde, K. (1993). 'Protection of Particularly Sensitive Sea Areas under International Marine Environmental Law'. *Marine Pollution Bulletin,* 26(1): 9-13.

this instrument are many, as can be evidenced by the fact that a number of countries are presently actively exploring the creation of PSSAs to protect key areas and appropriately manage shipping traffic.[73]

To date, PSSAs have been designated in 14 areas. The first such designation was in 1990 in Australia’s Great Barrier Reef and it was later extended to include the Torres Strait in 2005. The designation required compulsory pilotage and it was backed by criminal penalties (which are not permitted under other international conventions). It now extends 1,430 miles along the east coast of Queensland and covers an area of 215,000 square miles, passing through both Australia's territorial sea and its EEZ.[74] Subsequent PSSAs include Sabana-Camagüey Archipelago (Cuba, 1997),[75]Malpelo Island (Colombia, 2002), the Wadden Sea (Denmark, Germany, Netherlands, 2002), Paracas National Reserve (Peru, 2003), Western European Waters (2004) following the sinking of the *Prestige*, a single-hulled tanker which released over 20 million US gallons of oil into the sea,[76]Canary Islands (Spain, 2005), the Galapagos Archipelago (Ecuador, 2005), the Baltic Sea area (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden, 2005),[77] and the Strait of Bonifacio (France and Italy, 2011). These have been joined by Saba Bank (Caribbean Island of Saba, 2011), and The Netherlands (2012).

The United States has also already adopted and implemented two PSSAs. These are the waters around the Florida Keys (2002) and the Papahānaumokuākea Marine National Monument (2007). In the latter instance, the designation put into effect internationally recognized measures designed to protect marine resources of ecological or cultural significance from damage by ships, while helping keep mariners safe. In addition to enhanced

[73] Hazmi, M. (2012). ‘Protecting vital sea lines of communication: A study of the proposed designation of the Straits of Malacca and Singapore as a Particularly Sensitive Sea Area’. *Ocean & Coastal Management* 57: 79-94.
[74] See the IMO, MEPC, Identification of the Great Barrier Reef Region as a Particularly Sensitive Area, Annex, IMO Marine Env't Prot. Comm. Res. 44 (30) (Nov. 16, 1990). Also, Australia Government, Australian Maritime Safety Authority [AMSA], The Torres Strait Particularly Sensitive Sea Area, available at http://www.amsa.gov.au/ Marine_Environment_Protection/Torres_Strait (last visited December 22, 2012).
[75]Kristina, M. (1999). ‘Cuba's Particularly Sensitive Sea Area in the Sabana-Camaguey Archipelago’. *International Journal of Marine and Coastal Law*. 14(3): 415-435.
[76] Detjen, M (2006). ‘The Western European PSSA—Testing a Unique International Concept to Protect Imperilled Marine Ecosystems’. *Marine Policy* 30: 442–453.
[77] Uggla, Y. (2007). ‘Environmental Protection and the Freedom of the High Seas: The Baltic Sea as a PSSA from a Swedish perspective’. *Marine Policy* 31: 251–257.

monitoring and reporting requirements, special zones known as ‘Areas to be Avoided’, appeared on international nautical charts to direct ships away from them.[78]

All such PSSAs have been approved and designated, after first being requested by a member government at the IMO, once it has been proven that they meet a number of criteria including ecological, social, cultural and/or economic criteria.[79] Despite being the highest level of protection in this area, the PSSA does not, of itself, include any explicit prescribed protective mechanisms. Rather, the application to the IMO for PSSA designation needs to be accompanied by specific proposed Associated Protective Measures (APM). All IMO member governments are obligated to ensure that ships flying their flag comply with the APMs for that area.[80]APMs are those approved or adopted by the IMO to prevent, reduce, or eliminate the threat or identified vulnerability. There can be special discharge standards within PSSAs and specific measures can be used to control the maritime activities in that area, such as compulsory pilotage programs, separated shipping, traffic lanes, areas to be avoided, reporting requirements, no anchoring zones, equipment requirements for ships, and installation of Vessel Traffic Services.[81] It is also possible to encompass any measure that is already available under an existing IMO instrument; or is to be adopted by the IMO; and/or any measure that does not yet exist which is described as the development and adoption of other measures aimed at protecting specific sea areas against environmental damage from ships, provided that they have an identified legal basis.

[78] Anonymous (2008). ‘Marine National Monument Designated Sensitive Sea Area’. *Sea Technology* 49 (5): 60-61. Also, Anon (2008). ‘Papahanaumokuakea Marine National Monument designated a "Particularly Sensitive Sea Area’. *Ocean News & Technology* 14 (3): 20-21.

[79]Ecological criteria covers unique or rare ecosystem, diversity of the ecosystem or vulnerability to degradation by natural events or human activities; social, cultural and economic criteria include those having significance of the area for recreation or tourism; and scientific and educational criteria, such as biological research or historical value are also important. See IMO Resolution A.982(24) Revised Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas (PSSAs).

[80] IMO, Assembly, Revised Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas, Resolution A. 982 (Dec. 1, 2005).

[81] Vessel Traffic Services (as overlapping with guidance from the International Maritime Organisation) provides active monitoring and navigational advice and assistance for vessels in particularly areas which are confined and busy waterways, thereby improving the safety and efficiency of navigation, safety of life at sea and the protection of the marine environment. Advanced traffic organization (such as priority position, allocation of space, routes to be followed, and speed limits to be observed); navigational assistance, and overlapping technologies such as radar and other direction finding, location and management tools, combined with appropriate personnel, and a strong and supportive flow of information (for example reports on the position, identity and intentions of other traffic; waterway conditions; weather; hazards; or any other factors that may influence the vessel's transit) essential for making informed on-board navigational decisions. VTS is governed by the 1974 Safety of Life at Sea (SOLAS) Convention, Chapter V, Regulation 12, together with the Guidelines for Vessel Traffic Services, IMO Resolution A.857(20), as adopted by the IMO, on November 27, 1997.

8. Recommended research programs

Based on the assessment of the various risks posed by increased shipping from the proposed GPT and the consideration of potential mitigation options that are identified in this report, 10 research programs are recommended to assist in developing an understanding and evaluation of the impacts of the GPT. Five research programs are required for decision-makers to reach a full and informed decision with regards to assessing the significant risk of a substantial vessel accident in this region to endangered species and protected areas and a further five studies are required to assess the possibilities and potential effectiveness of the different mitigation options in this area.

Research programs to support decision makers

i. Create a cumulative risk assessment for all vessels with a high risk profile over 00 tons and/or carrying a dangerous cargo transiting through the area. This study should establish what the baseline is, how the proposed expansion will impact upon the baseline and what additional reasonably foreseeable growth in this area would look like in terms of increased volume and increased risk.
ii. Create a clear and accurate map of all of the critical habitats of endangered species and all of the established protected areas in the greater Puget Sound region which are at risk from the impacts of a vessel accident bearing in mind that impacts of oil spills can be regional in scope.
iii. Show if it is possible for alternative routes for the vessels to be charted which either do not pose, or significantly reduce, risks to eitherendangered species, their critical habitat or established protected areas.
iv. Investigate how a substantial vessel accident could potentially impact upon one or more endangered species (and their associated critical habitat) including Southern Resident killer whales, Chinook and Chum Salmon and any birdlife of conservation concern.
v. Complete an economic analysis of the potential costs of a substantial vessel accident.

Although economic cost is not an explicit consideration within NEPA, issues such as employment and availability of services are clearly part of the ‘human environment' that section 102 of the NEPA requires to be examined. In this regard, although there is an expectation that issues of cost will be considered through processes outside of NEPA, good practice within the application of the NEPA means that it should also be included. This ambiguity to include economic considerations within the NEPA assessment is not present within the SEPA. Within the SEPA, the requirement 'that presently unquantified environmental amenities and values will be given appropriate consideration in decision making along with economic … considerations' is explicit. This requirement is particularly so because it overlaps with the other requirement of the Legislature for an examination of impacts which have a 'relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity'.[82]

Accordingly, the fifth study, especially in light of the *Deepwater Horizon* accident, should seek to update the figures for predicted economic losses from oil spills for the greater Puget Sound region. The particular areas to draw out are the potential impacts upon the fishing industry, the tourism industry, especially the high value eco-tourism areas. The costs associated with cleanup operations, compensation and damages, fines and also long-term habitat and environmental restoration should also be assessed. Within this study, it would also be worthy to examine the question of the adequacy of the existing liability regime for vessel accidents within Washington State. As the *Deepwater Horizon* accident clearly showed, had it not been for the exceptionally deep pockets of BP, many of the costs would have fallen upon the taxpayer.[83]

[82] SEPA, Chapter 43.21C RCW.

[83] Davis, A. (2011). 'Pure Economic Loss Claims Under the Oil Pollution Act: Combining Policy and Congressional Intent'. *Columbia Journal of Law and Social Problems* 45 (1): 1-44. Rogers, C. (2011). 'Under Extraordinary Circumstance: NEPA Practice Post Deepwater Horizon'. *Natural Resources and Environment*. 26(2): 15-26. Gaskell, N. (2008). 'Marine Pollution Damage in Australia: Implementing the Bunker Oil Convention 2011 and the Supplementary Fund Protocol 2003'. *The University of Queensland Law Journal*. 27(2): 104-130. Ganten, R (2008). 'Developments in Oil Pollution Liability'. *Environmental Policy and Law* 38 (6): 312-315. Faure, M. (2008). 'Financial caps for oil pollution damage: A historical mistake?'. *Marine Policy* 32: 592–606. Faure, M. (2006). 'An Economic Analysis of Compensation for Oil Pollution Damage'. *Journal of Maritime Law and Commerce* 37(2): 179-217. National Commission, Chapter 9, pages 283 and 285.

Research programs to investigate mitigation options

vi. The utility of an extended range for the compulsory use of pilots and tugs for both empty and full oil tankers.

vii. The value of the mandatory use of pilots and tugs for all large vessels and/or those carrying potentially dangerous cargo.

viii. Assessment of whether cargo, including tarsands/bitumen and coal, should be classified as high risk and/or potentially dangerous and therefore requiring additional measures to ensure their safe transit. The definition of high risk and/or potentially dangerous should also be refined to include those cargoes that have the potential to result in significant environmental, social and/or economic impact on this region.

ix. Assessment of the benefits of reducing risk through mandating a reduced speed for all large vessels and/or those carrying high risk and/or dangerous cargo.

x. Investigate the possible benefits and costs of enhancing protected status of the region, especially in terms of the creation of an internationally mandated Particularly Sensitive Sea Area.

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Associated with Coal Freight

Prepared By: Alexander Gillespie

January 11, 2013

1. The base problem and the need for a cumulative view

The North American railroad system has a proud lineage which dates back to 1827. Since that time, it has evolved, expanded, contracted, and rebounded.In the 21st century, this $50+ billion per year industry moves more than 2 billion tons of freight per year on 140,000 miles of track. This industry, which currently employs nearly 200,000 people nationally, is expected to expand considerably in the future. National demand for freight train capacity(aside other rail demands) is expected to double in the next 20 years.[1] In Washington State, the increase is projected to be even greater, as ‘significant additional capacity is required at our ports to meet the future forecasts for international cargo flows…’.[2] The majority of this growth is projected to be in the transit of coal. That is, the current 40%, as a percentage of total freight volume,level of coal is expected to increase. Approximately 60% of all new rail tonnage predicted to be required is attributable to coal and related intermodal freight.[3]

The current Gateway Pacific Terminal(GPT) proposal is part of the overall growth trajectory for the freighting of coal in the Pacific North West (PNW). The current proposal aims to add between 16 to18 trainloads (i.e., half loaded coming, half empty returning) each day on top of existing capacity. Each of the proposed new trains will pull up to 150 freight wagonseach day with each train nearly one third longer than the average train length in the year 2000.[4]At a speed of 50-60 mph, it would take about 3 to 4 minutes for the train, at around one and a half miles in length, to pass a stationary objectsuch as a car at a crossing. At a speed of 35 mph, the travel time would be about 6 to 7 minutes. The impacts of the increased rail traffic will be felt all along the coal railway from Powder River Basin (PRB) to the coal terminals in the PNW. However, two cities, Spokane, WA and Billings, MT appear to be at the forefront of this increased transit, with Spokanereceiving an estimated 63 total transits per day, whilst Billings could average around 58.[5]

[1] See Transportation Research Board (2004). *2010 and Beyond: A Vision of America’s Transportation FutureTwenty-first Century Freight Mobility*. (NCHRP Project 20-24(33) A Final Report) Transportation Research Board (2011). *Impacts of Public Policy on the Freight Transportation System* (NCFRP, Report 6). Tarm, R. (2008). ‘Railroads Warn of Chronic Congestion’. *The Capital Times and Wisconsin State Journal*. June 1.
[2] Washington State Department of Transport (2009). *Washington State 2010-2030: Freight Rail Plan* (WSDT, Olympia). 9:2.
[3] Ibid, 4:26.
[4] Murray, T. (2010). ‘Where’s That Coal Train Going?’ *Trains* 70(4): 28-37.
[5]Gibson Traffic Consultants Inc. *Cherry Point Coal Export Facility Rail Operations-City of Seattle-Preliminary Report; GTC #11-036*. February 13, 2012. Report to City of Seattle, Director Seattle Department of Transportation. 126 p.

Whilst it is important for the Environmental Impact Statement (EIS) to assess and modelthe capacity and impact of the increased level of rail traffic proposed for the GPT, it is equally important for the impact assessment to critically evaluate the overall increase in rail demand across the board, as opposed to only considering the incremental increase posed by the development of the GPT. Two cumulative impact assessment studies are required. The first, acumulative impact analysis of the region, and directly impacted communities within Washington State en-route to the proposed GPT site should include a detailed examinationof the existing baseline levels, the current incremental increaseproposed for the GPTand other additional traffic that may be reasonably foreseeable in the future. Only by doing this cumulative impact analysis will it be possible to reveal the true extent of the significant risks of the train traffic at hand, thereby avoiding the more myopic analysis that would stem from focusing only upon theincremental addition of trains for the GPT. To act otherwise and focus only on the incremental increase will lead to a false and inaccurate assessment of impact and risk.[6]

A second cumulative impact study should also be undertaken which would also work upon the existing baseline, the current proposed increase, and additional increases which are reasonably foreseeable in the future for interdependent rail issues. This wider cumulative study should not be restricted to Washington State as the impacts (e.g., environmental, social, economic and public health) from significantly increased rail activity will also be issues for all the other states along the potential coal shipment routes including Idaho, Montana, Oregon, and Wyoming. In some cases, sections of rail in these other states will carry the biggest projected train loadings and pose the biggest risk to the efficient delivery of rail freight in the region as they contain the largest bottlenecks and choke points along the whole 4,000 mile rail transportation chain from the PRB to the PNW.[7]This second cumulative study,with full geographical coverage of the whole rail transportation chain,willgreatly assist the regional authorities in providing the necessary information to achieve meaningful, longer term planning, at reasonable cost, and in which uncertainties can be removed and effective, appropriate, and sustainable (in economic, social and environmental) choices can be made.[8]

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[6] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002) (quoting Churchill County v. Norton, 276 F.3d 1060, 1072 (9th Cir. 2001). Note also Fritiosfson v Alexander, 772 F2d 1225, 1243, 1245-1246, (5th Cir. 1985).
[7]Western Organization of Resource Councils. 'Heavy Traffic Ahead Rail Impacts of Powder River Basin Coal to Asia by way of Pacific Northwest Terminals'. July 2012. 64 p.
[8] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States'. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'. *Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective

This second cumulative study should be particularly cognizant of the impact that rail expansion is having upon farmland, as the loss of farmland is a national, regional and local concern. For example, Puget Sound has lost 60% of its farmland since 1950. Farmland loss is not just about land. It is about the farming communities, the environment they utilise and conserve, and the loss of traditional types rural identity. In 1950, the Puget Sound region hadnearly 1.4 million acres of farmland. The average annual loss over this period has been nearly 14,000 acres of farmland per year. Four counties—Pierce, King, Snohomish, and Whatcom—each lost more than 100,000 acres of farmland between 1950 and 2007, accounting for more than half the farmland loss in the region. By 2007 less than 600,000 acres remained, a 58 percent loss. Despite this rapid decline of farmland, the amount protected due to its high value, is only around five percent of the nearly 600,000 acres of farmland in the PugetSound region, with much of the remaining land under threat of conversion.[9]

2. Indicators ofsignificant risk

There are a large number of relevant standards of regulatory, legislative and other legal instruments from regional, state, federal and international agencies that the GPT development must meet or at least be assessed against to achieve approval. A summary of some of the more relevant standards are provided below:

- The Clean Air Act and associated National Ambient Air Quality Standards (NAAQS)
- Associated standards for the Prevention of Significant Deterioration regulations, and the State Implementation Plan.
- Associated standards promulgated by the North West Clean Air Agency (NWCAA) and Puget Sound Clean Air Agency (PSCAA).

Use of Cumulative Effects Assessment in Resource Management'. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'. *Environmental Impact Assessment Review.* 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?' *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'. *International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673.

[9] American Farmland Trust (2012).*Losing Ground: Farmland Protection in the Puget Sound Region* (AFT, Washington). 3-4, 12, 14-17.

- International best practice on air quality standards. For example, the US standards for 24-hour average PM_{10} is 150 µg/m3 which is 200% higher than the equivalent standard of 50 µg/m3 from the World Health Organization and other OECD countries such as Australia, New Zealand, the European Union and Canada (British Columbia). California also has a State standard of 50 µg/m3, consistent with international best practice.
- The (Federal) Noise Control Act
- The Federal Transit Authority (FTA), in association with the EPA, and the Railroad Noise Emission Standards
- The (Washington State) Noise Control Act and associated standards from the EPA and the Occupational Health and Safety Administration of the Department of Labor.
- The World Health Organization.
- Executive Order 12898, which requires federal agencies to consider the impacts of their actions on minority and low income populations.
- The Washington Transportation Plan (WTP)
- Washington State's Department of Transportation Program to reduce congestion
- The Blue Ribbon Commission on Transportation.
- The Farmland Protection Policy Act
- The (Washington State) Farmlands Preservation Executive Order 8001
- The (Washington State) Growth ManagementAct.
- The Federal Clean Water Act
- The State Water Pollution Control Act
- The Shoreline Management Act of Washington State.

3. The significant risks of coal freight

A. Air pollution and significant impacts on associated communities

Coal dust is an odorless, fine powdered form of dark brown to black dust created by the crushing, grinding, or pulverizing coal.[10] Its most explosive risk is in combustion and flammability. Coal dust also possesses the ability to cause, longer term, detrimental impacts

[10]Commonly, it is identified by its content of silicon dioxide which is most commonly found in nature with sand or quartz, with it containing less than 5% of free silica.

upon both humans and animals.These impacts may appear wherever coal is obtained, stockpiled and, particularly, when it is transported, dumped or otherwise handled (e.g. loading, unloading). At all of these stages there is the potential for the release of small particulate matter (i.e., dust) in significant quantities. Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust (including coal dust) particles. The size of particles is directly linked to their potential for causing health problems. The EPA is particularly concerned about particles that are 10µm[11] or smaller in diameter because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

The EPA groups particle pollution into two categories: (i) “Coarse particles” or PM_{10}such as those found near roadways and dusty industries that are larger than 2.5µmand smaller than 10µm in diameter and (ii) “Fine particles”or$PM_{2.5}$such as those found in smoke and haze, which are 2.5µm in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.[12] At the end of 2012, the EPA finalized an update to its national air quality standards for harmful fine particle pollution (PM2.5), including soot, setting the annual health standard at 12 micrograms per cubic meter. The new standard is based on an extensive body of scientific evidence that includes thousands of studies, including many large studies which show negative health impacts at lower levels than previously understood. The EPA estimated the health benefits of the revised standard to range from $4 billion to over $9 billion per year, with estimated costs of implementation ranging from $53 million to $350 million.[13]

The routes of human exposure to coal dust are inhalation, ingestion, and eye contact.These exposures are most well documented with workers in industries associated with coal, such as mining and/or transportation of coal, and/or use of coal. There is a considerable body of

[11]One µm is a measure of length and is one-millionth of a metre (or 1/34 millionth of an inch)

[12]Source: US Environmental Protection Agency Particulate Matter, viewed 27 December 2012, http://www.epa.gov/air/particlepollution/ Also, Querol, X., et al. (1999). ‘Characterisation of Atmospheric Particulates Around a Coal-fired Power Station. *InternationalJournal of Coal Geology*. 40: 175–188.

[13] See http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/a7446ca9e228622b 85257ad400644d82!OpenDocument (site visited, January 3rd, 2013).

international literature about the health effects of exposure to coaldust of respirable particle size (i.e., PM_{10} and smaller). In almost every case, the studies andassociated reported health effects relate to coal miners and coal mine sites, either underground oropen-cast, with links between workers exposed to various types of dust, overlapping with type, time, amount and location. In excessive amounts, coal dust can cause either acute or chronic impacts. Acute symptoms to excessive amounts of coal dust include coughing, wheezing, and shortness of breath, whilst chronic exposure to coal dust may result in symptoms of, *inter alia*, pneumoconiosis, bronchitis and emphysema.Coal dust is also a tumorigenic agent in experimental animals, with dusts being shown to be equivocal tumorigenic agents associated with lymphomas and, at the higher dose, adrenal cortex tumors in rats.[14]Due to such dangers, when people have to work around coal dust, strict standards are enforced tocontrol worker exposure to coal dust, including, *inter alia*,enclosure of the process and/or facility, high levels of ventilation, monitoringand personal protective equipment. Specifically, workersare required to wear respirators (if the dust exceeds prescribed exposure limits), appropriate personal protective clothing and equipment (based on the workers potential exposure to coal dust) that iseffective in preventing skin contact with coal dust (e.g., gloves, sleeves, encapsulating suits) and personal hygiene procedures, whereby all clothing contaminated with coal dust is removed and cleaned, and workers are able to washany affected skin areas with soap and water.[15]

Whilst the scientific evidence of the effects on people working with or around coal is well documented and robust, the same cannot be said for the literaturedealing specifically with environmental exposure of coal dust to the general community.This lack of evidence is problematic as it cannot be construed as a demonstration that coal dust does not have an impact on the general community outside the direct coal industry but rather that there have been few such specific studies, they are difficult to undertake, and results can often be inconclusive. However it is a widely accepted fact that when coal is transported in open-top freight wagons, there are a number of ways by which a considerable amount of coal dust may be lost en-route to and from its destination, including spillage when loading, escaping from

[14]United States Department of Labor. (2012). Occupational Safety and Health Guideline for Coal Dust (< 5% SiO2). 2-5. Jennings, R. and Flahive, M. (2005). Review of Health Effects Associated With Exposure to Inhalable Coal Dust. (Coal Services Pty Ltd). Finkelman, R. (2002). 'Health Impacts of Coal and Coal Use'. *International Journal of Coal Geology* 50: 425–443. Attfield, M. (1997). Exposure Response for Coal Workers' Pneumoconiosis'. *The Annals of Occupational Hygiene* 41(1): 341–345.
[15]United States Department of Labor. (2012). *Occupational Safety and Health Guideline for Coal Dust* (< 5% SiO2). 6-7.

doors or seams, or by being blown out of the top of open wagons which the most common mechanism by far.

Although the published literature on the amount of fugitive dust that leavesstandard, open wagons is not extensive, general figures would suggest that between 0.05% and 1% (and potentially up to 3%) of each coal wagon is lost as fugitive dust over a 600 mile trip.[16] For coal wagons such as those presently used by the BNSFrail company for coal freight, this would be in the region of 500 pounds to a ton of coal dust, from mine to ship. BNSF implemented coal dust emissions standards in 2011 and recommended mitigation techniques (e.g., using an approved surfactant and/or by using an approved profile of the coal in the wagon) that it says will reduce coal dust emissions by 85%. However, these new standards will require enforcement to be effective and, even if they are successful to the levels stated, there will still be coal dust escaping from thousands of loaded and unloaded wagons each year. These measures may reduce the coal dust problem but they will not remove it.

Whilst studies on emissions of coal dust have not documented direct evidence of health impacts for humans or flora, fauna, crops and livestock that can be directly attributable to coal dust from wagonseither inside or outside of the rail corridor, other evidence is raising serious questions about the reliability and sensitivity of such studies.Specifically, there is the risk of the unintended escape of damaging amounts of coal dust into sources of fresh water, contrary to the Clean Water Act.[17] There is also the difficulty that an increasing number of studies are beginning to directly link health issues with living or working close to coal mines or facilities. For example, increases inasthma incidence in a community living 'near' an open cast coal mine site in Australia have been noted.[18]Links between respiratory ill-health in school children in parts of Britain exposed to coal dust (and other overlapping pollutants) have also been identified in at least two locations.[19]Similarly, within the United States, public health records data for nearly 16,500 persons in West Virginia have shown a negative relationship betweenhealth indicators (in terms of higher rates of cardiopulmonary disease,

[16] Ferreira, A. (2003). 'Full-Scale Measurements for Evaluation of Coal Dust Release from Train Wagons with Two Different Shelter Covers'. *Journal of Wind Engineering and Industrial Aerodynamics* 91: 1271–1283. Lazo, J. et al. (1996). 'Community Perceptions, Environmental Impacts, and Energy policy: Rail Shipment of Coal'. *Energy Policy* 24: 531–540. OECD (1983). *Coal—Environmental Issues, Remedies* (OECD, Paris). 43-45.
[17]Note, Sections 230 and 404 of the Clean Water Act.
[18] Temple, J. and Sykes, A. (1992). 'Asthma and Open Cast Mining'. *British Medical Journal*. 305, 396.
[19] Department of Epidemiology and Public Health (1999). Do Particulates from Opencast Coal Mining Impair Children's Respiratory Health? (University of Newcastle-upon-Tyne). Brabin, B. et al. (1994). 'Respiratory Morbidity in Merseyside School Children Exposed to Coal Dust and Air Pollution'. *Arch Diseases in Childhood* 70: 305.

chronic obstructive pulmonary disease, hypertension, lung disease and kidney disease) and residential proximity to coal mining activities, including transportation.[20]

While coal dust provides a very visual source of pollution, there are other carcinogens, toxic pollutants and other harmful agents that are produced as a byproduct of rail transportation. These include, but are not restricted to, noise, diesel particulate matter, and heavy metals. Some of the documented health effects from these agents include increased cardiopulmonary mortality and overall mortality, increased severity and frequency of asthma attacks, cognitive impairment in children, increased rates of myocardial infarction, cardiovascular disease, increased blood pressure, and arrhythmia. The levels of these health impacts in people along the coal rail routes and alongside the tracks will presumably increase in direct proportion to the overall increase in the amount of rail freight carrying coal. Given that the national demand for freight trains alone is expected to double in the next 20 years[21] and that the increase is likely to be considerably higher in Washington State, then this region could see at least double the rates of these pollutants and associated health impacts within the community within the next 20 years and perhaps even earlier.

Due to the evidence that already exists in this area, and the need to take a precautionary approach when considering matters of public health, there is a justified need to conduct a formal Health Impact Assessment (HIA)[22]of the GPT project and its implications for public and environmental health. In this particular instance, the HIA should, in accordance with Executive Order 12898, specifically consider the impacts of the project to ensure that the burden of the environmental and healthimpact is not borne disproportionately by minority and low-income populations. Such an approach will helpevaluate the potential health effect(including identification ofwhich groups are likely to be impacted upon) of a plan, project or policy before it is built or implemented.It should also be able to provide recommendations to increase positive health outcomes and minimize adverse health outcomes. HIA brings potential public health impacts and considerations to the decision-making process for plans, projects, and policies that fall outside the traditional public health

[20] Hendryx, M. (2008). ‘Relations Between Health Indicators and Residential Proximity to Coal Mining in West Virginia’. *American Journal of Public Health*, 98: 669-671. Also, Harkinson, J. (2011). ‘Death of a Coal Town’. *Mother Jones* 36(2):14.

[21] See Transportation Research Board (2004). 2010 and Beyond: A Vision of America’s Transportation Future 21st Century Freight Mobility. (NCHRP Project 20-24(33) A Final Report) Transportation Research Board (2011). Impacts of Public Policy on the Freight Transportation System (NCFRP, Report 6). Tarm, R. (2008). Railroads warn of chronic congestion; the already crowded rail system is expected to get worse. The Capital Times and Wisconsin State Journal. June 1.

[22]See http://www.cdc.gov/healthyplaces/hia.htm

arenas, such as transportation and land use. Such an assessment would be consistent, for both governments and the commercial sector, with best practice in this area.[23]

B. Dust emissions and significant impacts upon infrastructure

The spread of coal dust is not only detrimental to people, it also impacts on the supporting infrastructure of the railway itself. Research has demonstrated that coal dust escaping from coal wagons can foul the ballast (i.e., the material that makes up the track-bed upon which railroad ties are laid) along rail lines which,in turn, can lead to weakened track structures and pose a serious threat to stability. As it stands, landslides on Puget Sound railroad tracks are reaching near record levels (with 40 to 50 slides big enough to affect rail traffic in 2012 alone).[24]The impacts of such dust emission are significant and have been identified as a contributing factor to derailments on the line out of the PRB. On the basis of this finding, BNSF have since implemented new standards for coal dust emissions and associated mitigation measures and, as an indication of the importance that BNSF puts on this issue, they developed anextra tariff for coal shippers that do not meet the emission standards.

C. Noise

The response of the human ear to sound depends both on the sound frequency, which is measured in Hertz, and the sound pressure on the eardrum, which is measured in decibels (dB).The unit A-weighted dB(A) is used to indicate how humans hear a particular sound.A soft whisper at one meter is about 30 dB(A).For a good night's sleep, the equivalent sound level should not exceed 30 dB(A) for continuous background noise.The sound pressure level of normal speech is about 50 dB(A). In a busy restaurant, the level is roughly equivalent to 55

[23]Negev, M. (2012). 'Integration of Health and Environment Through Health Impact Assessment'. *Environmental Research*. 114: 60-67. Morgan, R. (2011). 'Health and Impact Assessment'.*Environmental Impact Assessment* 31: 404-411. Tamburrini, A. (2011). 'Enhancing Benefits in Health Impact Assessment Through Stakeholder Consultation'. *Impact Assessment and Project Appraisal*. 29 (3): 194-204. Wernham, A. (2011). 'Health Impact Assessments Are Needed in Decision Making'. *Health Affairs* 30(5): 947-955. Danneberg, A. (2008). 'Use of Health Impact Assessments in the United States'.*American Journal of Prev. Medicine*. 34(3): 241-255. Briggs, D. (2008). 'A Framework for Integrated Environmental Health Impact Assessment'.*Environmental Health*. 7: 61-69. Cole, B. (2007). 'Health Impact Assessment: A Tool to Help Policy Makers'. *Annual Review of Public Health*. 28: 393-412. Birley, M. (2005).'Health Impact Assessment in Multinationals'.*Environmental Impact Assessment Review*. 25: 702-713.

[24]http://www.king5.com/news/environment/Dozens-of-mudslides-bury-railroad-tracks-between-Seattle-to-Everett-185003081.html

dB(A), while 75 to 80dB(A) is approximately the noise levels that can be heard at a very busy intersection or motorway.Heavy industries typically operate between 92 to 96 dB(A).A chainsaw can reach 110 dB(A).The sound level of 150 dB(A) can be foundstanding next to a Boeing 747 with its engines at full throttle.[25]

There is considerable variation in the type and volume of noise that is produced from a train. It will vary hugely depending on factors such as speed, locomotive and wagon type and age, size of the train (e.g., number of locomotives and wagons), load configuration and weight, type and condition of the track and, as such, it is difficult to generalize about train noise. To truly understand the noise produced by a specific train, it needs to be measured directly and empirically. That fact notwithstanding, advice from the Federal Transit Authority (FTA)has indicated that a single diesel locomotive operating at 50 mph on ballast and tie track with continuous welded rail (CWR) generates a sound exposure level of 92 dB(A) at a distance of 50 feet from the track centerline. A single freight railcar or passenger car operating under the same condition produces 82 dB(A) at a distance of 50 feet from the track centerline.[26]

The documented and specific effects of noise pollution (not specific to rail) include: noise-induced hearing impairment, interference with speech communication, disturbance of rest and sleep, psychophysiological, mental health and performance effects, effects on residential behavior and annoyance, and interference with intended activities.To avoid acute mechanical damage to the inner ear, adults should never be exposed to more than 140 dB(A) of noise, even for very short periods. For children, the level is 120 dB(A). In terms of prolonged exposure, the evidence suggests that susceptible individuals may develop permanent effects such as hypertension and ischemic heart disease. Workers exposed to high levels of industrial noise for between five to thirty years may show increased blood pressure and an increased risk of hypertension. Cardiovascular effects have also been demonstrated after long-term exposure to air- and road-traffic with values of 65 to 70 dB(A). Prolonged exposure to very

[25] Coghlan, A. (2007). ‘Dying for Some Peace and Quiet’.*New Scientist*, Aug. 25. At 6-9. Chepisuik, R. (2005). ‘Decibel Hell’.113 *Environmental Health Perspectives*. A35, A37. De Jong, (1996). ‘Is Freight Traffic Noise More Annoying Than Passenger Traffic Noise?’ *Journal of Sound and Vibration. 193(1) 35-38.* Mercier, V. (2002).‘ Is Electronically Amplified Music Too Loud?’. *Noise and Health*. April 16, 48. Mercier, V. (2003).‘Sound Exposure of the Audience at a Music Festival’. Noise and Health, May 19. 51-58. World Health Organisation (2001).*Occupational and Community Noise*.(WHO, Geneva.WHO Doc. N°258). 8. Griefahn, B. (2004). ‘Protection Goals for Residents in the Vicinity of Airports’, *Noise and Health*, 51-62. Alberti, P. (2003). *Pathophysiology of the Ear*.(WHO, Geneva).63, 66.

[26] 5.8.1.1 Noise Projections in Section 5 Environmental Consequences in Springfield Rail Improvements Project Vol II. p. 5-39. http://www.fra.dot.gov/eLib/details/L03985. Gidlof, A. (2012). ‘Railway Noise Annoyance and the Importance of Number of Trains, Ground Vibration, and Building Situational Factors’.14(59) *Noise and Health*. 190-201.

loud noise levels between 90 and 115 dB(A) has been linked to cardiovascular risks and alsoto suicide.[27]

Excessive (i.e., above 55 dB(A)) and especially prolonged noise can adversely affect performance of cognitive tasks.For places of learning (e.g., pre-school, school, and higher education)where understanding speech and communication of complicated ideas is critical to learning, background noise levels should not exceed 35 dB(A) during teaching sessions. An even lower sound level may be required for hearing impaired children. In schools with noise levels exceeding these limits, children often under-perform in proof reading, persistence on challenging puzzles, tests of reading acquisition, and motivational capabilities. Even repeated but ad-hoc exposure, such as living in the vicinity of a major source of noise, may detrimentally impact children's memory. The World Health Organizationnoise guidelines for areas such as hospitals are for between 30 dB(A) and 40 dB(A),depending on the time of day and the location of the hospital. If the goal is to protect patients with a susceptibility to stress, the level should not exceed 35 dB(A).[28]

In addition to the impacts of noise upon human communities, terrestrial animal communities are also vulnerable. The most observable effect of noise on wild animals appears to be behavioural changes. Whilst many animals learn to differentiate among acoustic stimuli and to adapt and live with different types of noise pollution, others have gone in the opposite direction, and have shown strong sensitivities to noise pollution. Whilst those that are wild are able to leave an area, those that are domestic, often do not have the same option. In this regard, between findings of negligible impact of rail noise upon domesticated species, yet below findings of high impact, a middle bracket exists of moderate impacts, in which breeding, and/or related food production, is reduced. Recent scientific evidence has shown that animal reproduction, even for species common in urban areas, under noisy conditions, can be reduced. These may carry a direct economic cost.[29]

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[27]World Health Organization (2004).*Guidelines for Community Noise.*(WHO, Geneva). http://whqlibdoc.who.int/hq/1999/a68672.pdf

[28]World Health Organisation.(1999). *Guidelines for Community Noise*.(WHO, Geneva). 3. Lee, C. (2002). General Health Effects of Traffic Noise.(US Department of Transportation, MA).Bluhm G. (2004). 'Road Traffic Noise and Annoyance- An Increasing Environmental Health Problem'.6(24) *Noise and Health* 43, 43.Griefahn,B. (2004). 'Disturbed Sleep Patterns and Limitations of Noise'.6(22) *Noise and Health* 27, 31.Matsui, T. (2004). 'Children's Cognition and Aircraft Noise at Home- The West London Schools Study'. *Noise and Health* 25, 49-58. Matheson, M. (2003). 'The Effect of Chronic Aircraft Noise Exposure on Children's Cognition and Health'. *5 Noise and Health* 31-40. Raloff,J. (1987). 'Airport Noise Linked With Heart Disease'. *Science News*. 123:19

[29]Halfwerk, W. (2011).Negative Impact of Traffic Noise on Avian Reproductive Success'.*Journal of Applied Ecology*. 48: 210–219.

D. Congestion

Rail is an energy-efficient and often cleaner transportation alternative to many other modes. It can also havea beneficial effect in reducing highway congestion via the reduction of competing methods of transport, such as truck traffic. However, if rail transportation isutilized in a short-sighted manner, it can end up creating the very problems it is advocated as resolving, such as transport congestion.Congestion, as the Blue Ribbon Commission on Transportation noted, is a key indicator of transportation dysfunction.[30] The manifestations of this dysfunction are slower speeds, longer trips,and long lines of idlingvehicles.Washington State is well familiar with this type of dysfunction. Seattlealready possessesthe third worst traffic congestion of all American cities. Currentlybetween 60 and 80% of all urban interstate highways are congested in Washington State and the annual average rate of congestion (i.e.,40 hours per year) is exceeded in many places. In 2010, vehicle hours of delay increased by 13%above the2009 average, with each personspending 12% more time delayed in traffic.[31]

Similar congestion problems are also appearing in parts of the rail network, with some sectionsalready exhibiting delays comparable to the worst examples in the United States. The fear isthat, without substantial foresight and planning, rail congestion could also increase rapidly in coming decades. This is especially so given the financial requirements to meet Washington state-wide rail needs over the next 20 years, estimated at requiring between $175 and $200 billion by 2032.[32]

[30]The Blue Ribbon Commission on Transportation.*Final Recommendations to the Governor and Legislature* (adopted November 29, 2000). 6.

[31]TomTom (2012).*North American Congestion Index*. 4, 5, 24-26. Washington State Department of Transportation (2011).*The 2011 Congestion* Report. (WSDOT).3-5. Washington State Department of Transport (2009). Washington State 2010-2030: Freight Rail Plan (WSDT, Olympia). 9:2, 3:27. The Blue Ribbon Commission on Transportation.*Final Recommendations to the Governor and Legislature* (adopted November 29, 2000). 13-14. See Transportation Research Board (2004). *2010 and Beyond: A Vision of America's Transportation Future 21st Century Freight Mobility*. (NCHRP Project 20-24(33) A Final Report) Transportation Research Board (2011).*Impacts of Public Policy on the Freight Transportation System* (NCFRP, Report 6).

[32]Washington State Transport Commission (2010).*Washington Transportation Plan 2030.Connecting Communities for a Prosperous Future.* December 2010. 56 p.

As it currently stands,rail congestionis already a clear issue in many parts ofthe PNW.[33] Earlier reports from 2006 identified six congested lines, 11 constrained lines and 11 lines that were expected to exceed practical capacity by 2015 across the Washington rail network, including the additional capacity gained by operating longer trains and implementing better scheduling. Growth projections suggestthat the total freight tonnage moved over the Washington State rail system is going to increase rapidly over the next decade. Demand for freight trains alone, nationally, is expected to double in the next 20 years. In Washington State, the increase is projected to be even greater, as 'significant additional capacity is required at our ports to meet the future forecasts for international cargo flows…'.[34] The impact of this growth in demand, on top of existing high levels of congestion, is highly dependent on the rate of growth and the mitigations adopted.[35]

It has been recognized for nearly 100 years that every time there is congestion (e.g., waiting for trains to pass crossings), it causes a loss of time for those stuck. The loss of this time may have implications in terms of lost productivity on both a personal and a professional level. As it currently stands, drivers consistently demonstrate a willingness to pay, on average, $1.33 to save ten minutes travel time, or at least $8.00 per hour, just to move at a standard speed. This means that in standard situations (and not the enhanced ones that are being proposed) the annual cost of being stuck in congestion comes to about $1,000 per driver, per year. Traffic congestion is also bad for the economy costing at least $50 billion per year in lost/restricted productivity. However, this is a difficult figure to dissect, as the economic impacts of congestion are often difficult to predict, as eachsector in a community responds differently. Despite these differences, it is clear that businesses that rely on efficiencies of time based upon the travel time between physical locations will make active choices to avoid areas of congestion, including (dependent on the weight of other factors) by relocation of the business. The attractiveness of relocation increases as the congestion gets worse. Within Washington State, when quantifying this delay in terms of total dollars, the cost to drivers

[33]Washington State Department of Transport (2009).*Washington State 2010-2030: Freight Rail Plan* (WSDT, Olympia). $;26, 9:2. Washington State Transport Commission (2006).*Statewide Rail Capacity and System Needs Study*.73 p.
[34]Washington State Department of Transport (2009).*Washington State 2010-2030: Freight Rail Plan* (WSDT, Olympia). 4:26. Transportation Research Board (2004). *2010 and Beyond: A Vision of America's Transportation Future 21st Century Freight Mobility*. (NCHRP Project 20-24(33) A Final Report) Transportation Research Board (2011).*Impacts of Public Policy on the Freight Transportation System* (NCFRP, Report 6).Tarm, R. (2008). 'Railroads Warn of Chronic Congestion'. *The Capital Times and Wisconsin State Journal*. June 1.
[35]BST Associates & Mainline Management (2011). Pacific Northwest Marine Cargo Forecast Update and Rail Capacity Assessment Final Report. Prepared for Pacific Northwest Rail Coalition.46 p.

and businesses was over $750 million in 2010 based on maximum throughput speed thresholds.[36]

Supplemental economic losses from increased congestion and the related impacts such as noise (and air) pollution from both trains and overlapping traffic are also quantifiable. These impacts can take up to 7 to 12% off the value of a standard residential house, if it is within 750 feet of a track that carries freight wagons. These figures can change dramatically depending on what amenity valuesare lost.[37] These private losses are supplemented by the losses to community property, such as parks, which also have an economic and social value that can be quantified.[38]

In certain instances, congestion may also prevent the flow of essential services, such as for emergencies. The loss of time may cause impatience, stress and rage for the people in the vehicle, and air pollution (owing to increased idling, braking, starting and stopping) outside the vehicle. In this regard, particulate matter emissions which can be traced back to traffic congestion in the nation's 83 largest urban areas led to more than 2,200 premature deaths in the United States during 2010, with at least $18 billion in related public health costs.[39] Congestion can also cause spill-over effects as people try to find alternate routes to their desired location, which may in turn impact upon the latter's amenity values and real estate prices.

[36]Washington State Department of Transportation (2011).*The 2011 Congestion Report.*(WSDOT).3-5. Lavis, F. (1927).'Grade Crossings.The Money Value of a Car-Minute'.*Annals of the American Academy of Political and Social Science*. 133: 172-177. Verheof, E. (2010). *The Economics Of Traffic Congestion*. (Edward Elgar, London). 2 Volumes.Sweet, M. (2011). 'Does Traffic Congestion Slow the Economy?' *Journal of Planning Literature* 26: 391-412. Goodwin, P. (2004). *The Economic Costs of Road Congestion*.(ESRC Transport Studies Unit University College London Arnett, R. (1994).'The Economics of Traffic Congestion'.*American Scientist*. 82: 446-456.

[37]Andersson, H. (2010). 'Property Prices and Exposure to Multiple Noise Sources: Hedonic Regression with Road and Railway Noise'. *Environ Resource Econ.* 45:73–89. Arsenio E, (2006) 'Stated Choice Valuations of Traffic Related Noise'. *Transp Environ* 11(1):15–31. Baranzini A, (2005) 'Paying for Quiteness: the Impact of Noise on Rents'. *Urban Stud.* 42(4):633–646. Day B, (2007) 'Beyond Implicit Prices: Recovering Theoretically Consistent and Transferable Values for Noise Avoidance from a Hedonic Property Price Model'. *Environ Resour Econ* 37(1):211–232. Simons, R. (2004). 'The Effects of Freight Railroad Tracks and Train Activity On Residential Property Values'. *The Appraisal Journal*. 72(2): 223-233. Theebe, M. (2004). 'Planes, Trains and Automobiles: The Impact of Traffic Noise on House Prices'. *Journal of Real Estate Finance and Economics*. 28 (2): 209-234. Miedema H (2001). 'Annoyance from Transportation Noise: Relationships with Exposure Metrics'. Environ Health Perspect 109(4):409–416. Wilhelmsson M (2000) 'The Impact of Traffic Noise on the Values of Single-Family Houses, *Journal of Environmental Planning and Management* 43(6):799–815. Nelson JP (1982) 'Highway Noise and Property Values: A Survey of Recent Evidence. *Journal of Transport and Economic Policy*16(2):117–138.

[38]Millward, A. (2011). 'Benefits of a forested urban park: What is the value of Allan Gardens to the city of Toronto, Canada?'.*Landscape and Urban Planning.* 100: 177–188.

[39]Levy, J. et al. (2011).*The Public Health Costs of Traffic Congestion: A Health Risk Assessment.* (Harvard Centre for Risk Analysis, a report for the Transportation Construction Coalition).

4. Alternatives

The most obvious alternative is the selection of routes which do not threaten the human communities in terms of air pollution, noise emissions and traffic congestion. In this regard, alternate routes which avoid all of the key areas should be investigated.

5. Mitigation

Mitigation actions should, ideally, render potentially significant impacts insignificant. This is not possible in this situation. However, what ispossible is a reduction in the magnitude of the significant risks.[40] This reduction (not elimination) of risk may be found in improving rail operations in three main areas – noise, coal dust and congestion.

A. Noise

Scheduling, time control and re-routing

Perhaps the easiest mitigation option for controlling the effect of noise emissions from freight trains on urban areas is controlling the flow in terms of times and/or speed.Subject to operational constraints, this approach can be used to timetable trains to times or placeswhere lower noise levels are desirable, such as at night and it can be encouraged through economic incentives, as is the practice in Europe. Of course this approach does not actually mitigate the noise produced by trains but only shifts the normal levels of noise to other times or places.[41]

Controlling the times that the train's horn must be used is also an effective mitigation measure. In this regard, 'quiet zones', in accordance with the new rules issued by the Federal Railroad Association,can be utilized for 'safe' stretches of tracks which do not permit whistles. 'Safe' tracks are those that are generally supplemented with safety systems such as medians, quadrant gates and pre-signals to warn vehicles and pedestrians of approaching trains. While this can be an effective mitigation measure, it is frequently a relatively

[40] See Eccleston, C. (2012). *Preparing NEPA Environmental Assessments*. (Taylor and Francis, NYC). 47.

[41]European Union Directorate General for Energy and Transport. MEMO – Rail noise abatement measures addressing the existing fleet. 6 p. Federal Railway Adminisration (2012). Chicago to St. Louis High-Speed Rail Program. Tier 1 Final Environmental Impact Statement Tier 2 Evaluation of Springfield Rail. Volume II - Section 5 – Environmental Consequences.63 p. King, A. (2011).Implementation of the EU Environmental Noise Directive'.Journal of Environmental Management. 92: 756-764.

expensive option as the infrastructure required to make a crossing ‘safe’ to comply with the ‘quiet area’ standards is generally large and the full cost is normally borne by the local or regional authority rather than the rail company.

Maintenance

One of the major causes of excessive train noise is poor maintenance. Enhanced maintenance of existing stock and rail to ensure everything is running efficiently should be an essential part of standard operational procedures.To better characterize this issue, it would be useful to evaluate the main sources of existing rail noise to determine the component that is due to poor or irregular maintenance. Depending on the results of this, it may be possible to improve the nature and frequency of maintenance schedules to reduce general noise. This additional maintenance would have to be met by the rail companiesand, if they were not willing to comply voluntarily, it may require regulation.

Technological Options

More substantive measures involve the use of technological change. Great strides have already been made by technological developments that reduce noise emissions with motor vehicles (i.e.,cars, trucks and planes are 85%, 90%, and 75%quieter than they were in 1970 respectively).[42] Similar improvements have been made with rail and potentially there is no end to where technological advances could be applied to locomotives, wagons and also to the lines themselves. The first step in this area would be an understanding of the contribution of each component part of overall train noise. This understanding would indicate what areas may be the most useful in investigating technological advancements. A good example of this can be found in Europe where regulations have supplemented technological developments in the area of brakes on freight wagons (i.e.,by replacing iron brake blocks with less abrasive synthetic brake blocks) which can reduce noise levels by around 10 dB(A) or more and is cost-neutral when building new wagons. In 2003, the International Union of Railways approved the use of synthetic brake blocks in international traffic for specific types of wagons and, since then, all new railway wagons in Europe have been fitted with the new technology – and thousands of old ones have been retrofitted.[43] The expected net benefit of this approach is

[42] See International Civil Aviation Organisation. (2009). *Environmental Report*. (ICAO, Chicago). 20, 24-28. U.N. Econ. & Soc. Council (2006).Inland Transportation.Committee.Report of the World Forum for Harmonization of Vehicle Regulations, U.N. Doc. ECE/TRANS/WP.29/1056.FEHRL, (2006).Tyre/Road Noise (Final Report SI2.408210) Vol. 1.

[43]Anon (2011). ‘Whispering Brakes Reduce Freight Train Noise’. *International Railway Journal*. 51(5): 12-16. Thompson, D. (2003). ‘Brake and Wheel Design Can Cut Train Noise’. *Railway Gazette International*. 159(10): 639-644.Lunstrom, A. (2003). ‘The New Policy of the European Commission for the Abatement of Railway Noise’. *Journal of Sound and*

the reduction of the perceived level of noise emissions of freight trains by about 50% by 2014.Supplemental technological mitigation measures for railbeds could include the use of ballast mats, resiliently supported ties, tire derived aggregate, floating slabs, and special track-work at crossovers and turnouts.[44]

Anothertechnological mitigation that should be investigated is the introduction of noise insulation around communities which are at risk of excessive noise pollution.European railways provide a good example of noise insulation programs as nearly all European countries require noise protection measures when building new or upgrading existing railway lines. The traditional method of confronting noise pollution associated with railway construction has been through adaptive measures such as building requirements and/or noise barriers. For example, in Scandinavia protection from railway noise is primarily achieved by protecting buildings, whereas in Italy noise barriers are the preferred method. Both means of noise abatement are used in Europe and there are now tens of thousands of noise-insulated houses, mostly fitted with special-insulated windows in the vicinity of existing railway lines.[45]

B. Coal Dust

Filling and profiling

One of the most simple and widely used mitigation methods is ensuring that wagons are not overfilled above the sidewalls (ideally maintaining a 100 mm freeboard around the top edge of the wagon).Otherlow cost mitigation measures involve regular maintenance of wagons to ensure that the bottom discharge doors close tightly and remain so to prevent the loss of coal. Recent research by BNSF and others has demonstrated that, given the correct profile of coal in the wagon, it can reduce dust emissions considerably. Another option is the cleaning of

Vibration 267: 397-405. Frid, A. (2006). ‘Noise Control Design of Railway Vehicles–Impact of New Legislation’.*Journal of Sound and Vibration* 293: 910–920. Leth, S. (2003).‘Train Noise Reduction Scenarios for Compliance with Future Noise Legislation’.*Journal of Sound and Vibration* 267: 675–687.Hubner, P. (2007). Status Report and Background Information on Noise Related Track Access Changes. (Swiss Federal Office for the Environment). 3. Int’l Union of Ry (2007), Status Report: Noise Reduction in European Railway Infrastructure, 4-5.

44European Union Directorate General for Energy and Transport. MEMO – Rail noise abatement measures addressing the existing fleet. 6 p. Federal Railway Adminisration (2012). Chicago to St. Louis High-Speed Rail Program. Tier 1 Final Environmental Impact Statement Tier 2 Evaluation of Springfield Rail. Volume II - Section 5 – Environmental Consequences. 63 p

[45]Hubner, P. (2007). *Noise Reduction in European Railway Infrastructure*.(International Union of Railways & Community of European Railways and Infrastructure Companies).3-4. Manning, J. (2003).Noise Control in the Transport Sector, *Noise and Health*. 43.

wagons after unloading so that no coal dust is lost on the return journey from the 'empty' wagon, which can amount to as much as 4% of the total emissions of the entire journey.[46]

Surfactants and wetting

One method that is being used more and more to reduce dust emissions is to ensure that the coal is made moist so that the particles are affixed to the bulk material. All tests show a strong response in reduction of dust emissions with increasing total moisture content. Each coal exhibits a critical moisture content around which no emissions occur. Assuming the correct amount and type of moisture is applied to the correlated particlethen dust, if it is not exposed to excessive wind, can be greatly reduced.A similar alternative is to spray the coal witha surfactant or protective layer, such as polyoxyethylene and polyglycerol-based nonionic surfactants.This is achieved through using a water additive that forms a skin over the coal, thereby keeping the dust in. If applied effectively, dust emissions can be reduced, in theory, by between 80 to 99%.[47]However, both water and protective layers can be negated by opposing forces of wind and excessive moisture (i.e., rain), and this, in turn, is influenced by considerations of both the speed of the train and the length of the journey. If these forces are superior to the bonding agents, the fugitive dust will continue to escape, typically,out of the rear end of thewagons. While this approach is used on loaded wagons, it is not generally used on empty but unclean wagons which can contribute a significant amount of coal dust on the return journey.

Wagon covers

The most effective mitigation to controlthe emission of coal dust from freight wagons is sealing the wagon with a cover. Wagon lids (or tarpaulins)are already used in the transport of manymaterials around the world which are more perishable than coal (such as grain). They are also used for coal in northern Queensland in Australia. Such lids have shown themselves to be >99% effective in reducingcoal dust emissions from the top of wagons. They are also both practical and cost-effective especially if they are included inthe construction of new wagons and not retrofitted, although this cost is not believed to be excessive. In addition, they

[46]Katestone Environmental (2012).Duralie Extension Project, Study of Dust Emissions from Rail Transport. February 2012. 51 p.

[47]KatestoneEnvironmental (2011).*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Office of Environment and Heritage, KE1006953, NSW).Kim J. (1994). 'The Effect of Added Base on Coal Wetting Ability of Non-ionic Surfactant Solutions Used for Dust Control'.*Mining Engineer*, 154: 151-155. Smitham, J. (1991). 'Physico-Chemical Principles Controlling the Emission of Dust from Coal Stockpiles'.*Powder Technology*. 64(3): 259-270..

reduce theaerodynamic drag of the train by up to 20% leading to fuel savings.[48]This approach has the potential to offer the single biggest improvement in coal dust emissions and is something that requires detailed consideration in the EIS.

C. Congestion

Scheduling and re-routing

As proposed as a mitigation tool for noise emissions, congestion between trains and vehicles can, most simply, be addressed bycareful routing and the creation of priority systems such as public transport trumping freight, and/or the creation oftemporal restrictions on who can travel where, when, and how much (i.e., by limiting train size). However, these options have limited capacity to deliver meaningful benefits when facing exponential growth in both rail and traffic sectors and where rail operations are already congested and confined to existing and established rail lines. In this scenario, the best mitigation method against further congestion is the separation ofcross-over points between rail and vehicle traffic. Such separation reduces both the risk of accidents, and increases efficiencies in the utilization of time, often for both sectors.

It has been evident for a long time that the best way to solve these problems in existing areas is through the utilization of tunnels and overpasses that separatethe two modes of transportation and reduce both vehicle commuter and train congestion. This method has the added benefit of also improving safety, reducing noise (eliminating the need for train whistles) and reducing air pollution (exacerbated by idling engines).Although these mitigation techniquesrequire large amounts of foresight, capital and commitment, it is evident that many of the multiple benefits noted above can be achieved, ifthe benefits of the overpass, in terms of traffic efficiency, environmental amenity and traffic safety, trump the costs of accepting increased congestion.This trade-off was evident in some ofthe cities which were facing difficulties over the issue ofautomobile traffic delays partially related to BNSF's 1996

[48]Ferriera, A (2004). 'Wind Tunnel Study of Coal Dust Release from Train Wagons'.*Journal of Wind Engineering and Industrial Aerodynamics* 92: 565–577. Vrins, E. et al. (1998). 'Monitoring and Control of Fugitive Coarse Dust Sources'.*Journal of Aerosol Science*. 29: 709-740. Vrins, E. (1996). 'Sampling Requirements for Estimating Fugitive Dust Emissions'.*Journal of Aerosol Science*. 27(l.): 571-572. Visser, G. (1992).'A Wind Tunnel Study of Dust Emissions'.*Atmospheric Environment* 26: 1453 1460. Hatch, C.(2008). Final Report Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems.(Report to Queensland Rail Limited). 414
http://www.aurizon.com.au/InfrastructureProjects/Rail%20Network/Coal_Loss_Management_Project_Environmental_Evaluation.pdf

reopening its Stampede Pass line. The solution which alleviated much of the problem in some particular areas,involved a combination with the private sector, dedicating a new $32 million overpass of the rail line in a particularly congested area.[49]Although traffic-splitting mitigation measures have great technical promise, it is important to note that they are expensive to pursue. Given the high costs,it would be useful to know, for the purposes of clarity, upon whom these costs will fall and what models currently exist to divide these costs equitably between the private and public sectors, at the local, state and national levels.[50]

6. Recommended research programs

Based on the assessment in this report of the various risks posed by increased rail traffic from the proposed GPT and a consideration of potential mitigation options, eight research programs are recommended to help in understanding and evaluating the impacts of the GPT. Four studies are required for decision makers to reach a full and informed conclusion with regard to assessing the significant risks and impacts to human communities of coal freight trains and four further studies are required to assess the possibilities of mitigation options in this area.

Research programs to support decision-makers

i. A first cumulative impact analysis should study rail activity in the region for the directly impacted communities within Washington State en-route to the proposed GPT site. This should start with the existing baseline levels and expand to include the current proposed incremental increase from the GPT, and the additional traffic that may be reasonably foreseeable in the future. The particular facts that must be collected from this study should include:

[49]Singstad, O. (1927). ‘The Relation of Tunnels and Bridges to Traffic Congestion’.*Annals of the American Academy of Political and Social Science* . 133: 67-77. Bektas, T. (2011).‘The Pollution-Routing Problem’.Transportation Research. 45: 1232–1250. National Cooperative Highway Research Programme (2007).*Railfreight Solutions to Roadway Congestion* (NCHRP, Report 586).Section 2.4.4.Busch, T. (2003).‘Where the Rail Meets the Road’.*Public Roads* 66(5): 44-47. Vantuono, W. (1994). ‘Crisis at the Crossing?’. Railway Age 195(2): 35-42. See Triantis, K. (2011). ‘Traffic Congestion Mitigation: Combining Engineering and Economic Perspectives’. *Transportation Planning and Technology*. 34(7): 637-645. Sohn, K. (2008). ‘A Systematic Decision Criterion for the Elimination of Useless Overpasses’.*Transportation Research*. 42(8): 1043-1055. Pooley, C. (2005).‘Coping with Congestion: Responses to Urban Traffic Problems in British Cities 1920–1960’.*Journal of Historical Geography* 31 (2005) 78–93. Welsh, J. (2002). ‘For Community-Railroad Cooperation, Look to Auburn, Washington’. Trains 62(12): 24.Cordeau, J. (1998). ‘A Survey of Optimization Models for Train Routing and Scheduling’.Transportation Science. 32(4): 380-390.

[50]Such as with the Congestion Mitigation and Air Quality Programme of the Intermodal Surface Transportation Efficiency Act.

a. Quantification of levels of coal dust deposited, diesel emissions from the engines, and noise emitted, by existing, future and projected rail traffic (whilst being aware of historic patterns, and differences between locations, operating conditions, train length and composition, and times of data collection).
b. Focus on both small and larger sizes of particulate matter.
c. Differentiation between a comparable (urban) situation without the emission source, and juxtaposition to the current, proposed and future expectations.
d. Measurements should be both constant and the coverage extensive.
e. Specifically target monitoring around potential hotspots of concern such as education establishments and hospitals, as well upon residential communities, and disadvantaged communities and/or minorities in particular.

ii. Associated with the first cumulative impact analysis, noise pollution and air pollution should both be clearly examined within a Health Impact Assessment (HIA). This HIA should include studies on:

a. Determinations as to whether there is a significant impact on human health from the emissions of noise and/or air pollution from coal dust and diesel emissions and associated heavy metals from the coal freight trains. Particular regard must be had to communities which are critical hotspots of concern such as education establishments and hospitals, as well upon residential communities, and disadvantaged communities and/or minorities in particular.
b. The implications of these impacts for different sections in society especially the young, elderly, and sick, as well as the general population, over the short, and longer, term.

iii. A third study should focus on the cumulative impact of coal dust and its ability to foul rail line ballast and lead to weakened track structure, reduce stability and thereby contribute to derailments. This study should focus on what are adequate safety standards in this area.

iv. A fourth study should also be undertaken that portrays the cumulative current and future congestion patterns, also working upon the existing baseline, the current proposed increase, and additional increases which are reasonably foreseeable in the future for interdependent rail issues. This study should cover the full geographical coverage of the whole rail transportation chain from the PRB to the PNW. This study should include assessments of:

a. existing and projected demand for rail in the PNW,
b. lines that are presently or expected to become congested, constrained or to exceed practical capacity, in five, ten and twenty year periods.
c. the overlay of the current and future demands in both rail and vehicle traffic, and models of congestion expectations in five, 10 and 20 year periods.
d. the quantification of the economic implications of this congestion for the commercial sector, individual citizens and residential communities.
e. the impact that rail expansion is having upon farmland.

Note, whilst economic cost is not an explicit consideration within NEPA, issues such as employment and availability of services are clearly part of the ‘human environment’ that section 102 of the NEPA requires to be examined. In this regard, although there is an expectation that issues of cost will be considered through processes outside of NEPA, good practice within the application of the NEPA means that it should also be included. This ambiguity around the inclusion of economic considerations within the NEPA assessment is not present within the SEPA. Within the SEPA, the requirement ‘that presently unquantified environmental amenities and values will be given appropriate consideration in decision making *along with economic … considerations*’ is explicit. This is particularly so because it overlaps with the other requirement of the Legislature for examination of impacts which have a ‘relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity’.[51]

Research programs to investigate mitigation options

[51] SEPA, Chapter 43.21C RCW.

v. The first step in this area would be an understanding of the contribution of each component part of overall train noise. To better characterize this issue, it would be useful to evaluate the main sources of existing rail noise to determine the component that is due to issues such as, *inter alia*, speed, horns, locomotion and wagon design, rail design, and poor or irregular maintenance.

vi. With regards to noise pollution, studies need to be undertaken in consideration of scheduling, time control and re-routing, and the benefits of enhanced and regular maintenance of the rail stock and lines.More substantial technological options to be investigated involve the use of different brake pads, ballast mats, resiliently supported ties, tire derived aggregate, floating slabs, special track-work at crossovers and turnouts. Finally, the use of noise insulation and noise barriers around parts of the community which require additional standards should be investigated.

vii. With regards to coal dust, the main options that need to be studied arelimits on overfilling, suitable and effective surfactants and the effectiveness and economics of wagon covers.

viii. With regards to congestion, the main options that need to be examinedare scheduling and re-routing, and more importantly,the utilization of tunnels and overpasses inseparating the two modes of transportation.Although traffic-splitting mitigation measures have great technical promise, it is important to note that they are expensive to pursue. Given the high costs, it would be useful, for this study, and for thepurposes of clarity, to not only estimate the economic costs involved, but also, point outto whom these costs will fall upon, and what models (if any) exist to equitably divide these costs between the private and public sectors, at the local, state and national levels.

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Underwater Noise from Vessel Traffic to Endangered Species, and Southern Resident Killer Whales in Particular

Prepared By: Alexander Gillespie

January 12, 2013

The base problem and the need for a cumulative view

Each year, around 11,000 large vessels and oil barges transit to and from the San Juan Islands Figure 1). This figure includes over 1,322 oil tankers, each of which carries an average of 30 to 40 million gallons of crude oil. Around 4,300 of these large vessels are destined for United States' ports in Puget Sound. The other 6,250 make for Canadian ports.[1]

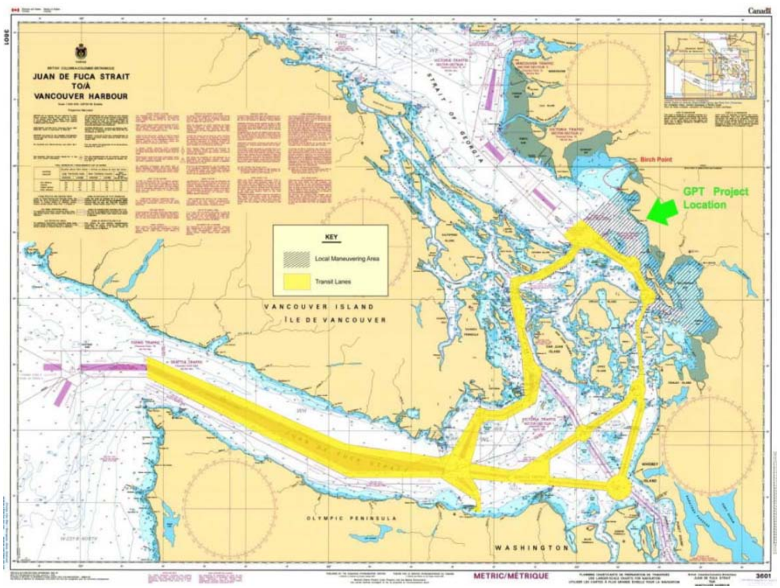

Figure 1. *Main shipping routes of Southern Puget Sound*

The proposed Gateway Pacific Terminal (GPT) will add approximately 440 ship transits per year, equating to a 4% increase to the 2011 traffic once it becomes operational. After it becomes fully operational, the GPT is projected to generate an additional increase of about 950 transits per year, or an increase of 9%, within 15 years.[2]This increase will be over and above other future expansion in other shipping operations. Impacts, in terms of emissions of underwater noise, from the specific increase in shipping from the development of the GPT needs to be understood and modeled. However, the impact assessment of the underwater noise must also evaluate the cumulative risks of all existing and projected transits through this area, as onlythis type of evaluation will reveal the true extent of the significant risk at hand. A cumulative assessment is required and essential as it will reveal risks that, while

[1] Hass, T. (2012). *The Vessel Traffic Risk Assessment for BP Cherry Point and Maritime Risk Management in Puget Sound*. (Puget Sound Partnership). 5.van Dorp, J.(2008). *Assessment of Oil Spill Risk due to Potential Increased Vessel Traffic at Cherry Point, Washington*. (Final Report - Submitted to BP : 8/31/2008**).**

[2] Pacific International Terminals, Inc. (2011). *Project Information Document, Gateway Pacific Terminal*, Whatcom County, Washington. 304 p. Also, *Vessel Entries and Transits: 2011* WDOE Publication 12-08-003 April 2012

perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework, may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk of noise pollution to the critical habitat of endangered species.[3]

In addition to the past, present and the currently proposed 8% increases in shipping traffic for the GPT development, the cumulative assessment should also scope the likely, further future additional expansions of vessel traffic in this area (even if they are not yet formal or approved proposals). This requirement is especially important when dealing with inter-related projects that will all utilize the same limited resource, in this case, shipping routes. That is, a forward projected assessment should also include data in the cumulative equation on traffic increases that can reasonably be foreseenincluding general increases in vessel traffic from other sources and also vessel traffic projections for other proposed major developments (including in Canada) that will need to use the same shipping route. This will greatly assist the authorities in providing the necessary information to achieve meaningful regional planning at a reasonable cost, in which uncertainties can be evaluated and effective, appropriate, and sustainable (in economic, social and environmental) choices can be made.[4]

It is essential to evaluate the cumulative impacts on vessel noise from the various port expansion projects through the Salish Sea including at minimum the twinning of the Trans Mountain pipeline and associated tanker traffic, expansion of the Delta Port container terminal as well as the Westshore Coal Terminal. However, it is also critical for the Corps to recognize the fact that if all five of the proposed coal terminals are built in the Pacific Northwest it would result in approximately an additional 2000 bulk carriers transiting through

[3] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002) (quoting Churchill County v. Norton, 276 F.3d 1060, 1072 (9th Cir. 2001).

[4] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States'. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'. *Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management'. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'. *Environmental Impact Assessment Review.* 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?' *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'. *International Journal of Environmental Studies.* 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673. http://www.aleutiansriskassessment.com/passing.htm

Unimak Pass in Alaska. This would approximately double the volume of traffic that currently ply through these biologically rich and vulnerable waters.

2. Indicators of significant risk

In order to be approved, the GPT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies that are indicators of significant risk. A summary of some of the more relevant standards are provided below:

- The Endangered Species Act.
- The Marine Mammal Protection Act
- In Winter v NRDC the Supreme Court of the United States recognized the need to regulate oceanic noise and its impact upon cetaceans.[5] Accordingly, it is now clear that, due to the importance of the Endangered Species Act and the Marine Mammals Protection Act, the significant impacts of underwater noise pollution on protected cetaceans must be considered and all possible attempts at mitigation and alternatives seriously examined, unless matters of utmost national security are involved.[6]
- The United Nations General Assembly called for scientific investigations into underwater noise pollution in 2010, a resolution supported by the United States.[7]
- The Parties to the International Whaling Commission (including the United States) have issued recommendations to control noise pollution around the critical habitats of some endangered whale species.[8]
- In 2008, the United States proposed that the International Maritime Organization begin to examine the issue of underwater noise from commercial shipping.[9]

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[5]Winter v. NRDC, 555 U.S. 7, 9 (2008). For a full discussion of this area, see Gillespie, A. (2012). 'The Limits of International Environmental Law: Military Necessity v. Conservation'. *Colorado Journal of International Environmental Law and Policy*. 32: 1.
[6]Horowitz, C. (2007). 'Precautionary Management of Noise: Lessons from the U.S. Marine Mammal Protection Act'. *Journal of International Wildlife Law and Policy,* 10:225–232.
[7]UNGA Resolution (2010) 64/71 Oceans and the Law of the Sea. Para 162.
[8](2004) 'The Western North Pacific Gray Whale' Resolution 1, IWC 56th Report, 66; (2005) 'The Western North Pacific Gray Whale' Resolution 3, IWC/57/25.
[9] See United States. (2008). Work Programme of the Committee and Subsidiary Bodies: Minimising the Introduction of Incidental Noise from Commercial Shipping Operations. MEPC 58/19. June 25.

- The Convention on Biological Diversity (CBD), to which the United States is not a signatory, called for scientific investigations into underwater noise pollution in 2010.[10]
- The Convention on Migratory Species (CMS), to which the United States is not a signatory, has urged Parties and non-Parties with jurisdiction over any part of therange of marine species listed in the appendices of CMS (which include Killer whales), or over flag vessels which areengaged within or beyond national jurisdictional limits, to take special care and, whereappropriate, endeavour to control the impact of emission of man-made noisepollution in the habitats of vulnerable species.[11]
- Similar recommendations to control noise pollution around cetaceans have been made by the Subsidiary Agreements to the CMS, to which the United States is not Party, including the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)[12] and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ACCOBANS).[13]

3. The particular species at risk: Southern Resident killer whales

Puget Sound is frequented by a number of marine mammal species including, *inter alia*, harbor seals, river otters, Steller sea lions, common minke whales and Dall's porpoise and habour porpoise. Humpback whales have also been recorded coming back to Haro Strait. Although many of these are of conservation concern, one sub-species in particular, the resident pods of Killer whales around the San Juan Islands known as the Southern Resident killer whale community (SRKW), are of a very high concern. The SRKW represent the smallest of four resident sub-species of Killer Whale within the eastern North Pacific Ocean. The SRKW comprises three pods (termed J, K and L). The SRKW population has fluctuated considerably over the 30 years that it has been studied. All three southern resident pods were reduced in number between 1965 and 1975 because of captures for marine parks. In 1974, the

[10](2010) 'New and Emerging Issues' Decision X/13.
[11](2008) 'Adverse Anthropogenic Marine/Ocean Noise Impacts On Cetaceans and Other Biota' Resolution 9.19.
[12] (2010) 'Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area Resolution 4.17. (2004) 'Assessment and Impact Assessment Of Man-Made Noise' Resolution 2.16.
[13](2003) 'Effects of Noise and of Vessels' Resolution 5.

group comprised 71 whales and it peaked at 97 animals in 1996, before falling to 86 as of the end of 2010.[14] Numbers may have fallen since then, as there were estimated to be fewer Killer Whale in the middle of 2012 than there were in the 2010 baseline year (N=83).[15]

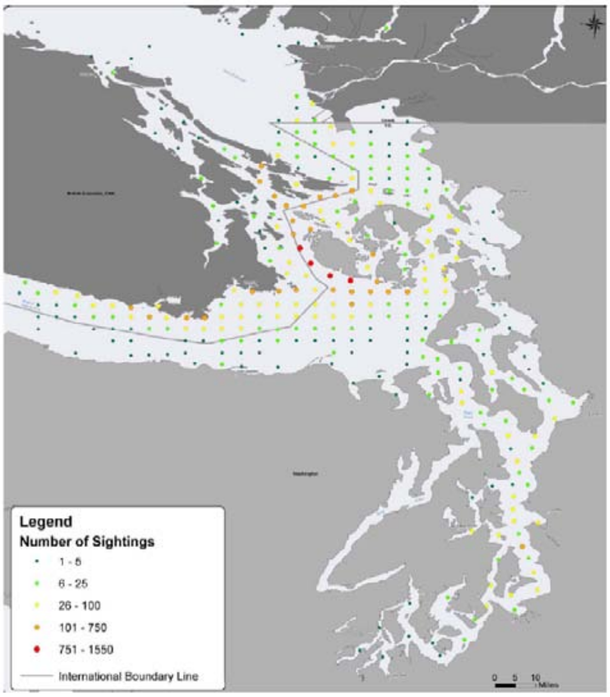

Figure 2. Distribution of Southern Resident killer whale sightings from 1990-2005.[16]

Due to being a distinct and significant population of very limited numbers, with a slow growth rate and low productivity,[17] after prolonged scientific and legal consideration,[18] the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration decided that SRKWs constituted a 'distinct population segment' that was endangered due to being 'threatened' with extinction, as per the 1973 Endangered Species Act (ESA).[19] This categorization was supplemental to their status as depleted (i.e., below its

[14] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle).
[15] Puget Sound Partnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24. NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). 2, 56-58.
[16] Source: NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). Figure 5. p. II-27. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]
[17] There is a limited number of reproductive-age Southern Resident males and several females of reproductive age are not having calves. This is a particular concern with the largest pod (L) with only three surviving females producing surviving female offspring in recent years.
[18] Center for Biological Diversity v. Lohn, 296 F. Supp. 2d. 1223 (W.D. Wash. 2003).
[19] Department of Commerce, NOAA, *Endangered Status for Southern Resident Killer Whales*. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

optimum sustainable population) under the Marine Mammal Protection Act (MMPA).[20] The national obligations upon authorities to conserve these species successfully are strengthened through both regional[21] and international conservation instruments, the latter through the International Convention for the Regulation of Whaling.[22]

The obligations imposed by all of these pieces of legislation mean that it is critical to protect the most important habitat on which a threatened/depleted species depends (Figure 2). This obligation is required under both the MMPA[23] and the ESA.[24] The designation of critical habitat[25] under the ESA is specifically focused upon the need to conserve habitat which is directly linked to the survival of the species. This designated habitat, which must not be destroyed or adversely modified, is well defined for the SRKW. Specifically, all pods use Haro Strait (i.e., west side of San Juan Island), particularly for transit. The southwest portion of San Juan Island is important for foraging and the southwest of Lopez Island is important for resting (as well as the south and west of Henry Island), whilst one pod (L) alone appears to frequent the area in the Strait of Juan de Fuca south of Vancouver Island.[26] In 2006, the NMFS designated critical habitat for SRKW as the Summer Core Area in Haro Strait and the waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca (which overall compromises approximately 2,560 square miles of marine habitat).[27] This critical habitat is shown in the following figure.

[20] 68 FR 31980; May 29, 2003.
[21] The Canadians concur that the SRKW are endangered.
[22] See Gillespie, A. (2006). *Whaling Diplomacy*. (Edward Elgar, London). Chapter 6.
[23] 'In particular, efforts should be made to protect essential habitats, including the rookeries, mating grounds, and areas of similar significance for each species of marine mammal from the adverse effect of man's actions'. See Section 2 (2). Findings and Declaration of Policy 16 U.S.C. 1361.
[24] *The 1973 Endangered Species Act*. Public Law 93–205, Approved Dec. 28, 1973, 87 Stat. 884; as Amended Through Public Law 107–136, Jan. 24, 2002. See section 4(2).
[25] The term ''critical habitat'' for a threatened or endangered species means the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of the ESA which are found as physical or biological features essential to the conservation of the species and which may require special management considerations or protection.
[26] National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 5.
[27] NOAA (2008). *Recovery Plan for Southern Resident Killer Whales*. (NOAA, Washington). II-67, 76-78.

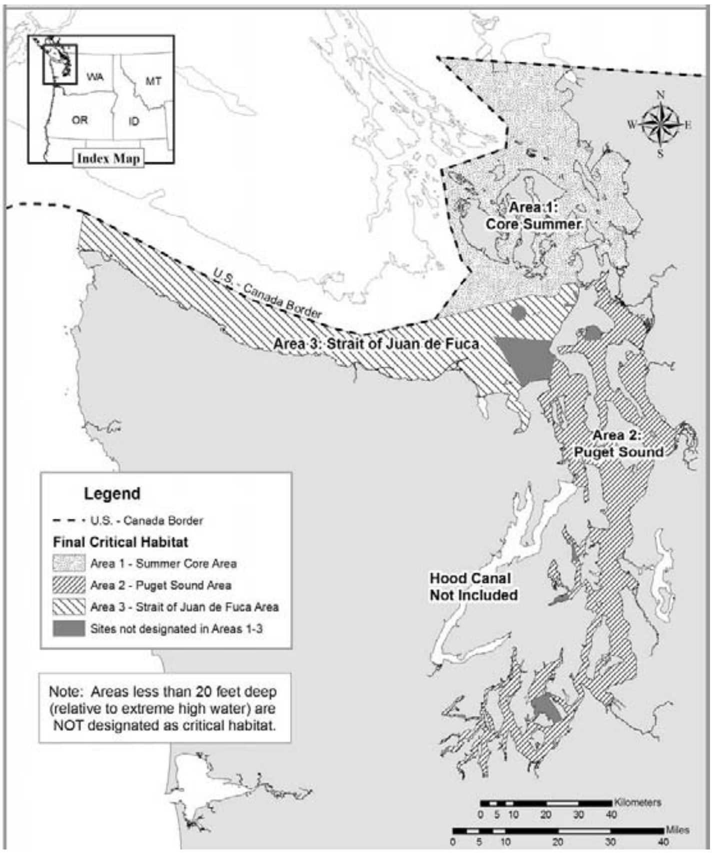

Figure 3. *Designated critical habitat for Southern Resident killer whales under the Endangered Species Act*[28]

4. The significant risk of underwater noise

Noise (i.e., sound) behaves differently in water than in air. Although the oceanis relatively opaque to light, it is relatively transparent to sound. Background, or ambient, noise occurs in all oceans and seas. Natural geophysical sources of noiseinclude wind-generated waves, earthquakes, precipitation, and crackingice. Natural biological sounds include whale songs, dolphin clicks, and fish vocalizations. Anthropogenic sounds are generated by a variety of activities, including commercial shipping, geophysical surveys, oil drilling and production, dredging and construction, sonar systems, and oceanographicresearch. Due to the physical properties of sound in water, low frequency noise can travel thousands of miles and thus can increase ambient noise levels in large areas of ocean. Moreover, as the oceans change in

[28] Source: NOAA (2008). *Recovery Plan for Southern Resident Killer Whales.* (NOAA, Washington). Figure 7. p. II-38. [*http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/upload/SRKW-Recov-Plan.pdf*]

terms of acidity, it appears that, in some areas, existing noise absorption of sound below 1 kHz, could be decreased by up to 40%.[29]

The conventional accounting of noise in the ocean suggests that the two largest contributors to the overall (space- and time-averaged) deep oceannoise budget are wind-generated ocean waves over the frequency band from 1 Hz to at least 100 kHz and commercial shipping at low frequencies (from 5 Hz to a few hundred Hz).Commercial ships generate external noise in the water via their shaft-line dynamics, propeller radiated pressures and bearing forces, air conditioning, cargo handling and mooring machinery, intakes and exhausts, and thrusters. However, it is engines, propellers, and vibration, all of which are directly related to the speed of the vessel, that are usually the principal sources of noise from vessels.[30]

In the Northern hemisphere, shipping noise is the dominant contributor in the band from 10 Hz to 200 Hz. In the Southern hemisphere, this band is less dominated by shipping given the significantly lower levels of shipping. In both hemispheres there is considerable spatial variation, with maximum ambient noise in this band being close to major shipping lanes.Shipping accounts for more than 75% of all human sound in the sea. It is estimated that from 1950 to 2000, there was a total increase of 16 dB in low-frequency noise in the oceans. This is unsurprising given that during this period the number of ships in the world tripled during the same time period. Given that shipping traffic is projected to grow in coming decades, so too is their expected contribution to underwater noise pollution. Shipping's contribution to ocean noise has been projected to increase greatly, especially in coastal areas, in the next 20 years.[31]

Noise pollution can produce detrimental impacts on all animals, including marine species. The most observable effect of noise on wild animals appears to be behavioral changes. Whilst many animals learn to differentiate among acoustic stimuli and to adapt and live with

[29]Brahic, C. (2008). ‘Hearing the Carbon Jolt Loud and Clear’. *New Scientist*. Sep 27. 10.
[30]Southall, B. (2005). ‘*Shipping Noise and Marine Mammals’*. Final Report of the National of the National Oceanic and Atmospheric Administration Symposium. (NOAA, 2004, May 18).
31 McDonald, M. (2006). ‘Increases in Deep Ocean Ambient Noise in the Northeast Pacific’. *Journal of the Acoustic Society of America*. 120: 711-718. Andrew, R. (2002). ‘Ocean Ambient Sound: Comparing the 1960s With the 1990s For a Receiver off the California Coast’. *Acoustics Research Letters Online*. 3 :65-70. National Research Council (2003). *Potential Impacts of Ambient Noise in the Ocean on Marine Mammals* (National Academies Press, Washington). 3. ICES Advisory Committee on Ecosystems (2005). *Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish* (AGISC). ICES CM 2005/ACE:06 (2nd Edn). at 3. Heitmeyer, R. (2004). ‘Shipping Noise Predictions: Capabilities and Limitations’. *Marine Technology Society Journal*. 37: 54-65.

different types of noise pollution, others have gone in the opposite direction, and have shown strong sensitivities to noise pollution.[32] Within the marine environment, evidence of significant impacts has been steadily accumulating since the first study on this topic in 1971.[33]

Some species of fish appear to also be impacted by some sources of noise pollution. Most fish species hear noise sounds from below 50 Hz up to between 500-1,500 Hz. If excessive noise overlaps with a species' hearing band, especially if the noise is repeated and at close range, long-term biological damage can result if the fish species does not move away from the source. Additional evidence also suggests that the survival rate of eggs and larvae of a number of fish species, when exposed to sound levels of 120 dB or above, *may* show statistically significant decreases.[34]

The relationship between underwater noise and marine mammals is much stronger than it is with fish because the acoustic output of underwater noise at relatively low frequencies of 10 to 200 Hz, overlaps extensively with the low frequency sound produced by baleen whales in the 12 to 500 Hz bandwidth. Studies suggest that the effects of this overlap span from negligible to fatal. At the fatal end, a few cases of beaked whale strandings appear to have

32 Hopkins,C. (1979). 'Effects of Noise on Wildlife'. 29 *Bioscience* 547.

33Payne, R. (1971). 'Orientation by Means of Long Range Acoustic Signaling in Baleen Whales'. 188 *Annual New York Academy of Sciences* 110–141.

[34]Popper, A. (2009). 'The Effects of Human Generated Noise on Fish'. 4 *Integrative Zoology*. 43–52. Popper, A. (2006). 'The Effects of Anthropogenic Noise on Fish'. 28 *Fisheries* 24–31. ICES Advisory Committee on Ecosystems (2005). *Report of the Ad-hoc Group on the Impacts of Sonar on Cetaceans and Fish*. (AGISC). ICES CM 2005/ACE:06 (2nd edn). Popper, A., et al. (2005). 'Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species'. *Journal of the Acoustical Society of America* 117(6): 3958–71. Popper, A.N., et al. (2005). 'Effects of Low Frequency Active Sonar on Fish' *Journal of the Acoustical Society of America 117:* 2440. Popper, A.N., et al. (2004). 'Anthropogenic Sound: Effects on the Behavior and Physiology of Fishes' 37(4) *Marine Technology Soc. J.* 35–40. Smith, M., et al. (2003). 'Noise-induced Stress Response and Hearing Loss in Goldfish. The *Journal of Experimental Biology.* 207. Popper, A. (2003). 'Effects of Anthropogenic Sounds on Fishes'. 28(1) *Fisheries* 24–31. Fewtrell, J., et al. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. *Journal of the Acoustical Society of America* 113(1): 638. McCauley, R. (2003). 'High Intensity Anthropogenic Sound Damages Fish Ears'. *Journal of the Acoustical Society of America* 113(1): 631–42. Banner, A. (1973). 'Effects of Noise on Eggs and Larvae of Two Estuarine Fishes'. *Transactions of the American Fisheries Society* 134–36. Kostyuchenko, L.P. (1973). 'Effects of Elastic Waves Generated in Marine Seismic Prospecting of Fish Eggs'. 9(5) *The Hydrobiology Journal* 45–48. Filadelfo et al. (2009). 'Correlating Military Sonar with Beaked Whale Mass Strandings: What do the Historical Data Show? *Aquatic Mammals* 35(4): 435-444. Frantzis (1998). 'Does Acoustic Testing Strand Whales? *Nature* 392(29).

coincided with seismic surveys and military sonar.[35] However, for most species, the extent of the impacts remains mostly or completely unquantified and is still being evaluated.[36]

With particular regard to Killer whale , there is good evidence that this species is impacted upon by various types of vessel noise.[37]Some of the sources of impacts identified during the listing of the SRKW as an endangered species, were commercial shipping, whale watching, ferry operations, and recreational boating traffic and all were linked to short term behavioral changes in this protected species.[38] Subsequent studies have confirmed that vessel noise has the capacity to mask the critical needs of the SRKW by, 'significantly reduc[ing] the range at which echolocating killer whales could detect salmon in the water column'.[39]

Despite the emerging scientific evidence of a potentially significant risk for SRKW in the Puget Sound area, there are a number of uncertainties that need to be resolved with respect to these Killer whale. These uncertainties pertain to, *inter alia*, basic physiology, potential intra-specific variation and responses to different levels of noise. That is, unlike some other cetaceans, Killer whales appear to have a greater reliance on ranges in the 1 khz – 10 khzband,

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[35]Parsons, E. et al. (2007). 'The Conservation of British Cetaceans: A Review of Threats and Protections'. 13 *Journal of International Wildlife Law and Policy* 29–33. Nieukirk, S. (2004). 'Low Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean'. 115 *J. Acoust. Soc. Am*. 1832–1843. Malakoff, D (2002). 'Suit Ties Whale Deaths to Research Cruise'. *Science* 298. Palacios. D., et al.. 2004. Cetacean Remains and Strandings in the Galápagos Islands, 1923-2003. 3(2) *Latin American Journal of Aquatic Mammals* 127–150.

[36]OSPAR (2009). *Assessment of the Environmental Impact of Underwater Noise* (OSPAR Commission, Paris, Publication Number 436/2009).McDonald, M. (2006). 'Increases in Deep Ocean Ambient Noise in the Northeast Pacific'. *Journal of the Acoustic Society of America*. 120: 711-718. National Research Council. (2005). *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. (National Academies Press, Washington). National Research Council. (2000). *Marine Mammals and Low-Frequency Sound: Progress Since 1994.* (NRC, Washington). National Research Council. (2003). *Potential Impacts of Ocean Noise*. (NRC, Washington). Hecht, J. (2005). 'Quest for Oil Could Injure Marine Life'. *New Scientist*. Aug 20. p.14. Edwards, R. (2003). 'Sonar Kills Whales.' *New Scientist.* Oct 11. p.10. Jones, N. (2003). 'Is Undersea Noise Harming Whales ?' *New Scientist.* Feb 22. p.8. Doleman, S. (2002). 'Noise Sources in the Cetacean Environment.' SC/54/E7 (unpublished report to the Scientific Committee of the IWC, 2002). Anon. (2002). 'Not So Pacific Ocean.' *New Scientist*. March 30. p.23. Marks, P. (2000). 'Cracking Up: Is the Din in the Arctic a Headache for Beluga Whales ?' *New Scientist.* September 30. p.12. Hrynyshyn, J. (2001). 'Going Round the Bend.' New Scientist. Dec pp.15. pp.17. Holmes, B. (1997). 'Noises Off.' *New Scientist.* March 22. p.24-27. Anon. (2005). 'Sonar Lawsuit'. *New Scientist*. Oct 29. p.4.

[37]Slaughter, G. (2011). 'The Impacts of Sound Pollution on Killer Whales'. *Canadian Geographer*. 131(6): 17-20. Holt, M. et al. (2009). 'Speaking Up: Killer Whales (Orcinus orca) Increase Their Call Amplitude in Response to Vessel Noise'. *Journal of the Acoustical Society of America (JASA) Express Letters*. 125: EL27-EL32.Malene, S. (2007). 'The Relationship Between Acoustic Behavior and Surface Activity of Killer Whales That Feed on Herring'. *Acta ethologica* 10(2): 47-53. Williams, R. (2006). 'Estimating Relative Energetic Costs of Human Disturbance to Killer Whales'. *Biological Conservation*. 133(3): 301-311. Boisvert, I. (2004). 'Puget Sound Orcas, Vessel Noise, and Whalewatching'. *Ocean and Coastal Law*. 10(1): 117-130. Morton, A. (2002). 'Displacement of Orca by High Amplitude Sound in British Columbia, Canada'. *ICES Journal of Marine Science*. 59(1): 71-80. Szymanski, M. et al, (1999). 'Killer Whale (Orcinusorca) Hearing: Auditory Brainstem Response and Behavioral Audiograms'. *Journal of the Acoustical Society of America* 106 (2): 1134-1141.

[38]Department of Commerce, NOAA, *Endangered Status for Southern Resident Killer Whales*. 50 CFR Part 224. Final Rule. As printed in the Federal Register/Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

[39]National Marine Fisheries Service (2011). *Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 10-11.NOAA (2008). Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). II-107. Anon. (2004). 'Boats Drown Out Orcas Cries.' *New Scientist*. May 1. p.19.

where most of the energy in orca calls resides and in the 10khz-30khz where most of the energy in their echolocation clicks resides. This inter-relationship between the Killer whale and these bands of underwater noise is different to some other cetacean species as much higher frequencies of noise, where the negative relationship is much more direct. In the instance of the Killer whale, the science required needs to show what are the ‘safe’ levels for this species in both the short- and long-term, and the question of at what point does noise pollution become ‘biologically significant’ needs to be addressed.This last area of uncertainty is critical because it relates to the issue of when noise may induce long-term abandonment of an area important for feeding, breeding or rearing the young, leading to a reduction in fecundity, carrying capacity, or both. It may be that these long-term but less apparent impacts directly impact on efficiencies in foraging, navigating or communicating over the long-term. These same impacts can in turn directly impact upon reproductive success and, therefore, it is possible that these long-term but less apparent impacts are the defining features for the survival of the SRKW and must be examined.[40] There is good evidence of this outcome for marine mammals in that the cumulative impacts of long-term but low level impacts (i.e. tourism and disturbance) have been shown to directly affect key demographic parameters and lead to both population decline and reduced population viability for small populations.[41]

5. Alternatives

The most obvious alternative available to attempt to reduce the impact of underwater noise from existing, proposed and future shipping traffic is the selection of alternative routes which would reduce, not increase, the esonification of the critical habitat of the SRKW. This search for alternative routes would be consistent with the jurisprudence in this area which requires

[40]ICES Advisory Committee on Ecosystems (2005), ibid, 15-17, 36-37. National Research Council. (2005), ibid, at 3. National Research Council. (2003). Potential Impacts, ibid, at 4-7. National Research Council.(2000), ibid, at 3.Department of Commerce, NOAA, Endangered Status for Southern Resident Killer Whales. 50 CFR Part 224. Final Rule. As printed in the Federal Register /Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907. National Marine Fisheries Service (2011).*Southern Resident Killer Whales: Five Year Review* (NMFS, Seattle). 8- 9. NOAA (2008).Recovery Plan for Southern Resident Killer Whales. (NOAA, Washington). V-14-15. Note also the earlier comments by the Department of Commerce, NOAA, Endangered Status for Southern Resident Killer Whales. 50 CFR Part 224. Final Rule. As printed in the Federal Register/Vol. 70, No. 222 / Friday, November 18, 2005 /Rules and Regulations 69907.

[41]Bejder et al. (2006). ‘Decline in Relative Abundance of Bottlenose Dolphins (*Tursiops*sp) Exposed to Long-Term Disturbance. *Conservation Biology*. 20 (6), 1791–1798. Bejder et al. (2006).‘Interpreting Short-Term Behavioural Responses to Disturbance within a Longitudinal Perspective’.*Animal Behaviour*. 72 (5): 1149-1158. Lusseau.&Bejder (2007).‘The Long-term Consequences of Short-term Responses to Disturbance’.*International Journal of Comparative Psychology* (Special Issue) 20: 228-236.

the meaningful exploration of alternative sites that are not, 'uniquely populous' or 'biologically important'.[42]

6. Mitigation

Technology has a very important role to play in the reduction of under-water noise pollution. Some vessels are already very noise sensitive, such as those involved in research, luxury travel or military work. Basic ship design and construction and choice of machinery can result in large reductions in noise emissions. This outcome is especially so in terms of the propellers, hull shapes and other methods necessary to counter vibration and associated noise problems.[43]

Despite the desirability of long-term technological change to improve noise emissions, these changes are unlikely to occur in the shorter term and therefore more immediate mitigation options are required. For immediate improvements in risk reduction, the foremost options that need to be examined are restricted times of entry for the dominant noise sources at key points of the year in the critical habitats. Such quiet zones, as NOAA originally recognized when it proposed to have a half-mile wide no-go zone along the west side of San Juan Island from May 1 through to the end of September,[44] need to be carefully re-examined.

A secondary form of mitigation relates to situations where the vessels cannot be excluded completely from critical areas at key times then they are obliged to operate in a manner which minimizes their noise emissions. The foremost method for this form of mitigation is to ensure that vessels operate at a reduced speed, thereby reducing the risk of both collision and noise impacts. The most recent example of utilizing speed restrictions with regard to the protection of endangered cetaceans involved North Atlantic Right Whales whereby vessels of 65 feet and greater in length have been obliged to travel at 10 knots or less near key port entrances and in certain areas of Right Whale aggregation along the U.S. eastern seaboard, known as

[42]See, in particular, NRDC v. Evans, 316 F.3d 904, 907 (9th Cir. 2003). .
[43]Eyres, D. (2006).*Ship Construction*. (BH Publishing, London). 36-39. Wijngaarden, E. (2005).'Recent Developments in Predicting Propeller-Induced Hull Pressure Points'.In Lloyds Maritime Academy. (ed). *First International Ship Noise and Vibration Conference*. (Lloyds, London). 17-23. Barrass, C. (2002).*Ship Design and Performance*. (Elsevier, London). 83-92. Rawson, K. (2005).*Basic Ship Theory*. (BH Publishing, London). 408-422.
[44]NOAA (2011).'New Rules to Safeguard Puget Sound's Killer Whales'.Press Release. April 14.

"Seasonal Management Areas".[45] These developments have been mirrored at the regional level, with similar attempts being undertaken to have 10 knot speed limits for vessel traffic within their national marine sanctuaries along the Californian coast.

6. Recommended research programs

Based on the assessment in this report of the various risks posed by increased shipping to and from the proposed GPT and the cumulative impacts of all of the shipping in the region, and a consideration of potential mitigation options, six research programs are recommended to help in understanding and evaluating the cumulative impacts in this area. Four research programs are required for decision makers to reach a full and informed decision with regards to assessing the significant risk of an underwater noise pollution in this region to endangered species. A further two studies are required to assess the possibilities and potential effectiveness of mitigations in this area.

Research programs to support decision makers

(i). A noise map is required of the critical habitat of the endangered SRKW and their critical habitat that may be significantly impacted upon by the transit of vessels. This map should be founded upon the existing baseline levels, the current proposed incremental increase proposed for the GPT, and the additional future traffic (from a cumulative perspective) that may be reasonably foreseen. The particular facts that must be collected from this study include:

- Quantification of underwater noise levels by existing, future and projected traffic. Whilst being aware of historic patterns, and differences between vessel types (e.g., cargo ships, passenger vessels, barges, tugs, tankers, fishing vessels, whale-watching vessels), the study should also differentiate between locations, operating conditions, and times of data collection)
- Focus on the noise frequencies of particular concern to the SRKW, in particular, within the range of 1khz-30 khz.

[45] Silber, G. (2012). *An Assessment of the Final Rule to Implement Vessel Speed Restrictions to Reduce the Threat of Vessel Collisions with North Atlantic Right Whales*.(US Department of Commerce, NOAA, Washington.NOAA Technical Memorandum NMFS-OPR-48.

- Differentiation between a comparable underwater situation of killer whales that are not being disturbed, and juxtaposition to the current, proposed and future expectations
- Measurements should be both constant and the coverage extensive

(ii).The levels of noise at which impacts approach biological significance should, as far as possible, be identified for the SRKW.

(iii). Once these levels of biological significance have been ascertained, the locations where these levels should not be transgressed should be identified, in addition to adequate safety zones (i.e., buffers). These locations should then be overlaid with the current, proposed and reasonably foreseeable (from a cumulative perspective) noise levels.

(iv). Research should be undertaken on the potential impacts of the noise levels on other marine species in this area, including, in particular, the Chinook and Chum salmon.

Research programs to investigate mitigation options

(v). A study should be undertaken to see if there are any possible alternative routes for vessel traffic that could be utilized to minimize noise impacts on SRKW.

(vi). Research on noise generated from shipping should be investigated to ascertain if there are improvements that can be made in reducing noise from shipping through operational practices such as reducing speeds and prioritizing ship traffic away from critical habitats.[46]

[46]NOAA (2004). Final Report of the 2004 NOAA symposium *Shipping Noise and Marine Mammals.*

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk and Management of Coal Dust

Prepared By: Alexander Gillespie

January 13, 2013

1. The base problem

Coal dust is an odorless, fine powdered form of dark brown to black dust created by the crushing, grinding, or pulverizing coal.[1] Its most explosive risk is in combustion and flammability. Coal dust also possesses the ability to cause, longer term, detrimental impacts upon both humans and animals. These impacts may appear wherever coal is obtained, stockpiled and, particularly, when it is transported, dumped or otherwise handled (e.g. loading, unloading). At all of these stages there is thelikelihood for the release of small particulate matter (i.e., dust) in significant quantities. Particulate matter, also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust (including coal dust) particles. The size of particles is directly linked to their potential for causing health problems. The EPA is particularly concerned about particles that are 10µm[2] or smaller in diameter because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

The proposed Gateway Pacific Terminal (GPT) at Cherry Point is estimated to have a capacity of approximately 54 million metric tons of goods annually, of which 48 million tons would be coal. If the GPT development goes ahead, it will be the largest coal exporting site in North America. To achieve these figures there will be an 80 to 105acre stockyard at Cherry Point for the storage of coal, other cargo and associated machinery. One of the significant impacts from the proposed terminal, in addition to the direct impacts from the construction of the facility and associated transportation infrastructure, will be the escape of coal dust into the environment. This dust will come from the stockpiled coal itself, escape when coal is being unloaded from the train and moved onto ships. While the developers have proposed some mitigation measures to try to address coal dust emissions, they cannot guarantee that 100% of coal dust will be contained within the facility.

[1]Commonly, it is identified by its content of silicon dioxide which is most commonly found in nature with sand or quartz, with it containing less than 5% of free silica.
[2]One µm is a measure of length and is one-millionth of a metre (or 1/34 millionth of an inch)

The primary driving force for the creation of coal dust will be wind as stockpiled coal provides an erodible surface for the wind generation of particulate matter emissions. Such dispersals of dust from coal piles are primarily governed by conditions with fluctuating wind rather than wind with constant flow rate. The characteristics of fluctuating wind depend on the weather (e.g., wind speed, wind direction, stability), terrain roughness and particle size with smaller sized particles being much more likely to become airborne than heavier ones.[3] According to the Naval Research Laboratory, the Puget Sound region experiences two primary wind regimes. The most significant occurs in late Autumn, Winter, and early Spring, when southerly winds prevail. Most of the southerly winds occur in advance of approaching low pressure/frontal systems moving eastward across the Pacific Ocean. Sustained winds of 23-38 mph are commonly experienced. Gale velocities (39-54 mph) may occur in advance of the stronger low pressure/frontal systems. Storm force (>55 mph) winds are only rarely observed. An additional high wind event occurs occasionally during the winter season when a very intense cold front (referred to as an Arctic front) moves southward into northern Washington State. When the cold continental polar air mass behind the front reaches southern British Columbia, it flows southwestward through the Fraser River Valley and accelerates toward Bellingham. Gale force (39-54 mph) northeasterly winds at Bellingham and very cold temperatures are not uncommon with such an event.[4]

The purpose of this document is to describe the potential impacts of coal dust emissions from the proposed GPT and provide insights into what data would be needed to evaluate these impacts. Local emissions from these rail sources (e.g., unloading and general coal dust emissions from wagons while the trains are present at the terminal) would also need to be included in the cumulative estimation of total levels of escaping coal dust emissions for the terminal.

[3] US Environmental Protection Agency (2006). AP 42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.2.5 Industrial Wind Erosion, Technology Transfer Network, Clearinghouse for Inventories & Emission Factors. http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0205.pdf. Also, Vrins, E. et al. (1998). ‘Monitoring and Control of Fugitive Coarse Dust Sources’. *Journal of Aerosol Science*. 29: 709-740. Vrins, E. (1996). ‘Sampling Requirements for Estimating Fugitive Dust Emissions’. *Journal of Aerosol Science*. 27(l.): 571-572. Visser, G. (1992). ‘A Wind Tunnel Study of Dust Emissions’. *Atmospheric Environment* 26: 1453-1460.

[4] Naval Research Laboratory (1996). *Puget Sound Area Heavy Weather Port Guide.* (NRL, California). Section 3.1.

2. Indicators of significant risk

In order to be approved, the GPT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies that are indicators of significant risk. A summary of some of the more relevant standards are provided below:

- The Clean Air Act and associated National Ambient Air Quality Standards (NAAQS)
- Associated standards for the Prevention of Significant Deterioration regulations, and the State Implementation Plan.
- Associated standards promulgated by the North West Clean Air Agency (NWCAA) and Puget Sound Clean Air Agency (PSCAA)
- The Endangered Species Act
- The Fish And Wildlife Coordination Act
- The Magnus-Stevens Fishery Conservation and Management Act-Essential Fish Habitat
- The Pacific Salmon Treaty
- The Clean Water Act
- The State Water Pollution Control Act
- The Shoreline Management Act of Washington State.

3. The significant risks of coal dust associated with the stockpile

Evidence suggests that the prolonged spread and settlement of coal dust on natural environments may have a discernible impact, and that this may be detrimental to non-tolerant species.[5] Within the marine environment, evidence of the impact of rising rates of coal-dust related pollutants from airborne sources is still emerging.[6]However, what is clear is that over time, the concentration of fugitive coal particles that escape from point sources (e.g.,

[5]Spencer, S. (2001). 'Effects of Coal Dust on Species Composition of Mosses and Lichens in an Arid Environment'. *Journal of Arid Environments* 49: 843-853. Spencer, S. (1997). 'Effects of Coal Dust on Plant Growth and Species Composition in an Arid Environment'. *Journal of Arid Environments* 37: 475–485.
[6]Bounds, W. (2007). 'Arsenic Addition to Soils from Airborne Coal Dust Originating at a Major Coal Shipping Terminal'. Water Air Soil Pollution (2007) 185:195–207.

industrial loading and storage facilities) via both normal operations and natural assistance (such as wind drift). These particles are likely to settle and accumulate around various points, into the ocean.[7]Although the implications of this evidence for species in the local environment are still being ascertained, further evidence suggests that at least three species of juvenile salmon (including Chinook and Chum), which use habitats which were detrimentally modified by a coal port, suffered a detrimental impact.[8]The importance of this linkage is in the fact that the Chinook salmon of Puget Sound **(**including the Straits of Juan De Fuca) is explicitly recognized as threatened with extinction, and listed under the ESA.[9]One of the populations of Chum salmon(Hood Canal), also resident in the Puget Sound, has been listed under the ESA as well.

The Chinook salmon of Puget Sound **(**including the Straits of Juan De Fuca) is explicitly recognized as threatened with extinction and it is listed under the ESA.[10] The Chinook is also subject to further conservation considerations under Fish and Wildlife Coordination Act, the Magnus-Stevens Fishery Conservation and Management Act-Essential Fish Habitat,[11] and international conservation efforts under the 1985 Pacific Salmon Treaty.[12]When this treaty was updated in 2008, new fishing regimes came to encompass, *inter alia*, Chinook Salmon and included responsibilities which sought to preserve the biological diversity of the Chinook resource and contribute to the restoration of currently depressed stocks by improving their abundance, productivity, genetic diversity and spatial structure over time.[13]

As a species listed under the ESA, both the Chinook and the Chum salmon have critical habitat that must be protected.[14]In this regard, the Puget Sound Salmon Recovery Plan[15] has placed considerable emphasis upon the restoration of the most important habitats of the Chinook salmon in this region, including amongst others, estuaries, floodplains, riparian

[7]Johnson, R. (2006). 'Coal Dust Dispersal Around a Marine Coal Terminal (1977–1999), British Columbia: The Fate of Coal Dust in the Marine Environment'. *International Journal of Coal Geology* 68: 57–69.
[8]Levings, C. (1985). 'Juvenile Salmonid Use of Habitats Altered by a Coal Port in the Fraser River Estuary, British Columbia'. *Marine Pollution Bulletin,* 16(6): 248 -254.
[9] See NOAA, *Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead*. 50448 Federal Register / Vol. 76, No. 157 / Monday, August 15, 2011 / Proposed Rules.
[10] See NOAA, *Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead*. 50448 Federal Register / Vol. 76, No. 157 / Monday, August 15, 2011 / Proposed Rules.
[11] Public Law 94-265.
[12]*The Treaty Between the Government of Canada and the Government of the United States of America Concerning Pacific Salmon*. See in particular, article 3.
[13] See chapter 3 of Annex IV of the Treaty.
[14] See http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/chinooksalmon.pdf
[15] National Marine Fisheries Service (2007). *Puget Sound Salmon Recovery Plan* (NOAA, Washington).

areas and particularly important nearshore (i.e., shoreline and marine) areas. In this regard, there has been considerable success with approximately 2,350 acres of habitat restoration projects being completed from 2007 to 2011 in the 16 major river delta estuaries.[16]While this habitat restoration work is to be commended, the risks of a substantial vessel accident upon this habitat must be assessed.[17]The main issue that needs to be evaluated is whether the proposed GPT will impact upon the critical habitat of the Chinook salmon and whether the proposal would lead to an impact on any of the other important elements in the local food web. Specifically, this evaluation must be undertaken in relation the local sea-grass communities around Cherry Point and the herring that exists within it, and whether these elements are essential for the conservation success of the Chinook. It is particularly important to examine this as the evidence suggests that Cherry Point herring biomass remains at critically low levels with no sign of recovery.[18]

4. Alternatives

Coal stockpiles should not be placed in areas of high wind. Alternative, more settled locations, should always be sourced as the overt primary threat in all locations of stored coal, is wind strength and its persistence. That is, if coal stockpiles are in the wrong location, no amount of mitigation will stop the release of coal dust. As such, the first alternative must always be that where possible, the site should not be placed in a location with excessive amounts of wind.[19]

5. Mitigation

As far back as 1941, scientists have expended a great amount of effort in trying to understand and control the impact of wind upon particulate matter which can become airborne.[20]Many examples can be cited including the prevention of desert expansion and farmland erosion but of most relevance to this assessment is the examination of airborne coal dust emissions. The main focus of these investigations has been upon efforts to keep wind off the material which

[16] PugetSoundPartnership (2012). *The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24.
[17] Ibid.
[18]PugetSoundPartnership (2012).*The 2012 State of the Sound: A Biennial Report on the Recovery of Puget Sound*. (PSP, Seattle). 22, 24.
[19]Cowherd, C. (1981).‘Control of Windblown Dust from Storage Piles’.*Environment International*. 6: 3
[20] Bagnold, R., 1941. The Physics of Blown Sand and Desert Dunes. (Methuen, London).

is volatile to being made airborne. Various mitigation options are available in this area (e.g., moisture, wind-breaks, pile geometry and management of the pile) that can, when combined, provide limited protection for a period of time. That period of time is always dependent on the elements that the stockpile is exposed to. Each of these mitigation measures should be critically examined.

