Lummi Intertidal Baseline Inventory

Appendix L: Annotated Bibliography of Lummi Reservation Intertidal Assessments and Adjacent Nearshore Surveys

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Executive Summary

This appendix lists the results of the literature review conducted during the scoping phase of the Lummi Intertidal Baseline Inventory (LIBI) during 2007 and 2008. In total, nearly 200 citations were discovered during the review. These citations are listed along with short summaries of many of these documents. The purpose of this review was to both determine the extent and quality of the available information in order to identify data gaps that could be addressed by the LIBI work plan, and to provide an informational resource for future work.

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1.0 Introduction

Many organizations have collected physical, chemical, and biological information regarding nearshore areas within and near the Lummi Indian Reservation. In the scoping phase of the Lummi Intertidal Baseline Inventory (LIBI), Lummi Natural Resources Department (LNR) staff conducted a literature review of all discoverable publications, reports, and memoranda that were relevant to Reservation tidelands. The purpose of this literature review was to obtain information to include in the LIBI, to identify information gaps that the LIBI might fill, to prioritize field activities, and to provide a concise summary of the literature pertinent to Lummi Reservation tidelands to date.

This appendix contains the citations of all relevant discoverable literature that was reviewed and, where possible, a short description of the document is provided. In some cases the publication could not be obtained.

2.0 Methods

The literature review was conducted between August 2007 and April 2008. There may be additional citations that were published subsequent to this review that do not appear in this list.

3.0 Results

During the literature review process, nearly 200 citations were discovered. Of these, 124 citations were obtained, reviewed, and briefly summarized.

Agee, J.K., J.A. Dragavon, and A.R. Weisbrod. 1978. *Environmental Reconnaissance Of Portage Island, Whatcom County, Washington*. National Park Service Cooperative Park Studies Unit and University of Washington, Seattle, Washington.

Anchor Environmental. 2001a. *Marine Resources of Whatcom County*. Report to Whatcom County, Washington.

This document presents a compilation of historical and current data on the marine resources of Whatcom County. Biological data from the Whatcom County shoreline and marine waters are compiled and summarized in this report. The area covered is from the US-Canada border near Drayton Harbor and Point Roberts to the southern boundary of the county at Governors Point, including Portage, Lummi, and Eliza Islands. This data compilation report has been prepared to support the Whatcom County Marine Resources Committee (MRC). This report is primarily graphical in nature, consisting of Geographical Information System (GIS) maps and written summaries.

Anchor Environmental. 2001b. *Fish Distribution and Periodicity in WRIA 01, Final Draft, October 2001.* Prepared for City of Bellingham Public Works Department.

This report summarizes the life history and temporal patterns of presence of various fish groups in the Washington State Water Resources Inventory Area 1 (WRIA 1) based on direct observations of presence and also speculations of possible presence by local biologists contributing to the report.

Anderson, K., D.W. Jamison, M. Kirk, and M. Ruef editors. 1977. *Whatcom County, Volume 1. In. Coastal Zone Atlas of Washington*. Washington Department of Ecology, Olympia, Washington.

Eelgrass was mapped on the shore west of Mt. Baker Plywood and at the mouth of the rerouted Squalicum Creek (destroyed to accommodate expansion of Squalicum Harbor). Eelgrass was not noted at Post Point, the shore between Uniflight and Boulevard Park, or the northern intertidal delta of the Nooksack River. Marine waters north of Post Point, including Squalicum Harbor and the area near the Cement Plant, were mapped as important winter areas for greater scaup and buffleheads. The Nooksack delta was mapped as an important winter area for whistling swans, northern bald eagles, buffleheads, and greater scaup. American widgeons, pintails, and mallards used the delta during fall and winter, and the dunlin used the area from spring through winter.

Anderson, C.M., R.K. Knapp, and J.K. Fackler. 1984. *The Behavior and Ecology of Fall Peregrine Falcons at Lummi Bay and Vicinity, Whatcom County, Washington*. United States Army Corp Engineers, Seattle, Washington.

The behavior and ecology of Peregrine-Falcons were studied at Lummi Bay, Whatcom County, Washington, from October through December 1983. Peregrines were observed 207 times and during 80% of the field days. The author's identified a minimum of 15 individual falcons during the study. The main peregrine activity was centered in the Lummi Bay adjacent area. Habitat preferred by the dominant adult female included a wooded ridge, tidal mudflats, and level agricultural fields. Combined observations yielded 154 hours and 46 minutes of direct study of peregrine behavior: falcons were perched 84% of that time, in flight 16%. Forty-two prey items, primarily ducks and shorebirds, were recovered. Peregrines were successful hunters 22% of the time; 153 hunting flights were witnessed. An adult female was radio-tagged on 1 December and followed over the next 30 days. She roosted in the San Juan Islands, 11 miles southwest of the main study area.

Applied Biomonitoring. 1999. *Cherry Point: 1998 Cage Mussel Study. Draft Final Report.* Applied Biomonitoring, Kirkland, Washington. Prepared for Washington Department of Fish and Wildlife, Olympia, Washington.

Mussels were used to estimate polycyclic aromatic hydrocarbon (PAH) exposure to caged herring eggs. Mussels were used as surrogates for herring eggs because of their inability to metabolize PAH compounds. Because mussels can metabolize PAH, PAH compounds are stored in mussel tissues over time. Mussels accumulated PAH compounds to concentrations shown to affect herring egg development in previous studies. Lipid-normalized total PAH concentrations were 37,736 ug PAH/g lipid-dw near Cherry Point compared to control site 13,864 ug PAH/g lipid-dw.

Ardea. 1990. *Results of 1990 Chemical and Biological Monitoring in the Southeast Georgia Strait for the Atlantic Richfield Company, Cherry Point Refinery*. Ardea Enterprises, Inc., Snohomish, Washington. Prepared for ARCO.

Ardea. 1991. *Results of 1991 Chemical and Biological Monitoring in the Southeast Georgia Strait for the Atlantic Richfield Company, Cherry Point Refinery*. Ardea Enterprises, Inc., Snohomish, Washington. Prepared for ARCO.

Baker, E.T., J.D. Clin, R.A. Freely, and J. Quan. 1978. *Seasonal Distribution, Trajectory studies, and Sorption Characteristics of Suspended Particulate Matter in the Northern Puget Sound Region.* Report No. EPA-600/7-78-126. National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory. Seattle, Washington.

Ballinger, D. and R. Vanderhorst. 1995. *Predation on Chinook Smolts in Georgia Strait*. Lummi Indian Business Council, Bellingham, Washington.

Barclay, M. 1998. *Water Surface Elevation Monitoring in the Nooksack and Lummi River Estuaries.* Lummi Indian Business Council, Bellingham, Washington.

Water surface elevations were recorded for Fish Point, Kwina Slough, Long drift, Sawdust, Marietta Slough, and Upper Kwina Slough at high tide to give predictions of surface elevations related to Nooksack River discharge and tidal elevations. At high discharges and high tides most of observation points will be inundated with water.

Bargmann, G. 1982. *The Biology and Fisheries for Lingcod (Ophiodon elongatus) in Puget Sound. WA*. Washington Department of Fisheries Technical Report No. 66

Bargmann, G. 1998. *Forage Fish Management Plan*. Washington State Department of Fish and Wildlife, Olympia, Washington.

Forage fish, including sardine, herring, sand lance, and smelt populations are highly variable and can be affected by a number of natural factors that lead to changes in survivorship and reproductive success. Fishing can also have a dramatic affected forage fish numbers and no management strategy will produce a stable population of forage fish. However, proper management action can help maintain healthy populations. No management action can be describe because of the lack of basic information on these groups of fishes.

Battelle. 1974. *Field and Laboratory Studies to Obtain a Comparative Baseline for Assessing the Impact of Refinery Discharge and Potential Oil Spillage on the Cherry Point Environs. Volumes I through IV. Final Report.* Battelle Pacific Northwest Laboratories. Prepared for Atlantic Richfield Company, Cherry Point Refinery, Ferndale, Washington.

Long-term monitoring and computerized modeling of the waste outfall discharges of the Cherry Point dock facility by Battelle suggests waste water effluent is fresh and its associated pollutants will be brought to the surface where prevailing winds will carry it southeastward along the shoreline. The net flow from the ARCO/BP outfall pipe is near shore and southward. This exposes Cherry Point herring spawning grounds south of the terminal to wastewater effluent.

The model developed by Battelle describes that a potential oil spill will be concentrated southward of the ARCO/BP terminal. These areas would likely have the highest level of PAH concentrations and cause more impacts to marine biota.

Bauer, W. 1974. *The Drift Sector of Whatcom County Marine Shores: Their Shoreforms and Geohydraulic Status*. Prepared to Whatcom County Planning Commission, Bellingham, Washington.

Shorelines in eastern Bellingham Bay were mapped from Squalicum waterway to Padden Creek. Rocky shores dominants the shoreline from Padden Creek to Clark Point. Feeder bluffs are situated between the mouth of the Nooksack River and Squalicum Creek with interspersed accretion shores at Little Squalicum Beach, near Smith Garden, and near Marietta. Net high tide shore drift originates at the cement plant dock moving northwest towards the Nooksack River and southeast towards Bellingham.

Beak Consultants Inc. 1978. *Assessment of the Effects of a Proposed Marine Construction Facility at Cherry Point on the Pacific Herring (Clupea harengus pallasi) of the Gulf of Georgia (With Observations on Other Aspects of the Marine Biology of the Whatcom County Coast.).* Beak Consultants Inc. Prepared for Whatcom County Planning Department, Washington and Chicago Bridge and Iron Company.

Beak Consultants Inc. 1982. *The 1982 Survey of the Intertidal Zone from Sandy Point to Birch Bay, Whatcom, Washington*. Beak Consultants Inc. Prepared for the Ferndale Refinery.

Beale, H. 1995. *Lummi Shore Road Environmental Assessment, Littoral Drift Evaluation*. Lummi Indian Business Council, Bellingham, Washington.

Becker, D. S., R. Sonnerup, and J. J. Greene. 1989. *Bellingham Bay Action Program: Initial Data Summaries and Problem Identification*. U.S. Environmental Protection Agency, Region 10. Seattle, Washington.

Nooksack River discharge has two annual peak flows, once during the winter period of maximum precipitation (October to April) and during early summer during snowmelt. Bellingham Bay intertidal areas occupy about 42 km^2 and about 1.4 km^2 have been converted to upland uses. Bottom salinities range from 29 to 31 ppt, similar to Rosario Strait, and tend to be stable throughout the year. Bottom currents are slow between 0.1 and 0.2 m/sec. Water characteristics within the upper 10 meters are variable with depth and time, responding to changes in air temperature and freshwater input. A 2-meter deep brackish layer often is found in the Bay. Surface salinities range from 20 to 26 ppt, but can be as low as 20 ppt. The water column tends to be isothermal in late fall and early spring, but may be stratified during other seasons. Surface currents are slow between 0.2 to 0.3 m/sec. The Nooksack River watershed is about 1,500 km^2 and the river is the primary source of bay sediment with an average annual sediment discharge of 650,000 m^3. Sediment sources are natural from glacial scour, and anthropogenic from agricultural and logging activities. During late spring and early summer, juvenile salmon leave streams and migrate within one kilometer of the bay shoreline. Economically important marine fish include Pacific herring, Pacific cod, rockfish, lingcod, rock sole, English sole, and Starry flounder. Dungeness crab occurs throughout the bay. Other shellfish include Pacific oysters, littleneck clams, Manila clams, horse clams, and butter clams. Marine mammal occurrences include harbor seal, harbor porpoise, orca, gray whale, California sea lion, northern sea lion, Dall porpoise, and minke whale. Sediment total volatile solids (TVS) indicate the amount of organic material. In 1983, sediment TVS values ranged from 1.2 to 17%, with the highest values observed near Whatcom Creek and lowest values in areas with coarse-grained sediments or increasing proximity to the Nooksack River delta. Analysis of mercury bioaccumulation in fish and shellfish tissues found values between 0.04 mg/kg WW for intertidal organisms to 0.28 mg/kg WW for

mussels. The FDA mercury maximum is 1 ppm. A 1974 study found up to 2.6 mg/kg WW in benthic macroinvertebrates with highest concentrations located near Squalicum Waterway and the former Squalicum Waterway marina.

Berry, H. and B. Ritter. 1995. *Puget Sound Intertidal Habitat Inventory 1995: Vegetation and Shoreline Characteristics*. Washington State Department of Natural Resources Olympia, Washington.

During 1995, 110 miles of shoreline were surveyed, remotely, in the Whatcom County area from Point Whitehorn southward to the Skagit County border. This is part of the Puget Sound Ambient Monitoring Program (PSAMP) that classified surface substrates and vegetation. Spatial data were developed from this survey and the quality was checked by this report. Positioning accuracy was +/- 40 feet with minimum mapping unit of 13 feet. Spatial layers can be found on the LIBC GIS server and at WADNR.

Bienert, R.W. and R,M, Thom. 1992. *Marine Habitat Monitoring in the Vicinity of British Petroleum Ferndale Refinery and Atlantic Richfield Oil Cherry Point Refinery.* Battelle Pacific Northwest Laboratories. Prepared for Adrea Enterprises, Inc., Snohomish, Washington.

