Economic Impacts of Crude Oil Transport on the Quinault Indian Nation and the Local Economy

April 2015

Resource Dimensions

Credits and Acknowledgments

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Cover Credit:

Background, Port of Grays Harbor, courtesy of KXRO (*photographer unknown*).

Lower left, clockwise from top: entrance to Quinault Beach Resort & Casino (*Resource Dimensions*); Quinault baskets and razor clams (*Larry Workman, QIN*); QIN commercial fishing boat *(Junior Goodell)*.

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Table of Acronyms

AARG	Average Annual Rate of Growth
ANS	Alaska North Slope
ATB	Articulated tug-barge
BEA	Bureau of Economic Analysis, U.S. Department of Commerce
Bbl	Barrel
CBR	Crude-by-rail
DWT	Deadweight tonnage
ESD	Employment Security Department, Washington State
FTE	Full-time equivalent
FY	Fiscal year
GDP	Gross domestic product
GHRT	Grays Harbor Rail Terminal, LLC
GIS	Geographic information system
GNOME	General NOAA Operational Modeling Environment
IMPLAN	IMpact analysis for PLANning
IO	Input-output
NAICS	North American Industry Classification System
NOAA	National Oceanic and Atmospheric Administration
NWR	National Wildlife Refuge, Grays Harbor
OMA	Oil-mineral aggregate
PAH	Polycyclic aromatic hydrocarbon
PGH	Port of Grays Harbor
ppb	Parts per billion
ppm	Parts per million
QBC	Quinault Business Committee
QDFi	Quinault Department of Fisheries
QDNR	Quinault Department of Natural Resources
QIN	Quinault Indian Nation
Reservation	Quinault Indian Reservation
RTIA	Rail traffic impact analysis
T1	Terminal 1, Port of Grays Harbor
T3	Terminal 3, Port of Grays Harbor
USCB	United States Census Bureau
USDA	United States Department of Agriculture
VTIA	Vessel traffic impact analysis

Executive Summary

INTRODUCTION

The Quinault Indian Nation (QIN) retained Resource Dimensions of Gig Harbor, Washington to conduct an independent study of the extent of potential costs and economic impacts to Treaty-reserved fishing and gathering rights and fishing opportunities, and select QIN-owned businesses, attributable to three proposed projects at the Port of Grays Harbor (PGH) in Grays Harbor County, Washington. These projects are the Westway Bulk Liquid Facility Project, the Imperium Bulk Liquid Facility Project, and the Grays Harbor Rail Terminal (GHRT) Bulk Liquid Logistics Terminal Facility Project.

This work included estimating the extent of potential costs, economic impacts and changes in economic contributions due to rail and marine vessel transport of crude oil, and to a crude oil spill in or near Grays Harbor. Study analyses center on (1) the proposed projects' inherent risks and impacts to the QIN's Treaty-reserved rights, and (2) defining the potential magnitude of economic impacts to the QIN in the event of a crude oil spill.

Nothing in this analysis purports to value – monetarily or otherwise – the cultural and spiritual aspects of tribal members' exercise of Treaty-reserved fishing and gathering rights. Through interviews with Treaty fishers and gatherers, we understand the inalienable bond to the resources and that any adverse impact to tribal members' exercise of Treaty-reserved rights would result in significant harm to social and cultural values not fully addressed in this report.

Potential business activity changes attributable to rail and marine transport of crude oil and crude oil spills were elucidated. Fish, shellfish and plants important to the QIN and QIN members were assessed to determine how these resources and access to them may be affected by transport or a crude oil spill.

Hypothetical crude oil spill scenarios were constructed to frame potential business activity changes. Economic impacts resulting from these scenarios were estimated for Treaty fishers and select QIN-owned businesses. The estimates developed do not include any costs or losses associated with the impacts of a potential spill to private property owners or governments. Similarly, given the complexities of ex-ante analysis on post-event changes in the labor market, impact estimates do not include jobs that may be created through post-spill response efforts.

DATA COLLECTION AND ANALYSIS

Several assumptions were required to facilitate this study. Most importantly, the accuracy of findings relies heavily on the methods, analyses and interpretations of findings from external data, and the assumptions that the study authors made regarding the validity of this data. Second, monetary values were adjusted to 2014 dollars using gross domestic product (GDP) implicit price deflators. Lastly, the impact scenarios used to estimate the economic effects of the spills do not consider a real oil spill event. Instead, it is necessary to rely on information learned from known spill events and relevant science to presume the impacts such events could cause to frame the economic models.

Valuation methods used include economic impact and economic contribution analysis, and market replacement. Economic impact analysis was used to assess business and activity changes in the local and regional economies attributable to externalities of the proposed projects. Economic input-output (IO) models were developed using IMPLAN software to conduct relevant analyses. IO modeling was also used to assess the economic contributions of industries considered to the study region's economy (Grays Harbor County, Washington). Market replacement approach assisted in estimating the costs required to purchase equivalent amounts of calories and protein as provided by the subsistence harvest of seafood.

After screening for possible impacts to Treaty-reserved rights and QIN businesses from crude oil transport or a crude oil spill, industries and topics were selected for assessment. Table ES-1 presents the topics, industries and business activities assessed.

Table ES-1. Industries and Topics Examined

Industries / Topics Assessed
Biological effects of oil contamination on economically and culturally important species
Treaty commercial fisheries
Ceremonial, spiritual and way-of-life values inherent in Treaty-reserved rights
Subsistence harvest of fish and shellfish
Commercial value of products made with traditionally gathered plant materials
Select QIN-owned businesses
Emergent QIN business enterprises

Source: Resource Dimensions, 2015

Three data collection approaches were used to compile required information: literature and data provided by QIN staff, independent data collection, literature review of publicly available resources, and interviews that yielded primary data. Telephone interviews with staff were conducted between mid-November 2014 and mid-December 2014. In-person interviews with Treaty commercial fishers, subsistence harvesters, and grass gatherers and weavers were conducted in Taholah, Washington on December 11, 12, 15, and 16, 2014.

Scenario Modeling: Potential Impacts of Oil Spills

Three oil spill scenarios were constructed from a Base Case scenario using the best available knowledge regarding oil types, characteristics, flow and fate and transport. This information assisted us in selecting the business activities most likely adversely affected in each scenario, and thus modeling economic impacts and changes in economic contributions post-spill.

Characteristics of the oil types most likely received and shipped by the proposed projects were assessed. There no known publically available model for oil flow in or near Grays Harbor, and there is no known fate and transport model for spilled oil in or near Grays Harbor. Cumulative rail and vessel traffic and accident risk analyses are not available as of writing.

Applying results a of known spill and a modeled spill to project environmental impacts is problematic, as each involved Bunker C fuel oil, occurred/were modeled to occur off the Grays Harbor entrance, and involved far less oil than could be shipped by vessels calling on the proposed projects.

With no risk analyses, oil flow model or fate and transport model specific to crude oil spills in Grays Harbor, at time of writing, assumptions were made regarding business activities affected, estimated economic impacts, and estimated changes in economic contributions post-spill. The oil spilled was assumed a crude oil, based on project proponent documents and DOE (2015). To facilitate these estimations four scenarios were constructed:

- Base Case Scenario, which assumes normal business activities (based on 2013 activities).
- Scenario 1: Derailment of or an accident involving a crude-by-rail (CBR) unit train between the Wishkah River crossing and Cow Point, causing a spill into the Chehalis River.
- Scenario 2: A marine vessel accident inside Grays Harbor in the navigable channel near Moon Island, causing a spill.
- Scenario 3: A marine vessel accident off the Grays Harbor entrance due to the bar crossing, causing a spill.

Scenario 1, 2 and 3 Assumptions:

- Spill incidents occur in 2020, assuming regulatory and proposed construction and operations timelines.
- Adverse effects to certain business activities continue until 2022.[2]
- The type of oil spilled in each scenario is diluted bitumen crude oil. This oil type was selected because it exhibits characteristics similar to oils studied in several crude oil spills, for which economic impacts are well known.
- Spill volumes are 542,000 gallons in Scenario 1 and 11,000,000 gallons in Scenarios 2 and 3, similar to volumes of actual crude oil spills.
- Spilled oil spreads eastward into the Chehalis River and its tributaries, throughout all of Grays Harbor, and seaward north and south along the Pacific coast in hours.
- Response efforts do not completely remove oil before it reaches sensitive areas within Grays Harbor.
- Spilled oil emulsifies, disperses and settles on substrates, adhering to and causing smothering and mechanical injury to aquatic life.
- Some spilled oil would not be cleaned and will persist in the environment.

This study is primarily concerned with assessing business activity changes, economic impacts and changes in economic contributions from the Treaty fisheries-based and QIN visitor-based industries. Known oil spills were researched to ascertain the severity and duration of impacts causing adverse business activity changes post-spill.

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[2] Environmental impacts of an oil spill can persist for many years post-spill. However, the economic impacts of spilled oil in these scenarios are covered for a three-year post-spill timeframe, consistent with the durations of economic impacts observed after known oil spills.

To model post-spill economic impacts of fisheries-based activities, landings-related revenue was decreased by a factor of 33% for 2020, 2021 and 2022. To model post-spill economic impacts of select QIN-owned visitor-based businesses, visitor-related revenue was decreased by a factor of 10% for 2020, 2021 and 2022.

Inferences about oil flow and environmental impacts drawn from current literature were used to select those business activities expected to be affected in Scenarios 1, 2 and 3. In Table ES-2, solid circles indicate that the business activity was assumed to be affected by externalities attributable to the spilled oil in that scenario. Likewise, the absence of a solid circle indicates that the business activity was assumed unlikely to be affected in that scenario.

Table ES-2. Business Activities Affected, by Scenario

Business activity	Scenario 1	Scenario 2	Scenario 3
Treaty commercial fishing			
Ocean salmon		●	●
River salmon and sturgeon	●	●	●
Dungeness crab	●	●	●
Halibut			●
Sablefish			●
Lingcod			●
Rockfish			●
Sardine			●
Razor clam		●	●
QIN business enterprises			
Maritime Resort	●	●	●
Quinault Beach Resort & Casino		●	●
Quinault Pride Seafood I	●	●	●
Quinault Pride Seafood II	●	●	●
Q-Mart I		●	●
Q-Mart II	●	●	●
Ramada Inn - Ocean Shores		●	●
QIN commercial aquaculture	●	●	●

Source: Resource Dimensions, 2015

Effects of Oil Contamination on Aquatic Resources

A literature review was conducted for toxic effects of oil contamination on several species economically and culturally important to QIN members found in Grays Harbor. These species include salmonids, shellfish and salt marsh plants. Scientific literature was reviewed for acutely toxic and sublethal effects of crude oils, long-term effects resulting from persistent exposure to crude oils, and generational impacts of oil contamination.

Chinook, coho and chum salmon, steelhead, and white sturgeon reside in the freshwater and marine habitats of Grays Harbor and its tributaries. Salmon embryos and fry reside in freshwater, and migrate to and reside in the Grays Harbor estuary as juveniles. Adults return to the Grays Harbor estuary on their passage to spawning grounds. Acute mortality of and sublethal effects on salmon embryos from oiling has been found. Sublethal effects can lead to a decrease in marine survival of adults. These effects result from both direct and persistent oil contamination. Loss of juvenile salmon from a given broodyear escapement in the freshwater environment due to oil exposure will result in subsequent lower returns of adults three through six years following the spawning of the particular brood. These findings indicate the potential for population-level effects in fisheries.

Shellfish such as Dungeness crabs and razor clams are less mobile than finfish. Spilled oil could contaminate the complete environment of these species. Direct and persistent oil contamination to these organisms has been shown to cause acute mortality and sublethal effects in shellfish larvae, juveniles and adults.

Short-term adverse effects of oil contamination on salt marsh plants range from sublethal effects to plant mortality. Oil may damage the roots of these plants, affecting their ability to tolerate saline environments. Long-term oil contamination, from either chronic oil spills or the persistence of oil in the environment, can constantly expose plant regeneration processes, posing continual adverse effects on growth, productivity and survival. Salt marsh vegetation typically requires one to four years to recover post-spill.

Potential Impacts of Oil Transport and Spills on Treaty Resources

Importance and Sociocultural Values of Fish and Plant Resources

Treaty resources, including fish and plants supported by the Pacific Ocean, the Pacific coast, Grays Harbor, and its rivers and tributaries are inextricable from the Quinault people's traditional and modern ways of life. The social, cultural and economic values provided by these Treaty resources and resource sites have been cherished and handed-down through generations. Today, the importance of Treaty resources remains of utmost important to the Quinault people. **Nothing in this analysis purports to monetize the cultural aspects of the exercise of Treaty-reserved rights.**

Fishing

Fish has historically been a dietary staple of the Quinault people. Interviewees explained that fish and shellfish, specifically salmon and razor clams, are essential for meeting dietary and nutritional needs. It is common for some QIN members to eat fish or shellfish three times a day.

Fish are also a source of social, economic and cultural values. Salmon has particular historic significance as a vital cultural and economic resource of the Quinault people. Salmon represent a means for employment in fishing, guiding and processing jobs. Often fish are used in trade between tribal members for other foods or goods. Salmon and razor clams are communally served at social and community events, such as ceremonies and funerals. Often, salmon and other fish and shellfish are shared with family members, elders and others in the community that do not, or can no longer, fish.

Interviewees reported using fishing as a way to educate younger generations in life lessons, both as a means to pass on traditional knowledge and to perpetuate ceremonial values. There are also spiritual values inherent in fishing, such as thanksgiving for the ability to utilize the resources. Stewardship and protection of natural resources for future generations, including fish and shellfish resources, are central to the Quinault people's identity. This necessarily includes preserving ideal habitats for all species.

Plant material gathering

The Quinault people have gathered plant materials for use in material goods since time immemorial. Plant materials are used to manufacture woven materials; including baskets, jewelry and clothing, and plants and roots are used as medicine. Sweetgrass and cattail stems, two traditionally used plant materials, are gathered from the salt marsh in Grays Harbor's Bowerman Basin.

Sweetgrass and cattail stems have both commercial and decorative functions. Sweetgrass stems are used to decorate basket surfaces, amongst other material uses, and are valued because of their strength, durability, and flexibility. Cattail also serves as basket-making material and was historically used as a primary component of mats.

The importance of weaving as a means for creating materials used in everyday life was and is a significant element of the Quinault culture. Further, weaving is a means to pass on life lessons, and recently there has been a resurgence of interest in weaving.

Gathering remains an activity performed with family and friends. Interviewees reported several social and cultural values inherent in gathering: a spiritual component, including thanksgiving for the availability of the plants, therapeutic value, and carrying on ancestral traditions.

Treaty Commercial Fisheries

Treaty commercial fishers harvest several fisheries in river and marine waters. These fisheries include gillnet (Chinook, coho and chum salmon, steelhead, and white sturgeon) on the Chehalis and Humptulips Rivers sides of Grays Harbor; ocean troll (Chinook and coho salmon); marine (halibut, sablefish, lingcod, rockfish and sardines); and Dungeness crab. Razor clams are harvested from Pacific coast beaches.

The Quinault Department of Fisheries (QDFi) provided the number of fish, crabs or clams taken, their total whole weights, and values for each fishery assumed to be affected in the spill scenarios. Yearly average values for the Treaty commercial fisheries are summarized in Table ES-3. Average total yearly value over 2004 to 2013 was estimated to be $9,223,236.

Table ES-3. Yearly Averages Value of Treaty Commercial Fisheries (2004-2013)

Fishery	Yearly Average ($2014)
River Gillnet	$ 654,210
Ocean Troll	$ 71,392
Marine Fish	$ 1,065,982
Dungeness Crab	$ 6,794,288
Razor Clam	$ 637,364
Total Fisheries	***$ 9,223,236***

Source: Resource Dimensions, 2015

QDFi provided data on the numbers of QIN vessels and Treaty fishers and helpers per fishery per year. On average, per year, from 2004 to 2013 there were:

- 13 ocean vessels for the ocean salmon, halibut, rockfish, sardine and sablefish fisheries, and 22 crab vessels.
- 123 Treaty fishers in the Grays Harbor system gillnet fisheries; five Treaty fishers and helpers in the ocean salmon fisheries; 13 Treaty fishers and helpers in the halibut, rockfish, sardine and sablefish fisheries; and 23 Treaty crab fishers and helpers.

Commercial gillnetter interviewees reported that they either fish by themselves, or employ one or two helpers. Crab fishers employ an average of three helpers. Helpers are compensated through an agreed-upon percent of the value of the daily or seasonal catch; percentages ranged from 10% to 50%, typically based on experience.

Subsistence Harvest of Seafood

The costs to replace the calories and protein provided by the subsistence harvest of seafood in the case of a crude oil spill, harvest closure, etc., was calculated.

First, yearly average whole weights of the subsistence harvest of seafood were estimated. The QDFi provided data on the subsistence harvests from 2004 to 2013 for the Dungeness crab, razor clam, halibut, lingcod and rockfish fisheries. Whole weights for the subsistence harvests of the Chinook, coho and chum salmon; steelhead; and white sturgeon fisheries were estimated at three levels of subsistence percentages of the commercial harvest: 5%, 10%, and 20% of the whole weights of the commercial catch of each fishery.

Seafood caloric content and protein content were accessed from a standard database, and typical meat yields (the amount of meat as a percent of the total whole weight) of the seafood were identified. Pounds of edible meats supplied by the subsistence harvest on a yearly average basis were determined by multiplying yearly average whole weights versus meat yield factors. These outputs were multiplied by the caloric content and protein content of one pound of each food to estimate the yearly average total calories and total grams of protein provided by the subsistence harvest.

Ground beef, chicken and ham were selected as substitutes for the subsistence harvest. Seafood substitutes were not considered due to distaste for seafood products (specifically salmon) not harvested from the Reservation, potentially prohibitive costs, and the lack of standard price data. Average prices for the substitutes were calculated. It was assumed that each substitute replaces an equal allotment of the total calories and grams of protein provided by the yearly average subsistence harvest, and the pounds and total cost of each substitute to replace its allotment of calories and protein was calculated.

To determine the costs per person to purchase the substitutes, the total population relying on the subsistence harvest for a portion of their dietary needs was estimated at 1,380.

At the 20% estimated subsistence harvest level, the cost to replace the equivalent amount of calories provided by the subsistence harvest was estimated at $155.16 per person per year (1.01% of per capita income). The cost to replace the equivalent amount of protein provided by the subsistence harvest was estimated at $260.16 per person per year (1.69% of per capita income).

Economic Values of Commercial Woven Products

Dried sweetgrass stems are used in a variety of woven products, including in baskets, jewelry and clothing. About 25% of these products are made commercially available. One full-time weaver is known; weaving commercial products is typically a secondary income source. Interviewees estimated some 15 to 20 people weave products for sale, and that on average, each weaver sells five to seven baskets per year.

Weavers estimated a necklace required about two hours of labor, selling in a range from $75 to $120. A pair of earrings was estimated to take about three hours of labor, with prices about $160. Gatherers interviewed provided information to assist in estimating the commercial value of the woven products made in part from dried sweetgrass stems. The following assumptions were made:

- An average of 20 weavers per year sell woven products;
- Each weaver sells seven baskets per year, three necklaces per year and three sets of earrings per year; and,
- Each basket sells for $100, each necklace sells for $100, and each pair of earrings sells for $160.

Under these assumptions, the yearly total commercial value of woven products was estimated to be $29,600, with baskets, necklaces and earrings estimated to be $14,000, $6,000 and $9,600, respectively.

Thus, oil contamination of the salt marsh in Scenarios 1, 2 and 3 could result in losses of $29,600 for each year of environmental impact, attributable to lack of gathering activity, or no sweetgrass stems to gather.

QIN-owned Businesses

Business activity changes for the seven QIN-owned businesses most likely affected in Scenarios 1, 2 and 3 were analyzed. These select businesses are the: Quinault Beach Resort & Casino; Ramada Inn at Ocean Shores; Quinault Pride Seafood I (Taholah) and Quinault Pride Seafood II (Westport); Q-Marts I and II at Ocean Shores and Aberdeen, respectively; and the Maritime Resort in Ocean Shores. Also included in the analysis is a potential QIN commercial aquaculture pilot project.

Rail and Marine Vessel Traffic Impacts

The potential economic losses to Treaty commercial fishers resulting from rail and marine vessel transport of crude oil, and from lost or damaged fishing gear were estimated as discussed below.

Rail traffic impacts

Rail traffic could affect any Treaty commercial fisher who needs to cross the railway to reach their fishing area or who must cross the railway to transport their catch to the processor, in terms of an inability to fish or a decrease in price. This conflict is assumed to be most relevant for those with fishing areas near Montesano.

The average value per fisher-day in Areas 2A, 2A1 and 72B was estimated to be $254 in 2013. To illustrate the effects these impacts on fishing, the example of a 10% reduction attributable to delays at railroad crossings was assumed. This reduction represents an annual loss of $763 per fisher (5.0% of per capita income).

Marine vessel traffic impacts

Treaty commercial gillnetters fishing around the PGH reported that increased vessel traffic due to the proposed projects is highly likely to impede their fishing ability. Fishers could be forced to remove their nets from the water, or may be prevented from placing their nets in the water entirely; both situations would result in economic loss.

The average value per fisher-day in Areas 2A and 2D was estimated to be $295 in 2013. To illustrate the effects of these impacts on fishing, the example of a 5% reduction in the ability to fish was assumed. This reduction represents an annual loss of $442 per fisher (2.9% of per capita income).