Surfactants and wetting

One method that is being used more and more to reduce dust emissions is to ensure that the coal is made moist so that the particles are affixed to the bulk material. All tests show a strong response in reduction of dust emissions with increasing total moisture content. Each coal exhibits a critical moisture content around which no emissions occur. Assuming the correct amount and type of moisture is applied to the correlated particle then dust, if it is not exposed to excessive wind, can be greatly reduced. A similar alternative is to spray the coal with a surfactant or protective layer, such as polyoxyethylene and polyglycerol-based nonionic surfactants. This is achieved through using a water additive that forms a skin over the coal, thereby, keeping the dust in. If applied effectively, dust emissions can be reduced, in theory, by between 80 to 99%.[21]However, both water and protective layers can be negated by opposing forces of wind and excessive moisture (i.e., rain). If these forces are superior to the bonding agents, the fugitive dust will continue to escape, typically, downwind. While this approach is used on loaded coal wagons, surfactants other than standard water are not generally used on coal stockpiles but this issue should be examined. In particular, whilst looking at the option of wetting, it will be necessary to study the impacts of the water required, in terms of both quantity, quality and the indirect effects this may have on associated ecosystems.

Wind barriers

The second mitigation option is the utilization of barriers, such as fencing, bunding, shelter-belts or windbreaks to prevent the potentially volatile material from becoming airborne. Evidence already suggests that if wind barriers are made of appropriate materials, are set at appropriate heights and depths (more than one layer), and configurations (e.g., rectangles,

[21]Keystone Environmental (2011).*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (Office of Environment and Heritage, KE1006953, NSW).Kim J. (1994). ‘The Effect of Added Base on Coal Wetting Ability of Non-ionic Surfactant Solutions Used for Dust Control’.*Mining Engineer*, 154: 151-155. Smitham, J. (1991). ‘Physico-Chemical Principles Controlling the Emission of Dust from Coal Stockpiles’.*Powder Technology*. 64(3): 259-270..

octagons, open boxes, etc.) they can be effective in controlling the spread of dust, with success rates (in ideal conditions)of up to 85%.[22]However, in order to achieve such high levels of mitigation, barriers must be optimally designed for the local conditions and built and maintained to a high standard.

Stockpile geometry

The third mitigation to be investigated is the geometry of the pile. The geometry of the stockpile (especially including the height, size, compaction and primary shape facing the dominant wind direction)can have a strong impact upon the amount of coal dust that is generated, with differences ranging from between 13 and 60% reductions in emissions (in ideal situations) when the correct shape is utilized.[23] However, as identified previously, to achieve these levels of mitigation, stockpiles must be optimally designed for the local conditions and continuously maintained to a consistently high standard.

Minimizing disturbance

The fourth mitigation is to ensure that already settled piles are disturbed as little as possible, as, over time, the surface of an undisturbed stockpile will become depleted in erodible material and emissions of particulate matter will reduce. If stockpiles are frequently disturbed, fresh surface material will be exposed, restoring the erosion potential and the problem will continue repeating itself. With respect to the handling of coal from the trains to the stockpiles, or the port to the vessel, best practice measures to control emissions are the

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[22]Cong, X. (2011).'Impact of the Installation Scenario of Porous Fences on Wind-Blown Particle Emission in Open Coal Yards'.*Atmospheric Environment* 45 (2011) 5247e5253. Cheng, Y. (2010). 'An investigation into the sheltering performance of porous windbreaks under various wind directions'.*Journal of Wind Engineering and Industrial Aerodynamics*. 98: 520–532. Park, C. (2003). 'Experimental Study on Surface Pressure and Flow Structure Around a Triangular Prism Located Behind a Porous Fence'. *Journal of Wind Engineering and Industrial Aerodynamics* 91(1): 165–184. Lee, S. (2002). 'Wind Tunnel Observations about the Shelter Effect of Porous Fences'.*Atmospheric Environment* 36: 1453–1463. Park, C. (2002). Verification of the shelter effect of a windbreak on coal piles in the POSCO open storage yards at the Kwang-Yang works'.*Atmospheric Environment* 36: 2171. Lee, S., (1999).Laboratory Measurements of Velocity and Turbulence Field Porous Fences.*Journal of Wind Engineering and Industrial Aerodynamics* 80: 311–329. Stunder, B., (1988). 'Windbreak Effectiveness for Storage Pile Fugitive Dust Control'.*Journal of the Air Pollution Control Association* 38: 135–143. Borges, A., (1988). Shelter Effects on a Row of Coal Piles to Prevent Wind Erosion'.*Journal of Wind Engineering and Industrial Aerodynamics* 29: 145–154. US Environmental Protection Agency (1986), *Field Evaluation of Windscreens as a Fugitive Dust Control Measure for Material Storage Piles*, Document EPA/600/S7-86/027. Billman, B (1985). *Windbreak Effectiveness for Storage-Pile Fugitive Dust Control*.USEPAReport No. EPA/600/3 - 85/059.

[23]Cong, X. (2012).'Effect of aggregate stockpile configuration and layout on dust emissions in an open yard'.*Applied Mathematical Modelling* 36: 5482–5491. Turpin, J. (2009). Numerical Modeling of Flow Structures over Various flat-Topped Stockpiles Height: Implications on Dust Emissions'. *Atmospheric Environment* 43: 5579–5587. Torano, R. (2007). 'Influence of the pile shape on wind erosion CFD emission simulation'. *Applied Mathematical Modelling* 31: 2487–2502.Badr, T. (2007).'Effect of Aggregate Storage Piles Configuration on Dust Emissions'.*Atmospheric Environment* 41 (2007) 360–368. Badr, T. (2005). 'Numerical Modelling of Flow Over Stockpiles: Implications on Dust Emissions'. *Atmospheric Environment* 39: 5576–5584.IEA Coal Research (1994).*Control of Coal Dust in Transit and in Stockpiles.* (IEA, London).

use of volumetric loading from an overhead silo or bin with a telescopic chute with the entire activity enclosed within a set space.

Cover

While not commonly used for large coal stockpiles, an alternative that would reduce coal dust emissions by 100% is by storing it under cover. The largest industrial structures have a useable floor area of between 2 and 4+ million square feet (i.e., 98 acres) with useable volumes of 250-470+ million cubic feet[24]. While the cost of building such a facility would be considerable, there are equivalent precedents with the storage of other bulk items such as grain that must be kept under cover, generally in silos or bins, to keep it dry. Such an alternative should at least be considered as it should be for the covering of coal wagons during transport. Together, these options would reduce coal dust emissions for transport and storage to nearly zero.

6. Recommended research programs

Based on the assessment of the various risks posed by coal dust from the proposed GPT and a consideration of potential alternatives and potential mitigation options that are contained in this report, four research studies are recommended to assist in developing an understanding and evaluation of the impacts of the GPT.

(i). The first study that should be undertaken relates to the rate of coal dust emissions from stock piles, in addition to other local sources, such as conveyor belts, as well as emissions from rail sources within the terminal (e.g., unloading). With regards to the primary risk that are the coal stockpiles, this will require examination of geometry of the stockpile, how often they are moved (including reshaping, compacting and maintenance by bulldozers) and the composition of the coal itself (e.g., the size distribution of the coal particles and the chemical composition). Most importantly, this study should focus upon an understanding of factors that influence coal dust emission rates including wind strength, averages and extremes, needs to be mapped.

[24]Boeing Everett Tour Fact Sheet.Available at http://www.boeing.com/commercial/tours/background.html.Downloaded on 2nd January 2013.

(ii). The second study needs to be built upon the conclusions of the first study. That is, once a clear view of the likely levels of emissions from the stockpile and associated activities is clear, these emissions should be juxtaposed against the adequacy of the possible mitigations of surfactants and wetting, wind barriers and enclosure. The adequacy of these mitigations then needs to be measured against the potential impacts the coal dust may have in the marine environment, and upon vulnerable species and ecosystems in particular.

(iii). The third study needs to examine the possibility of alternative locations which are not exposed to the dominant disturbing factors such as wind.

(iv). The fourth study needs to examine the the implications on the local freshwater ecosystems for mitigation techniques such as wetting, of which it will be necessary to study the impacts of the water required, in terms of both quantity, quality and the indirect effects this may have on associated ecosystems.

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Climatic Change

Prepared By: Alexander Gillespie

January 16, 2013

1. The reasonably foreseeable risk

According to the latest statistics from NOAA's National Climatic Data Center, the average temperature for the contiguous United States during July was 77.6°F, which is 3.3°F above the 20thcentury's average temperature. This made July, typically the warmest month of the year, the warmest month on record for the United States.[1] This record is consistent with the widely accepted view that climate change is currently underway. Climate-related changes are already observed in the United States and its coastal waters. These include increases in heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. Washington State is already recording average yearly temperatures rising faster than the global average. In addition, mountain glaciers in the North Cascades have lost up to a third of their area since 1950 and snow pack in the Cascades has declined by 35%. Peak spring river runoff is occurring 10 to 30 days earlier and the proportion of stream flow that arrives in summer decreasing as much as 34% in sensitive river basins.[2]

These changes are all consistent with, and linked into, one of the foremost challenges for humanity in the 21st century,which is climatic change. This concern is clear at the international[3] and domestic levels. President Obama identified climate change as one of the foremost threats to the United States. Specifically, he has stated, 'We want our children to live in an America that isn't burdened by debt, that isn't weakened by inequality, that isn't threatened by the destructive power of a warming planet'.[4]

The potential impacts of this change upon the Earth, the United States, and the region are astronomical. Within the United States, amidst dozens of other clear impacts, it is expected that crop and livestock production will be increasingly challenged by increased heat, pests, water stress, diseases, and weather extremes.Expectations are that human health will also be increasing challenged as a resultofheat stress, waterborne diseases, poor air quality, extreme

[1] http://www.climatewatch.noaa.gov/image/2012/july-2012-hottest-month-on-record
[2] The facts on Washington State are taken from the Office of the Governor, Executive Order 07-02, and Washington State Climate Change Challenge.
[3] See United Nations General Assembly Resolution 2011, A/RES/66/200.
[4] http://www.examiner.com/article/president-obama-addresses-climate-change-acceptance-speech

weather events, and diseases transmitted by insects and rodents.[5] Such impacts are also expected to impact the individual regions detrimentally. For example, Washington State is believed to be particularly vulnerable to a warming climate particularly because of its snow-fed water supplies that provide drinking water, irrigation for agriculture and which are also responsible for nearly three-fourths of the state's electrical power. Close to 40 communities, including some of the state's largest population areas, exist along 2,300 miles of shoreline, which is threatened by rising sea levels and ocean acidification.If no action is taken, potential costs to Washington (alone) from climate change impacts are projected to reach nearly $10 billion per year by 2020 from increased health costs, storm damage, coastal destruction, rising energy costs, increased wildfires, drought, and other impacts.[6]

2. Indicators of significant risk

- The United Nations Framework Convention on Climate Change.
- The Memorandum of Understanding to Enhance Cooperation on Climate Change, Energy and Environment Between the Government of the United States of America the Government of the Peoples' Republic of China.
- Federal Executive Order 12114: Environmental Effects Abroad.
- Washington State Executive Order EO 07-02 The Climate Change Challenge.
- Washington State Executive Order EO 09-05.Climate Leadership**.**

3. The base problem and the need for two cumulative views

A cumulative assessment is required to reveal risks that, which perhaps appearing to be minor on an individual level, once quantified in a much larger and integrated framework may actually turn out to be highly relevant contributors to the risk profile when placed in the context.[7]This requirement is especially important when dealing with inter-related projects

[5]Global Change Research Programme (2009). *Global Climate Change Impacts in the United States* (GCRP, Washington).
[6] Department of Ecology, State of Washington (2012). *Preparing for a Changing Climate Washington State's Integrated Climate Response Strategy*. (DOE, Olympia**,** Publication No. 12-01-004**) 2-6.**
[7] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002). As Judge Wright famously criticised 'crabbed interpretations' that made 'a mockery' of the NEPA, adding that, 'NEPA was meant to do more than regulate the flow of papers in the federal bureaucracy'. Calvert Cliffs v. U.S Atomic Energy Commission. 449 F.2d (D.C Cir. 1971).

that will utilize the same resource and where further growth, beyond the incremental increase of the project at hand, can reasonably be foreseen. To take all of these contributions together, cumulatively, greatly assists the decision-making authorities.[8] This type of cumulative thinking is especially important in the area of global warming, or as the Court of Appeals for the Ninth Circuit explained, 'the impact of greenhouse gas emissions on climate change is precisely the kind of cumulative impact analysis that NEPA requires agencies to conduct'.[9]

In the current situation, two cumulative assessments are required. The first pertains to to the contribution that coal freight trains in Washington State are contributing to the national budget of greenhouse gas (GHG) emissions. The second relates to the contribution of coal from the United States to China, and its scientific and contextual linkage into greenhouse gas emissions from a global perspective.

Before a cumulative assessment can be triggered, it is essential that the project(s) make a significant contribution to the alleged risk. Thus, as the Supreme Court explained there must be, 'a reasonably close causal relationship between the environmental effect and the alleged cause'.[10] In the instance of climatic change, the Courts have looked unsympathetically uponclaims which would not change overall GHG emissions or which would only make a minimal contribution, such as increasing global GHGs by 0.088%, or U.S. emissions by less than 0.03 %.[11] Overlapping with such concerns, and the need to have a significant

[8] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States'. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'. *Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management'. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'. *Environmental Impact Assessment Review.* 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?' *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'. *International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673.

[9] Center for Biological Diversity v. National Highway Traffic Safety Administration. 538 F. 3d 1172 (9th Cir. 2008)(NHTSA). Note also, Coalition for Progress v. Surface Transportation Board, 345 F.3d 520 (8th Cir. 2003). See generally, Reitze, A. (2012). 'The Role of NEPA in Fossil Fuel Resource Development and Use in the Western United States'. Boston College Environmental Affairs Law Review. 39(2): 283, 369-374.

[10] Department of Transportation v. Public Citizen. 541 U.S. 752, 767.

[11] Border Power Working Group v. Department of Energy, 260 F. Supp. 2d 997 (S.D. CaI. 2003) Barnes v. U.S. Department of Transportation, 655 F.3d 1 124, 1 139 (9th Cir. 201 1), Minnesota Center for Environmental Advocacy v. Holsten, No. 31-CV-07-3338 (Minn. 9th Jud. Dist., filed Oct. 15, 2008). Senville v. Peters, 327 F. Supp. 2d 335 (D. Vt. 2004). For some supporting academic commentary in this area, see Squillace, M. (2012). *NEPA and Climate Change*. Colorado Legal Studies Research Paper Series, number 12-16. Squillace, M. (2011). *NEPA, Climate Change, and Public Lands Decision Making*. Colorado Legal Studies Research Paper Series, Number 11-13. Smith, M. (2010). 'NEPA and Climate Change'. Environmental Practice 12(2): 182-186. Dupont, N. (2009). 'NEPA and Climate Change: Are We At The Tipping Point ?' *Natural Resources and Environment*. 23(4): 18-25. Allen, L. (2009). 'Indirect Impacts and Climate Change'. *Natural Resources and the Environment*. 23(4): 30-36.Kass, M. (2008). 'Little NEPAs Take on Climate Goliath'. *Natural Resources and the Environment.* 23(2): 40-42.

contribution to trigger concerns in this area, the Council on Environmental Quality has suggested in its *draft* NEPA Guidance on Climate Change, that projects that couldreasonably anticipated to cause direct emissions of 25,000 metric tons or more of CO2-equivalent greenhouse gas equivalent emissions on an annual basis, would be an adequate trigger to scope.[12]

(i). The Significant Contribution of Greenhouse Gases to the National Output

The first cumulative assessment that is required relates tothe contribution that coal freight trains in Washington State are makingto the national budget of GHG emissions.

Putting the requirement for such an assessment in context, at the global level, transport accounts for 13% of total greenhouse gas emissions by source and it is one of the few sectors where emissions are growing with little restraint. Car use, road freight and aviation are the principal contributors to greenhouse gas emissions from the transport sector. TheGHG emissions of the transport sector for the United States are more than double the global average. In 2010, greenhouse gas emissions from transportation accounted for about 27% of total U.S. greenhouse gas emissions, making it the second largest contributor of U.S. greenhouse gas emissions after the electricity sector. Greenhouse gas emissions from transportation have increased by about 19% since 1990.The combustion of petroleum-based products like gasoline, in internal combustion engines, of which private vehicles are the dominant source, are primarily responsible for this increase.

The internal dynamics of the transportsector are changing, as different modes jockey for position. With regards to trains, and freight trains in particular, many studies have shown that moving freight from road to rail creates many environmental benefits in terms of reducing traffic gridlock, better fuel consumption and energy intensity. However, rail is not a perfect solution. Rail transport is by no means as efficient as it could be. Its carbon footprint, largely attributed to diesel trains which typically make up nearly 90% of the source of rail emissions expands with its growth. This trend is evident is many comparable countries, such as Britain, which has seen a 35% increase in greenhouse gas emissions from rail between 1990 and 2010. A similar situation exists in the United States where this sector was responsible for 39

[12]Council on Environmental Quality (2010). *Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions* (CEQ, Washington). 3.

million tons of greenhouse gas equivalent emissions in 1990. By 2010, this figure had risen to 46.3 million tons.[13]

The need to take a cumulative view of this part of the transport sector as part of the national evaluation of the overall greenhouse budget is important, although the national obligations in this area are still emerging[14]and a number of states, such as Washington State, have their own targets set in law which states:,

> The legislature finds that Washington has long been a national and international leader on energy conservation and environmental stewardship, …. Washington is also unique among most states in that in addition to its commitment to reduce emissions of greenhouse gases, it has established goals to grow the clean energy sector and reduce the state's expenditures on imported fuels. The legislature further finds that Washington should continue its leadership on climate change policy by creating accountability for achieving the emission reductions established in RCW.[15]

Following on from this statement, the Governor of Washington State declared the state's commitment to address climate change in a series of Executive Orders.These Ordersestablished the target for Washington State to return to 1990 levels of emissions of greenhouse gas emissions by 2020, by 2035, toreduce emissions to 25% below 1990 levels, and, by 2050, to reduce emissions to 50% below 1990 levels.[16]The Governor subsequently ordered, *inter alia*,the Department of Ecology to begin focusing on sectors which emit more than 25,000 metric tons, or carbon dioxide equivalent, with a view to achieving the state's 2020 emission reduction targets. This directive overlaps with requirements for consultation to begin with business and other interested stakeholders, including the transportation sector, to develop emission benchmarks, based on industry best practices by industry sector, including transportation, which at 46% of the greenhouse budget, is the dominant contributor.[17]

[13] EPA (2012). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. (EPA, Washington). 1-3. Department of Transport (2011). *Greenhouse Gas Emissions From Transport* (DoT, London). 17-20.
[14] See generally, Council on Environmental Quality (2011): *Federal Actions for a Climate Resilient NationProgress Report of the Interagency Climate Change Adaptation Task Force* (CEQ, Washington). For some legal commentary, see Hillsdale Environmental Loss Prevention, Inc. v. U. S. Army Corps of Engineers, No. 10-2008-CM-DJW, 2011 WL2579799 (D. Kan. 2011). Natural Resources Defense Council, Inc. v. California Department of Transportation, Region Seven, 201 1 CaI. App. ULEXIS 8987 (Nov. 22, 2011) (unpublished).
[15]Revised Code of Washington (RCW). Section 70.235.005 Findings — Intent.
[16]Executive Order 07-02, Washington State Climate Change Challenge. http://www.governor.wa.gov/execorders/default.asp
[17] Executive Order 09-05, Washington's Leadership on Climate Change. http://www.governor.wa.gov/execorders/default.asp

(ii). The Significant Contribution of Greenhouse Gases to the Global Output

The second cumulative study that is required relates to the contribution of coal from the United States to China, and its scientific, and contextual, linkage into greenhouse gas emissions from a global perspective.

The need for this second cumulative study is consistent with the NEPA, which requiresFederal agencies to support international cooperation by recognizing:

> The global character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment.[18]

This requirement has been supplemented by Executive Order 12114,[19]Supreme Court decisions,[20]and mirrors obligations at the State level. For example, the (Washington) State Environmental Policy Act requires decision makers to:

> Recognize the worldwide and long-range character of environmental problems and, where consistent with state policy, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of the world environment.[21]

The usefulness of a second cumulative assessment is that it will help decision-makers to examine the extentto which the actions at hand are undermining or otherwise, the obligations that the United States has already accepted at the international level through the United Nations Framework Convention on Climate Change. The particular obligation of note is article 2 of this Convention which stipulates:

[18] Section 102(2) (F), 42 U.S.C. § 4332(2) (F).
[19] This order clearly extended the purpose of NEPA abroad by requiring federal agencies to consider the significant environmental effects of major federal actions outside of the United States, and in this case, to the global commons.
[20]Department of Transportation v. Public Citizen, 541 US 752 - Supreme Court 2004. 541 U.S. 752 (2004). Specifically, The Supreme Court has also applied itself to this area and has agreed with extending impact assessments beyond the borders when, amongst other issues, confirm to the 'rule of reason' which ensures that agencies determine whether and to what extent to engage in impact assessment, based on the usefulness of any new potential information to the decision-making process.
[21] SEPA, Chapter 43.21C RCW, section (f).

> The ultimate objective of this Convention and any related legal instruments that theConference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.[22]

The axiomatic problem is that the international community is failing to meet this commitment. The foremost reason for this failure is that the two countries which collectively are responsible for 42% of the global problem, the United States and China, have not accepted any binding commitments to reduce their national emissions of greenhouse gases.

In 1992, China produced half of the amount of national GHG emissions that the United States produced. Fifteen years later, around 2007, China passed the United States with its total of national emissions of GHG. China currently exceeded the United States in cumulative energy-related carbon dioxide equivalent emissions between 2002-2011, at an estimated 64.5 billion tonnes compared with 62.9 billion for the United States. Broadly, this means that China is responsible for 23% of the total greenhouse gases, whilst the United States is responsible for 19%.[23]

Although the United States is contributing less of the overall global anthropogenic basis of the greenhouse gas budget, it is still producing more than it did originally. That is, in 2010, total U.S. greenhouse gas emissions were 6,821.8 million metric tons of CO2 equivalence. Total U.S. emissions have increased by 10.5 % from 1990 to 2010.[24]China's industrial emissions of CO_2 have grown phenomenally since 1950, when China stood tenth among nations based on annual fossil-fuel CO_2 emissions. From 1970 to 1997, China's fossil-fuel CO_2 emissions grew at an annual rate of 5.4%, before jumping to a 7.5% annual growth from 1997 to 2010. During the last period, China doubled its energy output and electrification increased to just over 99%. However, it should be noted that these figures are speculative as China has not reported its annual output of greenhouse gases since 1994, and evidence

[22] See Gillespie, A. (2006). *Climate Change, Ozone Depletion and Air Pollution* (Brill, The Netherlands). Chapter 11.
[23] EPA (2011). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. (EPA, Washington). iii-v.
[24] See EPA (2012). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. (EPA, Washington). 3.

suggests that China's emissions could be as much as 20% higher than what they are assumed to be.[25]

Unlike most other countries, the growth in emissions from China is due to coal. Whilst the global average of coal in the energy budget is 30%, for China, it is closer to 70% which is also approximately the same figure that coal contributes to the total of greenhouse gas emissions for China. This is not surprising given that China, with an estimated 15% of the world's reserves (some 114,500 million tons), is the world's largest coal producer obtaining some 3,471 million tonsin 2011 with the United States coming second at 1004 million tons. China has an estimated 26,000 coal mines employing nearly 8 million workers. Coal accounted for 69% of the primary energy consumption in China2005 and 75% of total electricity generation.Coal-fired powerplants accounted for 83% of new generating capacity installed in 2005. In addition, coal is required for the country's roughly 410,000 industrial furnaces and 180,000 kilns. With such demands, in 2010, coal consumption in China reached, most probably, 2.5 billion tons. By comparison, at this point, China was providing more energy through coal than all the oil produced in the Middle East.[26]

It is expected that this increasing trend will continue. This is a safe assumption because of the strong growth rates in China. Electricity demand alone is growing at about 15% per year, faster than any other country in the world. To meet the new demand, China is fast-tracking the construction of new generation facilities with over 500 being built between 2005 and 2012 about 80% of which are coal-fired. With such growth, the projections are for China to be consuming 2.9 billion tons of coal by 2020, with this coal making up more than 70% of itsenergy budget at this point.[27]Since 2008, the demandfor coal within China has exceeded its own domestic supply capacity. Accordingly, China imports coal from other countries. This importation is part of a market of seaborne trade in coal which has increased, on average, by about 7% each year, reaching a global total of 1142 million tons in 2011.China is the largest importer of coal in the world, taking 190 million tons per year. The United States is fourth in

[25] Anon (2012). Climate Change Rate Could Be Faster Than Thought'. *The Guardian*. June 11. A4. Anon. (2009). 'Clean Up Call'. New Scientist. April 25. 5. Yanli, H. (2007). 'China and Her Coal'. *World Watch* 20 (1): 14-15. Green, S. (2006). 'The Changing Climate of Coal'. *Power Engineering International* 14. (2): 5.

[26] See generally, http://www.worldcoal.org/coal/coal-mining/

[27]Saeed, A. (2010). 'China: Climate Change is the Defining Challenge of our Age'. *Strategic Studies.* 30(3): 7-18. Liu, H. (2008). 'Strategic Thinking on IGCC Development in China'. *Energy Policy* 36. 1–11. Yanli, H. (2007). 'China and Her Coal'. *World Watch* 20 (1): 14-15. Hertgaard, M. (2000). 'China: The Coast of Coal'. *E : the Environmental Magazine* 11 (5): 27-28.

terms of total coal exports, at 97 million tons per year, and a large percentage of this export goes directly to China.[28]

The continual and expanding, inefficient burning of coal has created a multitude of problems in China, most notably with air pollution. China has applied itself to this particular problem with a strong commitment and hasadoptedthe significant technological achievements that have been reached in the developed world to reduce the coal related air pollutants of sulphur and nitrous oxide. In addition, in mid-2011, China announced a new emission standard for new and older thermal power plants, for nitrous oxide and mercury emissions, as well as tightening sulphur dioxide emissions and soot standards. The same progress has *not* been applied to reducing climate (carbon) pollution. China thus lags behind other industrialized countries in developing and deploying these technologies. Whilst some of the technologies that China has been investing in, such as much more efficient coal gasification programmes are underway, these remain both recent (the first being operational in 2009) and a very small percentage of their total coal plants.[29]

In sum, neither the United States nor China will accept reductions without the other, moving in a similar direction. This failure to find a 'grand bargain' is removing the chances of keeping the increasing concentrations of greenhouse gases below danger levels. This problem is being accentuated by the failure to set meaningful goals or commitments between the two Superpowers on this topic at the bilateral level. That is, although the 2009 Memorandum of Understanding to Enhance Cooperation on Climate Change, Energy and Environment between the Government of the United States of America and the Government of the Peoples' Republic of China was welcome, it did not actually achieve anything. It merely reiterated commitment to the United Nations Framework Convention on Climate Change and the promise to look at 10 wide-ranging environmental themes, including, 'cleaner uses of coal, and carbon capture and storage'. In the interim, the United States continues to ship to

[28] The countries ahead of the United States on coal exports each year are Indonesia at 309 Mt, Australia at 284 and Russia on 124. The import figures compare to others like Japan at 175 Mt, South Korea at 129 Mt, India at 105 Mt, Chinese Tapei at 66 Mt, Germany at 41 Mt and the UK at 33 Mt. Seehttp://www.worldcoal.org/resources/coal-statistics/ Also, http://www.eia.gov/coal/production/quarterly/

[29]Gong, G. (2011). 'What China Wants: China's Climate Change Priorities in a Post-Copenhagen World'. *Global Change, Peace & Security* 23(2): 159-175. Anon (2011). 'China Looks to Balance Its Carbon Books'. *Science.* 334: November, 18. Chen, W. (2010). 'Clean Coal Technology Development in China'. *Energy Policy* 38: 2123–2130. Ma, Y. (2010). 'China's View of Climate Change'. *Policy Review*. June. 25-37. Lo, A. (2010). 'China's Response to Climate Change'. *Environmental Science and Technology. 44:* 5689–5690.Zhao, L. (2007). 'Research, Development, Demonstration, and Early Deployment Policies for Advanced-Coal Technology in China'. *Energy Policy* 35 (2007) 6467–6477. Fairley, P. (2007). 'China's Coal Future'. *Technology Review* 110. (1): 56-61. Gillespie, A. (2006). *Climate Change, Ozone Depletion and Air Pollution* (Brill, The Netherlands). Chapter 15.

China the very fuels that help prevent the two sides from reaching the needed bilateral agreement.[30]

4. Mitigation

Ideally, mitigation actions should, render potentially significant impacts insignificant. This is not possible in this situation. What ispossible, however, is a reduction in the magnitude of the scale of the significant impact.[31]

(i). Freight transport emissions at the national level

Over recent years, it has become increasingly clear that there is scope for improvement in terms of reducing the greenhouse gas emissions from the freight-train sector. That is, in addition to the updated 2008 EPA Emission Standards for locomotives, which are a clear improvement as they are now more closely aligned with international best practice, especially for engines new built after 2015,[32] a considerable raft of measures for reducing greenhouse gas emissions exist for dealing with older, existing, and shorter-term growth projected freight traffic. This range of measures particularly relates to fuel choices (or refinements), technologies adopted, the age (and standards) of the locomotives, operating practices, organisation in terms of timing, routes interoperability, and enhanced cooperation with other freight providers.[33] The utilisation of such practices with some freight haulers in the United States has already seensavings of around 90% in fuel efficiency since 1980, with further

[30] For commentary in this area, see Carraro, C. (2012). ‘Energy and Climate Change in China’. *Environment and Development Economics*17 (6): 689-713. Harvey, F. (2012). ‘China and the United States Key to Climate Solution’. *The Guardian.* Dec 12. Saeed, A. (2010). ‘China: Climate Change is the Defining Challenge of our Age’. *Strategic Studies.* 30(3): 7-18. Seligsohn, D. (2009). *China, the United States, and the Climate Change Challenge*. (World Resource Institute, Washington). Anon (2009). ‘Let's Agree to Agree; America, China and Climate Change’. *The Economist*Nov. 21. At 47.

[31] See Eccleston, C. (2012). *Preparing NEPA Environmental Assessments*. (Taylor and Francis, NYC). 47.

[32] See generally, the Committee on State Practices in Setting Mobile Source Emissions Standards (2006). *State and Federal Standards for Mobile-Source Emissions* (National Research Council, Washington).

[33] Winebrake, J. (2012). ‘Assessing Energy, Environmental, and Economic Tradeoffs in Intermodal Freight Transportation’. *Journal of Air and Waste Management.* 58:1004–1013. Eom, J. (2012). ‘Trends in Freight Energy Use and Carbon Emissions in 11 IEA Countries’. *Energy Policy* 45: 327–341. Pan, J. (2010). ‘The Reduction of Greenhouse Gas Emissions from Freight Transport by Pooling Supply Chains’. *International Journal of Production Economics* 12(4): 23-43.
Watson, R. (2010). ‘Report Challenges Claims Of Rail's Fuel Efficiency’. *Transport Topics* 3878: 24. Spraggins, B. (2010). ‘The Impact of Rail Freight Transportation Upon Environmental Sustainability’. *Journal of Academy of Business and Economics*. 10(2): 91. Lopez, I. (2009). ‘A Methodology for Evaluating Environmental Impacts of Railway Freight Transportation Policies’. *Energy Policy* 37: 5393–5398. Chapman, L. (2007). ‘Transport and Climate Change: a Review’. *Journal of Transport Geography* 15: 354–367. Vanek, F. (2000). ‘Improving the Energy Efficiency of Freight in the United States Through Commodity-Based Analysis, Justification and Implementation’. Transportation Research Part D 5 11: 29. Plambeck, E. (2012). ‘Reducing Greenhouse Gas Emissions Through Operations and Supply Chain Management’. *Energy Economics* 34: S64–S74.

goals to reduce a further 8% from 2011 levels by 2020 by the active utilisation of cutting edge technologies.[34]

(i). Coal emissions at the international level

Theoretically, the most promisingmitigation of the emission of greenhouse gases from coal power stations is carbon capture and storage. Experiments in capturing carbon from power stations (either natural gas or coal) and storing it underground in deep geological formations,reflect success rates of up to 99.7% capture of all CO2 emissions. In theory, if such practices were widely deployed, carbon capture and storage has the capacity to claim over 20% of the total, required, greenhouse gas emissions needed to keep the climate at a safe level. However, despite the impressive possibilities in this area, it is critical to realise that this technology still requires significant research before it is either proven safe, reliable and/or economically viable. These limitations are currently of such a degree that carbon capture and storage projects do *not* currently qualify for inclusion under the various international mechanisms that are designed to promote clean development under the applicable international regimes. As such, this technology does not have a valuable possibility in practical terms, in the foreseeable future.[35]

The mitigation that has real potential in the present and the foreseeable future lies with power stations with much greater levels of efficiency. Efficiency in coal-fired power generation will play an important role in the production of electricity, both currently and in the future. A single percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO2 emissions. The average global efficiency of coal-fired plants is currently 28% compared to 45% for the most efficient plants. This means that highly efficient modern coal plants emit almost 40% less CO2 than their less efficient precedessors. This is particularly the case in developing countries and economies in transition where existing plant efficiencies are generally lower and coal use in electricity generation is increasing.Improving the efficiency of the oldest and most inefficient

[34] Anon (2012). Railroad Companies; CSX Sets Emissions Intensity Reduction Goal for 2020'. *Energy & Ecology*. June: 32.
[35] Biello, D. (2009). 'Can Captured Carbon Save Coal ?' 19(2) *Scientific American: Earth* 3.0. 52-29.

coal-fired plants, especially those older than 25 years, would reduce CO2 emissions from coal use by almost 25%, representing near a 6% reduction in global CO2 emissions.[36]

5. Recommended research programs

Based upon all of the above considerations, the decision-makers require four research programs as follows:

i. A cumulative assessment that shows the contribution of emissions that coal freight trainsin Washington State make in relation to the state budget of greenhouse gas emissions. This study should establish what freight trainsbaseline of greenhouse gas emissions are currently, how the proposed expansion will impact upon the baseline and what additional reasonably foreseeable growth in this area would look like in terms of increased volume.

ii. A second cumulative study needs to examine the amounts of coal being exported from the United States to China. This study should also attempt to estimate the contribution that this coal trade is makingto climate change from both the Chinese, and international, perspectives. This study should establish what the current baseline of contributions currently are, and how this may, with reasonable foresight, look in the future.

iii. A third study should examine the potential for mitigations in the emission of greenhouse gases in the freight transport sector, with a view to portraying best industry practices in this area.

iv. A fourth study, in accordance with existing national obligations and bilateral aspirations, should seek to conduct a program of joint exchange on a continuing basis of information, shared in a transparent manner, concerning the linkage between coal from the United States and emissions of greenhouse gases in China. In particular, this study should seek to examineif the coal from the United States is making the problem of climate change better via suitable

[36] World Coal Association (2012). *Coal – Energy for Sustainable Development* (WCA, London). 7-10.International Energy Agency (2011). *World Energy Outlook 2011* (IEA, London). 56-67.

mitigation techniques in China, or, if it is making the situation worse (by not mitigating impacts by being linked to the most inefficient power stations).

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Aquatic Invasive Species associated with Vessel Traffic

Prepared By: Alexander Gillespie

January 16, 2013

1. The base problem and the need for a cumulativeview

Each year, around 11,000 large vessels and oil barges, and tugs, transit through the Salish Sea. Around 4,300of these large vessels are destined for United States' ports in Puget Sound. The other 6,250make for Canadian ports.[1] The proposed Gateway Pacific Terminal (GPT) will add approximately 440ship transits per year, equating to a 4% increase to the 2011 traffic once the terminalbecomes operational. After it becomes fully operational, the GPT is projected to generate an additional increase of about 950 transits per year, or an increase of 9%, within 15 years.[2]This increase will be over and above other future expansion inother shipping operations. Each of these vessels presents a risk of bringing in invasive aquatic species (AIS). To assess this risk it is necessary that the additional vessels, in addition to all of the existing related vessels involved in this area, be assessed for AIS. Onlythis type of evaluation will reveal the true extent of the significant risk of AIS at hand. A cumulative assessment is essential as it will reveal risks that, while perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework, may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk to the greater Puget Sound area.[3]

In addition to the past, present and the currently proposed 8%increases in shipping traffic for the GPT development, the cumulative assessment should also scope the likelyfuture additional expansions of vessel traffic in this area (even if they are not yet formal or approved proposals).This requirement is especially important when dealing with inter-related projects that will all utilize the same limited resource, in this case, shipping routes.That is, a forward projected assessment should also include data in the cumulative equation on traffic increases that can reasonably be foreseenincluding general increases in vessel traffic from other sources and also vessel traffic projections for other proposed major developments (including those in Canada) that will need to use the same shipping route.This will greatly assist the authorities in providing the necessary information to achieve meaningful regional planning at a

[1]Hass, T. (2012).*The Vessel Traffic Risk Assessment for BP Cherry Point and Maritime Risk Management in Puget Sound*.(Puget Sound Partnership). 5. van Dorp, J.(2008). *Assessment of Oil Spill Risk due to Potential Increased Vessel Traffic at Cherry Point, Washington*. (Final Report - Submitted to BP : 8/31/2008).
[2] Pacific International Terminals, Inc. (2011). *Project Information Document, Gateway Pacific Terminal*, Whatcom County, Washington.304 p. Also, *Vessel Entries and Transits: 2011* WDOE Publication 12-08-003 April 2012.
[3] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002).

reasonable cost, in which uncertainties can be evaluated and effective, appropriate, and sustainable (in economic, social and environmental) choices can be made.[4]

2. The reasonably foreseeable risk of Aquatic Invasive Species

According to Presidential Executive Order 13112, aninvasive species is 'an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health'.[5] It is not a species which migrated naturally in accordance with usual background rates of migration. Plants, animals, and pathogens all can be invasive. Typical traits of an invasive species include it being able to survive in a variety of physical and biological situations, rapid reproduction, growth, and dispersal ability, and lacking natural predators or pests in the invaded ecosystem. Thus, invasive non-native species are successful competitors in new ecosystems, usually displacing native species and disrupting ecosystem processes.[6]

Collectively since the year 1600, species introductions are responsible for more extinctions than any other cause, claiming 39% of all extirpated species. In a contemporary global context, invasive species are responsible for 15%of all threatened plants and 10% of all threatened mammals. In the United States, about 42% of the species on the Threatened or Endangered species lists are at risk primarily because of alien-invasive species.Before the point of species extinction occurs, local ecosystems face a reduction of genetic diversity, loss of functions, processes, and habitat structure, and biotic homogenization.[7]

[4] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment Within State-Level Environmental Review Frameworks in the United States'. *Journal of Environmental Planning and Management.* 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'.*Environmental Impact Assessment Review.* 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management'. 31 *Environmental Impact Assessment Review*. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'.*Environmental Impact Assessment Review*. 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?'*Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'.*International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. 20 *Environmental Law*. 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'. 16 *Environmental Law*. 673. http://www.aleutiansriskassessment.com/passing.htm

[5] Executive Order 13112 of February 3, 1999. Section 1. Note also, the definition of alien species 'means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem'.

[6] Bauer, J. (2012). 'Invasive Species: ''Back-seat Drivers'' of Ecosystem Change?'.*Biological Invasions* 14:1295–1304. With, K. (2002).'The Landscape Ecology of Invasive Spread'.*Conservation Biology* 16:1192-1203.

7 IUCN (2012) *100 of the World's Worst Invasive Species* (Gland, IUCN); IUCN (2011) *A Global Species Assessment: The IUCN Red List of Threatened Species* (Gland, IUCN) xxii; Birdlife (2008) *State of the World's Birds: Indicators for Our Changing World* (Cambridge, Birdlife) 9;Galil, R. (2007). 'Loss or Gain?Invasive Aliens and Biodiversity in the Mediterranean Sea'.*Marine Pollution Bulletin.* 55: 314–322; Reilly, M (2007) 'Alien Vine is Public Enemy Number One'

Such invasive species are a global, national and local problem. There are approximately 50,000 invasive species in the United States and the number is believed to be increasing.[8]Within Washington State, approximately 700 invasive non-native species have become established.[9]Unless confronted, the projections are for increased rates of the spread and invasive species, due to accelerated levels of pathway introduction (more trade and exchange), depleted ecosystems providing less resistance, and possible catalysts, like climatic change.[10]

Whileall isolated and relatively stable ecosystems, such as islands and fresh-water systems,are at risk,coastal estuarine and marine ecosystems are among the most heavily invaded systems in the world.[11]This heavy invasion has resulted in a considerable amount of attention being directed towards invasive aquatic species (AIS). These species (also known as Aquatic Nuisance Species) are defined in the Aquatic Nuisance Prevention and Control Act as, 'nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters'.[12]These species are, as the international community noted at the Rio+20 conference in Brazil, in 2012, a 'significant threat …to marine ecosystems and resources'.[13] This position was agreed following a series of reports which have shown the magnitude of this problem. For example, the first global assessment

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New Scientist (Aug 11) 13; McNeely, J (2004) 'Strangers in Our Midst' *Environment* (July/August) 15, 21–22; Pimentel, I. (2004). 'Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States'. Ecological Economics 52: 273– 288.Gurevitch, J. (2004). 'Are Invasive Species a Major Cause of Extinctions?'.*Trends in Ecology & Evolution* 19:470-474.

[8] Pimentel, I. (2004). 'Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States'. *Ecological Economics* 52: 273– 288.

[9]Washington Invasive Species Council (2011).*Annual Report to the Legislature* (WISC, Olympia).

[10]Crooks, A. (2011). 'Aquatic Pollution Increases the Relative Success of Invasive Species'. *Biological Invasions* 13:165–176. Occhipinti, A. (2011). 'Alien Species Along the Italian Coasts: An Overview'. *Biological Invasions* 13:215–237. Hulme, P. (2009). 'Trade, Transport and Trouble: Managing Invasive Species Pathways in an Era of Globalization'. *Journal of Applied Ecology* 46*:* 10–18. Westphal, M. (2008). 'The Link Between International Trade and the Global Distribution of Invasive Alien Species'. *Biological Invasions* 10:391-398. Garcia-Berthou, E. (2005). 'Introduction Pathways and Establishment Rates of Invasive Aquatic Species in Europe'.*Canadian Journal of Fisheries and Aquatic Sciences* 62(2): 453-463.Westphal, M. (2008). 'The Link Between International Trade and the Global Distribution of Invasive Alien Species'. *Biological Invasions* 10:391–398.Walther, G. (2009). 'Alien species in a warmer world: risks and opportunities'. *Trends in Ecology and Evolution* 24(12): 684-690. EPA (2008).*Effects of Climate Change on Aquatic Invasive Species and Implications for Management*.(EPA, Washington, EPA/600/R-08/014).Grevstad, F. (1999) 'Factors Influencing the Chance of Population Establishment: Implications For Release Strategies in Biocontrol'. *Ecological Applications*, 9: 1439–1447.Grevstad, F. (1999) 'Experimental Invasions Using Biological Control introductions: the Influence of Release Size on the Chance of Population Establishment'. *Biological Invasions*, 1: 313–323.

[11]Grosholz, E. (2002). 'Ecological and Evolutionary Consequences of Coastal Invasions'.*Trends in Ecology & Evolution* 17:22-27.

[12]Section 4702. (1), of Aquatic Nuisance Prevention and Control Act, 16 USC, 4700.

[13]*Report of the United Nations Conference on Sustainable Development, Rio June 22nd, 2012*. A/CONF.216/16. Paragraph 164.

of AIS, in 2008, found that 84% of the world's coasts have been invaded. There are an estimated 500 alien marine species, already, within the coastal waters of the United States. Around 200 of these are found in San Francisco Bay alone. This means that more than half of the fish are aliens, as are the majority of animals and plants living on the bay floor.[14]There are numerous examples of the impacts of AIS in both marine and freshwater environments. One of the most well known species is the zebra mussel. The zebra mussel has caused extensive economic and ecological damage since arriving in the Great Lakes and is rapidly spreading throughout North America. The Quagga mussel, a sister species, is now present in Lake Mead (AZ) and Lake Havasu (CA). The presence of the Quagga mussel in these locations greatly increases the risk of its introduction into Washington State, which at the moment is one of five Western States without these particular AIS.

Readily observed examples of aquatic invasive species in the inland marine waters of Puget Sound and the Georgia Basin include Japanese eelgrass, Oyster drill, varnish or dark mahogany clam, and the European Green crab. In the past two years three species of non-native tunicates have developed rapidly expanding populations in Puget Sound and Hood Canal. The non-native tunicates *Didemnumvexillum*, *Cionasavignyi*, and *Styelaclava* are of concernto resource managers of Puget Soundbecause they have been shown to threaten nativespecies diversity and shellfish aquaculture in other regions.[15]Notably, in some susceptible ecosystems within the Salish sea, various forms of introduced cordgrass have, in the past 100 years taken over hundreds of hectares of native habitat. In many instances, the habitat available for fish, shellfish (commercial and native), migratory waterfowl and shorebirds has been greatly reduced.[16]

The economic costs of such invasions are vast. Invading alien species in the United States cause major environmental damages and losses adding up to over $100 billionper year.Associated damages and costs of controlling AIS are estimated to be $9 billion annually, with the Zebra mussel alone, being responsible for over $1 billion in the decade leading up to the end of the 20th century.[17] In a state like Washington, the risks are particularly high.

[14]IUCN (2012).*Marine Menace—An Overview of the Marine Invasive Species Issue* (IUCN, Gland). 7-8.
[15]Cordell, J., and Toft, L. (2012). 'Ecological Implications of Invasive Tunicates Associated with Artificial Structures in Puget Sound '. Biological Invasions.*Biological Invasions* VDOI 10.1007/s10530-012-0366-y., Washington, USA
[16]Washington Invasive Species Council (2011).*Annual Report to the Legislature* (WISC, Olympia).Phillips, C. (2008). *Spartina Eradication Program 2007 Progress Report*.Washington State Department of Agriculture. Williams, S. (2007). 'Introduced Species in Seagrass Ecosystems: Status and Concerns'.*Journal of Experimental Marine Biology and Ecology* 350:89-110. Grevstad, F. (2003).'Biological control of Spartinaalterniflora in Willapa Bay'.*Biological Control* 27:32-42.
[17]IUCN (2012).*Marine Menace—An Overview of the Marine Invasive Species Issue* (IUCN, Gland).

Washington is a top seafood supplier, producing about 12 million pounds of fresh finfish and 8 million pounds of oysters, and an estimated $77 million in sales of farmed bivalve shellfish each year. Whilenew invaders, such as the Asian clams found in Lake Whatcom which have the capacity to threaten the water supply to Bellingham, were found in 2011 and the possible economic costs have not been estimated, in other instances, they have. For example, if the zebra or quagga mussel invaded Washington State, estimates are that it will cost upwards of $300 million in annual maintenance and lost opportunities to the hydropower industry, hatcheries, public utility districts, and farmers.[18]

(i). The Pathways of Aquatic Invasive Species

The two dominant sources for the introduction of AIS are ballast water and hull fouling. With regards to ballast water, an estimated 10,000 species including, amongst others, fish, zooplankton species and planktonic taxa, including copepod species, are transported in roughly 4 billion gallons of the ballast water that is moved around the world each year.[19]Within this bracket, Puget Sound receives an annual average of 7.5 x 106 m3 of ballast water from both foreign (mostly trans-Pacific) and domestic waters. Foreign trans-Pacific vessels carried significantly fewer propagules($p < 0.001$) compared to ships on domestic west coast routes. Of the propagules detected, trans-Pacific ships contained almost twice as many non-native species (19 species) than those from ships on west coast routes (10 species), with seven species being common to both. However, even though trans-Pacific vessels had higher diversity of non-native species, densities of non-natives were 100-200% greater in domestic ballast water.[20]

In addition to being transported in ballast water, AIS are also carried across the seas attached to the outside of the vessels. This is known as hull-fouling, vessel-fouling, or bio-fouling. Fouling is defined by the International Maritime Organization (IMO) as the, ‘unwanted growth of biological material, such as barnacles and algae, on a surface immersed in

18. Pimentel, I. (2004). ‘Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States’. *Ecological Economics* 52: 273– 288.

[18]Washington Invasive Species Council (2011).*Annual Report to the Legislature* (WISC, Olympia). 3.

[19]European Communities (2008) *The Economics of Ecosystems and Biodiversity* (Berlin, Welzel) 6; Anon (2008) ‘Alien Stowaways’ *New Scientist* (Feb 23) 4; Chivian, E (ed) (2008) *Sustaining Life: How Human Health Depends on Biodiversity (*Oxford, OUP) 49; Williams, R. (1988). Cargo Vessel Ballast Water as a Vector for the Transport of Non-Indigenous Marine Species’.*Estuarine, Coastal and Shelf Science*. 26: 409-420. Bax, N. (2003). ‘Marine Invasive Alien Species: A Threat to Global Biodiversity’. *Marine Policy* 27: 313–323.

[20]Lawrence, D.(2010). Relative Contributions of Domestic and Foreign Sourced Ballast Water to Propagule Pressure in Puget Sound’.*Biological Conservation* 143: 700–709.

water'.[21]Studies suggest that a vessel bottom which is exposed to the water without any treatment, could attract up to 300 pounds of material on each square yard of the ship's hull over just a six-month period. This could add up to 6,000 tons of weight on a deep draft vessel.[22]

Hull fouling is also one of the foremost ways that aquatic invasive species transport themselves from one place to the next.Left unmanaged, a fouled vessel can pose a biosecurity risk through the detachment and dispersal of viable material and through spawning by adult taxa upon arrival in a recipient port or region. Even vessels that are meant to have been cleaned and treated, so as not to allow AIS to attach themselves, have proved problematic. For example, a2007 study of five vessels going to Antarctica that had practised hull-fouling found they had nevertheless acted as transport vectors for at least 18 species, including a number known to be invasive and had managed to survive in the Antarctic conditions.[23]Such examples, repeated many times, have shown that hull-fouling creates a clear risk as a direct pathway for the introduction of invasive aquatic species. Moreover, the possibility that hull-fouling, as opposed to ballast water, is a greater source of AIS has becomeincreasingly contended.[24]Research has shown that 70% of the 250 AIS in Australia and 74% of Hawaii's AIS have arrived via hull-fouling.[25]Similarly, it has been reported that 36% of AISin the United States can be attributed to hull-foulingwhile ballast water represented only 20% of the total.[26]Similarly, within Puget Sound, evidence suggests that whilst ballast waters have contributed 25 taxa of invasive species, ship-fouling has contributed a greater amountat 35 taxa.[27]

3. Indicators of significant risk

[21] See the International Convention on the Control of Harmful Anti-fouling Systems on Ships, article 2.
[22] See Rep Cummings Issues Statement on Control of Anti-Fouling Systems of Ships. Recorded in US Fed News Service, Including US State News 11 June 2009.
[23]SCAR (2007) 'Hull Fowling as a Source of Marine Invasion in the Antarctic' ATCM XXX (New Delhi, IP37); Anon (2008) 'Alien Stowaways' *New Scientist* (Feb 23) 4.
[24]Gollash, S. (2002).'The Importance of Ship Hull Fouling as a Vector of Species Introductions into the North Sea'.*Biofouling*18 (2), 105–121.Ferreora, C. (2006). 'Ship Hulls and Oil Platforms as Potential Vectors to Marine Species Introduction'. *Journal of Coastal Research.* 1340-1345.
[25] Godwin, S (2003). ' Hull Fouling of Maritime Vessels as a Pathway for Marine Species Invasions to the Hawaiian Islands'.*Biofouling*, 19 (1), 0892-7014.
[26]Savarese, J. (2005). 'Preventing and Managing Hull-Fouling: International, Federal, and State Laws and Policies'. *Proceedings of the 14th Biennial Coastal Zone Conference (*New Orleans, Louisiana July 17 to 21*).* 1-10.
[27]Escapes from commercial activities, such as aquaculture, contribute the dominant source of 39 taxa. Simkanin, C. (2009). 'Intra-Coastal Ballast Water Flux and the Potential for Secondary Spread of Non-Native Species on the US West Coast'. *Marine Pollution Bulletin* 58:366-374.

In order to be approved, the GPT development must reconcile a large number of relevant standards of regulatory, legislative and other legal and policy instruments from regional, state, federal and international agencies, all of which address issues of potential significant risk. The broad obligations to control alien invasive species are solidly entrenched in multiple areas of international environmental law.[28]Specific international and national laws and standards that need to be reconciled are:

- The 1990 Aquatic Nuisance Prevention and Control Act
- The 1996 National Invasive Species Act
- The 1999 Presidential Executive Order 13112
- The Convention for the Control and Management of Ships' Ballast Water and Sediments
- The Convention on the Control of Harmful Anti-fouling Systems on Ships.

4. The Gap in Confronting the Significant Risk of AIS

(i). Ballast Water

With regards to ballast water, the global process began in 1997 when theIMO implemented mid-ocean exchange regulations. Seven years later in 2004, the IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments.[29] The Parties to the Ballast Water Convention resolved to:

> 'prevent, minimise and ultimately eliminate the risks to the environment, human health, property and resources arising from the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.'[30]

This goal was been achieved by a system of certification, inspection and verification of the uptake and deposit of ballast water from ships covered by the regime. The regime includes

[28] See Gillespie, A. (2011). *Conservation, Biodiversity and International Law*. (Edgar, London). Chapter 7.
29 BWM/CONF/36 (16 February 2004). For commentary, see Anon (2004) 'New Convention on Ballast Water: Preventing Alien Invaders' 34(3) *Environmental Policy and the Law* 120–130.
30 Ballast Water Convention, Preamble. Also, Art 2(1).

special requirements for certain areas, such as near sewage outfalls, where ballast water may not be collected. The Convention sets both a universal standard for ballast water management and establishes ballast water control areas to be designated where additional measures to control the possible entry of alien species are required.[31] Complementing these international efforts, after a slow start in coming to terms with the problem of AIS and ballast water, the United States is now consistent with international best practice in this area.[32] The most recent manifestation of this status is the new regulations promulgated by the Coast Guard in mid-2012.[33]Whilesome questions remain over the general adequacy of the standards in this area,[34] assuming compliance is achieved, the ballast controls around Washington State are of good standing.

(ii). Hull-Fouling

Most owners go to various lengths to prevent the build-up of aquatic species on their vessels, as they directly impact upon the efficiency of the vessel by increasing its drag/friction and thus demanding more use of fuel. Accordingly, most ships maintain prescribed schedules for hull husbandry, including the cleaning of the hull and application of antifouling paints,to reduce the colonization of underwater surfaces. It was this application of anti-fouling paints, and the highly effective tributyltin in particular, that brought the issue of hull-fouling attention to the international community. Unfortunately, tributyltin had not been fully studied before it was released into the marine environment and it has proven to be highly toxic to marine life, including crustaceans, mollusks, fish and even marine mammals. Due to such problems, such anti-foulant paints were directly regulated at the national level in the United States with the Organotin Anti-Fouling Paint Control Act of 1998 and then at the international level with the 2001 International Convention on the Control of Harmful Anti-Fouling Systems on Ships (which came into force in 2008).These laws, rules and policies have been supplemented at the local level, with many States, including Washington, adding

31 MEPC (2000) 'Report of the MEPC on its 45th Session' MEPC 45/20, 10; MEPC (2001) 'Report of the MEPC on its 46th Session' MEPC 46/23, 23–29; MEPC (2002) 'Report of the MEPC on its 47th Session' MEPC 47/20, 6–8.

[32]Cangelosi, A. (2003). 'Blocking Invasive Aquatic Species'.*Issues in Science and Technology* 19(2):69-75.

[33] See the Federal Register /Vol. 77, No. 175 /Monday, September 10, 2012 /Rules and Regulations.

[34]Butron, A. (2011). 'Potential Risk of Harmful Algae Transport by Ballast Waters: The Case of Bilbao Harbour'. *Marine Pollution Bulletin* 62: 747–757.Cordell, J., et al (2009). 'Factors Influencing Densities of Non-Indigenous Species in the Ballast Water Of Ships Arriving at Ports in Puget Sound, Washington, United States'.*Aquatic Conservation: Marine And Freshwater Ecosystems* 19: 322–343.Smayda, T. (2007).'Reflections on the Ballast Water Dispersal—Harmful Algal Bloom Paradigm'.*Harmful Algae* 6: 601–622.

additional restraints in this area.[35] One of the short term impacts of this ending of the persistent pollutant of tributyltin is that there may be/have been a short-term increase in fouled hulls until the replacement anti-fouls have fully come on stream and reached similar levels of effectiveness as their very poisonous predecessor.[36] At the same time, afundamental gap exists in both international and national law in the United States inthat there areno specific rules requiring the adoption of particular measures to confront AIS from hull-fouling sources. The only guidelines that exist in this area, where the United States mirrors the IMO, is the recommended Guidelines on fouling maintenance and the required documentation of the anti-hull fouling maintenance for verification of the work undertaken.[37]

5. Mitigation

While the IMO Guidelines are a good first step, the leading work in this area is being carried out in Australia and New Zealand. The core of this work has been through detailed risk assessments that work on both the possible AIS and the vulnerable habitats. This risk analysis is then cross-referenced with those high risk vessels thatare most likely to be the pathways for hull-fouling AIS. Once identified, the vessels are inspected and, if necessary, diverted.

With regards to the possible AIS and vulnerable habitats, the emphasis is upon identifying areas that are especiallyvulnerable to invasion and particularly aggressive species and their likelihood of arriving, which therefore merits greater attention.[38]

[35] Washington Department of Ecology, 2010. Hull Cleaning and Boat Washing. http:// www.ecy.wa.gov/programs/wq/nonpoint/CleanBoating/hull.html
Washington State Legislature, 2011.RecreationalWater Vessels Antifouling Paints. Substitute Senate Bill 5436. Chapter 248, Laws of 2011. http://apps.leg.wa.gov/billinfo/summary.aspx?bill¼5436&year¼2011

[36] Piola, N. (2009). 'The Influence of Antifouling Practices on Marine Invasions'.*Biofouling* 25 (7): 633–644. Floerl, O. (2005). 'A Risk-Based Predictive Tool to Prevent Accidental Introductions of Nonindigenous Marine Species'.*Environmental Management* 35(6): 765–778.

[37] See the 2011 Guidelines for the Control and Management of Ships Biofouling for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species. Resolution MEPC. 207 (62), Annex 26. For the consistency in the United States with this, see 33 CFR 151.2050(g).

[38] Murray, C. (2012). 'Adapted for Invasion? Comparing Attachment, Drag and Dislodgment of Native and Nonindigenous Hull Fouling Species'. *Biological Invasions* 14:1651–1663. Gordon, D. (2011). 'Risk Assessment for Invasiveness Differs for Aquatic and Terrestrial Plant Species'. *Biological Invasions* 13:1829–1842. Pysek, P. (2010). 'Invasive Species, Environmental Change and Management, and Health'.*Annual Review of Environmental Resources* 35:25–55.Zaiko, A. (2007). 'Vulnerability of Benthic Habitats to the Aquatic Invasive Species'.*Biological Invasions* 9:703–714. Suedel, B. (2007). 'Application of Risk Assessment and Decision Analysis to Aquatic Nuisance Species'.*Integrated Environmental Assessment Management*. 3: 78-89. Keller, R. (2006). 'Risk Assessment for Invasive Species'.*Proceedings of the National Academy of Sciences.* 104(1): 203–207. Leung, B. (2002). 'An Ounce of Prevention or A Pound of Cure: Bioeconomic Risk Analysis of Invasive Species'. *Proceedings of Biological Science*. 269: 2407-13.

With regards to the possible pathways associated with hull-fouling AIS, the focus has been upon identifying (and controlling if suspicions are confirmed) particular vessels which are:

- ‘Slow-movers’ (vessels with a cruising speed of c. 5 knots, thus including barges and tugs when towing) as species can stick, and stay, for longer,although even faster commercial vessels can be subject to hull-fouling;[39]and/or
- plyingnon-traditional shipping routes, possibly linked with unique AIS;[40]and/or
- spending extended periods of time idle between voyages, potentially accumulating fouling biomass;[41]
- examination of the adequacy (especially in terms of covering all possible areas) and timing of the last coat of anti-fouling paint;[42]and/or
- which can be allowed to defouling in dry-docking so as to controlling wet-defouling whilst in sensitive places.[43]

6. Recommended research programs

Based on the assessment of the various risks posed by increased shipping from the proposed GPT and the consideration of potential mitigation options that are identified in this report, two research programs are recommended to assist in developing an understanding and evaluation of the impacts of the GPT, and thereby to reach a full and informed decision with regards to assessing the significant risk of AIS associated with the existing, proposed and reasonably foreseeable vessel traffic in the area.

Research programto support decision-makers

[39]Mineur, F. (2007).‘Hull Fouling on Commercial Ships as a Vector of Macroalgal Introduction’.*Marine Biology* 151:1299–1307.
[40]Ministry of Agriculture and Fisheries (2010).*Vessel Biofouling as a Vector for the introduction of Non-Indigenous Marine Species to New Zealand: Slow-Moving Barges and Oil Platforms*. (MAF Biosecurity New Zealand Technical Paper No: 2010/12, Wellington).
[41] Johnson, A. (2011). ‘A Binational, Supply-Side Evaluation for Managing Water Quality and Invasive Fouling Species on California’s Coastal Boats’.*Journal of Environmental Management* 92: 3071-3081. Murray, C (2011). ‘Recreational Boating: a Large Unregulated Vector Transporting Marine Invasive Species’. *Diversity and Distributions*. 17: 1161–1172. Davidson, I. (2008). ‘The Potential for Hull-Mediated Species Transfers by Obsolete Ships on Their Final Voyages’.*Diversity and Distributions.*14*:* 518–529. Coutts, A. (2004) ‘A Preliminary Investigation of Biosecurity Risks Associated with Biofouling on Merchant Vessels in New Zealand’. *New Zealand Journal of Marine and Freshwater Research*38:215–229. Coutts, A. (2003) Ships’ Seachests: an Overlooked Transfer Mechanism for Non-Indigenous Marine Species?’.*Marine Pollution Bulletin*, 46:1504–1515. Coutts, A. (2002).A Biosecurity Investigation of a Barge in the Marlborough Sounds. (Cawthron Report No. 744, NZ).
[42] Minchin, D. (2003). ‘Fouling and Ships' Hulls: How Changing Circumstances and Spawning Events may Result in the Spread of Exotic Species’. *Biofouling*, 19 (Supplement), 111–122.
[43]Hopkins, (2008). ‘Management Options for Vessel Hull Fouling: An Overview of Risks Posed by In-water Cleaning’. *International Council for the Exploration of the Sea*. 56: 712-720.

i. Create a cumulative risk assessment for AIS, related to hull-fouling, on all vessels transitingthrough the Salish Sea, including barges and tugs,and especially those that are docking. This study should establish what the baseline is, how the proposed expansion will impact upon the baseline and what additional reasonably foreseeable growth in this area would look like in terms of increased volume and increased risk.

Research program to investigate mitigation options

ii. The utility of adopting best international practices to prevent AIS related to hull-fouling, with particular regard to the detailed risk assessments that evaluate the possible AIS, the vulnerable habitats and then cross-referencing with particularly high risk vessels that are most likely to be the pathways for hull-fouling AIS.

Scoping Memorandum concerning the Pacific Gateway Terminal

Risk of Air Pollution associated with Vessel Traffic

Prepared By: Alexander Gillespie

January 13, 2013

1. The base problem and the need for a cumulative view

Around 11,000 large vessels and oil barges, and accompanying tugs, transit through the Salish Sea each year. Some 4,300 of these large vessels are destined for United States' ports in Puget Sound. The other 6,250 make for Canadian ports.[1] The proposed Gateway Pacific Terminal (GPT) will add approximately 440 ship transits per year, equating to a 4% increase to the 2011 traffic once the terminal becomes operational. After it becomes fully operational, the GPT is projected to generate an additional increase of about 950 transits per year, or an increase of 9%, within 15 years.[2] This increase will be over and above other future expansion in other shipping operations. Each of these vessels presents a risk of increasing air pollution in the region. To assess this risk it is necessary that the additional vessels, in addition to all of the existing related vessels, be assessed for both their incremental and cumulative air pollution, especially in light of the high standards that the governments of the United States and Canada are trying to achieve in this area. Only this type of evaluation will reveal the true extent of the significant risk of air pollution at hand. A cumulative assessment is essential as it will reveal risks that, while perhaps appearing to be minor on an individual level, once quantified in a cumulative assessment framework, may actually turn out to be highly relevant contributors to the risk profile when placed in the context of the overall risk to the air quality of the greater Puget Sound/Georgia Strait area.[3]

In addition to the past, present and the currently proposed 8% increases in shipping traffic for the GPT development, the cumulative assessment should also scope the likely future additional expansions of vessel traffic in this area (even if they are not yet formal or approved proposals). This requirement is especially important when dealing with inter-related projects that will all utilize the same limited resource, in this case, shipping routes. That is, a forward projected assessment should also include data in the cumulative equation on air pollution from traffic increases that can reasonably be foreseen including general increases in vessel traffic from other sources and also vessel traffic projections for other proposed major developments (including those in Canada) that will need to use the same shipping route. This

[1] Hass, T. (2012). The Vessel Traffic Risk Assessment for BP Cherry Point and Maritime Risk Management in Puget Sound. (Puget Sound Partnership). 5.

[2] Pacific International Terminals, Inc. (2011). Project Information Document, Gateway Pacific Terminal, Whatcom County, Washington. 304 p. Also, Vessel Entries and Transits: 2011 WDOE Publication 12-08-003 April 2012.

[3] Kern v. United States Bureau of Land Mgmt., 284 F.3d 1062, 1075 (9th Cir. 2002).

will greatly assist the authorities in providing the necessary information to achieve meaningful regional planning at a reasonable cost, in which uncertainties can be evaluated and effective, appropriate, and sustainable economic, social and environmental choices can be made.[4]

2. The reasonably foreseeable risk of vessel based air pollution

Studies assessing the potential impacts of international shipping on climate and air pollution demonstrate that ships contribute significantly to global climate change and health impacts through emission of GHGs (for example, carbon dioxide [CO2], methane [CH4], chlorofluorocarbons [CFC]), aerosols, nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO) and particulate matter (PM). Air quality impacts may result from the chemical processing and atmospheric transport of ship emissions. For example, NOx emissions from ships can combine with hydrocarbons in the presence of sunlight to produce ozone pollution, which can potentially affect visibility through haze, human and environmental health and has been associated with climate change effects. All classes of ocean-going marine vessels equipped with engines have the capacity to cause air pollution. Because more than 50% of a ship's operating expense is generally the cost of fuel oil, most of the world's ship operators seek the cheapest fuels available; in which high levels of pollutants is the price of their cheaper cost rather than cleaner alternatives. Accordingly, the diesel engines that power the vessels are often significant mobile source emitters of pollution in terms of sulphur oxides, fine particulate matter, nitrous oxides and resultant low level ozone.

[4] Zhao, M. (2012). 'Barriers and Opportunities for Effective Cumulative Impact Assessment within State-Level Environmental Review Frameworks in the United States'. Journal of Environmental Planning and Management. 55(7): 961-978. Senner, R. (2011). 'Appraising the Sustainability of Project Alternatives: An Increasing Role for Cumulative Impact Assessment'. Environmental Impact Assessment Review. 31: 502-505. Hegmann, G. (2011). 'Alchemy to Reason: Effective Use of Cumulative Effects Assessment in Resource Management'. 31 Environmental Impact Assessment Review. 31: 484-490. Gunn, J. (2011). 'Conceptual and Methodological Challenges to Cumulative Effects Assessment'. *Environmental Impact Assessment Review*. 31: 154-160. Therivel, R. (2007). 'Cumulative Effects Assessment: Does Scale Matter ?' *Environmental Impact Assessment Review*. 27: 365-385. Burris, R. (1997). 'Facilitating Cumulative Impact Assessment in the EIA Process'. *International Journal of Environmental Studies*. 53: 1-2, 11-29. Thatcher, T. (1990). 'Understanding Interdependence in the Natural Environment: Some Thoughts on Cumulative Impact Assessment Under the National Environmental Policy Act'. *Environmental Law*. 20: 611. Eckberg, D. (1986). 'Cumulative Impacts Under NEPA'.*Environmental Law*. 16: 673. http://www.aleutiansriskassessment.com/passing.htm

Given that many of these vessels are international in origin, they are not bound by national standards that impose restrictions upon similar technologies on the lands that they visit.[5]

Many of the worst air pollution spots in the United States (including 30 ports), in terms of low-level ozone and fine particulate matter, are attributed to the pollution from ships.[6] Without restraint, projections suggest that by 2030 emissions of nitrogen oxides from ships would more than double, growing to 2.1 million tons a year while annual emissions of fine particulate matter would almost triple to 170,000 tons. Within the shared air-corridor of the Georgia Basin-Puget Sound between the United States and Canada the annual emissions from shipping were estimated at 24,500 tons of sulpher dioxide, 86,500 tons of nitrous oxide and 4,000 tons of fine particulate matter. If unrestrained growth was permitted, projections suggested that, by 2015, marine vessels in this region would contribute 37% of the total air budget of sulpher dioxide, 22% of the nitrous oxide, and 16% of the fine particulate matter.[7]

If not controlled, the impacts of this pollution estimated for the year 2020, is as many as 14,000 premature deaths and related respiratory difficulties for nearly five million people each year in the United States and Canada. The monetized health-related benefits are estimated to be as much as $110 billion in the United States alone.[8]

3. Indicators of significant risk

The contribution that ocean going vessels contribute to air pollution in North America, and the US-Canadian trans-boundary regime, which includes the United States-Canada Border

[5] Han, C (2010). 'Strategies to Reduce Air Pollution in Shipping Industry'. *The Asian Journal of Shipping and Logistics.* 26(1): 7-30.

[6] Environment Canada (2005). Marine Vessels Emissions Survey. (EC, Vancouver). 2. Bailey, D. (2004). 'Pollution Prevention at Ports: Clearing the Air'. *Environmental Impact Assessment Review*. 24: 749–774

[7] McLaren, R. (2011). 'A Survey of NO2:SO2 Emission Ratios Measured in Marine Vessel Plumes in the Strait of Georgia'. *Atmospheric Environment* 46: 655-58. BMT Fleet Technology. (2005). Management Options for Marine Vessel Air Emissions (Ontario).

[8] See Schinas, O (2010). 'Cost Assessment of Environmental Regulation and Options for Marine Operators'. Transportation Research Part C 25: 81–99. Winebrake, J. (2009). 'Mitigating the Health Impacts of Pollution from Oceangoing Shipping: An Assessment of Low-Sulfur Fuel Mandates'. *Environmental Science and Technology*. 43(13): 4776-4785. Gallagher, K. (2005). 'International Trade and Air Pollution: Estimating the Economic Costs of Air Emissions from Waterborne Commerce Vessels in the United States'. *Journal of Environmental Management* 77: 99–103. For the 2020 figures, see a.gov/otaq/regs/nonroad/marine/ci/420f10015.pdf

Air Quality Strategy and its flagship program which is the Georgia Basin Puget Sound International Airshed Strategy, provided the impetus for both governments to approach the IMO to manage, collectively and internationally, vessel based air pollution around North America.[9]

The IMO, conscious that vessels under their auspice (above 400 tons and trans-national) have been responsible for nearly 8% of global emissions of oxides of sulphur and a similar amount of nitrogen oxides, has been attempting to regulate this problem since the end of the 20th century.[10] Working through Annex IV (air pollution) to the 1973/1978 International Convention for the Prevention of Pollution from Ships (MARPOL), standards on both nitrogen and sulfur have been implemented. The standards on the oxides of nitrogen have been dealt with through ever increasing technical standards whereby emissions must be kept below levels which are tagged to the amount of revolutions per minute of different engine sizes, dependent on their date of manufacture.[11] Conversely, oxides of sulphur are dealt with by restricting the type of fuel oil that may be used on board ships. Specifically, the sulphur content of any fuel used on board ships shall not exceed a given amount of its total volume.[12] This figure, which originally started at 4.5%, has been progressively lowered to 3.5% in 2012, with the goal of reducing it to 0.5% in 2020 or 2025.[13] Unhappy with these limits, two regions have campaigned for the recognition of special Emission Control Areas (ECA) in which even higher standards are applied. The Baltic Sea and the North Sea have been designated emission control areas for sulphur pollution, by which the sulphur fuel content in the area cannot rise above 0.5% with a subsequent revision downwards to 0.1%.[14]

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[9] http://www.epa.gov/pugetsound/pdf/international_airshed_strategy.pdf Also, Fraser, D. (2006). 'Collaborative Science, Policy Development and Programme Implementation in the Transboundary Georgia Basin/Puget Sound Ecosystem'. *Environmental Monitoring and Assessment* 113: 49–69.

[10] Anon. (2006). 'New Pathway to Pollution in the Arctic'. *New Scientist*. July 22. 23. Anon. (2006). 'Clouds Gather Over Polluting Ships'. *New Scientist*. Feb 11. 21. Bond, M. (1996). 'Dirty Ships Evade Acid Rain Controls'. *New Scientist*. June 22. 8. Pearce, F. (1993). 'Britain Faces Huge Bill to Cut Acid Rain'. *New Scientist*. March 13. 4.

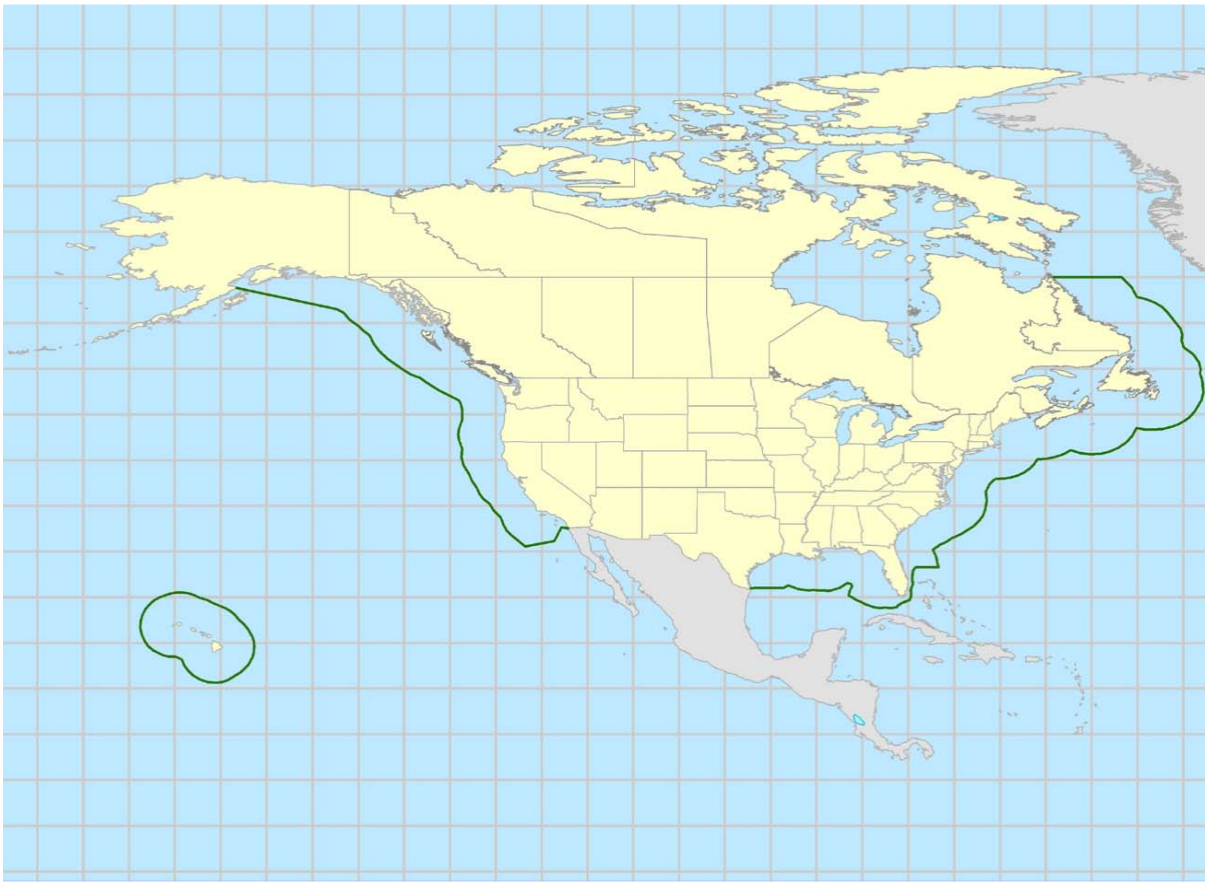
[11] See Regulation 13 of Annex VI of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL). This is reprinted in IMO (2003). MARPOL 73/78. (IMO, London). 408. Also, Anon. (2008). 'IMO Environment Meeting Approves Revised Regulations on Ship Emissions'. *IMO News*. 2: 7.

[12] See Regulation 14 of Annex VI. Ibid. 410.

[13] Anon. (2007). 'Marine Environment Protection Committee Progresses Key Issues'. IMO News. 2007 (3): 21. MEPC. (2004). Report of the MEPC on its 52nd Session. MEPC. 52/WP.13. 23.

[14] Matthias, V. (2010). 'The Contribution of Ship Emissions to Air Pollution in the North Sea Regions'. *Environmental Pollution* 158 (2010) 2241-2250. Anon. (2008). 'North Sea SECA Now In Effect'. IMO News. 2008 (1): 6. Annex 6. Availability and Use of Low Sulphur Bunker Fuel Oils in SOx Emission Control Areas Designated in Accordance With

The United States and Canada then followed suit in an attempt to make the regulation of air pollution from such vessels of the highest possible standards.[15] In 2010, the IMO officially designated waters off North American coasts as an area in which stringent international emission standards will apply to ships. For this area, the effective date of the first-phase fuel sulfur standard is 2012 and the second phase begins in 2015. Beginning in 2016, high standards for the emission of nitrogen oxides also become applicable. The results of these standards are expected to be that by 2020, emissions from these ships operating in the North American ECA are expected to be reduced annually by 320,000 tons for oxides of nitrogen, 90,000 tons for fine particulate matter, and 920,000 tons for oxides of sulphur, which is 23%, 74%, and 86%, respectively, below predicted levels in 2020 absent the ECA.[16]



Regulation 14(3) of Annex VI of MARPOL. MEPC. Report of the MEPC on its 44th Session. MEPC 44/20 (2000). 58-60. This was later confirmed by the IMO in Resolution A.926 (22).

[15] Anon. (2009). 'US Coastal Clean Up'. *New Scientist*. April 4. 4.

[16] http://www.imo.org/mediacentre/pressbriefings/pages/28-eca.aspx. Also, Kotchenruther, R. (2013). 'A Regional Assessment of Marine Vessel PM2.5 Impacts in the U.S. Pacific Northwest'. *Atmospheric Environment* 68: 103-111. Tran, T. (2012). 'Potential Impacts of an Emission Control Area on Air Quality in Alaska Coastal Regions'. *Atmospheric Environment* 50 : 192-202

Figure 1: Area of the North American ECA[17]

4. Recommended research program

There is no need to study mitigations in this area, as mitigations have already been established and adopted, via the IMO, for the North American ECA. However, with the projected increases in traffic, it is possible that the benefits of the ECA may be offset by the growth of vessel traffic in this region. Accordingly, a study should be undertaken to see what impact of air pollution associated with increased vessel traffic, in the present and the reasonably foreseeable future, may have in this area and what impact these increases will have upon air quality standards.

[17] http://www.epa.gov/otaq/regs/nonroad/marine/ci/420f10015.pdf

Scoping Memorandum concerning the Pacific Gateway Terminal

The Cumulative Effects of Shoreline Armoring on Forage Fish Spawning Beach Habitat in San Juan County, Washington

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August, 2011

The Cumulative Effects of Shoreline Armoring on Forage Fish Spawning Beach Habitat in San Juan County, Washington.

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Friends of the San Juans

August 2011

Prepared for the Bullitt Foundation

Introduction

Forage fish play a key role in marine food webs, with a small number of species providing the trophic connection between zooplankton and larger fishes, squids, seabirds and marine mammals, including ESA listed species such as Chinook salmon and the marbled murrelet. Beach spawning forage fish such as surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) are threatened by land use activities along shorelines, where development is also concentrated.

Forage fish spawning areas in San Juan County (SJC) and throughout Puget Sound are especially vulnerable to the impacts of shoreline armoring. Sea level rise is expected to exacerbate the impacts of shoreline armoring on forage fish spawning habitat. In addition, sea level rise and other implications of climate change such as increased storminess are anticipated to result in the increased demand for new shoreline armoring, which will further compound forage fish spawning habitat loss and degrade the nearshore sediment sources or feeder bluffs that sustain nearshore habitats. The objective of this assessment was to investigate the cumulative effect shoreline armoring is having on the upper intertidal sand and gravel beach habitats required for spawning substrate by two key forage fish in the Puget Sound region, surf smelt and Pacific sand lance. The geographic scope of the project was San Juan County, Washington. Generous funding for this research was provided by the Bullitt Foundation.

Background

With over 400 miles of marine shoreline located at the confluence of Puget Sound, Georgia Strait and the Strait of Juan de Fuca, the nearshore marine habitats of SJC play an important role in regional salmon and orca recovery efforts. Bulkheads and other shore modifications that bury habitat and limit bluff erosion and littoral sediment transport have led to major changes in sediment supply and associated changes in beach and habitat stability. The cumulative impact of human modifications to the shoreline may be far-reaching in terms of both habitat and existing human activities, particularly in the face of anticipated increases in the rate of sea level rise and storm induced erosion. Coastal geomorphic processes create and maintain the nearshore habitats upon which many Puget Sound species of concern rely, including forage fish spawning areas, and juvenile salmonid rearing and migratory habitats, among others (Fresh 2006, Penttila 2007, Johannessen and MacLennan 2007).

Shore modifications, almost without exception, impact the ecological functioning of nearshore coastal systems. The proliferation of these structures has been viewed as one of the greatest threats to the ecological functioning of coastal systems (Thom et al. 1994). Modifications often result in the loss of the very feature that attracted coastal property owners in the first place, the beach (Fletcher et al. 1997). With bulkheading and other shore modifications such as filling and dredging, net shore-drift input from bluffs is reduced and beaches become “sediment starved.” The installation of structures typically results in the direct burial of the backshore area and portions of the beach face, resulting in reduced beach width (Griggs 2005) and loss of habitat area (Bulleri and Chapman 2010). Beaches also become more coarse-grained as sand is winnowed out and transported away. The beach is often converted to a gravel beach which does not provide the same quality of habitat as a finer grain beach (Thom et al. 1994, MacDonald 1994). Large woody debris (LWD) is usually also transported away from the shore following installation of bulkheads, with corresponding changes in habitat (Tonnes 2008).

Habitats that are substantially impacted by shore modifications include forage fish (such as surf smelt and sand lance) spawning habitat. These habitat areas are only found in the upper intertidal portion of fine gravel and sand beaches, with a high percentage of 1-7 mm sediment (Penttila 1999), which is fine gravel (smaller than pea gravel) to coarse sand. Sand lance require 0.5-3.0 mm sediment for spawning. Beach sediment coarsening can also affect hard-shell clam habitat, by decreasing or locally eliminating habitat. A recent study by C. Rice (2006) documented the effects of shoreline modifications on Puget Sound beaches on surf smelt mortality. Results showed that anthropogenic alteration of the shoreline typically makes beaches less suitable for surf smelt embryo survival when compared with unmodified shores (Rice 2006). Loss of marine riparian areas is commonly associated with shoreline development and anthropogenically modified shores.

Shoreline modification was identified as a top threat to the SJC marine ecosystem (SJC Marine Stewardship Area Plan 2007) and protection of unmodified habitat was a primary focus for the San Juan Initiative's ecosystem research. In 2007, FSJ completed an *Analysis of Shoreline Permit Activity in San Juan County (1972-2005)* and found that over 300 permits are granted each year for shoreline structures, excluding houses (Whitman 2007). The analysis also found that no-net-loss and sensitive areas regulations adopted in the 1990's have not reduced the amount of shoreline permits granted that impact priority nearshore habitats including eelgrass and documented forage fish spawning habitats (Whitman 2007). Permits for expansion of existing armoring and new armoring of known surf smelt and Pacific sand lance spawning habitats also continue to be granted in SJC by both county and state regulators.

In 2009, FSJ conducted a field-based inventory and mapping project of shoreline modifications for the 408 miles of marine shoreline within SJC. Results show that the current level of impact to shorelines is much higher than previously believed and that the vast majority of impacts are associated with residential shoreline development. Just under 3,500 individual modifications were mapped, photographed and described (size, material, condition, tidal elevation) and include: 710 armored beaches, 472 docks, 32 groins, 55 marine railways, 70 improved boat ramps, 50 marina/jetty/breakwater, and 191 "other" beach structures (boathouses, stormwater outflow pipes, patios etc.). Over 18 miles of SJC's total shoreline is armored; and 22.5% of the 80 miles of sand and gravel beaches are armored (the remaining 320+ miles of shoreline is rocky). As documented by the San Juan Initiative's Case Study (Johannessen and MacLennan 2008), there was a predominance of shore modifications along not just feeder bluffs but also along transport zones, accretion shoreforms and pocket beaches, which all provide habitat for important marine species. The location of most modifications along non rocky shorelines means that impacts are concentrated in areas important to forage fish spawning habitat and habitat forming processes. With just ten miles of documented forage fish (surf smelt and Pacific sand lance) beach spawning habitat in SJC, improved protections are needed to ensure maintenance of these habitats over the long term.

Process-based restoration has been recognized as the ideal means of restoring Puget Sound nearshore environments (Leschine and Petersen 2007, Johannessen and MacLennan 2007). Processed-based restoration attempts to restore and protect those self-sustaining processes that support the ongoing maintenance of habitats on a landscape scale. Eroding bluffs (commonly referred to as "feeder bluffs") contribute sediment to net shore-drift cells (along shore sediment sub-systems); replacing sediment that is continuously transported to maintain down-drift habitats such as spits and pocket estuaries. Protecting and enhancing physical processes along Puget Sound area beaches and bluffs is essential to sustaining, preserving, restoring and creating more resilient nearshore habitats (Shared Strategy 2005). The connections between coastal processes and nearshore habitats is complex and occurs at multiple spatial and temporal scales, all of which require adequate policy language to effectively protect or manage these resources.

Methods

A spatially explicit analysis was conducted using the following GIS data layers: documented forage fish spawning habitat, shoreline armoring, shoreform, and drift cell. Technical assistance in the development of project methodology was provided by Andrea MacLennan of Coastal Geologic Services, Dan Penttila of Salish Sea Biological and James Slocomb. GIS analysis and mapping was conducted by Sally Hawkins. Forage fish spawning habitat and armor were assessed for their relationship to shoreform, and to each other. In addition, known impacts to spawning habitat including direct burial, changes to sediment supply and sediment transport were evaluated. The presence or absence of marine riparian vegetation at documented spawning sites, and associated armored spawn sites, is also underway but was not completed in time for this report.

Burial of spawning habitat was quantified by the linear shoreline length of impact of armor with a toe elevation at and below 9 feet Mean Lower Low Water (M.L.L.W.). A more detailed quantification would include an assessment of beach profile to support a calculation of the area of spawning habitat buried. Site specific field investigation of beach profiles was beyond the scope of this project, but should be considered for future work on this topic. Impacts to sediment supply, essential to formation and long term maintenance of the spawning substrate size range required by surf smelt and Pacific sand lance, were evaluated by the number and length of armoring of feeder bluffs, in drift cells with documented and potential spawning beaches. Impacts to sediment transport were evaluated by the number and length of shoreline armoring occurrences with a toe elevation below mean sea level (4.5 M.L.L.W. from NOAA Friday Harbor station applied countywide).

Results

Just over eleven miles of surf smelt and/or Pacific sand lance spawning beaches have been documented in San Juan County. Sporadic spawning habitat assessment surveys were conducted by the Washington Department of Fish and Wildlife beginning in the late 1980's and a concentrated survey effort was completed by Friends of the San Juans, in partnership with WDFW, Friday Harbor Marine Labs and the San Juan County Marine Resources Committee from 2001-2003. Potential spawning habitat was assessed through a combination of aerial photo interpretation and field based analysis of suitable spawning substrate. Over 80 miles of potential spawning habitat is documented in San Juan County.

The majority of documented forage fish spawning in San Juan County occurs on pocket beaches, with 44 of 186 shoretypes with spawn and 3.10 miles. Barrier beaches have the next highest occurrence of documented spawn, by length with 2.33 miles at 20 sites. Feeder bluffs also have substantial documented forage fish spawning habitat, with 39 sites and 1.98 miles. Forage fish spawn has also been documented in transport zones, with 28 sites making up just over 1.6 lineal shoreline miles of spawn habitat. The remaining mile or so of habitat occurs along artificial shorelines (those places where the shore has been modified to the extent that the original shoreform classification is uncertain, or along areas incorrectly classified as rocky shorelines.

The majority of armor impacts on documented spawn sites were located on feeder buffs, followed by pocket beaches, barrier beaches, transport zones and then rocky shores. With 2.23 miles of armoring in place at known surf smelt and Pacific sand lance spawning beaches, 20% of documented spawn sites are currently armored. See Forage Fish and Armor Habitat Impacts Mapbook, beginning on page 14 and Table 1. Forage fish spawning habitat and shoreline armoring by shoreform, below.

Table 1. Forage Fish Spawning Beaches and Armoring by Shoreform

Shoreform	*Documented Forage Fish Spawn Beaches - Count*	*Documented Forage Fish Spawn - Length feet (miles)*	*Armored Documented Forage Fish Spawning Beaches - Count*	*Armored Documented Forage Fish Spawn - Length feet (miles)*
Artificial	1	286 ft. (.05 mi)	0	0
Embayment	0	n/a	n/a	n/a
Feeder Bluff	39	10,477 ft. (1.98 mi)	30	3.073 ft.
Transport Zone	28	8,685 ft. (1.64 mi)	9	723 ft.
Barrier Beach	20	11,797 ft. (2.23 mi)	7	1,613 ft.
Pocket Beach	44	16,0359 ft. (3.10 mi)	22	2,986 ft.
Rocky Shoreline*	54	9,244 ft.* (1.75 mi*)	6	226 ft.
total	***186 sites***	***58,384 feet (11.06 miles)***	***71 sites***	***8,621 feet (1.63 miles)***

**NOTE: While shoreform maps of San Juan County have improved greatly over the past year with the completion of geomorphic feeder bluff mapping and pocket beach mapping (Coastal Geologic Services 2010 and 2011) some rocky shore remains incorrectly classified. Spawn not actually present on rocky shores, but shore segments classified as rocky due to resolution issues or errors including: small, unmapped pocket beaches, complex features such as tombolos or areas with heavy forest cover that may have limited classification efforts.*

Direct Burial of Spawning Habitat

Surf smelt and Pacific sand lance are obligate intertidal spawners, requiring suitable substrate on the upper elevation portion of beaches to successfully incubate and hatch their eggs. The preferred spawning range of the surf smelt is 7 to 9 feet M.L.L.W., roughly at and above mean higher high water in San Juan County.

On low profile beach types such as mud flats, the presence of armoring in the tidal elevation range of spawn can result in significant and permanent loss of spawning substrate through direct burial. While the overall area of impact may be less when quantified numerically at a steeper beach face site, as the area of suitable spawn area is also typically narrower at these types of sites, the loss of suitable spawning habitat may be just as severe. For this study, direct burial of spawning habitat was quantified by the lineal shoreline length of armoring with a toe elevation of 9 feet M.L.L.W. or below at documented surf smelt and Pacific sand lance spawning sites. The vast majority of armoring at documented sites are currently causing direct burial impacts to spawning habitat. With 2.07 miles of armor along documented forage fish spawning sites, 98% of these sites (1.60 miles) have a toe elevation at or below 9 feet M.L.L.W. See Forage Fish and Armor Habitat Impacts Mapbook, beginning on page 14 and Table 2. Direct burial of spawning habitat, below.

Table 2. Direct Burial of Spawning Habitat
(armored documented forage fish spawning beaches with armor toe elevation below 9 ft. M.L.L.W.)

Shoreform	**Armored documented forage fish spawning beaches with armor toe elevation at or below 9 ft. M.L.L.W. - count**	**Armored documented forage fish spawning beaches with armor toe elevation at or below 9 ft. M.L.L.W. - length Feet (miles)**
Artificial	n/a	n/a
Embayment	n/a	n/a
Feeder Bluff	30	3,073 ft. (mi)
Transport Zone	9	723 ft. (mi)
Barrier Beach	7	1,613 ft. (mi)
Pocket Beach	20	2,817 ft. (mi)
Rocky Shoreline*	5	202 ft. (mi)
total	**71**	**8,428 ft (miles)**

*See note about rocky shoreforms in Table 1,

Impacts to Sediment Supply

Erosion from bluffs provide over 90% of the beach sediment supply in Puget Sound and bluff sediment is an even larger percentage in San Juan County, which lacks major rivers to transport sediment from inland upland sources. Formation and maintenance of forage fish spawning beaches, with the required fine sediment size range to support beach spawning species such as surf smelt and Pacific sand lance, depends on long term protection and restoration of coastal sediment processes. Armoring of feeder bluffs, the primary sediment supply source, is a major concern for the long term maintenance of suitable spawning substrate. This is especially important in drift cells with documented forage fish spawn. Protection of sediment processes in all drift cells is a critical management imperative, to ensure protection of other substrate dependent functions and values such as shellfish and eelgrass. In addition, documentation of new spawning sites continues to occur in San Juan County and throughout the region.

In San Juan County, there are 167 instances of armored feeder bluffs, or 4.94 miles where sediment supply has been impacted. Roughly one third of these armored feeder bluffs (1.3 miles) are located within drift cells with documented spawn. In San Juan County, there are 18 drift cells with armored feeder bluffs that also contain documented forage fish spawn habitat. 58 drift cells have armoring of feeder bluffs, disrupting sediment supply to potential forage fish spawning habitat, or areas where spawn has not yet been documented. These areas are top restoration priorities to ensure adequate sediment supply to maintain forage fish spawning substrate at known spawning sites into the future. Protection of intact feeder bluffs within drift cells with documented forage fish spawning habitat should also be a top management strategy. See Forage Fish and Armor Process Impact Map Book, beginning on page 29 and Table 3. Sediment Supply Impacts, below.

Table 3. Sediment Supply Impacts to Forage Fish Spawn Habitat
(armored feeder bluffs and armored feeder bluffs in drift cells with documented forage fish spawn)

Drift cells	***Armored Feeder Bluffs - count***	***Armored Feeder Bluffs - length***	***Armored Feeder Bluffs in Drift Cells with Documented Forage Fish Spawning Beaches - Count***	***Armored Feeder Bluffs in Drift Cells with Documented Forage Fish Spawning Beaches - Length***
	167	26,076 feet 4.94 miles	58	6,813 feet 1.3 miles

Impacts to Sediment Transport

In addition to impacts to sediment supply, shoreline armoring can also disrupt sediment transport processes. Impacts to littoral drift were evaluated by identification of armoring with toe elevation at mean sea level and below. Mean sea level has been determined for multiple San Juan County sites by NOAA; the value of 4.5 feet M.L.L.W. (Friday Harbor NOAA station) was used in this countywide analysis. The severity of the impact to sediment transport processes also depends on shoreform, and location relative to documented or potential spawning habitat, with the largest impacts to sediment transport occurring when armoring with a toe elevation below mean sea level is located on feeder bluffs or transport zones updrift of documented forage fish spawning beaches. Nearly four miles of armoring with a toe elevation below mean sea level were documented in San Juan County, potentially impacting the transport of sediment to documented and potential forage fish spawning beaches. See Forage Fish and Armor Process Impact Map Book, beginning on page 29 and Table 4. Impacts to Sediment Transport, below.

Table 4. Impacts to Sediment Transport
(armor with a toe elevation below mean sea level defined as 4.5 M.L.W.)

Shoreform	***Armor located below mean sea level - count***	***Armor located below mean sea level – length Feet (miles)***
Artificial	4	2,937 ft. (.55 mi)
Embayment-Estuary	13	1,041 ft. (.20 mi)
Embayment-Lagoon	1	25 ft. (.004 mi)
Barrier Beach	8	1,120 ft. (.21 mi)
Pocket Beach	65	6,396 ft. (1.21 mi)
Rocky Shoreline	72	4,039 ft. (.76 mi)
Transport Zone	18	2,129 ft. (.40 mi)
Feeder Bluff	28	2,544 ft. (.48 mi)
total	***209 sites***	***20,231 feet (3.83 miles)***

Marine Riparian Conditions

Shoreline vegetation provides habitat structure and function for salmon and salmon prey. Research has shown that surf smelt egg survival is reduced up to 50% along armored shorelines (Rice 2006). The removal of shoreline, or riparian vegetation, is often associated with shoreline armoring. To help evaluate potential impacts to forage fish spawning success, and improve understanding of the relationship between armoring and shoreline vegetation, a visual assessment of overhanging vegetation at armored and unarmored documented forage fish spawning sites was conducted. Visual assessment was conducted using oblique and vertical aerial photographs from the Washington Department of Ecology as well as infrared vertical aerials (Friends of the San Juans and the WA Department of Natural Resources). Overhanging vegetation presence was classified into five categories (none, .1 to 25%, 26-50%, 51-75% and 75-100%). Changes to overhanging vegetation at armored documented spawn sites was most pronounced for feeder bluff, pocket beach and rocky shoreforms. See Table 5. Overhanging Marine Riparian Vegetation; results shown as for the dominant coverage classes only.

Table 5. Overhanging Marine Riparian Vegetation – dominant coverage class (coverage classes: none; .1-25%; 26-50%; 51-75%; 76-100%)

Shoreform	*Overhanging Vegetation Shoreform with Spawn**	*Overhanging Vegetation Unarmored Spawning Beaches**	*Overhanging Vegetation Armored Spawning Beaches**
Artificial	none	none	n/a
Embayment	n/a	n/a	n/a
Feeder Bluff	76-100%	76-100%	.1-25%
Transport Zone	76-100%	76-100%	76-100%
Barrier Beach	none	none	none
Pocket Beach	76-100%	76-100%	None
Rocky Shore	76-100%	76-100%	none

Note: table simplified to show dominant coverage class results only.

Conclusions/Management Implications

With over 700 armored beaches and a limited number of documented forage fish spawning beaches, improved efforts to understand and manage the cumulative effects of shoreline armoring to these critical spawning habitats and habitat forming processes are needed. Forage fish play a critical role in marine foods, with a small number of forage fish species providing the critical link between zooplankton and the predators, including seabirds, marine mammals and a multitude of fish species including Chinook salmon. Improved management, including both restoration and protection strategies, are needed to reduce the impacts of bulkheads and shoreline infrastructure such as roads on beach spawning habitat and the coastal processes that form and maintain suitable spawning substrate.

Top restoration priorities include: restoration to remove armoring from documented forage fish spawning beaches to uncover and restore buried spawning substrate; removal of shoreline armoring from feeder bluffs in drift cells with documented forage fish spawning habitat to restore sediment supply; and removal of shoreline armoring located below mean sea level updrift of documented spawning sites to restore sediment transport. Additional restoration priorities include the removal of armoring from feeder bluffs and removal of all armoring with a toe elevation less than mean sea level in drift cells with potential forage fish spawning habitat.

As restoration success is limited by feasibility and high cost, improved protection will play an essential role in ensuring that forage fish spawning habitat and habitat forming processes are maintained into the future. Improved protections are needed to clearly prohibit the construction of new bulkheads at documented forage fish spawning sites or at feeder bluffs in drift cells with document spawning sites. In addition, policies to promote the removal or relocation of existing armoring, perhaps through enhanced repair/replace regulations, are needed countywide. Demand for armoring is expected to increase and the documentation of additional spawning sites is also likely. As such, policies designed to minimize the need for future armoring at all shoreforms and drift cells and for potential as well as documented spawn sites, such as wider building setbacks and protection of vegetative buffers between structures and the shoreline, will be needed. Protection of beach habitats into the future, for fish, wildlife and people, will not be possible through restoration actions alone. Improved protection policies will be required.