Blakely, A. B. Leland, J. Ames, editors. 2000. *The 2000 Washington State Salmonid Stock Inventory (SASI): Coastal Cutthroat Trout.* Washington Fish and Wildlife, Olympia, Washington.

Bortleson, G. C., M. J. Chrzastowski, and A. K. Helgerson. 1980. *Historical Changes of Shoreline and Wetland at Eleven Major Deltas in the Puget Sound Region, Washington.* In Hydraulic Investigations Atlas HA-617. U.S. Geological Survey, Washington, D.C.

The earliest available and authoritative historical maps depicting the condition of Puget Sound shorelines and wetlands were compared to present-day topographic maps for eleven delta regions. Considerable effort was taken to transfer historical data to present-day maps. Factors affecting accuracy were noted, and included the land grid, analytical and interpretive limitations, delineation of shoreline and wetlands, low-water line, map symbols, judgment of compilers, data transfer, map stability, optical transfer and tracing.

Comparison of historical maps between 1855 and 1900 (80 to 125 years prior to the 1980 published date of this paper) to modern topographic maps provided documentation of shoreline alteration, wetland gain or loss, and change in delta land use. A general discussion of the principles and processes - natural and human caused- affecting delta shorelines as a means of evaluating change was presented. These included progradation and sediment supply, recession, shifting of stream channels, human-induced shoreline modifications, and development on the deltas. It was stressed that only overall changes in shoreline condition

could be distinguished since information was evaluated from only two periods in time (i.e., based on historical maps and present-day maps). Based on comparisons of historic and present-day maps, the loss of subaerial wetlands and intertidal areas for the 11 deltas were estimated. A majority of the 11 deltas showed a loss of subaerial wetlands, of which three deltas (Lummi, Snohomish, and Puyallup) exhibited a significant loss totaling $5km^2$ or more. Diking was identified as the primary causative agent. The Nooksack and Stillaguamish deltas exhibited a slight increase in subaerial wetland area. For intertidal areas, data were available for eight of the 11 deltas. The Lummi, Skokomish, and Dungeness deltas showed relatively minor loss of intertidal area, whereas the Duwamish and Puyallup deltas exhibited nearly a complete loss of intertidal area. Extensive dredge and fill operations were identified as the primary causative agent.

Brewer, L. W. 1980. *Waterfowl Habitat Inventory, Project No. W-27-R-28. Washington Department of Game*. Olympia, WA.

Bower, John. 2003. *Assessing Southern Strait of Georgia Marine Bird Population Changes Since 1980: What We Know and What We Need to Know*. Proceedings of the 2003 Georgia Basin/Puget Sound/Straits Research Conference.

Bower, J., B. Cary, C.Cowles, H. Donovan, K. Dixey, J. Hobart-Crane, D. Poe, S. Preecs, S. Sanborn, M. Staub, M. VanderVen. 2005. *Unknown Title.* Proceedings of the 2005 Puget Sound/Straits Georgia Basin Research Conference.

Broad, A. C., A. B. Benedict, and J. R. Mayer. 1984. *Infaunal Macrobenthos and Sediment Characteristics in Bellingham and Samish bays.* Western Washington University. Bellingham, WA. (Final report to U.S. Environmental Protection Agency) 107 pp.

The report provides a synopsis of physical characteristics of Bellingham Bay and integrates previous benthic studies (CH2M Hill, Smith, Webber) with 1983 research.

Within the top 10 m, salinity and temperature in Bellingham Bay vary with depth and time. A 2 m thick brackish layer (salinity < 20 ppm) forms in the area north of Point Francis and Post Point. Winds and tides cause mixing. The bay is isothermal in late fall and early spring, experiences a thermal inversion in winter, and is thermally stratified in summer for days to weeks. Oxygen concentration in bottom water decreases during periods of thermal stratification. Bottom water in the inner bay flows north with flood tides and south with ebbs. During periods of stratification, bottom water from the inner bay can flow in a clockwise eddy rather than flowing south past Post Point. Major sediment types include bay muds, delta platform sands, and lag gravels.

Much of the sediment in Bellingham Bay originates from streams, principally the Nooksack River, and from unconsolidated bluffs. The inner harbor also contains anaerobic sludge mixed with wood chips and fibers. In 1979, after the Georgia Pacific effluent lagoon began operation, about 30% more solids were discharged than before; however, these solids mostly consisted of bacteria rather than wood fibers. From 1965 to 1973, between 10 and 20 tons of mercury were discharged to the bay from the chloro-alkali plant. From 1974 to 1979, mercury concentration in sediments of Whatcom Waterway decreased to about 10% to 50% of initial levels in response to half-life (1.3 years) breakdown. From Nelson's study (1974), concentrations of mercury in animal tissue were thought, in part, to be due to more rapid mercury methylatation in the presence of well-oxygenated sediments of the marina than the anoxic sediments of the chloro-alkali lagoon. Sediments dredged from Squalicum, I & J, and Whatcom waterways were probably from the Nooksack River with an annual estimated sediment discharge of 688,500 cubic meters. Prior to the 1984 study, CH2M Hill, Smith, and Webber recorded a total of 241 macroinvertebrates from cores, grabs, or trawls. Polychaetes, bivalves, crustaceans, and echinoderms dominated. Diversity and abundance of macrobenthos was the same before and after the Post Point sewage treatment plant came on line. Historical commercial and recreational harvests of invertebrates include Dungeness crab, Pacific oysters, various clams (littleneck, Manila, horse, soft-shell, and cockles), squid, octopus, and sea cucumbers. Shrimps *Crangon* and *Pandalus* are numerous in the subtidal.

Results from the 1984 study of 44 VanVeen samples identify sediment size, color, TVS, presence of H_2S, temperature, salinity, and dissolved oxygen. The 1984 study found lower organic content in sediments than studies from 1974 and 1975. A total of 169+ species were identified in four regions including the Nooksack River to Squalicum Harbor, inner harbor, inner bay, and outer bay. The delta had the lowest diversity but the highest number of individuals and biomass. The number of species and organisms decreased with depth, silt content, and organic content. The numbers of organisms per unit area from the 1984 study were greater than previous studies. This was thought to be a response to different sampling methods and water quality management efforts. Bellingham and Samish bays had different infauna. Appendices include faunal informational by taxon and station.

Brown, M., M. Maudlin, and J. Hansen. 2004. *Nooksack River Estuary Habitat Assessment.* Lummi Indian Business Council, Bellingham, Washington.

The Nooksack Estuary provides vital habitat for Pacific salmon juveniles, particularly Chinook salmon, *O. tshawytscha*. Approximately 65% of the Nooksack floodplain has been converted to agriculture since the 1930’s and over the past 150 years much of the habitat diversity has been lost from the Lummi Delta. Channel alterations have led to abandonment of old delta areas and formation of new delta areas closer to the Lummi Reservation. Sediment

accretions in the new deltas are estimated at 21-25 feet in the last 150 years. Habitat type has change greatly over time as well where wetland areas have decreased over time; however, forested floodplains have greatly increased.

Water quality was investigated in this assessment, 10 water temperature loggers were installed over 2003 and 2004, all measured > 25 degrees C summer time temperatures. Salinity measures indicate a salt wedge extending upstream approximately 2.5 river miles in the mainstem Nooksack River. The salt wedge extends 1.1 river miles up Kwina Slough and 3.4 river miles up the Lummi River. A summary of supporting work (Ross *et al*. 2003, Spikes *et al*. 2004) where benthic macroinvertebrates were taken from 24 sites in the Nooksack River Estuary was also provided. The macroinvertebrate population available to salmon is diverse and highest macroinvertebrate densities are concurrent to salmon density in the estuary. Salmon presence and density are derived from Mackay 2003 and Mackay 2004.

Buchanan, K. D. 1985. *The General Purpose Herring Fishery 1957-1983. Technical report No.85*. Washington Department of Fisheries. Olympia, Washington.

Caldwell, J. 1983. *Portage Island Ecological Survey*. Caldwell Private Consultant. Bellingham, Washington.

This report is an ecological overview of Portage Island that took place between October 1981 and June 1982. It is a baseline survey of all the species and all the habitats found on Portage and Brant islands. The report is part of an investigation to enable the Lummi Nation to design and manage a future Swulesen Wilderness Park. Current cattle grazing and off road vehicle use has damaged some open meadows and fringes of salt marshes. The island is fairly resilient to these impacts. The report confirms that the area can support a park, but asks specific management questions of the park.

Cardwell, R.D. 1977. *Quality and Toxicity to Oyster Larvae of Marine Waters Between Point Whitehorn and Sandy Point, Washington in 1976*. Washington State Department of Fisheries, Salmonid Research and Development, Olympia, Washington.

Cardwell, R. D., M. I. Carr, and E. W. Sanborn. 1980. *Water Quality and Flushing of Five Puget Sound Marinas, Technical Report No.56*. Washington State Department of Fisheries, Olympia, Washington.

To define marina flushing rates, five marinas were investigated including Squalicum Harbor. Water temperature, dissolved oxygen, chlorophyll a, and flushing indices were assessed together with water quality of source water and 30 years of climatic data. Marina surface water temperature (within 1 meter) can be predicted based on 7-day average air temperatures. Average water

temperature in Squalicum Harbor (15 degrees C) was high because of minimal flushing of both the marina and bay. Daylight dissolved oxygen content was often higher than source waters due to plankton blooms and attendant oxygen production. During late summer, subsurface (2.1 to 3.1 meters) night levels of oxygen fell below state standards.

Because marinas emulate a protected embayment, certain species of juvenile salmon and baitfish are seasonal visitors. Included are surf smelt, Pacific sand lance, and Chinook salmon juveniles. Preferring shore edges, juvenile coho, chum, and pink salmon are not as frequently observed in marinas. Trawls in Birch Bay and Lummi Bay, naturally occurring protected embayments, found comparatively high counts of Pacific herring, surf smelt, Pacific sand lance, and juvenile Chinook, coho, chum, and pink salmon. These embayments contained substrates of eelgrass and sand or mud. Trawls in other locations with moderate to high exposure had rock/kelp, cobble, or gravel substrates. Fewer individuals of all enumerated fish species were encountered. Contains figures and appendices.

Carr, M. et al. 1974. *Bivalve Embryo Bioassays of Marine Waters and Industrial Waste Samples from the Sandy Point to Point Whitehorn Area in Puget Sound, Washington*. Washington State Department of Fisheries, Management and Research Division, Olympia, Washington.

Clark, J. et al. 1981. *The Nooksack Delta Environmental Impact Assessment*. Huxley College of the Environment Western Washington University Bellingham, Washington.

Environmental assessment of the unique features that make the Nooksack delta. The delta area is a significant fishery and used extensively for recreation. This report gives summaries on geology, hydrology, wildlife, water quality, and cultural resources of the delta. It poses that the delta is not suitable for development, unless major drastic measures are taken to stabilize soil and control channel migration. The delta is better kept in its natural state as a fishery, cultural resource, and system for study.

Cochrane, M. 1990c. *Nooksack Delta Sedimentation Investigation. Technical report # 91-1.* Department of Fisheries, Lummi Indian Business Council. Bellingham, Washington.

Cochrane, M. 1990a. *Impacts of Nonpoint Pollution on Fisheries Resources Lummi Fisheries. Technical Report #91-3*. Lummi Indian Business Council Bellingham, Washington.

Many sources of nonpoint pollution can affect the abundance and toxicity of recreational and commercial clam species. This report was developed to fulfill WADOE centennial grant requirements. The report estimated legal and

sublegal clam abundances for beaches on and off the Lummi Reservation. Also, it attempted to identify potential sources of nonpoint pollution along the specific beaches. It identifies fecal coliform, PSP, and industrial effluents as the most prominent nonpoint pollution to intertidal zones.

Cochrane, M. 1990b. *Impacts of Nonpoint Pollution on Fisheries Resources Lummi Fisheries. Technical Report #91-4*. Lummi Indian Business Council Bellingham, Washington.

Collias, E.E., C.A. Barnes, et al. 1966. *An Oceanographic Survey of the Bellingham – Samish Bay System, Vols. I & II. Special Report No. 32*. Oceanography Department, University of Washington, Seattle, Washington.

Collins, B.D. and A.J. Sheikh. 2000. *Historical Riverine Dynamics and Habitats of the Nooksack River.* Interim report prepared for the Nooksack Indian Tribe.

Collyer, C.T. 1998. *Current Patterns and Suspended Sediment Transport Through the Inner Harbor, Bellingham Bay, Bellingham, Washington*. Masters Thesis. Western Washington University, Bellingham, Washington.

Cubbage, J. 1991. *Bioaccumulation of Contaminants in Crabs and Clams in Bellingham Bay. Washington State Department of Ecology, Olympia, Washington.* Prepared for Puget Sound Estuary Program, Seattle, Washington.