Lost or damaged fishing gear replacement

Interviewees reported that oil contaminated nets have decreased effectiveness and are not useable. Nets severed by vessel propellers may be useless or significantly diminished. Interviewees estimated the average cost to replace a net at about $2,500. This cost is coupled with the revenue loss due to an inability to fish, and the time required to prepare new fishing gear.

Three types of economic loss are associated with lost crab pots – the value of the pots, the value of any crab lost, and the time needed to prepare the pots for use. The average value of crab per fisher-day in 2013 was $18,513. As an example, assuming 25 deployed pots are lost, at $235 per pot, the lost value is $5,875, or 1/75 of the 2013 season's average revenue.

Summary of Economic Contributions and Impacts

Economic impact tables, developed in IMPLAN, use business revenue and expenditure data (inputs) collected for selected QIN fisheries-based and visitor-based businesses. Multiple output files were then created for industry and business, including data for 2014; base data for 2020, 2021, and 2022; and post-spill data for 2020, 2021 and 2022.

IO model outputs provide estimated business activity data for the number of full-time equivalent (FTE) direct, indirect and induced jobs created for select activities; the direct, indirect and induced personal income generated from these jobs; business revenues; and local purchases made by these industries and businesses.

Economic Impacts of Select QIN Industries and Businesses on Local and Regional Economies

Table ES-4 indicates the total economic impacts for industries selected for analysis. IMPLAN models generated the following economic impacts for the local and regional economies in 2013:

- 668.5 direct jobs generated by Treaty fishery-based activities and select QIN-owned businesses. Purchases made by these entities supported an additional 132.2 induced jobs in the region.
- 107 indirect jobs were supported by $32.1 million of local purchases made by businesses supplying services to these firms.
- $27.6 million of direct wages and salaries were received by the 668.5 directly employed. Re-spending of this income created an additional $5.0 million of income and consumption expenditures in Washington, principally in Grays Harbor County. Those holding indirect jobs received $4.3 million in indirect income.
- Businesses providing services to these firms received $84.7 million of revenues.

Table ES-4. Total Economic Impact of Treaty Fisheries-based Activities and Select QIN-owned Businesses ($2014)

		TOTAL IMPACT for Select Activities
Jobs		
Direct		668.5
Indirect		107
Induced		132.2
	Total	**907.7**
Personal Income		
Direct		$ 27,563,371
Indirect		$ 4,302,513
Induced		$ 4,977,738
	Total	**$ 36,843,622**
Business Revenue		**$ 84,681,485**
Local Purchases		**$ 32,096,232**
State and Local Taxes		*

Source: Resource Dimensions, 2015

**Note: Due to the complexities of estimating the full extent of tax impacts generated by QIN-owned businesses and Treaty fishery-based activities and potential significant undercounting, we exclude presentation of state and local taxes in Table ES-4 and this study.*

Changes in Economic Impacts for Select QIN Industries and Businesses, in the event of a spill

To estimate the extent of changes in economic contributions under each scenario, we began with the Base Case scenario model for the period 2020 to 2022 for the select industries and businesses assessed. Sub-models were adjusted to estimate changes in local and regional economy resulting from changes in activities expected under each scenario.

Base data for 2020, 2021 and 2022 was extrapolated from the 2014 data set. Post-spill data for 2020, 2021 and 2022, also extrapolated from the 2014 data set, were adjusted by the average three-year factors (0.33 for fisheries-based activities and 0.10 for visitor-based activities) to represent expected changes in business activities under each scenario.

The values estimated for 2020, 2021 and 2022 post-spill scenarios were subtracted from the values estimated for the 2020, 2021 and 2022 base data. The differences in these values represent the changes in economic contributions by business activities affected in each scenario.

The numbers of direct, indirect and induced jobs estimated from 2020 to 2022 are reported as averages. Personal income, business revenues and local purchases are reported as aggregates.

Table ES-5 indicates the change in economic contributions by Treaty fisheries-based activities and select QIN-owned businesses to the local and regional economies from 2020 to 2022, by spill scenario:

- An average three-year decrease of 79.3 direct jobs in these activities in Scenario 1, 135.6 direct jobs in Scenario 2, and 161.3 direct jobs in Scenario 3. The majority of these direct job losses will be Treaty commercial fishers.
- Purchases made by businesses supplying services to these businesses are estimated to decrease by $10.3 million in Scenario 1, $19.8 million in Scenario 2, and $23.5 million in Scenario 3.
- Direct wages and salaries over 2020 to 2022 are estimated to decline for the individuals still employed by these firms by $10.3 million in Scenario 1, $18.2 million in Scenario 2, and $19.9 million in Scenario 3.
- From 2020 to 2022, businesses providing services to these firms can expect to receive $29.0 million less in revenues in Scenario 1, $56.0 million less in Scenario 2, and $70.5 million less in Scenario 3.

Table ES-5. Summary of Economic Contribution Losses for Treaty Fisheries-based Activities and Select QIN-owned Businesses (2020-2022)

	Scenario 1 TOTAL	Scenario 2 TOTAL	Scenario 3 TOTAL
Jobs			
Direct	79.3	135.6	161.3
Indirect	21.8	29.9	35.7
Induced	17.0	28.7	32.4
Total	**118.1**	**194.2**	**229.4**
Personal Income			
Direct	$ 10,351,169	$ 18,188,709	$ 19,852,707
Indirect	$ 2,401,773	$ 3,445,007	$ 4,601,911
Induced	$ 2,004,293	$ 3,391,332	$ 3,824,026
Total	**$ 14,757,235**	**$ 25,025,048**	**$ 28,278,645**
Business Revenue	$ 28,996,789	$ 56,000,586	$ 70,513,505
Local Purchases	$ 10,332,797	$ 19,817,162	$ 23,483,488
State and Local Taxes	*	*	*

Source: Resource Dimensions, 2015

**Note: Due to the complexities of estimating the full extent of tax impacts generated by QIN-owned businesses and Treaty fishery-based activities and potential significant undercounting, we exclude presentation of state and local taxes in Table ES-5 and this study.*

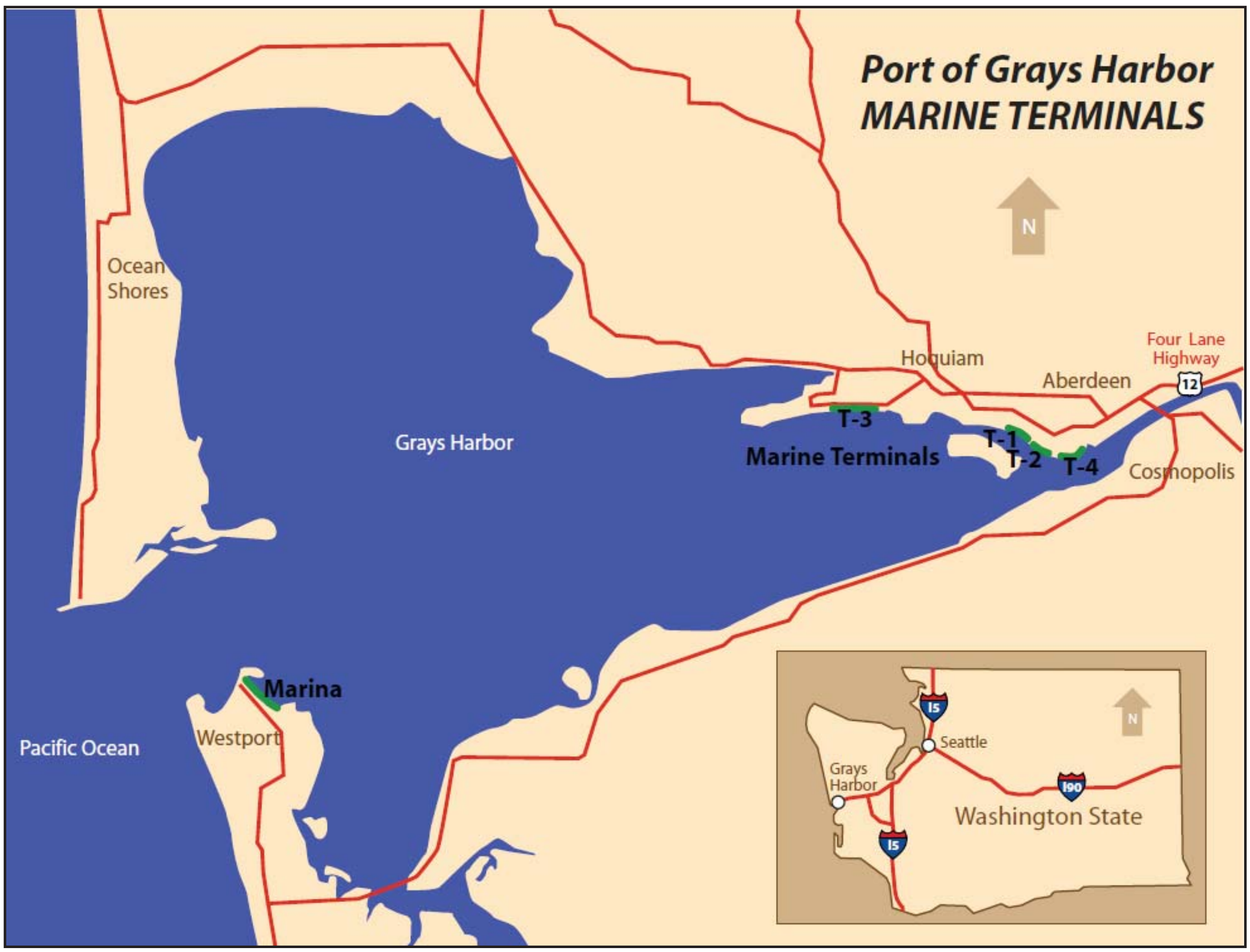
SECTION ONE: Introduction

1.1 BACKGROUND

The Port of Grays Harbor (PGH), located in Grays Harbor County, Washington, handles a diverse cargo mix. The highest volume of American-grown soybean meal in the United States is exported through the PGH, and the Port receives the highest volume of seafood landings in Washington. Other products shipped through the PGH include automobiles, forest products, fuels, and other dry bulk and liquid materials (PGH, 2015).

The PGH has four terminals bounding the northeast corner of Grays Harbor, in Hoquiam and Aberdeen, Washington. Two current PGH tenants are proposing expansion projects at the Terminal 1 (T1) property, and a third company is proposing to construct a new facility at the Terminal 3 (T3) property (Figure 1).

Figure 1. Port of Grays Harbor with terminal locations



Source: PGH, 2014

Project proponent Westway Terminal Company LLC, proposes to "*expand its existing bulk storage terminal to allow for the receipt of crude oil unit trains, storage of crude oil, and shipment of crude oil by ship or barge*" from T1 (City of Hoquiam and DOE, 2014c).

Project proponent Imperium Terminal Services, LLC, a wholly-owned subsidiary of Imperium Renewables Inc., proposes to expand its existing bulk liquid storage terminal at T1 to facilitate the receipt, storage and shipment of biofuels; feedstocks for biofuel production; petroleum products; and renewable fuels (City of Hoquiam and DOE, 2014b). Project information documents note that bulk liquids may be shipped to and from this property by rail, trucks, ships or barges.

At T3, project proponent Grays Harbor Rail Terminal, LLC (GHRT) is proposing *"a bulk liquids rail logistics facility*". The new facility is anticipated to accommodate the receipt of 45,000 barrels (bbls) per day, on average, *"of various liquid bulk materials, specifically, various types of crude oil and condensates"*. These materials are proposed to be delivered to the proposed facility *"via unit trains in fully contained rail cars, unloaded into on-site storage tanks, and then loaded onto barges or other marine vessels"* (City of Hoquiam and DOE, 2014a).

The Quinault Indian Nation (QIN) contends that the direct, indirect and cumulative impacts involved in these three proposals to ship millions of bbls of oils annually through Grays Harbor will have significant adverse environmental effects (Earthjustice, 2013c). Chief concerns of the QIN include: (1) the risk of an oil spill – large or small – incurred by receipt, storage and shipping of large volumes of oils; (2) that the routine operations of these projects could result in chronic environmental degradation; (3) that increased air toxics and greenhouse gas emissions from the operations of the proposed projects will have significant adverse effects on the environment; and, (4) that abilities of QIN members to access and use their cultural and Treaty-reserved fishing resources will be harmed (Earthjustice, 2013c). The QIN is also concerned about an explosive, catastrophic event occurring from oil transport through the Grays Harbor area.

1.2 PURPOSE AND LIMITATIONS

In November 2014, the Quinault Business Committee (QBC) retained Resource Dimensions of Gig Harbor, Washington to conduct an independent study of the extent of potential costs and economic impacts to Treaty-reserved fishing rights and fishing opportunities, and select QIN-owned businesses attributable to the proposed projects at the PGH. This work included estimating the extent of potential costs and economic impacts due to rail and marine vessel transport of crude oil, and to a crude oil spill in or near Grays Harbor.

The analyses in this study are designed to estimate economic impacts to the QIN and tribal members in the case that the abilities of QIN members to exercise Treaty-reserved rights are limited or harmed. No analyses herein are intended to value – monetarily or otherwise – the cultural and spiritual aspects of tribal members' exercise of Treaty-reserved rights.

Study analyses center on (1) the proposed projects' inherent risks and impacts to the QIN's Treaty-reserved rights, and (2) defining the potential magnitude of economic impacts to the QIN in the event of a crude oil spill.

Potential business activity changes attributable to rail and marine transport of crude oil and crude oil spills were elucidated. Fish, shellfish and plants important to the QIN and QIN members were assessed to determine how these resources and access to them could be impacted by transport or a spill of crude oil. As with all socioeconomic research, study results have limitations that reflect the trade-off between project resources (time, funding, etc.) and study robustness and accuracy. Notwithstanding, the principal goals of the study have been met under a compressed timeframe.

It is important to note that the vast majority of the analyses herein rely on secondary data – data not collected and analyzed by the study authors. The study authors make no claims on the veracity of secondary data.

We quantify many of the economic contributions and economic losses that may be incurred due to the proposed projects. This report also details the potential magnitude of changes in economic contributions given the proposed projects and their associated operations, using the best available data. Assumptions were taken to facilitate analytical frameworks for the various research areas of this study. These are noted to the extent practicable throughout.

Lastly, we have not been able to incorporate all of the valid qualitative data that we gathered because of its magnitude and the complexity of analyzing such data. The most pertinent of this information is discussed; that such data was not incorporated does not undermine the quantitative analysis or results.

1.3 Quinault Indian Nation

The QIN is a federally-recognized Indian Tribe and sovereign government organized pursuant to its Constitution adopted March 22, 1975. It is comprised of the Quinault and Queets Tribes, and descendants of the Chehalis, Chinook, Cowlitz, Hoh and Quileute Tribes. The QIN is signatory to the Treaty of Olympia (also known as the Quinault Treaty or Quinault River Treaty), signed on July 1, 1855, and January 25, 1856, establishing the creation of the Quinault Indian Reservation (Reservation) (Washington State Historical Society, 2004). Congress subsequently ratified the Treaty. The Reservation was established by Executive Order on November 4, 1873, and has been subsequently expanded by Congress.

The Reservation is located on the Pacific coast of Washington; the Reservation has 25 miles of Pacific Ocean shoreline (Figure 2). The area of the Reservation, including water bodies is approximately 207,000 acres, on which stand some of the most productive conifer forests in the United States. Lake Quinault, another of the Reservation's natural treasures, covers 3,729 acres and has 12 miles of shoreline, all of which lies within the Reservation (QIN, 2014b).

Figure 2. Quinault Indian Reservation

Source: QDNR GIS Program, 2015

Total enrollment of the QIN as of February 27, 2015 was 2,928 (A. Figg, 2015). 2,602 QIN members reside in Washington, 326 QIN members reside elsewhere. The Reservation lies within both Grays Harbor and Jefferson Counties with 1,101 and 148 QIN members residing on-Reservation in these counties, respectively. QIN members residing off-Reservation in Grays Harbor and Jefferson Counties are 581 and 10, respectively. The remaining 762 QIN members live elsewhere in Washington.

The QIN's General Council (comprised of all of its enrolled members) meets annually in March to discuss issues pertaining to tribal operations and elect members of the QBC, the governing body of the QIN. The QBC, consisting of four executive officers and seven council members, meets bi-monthly to conduct the regular business, governmental and legislative operations of the QIN pursuant to a Constitution and Bylaws.

The QIN currently employs 374 permanent employees and 81 seasonal/temporary employees in its governmental administration. Among its administrative Divisions and Departments are: Tribal Administration, Community Services, Human Resources, Natural Resources, Planning, Public Safety, the Quinault Museum, Social Services (which includes myriad social service and education programs), the Office of the Attorney General, two health clinics, Police Department, Tribal Court, the Tribal Employment Rights Office, and the Tribal Gaming Agency.

The QIN owns and operates many business enterprises in Grays Harbor County. Quinault Beach Resort & Casino is the QIN's largest business enterprise (QIN, 2014a). The QIN owns and operates several dining options within the Resort & Casino. Additionally, in Ocean Shores, the QIN owns the Quinault Maritime Resort, and in 2014 purchased the Ramada Inn – Ocean Shores (recently renamed the Quinault Sweet Grass Hotel) (*Nugguam*, 2014).

The QIN owns and operates Quinault Pride Seafood I in Taholah, which purchases and processes most of the Treaty commercial fisheries catch.[3] In July 2014, the QIN purchased RPPM, LLC and assumed the company's lease with the PGH to establish a branch of Quinault Pride Seafood (known as 'Quinault Pride Seafood II') at the Westport Marina (PGH, 2014).

The Tribe owns several retail enterprises, including Taholah Mercantile, the Amanda Park Trading Post, the Queets Trading Post, Q-Mart I (Ocean Shores) and Q-Mart II (Aberdeen). Other enterprises of the Tribe include commercial forestry (timber harvest operations) and forest products (e.g. boughs, grass, bark, etc.) harvesting.

1.3.1 Treaty rights reserved by the Quinault Indian Nation

In signing the 1856 Treaty of Olympia, the Tribes of the QIN reserved rights, including the right to take fish and the privilege of gathering, "*in exchange for ceding lands it historically roamed freely*" (Earthjustice, 2013b). Article 3 of the 1856 Treaty of Olympia states:

> *"The right of taking fish at all usual and accustomed grounds and stations is secured to said Indians in common with all citizens of the Territory, and of erecting temporary houses for the purpose of curing the same; together with the privilege of hunting, gathering roots and berries, and pasturing their horses on all open and unclaimed lands."*
>
> (Washington State Historical Society, 2004).

Thus, "*Treaty rights are not granted to tribes, but rather are "grants of rights from them – a reservation of those not granted"…..Treaty rights are akin to easements running with the lands or places they burden and include a right of access to those places*" (Earthjustice, 2013b).

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[3] Treaty commercial fishers can sell their catch to independent buyers (buyers not affiliated with Quinault Pride Seafood).

In the Boldt decision of 1974, "*a federal court confirmed that Indian tribes have a right to half of the harvestable fish in state waters and established the tribes as co-managers of the fisheries resource with the State of Washington….Specific to the Quinault Indian Nation, the Boldt decision affirmed the Quinault usual and accustomed fishing areas include "Grays Harbor and those streams which empty into Grays Harbor"* (Earthjustice, 2013b).

Treaty-reserved fishing and gathering rights may be impaired due to the proposed projects, as *"The Quinault Indian Nation has usual and accustomed fishing areas in Grays Harbor and the Chehalis River, and tribal members' right to access currently used fishing, hunting, and gathering sites will be impacted by increased vessel and rail traffic"* (Earthjustice, 2013a). As discussed below, the exercise of these Treaty-reserved rights remains of the utmost importance to the QIN and its members' lives.

1.4 Overview: Proposed projects at the Port of Grays Harbor

1.4.1 Westway Bulk Liquid Facility Project

The Westway Bulk Liquid Facility Project — the expansion of an existing bulk liquid storage terminal — is proposed to be located on two adjacent parcels at T1 and to be built in two phases. Five new storage tanks to accommodate crude oils would be constructed, each having an individual capacity of 200,000 bbls for a proposed new total storage capacity of 1,000,000 bbls. The annual maximum throughput of crude oil is anticipated to be 17,855,000 bbls (City of Hoquiam and DOE, 2014c).

An existing rail facility on the two parcels is proposed to be expanded from two short spurs, having 18 total loading/unloading spots, to four longer spurs having a total of 80 loading/unloading spots.

A new pipeline would also need to be constructed that would connect the new tanks, through an existing pipeline bridge, to T1. Work on the terminal dock is anticipated to include the addition of loading arms and components of a marine vapor combustion system. No in-water work would be performed.

Westway Terminal Company *"estimates that terminal operations would handle 458 unit trains a year (loaded and empty) or 1.25 trains per day. The company estimates that the terminal operations would handle 99 to 119 barges a year (198 to 238 entry and departure transits)"* (City of Hoquiam and DOE, 2014c).

1.4.2 Imperium Bulk Liquid Facility Project

The Imperium Bulk Liquid Facility Project — expansion of an existing bulk liquid storage terminal — is proposed to be located on a leased parcel at T1. A majority of the proposed project – new storage tanks and the bulk of rail facility improvements – will be in Hoquiam. A new office building and a portion of rail facility improvements will be in Aberdeen (City of Hoquiam and DOE, 2014b).