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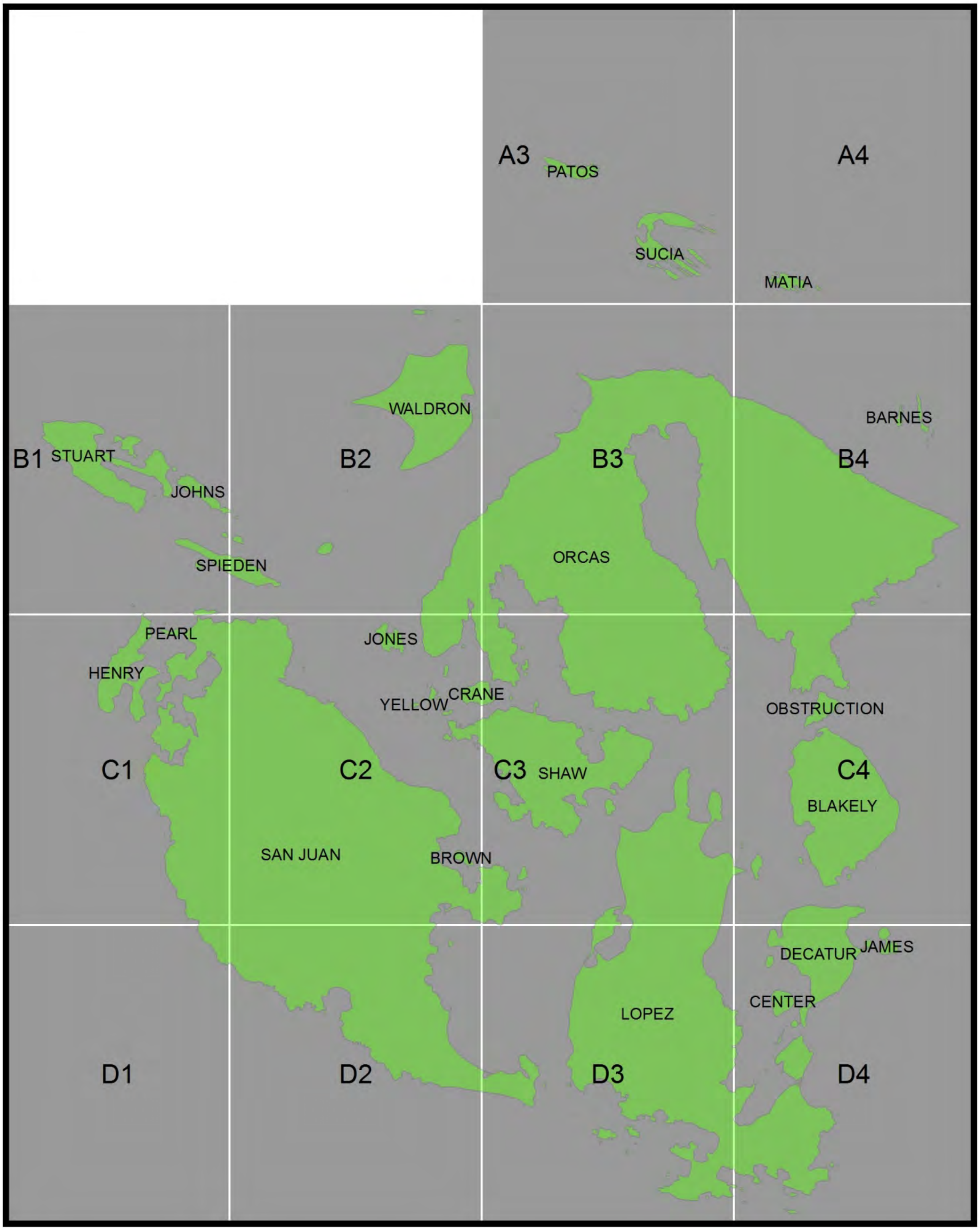
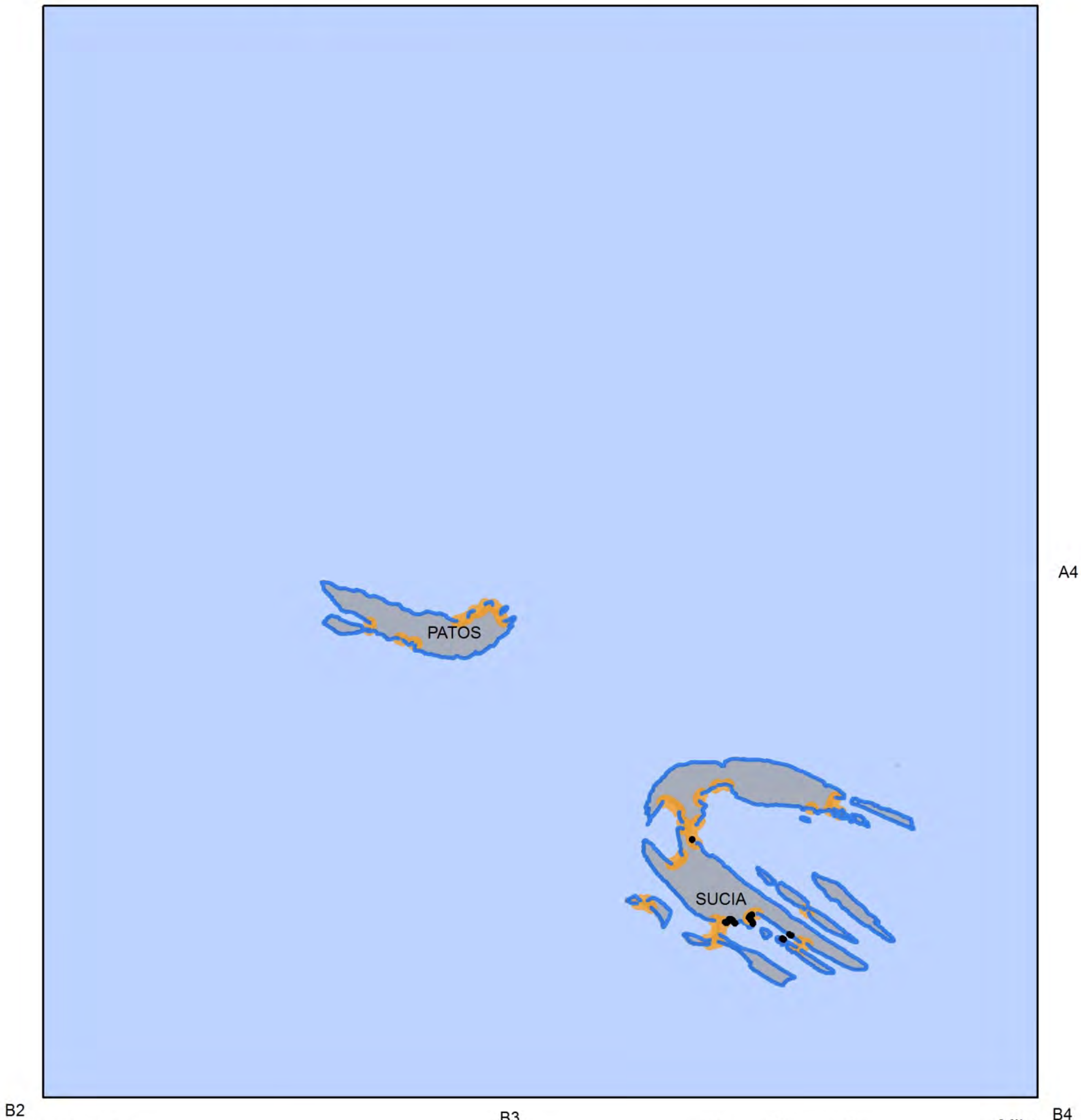


San Juan County
Forage Fish Spawning and Shoreline Armoring Impact Analysis
MAPBOOK

FRIENDS OF THE SAN JUANS

Forage Fish and Armor Habitat Impacts



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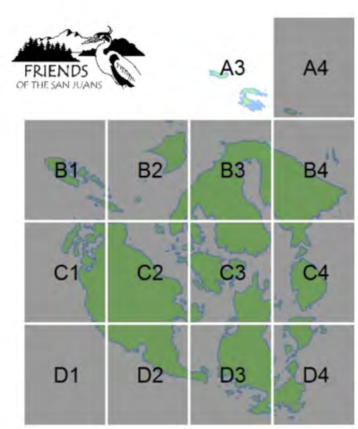
N

LEGEND:

Shoreform

- Artificial
- Barrier Beach
- Embayments - Estuary
- Embayments - Lagoon
- Feeder Bluff
- Pocket Beach
- Rocky Shoreline
- Transport Zone

- Shoreline Armoring
- Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
- Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
- Roads



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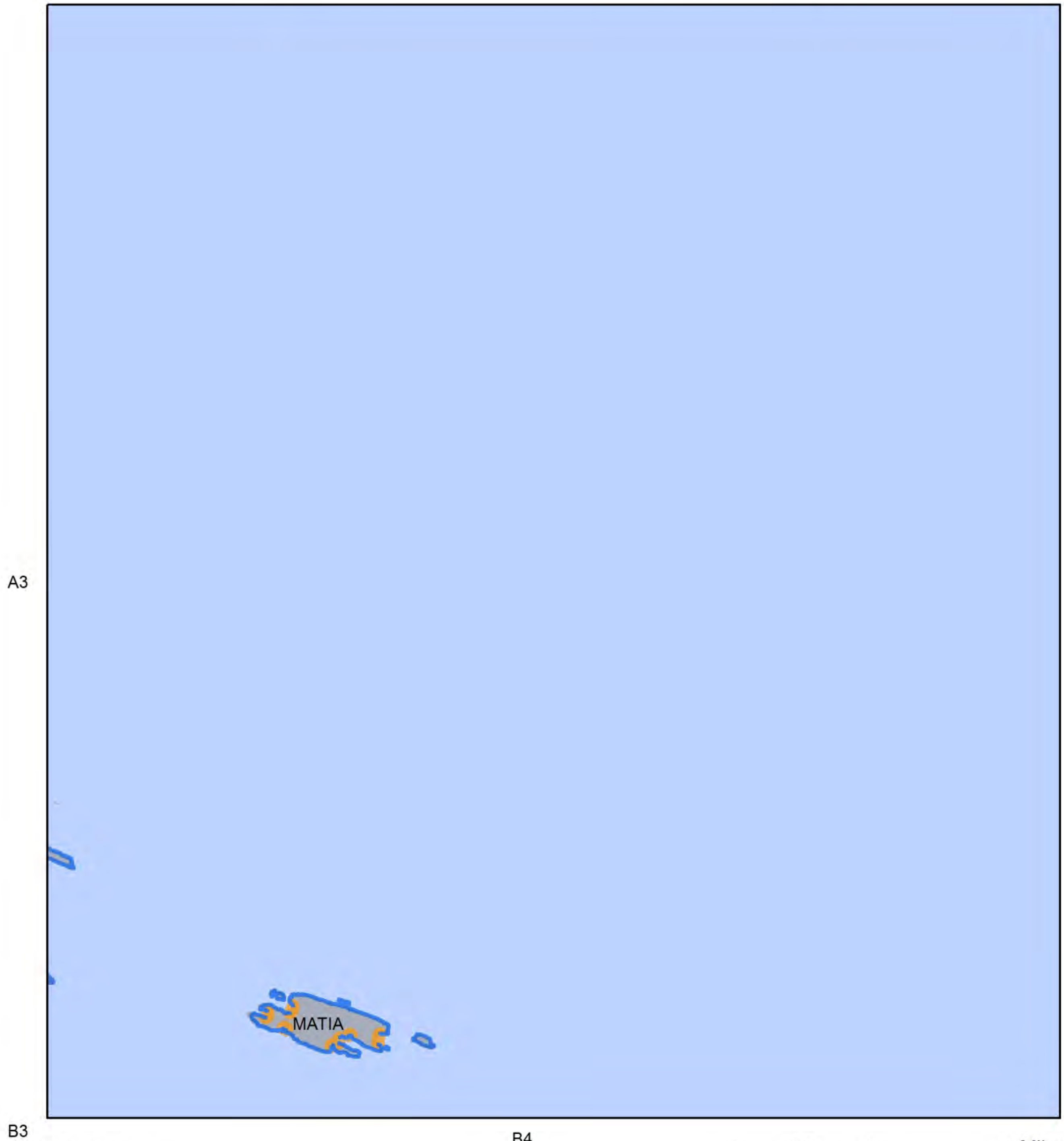
Forage Fish and Armor Habitat Impacts



1 0.5 0 1 Miles

LEGEND:

Shoreform

Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

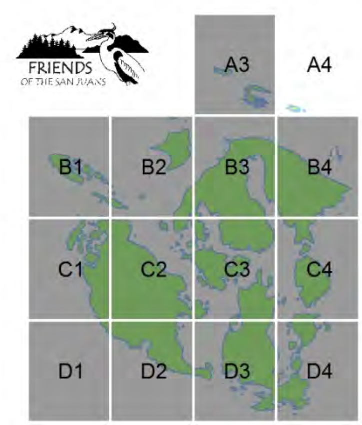
Shoreline Armoring

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.

Roads

N



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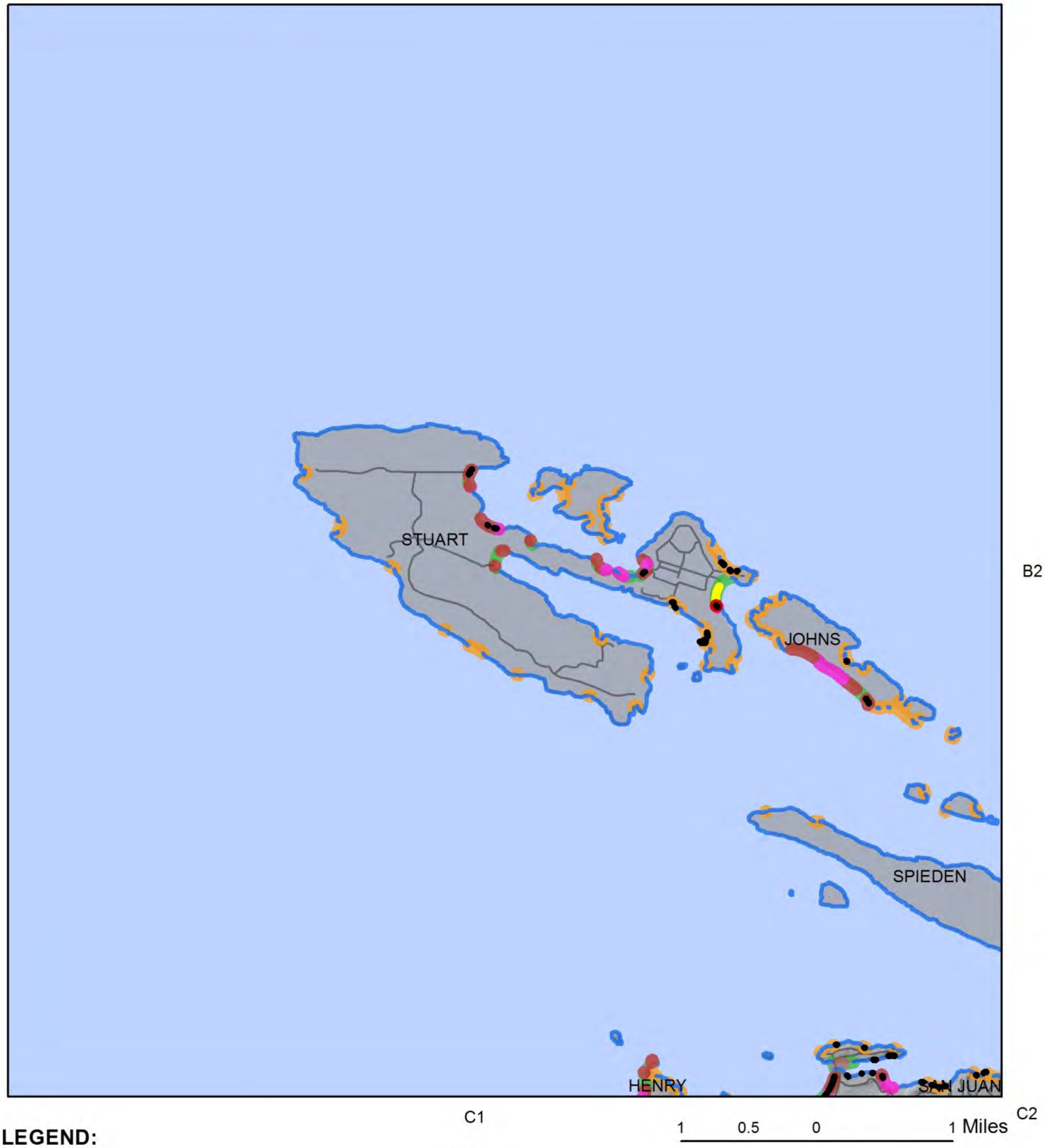


LEGEND:

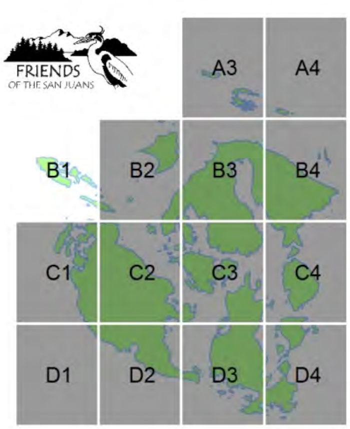
Shoreform

- Artificial
- Barrier Beach
- Embayments - Estuary
- Embayments - Lagoon
- Feeder Bluff
- Pocket Beach
- Rocky Shoreline
- Transport Zone

N

- Shoreline Armoring
- Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
- Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
- Roads

FRIENDS OF THE SAN JUANS



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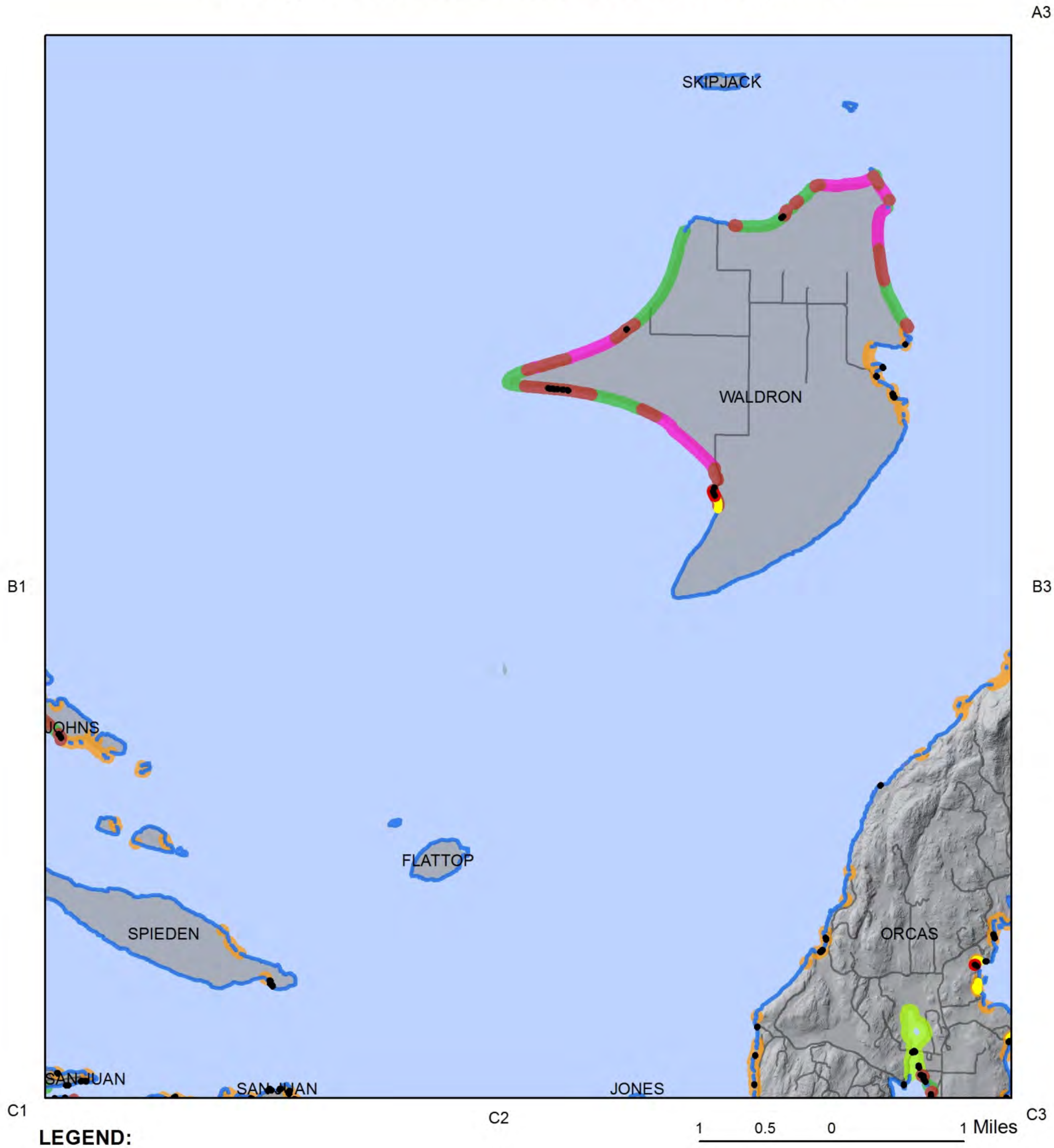
Forage Fish and Armor Habitat Impacts

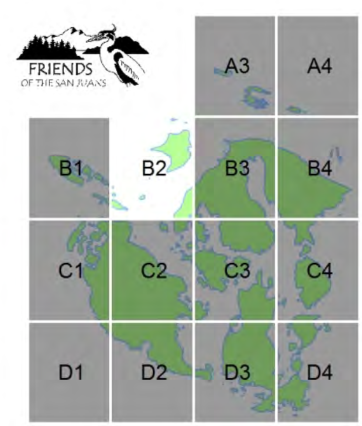


LEGEND:

Shoreform

Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

Shoreline Armoring
Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
Roads



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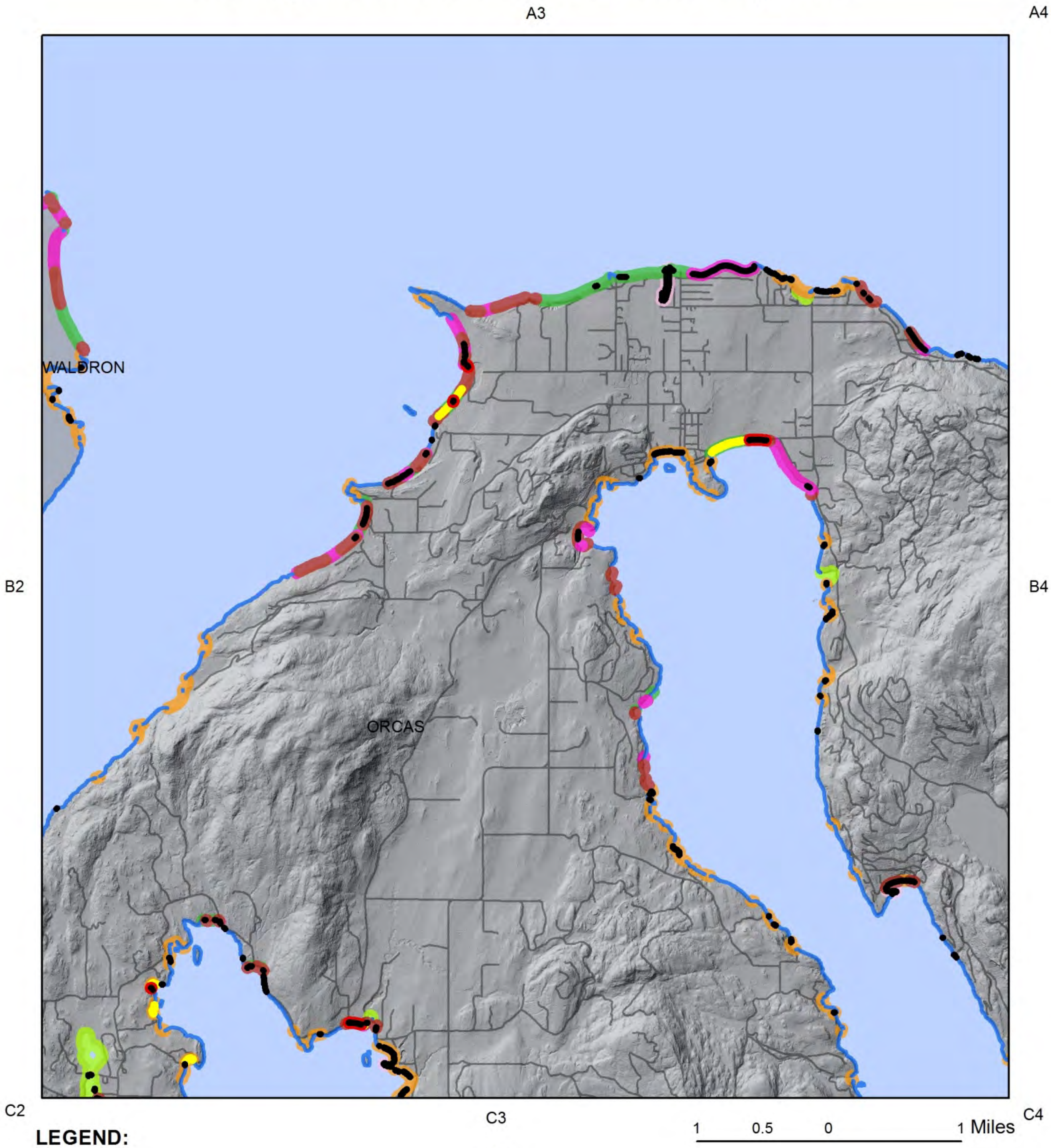


LEGEND:

Shoreform

Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

Shoreline Armoring

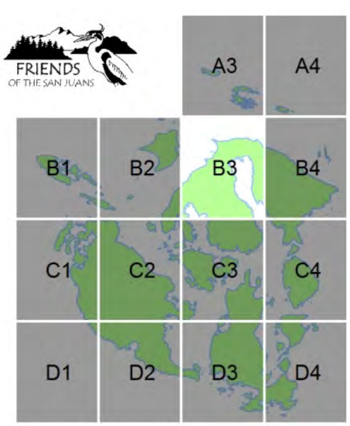
Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.

Roads

N

FRIENDS OF THE SAN JUANS



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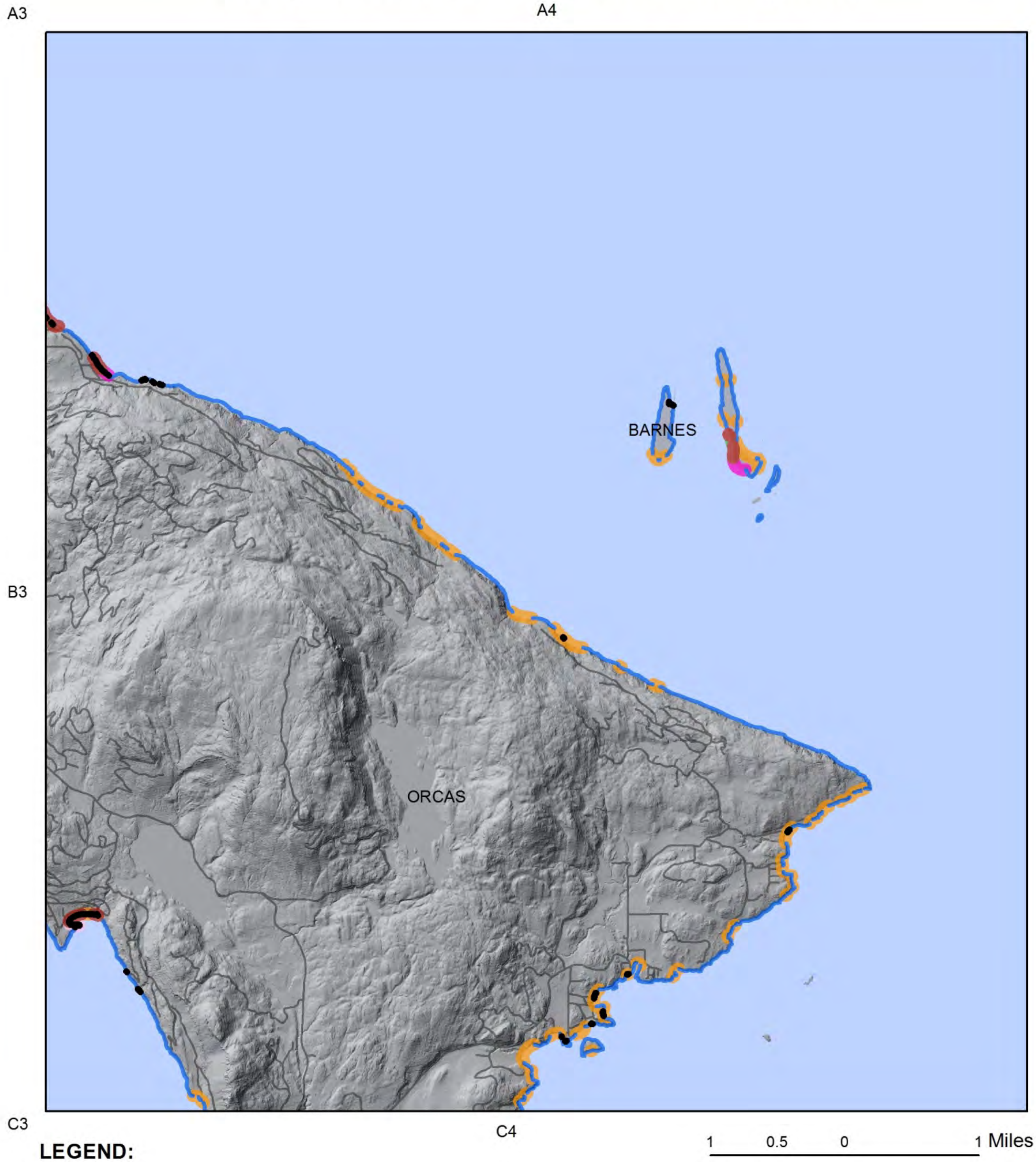

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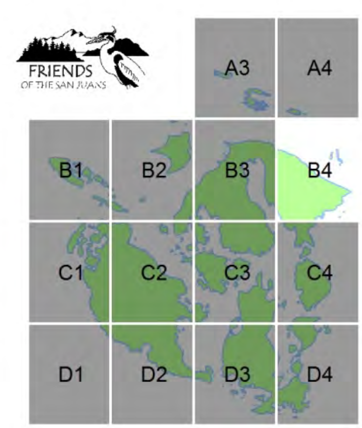

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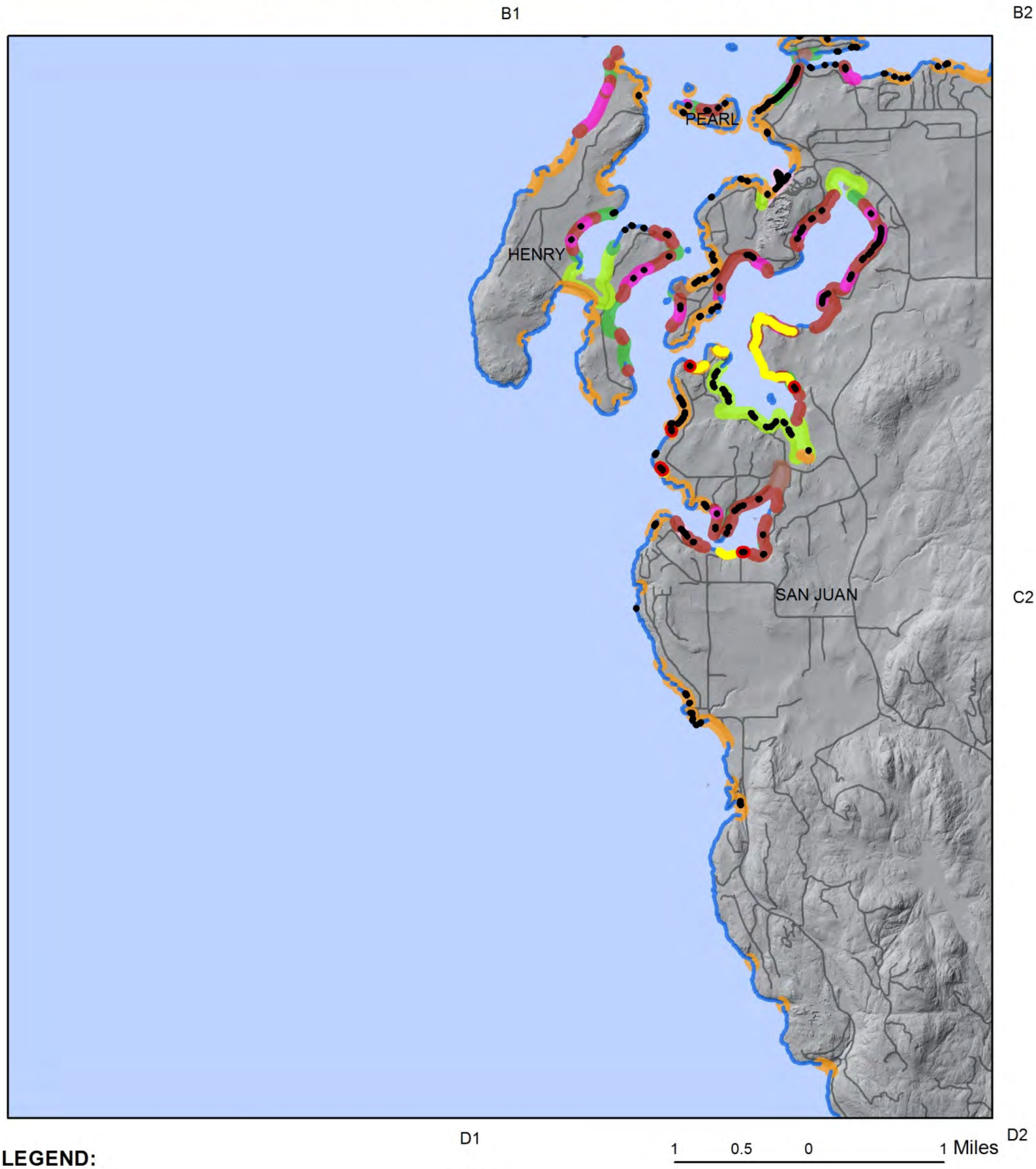
Forage Fish and Armor Habitat Impacts



LEGEND:

Shoreform

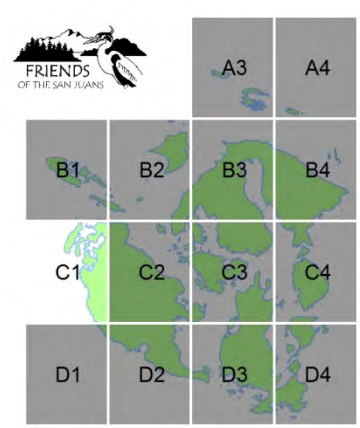
Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

Shoreline Armoring

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.

Roads



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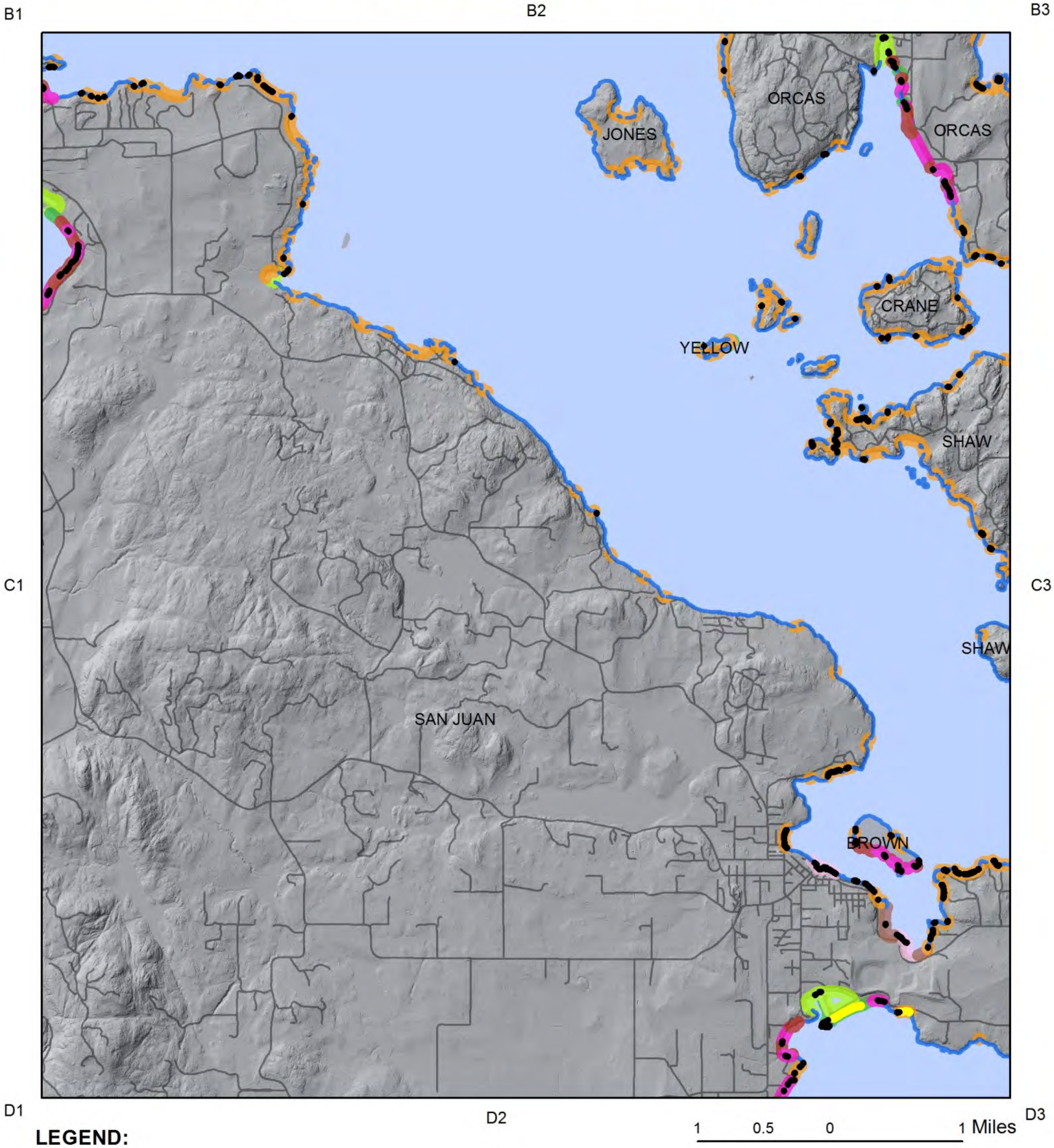
Forage Fish and Armor Habitat Impacts



LEGEND:

Shoreform

Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

Shoreline Armoring
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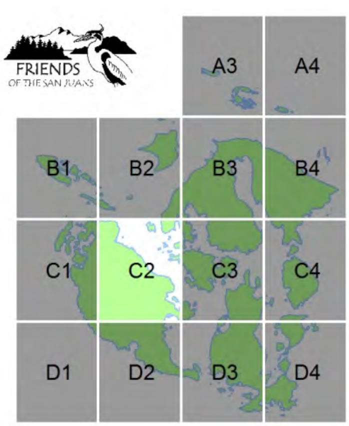
Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
Roads

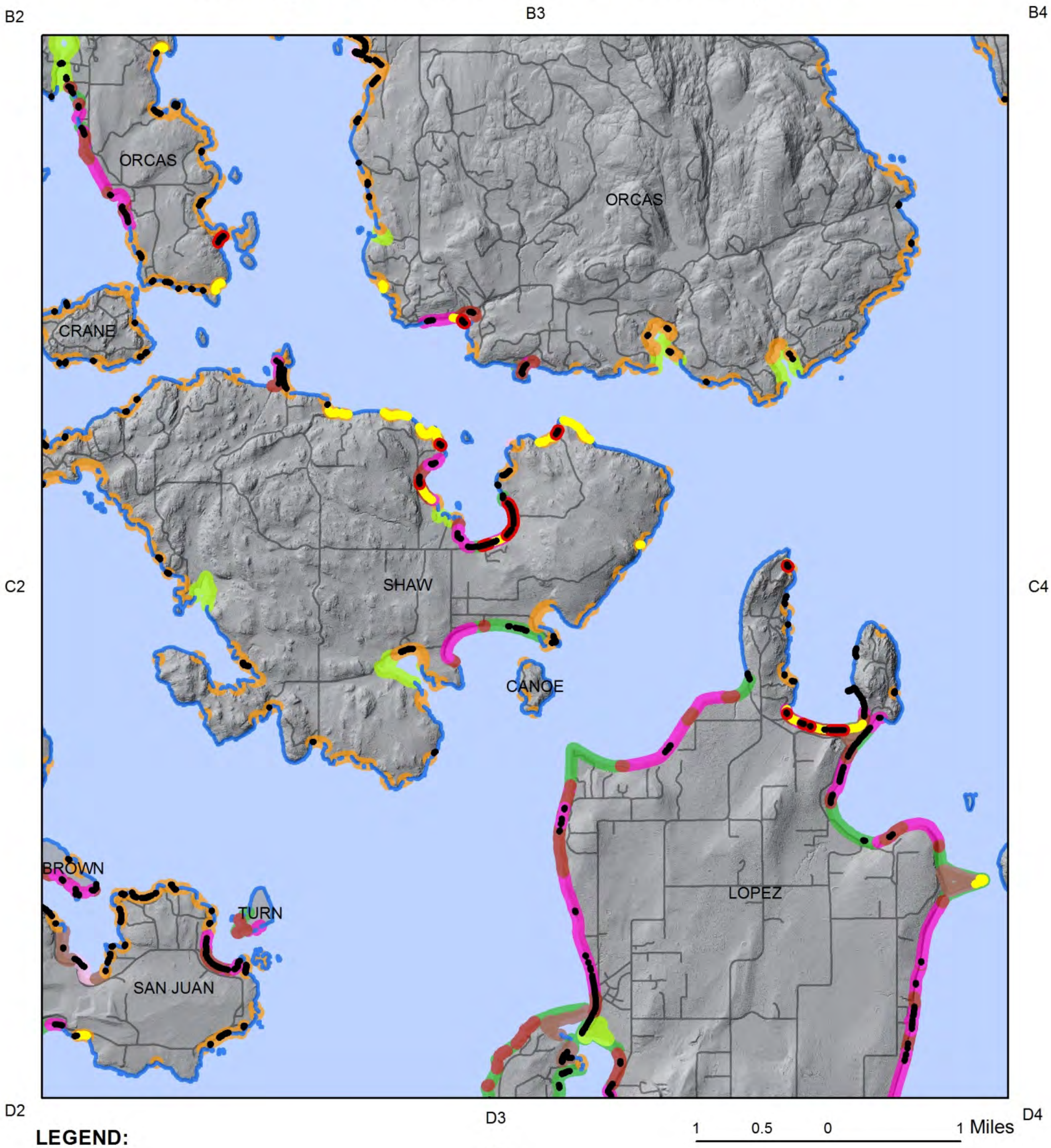
N

FRIENDS OF THE SAN JUANS



C2

Forage Fish and Armor Habitat Impacts



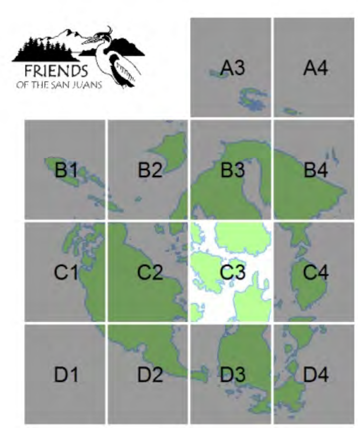
LEGEND:

Shoreform

- Artificial
- Barrier Beach
- Embayments - Estuary
- Embayments - Lagoon
- Feeder Bluff
- Pocket Beach
- Rocky Shoreline
- Transport Zone

- Shoreline Armoring
- Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
- Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
- Roads

N



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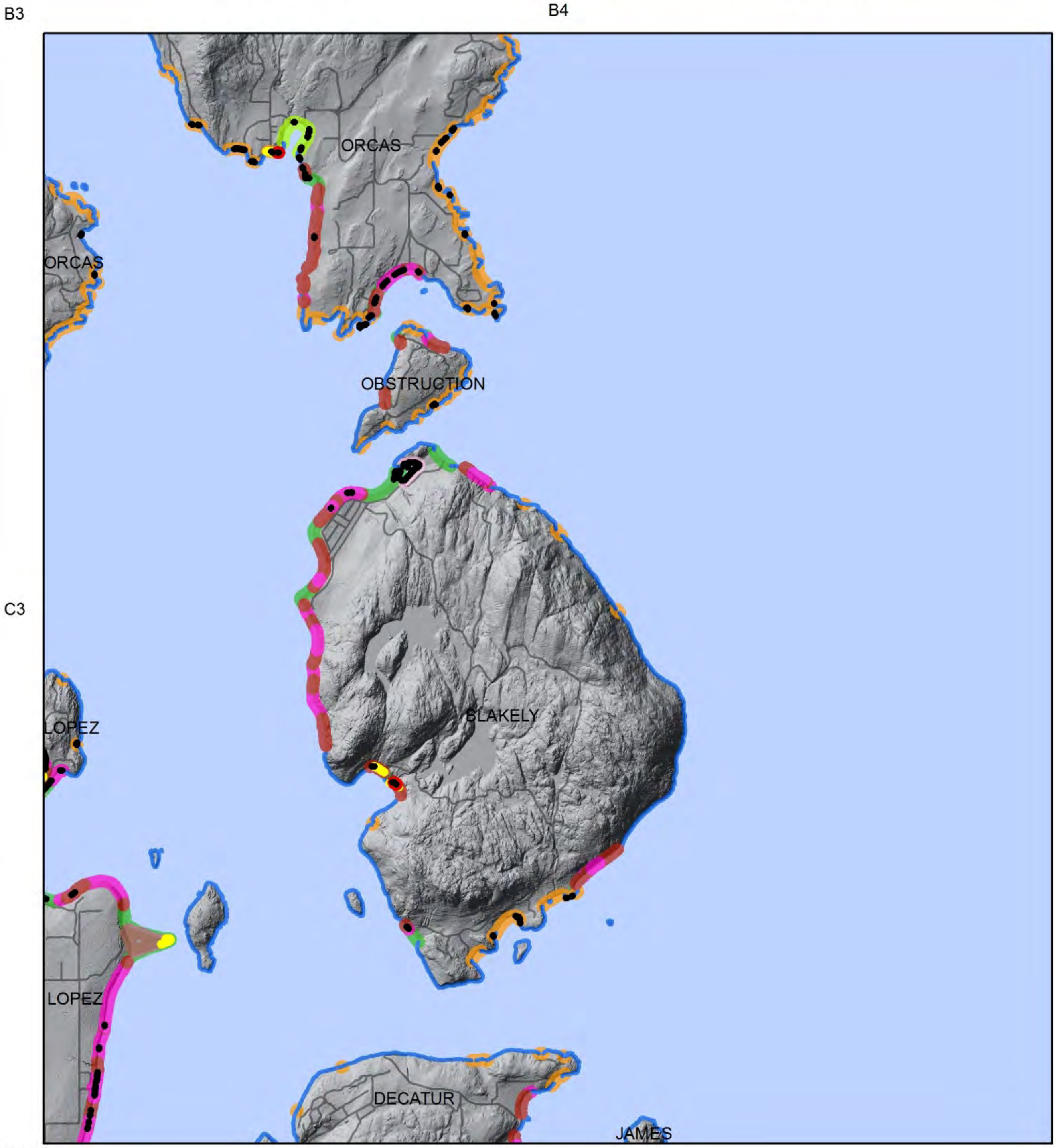
Forage Fish and Armor Habitat Impacts



LEGEND:

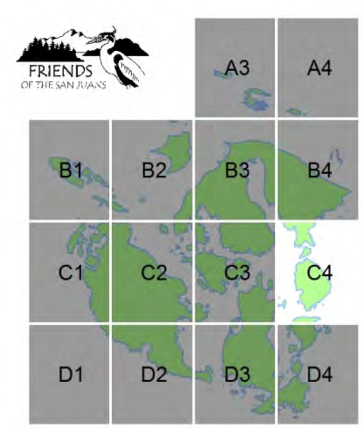
Shoreform

Artificial
Barrier Beach
Embayments - Estuary
Embayments - Lagoon
Feeder Bluff
Pocket Beach
Rocky Shoreline
Transport Zone

Shoreline Armoring
Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.
Roads

N

1 0.5 0 1 Miles



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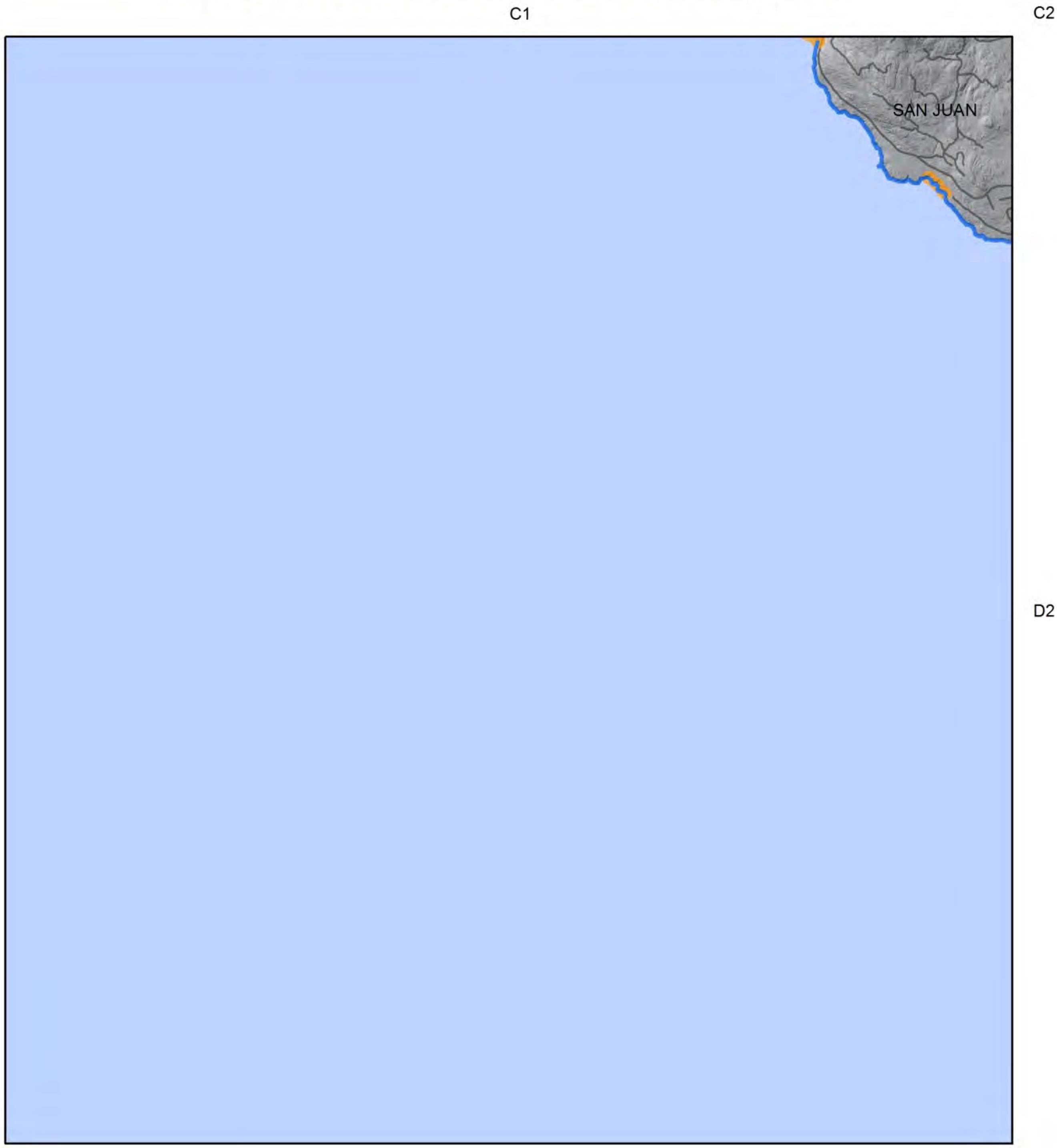


LEGEND:

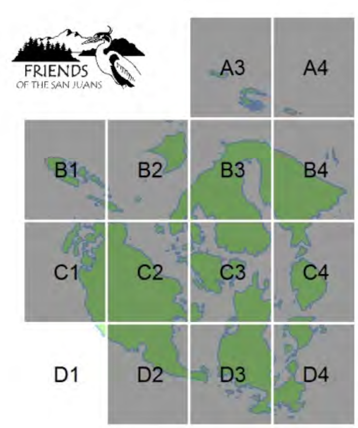
Shoreform

Shoreline Armoring

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Direct Burial-Documented Spawn Site with Armor Toe 9 ft. and below M.L.L.W.

Roads



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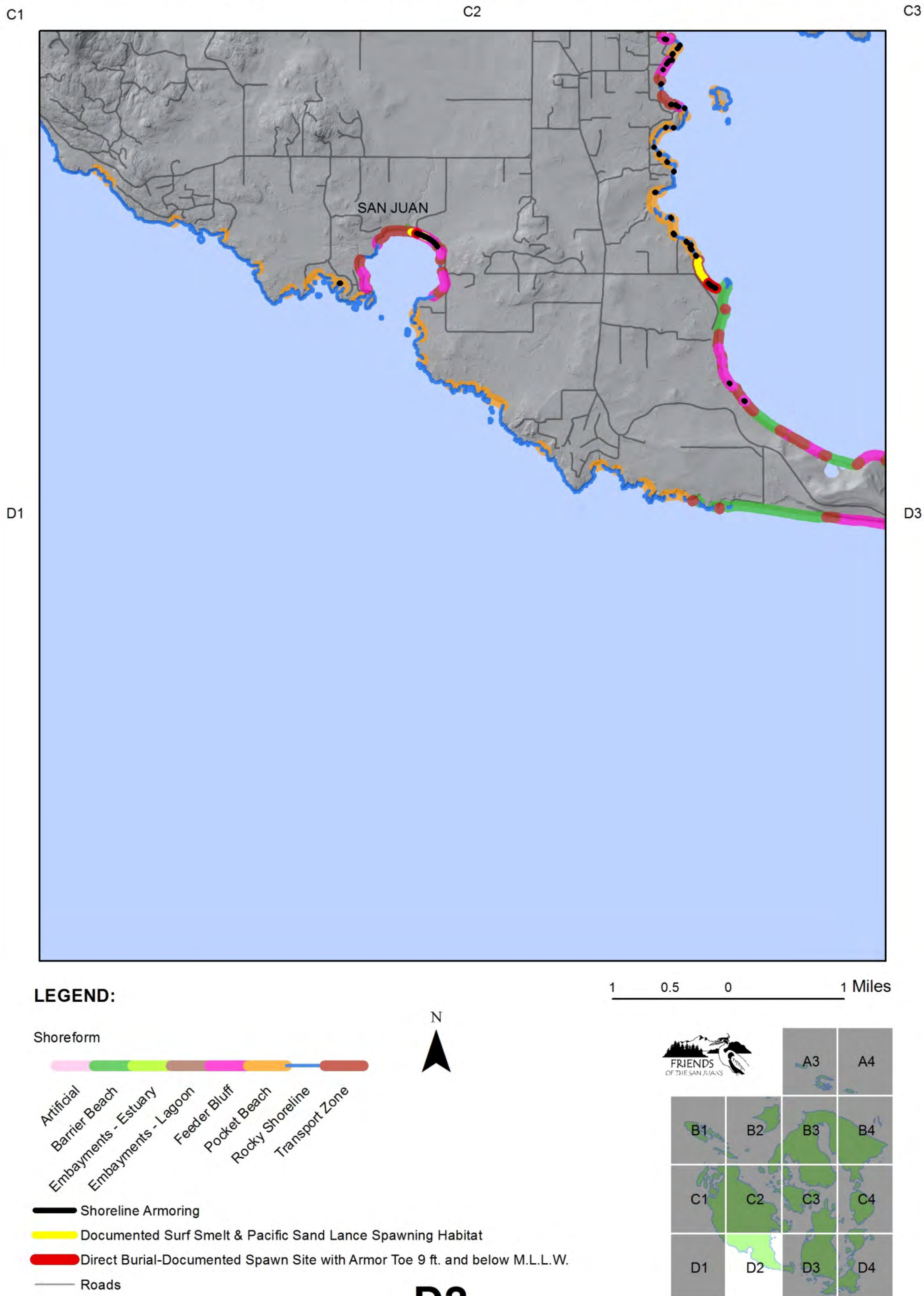
Forage Fish and Armor Habitat Impacts



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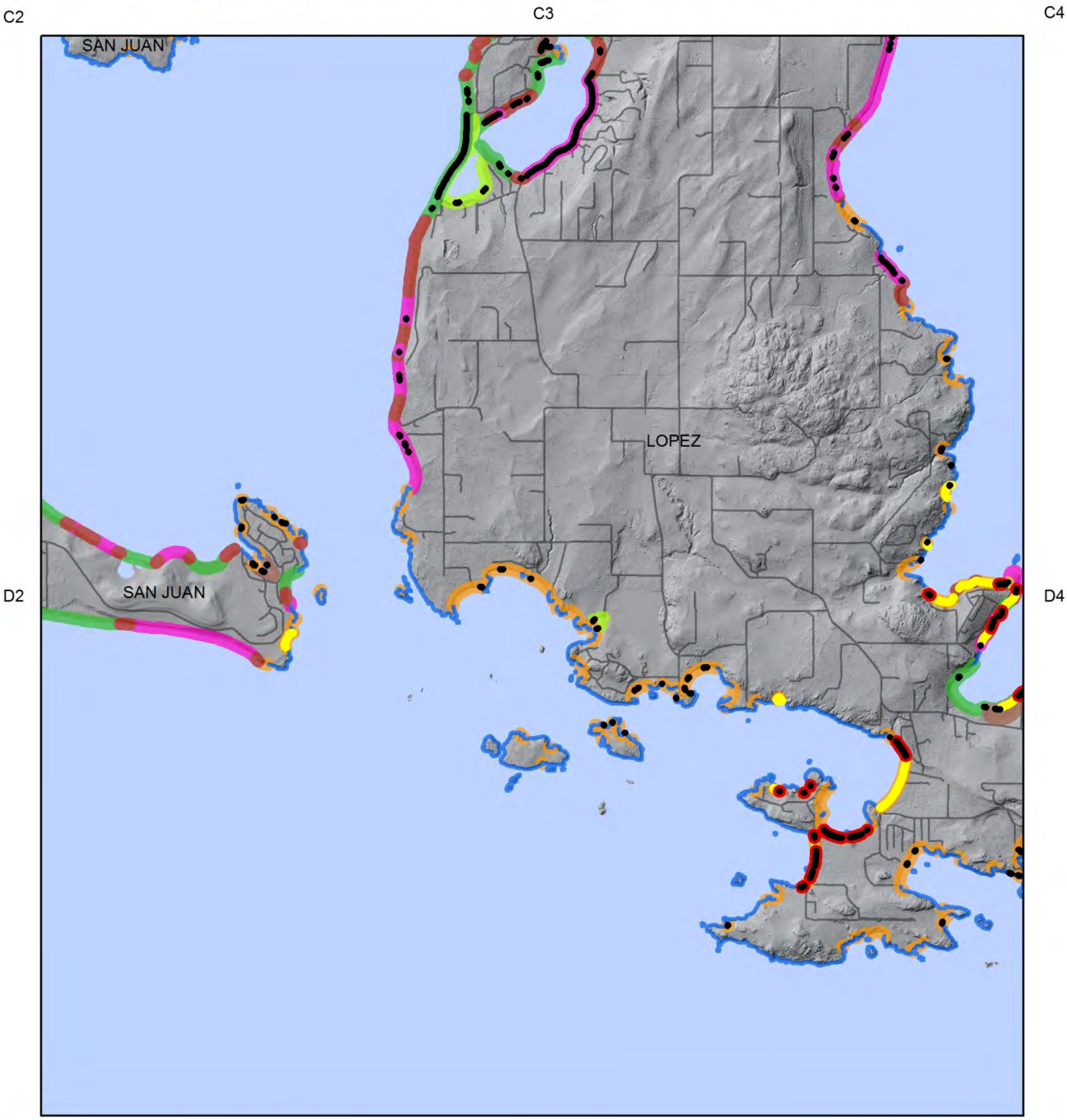
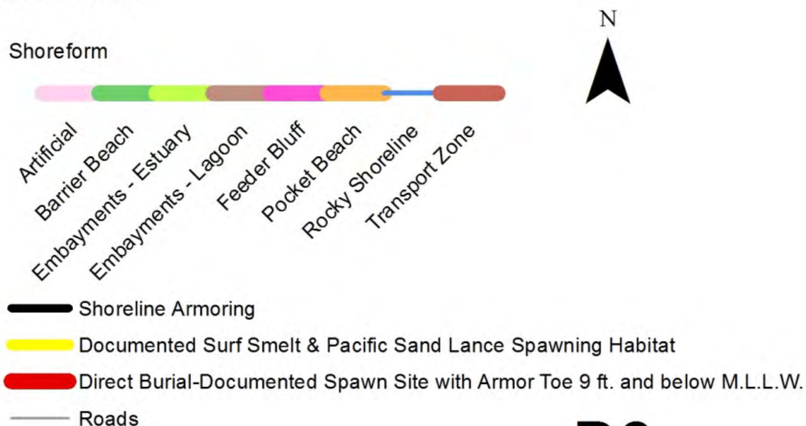
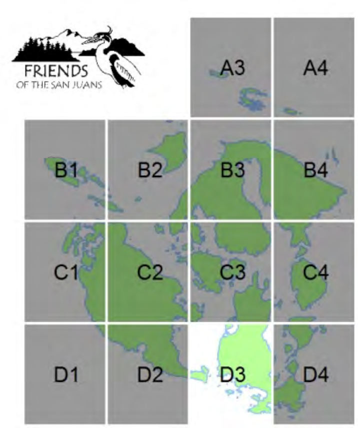
Forage Fish and Armor Habitat Impacts



1 0.5 0 1 Miles

LEGEND:





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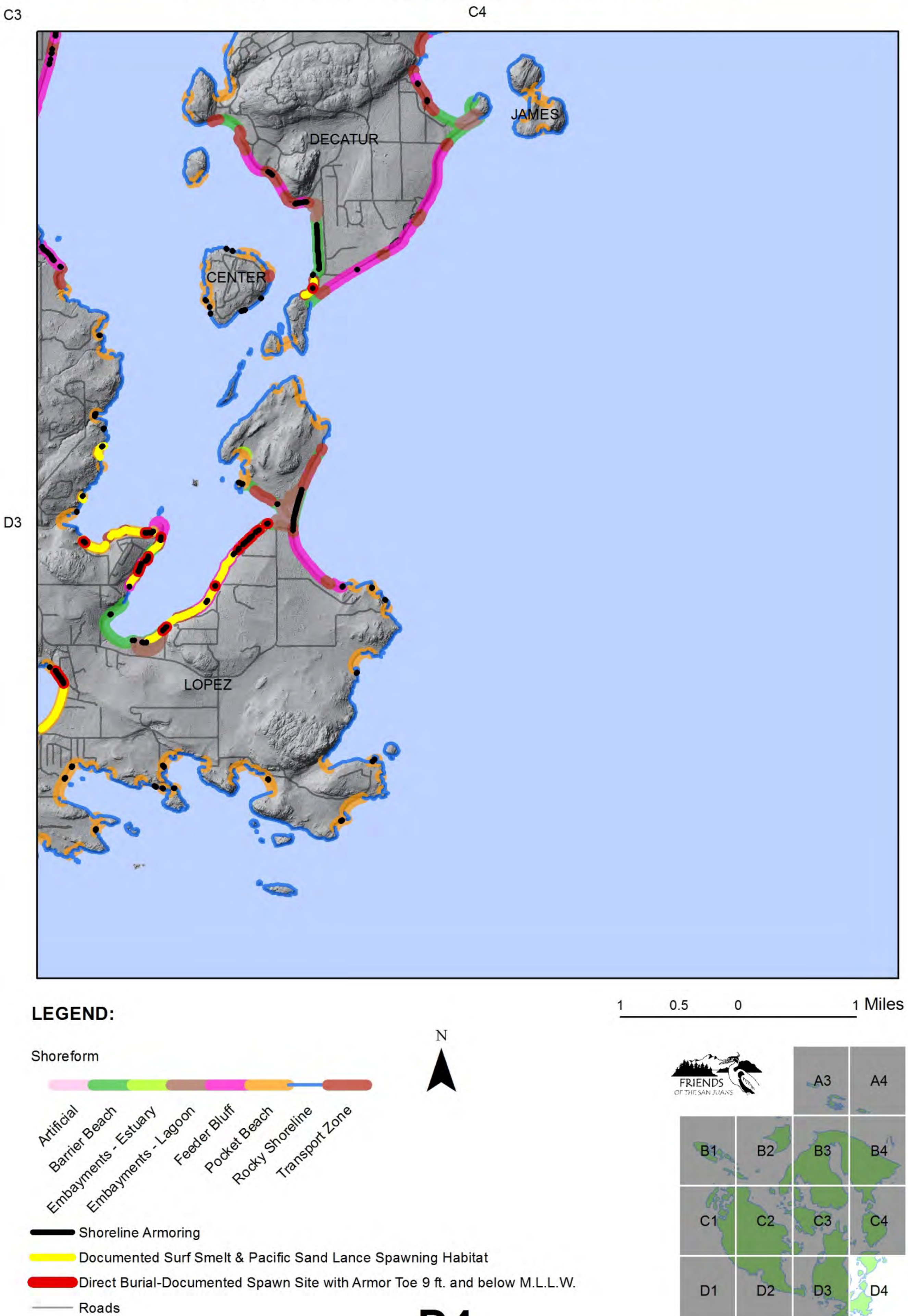

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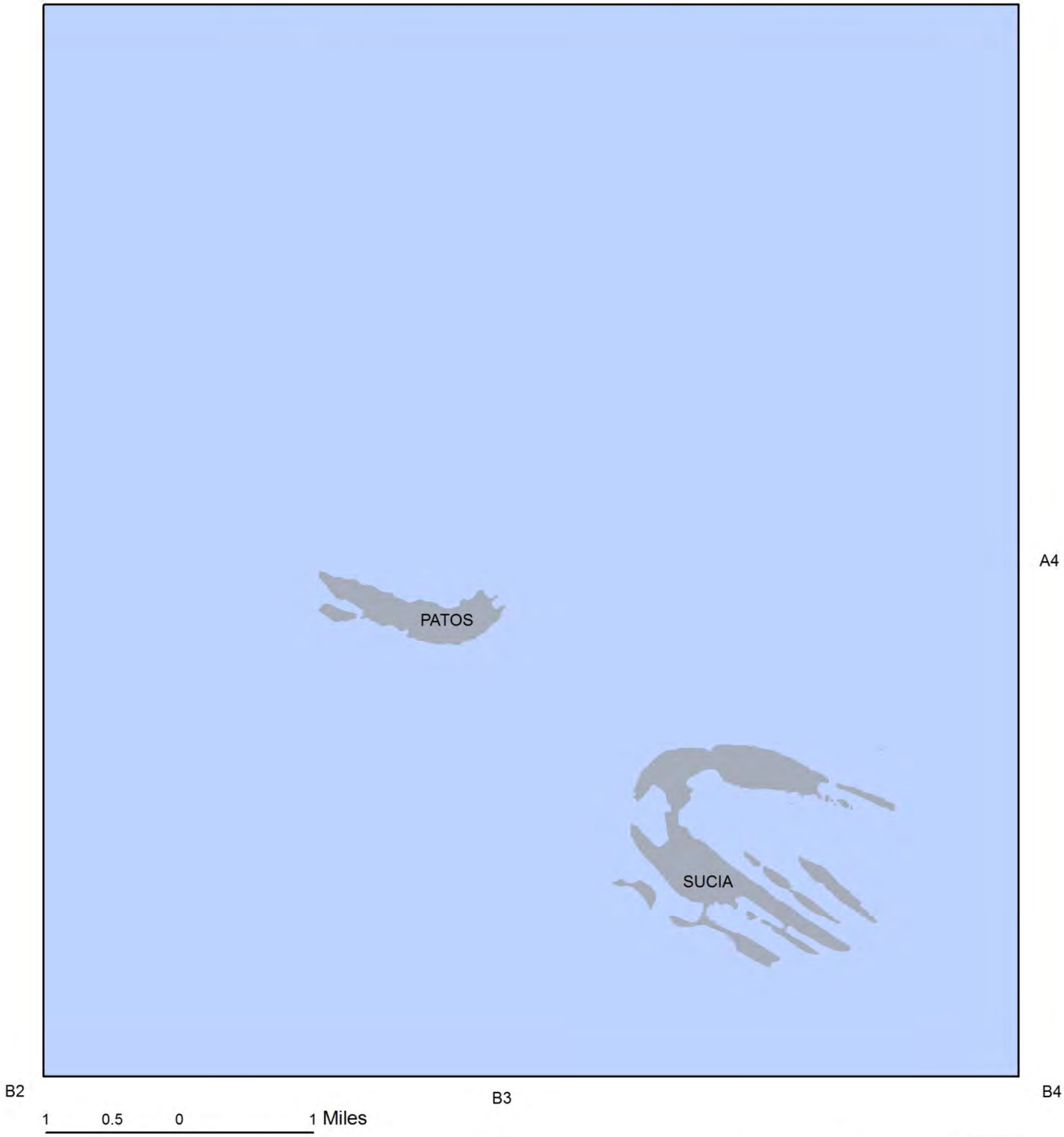
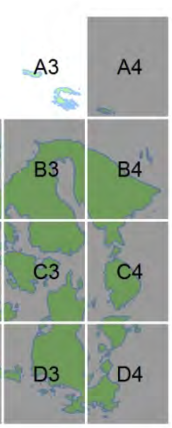


LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
Impact to Sediment Supply-Armored Feeder Bluff
Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below
Drift Cells
Direction of Drift
Left to Right
Right to Left

A3



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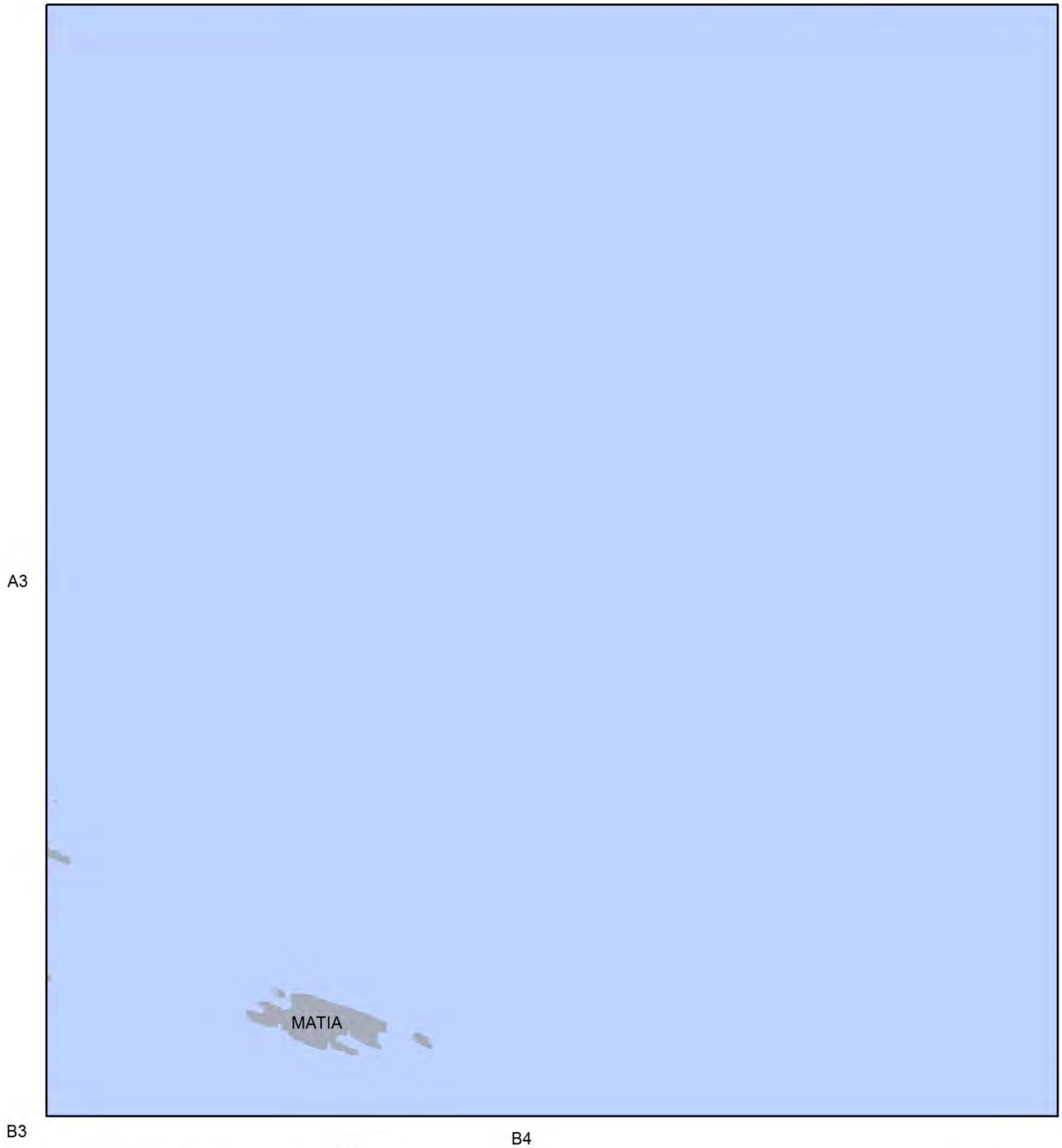
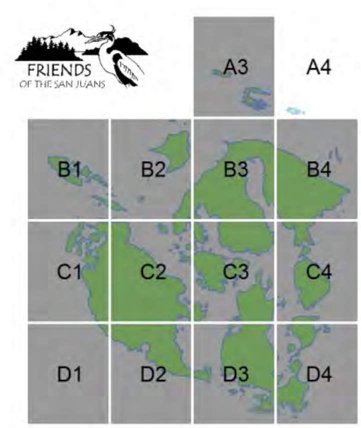


1 0.5 0 1 Miles

N



LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

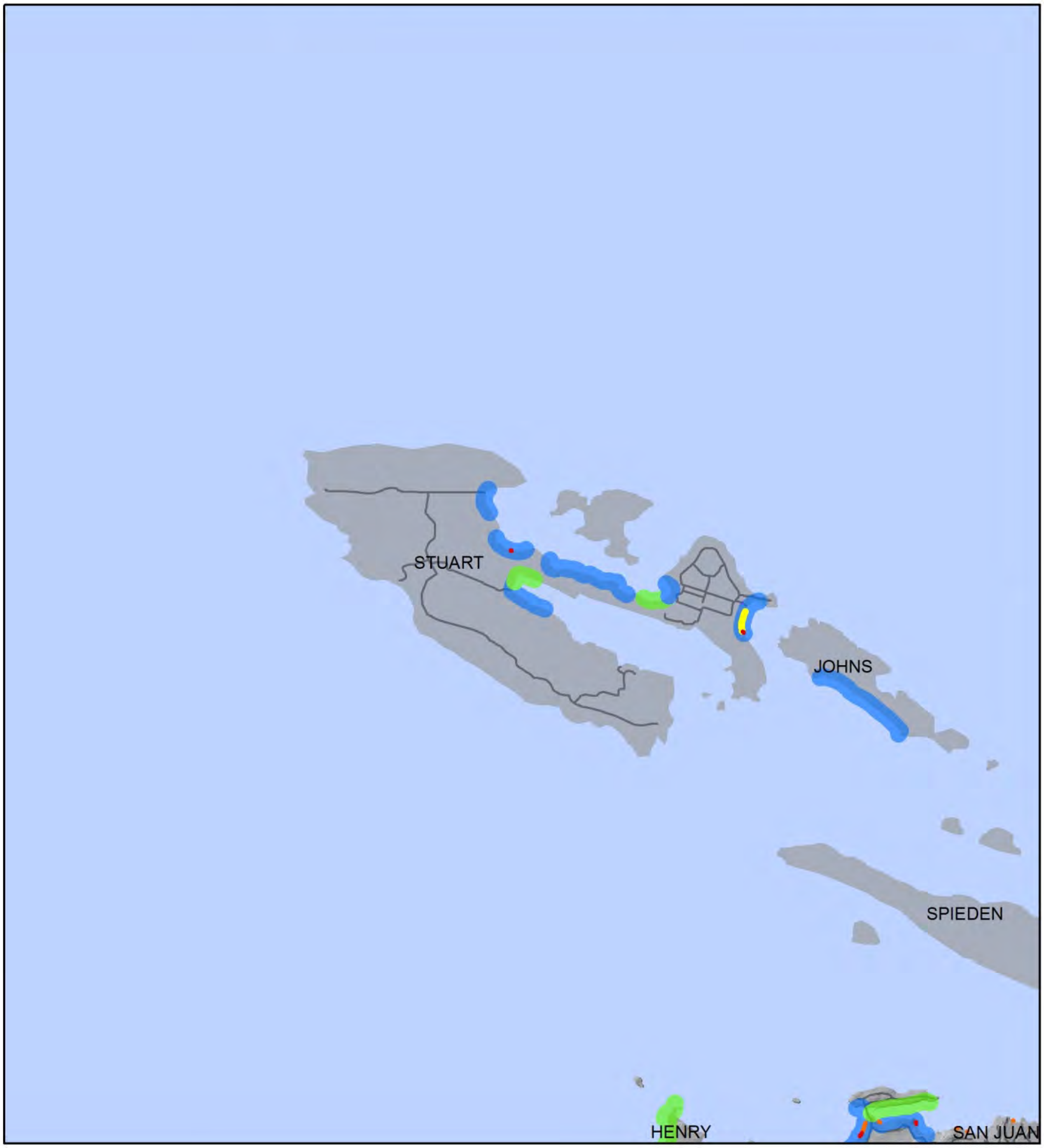
Direction of Drift

Left to Right

Right to Left

A4

Forage Fish and Armor Process Impacts



B2

C1

C2

1 0.5 0 1 Miles

N

LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

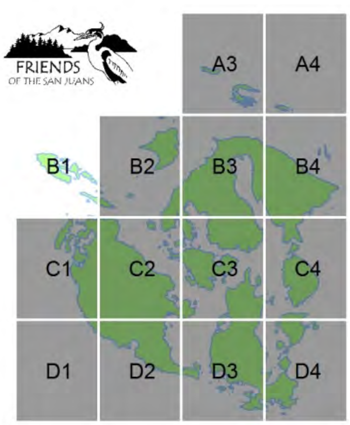
Drift Cells

Direction of Drift

Left to Right

Right to Left

FRIENDS OF THE SAN JUANS



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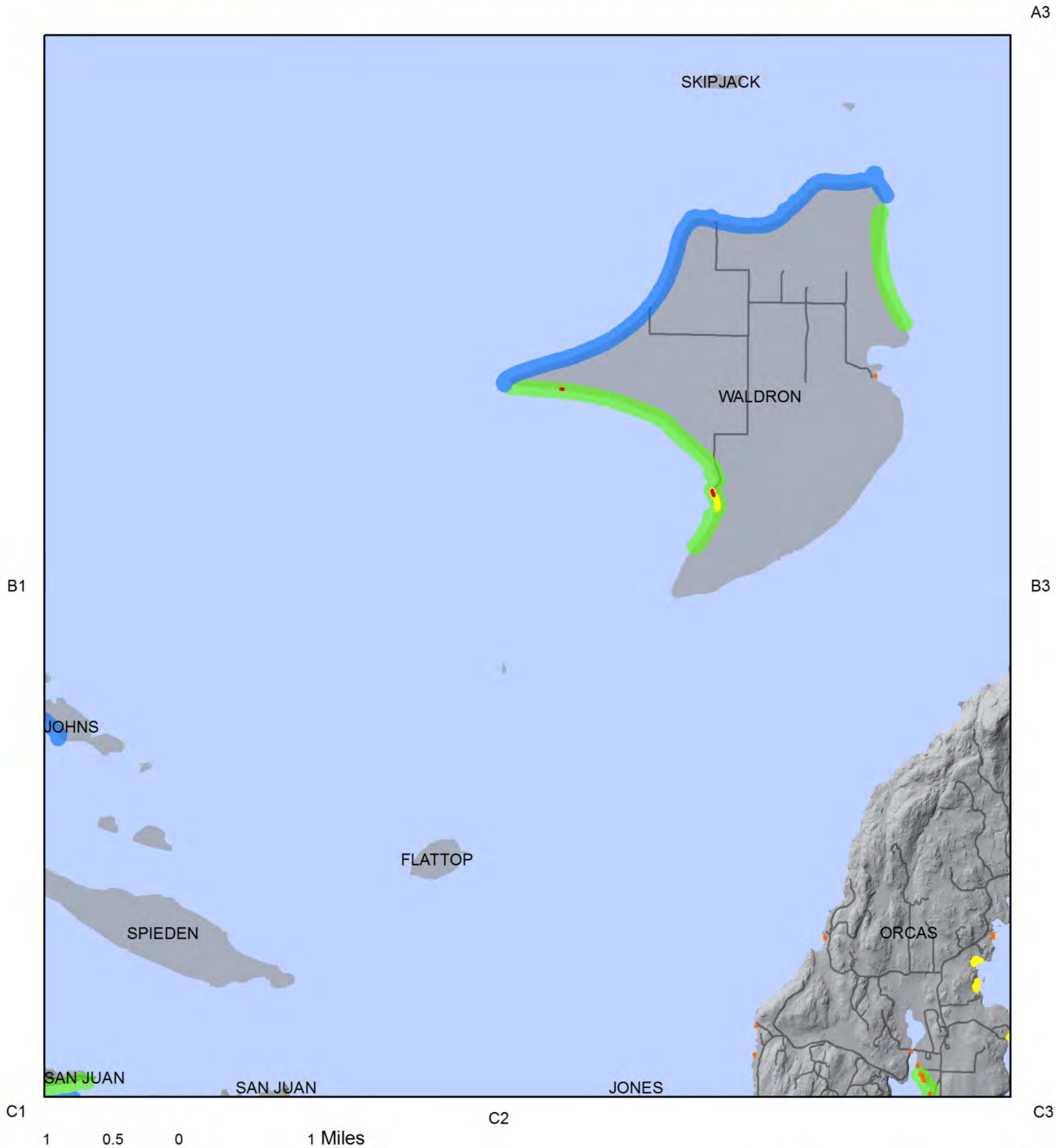
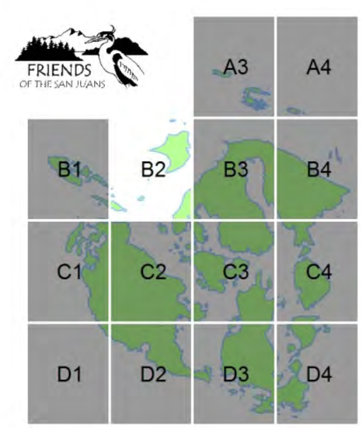




LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

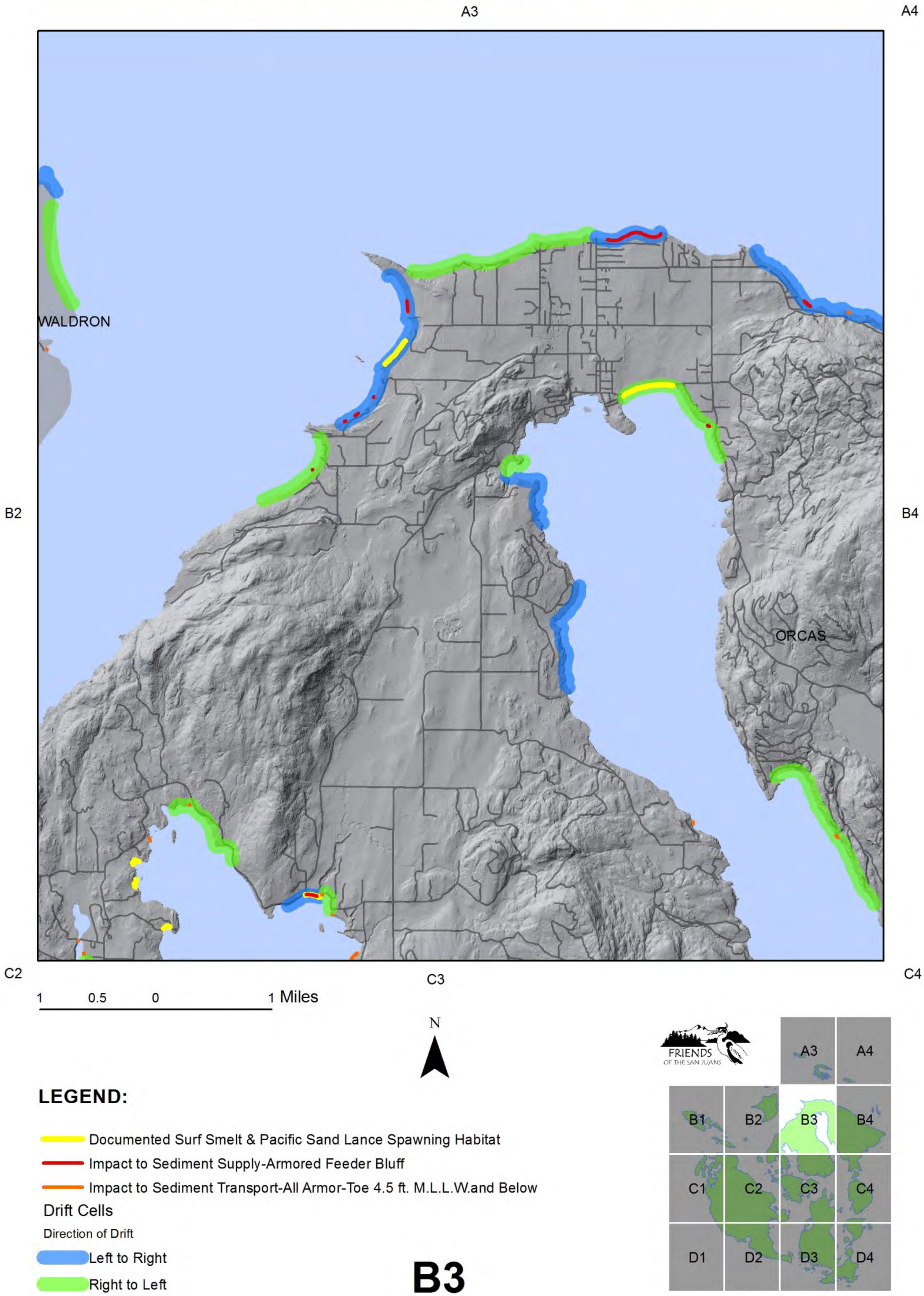
Direction of Drift

Left to Right

Right to Left

B2

Forage Fish and Armor Process Impacts



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Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

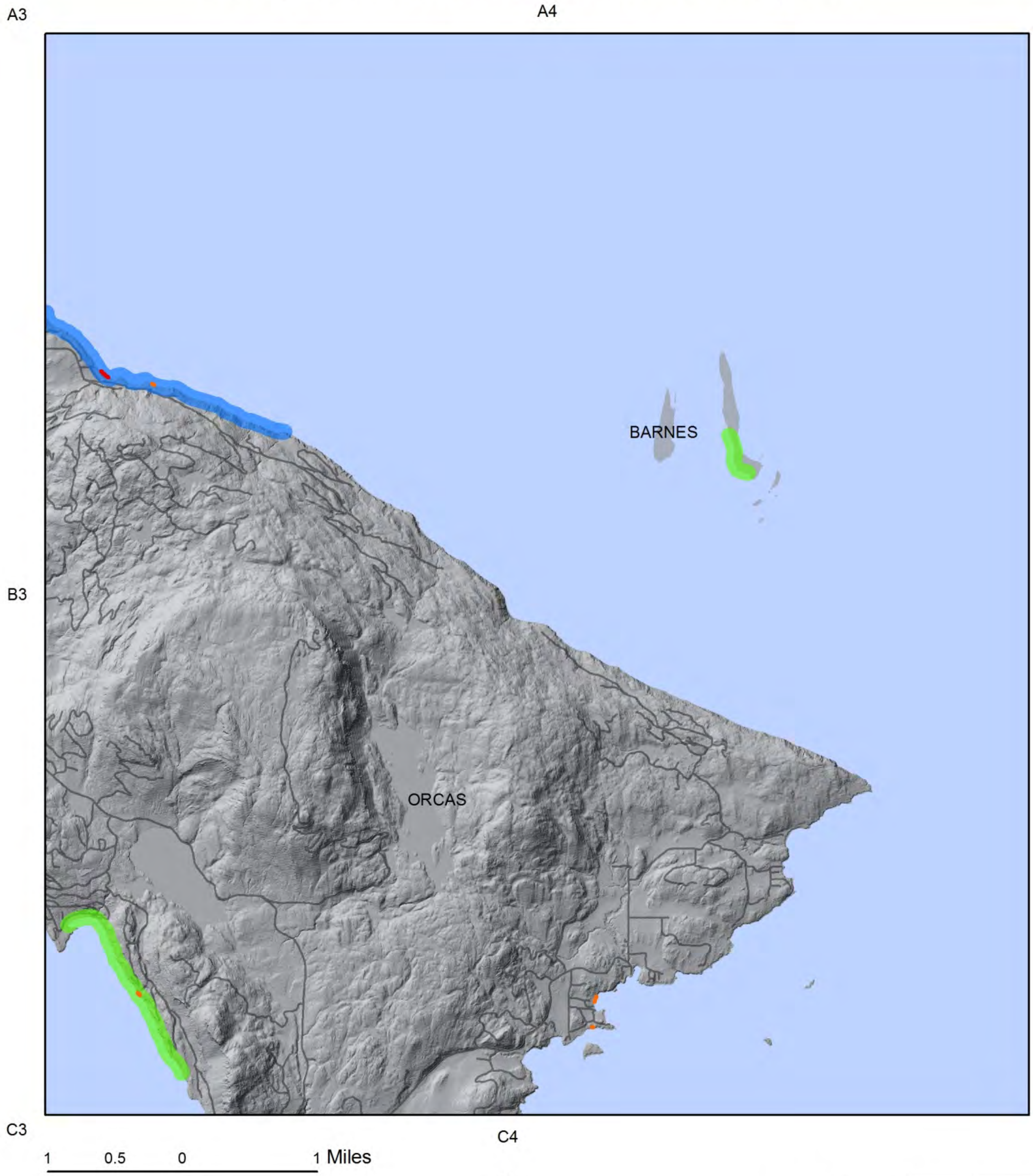
Direction of Drift

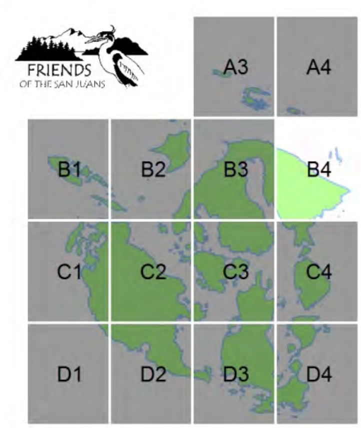
Left to Right

Right to Left

B3

Forage Fish and Armor Process Impacts





LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

Direction of Drift

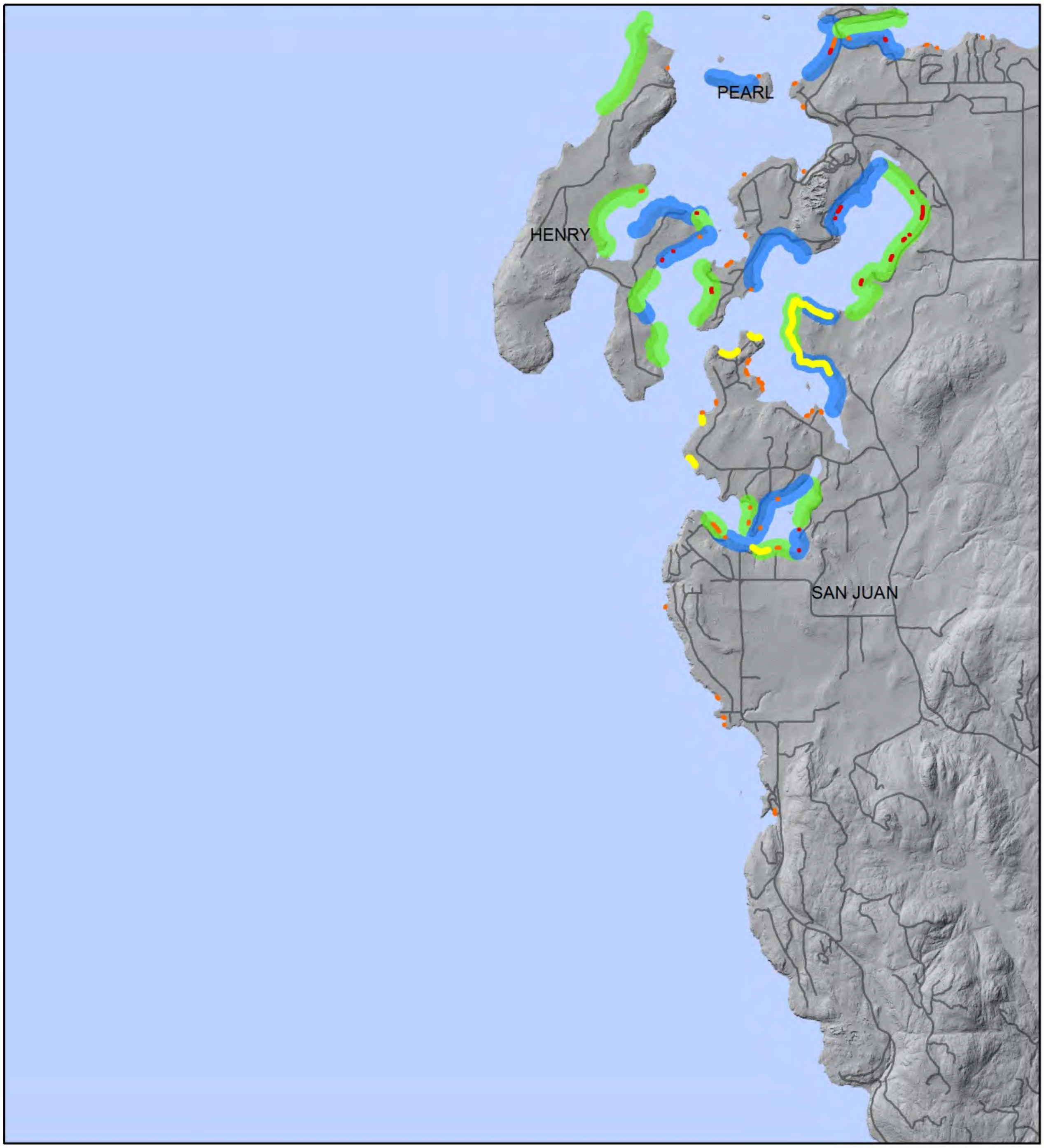
Left to Right

Right to Left

B4

Forage Fish and Armor Process Impacts

B1 B2

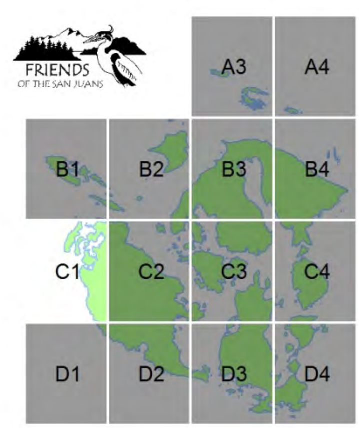


C2

D1 D2

1 0.5 0 1 Miles

N



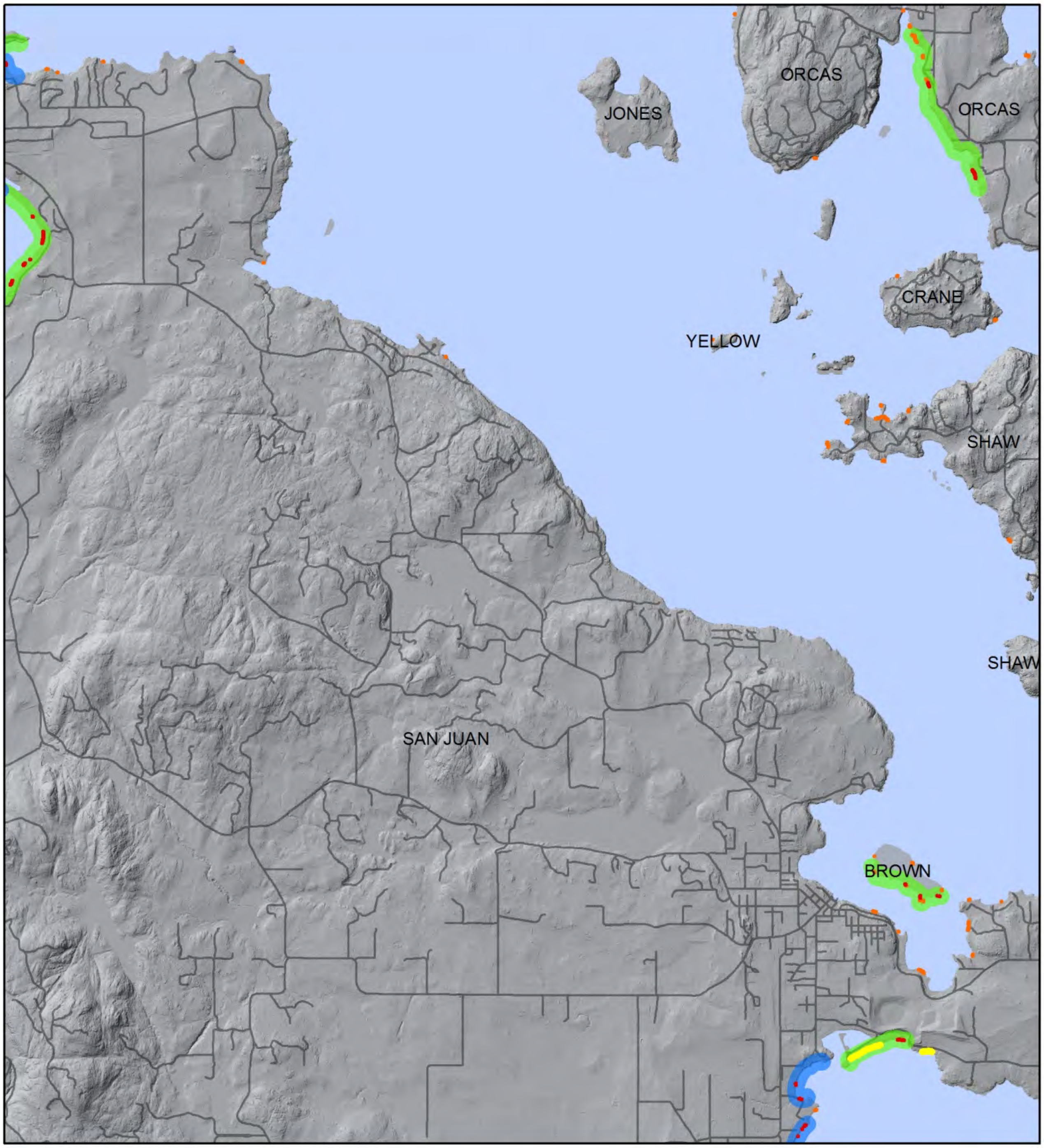
LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
Impact to Sediment Supply-Armored Feeder Bluff
Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below
Drift Cells
Direction of Drift
Left to Right
Right to Left

C1

Forage Fish and Armor Process Impacts

B1 B2 B3



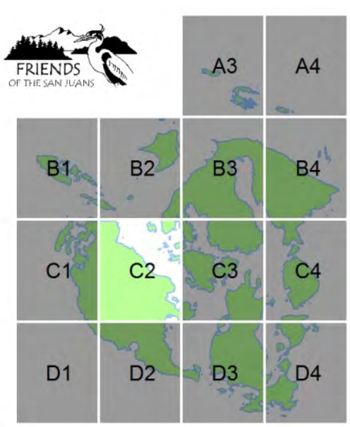
C1 C3

D1 D2 D3

1 0.5 0 1 Miles

N

FRIENDS OF THE SAN JUANS



LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

Direction of Drift

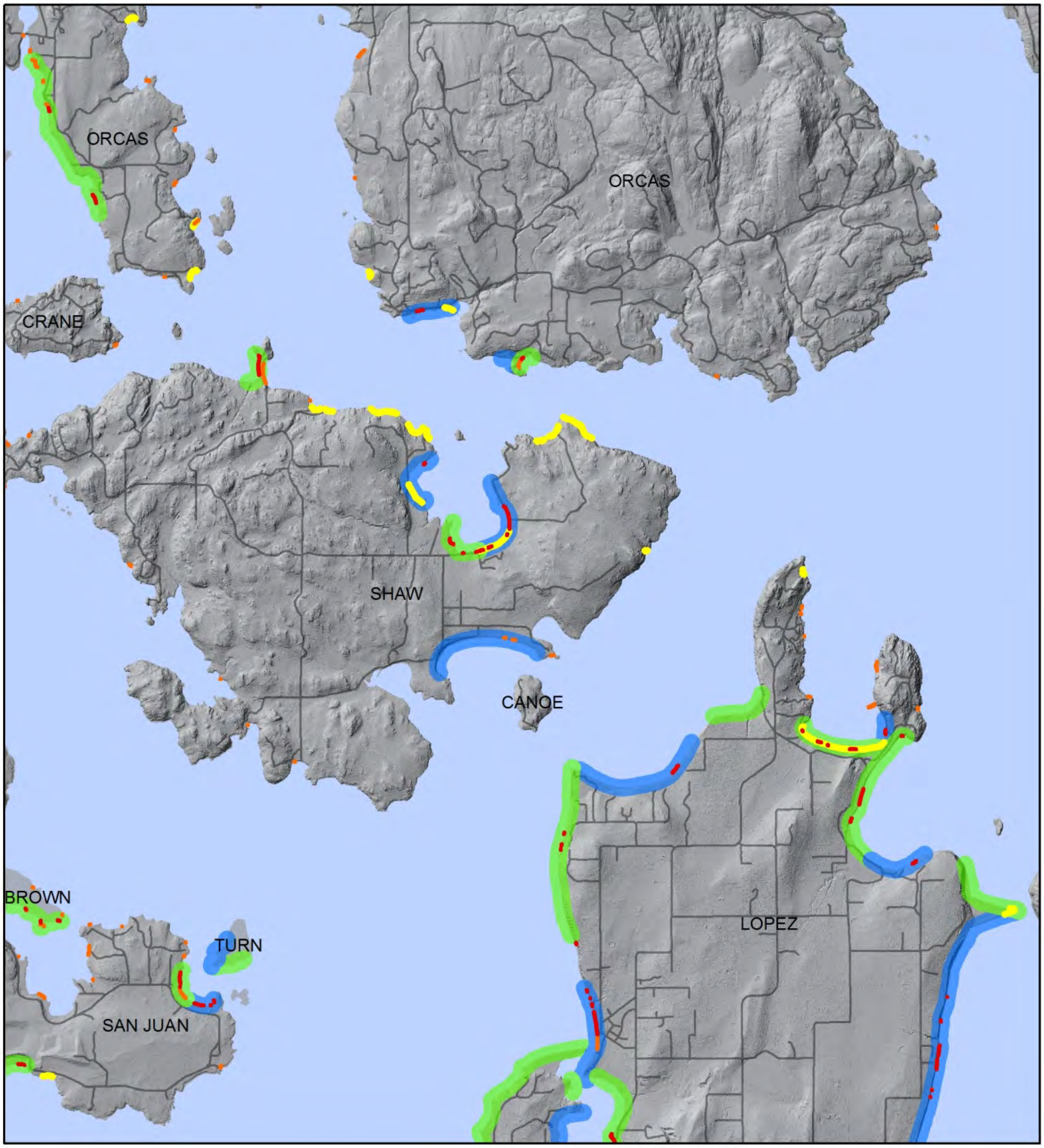
Left to Right

Right to Left

C2

Forage Fish and Armor Process Impacts

B2 B3 B4



C2 C4

D2 D3 D4

1 0.5 0 1 Miles

N

LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

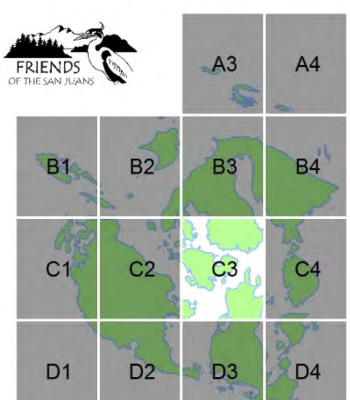
Drift Cells

Direction of Drift

Left to Right

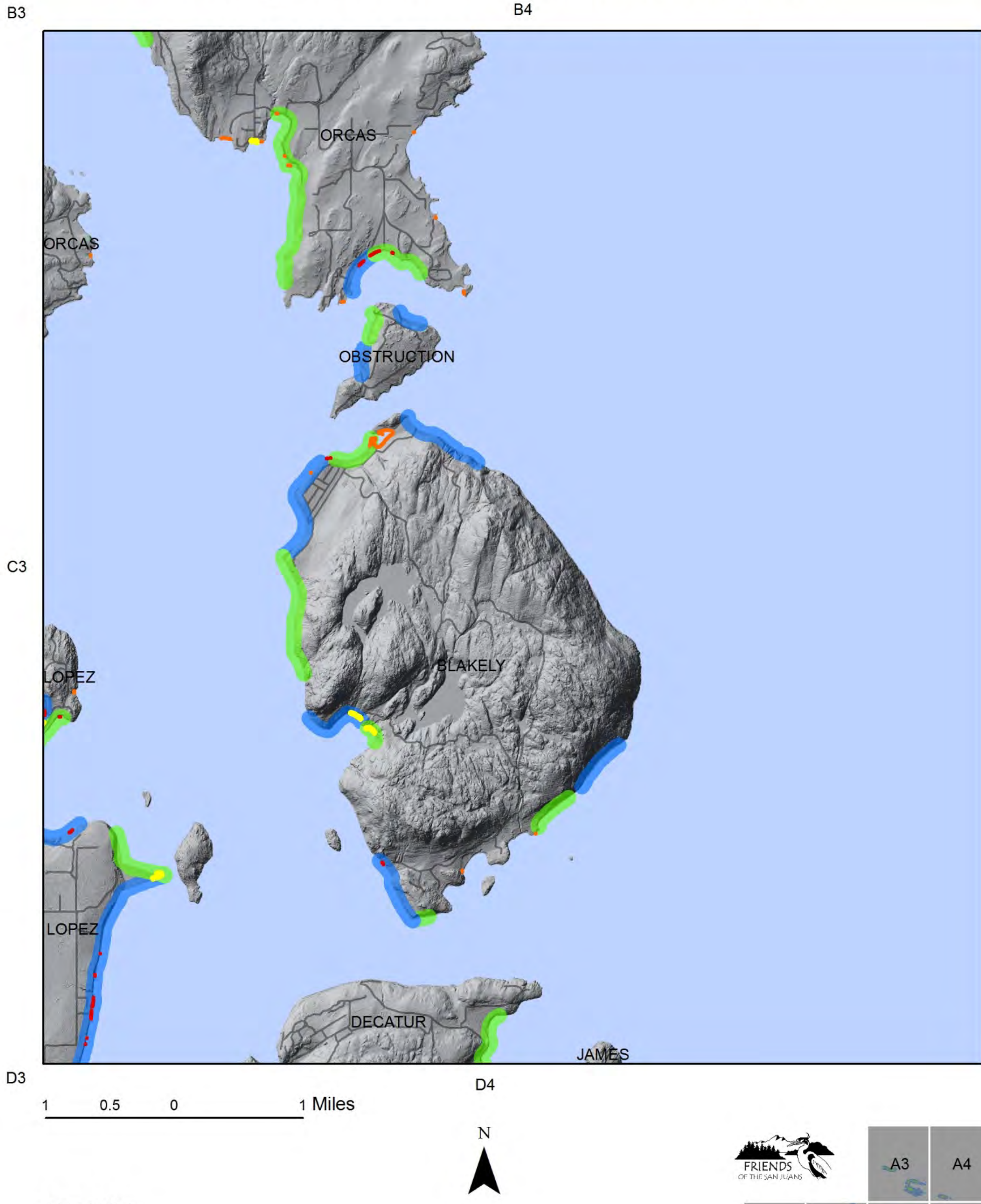
Right to Left

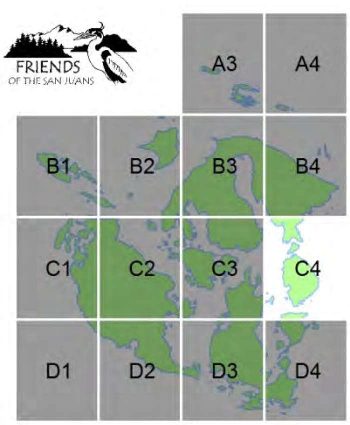
C3



FRIENDS OF THE SAN JUANS

Forage Fish and Armor Process Impacts





LEGEND:

- Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
- Impact to Sediment Supply-Armored Feeder Bluff
- Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

Direction of Drift

- Left to Right
- Right to Left

C4

Forage Fish and Armor Process Impacts

C1 C2

D2

1 0.5 0 1 Miles

N

LEGEND:

Documented Surf Smelt & Pacific Sand Lance Spawning Habitat

Impact to Sediment Supply-Armored Feeder Bluff

Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

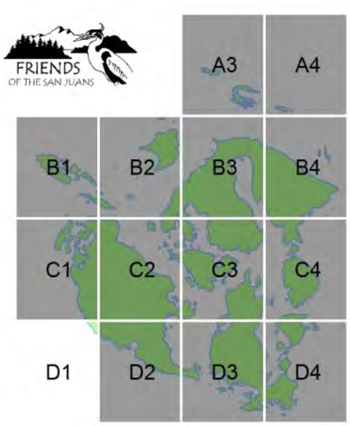
Direction of Drift

Left to Right

Right to Left

D1

FRIENDS OF THE SAN JUANS



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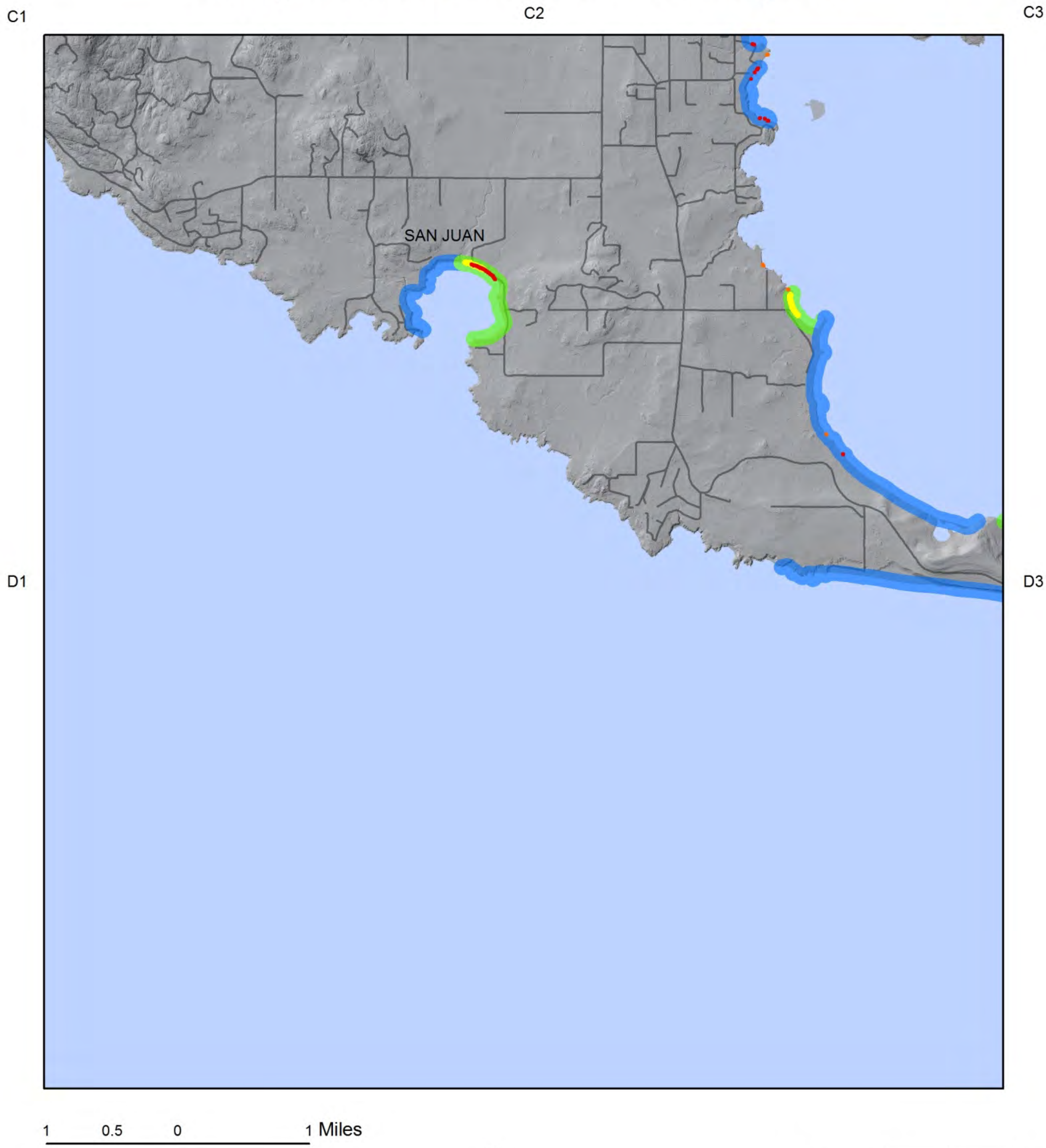

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Impact to Sediment Supply-Armored Feeder Bluff
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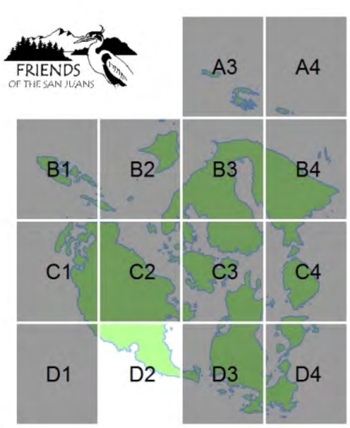
Drift Cells

Direction of Drift

Left to Right
Right to Left



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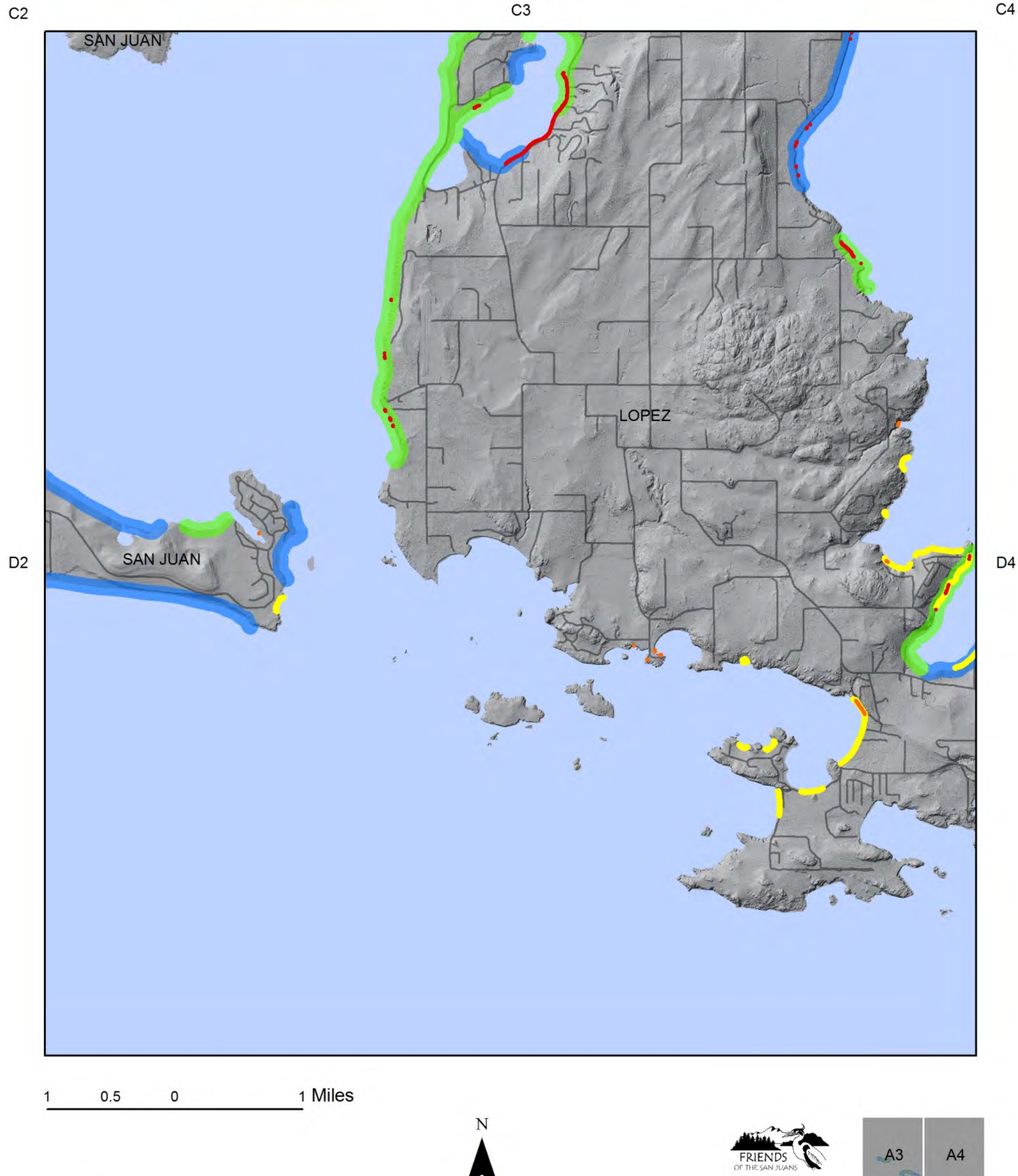

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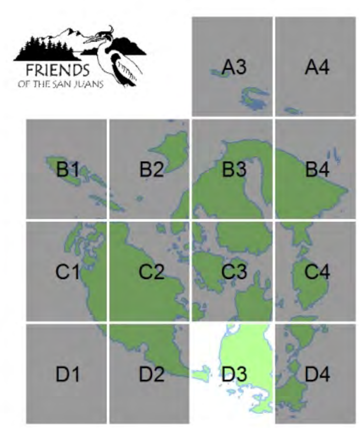
- Impact to Sediment Supply-Armored Feeder Bluff
- Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

Direction of Drift

- Left to Right
- Right to Left

D3



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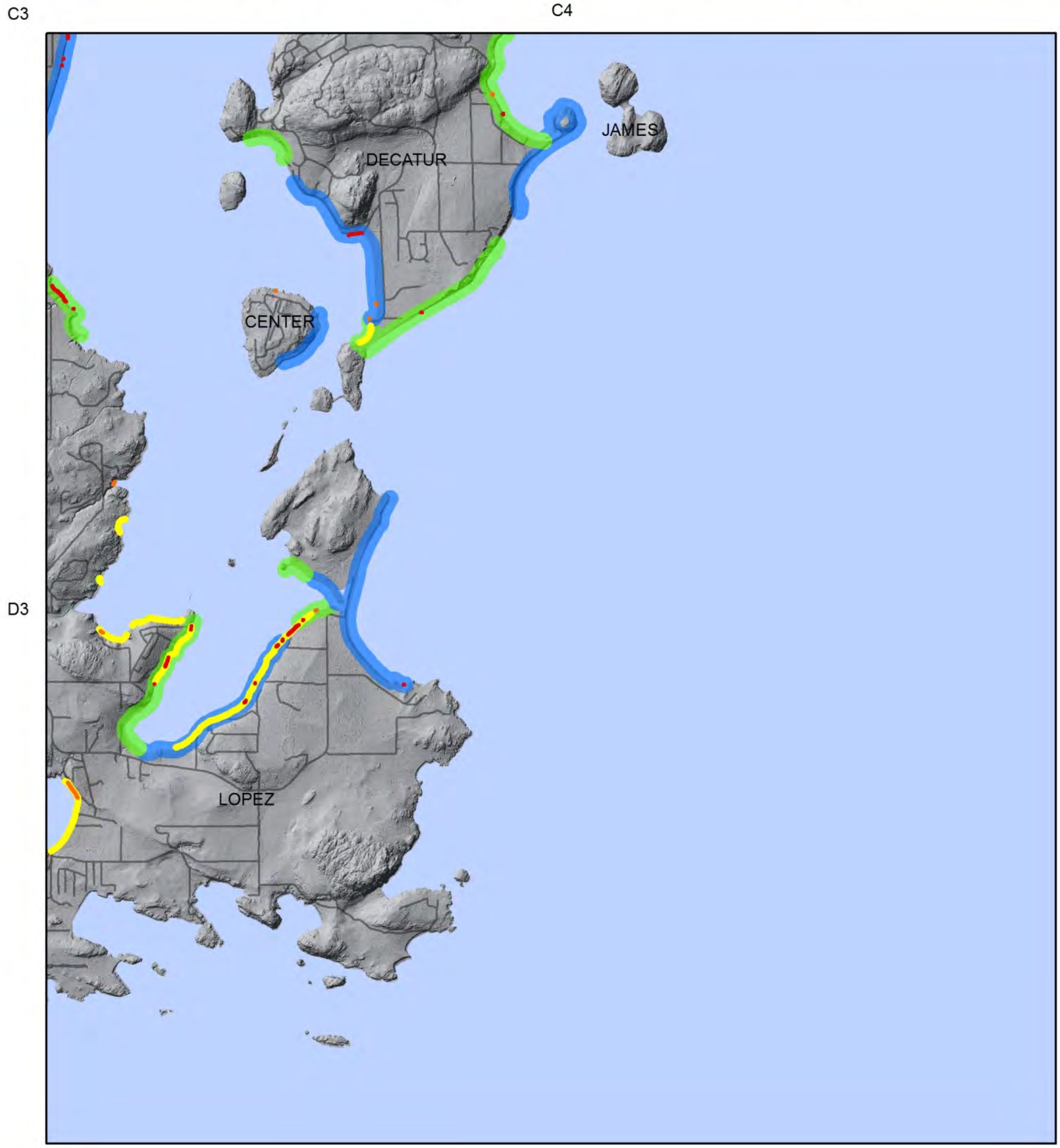


1 0.5 0 1 Miles

N

LEGEND:

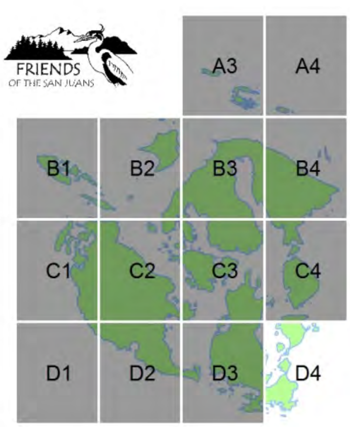
- Documented Surf Smelt & Pacific Sand Lance Spawning Habitat
- Impact to Sediment Supply-Armored Feeder Bluff
- Impact to Sediment Transport-All Armor-Toe 4.5 ft. M.L.L.W.and Below

Drift Cells

Direction of Drift

- Left to Right
- Right to Left

FRIENDS OF THE SAN JUANS



D4

Scoping Memorandum concerning the Pacific Gateway Terminal

Forage Fish:
Documented Surf Smelt and Pacific Sand Lance Spawning Beaches in San Juan County with a Summary of Protection and Restoration Priorities for Forage Fish Habitat

Final Report

Prepared By: Friends of the San Juans

February, 2004

DOCUMENTED SURF SMELT AND PACIFIC SAND LANCE SPAWNING BEACHES IN SAN JUAN COUNTY WITH A SUMMARY OF PROTECTION AND RESTORATION PRIORITIES FOR FORAGE FISH HABITAT

FINAL REPORT

FEBRUARY 2004

Prepared by:

Friends of the San Juans
P.O. Box 1344
Friday Harbor, WA 98250
www.sanjuans.org

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C. Lyshall, L. 2001. In Consideration of the Sustenance of Salmon- Updating Critical Area Ordinances with Best Available Science: A Forage Fish Story.
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Background

With the listing of many Puget Sound salmon stocks as threatened or endangered, the issue of maintaining forage fish stocks has been identified as a high priority. All the important forage fishes in our region (Pacific herring, surf smelt and Pacific sand lance) depend on nearshore marine habitats for spawning and rearing. Protection of nearshore habitats utilized as spawning and rearing areas for forage fish will be required if salmon recovery is to be successful.