Muscle from Dungeness crab (eight sites), and whole body littleneck and Manila clams (four sites) were tested for mercury, lead, arsenic, cadmium, PCBs, and other organochlorine compounds. Clams were also tested for polycyclic aromatic hydrocarbons. No pesticides or PCBs were found in clam or crab tissues. Low concentrations of PAH's were found in clams. Mercury was not detected in clam tissue but was detected in low concentrations in crab tissue. A slight correlation was found between muscle mercury concentrations and proximity to Whatcom waterway. Cadmium, arsenic, and lead were also detected in clam and crab tissues, but concentrations were similar to Puget Sound reference areas. Highest arsenic levels came from shellfish on the west side of the bay. A concurrent study by the Department of Natural Resources found similar mercury, arsenic, and lead concentrations; however, cadmium, DDE, and chlordane levels were higher than Department of Ecology results. Concentrations of mercury in Dungeness crab from Bellingham Bay have declined in the past 15 years, probably in response to decreased mercury discharge. In 1974, crab from Post Point had 0.23 ppm (wet weight) concentrations, whereas concentrations in the present study found 0.08 to 0.11 ppm (wet weight).

Cummins J.M. and C.E. Gangmark. 1986. *Results of Oyster Larvae Assays Conducted on Mobil, Arco and Intalco Effluents and Receiving Waters in the Vicinity of Cherry Point, Washington*. United States Environmental Protection Agency, Region 10 Laboratory, Manchester, Washington.

Custer, H. 1857. United States Boundary Survey. "*Sketch of the Lower Part of the Nucsac River.*" Made Aug. 25, 1857. From notebook "*Reconnaissance of Sumas Prairie, Frazer's River, Whatcom Lake, etc. 1857-1858, H. Custer*." RG 76 Series Entry 202, Reconnaissance Notes 1857-858.

Custer, H. 1858. *Sketch Map from Reconnaissance of Lummi Bay, Lake Whatcom, Nooksack River, and Whatcom Trail*. From reconnaissance of June 7-24, 1858. RG 76 Series 69.

Day, D. 1987. *Changes in the Natural Mortality Rate of the Southeast Strait of Georgia Sac-Roe Herring Stock, 1976-1985*. Technical Report No. 98 Washington Department of Fisheries, Olympia, Washington.

Department of Landscape Architecture, University of Washington. 1992. *Coastal Sensitive Areas Mapping Project.* Department of Ecology. Olympia, WA. (San Juan Islands booklet) 38 pp.

The shoreline of Bellingham Bay is mapped as marsh at the Nooksack River delta, wave cut platform between the Nooksack River and Little Squalicum Creek, gravel and cobble at Little Squalicum Beach, and rocky shore or seawall from Squalicum Creek south to Clark Point. The western shoreline is mapped as gravel and cobble. Bird colonies are identified at Squalicum Harbor and off Boulevard Park. Marine mammal sightings are noted for Portage Bay and east of Brant Point. Brant Point is noted as a marine mammal haul out site. The north shore of Bellingham Bay, including the Nooksack River delta, is identified as a set net fishing area. Subtidal waters of Bellingham Bay are considered as a Dungeness crab area. Eastern Portage Bay is identified as an area for Pacific oysters and the area surrounding Portage Island is noted as hard-shell clam habitat.

Deardorff, L.V. 1992. *A Brief History of the Nooksack River's Delta Distributaries*. Lummi Indian Business Council, Bellingham, Washington.

Dillon, J.E. and J.W. Johannessen. 1998. *Detailed Beach Nourishment Plan for Lummi Indian Reservation*. United States Army Corps of Engineers, Environmental Resources Section, Seattle, Washington.

Defines the plan of beach nourishment (adding sediment) and associated monitoring to assess its effectiveness. The plan sets surf smelt as a species of

concern and plans to mitigate potential effects from the Lummi Shore Road and associated revetment project. The plan provides estimated historic bluff erosion rates to beaches, and sediment type below revetment, primarily silty clay except for Hale Passage shore. It defines surf smelt spawning gravel criteria, approximately 1 – 8 mm.

Dinnel, P.A., A. Armstrong, and R.O. McMillan. 1986. *Dungeness Crab, Cancer magister, Distribution, Recruitment, Growth and Habitat Use in Lummi Bay, Washington*. Revised Draft Final Report. Fisheries Research Institute, University of Washington.

Dungeness crab *Cancer magister* distribution, recruitment, growth, and habitat preference were assessed in Lummi Bay, Washington from July 1984 to September 1985. Dungeness crab were sampled at 13 stations with a beam trawl; sampled at 4 stations with modified commercial-style crab pots; and sampled intertidally with 0.25 m^2 quadrat samples dug at low tide. Of samples collected, Dungeness crab was the dominant species of crab in Lummi Bay (78% of catch). Sampling gear had different efficiencies with different age classes of crab. Regardless of this, crab abundance was seasonal with the highest abundances in the summer months during time of YOY settlement and high adult activity. Settlement of 0+ crab begins in July of each year and continues until September. However, the most interesting finding from this survey was the apparent segregation of age classes by elevation on the tidelands. Juvenile crabs were higher in the intertidal while younger adults occupy the upper subtidal. Little overlap of age classes in space occurred probably due to a high degree of cannibalism from larger crabs. Crabs also occupied different habitats at different life stages. They relied on cover during early stages and then migrate to open channel at size of 100 mm.

The authors also give estimates of Dungeness crab production in Lummi Bay. Estimating 1 crab at 0+ per meter squared in eelgrass habitats. Shallow channels would contain 160 crabs/ha, which would be primarily 1+ ages, suggesting Lummi Bay is important rearing area for juvenile crab; however, recruitment to the fishery is hard to quantify.

Dinnel, P. A., D. A. Armstrong, and R. R. Lauth. 1988. *Invertebrate Resource Assessments in and Around Proposed Dredged Materials Disposal Sites in Puget Sound.* Contribution No. 747. University of Washington, School of Fisheries. Seattle, Washington.

Dinnel, P., A. Armstrong, R. Lauth, and K. Larsen. 1988. *Puget Sound Dredge Disposal Analysis (PSDDA) Disposal Site Investigations: Phase II Trawl Studies in North and South Puget Sound: Invertebrate Resource Assessments. FRI-UW-8818.* Fisheries Research Institute, University of Washington, Seattle, Washington. Final Report to Washington Sea Grant and the U.S. Arm Corps of Engineers, Seattle.

Dogfish Environmental Assessment Team. 1986. *The Spiny Dogfish (Squalus acanthias) and the Dogfish Fishery in Puget Sound*. Huxley College of Environmental Studies. Western Washington University, Bellingham, Washington.

Beginning in the 1880's, dogfish were commercially exploited for lamp oil. Dogfish livers were used as a Vitamin A source during the 1930s and 1940s. In 1975, a market began for dogfish as human food. Arrowac Fisheries and Dahl Fisheries process dogfish in Bellingham. A 1970 study found 75% of sampled dogfish had mercury content in excess of the 0.5 ppm maximum allowable standard. Until a 1978 court case caused a change in the method to calculate mercury content, dogfish could not be sold in domestic markets and had to be exported to countries were the maximum allowable standard was 1 ppm. An inshore dogfish population is centered in Georgia Strait with about 3% of commercial catches from Bellingham Bay. Midwater trawls catch juveniles of less than 60 cm in length. Larger juveniles and adults prefer deeper water. Females mature at an average of 23 years and males average 14 years at maturity. The dogfish is ovoviviparous with a two-year gestation period that produces an average of six to seven young.

Dold, A. et al. 1982. *Portage Bay Environmental Assessment*. Huxley College of the Environment Western Washington University Bellingham, Washington.

Dolphin, C. 2002. *2002 Spring Survey of Clam Populations at Brant Island and Brant flats*. Lummi Indian Business Council Bellingham, Washington.

Commercial bivalve harvest from Brant Island and Brant Flats have been previously closed due to elevated fecal coliform counts in Portage Bay. Interest has been expressed in the potential of this area for resumed commercial harvesting for Manila clams and butter clams for clam bait. Butter clams, Manila clams, native littlenecks, purple varnish clams, cockles, and horse clams were all observed on Brant Island and Brant Flats. Butter clams had highest estimated density of 426,208 lbs followed by native littlenecks at 102,779 estimated lbs, and Manila clams at 77,710 estimated lbs respectively, within the surveyed portion of the area. The survey methods were not sufficient to assess horse clam abundance.

Dolphin, C. 2004. *Manila Clam Growth and Mortality Rates Observed in a Small-Scale Growout Experiment in Lummi Bay*. Lummi Indian Business Council Bellingham, Washington.

Manila clam growth rates and mortality are poorly understood in North Puget Sound. Previous efforts to document Manila clam growth and mortality were not properly documented. Information from these experiments could not be sufficiently reconstructed. This work placed 4 experimental plots where clams of varies sizes were planted and then monitored for a year. Vandalism greatly affected the experiment, and thus limited the results, however the project could conclude that mortality and growth rates seem to be higher than what is currently used.

Dolphin, C. 2007. 2007 *Lummi Clam Survey Summary*. Lummi Indian Business Council Bellingham, Washington.

In 2007 Lummi Natural Resources surveyed clam densities on several important Reservation beaches. A total of 1,819 samples were dug, which is equivalent to 11,619 square feet. Legal biomass estimates for each area were: Lummi Bay 1,149,489 lbs, and Portage Bay 260,581 lbs. Results for most management areas, except northern Lummi Bay, showed modest increases or very slight decreases from densities observed in the previous survey year. Recommended harvest levels would provide 235,856 lbs in the coming year. This compares to the previous year harvest of 261,238 lbs for the same beaches. However, these recommendations do not include any harvest from Lummi Shore Road (S4), Inside Portage Bay (S6), or Inside Brant Point (S7A). Typically, S4, S6, and S7A combined add a further 10,000 lbs per year.

Eissinger, A. 1994. *Significant Wildlife Areas of Whatcom County*. Whatcom County Planning Department, Bellingham, Washington.

Maps of fish and wildlife habitat throughout Whatcom County. Lummi Bay is major Bald Eagle habitat and Lummi Bay nearshore environments are used by anadromous salmon.

Eissinger, A and D. Drummond. 1994. *The Wildlife and Habitat of the Lummi Reservation.* Nahkeeta Northwest. Prepared for Lummi Indian Business Council, Bellingham, Washington.

The Lummi Reservation has a diverse set of species that is a regionally significant concentration of wildlife. A total of 278 species were identified as occurring on Reservation lands and associated waters. Of this total, 142 species are associated with conifer forests, 112 species with red alder forests, while 83 of the total species are associated with farmlands. These represent the major terrestrial habitats within the Reservation. Fifty-six (56) sensitive wildlife were also identified. The report notes a general lack of empirical data on amphibians, reptiles, mammals, and wetland habitats. The report provides specific direction for the application of the Lummi Forestry Plan.

Eissinger, A. 1999. *Biological Assessment Report, Project: Lummi Shore Road Improvement, a Site Assessment for Listed Species and Species of Concern*. . Nahkeeta Northwest. Prepared for Lummi Indian Business Council, Bellingham, Washington.

This Biological Assessment lists potential impacts of the Lummi Shore Road Project on endangered species, threatened species, and species of concern. The author had some concerns with herring, salmon, and bald eagle population impacts, but concluded that the project "may affect, not likely to adversely affect" certain Federally listed species and species of concern including Chinook and coho salmon.

ENSR. 2001. Cherry Point Industries located near Ferndale, Washington *Effluent Plume Modeling Study. Final Report*. Document Numbers: ARCO – 0480-449-600, TOSCO –6752-015-200, Intalco – 3745-010-200.

ESA Adolfson Environmental, 2007. *Whatcom County Shoreline Master Program Update*. Prepared for Whatcom County, Washington.

The goal of the Shoreline Inventory and Characterization were to: 1) review and revise shoreline goals and policies, 2) inventory and analyze shoreline conditions, 3) determine and evaluate shoreline environment designations, 4) assess cumulative impacts of shoreline development, and 5) prepare for restoration plant. No specific information associated with the Lummi Reservation was described in this document; only qualitative efforts were made to describe potential physical processes, such as large woody debris sources, toxic chemical sources, and impervious areas effects.

Everitt, R., C. H. Fiscus, and R. L. Delong, 1980. *Northern Puget Sound Marine Mammals. DOC/EPA Interagency Energy /Environment R & D Program Report EPA-600/7-80- 139*. U. S. Environmental Protection Agency, Washington, D.C.

EVS Environmental Consultants. 1999. *Cherry Point Screening Level Ecological Risk Assessment (Preliminary Draft).* Washington State Department of Natural Resources Olympia, Washington.

This report has 4 specific objectives: 1) Identify all stressors that may be contributing to the observed decline in the Cherry Point herring stock and the pathways by which they act, and analyze available data to determine the importance of each; 2) Screen out unimportant stressors based on existing data, and retain stressors for which either (a) data do not exist or are highly uncertain, or (b) data suggest that the stressor may affect the stock; 3) For stressor that are retained, evaluate the potential contribution of each to the declining trend in the Cherry Point herring stock; 4) Specifically assess the potential influence on the stock of the proposed ARCO pier extension. Results suggest: A) Spawning biomass has decreased due to the loss of the oldest 7, 8, and 9-years age classes; B) Mortality from harvest has declined over time, so currently mortalities among older fish must be the result of other stressors, recruitment biomass of year 2 and 3 herring has not declined; C) Puget Sound herring stocks are resident while Cherry Point stocks are migratory that spend summers and winters on continental shelf and depend strongly on sea surface temperatures; D) Other considerations for ocean herring population declines, such as predation from Pacific hake; E) Puget Sound seals and some other predators have increased in population, F) Many other stressors that could offer alternative explanations are only affecting older age classes and not the early life stage recruitment.