Imperium Terminal Services proposes to build up to nine new storage tanks, each having a capacity of 80,000 bbls (a projected new storage capacity of 720,000 bbls). The project proponent anticipates that the annual maximum throughput for the entire facility, inclusive of the existing storage capacity and the proposed project, would total 30,000,000 bbls per year.

The new tanks are to allow for the storage of bulk liquids including: *"biofuels, such as ethanol, biodiesel, and additional feedstocks for biofuel production such as used cooking oil/waste vegetable oil and animal fat; petroleum products including naptha, gasoline, vacuum gas oil, jet fuel, no. 2 fuel oil, no. 6 fuel and kerosene; crude oil; and renewable fuels such as renewable diesel and renewable jet fuel"* (City of Hoquiam and DOE, 2014b).

The project proponent proposes constructing about 6,100 feet of railroad track in multiple new rail spurs on the parcel in connection with the existing rail line, and expanding the existing rail yard.

Two new pipelines would be installed to connect the new tanks, through an existing pipeline bridge, to T1. The project proponent also proposes to install a marine vapor combustion unit and a new building or buildings. No in-water work would be performed.

Imperium Terminal Services *"estimates that the terminal operations would handle a maximum of 730 unit trains a year (loaded and empty) or two (2) unit trains per day. The company estimates that the terminal operations would handle up to 200 ships or barges a year (400 entry and departure transits)"* (City of Hoquiam and DOE, 2014b).

1.4.3 Grays Harbor Rail Terminal Bulk Liquids Logistics Terminal Facility Project

The GHRT Bulk Liquids Rail Logistics Facility Project is proposed on one parcel at T3 in Hoquiam. The project proponent anticipates that the facility will receive an average of 45,000 bbls per day of various liquid bulk materials via unit trains. Materials would be unloaded into on-site storage tanks, and then loaded onto barges or other marine vessels (City of Hoquiam and DOE, 2014a).

GHRT proposes four 20-car yard tracks and two 20-car off-loading or staging tracks for the facility (accommodating 120 rail cars), as well as a 'runaround' track necessary for repositioning. Six to eight above-ground storage tanks are proposed, for a total storage capacity of 800,000 to 1,000,000 bbls. The project proponent also proposes to construct up to four additional mooring dolphins off the existing concrete wharf (City of Hoquiam and DOE, 2014a).

GHRT notes that T3 is "*a deep water port capable of mooring Panamax class vessels with carrying capacity up to 350,000 barrels".* The project proponent anticipates rail delivery of various liquid bulk materials to be a maximum of one unit train every two days. Marine vessel traffic is anticipated to include up to five vessels per month (*"up to 60 outbound vessel and barges per year are projected*") (HDR, 2014a).

1.5 TYPES OF CUMULATIVE ECONOMIC IMPACTS FROM PROPOSED PROJECTS

Rail and marine vessel traffic attributable to the proposed projects could cause direct and indirect changes in business activities for industries operating in the Grays Harbor area (such as in fisheries-based or visitor-based industries). Further, an oil spill, or chronic oil leakage from rail cars, the proposed facilities, or marine vessels could cause business activity changes. These impacts are briefly detailed in this section.

1.5.1 Attributable to rail traffic

Assuming all three proposed projects at full build-out, the anticipated total of loaded and unloaded new crude-by-rail (CBR) unit trains attributable to the proposed projects yearly is 1,371; an average of 3.75 new CBR unit trains daily (Table 1).

Table 1. Rail Traffic Attributable to the Proposed Projects

Project	Unit trains per year (loaded and empty)	Unit trains per day (loaded and empty)
GHRT Bulk Liquids Logistics Terminal Facility	183	0.50
Imperium Bulk Liquid Facility	730	2.00
Westway Bulk Liquid Facility	458	1.25
Cumulative: GHRT and Imperium	913	2.50
Cumulative: GHRT and Westway	641	1.75
Cumulative: Imperium and Westway	1,188	3.25
Cumulative: All projects	1,371	3.75

Sources: City of Hoquiam and DOE, 2014b and 2014c; HDR Engineering, 2014a

On average, CBR unit trains are 100 cars long, and hold about 3,000,000 gallons of crude oil (DOE, 2015). The length of these unit trains is variable (depending on car type and dimensions), as is their speed. However, any increase in rail traffic attributable to the proposed projects will cause direct and indirect economic impacts.

Among the most significant economic impacts of new CBR unit trains would be travel time delay and traffic blockage at specific intersections and crossings (Natural Resource Economics, 2014). Such delays could interrupt and impede any individual or firm conducting business activity proximate to the proposed train route. For example, Treaty commercial fishers needing to access their fishing areas, or bring their catch to a processor, may be prevented from fishing or from being able to sell their catch prior to spoilage. QIN natural resources enforcement could be adversely affected if the 28th Street boat launch is blocked by rail or rail-related traffic.

Damage to commercial and residential property could result from oil leaks, diesel emissions, vibration and noise from new rail traffic. Such damage, or the potential for such damage, could adversely affect property values. Likewise, new rail traffic could adversely affect property values if believed to limit access. The potential for accidents – including derailments, fires and explosions – would be heightened with new rail traffic, which could also adversely affect property values (Natural Resource Economics, 2014).

Further, due to some or all of the potential impacts described above, firms may forgo business opportunities and investments, resulting in no positive growth effect on jobs, income, other business activities or tax revenues in the local and regional economies.

Other impacts of new rail traffic include: impacts to public safety (i.e., rail-related accidents involving pedestrians); an increased potential for vehicle/train accidents; potential delays of emergency services vehicles (i.e. fire, police, ambulances); an increase in greenhouse gas emissions, and an increase in particulate emissions and concomitant health effects (Earthjustice, 2013a; Natural Resource Economics, 2014).

1.5.2 Attributable to marine vessel traffic

The anticipated total of entry (into the PGH) and departure (out of the PGH) transits of marine vessels attributable to the proposed projects yearly is 758, assuming all three proposed projects at full build-out. This is an average of 2.08 new tanker or barge transits daily (Table 2).[4]

Table 2. Marine Vessel Traffic Attributable to the Proposed Projects

Project	Entry and departure transits per year (maximum)	Entry and departure transits per day (maximum)
GHRT Bulk Liquids Logistics Terminal Facility	120	0.33
Imperium Bulk Liquid Facility	400	1.10
Westway Bulk Liquid Facility	238	0.65
Cumulative: GHRT and Imperium	520	1.43
Cumulative: GHRT and Westway	358	0.98
Cumulative: Imperium and Westway	638	1.75
Cumulative: All Projects	758	2.08

Sources: City of Hoquiam and DOE, 2014b and 2014c; HDR Engineering, 2014a

Each of the three project's information documents state that tankers or barges will be used to transport their products (City of Hoquiam and DOE, 2013; City of Hoquiam and DOE, 2014b; HDR Engineering, 2014a). The project information document for the GHRT project states that T3 "*is a deep water port capable of mooring Panamax class vessels with carrying capacity up to 350,000 barrels*". Imperium Renewables explains that "*The largest vessel expected to be loaded at Terminal 1 is a Panamax class vessel (60,000 to 80,000* (deadweight tonnage) *DWT) and 300,000 to 350,000 bbls of cargo capacity. Ocean going barges will also be loaded with capacities of up to 150,000 bbls*" (Imperium Renewables, 2013).

Panamax tankers are tank vessels having dimensions up to a "*length of 750 feet, a draft of 41 feet, and a deadweight tonnage (DWT) of 60,000 to 80,000*" (DOE, 2015). Panamax class vessels are mid-sized cargo ships, the maximum size capable of passing through the lock chambers of the Panama Canal. To provide context, a Panamax class vessel is shown in Figure 3.

[4] Vessel traffic attributable to the proposed projects will be in addition to existing vessel traffic. 2013 total entering transits in Grays Harbor by cargo/passenger ships, tankers and fishing vessels combined was 103 (DOE, 2015).

Figure 3. Panamax class vessel

Source: Imabari Shipbuilding, 2009

Articulated tug-barges (ATBs) can be used to transport crude oil products inland, near a coast, and at sea. ATBs are a tug-barge combination system (typically 100 to 150 feet long) wherein a normal barge is notched at the stern, allowing a tug to be connected to the barge via a hinged connection to aid maneuvering (Figure 4).

Figure 4. Articulated Tug-Barge (ATB) vessel

Source: Crowley Maritime Corporation, 2014

One bbl of oil is equivalent to 42 (U.S.) gallons of oil. Thus, a Panamax vessel capable of carrying 350,000 bbls has a capacity of 14,700,000 gallons, and an ATB capable of carrying 150,000 bbls has a capacity of 6,300,000 gallons.

Increases in marine vessel traffic attributable to the proposed projects will cause direct and indirect impacts to the ecology of Grays Harbor and to business activities occurring in the region.

Increased marine vessel traffic from tankers, barges and their escort tugs could disrupt the near shore environment of Grays Harbor, which is used by many species for habitat, such as juvenile salmon that reside there during migration to sea. Increased turbidity and suspended sediments could affect growth and survival of juvenile fish. Those fish residing in the near shore environment could be adversely impacted by noise, artificial light, and shading (from large vessels) attributable to the proposed projects (Earthjustice, 2013a).

Marine vegetation such as eelgrass and macroalgae, important to many species for spawning, forage and refuge, may also be adversely affected by shading (Earthjustice, 2013a).

Churning of the Grays Harbor estuary could occur from vessel propellers and wakes. As wave energy reaches shore, erosion (movement of sediment from the shoreline) or accretion (movement of sediment toward the shoreline) of the land could occur, thus altering the land surface and the habitat residing there. In a shallow area, propulsion systems of marine vessels can move sediment under water creating holes – an effect known as bottom scouring – that could adversely affect the benthic environment (Natural Resource Economics, 2014).

Ballast water discharged from ocean-going ships potentially carries invasive species, which over a long period could adversely affect ecological systems of Grays Harbor or the Pacific coast. Hull fouling is another potential source of invasive species.

Treaty commercial and subsistence fishers actively engage in Treaty-reserved fishing in Grays Harbor and its rivers and tributaries, including in the waters near T1 and T3. Treaty fishers will be directly impacted by increased marine vessel traffic attributable to the proposed projects. Further, increased vessel traffic increases the risk of vessel collisions, groundings, cargo and fuel spills, and leaks during vessel fueling (Earthjustice, 2013a).

Diminished revenues resulting from gear loss, damage, or the inability to actively fish are issues of concern to Treaty fishers. Vessel movements could present situations where nets can be damaged in the water, or could prevent Treaty fishers from putting their fishing nets in the water altogether. For example, Treaty fishers fish in waters around T1 and T3 where fish are known to congregate. Marine vessel movement attributable to the proposed projects would be expected to be most intense in these areas, thus magnifying this conflict. Crab pot buoys can be destroyed by vessel wake. When a crab pot buoy is destroyed, Treaty crab fishers incur opportunity costs of fishing, forgo revenue from landed crabs, and incur the costs of replacing gear.

1.5.3 Attributable to an oil spill

Oil spills on land or in water from the activities and traffic attributable to the proposed projects have the potential to adversely affect the ecology of Grays Harbor and near shore waters and habitats.

Oil contamination can have devastating effects on freshwater and estuarine habitats and the species that reside there. Not only are the habitats within Grays Harbor at risk from the effects of a spill, so too are upwater habitats of the freshwater tributaries draining into Grays Harbor: "*The Chehalis, Humptulips, Wishkah, Johns, Elk and Hoquiam Rivers are tidally influenced by Grays Harbor. Water moves from Grays Harbor into these drainages and periodically creates a back water effect into its tributaries. Pollutants would make their way into freshwater systems and disperse in the same manner as saltwater*" (Earthjustice, 2013a). Further, the proposed rail line parallels the Chehalis River within yards of, and crosses many fish-bearing streams in the Chehalis River Watershed, holding the potential for a spill directly into freshwater systems (Earthjustice, 2013a).

The potential for polluted runoff from the proposed facilities during storm events also exists in the absence of appropriate mitigation (Earthjustice, 2013a).

Oil contamination has been shown to cause adverse biological effects on plant and marine life. These effects can disrupt the entire food web of an area. Thus, the effects of oil contamination on all species – regardless of their commercial value – are a concern.

Spilled oil could also adversely affect business activities occurring in Grays Harbor, its tributaries, and adjacent marine waters. Many Treaty commercial fishers' livelihoods are wholly dependent on fishing these waters. An oil spill would threaten the economic securities of their families if these fishers were unable to fish due to an oil spill, or, if fish buyers and processors stop purchasing due to diminished market demand resulting from perceived or actual contamination of seafood. Treaty fishers may be unable to fish if their fishing areas are oiled, if they need to pass through oiled waters to reach their fishing areas, or if their ability to fish is impeded due to spill response.

Those tribal members reliant on the subsistence harvest of fish from these habitats would also be injured in multiple ways, as "*the importance of subsistence fishing and shellfishing to the diet, health, and cultural and spiritual well-being of Quinault members cannot be overstated*" (Earthjustice, 2014).

Oil contamination can damage or kill plants living in the Grays Harbor estuary. Quinault weavers have gathered and used several of these plant species for time immemorial. The ceremonial and spiritual aspects of gathering plant materials are highly important to the Quinault people. Moreover, some tribal members rely on gathered materials to produce commercial woven goods, which account for a substantial portion of their incomes.

Finally, the QIN could decide to forgo potential business opportunities due to risks associated with oil spills, resulting in no positive growth effect on jobs, income, other business activity or tax revenues.

SECTION TWO: Scope and Approach

2.1 FRAMEWORK AND KEY ASSUMPTIONS

The remainder of this document is organized as follows:

Section 2, Scope and Approach

The economic valuation methods utilized in this study are presented. The analytical scope and various data collection methods are explained.

Section 3, Economic Setting

The economic setting – demographics, employment and the labor force, and the industries and occupations – of Grays Harbor County, Washington (the regional economy) is described.

Section 4, Scenario Modeling: Potential Impacts of Oil Spills

Characteristics of oil types anticipated to be accepted and shipped by the proposed projects are discussed. Hypothetical oil spill scenarios used in estimating economic impacts are explained.

Section 5, Effects of Oil Contamination on Treaty Resources

Acute and persistent toxic effects of oil contamination on pertinent fish, shellfish and plant species are described.

Section 6, Potential Impacts of Oil Transport and Spills on Treaty Resources

The historical importance of and contemporary perspectives on fishing and gathering to the Quinault people is presented. The economic impacts of business activities changes in fisheries-based and visitor-based industries are assessed by scenario. The cost to replace the subsistence harvest of seafood is estimated. Traditional plant material gathering and the commercial value of products woven from these materials are described.

Key Assumptions

Several assumptions were required to facilitate this study. The majority of study analyses use secondary data – data taken from external sources. Thus, study findings are to a large part reliant on the methods and analyses of these sources, and the assumptions that the study authors made regarding their validity.

Second, all monetary values were adjusted to 2014 dollars using the United States Department of Commerce, Bureau of Economic Analysis (BEA) published seasonally adjusted gross domestic product (GDP) implicit price deflators.[5]

[5] The GDP deflator is an index number that represents the *average price* of all the goods and services produced in the economy. U.S. BEA Implicit Price Deflators for GDP, January 30, 2015. http://www.bea.gov

Lastly, there has not been an oil spill in or near Grays Harbor of the magnitudes considered here. Therefore, it is necessary to rely on presuming the impacts such an event could cause to construct hypothetical spill scenarios and consider potential changes to business activities.

2.2 Economic Valuation and Impact Methodology

Three economic valuation methods were used to assure that each topic and industry under study was appropriately analyzed. These methods were ***economic impact analysis***, ***economic contribution analysis*** and ***market replacement***. The specific uses for each valuation method, and the concepts inherent in each, are explained below.

2.2.1 Economic impact analysis

Economic impacts are those processes that track how spending changes attributable to an economic event – such as a business creation, modification or closure, or a natural or environmental change – move through an economy. An economic impact analysis studies the cumulative effects of those spending changes on a defined geographic study region (Day, 2012).

Two base impact models were developed to estimate the economic contributions and impacts of Treaty commercial fishing and related businesses (e.g. Quinault Pride Seafood) activities, and select QIN-owned business activities, on the geographic study region of Grays Harbor County, Washington. From the base impact models, sub-models were constructed for the Treaty fisheries and each QIN-owned business considered in this analysis. In total, eight sub-models were developed to evaluate the economic impacts and changes in contributions for the subject activities.

Economic input-output (IO) modeling can be used to estimate the impacts of business activity changes to a region's economy (an ***economic impact analysis***). The basic premise of the IO framework is that each industry sells its output to other industries and final consumers, and in turn purchases goods and services from other industries and primary factors of production. Thus, the economic performance of each industry can be determined by changes in both final demand and specific inter-industry relationships. IO tables assist in calculating overall changes in the flow of money in the local and regional economies, including direct, indirect, and induced effects.

Direct effects occur when an industry spends on goods and services, wages, materials and other related expenditures. These are typically referred to as direct costs of operation. **Indirect effects** occur when consequent purchases are made by suppliers of materials and services to sustain the direct expenditures. **Induced effects** occur when workers in the sectors stimulated by the direct and indirect expenditures spend their additional incomes on consumer goods and services. **Total effect** is the sum of direct, indirect and induced effects.

For illustration, consider the example of a Treaty commercial fisher. To conduct the business activity of fishing the fisher spends on materials at the local marine supply store. This transaction is a direct effect. To stock the materials, the store purchases them from a supplier or directly from the manufacturer. These transactions are indirect effects. The store clerk receives wages from his/her labor, and in turn purchases groceries. This transaction is an induced effect.

In this analysis, the effects are those associated with the income and expenditures related to the industry activities for QIN fisheries-based activities and select QIN-owned businesses. The outputs are shown as estimates of changes in employment, personal income, business output, and value added (gross regional product).

2.2.2 Economic Impacts of Treaty fishery-based activities and select QIN-owned businesses

QIN-owned businesses and Treaty commercial fishers contribute to the local and regional economies by generating business revenue that extends from local to national firms providing services to these sectors. Accordingly, these businesses provide employment and income to individuals. In understanding the linkages across the local and regional economy, note that a single number cannot summarize the impact of any sector; rather, each sector generates several impacts that include employment impacts (jobs), personal income impacts, business revenue impacts, and tax impacts. These impacts are intertwined and non-additive.

Throughout the study, care has been taken to ensure a realistic assessment of the impacts generated by the business activities examined. The estimates developed do not include any costs or losses associated with the impacts of a potential spill to private property owners or governments. Similarly, given the complexities of ex-ante analysis on post-event changes in the labor market, impact estimates do not include jobs that may be created through post-spill response efforts.

These impact classifications are outlined below to aid in understanding the results of the impact analyses presented in Section 6.

Employment impacts (jobs) consist of four levels:

- **Direct Jobs** are those directly generated by fisheries-based activities, businesses and related real property, seafood processing and marine activity, estimated using model data and data provided by QIN staff. Direct jobs generated by the Treaty commercial fishing fleet using the Westport Marina include fishing crewmembers, boat/shipyard employees, and local fishing gear suppliers, for example. Other direct jobs supported by related marina activity include those directly involved in the management of the facility, those supported by purchases made by boat owners including boat equipment and supplies, repairs, local hotels, restaurants, retail stores and transportation firms.

  These **jobs** are directly generated, in that there would be an immediate dislocation of jobs if harvests and the marina activities serving commercial fishing were closed for a period of time, and thus resulting in operations closing or leaving the area altogether.

- **Indirect Jobs** are those created in the region and state due to goods and services purchased by firms (not individuals) directly dependent upon the business activities examined. These jobs are estimated through a combination of IMPLAN model data and data provided by QIN staff. Jobs include those with maintenance and repair firms, parts and equipment suppliers, local office supply firms, etc.

- **Induced Jobs** are those created across the local economy because people directly employed in the business activities examined spend their wages. Induced jobs are estimated from local, regional and statewide purchase data, and they include those held by residents of the region and state.

Personal income impact is the measure of employee wages and salaries (e.g. income from commercial catch), not including benefits, received by individuals directly employed by fisheries-based activities, select QIN-owned businesses, and related marine and seafood processing, transportation and other activities. The statewide re-spending effect of these earnings for purchases of goods and services is estimated in each model iteration using the Washington State personal earnings multiplier, which reflects the percentage of purchases by individuals that are made within the state. Re-spending, in turn, generates induced employment impacts (additional jobs). Direct earnings are a measure of the local impact as those directly employed in the associated activities receive the wages and salaries.

Business revenue impacts are the activities of those employed in fisheries-based activities, select QIN-owned businesses, marine, transportation and other activities that generate business revenue for firms that provide services. This revenue is circulated throughout the economy in several ways (e.g., to hire service providers, to purchase goods and other services, to pay facility rents, and to make tax payments). For the purpose of this study, we limit the interpretation of business revenue impacts to that which can be identified as staying within Washington (e.g., wages paid to Washington employees, for local purchases by individuals and businesses directly dependent on the relevant operations, and in contributions to state, local and federal taxes).