Other priority fish and wildlife species in San Juan waters that depend on forage fish as critical prey resources include six stocks of Puget Sound rockfish; multiple species of seabirds, including the federally threatened marbled murrelet; and our resident marine mammal species. The same forage fish species and spawning habitat of interest in salmon recovery will also be vital for the protection and restoration of these additional key marine species.

The Washington Department of Fish and Wildlife (WDFW) presently endeavors to protect all known, documented surf smelt and Pacific sand lance spawning beaches from impacts of shoreline development. "No Net Loss" regulations for the protection of known forage fish spawning sites are included in the Washington State Administrative Code "Hydraulic Code Rules" (WAC 220-110). Washington Department of Fish and Wildlife conducted the intertidal baitfish spawning beach survey project from 1991 through 1997, with the goal of documenting spawning beaches of the surf smelt and the Pacific sand lance throughout Puget Sound. In 1997, the project was de-prioritized and lost the majority of its funding, despite incomplete assessments for northern Puget Sound. Because habitat protections are provided to documented spawning sites, not potential spawning beaches, the cooperative San Juan County (SJC) Forage Fish Project was developed as a means of completing the spawning habitat inventories in the San Juan County portion of northern Puget Sound.

Project Partners

The **San Juan County Forage Fish Habitat Assessment Project** was initiated in 2000. Project partners and roles include:

Friends of the San Juans (FSJ) manages the project. FSJ provides project coordination, design, protocols, training, field staff, data analysis and reporting. FSJ recruits and manages volunteers and coordinates field training and community outreach.

The **San Juan County Marine Resources Committee** (MRC) co-manages the project and assists with project design, protocols, training, community outreach, data analysis, and reporting. Dr. Lawrence Moulton, acting as the MRC forage fish coordinator, assisted with project design, protocols development, training of personnel in the use of field protocols, analysis of field and laboratory data, and reporting of sampling results.

Washington Department of Fish and Wildlife, through Dan Penttila, provided protocol development, field and lab training, technical expertise and project quality assurance and quality control. A 29-year member of the Washington Department of Fish and Wildlife (WDFW), Penttila is the fish biologist who first discovered Pacific sand lance spawning depositions on Puget Sound beaches. Penttila has led the research and inventory of surf smelt and Pacific sand lance spawning habitats throughout Puget Sound and the Washington Coast. Through an interlocal agreement, Penttila assists the forage fish project, and provides training, technical review and quality assurance/control. He authored the paper on surf smelt egg survival as it relates to riparian shade and coauthored the protocol now in use for mapping forage fish spawning habitat. Washington Department of Fish and Wildlife applies San Juan County Forage Fish Project data in its Hydraulic Project Approval Process.

University of Washington Friday Harbor Laboratories provides technical and lab support for sample analysis.

San Juan County applies forage fish project data to the review and action of shoreline project applications. Direction from the Board of County Commissioners to all County Department Heads in a Memorandum of Understanding (MOU) addresses the role of forage fish data. The MOU states that through the Marine Resources Committee, the county is participating in the inventory and mapping of nearshore habitat for spawning forage fish. The data collection and mapping protocols are designed and controlled to ensure that the product represents the "best available science" to identify spawning habitat. The memorandum instructs all county department directors to use the information. See *Appendix A: San Juan County "Best Available Science" Forage Fish Spawning Habitat Memorandum.*

Funding for the San Juan County Forage Fish Project has been provided by the generous support of: The Washington State Salmon Recovery Funding Board, The Northwest Straits Commission, The SeaDoc Society (formerly the Marine Ecosystem Health Program), NOAA/FishAmerica, The Russell Family Foundation, The Bullitt Foundation, Duraboat, Town of Friday Harbor, The San Juan County Marine Resources Committee and the National Fish and Wildlife Foundation.

Protocol Development and Potential Habitat Mapping

The purpose of the San Juan County Forage Fish Project was to document nearshore habitat supporting forage fish spawning activity within San Juan County. Once identified, these habitats may be adequately protected under existing Washington State Administrative Code (Hydraulic Code WAC 220-110) and the San Juan County Shoreline Master Program. In addition, initial protection and restoration priorities for forage fish habitat were identified and a nearshore marine education campaign was implemented.

Phase 1 of the SJC Forage Fish Project reviewed the status of existing information on forage fish spawning locations in the county and adapted Washington Department of Fish and Wildlife field and lab protocols for documenting surf smelt and Pacific sand lance spawning sites. This portion of the study was funded by a grant from the Northwest Straits Commission. The protocols were developed for use throughout the northern Puget Sound region so that surveys of spawning areas in other counties would employ consistent methods. Field and lab protocol were adapted from established WDFW methodology and written out for repeatable application and use by trained biologists across the region. In surveys conducted in San Juan County from 1989 to 1999, Washington Department of Fish and Wildlife documented 14 surf smelt and eight Pacific sand lance spawning sites (Penttila 1999). See *Appendix B: Forage Fish Spawning Distribution in San Juan County and Protocols for Sampling Intertidal and Nearshore Regions* and *Appendix C:*

In Consideration of the Sustenance of Salmon. Updating Critical Area Ordinances with Best Available Science: A Forage Fish Story for more information on initial steps of the Forage Fish Project.

Following protocol development and the summary of existing information, the Forage Fish Project identified and mapped the distribution of potential surf smelt and Pacific sand lance spawning beaches within San Juan County. Aerial photo analysis with follow-up field verification at a subset of the sites identified over 600 beaches (roughly 80 miles) of potential spawning habitat in San Juan County. Once potential spawning habitat was mapped, it was overlaid with county ownership maps to identify land ownership of potential spawning beaches for outreach activities. Over 1,700 individual owners with potential forage fish spawning habitat received introductory information on the San Juan County Forage Fish Project. See *Appendix D: Distribution of Potential Surf Smelt and Pacific Sand Lance Spawning Habitat in San Juan County* for more information on potential habitat mapping and initial shoreline landowner contact.

Database Development and Methodology

The Forage Fish Project database has the ability to view, analyze and trace to its original source, all the data collected. Information is compiled in an interactive tabular and spatial database, with linked digital imagery of field and lab reports and beach images. The use of linked imagery in the database allows the database user to verify the accuracy of the data entry and where a field surveyors comments were difficult to interpret, the original text and source has been preserved. All descriptive fields that use a standard coding per Washington Department of Fish Wildlife field and lab protocols are similarly coded and the data is entered via lookup tables that ensure accuracy. The database was developed to be compatible with both San Juan County and Washington Department of Fish and Wildlife internal mapping systems and its structure is used throughout the northern Puget Sound region by other forage fish and nearshore habitat projects.

The spatially explicit Arc View Forage Fish Project database includes historic Washington Department of Fish and Wildlife forage fish spawning habitat data, as well as additional nearshore variables including locations of eelgrass and county and state shoreline maps. This geographic information systems project contains spatial links to the forage fish project photos and is connected to the tabular Access database. One particular feature of this connection is programming that allows the user to link to the Access database data viewing and editing forms by clicking on a survey site point in Arc View. All maps contained in this report can be found within the Arc View project.

Training and Volunteers

Citizen involvement has been a primary objective of the San Juan County Forage Fish Project. Nine volunteer trainings were held on six islands (Orcas, San Juan, Shaw, Waldron, Stuart and Lopez) over the three years of the San Juan County Forage Fish Project, providing classroom and field sessions on the biology and habitat of forage fish as well as field training of the survey protocol. 75 citizens participated in the forage fish trainings and assisted with forage fish field surveys. Volunteers provided 1083 hours of assistance to the forage fish project. 754 hours devoted to field surveys and 329 hours in training and educational events. See *Appendix E: San Juan County Forage Fish Volunteer Photos.*

Spawning Habitat Surveys

Identification of Potential Spawning Habitat

Phase 1 of the San Juan County Forage Fish Spawning Habitat Assessment Project used aerial photo analysis and field verification to identify 631 potential surf smelt and Pacific sand lance spawning sites on 25 islands in the San Juans. Original potential spawning habitat distribution for San Juan County included 80 miles of potential spawning habitat. Of the original 631 potential spawning sites, 579 (92%) received field visits by certified Forage Fish Project survey staff. 67 (11%) of the mapped potential spawning habitat beaches, as identified in Phase 1: Potential Habitat Mapping, were determined at the time of the field visit to be unsuitable spawning habitat. Bulk samples were not collected from these sites, and the 4.4 miles were removed from the overall potential spawning habitat distribution. This reduction in actual potential habitat matches results from the field verification phase of potential habitat mapping conducted on Shaw Island and was an expected project outcome (Moulton 2000). In the course of field surveys an additional 26 potential spawning sites were identified, sampled and added to the overall potential forage fish spawning habitat maps for San Juan County, adding just under a mile of new potential spawning habitat. For an adjusted total of 590 potential spawning sites and just under 77 miles of potential forage fish spawning habitat. See *Figure 1. Distribution of Potential Spawning Habitat in San Juan County.*

Field Surveys

Between July of 2001 and December of 2003, 1251 bulk samples and forage fish field surveys were collected from 538 sites on 24 islands, representing 91% of potential spawning habitat San Juan County. Nine percent of potential spawning sites were not sampled as a result of: existing protected status (e.g.: total length in preservation lands), physical access issues, time constraints or a lack of landowner permission (just 17 sites out of 590 potential spawn beaches were not sampled due to denied access). Of the sampled sites, 254 (47%) were sampled one time and 284 (53%) were visited a minimum of two (and up to 11) times. See *Figure 2. San Juan County Forage Fish Project Sample Sites.*

At each survey site with suitable potential habitat, a bulk substrate sample was collected to determine evidence of spawn. Additional information on a variety of nearshore habitat variables was also recorded during field surveys. Variables recorded at each station included: latitude/longitude; tidal elevation; coded entries for beach substrate type, sample transect elevation, shade, spawn evidence and density; spawn incubation habitat width, potential spawn habitat length, and upland conditions. In addition, the presence of docks, eelgrass beds, seawalls, freshwater influence, outflow pipes, boat ramps and other major beach features were recorded. A digital photograph of the sample beach, with a latitude/longitude and date/time recorded on every photo, was also taken with each sample. See *Appendix F: Forage Fish Project Field Survey Sheet.*

Outreach and Education

Shoreline Landowners

As the day-to-day managers of forage fish spawning habitat in San Juan County, shoreline landowners were a major focus of information and outreach efforts related to the Forage Fish Project. Prior to initiating any field surveys in 2001, a mailing was sent to all landowners with potential forage fish spawning habitat (over 1,700) describing the forage fish project and requesting access for field survey work. As the project was implemented, personal communication between the project coordinator and shoreline landowners was ongoing, with more than 200 shoreline landowners receiving detailed information about the forage fish survey project. Over 100 shoreline landowners were present on their beaches at the time of the field survey. A Forage Fish Project update and thank you was mailed to 244 shoreline landowners. See *Appendix G: Forage Fish Project Outreach to Shoreline Landowners.*

Youth Programs

A variety of school and youth groups are involved in the San Juan County Forage Fish Project. Over three hundred local youth have participated in the project to date. Student participation has involved classroom, field and lab sessions and nearshore fish seines. Students learn about the significance of forage fish in the marine food web and the importance of healthy beach habitat for spawning. Students are also introduced to the field and lab protocol and the use of the scientific method and equipment to conduct applied research. To meet demand for ongoing educational programs relating to the forage fish project, Friends of the San Juans has secured funds to host a workshop in the summer of 2004 for local educators with the University of Washington Marine Labs Outreach Program. For photos of local students conducting Forage Fish Project field and lab activities, see *Appendix H: SJC Forage Fish Project- Youth Photos.* Specific schools and youth groups involved in the forage fish project are described below:

- Shaw Island 4-H: forage fish classroom, field, lab, poster presentations and nearshore habitat restoration. Fall 2003- current.
- YMCA Camp Orkila Marine Day Camp: forage fish classroom, field and lab. Summer 2002 and 2003.
- YMCA Camp Orkila's At Risk Urban Youth Program: forage fish field and lab. Spring 2003.
- Waldron School: forage fish classroom, field and lab. Fall 2003-current.
- Stuart School: forage fish classroom, field and lab. January through June 2003.
- Friday Harbor Middle School: forage fish classroom, field and lab, January 2003 through January 2004.
- Orcas Alternative Public School Program: forage fish classroom, field and lab. Fall 2003-current.
- Spring Street School: forage fish classroom, field and lab. Fall 2003.
- Lopez School: 8th Grade Community Service Project: forage fish classroom, field and lab. Spring 2003.

Student Interns

Six student interns participated in the San Juan County Forage Fish Project. Interns ranged from high school to the graduate school level. Interns assisted with a variety of tasks based on their interests and experience. Participants and projects included: Friday Harbor High School students who conducted forage fish research, writing and volunteer workshop preparation; a University of Washington School of Marine Affairs graduate student who wrote a white paper on Best Available Science; a Rollins College student who conducted forage fish lab analysis; a Spring Street School High School student who assisted with forage fish field and lab activities; a Western Washington University student who helped coordinate and implement a forage fish habitat restoration pilot project; and two University of Washington law students who assisted with forage fish field surveys.

Community Programs

In addition to outreach and education efforts targeted to specific groups (students, shoreline landowners,) information on the forage fish project has been presented to San Juan County residents in a variety of ways, including displays at public events, targeted training sessions, articles in local and regional papers and a National Public Radio story that reached over 3 million listeners. The objectives of community outreach efforts were to increase the general understanding and awareness of the community as to the presence and significance of forage fish in the marine ecosystem and the importance of healthy beach habitats for spawning sites. Efforts were made to coordinate with ongoing marine education efforts, especially those focused on salmon, orca whales or the nearshore marine environment.

Forage fish displays were presented at both the San Juan County Fair and the Orcas Library Fair in 2001, 2002 and 2003. In cooperation with The Whale Museum, a nearshore habitat exhibit was developed and on exhibition at the museum in 2001. A short presentation on the "Ecological role of forage fish" was made at the San Juan Island Earth Day Festival, in April of 2003. The Forage Fish Project coordinator staffed the forage fish lab for The University of Washington Friday Harbor Labs Bi-Annual Open House in 2003. Forage Fish and Eelgrass displays were posted at numerous public workshops and special events, such as the Salmon People- San Juan Community Theater event, community Marine Resources Committee meetings and the Waldron Island Community Fair. See *Appendix I: SJC Forage Fish Project-Educational Posters.*

Forage fish and nearshore habitat field sessions were held at annual Friends of the San Juans meetings, in September 2002 and 2003. Forage fish and nearshore marine habitat training was provided to new Outdoor Education and Salmon Center staff at YMCA Camp Orkila, each fall since the project's inception. A forage fish and nearshore marine habitat session was provided for the San Juan County Conservation District's Watershed Stewardship training program in the fall of 2003. A forage fish and nearshore marine habitat Educator's Toolkit was produced in 2001 and distributed to 40 local and regional educators. See *Appendix J: Educator's Toolkit-Cover and Contents.* Nine volunteer trainings were held on six islands, with 75 community members trained to assist with field surveys. In-field outreach was conducted with over 150 members of the general public over the course of field surveys; these interactions occurred primarily at public beaches and marine parks.

Articles on the role of forage fish in the marine ecosystem (and the SJC Forage Fish Project) were published in the Audubon Society's San Juan Island chapter newsletter (*The Trumpeter vol. 22 no. 3*), November 2003 and in the Skagit Fisheries Enhancement Group's 2003 winter/spring newsletter. Numerous articles on forage fish and nearshore marine habitats were published in the Friends of the San Juans quarterly newsletters. Volunteers from the San Juan County Forage Fish Project were highlighted in the Puget Sound Action Team's *2003 Report to the Legislature* and the project was also covered in The Northwest Straits Commission *Benchmark Report* in 2004. Extensive outreach efforts were made with local media and the forage fish project was covered numerous times. See *Appendix K: San Juan County Forage Fish Project Media.*

Data Distribution

The initial focus of the San Juan County Forage Fish Project was to identify forage fish spawning beaches and get the information on documented spawning sites to land managers charged with protecting known spawn locations, primarily the Washington Department of Fish and Wildlife, San Juan County and the Army Corps of Engineers.

Survey results of documented spawning sites were regularly distributed to WDFW and SJC. Three major distributions of data were provided to over seventy-five local, regional, state, federal and tribal governments; non-profit organizations; and private industry (predominately land use consultants). The comprehensive data distributions included a cover letter describing documented spawn locations, map sets and data disks with spatially explicit spawn habitat data for San Juan County in both PDF and Arc View formats. Large data distributions occurred in April of 2002, April of 2003 and February of 2004. See *Appendix L: San Juan County Forage Fish Project Distribution Map Set and Disk.*

In addition to communications regarding documented spawning habitat data, information on the overall San Juan County Forage Fish Project was presented to local and regional coastal scientists and land managers at numerous events over the three years of the project. Presentations covered project protocol, partnerships, documented spawn sites, the nearshore habitat database, education and involvement activities, application of the data and the identification of protection and restoration priorities. See *Appendix M: Example SJC Forage Fish Project Power Point.*

The survey portion of the Forage Fish Project concluded with two public presentations of results to policymakers:

1. Forage fish habitat, regulation and best available science training held for all San Juan County staff (and interested state park, national park, consultant, and non-governmental organization staff scientists, managers and planners), January 2004. See *Appendix N: County Forage Fish In-Service- Agenda and Participant List.*
2. Presentation to The Northwest Straits Commission Evaluation Committee, January 2004.

Additional forage fish project presentations to land managers included:

- Presentation at the annual Northwest Straits Commission/Marine Resources Committee Conference, November 2003.
- Shared Strategies Regional Salmon Coordination Meeting, November 2003.

- Poster Presentation at the Puget Sound Salmonid Conference, October 2003.
- Presentation and field trip with U.S. Department of Interior staff, August 2003.
- Poster Presentation at the Georgia Basin- Puget Sound Marine Research Conference, March 2003.
- Presentation to The Northwest Straits Commission Board, January 2003.
- Forage fish presentation at the Marine Ecosystem Health Project Conference, September 2002.
- Forage fish display at the Northwest Straits Commission/Marine Resources Committee Annual Conference, 2002.
- Monthly updates to: San Juan County Marine Resources Committee, Salmon Recovery Funding Board Lead Entity, Northwest Straits Commission, Washington Department of Fish and Wildlife and the San Juan County Planning Director, 2001-2003.

Survey Results

The San Juan County Forage Fish Project documented positive surf smelt or sand lance spawn at 50 beaches in San Juan County, 39 (62%) of which were previously undocumented spawning sites. Coupled with the historic Washington Department of Fish and Wildlife data, 63 discrete spawning locations are documented for San Juan County, representing 11% of potential spawning sites and 16% of potential spawning habitat by length. See *Figure 3. WDFW and SJC Forage Fish Project Documented Spawning Sites.*

Surf smelt spawn has been documented at 59 sites in San Juan County, while Pacific sand lance spawn activity has been documented at eight beaches. Four sites, Jackson's Beach and Cattle Point on San Juan Island, and two Mackaye Harbor sites on Lopez Island, are documented to contain both surf smelt and Pacific sand lance spawning sites. From the 81 positive samples collected at 63 discrete spawning beaches on eight islands in San Juan County, a total of 12.66 linear miles is now protected under "no net loss" regulations as documented forage fish spawning habitat.

Documented spawn sites include: two surf smelt sites on Blakely Island (0.24 miles protected); one surf smelt site on Decatur Island (0.16 miles protected); 17 sites on Lopez Island (three Pacific sand lance and 16 surf smelt, 6.16 miles protected); 11 sites on Orcas (two sand lance and nine surf smelt, 1.3 miles protected); 17 sites on San Juan Island (three sand lance and 16 surf smelt, 2.7 miles protected); 13 sites on Shaw Island (all surf smelt, 1.8 miles protected); one surf smelt site on Stuart Island (0.15 miles protected) and one surf smelt site on Waldron Island (0.15 miles protected). See *Figure 4. Documented Surf Smelt and Pacific Sand Lance Spawning Sites in San Juan County.*

The San Juan County Forage Fish Project also identified evidence of spawn activity (one-egg sites that do not meet the legal protocol requirement of two eggs for WAC protection) at nine additional locations on four islands. These include one-egg surf smelt sites on Orcas and Lopez Islands and one-egg Pacific sand lance sites on Orcas (four sites), Lopez (one site) and Waldron (one site). See *Figure 5. Spawn Evidence Sites in San Juan County* for the locations of 1-egg sites.

Application of Forage Fish Data: Results and Discussion

Initial analysis of the Forage Fish Project database has identified a range of protection and restoration priorities for forage fish habitat in San Juan County. Application of data from the San Juan County Forage Fish Project provides an objective, resource-based method of identifying project types and prioritizing sites for nearshore protection and restoration efforts. The Forage Fish Project database supports spatial and tabular identification of a wide range of protection and restoration variables as well as detailed overlays of multiple factors to identify priority habitats. Preliminary analysis has been completed for the following parameters: existing land protections, marine riparian protection priorities, freshwater influence, roads along the backshore, stormwater impact, seawalls and bulkheads, and marine riparian restoration priorities. Each parameter is then sorted depending on its impact to documented or potential forage fish spawning habitat in San Juan County, providing the first phase of prioritization.

The documentation of positive spawning sites and the identification of critical forage fish habitat regions that has been completed by the SJC Forage Fish Project greatly improves the efficiency and effectiveness of protection and restoration efforts by targeting the most significant habitats in San Juan County. Protection strategies include securing long-term preservation of forage fish habitat through improved land management by public and private entities, direct acquisition and conservation easements designed to meet specific nearshore marine habitat objectives. Preliminary restoration analysis focuses attention on seawalls, stormwater, shoreline vegetation and roads. Results of the initial protection and restoration analysis from the San Juan County Forage Fish Project are outlined below.

<u>Critical Nearshore Habitat-Priority Forage Fish Regions</u>

The San Juan County Forage Fish Project has identified four priority forage fish spawning habitat regions in the county. Information on these significant nearshore marine habitats is provided to San Juan County planners for inclusion in the critical areas update to the Comprehensive Plan. Information on Pacific herring, surf smelt and Pacific sand lance were included in the identification of priority nearshore habitat regions. Priority forage fish spawning regions were identified in consultation with the Washington Department of Fish and Wildlife and share the following characteristics:

1. Spawn activity of multiple species of forage fish documented in region.
2. Multiple spawning sites documented in close proximity.
3. Spawn activity documented in multiple seasons.
4. Spawn activity documented in region by historic WDFW surveys (1989-1999) and by the San Juan County Forage Fish Spawning Habitat Assessment Project (2000-2003).

The four priority forage fish nearshore habitat regions identified for San Juan County are:

A. Mud/Hunter Bay Region, Lopez Island
    - Eight surf smelt spawning sites.
    - Pacific herring spawn activity throughout the entire region.
    - Forage fish spawn activity noted February, March, April, May and September.

B. Westsound and Blind Bay Region, Orcas and Shaw Islands
   - 20 surf smelt spawning sites.
   - Three Pacific herring spawning sites.
   - One Pacific sand lance spawning site.
   - Forage fish spawn activity noted March, May, June, July, August, September, and November.

C. Mackaye Harbor Region, Lopez Island
   - Six surf smelt spawning sites.
   - Two Pacific sand lance spawning sites.
   - Forage fish spawn activity noted March, May, August, November, December, and January.

D. Greater Westcott Bay Region, San Juan Island.
   - 12 surf smelt spawning sites.
   - Pacific herring spawning throughout the region.
   - Forage fish spawn activity noted May, June, August, September, November, December, January, February, March and April.

See *Figure 6. Critical Nearshore Habitat-Priority Forage Fish Spawning Regions In San Juan County* for a map of priority forage fish regions.

<u>Existing Protections</u>

San Juan County Forage Fish Project beaches with their entire length in San Juan County Land Bank, San Juan Preservation Trust, The Nature Conservancy or University of Washington land ownership are categorized as protected sites based on the long-term management objectives of these organizations. One documented surf smelt spawning site is currently protected, representing just over 1.5% of the total number of documented spawning sites. A pocket beach on Lopez Island located on the San Juan County Land Bank's Upright Head Preserve is the one documented spawning site currently in protected status. Less than one mile of potential or documented forage fish spawning habitat is currently protected under existing land ownership and management conditions in San Juan County. Five islands have forage fish habitat beaches in protected status, including one documented spawn site on Lopez Island (177 ft.), two potential spawn sites on San Juan Island (341 ft), six potential spawn sites on Shaw Island (2,088 ft), one potential spawn site on Stuart Island (1,367 ft), and three potential spawn sites on Yellow Island (466 ft).

Beaches with their entire length in San Juan County Parks, United States Coast Guard, Washington State Parks, National Parks, or Washington Department of Natural Resources lands are categorized as moderately protected forage fish spawning habitat. While these sites are publicly owned and unlikely to host major development activities over the long term, they are also common locations for shoreline modifications that can negatively impact forage fish habitat, most frequently docks and boat ramps. Nine documented surf smelt or sand lance spawning sites are located on National Parks (seven), State Parks (one) and County Parks (one) lands on Lopez and San Juan Islands, representing 15% of documented spawning sites. A one-egg spawn evidence site is also located on San Juan County Park property on Lopez Island.

64 potential or documented forage fish spawning beaches are moderately protected under existing ownership and management conditions in San Juan County, representing 8.8 miles (11%) of habitat. These include five sites on James Island (1,407ft), six sites on Jones Island (1,949ft), three sites on Lopez Island (8,196ft), six sites on Matia Island (1,534ft), five sites on Orcas Island (1,278ft), four sites on Patos (924ft), 15 sites on San Juan (22,615ft), one site on Shaw Island (160ft), three sites on Stuart Island (1,749ft), 12 sites on Stuart Island (5,469ft), and four sites on Turn Island (2,017ft). See *Figure 7. Protected Forage Fish Habitat in San Juan County.*

Riparian Habitat Protection

Riparian habitat plays an important role in the health of the nearshore marine environment. Coastal forests provide shade to forage fish spawning habitat, bank stability, water quality protection, food web input through detritus and prey items and a source of large, woody debris which can help build backshore areas. Research conducted across Puget Sound by Penttila (2001) found that egg survival of incubating summer surf smelt was significantly higher at beaches with good shade and intact marine riparian forests, suggesting that attention should be paid to protecting these habitats. Analysis of the SJC Forage Fish Project nearshore habitat database provides a first-level identification of priority marine riparian protection sites in documented and potential forage fish spawning habitats.

Seven documented forage fish spawning sites with greater than 75% shade were identified as high priority sites for marine riparian protections efforts, one site on Orcas, and three each on San Juan and Shaw Islands. An additional 36 potential forage fish spawn habitat sites with 75% or greater shade values were identified, representing the next level of prioritization for marine riparian habitat in the county. Shade values are characterized for individual survey sites, not entire beach lengths, so one forage fish beach could have a variety of shade conditions at different locations along its length. The spatial nature of the database identifies the exact location of those sites with high shade value along any particular beach length. These areas can then be targeted for additional site analysis and inclusion in habitat protection strategies, including acquisition and easement plans of public entities and private land protection organizations such as the San Juan County Land Bank and the San Juan Preservation Trust. See *Figure 8. Priority Marine Riparian Habitat at Potential and Documented Forage Fish Spawning Sites in San Juan County.*

Freshwater Seeps, Springs or Streams

The presence of natural, freshwater influences to forage fish spawning habitat is thought to improve microclimate conditions and potentially influence success of spawning by forage fish. Freshwater influence is also an important ecological factor for additional, non-forage fish, salmon recovery goals for San Juan County. Freshwater influence was recorded in the notes section of the forage fish field surveys and can be used to aid in the prioritization nearshore marine habitat protection efforts. 27 forage fish project beaches with freshwater influence were documented in the San Juans, including one site on Blakely Island, two on Lopez Island, 15 sites on Orcas Island, two on Shaw island and seven on San Juan Island, representing 4% of total potential spawning beaches. Five freshwater influence sites are located on documented spawning beaches (7% of documented sites), including surf smelt sites on Lopez, Blakely and Orcas Islands and a Pacific sand lance site on San Juan Island. Freshwater influence was also noted on two Pacific sand lance sites on Orcas Island. This estimate is conservative as forage fish field protocols targeted survey points at greater than 1,000 ft. intervals along potential spawning beaches and likely missed some freshwater influence sites. Overlaying the documented and potential forage fish spawning habitat maps with the county stream layer can identify additional freshwater influence on forage fish beaches. See *Figure 9. Freshwater Influence on Potential and Documented Forage Fish Spawning Habitat in San Juan County.*

Riparian Vegetation Restoration

Marine riparian vegetation plays an important role in the overall health of the nearshore environment. In areas where vegetation is removed, damaged, or altered, the nearshore habitat is negatively affected both directly through sedimentation and indirectly through changes in nutrient flow, shading, and presence of large woody debris. Analysis of the San Juan County Forage Fish Project nearshore habitat database identified priority marine riparian vegetation restoration sites in potential and documented forage fish spawning habitats. Roughly 1,000 forage fish field survey sites with shading of less than 50% were documented in the course of field surveys. Shade values of less than 50% were noted during 64 field surveys on 42 documented forage fish spawning beaches. Shade values are characterized for individual survey sites, not entire beach lengths, so one forage fish beach could have a variety of shade conditions at different locations along its length. These preliminary results indicate that roughly two-thirds of documented forage fish spawning sites in San Juan County have at least some portion of their length limited in terms of marine riparian vegetation and shading of incubating eggs. The spatial nature of the database identifies exact locations with low shade value along any particular beach length, facilitating next steps in project prioritizations and development. These sites can be targeted for additional site analysis and inclusion in habitat restoration strategies, such as the marine riparian restoration pilot projects currently underway. See *Figure 10. Marine Riparian Restoration Priorities for Forage Fish Habitat in San Juan County.*

Roads

A major, existing impact to forage fish spawning habitat in San Juan County are roads located along the backshore. Road installation, long-term presence, and maintenance activities are potentially or currently impacting coastal processes and beach habitat. Potential forage fish spawning beaches with roads in close proximity were noted during forage fish field surveys. 34 forage fish beaches were identified as having roads located along the backshore, for a total of 14.12 miles of documented or potential forage fish spawning habitat with existing roads. Of these beaches, 11 are documented forage fish spawning beaches (eight documented surf smelt sites, two documented Pacific sand lance sites, one documented surf smelt and Pacific sand lance spawn site and two one-egg sites), for a total of 7.8 miles of spawning beach impacted by roads. Forage fish project staff have met with and provided forage fish information to the San Juan County Public Works Department Director and county project engineers. Additional distribution of spawning habitat data and discussions of improved road development and maintenance strategies will be conducted with road department staff to minimize impacts of future actions. See *Figure 11. Potential and Documented Forage Fish Spawning Habitat in Close Proximity to Roads in San Juan County.*

Outflow Pipes/Stormwater Drainage

Information on potential pollution impacts to forage fish spawning habitat was noted in the course of forage fish surveys by recording the presence of outflow pipes in the field. Ten outflow pipes were noted at forage fish project beaches; two on documented surf smelt spawning beaches and the remaining eight at potential spawning sites. The urban areas of Eastsound on Orcas Island and Fisherman's Village on Lopez Island are both located in close proximity to potential forage fish spawning beaches. As unincorporated towns, both communities currently lack stormwater systems. Numerous hamlets throughout the archipelago also drain onto documented or potential forage fish spawning sites, most notable are Olga and Westsound, which both have outflow pipes draining directly onto documented surf smelt spawning habitat. San Juan County planners are currently working on a stormwater management plan; regular updates from the forage fish project on documented spawning sites have been provided to stormwater project staff. See *Figure 12. Stormwater Outflow Pipes in Potential or Documented Forage Fish Spawning Habitat in San Juan County.*

Additional information on the potential stormwater impacts to forage fish spawning habitat and protection and restoration efforts can be gleaned from analysis of the county watershed inventories associated with the priority forage fish spawning regions identified in the forage fish project (See *Figure 6. Critical Habitat- Priority Forage Fish Regions in SJC).* The San Juan County watersheds that impact these important nearshore ecological regions include: Westsound Watershed, Blind Bay Watershed, Wasp Passage Watershed, Mud/Hunter Bay Watershed, Mackaye Harbor Watershed, Westcott/Garrison Bay Watershed and the Mitchell Bay Watershed.

Seawalls and Bulkheads

Because forage fish depend on nearshore habitat for their survival, they are especially vulnerable to shoreline development. Shoreline armoring – the addition of structures or material along the shoreline to decrease the impact of waves and currents, or to prevent the erosion of banks or bluffs – is one of the major contributors to loss of shoreline habitat. Shoreline armoring structures, such as sea walls, rip rap, and bulkheads, often bury the upper intertidal zone and increase erosion along the shoreline. They effectively prevent erosion of banks and bluffs, cutting off the sediment supply from a feeder bluff or upper beach causing the habitat structure to shift to a lower elevation, higher energy, and a harder substrate. Net drift continues to carry away the fine sediments that are there and thus armored beaches over time can become areas of hardpan mud and bedrock, unsuitable for spawning forage fish. The direct, indirect, and cumulative impacts of shoreline modification are complex. Limiting shoreline modification is one way to preserve the health of nearshore habitat.

Information on potential structural impacts to forage fish spawning habitat was noted in the course of forage fish surveys by recording the presence of seawalls, bulkheads or jetties in the field. Seawalls were noted on 72 forage fish project beaches (12% of total number of beaches), including ten documented surf smelt spawning sites (16% of documented sites), and three one-egg Pacific sand lance sites. This estimate is conservative as forage fish field protocols targeted survey points at greater than 1,000 ft. intervals along potential spawning beaches and likely missed some shoreline structures. The majority of seawalls in potential or documented forage fish spawning habitat were noted on Orcas Island (31), followed by San Juan (16), Lopez (10), Shaw (6), Brown (2), Crane (1), Waldron (2), Sucia (2), Blakely (1) and Decatur (1). See *Figure 13. Seawalls or Bulkheads on Potential or Documented Forage Fish Spawning Habitat in San Juan County.*

Alternatives to shoreline armoring exist and should be explored to protect and restore forage fish spawning habitat in San Juan County. The San Juan County Forage Fish Project nearshore habitat database provides a first level of analysis to address the issue of shoreline modification; in addition to the location of noted seawalls provided here, the database contains notes on the type of shoreline structure (wood, rock or concrete) and field survey site photos also provide information on the condition of existing structures, aiding in the ranking of restoration priorities.

Beach nourishment can be used in combination with development setbacks to maintain property as well as to minimize impacts to nearshore marine habitat. In nourishment projects, sand or gravel of the same sediment grain size of the natural substrate is transported from a land or offshore site and placed either directly on the beach, or seaward of the beach. Two such projects have been implemented in the San Juans (Blakely and Orcas Islands) and both have proved successful and popular with private landowners. Coastal vegetation is another management alternative that can improve slope stability. Natural protection of shorelines can also be provided by large woody debris that has naturally fallen on the beach or has drifted in. Surface and groundwater management can also have a huge impact on reducing erosion. Building setbacks reduce the stress on the slope to the beach, slow erosion, and allow for some natural erosion without concern for the structure. Constructing homes and other buildings a safe distance from eroding shorelines or bluffs is considered the safest and least expensive alternative to shoreline modifications.

Next Steps

The collaborative San Juan County Forage Fish Project has had a significant local and regional impact as a model for public-private partnerships to meet important scientific and land management objectives. Major accomplishments of the SJC Forage Fish Project include:

- Partnerships created;
- Protocol developed;
- Historic data compiled and mapped;
- Potential spawning habitat mapped;
- Nearshore database developed;
- Surf smelt and Pacific sand lance spawning habitat assessment conducted;
- Protection and restoration priorities identified;
- Shoreline landowners informed and engaged;
- Students and community volunteers involved and educated;
- Awareness by the general public improved; and

- Communication and distribution of information with scientists and land managers ongoing.

With the spawning habitat assessment phase of the project complete, the SJC Forage Fish Project now plans to expand the application and use of forage fish data by both public and private land managers. When combined with the comprehensive eelgrass mapping and herring spawn results expected later this spring, San Juan County will have the information it needs to ensure these critical habitat areas are protected from no net loss. Work with landowners will also emphasize the application of results, focusing on the development and implementation of nearshore marine restoration and protection projects. With over 400 miles of shoreline, the nearshore marine habitats of San Juan County play an important role in regional salmon recovery efforts as forage fish spawning sites and feeding, refuge and migration corridors for salmon species. Tagging efforts in the San Juans have identified 16 stocks of Coho as well as 5 federally listed stocks of Chinook (four fall and one spring); healthy nearshore marine habitats and food webs are an essential component in the life histories of these stocks.

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San Juan County Forage Fish Project

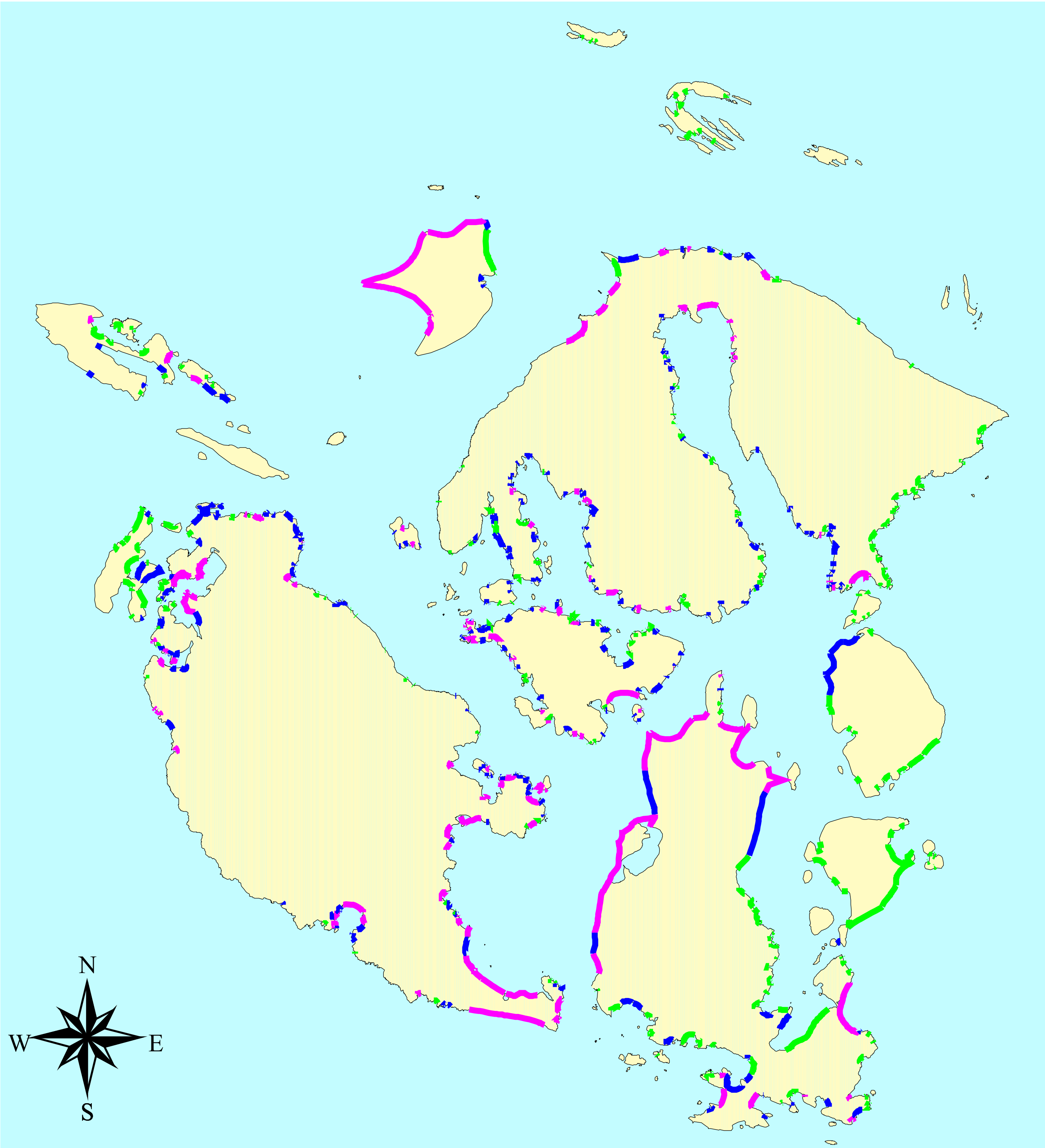
Initial and Adjusted Distribution of Potential Spawning Habitat in San Juan County

Figure 1

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Number of Surveys Performed



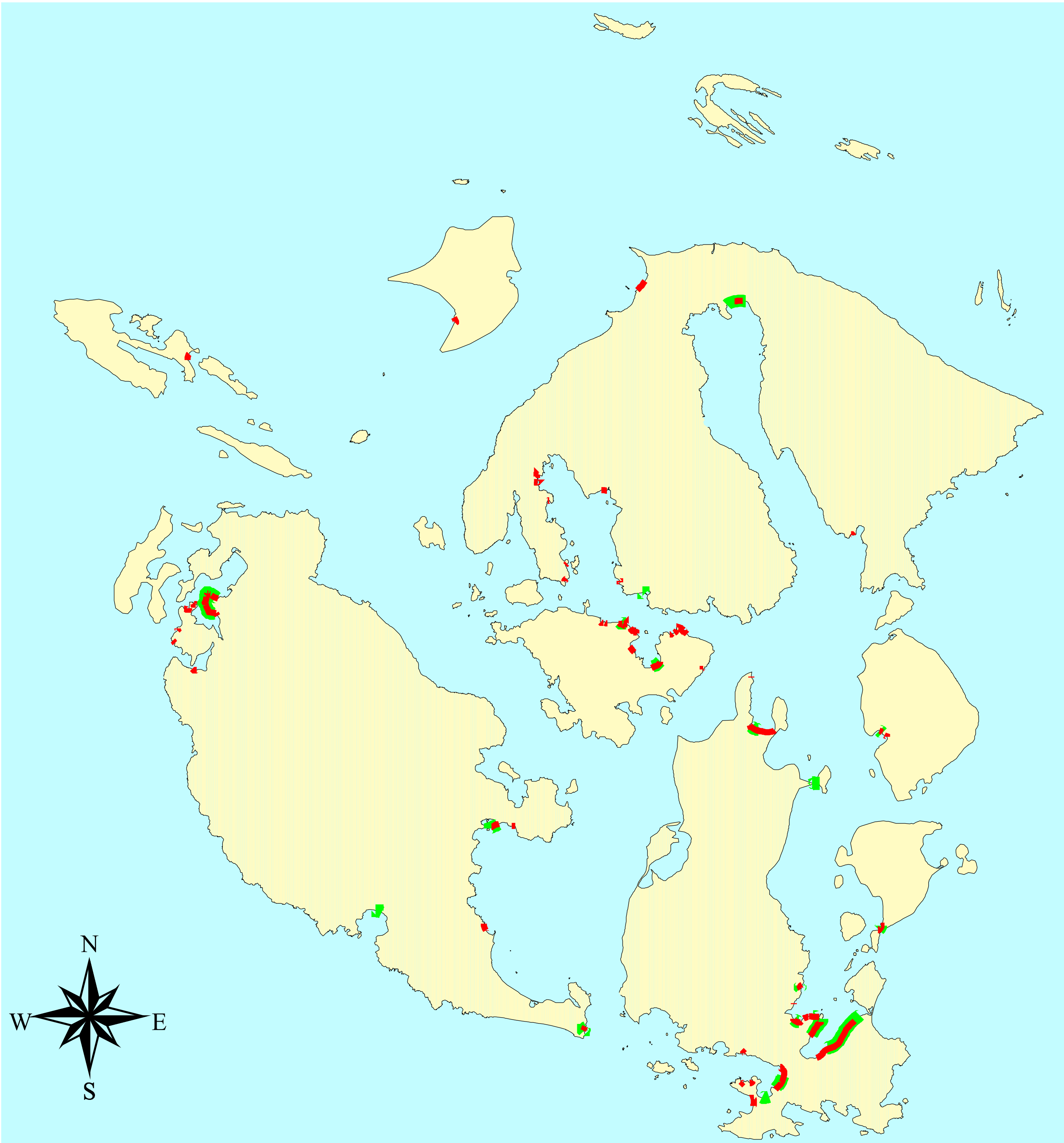
Number of Surveys
1 Survey
2 Surveys
3 - 11 Surveys

Figure 2

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

WDFW and SJC Documented Spawning Sites



San Juan County Documented Sites

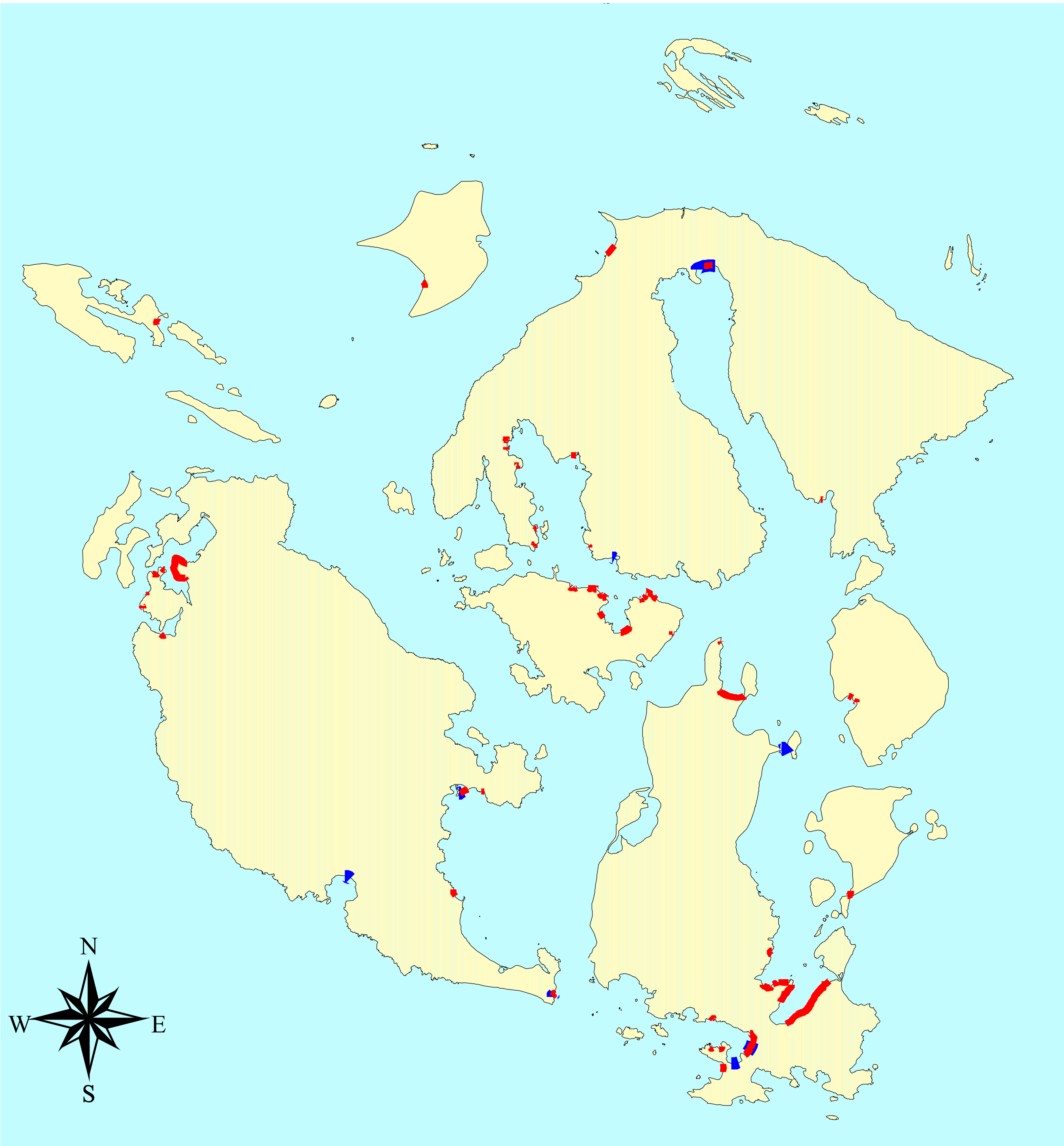
WDFW Documented Spawn Sites

Figure 3

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Documented Surf Smelt and Sand Lance Spawn Sites in San Juan County



Documented Surf Smelt Spawn Sites
Documented Pacific Sand Lance Spawn Sites

Figure 4

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Spawn Evidence Sites in San Juan County

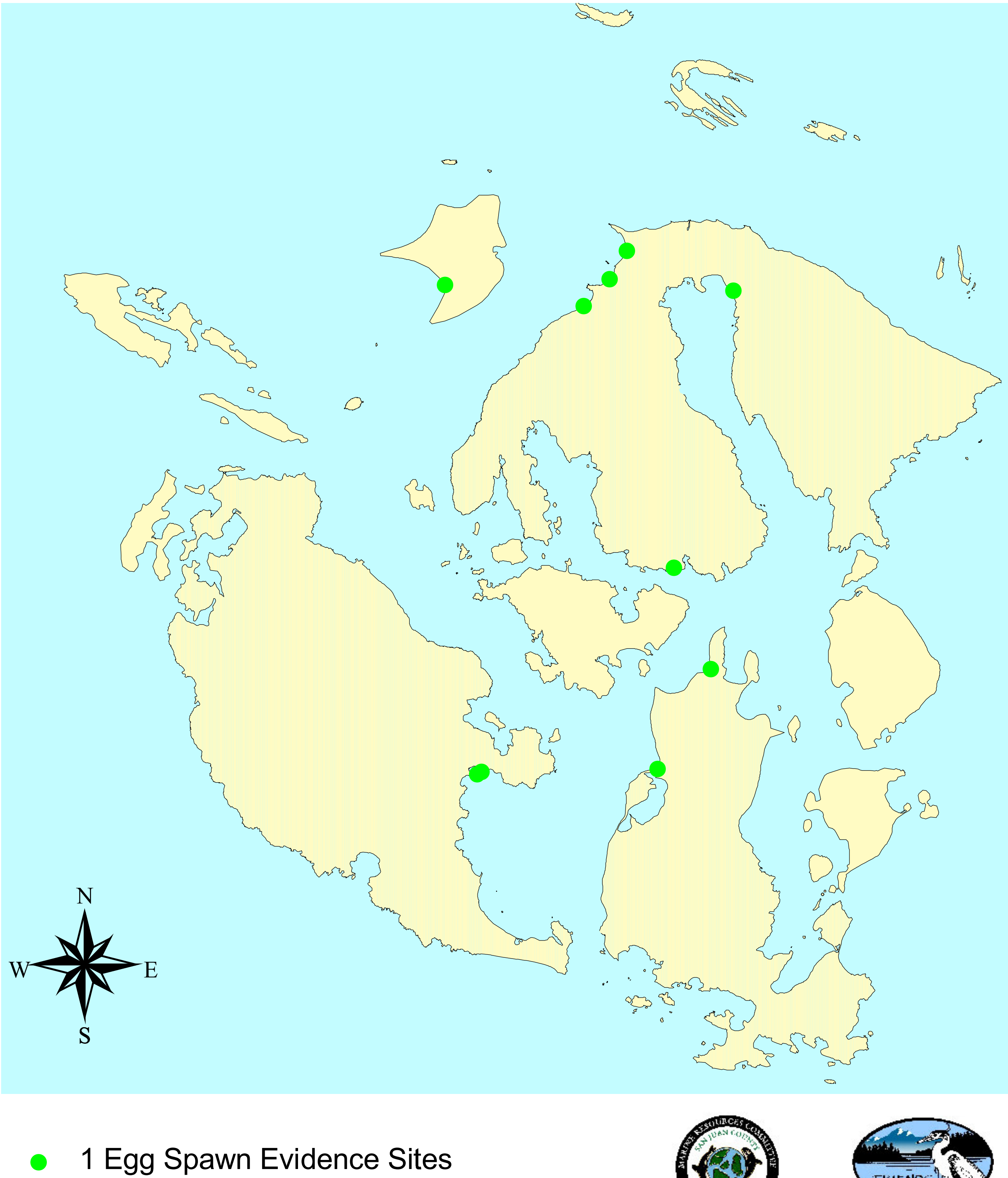


Figure 5

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Critical Nearshore Habitat- Priority Forage Fish Spawning Regions in San Juan County

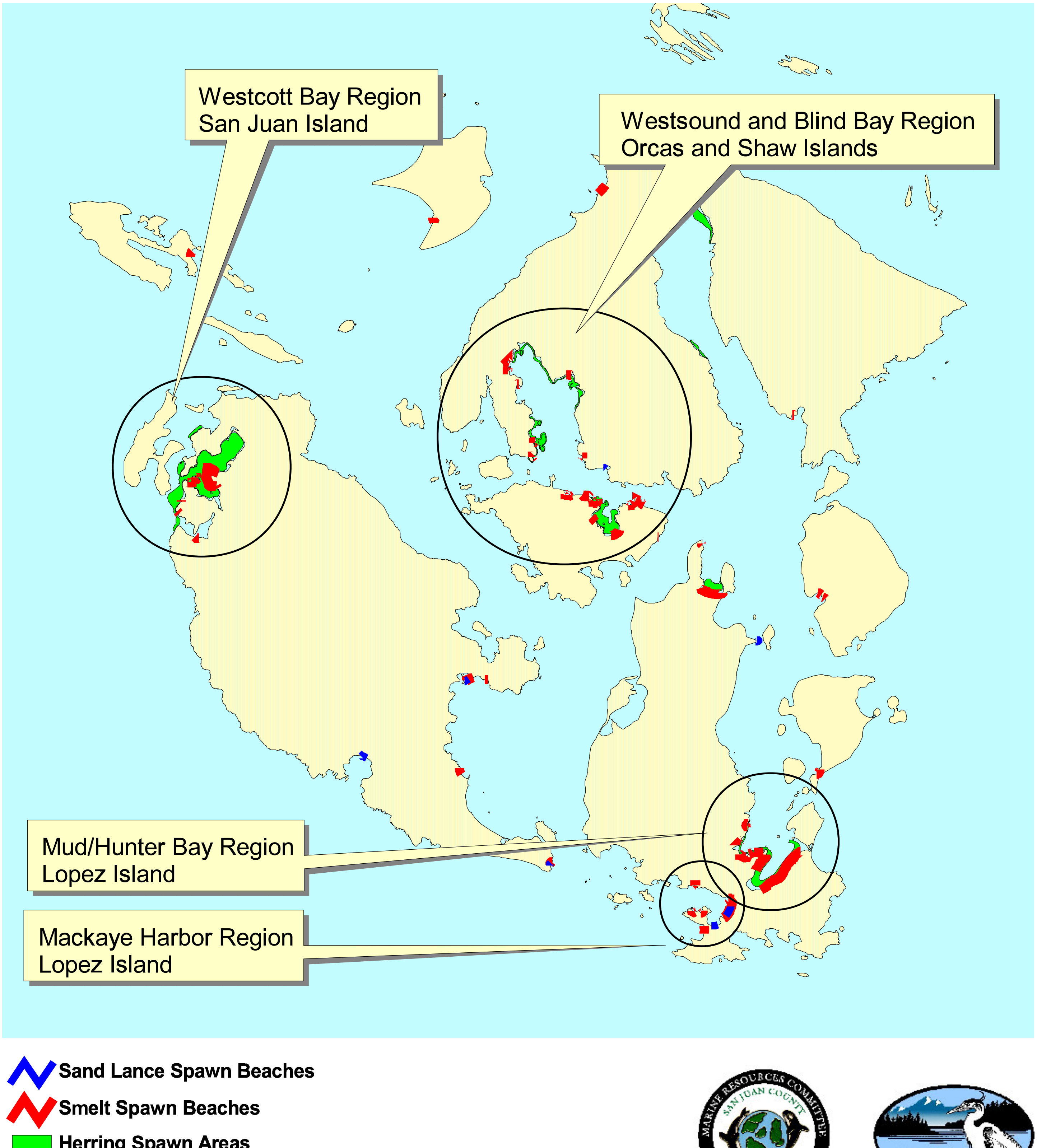
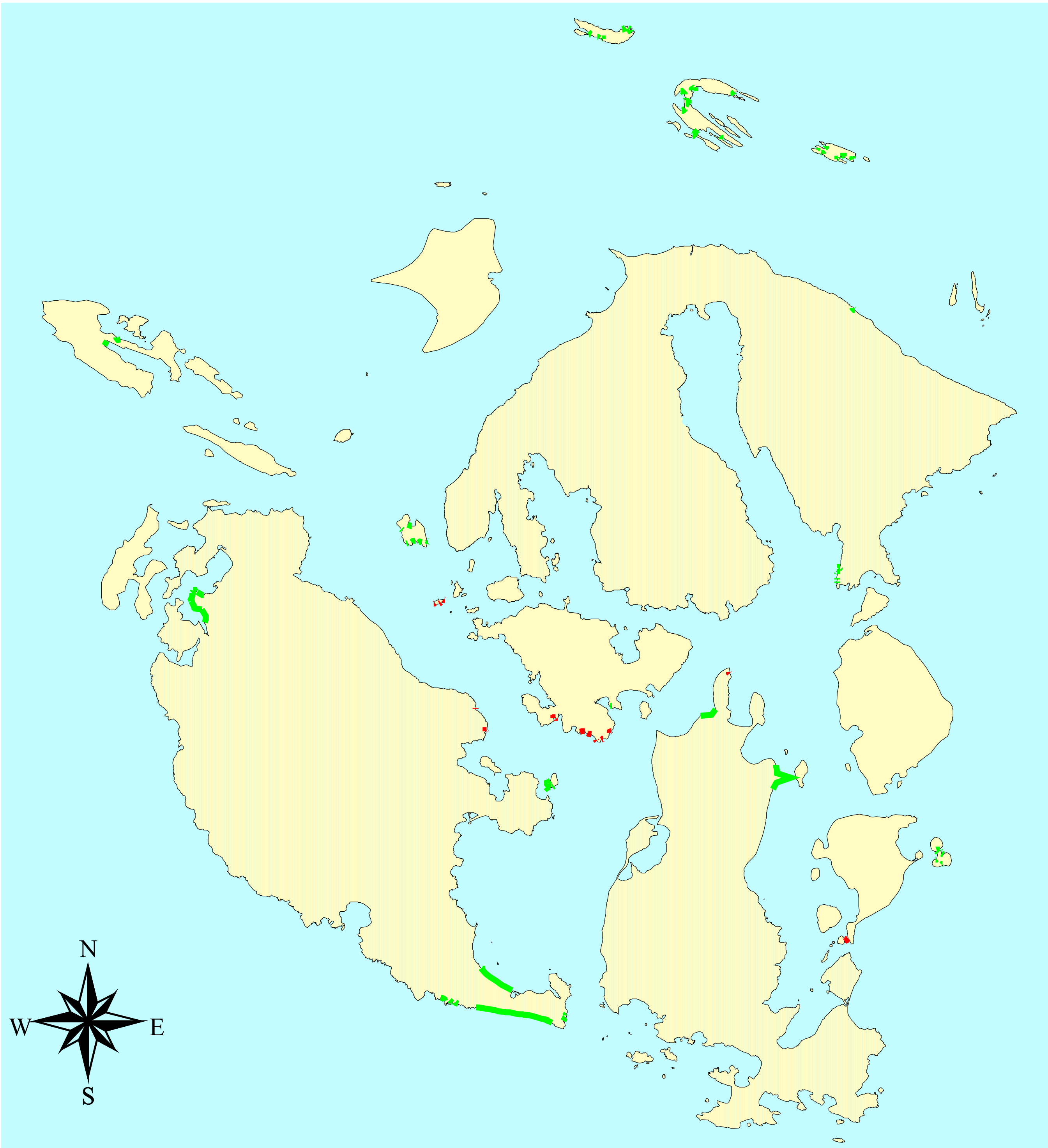


Figure 6

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Protected Forage Fish Habitat in San Juan County



Beaches Protected By Ownership

Moderately Protected

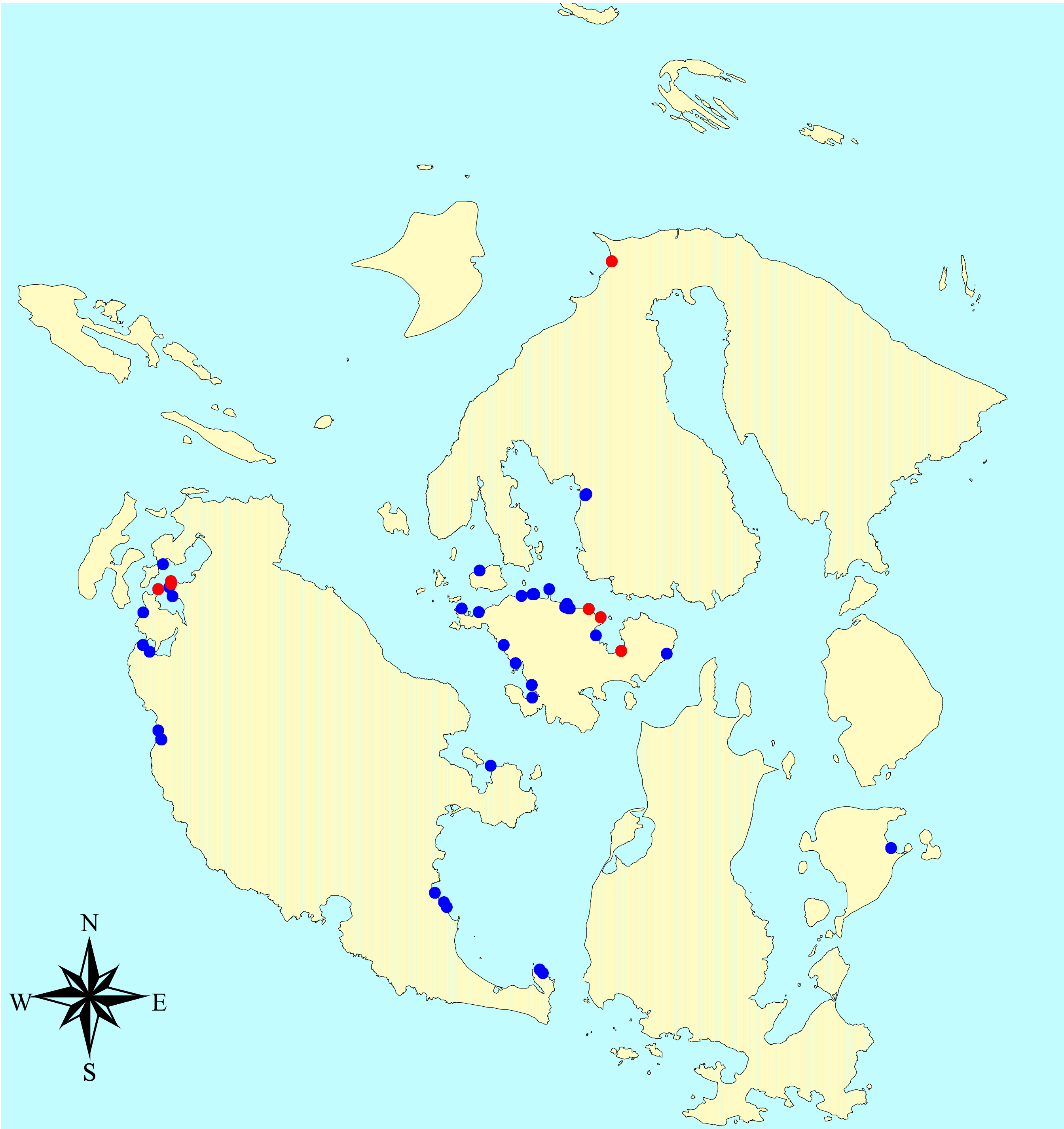
Fully Protected

Figure 7

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Priority Marine Riparian Habitat at Potential and Documented Forage Fish Spawning Habitat



High Protection Priority
● Documented Spawn Sites with 75% or more shading

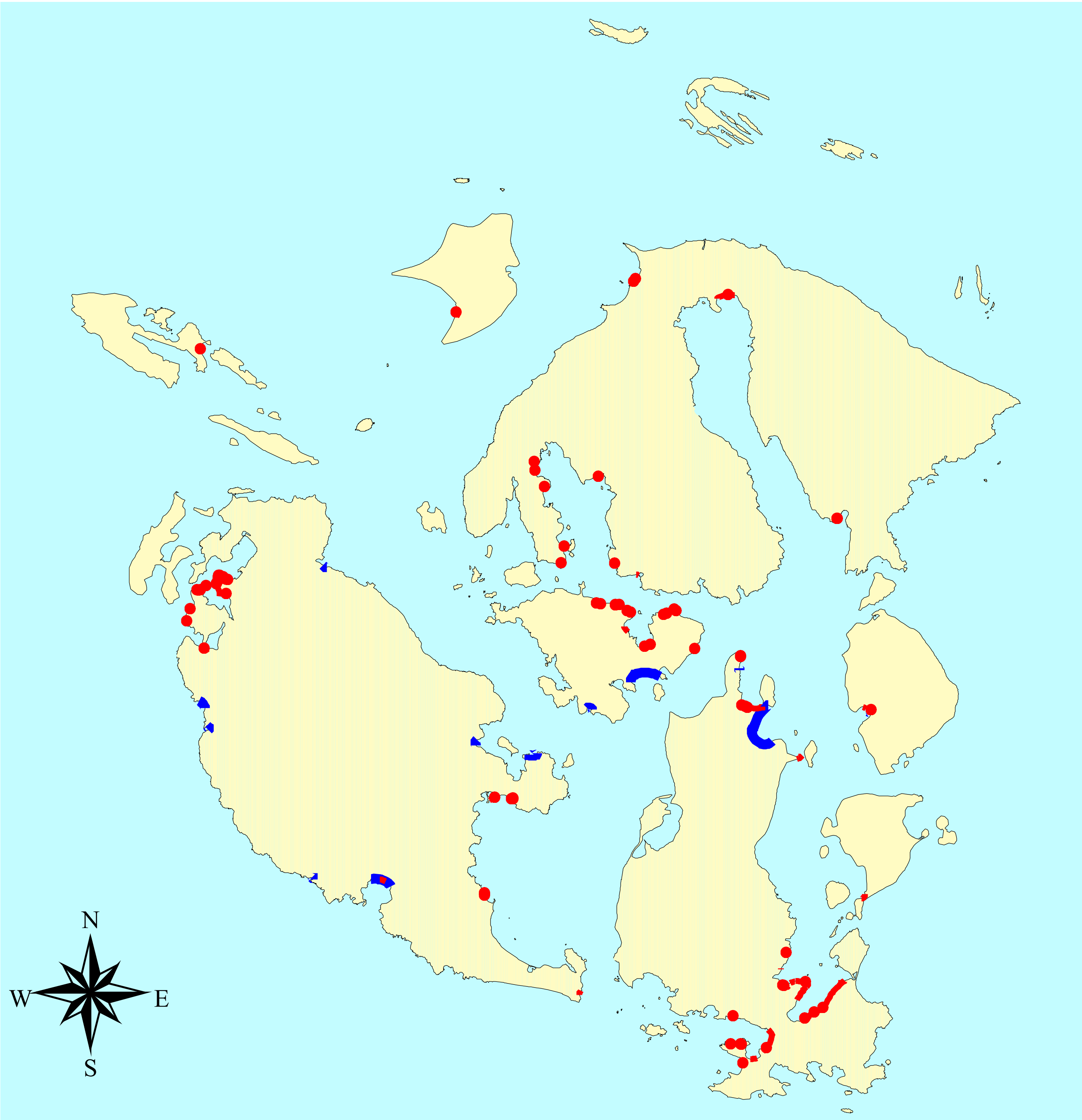
Moderate Protection Priority
● Potential Spawn Habitat with 75% or more Shading

Figure 8

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Freshwater Influence on Potential and Documented Forage Fish Spawning Habitat in San Juan County



Documented Spawn Sites
Beaches with Fresh Water Influence

Figure 9

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Marine Riparian Restoration Priorities for Forage Fish Habitat

High Priority

Documented Spawn Sites with less than 50% Shading

Moderate Priority

Potential Spawn Habitat with less than 50% Shading

Figure 10

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Potential and Documented Forage Fish Spawning Habitat in Close Proximity to Roads in San Juan County.

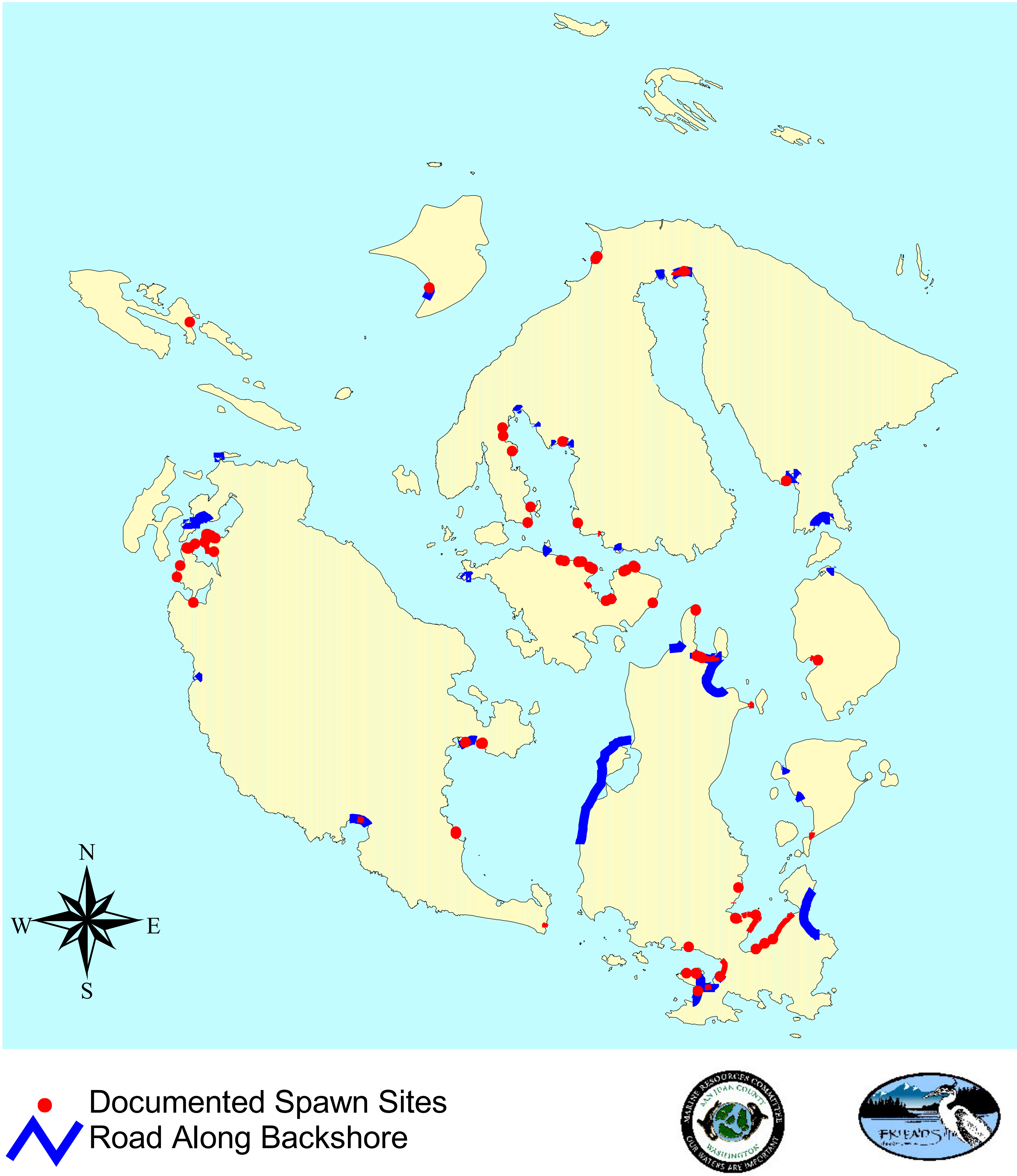


Figure 11

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Stormwater Outflow Pipes in Potential or Documented Forage Fish Spawning Habitat

Outflow Pipes
Documented Spawn Habitat

Figure 12

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

San Juan County Forage Fish Project

Seawalls or Bulkheads on Potential or Documented Forage Fish Spawning Habitat

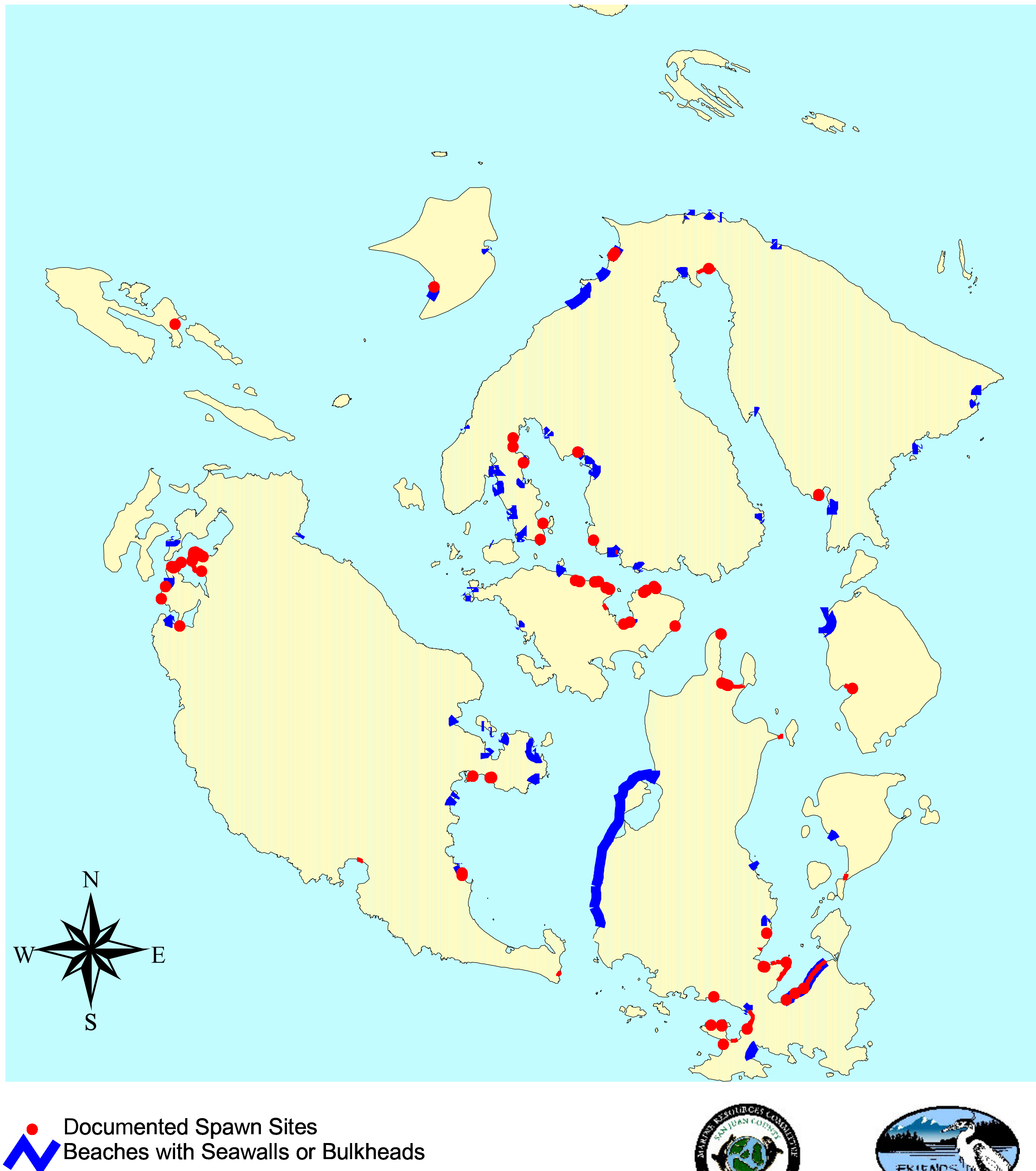


Figure 13

Note: Data from San Juan County Forage Fish Spawning Habitat Project Final Report

Scoping Memorandum concerning the Pacific Gateway Terminal

The Marine Environment of the San Juans

Excerpt from: *Personal Watercraft Use in the San Juan Islands*

Prepared By: Aquatic Resources Conservation Group
For: The Board of County Commissioners
San Juan County, Washington

September 7, 1998

PERSONAL WATERCRAFT USE
IN THE
SAN JUAN ISLANDS

A Report Prepared for
The Board of County Commissioners
San Juan County, Washington

by the
San Juan County
Planning Department

Aquatic Resources Conservation Group
Seattle, Washington

Provisional Final Draft
September 7, 1998

PERSONAL WATERCRAFT USE
IN THE
SAN JUAN ISLANDS

A Report
Prepared for
The Board of County Commissioners
San Juan County, Washington
by the San Juan County
Planning Department

This document is a provisional final draft in fulfillment of a contract with the San Juan County Planning Department, signed on June 16, 1998. Peer review is still underway; when concluded, a final copy will be issued.

Aquatic Resources Conservation Group is a nonprofit, 501(c)(3) consulting organization specializing in marine and watershed resource issues.

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*The University of Washington was not involved in any manner whatsoever in this endeavor.

III. San Juan County's Marine and Coastal Environments

A. Setting

San Juan County is located in the northwest corner of Washington. The San Juan Islands and associated land masses comprise the southern end of the San Juan Archipelago, which extends across the United States' border into British Columbia, Canada. The county consists of 743 islands (428 at high tide),[1] 172 of which are named.[2] Approximately 375 miles of shoreline encompass the 150 largest islands at high tide,[3] and about 440 square miles of marine waters bathe the county's shores.

Sixty islands are inhabited by people, and four are served by ferries.[4] San Juan County's population in 1990 was 10,035, amounting to a density of fewer than 100 people per square mile.[5] The projected population for 2000 is 13,029.

San Juan County is fortunate to have prime lands set aside for public enjoyment. Public lands with shoreline access in San Juan County include twelve county parks located on Orcas, Shaw, Lopez, and San Juan Islands; fourteen state parks, including lands on Lopez and Orcas Islands; and two National Parks on San Juan Island. As evident from the map of San Juan County, a number of public roads access the shoreline, and several public boat ramps are located throughout the islands. (Appendix III., Figure 1. a. - c.)

A network of wildlife refuges and marine preserves and reserves established to protect and preserve the islands' plants, animals, and critical habitats augment the largely undeveloped public lands just described. In 1923, five marine preserves were established in which fishing (except for salmon and herring; and crabs in Parks Bay) and collection of marine plants and animals are prohibited. The preserves are located off of San Juan and Shaw Islands. (Appendix III., Figure 2.) San Juan County also has eight additional marine reserves with voluntary no-take zones closed to bottom fishing.[6] (Appendix III., Figure 2.) In addition, the San Juan Islands National Wildlife Refuge and Wilderness Area comprises 84 islands and rocks. (Figure 3)

The climate in the San Juan Islands is enjoyable year-round. Temperatures are moderate; the average summer high is 65 degrees Fahrenheit and the average winter low is 40 degrees Fahrenheit.[7] The islands receive moist air from the Pacific Ocean, yet their location in the rain shadow of the Olympic Mountains and Vancouver Island limit the average annual precipitation to 25 inches. The dry season begins in May and peaks in midsummer; the wet season begins in October and peaks in winter.

From a geological perspective, the San Juan Islands are part of the Puget Sound Basin, which comprises the northern end of the Puget Trough physiographic province.[8] The region's geological history is composed of three fundamental processes.[9] First, structural development occurred during the Cordilleran mountain-building process, which began about 200 million years ago. During this time, convergent interactions between two crustal plates resulted in the rise of the Olympic and Cascade mountain ranges of Washington and the Insular Mountains of Vancouver Island, in addition to other ranges in western North America. Next, during the Pleistocene Epoch, when the Puget Sound Basin was covered by an icecap to a depth of more than 700 meters, glacial activity shaped the region's topography and bathymetry. Erosive forces caused by the moving ice shaped and rounded the land, creating glacial plains and basins. Glaciers also deepened Haro Strait, East Sound, and Rosario Strait. The debris from this glacial sculpturing are evident today as glacial deposits such as sills and shoreline features located throughout the area. The most recent ice sheet retreated 12,000 to 13,000 years ago. Post-glacial changes in sea level, and riverine and marine shoreline erosion, shaped the region's beaches and shorelines. The San Juans' numerous narrow channels, protected estuarine bays, and multitude of islands are predominant features that resulted from millions of years of geological construction and destruction.

Furthermore, through their influence on the physical oceanography of the islands, these three features affect the diversity and distribution of marine plants and animals.

The region's geological features affect its oceanographic characteristics. The San Juan Islands are situated in the inland waterway estuarine regime, a region including the Strait of Georgia, Puget Sound, and Strait of Juan de Fuca, and extending from southern Vancouver Island to the mainland coasts of British Columbia and Washington.[10] This region is one of the largest expanses of protected, relatively shallow estuarine waters along the West Coast of North America.[11] The oceanography of the marine waters in the region is strongly influenced by water circulation and freshwater input. Four large channels encompass the islands: Rosario Strait and Haro Strait to the east and west, respectively, connect the Strait of Juan de Fuca south of the islands with the Strait of Georgia to the north. A network of narrow channels also provides routes for water flow around and between the islands. The narrow channels and shallow sills impede water circulation to remote bays, however, resulting in heterogeneous pockets of water that vary in salinity, temperature, organic nutrients, and other factors.[12]

Four fundamental forcing mechanisms affect water flow in the inland waterway. Estuarine (buoyancy-driven) flow is the dominant factor in this system.[13] Winter rainfall and summer snowmelt provide an influx of freshwater into the system, resulting in a net seaward outflow of brackish water on the surface and a net landward inflow of higher salinity marine water underneath. The Fraser River in British Columbia, Canada, contributes 80% of the mean annual discharge of freshwater into the Strait of Georgia, and this creates a net southerly transport of surface water through Haro Strait, Rosario Strait, and the San Juan Archipelago. Tides also act periodically on the system to change the direction and speed of water flow, with the intensity of tidal currents varying by location and time of day. The inland waters experience semidiurnal tides: there are two high tides and two low tides per day. Strong tidal currents passing through the narrow channels between the islands produce turbulent mixing, bringing nutrients and prey to the water's surface, thereby contributing to the area's high productivity.[14] Wind forcing is the third mechanism affecting water flow. In the San Juans, wave action is usually negligible except on the shores facing the Strait of Juan de Fuca that are exposed to intense waves during storms.[15] Coastal ocean forcing, including upwelling and reversals in estuarine circulation, is the fourth mechanism impacting the flow regime.

B. Marine Habitats

Long et al.[16] classify the marine environment into three areas, namely: intertidal/subtidal, nearshore, and offshore. The main differences between these areas are proximity to shore and water depth. Further partitioning of each area into habitat types is possible, with each habitat type having a characteristic flora and fauna. Definitions of each habitat type and examples of their associated biota are discussed below. Details on select species are addressed in Section III., Part C.

1. Intertidal/Subtidal

The intertidal and subtidal zones define the shoreline. The intertidal zone is the region of shoreline that is alternately covered and uncovered by the changing tides, whereas the subtidal zone is always covered by water. Habitats within the intertidal and subtidal zones can be further divided into three categories each, based on sediment type and exposure to wave action and tidal currents. Those categories are 1) exposed unconsolidated sediments, 2) protected unconsolidated sediments, and 3) rock. (Appendix III., Figure 4.)

The first intertidal/subtidal shoreline habitat type comprises **exposed unconsolidated sediments**, including gravel and coarse sand like the intertidal areas of Deadman Bay and Eagle Cove on the west side of San Juan Island. This habitat type is characterized by high wave or current action, mobile and dynamic sediments, steeply sloping beaches, and absence of vegetation and relatively sessile animals such as clams and tube-dwelling worms. A few of the invertebrates commonly found in sandy habitats include moon snails, polychaete worms, mysids, and amphipods.[17] Phytoplankton and detritus provide the base of the food web; they are consumed by zooplankton, which attract fishes. Gravel and sand habitats, however, appear to support fewer fish species than habitats of any other type.[18] Among the species of fishes present here are Pacific staghorn sculpin, juvenile English sole, and juvenile Pacific tomcod. Migratory and nonmigratory birds are also found here, although the use of exposed unconsolidated sediments by shoreline foraging birds is relatively low in the San Juans due to the paucity of prey items. Bird species characteristic of these habitats include Bald Eagles, White-winged Scoters, Common Goldeneyes, Harlequin Ducks, Great Blue Herons, and various species of gulls. Harbor seals also frequent gravel and sandy beaches.

These habitats are susceptible to anthropogenic threats. Bacterial contamination and log storage threaten gravel habitats, while sandflats are declining in Puget Sound due to shoreline armoring and alterations to the environment such as filling and dredging.[19]

Protected unconsolidated sediments constitute the second shoreline habitat type. The dominant habitats include mud/gravel, mud/sand, and mud. This habitat type is typical of bays and harbors such as Garrison and Westcott Bays on San Juan Island, and Mud Bay on Lopez Island. It is characterized by the following features: protection from strong waves and currents; accumulation of fine sediments such as mud and silt; sediment stability; broad beaches with minimal slope; and backshore areas that occasionally have marshes. Relatively immobile infauna (animals living in bottom sediments) are also present, and some representatives are tube-dwelling polychaete worms; cockles; bent-nosed, hard-shell, and soft-shell clams; ghost and mud shrimp; and sea pens (limited to the subtidal).[20] Mud and mud mixtures are important habitats for birds and harbor seals. The seasonal species richness of birds is greater here than in any other intertidal or subtidal habitat type.[21] Common bird species include the Great Blue Heron, Black Brant, and Common Pintail; Bald Eagles and Harlequin Ducks are also present on occasion.

Eelgrass communities – of which *Zostera marina* is the native species – also thrive in these areas. This seagrass sends roots and rhizomes (horizontal stems) down into the soft sediments and projects erect, leafy shoots into the water column. Simenstad states that, “Seagrass communities likely rank with marine kelp (macroalgae) systems as the marine analog to tropical rain forests in structural complexity, biodiversity, and productivity.”[22] Numerous species of algae, vertebrates, and invertebrates utilize eelgrass habitats for at least part of their lives. Examples of the diversity of invertebrates include hydroids, snails, nudibranchs, sea anemones, jellyfish, brittle stars, and crabs.[23] Eelgrass communities provide a wide assortment of services, primarily: habitat structure and stability; shelter from waves; refuge from predators; shade from the sun; nurseries for juvenile fishes such as salmon; spawning grounds for fishes (e.g., Pacific herring); vital links in the carbon, phosphorus, nitrogen, and sulfur cycles; oxygen via photosynthesis; and, finally, high production and growth rates that provide a foundation for marine food webs.[24] Bacteria feed on detritus from eelgrass beds, and then the bacteria are consumed by detrivores, the next link in the food chain. The distribution of eelgrass depends upon substrate composition, turbidity, light penetration, and physical disturbance from waves and currents.

Eelgrass beds and the protected unconsolidated sediments in which they grow are also vulnerable to human disturbance. These habitats may be physically disrupted by development, shoreline armoring, dredging, and filling; and scars from boat propellers and anchors are an additional concern for eelgrass beds. Physical, chemical and biological threats to eelgrass include decreasing water quality (including increases in turbidity, as well as oil and other toxic pollutants) and introduced species (e.g. *Zostera japonica* and *Spartina spp.*). Mudflats are declining in Puget Sound and, although estimates of previous abundance for eelgrass in Puget Sound are lacking, this seagrass may be also be declining.[25]

Rock is the third intertidal/subtidal habitat type. Three types of rocky habitats are protected solid rock, exposed solid rock, and cobble.[26] Lime Kiln State Park on San Juan Island and Iceberg point on Lopez Island are characteristic rocky shores. Features such as shoreline slope and physical disturbance that were used to define the previous intertidal and subtidal habitat types are highly variable for rocky shores. Tidepools and the epiflora and epifauna attached to rocky substrates are diagnostic features of this habitat type. Representative invertebrates that contribute to the diversity of rocky shorelines are sea anemones; a variety of worms, including nemerteans, flatworms, and polychaetes; numerous molluscs such as oysters, mussels, chitons, snails, limpets, and nudibranchs; many crustaceans, for example barnacles, crabs, hermit crabs, and shrimps; sea urchins, sea stars, and sea cucumbers, all of which are echinoderms; and tunicates (sea squirts) - some of our closest living invertebrate relatives![27] Macroalgae are significant contributors to the character of many rocky habitats. Like the eelgrass *Zostera marina*, macroalgal species such as *Laminaria*, *Egregia*, *Alaria*, *Fucus*, and especially *Nereocystis* (the bull kelp) serve multiple functions in rocky communities. Indeed, the functions provided by macroalgae are analogous to those listed previously for eelgrass. The geophysical differences between eelgrass and macroalgae habitats are reflected in each habitat's species assemblage. For instance, the mud and mud mixture habitats where eelgrass is found support high densities of birds, whereas the rocky habitats of macroalgae support relatively low densities of birds.[28] Harlequin Ducks, Bald Eagles, Greater Scaups, and Surf Scoters are a few of the bird species that frequent rocky habitats. In addition, harbor seals are the only species of marine mammal to frequent muddy habitats, whereas rocky habitats are commonly utilized by three species, namely Steller sea lions, California sea lions, and harbor seals. A few of the fish species characteristic of subtidal rocky habitat in the San Juans are copper and black rockfish, lingcod, and kelp greenling.

Rocky habitats may also be affected by human activities, including shoreline pollution, overharvest, introduced species, and trampling. The extent of kelp beds in Puget Sound has actually increased, probably due to accelerated erosion of soft sediments and associated increases in rocky habitats resulting from construction and development along the shoreline.[29]

2. Nearshore

The nearshore area, as designated by Long et al, consists of habitats in the water column from the high tide line to a depth of 20 meters offshore. They chose the 20 meter isobath as the boundary between nearshore and offshore areas because of the "relatively abrupt change in species composition, richness, and numbers" that occurs at that depth contour, "as exemplified by the birds." [30] The distribution of some nearshore bird species is related to the underlying substrate and it is therefore possible to define nearshore habitat types by substrate, analogous to the system presented above for the intertidal/subtidal area. For example, Marbled Murrelets and Pigeon Guillemots are found in nearshore waters over protected rock, and grebes are abundant nearshore over mud-gravel. When species distributions do not appear substrate-dependent, a single habitat may be considered, as is the case for many marine mammals and fishes. Harbor seals, harbor porpoises, and orcas are the most common nearshore marine mammals, although other species also venture close to shore. The diversity of fishes in the nearshore area is low, yet these are critical nursery habitats for some ecologically and economically important fishes - Pacific herring and salmon, for example.

3. Offshore

Waters deeper than 20 meters are designated offshore habitats.[31] Water dynamics, namely current velocity and tidal turbulence, are the principal factors dividing the different habitat types, which include bays, narrow passages, open waters, and broad passages. Open waters will not be addressed because they are not characteristic of the environment in the San Juans. As in the nearshore waters, the major threats to offshore habitats are overharvest and biological and chemical pollution. Each habitat type is discussed separately below.

Narrow passages are exemplified by Speiden Channel and San Juan Channel. They have strong tidal currents and turbulence associated with tidal fronts, which tend to concentrate prey species. The prey species, in turn, attract predators. Narrow passages are important foraging habitats of both Steller and California sea lions. Seabirds forage on zooplankton and fish in these offshore waters; the Pacific Loon, Brandt's Cormorant, and Common Murre are piscivorous, whereas Bonaparte's Gull feeds on zooplankton, including pelagic fish eggs and larvae.

Haro Strait, Rosario Strait, the Strait of Juan de Fuca, and the Strait of Georgia are typical **broad passages**. They are characterized by very deep, open waters with noticeable tidal fronts that often have lower current velocity and less turbulence than narrow passages. Juvenile and adult Pacific herring and various species of adult salmon are representative of ecologically and economically important fishes that live in these offshore waters. Congregations of herring are important prey for seabirds such as Common Murres, Marbled Murrelets, cormorants, and gulls. Harbor porpoises, California sea lions, harbor seals, minke whales, and other marine mammals also feed on these schools of herring. Additionally, adult salmon are favorite prey of the resident orca pods.

The **deep-water bay** is the last offshore habitat type to be discussed. East Sound and West Sound on Orcas Island are representatives of this type of habitat. Of all the offshore habitats, deep-water bays usually support the lowest numbers of species.[32] Common Loons, Pacific Loons, Common Murres, and Marbled Murrelets use this habitat type during certain seasons, and harbor seals are the most common marine mammals found here.

C. Species Accounts

1. Marine Mammals

San Juan County provides primary habitat for several species of pinnipeds (seals and sea lions[33]) and cetaceans (whales, dolphins, and porpoises), and for river otters. Twelve diverse species of seasonally resident marine mammals frequent the islands: the river otter, harbor seal, northern elephant seal, Steller sea lion, California sea lion, harbor porpoise, Dall's porpoise, Pacific white-sided dolphin, orca, minke whale, humpback whale, and gray whale.[34] (Appendix III., Table 1.) All of these species depend upon the highly productive and relatively undisturbed marine environment of the San Juan Islands. For humpback and gray whales, the San Juan Islands are a rest area on their migrations between southern breeding and northern feeding grounds. For others, such as the California sea lion, Steller sea lion, and northern elephant seal, the San Juans mark the final destination of long annual journeys to haul out sites and productive feeding areas. Minke whales migrate to these waters to feed, and Pacific white-sided dolphins reside here during the summer and fall, corresponding to their breeding and calving seasons. The remaining species, the harbor porpoise, Dall's porpoise, harbor seal, river otter, and orca, are year-round residents, and therefore the marine habitats around the San Juans function as breeding, nursery, and feeding areas for them.

All marine mammal species are protected under the Marine Mammal Protection Act of 1972.[35] The Steller sea lion, harbor porpoise, and humpback whale are also protected by the Endangered Species Act of 1973.[36] Detailed descriptions for the orca (Appendix III., Figure 5.), harbor porpoise (III., 6.), minke whale (III., 7.), harbor seal (III., 8.), and California (III., 8.) and Steller sea lions follow.

a. Orca (*Orcinus orca*)

The orca is emblematic of the ecological and economical importance of marine mammals in the San Juans. It is the largest member of the dolphin family.[37] Orcas in British Columbia and Washington comprise two sympatric populations, termed "resident" and "transient."[38] These differ in a number of respects, primarily diet. Residents specialize on salmon (although occasionally eating bottomfish), whereas transients specialize on marine mammals – primarily harbor seals, but including Dall's and harbor porpoises, California and Steller sea lions, and elephant seals – and seabirds. Resident and transient populations are each composed of communities; communities are divided into pods; and certain subgroups within each pod are regularly seen together and are believed to be matriarchal family units.[39] The life history of orcas is characterized by a low reproductive rate, the gestation period being about 16 months with, on average, an eight-year calving interval. Female orcas become sexually mature at 13-17 years of age, while males reach sexual maturity at 15-19 years; the overall lifespan is at least 40-50 years.