Extensive data summaries on environmental factors affecting Pacific herring are given in this report. No clear factor has been discovered for the decline in Cherry Point herring stock, since the stock is declining on all fronts from reproduction, emergence, juvenile survivorship, adult recruitment, and spawning success.

Appendix D provides interesting information on historic spills at ARCO Cherry Point refinery. Most spills reported are less than 400 gallons and are primarily longer chained hydrocarbons such as crude, diesel, and jet fuel. In 1972, 21,000 gallons of crude oil was spilled due to a failed flange on an oil tanker.

Fackler, R.C., E.A. Hoeranf, C.E. Larson, K.L. Lingbloom, M.A. Short, and M.C. Schwartz. 1971. *A Preliminary Study of the Nearshore Currents in the Vicinity of Birch Bay and Cherry Point, Washington*. Geology Department, Western Washington College, Bellingham, Washington.

Fresh, K. L. 1979. *Distribution and Abundance of Fishes Occurring in the Nearshore Surface Water of Northern Puget Sound, Washington*. Master's Thesis. University of Washington, Seattle.

The abundance and spatial and temporal distribution of fishes in nearshore surface waters of northern Puget Sound were studied during 1974-1976. Five sites representing different habitat types in three distinct geographic areas were sampled by tow net on monthly and bimonthly schedules. In addition, the study sought to "define associations between specific fish assemblages and specific habitats and evaluate potential impacts of oil pollution." Primarily juvenile fish were captured throughout the year, with larval fish most abundant in the spring. Seventy-one species were captured; most were schooling species, with six species (herring, sand lance, stickleback, surf smelt, longfin smelt, tadpole sculpin) accounting for 98% of the total catch (herring were the most abundant and common species). Chinook salmon (*Oncorhynchus tshawytscha*) was the most abundant of the five species of Pacific salmon caught in the sample areas. Seasonal patterns in catch-per-unit-effort and species numbers emerged, with the lowest during winter and highest during summer. The dominant schooling species were caught at most of the sites. The catches of most species "were greatest in the Cherry Point area and in protected eelgrass bays." Fewer species and smaller catches were recorded at exposed sites and habitat types. The nearshore surface zone was suspected as being "exploited as a single habitat type." Impacts of an oil spill on nearshore fish species in northern Puget Sound was also discussed (e.g., severe impacts if occurring during spawning periods, protected eelgrass regions important as rearing areas).

Gonyea, G. et al. 1982. Summary of 1981 *Herring Recruitment Studies in Puget Sound. Progress Report No. 157*. Washington State Department of Fisheries, Olympia, Washington

Goodwin, C. L., and W. Shaul. 1978. *Puget Sound Subtidal Hardshell Clam Survey Data. Progress Report No. 44*. Washington State Department of Fisheries. Olympia, Washington.

GPA Consulting Services. 1979. *Lummi Coastal Zone Management Plan*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Gustafson, R.G., J. Drake, M. Ford, J. Myers, E. Holmes, and R. Waples. June 2006. *Status Review of Cherry Point Pacific Herring (Clupea pallasii) and Updated Statues Review of the Georgia Basin Pacific Herring Distinct Population Segment under the Endangered Species Act*. NOAA Technical Memorandum, NMFS-NWFSC-76. Seattle, Washington.

After many petitions to review Cherry Point (CP) Pacific herring stock status, NOAA reviewed the potential of protecting CP herring under the Endangered Species Act. The review specifically addressed the stocks discreetness, the stocks genetic significance, and the current viability of the population to sustain itself.

The NOAA concluded that the CP Pacific herring were a discrete stock through evidence of locally unique spawn timing, location of spawning, unusual growth rate characteristics, and differential accumulation of toxic contaminants in relation to other local Puget Sound Pacific herring populations. However, CP herring are a transient stock intermixing with other stocks and considered as part of the greater Georgia Strait distinct population segment (DPS). The NOAA did conclude the loss of CP herring would result in the weakening of the Georgia Strait DPS.

Hanna, T. 1981. *Draft Case Study on Portage Island*. Commission on State-Tribal Relations, Olympia, Washington.

Harman, R. A., and J. C. Serwold. 1975. *Summary of Northern Puget Sound Studies.* For Northern Puget Sound Baseline Study.

HDR Engineering. 1995. *Environmental Assessment, Lummi Shore Road Restoration and Shore Protection Project, Lummi Indian Reservation, Washington*. HDR Engineering, Inc., Bellevue.

As an environmental assessment of the Lummi Shore Road Restoration and Shore Protection Project, the assessment describes armoring 14,300 feet of beach at the toe of the bluff, reconstruction of the roadway, and improvement of drainage in specific areas. The assessment provides general design suggestions for road building, armoring design, and drainage placement. Not net affect to fish and wildlife were found in this assessment if best management practices were implemented.

Heath, W., M. King, and R. Patton. 1975. *Lummi Aquaculture: Final Report Chapter 2*. Lummi Indian Business Council Bellingham, Washington. pp. 21-89.

The Seapond was constructed as an alternative form of food production that could be developed by the Lummi Tribe. This report assesses water exchange and storage of the Seapond and to associated biota and sediment that occur

inside and outside of the Seapond. Surface drift was also investigated in Hales Passage and Lummi Bay proper. The Seapond can exchange a little more than 10% of its capacity per day. Sediment does not greatly differ from outside the Seapond. Sediment may start aggregating near inflow gates overtime due to low dispersion rates.

Biota was collected at 25 sites, 16 sites inside the sea pond and 9 outside the Seapond. At the time of sampling, *Zostera sp.* was observed in large concentrations in the southern and northwestern sections of the Seapond. Some filamentous diatoms were also reported in areas where *Zostera sp.* was not observed. Sediment was predominantly medium to fine sand (75% to 99%). Biomass outside the Seapond was slightly higher than within the seapond, but can largely be attributed to polychaete worms. Stations near the tide gates had the least biomass of all stations sampled. The report continues by giving raw data on benthic abundance by species and by station, in addition to growth calculations of commercially valued species (Oysters and clams).

A tidal current investigation was also performed, during different tidal and atmospheric conditions. Ebb tides disperse quickly out of Lummi Bay. Water seems to enter Lummi Bay from Hale Passage rather than from Georgia Strait.

Hershberger, Pl and R. Kocan. 1999. *Final Report 1999: Survival Potential of Cherry Point Herring*. University of Washington, School of Fisheries. Prepared for Washington Department of Natural Resources, Olympia, Washington.

Results from the 1999 Cherry Point herring *in situ* egg incubation studies indicate a 2-part problem. First, site-specific problems are suggested by greater percentages of abnormal larvae, which were incubated at the southern extreme of the study area, near the Tosco (now Conoco Phillips) and Intalco off-loading docks. Second, larval weight at hatch from both artificially and naturally spawned herring eggs average 77 ug in 1999; 15% less than that of larvae from the same stock in 1991, 27% less than that of 1999 Holmes Harbor larvae, and 33-36% less than that of larvae from other Pacific herring stocks. Low survivability among the Cherry point larvae was realized when cumulative mortality among laboratory reared larvae reached 100% in less than 2 months.

Huxley College. 1978. *Costal Environmental Assessment, Portage Island*. Huxley College of the Environment Western Washington University Bellingham, Washington.

Johannessen, J.W.1997a. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project, Spring 1997*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Included in Johannessen, J.W. and M.A. Chase. 2003.

Johannessen, J.W.1997a. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project, Fall 1997*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Included in Johannessen, J.W. and M.A. Chase. 2003.

Johannessen, J.W.1998. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project, Summer 1998, Pre-Construction*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Included in Johannessen, J.W. and M.A. Chase. 2003.

Johannessen, J.W.1999a. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project: Spring-Summer 1999, Post Nourishment Monitoring*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Included in Johannessen, J.W. and M.A. Chase. 2003.

Johannessen, J.W.1999b. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project: Fall 1999, Post Nourishment Monitoring*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Included in Johannessen, J.W. and M.A. Chase. 2003.

Johannessen, J.W. and M.A. Chase. 2002. *Coastal Processes, Historic Shoreline Change, and Sediment Distribution of Portage Bay, Lummi Indian Reservation, Washington*. Coastal Geologic Services, Inc. Bellingham, Washington. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Shoreline change was quantitatively mapped as data allowed from 1887 to 1999, and were qualitatively documented for the mid and late 1800's. Significant changes in shoreline were noted at the Portage and along Brant Spit and North Spit. It seems the Portage was lowered in the 1870's or early 1880's through hand digging, and once breached caused positive feedback and

continued to lower the Portage. Brant Spit and North Spit have both grown. From these historical accounts accretion or erosion rates were estimated. Shoreline morphology was described.

Johannessen, J.W. and M.A. Chase. 2003. *Physical Monitoring/Beach Profiling at Lummi Shore Road Restoration Project: Winter 2003, Post Nourishment Year 4 Monitoring*. Coastal Geological Services, Inc., Bellingham, Washington. Prepared for Lummi Nation, Bellingham, Washington.

Summary of beach profiles and surf smelt spawning habitat on Lummi Shore Road from 1999 to 2003 are discussed. A significant storm event with a high tide caused damage to areas of Lummi Shore Road and more than normal erosion of sediment. Overall, beach elevations were generally below design elevations within Central Shore, and were consistently lower than design elevation in the North Smokehouse sub-cell, however at the South Smokehouse sub-cell 2 of 3 beach profile elevations were above design elevations. Total volume loss in the 3 sub cells was 467 cubic yards from winter 2002 to 2003 and 207 cubic yards from winter 2001 to 2002. A net of 1,120 cubic yards of sediment was lost from the 3 sub cells combined from summer 2001 to 2002. Approximately 40% of the 1-8 mm sediment was lost from Central Shore and South Smokehouse, while Seining Grounds had more the 40% of the 1-8 mm sediment from the start of Beach nourishment. A total of 46,591 sq. ft. of surf smelt spawning habitat was mapped in summer 2002 compared to the average of 50,226 sq. ft. from 1996 and 1998. Overall, beach nourishment may have increased surf smelt spawning habitat in the short term, it did not meet goal for total length of habitat.

Johannessen, J.W. 2003. *Lummi Reservation Shoreline Erosion Rate Compilation*. Coastal Geologic Services, Inc. Bellingham, Washington. Prepared for Lummi Indian Business Council Bellingham, Washington.

Johannessen, J.W. and A. MacLennan. 2004. *Physical Monitoring/ Beach Profiling Lummi View Drive: Summer 2004*. Coastal Geologic Services, Inc. Prepared to Lummi Indian Business Council, Bellingham, Washington.

Johannessen, J.W. and J.F. Waggoner. 2006. *Physical Monitoring/ Beach Profiling Lummi Shore Road Project: Winter/Summer 2006*. Coastal Geologic Services, Inc. Prepared to Lummi Indian Business Council, Bellingham, Washington.

Johannessen, J. and A. MacLennan. 2007. *Final Lummi Reservation Coastal Protection Guidelines.* Coastal Geologic Services, Inc. Prepared to Lummi Indian Business Council, Bellingham, Washington.

Kilambi, V.R. 1965. *Heterogeneity Among Three Spawning Populations of the Surf Smelt Hypomesus pretiosus (Girard) in the State of Washington*. Ph. D. Dissertation. Thesis No. TH14401. University of Washington, Seattle, Washington.

Kincaid, T., M.P. Wennekens, and R.O. Sylvester. 1954. *A Study of the Oceanographical and Biological Characteristics of Southeast Georgia Strait Prior to the Operation of the General Petroleum Corporation Refinery at Ferndale Washington*. University of Washington, College of Engineering, Seattle, Washington.

Kocan, R.1991. In situ *and Laboratory Assessment of Herring Embryo Survival at Cherry Point, Washington, April/May 1990*. University of Washington, School of Fisheries, Seattle, Washington.

Kocan, R.1992. *Draft: Final Report Cherry Point Herring Embryo Study 1992.* University of Washington. School of Fisheries, Seattle, Washington. Prepared for Lummi Indian Business Council Bellingham, Washington.

This report verifies previous observations of an unusually high number of deformities in larval herring at two locations during in situ exposures of herring embryos that were performed along the Cherry Point shoreline during 1990-1991. The field experiment was duplicated during 1992 in coordination with a lab-based experiment. The 1992 findings showed no difference in larval abnormalities between sites, which differed from the 1990-1991 observations. The rate of larval herring abnormalities varies and it is difficult to compare from year to year. Laboratory work using water from a stream entering Cherry Point in proximity of the 1990-1991 sites of concern produce significant increases in larval abnormalities in April, but this affect was not observed in the second sample.

Kocan, R.1993. *Cherry Point Herring Embryo Study*. University of Washington, School of Fisheries, Seattle, Washington. Prepared for Lummi Indian Business Council Bellingham, Washington.

Throughout Kocan's research, 14 sites were investigated for exposures to Pacific herring from Birch Point to Sandy Point to Gooseberry Point. The number of abnormal herring larvae increases as the distance to Cherry Point industrial complexes decreases. Site 6 had 100% abnormal herring larvae. Site 6 falls between Intalco and BP complexes.

Kocan, R.1998. *Herring Embryo-Larval Success Evaluation at Cherry Point: Comparison of* In situ *Exposures with Laboratory Controls*. University of Washington, School of Fisheries, Seattle, Washington. Prepared for Washington Department of Natural Resources, Olympia, Washington.