Tax impacts are tax payments (federal, state, local) by firms and individuals whose jobs are directly dependent upon and supported (induced and indirect jobs) by fisheries-based activities and related seafood processing activities, select QIN-owned businesses, and related marine activity. Tax impacts include state and local taxes collected from all sources. Given the complexities of estimating the full extent of tax impacts generated by QIN-owned businesses and fishery-based activities, and potential significant undercounting, we exclude analysis and presentation of tax impacts in this study.[6]

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[6] As is true of all American Indians and Alaska Natives, QIN members pay the same taxes as other citizens with the following exceptions: (1) Federal income taxes are not levied on income from trust lands held for them by the U.S.; (2) state income taxes are not paid on income earned on the reservation; (3) state sales taxes are not paid by on transactions made on the reservation; and, (4) local property taxes are not paid on reservation or trust land. Tribes, tribe-owned businesses, and individual members may also own land as private property. In such cases, they are subject to state and local laws, regulations, codes, and taxation. Economic impact models assume some tax is paid; however, the portions paid by individuals or individual entities are not parsed.

Value added figures represent the total value of the production of goods and services in the economy resulting from direct expenditures under analysis (valued at market prices).

2.2.2.1 IMPLAN model

The approach used joins that of an IO survey model, which involved obtaining data on the distribution of local sales and expenditures for each sector, with that of the IMPLAN system, which uses secondary data to construct estimates of local economic activity. IMPLAN is a computerized database and modeling system used for creating economic models and IO tables.[7] IMPLAN can be used to construct zip code, county or multi-county IO models for any region in the United States. The customized regional model developed for this study is derived from economic response coefficients of a national IO model and localized estimates of total gross outputs by sectors. The IMPLAN system adjusts national level data to fit the economic composition and estimated trade balance of a selected region.

The 2013 IMPLAN data set, County Data for Grays Harbor County, Washington, was used to develop all models and sub-models in IMPLAN version 3.0, for this study. To ensure consistency, 2013 is used as the base year for all analyses; dollar amounts are expressed in 2014 U.S. dollars.

2.2.2.2 Economic sectors used in IO models

Expenditures by Treaty commercial fishers typically include purchases of goods (gear, supplies, hardware, electronics); repair expenses (boats, nets, gear, engines); trip expenses (bait , fuel, groceries, ice); fixed expenses (moorage, licenses, insurance, accounting, etc.); labor expenses and the owner's profit. Similarly, there are categories or classifications of expenditures made by each of the QIN-owned businesses selected for analysis. With guidance provided by IMPLAN, a bridge table (Appendix A) was created to translate North American Industry Classification System (NAICS) codes into IMPLAN industry codes to map the splits and aggregations used in the IO models' sectoring schemes.[8]

2.2.3 Economic contribution analysis

Regional economic contribution analysis for an industry, event or policy is commonly performed using IO models. IO models capture the complex interactions of consumers and producers of goods and services in the economy, such that goods produced by one sector become inputs of another, and the goods produced by that sector can become inputs to yet other sectors. Thus, the change in demand for a good or service can generate a ripple effect throughout the local and regional economies, and IO models are constructed to measure this effect.

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[7] IMPLAN was developed by researchers at the University of Minnesota working with the U.S. Forest Service in cooperation with the Federal Emergency Management Agency and the U.S. Department of the Interior, Bureau of Land Management to assist in land and resource management planning. In 1993, the founders incorporated as Minnesota IMPLAN Group, Inc. (MIG), and expanded to improve the original system. Today, software and data sets are available through IMPLAN Group LLC, Huntersville, NC.

[8] The NAICS was jointly developed by the United States, Canada and Mexico to provide comparability in statistics about business activities across North America.

In terms of IO models, spending associated with one industry or sector of the economy can directly affect levels of activity in another industry or sector. In turn, directly affected industries can indirectly affect further industries or sectors due to how their activity is affected. For example, visitors to Ocean Shores spend money on goods and services. Local businesses in turn purchase labor and supplies to meet the demand for these goods and services. The income and employment resulting from the visitor purchases of goods and services from local businesses represent the direct effects of visitor spending within the economy.

Relevant to this study, the economic contribution of the Treaty commercial fishing industry to the Grays Harbor County economy is the portion of the County's economy attributable to the total impact of the Treaty commercial fishing industry within the County. Thus, it is possible to examine the relative magnitude of the Treaty commercial fishing industry in the study region.

IMPLAN uses backward linkages (through supply chains) to calculate, using inputs and implicit data to estimate the overall effects that an economic event has on a study region's economy. To determine the effect of increased or decreased production in an industry, IMPLAN assesses the industries that supply the producing industry (e.g. commercial fishing), and the goods and services the producing industry requires for conducting business (Day, 2012). In a simple explanation, if a producing industry decreases demand for a good (e.g. fishing gear), the suppliers' sales of that good and their production of that good will decrease in turn.

In this study, ***economic contribution analysis*** is used to estimate changes in the local and regional economies resulting from production impacts to Treaty fisheries-based activities and select QIN-owned business activities associated with three hypothetical oil spill scenarios.

2.2.4 Market replacement

QIN members exercise the Treaty-reserved right for subsistence harvesting of seafood in Grays Harbor, its tributaries and the coastal environments. If QIN members were unable to partake in subsistence harvesting because of marine vessel traffic or an oil spill, this right would be impaired.

The ***market replacement*** technique allows us to estimate costs incurred to replace the subsistence harvest of seafood. Seafood is bought and sold in a conventional market, and has close substitutes in other types of food that are marketed. The costs to replace the calories and protein provided by the subsistence harvest were estimated by calculating the costs of potential substitutes. This analysis is presented in Section 6.3. Assessing both the caloric and protein content of the subsistence harvest allows different decision-making avenues. The caloric value of the seafood represents the nutritional trade-offs that occur at the individual level. In other words, what will the cost be to fill the stomach by eating the most likely substitutes? The protein value of the seafood is useful at the policy-making level, as one may examine the flow of money in the local economy – if more funds are spent at the grocery store, how may that affect spending elsewhere?

A full accounting of the costs to replace the subsistence harvest would include the costs of travel to the grocery store. To estimate travel costs, a survey of purchasing habits and distances traveled is required, which is beyond the timeline and scope of this analysis. However, it is important to note that costs beyond those of the most likely substitutes would be incurred at the individual level.

2.3 Scope of Analysis

After screening for potential impacts to Treaty-reserved fishing and gathering rights from rail and marine traffic, and in the event of an oil spill, multiple topics and industries were selected for analysis. Impact screening was an iterative process between the staff and the study authors, performed by culling potential impacts from project proponent documents and the legal record, and by examining studies performed in a similar context.

First, the biological effects of oil contamination on fish, shellfish and salt marsh plants were assessed via literature review. This was necessary to understand how economically and culturally important species could be adversely affected by spilled oil.

The potential revenue losses to the Treaty fisheries-based activities in the event of an oil spill were estimated. The total economic impacts; and impacts on personal income, employment and taxes generated by commercial fishing were derived using economic impact models. The analysis was extended to a potential QIN commercial aquaculture pilot project. Revenue losses attributable to rail traffic, marine vessel traffic, and from lost or damaged fishing gear were also estimated. Potential revenue losses to QIN-owned businesses were estimated. Such losses could result from decreased patronage in the event of oil-contaminated beaches, or from the loss of visual amenities.

Various perspectives on assessing culture loss have emerged within the fields of economics and anthropology during various attempts to assess natural resource damages, as in the case of the *Exxon Valdez* oil spill. Fundamentally, culture loss addresses two expansive interrelated classes of loss – loss of possession and loss of kinship or belonging (Kirsch, 2001). With respect to the loss of possession, such as livelihoods reliant upon natural resources, implied are property and value relationships amenable to economic valuation. However, the latter class involves the inalienable bond to the resource – social relationships and traditional lifestyles that test the limits of current approaches to economic valuation for natural resource damages that result in culture loss (e.g., impacts on Treaty-reserved fishing and gathering rights).

As found in similar studies, conducting valid and reliable economic valuation for every important impact, particularly non-market impacts, is not achievable for three reasons: 1) the monetary standard is not always the appropriate paradigm; (2) where economic valuation is appropriate, available approaches remain inadequate; and (3) associated time and costs required in the application of available methods to assure reasonable quality.

Thus, non-market impacts on Treaty-reserved fishing and gathering rights are qualitatively and quantitatively considered and discussed. The ceremonial, spiritual and way-of-life values inherent in the Treaty-reserved fishing and gathering rights are described in the context of the potential impacts from the proposed projects. The study does not seek to monetize these cultural values or their associated range of social and material goods given long-standing challenges to do so in economic terms. Table 3 presents the industries and topics assessed in this study.

Table 3. Industries and Topics Examined

Topic / Area Assessed	Type of analysis
Biological effects of oil contamination on economically and culturally important species	Qualitative
Treaty commercial fisheries	Quantitative
Ceremonial, spiritual and way-of-life values inherent in Treaty-reserved rights	Qualitative
Subsistence harvest of fish and shellfish	Quantitative
Commercial value of products made with traditionally gathered plant materials	Quantitative
Select QIN-owned businesses	Quantitative
Emergent QIN businesses	Quantitative

Source: Resource Dimensions, 2015

2.4 DATA COLLECTION

Three data collection approaches were used to compile necessary information: literature and data provided by staff, an independent literature review, and an interview process that yielded primary data.

Staff provided data on fisheries, the subsistence harvest of seafood, QIN-owned businesses, and the comment record regarding the proposed projects. This data was furnished both at the behest of QIN staff, and as a result of specific requests from the study authors. Information was also provided regarding cultural resources and tribal enrollment.

The literature review was necessary to (a) supplement data provided by staff; and (b) collect data necessary for impact modeling and analyses. This process also ensured that relevant studies published between mid-2013 and early 2015 were considered.

The study authors, assisted by QIN staff and QIN members conducted telephone and in-person interviews. Most interviews were conducted with one person at a time. These interviewees were comprised of Treaty commercial and subsistence fishers, grass gatherers and weavers, and Quinault Department of Natural Resources (QDNR) staff.

For each group (i.e. commercial fishers, subsistence fishers, grass gatherers, and staff) interview guides were developed and used to ensure consistency across interviews. Telephone interviews were conducted between mid-November 2014 and mid-December 2014. In-person interviews were conducted in Taholah, Washington on December 11, 12, 15, and 16, 2014.

To aid in understanding the locations where QIN members fish and gather Treaty resources, the QDNR Geographic Information System (GIS) Program produced two three-map series of Grays Harbor. Aerial image maps were constructed with data from the United States Department of Agriculture (USDA) National Agricultural Imagery Program; map scales were 1:200,000, 1:75,000, and 1:40,000. National Oceanic and Atmospheric Administration (NOAA) Electronic Nautical

Charts, at identical scales, were developed to assist in identification of important characteristics, such as depths, of Grays Harbor. Interviewees were provided a clean map set for use in identifying where they fish or gather Treaty resources using a marking pen

SECTION THREE: Economic Setting

3.1 DEMOGRAPHICS

Demographic trends for the Reservation, Grays Harbor County and Washington are briefly explored in this section. This data has significant bearing on the local and regional economy, and is included in the IMPLAN models – figuring in calculations made by the users and the system.

Table 4 presents statistics in several demographic categories for the Reservation, Grays Harbor County and Washington. Note that a portion of the Reservation lies within Jefferson County, Washington, but because the business activities considered in this study occur in Grays Harbor County, Jefferson County statistical data is not considered or utilized.

The population density of the Reservation is significantly lower than either Grays Harbor County or the State. As estimated in the 2010 United States Census, the median age of Reservation residents is notably lower than the median ages of Grays Harbor County residents and Washington residents. Further, the average household size and the average family size reported for the Reservation's population are considerably larger than that reported for Grays Harbor County or Washington.

The median household income, median family income and per capita income are highest for Washington and lowest for the Reservation, as reported in 2013 dollars. Grays Harbor County reports lower incomes than Washington, but higher than those reported for the Reservation.

Grays Harbor County and the Quinault Reservation report substantially higher housing vacancies than reported for Washington (the vacancy rate of Grays Harbor County is more than double that of the state). Further, Grays Harbor County and Reservation populations report higher rates of housing units for seasonal, recreational or occasional use. The rate of seasonal, recreational or occasional use of housing units in Grays Harbor County is more than triple that of Washington.

With respect to educational attainment for the population 25 years old and older, rates of those with bachelor's degrees and graduate or professional degrees in Washington is much higher than that of the populations of Grays Harbor County or the Reservation. The Reservation population reported a higher percent with a 9th to 12th grade education, with no diploma, than the populations of Washington or Grays Harbor County.

Table 4. Select Demographic Statistics, Reservation, Grays Harbor County and Washington

Population characteristics	Reservation	Grays Harbor County	Washington
Population	1,408	72,797	6,724,540
Population density (per sq. mile)[1]	4.3	38.3	101.2
Percent male	52.8%	51.3%	49.8%
Percent female	47.2%	48.7%	50.2%
Median age (years)	28.7	41.9	37.3
Average household size	3.35	2.45	2.51
Average family size	3.74	2.94	3.06
Economic characteristics[2] (2013 $)			
Median household income	$29,276	$42,405	$59,478
Median family income	$32,344	$52,948	$72,168
Per capita income	$15,160	$21,828	$30,742
Housing characteristics			
Occupied housing units	83.8%	81.3%	90.8%
Owned-occupied	63.4%	67.8%	63.9%
Renter-occupied	36.6%	32.2%	36.1%
Vacant housing units	16.2%	18.7%	9.2%
For seasonal, recreational or occasional use	8.0%	9.6%	3.1%
Median home value[3]	$71,900	$157,600	$262,100
Educational Attainment (Population 25 and older)[4]			
Less than 9th grade	6.7%	5.6%	4.1%
9th to 12th grade, no diploma	14.2%	9.0%	5.9%
High School graduate (includes equivalency)	32.1%	31.6%	23.6%
Some college, no degree	26.0%	29.2%	25.1%
Associate's degree	7.7%	10.7%	9.5%
Bachelor's degree	9.4%	9.8%	20.4%
Graduate or professional degree	3.8%	4.2%	11.2%

Sources: USCB 2010a, 2010b, 2013a, 2013b, 2013c

[1] 2010 Census Summary File 1. Population, Housing Units, Area, and Density: 2010-State--County/County Equivalent.
[2] 2009-2013 American Community Survey, Selected Economic Characteristics (USCB, 2013a).
[3] 2009-2013 American Community Survey, Selected Housing Characteristics (USCB, 2013b).
[4] 2009-2013 American Community Survey, Selected Social Characteristics (USCB, 2013c).

The Washington State Employment Security Department (ESD) estimated that the population of Grays Harbor County will grow by about 4,200 from 2011 to 2040, shown in Table 5 (ESD, 2014). The state population was estimated to grow by more than 2,000,000 over the same period.

Table 5. Historic and Projected Populations, Grays Harbor County and Washington

	1981	1991	2001	2011
Washington	4,229,281	5,021,335	5,970,329	6,767,900
Grays Harbor County	66,732	65,296	68,710	72,900
	2016	**2021**	**2031**	**2040**
Washington	7,124,447	7,514,897	8,250,339	8,820,691
Grays Harbor County	73,741	74,739	76,600	77,112

Source: ESD, 2014

Five-year population average annual rate of growth (AARG) increments are estimated to range from 0.2% to 0.3% for Grays Harbor County from 2011 through 2030, whereas AARGs for Washington range from 0.9% to 1.1% for the same time period, as projected by ESD (Table 6).

Table 6. Average Annual Population Growth Rates, Grays Harbor County and Washington

Period	Grays Harbor County	Washington
1991-2000	0.5%	1.9%
2001-2005	1.1%	1.3%
2006-2010	0.6%	1.3%
2011-2015*	0.2%	1.0%
2016-2020*	0.2%	1.1%
2021-2025*	0.3%	1.0%
2026-2030*	0.2%	0.9%

Source: ESD, 2014

3.2 EMPLOYMENT AND LABOR FORCE

The total Grays Harbor County civilian labor force ranged between 27,050 and 31,300 from 2008 to 2013, and the unemployment rate ranged between 11.0% and 13.6% over the same period (Table 7). Grays Harbor County's civilian labor force was reduced about 4,250 people from 2008 to 2013, and the unemployment rate declined about 2.2% over that time.

The AARG in the total labor force was 0.29% from 2003 to 2008, and the AARG of the employed labor force was -0.85% over the same period. From 2008 to 2013, the AARG of the total labor force was -2.97%, and the AARG of the employed labor force was -2.46%. Employment data is not reported at the sub-county level.

Table 7. Grays Harbor County Civilian Labor Force

Year/Time Period	Total	Employed	Unemployed*	Unemployment Rate
1993	27,730	23,900	3,470	12.7%
2003	30,840	28,280	2,560	8.3%
2008	31,300	27,180	4,120	13.2%
2009	30,830	26,630	4,200	13.6%
2010	29,750	25,830	3,920	13.2%
2011	28,650	25,050	3,600	12.6%
2012	27,470	24,220	3,250	11.8%
2013	27,050	24,080	2,970	11.0%
AARG, 1993-2003	1.15%	1.61%		
AARG, 2003-2008	0.29%	-0.85%		
AARG, 2008-2013	-2.97%	-2.46%		
AARG, 2003-2013	-1.34%	-1.66%		

Sources: ESD, 2014; Resource Dimensions, 2015

3.3 Industries and Occupations

Grays Harbor County was reported by the United States Census Bureau (USCB) to have 1,690 business establishments in 2012. The Retail trade sector had the highest share of business establishments (15.6%), followed by the Accommodation and food services sector (13.8%) and the Health care and social assistance sector (11.8%) (Table 8). Data, current as of June 26, 2014, is reported by the USCB using five-digit NAICS codes.

Table 8. Business Patterns of Grays Harbor County, by NAICS code

2012 NAICS code	Meaning of 2012 NAICS code	Number of establishments
00---	Total for all sectors	1,690
11---	Agriculture, forestry, fishing and hunting	75
22---	Utilities	3
23---	Construction	160
31-33---	Manufacturing	83
42---	Wholesale trade	52
44-45---	Retail trade	263
48-49---	Transportation and warehousing	76
51---	Information	20
52---	Finance and insurance	86
53---	Real estate and rental and leasing	84
54---	Professional, scientific and technical services	90
55---	Management of companies and enterprises	3
56---	Administrative and support and waste management	61
61---	Educational services	8
62---	Health care and social assistance	200
71---	Arts, entertainment and recreation	29
72---	Accomodation and food services	234
81---	Other services (except public administration)	159
99---	Establishments not classified	4

Source: USCB, 2014

The Educational services, and health care and social assistance industry employs the highest percentage of the workforce in Grays Harbor County (20.6%) (Table 9). A group of three industries: Arts, entertainment, and recreation, and accommodation and food services (12.2%), Retail trade (11.0%), and Manufacturing (10.8%), employ the next higher percentages of the workforce.

Table 9. Workforce by Industry, Grays Harbor County

Industry	Estimate	Percent of workforce
Civilian employed population, 16 years and over	27,434	
Educational services, and health care and social assistance	5,658	20.6%
Arts, entertainment, and recreation, and accomodation and food services	3,359	12.2%
Retail trade	3,027	11.0%
Manufacturing	2,961	10.8%
Public administration	2,699	9.8%
Construction	1,965	7.2%
Transportation and warehousing, and utilities	1,622	5.9%
Agriculture, forestry, fishing, and hunting, and mining	1,405	5.1%
Professional, scientific, and management, and administrative and waste management services	1,382	5.0%
Other services, except public administration	1,162	4.2%
Finance and insurance, and real estate and rental and leasing	1,007	3.7%
Wholesale trade	694	2.5%
Information	493	1.8%

Source: USCB, 2013a

Of the civilian employed population (16 years and over), the highest rate of Grays Harbor County residents are employed in Management, business, science and arts occupations (25.2%), followed by Service occupations (23.5%) and Sales and office occupations (22.1%) (Table 10).

Table 10. Workforce by Occupation, Grays Harbor County

Occupation	Estimate	Percent of occupations
Civilian employed population, 16 years and over	27,434	
Management, business, science and arts occupations	6,915	25.2%
Service occupations	6,451	23.5%
Sales and office occupations	6,059	22.1%
Production, transportation and material moving occupations	4,346	15.8%
Natural resources, construction and maintenance occupations	3,663	13.4%

Source: USCB, 2013a

ESD projects occupational job growth for a ten-year period from current occupational data (2012). Occupational job growth is projected by regions based on state Workforce Development Councils. Grays Harbor County resides in the Pacific Mountain region (Table 11), which also includes Lewis, Mason, Pacific and Thurston Counties.

By AARG, 2012-2017, the highest occupational growth is in Construction and Extraction (4.0%; 362 average annual openings), Transportation and Material Moving (2.8%; 370 average annual openings) and Healthcare Support Occupations (2.4%; 115 average annual openings). Healthcare Support is projected to have the highest AARG, 2017-2022, at 2.0%, or 107 average annual openings.