The local transient population is composed of a single community and, although the exact population size is unknown, it is thought to number at least 160 animals.[40]

The resident population has two communities, northern and southern, and is one of the most studied cetacean populations in the world. Individual identification by photographic techniques provides researchers with the opportunity to investigate distribution, feeding, and life history characters of these cetaceans. Habitat ranges of the northern, southern, and transient orca communities overlap, although social and reproductive isolation has probably existed for many generations.[41] The center of the northern resident community's range is outside of the study area and therefore will not be discussed. The southern resident community, which consists of three pods, J, K, and L, has experienced annual population increases of 1.3-2.0% since 1977, when live-capture of orcas for the aquarium trade stopped.[42] Currently the southern resident community totals 89 individuals[43] and is larger than it was prior to 1962 when the live-capture practices began.[44] Orcas do not have a well-defined breeding season, but in Puget Sound most mating behavior occurs when the three resident pods meet and cooperatively feed on migrating salmon in the summer and fall.[45]

Orcas are present in the waters surrounding the San Juan Islands year-round. Transients range north to southern Alaska and south to Oregon, possibly California. They use all marine habitats at low densities, yet they are particularly common at major harbor seal haul outs. The southern residents occupy a smaller range, residing within a 200-mile radius of the islands; their distribution coincides with that of migrating salmon. Pods K and L regularly cruise the outer coast (the Pacific Ocean waters adjacent to the west coasts of British Columbia and Washington), while J-Pod frequents the inland waters and is therefore the focus of the following discussion. From late May through October, J-Pod is joined by K- and L-Pods in an area bordered by the eastern Strait of Juan de Fuca and the Fraser River, where migrating salmon congregate. The west side of San Juan Island is critical orca habitat; it has some of the greatest densities of orca sightings of all the marine waters in the San Juans. (Appendix III., Figure 5.) Rosario Strait, along the eastern sides of Lopez and Orcas is also frequented by resident orcas. Orcas use other offshore waters such as President Channel, San Juan Channel, and Boundary Pass, although less frequently.

Orca populations presently appear healthy. Their life history characters, however, are such that negative effects to the population may not be detected until considerable damage has been done. Therefore, continued monitoring of orca populations is crucial, especially as human activities in the area rise with the growing human population. In addition, measures should be taken to reduce the risk of threats such as human disturbance, pollution, and overharvest of salmon populations on the local orcas.

b. Harbor Porpoise (*Phocoena phocoena*)

Harbor porpoise distribution along the eastern North Pacific coast extends from Point Barrow, Alaska southward to Point Conception, California.[46] These porpoises are generally observed in groups of less than ten individuals,[47] and one to three individuals is the most common group size range in the inland waters.[48] Aerial surveys conducted over the inland waters in 1996 found that "harbor porpoise occurred throughout the study area with few breaks in their geographic distribution."[49] (Appendix III., Figure 6.) Furthermore, waters northwest of Orcas Island had the highest sighting rates (21 groups/100 km).[50] Increased sightings were also apparent with increased depths in the island regions (which includes the San Juan Islands and the Canadian Gulf Islands), although no clear trend was evident for all regions of the inland waters combined. No documentation of a strong seasonal migration exists for harbor porpoises in the North Pacific Ocean, although certain areas experience seasonal peaks in abundance. For instance, the largest annual concentrations of porpoises in Greater Puget Sound occur during the summer and early fall in the San Juans.[51]

Reliable trend data is lacking for harbor porpoise populations along the outer coast of Washington, Oregon, and British Colombia, and in Washington's inland waters. In Puget Sound, however, a substantial decrease is known to have occurred.[52]

> One of the most abundant cetaceans in Puget Sound four decades ago, the harbor porpoise was reportedly common enough to be seen on any day of the year throughout the inland waters of Washington State. Today, however, it appears only occasionally in Puget Sound proper, occurring primarily in the northern reaches around the San Juan Islands and the Strait of Juan de Fuca.[53]

Aerial surveys conducted in 1996 resulted in a population estimate of 1,616 harbor porpoises in the San Juans, and a total of 6,404 in the inland waters of Washington and British Columbia.[54]

With a lifespan of not more than 15-20 years, harbor porpoises are relatively short-lived cetaceans.[55] They reach sexual maturity at about age 4 and their gestation period is 11 months. These porpoises mate and calve in the transboundary waters of Washington and Canada.[56] Calving occurs during late spring or early summer, and the peak numbers in the summer and early fall may correspond to mating activity.[57] The primary prey for these cetaceans include squid and small fish such as herring and smelt. Small numbers of harbor porpoises are eaten by transient orcas.

The harbor porpoise is considered vulnerable to human disturbance.[58] Osborne et al. describe it as "a shy, retiring animal that may not be able to tolerate the increasing presence of humans on the inland waters."[59] Definite reasons for the decline are unknown, but possibilities include incidental mortality in gillnets, vessel traffic, human-generated noise, environmental contamination, unusual mortality events, and competition from an increasing abundance of Dall's porpoise.[60]

c. Minke Whale (*Balaenoptera acutorostrata*)

The minke whale is the most numerous and widely distributed baleen whale in the world.[61] It is also the most common baleen whale in the inland waters of Washington and Canada. Minke whales are found in the inland waters throughout the year, yet their population in the San Juans peaks from July through September.[62] Adults and subadults form the majority of the local population.[63] Although widely distributed in the inland waters, minke whales concentrate in four feeding areas in the San Juan Islands, with distinct populations returning to the same feeding area each year.[64] (Appendix III., Figure 7.) The minke whale feeding areas that have been identified are Hein Bank and Salmon Bank, located south of

San Juan Island; San Juan Channel, near Pear Point on San Juan Island; and south and west of Sandy Point on Waldron Island. Additional feeding areas may be present, but have yet to be identified.

Further monitoring is necessary to determine the population size and trends of minkes in the eastern North Pacific. Some information on the minkes that frequent local waters is provided by an 11-year study conducted in the San Juan Islands during the 1980's, which photo-identified 30 individual minke whales.[65] Up to 19 individuals were sighted in a single year. Minke whales are thought to reach sexual maturity at 3-8 years of age.[66] Females calve every 1-2 years, and they nurse their young for 4-6 months. Minke whale breeding or calving grounds have not been identified,[67] but they are believed to be located in lower latitude, warm waters.[68] Indeed, the conservation and management of this species would be facilitated by knowledge about their winter distribution, e.g., their calving and breeding grounds.

Minke whales feed on herring and sand lance, and individual whales appear to specialize on one of two different foraging strategies. The small-scale site fidelity exhibited by local minke whales may be one method of maximizing foraging efficiency: individuals specialize on the feeding strategy that results in the greatest catch given the topography and hydrodynamics of a specific feeding site.[69]

d. Harbor Seal (*Phoca vitulina richardsi*)

The harbor seal's geographic distribution spreads from Baja, California to the Aleutian Islands and Bering Sea.[70] The harbor seal is a year-round resident of the islands, and the only pinniped (seal or sea lion) species that breeds in Washington's inland waters.[71] It is also the most abundant marine mammal in these waters,[72] and the most abundant pinniped in Washington.[73] The estimated population of harbor seals in the inland waters during the 1996 pupping season was 17,036 individuals, with a peak count of 5,478 animals occurring during the first half of August. These numbers reflect a population increase of 6% between 1983-1996, and 10% for the more recent period of 1991-1996. Maximum life expectancy for these seals is approximately 30 years.[74] Harbor seal females mature between ages 3-5, and subsequently produce one pup per year. In the San Juan Islands, pupping occurs during June and July. Females mate approximately one month after giving birth to their previous pup, although implantation of the fertilized embryo does not occur for another two months. The duration of gestation from implantation to birth is nine months.

The results from 1996 aerial surveys over the inland waters of Washington and British Columbia concluded that "harbor seal sightings were common and occurred throughout the study area in the narrow passages as well as in open water."[75] Additionally, although harbor seals were most often sighted in shallow nearshore waters, they were also found "at all depths and distances to shore." Interestingly, 85% of the pups sighted in the aerial surveys were close to shore in the San Juan and Gulf Island regions. Harbor seal haul outs are located throughout San Juan County. (Appendix III, Figure 8. a.-c.) Areas with high concentrations of harbor seal haul outs include the southwest end of Lopez, in and around Davis Bay, Mackay Harbor, Iceberg Point, and Aleck Bay; the north and west sides of Shaw Island; the Wasp Islands located between Shaw and Orcas; islands and rocks around Patos, Sucia, Matia, Barnes, and Clark Islands, which border the north and east sides of Orcas; and the islands and rocks near Stuart, Spieden, and Johns Islands, north of San Juan Island. Some haul outs are also used as rookeries, where female harbor seals give birth to, and raise, their pups.

Harbor seals eat a variety of fishes, including hake, herring, pollock, sculpin, and tomcod.[76] Their position high on the food chain makes them especially susceptible to high levels of chlorinated hydrocarbons, which become concentrated at each trophic level.[77] Human disturbance is another potential threat to harbor seals. Calambokidis and Baird state:

> Harbour seals are one of the most wary pinnipeds to approach while hauled out, and typically enter the water upon approach….Potential impacts of disturbance include separation of mother and pups, interruption of nursing, and abandonment of haul-out areas.[78]

As the likelihood of human disturbance increases with increasing human population, it is essential to monitor these harbor seal populations.

e. Sea Lions

The California sea lion (*Zalophus californianus californianus*) and Steller (Northern) sea lion (*Eumetopias jubatus*) can be found in the San Juans during the non-breeding months, from early fall through late spring.[79] California[80] and Steller[81] sea lions have been known to congregate on Sucia Island, in northern San Juan County.[82] California sea lion haul out sites are shown in Appendix III., Figure 8. b. California sea lions breed south of here, on islands and on the mainland from central California to the tip of Baja, including the Sea of Cortez.[83] The majority of California sea lions present in the inland waters are males; females tend to stay closer to their breeding grounds year-round. The Steller sea lion's breeding range extends from southern California to the Bering Sea, but excludes Washington. Stellers are most abundant north of Washington, their core being in the central and western Gulf of Alaska and in the Aleutians.[84] Both species are polygamous, with males establishing territories on breeding grounds, and females typically producing one pup per year.[85] Both species are also primarily piscivores (fish-eaters). California sea lions prefer to eat hake and herring, and a group of locals have a notorious appetite for steelhead salmon. Steller sea lions eat a variety of fishes and invertebrates, principally walleye pollock, hake, herring, octopus, cod, rockfish, and salmon; they also occasionally eat other pinnipeds, such as harbor seals.[86]

The populations of these two sea lion species show opposite trends in abundance. The number of California sea lions in the inland waters has increased dramatically since the late 1970's,[87] and continued to rise until at least 1995.[88] Steller sea lions, by contrast, are listed as threatened under the Endangered Species Act.[89] Populations in core Steller area declined by 63% between 1985 and 1989,[90] and the range-wide estimate for 1989 was about 39-48% below that from 30 years prior.[91] This steep decline in Steller sea lion numbers is most likely due to low juvenile survival.[92] Changes in their prey resulting from competition with commercial fisheries or natural changes in the environment may have had a role in the recent declines.

2. Birds

A wealth of temporary or permanent residents totaling 291 species of birds have been recorded from the San Juan Archipelago,[93] and seabird colonies are located throughout the islands. (Appendix III., Figure 9.) The San Juan Islands foster approximately 37 species of birds that either depend on critical shoreline habitat for reproducing or feeding, or are common year-round and depend on the marine environment.[94] (Appendix III., Table 2.) An additional 61 species of birds are either fairly rare, relatively short-term visitors, or are non-nesting birds that exhibit low sensitivity to vessel traffic.

The birds in the San Juans exhibit a diversity of lifestyles. Loons and grebes use the islands as wintering grounds or as rest sites on their migration from northern breeding grounds to more southerly locations for the winter. Belted Kingfishers and Double-crested Cormorants are among the year-round fish-eating residents in the islands, both of whom breed here, although human disturbance is thought to have had negative impacts on the cormorant's breeding colonies.[95] The Peregrine Falcon is an endangered species that, in contrast to the Double-crested Cormorant, appears to be reclaiming historical nesting territories in the San Juan Islands.[96] Foraging habitat ranges from the rocky intertidal used by American Black Oystercatchers to the narrow passages fished by Common Murres.

Among the 37 species listed in Table 2, all receive protection under the Migratory Bird Treaty Act of 1918[97]; the Marbled Murrelet, Common Loon, Bald Eagle, and Peregrine Falcon are covered by the Endangered Species Act; and the Bald Eagle receives further protection under the Bald and Golden Eagle Protection Act.[98] Below are detailed accounts of five species of local birds: the Marbled Murrelet (Appendix III., Figure 10.), Common Murre, Black Oystercatcher, Harlequin Duck, and Bald Eagle.

a. Marbled Murrelet (*Brachyramphus marmoratus*)

Marbled Murrelets are members of the family Alcidae. This species was listed as threatened under the U.S. Endangered Species Act in 1992, and its current population in Washington numbers about 5000 individuals.[99] These birds nest in trees within old growth forests adjacent to the ocean, where they feed on sand lance, sea perch, and other small crustaceans and schooling fish.[100] Currently there is not enough information to say definitively that Marbled Murrelets nest in the San Juans, although suitable habitat exists.

Marbled Murrelet distribution displays daily and seasonal variation due to the birds' breeding and foraging needs. Their foraging patterns are thought to be closely linked to tidal patterns, suggesting that they take advantage of spatial and temporal variability in prey distributions resulting from tidal activity.[101] Their proximity to shore also exhibits daily periodicity: by day they occupy nearshore habitats, generally within 500 meters of shore; at night, however, Marbled Murrelets move further offshore into areas such as the San Juan Channel and Rosario Strait.[102]

These birds are present in the San Juans year-round. The local population in the early summer includes both breeding and non-breeding birds, totaling approximately 500-800 individuals - about 20% of the state's breeding population. During this period, Marbled Murrelets are concentrated in two locations in the San Juans: the south end of Lopez Island, from Davis Bay to Point Colville, with a particularly high concentration at Iceberg Point; and along the west side of San Juan Island from Andrews Bay to False Bay. (Appendix III., Figure 10.) In mid-June the population increases to about 2000 birds as those who apparently spent the spring and summer (their breeding season) in the western Strait of Juan de Fuca and British Columbia return to the San Juans for the fall and winter. The migrants may come to the inland waters for more efficient foraging or to avoid harsh winter storms. This population of Marbled Murrelets, beginning to arrive in late summer, is distributed across a wider area than the early summer population. Of the early summer distribution, the south end of Lopez Island remains important as numbers increase threefold, but birds vacate the west side of San Juan Island. In addition, Marbled Murrelets expand their distribution into the following areas: the east side of Lopez Island from Shoal Bight up to Lawrence Point on Orcas Island, with particularly large numbers of birds near Decatur Head and Fauntleroy Point; the Wasp Islands; Cowlitz Bay off Waldron Island, which supports a high concentration of birds; the east side of San Juan Island from Limestone Point south to a location opposite Yellow Island; and many young
birds are present in Griffin Bay on San Juan Island.

Marbled murrelets are long-lived, have a clutch size of one, and are often found in pairs, suggesting that they mate for life. A consequence of this type of life history is that decreased survival or fitness of a relatively small number of individuals has severe implications for the population as a whole. The primary reason for concern about Marbled Murrelet populations is the loss of old-growth forests, which provide nesting habitat.[103] Incidental take in gillnet fisheries also contributes stress to Marbled Murrelet populations. Because of this, some gillnetting closures are currently in effect, but not all biologically significant areas are protected. Human disturbance, oiling, and pollution also threaten these vulnerable populations of birds.

b. Common Murre (*Uria aalge*)

The Common Murre, like the Marbled Murrelet, is a member of the alcid family. Breeding populations of this species in Washington dropped precipitously from approximately 30,000 birds during 1979/1982 to 565 in 1993.[104]

Common Murres nest on cliffs along the outer coast, but they migrate to the inland waters to feed.[105] These birds arrive from the outer coast in late summer, staying in the islands until they return to their breeding grounds in April. Common Murres feed in deep water tide rips and channels[106] typical of San Juan Channel, Rosario Strait, and the south and west sides of Lopez and San Juan Islands.[107] Their primary prey are sand lance, herring, smelt, and bottomfish.

Multiple factors limit the recovery of Common Murres, including gillnet mortality, oiling, eagle-induced reduction in breeding success, anthropogenic disturbance, and El Nino events.[108] Mahaffy et al[109] note that, "Because of their depressed population, any additional mortality incurred from unnatural causes in the inner marine waters is cause for concern." Like Marbled Murrelets, Common Murres have a clutch size of one so any recovery for decimated populations will be slow.

c. Bald Eagle (*Haliaeetus leucocephalus*)

Bald Eagles are large raptors of the family Accipitridae. They are listed as threatened under the U.S. Endangered Species Act. In the San Juan Archipelago, Bald Eagles nest in greater concentrations than anywhere else in the contiguous United States.[110] The Bald Eagle population in Washington is doing well; nevertheless, long term habitat security for this species is uncertain.[111]. The number of nesting pairs has increased from approximately 250 in 1986 to over 580 in 1997. The majority of new territories were established along marine coastlines. San Juan County alone has 118 occupied nesting territories, which accounts for 1/3 of the total for King, Whatcom, Skagit, Snohomish, and Island Counties.[112] Although some Bald Eagles reside in the area year-round, during autumn the population declines as birds move north and inland to eat salmon spawning in streams and rivers; the population rebounds in the winter months as adults return to their breeding territories.[113]

Bald Eagles exhibit extreme fidelity towards their mates, remaining together for life. In the islands, they nest in old growth trees or mature trees with old growth characteristics such as those with broken or spiked tops. Bald Eagles are tenacious in defending an established territory during the breeding season. In the San Juans, almost all the nests are within 250 feet of shore, and there are very few places where shoreline is not part of eagle-defended territory.[114] It is common for a breeding pair to have more than one nest, including one favorite and one or more alternates. Nests are constructed of large sticks and lined with soft materials such as pine needles and grasses, and may measure over six feet in width and weigh hundreds of pounds.[115] During January and February the couple rebuilds their nests in preparation for nesting in the spring.[116] Females normally lay one or two eggs per year but occasionally lay three,[117] beginning in late Februray.[118] By the third week of March most of the egg-laying is complete,[119] and both parents incubate the eggs and care for the young.[120] The incubation period is thirty-five days and, if multiple eggs are present, the hatch interval is a few days. Often the first eaglet to hatch is the strongest and largest, and outcompetes its siblings for food; therefore, the oldest eaglet may be the only one to survive. In western Washington, young eagles normally spend 10-12 weeks in their nests before fledging, and may remain in their parents' home territories through their first summer, but then they are driven away to establish their own territories after obtaining breeding status at four to five years of age.[121]

These birds are opportunistic feeders, scavenging carrion when it is available, capturing marine birds, small terrestrial mammals, and fish at other times.

The most serious threat to Bald Eagles in the Northwest is logging and the continued development of shoreline areas. The continued loss of quality shoreline trees is especially disruptive. A typical nest or perch tree is often well over 100 years old. Commercial forest lands are now managed on a 60-80 year rotation. Cleared, landscaped lots eliminate forest regeneration and the few remaining large trees will eventually die or blow over. When trees do approach a size that is suitable to eagles, landowners often decide they are "danger" trees and have them removed. The net result of forest practices and residential development has been a virtual mining of suitable eagle habitat. If eagle populations are to remain viable 20-200 years from now, suitable and potential habitat must be protected.[122]

Human disturbance may also contribute to the loss of essential habitat for nesting, feeding, roosting, and perching. In addition, toxic contaminants and secondary poisoning from pesticides may have deleterious effects on some eagle populations in Washington.

d. **American Black Oystercatcher (*Haematopus bachmani*)**

The American Black Oystercatcher is the only representative of the family Haematopodidae in the San Juans.[123] These birds are more abundant in the San Juan Islands than in anywhere else in the Puget Trough[124]; a 1989 report estimated the number of breeding birds in the northern Puget Sound region to be 120.[125] Black Oystercatcher populations have been declining since the 1950s,[126] and this downward trend continues today throughout the Northwest.[127] They lay clutches of 1-3 eggs and may live to be over 30 years old.[128]

Black Oystercatchers are permanent residents in the San Juan Islands.[129] This species breeds, nests, and forages on clean, undisturbed rocky shorelines, preferring offshore rocks and islands to the more developed main islands.[130] During the breeding season in the spring these birds are highly territorial and do not form dense colonies, but from September to April they form flocks of up to several dozen.[131] They feed almost exclusively on invertebrates (e.g., mussels, limpets, chitons, crabs, and occasionally oysters) in the rocky intertidal zone.[132] Critical breeding habitat for Black Oystercatchers in San Juan County include the following locations: Patos and Matia Islands to the north of Orcas; Skipjack Island, north of Waldron; Flattop, Sentinel, Johns, Cactus, and Stuart Islands, located northwest of San Juan Island; Yellow Island, in San Juan Channel; the Wasp Islands; small rocks and islands south of Lopez, including Colville Island; Flower Island, Lawson Rock, and Pointer Rock surrounding the southern point of Blakely Island; Peapod Rocks in Rosario Strait, east of Orcas; and Clark Island and The Sisters to the northeast of Orcas.[133]

Black Oystercatchers are extremely sensitive to disturbance. Lewis and Sharpe assert that "all too frequently, uninformed boaters and fishermen inadvertently disturb the breeding birds and thus provide opportunities for the omnipresent gulls and crows to pilfer the temporarily unprotected nests."[134] Other concerns for the survival of this species include long-term degradation of the intertidal zone, and oil contamination.[135]

e. Harlequin Duck (*Histrionicus histrionicus*)

The Harlequin Duck is a candidate for listing under the U.S. Endangered Species Act. It is present year-round in the San Juan Islands.[136] The winter population consists of small, evenly dispersed groups. In late summer the local population is augmented by males returning from their breeding and nesting grounds in whitewater rivers of the Olympic, Cascade, and Rocky Mountains; in October, females and their young arrive in the islands.[137] In the marine environment, Harlequin Ducks inhabit offshore rocks and reefs, and their diet includes a variety of invertebrates typical of rocky shores, for example, snails, limpets, crabs, chitons, and mussels.[138] They also occasionally eat fish. Areas of high concentration are found along San Juan Channel, particularly Turn Island and Turn Rock, and the southern end of Lopez Island.[139]

The migration of Harlequin Ducks resembles that of Pacific salmon in that they travel between breeding grounds in riparian areas (along the banks of rivers and streams), and marine feeding grounds. Therefore, these ducks are susceptible to many of the same threats that plague salmonids, namely loss of critical nesting habitat due to hydroelectric projects, road construction, logging, and mining. They also face pressures from overhunting by poachers and by hunters who confuse them for other species.

3. Fishes

The shared waters of Washington and British Columbia are inhabited by over 200 species of fishes,[140] all of which are ecologically important, and some, such as salmon, herring, flatfish, rockfish, and cod, are important components of commercial, recreational, or tribal fisheries. The adults of some species are migratory, as exemplified by salmonids, who swim great distances from productive marine feeding grounds to freshwater spawning grounds, recognizing no political boundaries on their journeys. Others, such as certain rockfish, travel very little and are therefore highly susceptible to local disturbance and fishing pressures. Many species utilize a variety of marine habitats at different stages in their lives. Developing eggs may be found on rocky or sandy substrates, on aquatic vegetation, or directly in the water column. After hatching, the larvae typically undergo a planktonic phase in which water currents disperse the new recruits to areas distant from their parental population. Juveniles may then occupy the same habitat type as adults, or wait until they are larger to move into adult habitat. A life history that involves a series of habitats, each one critical for a given stage, amplifies the number of anthropogenic and environmental threats that a fish experiences throughout its life. In addition, the degradation or destruction of a single habitat type may have consequences for the population as a whole by dramatically increasing mortality rates at a particular life stage. It follows that effective conservation and management of these ecologically and economically valuable fishes require preservation and maintenance of all marine habitats.

Pacific herring (Appendix III., Figure 11.), rockfish (III., Figure 12. and Table 3.), salmonids (III., 13.), lingcod (III., Figure 12. and Table 3.), and walleye pollock are discussed in greater detail below.

a. Pacific Herring (*Clupea harengus pallasi*)

Pacific Herring are the most abundant forage fish in the transboundary waters of Washington and Canada.[141] Adult herring return to the same location annually to spawn, and therefore each spawning ground is considered a discrete stock for management purposes.[142] The San Juan Islands foster the following stocks: Westcott and Garrison Bays on San Juan Island; East and West Sound on Orcas Island; Blind Bay on Shaw Island; and Mud and Hunter Bays on Lopez Island. (Appendix III., Figure 11.) The status of these stocks are unknown.[143] Pacific herring stocks typically exhibit fluctuations in spawner abundance due to variable natural mortality and recruitment.[144] Recently, however, there have been several indications that Puget Sound herring stocks may be in jeopardy: 1) four stocks (Cherry Point, Port Susan, Port Orchard, and Discovery Bay) are considered either “depressed” or “critical”; 2) the estimated natural mortality has risen from 30-40% before 1982 to 60-70% in 199_; 3) the number of age classes comprising the majority of the Puget Sound populations has decreased from five to two or three; and 4) changes in the schooling behavior of herring, in addition to increased sightings of harbor seals near herring schools at night, may be due to increased harbor seal predation on these fish.[145]

Most Pacific herring stocks undergo annual migrations to reproduce; some stocks in southern Puget Sound and the Strait of Georgia, however, are believed to be residents, never leaving the inland waters for the outer coast.[146] In Washington, most herring spawn in late January to early April; the Cherry Point stock is an exception, spawning from early April to early June.[147] Adults spawn in inshore waters, the females deposit adhesive eggs on algae and eelgrass.[148] The incubation period is temperature-dependent and lasts for about 10-21 days. Recently-hatched larvae subsist for six days on energy reserves provided by a yolk sack. The larval stage is a period of passive dispersal; planktonic larvae drift with the prevailing nearshore currents. After five weeks in the plankton, herring larvae metamorphose and begin active schooling in protected bays. Some fish migrate to the outer coast during their first winter, yet many delay their first migration until the following summer, traveling with groups of post-breeding adults and subadults. They remain in waters along the outer coast until age 2 or 3, and then join the inshore migration to spawning grounds in the fall. Throughout the winter and early spring herring form large congregations, but these divide around mid-February as the fish disperse to their spawning grounds. Once the spawning process is complete, the herring return to the outer coast to build energy reserves for the following year's reproductive effort. Although Pacific herring can live up to 15 years, in Puget Sound they typically do not live past age 5 or 6.[149] They provide prey for numerous species, including Pacific salmon, Pacific cod, Pacific hake, walleye pollock, lingcod, spiny dogfish, halibut, rockfishes, Common Murres, Tufted Puffins, Marbled Murrlets, Cormorants, gulls, harbor porpoises, California sea lions, and harbor seals. Herring also support a commercial fishery in Washington that is predominantly used for bait in salmon sport fishing.[150]

b. Rockfishes (*Sebastes spp.*)

Rockfishes comprise a group of approximately 100 species,[151] over 20 of which are found in north Puget Sound.[152] Four species present in the San Juans are copper (*Sebastes caurinus*), quillback (*S. maliger*), black (*S. melanops*), and yelloweye (*S. ruberrimus*) rockfish. The local distribution of rockfish and other groundfish is shown in Appendix III., Figure 12; further information is provided in Table 3. The geographical distribution of these four species extends from Alaska to California.[153]

Rockfish are long-lived species. Members of the genus *Sebastes* have estimated maximum lifespans of 20-140 years.[154] Copper and quillback rockfish may live up to 55 years,[155] black rockfish can live at least 36 years, and yelloweyes can reach 114 years.[156] Because of their longevity and the resulting generation overlap, rockfish populations are buffered to a certain extent against episodic failures in recruitment (the number of first-year fish added to the population each year).[157] The age at which rockfish mature varies by species and location, but copper and quillback rockfish in Puget Sound reportedly mature at ages 4 and 5, respectively, and black rockfish off central Oregon mature at age 5 for males and 6 for females.[158] Rockfish are iteroparous (adults have more than one opportunity to breed) and viviparous, internal fertilization is followed by the release of thousands of free-swimming pelagic larvae.[159] The timing of parturition (birth) varies by species, ranging from winter to summer.[160] Predation is highest on young fish and, therefore, relatively few survive to adulthood. Rockfish undergo deterministic growth: many have extremely low growth rates for up to 50% of their lives.[161] Juvenile rockfish eat plankton, and adults eat a variety of invertebrates (e.g. shrimp, crab, and octopus), and many species of fishes, including rockfish.

Habitat utilization varies by species and by life stage or season within a given species. Larval rockfish are pelagic, found in the water column as opposed to on the bottom of the ocean. Matthews studied the habitat utilization of rockfish in central Puget Sound, and she found that young-of-the-year rockfish seek protection and food in eelgrass beds and in algae on reefs with low currents.[162] Adult yelloweye and black rockfish are semi-demersal, they may be found either near the bottom or higher in the water column.[163] Black rockfish can be highly mobile, as is evident from the recovery of one tagged fish that traveled from Tillamook Hook, Oregon, to Mendocino, California – a distance of 345 miles.[164] By contrast, adult copper and quillback rockfish are demersal, usually found on the bottom and closely associated with rock, vegetation, or artificial substrate.[165] Furthermore, copper and quillback rockfish are relatively sedentary, roaming very little as adults.[166]

Habitats that experience seasonal vegetation and subsequent structural changes - namely sand/eelgrass and low-relief rocky reefs – reportedly have the lowest densities of rockfish and the most dramatic differences in rockfish density over time.[167] Nevertheless, these low density areas are important temporary habitat in the summer when the vegetation is the most dense. Consistent densities of rockfish seem to utilize high-relief rocky reefs year-round; these are considered the highest quality habitats because they provide prey and shelter (rocks and crevices) even when vegetation is sparse. Matthews stated that the artificial reefs in her study seemed to represent an “anomalous habitat” because their rockfish assemblages were unlike those of any natural habitats, namely sand/eelgrass, low-relief rocky reefs, and high-relief rocky reefs. The dissimilarity of rockfish communities on artificial reefs and those on natural reefs creates doubts as to whether artificial reefs have the resources to replace lost natural habitats. Therefore, successful conservation and management of rockfish may necessitate the conservation and management of their natural habitats.

The conservation and management of sedentary and long-lived species like copper and quillback rockfish require a different approach than those used for migratory, short-lived fishes such as salmon and herring. These rockfish are easily overfished because many years must pass before another individual settles and grows to replace a large adult taken in recreational or commercial fisheries.[168] Furthermore, if a breeding population is not available to produce recruits, then the entire stock is vulnerable to extinction. In North Puget Sound, recreational fishers take over half of the recorded annual rockfish catch, and this fishery is considered fully utilized.[169] The commercial fishery for demersal rockfish is currently closed:

> Areas of high rockfish abundance have been closed to trawling, and gears designed specifically to harvest fish from rocky substrate (commercial bottomfish troll and jig gears) have been prohibited. Commercial landings of demersal rockfish are now limited to by-catch from trawling, and from setline and setnet fisheries targeting spiny dogfish (*Squalus acanthias*).[170]

Although recent catch rates in the recreational fishery are near the long-term average, there is concern for local rockfish populations because biological data show that the rockfish caught are smaller now than in the 1970s and that several species have become rare. Furthermore, a recent study comparing rockfish populations at Turn Island, which is open to fishing and is a short boat ride away from Friday Harbor, with those at San Juan Island’s Shady Cove, a marine harvest refuge bordering San Juan Island, showed that copper rockfish in the refuge were significantly larger, more abundant, and had greater reproductive outputs than those in the fished area.[171] These data indicate that growth and recruitment overfishing have occurred. Growth overfishing “causes a depression of the average size of fish in a given population, as a result of chronically harvesting the largest fish,” whereas recruitment overfishing “occurs when adult populations are reduced to such levels that production of progeny is insufficient to maintain stocks at desirable levels.”[172]

The establishment of marine refuges can potentially be a very effective conservation and management tool that operates on the ecosystem level, incorporating both physical and biological aspects of the environment. In addition to increasing mean individual size and age, abundance, and reproductive output of target species within refuges, these protected habitats may compensate for overfishing of target species in neighboring areas by enhancing recruitment inside and outside of the refuges, maintaining genetic diversity of stocks, and increasing fishery yields in surrounding fishing grounds.[173] The benefits of marine harvest refuges are not limited to the target species, however; they can also potentially affect the community ecology of the area by increasing species diversity, habitat complexity and quality, and community stability.

c. Salmonids (*Oncorhynchus spp.*)

Pacific salmon and steelhead are crucial components of local ecosystems and they comprise a substantial portion of commercial, tribal, and recreational fisheries in the Pacific Northwest. All salmon species are caught in fisheries surrounding the islands.[174] (Appendix III, Figure 13) Although the exact timing and location of anadromous salmon life history stages vary between species and between stocks within a given species, the general pattern is as follows: first, adults spawn in freshwater rivers, streams, or lakes; second, juveniles migrate to the ocean where growth and development occurs; finally, adults return to their natal watersheds to spawn.[175] These fishes are managed based on a stock system in which each stock represents a discrete population originating from and adapted to a specific watershed. Fisheries managers have not put much effort into identifying or monitoring salmon stocks originating in the San Juans because those runs are thought to contribute relatively few fish to fisheries. The 1992 Washington State Salmon and Steelhead Stock Inventory identifies only one native salmonid stock, Orcas Island Coho.[176] Other opportunistic runs may exist when water flow down creeks and streams is sufficient to permit adult access to spawning grounds.[177]

Some of the salmonids caught in local fisheries in the San Juans originate in Washington, whereas others come from British Columbia. Fraser River sockeye salmon form a significant component of Puget Sound fisheries,[178] and these stocks have been relatively healthy in recent years. The forecasted Fraser River escapement (number of fish surviving to reach spawning grounds, hatcheries, or in-river fisheries) for 1997 was between 11 and 73 million fish, and reflects increased production over the past several decades.[179] By contrast, many Puget Sound stocks of salmonids are in decline. The Nooksack, Samish, Skagit, and possibly Stillaguamish Rivers in Washington produce fish that are probably caught in fisheries in the San Juan Islands.[180] Coho salmon from the Puget Sound/Strait of Georgia are abundant, yet most existing populations have considerable hatchery contributions that may pose ecological, genetic, or sustainability risks to native stocks.[181] These coho stocks are not presently in danger of extinction, but are likely to become so in the foreseeable future. Chinook salmon from Puget Sound are also experiencing declines. The current overall abundance of chinook is substantially lower than historical counts, and both long- and short-term trends show declines.[182] Recent population trends for Puget Sound steelhead also exhibit declines, yet the two largest stocks (Skagit and Snohomish Rivers) are producing significant increases.[183] Chum and pink salmon stocks are relatively healthy, although recent declines in body length of odd-year pinks may signify reduced reproductive potential.[184]

Native salmon stocks are at risk due to a variety of factors. Chief among them are habitat loss, damage or modification resulting from hydropower, agriculture, logging, and other developments.[185] Other reasons for decline include overfishing and negative interactions with other fishes, such as hatchery-produced salmon and steelhead.

d. Lingcod (*Ophiodon elongatus*)

Lingcod are large predatory fish that inhabit rocky reefs as adults. Since 1992 the commercial lingcod fishery has been closed, and, therefore, recent stock indicators rely primarily on the recreational catch rate.[186] The North Sound lingcod stock encompasses most of the waters in the Strait of Juan de Fuca, the San Juan Archipelago, Bellingham Bay, and the U.S. Strait of Georgia. A 1994 video-acoustic survey estimated the abundance of North Sound lingcod to be at least 440,000 fish. This stock exhibits both long-term and short-term declines, and is considered depressed by the Washington Department of Fish and Wildlife. In addition, a recent study found that lingcod in the Shady Cove harvest refuge were larger, produced more eggs, and were present in greater densities than those found in the fished waters surrounding Turn Island.[187]

Like all of the fish accounts previously discussed, habitat utilization by lingcod varies with the life stage of the fish, thereby complicating conservation and management issues. Lingcod are found in nearshore habitats along the west coast of North America from Baja, California to the Shumagin Islands in Alaska.[188] They are present throughout the San Juan Islands[189] (Appendix III, Figure 12 and Table 3), and range in depth from 3-400 meters, although they are most common in waters 10-100 meters deep.[190] Adults are non-migratory, yet undergo localized seasonal movements to spawn. On average, males are sexually mature by age 2, and females mature between 3-5 years of age. In November - December, males aggregate in rocky, strong current areas 5-60 meters deep and establish nesting territories. Females generally remain in deeper waters except for brief periods to spawn. Females lay masses of large eggs that become cemented to the rocky substrate and to each other. Males guard the eggs until larvae hatch; hatching occurs synchronously after an average incubation period of 7 weeks. Lingcod dispersal occurs during the larval stage. Larvae rise to the surface waters in March – May; they are planktonic until juveniles settle to the bottom in late May - June. Kelp and eelgrass beds are critical habitat for juvenile lingcod. By September, juvenile lingcod have dispersed from these nearshore nurseries to flat bottom areas located at a wide range of depths. By age 2, lingcod begin to move into the rocky, high energy habitats typical of adults. Females are larger and longer-lived than males: the maximum reported age of lingcod on the west coast of Canada is 14 years for males and 20 years for females.

Lingcod diet composition changes with maturation, reflecting their change in habitat. Small larvae eat small invertebrates until they are large enough to consume larger invertebrates and other larval fish, such as Pacific herring. As juveniles, lingcod rely mostly on small fish - juvenile Pacific herring, sand lance, flatfish, and juvenile walleye pollock, for example. Juveniles also eat shrimp and prawns in lesser amounts. Pacific herring and Pacific hake are primary components of the diet of adult lingcod, although they also eat other fishes (including young lingcod) and invertebrates. As adults, lingcod have few predators aside from humans, sea lions, and harbor seals.

e. Walleye Pollock (*Theragra chalcogramma*)

The inland waters represent the extreme southern end of walleye pollock distribution, and this fish is much more abundant in the North Pacific Ocean at higher latitudes, including the Bering Sea and Gulf of Alaska.[191] The North Sound stock of walleye pollock frequents the Strait of Georgia,[192] and these fish have been found off of all the major islands in the San Juans.[193] This stock moves between U.S. and Canadian waters, and is one of the stocks that Washington shares with British Columbia.[194] Bottom trawl catch rate is the primary stock indicator for these fish, and low catches over the past several years suggest that this stock is declining and may be critically depressed. One limitation of using fishery statistics to determine population trends, however, is that low catch rates could be due to low fish abundance or to fisheries not catching available fish; for North Sound Walleye Pollock, it is not known why recent catch rates are low.

Walleye pollock adults are pelagic and semi-demersal, and are not clearly associated with any particular habitat.[195] They become sexually mature between ages 2-4, and may live to be greater than 17 years.[196] These fish are broadcast spawners, with females releasing eggs into the water column to be fertilized by schools of males nearby. Spawning occurs between February and April in local waters. The eggs are pelagic, and have been found at 100-300 meters deep in the Strait of Georgia. Larvae are found at the water's surface, where they eat small crustaceans.[197] Juveniles leave the surface of the water and move to eelgrass, gravel, or cobble habitats. Small juveniles eat crustaceans, and adults eat crustaceans and small fish, including juvenile pollock.

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[2] San Juan County, Wash., Ordinance No. 3-1996 (Jan. 30, 1996).
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[5] Puget Sound Water Quality Authority and Department of Natural Resources Division of Aquatic Lands, The 1992 Puget Sound Environmental Atlas Update, Region 2 (1992) [hereinafter PSWQA 1992].
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[7] U.S. Fish and Wildlife Service, San Juan Islands National Wildlife Refuge Management Plan 6 (1986).
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[12] Eugene N. Kozloff, Seashore Life of the Northern Pacific Coast: An Illustrated Guide to Northern California, Oregon, Washington, and British Columbia 5 (1996) [hereinafter Kozloff 1996].
[13] Thomson 1994, *supra* note 10.
[14] Long et al. 1983, *supra* note 9.
[15] Kozloff 1996, *supra* note 12, at 116.
[16] Long et al. 1983, *supra* note 9, at 26-116. Long et al.'s classification system is presented in this report because it gives general characteristics of broad habitat types. For finer resolution, other habitat classification systems that are more detailed than Long et al.'s are used. For example, Dethier (reference follows) developed a marine and estuarine habitat classification system that is the standard for several government agencies in Washington State. Dethier considers more physical parameters in her classification scheme than Long et al. do, and therefore recognizes more habitat types than they do. Dethier acknowledges that one advantage to using a more detailed system is that "the more physical constraints considered, the greater the predictive power we gain about the organisms present." Megan N. Dethier, A Marine and Estuarine Habitat Classification System for Washington State (1990).
[17] Kozloff 1996, *supra* note 12, at 258-88.
[18] Long et al 1983, *supra* note 9, at 38.
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[20] Kozloff 1996, *supra* note 12, at 288-339.
[21] Long et al 1983, *supra* note 9, at 40.
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[29] Levings and Thom 1994, *supra* note 19.
[30] Long et al. 1983, *supra* note 9, at 80-87.
[31] *Id.*at 97.

[32] Long et al. 1983, *supra* note 9, at 111.
[33] Walruses are also pinnipeds, but they are not found in the San Juan Islands.
[34] Memorandum from Richard Osborne, Curator of Science Services, The Whale Museum, to San Juan County Board of Commissioners (Jan. 15, 1996) (on file with San Juan County Prosecutor's Office) [hereinafter Osborne 1996].
[35] Marine Mammal Protection Act of 1972, 16 U.S.C.S. §§ 1361 – 1421h. (1984 & Supp. 1998)
[36] Endangered Species Protection Act, 1973, 16 U.S.C.S. §§ 1531 – 1554 (1984 & Supp. 1998)
[37] Richard Osborne et al., A Guide to Marine Mammals of Greater Puget Sound 29-42 (1988) [hereinafter Osborne et al. 1988].
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[39] Osborne et al. 1988, *supra* note 37.
[40] Calambokidis and Baird 1994, *supra* note 38.
[41] Osborne et al. 1988, *supra* note 37.
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[53] Osborne et al. 1988, *supra* note 37, at 25-27.
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[57] Osborne et al. 1988, *supra* note 37, at 25-27.
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[67] Dorsey et al. 1990, *supra* note 65.
[68] Osborne et al. 1988, *supra* note 37, at 79.
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[71] Calambokidis and Baird 1994, *supra* note 38, at 282.
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[76] Osborne et al. 1988, *supra* note 37, at 103.
[77] Osborne et al. 1988, *supra* note 37, at 103. Calambikidis and Baird 1994, *supra* note 38, at 290.
[78] Calambikidis and Baird 1994, *supra* note 38, at 291.
[79] Everitt et al. 1980, *supra* note 70, at 18-22.
[80] Everitt et al. 1980, *supra* note 70, at 18.
[81] Osborne et al. 1988, *supra* note 37, at 120. Everitt et al. 1980, *supra* note 70, at 22.
[82] Telephone Interview by author Bricklemyer, with Patrick Gearin, Wildlife Biologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Marine Mammal Laboratory (Aug. 14, 1998). Gearin stated that very few Steller sea lion sites exist in the San Juan Islands. Recently, however, more Stellers are using the north side of Orcas Island, where he observed 50-100 individuals. Gearin also said that California sea lions move through the area and may utilize the waters, but the San Juans do not have important haul out sites for these pinnipeds. *See also* Telephone Interview by author Bricklemyer, with Steve Jeffries, Wildlife Biologist, Washington Department of Fish and Wildlife (Aug. 18, 1998). Jeffries said that the nearest Steller sea lion haul out is Race Rocks in British Columbia, but that he has observed Stellers feeding between the southeast end of Speiden Island and the north end of San Juan Island from December to May. Jeffries also mentioned that California sea lions use navigational buoys as haul outs in these waters.
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[97] Migratory Bird Treaty Act, 16 U.S.C.S. §§ 703 – 712 (1994)

[98] Bald and Golden Eagle Protection Act, 16. U.S.C.S. §§ 668, 668(a) – (d) (1994); *see also* Letter from Steve Negri, Wildlife Biologist, Washington Department of Fish and Wildlife to author Ferguson (Sept. 2, 1998) [hereinafter Negri Letter]. Negri states that the Bald Eagle is classified as a threatened species at both the state and federal level. The bird, egg, nest, and nest tree rules are strictly enforced by both state and federal authorities. General habitat protection is provided by the Wash. Rev. Code Ann. § 77.12.655 (West 1996) and Wash. Admin. Code § 232-12-292 (1997)

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[107] Courtney 1998, *supra* note 102.

[108] West 1997, *supra* note 103, at 30.

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[172] West 1997, *supra* note 103, at 35.

[173] Jenifer E. Dugan and Gary E. Davis, Applications of Marine Refugia to Coastal Fisheries Management, 50 Can. J. Fish. Aquat. Sci. 2029 (1993).

[174] Telephone Interview by author Ferguson, with Laurie Weitkamp, Fisheries Biologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (Jul. 28, 1998) [hereinafter Weitkamp 1998].

[175] Schmitt et al. 1994, *supra* note 140, 219. *see also* Interview by author Ferguson, with Laurie A. Weitkamp, Fisheries Biologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (Aug. 27, 1998). Weitkamp adds that some salmon (e.g., steelhead, sockeye, coho, and spring chinook) grow and develop in freshwater for at least one year before migrating to the ocean. Others (chum, pink, and fall chinook) enter the ocean the year they hatch.

[176] Washington Department of Fisheries et al., 1992 Washington State Salmon and Steelhead Stock Inventory 133 (Mar., 1993).

[177] Telephone Interview by author Bricklemyer, with Pete Castle, Fisheries Biologist, Washington Department of Fish and Wildlife (Aug. 5, 1998). Castle said that some coho and searun cutthroat may spawn in tributaries emptying into West Sound on Orcas Island, especially in years with above-average flow during October, November, and December. In addition, there may be a run of salmon at the south end of Lopez Island, near the town of Richardson, flow-permitting. Mackay Harbor on Lopez also occasionally hosts spawning salmon. Finally, False Bay on San Juan Island has coho runs during some years. *See also* Williams et al., A Catalog of Washington Streams and Salmon Utilization, at San Juan 01-04 and 101-104 (1975). This reference seems to agree with Castle’s comments. It mentions several streams located throughout the islands that are used by spawning coho and chum salmon. It notes the following streams specifically: Cascade Creek on Orcas Island, draining Cascade and Mountain Lakes on the south side of Mount Constitution and entering East Sound; and two unnamed streams on San Juan Island, one draining from the Beaverton Valley area and entering on the east side of the island north of Friday Harbor, and the other draining the Trout Lake Cady Mountain area and entering False Bay. In addition to those streams already mentioned, it also adds: “intermittent spawning is expected in those island streams that provide access and suitable habitat, but only occasional adequate flows.”

[178] Schmitt et al. 1994, *supra* note 140, at 222.

[179] Rick Routledge, Trends in Salmon Stocks and Stock Assessments, *in* British Columbia Salmon/A Fishery in Transition 9 (Pacific Fisheries Think Tank Reports No. 1, 1997).

[180] Weitkamp 1998, *supra* note 174.

[181] Laurie A. Weitkamp et al., Status Review of Coho Salmon from Washington, Oregon, and California 130-31 (NOAA Technical Memorandum NMFS-NWFSC-24, 1995) [hereinafter Weitkamp et al. 1995]. *see also* Interview by author Ferguson, with Laurie A. Weitkamp, Fisheries Biologist, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (Aug. 27, 1998). Weitkamp says that the entire Puget Sound/Strait of Georgia evolutionarily significant unit (ESU) is a candidate for listing under the U.S. Endangered Species Act. *see also* Washington Department of Fisheries et al., 1992 Washington State Salmon and Steelhead Stock Inventory (Mar., 1993). WDF et al. consider the Skagit, Stilliguamish, and Snohomish River coho to be depressed.

[182] James M. Myers et al., Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California 250 (NOAA Technical Memorandum NMFS-NWFSC-35, 1998).

[183] Peggy J. Busby et al., Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California 165 (NOAA Technical Memorandum NMFS-NWFSC-27, 1996).

[184] Jeffrey J. Hard et al., Status Review of Pink Salmon from Washington, Oregon, and California 104 (NOAA Technical Memorandum NMFS-NWFSC-25, 1996). Orlay W. Johnson et al., Status Review of Chum Salmon from Washington, Oregon, and California (NOAA Technical Memorandum NMFS-NWFSC-32, 1997).

[185] Schmitt et al. 1994, *supra* note 140, 222.

[186] Palsson et al. 1997, *supra* note 152, at 60.

[187] Palsson and Pacunski 1995, *supra* note 171.

[188] Alan J. Cass et al., Lingcod *(Ophiodon elongatus)* 109 Can. Spec. Publ. Fish. Aquat. Sci. 5 (1990) [hereinafter Cass et al. 1990].

[189] 2 Bruce S. Miller and Steven R. Borton, Geographical Distribution of Puget Sound Fishes: Maps and Data Source Sheets 54.4 (1980) [hereinafter Miller and Borton 1980].

[190] Cass et al. 1990, *supra* note 188.

[191] Kathleen Matthews, Habitat Utilization by Recreationally Important Bottomfish in Puget Sound: An Assessment of Current Knowledge and Future Needs 22-25 (State of Washington Dept. of Fisheries Progress Report No. 264, 1987) [hereinafter Matthews 1987].
[192] Palsson et al. 1997, *supra* note 152, at 40.
[193] Miller and Borton 1980, *supra* note 189, at 24.4.
[194] Palsson et al. 1997, *supra* note 152, at 40.
[195] Matthews 1987, *supra* note 191, at 22.
[196] Schmitt et al. 1994, *supra* note 140, 239.
[197] Matthews 1987, *supra* note 191.

Scoping Memorandum concerning the Pacific Gateway Terminal

Juvenile Salmon and Forage Fish

Prepared by: Eric Beamer and Kurt Fresh

Prepared for: San Juan County Department of Community Development and Planning and San Juan County Marine Resources Committee

December 2012

JUVENILE SALMON AND FORAGE FISH PRESENCE AND ABUNDANCE IN SHORELINE HABITATS OF THE SAN JUAN ISLANDS, 2008-2009: MAP APPLICATIONS FOR SELECTED FISH SPECIES

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December 2012

Prepared for:
San Juan County Department of Community Development and Planning and
San Juan County Marine Resources Committee, both located in Friday Harbor, WA

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Abstract

Fish presence probabilities for the San Juan Islands' shorelines were calculated for seven juvenile fish species or species groupings from results of 1,350 beach seine sets made at 80 different sites throughout the San Juan Islands in 2008 and 2009. The juvenile fish species evaluated were: unmarked (assumed wild) Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbuscha*), Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosus*), and lingcod/greenling (*family Hexagrammidae*).

Because juvenile salmon are known to be migratory in nearshore waters, our sampling plan was established to encompass the times of year when it is possible for juvenile salmon to be present within shoreline habitats of the San Juan Islands. Beach seining typically occurred at each site twice per month from March through October each year.

We hypothesized that space (i.e., where within the San Juan Islands) and habitat type differences would influence whether or not fish were present (or abundant) at specific locations within the San Juan Islands. Beach seine sites were selected to represent different regions within the San Juan Islands (SiteType2) and different geomorphic shoreline types (SiteType3). We also stratified by two coarser-scale variables for space and habitat type. The coarse variable for space has two possible values related to whether the site is located in "interior" or "exterior" areas of the San Juan Islands. The coarse scale variable for habitat was either "enclosure" or "passage." All 80 sites were characterized by these space and habitat type variables.

We used generalized linear models (GLM) to test whether our hypothesized variables of space and habitat type influence fish presence and abundance. We found strong support for both influences with no strong indication to weigh one variable over the other. Thus, we created two model versions to predict indices of fish presence probability based on fish presence rate results summarized by each of the 80 sites for each space and habitat type variable. Models were created for each of the seven juvenile fish species or species grouping. A high resolution model (HRM) multiplied fish presence values for SiteType2 by SiteType3. A lower resolution model (LRM) multiplied fish presence rate values for the coarse space variable by the coarse habitat type variable. For each model, the calculated fish presence probabilities could range between 0 and 1. The resulting fish probability of presence estimates relate to our beach seine sampling regime of twice per month from March through October. For example, a Chinook probability of presence value of 1 for a site means you are certain to find Chinook salmon present at the site if you beach seine twice per month from March through October.

We also found fish presence rates to be positively correlated with fish density for all fish species or species groupings in this report. This means sites with higher values of fish presence also have higher values of fish abundance. The strength and type (e.g., linear, exponential) of the correlated relationships varied.

Background and Purpose of Study

Estuary and nearshore habitats are occupied by juvenile salmon during their transition from freshwater spawning and rearing habitats to ocean feeding grounds. Duration of estuarine/nearshore residence and attributes of estuarine/nearshore habitats can be important limiting factors in recovery of salmon populations (Beamish et al. 2000 & 2004; Mortensen et al. 2000; Magnusson and Hilborn 2003; Greene and Beechie 2004; Greene et al. 2005; Bottom et al. 2005a & 2005b).

Chinook salmon populations originating from Puget Sound are now federally protected, and the subject of significant population rebuilding efforts (Federal Register 64 FR 14208, March 24, 1999; Federal Register 69 FR 33102, June 14, 2004). Chinook salmon are thought to be the most estuarine/nearshore dependent of the Pacific salmon species (Healey 1982 & 1991; Simenstad et al. 1982) and therefore the most vulnerable to human alterations of estuarine/nearshore ecosystems.

A major data gap apparent in efforts to develop a recovery plan for Puget Sound Chinook salmon is information on juvenile Chinook salmon use of estuarine/nearshore habitats in the mixed stock rearing environments such as those found in the San Juan Islands. To date, our ability to document differences between Chinook salmon populations in their use of estuarine/nearshore habitats has been limited to coded wire-tagged, hatchery-origin fish in the main basin of Puget Sound (Duffy 2003; Brennan et al. 2005; Fresh et al. 2006). Hatchery origin salmon do not necessarily represent wild salmon life history types and results from the main basin of Puget Sound do not represent other areas throughout Puget Sound. Much in the same way as for juvenile salmon, data gaps exist for the juvenile nearshore habitat associations of three forage fish species (Pacific herring, surf smelt, and Pacific sand lance), which are also identified in salmon recovery plans as important to protect and restore because of their key role in Puget Sound food webs.

This study helps fill these fish use data gaps for the San Juan Islands. Its results are inteneded to help San Juan County planners and salmon recovery staff know what nearshore areas are providing juvenile habitat opportunity to juvenile salmon and forage fish species. Coupled with shoreline type characterization in GIS (McBride et al. 2009), the fish use results were used to create models of fish probability of presence estimates for all San Juan County shorelines, including areas not sampled directly in this study. The mapped application of these models can be used to identify specific areas for restoration or protection through salmon recovery or environmental regulatory processes.

Methods

This study is based on a stratification scheme using *time* (year and month), *space* (area within the San Juan Islands), and *habitat type* (shoreline type). The conceptual foundation for this stratification is based upon results of research from throughout the Pacific Northwest demonstrating that juvenile salmon use of estuarine and inland coastal landscapes will vary with time period, region, and habitat type. For example, Zhang and Beamish (2000) found a bimodal seasonal abundance curve for wild sub-yearling Chinook salmon in Georgia Strait; each mode was potentially a different group of fish (e.g., different life history strategy). Similarly, Beamer et al. (2003) found that differences in time (season or month) and habitat type directly affect the relative abundance of juvenile Chinook salmon life history types within Skagit Bay.

In the San Juan Islands, few salmon can originate from spawners within local watersheds because of the limited amount of stream habitat in this region. Therefore, the majority of juvenile salmon using San Juan County's shorelines originate from areas outside of our study area (Figure 1). Thus, we hypothesize that juvenile salmon use of the San Juan Islands' nearshore will vary spatially and temporally because of differences in the migratory pathways and habitats potentially available to source salmon populations. Migratory pathways could be influenced by the shape and diversity of the landscape, distance from natal river mouths, water quality, and water currents. For example, the northern side of the San Juan Islands is in closer proximity to the Fraser River than southern Rosario Strait, which is closer to the Skagit and Samish Rivers. Differences between source population sizes (e.g., millions of smolts migrating from some natal rivers versus only a few thousand smolts migrating from other natal rivers) and source population characteristics (e.g., composition of life history types, such as many fry migrants verses many yearling migrants) could influence the composition of juvenile salmon populations within San Juan County's nearshore habitats. Thus, our study was designed to collect fish data to determine the spatial and habitat patterns of fish in the nearshore habitats throughout the San Juan Islands.

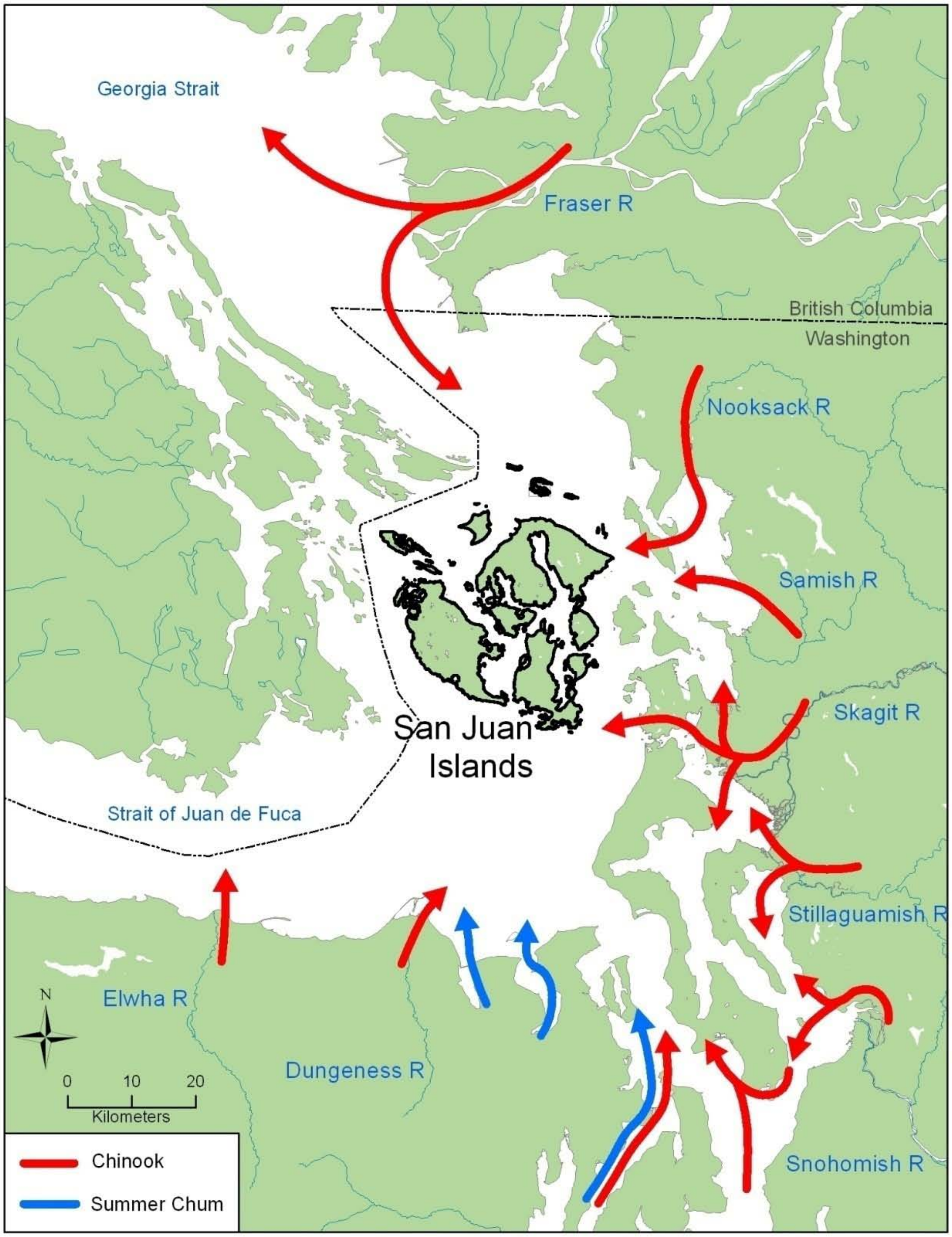

Figure 1. Location of San Juan Islands study area and conceptual varying migratory pathways for juvenile salmon coming from their source population rivers to mixed stock rearing areas within the southern Salish Sea.

Stratifying Variables

Time

Year: We sampled over a two-year period in order to capture the possibility of varying abundance levels of different fish species. For example, pink salmon abundance varies considerably between years due to their two year old life cycle. Adult pink salmon returning to river systems near the San Juan Islands (Fraser, Nooksack, Skagit, etc.) are much greater in abundance in odd-numbered years than in even-numbered years. Thus, the progeny of pink salmon, which migrate to sea as fry, are more abundant in even-numbered years than in odd-numbered years.

Month: We sampled over the entire period when juvenile salmon could be present in shoreline habitats of the San Juan Islands. Because juvenile salmon are migrating from their natal rivers to the ocean, we expect them to show some seasonal curve of absence to presence and again to absence. During their migration to the ocean, the different species of salmon are expected to transiently occupy and rear in nearshore habitats. As the fish grow in size they tend to be less associated with shoreline habitats. Logically, fish size and time of year are correlated with larger juvenile salmon occurring later in the season. To capture the seasonal patterns of use by juvenile salmon in nearshore habitats we sampled monthly from March through September or October each year. The sampling period was biased toward capturing the seasonal curve of juvenile Chinook salmon and was inferred largely from patterns known to occur in the Skagit estuary and its adjacent nearshore (Beamer et al. 2005). We hypothesized all the nearshore fish species we would encounter in this study have their own seasonal patterns of nearshore habitat use based on their unique life cycles.

Space

We defined fourteen (14) different areas within the San Juan Islands for this purpose; they are called “SiteType2” in the GIS (see Appendix B). Each area represents a subset of the San Juan Islands’ nearshore habitat where juvenile salmon stock and species composition might be unique based on differences in salmon migration pathways and proximity to source population areas like the Skagit, Nooksack, or other rivers (Figure 2).

Because we were uncertain whether we could beach seine all areas of the San Juan Islands (i.e., all SiteType2s), we also defined a coarser scales for space within the San Juan Islands that is based on an area being in the interior or exterior of the San Juan Islands (Figure 3). The coarse binning of space is “Int_Ext” in the GIS analysis (see Appendix B).

Figure 2. Map of 14 areas within the San Juan Islands. These areas are our primary spatial strata (Sitetype2). Beach seine sampling occurred in 12 of the 14 areas.

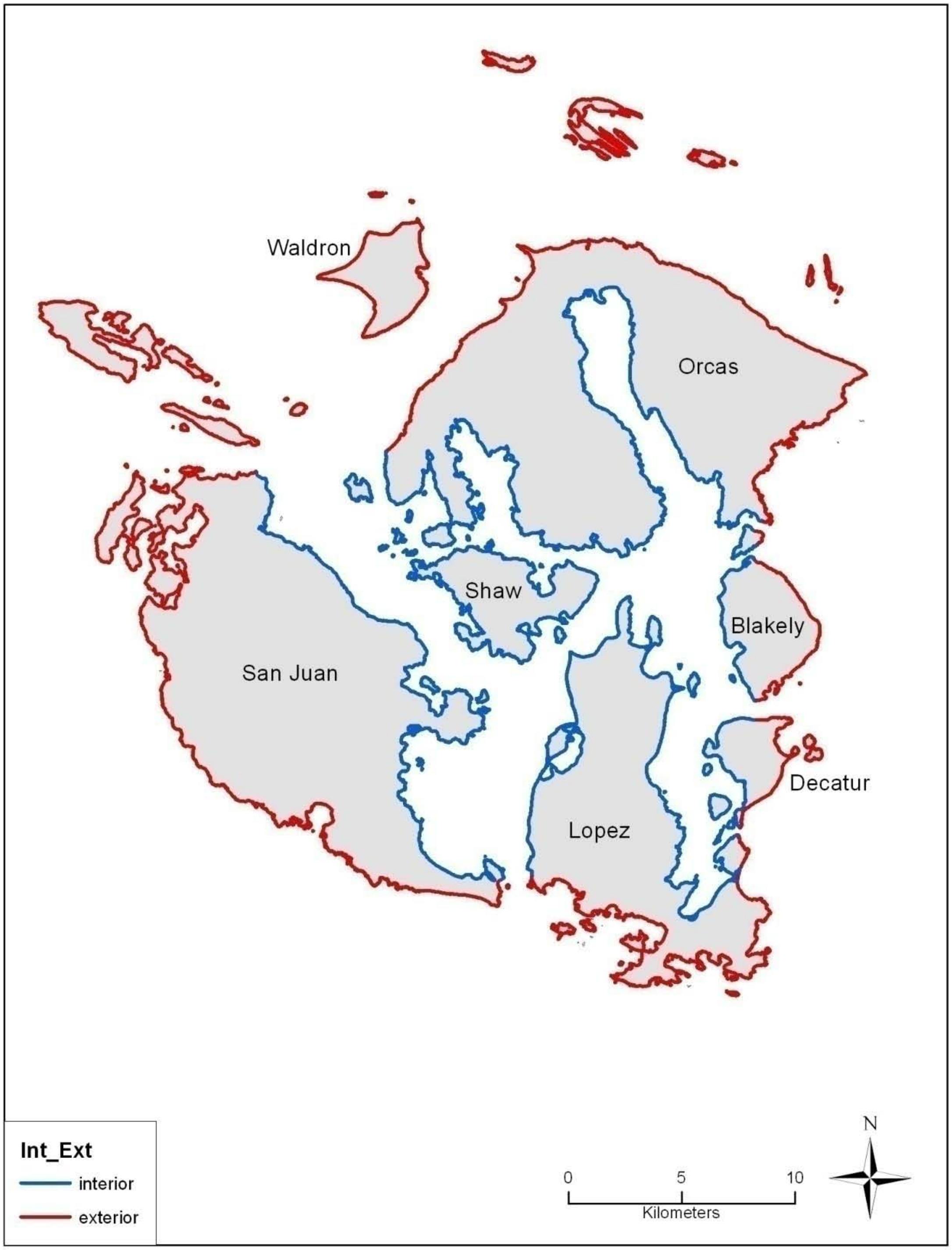

Figure 3. Interior and exterior areas within the San Juan Islands per our coarse space variable.

Habitat type

We created two habitat type variables: SiteType3 (shoreline type) and Enclosure/Passage.

SiteType 3: We chose to group geomorphic units based on similarities in beach form into five groups (described below) and applied the groupings to all shorelines of the San Juan Islands (Figure 4). The groupings are simplified geomorphic typology after the classification by McBride et al. (2009). Examples of shoreline types used in this study are shown in Appendix A along with a crosswalk table of classifications used by the RITT (Bartz et al. 2012) and SSHIAP. The SSHIAP program has a Puget Sound-wide GIS data layer using the McBride et al. (2009) method.

> **Barrier beach**: The *barrier beach* group includes true barrier beaches, which are depositional landforms, and pocket closed lagoon and marsh units that look like barrier beaches even though these are erosional beaches (see *pocket beaches* below). The barrier beach group is characterized by low relief beaches with well developed backshore areas and leeward tidal and/or freshwater impoundments. The impoundments themselves are part of the *pocket estuary* group if there is a consistent surface connection to marine water.
>
> **Bluff backed beach***:* The *bluff backed beach* group includes erosional depositional beaches at the base of sediment bluffs. This group also includes sediment-covered rock beaches and seeps/small streams that enter the beach via the bluff rather than via a pronounced stream valley. Bluff backed beaches do not form lagoons (except as a sediment source to the barrier beaches that do form lagoons).
>
> **Pocket beach**: *Pocket beaches* are a particular variation of a beach that can look like 'bluff-backed beach' at the base of rocky bluffs. Unlike bluff-backed beaches, however, pocket beaches have no adjacent sediment source from drift cells and thus are not part of drift cell systems. Beach sediments in pocket beaches are derived locally.
>
> **Pocket estuary like**: The *pocket estuary like* group includes all the impoundments behind spits or other barrier beaches, and those habitats impounded behind pocket beaches. They also include stream estuaries not partially enclosed by lagoons/barrier beaches (deltas, drowned channels and tidal deltas). Most pocket estuaries have freshwater inputs because most are created by streams or as a result of a stream or glacial valley intersecting the shoreline. The shoreline forms an indentation at valleys. These valley indentations are often crossed and then partially enclosed by beach sediments moving across the indentation opening, creating lagoons. Lagoons can also form parallel to bluffs, when tides encroach into the backshore. These cases of pocket 'estuaries' may not have a freshwater input. Pocket beach lagoons also may not have a freshwater input. In both of these salty cases, we have observed that freshwater does accumulate in the impoundments during the wet season. The estuarine character of these sites needs to be determined on a site by site basis. A third salty pocket

‘estuary’ is the tidal channel marsh that forms where tides encroach into coastal lowlands.

Rocky shoreline: The *rocky shoreline* group includes both the low-to-medium gradient rocky shorelines and plunging rock cliffs.

Some shorelines were so heavily modified that we could not determine their shoretype. These were by default classified as ***modified*** and were not included as potential beach seine sites.

Enclosure/Passage: We defined Enclosure/Passage as an intermediate-scale variable for habitat type based on shoreline length, shape, and watershed area contributing to the shoreline length. We mapped enclosure and passage area for all shorelines within the San Juan Islands (Figure 5).

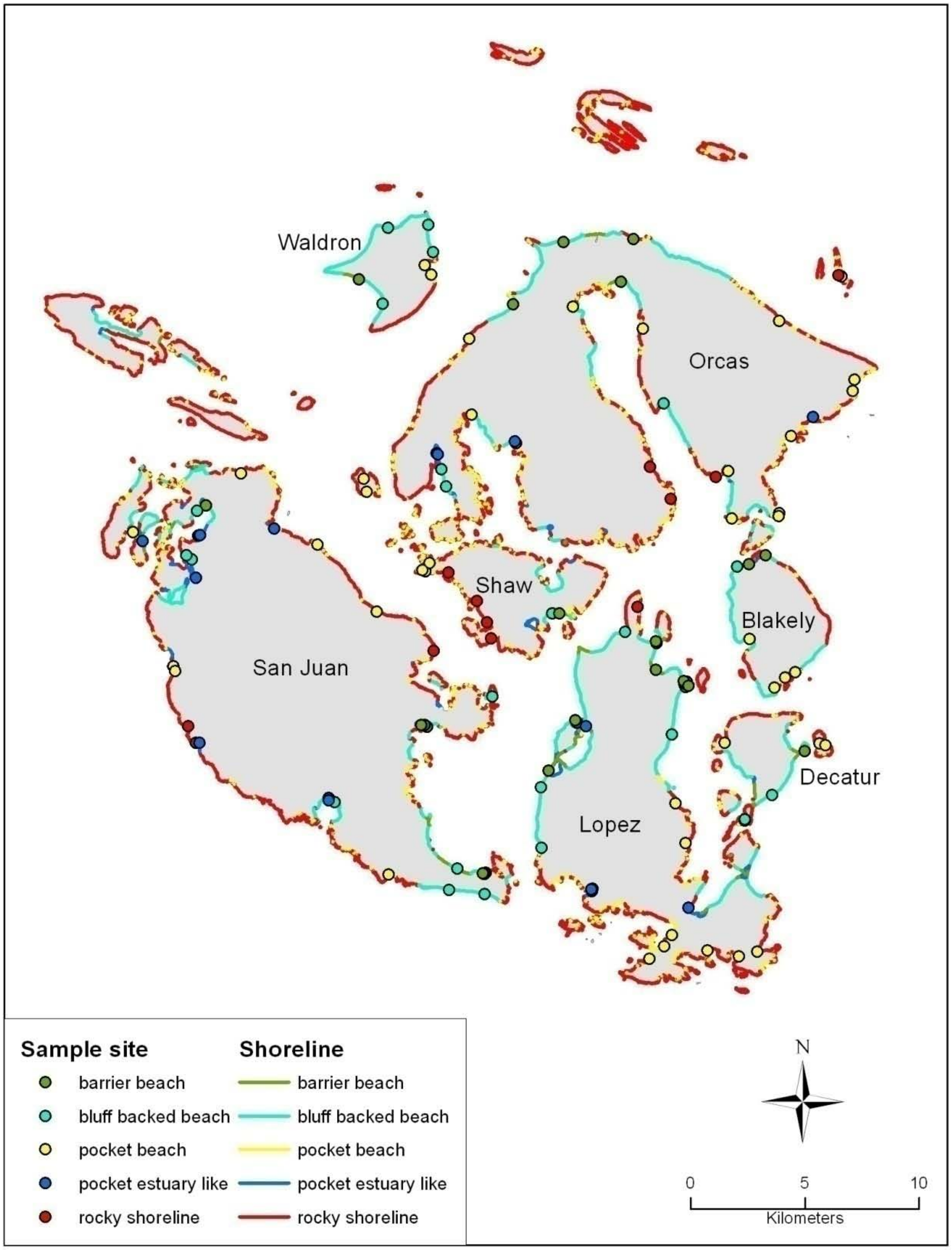

Figure 4. Location of 82 beach seine sites sampled in 2008 and 2009 in the San Juan Islands. Shown by shoreline type (SiteType3).

Figure 5. Enclosure and passage areas within the San Juan Islands per our intermediate-scale variable.

Site Selection and Sampling Effort

We selected beach seine sites from 12 of the 14 different areas (SiteType2) within the San Juan Islands. Within each of 11 of the 12 areas, we sampled a diversity of shoreline types (SiteType3). In SiteType2 #12 (Upright Channel) we only sampled bluff backed beaches. The number of sites and habitats within each of the 12 areas sampled varied based on factors such as logistics, access, and the shoreline types available for sampling (Table 1). A total of 1,375 beach seine sets were completed at 82 different sites over the two-year period (Table 2).

Our beach seine sampling effort under-sampled the amount of rocky shoreline present in the San Juan Islands when compared based on the count of shoreline segments or their total length (Figure 6). We also over-represented pocket estuaries and barrier beaches in our beach seine sampling.

Table 1. SiteType2 unique identifier numbers, and number of beach seine sets completed per area and shoreline type.

Area within San Juan Islands (SiteType2)	**Site-Type2 ID#**	**Shoreline type (SiteType3)**				
		Barrier beach	**Bluff backed beach**	**Pocket beach**	**Pocket estuary like**	**Rocky shoreline**
Str Juan de Fuca - S Lopez Is	1			133	38	
Str Juan de Fuca - San Juan Is	2		49	12	40	
Haro Strait NE	3	19	24	37	49	7
Waldron Is - President Channel	4		46	14		
Rosario NW	5			51	22	11
Rosario Strait SW	6	14		40		
Blakely Sound - Lopez Sound	7	38	46	37	34	
East Sound	8			48		39
Deer Harbor - West Sound	9		70	15	51	
San Juan Channel South	10	91	32		72	
San Juan Channel North	11			64	24	83
Upright Channel	12		25			

Table 2. Number of beach seine sets completed by year and month.

Month	**Year**		**Total**
	2008	**2009**	
March	62	72	134
April	91	114	205
May	87	109	196
June	101	120	221
July	93	121	214
August	101	114	215
September	62	95	157
October		33	33
Total	597	778	1375

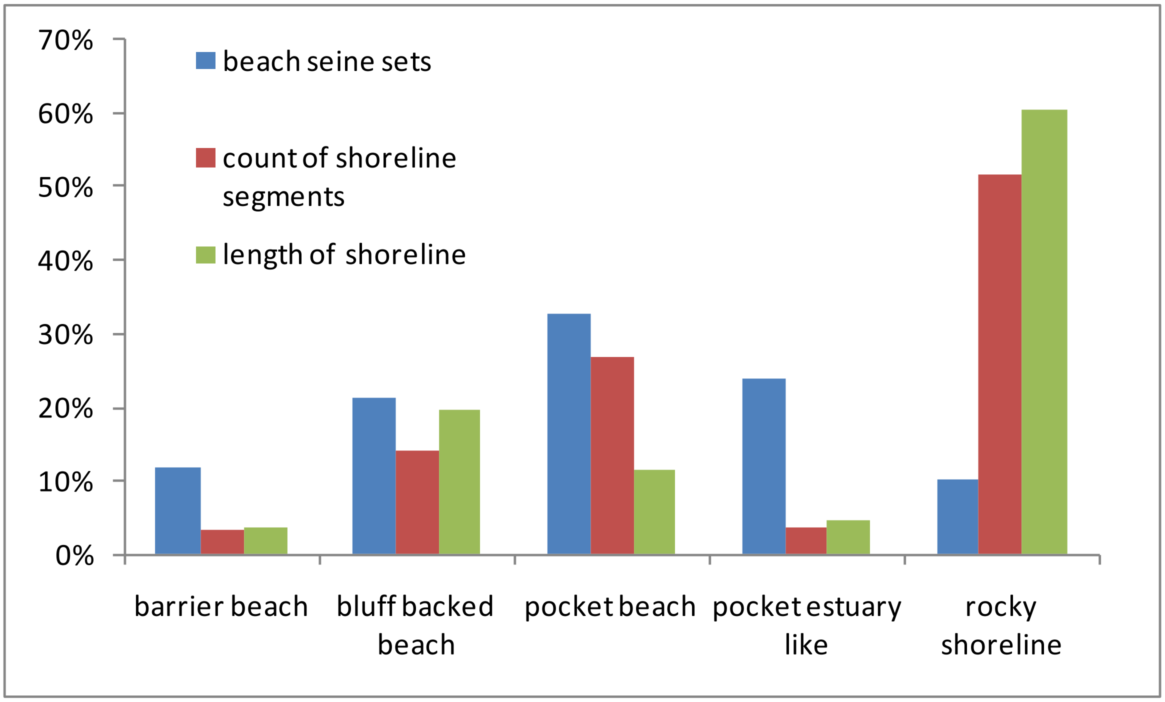

Figure 6. Relationship between beach seine effort by shoreline type and the amount of shoreline habitat by type.

Fish Sampling

Beach seine

We used beach seine methods to capture fish in shoreline habitats of the San Juan Islands (see cover photos). We used two different sized nets depending on the conditions at the site such as water depth, size of area, and substrate.

The small net beach seine methodology employed an 80-ft (24.4 m) by 6-ft (1.8 m) by 1/8-inch (0.3 cm) mesh knotless nylon net. The net was set in “round haul” fashion by fixing one end of the net on the beach, while the other end was deployed by setting the net “upstream” against the water current, if present, and then returning to the shoreline in a half circle. Both ends of the net were then retrieved, yielding a catch. The small net beach seine was usually deployed from a floating tub that was pulled while wading along the shoreline. Large net methods used a boat to set the net due to the nets larger size and deeper water at the site. The large net beach seine was 120-ft (36.6 m’ by 12-ft (3.7 m) by 1/8-inch (0.3 cm) mesh knotless nylon net where one end of the net wass fixed on the beach while the other end was set by boat across the current (if present) at an approximate distance of 65-85% of the net’s length depending on the site.

For each beach seine set, we identified and counted fish by species, and measured individual fish lengths by species. When one set contained 20 individuals or less of one species, we measured all individual fish at each site/date combination. For sets with fish catches larger than 20 individuals of one species, we randomly selected 20 individuals for length samples.

Fish density

For all fish sampled by beach seines, we calculated the density of fish by species for each set (the number of fish divided by set area). Set area is determined in the field for each beach seine set.

Analysis Methods

Statistical and graphical analysis of fish species

To accommodate our unbalanced sampling design (Table 1) we used generalized linear models (GLM) to evaluate the effects of temporal and habitat variables on fish density. Fish densities were log (x+1) transformed to reduce the effects of high skew and unequal variance across groups. Year, month, space, and shoreline type were evaluated for main effects as fixed factors for their influence on each species or species group. Statistical results from GLM for each effect are reported in tables for each species or species grouping along with graphical presentations. We excluded from the GLM analysis fish data from SiteType2 #12 (Upright Channel) to reduce effects of our unbalanced design. The 25 beach seine sets for Upright Channel (Table 1) were from one year (2009) and one shoreline type (bluff backed beach). We created box plots of fish size by month to characterize fish size and scatter plots of regressions between fish presence rate and fish density to determine whether results were correlated.

Fish probability of presence mapping

Based on results of GLM testing of effects for fixed variables (see results section below), we found strong support that both space and habitat type affected fish abundance but one variable did not appear more important than the other. Thus, we created two model versions to develop indices of fish presence probability based on fish presence rate results summarized by each of the 80 sites used in the GLM analysis. We ignored temporal effects (month and year) on fish species for these models because the purpose of each model is to map places in the San Juan Islands with varying levels of fish use, not to predict the when fish are present.

Models were created for each of the seven juvenile fish species or species groupings. A high resolution model (HRM) multiplied fish presence values for SiteType2 by SiteType3. A lower resolution model (LRM) multiplied fish presence rate values for the coarser-scaled space variable (interior/exterior) by the coarser scaled habitat type variable (enclosure/passage). For each model, the calculated fish presence probabilities could range between 0 and 1. The resulting fish probability of presence estimates relate to our beach seine sampling regime of twice per month from March through October. For example, a Chinook probability of presence value of 1 for a site means you are certain to find Chinook salmon present at the site if you beach seine twice per month from March through October.

Because we did not beach seine adequately in 3 of the 14 geographic regions (SiteType2s shown in Figure 2), we used fish presence rate results from the coarser-scaled spatial variable ‘interior/exterior’ as a substitute for results from missing geographic areas (SiteType2 codes: 12, 13, and 14). We also lacked fish presence results for the shoreline type classified as ‘modified’ in GIS. There was no suitable fish presence rate result to use as a surrogate for modified shorelines so we did not make an estimate for modified shoreline areas in the HRM.

Because of the odd/even year abundance cycle of pink salmon, we used fish presence rate results from 2008 to create both HRM and LRM maps for juvenile pink salmon. We used both 2008 and 2009 fish presence rate results to create the map application models for all other fish species.

Results

Abundance, Timing, and Size

Chinook salmon

GLM testing for effects of fixed factors revealed log-transformed Chinook density was not influenced by years but was influenced by season (month), area within the San Juan Islands (SiteType2), and shoreline type as well as both coarse variables for space (int/ext) and habitat type (encl/pass) (Table 3).

Juvenile Chinook arrived in the San Juan Islands by April, peaked in the month of June, and remained relatively high in shoreline areas during summer months (Figure 7, Panel B). Juvenile Chinook salmon were most abundant in Region 4 (Waldron-President Channel) (Figure 7, Panel C) and bluff backed beach and pocket beach shoreline types (Figure 7, Panel D).

Fish size increased from April through October (Figure 8). Very few Chinook caught were fry sized fish (only 5 of the 491 fish measured were 50 mm or less in fork length) when they arrived in the San Juan Islands

Regression analysis revealed juvenile wild Chinook salmon presence and density was strongly and positively correlated in the San Juan Islands when beach seine sets are averaged by SiteType2 (Figure 9). Thus, shorelines in the San Juan Islands with higher juvenile wild Chinook presence rates also have greater abundance levels of wild juvenile Chinook The regression relation is a power function.

Table 3. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Chinook salmon density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	0.150	1	0.150	0.539	0.463
Month	3.916	1	3.916	14.079	0.000
SiteType2	4.904	1	4.904	17.631	0.000
Shoreline type	7.641	4	1.910	6.869	0.000
Int_Ext	6.031	1	6.031	21.924	0.000
Encl_Pass	7.617	1	7.617	27.692	0.000

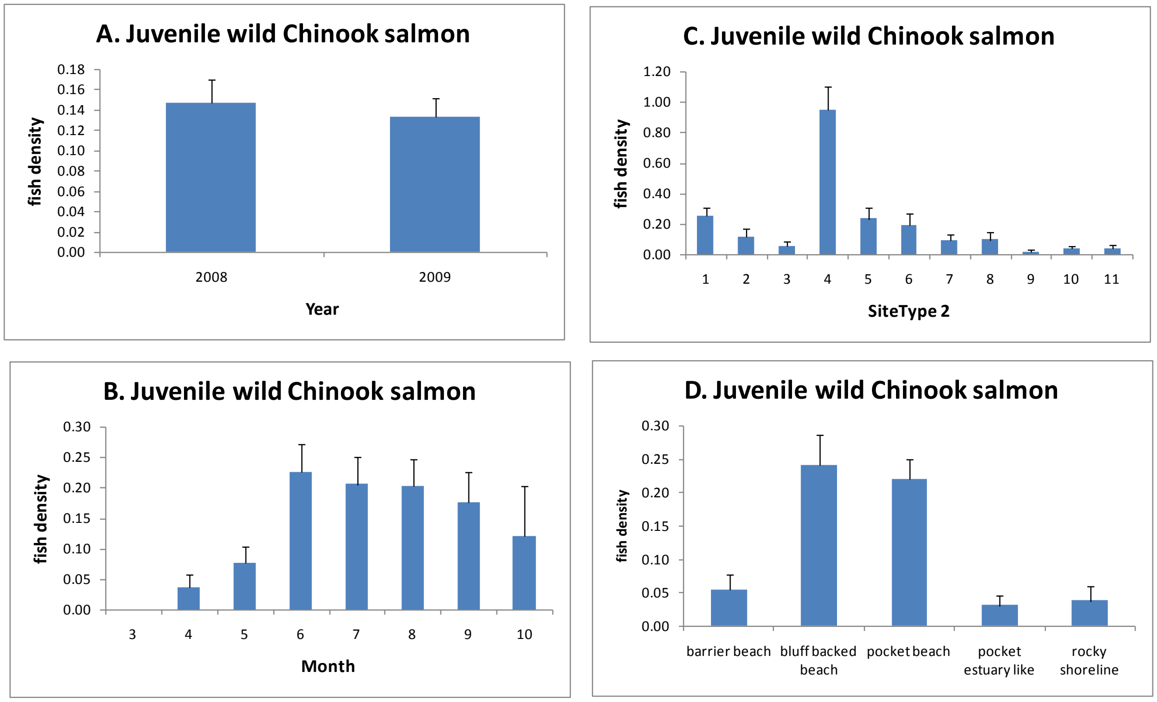

Figure 7. Relationship between average juvenile wild Chinook salmon densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific Sitetype2 codes (Panel C) are shown in Table 1 and Figure 2.

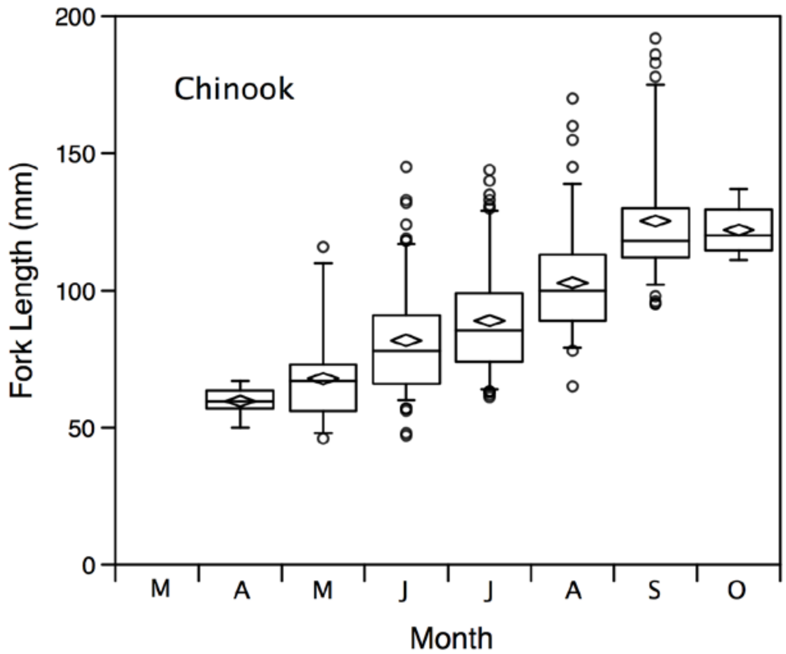

Figure 8. Fork lengths of wild juvenile Chinook salmon caught in shoreline habitats of the San Juan Islands, 2008-2009 combined. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

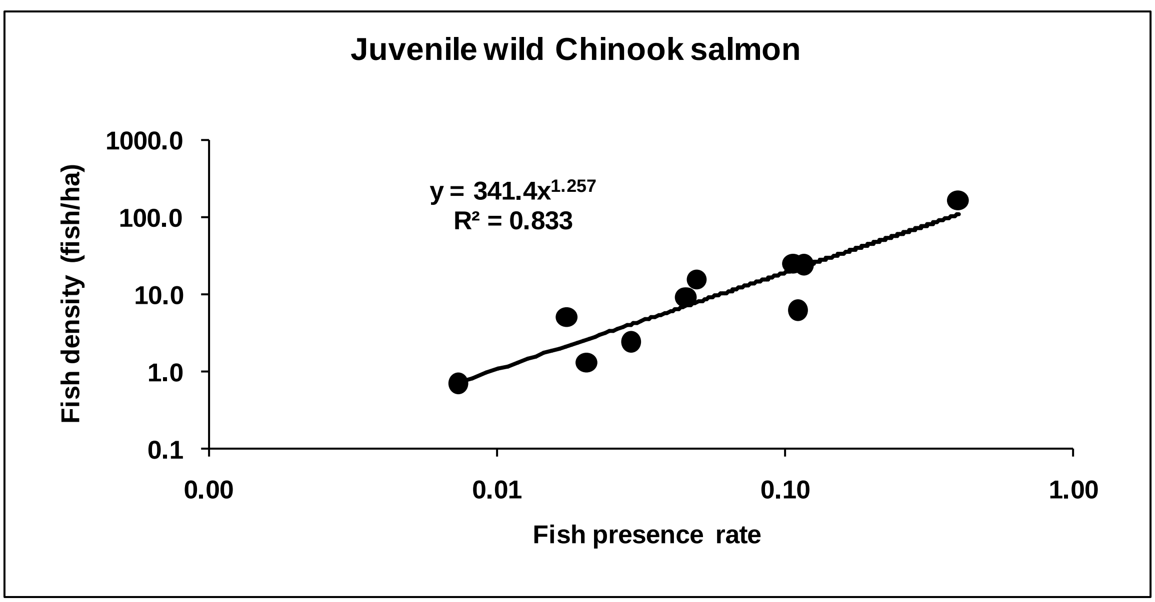

Figure 9. Correlation between presence and abundance of juvenile wild Chinook salmon in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Chum salmon

GLM testing for effects of fixed factors revealed log-transformed chum density was not influenced by area within the San Juan Islands (SiteType2), but was influenced by season (year and month), and shoreline type as well as both the coarse variables for space (int/ext) and habitat type (encl/pass) (Table 4).

Juvenile chum arrived in the San Juan Islands by March, peaked in the month of May, and disappeared from shoreline areas by August (Figure 10, Panel B). Juvenile chum salmon were most abundant at pocket beaches (Figure 10, Panel D).

Fish size increased more slowly from March through May than after May (Figure 11), possibly reflecting requirement of new fish each month. Most juvenile chum are fry-sized when they arrive in the San Juan Islands, but the length distribution does include some larger fish. Fish size increased steeply after May, possibly reflecting growth of individual fish residing in shoreline areas of the San Juan Islands and a lack of near recruitment of newly outmigrated fish from freshwater.

Regression analysis revealed juvenile chum salmon presence and density were positively correlated in the San Juan Islands when beach seine sets are averaged by SiteType2 (Figure 12). Thus, shorelines in the San Juan Islands with higher juvenile chum presence rates were also higher in juvenile chum abundance. The regression relation is an exponential function.

Table 4. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile chum salmon density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	14.202	1	14.202	14.333	0.000
Month	81.028	1	81.028	81.777	0.000
SiteType2	0.013	1	0.013	0.013	0.909
Shoreline type	49.403	4	12.351	12.465	0.000
Int_Ext	10.020	1	10.020	10.736	0.001
Encl_Pass	87.988	1	87.988	94.270	0.000

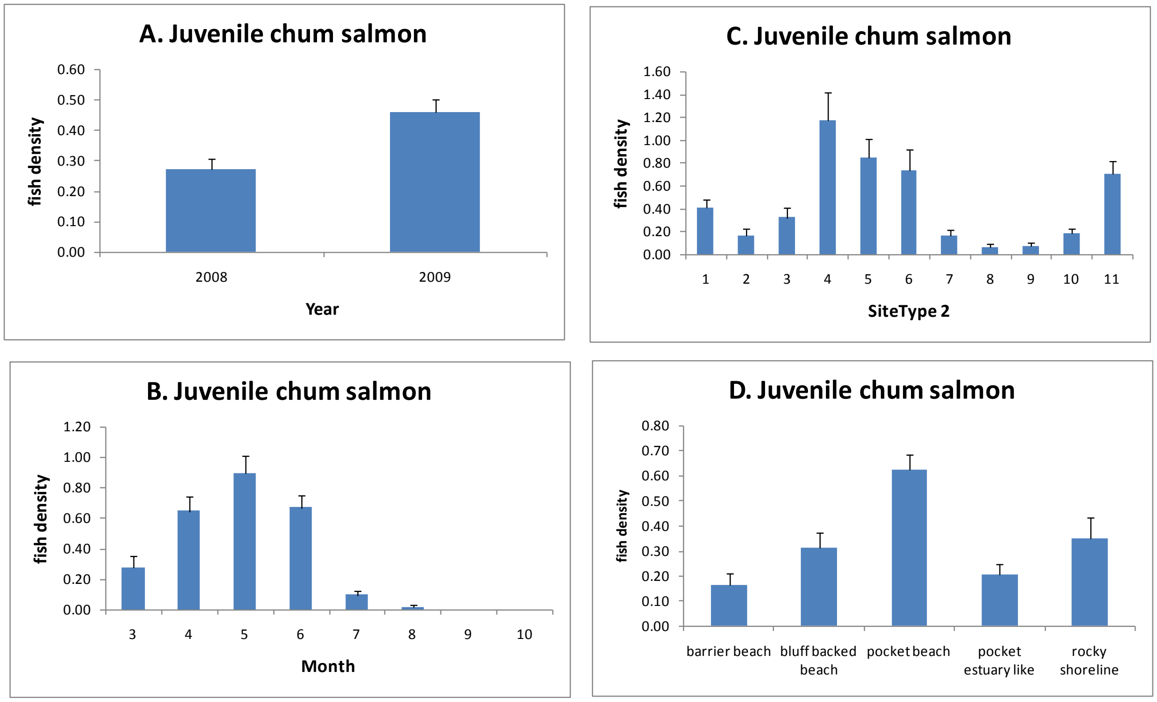

Figure 10. Relationship between average juvenile chum salmon densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific Sitetype2 codes (Panel C) are shown in Table 1 and Figure 2.

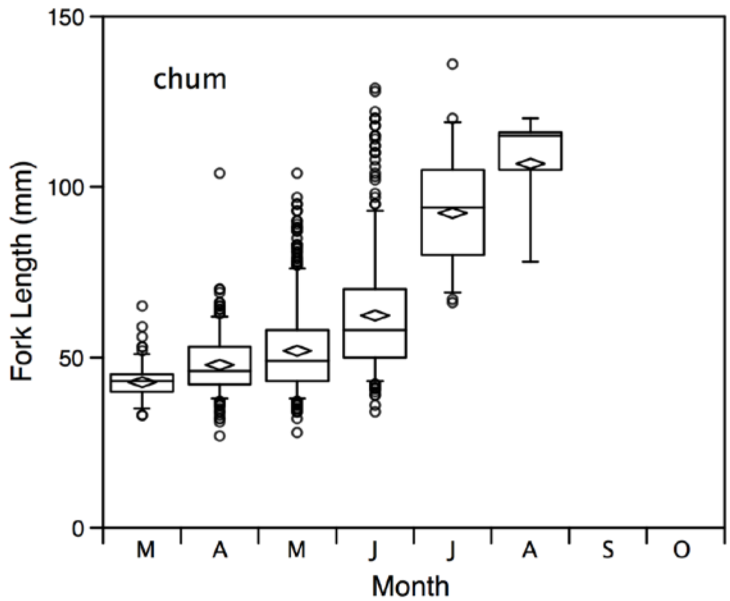

Figure 11. Box plot of fish size for juvenile chum salmon caught in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

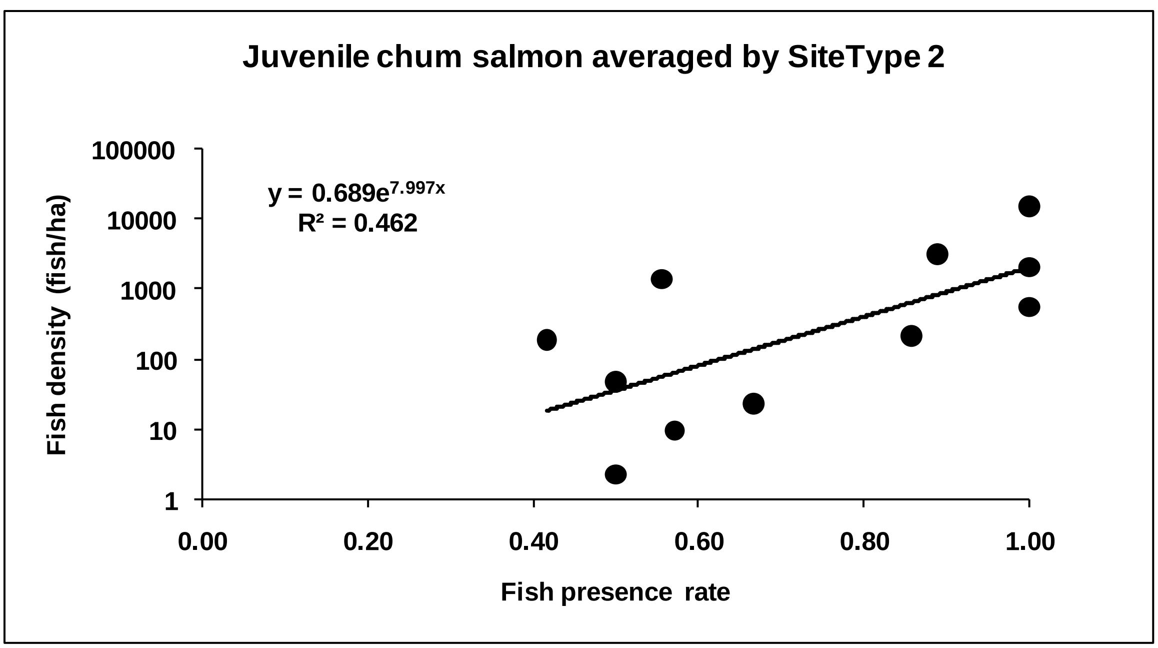

Figure 12. Correlation between presence and abundance of juvenile chum salmon in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Pink salmon

GLM testing for effects of fixed factors revealed log-transformed pink density was influenced by season (year and month), by area within the San Juan Islands (SiteType2) and by shoreline type (Table 5). For our coarser-scaled space and habitat type variables, pink salmon density was influenced by encl/pass but not by int/ext.

Juvenile pink salmon arrived in the San Juan Islands by March, peaked in the month of May, and disappeared from shoreline areas by August (Figure 13, Panel B). Juvenile pink salmon were most abundant pocket beaches (Figure 13, Panel D).

Fish size increased monthly (Figure 14). Most juvenile pink salmon are fry-sized when they arrive in the San Juan Islands, but the length distribution does include some larger fish.

Regression analysis revealed juvenile pink salmon presence and density was positively correlated in the San Juan Islands when beach seine sets were averaged by SiteType2 (Figure 15). Thus, shorelines in the San Juan Islands with higher juvenile pink presence rates also had greater abundance levels of juvenile pink abundance. The regression relation is a power function.

Table 5. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile pink salmon density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	61.828	1	61.828	95.661	0.000
Month	16.307	1	16.307	25.230	0.000
SiteType2	3.484	1	3.484	5.390	0.020
Shoreline type	23.273	4	5.818	9.002	0.000
Int_Ext	0.329	1	0.329	0.516	0.473
Encl_Pass	29.881	1	29.881	46.929	0.000

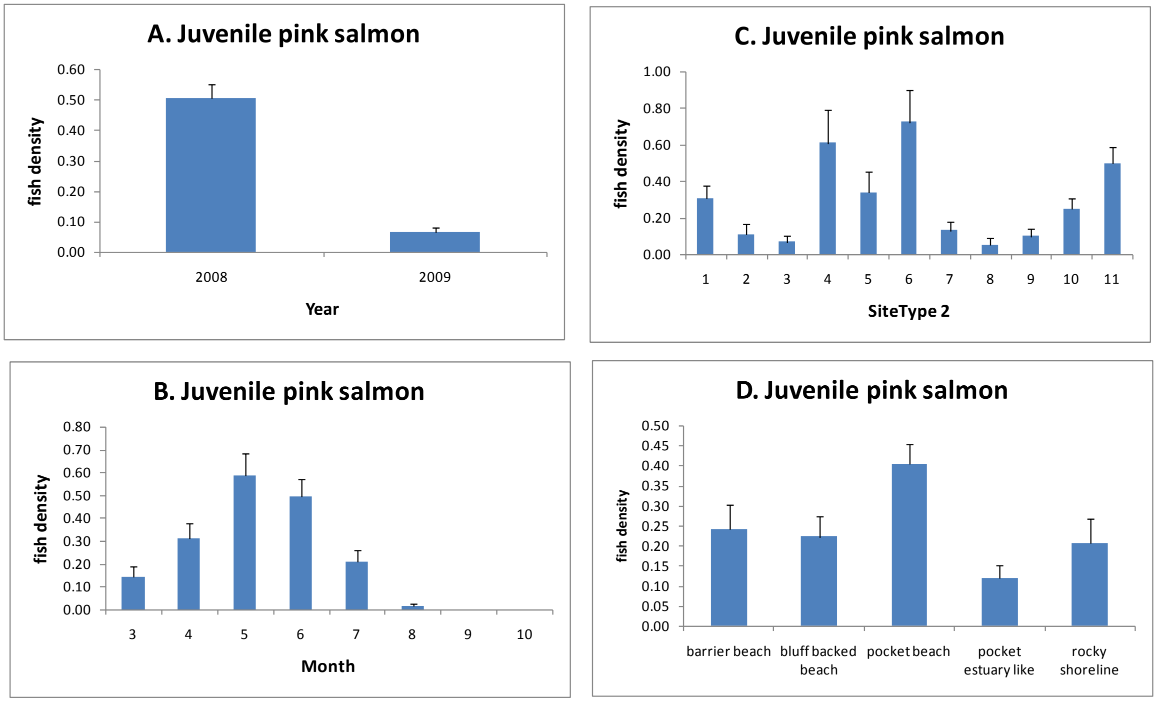

Figure 13. Relationship between average juvenile pink salmon densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific Sitetype2 codes (Panel C) are shown in Table 1 and Figure 2.

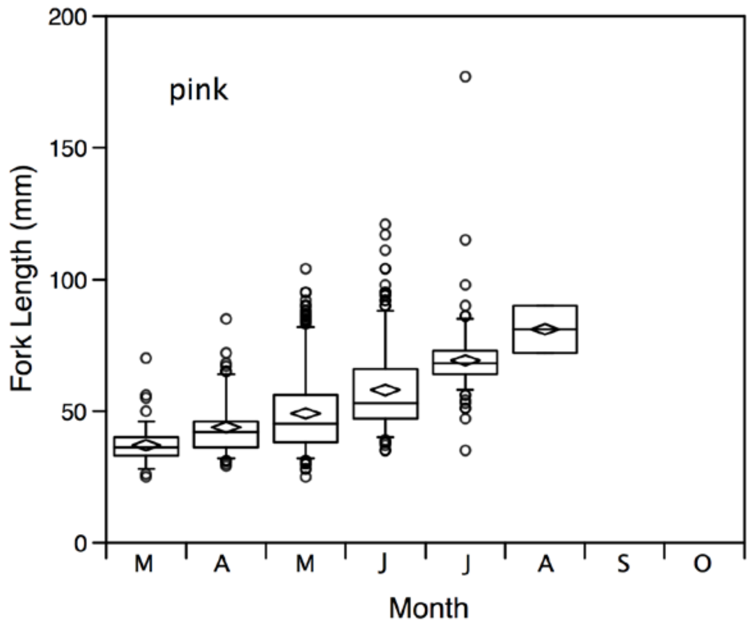

Figure 14. Box plot of fish size for juvenile pink salmon caught in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

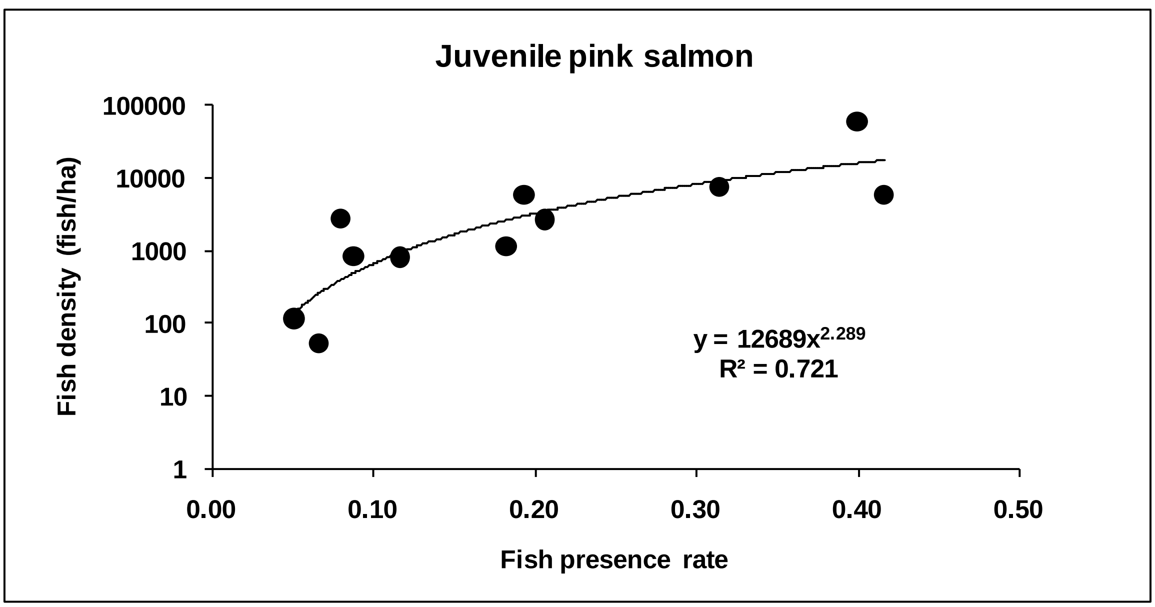

Figure 15. Correlation between presence and abundance of juvenile pink salmon in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Pacific herring

GLM testing for effects of fixed factors revealed log-transformed herring density was influenced by season (year and month), by area within the San Juan Islands (SiteType2) and by shoreline type (Table 6). For our coarser-scaled space and habitat type variables, herring density was influenced by int/ext but not by encl/pass.

Herring were present in shoreline habitats of the San Juan Islands throughout our study period, but abundance levels were substantially greater in October than any other month (Figure 16, Panel B). No herring were caught at any site within one SiteType2, number 11 (Figure 16, Panel C). Herring were most abundant associated with pocket beaches and rocky shorelines (Figure 16, Panel D).

Most herring measured were juvenile-sized (Figure 17). Overall, fish size increased monthly, but starting in July a new age class of young-of-the-year herring was found in shoreline habitats.

Regression analysis revealed herring presence and density to be positively correlated in the San Juan Islands when beach seine sets were averaged by SiteType2 (Figure 18). Thus, shorelines in the San Juan Islands with higher herring presence rates also have more herring. The regression relation is a power function.