In May 1998, 12 sites were selected from Point Whitehorn to Neptune Beach and one control "reference" site. All the 12 sites of Cherry Point proper had lower percent hatches and percent live hatch than the reference site. Differences in abnormalities in larvae were more difficult to determine. Overall reproductive success was more depressed near industrial complexes than the control site. Control site, however, did not perform as well as expected based on previous studies with this and other herring stocks over the past several years.

Koons, R. R. and R. D. Cardwell. 1981. *Significant Areas for Certain Species of Food Fish and Shellfish in Puget Sound*. Technical Report No. 59. Washington State Department of Fisheries, Olympia, Washington.

Kyte, M. 1999. *Beach Walk 1999: Observations on a Qualitative Examination of the Intertidal Zone of the Cherry Point Reach*. Prepared for ARCO, Intalco, and Tosco industrial complexes Ferndale, Washington.

Beach walk was done along specific reaches that compose the Cherry Point shoreline. Gulf Road Pier to Arco Pier: large numbers of molted Dungeness crab shells observed, wetland area associated with a stream contained *Salicornia virginica* and *Cuscuta salina*, mouths of streams had an abundance of drift logs. Approximately 2,000 feet north of Gulf Rd, 2 patches of herring spawn were found on macroalgae equaling 3 to 4 on WDFW spawn intensity scale. In this area was evidence of sport clammer holes increasing erosion, Amount of sand increases as one gets closer to Cherry Point. Feeder bluffs show no sign of slope failure. Arco Pier to Whitehorn to Birch Bay State Park: areas around the Arco Pier was similar to observations in 1996 except for some vegetation under the pier were covered by sediment, the east side of Point Whitehorn is subject to high wave energy. Sediment is composed of large gravel and cobble, the feeder bluffs in this area are especially active, Point Whitehorn to Birch Bay State Park had a number of bulkheads that impacted the upper intertidal; lower intertidal had eel grass beds. Gulf Road to Intalco: substantial evidence of clam digging south of Gulf Road, 100 to 200 yards south of the pier is sandy and supports eel grass extending ~200 north of Gulf Rd Pier to ~ 300 yards south, some eel grass beds seem to be loss from erosion and deposition, a shadow "foot print" was not evident under the Intalco pier as the pier is high and narrow. Intalco to Tosco Ferndale: boulders with small patches of eelgrass. Tosco Pier to Neptune Beach: Tosco pier had a distinct shadow "foot print", high wave energy in this region, 6 to 8 small landslides were encountered.

Kyte, M. 2000. *Beach Walk 2000: Observations on a Qualitative Examination of the Intertidal Zone of the Cherry Point Reach*. Prepared for ARCO, Intalco, and Tosco industrial complexes Ferndale, Washington.

Kyte, M. 2001. *Beach Walk 2001: Observations on a Qualitative Examination of the Intertidal Zone of the Cherry Point Reach*. Prepared for ARCO, Intalco, and Tosco industrial complexes Ferndale, Washington.

No new observations were observed from previous walks. As stated before, habitat conditions for herring spawning, juvenile flatfish, and salmonids are overall good to excellent with abundant submerged aquatic vegetation in the form of macroalgae and eelgrass. The distribution and quantity of the vegetation varies from year to year. *Sargassum muticum* is becoming increasingly dominant in the intertidal to the detriment of the native algal assemblage. Clam digging is the most serious sources of human impacts on the intertidal habitats observed.

Kyte, M. 2002. *Beach Walk 2002: Observations on a Qualitative Examination of the Intertidal Zone of the Cherry Point Reach*. Prepared for ARCO, Intalco, and Tosco industrial complexes Ferndale, Washington.

The distribution and quantity of submerged aquatic vegetation varies from year to year due to storms, natural littoral processes, and growth or recession of eelgrass beds. However, in general, habitat conditions for herring spawning, juvenile flatfish, and salmonids have been good to excellent. Two of the more serious sources of impacts on the intertidal habitats are recreational clam digging and the invasion of *Sargassum*. *Sargassum*, however usable by herring as egg deposition substrate, is seriously reducing quality of habitat through reduction of native plant diversity and abundance. Groundwater seeps may also be impacting herring stocks due to pollution of the ground water.

Kyte, M. 2003. *Beach Walk 2002: Observations on a Qualitative Examination of the Intertidal Zone of the Cherry Point Reach*. Prepared for ARCO, Intalco, and Tosco industrial complexes, Ferndale, Washington.

The distribution and quantity of submerged aquatic vegetation varies from year to year due to storms, natural littoral processes, and growth or recession of eelgrass beds. However, in general, habitat conditions for herring spawning, juvenile flatfish, and salmonids have been good to excellent. *Sargassum* now has the potential to replace eelgrass in the Cherry Point shoreline. *Sargassum* is usable by herring for egg deposition, but has been noted to be toxic and can alter nearshore water quality. Ground water is still a concern and not investigated.

Landis, W.G., and A. Markiewicz. 2000. *Regional Risk Assessment for Cherry Point Herring Stock*. Institute of Environmental Toxicology and Chemistry, Huxley College of the Environment, Western Washington University, Bellingham, Washington.

Compared to run sizes of the 1970's, the Cherry Point (CP) Pacific herring stock is in a dramatic state of decline. A regional risk assessment was conducted to determine the cause of the decline and identify potential future risks to the area. They used the relative risk methodology to rank the probabilities of a particular stressor or risk factor affecting the overall region, including: from Point Roberts to southern end of Hale Passage. The regional risk assessment indicates that over-harvesting coupled with a decline in the rate of recruitment of mature herring were responsible for the current low population levels. Alden Bank, the pre-spawning holding area, was determined to be the area with the highest historical risk because of vulnerability to exploitation. Current risks to the CP herring are due to a variety of causal factors that can alter the habitat, food supply, or spawning substrate, as well as disturb the spawning process or generate contaminants to create toxicity. The region with the highest potential risk encompasses south Birch Bay, Point Whitehorn, and Cherry Point. The report makes recommendations for reducing risk and stress to the population.

Lemberg, N.A. 1978. *Hydroacoustic Assessment of Puget Sound Herring, 1972-1978. Technical Report No. 41*. Washington Department of Fisheries, Olympia, Washington.

Lemberg, N. S. Burton, and W. Palsson. 1990. *Hydroacoustic Results for Puget Sound Herring, Whiting, and Pacific Cod Surveys, 1988 and 1989.* Technical Report No. 281. Washington Department of Fisheries, Olympia, Washington

Lemberg, N., M. O'Toole, D. Pentilla, and K. Stick. 1997. 1996 *Forage Fish Stock Status Report*. Washington State Department of Fish and Wildlife Olympia, Washington.

The second edition of marine forage fish stocks in Washington. Specifically, this report discusses the stocks of Pacific herring, surf smelt, Pacific sand lance, and northern anchovy. Stock numbers of each fish, pre-spawning holding areas, and spawning areas in Washington State are describe in this report. These forage fishes are important ecological resource for other marine organisms. Declines in forage fish populations and their relative ecological importance has resulted in a conservative harvest rate of 5-10% compared to the generally accepted level of 20% for herring fisheries worldwide.

Long, E. R. (editor), A. Benedict, R. Everitt, B. Miller, C. Nyb1ade, C. Simenstad, S. Speich, T. Wahl, and H. Webber, 1982. *A Synthesis of Biological Data from the Strait of Juan de Fuca and Northern Puget Sound*. NOAA-EP A- 600 /7 -82 -004.

Lummi Fisheries. 1984. *Survey of Zostera marina L. in the Proposed Access Channel. Report no. 84-1*. Lummi Bay Marina. Lummi Fisheries Department, Bellingham, Washington.

Lummi Fisheries. 1989. *Dredge and Fill Activity in Bellingham Bay. Water Quality Problems in Two Northern Puget Sound Embayments*. Lummi Fisheries Department. Lummi Indian Business Council, Bellingham, Washington.

Lummi Indian Business Council (LIBC). 1996. *Environmental Assessment: Lummi Shore Road Restoration and Shore Protection Project*. Lummi Indian Business Council, Bellingham, Washington.

This environmental assessment evaluates different plans for mitigation and protection of environmental resources during the Lummi Shore Road revetment project. The assessment describes multiple proposals from no action to moving the road inland 500 to 800 feet from the active shore erosion. The proposed action is to armor the current Lummi Shore Road and provide mitigation that includes beach nourishing. This plan was the most economical and with mitigation efforts was deemed "no effect" to fish and wildlife.

Lummi Water Resources Division. 2003. *Water Quality Summary Report*. Lummi Natural Resources, Bellingham, Washington.

Overall, water quality in 2003 is similar to previous years, with the previously mentioned exception of the reversal in decreasing levels of bacteria. The marine waters of Lummi Bay and Sandy Point Marina continue to maintain good water quality, while the waters of the Lummi River watershed continue to have the poorest water quality. Bacteria levels increased in 2003 in the Lummi River watershed, the Nooksack River, and to a lesser degree in Portage Bay.

In general, upland sample sites dry out or become saline during the summer months as the dry season progresses. Once the wet season begins in the fall, flow begins again at the sample sites that dried out and the water column becomes less saline over the course of the wet-season. Once the dry season begins, the cycle starts again. In general, elevated bacteria levels are associated with fresh water and low bacteria levels associated with marine waters. Water temperatures show strong seasonal variation across all sample sites and are remarkably similar between sample sites. Dissolved oxygen levels also vary considerably, but not as predictably as water temperature

Lummi Water Resources Division. 2003. *Northern Lummi River Distributary Channel Area Wetland Mitigation Banking Assessment*. Technical report. Lummi Nation Department of Natural Resources, Water Resources.

Lummi Water Resources Division. 2005. *2004 Water Quality Summary Report Lummi Indian Reservation.* Prepared for Lummi Indian Business Council, by Water Resources Division, Lummi Natural Resources. Bellingham, Washington.

The purpose of this report is to present the water quality data collected during calendar year 2004, to compare them to previous data from the period of record, and to present interpretations of these data. This information is used to evaluate regulatory compliance of waters flowing onto the Reservation, and to support the development and implementation of a water quality regulatory program on the Reservation, including the creation, adoption, and implementation of Water Quality Standards.

Water quality during calendar year 2004 was largely similar to water quality during previous years, with a few exceptions. Most notably, previous declines in bacteria levels reversed in 2003 and 2004 for the majority of water quality sites on the Reservation. The marine waters of Lummi Bay and Sandy Point Marina continue to maintain moderate water quality, while the surface waters within the Lummi River watershed continue to have the poorest water quality. Bacteria levels increased in 2003 and 2004 in the Lummi River watershed, the Nooksack River, and, to a lesser degree, in Portage Bay.

Lummi Water Resources Division. 2006. *Water Quality Summary Report*. Lummi Natural Resources, Bellingham, Washington.

Information is unchanged from the 2003 report.

Lummi Water Resources Division. 2007. *Water Quality Summary Report*. Lummi Natural Resources, Bellingham, Washington.

Water quality during calendar year 2006 was largely similar to water quality during previous years, with a few exceptions. The water quality parameters at the sites during 2006 followed the trends of 2003 through 2005: a reoccurrence of the higher bacteria levels, high temperatures, and low dissolved oxygen levels compared to the improvements in these parameters observed during 2000 and 2001. The degraded water quality parameters are generally worse in the sites further inland, and gradually improve downstream towards the marine waters. As a result, the marine waters of Lummi Bay and the Sandy Point Marina continue to maintain moderate water quality, while the surface waters within the Lummi River watershed continue to have the poorest water quality.

Mackay, M.T. 1981. *A Review of the Effects of Oil Exposure on the Spawning Pacific Herring*, *Clupea harengus pallasi*. Lummi Indian Fisheries, Bellingham, Washington.

Mackay, M.T. 2000. *Salmon Smolt Catch by a Rotary Screwtrap Operated in the Nooksack River: 1994 – 1999*. Northwest Fishery Resource Bulletin Data Report Series. Lummi Indian Business Council, Bellingham, Washington.

Mackay, M.T. 2004a. 2004 *Nooksack River Estuary Seine Study*. Lummi Indian Business Council, Bellingham, Washington.

Mackay, M.T. 2004b. *Nooksack River Salmon Seine Study, 2003*. Progress Report. Lummi Indian Business Council, Bellingham, Washington.

Mackay, M.T. 2005. *Nooksack River salmon seine study, 2004*. Progress Report. Lummi Indian Business Council, Bellingham, Washington.

Juvenile salmon sampling was undertaken with a beach seine at 21 delta and 29 nearshore locations within the Nooksack River Estuary. A total of 612 bi-weekly seine sets were performed over 18 sampling periods from December 2004 to August 2005.

Season and habitat tended to be drivers for salmon and baitfish fishing success. Overall catches of salmon were Chinook (1,071), chum (4,400), coho (983), pink (1), sockeye (1) steelhead (8), and char (13). Overall catches of baitfish were herring (139), surf smelt (626), sandlance (2,383), longfin smelt (72), and shad (4).

Manuwal, D. A., et al. 1979. *The Seasonal Distribution and Abundance of Marine Bird Populations in the Strait of Juan de Fuca and Northern Puget Sound in 1978.* Technical memo ERL MESH-44. University of Washington and National Oceanic and Atmospheric Administration, Seattle.