Table 11. Recent and Projected Job Growth in Selected Occupations for the Pacific Mountain Region

						Average Annual			
	Estimated Employment			AARG		Openings due to growth		Total Openings	
Occupations	**2012**	**2017**	**2022**	**2012-17**	**2017-22**	**2012-17**	**2017-22**	**2012-17**	**2017-22**
Total, All Occupations	189,737	206,152	216,431	1.7%	1.0%	3,267	2,035	7,972	6,880
Management	9,948	10,514	10,969	1.1%	0.9%	113	90	309	334
Community and Social Service	3,744	3,988	4,193	1.3%	1.0%	49	39	136	143
Education, Training, and Library	12,351	13,326	14,097	1.5%	1.1%	190	153	457	452
Healthcare Support	4,590	5,174	5,705	2.4%	2.0%	115	107	193	212
Food Preparation and Serving Related	14,419	15,913	16,560	2.0%	0.8%	298	129	976	610
Sales and Related	20,074	21,427	22,513	1.3%	1.0%	271	218	975	804
Office and Administrative Support	26,083	27,868	29,035	1.3%	0.8%	358	234	920	827
Farming, Fishing, and Forestry	5,978	6,285	6,296	1.0%	0.0%	63	1	201	135
Construction and Extraction	8,368	10,179	10,764	4.0%	1.1%	362	115	507	292
Installation, Maintenance, and Repair	7,357	7,953	8,288	1.6%	0.8%	120	62	283	259
Production	7,577	8,328	8,551	1.9%	0.5%	149	43	325	224
Transportation and Material Moving	12,548	14,396	15,011	2.8%	0.8%	370	121	657	454

Source: ESD, 2014

SECTION FOUR: Scenario Modeling: Potential Impacts of Oil Spills

As described in Section 1.4, project proponents state that they will receive and ship a variety of bulk liquids, including (and specifically in the case of the GHRT) crude oils. The Washington State Department of Ecology (DOE) recently stated that the transportations of oils "into and through the state of Washington have primarily involved the transport by rail of two different types of crude oil – Bakken crude from North Dakota, and diluted bitumen from Alberta, Canada" (DOE, 2015). Thus, it was assumed that these are the crude oil types most likely accepted and shipped by the proposed projects. Much of the information presented below on oil characteristics is sourced from the March 1, 2015, "Washington State 2014 Marine & Rail Oil Transportation Study" (DOE, 2015). It should be emphasized that the study authors have not independently verified the information or conclusions within this publication, and thus cannot attest to its accuracy.

Assumptions inherent in hypothetical oil spill scenarios in and near Grays Harbor are described in this section. These scenarios are required to estimate economic impacts and changes in economic contributions by affected business activities.

4.1 CRUDE OILS OVERVIEW

Crude oils are typically placed in one of three groups: light oils, medium oils and heavy oils. Light oils (including light crude oils) are considered moderately toxic, and are less likely to persist in the environment and adhere to surfaces and substrates than are medium and heavy oils (DOE, 2015). Light oils are capable of contaminating surfaces and subsurfaces, and hold the potential for long-term contamination. Light oils leave a residue of up to one-third of the spill amount after a few days, and are generally possible to clean up with typical response methods and tools.

Medium oils (including medium crude oils) are considered moderately toxic, moderately persistent and moderately adherent (DOE, 2015). Typically, up to one-third of a medium oil spill will evaporate within 24 hours; contamination of surfaces and subsurfaces by medium oils can be severe and long-term. It has been observed that cleanup of a spill of a medium oil is most effective if conducted soon after the event. Medium oils can have severe adverse impacts to waterfowl and fur-bearing mammals.

Heavy oils (including heavy crude oils) are considered moderately toxic, highly persistent and highly adherent. Heavy oils tend to exhibit low volatility, weather slowly, and cause heavy contamination (DOE, 2015). Long-term contamination of surfaces and subsurfaces by spilled heavy oils is possible, and cleanup of spilled heavy oils are difficult under all conditions. Heavy oils can have severe adverse impacts to waterfowl and fur-bearing mammals, and other organisms through smothering, ingestion and mechanical injury.

Bakken crude oils exhibit characteristics most similar to light crude oils (DOE, 2015). Bakken crude oils are more volatile than most other domestic crude oils, and are more ignitable and flammable.

These oils also have a low viscosity (meaning that it has a low resistance to flowing once set in motion), more similar to diesel or gasoline than to other crude oils.

Diluted bitumen crude oils, also known as 'dilbit' or Canadian 'tar sands oil', are a broad category of oils comprised of bitumen blends. These blends exhibit characteristics most similar to heavy crude oils (DOE, 2015). Diluted bitumen crude oils are produced by mixing bitumen (the highly viscous heavy crude oil extracted) with diluents of naphtha-based oils (such as natural gas condensates) to a 70:30 bitumen:diluent ratio. Diluents assist in moving the mixture through pipelines. The diluent fraction will evaporate quickly after an oil spill; the heavier bitumen fraction will remain. Diluted bitumen crude oils have been found to exhibit similar corrosiveness, densities and viscosities to conventional heavy crude oils (DOE, 2015).

4.2 Oil Characteristics

Spilled oil undergoes physical and chemical processes called 'weathering' in the environment. Weathering processes occur at different rates, which are functions of oil type, if the spill is on land or in water, and climatic and environmental conditions. Weathering processes include evaporation, emulsification, oxidation, spreading, dissolution, dispersion, sedimentation and biodegradation. These processes can cause spilled oil to become available for uptake by plants and animals, and affect toxicity and spill response.

Density is an important characteristic of oils. Diluted bitumen crude oils are denser than Bakken crude oils. When oil spills into water, its more volatile components evaporate, leaving less volatile, denser components. As oil density increases, it is more prone to sink. When sinking oil adheres to suspended sediments or debris in the water column an oil-mineral aggregate (OMA) is formed. If the OMA is denser than the water, it will sink. OMAs are more likely to occur when the spilled oil is in fine droplets, where there is a high concentration of sediments in the water column (for example in the surf zone of a beach or around a vessel loading zone), and where the water is highly turbulent. OMAs can remain suspended in the water column, mix with sediment and settle on the substrate, or diffuse through a substrate, and can be ingested by fish or shellfish (DOE, 2015).

Salinity and temperature also influences whether oil will float, become suspended in the water column, or sink. Saltwater and estuarine water are denser than freshwater. Thus, the same oil can float in saltwater but sink in estuarine water. Oil density increases as temperature decreases.

Denser oils disperse more readily through the water column, and tend to spread faster on the water surface in the early stages of a spill than do less dense oils (DOE, 2015). Denser oils are also more likely than less dense oils to form stable emulsions in the water (DOE, 2015). Emulsified oils are more likely to persist in the environment, and are often much more viscous than the parent oil. Emulsions can present a range of challenges and complications in spill response, such as needing to collect and store and large volume of an oil/water mix.

Recently, Government of Canada researchers found that two diluted bitumen products float on saltwater "even after evaporation and exposure to light and mixing with water" (DOE, 2015).

However, both products, when mixed with suspended sediments by high-energy wave action; either sunk or were dispersed as floating tarballs. They also found that the effectiveness of chemical dispersants on these products was limited under normal conditions, and that dispersants were not effective when the products were mixed with sediments. However, DOE (2015) notes the behavior of oils is dynamic in real-world spills – some of the oil floats, some sinks, and some remains suspended in the water column (DOE, 2015).

Heavy and medium oils tend to be more adhesive (the degree to which oil remains after contact and draining) to surfaces, substrates and structures than are light oils. Oils exhibiting strong adhesiveness increase damage and cleanup costs, and limit the effectiveness of some on-water recovery methods (DOE, 2015).

More strongly adhesive oils can cause severe mechanical injuries to organisms. Mechanical injuries can be caused by coating, fouling or clogging "of organisms and their appendages and apertures, such that movements and behaviors are mechanically inhibited" (DOE, 2015).

The persistence of oil in the environment varies on many factors, including environmental conditions and other oil characteristics. Persistent oil fractions can adhere to and penetrate surfaces and substrates, causing serious ecological consequences. For example, highly persistent oil can adhere to feathers and fur, and shoreline and wetland communities, causing hypothermia, smothering and mechanical injury, and thus mortality (DOE, 2015). Persistent oil can also "interfere with the normal physical characteristics of substrates and sediments and make them inhabitable [sic]. Oil residues can also agglomerate with inorganic and organic particles or debris and become ingestible" (DOE, 2015).

DOE considers heavy and medium oils to be highly persistent in the environment (with an anticipated time of persistence five to ten years, or more), and light oils to be moderately persistent (with an anticipated time of persistence one month to one year).

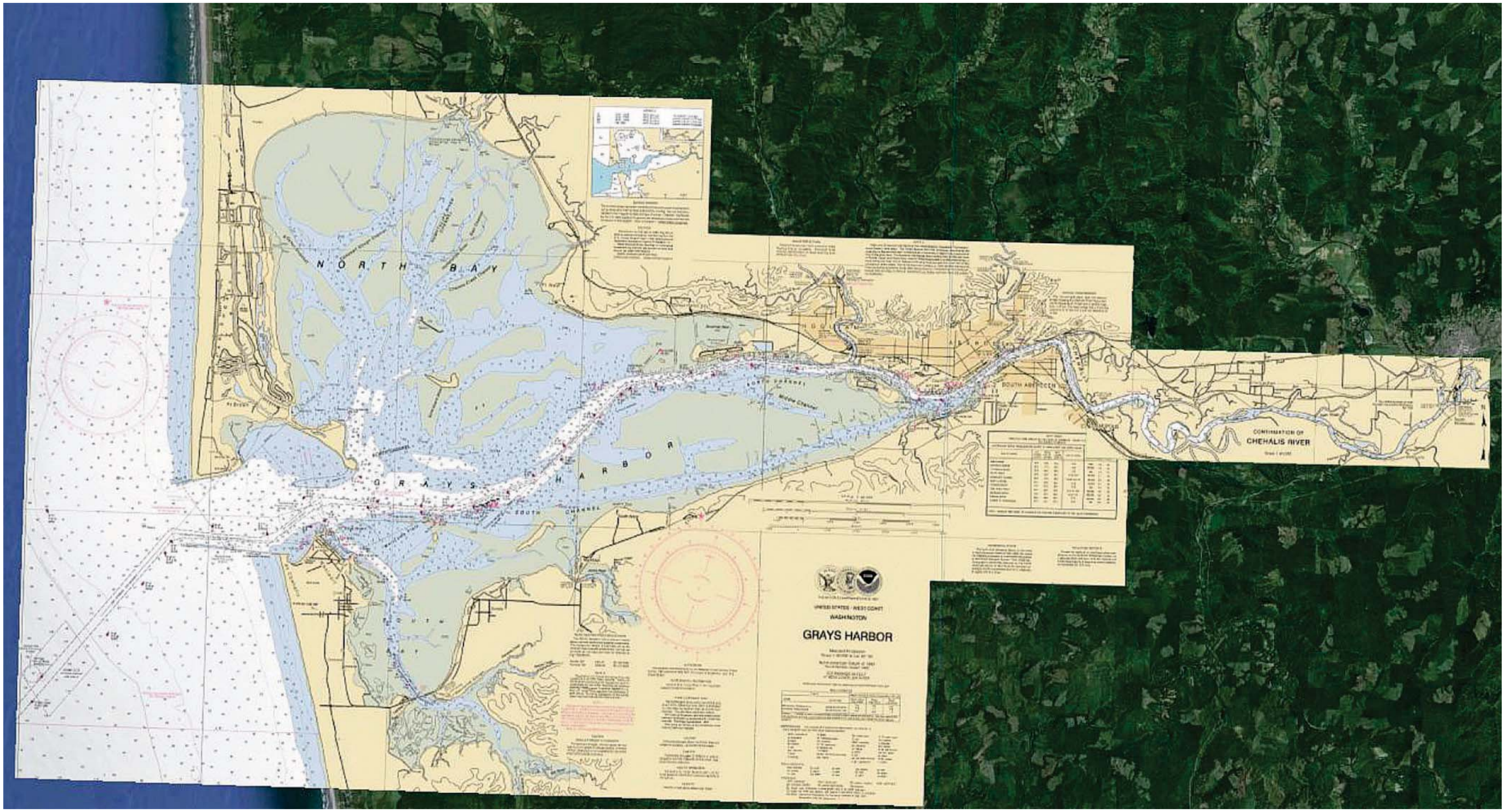
Oil spilled on land or onto shorelines can spread, move downslope, evaporate or penetrate the substrate. Lands in the study area include shorelines inside Grays Harbor that are primarily marshes and sheltered tidal flats, and coastal shorelines consisting mainly of fine-grained sandy beaches (DOE, 2013a). Penetration rates of substrates are functions of temperature, porosity, saturation, land cover, oil viscosity and effective permeability. Diluted bitumen crude oils exhibit a high degree of penetration in sandy shores and estuarine sand sediments (DOE, 2015).

4.3 Physical characteristics of Grays Harbor

Grays Harbor is approximately 15 miles long, and at its widest, the Grays Harbor estuary is about 13 miles wide, narrowing to less than 100 yards wide in some places. The Chehalis, Wishkah, Hoquiam, Humptulips, Johns and Elk Rivers drain into Grays Harbor, as do numerous smaller rivers, creeks and streams. The entrance to Grays Harbor is about 2.5 miles wide (DOE, 2013a). Navigation of marine vessels in and out of Grays Harbor is challenging, as Grays Harbor "has a complex navigation route due to a breaking bar at the entrance, a constrained channel and limited depth" (DOE, 2015). At the bar, "inward-flowing ocean swells converge with outward flowing river currents" (DOE, 2013a). This convergence, combined with sometimes strong and erratic currents and limited visibility, can be hazardous to vessel traffic. Further, two jetties (comprised of rocks placed by U.S. Army Corps of Engineers) extend seaward from the Grays Harbor entrance for 0.2 miles (north jetty) and 0.9 miles (south jetty). Hazardous breakers can sometimes form near these jetties, especially during rough weather (DOE, 2015).

The predominant features of Grays Harbor are intertidal mud and sand flats that are formed as river-borne sediments and marine sediments deposit; water depths throughout the estuary are usually less than 20 feet (DOE, 2013a). The Grays Harbor navigable channel (the North Channel) has many shoals and flats, and it "*narrows to 0.6 miles wide with a number of turns where course changes are required*". See Figure 5 for the nautical chart of Grays Harbor. This dredged channel is 46 feet deep at the bar, 42 to 40 feet deep at the entrance, decreasing to 36 feet deep to Cow Point, and to 32 feet deep to Cosmopolis (DOE, 2015). The Middle and South Channels "*remain shoaled by erosion and sediment deposits*" and have not been dredged for navigation (DOE, 2013a).

Figure 5. Grays Harbor nautical chart



Source: Grays Harbor, NOAA Chart 18502, 2014. http://www.nauticalcharts.noaa.gov/csdl/seamlessraster.html

4.4 AVAILABLE RESEARCH ON OIL SPILLS IN GRAYS HARBOR

This study has been conducted prior to an actual crude oil spill event in or near Grays Harbor attributable to the proposed projects. From real-world spills, it is known that the behavior of spilled oil in the environment is a function of the type and volume of oil spilled, climatic and environmental conditions, and geographic location. Spilled oil undergoes weathering processes once it is released into the environment. Spilled oil is also transported through the environment by physical forces, for example by wave action or wind. To understand the risk of crude oil spills resulting from the proposed projects, and the fate and transport of spilled oil in or near Grays Harbor, the study authors conducted a literature review for research on these topics specific to Grays Harbor.

Understanding the risk of a crude oil spill in Grays Harbor is predicated on understanding its marine vessel traffic system, and that Grays Harbor and the Pacific coast are dynamic. The risk of an oil spill from an individual marine vessel is a function of a complex set of internal and external variables (Finley, 2013). Finley (2013) explains that "Internal variables relate to the operation and maintenance of the vessel itself. External variables relate to the conditions and environment in which the vessel operates." Internal variables that lead to oil spills may result from "poor training of personnel, errors in judgment or perception, lack of skill, corporate culture, inadequate safety procedures, poor equipment maintenance, or malfunctioning equipment" (Finley, 2013). External variables include "environmental conditions such as weather conditions, visibility, sea state, currents and tides" or interactions with other marine vessels in the vicinity that may cause an accident or grounding (Finley, 2013). Finley (2013) concludes that *"By increasing the number of vessels in a system, the risk of a single vessel spilling oil will likely also increase as a result of the change in external variables, such as the presence of other vessels".*

Further, Finley (2013) explains, "*Each vessel poses an individual risk that an oil spill could occur. More vessels operating means more chances of a spill. However, because the vessels are not operating independently in the system, this overall increased risk of a spill is not a simple additive increase based on the number of vessels. Rather, interactions between vessels in an increasingly complex system enhance the increased risk of a spill occurring in Grays Harbor. With each additional vessel operating in Grays Harbor, the risk or chance that an oil spill will occur in Grays Harbor goes up*".

As of March 2015, neither a vessel traffic impact analysis (VTIA) nor a rail traffic impact analysis (RTIA) has been conducted for the cumulative traffic attributable to the proposed projects. In the absence of these risk analyses, it is not possible to realistically gauge the risks of accidents involving marine vessels transporting crude oil or involving CBR unit trains.

As of March 2015, there are no publically available location files of Grays Harbor for the General NOAA Operational Modeling Environment (GNOME) tool. GNOME is used by NOAA to predict the possible trajectory a pollutant might follow in a body of water (i.e. the flow of oil). Though it is possible for users to create their own location files, NOAA forewarns that doing so requires regional physical oceanographic expertise, and thus is outside of the scope of this study.

DOE was apparently provided GNOME model location files for Grays Harbor prior to December 2013. These files will help DOE "*better understand the possible route, or trajectory, an oil spill might follow in Grays Harbor based on different input variables including the date and time of a spill, location, product types and quantity, and certain environmental conditions*" (DOE, 2013b). No results of this modeling have been publicly released as of March 2015.

Further, there is no publically available fate and transport model for spilled oil in or near Grays Harbor as of March 2015. Thus, it is not possible to realistically predict what happens to spilled oil once it is in water or on land in Grays Harbor. These would include the resources impacted, the severity and magnitudes of environmental impacts, and the duration of these impacts. For example, a fully loaded tanker can transport more oil than a fully loaded ATB; thus the tanker would pose a higher magnitude of environmental impact. Environmental impacts also depend to an extent on the type of oil transported. There may be more severe environmental impacts from an oil spill in one area of Grays Harbor than another area, due to the shipping channel, vessel traffic patterns or environmental conditions (Finley, 2013).

One publicly available study has assessed the fate and transport of oil spilled outside the mouth of Grays Harbor. A spill of 25,000 bbls (1,050,000 gallons) of Bunker C fuel oil three miles off the entrance to Grays Harbor was modeled under several response scenarios. Modeling results showed that in the absence of response, spilled oil could spread through the majority of Grays Harbor within six hours post-spill, and could penetrate salt marsh habitat as soon as 12 hours post-spill (ASA, 2006). Though these findings are of limited utility for this study, given significant difference in characteristics between Bunker C fuel oil (a heavy oil) and Bakken and diluted bitumen crude oils, it suggests that oil spilled inside Grays Harbor could spread throughout and penetrate sensitive habitats in less time.

There is one known, large oil spill near Grays Harbor, the Nestucca spill. In December 1988 the barge Nestucca, loaded with over 70,000 bbls of Bunker C fuel oil was being towed from Ferndale, Washington to Portland, Oregon by the tug Ocean Service. A stop was planned in Aberdeen, Washington. At 11:00 p.m. on December 22, 1988, the Ocean Service prepared to cross the Grays Harbor bar in rough conditions – reportedly "wave heights of up to 14 feet with occasional 16-foot breaking swells, with winds of 10 knots out of the west" (Yaroch, 1991). To cross the bar, the tug shortened the towline to the barge. The towline snapped and in an attempt to recover the free-floating barge the tug was lifted in a swell, colliding with the barge and opening a hole in the cargo tank. About 5,500 bbls (231,000 gallons) of Bunker C fuel oil was spilled until the hole could be temporarily patched about 24 hours later (Yaroch, 1991).

Due to high seas and strong currents, responders used no containment booms. Most of the spilled oil washed ashore close to Ocean Shores, Washington; however, the oil slick dispersed as far south as Oregon and as far north as Vancouver Island, British Columbia, washing oil ashore. The Washington coastline was oiled from Grays Harbor north to the Strait of Juan de Fuca; shorelines within Grays Harbor were also oiled (USFWS, 2004).

Spilled oil reached shore on the west coast of Vancouver Island in discontinuous patches first on December 31, 1988. Small amounts of oil eventually washed ashore from near Victoria to Cape Scott, British Columbia over the next three weeks. Most of the oil that washed ashore was comprised of weathered tarballs that usually covered less than five percent of the intertidal zone. Continuous covering of the intertidal zone occurred on a few beaches, typically in coatings 10 to 15 feet wide, 40 to 60 feet long and up to 1.5 feet thick (Owens, 1991). Harvest closures for crab and shellfish occurred as many populations were exposed; multiple commercial crabbing areas were closed for six months due to persistent contamination (Davis, 1989). Estimated migratory bird mortality from the Nestucca spill ranged from 52,000 to 78,000 seabirds (USFWS, 2004).