Table 6. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Pacific herring density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	7.896	1	7.896	18.388	0.000
Month	14.803	1	14.803	34.474	0.000
SiteType2	4.173	1	4.173	9.719	0.002
Shoreline type	6.710	4	1.678	3.907	0.004
Int_Ext	3.063	1	3.063	7.063	0.008
Encl_Pass	0.579	1	0.579	1.335	0.248

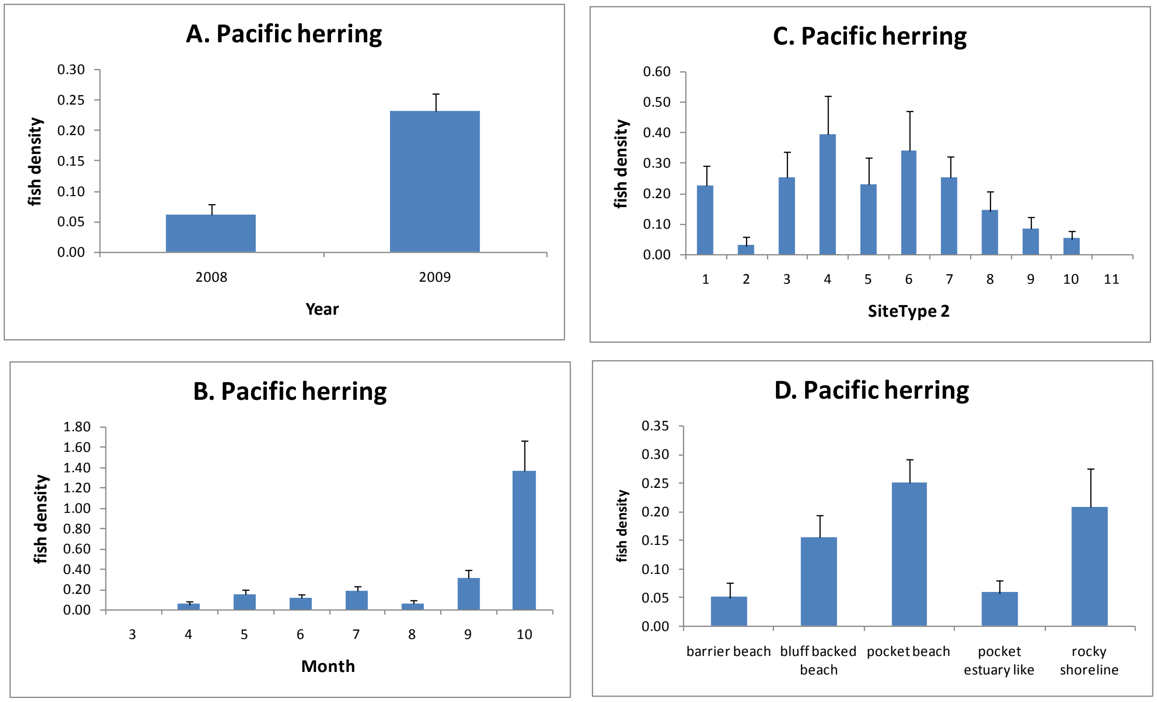

Figure 16. Relationship between average juvenile Pacific herring densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific SiteType2 codes (Panel C) are shown in Table 1 and Figure 2.

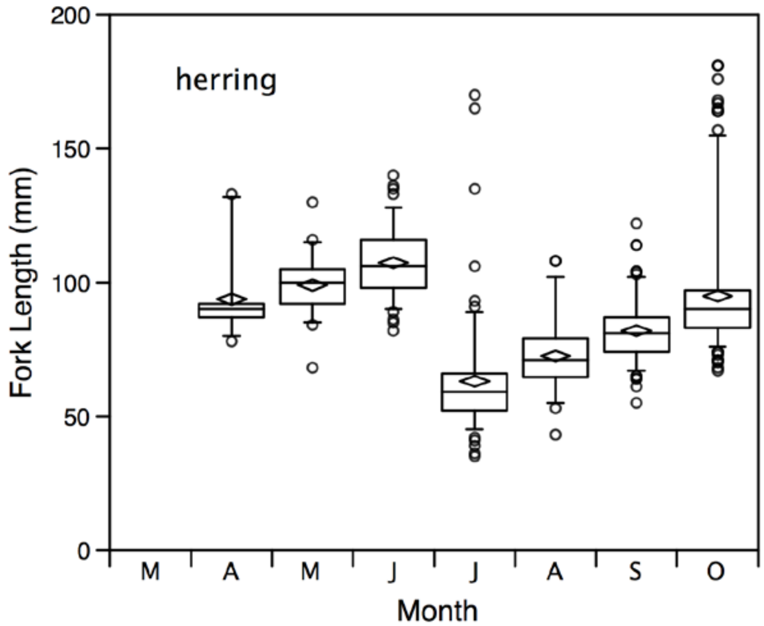

Figure 17. Box plot of fish size for Pacific herring caught in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

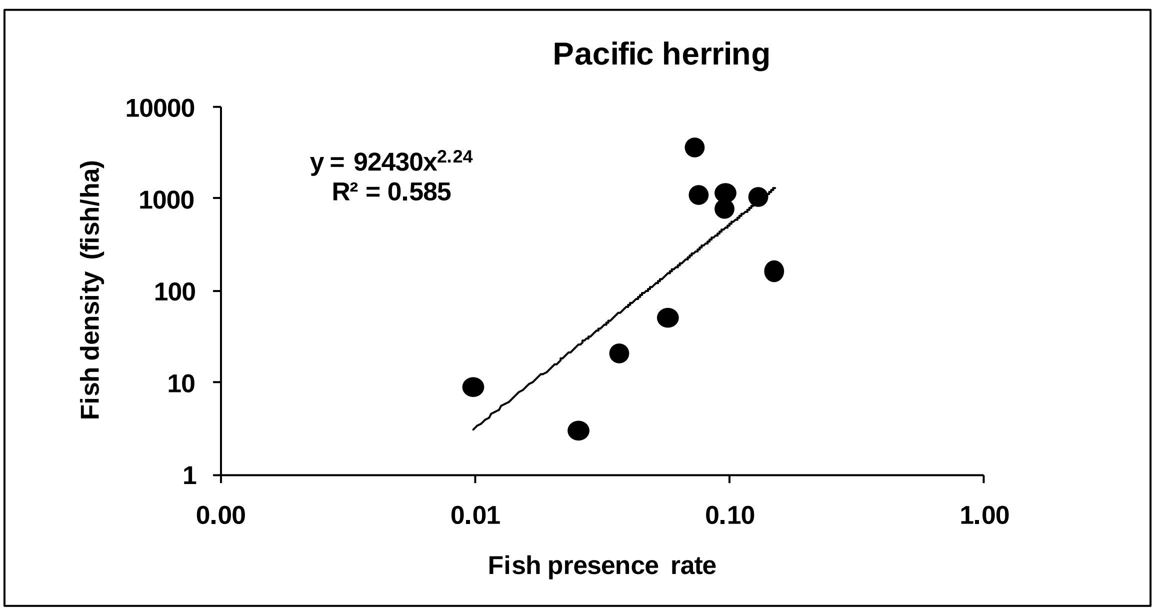

Figure 18. Correlation between presence and abundance of juvenile Pacific herring in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Surf smelt

GLM testing for effects of fixed factors revealed log-transformed smelt density was influenced by season (year but not month), by area within the San Juan Islands (SiteType2), and by shoreline type (Table 7). For our coarser-scaled space and habitat type variables, smelt density was influenced by both int/ext and encl/pass.

Surf smelt were present in shoreline habitats of the San Juan Islands throughout our study period (Figure 19, Panel B). Surf smelt were most abundant in barrier beaches and pocket beaches and least abundant in rocky shorelines (Figure 19, Panel D).

Most smelt measured were juvenile-sized through July, after which both juvenile- and adult-sized fish were present in shoreline habitats (Figure 20).

Regression analysis revealed that smelt presence and density were positively correlated in the San Juan Islands when beach seine sets were averaged by SiteType2 (Figure 21). Thus, shorelines in the San Juan Islands with higher smelt presence rates are also higher in smelt abundance. The regression relation is a power function.

Table 7. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile surf smelt density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	14.244	1	14.244	17.785	0.000
Month	0.388	1	0.388	0.485	0.486
SiteType2	10.871	1	10.871	13.573	0.000
Shoreline type	11.901	4	2.975	3.715	0.005
Int_Ext	8.757	1	8.757	10.908	0.001
Encl_Pass	18.565	1	18.565	23.124	0.000

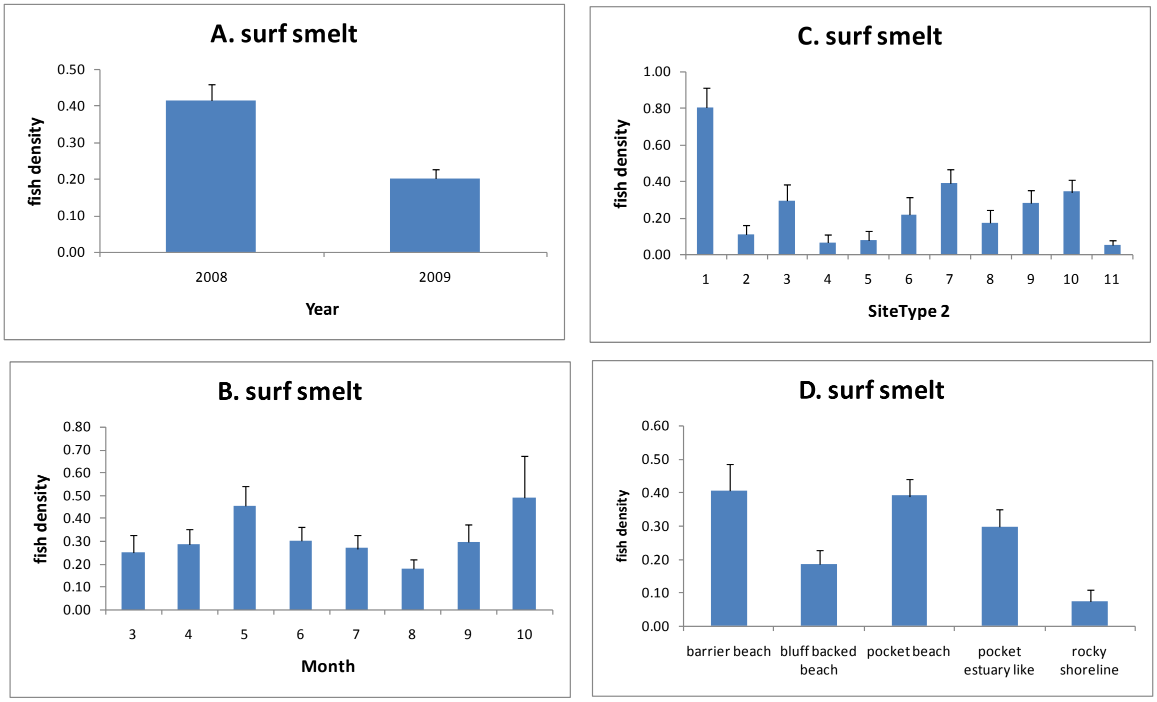

Figure 19. Relationship between average juvenile surf smelt densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific SiteType2 codes (Panel C) are shown in Table 1 and Figure 2.

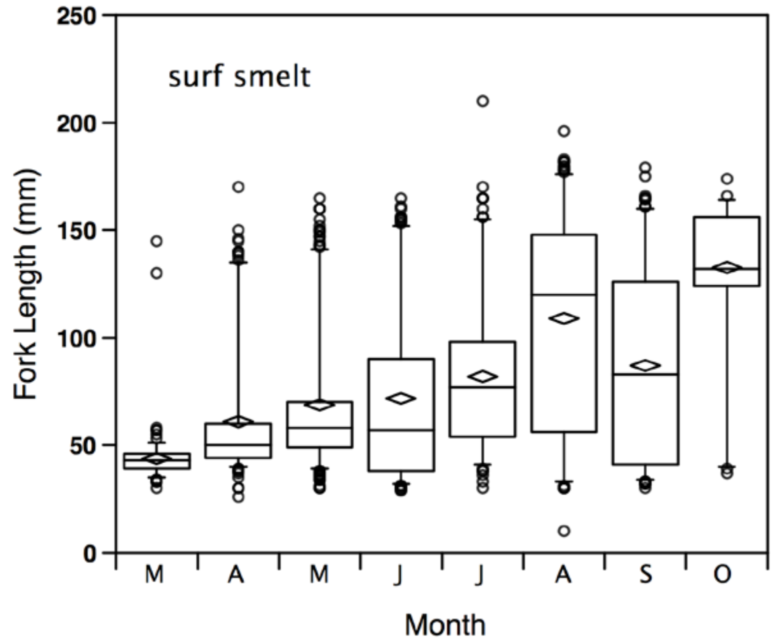

Figure 20. Box plot of fish size for juvenile surf smelt caught in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

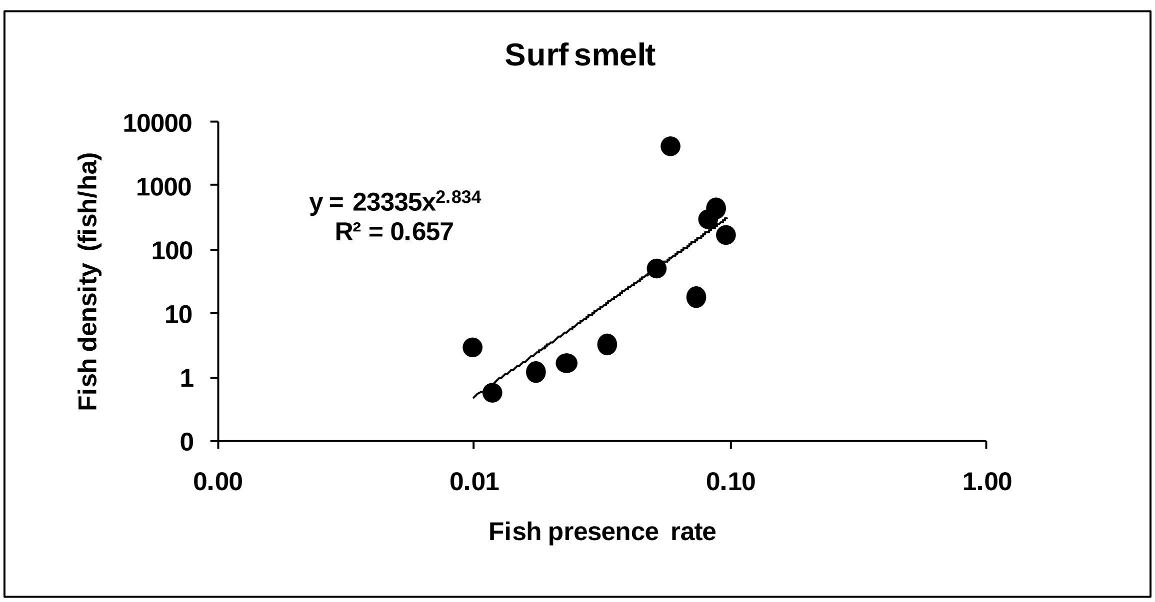

Figure 21. Correlation between presence and abundance of juvenile surf smelt in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Pacific sand lance

GLM testing for effects of fixed factors revealed log-transformed sand lance density was influenced by season (year and month), by area within the San Juan Islands (SiteType2), and by shoreline type (Table 8). For our coarser-scaled space and habitat type variables, sand lance density was influenced by encl/pass but not by int/ext.

Sand lance were present in shoreline habitats of the San Juan Islands throughout our study period (Figure 22, Panel B). Sand lance were most abundant in barrier beaches, bluff backed beaches, and pocket beaches (Figure 22, Panel D).

Juvenile- and adult-sized sand lance were found in shoreline habitats from March through June, but after June a new cohort of smaller (possibly young-of-the-year) sand lance dominated our catch (Figure 23).

Regression analysis revealed sand lance presence and density to be positively correlated in the San Juan Islands when beach seine sets were averaged by SiteType2 (Figure 24). Thus, shorelines in the San Juan Islands with higher sand lance presence rates also had higher numbers of sand lance. The regression relation is a power function.

Table 8. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile Pacific sand lance density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	19.193	1	19.193	22.645	0.000
Month	9.817	1	9.817	11.582	0.001
SiteType2	4.980	1	4.980	5.876	0.015
Shoreline type	30.989	4	7.747	9.140	0.000
Int_Ext	1.700	1	1.700	1.978	0.160
Encl_Pass	12.406	1	12.406	14.435	0.000

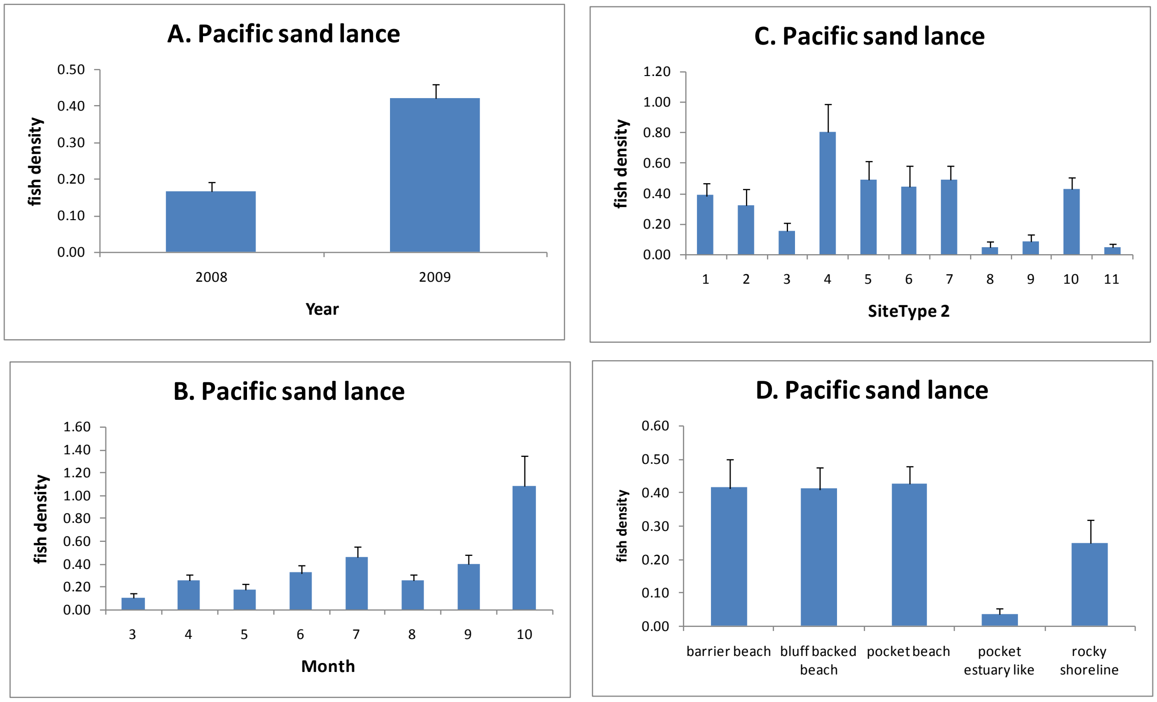

Figure 22. Relationship between average juvenile Pacific sand lance densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific SiteType2 codes (Panel C) are shown in Table 1 and Figure 2.

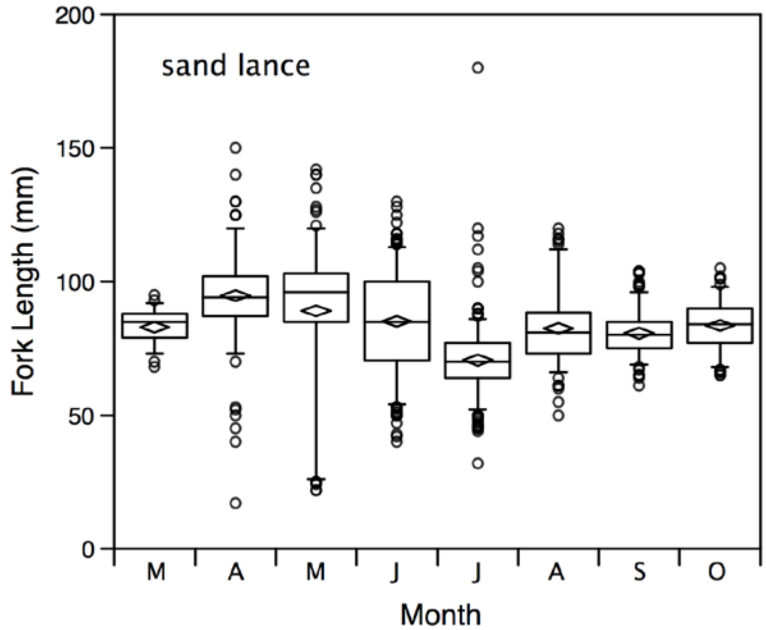

Figure 23. Box plot of fish size for Pacific sand lance caught in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25th and 75th percentiles. Whiskers show the 5th and 95th percentile. Circles are outliers.

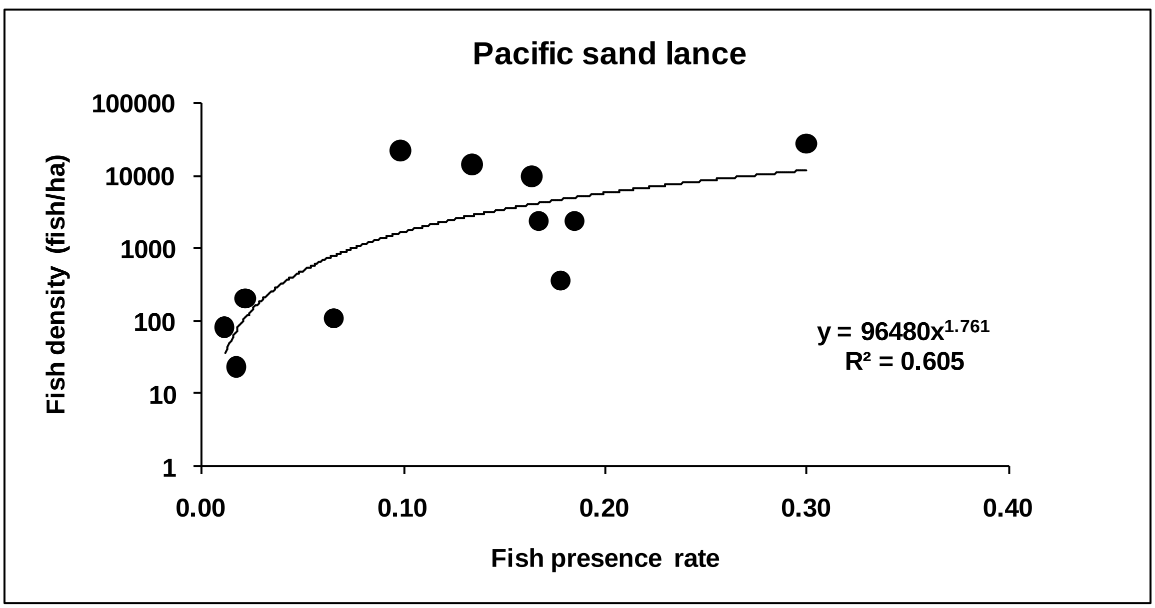

Figure 24. Correlation between presence and abundance of juvenile Pacific sand lance in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Lingcod and greenling

We combined lingcod and greenling catches as one group for abundance analyses because they are members of a single taxonomic family (Hexagrammidae). GLM testing for effects of fixed factors revealed log-transformed greenling/lingcod density was influenced by season (year and month), by area within the San Juan Islands (SiteType2), and by shoreline type (Table 9). For our coarser-scaled space and habitat type variables, greenling/lingcod density was influenced by encl/pass but not by int/ext.

Greenling/lingcod were present in shoreline habitats of the San Juan Islands throughout our study period, peaking in June and July (Figure 25, Panel B). Greenling/lingcod were most abundant in pocket beaches, but were relatively abundant in all shoreline types except pocket estuaries (Figure 25, Panel D).

Most greenling and lingcod caught were likely young-of-the-year juveniles from the previous winter (Figure 26). Greenling and lingcod each showed a steady seasonal increase in length.

Regression analysis revealed greenling/lingcod presence and density to be positively correlated in the San Juan Islands when beach seine sets werere averaged by SiteType2 (Figure 27). Thus, shorelines in the San Juan Islands with the greatest greenling/lingcod presence rates also had the greatest abundance of greenling/lingcod. The regression relation is a power function.

Table 9. ANOVA results from Generalized Linear Model effects testing for log-transformed juvenile lingcod and greenling density.

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Year	11.435	1	11.435	10.025	0.002
Month	14.658	1	14.658	12.850	0.000
SiteType2	12.254	1	12.254	10.742	0.001
Shoreline type	172.241	4	43.060	37.749	0.000
Int_Ext	0.290	1	0.290	0.256	0.613
Encl_Pass	162.233	1	162.233	143.124	0.000

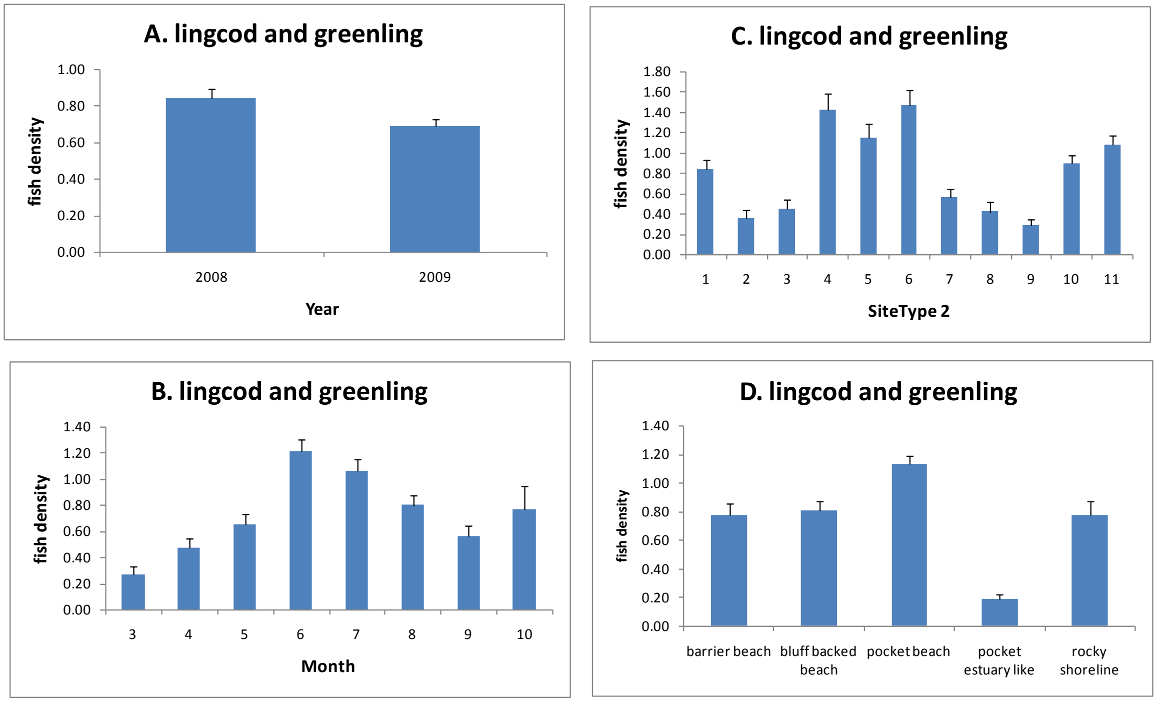

Figure 25. Relationship between average juvenile lingcod and greenling densities (log-transformed fish per hectare) and year (Panel A), month (Panel B), SiteType2 (Panel C), and shoreline type (Panel D). Results are from 80 beach seine sites throughout the San Juan Islands in 2008 and 2009. Error bars are standard error. A description and location of the areas within the San Juan Islands coinciding to specific Sitetype2 codes (Panel C) are shown in Table 1 and Figure 2.

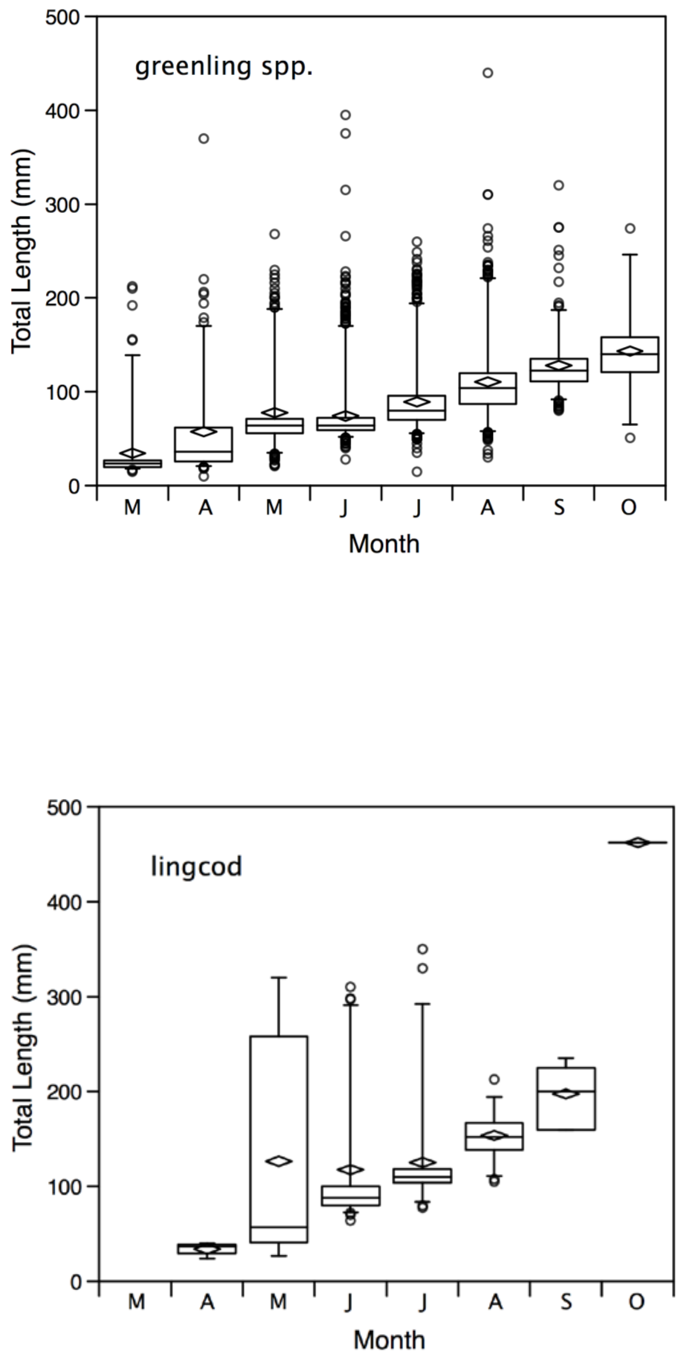

Figure 26. Box plot of fish size for greenling (top panel) and juvenile lingcod (bottom panel) in shoreline habitats of the San Juan Islands, 2008-2009. Diamonds are means, and boxes show median, 25^{th} and 75^{th} percentiles. Whiskers show the 5^{th} and 95^{th} percentile. Circles are outliers.

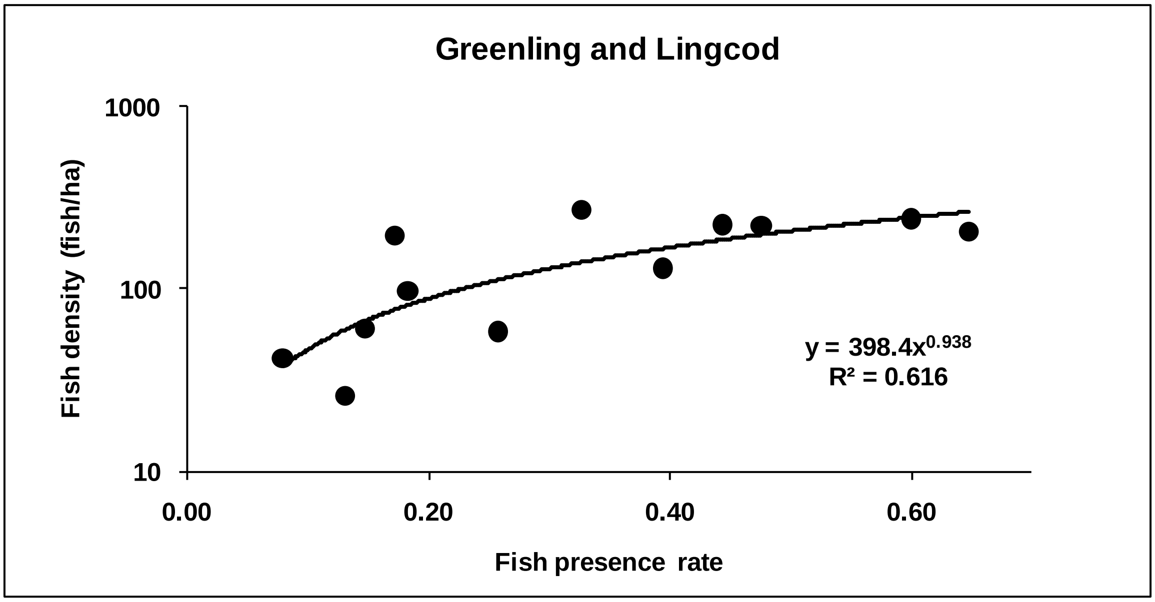

Figure 27. Correlation between presence and abundance of juvenile lingcod and greenling in San Juan Islands shoreline habitats when beach seine sets are averaged by SiteType2.

Fish Probability of Presence Mapping

Chinook salmon

The estimated values of wild juvenile Chinook salmon presence probability ranged from 0.027 to 0.625, a 23-fold difference (Table 10). Two of the eleven SiteType2s had juvenile Chinook salmon in caught at all sites. Pocket beaches had the highest juvenile Chinook salmon presence rate, while pocket estuaries had the lowest.

Table 10. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of wild (unmarked) juvenile Chinook salmon. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
		HRM Fish presence rate:	**0.273**	**0.389**	**0.625**	**0.190**	**0.250**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.286**	0.078	0.111	0.179	0.054	0.071
	Str Juan de Fuca - San Juan Is	**0.429**	0.117	0.167	0.268	0.082	0.107
	Haro Strait NE	**0.444**	0.121	0.173	0.278	0.085	0.111
	Waldron Is - President Channel	**1.000**	0.273	0.389	*0.625*	0.190	0.250
	Rosario NW	**0.500**	0.136	0.194	0.313	0.095	0.125
	Rosario Strait SW	**1.000**	0.273	0.389	*0.625*	0.190	0.250
	Blakely Sound - Lopez Sound	**0.250**	0.068	0.097	0.156	0.048	0.063
	East Sound	**0.500**	0.136	0.194	0.313	0.095	0.125
	Deer Harbor - West Sound	**0.143**	0.039	0.056	0.089	*0.027*	0.036
	San Juan Channel South	**0.167**	0.045	0.065	0.104	0.032	0.042
	San Juan Channel North	**0.375**	0.102	0.146	0.234	0.071	0.094

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.258**	**0.451**
Interior	**0.227**	*0.059*	0.102
Exterior	**0.553**	0.143	*0.249*

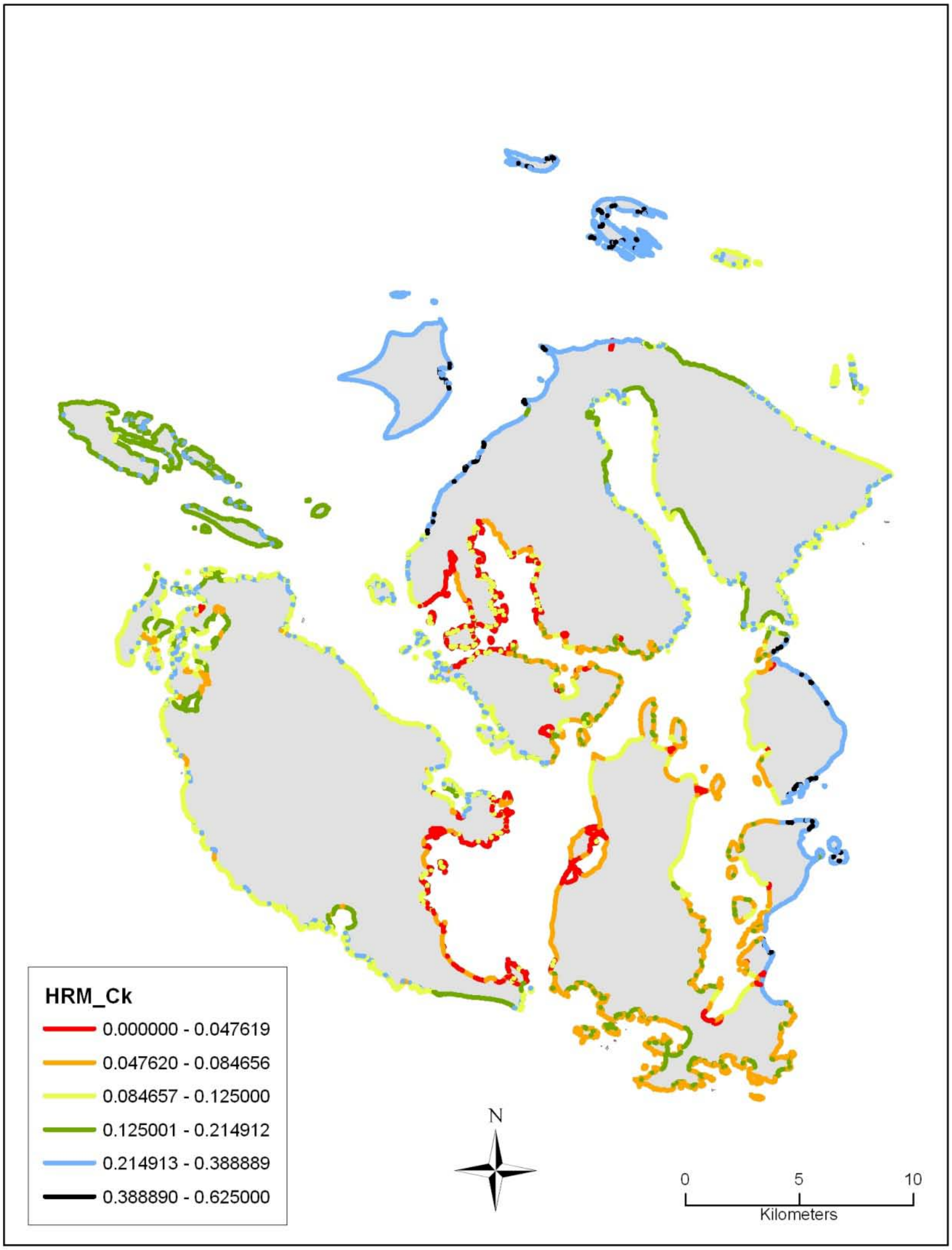

Figure 28. Fish presence probability for wild (unmarked) juvenile Chinook salmon for shoreline habitats (high resolution model).

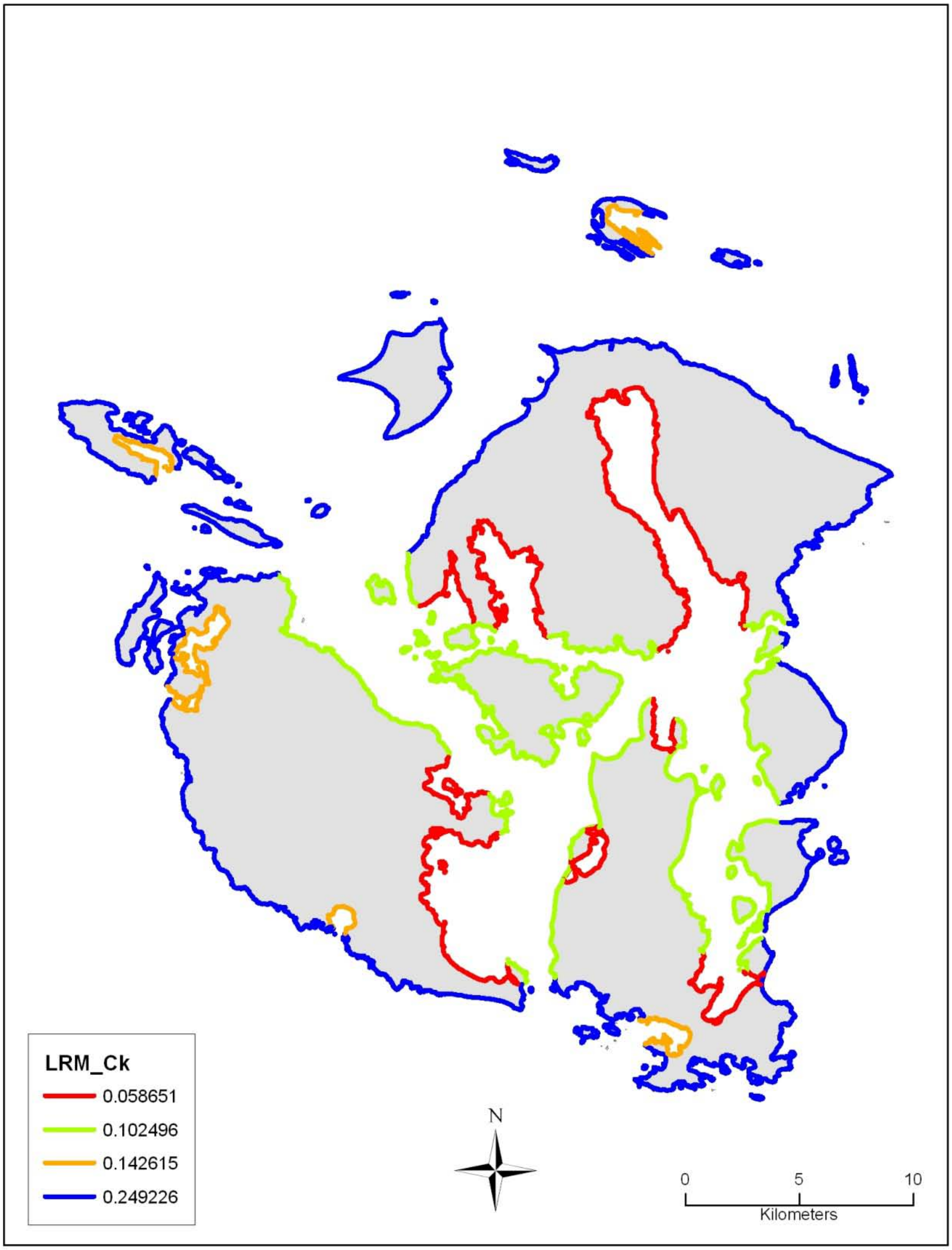

Figure 29. Fish presence probability for wild (unmarked) juvenile Chinook salmon for shoreline habitats (low resolution model).

Chum salmon

The estimated values of juvenile chum salmon presence probability ranged from 0.152 to 0.960, a 6-fold difference (Table 11). Three of the eleven SiteType2s had chum caught at all sites. All remaining SiteType2s – except Blakely Sound / Lopez Sound – had relatively high (0.500 or greater) fish presence rates. Pocket beaches had the highest juvenile chum salmon presence rate.

Table 11. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile chum salmon. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
		HRM Fish presence rate:	**0.364**	**0.722**	**0.960**	**0.450**	**0.750**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.857**	0.312	0.619	0.823	0.386	0.643
	Str Juan de Fuca - San Juan Is	**0.667**	0.242	0.481	0.640	0.300	0.500
	Haro Strait NE	**0.556**	0.202	0.401	0.533	0.250	0.417
	Waldron Is - President Channel	**1.000**	0.364	0.722	*0.960*	0.450	0.750
	Rosario NW	**1.000**	0.364	0.722	*0.960*	0.450	0.750
	Rosario Strait SW	**1.000**	0.364	0.722	*0.960*	0.450	0.750
	Blakely Sound - Lopez Sound	**0.417**	*0.152*	0.301	0.400	0.188	0.313
	East Sound	**0.500**	0.182	0.361	0.480	0.225	0.375
	Deer Harbor - West Sound	**0.571**	0.208	0.413	0.549	0.257	0.429
	San Juan Channel South	**0.500**	0.182	0.361	0.480	0.225	0.375
	San Juan Channel North	**0.889**	0.323	0.642	0.853	0.400	0.667

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.477**	**0.921**
Interior	**0.568**	*0.271*	0.523
Exterior	**0.816**	0.389	*0.751*

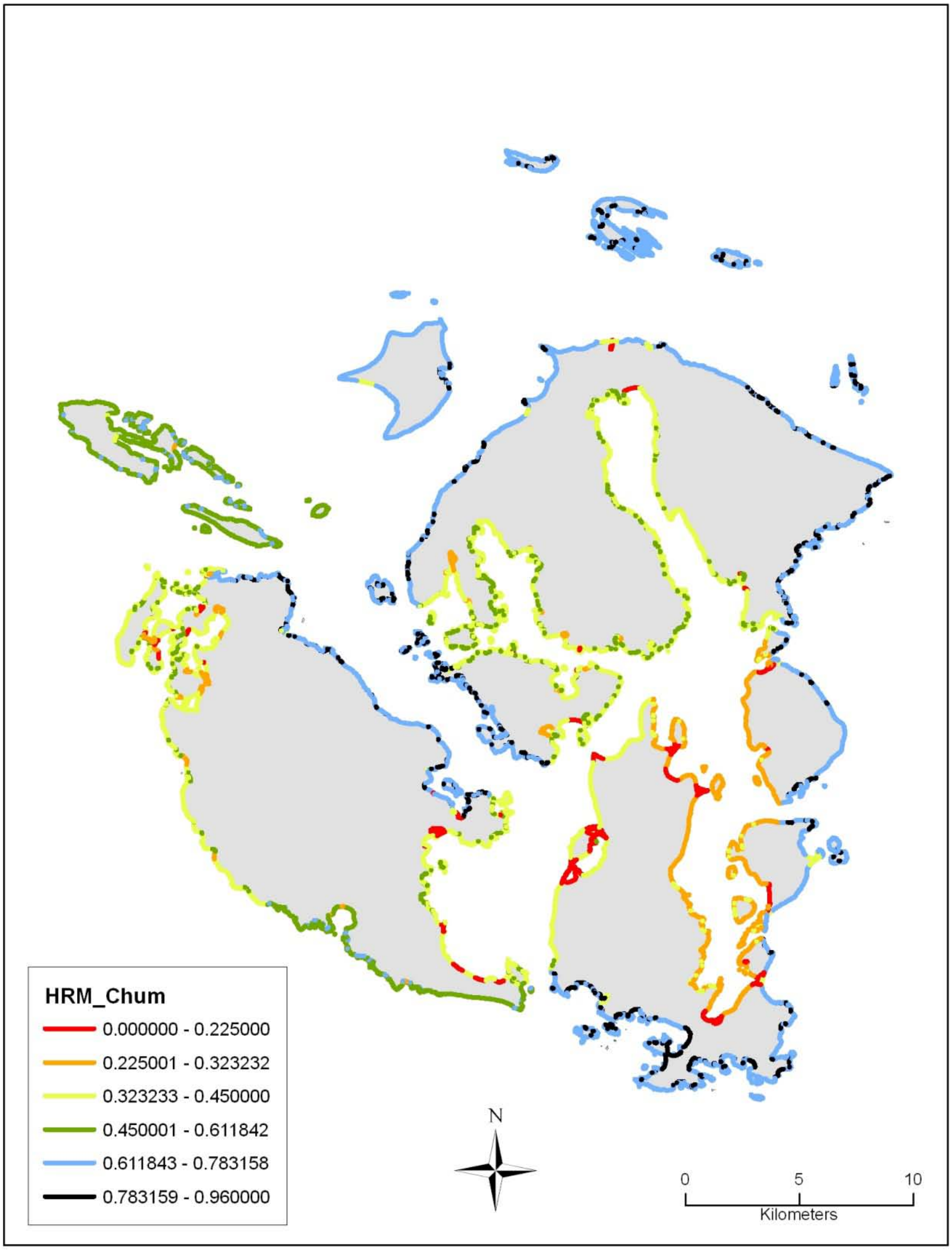

Figure 30. Fish presence probability for juvenile chum salmon for shoreline habitats (high resolution model).

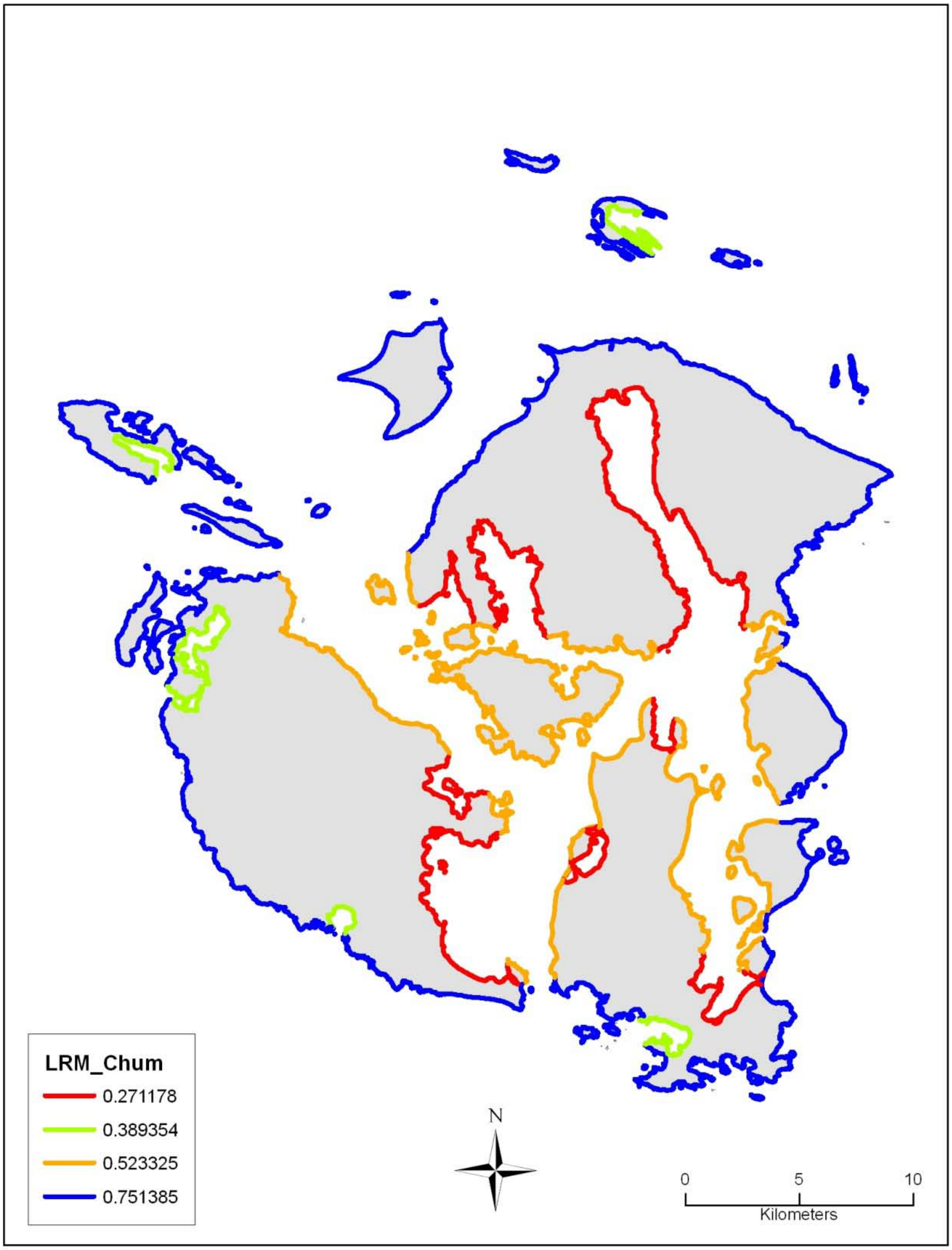

Figure 31. Fish presence probability for juvenile chum salmon for shoreline habitats (low resolution model).

Pink salmon

The estimated values of juvenile pink salmon presence probability ranged from 0.07 to 0.857, a 12-fold difference (Table 12). All but one SiteType2 (Haro Strait NE) had high (0.500 or greater) juvenile pink salmon presence rates. Pocket beaches, bluff backed beaches, and rocky shorelines had the highest juvenile pink salmon presence rates.

Table 12. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile pink salmon. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
	HRM Fish presence rate:		**0.545**	**0.800**	**0.818**	**0.421**	**0.857**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**1.000**	0.545	0.800	0.818	0.421	*0.857*
	Str Juan de Fuca - San Juan Is	**0.500**	0.273	0.400	0.409	0.211	0.429
	Haro Strait NE	**0.167**	0.091	0.133	0.136	*0.070*	0.143
	Waldron Is - President Channel	**1.000**	0.545	0.800	0.818	0.421	*0.857*
	Rosario NW	**0.667**	0.364	0.533	0.545	0.281	0.571
	Rosario Strait SW	**1.000**	0.545	0.800	0.818	0.421	0.857
	Blakely Sound - Lopez Sound	**0.545**	0.298	0.436	0.446	0.230	0.468
	East Sound	**0.500**	0.273	0.400	0.409	0.211	0.429
	Deer Harbor - West Sound	**0.714**	0.390	0.571	0.584	0.301	0.612
	San Juan Channel South	**0.636**	0.347	0.509	0.521	0.268	0.545
	San Juan Channel North	**0.875**	0.477	0.700	0.716	0.368	0.750

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.558**	**0.839**
Interior	**0.714**	0.399	*0.599*
Exterior	**0.641**	*0.358*	0.538

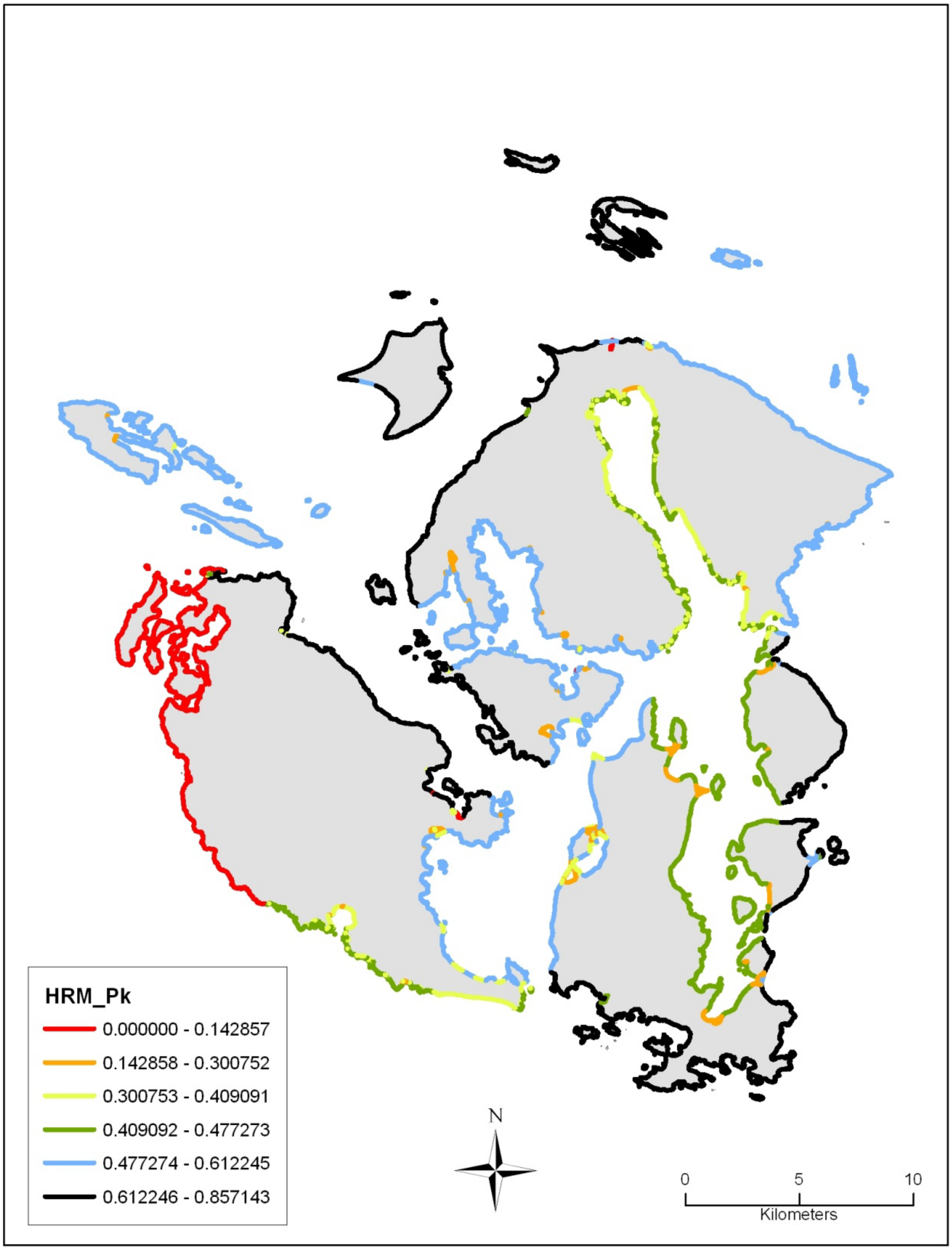

Figure 32. Fish presence probability for juvenile pink salmon for shoreline habitats (high resolution model).

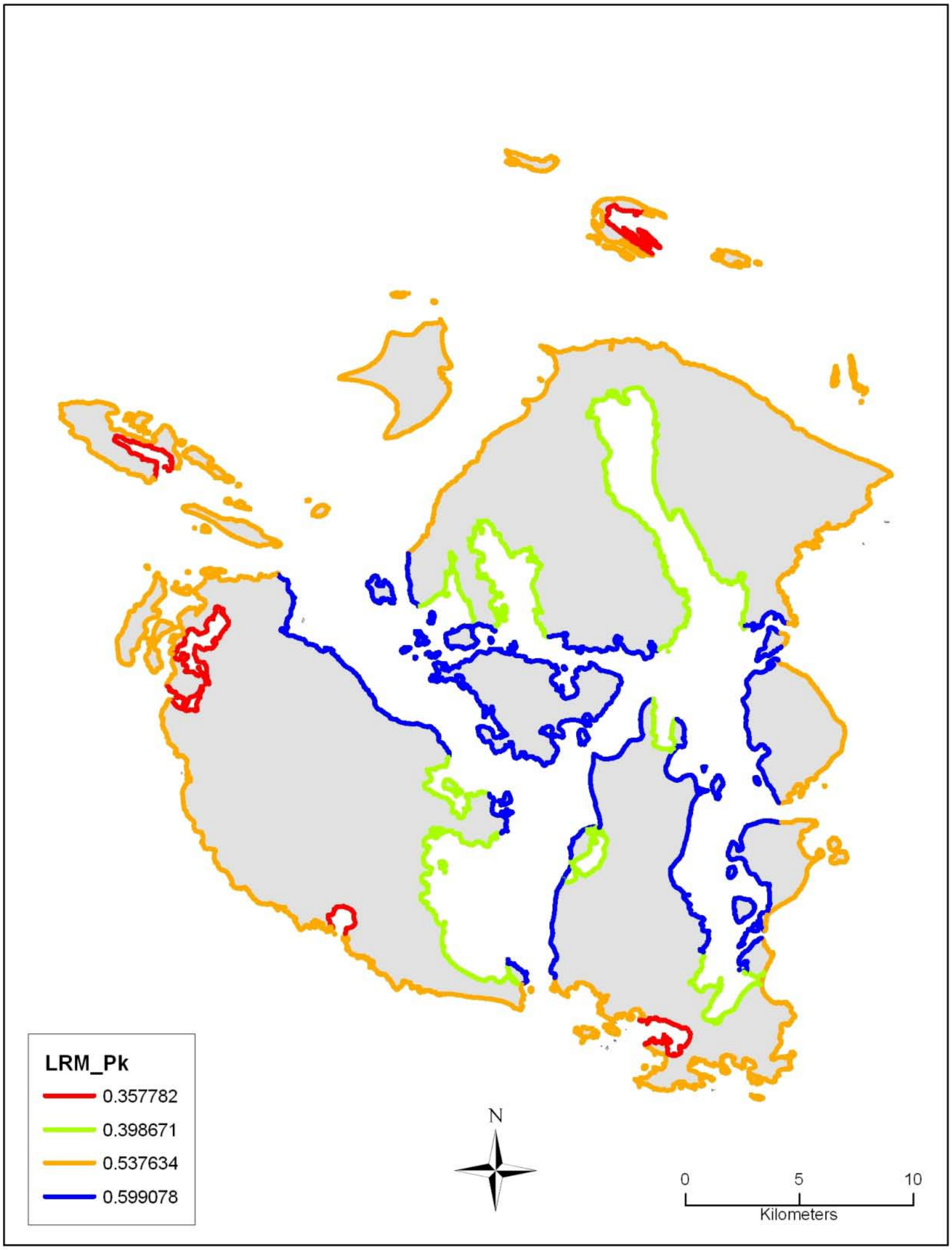

Figure 33. Fish presence probability for juvenile pink salmon for shoreline habitats (low resolution model).

Pacific herring

The estimated values of Pacific herring presence probability ranged from zero (0.000) to 0.625 (Table 13). One SiteType2 (Waldron-President Channel) had herring caught at all its sites, while no herring were caught in the San Juan Channel North area. Pocket estuaries had the lowest fish presence rate by shoreline type. The highest herring presence rate was in pocket beaches.

Table 13. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile Pacific herring. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
		HRM Fish presence rate:	**0.250**	**0.389**	**0.625**	**0.200**	**0.375**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.429**	0.107	0.167	0.268	0.086	0.161
	Str Juan de Fuca - San Juan Is	**0.167**	0.042	0.065	0.104	0.033	0.063
	Haro Strait NE	**0.444**	0.111	0.173	0.278	0.089	0.167
	Waldron Is - President Channel	**1.000**	0.250	0.389	*0.625*	0.200	0.375
	Rosario NW	**0.667**	0.167	0.259	0.417	0.133	0.250
	Rosario Strait SW	**0.750**	0.188	0.292	0.469	0.150	0.281
	Blakely Sound - Lopez Sound	**0.417**	0.104	0.162	0.260	0.083	0.156
	East Sound	**0.333**	0.083	0.130	0.208	0.067	0.125
	Deer Harbor - West Sound	**0.429**	0.107	0.167	0.268	0.086	0.161
	San Juan Channel South	**0.308**	0.077	0.120	0.192	0.062	0.115
	San Juan Channel North	**0.000**	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.349**	**0.436**
Interior	**0.273**	*0.095*	0.119
Exterior	**0.526**	0.184	*0.229*

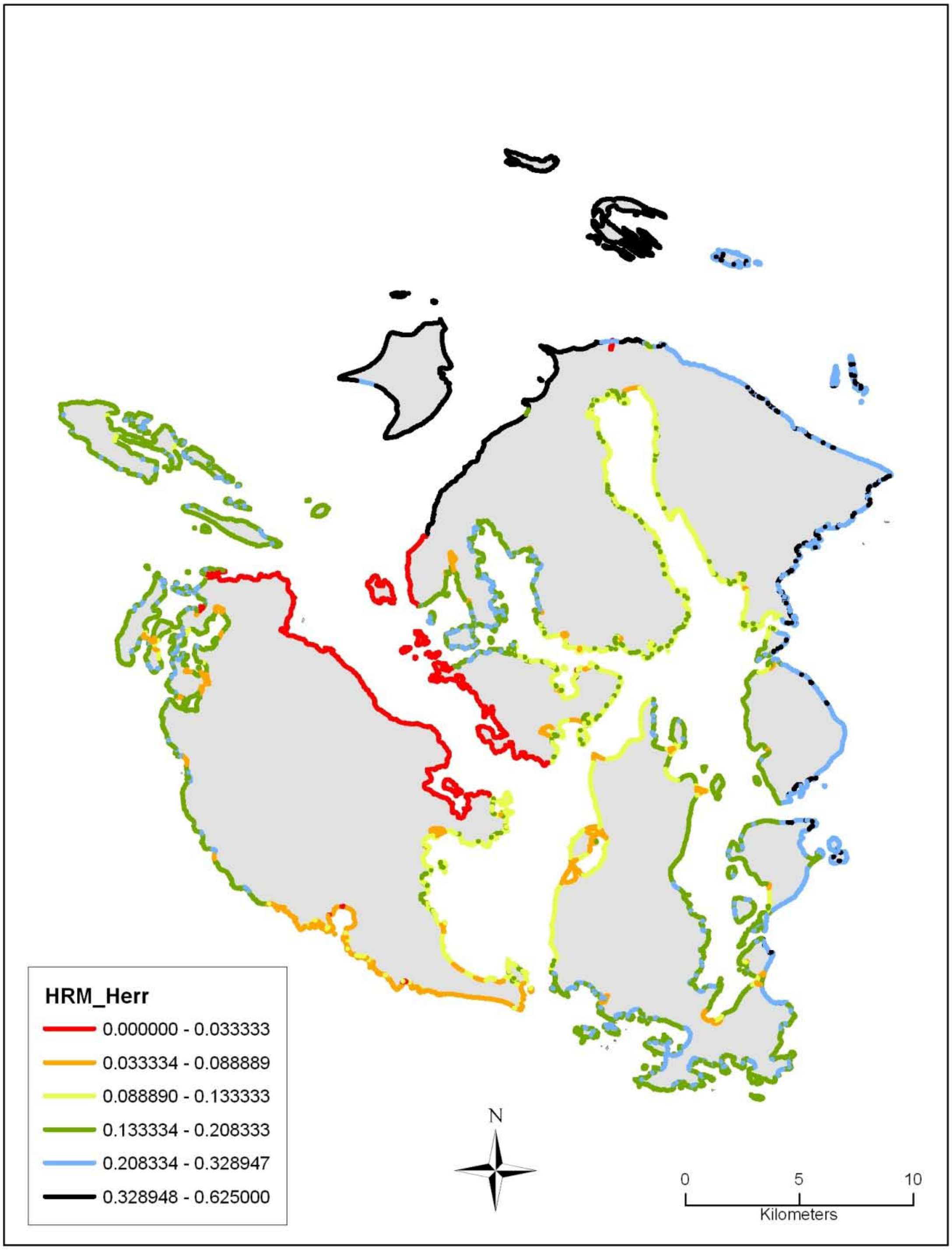

Figure 34. Fish presence probability for juvenile Pacific herring for shoreline habitats (high resolution model).

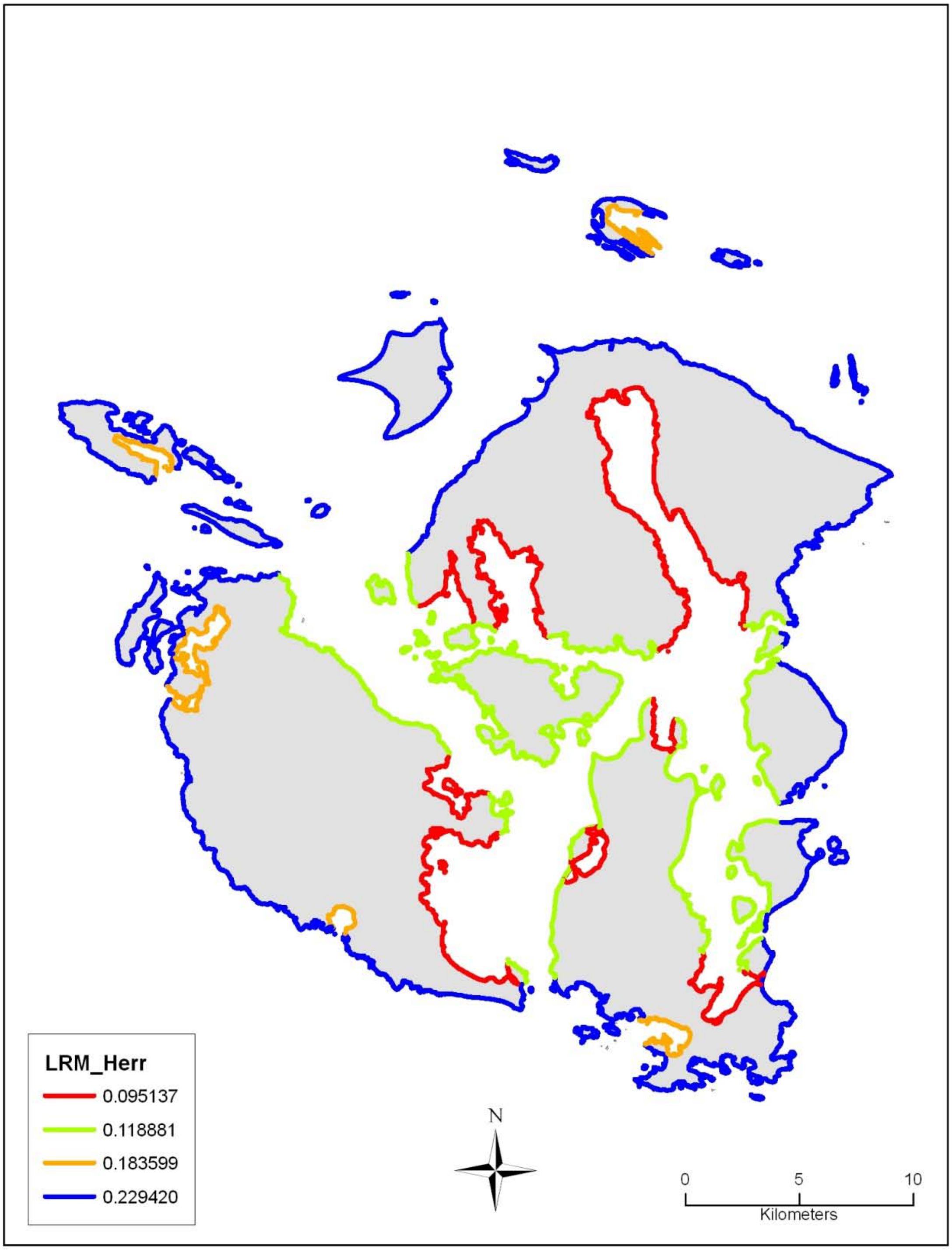

Figure 35. Fish presence probability for juvenile Pacific herring for shoreline habitats (low resolution model).

Surf smelt

The estimated values of surf smelt presence probability ranges from very low (0.021) to 0.545, more than a 26-fold difference (Table 14). The lowest surf smelt presence rates were in rocky shoreline while the highest rates were associated with barrier beaches. All other shoreline types had intermediate surf smelt presence rates.

Table 14. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile surf smelt. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
		HRM Fish presence rate:	**0.727**	**0.389**	**0.440**	**0.400**	**0.125**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.571**	0.416	0.222	0.251	0.229	0.071
	Str Juan de Fuca - San Juan Is	**0.167**	0.121	0.065	0.073	0.067	*0.021*
	Haro Strait NE	**0.444**	0.323	0.173	0.196	0.178	0.056
	Waldron Is - President Channel	**0.500**	0.364	0.194	0.220	0.200	0.063
	Rosario NW	**0.167**	0.121	0.065	0.073	0.067	*0.021*
	Rosario Strait SW	**0.750**	*0.545*	0.292	0.330	0.300	0.094
	Blakely Sound - Lopez Sound	**0.500**	0.364	0.194	0.220	0.200	0.063
	East Sound	**0.250**	0.182	0.097	0.110	0.100	0.031
	Deer Harbor - West Sound	**0.571**	0.416	0.222	0.251	0.229	0.071
	San Juan Channel South	**0.583**	0.424	0.227	0.257	0.233	0.073
	San Juan Channel North	**0.222**	0.162	0.086	0.098	0.089	0.028

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.548**	**0.353**
Interior	**0.409**	0.224	*0.144*
Exterior	**0.447**	*0.245*	0.158

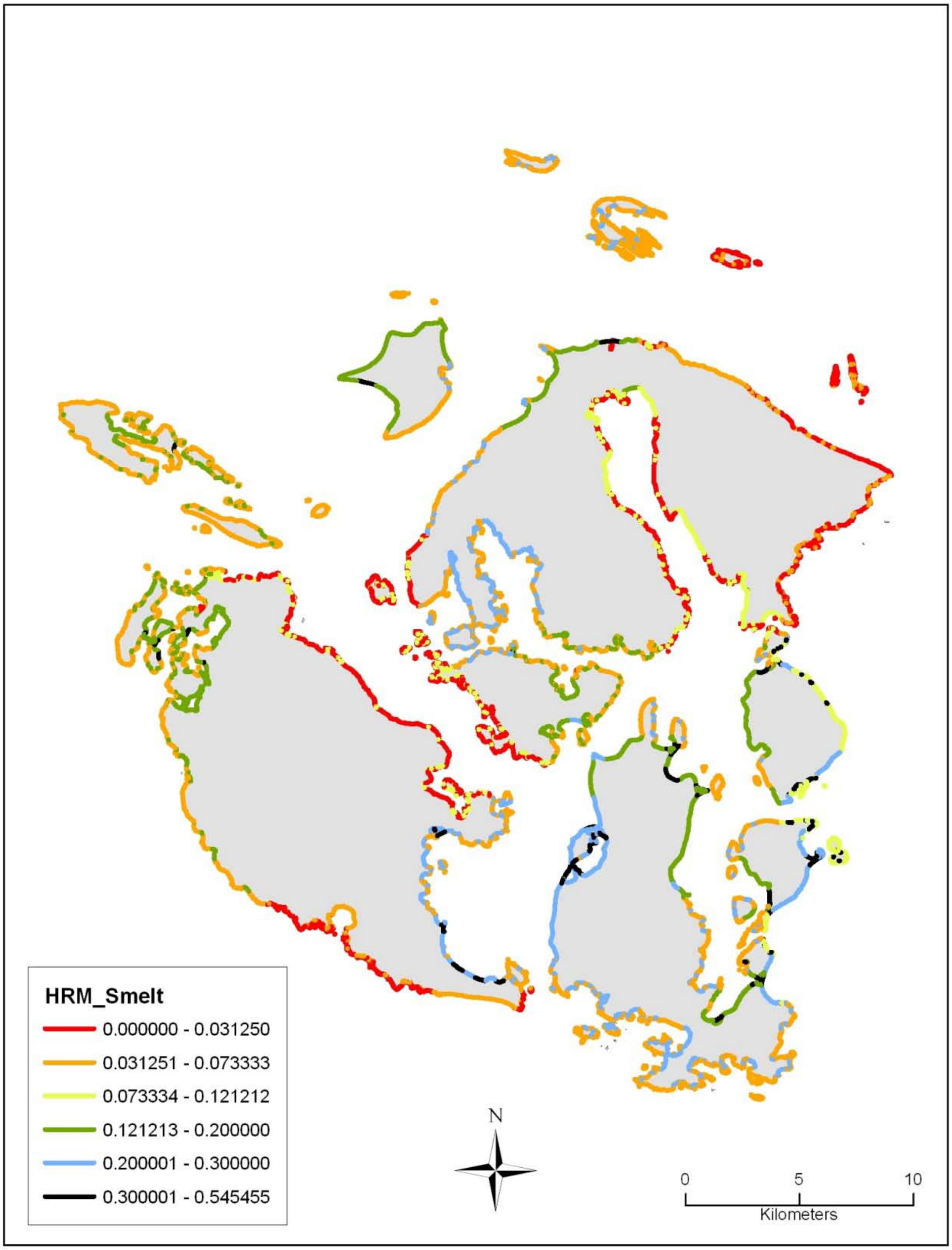

Figure 36. Fish presence probability for juvenile surf smelt for shoreline habitats (high resolution model).

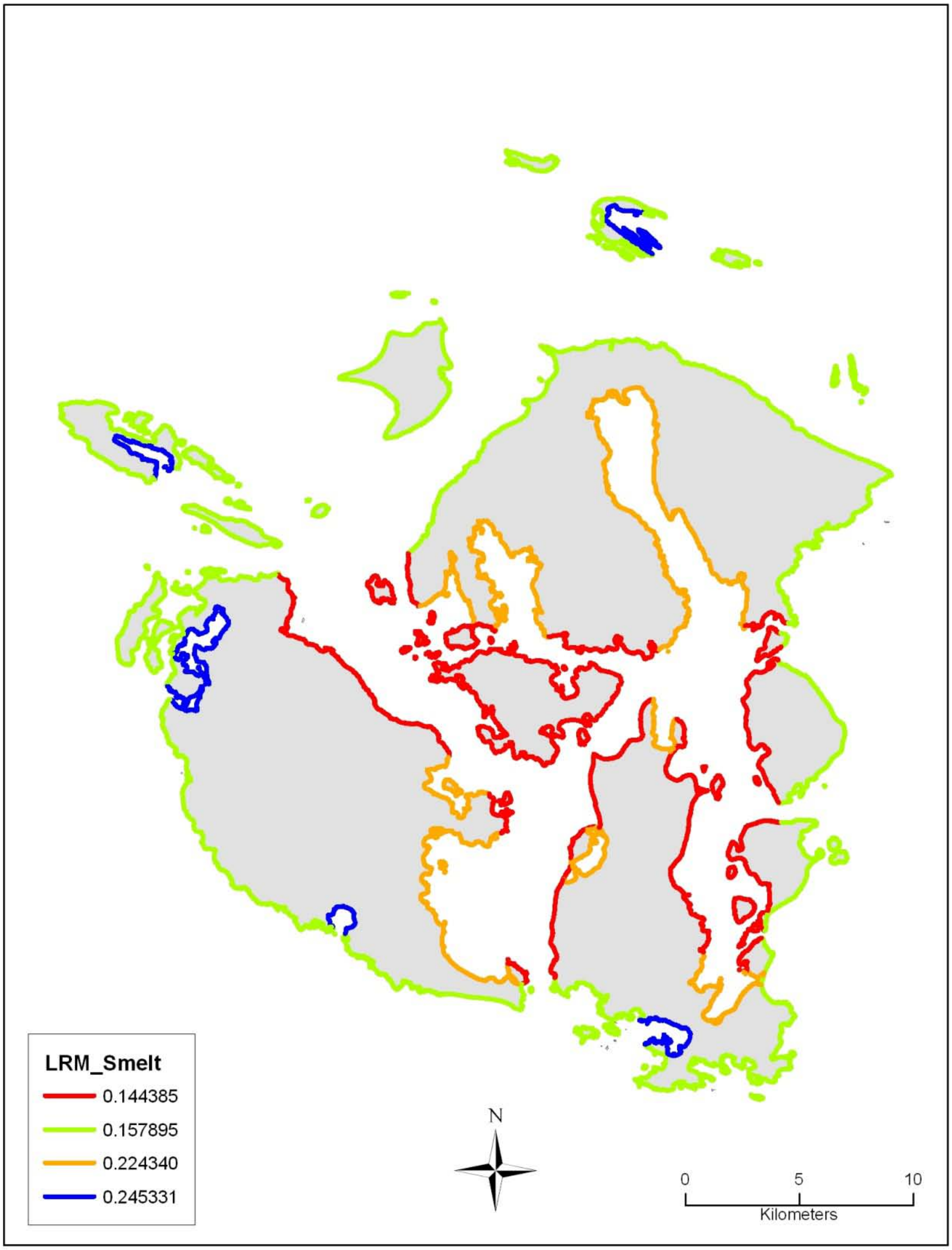

Figure 37. Fish presence probability for juvenile surf smelt for shoreline habitats (low resolution model).

Pacific sand lance

The estimated values of Pacific sand lance presence probability ranged from nearly zero (0.014) to 0.625, a 44-fold difference (Table 15). Two SiteType2s (Waldron-President Channel and Rosario NW) never caught sand lance. Pocket estuaries had the lowest fish presence rate.

Table 15. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile Pacific sand lance. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
	HRM Fish presence rate:		**0.455**	**0.556**	**0.600**	**0.100**	**0.625**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.286**	0.130	0.159	0.171	0.029	0.179
	Str Juan de Fuca - San Juan Is	**0.500**	0.227	0.278	0.300	0.050	0.313
	Haro Strait NE	**0.333**	0.152	0.185	0.200	0.033	0.208
	Waldron Is - President Channel	**1.000**	0.455	0.556	0.600	0.100	*0.625*
	Rosario NW	**0.667**	0.303	0.370	0.400	0.067	0.417
	Rosario Strait SW	**1.000**	0.455	0.556	0.600	0.100	*0.625*
	Blakely Sound - Lopez Sound	**0.333**	0.152	0.185	0.200	0.033	0.208
	East Sound	**0.250**	0.114	0.139	0.150	0.025	0.156
	Deer Harbor - West Sound	**0.143**	0.065	0.079	0.086	*0.014*	0.089
	San Juan Channel South	**0.667**	0.303	0.370	0.400	0.067	0.417
	San Juan Channel North	**0.333**	0.152	0.185	0.200	0.033	0.208

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.300**	**0.538**
Interior	**0.364**	*0.109*	0.196
Exterior	**0.553**	0.166	*0.298*

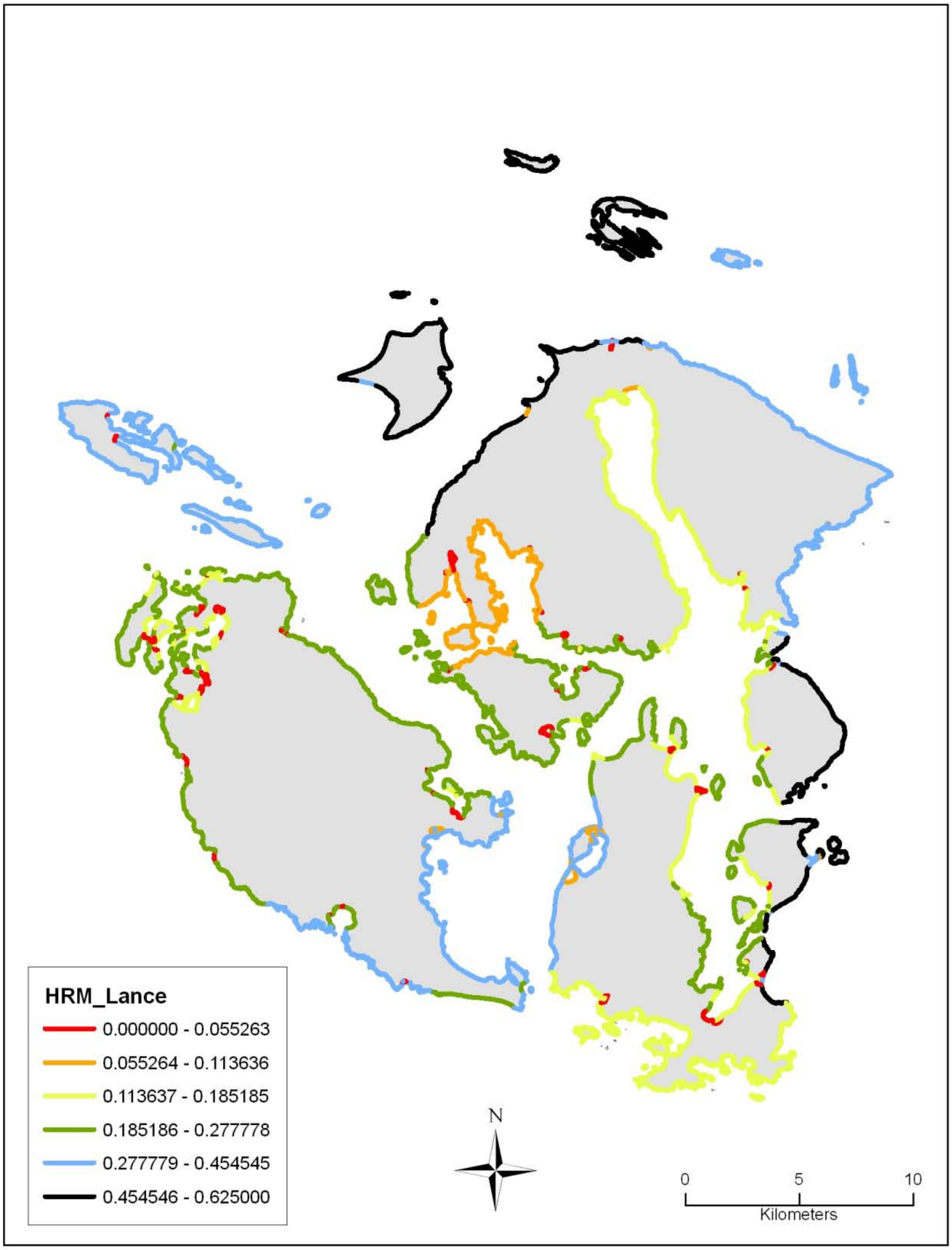

Figure 38. Fish presence probability for juvenile Pacific sand lance for shoreline habitats (high resolution model).

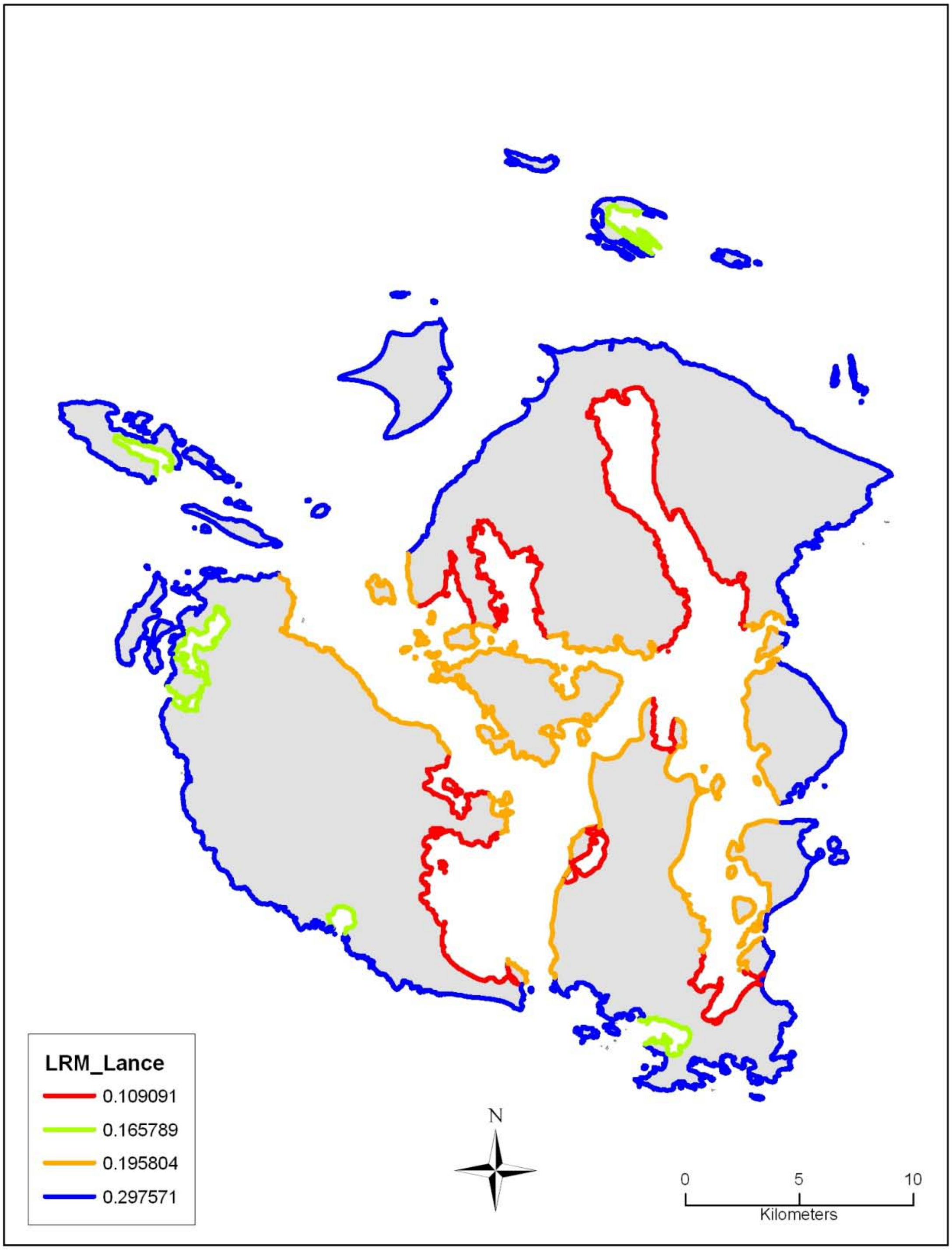

Figure 39. Fish presence probability for juvenile Pacific sand lance for shoreline habitats (low resolution model).

Lingcod and greenling

We combined lingcod and greenling as one group for fish presence results because they are members of a single taxonomic family (Hexagrammidae). The estimated values of lingcod/greenling presence probability ranged from 0.15 to 0.96, a 6-fold difference (Table 16). Nearly half of the SiteType2s had lingcod/greenling caught at all sites. Pocket beaches had the highest fish presence rate; all shoreline types - except pocket estuaries - had high (> 0.700) values.

Table 16. Fish probability of presence matrices for high (top table) and low (bottom table) resolution models of juvenile lingcod and greenling. Fish presence rate results are shown in bold. Indices of fish presence probability are not bolded. The maximum and minimum value for each model is in *italics*.

			SiteType3 (Shoreline Type)				
			barrier beach	**bluff backed beach**	**pocket beach**	**pocket estuary like**	**rocky shoreline**
	HRM Fish presence rate:		**0.727**	**0.833**	**0.960**	**0.450**	**0.875**
SiteType2	**Str Juan de Fuca - S Lopez Is**	**0.571**	0.416	0.476	0.549	0.257	0.500
	Str Juan de Fuca - San Juan Is	**0.333**	0.242	0.278	0.320	*0.150*	0.292
	Haro Strait NE	**0.667**	0.485	0.556	0.640	0.300	0.583
	Waldron Is - President Channel	**1.000**	0.727	0.833	*0.960*	0.450	0.875
	Rosario NW	**1.000**	0.727	0.833	*0.960*	0.450	0.875
	Rosario Strait SW	**1.000**	0.727	0.833	*0.960*	0.450	0.875
	Blakely Sound - Lopez Sound	**0.667**	0.485	0.556	0.640	0.300	0.583
	East Sound	**0.750**	0.545	0.625	0.720	0.338	0.656
	Deer Harbor - West Sound	**0.571**	0.416	0.476	0.549	0.257	0.500
	San Juan Channel South	**1.000**	0.727	0.833	*0.960*	0.450	0.875
	San Juan Channel North	**1.000**	0.727	0.833	*0.960*	0.450	0.875

		Enclosure	**Passage**
	LRM Fish presence rate:	**0.659**	**0.895**
Interior	**0.795**	0.524	*0.712*
Exterior	**0.737**	*0.486*	0.659

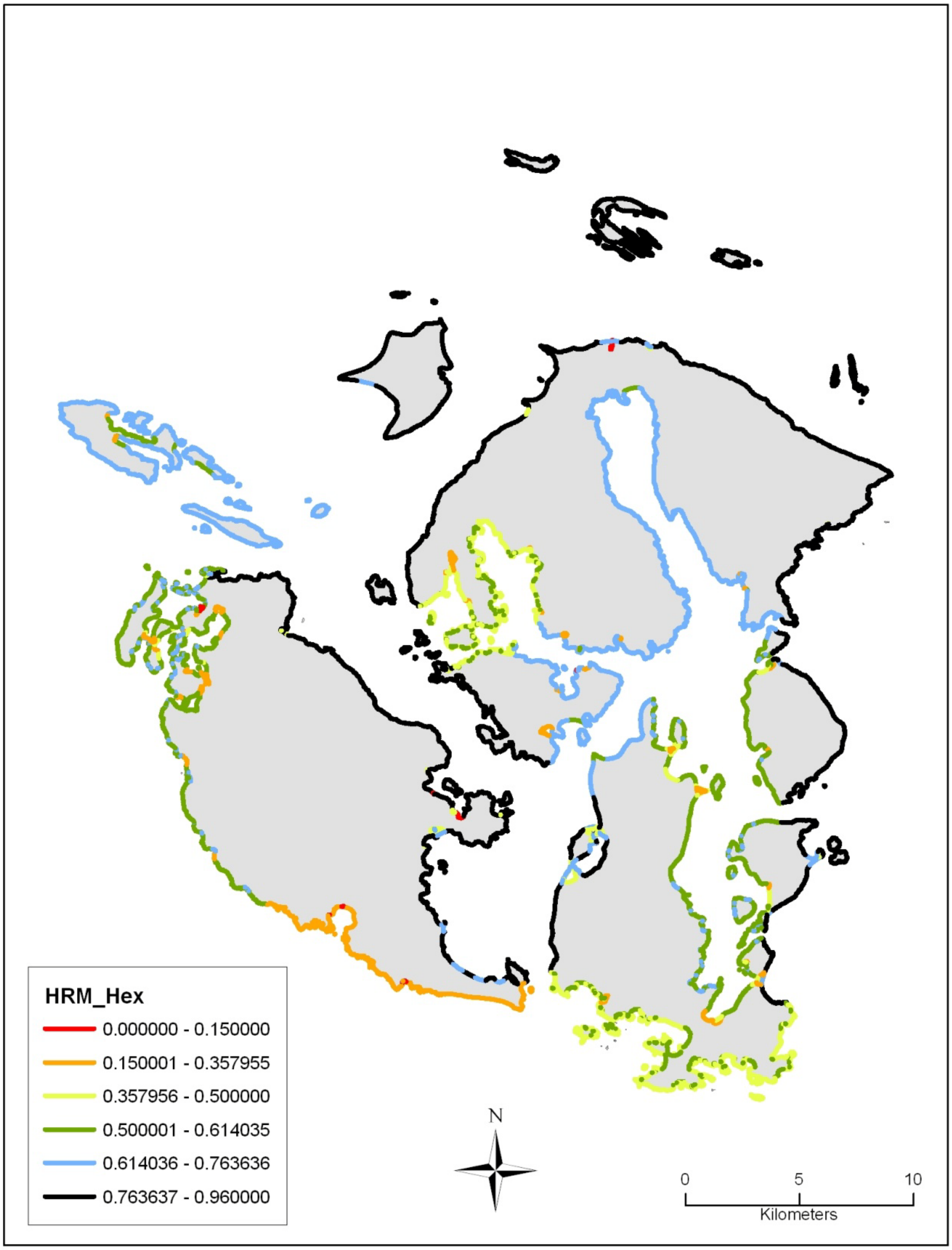

Figure 40. Fish presence probability for juvenile lingcod and greenling for shoreline habitats (high resolution model).

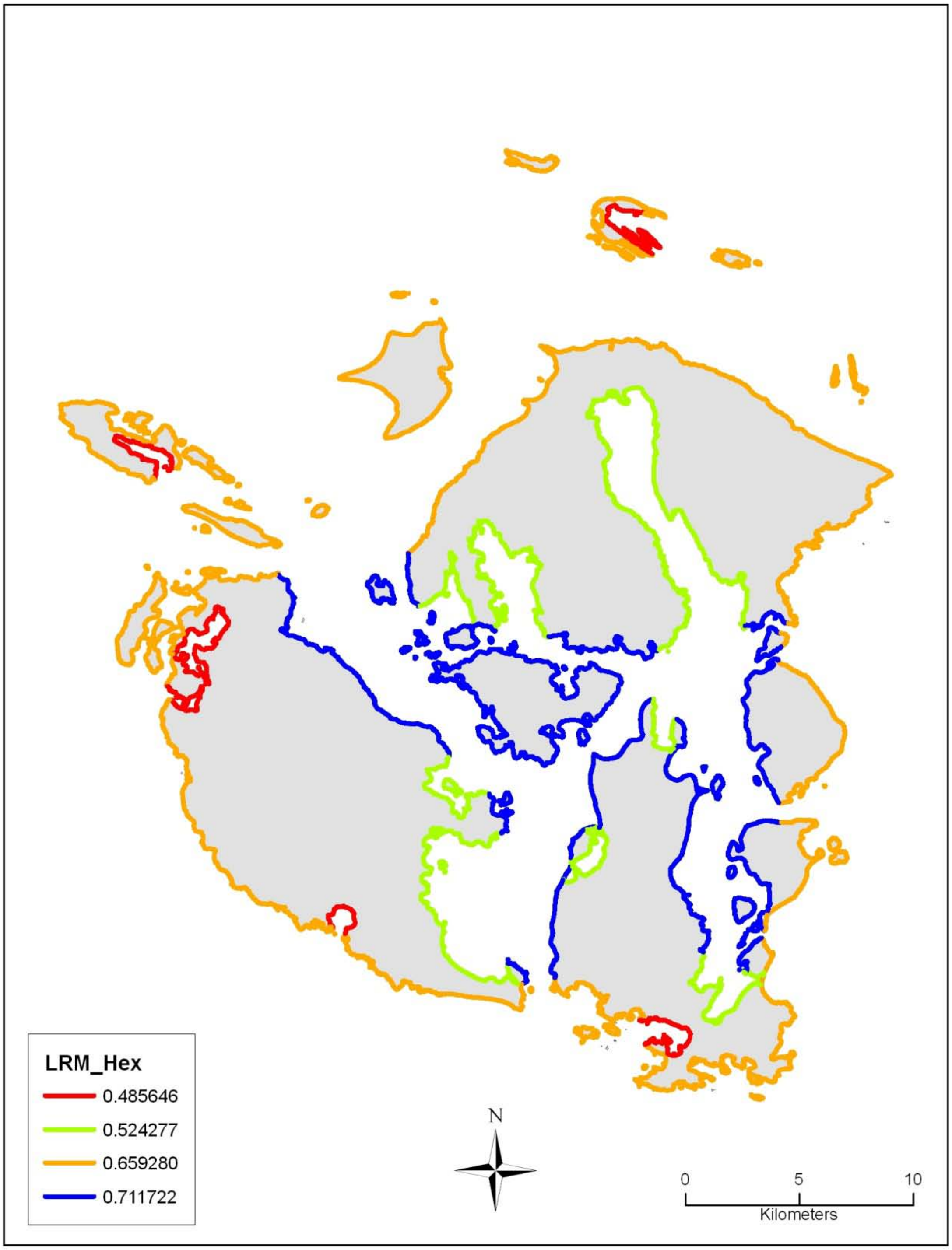

Figure 41. Fish presence probability for juvenile lingcod and greenling for shoreline habitats (low resolution model).

Discussion

Achieving study objectives

The primary objective of this research was to determine if we could define predictable relationships between habitat type and fish presence or abundance and, then convert these relationships into applications that could be used by shoreline planners to help identify places for fish species protection and restoration actions. Our hypothesis was that fish using shallow shoreline areas would vary in presence and abundance with habitat conditions as measured at different scales (shoreline type and place) and over time (month and year). We tested this for three species of juvenile salmon, three species of forage fish, and lingcod/greenling. We found, not unsurprisingly, that there were significant differences in fish density as a function of shoreline type and place (or both) for these seven species.Further, there were strong temporal signals for six of the seven species. For example, juvenile Chinook salmon were abundant from June to September while herring were primarily abundant in September-October. Surf smelt was the only species examined that did not exhibit statistically significant variation in monthly abundance. Smelt were abundant at similar levels throughout our sampling period. We found that fish density and fish presence were positively correlated but the strength of these relationships varied with species. This then allowed us to develop maps of fish presence based upon these factors. As we defined it, fish presence refers to the likelihood a particular species would be found in a particular shoreline type or place. Our maps (Figures 28 through 41) and accompanying tables (Tables 10 through 16) provide a relative sense of where a fish species is more likely to be found when viewed within the context of our sampling design.

Our maps of fish presence do not imply that if you sampled by beach seine one time between March and October at a barrier beach in East Sound that you would have a 13.6% chance of finding juvenile Chinook salmon (see Table 10). Rather, our results suggest that if you sampled according to our beach seine methods monthly from March to October in years like 2008 and 2009 that you would find juvenile Chinook salmon 13.6% of the time in East Sound barrier beaches. However, even though repeating our sampling years of 2008 and 2009 with their unique fish population sizes is not possible, relationships within years should be consistent regardless of the type of year. Thus, a better example use of our results in context would be:

- All shoreline types or areas in the San Juan Islands have a greater than zero probability of juvenile Chinook salmon presence (i.e., no values in Table 10 are zero), but some places in the San Juan Islands are up to 23 times higher in their fish presence value than the lowest value area in the San Juan Islands.
- The highest value places for juvenile Chinook presence are pocket beaches compared to other geomorphic shoreline types and the locations/landscape areas where you are least likely to find juvenile Chinook salmon are West Sound/Deer Harbor and San Juan Channel South (Table 10).
- If you sampled according to our beach seine methods monthly from March to October, the chance of finding juvenile Chinook at a barrier beach in East Sound would be twice that as at a barrier beach in Blakely Sound (Table 10).

Differences between high and low resolution fish presence models

Because of limitations in fish sampling effort, we created two model versions of fish presence probability to in order to provide indices of fish presence for all areas of the San Juan Islands. The high resolution model (HRM) is our best predictor of fish presence for areas with adequate fish sampling. The low resolution model (LRM) is a useful comparison to HRM results for areas without adequate fish sampling. The only estimate of fish presence for shorelines classified as "modified" in GIS is in the LRM. Each HRM has fish presence values for 55 different possibilities (11 SiteType2's by 5 SiteType3s) while each LRM has fish presence values for only four different possibilities (2 exterior/interior values by 2 enclosure/passage values) (see Tables 10 through 16). Thus, the LRM fish presence ranges are always smaller than the HRM fish presence ranges. Also, the low side of the LRM range is always higher than low side of the HRM range while the high side of the LRM range is always lower than high side of the HRM range.

The coarse spatial variable (interior/exterior), while a statistically significant for mean fish abundance, over simplifies fish spatial patterns within the San Juan Islands compared to our higher resolution spatial variable (SiteType2) and based on our fish migration pathway hypotheses (see later discussion on juvenile salmon and forage fish). The same appears true for shoreline habitat type. The five shoreline types (SiteType3) are better at explaining mean fish abundance than enclosure/passage. Thus, we do not recommend use of the LRM results except for: a) shorelines classified as "modified" and b) spatial areas where inadequate fish sampling occurred. The areas with inadequate fish sampling are:

- Blind Bay, and Stuart – Spieden Islands (SiteType2s with no fish sampling as a part of our study),
- Upright Channel (a SiteType2 with inadequate fish sampling during our study, see Table 1), and
- Matia, Sucia, and Patos Island area (an area classified within two different SiteType2s that were adequately sampled for fish during our study, but are very distant from the actual sampling sites, see Figure 4).

Study limitations

Nearshore habitats are considered to provide at least three general ecological functions for juvenile salmon: 1) refuge from predators, 3) a place for feeding and high growth rates, and 3) pathway for fish to move from their natal river to ocean rearing areas (after Simenstad et al. 1982). Shoreline habitats may provide similar functions for forage fish species. In addition, shoreline habitats provide a direct role in reproduction because of the intertidal (surf smelt and sand lance) or shallow subtidal (herring) spawning nature of forage fish. Shallow shoreline habitats may provide a nursery function to greenling and lingcod populations based on their seasonal abundance patterns observed in our study. Clearly, additional studies and analyses would be required more explicitly link fish abundance and occurrence levels to the functional uses described above.

We did not directly measure how fish "used" any particular habitat type or place in the San Juan Islands. For example, we did not measure diet, residence time, or growth rates of individual fish in a particular place or habitat type. Thus, we do not know solely based on results from our study if changes in fish abundance or presence also infer a change in the functional value of shoreline habitats. For example, are places with higher fish presence or abundance also places with a higher level of a particular ecological function or places with more ecological functions?

Many studies, for a wide variety of species, suggest that abundance or occurrence of a species in a place can be correlated with use or value of that place. For example, Dunlin – a wading shorebird species – are more abundant on intertidal mudflats when they are foraging compared to other habitat types because these places provide abundant and high quality food but roosting Dunlin favor other habitat types (Mouritsen 1994; Warnock 1996; Shepherd and Lank 2004). An obvious salmon example is aggregations of fish in a spawning areas such as a particular channel type that provides optimal characteristics for reproductive success in the face of naturally occurring disturbances such as stream bed mobilizing flood events (Montgomery et al. 1999). Another example is juvenile coho salmon, which rear primarily in pools in streams and are rarely found in riffles or glides (Sandercock 1991).

Likewise, we hypothesize shoreline areas within the San Juan Islands with higher ecological function for a fish species are also areas where that particular fish species is more abundant (or more frequently occurring). Our study is a good first step in documenting the temporal and spatial variability of fish abundance and presence throughout the San Juan Islands and does support our ecological function hypothesis in several simplistic ways.

We found fish are directly living in shallow shoreline areas of the San Juan Islands. At the risk of stating the obvious – we caught many fish rather than the opposite (no fish). At the population level, fish are directly occupying shallow shoreline habitats for periods of months (or longer) and not days, suggesting that functions related to foraging and survival will be important to individuals. Our fish timing curve results (Figures 7D, 10D, 13D, 16D, 19D, 22D, 25D) demonstrate how long each species' population is present in shallow shoreline habitats of the San Juan Islands and thus exposed to beneficial resources (and threats) provided by shoreline habitats. We argue later in this report why certain shoreline types may (pocket beaches) or may not (pocket estuaries) exhibit high abundance or presence values for juvenile Chinook salmon. For juvenile salmon, we also show that shallow shorelines of the San Juan Islands are being used as a migratory pathway and that places with higher abundance or presences rates are likely along more heavily used pathways. As stated later in this report, proximity to salmon bearing rivers is consistent with our spatially explicit results for juvenile salmon.

Individual Fish Species

Chinook salmon

Because Chinook salmon are federally protected in Puget Sound, a major focus of our work was on Chinook salmon. Streams in the San Juan Islands are too small to be used by Chinook salmon for spawning and the proximity of the islands' shoreline are not immediately adjacent to any major Chinook salmon bearing river (Figure 1). Thus, the San Juan Salmon Recovery Plan (WRIA 2 TAG 2005) hypothesized:

- Early outmigrant life history stages of Chinook salmon are not likely to be found in shoreline habitats of the San Juan Islands.
- Timing of juvenile Chinook salmon within the San Juan Islands is likely to be later than in mainland nearshore areas.

Both hypotheses were largely confirmed by our study. Very few fry sized ($\leq$ 50 mm) Chinook salmon were caught in our sampling effort (Figure 8) and the arrival time of juvenile Chinook salmon in shallow shoreline habitats of the San Juan Islands was April (Figure 7B), several months later than in nearshore areas adjacent to Chinook bearing river systems (e.g., Beamer et al. 2005).

Juvenile wild Chinook salmon were most abundant in bluff backed and pocket beaches of the San Juan Islands, but not in pocket estuaries, with the pocket beaches in the Waldron and Rosario SW areas having the greatest occurrence and abundance of juvenile Chinook salmon. All combinations of shore types and place had a greater than zero probability that Chinook salmon would be present which suggests that juvenile Chinook salmon can potentially use any shallow shoreline in the San Juan Islands. The 23 fold difference in juvenile Chinook salmon presence probability based on the different shoretype/place combinations suggests that certain places within the San Juan Islands are more likely to support juvenile Chinook salmon than others.

The low catches of juvenile Chinook salmon associated with pocket estuaries in the San Juan Islands were different than observations for juvenile Chinook salmon in shoreline habitat nearer to natal river systems where pocket estuaries are high abundance areas, especially late winter through early spring periods (Beamer et al 2006). In pocket estuaries located near Chinook salmon bearing river systems, fry sized juveniles colonize pocket estuary habitats where they are thought to have a growth/survival (Beamer et al 2003) and osmoregulatory (Beamer et al 2009) advantage compared to adjacent nearshore habitats.

The lack of juvenile Chinook in pocket estuary habitats of the San Juan Islands may be in response to the distance from Chinook salmon bearing river systems. Logically, salmon fry can only occur early in the year (late winter and early spring) before they outgrow that life stage. By the time juvenile Chinook arrived in the San Juan Islands they were typically larger than fry sized. Also, juvenile Chinook salmon arrived in the San Juan Islands on the late side of the pocket estuary use period known to exist in other nearshore areas (e.g., the Whidbey Basin: Jan/Feb through May/June).