Northeast Bellingham Bay and Chuckanut Bay were identified as locations of less than 50 breeding pairs of Glaucous-winged Gulls. These same locations contained less than 25 breeding pairs of Pigeon Guillemots. The largest wintering population of Western Grebes (22,000) was found in Bellingham Bay. During winter, about 50 Whistling Swans (Tundra) were noted on the Nooksack River delta. Bald eagles were also present on the Nooksack delta throughout the year. Dunlins were the most common shorebird on the delta from November to April, and Western Sandpipers were the most common fall and spring migrants. The amount of spawning herring affected spring counts of diving ducks and gulls in Hale Passage. Bellingham Bay was identified as an

important biologically productive area for migrant and wintering diving birds, waterfowl, and non-breeding congregations of various species. Bellingham Bay has 36 km^2 of shoreline and 122 km^2 of open water bird habitat.

Markiewicz, A.J., E. Hart Hayes, and W. Landis. 2001. *Cherry Point Herring Regional Risk Assessment Phase II.* Institute of Environmental Toxicology and Chemistry, Huxley College of the Environment, Western Washington University, Bellingham, Washington.

This report summarizes the continuing research effort to characterize the risks to the Cherry Point (CP) Pacific herring. The project had four goals: 1) use population modeling to better describe the past and current state of the CP Pacific herring population, 2) collect data to reduce the uncertainty associated with the risk assessment, 3) recalculate the Relative Risk Model based on the scoring method we used in the Port Valdez, AK ecological risk assessment; and 4) create a list of assessment endpoints that can serve as alternatives to Pacific herring and be used for site-specific, long-term management of the CP region. Population modeling clearly demonstrated the switch from a positive population growth in the 1970s and early 1980s, to a negative growth rate in the late 1990's. This decline is a result from loss of older age class fish. Currently the CP herring is being maintained by less fecund Age 2-4 herring. This age class compression is also found in other Puget Sound herring stocks. The second phase of this assessment recalculated the new uncertain possible risks with previously identified certain risks. High risks similar to phase 1 were identified as harvest, loss of habitat, and climate change. During the phase 2 recalculations, containments such as heavy metals, PAHs, and PCBs have been added as high risk to CP Pacific herring.

Marshall, R. 2002. *Cherry Point Herring and the Strait of Georgia Copepods*. 2002 Herring Summit and Pacific Coast Herring Workshop, Washington Department of Fish and Wildlife. June 12, 2002.

Martin, J. L. 1973. *The Effect of the Twin Delta of the Nooksack River on the Benthos of the Lummi Peninsula*. Master's Thesis. Western Washington State College, Bellingham, Washington.

McKay, W. 1978. *The Native Food Fisheries and the Environmental Protection Service*. Environment Canada, Pacific Region. Vancouver, British Columbia.

Author discusses, qualitatively, impacts to indigenous peoples' livelihoods if an oil spill were to occur in Georgia Strait. Discussion points to the high utilization of marine resources by tribal communities from Port Angeles to Cherry Point. With increased oil tanker traffic these communities are at a higher risk of loosing marine resources in the event of an oil spill. The author

recommends management programs that would reduce the chance of an oil spill and to have programs ready to quickly respond in the event of an oil spill.

McMillan, R. 1991. *Settlement, Growth, Abundance, and Habitat use by Juvenile Dungeness crab, Cancer magister, in Inland Waters of Northern Puget Sound, Washington*. Master's Thesis. University of Washington, Seattle, Washington.

The author investigated abundance, growth, and habitat use by early post-larval Dungeness crab. Samples were taken bi-weekly from 1984 to 1987 at one location in five major bays in Northern Puget Sound waters. Lummi Bay was one of the bays sampled. Intertidal abundance of juvenile crab peaked around August and September in Lummi Bay from 15 crabs/m^2 to 20 crabs/m^2. Lummi Bay overall had the lowest densities of juvenile crabs compared to Samish Bay, Padilla Bay, Birch Bay, and Semiahmoo spit. Dungeness crab primarily used gravel/sandy beaches with *Ulva* and then eelgrass for cover.

Meyer, J.H. and R. A. Adair. 1978. *Puget Sound Herring Surveys including Observation of the Gulf of Georgia Sac-Roe Fisheries, 1975-1977*. United States Fish and Wildlife Service, Seattle.

Meyer Resources, Inc. 2004. *A Guide for Analysis of Project Impacts on the Lummi Nation*. Lummi Indian Business Council Bellingham, Washington.

This guide will assist persons, corporations, and government entities considering projects that may impact the resources and people of the Lummi Indian Nation. Past failures to consider Lummi Treaty guarantees and effects on the Lummi have often led to project delay, conflict, or pre-emption of a project entirely. The guide summarizes the present circumstances of the Lummi, and points project proponents toward consideration of selected key impact issues important to the Lummi Nation. Guide provides a summation of the social-economic factors of the Lummi and describes importance of natural resources to the Lummi way of life.

Miller, B., C. Simenstad, L. Moulton, K. Fresh, F. Funk, W. Karp, and S. Borton, 1977. *North Puget Sound Baseline Program; Nearshore Fish Survey. FRI- UW- 7710*. University of Washington. Final report to Washington State Department of Ecology, Olympia, Washington

Miller, B. and S. Borton, 1980. *Geographical Distribution of Puget Sound Fishes; Maps and Data Source Sheets*. Washington Sea Grant Publication and University of Washington Fisheries Research Institute Publication Vo1s. I- III.

Nearshore Habitat Program. 1995. *Washington State Department of Natural Resources GIS layer found in: Nearshore Habitat Program. Puget sound*

Intertidal Habitat Inventory 1995 CD-Rom. Washington Department of Natural Resources, Olympia, Washington.

Nelson, J. M. 1981. *Age Classes, Growth, and Population Density of the Butter Clam Saxidomus giganteus Deshayes at Brant Point, Bellingham Bay, Washington.* Master's Thesis. Western Washington University, Bellingham, Washington.

North Cascades Audubon Society, 2008 *Whatcom County Christmas Bird Counts*. North Cascades Audubon Society. National Audubon Society. Available: http:// www.northcascadesaudubon.org/php/index.php?birding,birdcount#Bham.

The National Audubon Society's annual Christmas Bird Count (CBC) began in 1900 as an alternative to the traditional Christmas "side hunt," where the objective was to kill as many birds as you could. Ornithologist Frank Chapman called for an end to this slaughter by suggesting that, rather than shooting birds, people count them instead. The first CBC took place on Christmas Day of 1900.

There are 25 territories within the count circle of the Bellingham CBC. The areas cover a wide variety of habitats ranging from saltwater and urban parklands to the fields and farms of Whatcom County. The Bellingham CBC was started in 1967 by Terry Wahl and Jim Duemmel. Terry Wahl is still the compiler of all the Bellingham CBC data.

Oceanographic Institute of Washington. 1977. *1977 Environmental Assessment of Three Marine Sites on the Lummi Indian Reservation*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

Oglesby, R.T. 1965. *Survey of the Intertidal Zone and Related Environment in the Vicinity of the Mobil Oil Refinery, Ferndale, Washington*. Washington University, College of Engineering. Seattle, Washington.

O'Toole, M.F. 1993. *Characteristics of the 1993 Cherry Point Herring Spawning Run and Projection of Run Size for 1994. Briefing Report*. Washington Department Fisheries, Olympia, Washington.

O'Toole, M.F. 1995. *Puget Sound Herring Age and Size Composition, 1994*. In. Lemberg, N. editor. Puget Sound Baitfish Review, 1994. Progress Report. Washington Department of Fisheries, Olympia Washington.

Palm, S. 1995. *An Assessment of Marine Habitats Located Within Urbanized Areas of Bellingham Bay, Washington*. Prepared for Washington State Department of Ecology, Northwest Regional Office, Toxics Cleanup Program, Bellevue, Washington.

Palsson, W.A. 1984. *Egg Mortality Upon Natural and Artificial Substrata Within Washington State Spawning grounds of Pacific herring (Clupea harengus pallasi).* Master's Thesis. University of Washington, Seattle, Washington.

Parker, G. 1972. *A Progress Report on the Investigation of Surface Water Resources of the Lummi Indian Reservation*. US Department of the Interior Geological Survey Tacoma, Washington.

Provides baseline sampling of toxics and trace metals in Kwina Slough during the summer 1971. Identifies fecal coliform numbers for Nooksack River and Kwina Slough for 1971 and 1972. Toxics and trace metals were low, however fecal coliform samples were consistently high. A noticeable water quality nuisance occurs in the fall in the Nooksack River referred to locally as "Pea Slime".

Parker Jr., G.G. 1974. *Surface-Water Investigations of the Lummi Indian Reservation, Washington*. US Department of the Interior Geological Survey Tacoma, Washington.

The investigation evaluated potential water-related problems that could affect the success of the Lummi Indians' aquaculture program. Included were studies of the Skookum Creek hatchery, the Kwina slough fish pens, which use water from the slough and Nooksack River, travel times and rates of dispersions of water in the Nooksack River and the slough relative to possible effects of pollutants from upstream areas, and the aquaculture pond and adjacent marine waters, to determine volume of the pond and the patterns of water movement within, and to and from, the pond.

Parker Jr., G.G. 1977*. Surface-Water Investigations of the Lummi Indian Reservation, Washington*. US Department of the Interior Geological Survey Tacoma, Washington.

Partridge, V., K. Welch, S. Aasen, and M. Dutch. 2005. *Temporal Monitoring of Puget Sound Sediments: Results of the Puget Sound Ambient Monitoring Program, 1989-2000.* Washington State Department of Ecology. Olympia, Washington.

(From Text): Sediment chemistry and biota samples collected from 1989 - 2000 for the Puget Sound Ambient Monitoring Program were analyzed to establish conditions at ten monitoring stations in Puget Sound, and to identify changes occurring over time. Generally, metals concentrations in 2000 were lower than in 1989-1996, while the opposite was true of polycyclic aromatic hydrocarbons (PAHs). Grain size and benthic community changes in the Strait of Georgia were probably linked to increased precipitation, Fraser River flow, and

sediment loading events. This 12-year time series provides a valuable long-term record of Puget Sound sediment conditions against which we can compare future environmental changes.

Five sampling locations are identified within this document that are either on the Reservation or within close proximity.

Partridge, V. 2007. *Condition of Coastal Waters of Washington State, 2000-2003: A Statistical Summar*y. Washington State Department of Ecology. Olympia, Washington.

This report is a data summary from the Coastal Environmental Monitoring and Assessment Program (EMAP) sampling in Washington State, 2000-2003. On the Reservation, three locations were sampled over 2 years. Habitat and Benthic organisms were sampled along with basic suite of chemical parameters.

Peak Northwest, Inc. 1986. *Nooksack River Basin Erosion and Fisheries Study. Lummi Fisheries*. Lummi Indian Business Council Bellingham, Washington. March.

Pentilla, D. 1978. *Studies of Surf Smelt (Hypomesus pretiosus) in Puget Sound. Technical Report No. 42.* Washington State Department Fish and Wildlife, Olympia, Washington.

Pentilla, D. 1984. *Summary of Winter Herring Hydroacoustic/Trawl Surveys in the Bellingham Bay Area, December 1983 - January 1984*. Washington Department of Fisheries. Olympia, Washington.

Pentilla, D. 1985. *Summary of Winter Herring Hydroacoustic/Trawl Surveys in the Bellingham Bay Area, December 1984 - January 1985*. Washington Department of Fisheries. Olympia, Washington.

Pentilla, D. 1986. *Summary of Winter Herring Hydroacoustic/Trawl surveys in the Bellingham Bay Area, January 1986*. Washington Department of Fisheries. Olympia, Washington.

Pentilla, D.E. 1995a. *Spawning Areas of the Pacific Herring* (*Clupea*), *Surf Smelt (Hypomesus), and the Pacific Sand Lance (Ammodytes) in Central Puget Sound, Washington*. Manuscript Report. Washington Department of Fish and Wildlife, Olympia, Washington

Pentilla, D.E. 1995b. *The WDFW's Puget Sound intertidal baitfish spawning beach survey project*. In. Puget Sound research - 95 Conference proceedings, vol. 1, Puget Sound Water Quality Authority, Olympia, WA, pp. 235-241.

Pentilla, D.E. 1995c. *Investigations of the Spawning Habitat of the Pacific Sand Lance, Ammodytes hexapterus, in Puget Sound*. In. Puget Sound research - 95 Conference Proceedings, vol. 2, Puget Sound Water Quality Authority, Olympia, WA. pp. 855-859.

Pentilla, D. E. 1996. *Documented Spawning Beaches of the Surf Smelt (Hypomesus) and the Pacific Sand Lance (Ammodytes) in Whatcom County, Washington. Manuscript Report. Revised, 1997*. Marine Resource Division, Washington Department of Fish and Wildlife.

This document depicts all currently known spawning areas for the surf smelt and Pacific sand lance within Whatcom County, Washington. These types of forage fish species are an important part of the local marine nearshore food web. The spawning beaches designated in this document include: Point Roberts Peninsula, the Semiahmoo Bay area, the Birch Point area, the Point Whitehorn area, Cherry Point, the Portage Bay area, the Southern Bellingham Bay area, and the Northern Bellingham Bay area.