4.5 Hypothetical oil spill scenarios

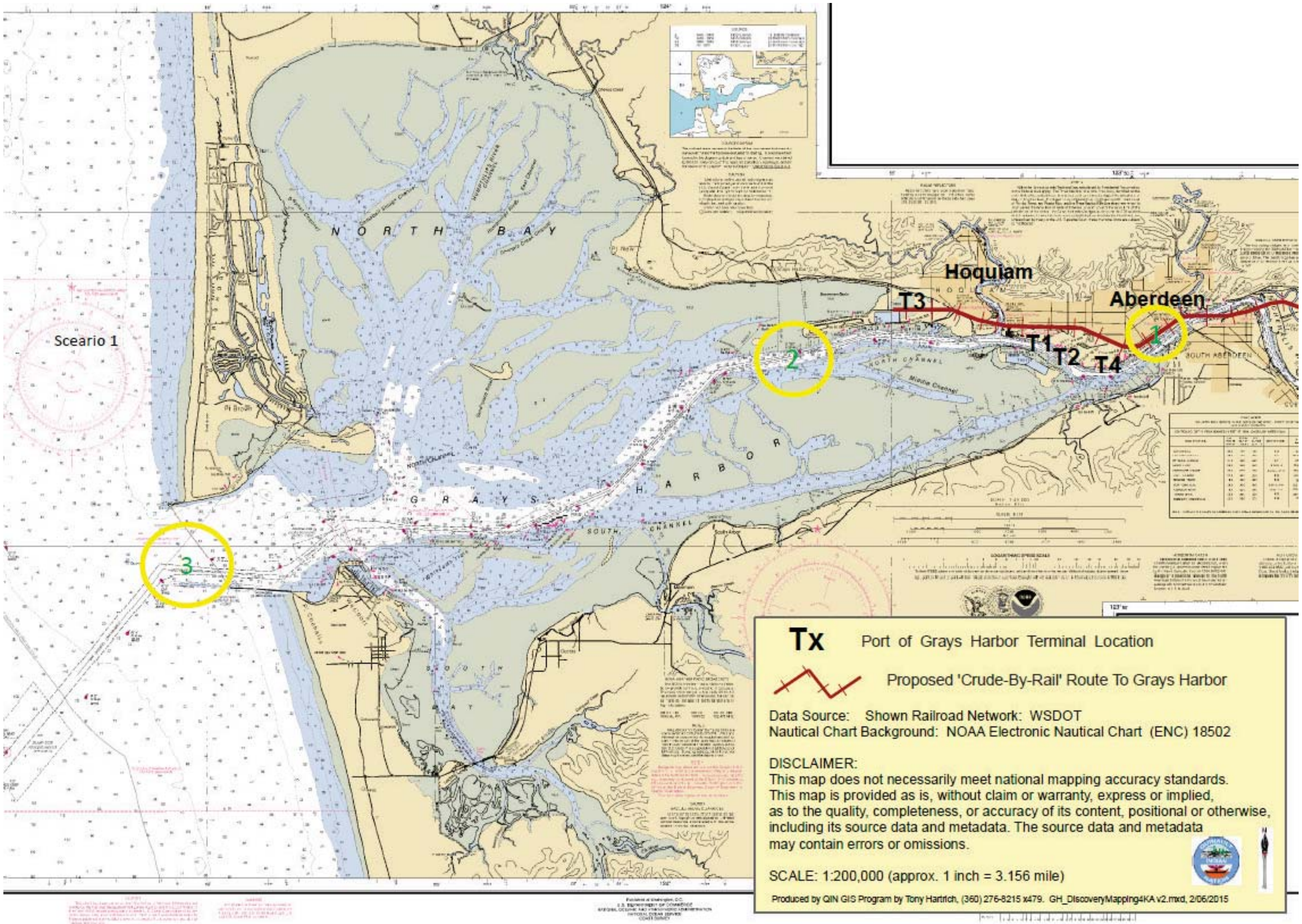
Applying the *Nestucca* spill and the ASA (2006) modeling results to project likely environmental impacts in the event of an oil spill is problematic as these cases involved Bunker C fuel oil. Further limiting their utility is that they occurred/were modeled to occur outside of the entrance of Grays Harbor, and involved much less oil than could be shipped by Panamax tankers or ATBs.

With no traffic risk analyses, oil flow model or fate and transport model specific to oil spills in Grays Harbor as of March 2015, assumptions were made regarding business activities affected, estimated economic impacts and thus estimated changes in economic contributions post-spill. It was assumed that the type of oil spilled was a crude oil, based on project proponent documents and DOE (2015). To facilitate these estimations four scenarios were constructed:

- **Base Case:** Assumes status quo for typical activities, based on those in existence in 2013.
- **Scenario 1:** Derailment of or an accident involving a CBR unit train between the Wishkah River crossing and Cow Point, causing a spill into the Chehalis River.
- **Scenario 2**: A marine vessel accident inside Grays Harbor in the navigable channel near Moon Island, causing a spill.
- **Scenario 3:** A marine vessel accident off the Grays Harbor entrance due to the bar crossing, causing a spill.

The selected locations of Scenarios 1, 2 and 3 (Figure 6) are relatively close to the 'Potential Oil Spill Origin Points' used for response planning in the Grays Harbor Geographic Response Plan (DOE, 2013a). The Scenario 1 location was selected due to its proximity to the Chehalis River and to potential accidents with other traffic. The Scenario 2 location was selected because it is seaward of both T1 and T3, where loaded departing tankers and ATBs could conflict with other vessel traffic in the narrow navigable channel. The Scenario 3 location was selected because the Grays Harbor bar crossing is known to be highly dangerous in rough weather, and because of the potential for grounding on the jetties.

Figure 6. Oil spill scenario locations



Source: QDNR GIS Program, 2015

Scenario parameters are defined through a series of assumptions, explained below:

Year of hypothetical oil spill events

Scenarios 1, 2 and 3 are assumed to occur in 2020, the first year of full build-out and operation of all three projects.

Westway proposes two phases of project construction, with Phase 1 occurring from March 2016 to March 2017. The start date of Phase 2 is undefined, but it is anticipated that this phase will require ten months; apparently total construction is anticipated to require at least 24 months (Westway, 2014). Imperium proposes to begin construction of project elements in several phases, with construction beginning in June 2013 and continuing until December 2014 (19 months) (Imperium Renewables, 2013)[9]. GHRT anticipates a construction phase of approximately 12 months (HDR Engineering, Inc., 2014a).

We assume all proposed projects progress through the regulatory process and are permitted in their current (March 2015) incarnations, that all construction requires at least two years, and that facility operations will ramp up to full capacity. Thus, we assume that 2020 is the year of incident for each scenario.

Type of crude oil spilled

Much of the data on impacts of oil spills relied on in this study was collected from the Exxon Valdez oil spill. After grounding on March 24, 1989, the Exxon Valdez (Exxon) spilled approximately 258,000 bbls (10,836,000 gallons) of Alaska North Slope (ANS) crude oil into Prince William Sound, Alaska. It is estimated that about 20% of the spilled oil evaporated, and about 40% of the spilled oil coated the intertidal areas of Prince William Sound (Rice, et al., 2001).

Of the two crude oil types considered, diluted bitumen crude oils are characteristically more similar to ANS crude oil than are Bakken crude oils, in terms of volatility, persistence and potential for smothering and mechanical injury (DOE, 2015). The biological effects of spilled ANS crude oil are well-known, and likely affected business activities, and hence economic impacts, can be readily projected. Thus, it was assumed that diluted bitumen crude oil was the type of oil spilled in Scenarios 1, 2 and 3.

Volume of oil spilled

Recent CBR unit train derailments have resulted in crude oil spills ranging from 4,550 gallons to 748,400 gallons (DOE, 2015). It was assumed that the volume of crude oil spilled in Scenario 1 is 542,000 gallons, or about five percent of the volume spilled by Exxon.

Panamax tankers have a capacity of 14,700,000 gallons. It was assumed that the volume of crude oil spilled in Scenarios 2 and 3 is 11,000,000 gallons. This volume is nearly equivalent to the volume of spilled by Exxon, and is about 75% of the capacity of a Panamax tanker.

[9] This period has passed as of writing (March 2015).

Fate and transport of spilled oil

Diluted bitumen crude oils are not highly volatile; however, some fraction of the spill will evaporate. As discussed in Section 4.2, diluted bitumen crude oils tend to form stable emulsions and adhere strongly to hard surfaces, making cleanup difficult. Strongly adherent oils have exhibited a high capacity to cause smothering and mechanical injury.

Spilled oil was assumed to disperse rapidly in the water column and spread on the water surface. Fine droplets are assumed to form OMAs and settle in the water column or sink, especially where there is a high volume of suspended sediments such as around the PGH. Diluted bitumen crude oils are also thought to be highly persistent in the environment, possibly for up to ten years (DOE, 2015); thus, it was assumed that spilled oil would persist for this duration.

It was assumed that oil spilled in Scenarios 1, 2 and 3 spreads eastward through the intertidal zone, and throughout all of Grays Harbor in a matter of hours. It was assumed that oil spilled in Scenarios 2 and 3 spreads seaward north and south on the Pacific coastline of Washington in a matter of hours. Note that oil spread could vary considerably depending on tidal stage.

Spill response

Spill cleanup techniques for Grays Harbor include the use of containment booming, skimmers and vacuum trucks (DOE, 2013a). Chemical dispersion is also an option within one to two days after a spill.[10]

It is dubious whether the current (December 2013) response plan for oil spills in Grays Harbor is adequate for large spills such as in the scenarios, and whether sufficient resources and work force is available. Spill response capacity is limited in Grays Harbor, as the two primary spill response contractors have relatively small stockpiles of containment booms, vacuum trucks, storage tanks and other support equipment (O'Brien, 2013). These contractors would require additional response assets brought from offsite were a spill to exceed their current capacities (O'Brien, 2013). These limitations could delay spill response, allowing oil to spread.

The use of containment booms and other response techniques on the Chehalis River are not likely to be effective due to swift currents and debris (O'Brien, 2013). Oil can disperse and affect shorelines quickly in this situation. Sediment and debris can also contribute to oil becoming suspended in the water column or sinking, impeding spill response. Further, currents, wind and tidal flows (acting on currents in Grays Harbor and at the terminus of the Chehalis River) can decrease the effectiveness of containment booming (Finley, 2013).

In the event of a significant spill, as in the scenarios, there is the possibility of a large volume of contaminated water that must be stored, as emulsions require a large storage capacity because they are oil/water mixtures (DOE, 2015). It has been demonstrated that *"providing sufficient water storage capacity in Grays Harbor for recovered waste liquids from a significant oil spill has been*

[10] The toxicities of chemical dispersants to plants and animals are not considered in this study, due to uncertainties as to the specific dispersants that might be used, and the interactions of these dispersants with different oils.

problematic for response contractors and cooperatives such as NRC, CCS, and WSMC in this area due to the limited availability" (O'Brien, 2013).

It was assumed that spilled oil reaches shorelines and the Grays Harbor estuary in a matter of hours. Chemical dispersants apparently have limited utility in dispersing diluted bitumen crude oils: "*Under conditions simulating breaking waves, where chemical dispersants have proven effective with conventional crude oils, a commercial chemical dispersant (Corexit 9500) had quite limited effectiveness in dispersing diluted bitumen*" (DOE, 2013a).

Thus, it was assumed that due to limited spill response capability, climatic and environmental conditions, storage volume, and likely cleanup techniques in or near Grays Harbor, minimal containment and recovery of spilled oil was anticipated in Scenarios 1, 2 and 3.

4.6 BUSINESS ACTIVITY CHANGES AFTER OIL SPILLS

Oil spilled in Scenarios 1, 2 and 3 was assumed to cause environmental externalities that in turn affect business activities in many industries. This study is primarily concerned with assessing business activity changes, economic impacts, and changes in economic contributions by Treaty fisheries-based businesses and select QIN-owned businesses likely affected. Known oil spills were researched to ascertain the severity and duration of effects to business activities post-spill.

4.6.1 Fisheries-based activities

Smothering and mechanical injury due to oil contamination can cause acute mortality to juvenile and adult fish and shellfish via exposure pathways including physical contact, respiration and ingestion. It was assumed that acute mortality would result in decreased numbers of harvestable fish and shellfish.

Finfish are highly mobile and tend to swim away from unfavorable conditions. However, adult salmon returning through Grays Harbor to spawn were assumed to be at-risk of acute mortality due to oil ingestion and mechanical injury in Scenarios 1, 2 and 3. Juvenile salmon entering or residing in the Grays Harbor estuary were also assumed at-risk of acute mortality due to oil ingestion and mechanical injury.

Juvenile and adult Dungeness crabs, less mobile than finfish, were assumed to be at-risk to acute mortality due to oil ingestion, smothering and mechanical injury. In Scenarios 1, 2 and 3 it was assumed likely that OMAs would settle in the water column and on the substrate, polluting the crabs' entire environment.

Mollusks including razor clams were assumed to be extremely vulnerable to spilled oil, and at-risk to acute mortality due to oil ingestion, smothering and mechanical injury. As with Dungeness crabs, the razor clams' entire environment was assumed to be polluted – continuing to harm organisms until cleaned.

Oil spills can cause harvest closures or render seafood harvests unmarketable and unsafe. Carcinogenic constituents (the chemical compounds that comprise an oil) released by weathering processes have been shown to rapidly build-up in finfish and shellfish tissue (NOAA, 2002). Finfish can rid themselves of these toxins quickly due to high metabolisms. However, mollusks require a long time to cleanse themselves, perhaps weeks or months depending on the species and site-specific conditions. If the levels of carcinogenic compounds in finfish and shellfish tissues were above safe levels for human consumption, harvests of these fisheries would be closed. Further, persistent exposure to carcinogenic compounds could close harvests for a long period.

Harvest closures after oil spills have ranged from months to years (Kingston, 1999; Gilroy, 2000; NOAA, 2002; Gohlke, 2011). For example, after Exxon salmon and herring harvests were closed for one season and advisories were published for four shellfish subsistence harvest areas. All fisheries were closed after the Deepwater Horizon spill (spill started April 20, 2010) for at least one month, some for up to 12 months (Gohlke, 2011).

Decreased market demand for perceived unsafe seafood products could also limit landings and revenues in the months post-spill. Seafood can be unpalatable at very low levels of oil contamination, and consumer concerns regarding food safety can limit demand for potentially tainted seafood (Moller, et al., 1999). Significant brand damage to seafood was incurred after the 1993 *Braer* spill off Shetland, Scotland, and market demand for fish and shellfish plummeted, severely harming the local fishing industry (Goodlad, 1996). Consumer demand for Gulf of Mexico seafood products decreased sharply in the months after the Deepwater Horizon spill over concern about seafood safety, and the seafood supply chain was disrupted (CRS, 2011).

Weathered constituents of ANS crude oil have been shown to cause mortality to salmon embryos and decrease the marine survival rate of exposure survivors by 15% (Heintz, Short and Rice, 1999; Heintz, et al., 2000).[11] Embryos residing in rivers and tributaries draining into Grays Harbor or juveniles residing in the Grays Harbor estuary are assumed to be exposed to the spilled oil in Scenarios 1, 2 and 3. Chinook and coho salmon exposed as embryos could be adversely affected up to six years post-exposure (the oldest salmon of a broodyear return to their birth places for spawning at six years) (Jorgensen, 2013). In other words, a portion of oiled embryos will be killed immediately, and survivors are less able to survive their time at sea and return to spawn. Ostensibly, there will be less fish to catch, and it was assumed that fisheries-based activities associated with fishing these populations are diminished post-spill.

It was also assumed that a portion of Dungeness crab larvae and razor clam larvae exposed to spilled oil and oiled sediments would be killed immediately.[12] Reproductive maturity for razor clams in the Pacific Northwest is typically reached at an age of two years, and reproductive maturity for Dungeness crabs is typically reached at an age of two or three years (USFWS, 1989; WDFW, 2008). As in the finfish fisheries, if razor clams and Dungeness crab are killed before they reproduce, or from smothering or mechanical injury, it was assumed that less clams and crabs would be available to harvest post-spill.

[11] Toxic effects of oil contamination to finfish are explained in more detail in Section 5.1.
[12] Toxic effects of oil contamination to shellfish are explained in greater detail in Section 5.2.

There is also the issue of the impracticality of fishing in oiled areas. Fishing vessels, nets and other gear could be fouled by oil, and fish contacting oiled nets would most likely be unmarketable (Jorgensen, 2013). Interviewees reported they would not attempt to fish in oiled areas, out of concern for fouling gear and the likelihood of fish and shellfish contamination.

To facilitate estimations of economic impacts, it was assumed that the combined impacts of acute mortality, harvest closures, an inability to fish and decreased demand reduce landings-related revenue by 50% from baseline in Scenarios 1, 2 and 3 in the first 12 months post-spill.[13] By extension, it was assumed that these impacts continue, and combined with generational impacts of oil contamination, reduce landings-related revenue by 33% from baseline over the next 12 months (to 24 months post-spill; 33% is also the median of the 12 months post-spill and 36 months post-spill reductions). Finally, it was assumed that generational impacts of oil contamination reduce landings-related revenue by 15% from baseline over the subsequent 12 months (to 36 months post-spill).[14]

It was assumed that the duration of impacts to fisheries-based activities begin in 2020, with landings-related revenue reductions occurring until 2022. To model economic impacts and changes in economic contributions of fisheries-based businesses, landings-related revenue was decreased by a factor of 33% (the median of the assumptions) for 2020, 2021 and 2022.[15]

4.6.2 Visitor-based activities

Most of the research on impacts of oil spills to the visitor-based industry was conducted after the Exxon and Deepwater Horizon spills. In the case of Exxon, the visitor-based industry was relatively limited, it that it predominately served hunters and sport fishers, rather than beachgoers as the Grays Harbor County visitor-based industry does. Data relative to the local visitor-based industry post-Exxon is mainly comprised of prospective survey results.

The Deepwater Horizon spill lasted 87 days, eventually discharging 20 times the volume of oil assumed in Scenarios 2 and 3. Researchers estimated that there was not a large drop in visitor-related spending, as business-related spending from spill responders offset trip-related spending by tourists (Tourism Economics, 2011). While it is likely that in the case of Scenarios 1, 2 and 3 some tourist-related spending losses would be offset by spill response-related spending increases, it was assumed to not be to the extent as estimated after Deepwater Horizon given differences in the nature and volumes of the events.

Scientific research has found that perceptions of risk can affect consumer patterns of demand (Crotts and Mazanec, 2013; Ritchie, et al., 2013; Ofiara and Brown, 1999). For example, even if a tourist would not be personally affected by an oil spill, simply their perception that they could be

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[13] A 50 percent reduction from baseline is a conservative value that reflects limitations in assuming the timing of the fisheries, timing of the spill event, severity of acute mortality, duration of harvest closure(s), uncertainties in consumer demand, etc.
[14] In accordance with the 15% reduction in marine survival in oil-exposed fish explained previously.
[15] Note that environmental impacts of oil spills can persist for many years. However, the economic impacts of these scenarios are only covered for three years post-spill, consistent with impacts observed after known oil spills.

personally affected or that their trip experience would be adversely affected could cause them to cancel or shorten their trip.

To estimate economic impacts from decreased visitation after Deepwater Horizon, Oxford Economics (2010) evaluated the duration of spill impacts on tourism after several oil spills, including Exxon, and concluded that the average range of time required for visitor spending to return to baseline was 12 to 28 months post-spill. For reference, visitor spending in the areas affected in Exxon required about 24 months to return to baseline.

Oxford Economics (2010) used low and high impact scenarios to estimate lost visitor revenue. The low impact scenario assumed a 12% decrease from baseline in the first 12 months post-spill, continuing to a 4% decrease from baseline 36 months post-spill. This trend was based on disruptions to visitor patterns lasting for 15 months post-spill. The high impact scenario assumed a 25% decrease from baseline in the first 12 months post-spill, continuing to an 8% decrease from baseline 36 months post-spill. This trend was based on disruptions to visitor patterns lasting for 36 months post-spill.

Ritchie, et al. (2013) reported significant decreases from baselines in vacation rentals on the U.S. Gulf Coast in the first six months after *Deepwater Horizon*. Decreases ranged from 7.5% in central west Florida to 29% in Alabama and Mississippi. Vacation rental revenue decreased by an average of 7.9% from baseline in the study area; Alabama and Mississippi – where beaches were heavily oiled – experienced a decrease in vacation rental revenue of 38.5% (Ritchie, et al., 2013).

Garza, et al. (2009) reported an estimated 15% decrease from baseline in uses of France's Atlantic Coast after the nearby *Erika* (December 12, 1999) and *Amoco Cadiz* (March 16, 1978) oil spills.

It was assumed that visitor-related revenues decreased 15% from baseline in Scenarios 1, 2 and 3 in the first 12 months post-spill. It was further assumed that visitor-related revenue was decreased 10% from baseline over the next 12 months (to 24 months post-spill), continuing to a decrease in visitor-related revenue of 5% from baseline over the next 12 months (to 36 months post-spill). This mimics the trendlines used by Oxford Economics (2010), is in the middle of their impact scenario estimates, and lasts for a post-spill duration typically observed after known oil spills.

It was assumed that the duration of impacts to visitor-based activities begin in 2020, with visitor-related revenue reductions occurring until 2022. To model economic impacts and changes in economic contributions of visitor-based businesses, visitor-related revenue was decreased by a factor of 10% (the median of the assumptions) for 2020, 2021 and 2022.

4.7 Business Activities Affected in Spill Scenarios

As previously discussed, assumptions regarding oil flow, environmental impacts and business activities affected by scenario are required to estimate changes in economic contributions from the affected industries and businesses.[16]

Table 12 presents the results of these assumptions. Solid circles signify that the business activity was assumed likely to be affected in that scenario. For example, it is likely that Dungeness crab fishing is likely to be affected by environmental externalities resulting from the spilled oil in each scenario. The absence of a solid circle indicates that the business activity was unlikely to be affected in a scenario. The business activities affected by scenario are explained in subsequent sections.