Thus, we suggest that pocket estuary habitats in the San Juan Islands do not provide direct habitat use for fry migrant Chinook salmon because the fish that move into the San Juan Islands are too large and arrive too late in the year to need this type of habitat. In essence, juvenile Chinook have already outgrown their need for this type of habitat by the time they reach the San Juan Islands. This may be purely a geographic issue (distance to natal rivers with large numbers of migrant fry) or may be a geographic and current population status issue (e.g., the natal river systems nearest to the San Juan Islands are currently producing low numbers of fry migrants). We point out the potential population status issue because population status can change while geographic position does not change. Certainly, Puget Sound Chinook populations are at less than desired levels. Actions to improve their status are being implemented which may increase migrant Chinook fry populations in the future.

Pink and Chum Salmon

The other two juvenile salmon species analyzed in this report, pink and chum salmon, were more abundant than Chinook salmon and were also present earlier in the year than juvenile Chinook salmon. Pink salmon do not spawn in streams within the San Juan Islands and only limited spawning by chum salmon is possible within the San Juan Islands, so most fish we captured are from other, more distant sources. We speculate that many of the pink and chum salmon are from Canadian sources such as the Fraser River and possibly Vancouver Island streams. Potential United States sources of juvenile Pink salmon in the San Juan Islands include two northern Puget Sound Rivers with abundant pink and chum salmon populations: the Skagit and Nooksack Rivers.

Both pink and chum salmon had similar fish presence rates in the geomorphic shoreline types with both species most likely to be found in pocket beaches, barrier beaches, and rocky shore areas. As was the case with juvenile Chinook salmon, presence of pink and chum salmon was highest in the Rosario SW and Waldron shorelines, compared to other areas. These shorelines are areas within the San Juan Islands expected to be encountered first by fish coming from the Fraser River, Nooksack, and Skagit rivers.

Forage Fish

We consistently caught three species of forage fish (Pacific herring, surf smelt and sand lance) in shoreline areas of the San Juan Islands. In most shoreline areas of Puget Sound, some combination of the three species is typically found (Fresh et al. 1979; Miller et al. 1980; Fresh et al. 2006; Greene et al. 2012). Spawning areas of the three species are widely distributed in northern Puget Sound and into Canada and include local spawning populations (Pentilla 2007). Although we did not age any of the forage fish we captured, length/age data from other studies (Pentilla 2007) suggested that at least two age classes of each species of forage fish were present based on our length results: herring (age 0 and age 1; Figure 17), smelt (age 0, age 1, and likely age 2+; Figure 20), and sand lance (age 0, age 1, and possibly age 2+; Figure 23). Juvenile life stages were the most abundant stage for all three species, suggesting shallow shoreline habitats in the San Juan Islands were functioning as a nursery area for forage fish.

All three forage fish species exhibited monthly variability in density in shoreline areas and there also was interannual variability in abundance. Pacific herring and sand lance exhibited similar monthly patterns in density with the largest catches of both species occurring in the fall. Surf smelt did not exhibit a consistent pattern in monthly density values. Pacific herring and sand lance were more distributed throughout the San Juan Islands, although both species tended to be more abundant along the northern perimeter of the San Juan Islands. Surf smelt on the other hand were primarily caught along the southern part of Lopez Island.

Factors that could account for variability in forage fish density between years, months and areas are complex but we propose that the timing of spawning and how water currents transport larvae and post larval fish are especially important. Because all three species spawn in the San Juan Islands, the temporal and spatial distribution of these species in shoreline areas is to some degree driven by when and where these species spawn in the San Juan Islands. For example, surf smelt are known to spawn along Lopez Island and so their high density in this area may be driven by local spawning populations. Conversely, although Pacific herring spawn in several parts of the San Juan Islands, much larger herring populations spawn to the north in Canada and to the east in the United States along the mainland between Birch Bay and Sandy Point. Prevailing ebb tide currents (from the north) would be expected to transport herring larvae and post larva fish from these spawning populations towards the San Juan Islands. Thus, many of the herring utilizing the nearshore habitats of the San Juan Islands, may come from more distant, non-local populations. The situation with sand lance is less clear because while local beach spawning populations have been identified, recent evidence suggests that there may be much larger groups of sand lance spawning subtidally. It is unclear where subtidal populations spawn, when they spawn and how they are distributed following spawning.

Similar to juvenile Chinook salmon, the presence of herring was greatest in pocket beaches. However, one difference between herring and juvenile Chinook salmon was the strong association of herring with rocky shore types; juvenile Chinook salmon did not have a strong association with this shore type. Sand lance and surf smelt were also strongly associated with pocket beaches but were also associated with drift cell systems, likely reflecting an association with their intertidal spawning locations which can only occur in erodible shoreline types.

Importance of pocket beaches

Pocket beaches were an important shoretype in the San Juan Islands for all seven species or species groupings with respect to fish density or presence. In Puget Sound, pocket beaches are relatively rare (Fresh et al. 2011) but because of the extensive rocky shoreline geology of the San Juan Islands, they are relatively common in this area (Figure 6).

Pocket beaches are typically semi enclosed so they are relatively protected from the strong tidal currents and wind driven waves that characterize straighter unprotected shorelines. As such, these “backwater” areas of the nearshore may provide a hydrodynamic refuge where small migratory fish (e.g., juvenile salmon) and other young fishes may be using tidal currents as highways and pulling off into these calm relatively enclosed areas for transitory rearing. The semi enclosed nature of pocket beaches and their smaller and unconsolidated substrate (compared to adjacent rocky shoreline beaches) may offer juvenile fish a higher quality environment for feeding on certain substrate associated food items such as amphipods and copepods.

Upland disturbance potential on nearshore habitat types

Pocket beaches and pocket estuaries have relatively short shoreline lengths but differentially large watershed areas associated with them. Pocket beaches and pocket estuaries have disproportionately more watershed area than other shoreline types (Figure 42). This fact has both potentially positive (pathways for upland derived nutrients, terrestrial prey items, etc.) and negative aspects (pathways for pollutants or other stressors to nearshore habitats).

Pocket beaches (and pocket estuaries) have several elements that distinguish them from other shoreline types that should be considered in any plans to protect and restore these habitats. Unlike drift cell systems (barrier and bluff backed beach systems), which dominate in the rest of Puget Sound (Fresh et al. 2011), the processes that maintain pocket beaches do not involve sediment dynamics over long stretches of shoreline. We propose that the processes and disturbances that affect these systems are more restricted to the pocket beach themselves and the surrounding watershed. Thus, protection of pocket beaches may involve more of a focus on local and watershed threats than would need to occur for a beaches within drift cell systems.

Applications of this study

As indicated, the main application of our work was targeted at developing models that would support developing conservation strategies for salmon in the San Juan Islands. Our work provides a method of developing strategies for different types of habitats and places. Because of the length of its shoreline (>650 kilometers), fish density or presence can only be directly measured for a small part of an area like the San Juan Islands. Thus, there is a need to predict what fish distribution and abundance is in places that are not sampled. Our approach which generated map applications was intended to provide a way to identify the conservation approach that should be adopted in places that had not been directly sampled.

Our results also can be used by planners to help manage the types of human activities that could influence different shoreline habitats. For example, the types of disturbances that would seem to most likely affect a pocket beach are local, along the shoreline and associated with the surrounding watershed connected to the pocket beach. Conversely, in drift cell shoreline types, disturbance may be both local or occur at considerable distances from a place, such as bluff back beaches supplying appropriate sediment grain sizes to barrier beaches where smelt spawn. Our study results can also be used to help define work windows for shoreline construction activities that minimize disturbance to key fish species.

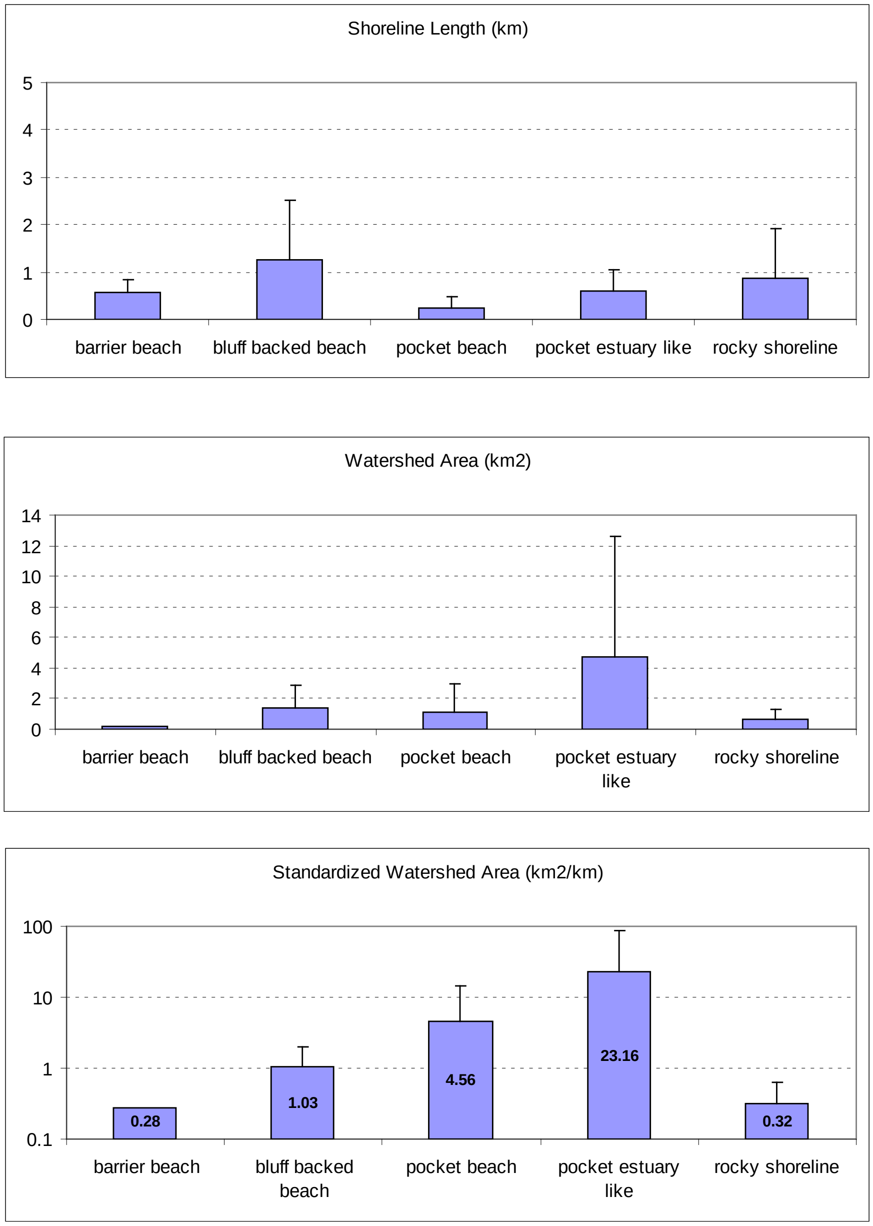

Figure 42. Summary of shoreline length and watershed area by shoreline types for 141 individual shoreline units in the San Juan Islands. Individual shoreline data are from McBride et al. (2009). Watershed areas are from Simenstad et al. (2011). The average value is shown for all three figure panels and error bars are one standard deviation. Top panel: Length (in kilometers) of individual shoreline units by type. Middle panel: Watershed area (in square kilometers) associated with individual shoreline units by type. Bottom panel: Standardized watershed area associated with individual shoreline units by type. Standardized watershed area is watershed area divided by shoreline length. The Y axis is logarithmic scale.

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Appendices

Appendix A: Shoreline Type Examples

<table>
<tr><th colspan="3">RITT classification (Bartz et al. 2012)</th><th rowspan="2">Shoreline type used in this study
(Beamer & Fresh 2012)</th></tr>
<tr><th>System Type</th><th>System Sub-Type</th><th>Shoreline Type</th></tr>
<tr><td rowspan="3">Mayor River System</td><td rowspan="3">Natal Chinook Estuary</td><td>Drowned Channel</td><td rowspan="3">Not used.
Major river systems do not exist in the San Juan Islands.</td></tr>
<tr><td>Tidal Delta</td></tr>
<tr><td>Delta Lagoon</td></tr>
<tr><td rowspan="11">Drift Cell System</td><td>Coastal Landform</td><td>Barrier Beach
(including spits, cusps, tombolos)</td><td>Barrier Beach</td></tr>
<tr><td rowspan="4">Bluff Backed Beach</td><td>Sediment Source Beach</td><td rowspan="4">Bluff Backed Beach</td></tr>
<tr><td>Depositional Beach</td></tr>
<tr><td>Beach Seep</td></tr>
<tr><td>Plunging Sediment Bluff</td></tr>
<tr><td rowspan="6">Pocket Estuary (embayment)</td><td>Drowned Channel Lagoon</td><td rowspan="9">Pocket Estuary</td></tr>
<tr><td>Tidal Delta Lagoon</td></tr>
<tr><td>Longshore Lagoon</td></tr>
<tr><td>Tidal Channel Lagoon (or Marsh)</td></tr>
<tr><td>Closed Lagoon and Marsh</td></tr>
<tr><td>Open Coastal Inlet</td></tr>
<tr><td rowspan="7">Rocky Shoreline</td><td rowspan="3">Rocky Pocket Estuary</td><td>Pocket Beach Lagoon</td></tr>
<tr><td>Pocket Beach Estuary</td></tr>
<tr><td>Pocket Beach Closed Lagoon and Marsh</td></tr>
<tr><td rowspan="4">Rocky Beach</td><td>Veneered Rock Platform.</td><td rowspan="3">Rocky Shoreline</td></tr>
<tr><td>Rocky Shoreline</td></tr>
<tr><td>Plunging Rocky Shoreline</td></tr>
<tr><td>Pocket Beach</td><td>Pocket Beach</td></tr>
</table>

Figure A1. Crosswalk of shoreline habitat types used in this study (Beamer and Fresh 2012) compared to the Puget Sound Recovery Implementation Technical Team (RITT) framework for monitoring recovery of Puget Sound Chinook salmon (Bartz et al. 2012).

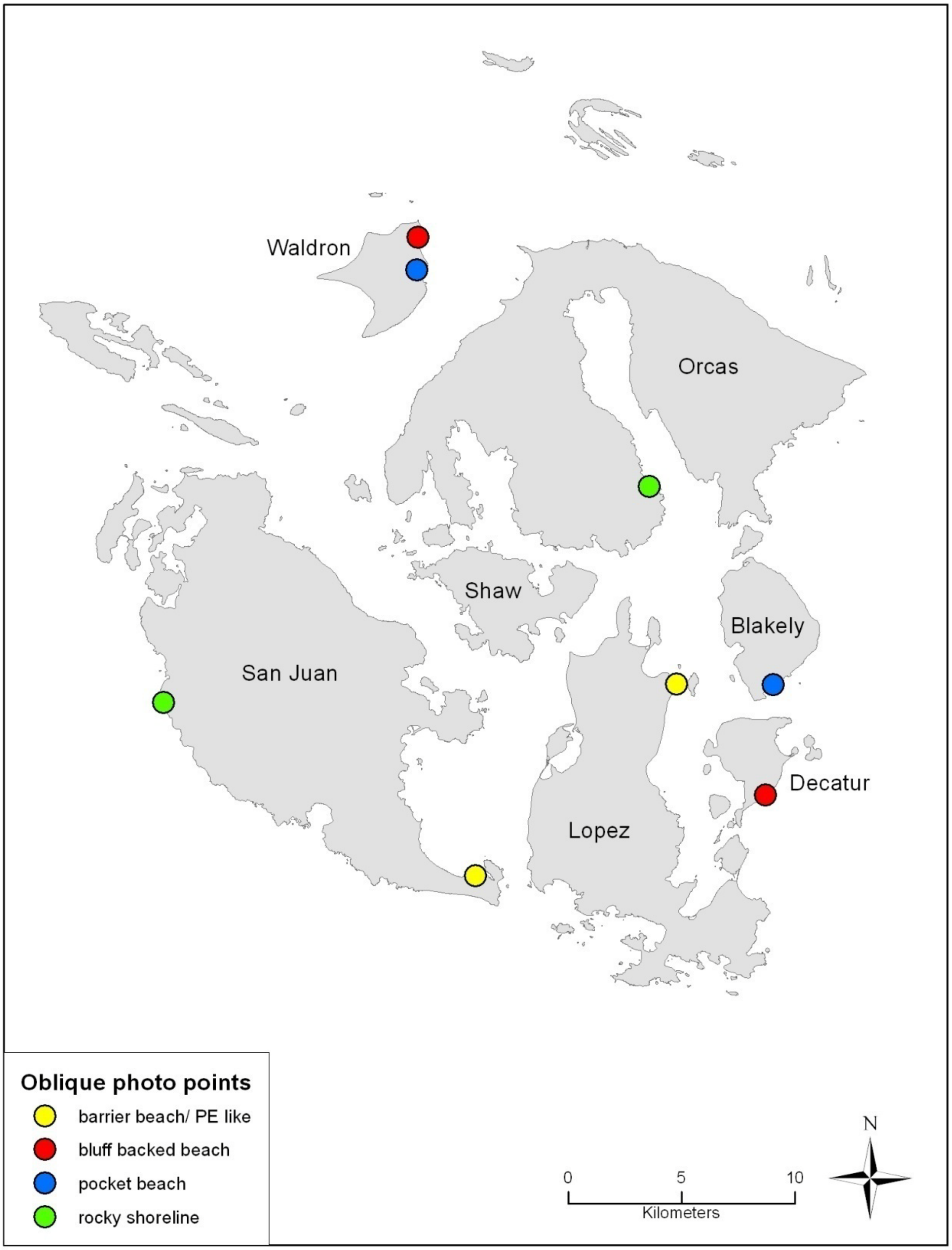

Figure A2. Location of oblique shoreline photos showing examples of different shoreforms. Photos downloaded from Washington State Department of Ecology website.

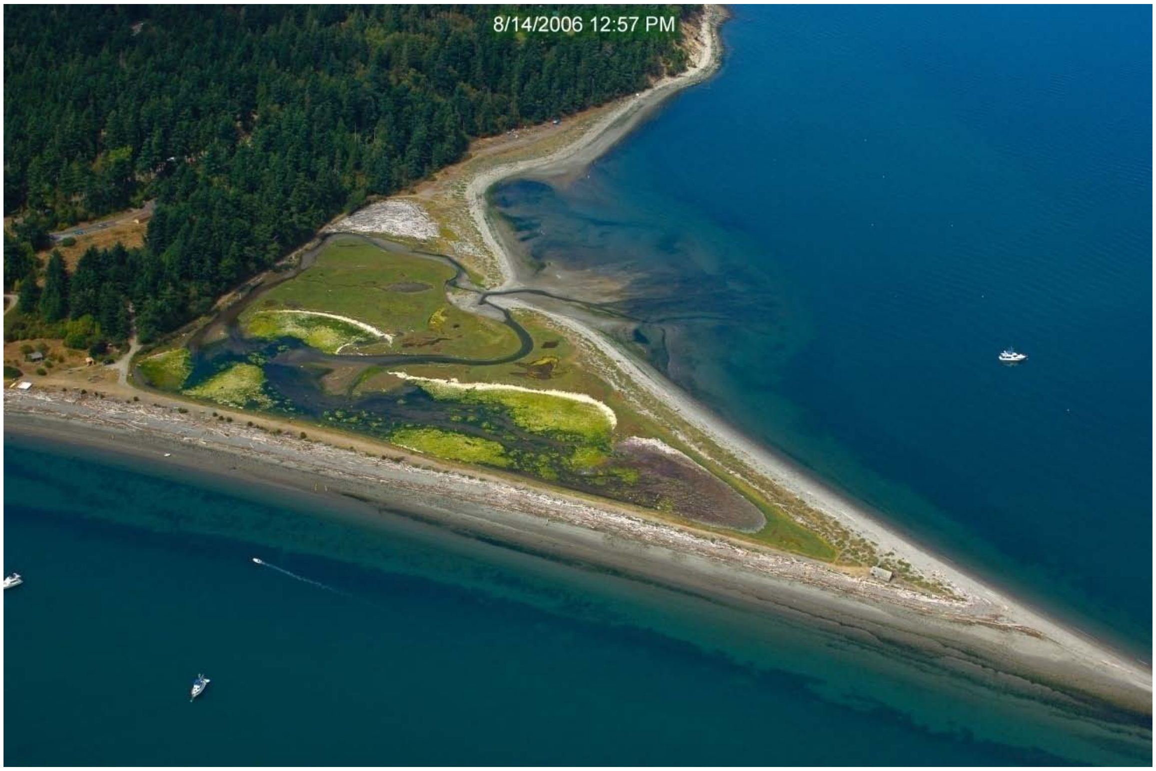

Figure A3. Photo of Spencer Spit on Lopez Island, showing both barrier beach and pocket estuary like shoreforms.

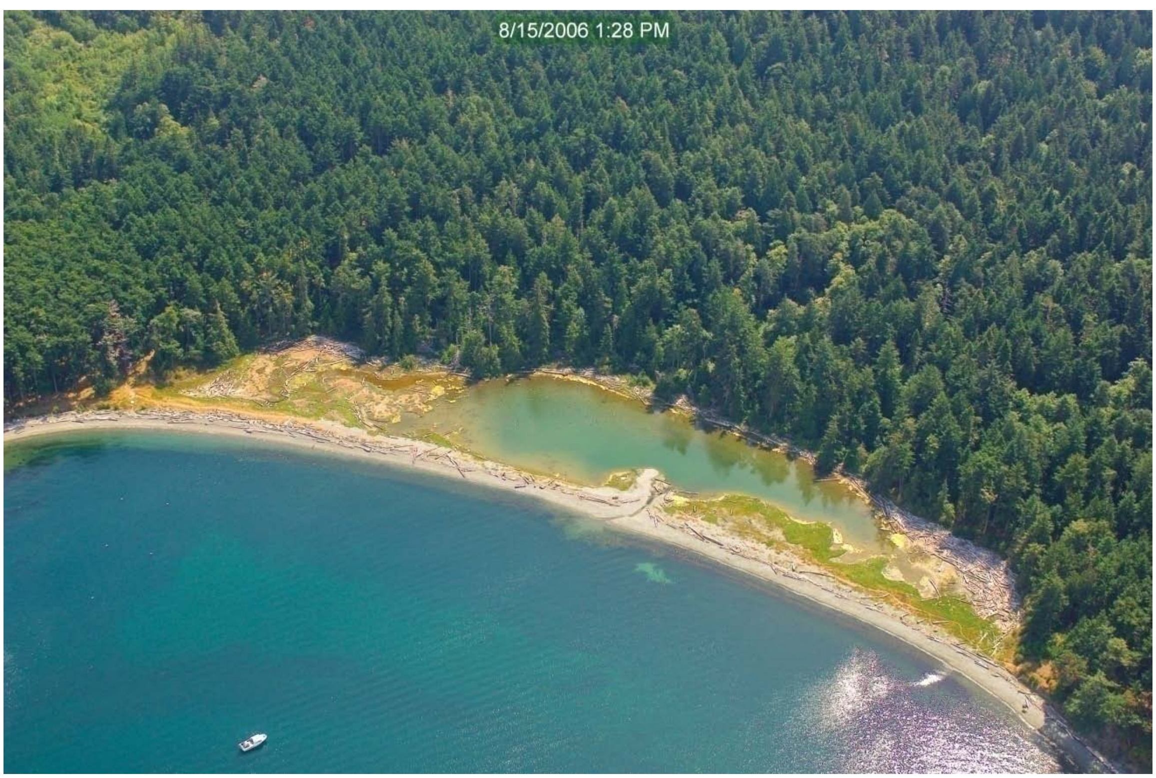

Figure A4. Photo of Third Lagoon on San Juan Island, showing both barrier beach and pocket estuary like shoreforms.

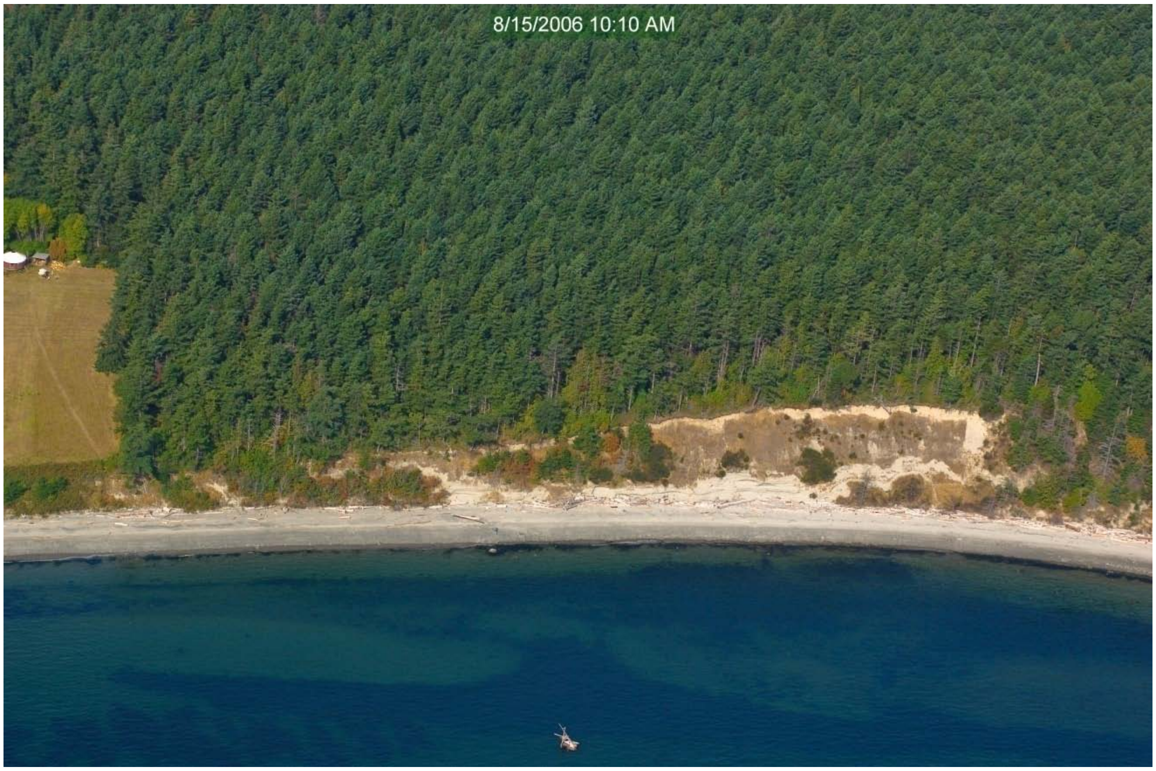

Figure A5. Photo of bluff backed beach on Waldron Island (Little Hammond).

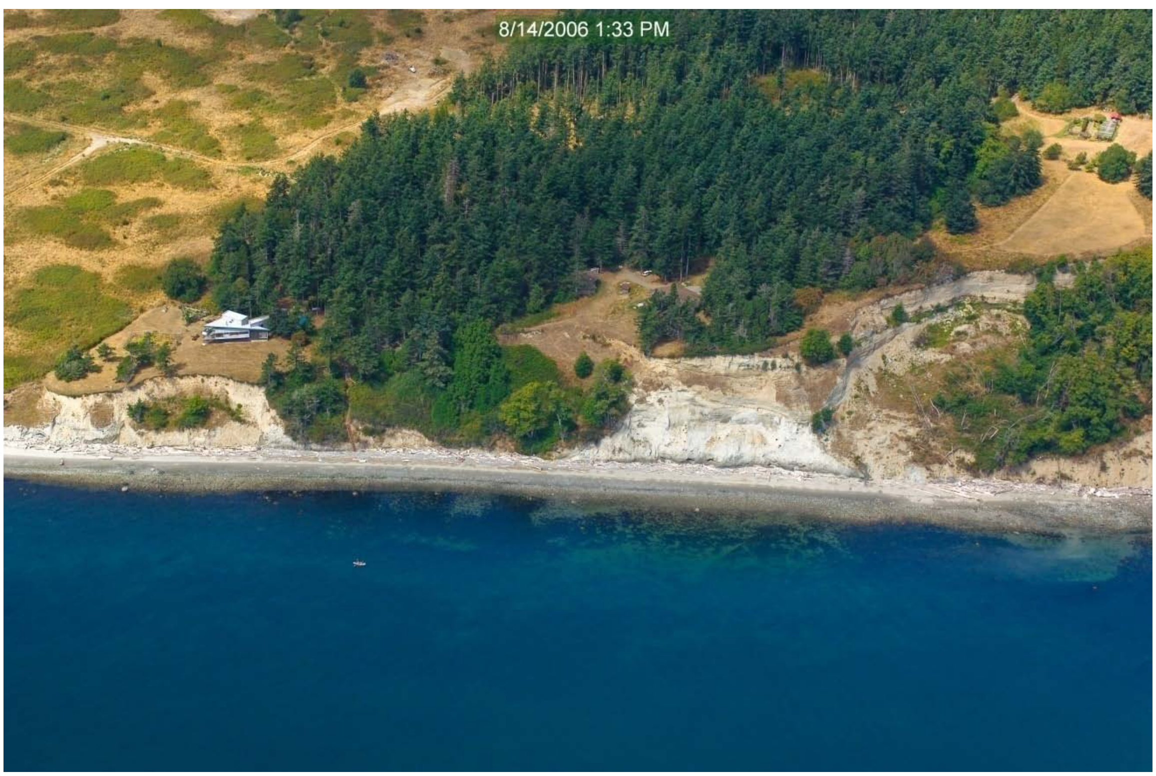

Figure A6. Photo of bluff backed beach on Decatur Island (White Cliff).

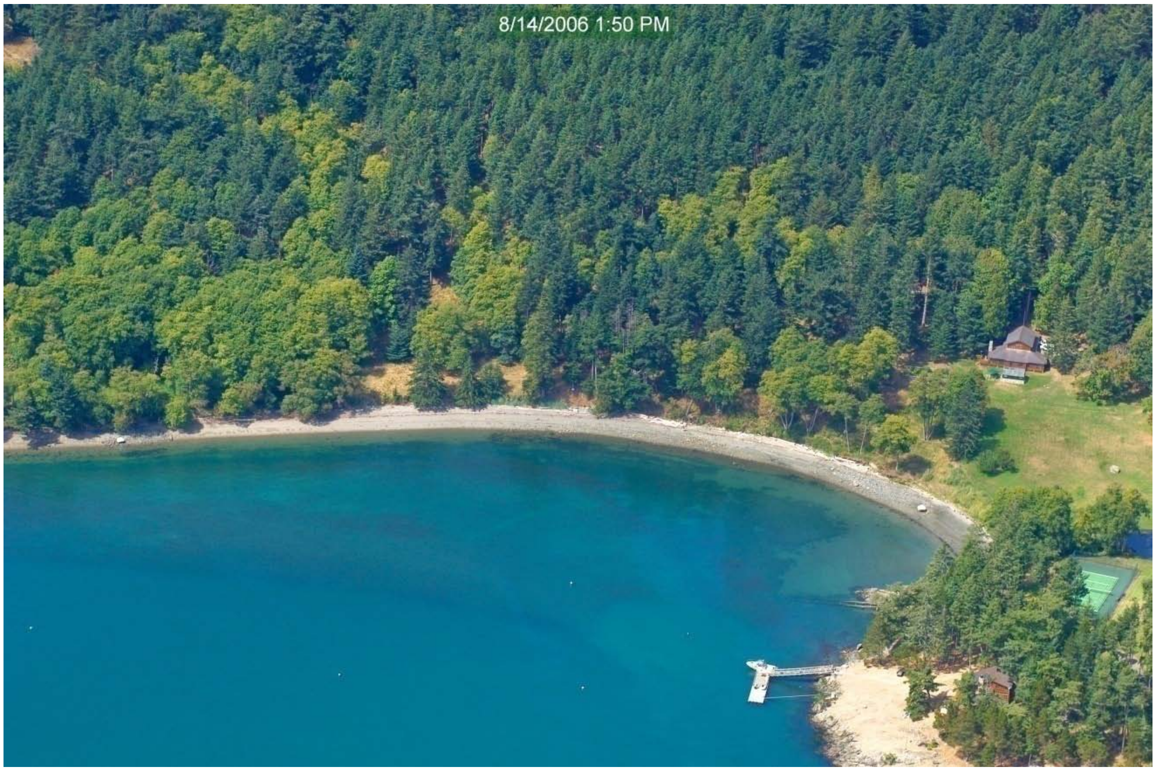

Figure A7. Photo of pocket beach on Blakely Island (Runstad Cove).

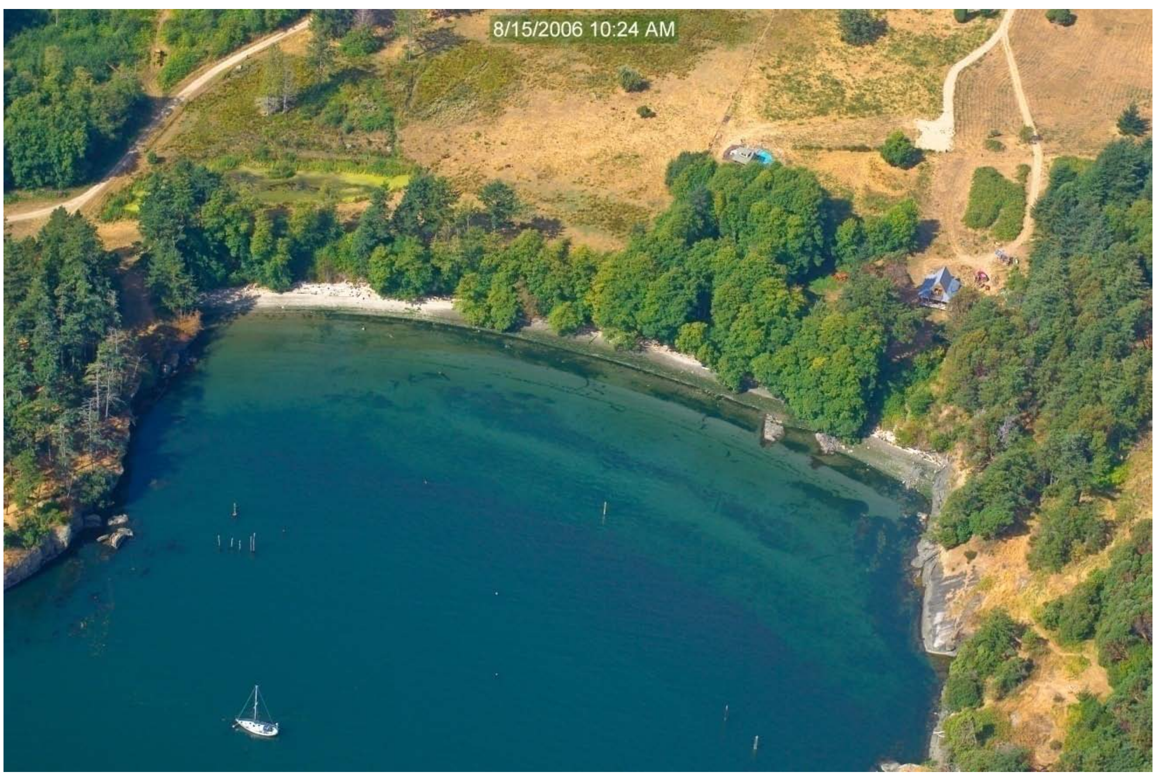

Figure A8. Photo of pocket beach on Waldron Island (Mail Bay).

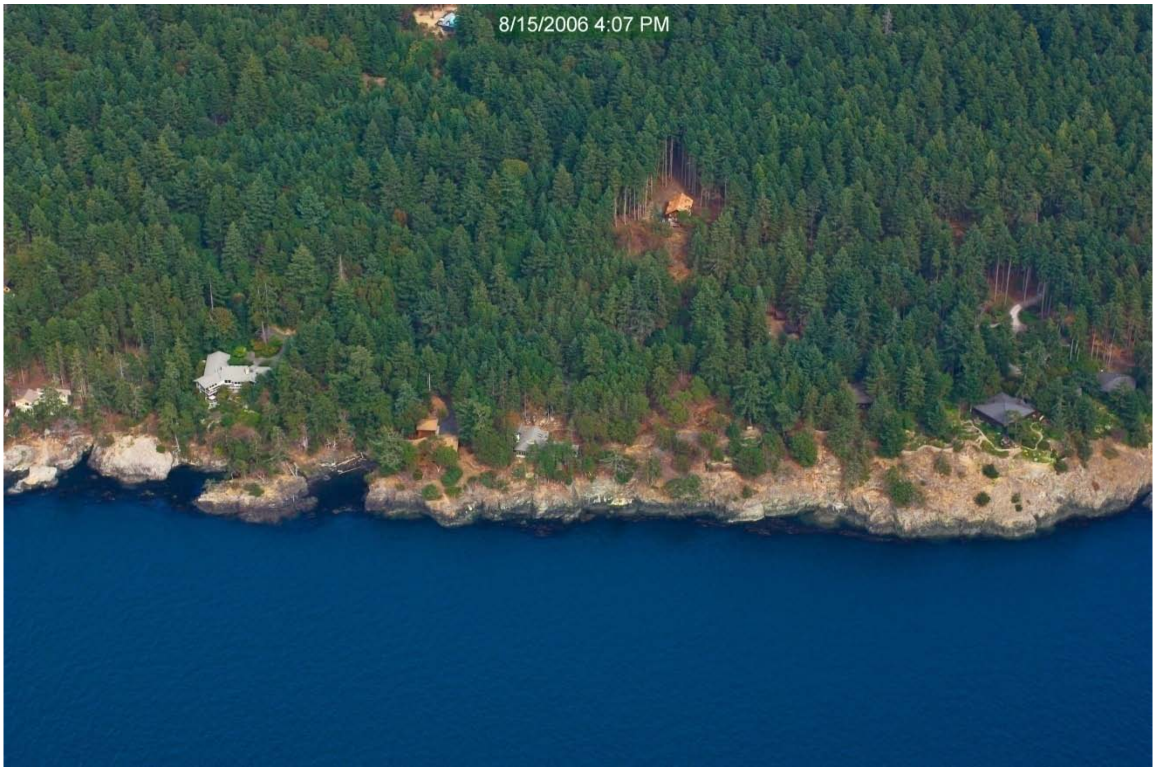

Figure A9. Photo of rocky shoreline on the west side of San Juan Island.

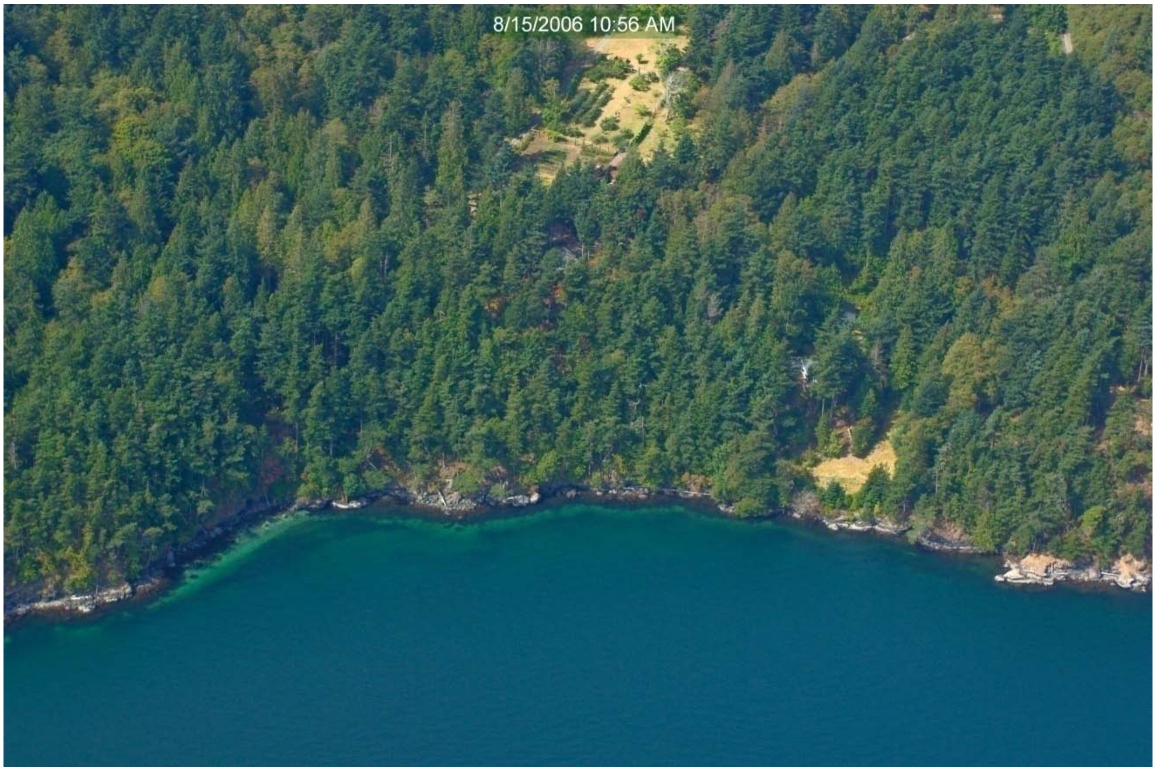

Figure A10. Photo of rocky shoreline on Orcas Island (within East Sound).

Appendix B: GIS Metadata

Metadata for: *SJ_geomorph_FishProb.shp*

DESCRIPTION:
Shoreline arcs for San Juan County (WRIA 2) showing geomorphic data and fish probability of presence by species.

PURPOSE:
To show shoreline habitat, geomorphology, and fish presence probabilities for the WRIA 2 Habitat-Based Assessment of Juvenile Salmon project.

SUPPLEMENTARY INFORMATION:
Arcs for this theme were pulled from SSHIAP's (Salmon & Steelhead Habitat Inventory & Assessment Program, under WDFW & Northwest Indian Fisheries Commission) geomorphic arcs for the WRIA 2 area only. All of SSHIAP's attribute fields were kept in the theme, including their shoretype designation 'GeoUnit'.

Arcs were attributed with Puget Sound RITT (Recovery Implementation Technical Team, appointed by NOAA) shoretype determinations. The RITT nested shoreline habitat classification was compiled from Shipman's 2008 (WDOE) and McBride et al.'s 2009 (SRSC) geomorphic classifications. It includes several scales, three of which we use because they are geomorphic and process-inferred: System Type (RITT_SysTy), System Sub-Type (RITT_SubTy), and Shoreline Type (SiteType3). The coarsest classification is System Type which includes: Major River Systems, Drift Cell Systems, and Rocky Shorelines. The next tier down is Sub-Type which includes: Source Population (natal) Chinook Estuaries (a Major River System); Coastal Landforms, Bluff Backed Beaches, and Pocket Estuaries (all Drift Cell Systems); and Rocky Pocket Estuaries and Rocky Beaches (both Rocky Shoreline systems).

Arcs were also attributed by region (SiteType2), whether they are interior or exterior (int/ext), enclosure or passage (encl/pass), and for fish probability of presence. Region and interior/exterior boundaries were determined by Eric Beamer of SRSC. Shoreline type determinations were taken from SSHIAP's 'GeoUnit', categorized by SRSC, and edited per Coastal Geologic Services (CGS, of Bellingham, WA) 2011 mapping of pocket beaches in the San Juan Islands. While many pocket beaches were mapped by CGS that weren't in SSHIAP's data, there were a few pocket beaches in SSHIAP's data that weren't mapped by CGS. Arcs in these places were re-typed by SRSC, usually to the dominant adjacent shoretype. These determinations are noted in the Comments field. Enclosure/pass determinations were done by SRSC at an intermediate scale only (i.e. larger than a SiteType3 [shoreform] size but smaller than a SiteType2 [region] size). Scale was determined for each watershed by shoreline length and watershed area, with special exceptions for small islands and headlands. Enclosure was determined by shoreline sinuosity (length of bay opening and average bay depth). Fish probability of presence was determined by both high and low resolution models per Beamer and Fresh (2011) for seven juvenile fish (wild Chinook salmon, chum salmon, pink salmon, lingcod

& greenling (family Hexagrammidae), surf smelt, Pacific herring, and Pacific sand lance).

ATTRIBUTES (created by SRSC):
SiteType2 = Intermediate geographic scale, descriptively named after waterbodies or islands.
SiteType3 = Dominant simplified geomorphic shoreform, categorized by SRSC per SSHIAP's 'GeoUnit' (and incorporating CGS' new determinations).
RITT_SysTy = Geomorphic, process-inferred system type, per RITT's nested shoreline habitat classification.
RITT_SubTy = Geomorphic, process-inferred sub-system type, per RITT's nested shoreline habitat classification.
Int_Ext = Classification of whether arc is within the interior or exterior of the San Juan landscape.
Encl_Pass = Classification of whether arc is within a tidal and wind-protected water body such as a bay or inlet (enclosure) or a less protected water body such as a strait, sound, or pass (passage).
Length_km = Length of arc in kilometers.
Watershed = Name of watershed.
HRM_Ck = Wild juvenile Chinook salmon presence determined by high resolution model.
LRM_Ck = Wild juvenile Chinook salmon presence determined by low resolution model.
HRM_Chum = Juvenile chum salmon presence determined by high resolution model.
LRM_Chum = Juvenile chum salmon presence determined by low resolution model.
HRM_Pk = Juvenile pink salmon presence determined by high resolution model.
LRM_Pk = Juvenile pink salmon presence determined by low resolution model.
HRM_Hex = Juvenile lingcod and greenling presence determined by high resolution model.
LRM_Hex = Juvenile lingcod and greenling presence determined by low resolution model.
HRM_Smelt = Juvenile surf smelt presence determined by high resolution model.
LRM_Smelt = Juvenile surf smelt presence determined by low resolution model.
HRM_Herr = Juvenile Pacific herring presence determined by high resolution model.
LRM_Herr = Juvenile Pacific herring presence determined by low resolution model.
HRM_Lance = Juvenile Pacific sand lance presence determined by high resolution model.
LRM_Lance = Juvenile Pacific sand lance presence determined by low resolution model.

Metadata from SSHIAP:
The Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) has mapped the Washington State shoreline according to geomorphology. In 2008 SSHIAP completed a quality assurance (QA) on the initial draft dataset for the Puget Sound region. In 2009, SSHIAP completed a QA version for the outer Washington coast using similar methodologies. The mapping was based on a geomorphic classification model developed by McBride et al. (2005). The model uses existing information to determine dominant processes (i.e., tidal erosion, wave deposition, fluvial deposition), surface

geology/shoreline material (e.g. bedrock, cohesive sediments, loose sediments), and topography (i.e., steep, gentle, and flat) to map the shoreline into geomorphic units. The Washington Department of Natural Resources (WDNR) ShoreZone spatial dataset represents the shoreline, and WDNR aquatic boundary spatial dataset and National Wetlands Inventory spatial dataset represent the Extreme Low Water (ELW). In performing the quality assurance phase of the mapping for the Puget Sound region, SSHIAP used supplemental datasets that were not widely available during the initial mapping phase, including a revised drift cell dataset (unpublished from PSNERP 2008), 1:24000 scale geology maps in a few locations, historic and current tidal wetland datasets available through the University of Washington River History Project (UWRHP), and the Washington Department of Ecology oblique air photos from 2006, available via the world wide web at the Washington Digital Coastal Atlas. Data is available as ArcGIS geodatabase format.

This nearshore classification was developed for addressing specific applications regarding habitat protection, restoration, and land use policies and regulations that affect nearshore processes, including salmonid habitat structure and function.

Scoping Memorandum concerning the Pacific Gateway Terminal

Individual Comment on Species in the Salish Sea

Prepared By: Joseph K. Gaydos, VMD, PhD
Chief Scientist and Wildlife Veterinarian
UC Davis Wildlife Health Center - Orcas Island Office

November 3, 2012

UNIVERSITY OF CALIFORNIA, DAVIS

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November 3, 2012

GPT/BNSF Custer Spur EIS Co-Lead Agencies
c/o CH_2M HILL
1100 112th Avenue NE, Suite 400
Bellevue, WA 98004

Dear U. S. Army Corps of Engineers, Whatcom County Planning Department and Washington Department of Ecology Representatives,

Thank you for the opportunity to comment on the scope of the Environmental Impact Statement (EIS) for the Proposed Gateway Pacific Terminal / Custer Spur. The proposed deepwater multimodal terminal in the Cherry Point area of Whatcom County will be designed to ship copious amounts of coal and other product and consequently, the building of this terminal and the associated BNSF Railway Custer Spur connection will greatly increase vessel traffic within the US and Canadian waters of the Salish Sea. While much of the EIS will focus on the terrestrial impacts of development as well as the nearshore impacts of developing the deepwater port, the EIS would be woefully incomplete if it did not also include examination of the probable impacts to the marine ecosystem in the regions where the vessels transiting to and from the port will travel, specifically, the marine waters of Whatcom, Skagit, San Juan, Jefferson, and Clallam Counties as well as the potentially impacted Canadian waters adjacent to and contiguous with the US waters mentioned.

The Salish Sea is approximately 17,000 square kilometers of marine water that is habitat to 37 species of mammals, 172 bird species, nearly 300 species of marine and anadramous fishes and over 3,000 macroinvertebrates.[1,2,3] As of January 1, 2011, one or more jurisdiction within the region (British Columbia, Washington State, the US Federal Government or the Canadian Federal Government) has listed 113 of these species as threatened, endangered, of concern, or candidates for listing.[1] The listing of nearly 33% of the mammal species, 33% of the bird species and 13% of the fish species suggests an ecosystem that is a non-resilient state of decay and is not in a good position to fare well from potential incremental stressors such as increased vessel noise or catastrophic events such as a major oil spill.

The marine waters of the Salish Sea are important culturally to the Tribes and First Nations of Washington and British Columbia and the areas non-native residents. These natural resources are also economically important to the people of the region. In addition to supporting the obvious subsistence, recreational and commercial fisheries, the watchable wildlife of the region support a $2 billion / year

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industry.[4] This is money brought by residents of richer counties and cities into rural, less wealthy counties like San Juan, Jefferson and Clallam. The economic trade off of creating a few jobs in a more wealthy urban area like Bellingham needs to be weighted in light of the potential damage it could bring to both harvestable and watchable fish and wildlife resources of less economically well off rural counties.

I implore you to ensure that the scope of the EIS being developed for the proposed deepwater multimodal terminal in the Cherry Point area of Whatcom County also extend to the counties and regions where ships entering and leaving this proposed port would transit, including Clallam, Jefferson and San Juan County as well as to the waters and resources of neighboring British Columbia. The potential impact of increased vessel traffic needs to be evaluated in light of potential major stressors such as increased vessel-related noise, increased potential for a catastrophic oil spill, increased potential for vessel strike to marine birds and mammals, and increased pollution associated with the ship's marine diesel engines. These stressors should be evaluated for every species of concern, including candidate species that are not yet Federally listed by the U.S. or Canada.[1] Risks also need to be considered for their potential economic impact to the marine ecosystem and the businesses and livelihoods they support. I appreciate you including these factors in the draft EIS and look forward to reviewing it when it becomes available.

Sincerely,

Joseph K. Gaydos, VMD, PhD
Chief Scientist and Wildlife Veterinarian
UC Davis Wildlife Health Center – Orcas Island Office

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4. Washington Department of Fish and Wildlife and Washington Department of Community, Trade and Economic Development. Wildlife Viewing Activities in Washington: A Strategic Plan. Report to the Washington State Legislature, March 2004.

Scoping Memorandum concerning the Pacific Gateway Terminal

Impact of Fugitive Dust on Forage Fish, in particular the Pacific Sand Lance

Prepared By: Gary Greene
Professor Emeritus
Moss Landing Marine Labs/Tombolo

January 3, 2013

Individual comment detail

Name: Greene, Gary
Date: Jan. 3, 2013
City: Eastsound
Part: Multiple/not listed
Natural environment: Marine species, fish or fisheries, Water quality
Comment: Comment on Potential Fugitive Coal Distribution from the Proposed Cherry Point Coal Loading Facilities and Outward Transport of Product

H. Gary Greene, Professor Emeritus, Moss Landing Marine Labs/Tombolo

I am a marine geologist (PhD, Stanford University, 1977) involved in the past 18 years in mapping the seafloor of the Salish Sea for the purpose of evaluating geohazards and marine benthic habitats. I am a research faculty member at Friday Harbor Laboratories of the University of Washington and Emeritus Professor at Moss Landing Marine Labs, San Jose State University in California. One of my major research interests is the health of the forage fish Pacific sand land (PSL) and the subtidal benthic habitats they occupy. The scientific community is just starting to understand the habitat needs of this critical fish and the introduction of exotic components, such as coal to PSL benthic habitats will exacerbate our studies, a personal concern for me. I also live on Orcas Island and adverse impacts to the marine environment matters to me.

My specific concerns about the development of the coal loading facilities at Cherry Point are in regard to the potential impact that fugitive coal particles would have on the health and survival of a critical forage fish in the region, PSL (Ammodytes hexapterus). It appears to me that not much is known about the transport and toxicity of coal particles in the Salish Sea and what impacts to marine benthic habitats may occur if coal is introduced into the estuary of the San Juan Archipelago and southern Georgia Basin, including the Whatcom County shoreline and subtidal habitats. Whatcom County's seafloor, and most of Rosario Strait, is unmapped in high-resolution and critical PSL benthic habitats there are not fully identified. However, poor resolution and single trace echosounder data indicate that subtidal PSL benthic habitats may be present in close proximity to the proposed coal loading facilities.

The Pacific sand lance (PSL) is an important forage fish along the coastal North Pacific Ocean from northern California to northern Hokkaido, Japan, and is one of six species in the genus Ammodytes (Robards et al., 1999a,b). Although PSL is a key component in the Northwest Straits regional food web, very little is known of this species' biology. For example, only three peer-reviewed papers detail the biology of PSL in Puget Sound compared with 16 such manuscripts on Pacific herring (Clupea harengus pallasi). The burrowing behavior, recruitment rates and conditions, relative abundance and distribution, population structure, local spawning habits, and spawning and burial substrates remain largely unknown (Robards et al., 1999a, 2002; Tribble, 2000). The work that has been done on the biology and habitat of PSL has focused on the nearshore and shallow sub-tidal areas; little work has been done on the deep sub-tidal habitats, although recent initial studies have been completed (Greene et al. 2011). A disjunction occurs between the abundance of sand lance and the availability of known habitat and the hypothesis put forward by Greene et al. (2011) that predominant and important habitats exist in the deep sub-tidal areas.

In the Northwest Straits region, PSL serve as the primary link between zooplankton and higher order predators, and are a vitally important food source for 29 species of birds, 10 species of marine mammals, and 30 species of commercial and sport fishes (Meyer et al., 1979; Auster and Stewart, 1986; Geiger, 1987; Robards et al., 1999a,b; Tribble, 2000). Specifically, this species is a crucial component in the diet of common murres, rhinoceros auklets, tufted puffins, harbor seals, minke whales, salmon, lingcod, rockfish and other groundfishes (Geiger, 1987). The condition of the Northwest Straits region's ecosystem depends in large part on the large biomass of forage fish, including PSL, that transfer phytoplankton production to higher trophic levels (Fresh, 1979; Fresh et al., 1981; Duffy, 2003; Zamon, 2001, 2003; Johnson et al., 2008)

The PSL is known to deposit its spawn on sandy upper intertidal beaches throughout the Puget Sound Basin (Penttila 1995a, 2007). Roughly 10% of the shoreline of the Puget Sound basin comprised of fine-grained beaches has been found being used by spawning sand lance. It has been hypothesized that PSL might also use sub-tidal sandy substrates for spawn deposition, although no conclusive physical evidence of this has ever been documented.

Much of what is known about PSL benthic habitat comes from shallow water studies. Sand lance are dependent upon benthic sediment habitats to burrow into and, therefore, this species is most often associated with fine- to coarse-grain sand- or gravel-oxygenated sediments (Meyer et al., 1979; Auster and Stewart, 1986) in nearshore inter-tidal (-0.3m MLLW) and shallow (to 100 m) habitats (Wright et al., 2000; Pinto, 1984; Ostrand et al., 2005; Quinn, 1999; Robards et al., 1999a,b; Auster and Stewart, 1986). In the inter-tidal, sand lance were found to be buried 5.0 cm deep and to be oriented horizontally in the oxygenated sediment layer at densities of 5 fish per square meter and can remain buried in inter-tidal sediments during low tide exposure (Quinn, 1999). Sediment size conducive for sand lance to penetrate and burrow into ranged in size from 0.36 to 1.0 mm in diameter (Quinn, 1999). Inter-tidal beaches have been documented as habitat for PSL and their eggs (Moulton and Penttila, 2000). Sediments provide habitat for overwintering (Healy, 1984), to rest and conserve energy (Quinn, 1999), to avoid predation (Reay, 1970) and as spawning substrate where their adhesive eggs attach while incubating. When the fish emerge from the substrate they form large schools and feed on zooplankton in the water column during the day (Dick and Warner, 1982; Robards et al., 1999a, b; Auster and Stewart, 1986; Geiger, 1987). They emerge from the sand at dawn and are vulnerable to predators as they enter the water column (Hobson, 1986).

Deposits of clean sand at the water depths where PSL reside in the sub-tidal environment (typically < 100 m) are common where relatively strong currents continuously sweep the seafloor. In order to maintain a deposit, a plentiful sand supply is necessary, although finer sediment might transit through the area and coarser sediment might be present as a lag. Sand-wave fields consisting of ripples, waves and dunes are common in such areas, and several fields have been mapped near the San Juan Islands (Barrie et al., 2009; Greene et al., 2011). One such sand-wave field was documented by Blaine (2006) in San Juan Channel of the San Juan Islands and was found to be a productive PSL habitat. The aerial extent of this sand-wave field is delimited by a distinct boundary where the sand waves are in sharp contact with a relatively featureless surrounding seafloor. Such abrupt transitions have been reported in other nearby sand-wave fields (Barrie et al., 2009). However, although it is suspected that such fields may be present in and around the proposed coal loading facilities, no clear bathymetric images exists to confirm this.

The results of the Greene et al. (2011) study are far-reaching and multidisciplinary. Extensive sampling of the San Juan Channel sand wave field, a proto-typical PSL sub-tidal habitat type, on a regular basis through the summer, fall and winter seasons of 2010 and through the winter, fall and spring seasons of 2011 allowed for documentation of PSL occupancy and relative abundances. Comparative evaluation of the results from a tank experiment study and the in situ sampling confirmed the assumption of Greene et al. (2011) that PSL prefer grain sizes of 0.5-1.0 mm (medium- to coarse-grain sand) to any other grain sizes, although PSL were found to occupy all types of substrate from gravels to silt, and that dynamic bedforms can act as preferred habitats for the fish. All life stages of PSL after the larval stage were represented in the proto-typical habitat and one egg was recovered suggesting that recruitment may also occur in PSL sub-tidal habitats.

Tentative conclusions drawn from the work of Greene et al. (2011) that PSL prefer to burrow into medium- to coarse-grain (~0.5-1 mm) size sand in dynamic bedforms that have a wave amplitude of 3-5 m and wavelength of ~100 m, the seafloor conditions found at the proto-typical habitat type in San Juan Channel where the highest concentrations of PSL was found during the investigation. Mature fish found in the San Juan Channel sand wave field were primarily caught in the northern and southern part of the bedform where sediment is smaller in size. It was found that more fish burrow into the sediment during winter months than during summer months (Greene et al., 2011).

Although Greene et al. (2011) prepared a predictive potential PSL sub-tidal habitat model that would have a geomorphology similar to the San Juan Channel sand wave field, further investigation needs to be done to validate the most promising habitat types. Metrics for the predictive model include grain size (0.5-1.0 mm, ~1 phi), depth (30-80 m), wave amplitude (3-5 m), wavelength (50-100 m), and current strengths of ~0.06 m/sec. However, smaller concentrations of fish occur at different types of fields or sand flats and further study needs to be undertaken to place limits and threshold conditions for the habitat attraction for these smaller concentrations of fish within the Salish Sea. In addition, Greene et al. (2011) tentatively concluded that PSL can travel a fair distance from their egg laying sites to sub-tidal habitats, however this relationship also needs further investigation.

Stability of the dynamic bedforms that may be promising sub-tidal habitats in the Salish Sea appear to be near the threshold of stability. Any changes in current strength could upset this stability and such change could come about from continued tectonic uplift or eustatic rebound (possibly leading to increase in current strength) or sea level rise (possibly leading to decrease in current strength). More physical oceanographic measurements need to be made in order to better understand this process.

Based on the known habitat types of PSL and the tendency of the fish to occupy clean, well-aerated substrates, the possibility that fine- to medium-size coal particles could be swept onto beaches and into the subtidal habitats is of paramount concern as interstitial clogging of important habitats in close proximity to the facilities can be impacted. Nothing is known about how coal particles will transit through the San Juan Archipelago or wash up on beaches. Strong tidal currents and winter storm waves all have the potential to sweep fugitive coal particles into the critical habitats of PSL. Concentration of these particles may be detrimental to the survival of PSL.

Questions that should be addressed and hopefully answered in the Environmental Impact Statement for the Gateway Pacific Terminal include:
1) how will fugitive coal particles be incorporated into natural sediments, if at all;
2) how concentrated will the particles become and what will be the toxicity to benthic organisms, especially Pacific sand lance; and
3) how far will the particles be distributed from their point of entry into the water.
All sub-tidal PSL habitats should therefore be located and mapped within close proximity to the coal-loading facilities and along the bulk carrier routes, where coal is likely to be introduced into the marine environment. Coal toxicity associated with dissolution or any other chemical processes that occur in marine and estuarine environments also need to be addressed. If potential impacts are found, how will they be mitigated?

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Scoping Memorandum concerning the Pacific Gateway Terminal

Cumulative Effects of Coal Shipping

Prepared By:
Terry J. Wechsler, Esq.,
Coal Costs Us! Project Whatcom

December 2012

Table 1 Proposed Coal Terminals on the Columbia River (2012 Commercial Vessel Port Calls Approx. 1340)[1]				
Terminal Name	Millenium Bulk Logistics	Port Westward Morrow Pacific Project	Port Westward Project	Subtotals
Proponent	Millenium Bulk Terminals, LLC (Subsidiary of Ambre Energy & Arch Coal)	Coyote Island Terminals, LLC (Subsidiary of Ambre Energy)	Kinder Morgan Energy Partners	
Location	Longview, WA, On Columbia R.	Boardman, OR, Columbia R., barges to Port of St. Helens	Port of St. Helens, OR, Port Westward Indus.Pk.	
Coal Pile	Not discussed in JARPA	3 storage barns	Unknown	
Coal Vol.	44 mmta	8 mmta	30 mmta	82 mmta[2]
Other Vol.	n.a.	n.a.	n.a.	
Mining Co.	Arch	Unknown	Unknown	
Rail/Day (going/coming)	14.5 Not discussed in JARPA[2]	2.6	9.9	27 min.[3] Going/coming
Rail Expansion Plans	Unknown	Unknown	$50 mil. for sidings	
Pier	2202', Columbia R. (Existing pier 670')			
Vessels/ Year (one way)	850 Panamax[4] Bulkers[5] Not discussed in JARPA	672 barge transits, 156 Panamax Bulkers	590 (est.) Panamax Bulkers[3]	1596[3] One way
Permits Required	USACE, WA ECOL, Cowlitz Cty.	USACE, OR Dep't St. Lands		
POCs	Mike Wojtowicz, Cowlitz Cty Dep't Bldg & Planning, Kelso, (360) 577-3052 x 6671, wojtowiczm@co.cowlitz.wa.us	Steve Gagnon, Project Mgr, USACE (503) 808-4379, steven.k.gagnon@ usace.army.mil		
Examples: at-grade crossings	422/423 intersection, base of Lewis&Clark Br., Longview, at-grade. St. Johns Hosp. cut off	Ranier	Ranier	
Status	RFP closes 1/15/13	Dep't St. Lands cmts close 1/3; Cmts closed for EA; pending decision re EIS in 6 mos.-1yr.	"Due diligence" stage; no problems i.d.'d	
Website	www.co.cowlitz.wa.us/ buildplan/WhatsNew/ MBTL.htm	www.nwp.usace.army.mil/ Missions/Currentprojects/ CoyoteIslandTerminal.aspx		
Proponent Website	millenniumbulk.com/	morrowpacific.com/	portwestwardproject.com	

Prepared by Protect Whatcom. Revised 12/26/12.

1 Marine Safety: Coast Guard Sector Columbia River, Ore. Dist. 13, Astoria, 503-861-6211; Columbia River Bar Pilots, 503.325.2643, http://www.columbiariverbarpilots.com/columbiariverbarpilots_marinetraffic.html. On December 25, 2012, of 18 vessels listed at http://crbp.web.kleinsystems.ca/webx/, 2 had drafts of 30 and 35.5'; all others were 25' or less. Merchant Exchange; OR Board Maritime Pilots.

2 According to Pacific Northwest Waterways Ass'n, "In 2010, 42 million tons of cargo moved on the Lower Columbia River…." http://morrowpacific.com/wp-content/uploads/2012/06/PNWA_Letter_6012012.pdf. Inexplicably, the association claims in that comment on the Port of Morrow proposal, traffic would not increase significantly on the river, and the government would set an inappropriate precedent if it conducted a programmatic EIS.

3 Rate applied: .33 trains/1 mmta ***if*** all trains are 1.6 miles long.

4 Maximum allowable draft for Panamax bulkers, due to constraints in the Panama Canal, is 39.5'. Maximum depth dredged in the Columbia River is 43'.

5 Extrapolating from numbers provided for the Port of Morrow Project, which is 19.5 bulkers/1 mmmta coal volume.

Table 2 All Proposed Coal Terminals, Oregon and Washington				
Termanal Name	Gateway Pacific	Port of Coos Bay "Project Mainstay"	Columbia River Subtotals (See Table 1)	Totals
Proponent	Pacific Int'l Term. (Subsidiary, SSA Marine; Goldman Sachs 49% owner)	Port in Partnership with Mitsui Group and Metro Ports (Subsidiary, Nautilus Int'l Holding Corp.)		
Location	Cherry Pt., WA	Coos Bay, OR		
Coal Pile	80 ac. X 60' H, Uncovered			
Coal Vol.	48 mmta	11 mmta	82 mmta	141 mmta
Other Vol.	6 mmta other[6]			
Mining Co.	Peabody			
Rail/Day (going/coming)	16 BNSF	3.6 Coos Bay Rail Link + Main Line	27	47 min.[7] Going and coming
Rail Expansion Plans				
Pier	2980', Salish Sea			
Vessels/ Year (one way)	318 Panamax, 169 Cape Class Bulkers	100	1596	2183 One way
Permits Required	USACE, ECOL, Cty.			
POCs	Randel Perry, USACE, 360-734-3119 Tyler Schroeder, WCPDS, 360-676-6907	David Koch, Port CEO, dkoch@portofcoosbay.com Elise Hamner, Port Rep., (541) 267-7678		
Examples: at-grade crossings	Mt. Vernon,			
Status	Comments for DEIS closes 1/21/13			
Website	www.co.whatcom.wa.us/ pds/plan/current/gpt-ssa/			
Proponent Website	gatewaypacificterminal.com/	www.portofcoosbay.com/index.html		

Prepared by Protect Whatcom. Revised 12/26/12.

6 Stage 2, after 10 years, if market conditions warrant, at second terminal. Initially, calcined coke, a by product of BP Cherry Point operations., and Canadian potash. Other commodities later could include wheat, wood chips, and sulfur.

7 If any trains are less than 1.6 miles long, this number will be higher.

Fig. 1. Proposed West Coast Coal Terminals

Fig. 2. Most Likely Rail Route to West Coast for Proposed Terminals

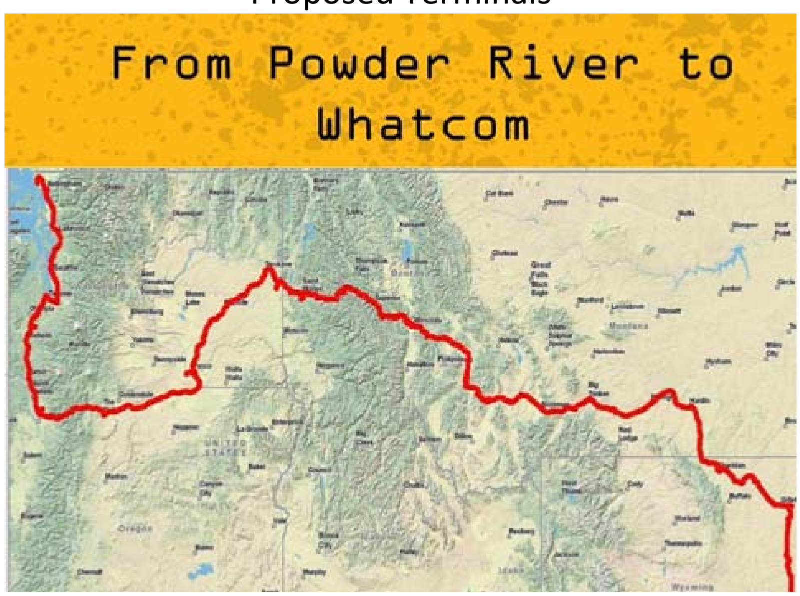
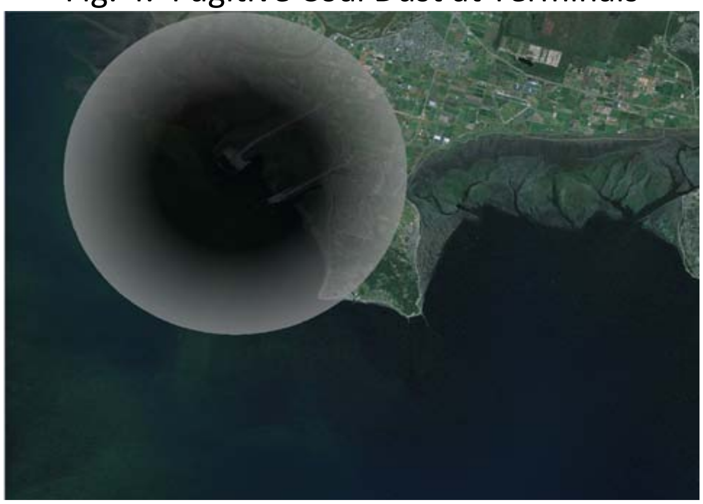


Fig. 3. Westshore Terminals Coal Storage.
(Maximum Capacity: 25 mmta)

GPT describes an 80-acre coal storage pile 60’ high, similar to the Westshore footprint.

Fig. 4. Fugitive Coal Dust at Terminals

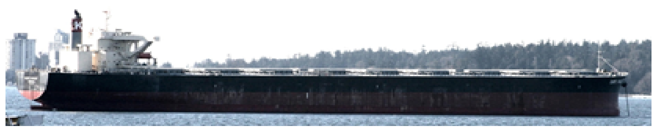


Westshore Terminals emits roughly 715 metric tons of coal dust a year.
Source: Douglas L. Cope and Kamal K. Bhattacharyya,
A Study of Fugitive Coal Dust Emissions in Canada, Ch. 8,
prepared for The Canadian Council of Ministers of the Environment, November 2001.
Some of that dust lands on Point Roberts, three miles away.

Fig. 5. Fugitive Coal Dust Lost During Loading

Fig. 6. Panamax-class Bulkers

Panamax (L 950’, max. draft 39.5’, 65K deadweight tons)
Capesize Carriers (L 950-1500’, draft 80’, 175-400K dwt)
Jumbo Class Ferry (L 440’, draft 18’)
Nimitz-class Aircraft Carrier (L 1092’, draft 37’)



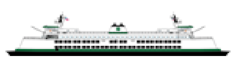
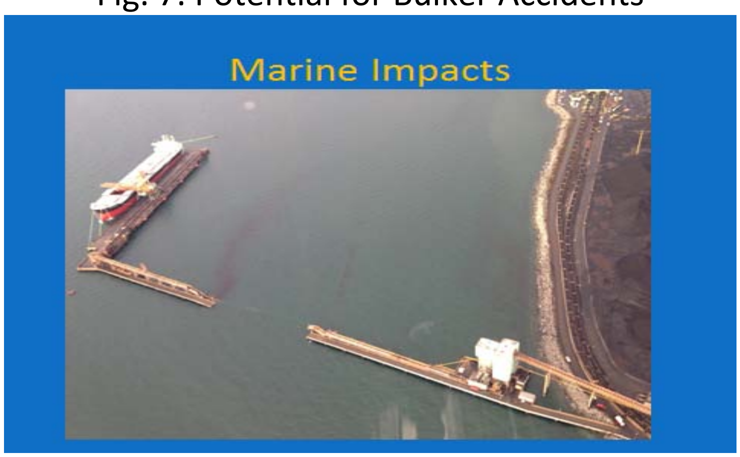


Fig. 7. Potential for Bulker Accidents



Accident at Westshore Terminal Trestle, December 2012. This ship had a pilot on board. Bulkers can travel 7.5 miles when they lose their engines, with no current or wind influences, 2-3 miles after they drop anchor if the chain does not break, which they often do over 12.5 knots. The rescue tug for the Salish Sea is at Neah Bay. There is no rescue tug on the Columbia. Bulkers carry approximately 470,000 gallons of bunker fuel.

Fig. 8. Examples of

Scoping Memorandum concerning the Pacific Gateway Terminal

The Fate of Coal Dust in the Marine Environment

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Prepared For: International Journal of Coal Geology 68 (2006)

March, 2006

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Coal dust dispersal around a marine coal terminal (1977–1999), British Columbia: The fate of coal dust in the marine environment

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Abstract

A 1999 assessment of sediments, adjacent to the Roberts Bank coal terminal in Delta, British Columbia, Canada, shows that the concentration of coal particles (reported as non-hydrolysable solids or NHS) has increased substantially since a prior study in 1977. NHS concentrations have doubled from a mean concentration of 1.80% in 1977 to 3.60% in 1999. Overall the dispersal distance of coal has not increased over the 22-year period but rather the abundance of coal in the surface sediment within the dispersal area has increased. Since 1977 the main deposition of coal has occurred in the vicinity of the coal-loading terminals, where concentrations of 10.5% and 11.9% NHS (non-hydrolysable solids = coal) occur.

The settling properties of fresh and oxidized coal particles (<53 μm up to >2.36 mm) were examined in order to better understand the dispersal of coal in marine waters. No change in settling velocity of coal particles occurred with increasing oxidation. However, the proportion of buoyant coal particles decreases with oxidation in all size fractions, reflecting the decrease of coal hydrophobicity with oxidation.

The distribution of coal around the terminals agrees with measured particle settling velocity and current velocity, with coal concentration decreasing rapidly away from the terminal. Coarser sediment fractions contain the highest coal (NHS) concentrations and carbon/nitrogen ration when compared to finer fractions. Coal particles with >2.36 mm diameter (settling velocities ≤10.54 cm/s) settle out close to the terminal (depending on currents), whilst small (<53 μm) and weakly oxidized coal particles travel further and take longer to settle out (settling velocities ≥0.16 cm/s). This results in a wider dispersal of coal particles, and a corresponding decrease in the coal concentration.

Coal distribution would likely affect those benthic flora and fauna, most susceptible to coal dust coverage and possible anoxic conditions that might arise during coal oxidation within very close proximity (0–100 m) to the coal-loading terminal.

Keywords: Coal contamination; Coal environment; Coal settling velocity

1. Introduction

The Roberts Bank coal terminal has been in business for over thirty years and is presently operated by Westshore Terminals Ltd (Fig. 1). Located on Roberts Bank in the municipality of Delta, British Columbia, Canada, it is the first stage in a proposed development of a major bulk-loading port and industrial park, as the major terminals in Burrard Inlet (Vancouver, B.C.) exceed their exporting and development capacities.

However, Roberts Bank is not naturally a deep-sea port and is located in one of the most ecologically

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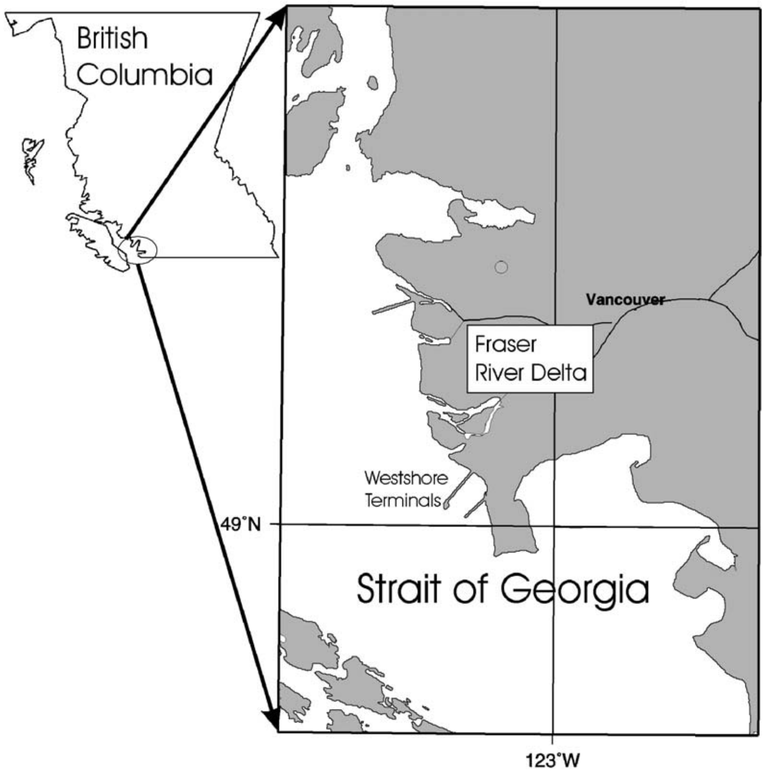

Fig. 1. Location of Westshore Terminals and Fraser River Estuary, British Columbia, Canada.

important estuaries on the west coast of North America. The construction of the coal terminal has had numerous effects on the local ecology, and the release of coal dust has had a detrimental impact on the region.

This paper investigates the coal content of the sediments in the vicinity of the coal loading facility, and reveals significant changes in sediment coal content and distribution in the 23 years since the previous study. An assessment of the settling properties and velocities of the coal particles in the water column were conducted to predict coal particle dispersal around the terminal, and these results are compared with the observed distribution of coal in the sediments adjacent to the coal loading facility. Some of the effects of this coal accumulation on the local ecology are also discussed.

2. History and previous studies

In April 1970, shipments of coal mined in the interior of British Columbia and Alberta began from the Roberts Bank coal terminal located south of the Main Arm of the Fraser River, just south of Vancouver (Fig. 1). The present facility consists of a 96-hectare man-made island situated at the end of a 4.8-km long causeway, serviced by a 20-m deep dredged waterlot and a large ship turning basin located between the terminal and the Tsawwassen Ferry terminal (Fig. 2).

Westshore Terminals handle approximately 30% of the shipping volumes of the British Columbia Lower Mainland. Approximately 90% of this volume is coal that is transported to the facility in unit trains, where the coal is unloaded and stored in large unprotected stockpiles. The coal is subsequently loaded aboard ships ranging in size form 45 000 deadweight tonnes (DWT) to 250 000 DWT for export from two major coal-loading terminals, referred to as pods #1 and 2 (Fig. 2). Coal shipments have increased from 10.6 million metric tonnes in 1980 to a maximum of 23.5 million in 1997. Estimates forecast a continued increase of 4% per annum until 2010 (Fraser River Estuary Management Program (FREMP), 1990a,b). Annual shipments are projected to reach 30 million metric tonnes of coal only with modification of Pod #3, as this terminal is presently being used as a bulk cargo terminal (Deltaport).

In 1975, Westshore Terminals Ltd. applied for a permit under the British Columbia Pollution Control Act, 1967 (Emissions), to discharge “unknown and immeasurable” quantities of coal dust to the air (Pearce and McBride, 1977) as they had previously operated

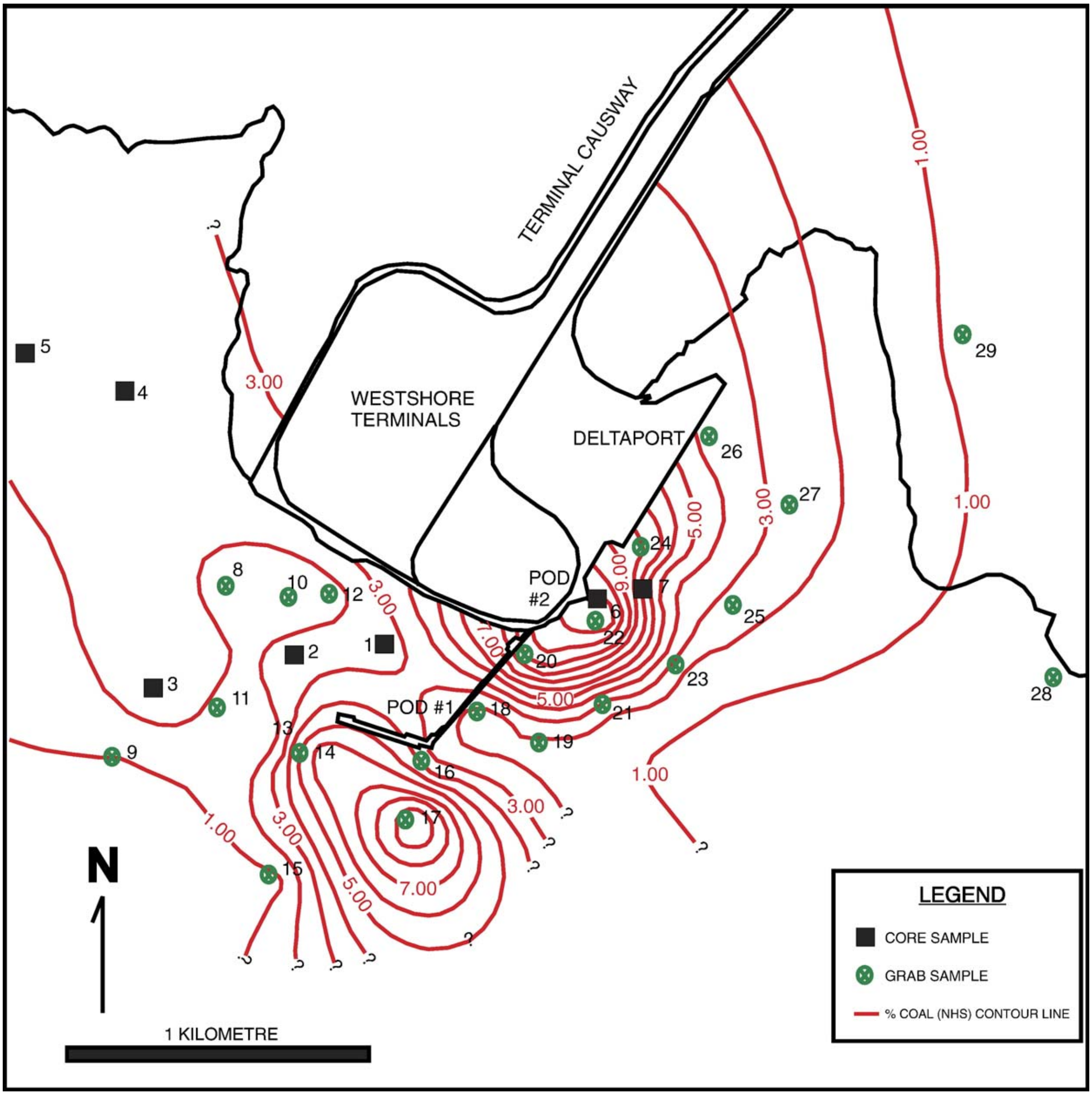

Fig. 2. Sample location and coal dust distribution in surface sediment as measured in weight percent NHS.

without a Pollution Control Branch permit. Local residents as far away as Pt. Roberts, have often complained of the coal dust escaping the terminal (Department of Fisheries and Environment Canada, 1978) from the incoming loaded rail cars, conveyor belts, and returning empty trains during the loading processes. Emissions from open stockpiles also contribute to the coal dust (especially during high wind periods), though it occurs to a lesser degree due to the use of resin binders such as polyvinyl acetate (Pearce and McBride, 1977).

Coal accumulation in bottom sediments, documented by Butler (1972) and Butler and Longbottom (1970) stimulated the Habitat Protection staff of the Fisheries and Marine Service to undertake a limited program in 1975 to study the further accumulation of coal in marine sediments around the terminal, and the possible effect of this coal accumulation on the local ecology. Pearce and McBride conducted the last of these studies in 1977 (Darrel Dejerdin, Vancouver Port Authority, Environmental Services, pers. Comm., 1999) and concluded that the coal content of the sediments adjacent to the Roberts Bank (reported as non-hydrolysable solids) increased only slightly in the five years since Butler's investigation.

3. Study area

Historically, man's encroachment upon, and development of the ecologically important Fraser Estuary/Delta has generally been both ad hoc and unrestricted. This uncoordinated approach to resource use, without regard to, or knowledge of effects on the environment has led to very significant changes in the environment. Since the 1800's, roughly 70% of the estuary's original wetlands have been lost to dyking, dredging, draining, and filling (FREMP, 1997). However, the total area of freshwater and brackish marshes on the outer estuary may have increased in the last century due to the accretion of mudflats on Sturgeon and Roberts Banks (FREMP, 1996).

3.1. Physical environment

Annual deposits on Roberts Bank of approximately 17 million tonnes of sediment are supplied by the Fraser River (FREMP, 1996), the largest river on the west coast of North America (Fig. 1). This sedimentation plays a vital role in the creation of much of the aquatic habitat on Roberts Bank, and is in a dynamic state due to interacting and variable river flows and tides. Constant dredging is necessary to maintain depths of navigable shipping lanes in the vicinity of Westshore Terminals, and recent applications (Westshore Terminals Administrative Department, 1998) have been submitted to dredge approximately 4000 m^3 in the immediate vicinity of Pod #2, (Fig. 2; Dariah Hasselman, FREMP, Project Review Coordinator, pers. comm.).

Roberts Bank comprises approximately 8000 of the total 14,000 hectares of tidal flat associated with the Fraser River Delta. The dominant platform of Roberts Bank is over 6-km wide and slopes gently from the dyked delta lowlands out to a distinct break in slope, approximately 9 m below the lowest normal tide level (Fig. 2). In the vicinity of the Westshore Terminals causeway, the intertidal area exposed between high and low water is approximately 3000-m wide. Tidal channels, current, and wave ripples interrupt the otherwise featureless bank (Luternauer and Murray, 1973; Luternauer, 1974.

3.2. Estuarine ecology

The Fraser River estuary is notable for its biological productivity. This is especially evident between the Roberts Bank Coal Loading Port and the Tsawwassen Ferry Terminal, home to tidal flats, wetlands and eelgrass beds. These habitats form the basis for populations of varied estuarine life forms (in addition to the large numbers of migratory salmon and waterfowl) including the benthos, plankton and fish (Federal Environmental Assessment Review Office, 1979; Fraser River Estuary Management Program, 1989, 1991a, 1991b, 1993, 1994).

The benthos, composed of organisms dwelling on the sea bottom and in sediments are the most greatly affected due to the disturbance of the bottom caused by deposition of coal particles. Anoxic conditions, evident from the presence of hydrogen sulphide, in the sediments receiving very high levels of organic input (including coal), caused by the consumption of oxygen during the degradation (oxidation) of organic matter, would likely have the most detrimental impact on the benthic florae and faunae.

The ecological contribution of bottom microinvertebrates is very significant, as larvae from clams, mussels, barnacles, and crabs drift out to sea and constitute a substantial proportion of the seasonal food for juvenile salmonids and herring. Damage to the benthos therefore has serious implications for both the mature invertebrate populations as well as those creatures that predate upon the benthic larvae.

The Fraser River and its estuary support one of the largest commercial, recreational, and aboriginal salmon fisheries in British Columbia, which includes salmon, surf smelt, eulachon, cutthroat trout, steelhead trout, white sturgeon, mountain whitefish, and Dolly Varden. The annual commercial fishery of Fraser River salmon between 1989 and 1992 was valued of over $115 million (Canadian dollars), with a post-processing wholesale value of over $230 million (Environment Canada and Fisheries and Oceans Canada, 1995). Additionally, sport fishing throughout British Columbia earns about $180 million/year in direct revenues, with Fraser River Chinook and Coho comprising a large percentage of this catch (Environment Canada and Fisheries and Oceans Canada, 1995). Furthermore, seven native bands (Musqueam, Tsawwassen, Semiahmoo, Coquitlam, Katzie, Matsqui, and Langley) participate in the aboriginal food fishery in the Fraser River Estuary.

On Roberts Bank, the Dungeness crab is the only species that is exploited commercially and recreationally, representing approximately 10% of the total catch in British Columbia (Environment Canada and Fisheries and Oceans Canada, 1995). The reported darker coal-coloration of some crabs taken from Roberts Bank is a concern of local fishermen who find the darker crabs more difficult to market.

4. Material and methods

4.1. Sediment and sample collection

A benthic sample of the sediments was collected from each of 29 subtidal sampling stations (Fig. 2). The station locations were established using a differential GPS device and cross-referenced with the Canadian Hydrographic Chart #3492 (Fig. 2) and were chosen at roughly 200 m intervals radiating from the two main coal-loading terminals (pods #1 and 2). Stations 28 and 29 were situated closer to the Tsawwassen ferry terminal to act as 'controls'.

A gravity impact corer was used to collect the first seven samples at high tide on October 22, 1999 and a Shipek© model sediment sampler was used to collect the last 22 samples on November 26, 1999.

Upon retrieval, the uppermost 2–3 cm (approximately 200 g) of the samples were removed and placed in sealed plastic bags while the remainder of the samples were placed in larger bags, or retained in the core tubes. The samples were transported immediately to the laboratory and placed in a freezer to prevent decomposition.

Two coal samples (samples 30 and 31) from the Balmer seam (R_0 ~1.4%) of the Early Cretaceous Mist Mountain Formation (Kootney Group) were used in both the sediment coal content and coal settling property analyses, as these metallurgical coal samples are representative of the majority of coal exported from the Westshore Terminals facility.

4.2. Analytical techniques

4.2.1. Sediment coal content analysis

Determination of the coal content in the 29 sediment samples (each measured in duplicate) was performed using a modified hydrochloric acid hydrolysis method, mimicking the analytical procedure of Pearce and McBride (1977). During this process hydrolysable protein and acid-soluble carbonates are removed by hydrochloric acid hydrolysis with the remaining non-hydrolysable organic matter being removed by hydrogen peroxide oxidation.

Coal is essentially unaffected by the peroxide oxidation and hydrolysis, and its concentration is determined by subsequent gravimetric analysis and ashing. Coal content is reported here as percent total non-hydrolysable solids (NHS), while the organic content is reported as the percent total hydrolysable solids (HS).

The percent NHS is not a measure of the actual coal content of the marine sediments, mainly due to the presence of hydrolysis-resistant organic material such as wood, charcoal, and bark. Post-hydrolysis combustion of such materials would provide an overestimate of the actual coal content by resulting in an elevated NHS value. Despite this source of error, investigations have shown that NHS values do provide an indication of the coal content in marine sediments (Pearce and McBride, 1977).

Two coal samples from the Balmer seam were also analyzed to allow an estimate of coal lost during the digestion process as well as determining the ash content.

4.2.2. Sediment particle size analysis

Sediment particle size analyses were performed on the seven core samples using the wet sieve method described by Morgans (1956) to minimize the loss of particles and reduction in their grain size. The sediments were sieved into five different size fractions and then dried at 50 °C for 3 h prior to being weighed. Cumulative weight percents were plotted against grain size values to obtain an estimate of the grain size distribution in the vicinity of Westshore Terminals, as well as the degree of sediment sorting. Individual sieve fractions were examined with a microscope to determine an estimate of the fractions in which most of the coal grains occur.

4.2.3. Sediment organic/inorganic carbon and nitrogen analysis

Upon completion of the sediment particle analysis, samples were ground to less than 53 μm using a mortar mill. The organic carbon content for the various sediment size fractions was determined from the difference between total carbon content and inorganic carbon (IOC) content, with IOC content being determined by coulometric analysis.

Sediment total organic carbon (TOC) and nitrogen content for the sediment size fractions were determined using an instantaneous oxidation of the sample by 'flash combustion' and subsequent chromatographic analysis.

4.2.4. Coal settling properties analysis

A series of settling velocity experiments were performed to determine the settling characteristics of coal under various conditions in an attempt to explain the distribution of coal in the sediments surrounding Westshore Terminals. The effects of moisture and various degrees of oxidation on the hydrophobicity of the coal particles were investigated to determine the conditions under which various size fractions would float or sink, as well as to determine their settling velocities.

Coal samples from the Mist Mountain Formation were crushed using a mortar and pestle, dry sieved to the desired size fractions, and placed in sealed plastic containers. Five, 1-g samples of the smallest coal size fraction (<53 μm) were gently placed on the surface of 200 ml of seawater in open jars, and left exposed to the atmosphere for a month without agitation.

The remaining samples of the larger size fractions were divided into four subsamples. One group remained in the sealed plastic containers; the second group was placed on open aluminum foil trays at approximately 25 °C; the third group was placed in open beakers an oven at 50 °C; and the fourth group was placed in open beakers in the oven at 100 °C.

Settling velocities were determined in a 1000-ml test tube filled with 25 °C seawater by dropping individual coal particles from 8 cm above the water surface (to partially overcome surface tension), and the settling time was recorded for individual particles to settle 30 cm in the test tube. Ten trials were run for each size fraction, and an average of the trials was calculated. The number of buoyant coal particles was also recorded, as well as whether agitation was necessary to initiate particle settling. Agitation of the samples involved gently pushing the samples below the water surface with a glass rod; their displacement being factored into the settling times.

The settling velocities of the thirteen different coal size fractions of the first group of ‘fresh’ (least oxidized) coal samples were measured immediately, while the other three groups were allowed to oxidize for a week at temperatures of 25, 50, and 100 °C. The ‘100 °C’ group of coal particles was returned to the oven for further oxidation and their settling properties were measured on a weekly basis for the following two weeks. Oxidation was confirmed by measuring the loss of caking ability of the coal. Because of the fine particle size, petrographic observations of the samples by light microscopy was not possible.

The densities of the coal samples (larger than 2.36 mm) were measured for the fresh, saturated, and oxidized (25, 50, and 100 °C) groups by weighing the samples in air and in toluene. Specific gravities were determined from the particles’ displacement in toluene.

5. Results

5.1. Sediment coal content

The coal and organic content of the sediments, expressed as the percentage of non-hydrolyzable solids and hydrolysable solids respectively, are shown in Table 1.

Based on the sediment NHS content, the subtidal coal distribution in the area around the coal terminal is shown in Fig. 2. The area of greatest accumulation (>11%) is located directly southeast of the Pod #2 coal-loading terminal. This region of high concentration is limited to within a hundred metre radius of the loading facility, and the coal concentration diminishes rapidly to less than 1% within 700 to a 1000 m. A second region of elevated coal dust concentration (>10%) is found approximately 200 m directly south of the Pod #1 coal-loading terminal. Samples were not taken closer to Pod #1 (between stations 14 and 16) because a large coal transport ship was moored at the terminal on both sample collection dates. This region around Pod #1 is

Table 1
Sample location with average total organic carbon content and average coal content (NHS)

Sample station	Average OM content (%)	Average coal content (%)	Sample station	Average OM content (%)	Average coal content (%)
1	17.98	2.74	16	18.62	3.02
2	12.71	2.66	17	31.47	10.47
3	14.46	2.97	18	18.92	1.20
4	14.47	2.52	19	15.45	1.61
5	15.61	2.31	20	14.02	9.90
6	15.17	10.85	21	19.60	2.14
7	22.92	4.22	22	16.12	11.90
8	23.95	1.74	23	16.48	1.95
9	18.28	0.91	24	23.10	7.80
10	17.01	1.62	25	18.26	2.48
11	15.79	1.52	26	24.26	3.29
12	20.74	1.82	27	31.70	2.58
13	14.86	1.04	28 (control)	14.02	0.77
14	14.02	6.72	29 (control)	13.71	0.65
15	13.06	0.92	30 (coal)	0.12	94.89
			31 (coal)	0.77	93.41

also characterized by a high NHS concentration gradient, dropping to levels less than 1% within 500 to 1000 m. An area of moderate accumulation (1–3%) completely surrounds the coal terminal and extends outward for at least 1000 m to the north (limit of sampling), west, and east, and 800 m towards the south. Contouring of Fig. 2 south of stations 15 and 16 is based on limited data. Subtidal control samples collected at stations 28 and 29 (near the Tsawwassen ferry terminal and causeway) contained low (<0.8%) NHS concentrations.

The coal content in the sediments decreased significantly with distance from the terminal (Fig. 3).

Concentrations of hydrolysable matter, assumed to represent organic matter (OM) content, consistently exceeded the non-hydrolysable (coal) content in the sediments in each of the twenty-nine stations sampled. OM was found to compose at least 12% (by weight) of the surface sediment content on Roberts Bank, with a maximum of 31 OM at station 17 (Table 1).

The two Mist Mountain coal samples have an average of 0.44% HS. However, this apparent hydrolysable solid content most likely represents the irremovable coal residue in the test tubes upon completion of the digestion process. The coal samples were analyzed to contain an average of 94.15% NHS, with the decreased mass likely representing the ash content of the coal.

5.2. Sediment particle size

Results from the physical analysis of the sediment samples from the core samples are presented in Figs. 4–6. Subtidal grain sizes range between silt and clay to medium grained sand (<53 to >355 μm). The sediments to the north and northwest of the terminal are primarily silt and fine sand (<53 to 250 μm), while the area to the south and east is dominated by fine to medium sand (125 to 500 μm). The nearshore area adjacent to the coal terminal in the lee of the Pod #1 terminal (Core #1) is dominated by fine sediments in the silt and clay range (<63 μm).

Quartz grains dominate the sand, though a high abundance of lithic grains, shell fragments and mica also occur. Large coal fragments (up to 2 cm in diameter) occur in several of the core and grab samples, and are especially abundant in sample locations 6, 17, 20, and 22. The sediments have a moderate to poor degree of sorting and the larger grains are predominantly subangular with a moderate degree of sphericity. Both the degree of angularity and the composition of these sediments are indicative of poor to moderate chemical and physical maturity.

5.3. Sediment organic/inorganic carbon and nitrogen content

Results from the analysis of the total organic carbon (TOC) indicate that the TOC is highest in the coarser sediment size fractions (>250 μm), with a maximum of 16.8% in Core #6 (Fig. 4). TOC values in the smaller size fractions are generally less than 2%, and the lowest values occur in the 150-μm size fraction.

The inorganic carbon (IOC) values are generally less than 0.7%, with a maximum value of 1.2% occurring in the coarsest fraction (355 to 500 μm) in cores 1 and 7.

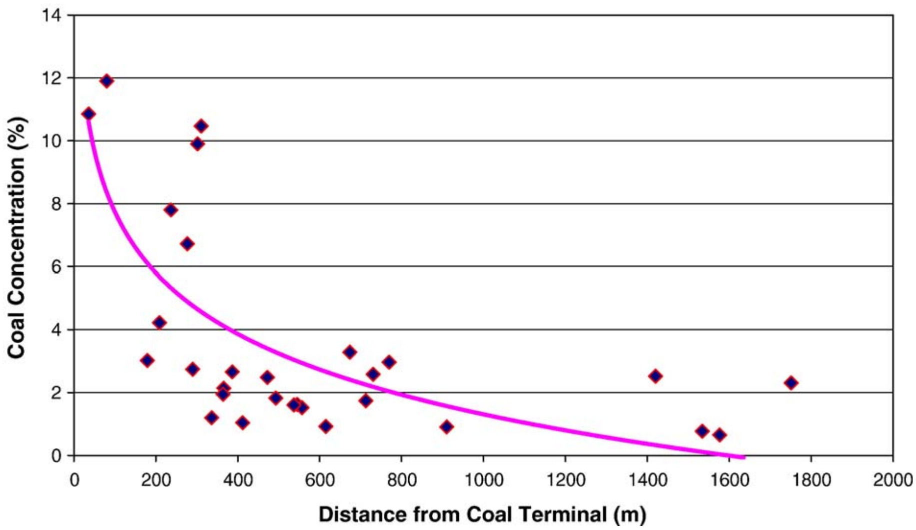

Fig. 3. Coal concentration (wt.%) with distance from the coal terminal.

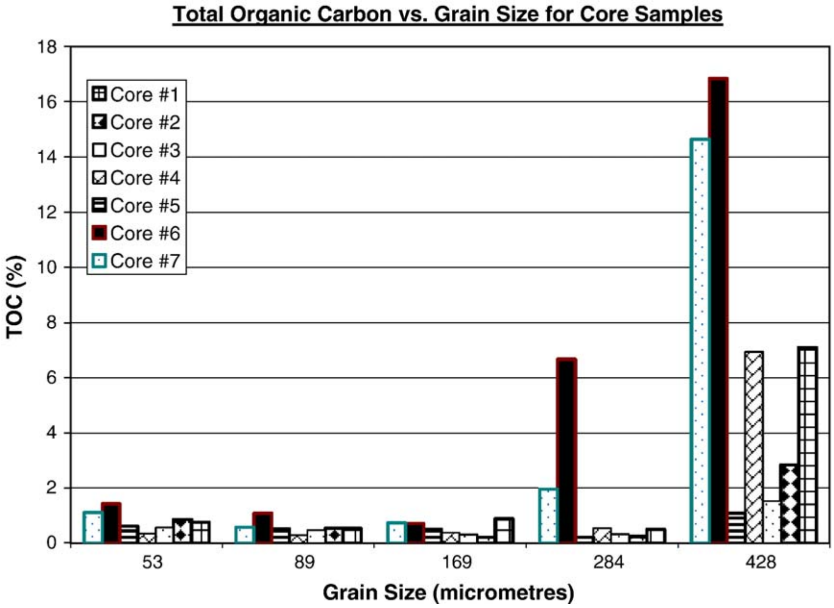

Fig. 4. Total organic carbon content vs. particle size distribution of samples for cores collected across study area (core locations are shown in Fig. 2).

Minimum values of IOC content are found to coincide with a grain size of approximately 200 μm, albeit a poor correlation.

Trends in the sediment nitrogen concentrations are found to generally conform to those of the TOC concentrations, although the nitrogen concentrations are considerably less (Fig. 5). Maximum nitrogen concentrations reached 0.34% in the largest size fraction (355 to 500 μm), while the nitrogen content in the majority of the other size fractions rarely exceed 0.10%. Minimum concentrations of approximately 0.03% nitrogen occur near the 200 μm size fraction.

A ratio between the carbon and nitrogen was plotted against the various core sample grain size fractions to determine whether or not the carbon being measured was from a terrestrial or marine source. Terrestrial carbon sources are known to generally have a higher C/N ratio than their marine counterparts (Mayer, 1994).

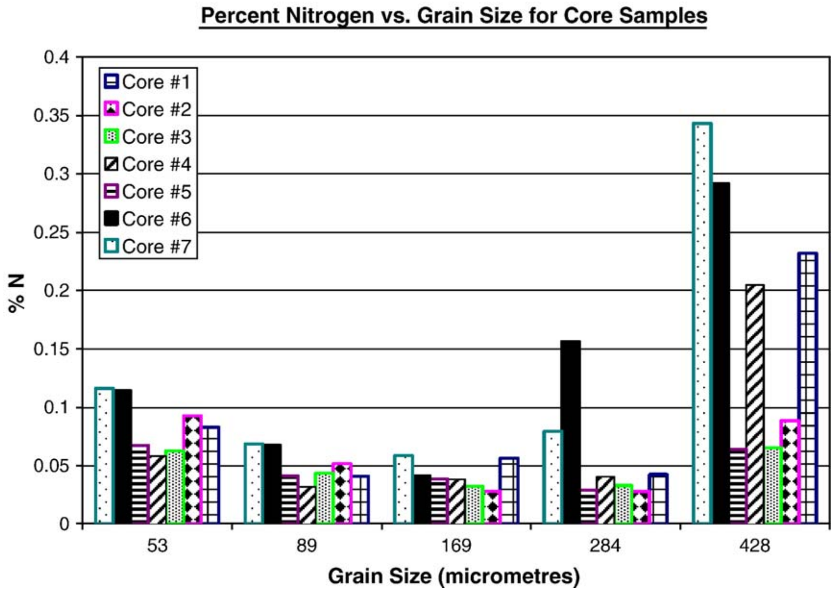

Fig. 5. Particle size distribution of samples vs. the total nitrogen content for cores collected across study area (core locations are shown in Fig. 2).

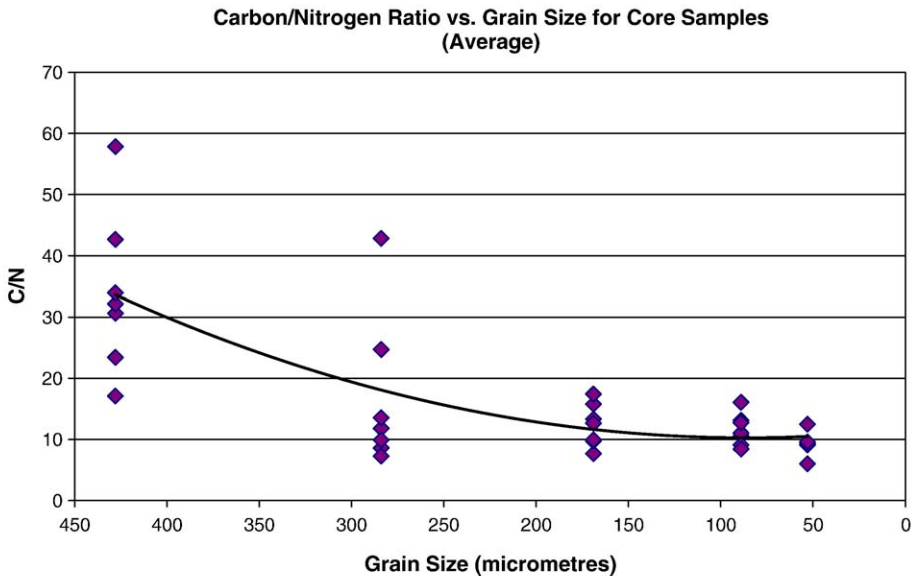

Fig. 6. Carbon to nitrogen ratio vs. grain size.

The highest C/N values occurred in the larger size fractions, and the C/N ratios generally decrease with decreasing particle size (Fig. 6). Cores 6 and 7 have the greatest C/N ratios, with a maximum value of approximately 68 for the 355 to 500 μm size fraction of Core 6. These elevated C/N values generally coincide with the maximum TOC and nitrogen values in the larger size fractions (Figs. 4 and 5), while the lowest C/N values have an approximate correlation with the minimum TOC and nitrogen values of cores 3 and 5 in the smaller size fractions. Cores 1, 2, and 4 lacked correlation between the TOC, nitrogen, and C/N values, although the same general trend can be observed.