Peterschmidt, M. Unknown Date. *Population Survey of Intertidal Clams on Semiahmoo Spit.* Whatcom County Parks Bellingham, Washington.

Many species of bivalves are encountered on Semiahmoo Spit. The most heavily exploited varieties are the hardshell clams. The standing crops of hardshell clams on Semiahmoo spit are 60,193 kg (132,703 lbs) of butter clams, 552,564 kg (115,885 lbs) of Japanese littlenecks and 207,156 kg (45,670 lbs) of native littlenecks. The approximate portion of these populations that are harvested by sports diggers in a six-month period is 26.7% of the total standing crop. The high digging pressure makes it advisable to monitor the populations and digging pressure.

Phillabaum, S. D. 1973. *A Geomorphic Inventory of Whatcom County Marine Shoreline, with Considerations for its Management*. Master's Thesis. Department of Geology Western Washington University Bellingham, Washington.

Puget Sound Water Quality Authority. 1986. *Issue paper: Habitat and Wetlands Protection.* Puget Sound Water Quality Authority. Seattle, Washington.

A 0.2% increase in area is estimated for the Nooksack River delta. An estimated 52 acres of mud flats and salt marshes were lost in the late 1970s in Bellingham Bay for expansion of Squalicum Marina. Surf smelt spawning beds are defined in WAC 220-110.

Puget Sound Water Quality Authority. 1988. *State of the Sound: 1988 Report. Puget Sound Water Quality Authority.* Seattle, Washington.

Western Bellingham Bay is identified as a major holding area for Pacific herring, and Portage Bay and Governor's Point are identified as major spawning areas. Herring stocks are declining near Bellingham. The north bay between the Nooksack delta and Squalicum Creek is identified as a major surf smelt spawning beach. The bay is mapped as a commercial salmon harvest area, a major groundfish resource area, and a location of major Dungeness crab populations. The delta is identified as a seal haul out area. Shorelands surrounding Portage Island are locations of commercially harvested intertidal clam and oyster beds. The bay is not identified as a major location for geoducks, waterfowl, kelp beds, or eelgrass meadows. The design flow for Bellingham's sewer treatment plant is 10.4 MGD; that for Georgia Pacific was unavailable. Bay sediments contain high levels of mercury and moderate levels of copper and zinc. Greater than 50% amphipod mortality occurred when exposed to bay sediments. Reduction in sulfite waste liquor is noted. A beach is closed to bivalve harvest when PSP tissue toxin exceeds 0.8 ppm. The PSP toxins have been found below concern levels for limpets, snails, and Dungeness crabs. In 1987, the north bay was closed to bivalve harvest.

Puget Sound Water Quality Authority. 1991. *Puget Sound Update: 2nd Annual Report of the Puget Sound Ambient Monitoring Program*. Puget Sound Water Quality Authority. Olympia, Washington.

In surveys conducted between 1984 and 1989, the National Status and Trends (NS&T) program of NOAA, found high levels of arsenic in Bellingham Bay sediments, although levels did not exceed the 57 ppm standard. The NS&T found about 275 ppm phenathrene (standard = 100 ppm) in bay sediments. Sediment mercury of 0.25 ppm based on NS&T findings was less than the 0.41ppm standard. The PSSDA studies in 1988 and 1989 found bay sediments to contain about 0.35 ppm mercury. During 1989 and 1990, nitrate/nitrite in the bay reached seasonal highs of 32 μmoles during winter and lows of 2 μmoles during the April to September phytoplankton growing season. These ranges are indicative of water columns that stabilize during spring and summer. Nooksack River runoff is considered the main nutrient source. Hatchery steelhead populations have been decreasing in the Nooksack and Samish river systems since the 1980s. A 1989 survey found no liver abnormalities in English sole sampled from the bay. A 1989-90 sampling found fecal coliform counts from Bellingham Bay bivalves to not be in excess of state standards for commercial shellfish. In 1990 gray whale(s) were sited near Chuckanut Bay. The northern bay is mapped as a colony site for marine birds. Bird species that have reproductive problems due to contaminants or habitat impacts include Glaucous-winged Gulls, Great Blue Herons, Pigeon Guillemots, Bald Eagles, Osprey, Peregrine Falcons, and Merlins. A 9% increase in salt marsh area is indicated for the Nooksack River delta, although throughout Puget Sound there has been a 73% decline in salt marshes since the 1880s. Within Bellingham Bay, use of old navigation charts suggests a 30% decline in shoreline eelgrass most probably due to diking, filling, and contamination.

Rensel, J. 1973. *A Benthic Survey of the Lummi Indian Aquaculture Sea Pond and Adjacent Areas*. Huxley College of Environmental Studies Western Washington University, Bellingham, Washington.

Rice, C.A. 2006 *Effects of Shoreline Modification on a Northern Puget Sound Beach: Microclimate and Embryo Mortality in Surf Smelt (Hypomesus pretiosus).* Estuaries and coasts, vol. 29, no. 1 pp. 63-71.

Ross, C. and A. Weispfenning. 2004. *Assessment of macroinvertebrate prey for Pacific salmonids in the Nooksack River estuary, Lummi Nation, Washington*. Technical Report to Lummi Nation Natural Resources, Bellingham, Washington.

Salazar, M.H. and S.M. Salazar. 2002. *Potential Effects of PAH and Temperature on Cherry Point Herring*. Proceedings of Herring Summit, Bellingham, WA.

Schneider, D.E. and M.A. Dube. 1969. *1969 Survey of the Intertidal Zone from Sandy Point to Birch Bay, Whatcom County, Washington*. Western Washington State College, Bellingham, Washington. Prepared for Mobil Oil Corporation and the Atlantic Richfield Co.

Schneider, D.E. and M.A. Dube. 1972. *1971 Survey of the Intertidal Zone from Sandy Point to Birch Bay, Whatcom County, Washington*. Western Washington State College, Bellingham, Washington. Prepared for Mobil Oil Corporation and the Atlantic Richfield Co.

Schwartz, M.L. 1983. *Marina Inlet Shoaling at Sandy Point, Washington*. Coastal Consultants, Inc. prepared for United States Army Corp Engineers, Seattle, Washington.

Schwartz, M.L. et al. 1991. *Marine net shore drift in Washington State, Vol 5: Northern Bays and Straits (Whatcom and Skagit). Report #00-06-34.*Washington State Department of Ecology, Olympia, Washington.

Seymour, S. 1983. *Final Report of the Tidal Resource Evaluation Study, Lummi Indian Enhancement Program*. Lummi Indian Business Council, Bellingham, Washington.

Shea, G.B., C.C. Ebbesmeyer, Q.J. Stober, K. Pazera, J.M. Cox, S. Hemingway, J.M. Helseth, and L.R. Hinchey. 1981. *History and Effluent of Pulpmill Effluent Discharges, Bellingham, Washington*. Northwest Environmental Consultants. U.S. Environmental Protection Agency, Seattle, Washington.

The document summaries existing studies and maps as of 1981, related to oceanographic, toxicological, and biological studies for Bellingham Bay. The pulp operation began in 1928 using a sulfite process. In 1943, an alcohol recovery plant came on line. In 1965 the chlor/alkali plant began operation and bi-product was dumped into Whatcom Waterway until 1970 when a mercury recovery unit was installed. Further mercury recovery occurred in 1973 with a mercury sulfide process. Start up of lignin processing in 1971, primary treatment in 1970, secondary treatment in 1979, and a submarine diffuser in 1979, contributed to improved water quality especially in Whatcom Waterway.

Surface seawater in the bay tends to move clockwise, flooding to the west, ebbing to the east, and is affected by prevailing southerly winds. Subsurface flows (3 m) are variable and tend to be counter clockwise. Waters leave the system through Bellingham and Guemes channels. Residence time for dilute water is between one and 11 days, with a typical residence of 4 to 5 days. Residence time is shortened with increased Nooksack River discharge and lengthened by southerly winds.

Bellingham Bay biological resources include phytoplankton, macro-algae, and eelgrass, zooplankton, shellfish, other invertebrates, fish, birds, and marine mammals. Species lists are provided. Phytoplankton showed seasonal abundance and diversity with summer peaks. Although some eelgrass beds were documented, a systematic study of macro-algae was lacking. Zooplankton included holoplankton and larval forms of fish and invertebrates. Documented shellfish included cockles and butter, littleneck, Manila, horse, softshell, and bentnose clams. Diversity of benthic subtidal annelids, mollusks, and echinoderms increased with distance from Whatcom Waterway. A bryozoan, *Schizoporella unicornis*, was noted as sensitive to poor water quality.

The bay supported commercial fisheries for crab, salmon, herring sac-roe, and bottom fish. From 1943-1975, between 28,000 and 415,000 crabs were annually landed from Bellingham and Samish bays. Trawl species included English sole, rock sole, starry flounder, butter sole, sand sole, true cod, lingcod, and several rockfish types. Wild Nooksack salmonids included coho, chum, pink, sockeye, spring Chinook, summer-fall Chinook, steelhead, sea-run cutthroat, and sea-run Dolly Varden. Nooksack hatchery salmon included fall Chinook, coho, and chum. Herring spawning occurred in Portage Bay, Samish Bay, and Hale Passage. The area west of Mt. Baker Plywood supported surf smelt spawning.

Bird habitats of the Nooksack delta included tide flats, salt marsh, sandy islands, and undeveloped sandy beaches. Bird habitats of shorelines between Chuckanut Bay and south Bellingham included undeveloped rocky shores, protected harbors, and rocky islands. Bird habitats of Bellingham Bay included sandy undeveloped beaches and protected harbors. Important bay nesting sites include the Nooksack delta for Great Blue Heron, and the inner harbor for Pigeon Guillemots and Glaucous-winged Gulls. The Nooksack delta was considered to be a biologically significant area for Dunlin, Bald Eagles, Mew Gulls, Great Blue Heron, Mallards, Pintails, and American Widgeons. Bufflehead and Greater Scaup are noted as important species of the open bay.

Harbor seals hauled out in three bay locations: Chuckanut shore south of Governor's Point, near Brant spit, and near Eliza Island. Harbor porpoises were sited near Portage and Eliza islands. Gray whales were occasionally spotted in Chuckanut Bay.

Shapiro and Associates. 1994. *Cherry Point Natural Resources Baseline Studies. Shapiro and Associates, Seattle, Washington*. Prepared for Pacific International Terminals.

The document is a summary of studies conducted on bald eagles, Peregrine falcons, sea birds, macroalgae, eelgrass, marine vegetation shading, surface water hydrology, stream habitat, and amphibians.

Focusing on marine resources, bald eagles, Peregrine falcons, and sea bird observation began in November 1992 and April 1993. Field observations occurred on 40 different occasions where 5 individual bald eagles and one peregrine falcon were observed. Seabird densities were generally low and on April 30 several thousand scoters congregated near Cherry Point to feed upon herring spawn.

Macro algae and eelgrass surveys were conducted at extreme low tide in November 1992. No eelgrass was observed near the pier site, however macro algae was thick and often reached 100 % density.

Simenstad, C., B. S. Miller, C. F. Nyblade, K. Thornburgh, and L. J. Bledsoe. 1979. *Food Web Relationships of Northern Puget Sound and the Strait of Juan de Fuca. A synthesis of the available knowledge*. EPA-600 / 7-79-259. U.S. Environmental Protection Agency. Washington, D.C.

Sjolseth, D.E., E.O. Salo, R.A. Bishop, and W.G. Williams. 1968. *Studies of Juvenile Salmon in Nooksack River System and Bellingham Bay. Final Report.* Friday Harbor Labs, University of Washington, Seattle Washington.

Smith, C.J. 2002. *Salmon and Steelhead Habitat Limiting Factors in WRIA 1, The Nooksack Basin*. Washington State Conservation Commission, Olympia, Washington.

Smith, G.F. and H.H Webber. 1978. *A Biological Sampling Program of Intertidal Habitats of Northern Puget Sound*. Produced for the Washington State Oil Baseline Program. Western Washington University, Bellingham, Washington

Spikes, K., J. Lanphier, and L. Bodensteiner. 2003. *Macroinvertebrate Population Abundance and Distribution in the Nooksack River Estuary, Whatcom County, Washington.* Huxley College of the Environment Western Washington University Bellingham, Washington.

A 2003 data summary of 23 sampling locations collected water quality, substrate, zooplankton, and benthic macroinvertebrates (abundance and biomass) within Nooksack estuary, Portage Bay, and Lummi Bay. No zooplankton was observed near the Nooksack River, and communities were highly dependent on salinity. Data on findings are published in this report in addition to Brown et al. (2004). Biota abundance and biomass was highly variable and author recommends patterns could be observed with more sampling.

Sternberg, R.W. 1967. *Recent Sediments in Bellingham Bay, Washington*. Northwest Sci. vol. 44 pp. 63-79.

Stewart, B.C., C. Olson, and S. Lutz. 1990. *VHS Virus Detected at Lummi Bay Sea Ponds, Bellingham, Washington.* Fish Health Section Newsletter. Fish Health Section, American Fisheries Society. 18(1):2.

Stick, K. 1990. *Summary of 1989 pacific herring spawning ground surveys in Washington state waters. Progress Report No.280*. Washington Department of Fisheries. Olympia, WA.