Table 12. Business Activities Affected by Scenario

Business activity	Scenario 1	Scenario 2	Scenario 3
Treaty commercial fishing			
Ocean salmon		●	●
River salmon and sturgeon	●	●	●
Dungeness crab	●	●	●
Halibut			●
Sablefish			●
Lingcod			●
Rockfish			●
Sardine			●
Razor clam		●	●
QIN business enterprises			
Maritime Resort	●	●	●
Quinault Beach Resort & Casino		●	●
Quinault Pride Seafood I	●	●	●
Quinault Pride Seafood II	●	●	●
Q-Mart I (Ocean Shores)		●	●
Q-Mart II (Aberdeen)	●	●	●
Ramada Inn - Ocean Shores		●	●
QIN commercial aquaculture	●	●	●

Source: Resource Dimensions, 2015

4.7.1 Scenario 1 - Derailment / Accident involving a CBR unit train

As discussed previously, it was assumed that a portion of spilled oil would not be cleaned up and would spread throughout Grays Harbor in Scenario 1. Spilled oil was assumed to affect river gillnetting and Dungeness crab fishing near the entrance to Grays Harbor, and thus landings and expenditures. A decrease in landings volume would affect Quinault Pride Seafood I and II, and a

[16] Potential post-spill habitat remediation and restoration costs are assumed to be borne by responsible parties and are not assessed in this study.

decrease in expenditures for fishing was assumed. The QIN commercial aquaculture pilot project in Grays Harbor was also assumed to be adversely affected by spilled oil. Based on the limited knowledge of oil flow, spilled oil in Scenario 1 was assumed to not affect offshore fishing and razor clam digging.

Post-spill, it was assumed that visitors would decline to visit the Grays Harbor area. Decreased visitation leading to decreased retail sales, etc., was assumed to adversely affect the those businesses dependent on visitor spending in Grays Harbor, such as the Maritime Resort and Q-Mart II. Accordingly, it was assumed that these businesses would decrease their spending. Due to their locations, it was assumed that the Quinault Beach Resort & Casino, Ramada Inn and Q-Mart I would not be adversely affected in Scenario 1.[17]

4.7.2 Scenario 2 - Marine vessel accident inside Grays Harbor

A much larger volume of oil is assumed to be spilled in Scenario 2 than in Scenario 1, and the spill location was assumed further seaward. Oil not cleaned was assumed to disperse throughout Grays Harbor and flow seaward due to tidal drainage, eventually exiting Grays Harbor and migrating north and south along the Pacific coast.

Spilled oil was assumed to affect ocean salmon fishing, river gillnetting, and Dungeness crab fishing, and thus landings and expenditures. It was also assumed that razor clam digging in coastal beaches would be adversely affected in Scenario 2. As in Scenario 1, a decreased volume of landings would adversely affect Quinault Pride Seafood I and II, and a decrease in expenditures for fishing was assumed. The QIN commercial aquaculture pilot project in Grays Harbor was also assumed to be adversely affected by spilled oil. Spilled oil in Scenario 2 was assumed to not affect offshore fishing.

It was assumed that all visitor-based businesses considered in this study would be adversely affected in Scenario 2, due to decreased visitation. It was assumed that these businesses would decrease spending accordingly.

4.7.3 Scenario 3 - Marine vessel accident off the Grays Harbor entrance

Based on the limited knowledge of oil flow, it was assumed that all fisheries-based activities and visitor-based activities considered in this study would be adversely affected by spilled oil in Scenario 3. It was assumed that these businesses would decrease spending accordingly. The difference between Scenarios 2 and 3 is that offshore fishing activities are assumed to be adversely affected in Scenario 3.

[17] The Maritime Resort is located at the southern end of Ocean Shores, near the entrance to Grays Harbor. It is assumed that visitation to the Maritime Resort would be adversely affected in Scenario 1 due to its proximity to the spill location. In contrast, it was assumed unlikely that visitation to the Quinault Beach Resort & Casino and the Ramada Inn would be adversely affected, due to their distances from the spill location.

SECTION FIVE: Effects of Oil Contamination on Treaty Resources

Discussion in this section reflects the findings from the literature review for effects of oil contamination on some of the economically and culturally important Treaty resources of the Grays Harbor Basin. These selected species include salmonids, shellfish and salt marsh plants that reside in the freshwater and estuarine environments of Grays Harbor, its rivers and tributaries, and Pacific coast beaches.

Toxicities of crude oils are determined by the concentrations of their chemical constituents, including aliphatics[18], monoaromatic hydrocarbons[19] and polycyclic aromatic hydrocarbons[20] (PAHs) (DOE, 2015). Scientific literature was reviewed to elucidate acutely toxic effects of crude oils (i.e. causing acute mortality); sublethal effects of the same; chronic toxicity resulting from persistent exposure to spilled oil; and generational impacts of oil contamination.

5.1 FISH

Several species of salmonids (including Chinook, coho and chum salmon and steelhead) and white sturgeon reside in the freshwater and marine habitats of Grays Harbor and its rivers and tributaries. Figure 7 displays the extent of documented salmonids in the Chehalis River Watershed.

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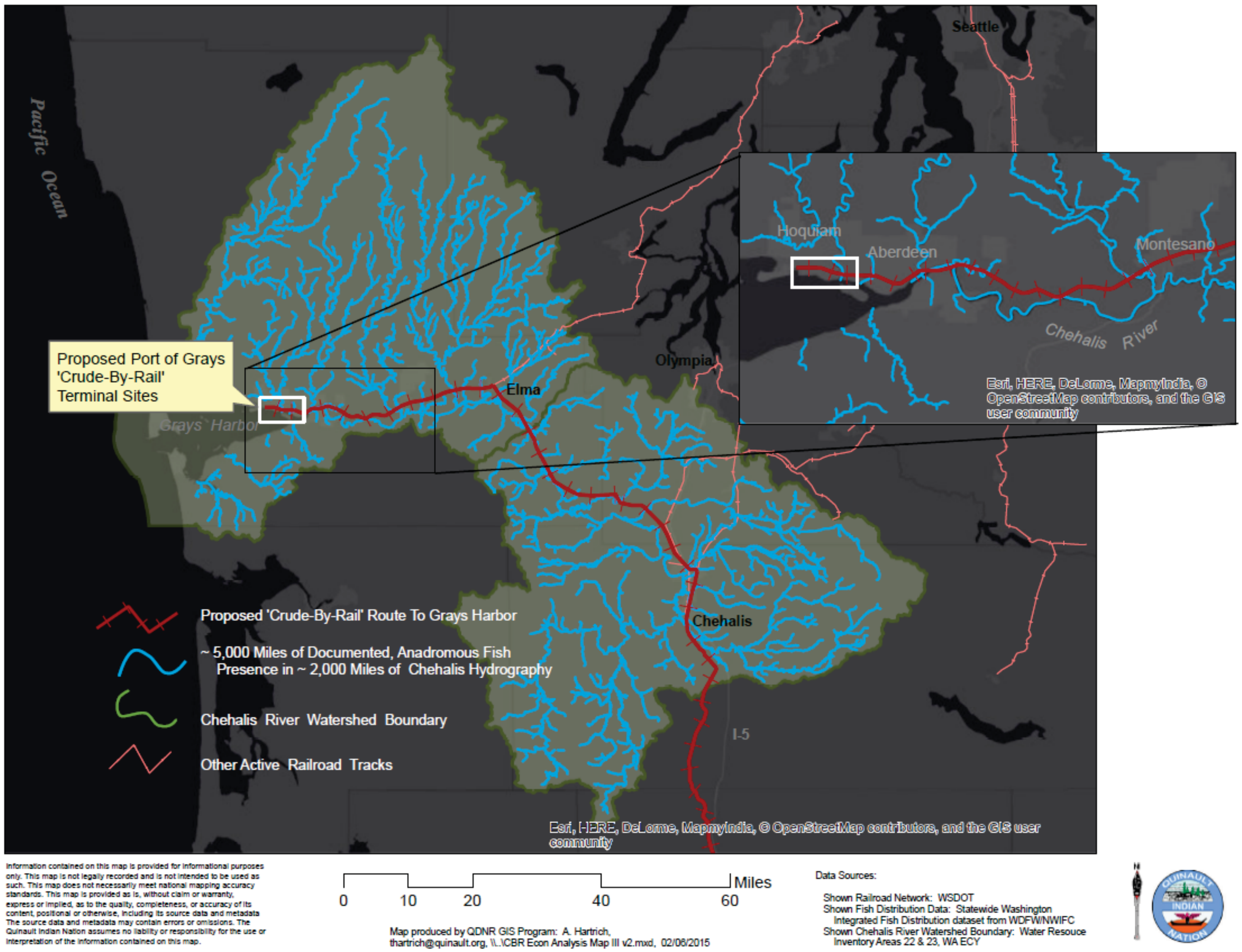
[18] Straight-chain hydrocarbons, such as alkanes.
[19] Benzene, toluene, ethylbenzene, xylene (BTEX), and alkyl-substituted benzenes.
[20] Napthalenes, phenanthrenes, fluorenes, dibenzothiophenes, etc.

Figure 7. Documented anadromous fish presence in Chehalis River Watershed



Source: QDNR GIS Program, 2015

Grays Harbor is the main conduit of migration for these species, for both adults returning to their home river to spawn, and for juveniles leaving the protection of Grays Harbor's 99 square miles of estuaries for open sea (Jorgensen, 2013).

Fertilized eggs incubate in redds dug into the gravel bottoms of rivers and streams for a few months until they hatch as alevins. Alevins grow in the gravel for several months, protected from predation and environmental threats. After alevins have consumed their yolk sacs, they freely swim from the gravel as fry. The Washington Department of Fish and Wildlife (WDFW) notes that "*Chum fry swim directly to the sea. Coho remain in fresh water for an average of one year while Chinook usually have a freshwater residence time of between three months to a year"* (WDFW, 2014b).

Fry begin their outmigration to the Pacific Ocean through the Grays Harbor estuary, where they remain for several weeks or months undergoing smoltification (growing into juvenile salmon) and consuming plankton and other nutrients.

Adult salmon, depending on the species, remain in the ocean from six months to four years, until returning to their home river for spawning. Chinook, coho, and chum salmon, and steelhead spawn in Grays Harbor's rivers and tributaries. For example, roughly 40% of the Chehalis fall Chinook and 37% of the steelhead fisheries spawn in the lower mainstem of the Chehalis River and in larger upriver tributaries (Jorgensen, 2013).

In testimony prepared for the State of Washington Shorelines Hearings Board, James E. Jorgensen, Salmon and Steelhead Management Biologist for the QDFi, explains the juvenile and adult life stages of salmon in the Grays Harbor area (Jorgensen, 2013, excerpted at 33):

> "*Chinook juveniles rear in the larger tributary and main stem areas where they collect as they progress downstream following their emergence from gravel which can begin after mid-February and continue through September. Juvenile chum leave the lower river and the estuary fairly early moving downstream along main stem areas. Coho during their first summer remain in habitat near or below their natal streams, overwintering then migrating to the ocean at a rapid pace in spring. Juvenile natural origin steelhead typically rear during two summers of residence to smolt size and migrate to the ocean following their second year of residence. Some coho and steelhead fry appear to pass into the estuary on their first summer and enter the estuary where they may migrate to the ocean following one overwinter in the freshwater."*
>
> *"Adult chinook have the longest river entry period from early May through November….followed by fall Chinook beginning to enter in mid-August and early September. Coho and fall Chinook generally begin their most significant entry into Grays Harbor terminal fishing areas beginning the last week of September through the 3rd week of October…..Coho extend their entry into February. Natural origin winter steelhead enters Quinault Nation fisheries beginning in December and extending through April."*

Much of the research conducted on the toxicity of crude oils to salmonids results from the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska (Exxon), specifically on chum salmon and pink salmon *(Oncorhynchus gorbuscha)*. This research extends from the effects of direct oil contamination and weathered oil on embryos, to delayed or sublethal effects of oil exposure on adults.

For example, directly after an oil spill event PAHs can immediately cross the cellular membranes of organisms, either as droplets in the water or from coating a substrate (such as the gravel of a redd). Exposure routes include direct physical contact to dissolved PAHs by embryos, alevins and fry, and ingestion of whole oil by juveniles, either from ingesting oil-contaminated prey or from mistaking oil droplets for prey (Carls, et al., 2008; Carls, et al., 1996). In other words, direct physical contact by embryos with spilled or weathered oil is not necessary for lethal or sublethal effects to occur in developing fish; merely the presence of dissolved PAHs makes them potentially toxic to embryos.

Further, the potential for exposure to PAHs by aquatic organisms has been shown to be increased in lower salinity waters, where PAHs are more soluble (i.e. PAHs are more readily dissolved in freshwater and estuarine water than saltwater) (Ramachandran, et al., 2006).

A preponderance of evidence has shown chronic adverse effects to biota from persistent sources of oil after Exxon. Some oil remained in subsurface sediments of oil-contaminated shores for at least 16 years after the spill (Peterson, et al., 2003; Short, et al., 2007). Subsurface oil did not weather until it was exposed, and posed as a persistent source of oil contamination (Short, et al., 2004).

Bue, Sharr and Seeb (1998) observed that significantly elevated mortality of pink salmon embryos incubated in oil contaminated streams continued for at least four years post-Exxon. Heintz, Short and Rice (1999) found that embryonic exposure to a 18.0 parts per billion (ppb) dose of oil-coated gravel resulted in a 25% reduction in survival, and that between the end of exposure and maturity marine survival was reduced a further 15%. Thus, 40% fewer mature adults were produced by the exposed population than by the control (unexposed) population.

In a meta-analysis, Rice, et al. (2001) concluded that long term, persistent exposure to weathered PAHs from Exxon caused a decreased rate of growth in fry, and a population decrease from depressed size.

Heintz, et al., (2000) found that pink salmon stocks incurred delayed effects on growth and marine survival resulting from embryonic exposure to conditions similar to that of the ANS crude oil spilled from Exxon. A portion of embryos surviving the initial exposure was released to the marine environment. When analyzed upon return two years later, pink salmon exposed to an initial concentration of 5.4 ppb total PAH experienced a 15% decrease in marine survival. Another portion of the exposed embryos were retained in net pens, and showed a delayed effect in juvenile growth (Heintz, et al., 2000).

Payne, Mathieu and Collier (2003) observed that PAHs concentrations in the 10 parts per million (ppm) range have been measured in sediments worldwide, yet aqueous concentrations of PAHs as low as 1 ppb have caused adverse impacts in fish larvae and sublethal effects in adult fish.

In addition to acute mortality, exposure to dissolved and weathered PAHs induces sublethal biochemical effects in fish embryos, including cardiac dysfunction, edema, spinal curvature and jaw size reduction (Incardona, Collier and Scholz, 2004). Direct effects of dissolved PAHs to cardiac conduction in developing fish embryos cause secondary effects in heart development, kidney development, neural tube structure and craniofacial skeleton formation. Additional research has shown that the initial effect is due to disruption of cardiac muscle cell processes by dissolved PAHs (Brette, et al., 2014). Different types of dissolved and weathered crude oils cause similar cardiac injuries in fish (Incardona, et al. 2014). For example, direct exposure to Deepwater Horizon-contaminated sediments caused edema, craniofacial and spinal defects, and injured tissue in fish (Raimondo, et al., 2014).

Chronic, low-level oil pollution produces similar effects as a one-time event. Hicken, et al. (2011) found that reduced cardiac output due to heart malformation can result in reduced swimming performance in PAH-exposed fish embryos. As salmonids are continuously swimming species, reduced swimming performance could contribute to reduced survival.

Incardona, Collier and Scholz (2004) note "*It is possible that PAH-exposed fish in the natural environment may experience sublethal reductions in cardiac function that translate, in turn, to impaired performance at later life history stages. Although affected fish might appear grossly normal, their physiology and behavioral performance could be impaired. This could explain, for example, the reduced rate of marine survival among pink salmon exposed to PAHs as embryos (Heintz, et al., 2000)*".

These results implicate the potential for population-level effects to result from embryonic exposure to PAHs, in that even at low doses sublethal biochemical effects could occur in developing fish, in the form of biochemical impairments incurred during early development (Heintz, et al., 2000). For example, the need to metabolize and depurate oil in the developing fish could result in less energy available for growth, eventually contributing to reduced marine survival – either from delayed mortality, a lack of swimming ability leading to decreased ability to predate, an increased risk to be predated, etc. Further, reduced jaw size in PAH-exposed fish could affect choices of prey – having implications for survival factors such as size and growth (Incardona, Collier and Scholz, 2004).

5.2 Shellfish

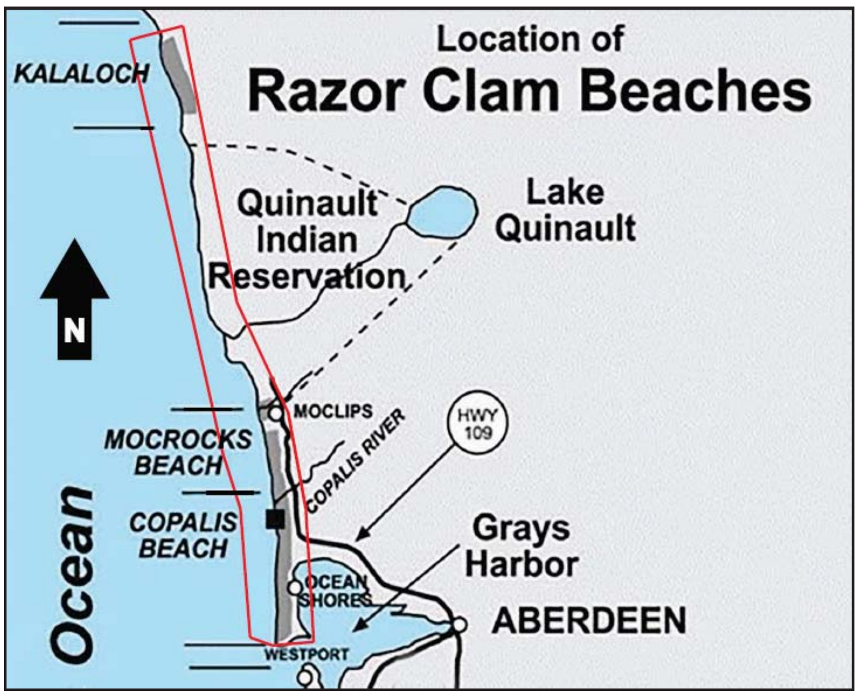
The Grays Harbor estuary and Pacific coast beaches are home to many shellfish species, including Dungeness crab (*Cancer magister*), razor clam (*Siliqua patula*) and Pacific oyster (*Crassostrea gigas*). When hatched, Dungeness crab larvae are free-swimming and must find a suitable area for growth on the sea floor. The majority of juveniles that settle in the intertidal areas outside of Grays Harbor will migrate into the subtidal waters of the Grays Harbor estuary the spring following settlement (WDFW, 2008).

Juvenile Dungeness crabs given its many sheltered areas (eelgrass beds, woody debris, piling areas, etc.) and ample prey (WDFW, 2008; Schumacker, 2013) prefer the shallow estuarine environment of

Grays Harbor. The juvenile life stage of the Dungeness crab lasts up to two years after hatching; during this time, juvenile crabs molt up to six times per year. The molting process leaves crabs vulnerable to the environment and predators for days, until their new shell hardens. Thus, juvenile Dungeness crabs actively seek a place to bury themselves for cover in the coastal estuary or nearshore sandy areas during molting (Schumacker, 2013).

Fertilization of razor clam eggs occurs in the water column via free-floating sperm and eggs. Redistribution from swimming or surf action occurs at this time, and after one to four months razor clam larvae 'set' and dig into the sand (USFWS, 1989). Larger juveniles typically remain in place in the upper few inches of sand, whereas adult razor clams usually live about one foot below the surface. Razor clams are rapidly mobile downward but have very limited mobility laterally (USFWS, 1989). Figure 8 presents Washington's razor clam beaches local to the Reservation.

Figure 8. Washington's razor clam beaches most local to the Reservation



Source: WDFW, 2015.

Adapted from http://wdfw.wa.gov/fishing/shellfish/razorclams/graphics/map_beaches.jpg

Fertilization of Pacific oyster eggs also occurs in the water column via free-floating sperm and eggs (USFWS, 1988). The free-swimming larvae feed on phytoplankton, and after a few weeks when the larvae reach a length of about 0.3 mm they set as spat, or a juvenile, on a hard substrate. Pacific oysters are sessile – the juvenile oyster will grow to adult size and die where the larvae has set (i.e. they are unable to move themselves around) (USFWS, 1988).

The harm of oil contamination to shellfish can be realized in acute mortality of larvae, juveniles and adults; in sublethal effects leading to less robust larvae; and in the energy expenditures necessary to adjust to an oil-contaminated environment (Jeong and Cho, 2007; Karinen, Rice and Babcock, 1985; Law and Kelly, 2004).

The toxicity of PAHs to shellfish can also be evidenced by exposure pathways, and abilities to metabolize and cleanse themselves of PAHs (Law and Hellou, 1999). The major exposure pathways of shellfish include direct physical contact to oil-contaminated water and ingestion. The biological mechanisms of shellfish will induce an equilibrium-partitioning process – where the concentrations of oil in the aqueous environment are in equilibrium with the concentrations of PAHs in the shellfish (requiring an expenditure of energy). Further, as razor clams and Pacific oysters are filter feeders, they tend to bioaccumulate low molecular weight PAHs that are prevalent in crude oil.