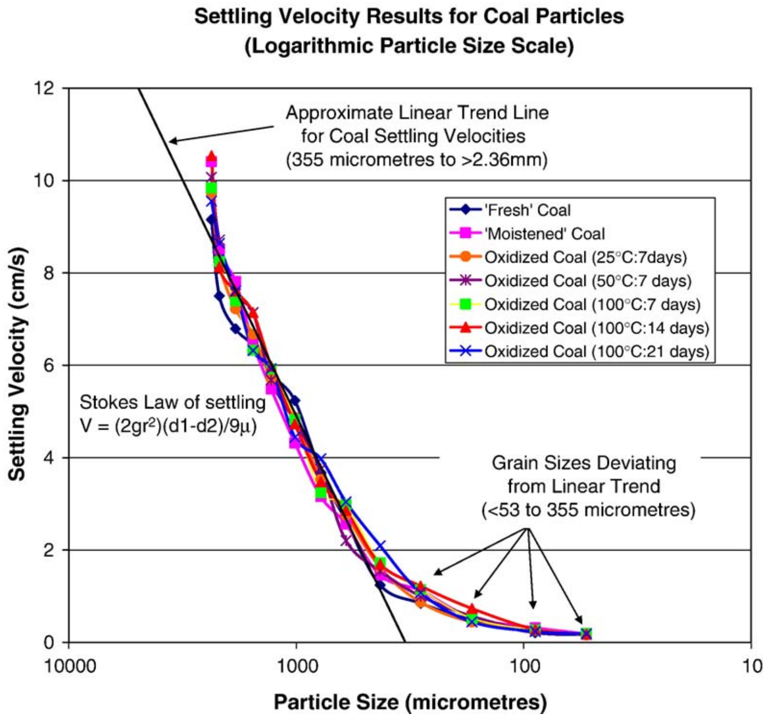

Fig. 7. Variation in coal particle settling velocity with particle size and degree of oxidation. For most particle sizes settling rates follow Stoke's Law.

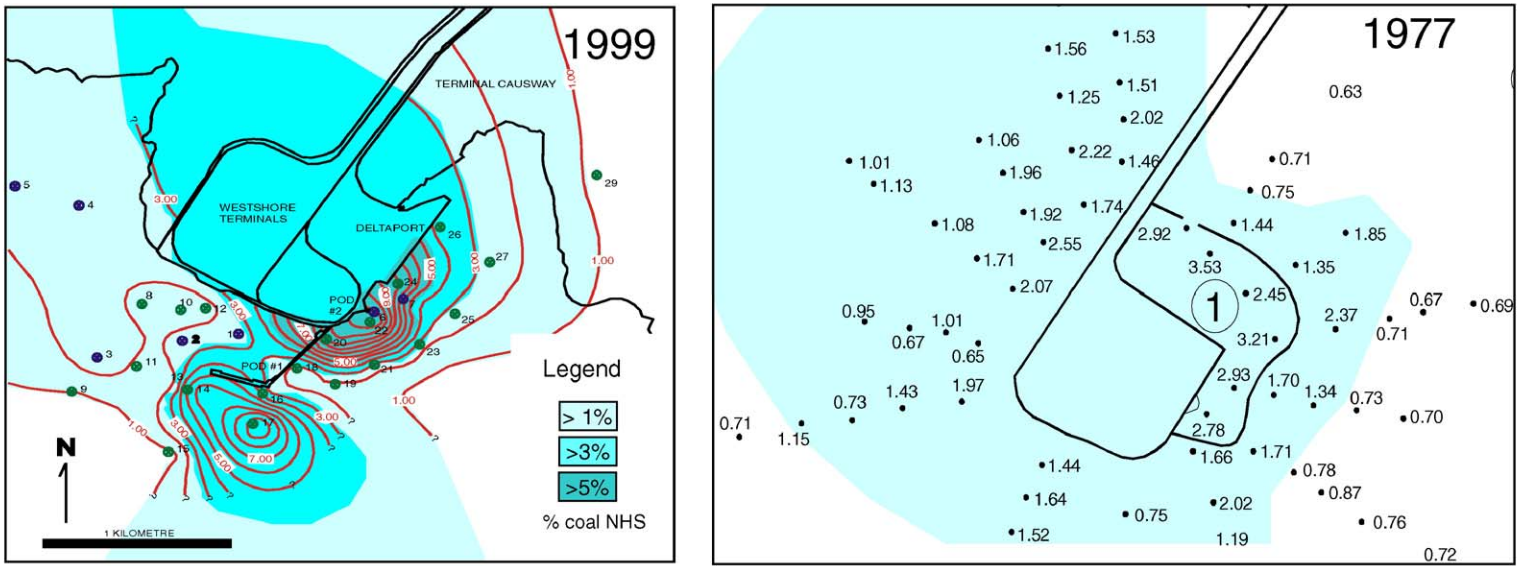

Fig. 8. Comparison of coal distribution (NHS) in 1977 and 1999 in the vicinity of the Terminal. Scale on each map is approximately the same. The aerial extent of the coal has changed little between 1977 and 1999 however the abundance of coal is markedly higher in surface sediments in 1999. The scale for both maps is the same.

5.4. Coal settling properties

The settling velocity results are presented in Figs. 7 and 8. The vast majority (>99%) of the five smallest samples (<53 μm) placed in open jars of quiescent seawater remained on the surface after a month; agglomerating into balls up to 1 cm in diameter. This agglomeration is likely the result of a weak electrostatic attraction between the fine coal particles as they also aggregate in a dry container, disintegrating only when shaken vigorously. The rest of the coal dust remained on the surface as a thin film, attesting to the hydrophobicity of the coal. The resistance to settling of the coal particles could also be due to surface tension, although one would expect this effect to be overcome when the particles were temporarily immersed in the water during vigorous shaking of the jars. Larger particles that did not settle, aggregated at the surface, even when initially separated by up to 5 cm. This attraction might be due to electrostatic forces and mutual repulsion from the water (hydrophobicity). The particles remained bound even after agitation and would settle at a greater velocity due to their combined radii.

The settling velocities of the different coal size fractions did not change significantly with oxidation, as illustrated by the similar trends in settling velocities in Fig. 7. Nonetheless, the settling velocities for the larger grain sizes (1.7 to >2.36 mm) increased slightly when the samples were moistened and exposed to various degrees of oxidation. The settling velocity for coal grains larger than 2.36 mm increased from a minimum of 9.15 cm/s ('fresh' coal) to 10.54 cm/s (100 °C: 14 days). However, exposure of the coal to 25, 50, and 100 °C oxidation conditions over the course of the experiment did not result in a consistent increase in settling velocity for the remaining grain size fractions.

As predicted by Stokes Law, the settling velocities decreased exponentially with decreasing particle size (diameter) for the majority of the grain sizes. The approximate linear trend line illustrated in Fig. 7 when the particle sizes are plotted on a logarithmic scale demonstrates this relationship. The smaller grain sizes (<53 to 355 μm) deviated from this trend, with a reduced rate of settling velocity increase with increasing particle size.

Although the settling velocities of the coal did not change significantly with oxidation, there was a consistent decrease in the size fraction where agitation was necessary. The least oxidized coal samples (based on time of exposure and confirmed by loss of caking ability) were found to have a greater proportion of particles that would float than those oxidized more thoroughly. Agitation was generally necessary for grain sizes smaller than 500 μm.

The specific gravities of the coal particles did not change dramatically under the various exposure conditions averaging 1.39±0.05 for all of the subgroups. However, the specific gravity did vary by as much as 0.10 within each group, attesting to the heterogeneity of the small coal samples.

6. Discussion and conclusion

An assessment of the benthic sediments adjacent to the Westshore Terminals coal terminal on Roberts Bank has shown that the concentrations of coal in the sediments (reported as NHS) has increased substantially since it was last investigated in 1977, having doubled from a concentration of 1.8% in 1975 to a mean concentration of 3.60% in 1999. NHS concentrations range from 0.65% in the 'background' samples 1.5 km away up to 11.90% in the immediate vicinity of the coal loading terminals. Since 1977 the main deposition of coal appears to have occurred in the vicinity of Pods #1 and 2 coal loading terminals, although limited samples were taken on the north side of the coal terminal causeway (Fig. 8). Coal concentrations in the sediments generally decrease rapidly with increasing distance from the terminal. Overall, the dispersal distance of coal has not increased over the 22-year period but rather the abundance of coal in the surface sediment within the dispersal area has increased.

The settling velocities of coal particles ranging from <53 to >2.36 mm did not change significantly with increased saturation and oxidation, although the saturated samples and those that were oxidized did settle faster in the largest size fraction (>2.36 mm). However, the proportion of buoyant coal particles decreased with increasing exposure to oxygen and temperature of heating throughout the range of coal size fractions examined, supposedly reflecting the decrease of coal hydrophobicity with increased oxidation.

Settling velocities for the coal particles in sea water analyzed in this experiment range from 0.16 to 10.54 cm/s for the <53 μm and >2.36 mm size fractions, respectively. These size fractions represent the majority of coal that could escape in the local winds (via deflation and saltation) during the loading processes and from the stockpiles themselves. Local winds average between 10–15 km/h throughout the year and attain speeds in excess of 60 km/h, especially during the winter months (Environment Canada, 1963–1990).

The regions around the coal terminal with the highest coal concentrations average depths between 5–20 m (Fig. 2). According to this experiment, the largest size fraction (>2.36 mm) would take between 47 s and 3 min to settle 5 and 20 m, respectively. Assuming that the smallest fraction (<53 μm) would settle, it would take coal particles of this size fraction between 52 min and 21 h to settle the same depths. However, both of these calculations assume that the water column lacks any vertical or horizontal currents. Such conditions are rare at Roberts Bank, and would only occur at slack tide on an extremely calm day. The action of any currents in the water column would have drastic repercussions on the settling velocities of the coal particles, especially for the smaller size fractions. ` On Roberts Bank, normal maximum tidal currents alone can reach 0.051–0.76 m/s near Pod #1 (Canadian Hydrographic Service). In such currents the coal particles larger than 2.36 mm could travel laterally up to approximately 60 m to settle 5 m through the water column, and travel 230 m to settle 20 m. In the same currents, the smallest size fraction could travel between 4 and 96 km laterally to settle to the same depths (although it is highly unlikely that maximum tidal currents could be sustained for the 21 h necessary for 96 km of dispersal). Upwelling currents and turbulence would also contribute to the residence time of the coal particles in the water column. Furthermore, these calculations assume that the particles would settle in the first place, though the waves and currents would undoubtedly agitate the coal particles to a degree and initiate settling.

The hydrophobicity of the coal particles would result in particles staying afloat longer than assumed in the above calculations. During the sampling a thin layer of small coal particles floating on calm water approximately 200 m east of Pod #2 was observed. This film of fine coal particles was observed when there was no coal loading activities in progress, and no ship was docked.

The distribution of coal around Westshore Terminals is in agreement with the data from the analysis of the coal settling properties. The sediments that contain the highest coal concentrations are in the coarser size fractions in close proximity to the coal loading facility. The experiments studying the settling velocities of the coal particles indicate that the larger coal particles (with settling velocities of up to 10.54 cm/s) settle out within the first few hundred metres of the terminal (depending on the currents). The degree of coal oxidation would dictate which coal size fraction would readily settle, with the increasingly oxidized particles tending to settle due to their decreased hydrophobicity. The smaller particles (as well as those oxidized to a lesser degree) would float longer and take longer to settle (with minimum velocities of 0.16 cm/s) through the water column, resulting in an increased dispersal of the coal, and coincident decrease in the sediment coal content. These low concentrations would be difficult to detect using the hydrolysis method of this study.

Benthic flora and fauna, which are most susceptible to coal dust coverage and possible anoxic conditions that might arise due to the oxidation of the coal, would likely only be affected on sediments within very close proximity (0–300 m) to the coal loading terminals at pods #1 and 2. Creatures dwelling further away would unlikely experience coal concentrations sufficient to blanket the bottom (thereby decreasing insulation) and give rise to anoxic conditions in the upper sediments. Furthermore, in all of the sediments sampled in this study, the hydrolysable organic matter content of the sediments ranged between one-and-a-half to 20 times the coal content (NHS) of the sediments. If anoxic conditions were to arise, they would likely be the result of the natural organic detritus rather than the coal content. Inspection of the sediments around Westshore Terminals failed to reveal any evidence of anoxic conditions in the upper sediments. If anoxic conditions did prevail, the sediments (at a variable depth below the sediment–water interface, depending on the degree of oxidation) would be expected to have a dark (black) coloration and pungent aroma. Such characteristics would reflect a reducing environment in which bacterial degradation of the organic matter (as well as the activities of detritivores) was inhibited by a lack of oxygen.

The benthic creatures dwelling in the sediments adjacent to the coal terminal would more likely be adversely affected by the alteration of their habitat through changes in the physical nature of the substrate such as size, weight, particle shape, porosity, permeability, and stability of the sediments (Pearce and McBride, 1977) due to the dredging operations in the area.

Though this report does not directly address the amount of suspended solid levels (i.e. coal) in the waters around Westshore Terminals, Shelton (1971) documented the effects of dumping annually 6.2 million metric tonnes of fine coal, fly ash and other colliery wastes off the north coast of England. Investigations demonstrated that the growth of periphytic (attached) algae was inhibited by the reduction of light penetration from increased levels of suspended solid load, adversely affecting the fauna associated with the attached algae. While the volume of coal dust settling on Roberts Bank is undoubtedly much less than that documented by Shelton (1971), the study does indicate the effects of suspended coal levels may have on marine flora and fauna.

Acknowledgements

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Scoping Memorandum concerning the Pacific Gateway Terminal

Impact on "Sea Butterfly"

Individual Comment By: Peter Knutson
Salmon Fisherman

December 13, 2012

Testimony Given for:
Gateway Pacific Terminal,
Seattle Public Comments
Taken at: Seattle Convention Center
800 Convention Place
Seattle, Washington
Reported by: Thad Byrd, CCR
Reported on: December 13, 2012

Obtained at:
http://www.eisgatewaypacificwa.gov/sites/default/files/content/files/SeattleTranscripts.pdf

<u>Pete Knutson, Coal Hearing 12/13/12</u>

For the last 40 years I've been a salmon fisherman in southeast Alaska and Puget Sound. Our boats at Fishermen's Terminal support processing workers, welders, technicians, shipwrights and craftspeople in many fields. Our family's fish feed the people of King County at many farmers' markets.

Anyone who claims that this massive coal project is about jobs had better learn how to subtract. There are 15,000 family wage incomes generated from the Seattle-based fishing industry, according to a Port of Seattle economic study. And we're just one coastal region on a Pacific Rim that runs from California to Korea. All of these marine livelihoods will be jeopardized in this century as the oceans rapidly acidify due to the burning of fossil fuels.

Coal trains through downtown Seattle, rail interference with the Ballard Locks, coal dust in our communities: these impacts will certainly degrade the quality of our local economy and our health.

But the deadliest catch of all is ocean acidification. About 30% of the carbon dioxide generated from fossil fuel burning is absorbed by the earth's oceans, which then become more acidic. We are already seeing impacts to shellfish in Puget Sound, impacts now recognized in the scientific literature, impacts now being studied by NOAA.

North Pacific salmon eat huge quantities of a microscopic floating mollusc called a pteropod, also known as a "sea butterfly". It has a shell which is vulnerable to ocean acidification. If we lose the pteropod, we endanger the salmon which feeds orca, bear, cedar, human and the whole living web of the north pacific rim.

As we plan for future generations, let's bear in mind that a job is not necessarily a livelihood. There's a qualitative difference between a job based on a one-time exploitation of fossil fuel and a livelihood based on the sustainable harvest of a renewable resource.

If we look at the consequences of this coal proposal from the broadest possible perspective the only moral option is to reject it.

Scoping Memorandum concerning the Pacific Gateway Terminal

Ocean Acidification

Prepared by San Olsen,
President, Friends of the San Juans

December 27, 2012

Letter to the editor, San Juan Journal, Dec 27, 2012

We have many problems demanding our attention, but ocean acidification is one which could forever change our islands.

Since the dawn of the industrial age, ever-increasing amounts of carbon dioxide have been released into the atmosphere, not only warming the planet but increasing ocean CO2 content by 30%. For years scientists have been reporting that CO2 absorption is causing seawater to be more acidic; this change is already destroying coral reefs and threatens the entire marine food chain.

According to the Journal *Nature Geoscience*, Pteropods, small snail-like sea creatures important to many fish including pink salmon, are experiencing thinning and dissolution of their shells resulting in increasing mortality. This is occurring at current pH levels, which is a level initially not expected to be reached until 2038. Any marine organism dependent on calcium carbonate for a shell or body parts is now at risk from acidification. Fish eggs and a host of organisms at the very base of the ocean's food web are likewise threatened.

In past epochs, mass extinctions occurred when the oceans became similarly acidic. However, because the chemical changes occurred over many centuries, the ancestors of today's sea creatures were able to adapt. The present rapid chemical changes may not allow marine organisms to develop survival strategies.

If we value the present oceanic biodiversity and food species, it would seem illogical to promote the use of a fuel associated with physical and economic damages linked to atmospheric and oceanic changes.

We have until January 21st to express our concerns about the transportation and burning of coal overseas. Lowering our planetary CO2 and other green house gas emissions could help save the biology, culture, and economy of our islands. See the Lopez or Orcas NO COALition, or the FRIENDS, web-sites for scoping comment assistance.

San Olson, Lopez Island

Scoping Comment concerning the Pacific Gateway Terminal

Consequences of Pollution from Asia

Prepared By: San Olson
President, Friends of the San Juan

January 16, 2013

I live on a west facing waterfront parcel on Lopez Island. Along the shoreline I have many madrone trees (*Arbutus menziesii)*, some of which are having normal limb dieback and others with obvious disease. This past week I had a certified arborist examine these trees because of the disease progression. He mentioned that madrone trees all over the Puget Sound region are having difficulties. He said that madrone trees are “canaries in the coal mine” in that they are more sensitive to pollution than other trees in a mixed forest environment.

I can understand given air quality in the more industrial areas down sound that pollution certainly could be playing a stressor role in the morbidity and mortality of these trees. However there is little industry to the west of the San Juan Islands, except in Asia where industry and power generation is creating massive pollution. This pollution is being carried by prevailing wind patterns across the Pacific Ocean and may be causing our air quality to be less than healthy.

After a little research on coal combustion products and constituents I learned that Sulfur compounds, soot, and other byproducts of Asian coal burning have been detected on mountaintops in the western US. Research has also linked ozone in the air above the US to pollution from Asian countries that are burning fossil fuels. Mercury, a neurotoxin, which is particularly dangerous for children, is especially likely to travel across the ocean. As much as 18% of the mercury in the Willamette River comes from overseas sources, mostly China. On Mt. Bachelor, in central Oregon, 14% of the mercury present was human-created from Asia. I can only conclude that atmospheric effluents from Asia are reaching the Northwest in measurable amounts.

Even in ‘pristine’ Alaska, chemical contaminants are among many factors suspected to be affecting the survival of stellar sealions, northern fur seals, and harbor seals. Because there are no major sources of industrial pollution (other than infrequent oil spills and localized sources) Asia and other Pacific Rim polluters are thought to the major culprits contaminating Alaskan oceanic ecosystems. This is additional evidence that industrial pollutants are transported far from their origins in Asia.

More worrisome are the large amounts of CO2 being released into the atmosphere. If the proposed coal export terminals come online, at full capacity they could export 100 million tons of coal to be burned in Asia. This thermal coal from the Powder River Basin would add 183 million tons of CO2 into the atmosphere each year. I my view should this happen, it will accelerate and lock in climate change for many decades beyond the lifetimes of Asian coal power plants.

Climatologists are hoping to keep atmospheric CO2 to under 350 parts per million (ppm); presently we have 390 ppm in the atmosphere and it is increasing 2 ppm each year. We may be approaching the “tipping point” where our efforts to reduce CO2 loading will not reverse the climatological changes that will alter life as we know it on our planet. Continuing to add ever more CO2 from coal and other fossil fuels will ensure that we will go beyond the tipping point into irreversible massive climate change within the life time of our grandchildren.

That is what the mining, shipping and burning coal, via the proposed Northwest export terminals, will create if they acquire the requisite permits from our local, state and federal agencies. I realize the coal companies and shippers wish to limit EIS scoping to the relatively small foot print of a given export facility. But, I submit that ignoring the climate changing capacity of those millions of tons of CO_2, and other greenhouse gases, is not only scientifically dishonest, it is immoral.

Please study the effects of pollution on the air quality and human health in the Northwest from the combustion byproducts of coal shipped from the US and burned in Asia.

Please study the climate changing consequences of burning exported US coal in Asia, on global warming, sea level rise, and ocean acidification and any other scientifically recognized problems associated with the combustion products of Powder River Basin coal.

Your decisions may well affect more than Whatcom or San Juan Counties, the State of Washington, or the United States of America. Please keep the long-term health of our planetary chemistry and biosphere in mind when you are weighing these complex legal and policy decisions.

Scoping Memorandum concerning the Pacific Gateway Terminal

Anchoring

Prepared by San Olsen,
President, Friends of the San Juans

December 31, 2012

I previously asked for a through, comprehensive, vessel traffic study that would consider the cumulative impact of increased shipping traffic from the proposed GP Terminal moving through the confined waters surrounding the San Juan Islands. The GPT bulk carriers would be a significant addition to the large number of container, bulker, barge and tanker vessels from US and Canadian ports and terminals already plying these hazardous waters. In that request, I asked that the study include evaluations of the capability of the Vessel Traffic Service (VTS) to handle the current and projected work load, the availability of qualified pilots, the availability of “vessels of opportunity,” the capability of existing spill response resources (both US and Canadian) and the adequacy of navigational aids to handle this increased traffic.

After reading other comments, I request that the vessel traffic study also include the probability and consequences of an accumulation of ships associated with the existing terminals, and the GP Terminal, due to delays in product delivery (such as our frequent mudslides closing the rail lines or derailment), mechanical or accidental delays within the terminal complex (such as occurred at Deltaport recently), as well weather delays of inbound or outbound ships waiting for more favorable conditions or queuing to load.

Please study what bathymetric, geographic, and climatic characteristics would be required to determine where safe anchorages could be located for these deep draft vessels during a disruption of product shipment or shipping schedules due to reasonably foreseeable causes.

As a former navigator of a deep draft US naval vessel, I have multiple concerns about the problems inherent in finding and keeping a safe anchorage under difficult weather conditions, particularly when multiple large vessels are present. It would appear that there are a limited number of suitable anchorages in proximity to the existing oil export terminals and the proposed coal terminal for large vessels. For instance, the one designated General Anchorage, 110.230, just west of Neptune Beach, (Chart # 18421) is 1650 yards in diameter and would safely accommodate two vessels of around 1000 feet in length, assuming anchorage diameters of 600 to 800 ft. (using scopes of 3 times water depth) and at least a 550 yard separation. In any high wind situation, probably only one large vessel should occupy this anchorage.

There is no room in the San Juan Islands archipelago to anchor coal ships. Any anchoring in the small offshore areas around the islands would be destructive of seafloor plants and animals through large diameter scouring by anchor chains.

Bellingham Bay is already occasionally used by tankers waiting to dock at their respective refineries. Repeated anchoring in that embayment will likely release significant amounts of contaminated sediment to the water column. Those sediments contain numerous chemicals acquired over many decades of industrial activity on the Bellingham waterfront plus agricultural and residential input from streams and shorelines. What would be the biological and economic consequences of the use of Bellingham Bay as a temporary but repetitive standby anchorage?

West Samish Bay might be an alternative anchorage, but comparable disruption of contaminated sediments and devastation of seafloor biological communities would result from even occasional use by ships with hefty anchors and heavy anchor chains. What would be the economic and biological consequences should Samish, or similar bays, be utilized as temporary backup anchorages?

I would also point out that in almost all instances any ships anchored in the above mentioned bays and off Cherry Point are on lee shores in any of our typical SE and SW strong wind directions. In heavy weather, multiple large ships in constrained anchorages increase the opportunity for collision, allision, or grounding. Numerous ships seeking sea room may find the narrow sinuous channels leading to the Strait of Juan de Fuca quite challenging. The Strait of Georgia might be an alternative for underway storm evasion, but again the challenge of safe vessel separation and control would present a real test for the VTS and ship captains.

Please include in the vessel traffic study, emergency contingencies when ships are waiting for cargo, loading, or waiting for departure at terminals within the Salish Sea. The study should include, scenarios created by storm driven weather, onboard fire, or other foreseeable crises, and an evaluation of the availability and capability of responding personnel and equipment in such emergencies.

Also, please include a comprehensive evaluation, as part of the vessel traffic study, all potential costs and consequences of anchoring in dangerous weather, accumulation of multiple ships at anchor, engineering casualties, and environmental damage at anchorages. Any or all of these situations could arise because of the cumulative growth in ship traffic when GPT vessels are added to existing traffic in and around the San Juan Islands and mainland terminals.

If there is no feasible mitigation for these problems, please consider the no-build option for the Gateway Pacific Terminal.

Scoping Memorandum concerning the Pacific Gateway Terminal

Coal Train Derailments

Prepared By: Friends of the San Juans

January, 2013

Obtained at:

obtained from http://www.coaltrainfacts.org/key-facts#trains

Coal Train Derailments

- St. Charles, VA – December 2012
- Grantville, KS – November 2012
- Painstville, KY – November 2012
- Ashby, NE – October 2012
- Oktaha, OK – September 2012
- Ellicott City, MD – August 2012
- Grants, NM – August 2012
- Raleigh, WV – August 2012
- Saline County, KS – July 2012
- Havelock, NC – July 2012
- Jefferson County, KS – July 2012
- Princeton, IN – July 2012
- Pendleton, TX – July 2012
- Northbrook/Glenview, IL – July 2012
- Mesa, WA – July 2012
- Portageville, MO – June 2012
- Junction City, KS – June 2012
- Collins, MS – May 2012
- Salmon Arm, BC – April 2012
- Houston, BC – February 2012
- Hinton, Alberta – January 2012
- Vanderhoof, BC – January 2012
- Montrose, IA – December 2011
- Vanderhoof, BC – December 2011
- Galland, BC – December 2011
- Topeka, KS – November 2011
- Peetz, NE – October 2011
- Charleston, WV – October 2011
- Emmett, KS – September 2011
- Denison, IA – July 2011
- Omaha, NE – July 2011
- Bloomington, IN – July 2011
- Ashdown, AK – July 2011
- Pueblo, CO – November 2010
- Surveyor, WV – April 2011
- Kearney, NE – September 2010
- Quantico, VA – August 2010
- Drummond, MT – August 2010
- Ferry Farm, VA – July 2010

And, a 2006 spill that resulted in 2 loaded cars being submerged in the Clark Ford River:

Trout Creek, MT – November 2006, 2-4 cars spilled and submerged into Clark Fork River – resulting in EPA Superfund action.

Scoping Memorandum concerning the Pacific Gateway Terminal

Treaty Rights at Risk

Prepared By: A Report from the
Treaty Indian Tribes in Western Washington

July 14, 2011

A REPORT FROM THE
TREATY INDIAN TRIBES IN WESTERN WASHINGTON

Treaty Rights At Risk

Ongoing Habitat Loss, the Decline of the Salmon Resource, and Recommendations for Change

July 14, 2011

Executive Summary

This paper examines how the rights of western Washington treaty tribes to harvest treaty fish and shellfish, and the federal government's salmon and orca protection efforts, are at grave risk. This is being caused by a lack of coordinated federal leadership, a failure to exercise authorities and the disparate application of salmon conservation measures. The U.S. government must step up and provide the leadership needed to resolve these issues if salmon are to be successfully recovered and protected.

Stopping habitat degradation is the cornerstone of salmon recovery, but habitat is still declining.

According to the Puget Sound Chinook Salmon Recovery Plan developed by the state and tribal salmon co-managers and adopted by the National Marine Fisheries Service (NMFS), protecting existing habitat is *the most important action needed in the short term.* Despite this commitment, NMFS' 2010 assessment of the Puget Sound Chinook Salmon Recovery Plan declared that habitat is still declining and protection efforts need improvement.

Tribal harvest is accountable and tribes are doing their share to promote recovery.

In 1974, the federal court decision in *United States v. Washington* – known as the Boldt decision – affirmed the tribes' treaty right to half of the harvestable salmon, and established the tribes as co-managers of Washington fisheries. Initially, this recognition of the tribes' rights led to a significant increase in treaty harvest because the tribes finally were able to catch their share. However, harvest has been and continues to be constrained dramatically by degraded habitat. As a direct result, treaty harvest has been diminished to levels not seen since before the Boldt decision.

Tribal co-management of harvest is governed by the tribes' commitment to support salmon rebuilding efforts. NMFS' own analysis of recovery plan implementation indicates that harvest is doing its share to support salmon recovery. NMFS also concedes that salmon populations in many watersheds cannot recover even if harvest were completely eliminated. Yet, while harvest is accountable for recovery, habitat degradation continues steadily, destroying the salmon resource and along with it, the cultures and communities of the treaty Indian tribes in western Washington.

NMFS is applying disparate conservation standards to harvest actions versus habitat actions, thereby threatening treaty rights and impeding salmon recovery.

NMFS holds the tribes to a different standard than all others by applying more stringent standards to tribal salmon harvest than to actions that degrade salmon habitat. In reviewing harvest decisions, NMFS expects tribal harvest plans to contribute to salmon recovery over time. In contrast, when reviewing actions affecting Puget Sound habitat, NMFS seeks merely to maintain existing habitat productivity and quantity – regardless of whether it is adequate to support recovery.

NMFS' Biological Opinion and Reasonable and Prudent Alternative (RPA) for the Federal Emergency Management Agency (FEMA) National Flood Insurance Program is a key example of this disparate treatment. This flood insurance program sets the minimum requirements for floodplain management throughout most of Puget Sound. However, NMFS does not require an increase in habitat productivity and quantity, even in watersheds where NMFS concedes that habitat conditions are the key obstacle to salmon recovery. Another example of disparate treatment is NMFS' approach to southern resident killer whales (orca). NMFS claims orca are not recovering because there are too few large chinook salmon for them to eat. But instead of addressing all activities that affect chinook abundance, NMFS looks only to harvest reductions to address the problem.

This overemphasis on harvest restricts the tribes' treaty rights, while ignoring the science that indicates that habitat loss and degradation account for an even greater take of salmon and orca. These discriminatory actions contravene the federal government's trust responsibility to the western Washington treaty Indian tribes and undermine accomplishment of federal fish and wildlife management objectives.

The federal government is not fully implementing its obligation to protect treaty rights.

Salmon recovery is based on the crucial premise that we can protect what habitat remains while we restore previously degraded habitat conditions. Unfortunately, significant investments in recovery may not be realized because the rate of habitat loss continues to outpace restoration. The resulting net decline in habitat demonstrates the federal government's failure to protect the tribes' treaty-reserved rights.

The federal government has existing tools that it could employ to better protect habitat and support salmon recovery, but in many cases those tools are either misapplied or not being implemented adequately. For example, the U.S. Army Corps of Engineers' § 404 permitting authorizes the very same structures that salmon recovery actions seek to remove. Also, the federal government has approved and continues to fund state programs under the guise of coastal zone management that actually impede salmon recovery. For instance, the state's Shoreline Management Act also permits shoreline development for single-family residences, including bulkheads and docks that degrade habitat.

Instream flows also are under assault and need protection from excessive withdrawals. The tribes have pursued a number of approaches to define and establish the instream flows necessary to protect and restore salmon resources. Unfortunately, each of these efforts has been undermined by flawed state policies that failed to institute a comprehensive effort to establish instream flows. Therefore, federal intervention is needed to adjudicate instream flows that are protective of fish habitat, and consistent with treaty-reserved rights.

Finally, federal agencies such as NMFS have failed to use their authority to prosecute those who degrade salmon habitat. In July 2000, NMFS formally published its policy governing enforcement of the Endangered Species Act (ESA) prohibition against take, and included a series of habitat impacts that would receive “heightened scrutiny.” Although shoreline armoring and riparian vegetation removal were on NMFS’ priority list, there appears to be only one instance of NMFS exercising its enforcement authority over these activities during the past decade.

Salmon recovery crosses many jurisdictions, and leadership is needed to implement recovery consistently across those jurisdictional lines.

The government’s piecemeal approach to recovery has resulted in a lack of agency consistency and ultimately the implementation of federal programs that serve neither to recover salmon nor protect treaty rights. For example, many federally funded environmental and conservation grant programs are not required to protect salmon. Instead, in many cases those programs rely on a planning process that ultimately lets the landowner decide what is best for salmon, even if those choices are contrary to federally approved total maximum daily loads (TMDLs) or federally-approved salmon recovery plans.

Moreover, despite ESA listing, and declining harvest and habitat, basic federal obligations remain unfulfilled. For example, the National Oceanic and Atmospheric Administration (NOAA) and U.S. Environmental Protection Agency (EPA) have failed to use their authority under the Coastal Zone Management Act (CZMA) to protect salmon and treaty rights**.** The CZMA obligates EPA and NOAA to assure that state nonpoint source coastal protection plans are consistent with applicable federal law, including the Clean Water Act, ESA, and federally secured treaty rights. These plans were supposed to be developed by 1995, but 17 years later, the federal agencies have failed to obtain the state of Washington’s compliance.

Given the critical importance of protecting habitat, it is essential that leadership is exercised to ensure that these basic federal obligations are met, including protection of treaty rights.

The federal government can remedy this erosion of treaty-reserved rights by taking action:

I. Stop the disparate treatment of Indian tribes when applying salmon conservation measures.

- Apply at least as stringent a conservation standard to actions affecting salmon habitat as is applied to salmon harvest.
- Assure that all federal actions affecting habitat contribute to recovery of salmon and orca.
- Develop a comprehensive and timely plan for addressing orca prey consumption needs that does not result in disparate treatment of treaty fishing and addresses all identified factors for decline.

II. Protect and restore western Washington treaty rights by better protecting habitat.

- Require federal funding that supports state programs and pass-through grants to be conditioned so that all funded efforts are designed to achieve consistency with state water quality standards and salmon recovery plan habitat objectives.
- Direct federal agencies to increase enforcement of federal obligations to protect habitat including the ESA and Clean Water Act.
- Direct NMFS and EPA to assure that state Shoreline Master Program updates are consistent with all federal obligations involving treaty rights.
- Direct the Department of Justice to initiate limited water rights adjudications to identify treaty-reserved rights for instream flows in selected watersheds.

III. Establish federal oversight and coordination to align environmental and conservation programs to achieve salmon recovery and protect treaty-reserved rights.

- Oversee and align funding programs to ensure achievement of recovery objectives.
- Unify federal agencies and resolve inter-agency conflicts to support salmon recovery.
- Hold federal agencies accountable for acts or omissions that lead to disparate treatment of tribes and failure to protect treaty-reserved rights.
- Harmonize federal actions to ensure consistency and compliance with federal obligations and treaty rights.

Introduction

> *"Through the treaties we reserved that which is most important to us as a people: The right to harvest salmon in our traditional fishing areas. But today the salmon is disappearing because the federal government is failing to protect salmon habitat. Without the salmon there is no treaty right. We kept our word when we ceded all of western Washington to the United States, and we expect the United States to keep its word."* – BILLY FRANK JR., CHAIRMAN OF THE NORTHWEST INDIAN FISHERIES COMMISSION

As sovereign nations, 20 treaty Indian tribes in western Washington signed treaties with the United States, ceding most of the land that is now western Washington, but reserving our rights to harvest salmon and other natural resources. For those rights to have meaning there must be salmon available for us to harvest.

Today our fishing rights have been rendered almost meaningless because the federal and state governments are allowing salmon habitat to be damaged and destroyed faster than it can be restored. Salmon populations have declined sharply because of the loss of spawning and rearing habitat. Tribal harvest levels have been reduced to levels not seen since before the 1974 *U.S. v. Washington* ruling that reaffirmed our treaty-reserved rights and status as co-managers with the right to half of the harvestable salmon returning to Washington waters.

As the salmon disappear, our tribal cultures, communities and economies are threatened as never before. Some tribes have lost even their most basic ceremonial and subsistence fisheries – the cornerstone of tribal life.

The Northwest tribes are heartened by millions of dollars and years of focused cooperative work that have been spent on salmon recovery in the region during the past two decades. We have been at the center of most of these efforts. While we have made progress in some areas, the overall quality and quantity of salmon habitat continues to decline. Four species of salmon in western Washington are listed as "threatened" under the Endangered Species Act, some for more than a decade.

Our considerable investment in habitat restoration has not been able to turn the powerful tide of loss and degradation. We are steadily losing habitat throughout the region, and that trend shows no sign of improvement.

The reason is not a lack of effort or a lack of desire to recover salmon. The reason is a lack of federal and state government leadership, policy, commitment and coordination toward a set of salmon recovery goals and objectives.

We know that we cannot stop the massive population growth anticipated in this region over the coming decades, but we can ensure that the associated development is designed and implemented in ways that will better protect salmon and its habitat.

Habitat loss and degradation are the biggest contributors to the decline of the salmon resource, yet the federal government's primary response is to restrict harvest. Tribes are required to prove that our fishing and hatchery plans will lead to increased salmon populations and will not harm ongoing wild salmon recovery efforts. But we have observed that those who damage and destroy salmon habitat aren't held to the same standard.

Instead, the U.S. government continues to approve federal actions and federally funded state actions that either do not contribute to, or actually impede recovery of salmon habitat. The result is the continued slow degradation of habitat that already has suffered from years of pollution, poor land use practices, and other factors. This situation sets the bar higher and higher for tribes to continue our way of life, while setting it lower and lower for those who would destroy the salmon's home. This uncoordinated approach solidifies habitat losses and ultimately fails to protect our huge investment of funding, time, and effort.

The federal government's over-reliance on restricting harvest as the primary means to protect salmon is unfair, ineffective, and contrary to established principles of Indian law. In the end, this policy undermines the recovery of salmon and other listed species in western Washington. Like harvest and hatchery operations, habitat quality and quantity must be calibrated across the spectrum of agencies and jurisdictions involved in salmon recovery.

Salmon recovery begins and ends with habitat. No amount of fishery restrictions can restore the resource unless salmon have good spawning and rearing habitat.

An example is the Nisqually River, with its headwaters in a national park and its mouth in a national wildlife refuge. It is one watershed in Puget Sound where we have made significant habitat gains in recent years. More than 85 percent of lower river estuary habitat has been reclaimed through cooperative federal, tribal, and state work to remove dikes; nearly 75 percent of mainstem river habitat is in permanent stewardship.

Despite this massive cooperative effort, research shows that young ESA-listed salmon and steelhead from the Nisqually River are dying before they can reach Seattle, just 30 miles away. The main cause is believed to be a lack of good nearshore habitat caused by ongoing development practices.

If salmon are to survive, we must begin to achieve real gains in habitat protection and restoration. The path we are on leads to the extinction of the salmon resource and our treaty-reserved rights.

The federal courts have recognized four basic values associated with the treaty-reserved rights of the tribes: (1) conservation value of the resource, (2) ceremonial, religious, and spiritual values, (3) subsistence, and (4) commercial value. The treaty right to fish is a property right of the tribes and is protected under the Fifth Amendment of the U.S. Constitution, our treaties and the U.S. Supreme Court affirmation of this right.

In failing to protect salmon habitat, the federal government is failing in its trust responsibility to honor its treaties with the tribes. We are left with few choices other than the courts to protect our treaty-reserved rights and the salmon that are so essential to our culture.

We are at a legal and biological crossroads in our efforts to recover the salmon and preserve our tribal cultures, subsistence, spirituality, and economies. Not since the darkest days of the fishing rights struggle before Judge Boldt's decision in *U.S. v. Washington* have we feared so deeply for the future of our treaty rights.

This document discusses specific federal government actions that are impeding salmon habitat recovery and restoration, including:

- The application of disparate standards to harvest and habitat.
- Failure to protect treaty rights and financial investments by fully implementing existing federal authority.
- A general lack of alignment by the federal government of its actions with salmon recovery efforts.

This document also recommends specific solutions that will help the federal government meet its trust responsibilities to the treaty Indian tribes in western Washington as we rebuild the salmon resource. Broadly, those actions encompass:

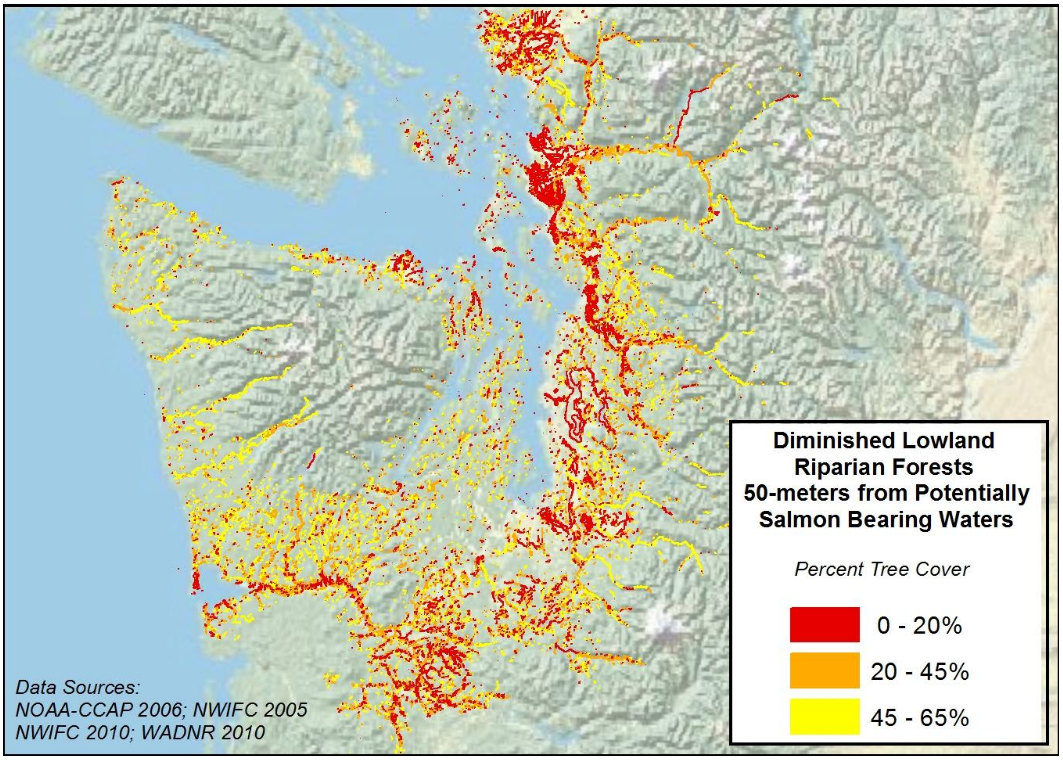
- An urgent call for the federal government to hold the degradation of habitat to the same standards applied to tribal harvest.
- A demand that federal government begin to protect treaty-reserved rights by better protecting habitat.
- Urging federal leadership to provide leadership and oversight to ensure alignment and harmonization of federal programs with salmon recovery efforts.

These actions are critical to reverse the trend toward extinction, and ultimately to recover salmon and restore treaty-reserved harvest rights.

Salmon Habitat Still Declining Despite Recovery Efforts

> *"We have worked for decades to restore habitat in the Elwha River system, and we are still not fishing on the salmon stocks we have been working to protect. We had to push for an act of Congress to remove two fish-blocking dams on the river, but the way it's going now, we still may never be able to fish for chinook again."*
>
> – RUSS HEPFER, LOWER ELWHA KLALLAM VICE CHAIRMAN

Diminished riparian forests in the lowlands of Western Washington continue to impair habitats critical to the recovery of the region's anadromous salmon.



Wild salmon are naturally productive and have just a few basic needs for their survival: access to and from the sea, good spawning and rearing habitat, and the opportunity to reproduce.

Salmon harvest already has been eliminated to the point that further cuts can no longer contribute significantly to the recovery of wild salmon stocks. Yet habitat loss and degradation continue steadily destroying the salmon resource and along with it, the cultures and communities of the treaty Indian tribes in western Washington.

Protecting existing salmon habitat from further decline is the key to recovering endangered salmon populations. According to the 2007 Puget Sound Chinook

Salmon Recovery Plan adopted by NOAA Fisheries and developed by the state and tribal salmon co-managers, and numerous watershed entities:

> Protecting existing habitat and the ecological processes that create it is *the most important action needed in the short term* to increase the certainty of achieving plan outcomes. Protection must occur in both urban and rural areas if we are to ensure the long-term persistence of salmon in Puget Sound.[1]

In the final supplement to the recovery plan, NMFS concurs with the imperative of immediate habitat protection, stating that "protecting functioning habitat is one of the top priorities and first steps for achieving a viable ESU (evolutionarily significant unit)."[2]

However, despite ESA listing of Puget Sound chinook in 1999 and the subsequent call for enhanced protections of remaining habitat, NMFS' 2010 assessment of the Puget Sound Chinook Salmon Recovery Plan declared:

- Habitat is still declining; and
- Habitat protection needs improvement.[3]

The status and trend data summarized in the NMFS report revealed extensive habitat losses across key indicators such as intertidal wetlands and forest cover. The report identified declining trends in habitat by comparing both historical data and trends since the ESA listing of Puget Sound chinook salmon.[4] For example:

- After ESA listing, from 2001 to 2006, about 10,700 acres of forest and 4,300 acres of agricultural land were converted to impervious surfaces.[5]
- Washington has lost an estimated 70 percent of its estuarine wetlands, and 90 percent of its old-growth forest. Together, these native habitat types have been considered among the most diverse and productive in the state.[6]

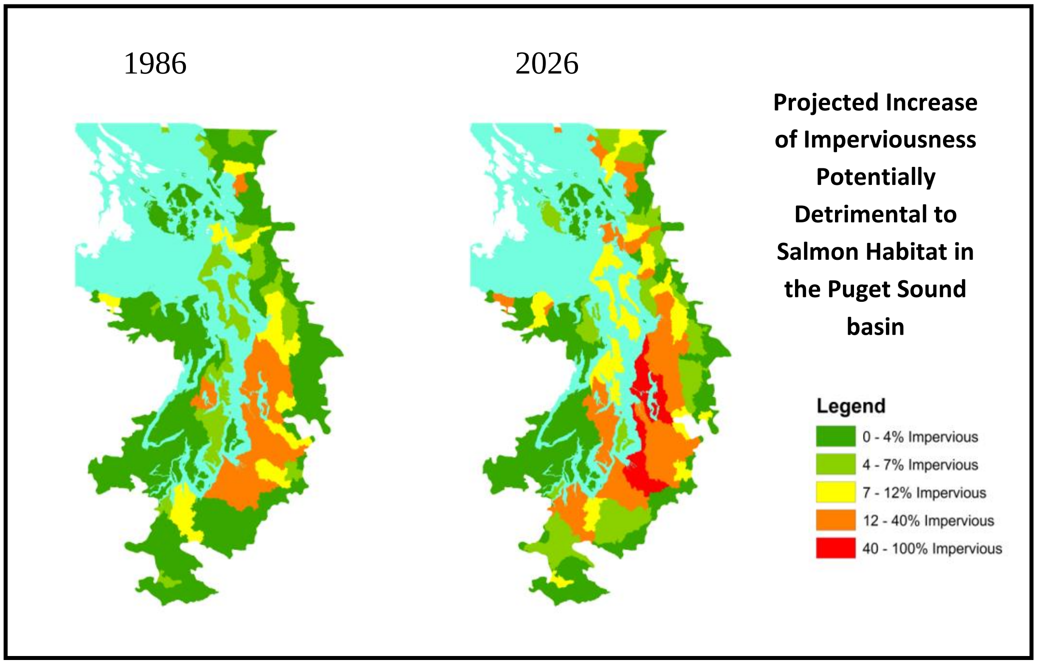
Other studies and analyses echo the NMFS report findings. Key indicators of a declining trend in salmon habitat include:

- Since the ESA listing of Puget Sound fall chinook in 1999, loss of shoreline habitat and function through shoreline armoring continues at a rate of 1.5 miles per year.[7]
- 83 percent of waters sampled to compile the state's 305(b) and 303(d) Clean Water Act lists violate state water quality standards and are polluted.[8]
- About half of critical low gradient riparian forest habitat has insufficient forest cover to support salmon.[9]

- A Puget Sound Nearshore Ecosystem Restoration Project study revealed dramatic losses of habitat in all but one place in the sound during the last 150 years.[10]

- Hood Canal is highly impaired by a lack of dissolved oxygen, and the resultant hypoxia causes fish kills.[11]

- Eelgrass beds, essential to the intricate food web for salmon, are in overall decline.[12]



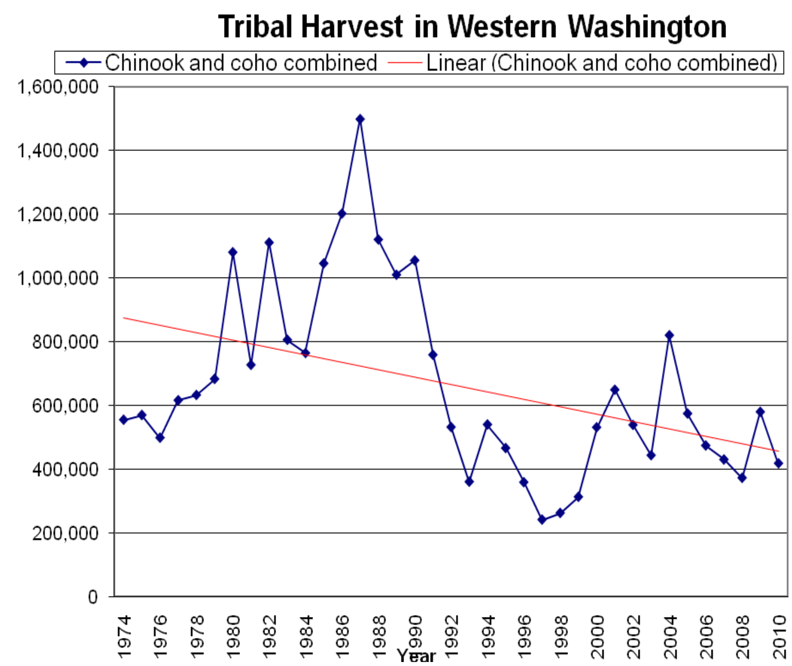
In a recent geographic information system (GIS) analysis of Puget Sound land cover data and population growth rates,[13] existing and projected trends demonstrate dramatic increases in the conversion of vegetated areas to concrete. These increases in impervious surfaces impact salmon habitat by removing essential vegetation and biota, increasing runoff, conveying pollutants, and altering hydrology. Without appropriate planning, placement, and mitigation, these actions will continue to imperil salmon.

Trends at the watershed scale in western Washington also provide a bleak outlook:

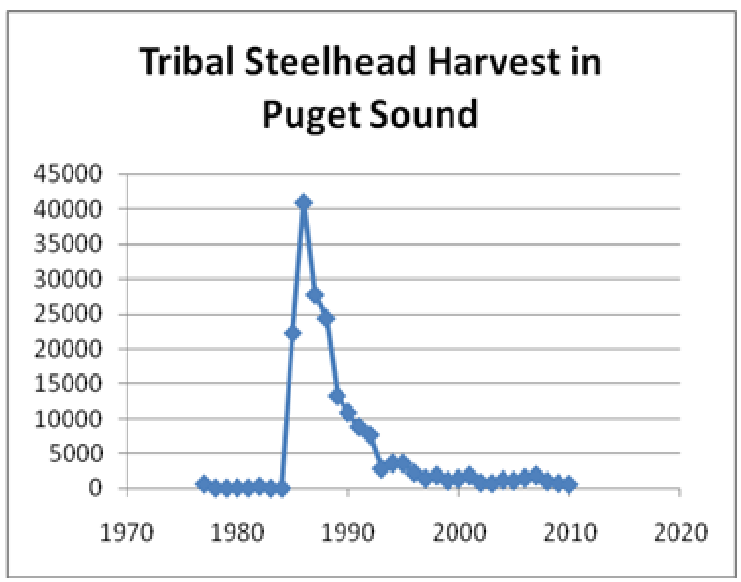
- Within the Stillaguamish watershed, during the time period of 1996 through 2006, there was a decrease of 41 percent in forest cover within the Urban Growth Area and a 22 percent decrease of forest cover inside rural residential areas. Now, only 23 percent of the 1,777 acres of riparian area within the floodplain have any forest cover.[14]
- In the Hoh watershed, approximately 31 percent of private forestlands were harvested between 1998-2010 (post ESA listing).[15]
- In the Snohomish watershed, dikes, levees, and flow devices have resulted in the loss of 55 percent of critical mainstem salmon habitat.[16]
- In the Port Gamble S'Klallam Tribe's usual and accustomed grounds, places such as Port Gamble Bay have had 74 percent of the shoreline armored or modified.[17]
- In the Skokomish basin, the watershed has experienced a 51 percent increase in impervious surfaces, with a third of that paving occurring just one mile from Hood Canal.[18]
- In the Muckleshoot Indian Tribe's area of concern, NOAA models predict that more than half of the stream miles of known coho salmon habitat will experience pre-spawn mortality rates greater than the average, and that 141 of those miles will experience mortality rates greater than 35 percent, when under normal conditions these rates are generally less than 1 percent.[19]

Loss of Harvest and Catch Opportunity

> *"We volunteered not to fish for chinook and to focus on the recovery of our salmon. But even with the nets out of the river, our fish numbers are not increasing. We work hard to restore habitat and recover Stillaguamish chinook, but in the meantime, our culture faces extinction. We are a living culture and we must have salmon to harvest."* –SHAWN YANITY, STILLAGUAMISH CHAIRMAN



Western Washington tribes pursued recognition of their treaty-reserved salmon fishing rights in *U.S. v. Washington* 384 F. Supp. 312 (1974) because their fisheries were being pre-empted by the state of Washington. The state was allowing its ocean and Puget Sound fisheries to overharvest returning adult chinook and coho salmon, but was denying the tribes' their treaty rights to fish in their traditional waters. Tribes were left with little or no fishing opportunity.

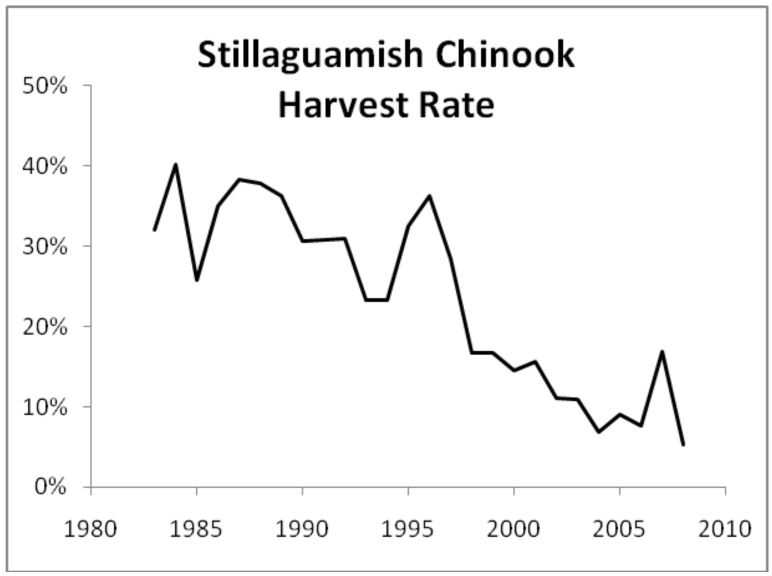


U.S. v. Washington – known as the Boldt decision – affirmed the tribes' treaty fishing rights and established the tribes as co-managers of the resource with the right to half of the harvestable salmon returning to Washington waters. [20]

The years following the 1974 ruling witnessed the growth of harvest opportunity and catch, as tribal fisheries accessed 50 percent of the harvestable run. A joint management framework developed by the state of Washington and the treaty tribes led to better balancing of harvest opportunity across all salmon fisheries.

Despite highly conservative fisheries and the prudent use of hatcheries, ongoing salmon habitat loss and degradation have led to pre-*U.S. v. Washington* tribal harvest levels. This habitat loss has continued even after the establishment of Puget Sound coho as a species of concern (1995), and the listing of Puget Sound chinook (1999) and steelhead (2007) as threatened under the Endangered Species Act.

For more than two decades, harvest rates in all fisheries have been sharply reduced to compensate for the precipitous decline of salmon abundance in Washington state waters, but today harvest cuts can no longer compensate for losses in salmon spawning and rearing habitat.[21]



Analysis of total U.S. harvest rates and run sizes for North Fork Stillaguamish River chinook illustrates this point. Washington harvest rates have been sharply and steadily reduced in reaction to declining returns. While this harvest action maintained spawning at targeted levels, it did not result in more fish returning to spawn, clearly indicating that factors other than harvest are responsible for the stock's decline.[22]

As a result, the Stillaguamish Tribe's treaty-protected river fishery was effectively eliminated and with it, an essential element of tribal culture and source of traditional food. Although the action was not matched by other managers, the tribe gave up even its most basic treaty-reserved ceremonial and subsistence harvest for more than 25 years in an effort to ensure the conservation of this run. In recent years, the Stillaguamish people had to purchase fish from outside their river system to conduct the traditional first salmon ceremony that welcomes and honors the salmon that are the foundation of their culture.

Request for Federal Action

I. Stop the disparate treatment of Indian tribes when applying salmon conservation measures.

The Problem

Currently, NMFS holds the tribes to a different standard than all others by applying more stringent standards to tribal salmon harvest than to actions that degrade salmon habitat. NMFS requires salmon harvest to be managed to contribute to salmon recovery, but fails to apply a corresponding obligation to activities affecting salmon habitat. Similarly, NMFS claims that southern resident killer whales (orca) are not recovering because there are too few large chinook salmon for them to eat. But instead of addressing all activities that affect chinook abundance, NMFS looks only to harvest reductions to address the problem. The federal government continues to focus on restricting the tribes' treaty rights even though the science indicates that salmon will not recover or survive unless the government reduces the even greater take of salmon and orca caused by habitat loss and degradation. The federal government's disparate treatment contravenes its trust responsibility to the western Washington treaty Indian tribes and undermines accomplishment of federal fish and wildlife management objectives.

The Remedy

To eliminate these discriminatory practices, NMFS must hold habitat actions to no less a standard than harvest. Specifically**,** NMFS should be directed to:

- Apply at least as stringent a conservation standard to actions affecting salmon habitat as is applied to salmon harvest.[23]

- Ensure that all federal actions affecting habitat contribute to recovery of salmon and orca.

- Develop a comprehensive and timely plan for addressing orca prey consumption needs that does not result in disparate treatment of treaty fishing.

- In areas where NMFS has declined to designate critical habitat, adopt commensurate harvest management policies.

How the federal government is failing in its trust responsibility:

NMFS applies disparate standards under the ESA, by treating harvest management requirements differently than habitat management requirements.

The Endangered Species Act (ESA) created a responsibility for federal actions affecting listed species to provide an adequate potential for recovery, not just maintain the degraded status quo. For example, as a consequence of the Ninth Circuit's decision in *NWF v. NMFS*,[24] the federal operating agencies and NMFS now recognize that the dams comprising the Federal Columbia River Power System are obligated to contribute to the recovery of salmon. In response to the decision, NMFS and the federal action agencies (in consultation with state and tribal co-managers) assessed the proposed operation of the dams and determined that it would jeopardize ESA-listed salmon. They also determined what improvements were necessary to assure salmon survival and "provide an adequate potential for recovery." Generally, any level of population growth greater than 1 to 1 replacement meets NMFS' interpretation of providing an adequate potential for recovery with respect to the Columbia River dams.[25] While there are differences of opinion among states, tribes, and federal agencies as to whether this interpretation adequately addresses recovery, no one questions that there is a recovery obligation on the Columbia River.

The western Washington treaty tribes' harvest plans are designed to contribute to recovery. NMFS has developed an elaborate procedure for determining whether the impacts of tribal harvest will interfere with recovery of Puget Sound chinook. This includes modeling the likely effects of harvest on 22 individual populations that make up the Puget Sound chinook evolutionarily significant unit (ESU). This analysis looks at the current productivity of existing habitat and assesses the likelihood of a given population falling below a certain critical level or rising above a rebuilding level. Using this approach, harvest is managed to assure both survival *and* eventual recovery.[26]

In analyzing the tribes' harvest plan, NMFS also has stated that poor habitat productivity, not harvest, is the factor preventing chinook rebuilding in river systems such as the Nooksack, Puyallup, Sammamish, Skokomish, Dungeness, and Stillaguamish.[27] NMFS' own federal assessment of recovery plan implementation states that harvest has been managed consistently with this obligation to support recovery, while habitat continues to be the limiting factor to recovery.[28]

In stark contrast to the standards applied to the harvest of listed salmon, NMFS' review of the Federal Emergency Management Agency (FEMA) floodplain insurance program does not address Puget Sound salmon recovery. Instead NMFS applies a no net loss standard that attempts, at best, to maintain existing degraded habitat conditions. In September 2008, NMFS determined that the continued implementation of the National Flood Insurance Program in Puget Sound (and the land use practices that go along with it) jeopardizes the continued existence of chinook, steelhead, summer chum, and orca. FEMA's flood insurance program subsidizes the alteration and destruction of salmon habitat by providing inexpensive insurance coverage for property and structures that are built in the floodplain.[29] As required by the ESA when it finds jeopardy, NMFS designed a "reasonable and prudent alternative" (RPA) as part of its biological opinion (BiOp), to allow the flood insurance program to go forward. NMFS' RPA is intended explicitly to result in no net loss of floodplain habitat and no adverse impact to "protected areas" (riparian areas, floodways, and channel migration zones).[30] In other words, NMFS' RPA is intended to maintain current degraded habitat conditions.

In crafting its RPA, NMFS did not identify management practices intended to address the gap between current productivity of salmon habitat, and what is needed to provide an "adequate potential for recovery," as it did in the Columbia basin. In contrast, NMFS' analysis of the tribes' Chinook Harvest Plan includes harvest rate ceilings which insure that populations will achieve escapement levels consistent with rebuilding abundance, as needed to foster recovery.[31] Essentially, NMFS fails to apply the same escapement and rebuilding levels required of tribes to its habitat protection decision in the FEMA BiOp.

The problem gets worse. Whereas the RPA calls for no adverse impacts in floodways, channel migration zones, and riparian areas, FEMA's response promises more habitat degradation and allows for local governments to permit development in these areas, with mitigation. NMFS is supporting this response.[32] However, the initial failure of mitigation to alleviate the impacts of development in these areas is one of the reasons why treaty rights aren't being met and salmon became subject to the ESA.[33] Moreover, this is bad flood policy because this development impairs watershed flood capacity and exacerbates flood damages.

Along with allowing more habitat degradation, FEMA and NMFS are delegating to local governments the responsibility for deciding what riparian/floodplain salmon habitat still retains value and what habitat can be written off as undeserving of protection.[34] The federal agencies provide no watershed and salmon population context for how these decisions ought to be made. Nor do NMFS and FEMA explain how writing off salmon habitat is consistent with their obligations to support salmon (and orca) recovery and comply with treaty rights. Moreover, local governments have neither the expertise nor the interest in meeting these obligations.

Despite NMFS' findings regarding the crucial need for increased habitat quantity and productivity to reverse declining population trends, the FEMA BiOp and RPA lack specific provisions for improving habitat to assure the survival and eventual recovery of these populations. By failing to hold FEMA's flood insurance program to the same standard that it holds harvest, NMFS both applies disparate treatment of treaty harvest and fails to apply conservation measures necessary to assure the survival and recovery of salmon (and the orca that depend on them). If Columbia River dams and Puget Sound treaty fisheries had been managed this way, ESA compliance could have been achieved by simply freezing salmon mortality levels to those occurring at the time salmon were listed. Obviously, this has not occurred.[35] To the contrary, exercise of treaty rights has been restricted and millions of dollars have been spent changing both the configuration and the operation of the dams, as needed to assure an adequate potential for recovery.

In "protecting" orca, NMFS focuses on chinook harvest while ignoring other more damaging impacts.

Southern resident killer whales (orca) were listed as "endangered" under the ESA in November 2005. Prior to December 2010, NMFS indicated that harvest did not significantly affect the availability of prey for orca. Since then, NMFS has gathered additional information regarding orca prey requirements, and concluded that further reduction of chinook harvest may be necessary for orca recovery.

The treaty tribes and states of Alaska and Washington have significant concerns regarding the quality of the new data and the assumptions underlying NMFS' analysis. However, should the data withstand rigorous scientific review, they underscore the need to protect and increase overall chinook abundance, not simply reallocate harvest from humans to orcas. Unfortunately, NMFS's current focus on the reallocation of harvest does not address important factors causing orcas' decline, including toxic contaminants, vessel disturbance, noise, and the continued loss and fragmentation of salmon spawning and rearing habitat.

NMFS, in cooperation with the Canadian Department of Fisheries and Oceans, is convening an expert panel and a series of workshops to evaluate the effects of salmon fisheries on orca. The workshops are being focused narrowly on just one factor that affects chinook abundance – harvest. They will not address key factors such as habitat, even though habitat decline is the critical factor limiting chinook abundance.[36] NMFS has declared that it will start identifying alternative harvest regimes in response to the workshop before the process is even complete. Essentially, NMFS is proposing to preempt their scientific process by acting on conclusions yet to be established. By any standard, this is not an objective approach.

If prey availability (i.e. chinook abundance) is an important problem affecting orca, then the federal government needs to address all the key factors. Other actions and policies affecting chinook abundance include land management, such as FEMA's National Flood Insurance Program, pesticide management, evaluation of Puget Sound hatchery programs, and NMFS' recently issued "Population Recovery Approach."

For example, NMFS is consulting with the EPA about the impacts of a number of pesticides on ESA-listed salmon. Despite the evidence that orca are harmed by the toxic chemicals in the fish they eat[37], NMFS has yet to assess the impacts on orca from ingesting chinook exposed to pesticides and other toxic compounds. Given NMFS' findings that several of these chemicals pose jeopardy to Puget Sound chinook,[38] it would logically follow that NMFS should promptly assess the effects of these pesticides on orca, prior to altering harvest regimes and impacting treaty rights. However, NMFS continues to focus on harvest and ignore the impacts of pesticides on chinook, orca, and the tribes' treaty rights, even though action on toxic chemicals would provide benefits for chinook and orca, as well as improve the overall health of Puget Sound and all the people that reside within the region.

In the case of FEMA's flood insurance program, NMFS found that the program jeopardizes both chinook and orca. Since that 2008 finding was made, NMFS has modified its views regarding orca consumption of chinook. As a result, the impacts stemming from the flood insurance program pose even greater jeopardy to orca. Despite this, NMFS maintains its position that the flood insurance program is obligated only to preserve existing habitat conditions. Worse yet, as discussed above, FEMA's plan allows continued degradation of salmon habitat even though NMFS insists that more chinook are necessary for orca to survive and recover.

Again, the federal government imposes one standard on the treaty tribes and a less stringent standard on activities that jeopardize salmon. As a consequence, treaty rights are impaired and the species these rights depend upon will not recover. The federal government needs to address *all* the sources of the problem in a manner that is consistent with the salmon conservation necessity principles established in treaty case law.[39]

Request for Federal Action

II. Protect and restore western Washington treaty rights by better protecting habitat.

The Problem

Although the federal government makes significant investments in restoring degraded habitat, it does not fully exercise its authority to protect the essential habitat that remains. Without these protections, overall habitat will continue to decline. This progressive habitat degradation will make recovery impossible and threatens the ability of tribes to protect, restore and exercise their treaty-reserved rights to fish.

The lack of habitat protection does not stem from an absence of authority – it is caused by the federal agencies' inability to align environmental and conservation programs with recovery efforts, and to effectively implement and enforce existing laws. For example, federal funding from a number of agencies continues to support state environmental and conservation programs that are inconsistent with salmon recovery and do not achieve compliance with state water quality standards. Moreover, federal agencies have not enforced key environmental statutes such as the ESA, which could serve to protect salmon habitat.

The Remedy

Protecting salmon habitat is an essential element of the fiduciary duty to ensure that the tribes can exercise treaty-reserved rights. In implementing this duty, the federal government must employ *all* authorities and tools to leverage better habitat protection. Specifically, we ask the Administration to:

- Require federal funding supporting state programs and pass-through grants to be conditioned so that all funded efforts achieve consistency with state water quality standards and salmon recovery plan habitat objectives. Examples include:
    - Clean Water Act funds, National Estuary Program funds and Coastal Zone Management Act funds should implement actions designed to achieve state water quality standards, total maximum daily loads (TMDLs), and salmon recovery plan habitat objectives.
    - USDA funds, including Farm Service Agency (FSA) and National Resource Conservation Services (NRCS) programs should implement riparian buffers comparable to those that NMFS has called for in its RPA for FEMA's National Flood Insurance

Program, and implement all other practices consistent with TMDLs, water quality standards, and salmon recovery objectives.

- Direct federal agencies to increase enforcement of their obligations to protect habitat, including the Endangered Species Act and Clean Water Act.
- Direct NOAA and EPA to ensure that state shoreline master program updates are consistent with all federal obligations, including treaty rights.
- Direct the Department of Justice to initiate limited water rights adjudication to identify treaty-reserved rights for instream flows in selected watersheds.

How the federal government is failing in its trust responsibility:

Habitat continues to decline despite investments in habitat enhancement.

Salmon recovery is based on the crucial premise that we can protect what habitat remains while we restore degraded habitat conditions. In the effort to restore salmon, many millions have been spent to protect and restore salmon habitat:

- The Salmon Funding Recovery Board has administered approximately **$788 million** in federal, state, and local funds since 1999.[40]
- The USDA's Farm Service Agency Conservation Reserve and Enhancement Program – developed to rebuild salmon habitat on agricultural lands – has allocated approximately **$71 million** since 1998 (80 percent is federal).[41]
- Since 1987, the Department of Ecology has administered approximately **$60 million** in federal clean water funds to protect beneficial uses – namely salmon.[42]

Unfortunately, these and other significant investments in recovery may not be realized because the rate of habitat loss continues to outpace restoration.[43] This decline can be attributed to the fact that current habitat protection is contingent upon the same programs that existed prior to the ESA listing of Puget Sound salmon. Moreover, since ESA listing, these programs have yet to be recalibrated to protect salmon habitat. The result, as the NMFS report explains, is that the current habitat protection system is based on the very same programs that failed to prevent ESA listing.[44] Nonetheless, many of these outmoded tools continue to be funded by federal dollars and authorized by federal agencies without conditions to require recalibration and alignment with recovery objectives.

The federal government approves funding for state programs that should protect salmon habitat, but do not.

The federal government financially supports the development and implementation of Washington's Shoreline Management Act (SMA), because it is the cornerstone of the state's Coastal Zone Management Program (CZMP).[45] As a result, extensive coastal zone management funds have been given to local governments to develop local plans for their shorelines, and to the state government to subsequently approve them. Since these programs relate to the shorelines, they also govern a large portion of critical salmon habitat.

The SMA was adopted prior to the ESA listing of salmon and has never been calibrated to protect the species, habitat, or the financial investments to rebuild habitat. In fact, in some instances, the SMA has been used to undermine it. For example, Washington state's highest court struck down the City of Bainbridge Island's moratorium on shoreline development, passed in part to prevent potential impacts to endangered salmon.[46] The court rejected the city's protective efforts because its moratorium prohibited what the SMA permits – shoreline development for single family residences, including bulkheads, and docks.[47]

Essentially, although the SMA is funded under the guise of coastal protection, it does not serve to protect coastal species such as ESA-listed chinook salmon and its habitat. In fact, as determined by the programmatic biological assessment for the Shoreline Master Program Guidelines:

> Many project types specifically regulated by *and allowed* under the guidelines are likely to adversely affect proposed critical habitat for Puget Sound chinook salmon.[48]

Another problem with the federally funded SMA program is that it employs a standard that is neither quantifiable nor specific enough to provide concrete performance standards to protect salmon habitat. For example, development of new SMA rules, which amended the state's CZMP, prompted NMFS to declare that the rules were so broad that they could not assess the effects of the rules on salmon.[49] Moreover, even the implementing state agency agreed that the SMA contains an incalculable performance standard, which the state then defers to local governments to quantify.[50]

The nationwide permit system is streamlining habitat modification and inhibiting treaty rights.

The U.S. Army Corps of Engineers is responsible for permitting actions that discharge dredge and fill material into waters of the state. These actions commonly include shoreline armoring, stream modifications, and the attending maintenance of those structures. The Corps' nationwide permit process provides a streamlined system for this work. In the Seattle District, approximately 1,000 permits are obtained each year.[51] The resulting cumulative armoring of waterways is a key cause for Puget Sound decline and habitat loss, in part because it affects nearshore fish abundance, distribution, and behavior patterns.[52] Ironically, the Corps' streamlined system helps build the very structures in which we are investing federal funds to remove as part of habitat improvement projects.

State policies are not protecting instream flows necessary for salmon, and federal protection is needed.

For more than four decades, the western Washington treaty Indian tribes have pursued a number of administrative, cooperative, voluntary, and inter-governmental approaches to define and establish the instream flows necessary to protect and restore salmon resources. Unfortunately, each of these efforts has failed to institute a comprehensive effort to establish instream flows to protect and restore fish habitat consistent with the treaty-reserved rights of the tribes.

Tribes are left with few options, because of a combination of the state-based priority date for instream flows (which is junior to most appropriations); municipal water purveyors' ability to dewater streams; the state's broad use of a vague "public interest" exception to override habitat protection; and the unwillingness of the state to enforce its own laws or control the cumulative impacts from permit-exempt wells. Based on the policies of state law, it will be impossible to truly restore or, at best, protect instream flows. The federal government needs to aggressively secure the protection of tribal rights to instream flows and resources through initiation of litigation or limited adjudications.

Enforcement is necessary to implement salmon recovery, yet federal agencies fail to take action.

On July 10, 2000, NMFS published its take guidance for Puget Sound. It listed a range of activities most likely to cause harm to endangered salmon habitat, which therefore violate the ESA. Implementing this guidance is critical to supporting salmon recovery. There appears to be only one instance of NMFS exercising its enforcement authority over these activities during the past decade. [53] Aside from this anomaly, we know of no further instances of NMFS exercising its enforcement authority to protect habitat.

The first item on NMFS' list of harmful activities is constructing or maintaining barriers to fish passage, e.g., fish-blocking culverts.[54] The Washington Department of Fish and Wildlife recently disclosed that 30 percent of randomly sampled culverts, despite receiving a state permit in the last 10 years, still resulted in blocked fish passage.[55] A state report also noted that increased regulatory presence and subsequent enforcement were necessary to ensure that landowners complied with the ESA. However, NMFS has not instituted ESA enforcement to help remedy this.

Another example of an action known to harm salmon is shoreline armoring. Washington's Shoreline Management Act provides an exemption from state regulation for shoreline homeowners who armor their shoreline.[56] Between 2004 and 2008 alone, the Washington Department of Fish and Wildlife granted 456 permits for new bulkheads in Puget Sound. This doesn't include replacement of old bulkheads.[57] However, NMFS has not used its authority to address any of these harmful habitat modifications.

Request for Federal Action

III. Establish federal oversight and coordination to align environmental and conservation programs to achieve salmon recovery and protect treaty-reserved rights.

The Problem

The federal government has a fiduciary responsibility to exercise its authority so that the tribes receive the benefit of the rights they reserved in their treaties. In western Washington, the government's fiduciary responsibility includes the protection and restoration of salmon and the habitat needed to ensure their survival and recovery. However, the process of salmon recovery crosses many jurisdictions, and there is a lack of leadership to ensure that programs are implemented consistently across those jurisdictional lines. This piecemeal approach to recovery has resulted in a lack of agency consistency and the implementation of federal programs that serve neither to recover salmon nor protect treaty rights. For example, NMFS threatens significant changes in approaches to salmon harvest because of orca concerns. However, EPA and NOAA remain complacent about the state of Washington's 17 years of non-compliance with the Coastal Zone Management Act – a key salmon and orca recovery component. In the meantime, federally funded salmon restoration actions are undermined by state and federal permitting processes that degrade salmon habitat.

The Remedy

The tribes seek stronger federal leadership to oversee the salmon recovery process and ensure successful implementation of recovery actions across jurisdictional lines. This leadership must serve to:

- Align funding programs to ensure achievement of recovery objectives.
- Unify federal agencies and resolve inter-agency conflicts to support salmon recovery.
- Hold federal agencies accountable for acts or omissions that lead to disparate treatment of treaty tribes or failing to protect treaty-reserved rights.
- Harmonize federal actions to ensure consistency and compliance with federal obligations and treaty rights.

How the federal government is failing in its trust responsibility:

Federal funding lacks alignment with salmon recovery efforts.

Many state and federal grant programs, while intending to make improvements, lack mechanisms to ensure that projects are consistent with recovery and protect treaty-reserved rights. For example, water temperature is a limiting factor for salmon survival, and many western Washington watersheds are temperature-impaired. To address this type of water pollution, the state, with significant federal funding, follows the federal Clean Water Act process and develops temperature total maximum daily loads, or TMDLs. Temperature TMDLs develop site-specific prescriptions to reduce stream temperatures, which ultimately are approved by EPA.

However, there are no assurances or accountability mechanisms that ensure that these pollution control prescriptions get implemented through relevant federal programs. For example, despite the fact that grants are the only tool used to implement TMDLs, neither the state nor EPA require that grant recipients actually follow the specific requirements of the TMDL. Instead, in an effort to provide assurances of implementation efficacy, the state requires riparian buffers be a mere 35 feet wide, which under most circumstances does not satisfy the requirements of their own TMDLs,[58] let alone the needs of salmon.[59]

Other state and federal conservation programs, such as the Natural Resources Conservation Service and Washington State Conservation Commission grants, also do not require their grant programs to implement these Clean Water Act prescriptions. Instead those programs rely on a planning process that ultimately lets the landowner decide what is best for salmon and water quality, even if those choices are contrary to federally approved TMDLs or salmon recovery plans.

Federal funding is not conditioned to ensure protection of treaty rights.

The tribes have called for state and federal action to better prevent pervasive pollution problems impacting treaty-reserved rights,[60] with little response or change. However, when non-Indian commercial shellfish interests recently cried for relief from fecal pollution problems, the EPA promptly provided $1 million to a local county for a pollution identification and correction program.

Unfortunately, the granting of funds did not include conditions that required the program to be consistent with water quality standards. After funds were turned over to the county, a governor-led inquiry into the process revealed that even the most basic of pollution controls, such as keeping cows out of streams, were not implemented.[61] Despite the EPA funding, a recent downgrading of 4,000 acres of shellfish beds occurred in this area, impairing treaty-reserved rights and prompting the governor to declare the overall effort a “failure.”[62]

Federal approval of coastal protection plans has been unlawfully delayed for 17 years.

The Coastal Zone Act Reauthorization Amendments (CZARA), a component of the Coastal Zone Management Act, requires coastal states to develop and implement nonpoint pollution control programs that "restore and protect coastal waters."[63] To receive approval, a state program must meet both statutory and administrative criteria. If a state fails to submit an approvable program, up to 30 percent of coastal management assistance and 30 percent of the Clean Water Act nonpoint source pollution funding is to be withheld.

These programs were supposed to be developed by 1995, but 17 years later, the federal agencies have failed to approve the state's program. Final approval was withheld because of numerous deficiencies in the state's program, including a lack of communication between the involved agencies.[64]

With ESA listing of salmon and orca, the need for coastal protection is now more pressing than ever. Nonetheless, NOAA and EPA continue their complacency with the state's noncompliance, and have failed to rescind funding in accordance with the law. In Oregon, this institutional lethargy resulted in a recent lawsuit filed against NOAA and EPA to compel final agency action under the Administrative Procedure Act. The subsequent settlement ought to result in enforcement of TMDLs along the Oregon coast. Given the critical importance of protecting habitat, it is essential that leadership is exercised to ensure that basic federal obligations in Washington are met, and in a way that better protects salmon and treaty rights.

Leadership and oversight are needed to align salmon protection programs.

The tribes have worked hard to foster salmon recovery while other federally supported programs undermine this progress. Examples include:

- The federal government significantly invests in habitat enhancement, while federally supported programs such as the state Shoreline Management Act and Corps of Engineers permitting processes continue to degrade habitat.

- NMFS requires tribal harvest to foster salmon and orca recovery, while FEMA is allowed to administer its flood insurance program in a manner that results in continued degradation of salmon habitat and fewer orca.

- The federal government prepares to alter treaty harvest requirements because of orca prey needs, but continues a 17-year streak of not pressuring the state to finalize its coastal nonpoint pollution plan – a key salmon and orca recovery component.

- Funding secured for conservation and environmental protections are handed out without basic conditions and assurances to require that those actions be consistent with recovery efforts.

Leadership and oversight of salmon recovery is critical to ensure that the myriad federal programs relied upon to implement salmon recovery are in fact working together to accomplish this fundamental goal. Federal leadership must be provided to synchronize actions and ensure protection of the tribes' treaty-reserved rights.

Afterword

This paper is an immediate request for action. Faced with waning salmon populations and declining habitat, the tribes fear for the loss of their cultures and treaty rights. For the tribes, fish and fishing are as essential to life as water and air.

Our requests are simple: Stop the disparate treatment of tribes. Start protecting our treaty rights. Provide leadership to ensure that this is done.

We ask you to act now, before it is too late for the salmon and the treaty Indian tribes in western Washington.

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[1] Puget Sound Chinook Salmon Recovery Plan at p. 354

[2] NFMS Northwest Region, Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan, November 17, 2006.

[3] NMFS, Puget Sound Chinook Salmon Recovery Plan – 2011 Implementation Status Assessment Final Report, 2011, at p. 6.

[4] Id at 20.

[5] Id at 15

[6] NMFS, Puget Sound Chinook Salmon Recovery Plan – 2011 Implementation Status Assessment Final Report, 2011, at 6.

[7] Carman, Taylor, and Skowlund, 2010, Regulating Shoreline Armoring in Puget Sound, in Shipman, Dethier, Gelfenbaum, Fresh and Dinicola eds, 2010 Puget Sound Shorelines and the impacts of Armoring – proceedings of a state of the science workshop, May 2009: U.S. Geological Survey Scientific Investigations Report 2010-5254. P. 49-54.

[8] SSHIAP analysis of Washington's 2008 Water Quality Assessment Data.

[9] SSHIAP analysis of data sources: *NOAA-CCAP 2006; NWIFC 2005; NWIFC 2010; WADNR 2010* . Conservatively, riparian forest cover with less than 65% cover has been determined to be insufficient for anadromous salmon and corroborated. However, NOAA has indicated in guidance that 80% cover was properly functioning, and <70% as not functioning. See National Oceanic and Atmospheric Administration, Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast. Washington, D.C., (1996).

[10] Puget Sound Partnership, State of the Sound Report, Ecosystem Status and Trends at pp 80-82 (2009).

[11] Further information about Hood canal D.O. is available at http://www.hoodcanal.washington.edu/

[12] Further information is available in the annual monitoring report: http://www.dnr.wa.gov/ResearchScience/Topics/AquaticHabitats/Pages/aqr_nrsh_eelgrass_monitoring.aspx

[13] The following datasets were used to generate the Impervious Surface analysis and forecast for the Puget Sound region: Washington State Department of Natural Resources (DNR) Watershed Administrative Unit (WAU); NOAA CCAP. Coastal Change Analysis Project: Washington State Impervious Surface Polygons 1986 and 2006. NOAA Coastal Services Center. Charleston, S.C.; WA OFM. 2007. Projections of the Total Resident Population for the Growth Management Act (2000 to 2030, Low to High) Washington State Office of Financial Management. Olympia, WA; WA OFM. 2010. April 1 Population Determinations Official Change from April 1, 2000 to April 1, 2010. Washington State Office of Financial Management. Olympia, WA. WA OFM. 2011. WA OFM web site search to determine 1986 population by county. Using ArcGIS Desktop 9.3.1 Zonal Mean

function, the mean impervious surface value was calculated for each WAU draining to Puget Sound for both the 1986 and 2006 years. The 1986 and 2006 population totals were calculated for the counties containing the WAUs. The 2026 low, medium and high population estimates were also totaled for the same counties. Change values were calculated for population (2006-1986 & 2026 forecast - 2006) and impervious surface (2006-1986). A ratio analysis was performed comparing the change in population to the change in impervious surface to forecast the 2026 impervious surface change. The regional percentage increase in impervious surface was calculated for each WAU to generate the final thematic map using OFM's "High" 2026 county population estimate. The impervious surface categories are based upon the analysis by Tyson Waldo in the 2010/2011 Tulalip State of the Watershed report.

[14] SSHIAP, State of Our Watersheds Report - Principle Findings, 2011, p. 1.

[15] Id at p. 1

[16] Haas, A and Collins B., A Historical Analysis of Habitat Alterations in the Snohomish River Valley, Washington since the Mid-19th Century: Implications for Chinook and Coho Salmon. Report Funded by the Tulalip Tribes with some additional funding from Snohomish County, 2001.

[17] SSHIAP, State of Our Watersheds Report - Principle Findings, 2011, p. 3.

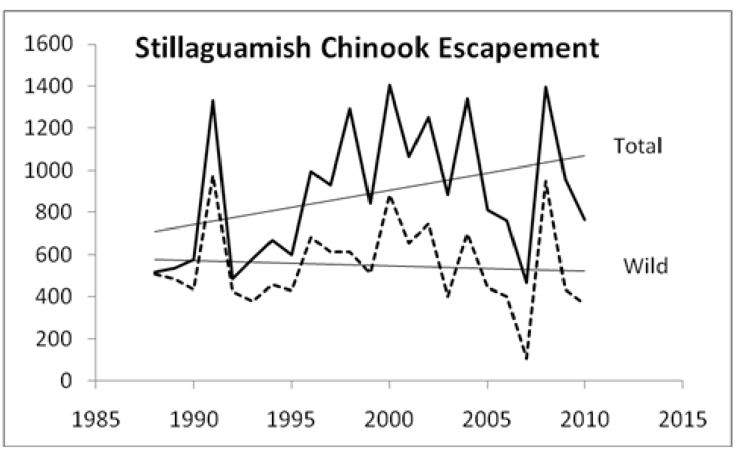
[18] Id. at p. 4.

[19] Id at 5.

[20] The Boldt decision was largely affirmed by the United States Supreme Court in *Washington V. Fishing Vessel Assn.***,** 443 U.S. 658 (1979)

[21] Harvest Rates and Graphs in this section are based upon the following: NWIFC, Analysis of Harvest Data from Tribal Online Catch Accounting System (TOCAS), 2011

[22] Despite dramatic reduction in the harvest rate of Stillaguamish Chinook, which has resulted in an increasing trend in the total number of spawners (escapement), the number of wild fish returning has not increased. Wild productivity is constrained by degraded habitat.



[23] To the extent that conservation-based restrictions on treaty fisheries are necessary, these are governed by the conservation necessity principles established in federal case law and reflected in Secretarial Order 3206.

[24] *See National Wildlife Federation v. NMFS*, 524 F.3d 917, 931 (9th Cir. 2008) (amended opinion) where the court held that NMFS read the species recovery requirement out of the ESA.

[25] *See* NMFS, Supplemental Comprehensive Analysis (May 5, 2008) at 7-5.

[26] *See* NMFS, Proposed Evaluation and Determination on Chinook Plan (12/14/10) (E&D) at 38-39.

[27] *Id*. at 69.

[28] *See* NMFS, Puget Sound Chinook Salmon Recovery Plan – 2011 Implementation Status Assessment Final Report, 2011, at 45 (Harvest plans have been implemented as anticipated. Harvest being managed to meet or exceed established thresholds); *see id*. at 43 (Habitat quality continuing to decline. Current habitat protection tools generally the same as those that failed to forestall ESA listing).

[29] *See* NMFS, ESA Section 7 Consultation Final Biological Opinion: Implementation of the National Flood Insurance Program in the State of Washington, Phase One Document – Puget Sound Region, NMFS Tracking No. 2006-00472) (September 22, 2008) at 3. *See also National Wildlife Federation v. FEMA*, 345 F. Supp. 2d 1151, 1163-65 (W.D. Wash. 2004).

[30] *See* NMFS, ESA Section 7 Consultation Final Biological Opinion: Implementation of the National Flood Insurance Program in the State of Washington, Phase One Document – Puget Sound Region, NMFS Tracking No. 2006-00472) (September 22, 2008) Appendix 4 at 222-223.

[31] NMFS requires that harvest management contribute to recovery by assuring that sufficient escapement occurs to make optimal use of current habitat conditions. Further harvest constraint, to produce higher escapement, would not result in higher productivity beyond the capacity of habitat. In concluding this is sufficient constraint of harvest NMFS, has stated that rebuilding to higher abundance, en route to recovery goals, is contingent on alleviating the habitat constraints, but federal consultations on actions affecting habitat are failing to require that habitat conditions improve.

[32] Public statements by NMFS staff at May 2, 2011 workshop instructing local governments how to comply with the RPA and flood insurance requirements. *See also* Letter from Dan Siemann, National Wildlife Federation, to Will Stelle, NMFS, and Ken Murphy, FEMA (May 17, 2011).

[33] As recently conceded by the Washington Department of Ecology: "Estimates of mitigation success vary, but local, regional, and national studies show that most mitigation projects fail to fully achieve their intended goals and are not effectively replacing lost or damaged resources, habitats, and functions. We are not even close to achieving the goal of no net loss for wetlands and other aquatic habitats." *See* WDOE, Making Mitigation Work: Report of the Mitigation that Works Forum (December 2008) at 1. This report is available at: www.ecy.wa.gov/biblio/0806018.html

[34] FEMA's Model Ordinance, and apparently NMFS' interpretation of its RPA, allows local governments to decide (regardless of expertise): (a) whether a given piece of floodplain or riparian habitat retains any fish habitat functions (*See* FEMA Revised Model Ordinance at 46 (commentary)); (b) whether a proposed action may affect any of these habitat functions (*Id*. at 52, §7.7(d)); and (c) how those impacts should be mitigated (*Id*. at 52-53, §7.8).

[35] While it is not yet fully recognized in the land management realm, harvest managers have long understood that they have a duty to manage salmon as needed to perpetuate harvestable runs. *See e.g., Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n*, 443 U.S. 658, 684 (1979).

[36] See NMFS, Puget Sound Chinook Salmon Recovery Plan – 2011 Implementation Status Assessment Final Report, 2011

[37] *See* NMFS, Recovery Plan for Southern Resident Killer Whales (Orca) (2008) at II-87-96.

[38] *See e.g*., NMFS, ESA Section 7 Biological Opinion on the Effects of EPA Registration of Pesticides Containing Carbaryl, Carbofuran, and Methomyl (April 20, 2009) (finding that registration of such pesticides would result in both jeopardy and adverse habitat modification to Puget Sound Chinook); *see also* NMFS, DRAFT ESA Section 7 Biological Opinion on the Effects of EPA Registration of Pesticides Containing 2,4-D, Triclopyr BEE, Diuron, Linuron, Captan, and Chlorothalonil (May 2011 DRAFT) (finding that registration of pesticides containing 2,4-D jeopardizes Puget Sound Chinook and that adverse modification of habitat results from use of pesticides containing diuron, and chlorothalonil).

[39] The Departments of the Interior and Commerce have some familiarity with the conservation necessity principles. They are referenced in Principle 3 of Department of the Interior Secretarial Order 3206, American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act (June 5, 1997).

[40] Governors Salmon Recovery Office, State of Salmon in the Watersheds Report, 2010, at p. 20.

[41] Based upon correspondence with Washington State's CREP coordinator

[42] Based upon correspondence with Department of Ecology's nonpoint source pollution (CWA § 319) coordinator

[43] NMFS, Puget Sound Chinook Salmon Recovery Plan – 2011 Implementation Status Assessment Final Report, 2011, at 43.

[44] *Id*.

[45] Department of Ecology, *Managing Washington's Coast, Washington's Coastal Zone Management Program*, Publication 00-06-029, February 2001, at p. 98.

[46] *Biggers v. City of Bainbridge Island*, 162 Wash.2d 683 (2007).

[47] *Id* at 698.

[48] National Oceanic and Atmospheric Administration - Ocean and Coastal Resource Management, Washington State Shoreline Master Program Guidelines Programmatic Biological Assessment, March 15, 2005.Page 7-12, emphasis added

[49] Letter From Steven W. Landino, Washington State Director for Habitat Conservation Division of the National Marine Fisheries Service to John King, Chief Coastal Programs Division NOAA Office of Ocean and Coastal Resource Management, re: Endangered Species Act Section 7 Informal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for NOAA's proposed approval of the Washington State Shoreline Master Program guidelines promulgated by the Washington State Department of Ecology, April 23, 2009.

[50] In Washington State Department of Ecology's response to comments on Coastal Zone Management Section 309 Program Assessment and Strategy 2011-2015, the agency stated the following: "The [shoreline master program] SMP process involves conducting a cumulative impact analysis to determine whether or not the SMP will result in no net loss of ecological functions…However, at this time there are no broad tools available to quantitatively measure cumulative impacts, and jurisdictions are responsible for developing their own analysis."

[51] According to a recent meeting with the Corps in the Seattle district regarding renewal of nationwide permits

[52] Toft, J.D., Cordell, J.R. Simenstad, C.A. and stamatiou, L.A. 2007 fish distribution, abundance, and behavior along city shoreline types in Puget Sound: North American Journal of Fisheries Management, v. 27, p 465-480.

[53] On June 15, 2011, Darigold, Inc., pleaded guilty to dumping ammonia from its milk-processing plant into an adjacent creek, which resulted in the death of several ESA-listed Puget Sound chinook salmon. The corporation signed an agreement to pay a $10,000 fine and to donate $60,000 to a non-profit foundation to pay for habitat restoration work. In addition, the corporation committed to develop an environmental compliance plan to address risks at the half dozen plants it operates in five western states. EPA agents involved in the enforcement action noted that Darigold has a history of spills over the last decade in Washington streams. Seattle Times, Darigold Pleads Guilty to Federal Polluting Charges (June 16, 2011), http://seattletimes.nwsource.com/html/localnews/2015331678_darigold16m.html (accessed June 16, 2011).

[54] 65 Fed Reg 42472 (July 10, 2000) (NMFS Take Guidance).

[55] *See* Price, D., Quinn, T., and Barnard, J. Fish Passage Effectiveness of Recently Constructed Road Crossing Culverts in the Puget Sound Region of Washington State, North American Journal of Fisheries Management 30:1110–1125 (2010).

[56] *See* RCW 90.58.030(3)(e)(ii) (Shoreline Management Act exempts from regulation "construction of the normal protective bulkhead common to single family residences").

[57] *See* Seattle Times "Beaches Suffer as Walls Go Up" by Warren Cornwall and Justin Mayo (May 13, 2008) found at http://seattletimes.nwsource.com/html/localnews/2004409777_growth_shorelines15m1.html.

[58] *See e.g.* Washington State Department of Ecology, Stillaguamish River Watershed Temperature Total Maximum Daily Load Study, March 2004, Publication No. 04-03-010, at p. 71 *stating* that the load allocation for effective shade for all perennial streams in the Stillaguamish River watershed is the maximum potential effective shade that would occur from mature riparian vegetation.

[59] Washington State Department of Ecology, SFY 2012-2013 Water Quality Financial Assistance Guidelines, August 2010.

[60] *See e.g.* Lummi Nation letter to EPA, or Upper Skagit Tribe letter to Governor Gregoire.

[61]Government Management Accountability & Performance regarding Puget Sound, April 06, 2011 8:30am available at

http://www.tvw.org/media/mediaplayer.cfm?EvID=2011041010&CFID=4788631&CFTOKEN=15725173&bhcp=1

[62] *Id.*

[63] 16 USC § 1455b (a)(1)

[64] NOAA and EPA's Findings For The Washington Coastal Nonpoint Program

Scoping Memorandum concerning the Pacific Gateway Terminal

Tourism Matters to the San Juan Islands

Prepared By: Dean Runyan Associates
Prepared For: Washington State Tourism Office

2010

San Juan Islands
Visitors Bureau

Tourism Matters to the San Juan Islands

Tourism infuses "new" dollars into San Juan County's economy which are disbursed throughout our Island communities. In 2009, visitors spent $116.5 million in the Islands. The San Juan Islands Visitors Bureau and the Islands' tourism industry recognize that the economic vitality of tourism is only sustainable if our natural beauty, rural character and watchable wildlife are preserved. Our goals and missions guide us all to instill an environmental stewardship ethic in our visitors, promoting responsible, low-impact visitation to our beautiful Islands.

What does tourism mean for Washington State?

- Tourism is Washington State's 4th largest export industry, following software, aerospace and agriculture/food.
- Total direct visitor spending in Washington was $14.1 billion in 2009. Visitor spending accounted for just under $1 billion in local and state tax revenue in 2009.
- Tourism supports 144,000 jobs and $4.1 billion in earnings in Washington State.

What does tourism mean for San Juan County?

- **Visitors Spend "New" Money in our County:** In 2009, visitor spending in San Juan County was $116.5 million.

- **Visitors Create Small Businesses & Jobs:** In 2009, 1,580 jobs were generated by travel spending. Industry earnings generated by travel spending were $39.4 million in 2009. San Juan County is one of six non-urban counties in Washington with more than 10 percent of travel-generated jobs.

- **Visitors Help Support Our County Through Taxes:** In 2009, visitors generated $2.1 million in local tax receipts to help support our parks, museums, community centers/theaters, county fair grounds and essential services such as roads, schools, etc. Visitors' tax dollars help keep resident-paid taxes lower. Visitors to our county generated $6.2 million in state tax receipts.

- **In 2009 visitors spent their money on the following in San Juan County:**
  $37.9 million on food and beverage services
  $30.3 million on accommodations
  $17.8 million on arts, entertainment and recreation
  $16.4 million on retail sales
  $ 7.8 million on food stores
  $ 6.2 million on local transportation and gas

Source: Washington State County Travel Impacts 1991-2009, prepared by Dean Runyan Associates for the Washington State Tourism Office

Scoping Memorandum concerning the Pacific Gateway Terminal

San Juan Tourism

Prepared By: Deborah Hopkins Buchanen
Executive Director
San Juan Islands Visitors Bureau
For: Friends of the San Juan

January 2013

Deborah Hopkins Buchanan
Executive Director
San Juan Islands Visitors Bureau

1. 1. 700,000-1,600,000 visitors to the San Juan Islands between annually.

According to the Washington State Office of Financial Management, average annual visitation to all state parks in San Juan County typically ranges from around 1,300,000 to around 1,600,000. This includes visitation to more than fifteen sites managed by Washington State Parks in the islands—Moran State Park on Orcas, Lime Kiln Point State Park on San Juan, and various other smaller parks and marine parks on other islands. State parks visitation in the county reached a high of 2.24 million in 2004. Visits are calculated as visitor "days"—one visitor's presence during a single day in a state park. Moran State Park visitation reaches to nearly 700,000 annually (including travelers passing through the park) and Lime Kiln Point State Park visitation is typically above 200,000. The visitation includes residents of the islands as well as day-use and overnight visitors. (*Source: Dean Runyan Associates, Economic Impacts to Visitors of Washington State Parks*).

My source for numbers is our Scenic Byways Corridor Management Plan, Section 5, found here:
http://sanjuanco.com/ScenicByWay/Default.aspx

2. 2. San Juans are an international Destination

New York Times: The 41 Places to Go in 2011—listed as the number 2 place to visit in the world, in between Santiago, Chile as number 1 and Koh Samui, Thailand as number 3. (Editor's tagline related to the San Juan Islands: "Bold-face restaurateurs vie with unspoiled nature. Nature wins."), National Geographic Traveler: The world list featured San Juan Islands as number 3 in the 10 Best Trips of Summer 2011, "all about weather, whales, and water", Travel + Leisure: World's Best List in 2011 and 2010, the number 4 position for Top Islands (moving up from number 5 in 2009), Life: 100 Places to See in Your Life Time, July 2011, USA Today: Best Wildlife Watching Spots in Each State, July 2011, Lonely Planet: US Islands that Won't Break the Bank, July 2011, New York Times: A Directory of Rare Wonders, May 2011, HUFFPOST TRAVEL: 10 Best Whale Watching Destinations Around the World, April 2011, The TODAY Show, NBC: Affordable Secret Island Getaways, April 2011, AOL Travel: Six Best Beach Vacation Spots in the Pacific Northwest, February 2011, Sunset magazine: "One of the Best Coastal Vacation Spots in the West 2010"

There's even more articles & info on our website under "San Juans in the News" at
http://www.visitsanjuans.com/media/san-juans-in-the-news?utm_source=www.VisitSanJuans.com&utm_medium=Teaser%2BAd&utm_content=Front%2BPage

3. Outdoor industry generates **$116.5 million** dollars to SJ County and creates 669 local jobs.

Dean Runyan, 2009. A National Park Service Visitation and Payroll Study for the San Juan Island National Historic Park identified 209 jobs and approximately $33 million from income were generated by visitors to the SJINHP in 2010. A multiplier of 3 was used to normalize this information for 700,000 visitors to the county.

We don't have specifics re: the outdoor industry, but I recall that the EDC did a study on kayaking re: the west side and new NOAA regulations 2-3 years ago which Victoria Compton should have.

4. Outdoor industry generates $8.5 Billion dollars to Washington State, creates 115,000 jobs.

In Washington State: Active outdoor recreation: $8.5 billion in retail sales and services (3.5% of gross state product) 115,000 jobs $650 million in sales tax revenue. (3.5% of gross state product) 115,000 jobs $650 million in sales tax revenue (Source: Outdoor Industry Foundation study, 2006)

Forest Ethics estimates recreation contributes $10.8 billion to our state economy and creates 165,000 jobs. (Source is the Washington Department of Ecology, year ???).

"In nonmetropolitan America today, areas with significant natural amenities, recreational opportunities or quality of life advantages have new prospects for growth and development. Many nonmetropolitan areas that are seeing significant population growth benefit from scenic landscapes, mild climates, proximity to rapidly growing metropolitan areas, or a combination of these elements." (Source: Carsey Institute, Univ. of New Hampshire. Demographic Trends in Rural and Small Town America 2006).

Scoping Memorandum concerning the Pacific Gateway Terminal

Brief Description of Examples of Federal and State Protected Lands in San Juan County

Prepared By: Friends of the San Juans

January, 2013

FEDERALLY PROTECTED LANDS IN SAN JUAN COUNTY

San Juan Island National Historical Park

This Park encompasses 1752 acres and 6.1 miles of shoreline, the most extensive publicly accessible shoreline in the San Juan Islands. The National Park Service mission is to preserve park resources unimpaired and provide for visitor enjoyment of this precious place. The park receives more than 250,000 visitors each year and is an important piece in the mosaic of attractions that draws tourists to the islands.

San Juan Islands National Wildlife Refuge

San Juan Islands National Wildlife Refuge ("SJNWR") consists of 83 rocks, reefs, grassy islands, and forested islands scattered throughout the San Juan Islands of northern Puget Sound. These islands, totaling almost 450 acres, were set aside to protect colonies of nesting seabirds, including pigeon guillemots, double-crested cormorants, and pelagic cormorants.

The San Juan Islands National Wildlife Refuge is comprised of 83 specks of land of which 80 have been designated Wilderness. It is a sanctuary for gulls, cormorants, guillemots, puffins, brants, oystercatchers, auklets, and bald eagles and attracts a variety of other wildlife, including bald eagles and harbor seals. In order to help maintain the natural character of these islands, all the refuge islands except Matia and Turn are closed to the public. These two see considerable public use and are managed by cooperative agreement with Washington Department of Parks and Recreation. On Matia Island, only 5 acres are considered Marine State Park, with the remaining 140 acres included in the San Juan Islands Wilderness. Many of the SJNWR islands are adjacent to shipping lanes that vessels will pass transiting through the San Juans

The United States Bureau of Land Management (BLM) manages about 1,000 acres in the San Juans. Spread over about 75 sites including dozens of small islands and reefs that provide breeding grounds for birds and safe refuges for everything from harbor seal pups to rare plants. These lands also shelter historical sites - from ancient fishing sites and camas gardens to pre-automation light houses on Patos Island and Turn Point. And they include popular recreation destinations like Iceberg Point, Chadwick Hill and Watmough Bight on Lopez; the campgrounds on Patos Island, Posey Island and Blind Island; and the site of the Cattle Point lighthouse on San Juan Island.

THE FRIDAY HARBOR MARINE PRESERVE[1]

The Friday Harbor Marine Preserve is one of the five San Juan Marine Preserves created in 1990 in conjunction with the University of Washington's Friday Harbor Laboratories (FHL). Washington Department of fish and Wildlife (WDWF) created these partial-take reserves after FHL requested that the intertidal and subtidal waters adjacent to their upland biological preserves be protected from harvesting pressure for bottomfish and invertebrates.

The primary goals of this reserve are to foster stewardship of unique or important resources or habitats, provide research and education areas, and provide baseline areas or reference sites. Research and monitoring is actively conducted in this reserve by WDFW and UW scientists and students.

The Friday Harbor Marine Preserve is the second largest WDFW marine reserve in inland marine waters of Washington. The University of Washington and its FHL own almost all of the uplands. Most of the shore habitat consists of bedrock cliffs and ridges with sand or rocky grottos punctuating small headlands. The rocky shore habitat steeply descends as bedrock walls and boulder fields into the subtidal zone. Unconsolidated substrates meet the walls and boulder fields at various depths. Inside Friday Harbor, sand and mud substrates predominate and meet the rocky habitats at depths of 15 feet (mllw). However, in San Juan Channel, the rocky slopes may extend to depths greater than 100 feet before coarse unconsolidated sediments are found. The unconsolidated sediments likely dominate the offshore extensions of the reserve to depths of over 400 feet (mllw), and boulders and cobbles likely occur throughout the deeper habitat.

The nearshore subtidal habitats have a variety of marine vegetation. In the shallow sections inside Friday Harbor, patches of eelgrass (*Zostera marina*) persist. As the habitats become more rocky toward San Juan Channel, bladed kelps such as *Laminaria saccharina* and *Costaria costatum* and foliose red algae become abundant in the photic zone.

The rocky habitats support rockfishes, lingcod, and greenlings. The pelagic and schooling Puget Sound rockfish (*Sebastes emphaeus*) is the most abundant rockfish followed by the demersal copper rockfish (*S. caurinus*). Lingcod (*Ophiodon elongatus*) are very common in this

[1] **The Washington Administrative Code (WAC 220-16-440(2)** established the Friday Harbor Marine Preserve for "Those tidelands and bedlands adjacent to San Juan Island within a line beginning on the shore 500 yards west of Point Caution, thence 500 yards offshore, thence south and east following the shoreline to the intersection with a line projected from a University of Washington marker located 100 feet north of the north entrance of the floating breakwater of the Port of Friday Harbor and projected towards Reid Rock Buoy, thence along said line to shore on San Juan Island." *Effective since **3/31/1990**.*

reserve and use the rocky habitats for nesting to a high degree. Other large species present at the site include kelp greenling (*Hexagrammos decagrammus*), cabezon (*Scorpaenichthys marmoratus*), tiger rockfish (*S. nigrocinctus*), and black rockfish (*S. melanops*). Small fishes present inside the reserve include longfin sculpin (*Jordania zanope*), scalyhead sculpin (*Artedius harringtoni*), and blackeye goby (*Coryphopterus nicholsii*).

The Friday Harbor Marine Preserve contains a high diversity of marine invertebrates dominated by a rich community of encrusting organisms. Large macro-invertebrates that are common include Puget Sound king crab (*Lopholithodes foraminatus*), red sea urchin (*Stronglylocentrotus franciscanus*), red sea cucumber (*Parastichopus californicus*), sunflower star (*Pycnopodia helianthoides*), and shrimp (*Pandalidae*). Harbor seals (*Phoca vitulina*) and northern sea lions (*Eumetopias jubatus*) are observed within the reserve boundaries.

WDFW manages the site as partially-protected marine reserve for non-tribal citizens. WDFW regulations prohibit commercial and recreational fishing for bottomfish and classified shellfish. Recreational and commercial fishing may occur for the harvesting of salmon, trout, and forage fishes except that commercial fisheries for forage fishes are limited to Pacific herring (*Clupea harengus pallasi*).

WDWF scientists actively study the response of marine fish to the marine reserves at this site and have engaged in survey activity since the early 1990's. The site is visited during the winter when special surveys are conducted to assess lingcod abundance and nesting activity. Another series of springtime surveys is conducted on a periodic basis to assess the species composition, density, and size of bottomfishes inside the reserve.