Stick, K.C. 1994. *Summary of 1993 Pacific Herring Spawning Ground Surveys in Washington State Waters. Progress Report No. 311.* Washington State Department Fish and Wildlife, Olympia, Washington.

Stick, K.C. 2005. 2004 *Washington State Herring Stock Statues Report*. Fish Program Washington State Department Fish and Wildlife, Olympia, Washington.

Stick describes the Pacific herring stock assessment across Washington State, representing stock trends over time including: stock assessments from 1994, 1996, 1998, 2002, and 2004. Herring spawner biomass estimates were also compiled over time from 1975 to 2004.

(From Stick 2005): This report considers each documented herring spawning ground in Washington waters to represent a discrete stock. The WDFW herring assessment survey results indicate stock specific characteristics that continue to support the assumption of stock autonomy for Puget Sound herring (Trumble 1983 and O'Toole et al. 2000). Resource managers in British Columbia group their herring populations on a considerably larger scale; stock groupings consist of five assessment regions, one of which is the entire Strait of Georgia (Schweigert 2004). In their recent status review of Puget Sound herring the National Marine Fisheries Service concluded that local populations are the appropriate scale for fisheries management activities for Puget Sound herring (Stout et al. 2001).

(From Stick 2005): Microsatellite DNA studies conducted by WDFW suggest that the Cherry Point stock is distinct from other sampled Puget Sound stocks. Other sampled Puget Sound stocks were not demonstrated to be genetically distinct from each other (Small et al. 2004). Recent analyses of herring microsatellite DNA variation also suggests that the Cherry Point herring stock is genetically distinct from other examined British Columbia herring populations (Beacham et al. 2002).

Sylvester, R.O., D.A. Carlson, R.F. Christman, and R.T. Oglesby. 1966. *A Study of Wastewater Disposal for the Intalco Aluminum Corporation*. Washington University, College of Engineering. Seattle, Washington.

Tarr, M.A. et al. 1971. *Final Report of Investigations for Lummi Aquaculture Project: Section A (Hydrographic Studies of Lummi and Vicinity), Section B (Biological Evaluation of Floating Oyster Culture), Section C (Economic Evaluation of Floating Oyster Culture).* Washington State Department of Fisheries.

Thom, R.M., C.A. Simenstad, J.R. Cordell, and E.O. Salo. 1989. *Fish and their Epibenthic Prey in a Marina and Adjacent Mudflats and Eelgrass Meadow in a Small Estuarine Bay. FRI-UW-8901.* University of Washington, Wetland Ecosystem Team. Prepared for Port of Bellingham, Washington.

High elevation intertidal mudflat (+3 to +6 ft MLLW) areas within a marina basin were observed from March to October 1987 for utilization of juvenile salmon and Dungeness crab. Juvenile salmon began appearing on the nearshore habitats in early April when chum salmon appeared in catches on the marina mudflat. Chum salmon appeared in the eelgrass meadow near the end of April. Chum salmon averaged 45 mm in early April, averaged 54 mm in late April, and averaged 62 mm in May. Young of the year Chinook salmon and coho salmon were present in catches in May and June. The mudflat areas contained more salmon and more prey than within the marina basin.

Tollefson, R. 1962. *Basic Biological Productivity – Bellingham Bay, March 1959-July 1961*. 128 pp.

Tollefson, R. 1963. Journal of Water Pollution Control Fed. 35:989-1005.

Plankton from Bellingham Bay were identified and counted. Growth rates, seasonal population composition, and area of occurrence are described. No biological depression was found in response to industrial waste discharges. Natural hydrographic variations accounted for 85% of population standard deviation.

Trumble R. J. 1979. *Summary of the 1979 Sac-Roe Herring Population in Northern Puget Sound. Progress Report No. 80.* Washington State Department of Fisheries, Olympia, Washington.

Strait of Georgia herring are older and larger than other herring stocks. The Strait of Georgia stock is biologically different than other Puget Sound Stocks. All stocks have high annual variability; however, all stocks population dynamics are relatively unknown, especially the environmental controls on the stock.

Trumble R. J. 1981. *Summary of the 1981 Sac-Roe Herring Population in Northern Puget Sound. Progress Report No. 152*. Washington State Department of Fisheries, Olympia, Washington.

Tyler, R.W. 1964. *Distribution and Migration of Young Salmon in Bellingham Bay, Washington*. University of Washington Fisheries Research Institute Seattle, Washington.

Beach seine, fyke net, and tow net sampling was conducted in Bellingham Bay from mid-April through May. Beach seine sampling collected large numbers of chum, and much smaller numbers of coho, Chinook, and pink salmon. Chum collected by beach seine were predominantly 37-55 mm, while those collected offshore by tow net were generally 60-75 mm in length. Chinook were present in seine catches only in late May to early June, and coho primarily in May. Fish commonly collected with the salmon included staghorn sculpin, starry flounder, shiner seaperch, and three-spined stickleback. Chum caught by tow net were generally sparsely distributed throughout the open water of Bellingham Bay. One relatively concentrated group of small chum fry (34-38 mm) was collected in the turbid plume of the Nooksack River during an ebb tide. Chinook and coho were collected in the offshore areas by tow net primarily in May, with concentrations at several outer bay locations and a log storage area. Fyke net sampling showed many chum reared in the river for some time and then migrated into the estuary at a larger size in late May.

Tyler, R. W., and D. E. Bevan. 1965. *The Distribution of Juvenile Salmon in Bellingham Bay.* 1964 Research in Fisheries, University of Washington, College of Fisheries. Contribution No. 184, pp. 23-29

USFW. 1985. *Lummi Bay Marina Study*. United States Fish and Wildlife Service, FWCA Report, Region 1, Portland, Oregon.

U.S. Army Corp of Engineers. 1988. *Final Environmental Impact Statement: Lummi Bay Marina Whatcom County, Washington*. United States Army Corp Engineers, Seattle, Washington.

Environmental Impact Statement for Lummi Marina in the Lummi Bay Seapond. Project describes using the northern portion of the Seapond to moor a commercial fishing fleet that will alleviate slip demands at Squalicum Harbor. This was a joint investigation with LIBC and Army Corp. To complete this project, 65 acres of nearshore habitat will have to be dredged or filled with dredging material. Eelgrass was surveyed and maps detailing eelgrass density and distribution in 1987 are provided in this document.

U.S. Army Corp Engineers. 2000. *Nooksack River Estuary Recovery Project. United States Army Corp Engineers, Seattle, Washington*. Prepared for Lummi Indian Business Council, Bellingham, Washington.

The report identified possibilities and the associated costs and benefits for restoring the natural hydrologic processes of the Nooksack estuary. Primary goals of the plan are to restore fish access and use of the Lummi/Nooksack Rivers and to restore and maintain wetlands/estuarine habitats. This report suggests modifying the intake structure along the Nooksack River to restore flows to the Lummi River. Also providing different plans to breach river dikes to expand Nooksack delta.

USGS. 1979. *Water Resources Data for Washington*. US Department of the Interior Geological Survey Tacoma, Washington.

Water quality analysis along 3 sites on the Kwina slough from 1976 to 1979. Parameters collected (Temperature, Turbidity, DO, TN, TP, Ortho-P). All parameters did not exceed water quality standards, temperature was below 20 degrees C within all measures.

Von Heeder, E.R. 1972. *Origin and Development of Coastal Landforms at Point Francis, Washington*. Master's Thesis. Department of Geology Western Washington University Bellingham, Washington.

Wahl, T. 1995. *Birds of Whatcom County: Status and Distribution*. T. R. Wahl publisher, Bellingham, Washington.

Compilation of bird species their distribution and their seasonality across Whatcom County. This book draws upon the author's experience of birding across Whatcom County and upon data compiled from the Audubon Society's Christmas bird counts.

Wahl, T. 2001. *Channel Changes of the Lummi River*. Technical Report to Lummi Nation Natural Resources Department, Bellingham, Washington.

Wahl, T. 2002. *Images and Accounts of Portage Island, the Swulesen Narrowing and Point Frances*. Prepared for Coastal Geologic Services, Inc. Bellingham, Washington.

This report is a supplement to Coastal Geologic Services examination of bathymetric changes taking place on and around Portage Island and Portage Bay. The approach was to collect and summarize material of record, including published and unpublished maps and documents, and written notes and taped recordings of oral interviews made in the 1940s and 1950s. The timeframe of investigation began with 1971 Spanish image of the area then continued with camera photography to aerial photography.

Ward, L. 2002. *1996 to 2002 Surf Smelt Spawn Data.* Memorandum to Jeremy Freimund. Lummi Department of Natural Resources, Water Resources.

The author describes no change in surf smelt spawn amounts during pre- and post-revetment work at observed locations along the Lummi Shore Road Project area. Attached figure describes the most spawn during the months of July and August with spawn being observed from April to December. Sites with surf smelt spawn are associated to Coastal Geologic Survey Lummi Shore Rd beach monitoring.

Washington Department of Natural Resources (WADNR). 1995. *Puget Sound Intertidal habitat Inventory 1995: Vegetation and Shoreline Characteristics*. Washington Department of natural Resources, Aquatic Resources Division, Nearshore habitat Program, Olympia, Washington. http://www.wa.gov/dnr/htdocs/aqr/nshr/methods.htm

Washington Department Fish and Wildlife (WDFW). 2000. *Critical spawning habitat for herring, surf smelt, sand lance, and rock sole in Puget Sound, Washington*. Washington Department Fish and Wildlife, Fish Program, Olympia, Washington.

A compilation of Township/Range maps highlighting critical spawning areas for herring, surf smelt, sand lance, and rock sole in Puget Sound and Strait of Juan de Fuca. Information is derived from Dan Pentilla's field observations and information compiled at WDFW. On Lummi Reservation Pacific Herring spawn in Lummi Bay, Hale Passage, and Portage Bay. Surf smelt spawn and sand lance spawn on Lummi Shore Road and on the southern edge of Portage Island.

Washington Department of Fish and Wildlife, and Oregon Department of Fish and Wildlife. 2001. Washington and Oregon Eulachon Management Plan. Washington Department of Fish and Wildlife. Olympia, Washington.

The main Eulachon, or Columbia River smelt (*Thaleichthys pacificus*) run in Washington and Oregon returns to the Columbia River and its tributaries. However, the eulachon are known to spawn in the Nooksack River. This resource has not been well investigated. Overall, Eulachon populations are in recent decline and are the subject of increasing management and research activity.

Webber, H.H. 1974. *The Bellingham Bay Estuary: a Natural History Study.* Final Report for USFWS by Huxley College of Environmental Studies, Western Washington University, Bellingham, Washington.

Diversity and abundance of fish, invertebrates, birds, and marine mammals were analyzed. Zooplankton, fish stomach contents, location of eelgrass beds, log booms, and wood debris were assessed. Oyster larvae bioassays were conducted. Salinity, temperature, and turbidity were measured. Methods included beach seines, otter trawls, plankton tows, Peterson grabs, Ekman grabs, beach transects, and Hydrolab analyses. No studies of primary productivity were conducted.

Webber, H.H. 1977. *Bellingham Literature Survey*. Huxley College of Environmental Studies, Western Washington State College, Bellingham, Washington.

Webber, H.H. 1978. *Studies on Intertidal and Subtidal Benthos, Fish and Water Quality in Bellingham Bay*. Huxley College of Environmental Studies, Western Washington University, Bellingham, Washington. Prepared for United States Army Corps of Engineers, Seattle District, Seattle, Washington.

Whatcom County Planning. 1994. *Whatcom County Fish and Wildlife Habitat. A Map Portfolio of Fish and Wildlife Habitat*. Whatcom County Planning and Development Services, Bellingham, Washington.

Wilson, R.C.H., R. J. Beamish, F. Aitkens, and J. Bell. 1948. *Review of the Marine Environment and Biota of Strait of Georgia, Puget Sound, and Juan de Fuca Strait*. Canadian Technical Reports on Fisheries and Aquatic Sciences. 390 p.

Woelke, C. et al. 1971. Bivalve Embryo Bioassays of Marine Waters from Drayton Harbor to Hale Passage. Washington State Department of Fisheries, Management and Research Division, Olympia, Washington.

4.0 Discussion

Although there are clearly a large number of publications that contain information pertinent to the Lummi Reservation tidelands, much of this information is presently contained within the internal reports of various agencies. Such reports are typically difficult to find using traditional academic tools that focus primarily on publications appearing in peer-reviewed journals. The institutional knowledge of previous work performed was the key to discovering and obtaining the information. However, institutional knowledge is prone to being lost over time as a result of staff turnover. This bibliography is the result of discussions with many people in multiple agencies and is intended to provide a useful resource for future researchers that are interested in the Lummi Reservation tidelands. However, given the challenge of discovering literature of this type, it is possible that additional citations exist that were not included in this bibliography. In addition, work continues in various programs (e.g., Lummi Water Resources Division Water Quality Monitoring Program) and the more recent findings were not included in this bibliography.

Numerous citations were discovered could not be obtained during the literature review process. This lack of accessibility indicates the need for agencies to have publishing/archiving systems that preserve technical data for future requirements.

Finally, although there were a lot of citations that were relevant to this literature review, much of the information in them lacks sufficient spatial information that could be used for mapping purposes or that can be combined with other data.