Invertebrates are relatively less able to metabolize xenobiotic (foreign) compounds than vertebrates. Depuration, or the elimination of PAHs by an organism as the concentrations of PAHs in the surrounding aqueous environment decrease, typically takes longer for invertebrates (Law and Hellou, 1999; Law and Kelly, 2004). This is important, as shellfish must expend energy for depuration – energy that is not spent elsewhere such as on feeding, etc.

Re-oiling of a substrate, such as in chronic oil spills or persistent oil contamination, can continually adversely affect the same generation or future generations of sessile organisms (Babcock, et al., 1998; Soriano, et al., 2006; Vinas, et al., 2009).

Toxic accumulation of PAHs in shellfish tissue ca cause economically and culturally important species, including razor clams and Pacific oysters to be unfit for human consumption or merely the perception that a resource is unsafe for consumption, thereby rendering a product unmarketable (Gilroy, 2000; Law and Kelly, 2004).QDFi biologists note "*razor clams may be particularly vulnerable to oil spills*" (Schumacker, 2013).

QDFi biologists note "razor clams may be particularly vulnerable to oil spills" (Schumacker, 2013). For example, a close relative of the razor clam, the pod razor shell (Ensis siliqua) appeared to be exhibit an escape response to spilled oil in Wales, United Kingdom, resulting in stranding of both subtidal and intertidal populations (Law, et al., 1997). If razor clams were to behave similarly by fleeing their burrows, fish and seabirds may predate them if they do not re-burrow quickly. It is unlikely razor clams would reach an area that would not trigger an escape response in a short time (Schumacker, 2013). Further, a drop in genetic variability has been found in pod razor shell populations several years after an oil spill (owing to a reduction in population size from spill-related mortality) (Fernandez-Tajes, et al., 2012).

5.3 SALT MARSH PLANTS

The toxicity of oils on plants depends on factors including the quantity of the oil, its chemical constituents and concentrations, and environmental conditions. For example, oils differ in their ability to penetrate leaves and travel within a plant. Cellular membranes may become damaged by oil penetration, causing nutrient and water loss. Further, oils can reduce the transpiration rate of plant cells and cause a decrease in photosynthesis (Baker, 1970).

Short-term adverse effects of oils on plants range from sublethal effects to plant mortality. In the salt marsh plant *Spartina alterniflora*, high concentrations of accumulated crude oil in the soil or the marsh have led to plant mortality (Pezeshki, et al., 2000). Causes of mortality include temperature stress caused by an inability to respire (i.e. leaves coated by oil). Specifically in salt marsh plants, it has been shown that oil can damage roots, eventually affecting the plant's ability to tolerate saline environments (Pezeshki, et al., 2000). Some salt marsh plants are more sensitive to oiling during the growing season than when dormant. Long-term oil contamination, from either chronic oil spills or persistence of oil can constantly expose regenerated shoots and plant regeneration processes. Such continual adverse effects on growth and biomass productivity can result in plants less capable of recovery (Pezeshki, et al., 1997; Pezeshki, et al., 1998).

The most sensitive intertidal habitats to spilled oil include mangrove forests and salt marshes, and the vulnerability of coastal wetland plants found in salt marshes has been shown to increase when soils are contaminated with oil (USEPA, 1993; Lewis and Pryor, 2013). However, recovery of salt marsh plants after oil exposure has been shown in multiple studies as roots and rhizomes regenerate (Lewis and Pryor, 2013).

Hoff (1995) surveyed the recovery times of salt marshes after exposure to spilled oil, finding vegetation takes anywhere from a few weeks to 20 years after contamination to recover. Recovery times are dependent on many factors, including climate, physical location, severity of contamination, type of spilled oil, and response method, concluding that heavily oiled marshes in colder climates can take many years to recover (Hoff, 1995).

The most comparable environment to Grays Harbor where the effects of spilled crude oil on salt marsh plants were studied was a February 1991 spill of Prudhoe Bay crude oil from the Texaco pipeline in Fidalgo Bay, Washington. Salt marsh plants required three to four years to recover. [21]

If soils are heavily oiled, or oil is otherwise persistent in the environment, the roots and rhizomes of salt marsh plants can be unable to regenerate (Culbertson, et al., 2008). As the plants become weaker, die, or cannot reestablish themselves as rapidly, other ecological impacts can result. More oil-resistant plants can colonize the marsh, or the marsh can erode, affecting other species dependent on the habitat provided by the plants. Lack of reestablishment from one oiling event lasted at least one to three years (Hampson and Moul, 1978; de la Cruz, Hackney and Rajanna, 1981).

[21] Moderate to heavy oiling, temperate climate, medium crude oil.

SECTION SIX: Potential Impacts of Oil Transport and Spills on Treaty Resources

6.1 HISTORICAL IMPORTANCE AND CONTEMPORARY PERSPECTIVES

Treaty resources, including fish and plants, supported by the Pacific Ocean, the Pacific coast, Grays Harbor, and its rivers and tributaries are inextricable from the Quinault people's traditional and modern ways of life. The social, cultural and economic values provided by Treaty resources have been cherished and handed-down through the generations. Today, the importance of these resources, and their guarantee by Treaty, remains of utmost importance to the Quinault people, as *"The Quinault people are acutely aware of these special gifts and thank the Creator for his offerings,"* (James and Chubby, 2002).

The place, or site, that supports Treaty resources is also paramount. Quinault families have preferred resource sites for fishing, gathering and spiritualism. Many Quinault families have preferred resource sites in Grays Harbor and its rivers and tributaries.

An interviewee explained that the Quinault people realize they are caretakers for Treaty resources, and must do their best to minimize harm to them. To ensure this relationship is symbiotic, the Quinault people engage in spiritual blessings after caretaking of these resources. Another interviewee explained that razor clam digging makes this person "*feel like ancestors are with me on the beach….Going to the beach is like the rejuvenation of me as a Quinault person*."

6.1.1 Fishing

Fish has historically been the one dietary staple of the Quinault people (Olson, 1936). Interviewees explained that fish and shellfish, specifically salmon and razor clams, are essential for meeting dietary and nutritional needs. The Quinault people also consume other fish including lingcod, various rockfish species, halibut, smelt, and many intertidal species such as anemones and limpets (Schumacker, 2013). It is common for some QIN members to eat fish or shellfish three times a day.

Like many interviewees, a subsistence fisher explained that not having salmon and other fish readily available for sustenance is "*an unimaginable scenario*", as the Quinault people "*have had access to these resources since time immemorial*". A commercial fisher who takes home part of her catch explained that, "*We harvest our needs to provide for ourselves and friends. We feel it's a responsibility to provide food to people*".

Razor clams were and are also an important food. (Olson, 1936). James and Chubby (2002) explain, "*Razor clams were harvested on Point Grenville, Roosevelt, Kalaloch and Copalis beaches; other mollusks were taken from Point Grenville and Cape Elizabeth; and crab was taken all along the coastline*".

Fishing is also a source of cultural values. James and Chubby (2002) succinctly state this relationship: "*Fishing on the ocean, beaches, and rivers is a cultural activity that reinforces person and tribal identity and also provides nourishment"*. One interviewee stated, "*The most important thing to me, my identity, my existence, hinges on my ability to exercise the* [Treaty-reserved] *rights of the Quinault Indian Nation*. *If that is taken away, I don't know what I'd do. I have built my life around fishing, and the values and traditions passed down* [while fishing]".

One of the Quinault people's most important traditions is the first salmon ceremony: "*The salmon must be treated with honor and respect so that they will return to the place of their birth. The Quinault understand that they are not simply the beneficiaries of the salmon as food; they also have responsibilities to carry out the practices of their ancestors"* (James and Chubby, 2002).

Olson (1936) explained the first salmon ceremony as told to him by tribal elders in the mid-1920s. When the first blueback sockeye of the year was caught, it was laid on the bank with its head upstream for a period of time. The fish was then prepared with a mussel shell knife, cutting down either side of the backbone to create a fillet. The entrails were removed, and the heart was burned in a fire, to ensure that it was not eaten (which would stop the fish run). The head was cooked or dried with the rest of the meat, and all were given a portion of the first fish (Olson, 1936).

Olson also noted that, "*The bones of all salmon were thrown on the bank of the river…The salmon, returning to the ocean were believed to take these bones back with them to the salmon home where they again became salmon*" (Olson, 1936). The Quinault people also believe the spirits of the fish that die upriver return to their home under the ocean again, and that the old salmon who return to the ocean serve as guides for the younger salmon in the following year's run – and that they are people-like in this manner (Olson, 1936).

Fish and shellfish are also the basis for several economic and social values (Amberson, 2013; Biedenweg, Amberson and James, 2014). For example, salmon represent a means for employment in fishing, guiding and processing jobs. One interviewee explained that as far back as she could remember, "*I have dug clams. Being from a large family, it's how we made ends meet. As I got older, it is a huge part of the economic support for our family. The use of clams in my life is very important for my family."*

Fish are often used in trade with other tribal members for other foods or goods. Salmon and razor clams are communally served at social and community events, such as ceremonies and funerals. Salmon, and other fish and shellfish, are often shared with family members that do not, or can no longer fish or dig. As one interviewee explained, "*Sharing* [fish] *with off-reservation tribal members is important because they can't get it themselves*". Many interviewees reported that they share their take home catch with elders.

Interviewees reported using fishing as a way to educate younger generations in life lessons, to pass on traditional knowledge, and to perpetuate ceremonial values. One interviewee explained that she would fish "*even if our income isn't that large.* [Fishing is] *our family time, time that I get to spend with* [with relatives]. *Income varying, we would do it regardless. We're fishermen; that's who our* *people are*." Another stated, "*Spending time with my family* [fishing] *is more important than the commercial value* [of the catch]". There are also spiritual values assigned to fishing. For example, one interviewee reported that upon fishing he gives thanks that tribal members can fish and utilize the Treaty resources.

Stewardship of the salmon resource, and other natural resources, is a point of pride for the Quinault people (Biedenweg, Amberson and James, 2014). As explained by one interviewee, preservation of natural resources for the use of future generations is a significant part of the Quinault people's identity. This necessarily includes preserving ideal habitats for all species. A commercial razor clam digger stated, "*The pristineness of our beaches is something I take very seriously*." Further, a commercial fisher explained, "*For us, fishing is our life. Water is deeply rooted in our life; we have to have clean water*".

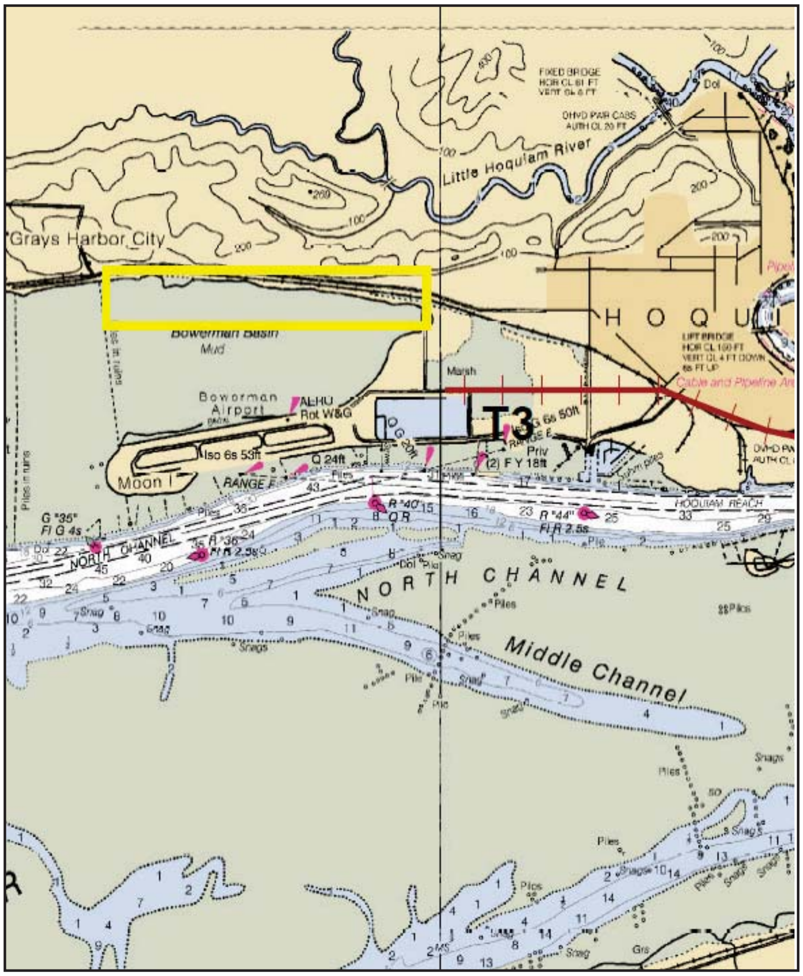
6.1.2 Plant material gathering

The Quinault people have gathered plant materials for various uses since time immemorial. James and Chubby (2002) explain that "*Each year the Quinault people travel to various sites on and off the reservation to gather basketry materials, cedar bark, bear grass, cattail, sweetgrass, and beach grass, as the Quinault people have done for hundreds of years*". Plant materials have been used to manufacture woven materials, such as baskets, jewelry, and clothing, and plants and roots are used as medicine.

This study concentrates on plant materials the Quinault people gather from the Bowerman Basin in the Grays Harbor estuary, including sweetgrass stems and cattail stems. Sweetgrass (Schoenoplectus pungens) is an estuarine plant that is a member of the sedge family. Sweetgrass plants store nutrients and energy in their underground tissues for the next year's growth (Shebitz and Crandall, 2012). Sweetgrass is found on the Olympic Peninsula in semi-protected estuarine environments, including in Grays Harbor and Hood Canal. The plant grows in the lower intertidal zone – about six to nine feet above mean lower low tide. At this elevation sweetgrass is covered at least once, and often twice per day by water (Shebitz and Crandall, 2012). Ecologically, sweetgrass assists estuarine function, and provides cover for juvenile salmonids and other fish, and habitat for many bird species.

Sweetgrass stems are gathered in the Bowerman Basin, near the Grays Harbor National Wildlife Refuge (NWR) (the boxed area in Figure 9).

Figure 9. Plant material gathering area in Bowerman Basin



Source: QDNR GIS Program, 2015. Adapted, Resource Dimensions.

Sweetgrass has "*unjointed, unbranched, three-sided stems with short, narrow leaves attached to the base of the stem. Once the leaves are removed, the elegantly simple stem is an ideal weaving material*" (Shebitz and Crandall, 2012). The tallest and thus preferred stems are found where salinity is lowest (Shebitz and Crandall, 2012).

Sweetgrass stems are used to make up the decoration on basket surfaces, amongst other material uses, and are valued because of their strength, durability and flexibility (Shebitz and Crandall, 2012). When bleached by the sun, sweetgrass stems turn a light cream color, and can be dyed other colors (Jones, 2012).

Cattail is also gathered in the Bowerman Basin. Traditionally, cattail was a primary component of mats and baskets, and its roots were eaten (Olson, 1936; Storm and Capoeman, 1990). Cattail mats were used as roofing, mattresses and pads, and insulation, and could be fashioned into backpacks (Storm and Capoeman, 1990).

The importance of weaving as a means for creating materials used in everyday life – products necessary for food storage or transport, for example – was and is a significant element of the Quinault culture (Shebitz and Crandall, 2012). Though perhaps the need for woven materials for material goods has changed in modern times, Jones (2012) explains, "*One important part of their traditional culture, basket making, has managed to survive and continue to the present day. The traditions and skills of the creative and productive Quinault basket makers have been passed down through succeeding generations, as well as displaying innovation and change*" (Jones, 2012). In the last few years there has been a resurgence of interest in weaving – "*Quinault weavers today are keeping the respect for the old traditions alive and giving them a vital and exuberant new interpretation*" (Jones, 2012).

Traditionally, weaving was a female-oriented activity. Women communally collected and prepared plant materials, and girls would accompany their older female relatives on gathering trips and in cleaning and processing the materials in the spring and summer. Weaving was typically conducted in the winter months, and girls would learn construction basics, continuing their education until obtaining a good understanding of techniques and designs (Jones, 2012). In this manner, weaving was a means to pass on life lessons. One weaver Jones interviewed recalled that "*in the old days…there were songs and dances performed after a long day of gathering, as a way of thanking the Creator…for giving them the grasses so they could make their baskets*" (Jones, 2012).

Gathering remains an activity performed with family and friends, and today males assist in collecting and transporting materials. Interviewees reported several social and cultural values inherent in gathering: a spiritual component, including thanksgiving for the availability of the plants; therapeutic value; and carrying on ancestral traditions.

Today, dried sweetgrass and cattail stems are used in baskets, jewelry and clothing, and have both a commercial and decorative function. The process of gathering these materials, and the commercial value of the products made with them are described in Section 6.4.

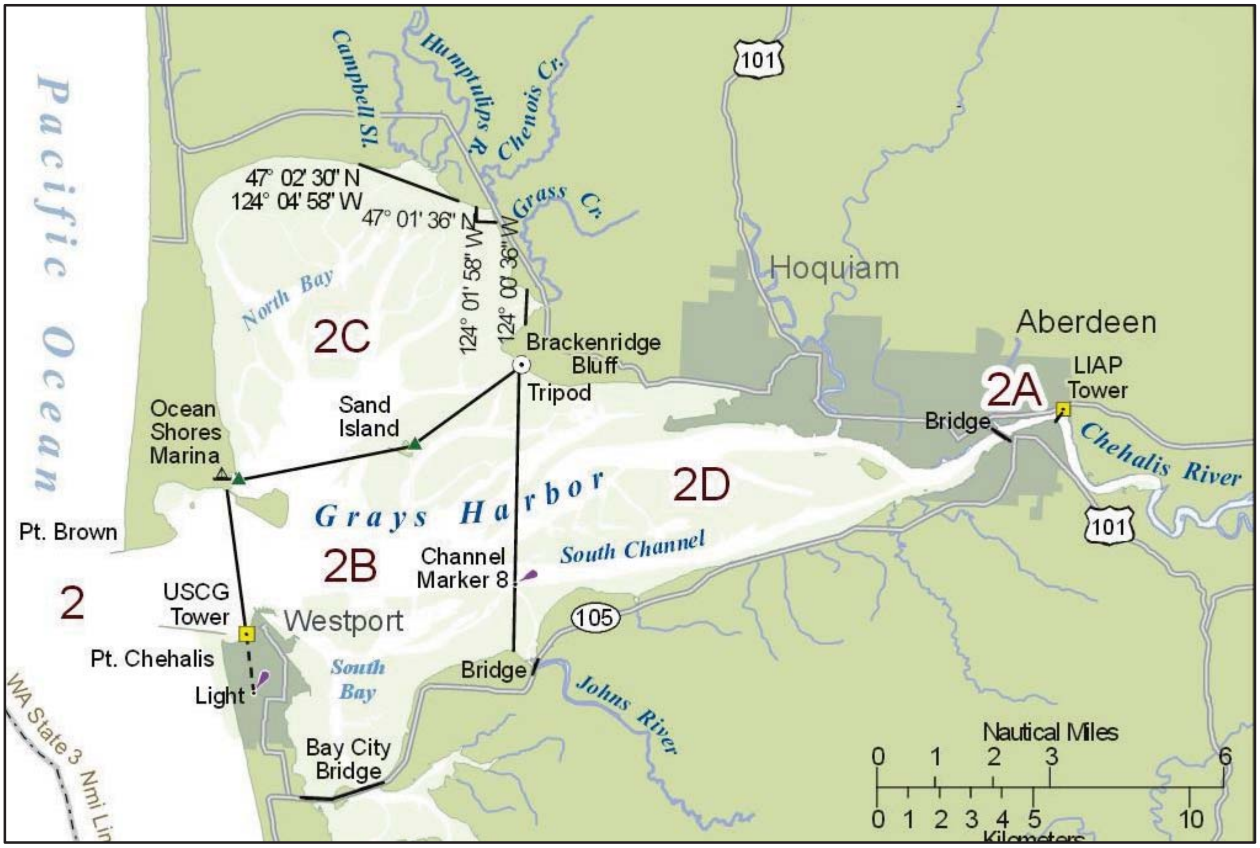
6.2 TREATY COMMERCIAL FISHERIES

Treaty commercial fishers fish in multiple fisheries in the Grays Harbor area, including its rivers and tributaries and offshore, and land their catches in Grays Harbor. These fisheries include gillnet fisheries (Chinook, coho and chum salmon, steelhead, and white sturgeon); ocean troll fisheries (Chinook and coho salmon); marine fisheries (halibut, sablefish, lingcod, rockfish and sardines) and Dungeness crab. Treaty commercial diggers fish the razor clam fishery on Pacific coast beaches (Figure 8).

Landings

The QDFi provided data on the number of commercial fish, crabs and razor clams taken, the total whole weights of the catch for each fishery, and current year values for the period 2004 to 2013 (QDFi Database, 2015). The total commercial numbers of fish taken, whole weights, and values for each gillnet fishery, by year, was calculated by summing the whole weights caught from each Area in the Grays Harbor system (i.e. Chehalis River Areas 2A, 2D, 2A1, and 72B; Humptulips River Areas 2C and 72F), Figure 10. Values were adjusted to 2014 dollars, and total values for the five fish species (Chinook, coho and chum salmon, steelhead, and white sturgeon) were summed to calculate a yearly total. Yearly totals were averaged from 2004 to 2013; the average yearly value of the gillnet fisheries was estimated at $654,210 (Table 13).

Figure 10. Grays Harbor Commercial Gillnet Areas



Source: QDNR 2015. Adapted, Resource Dimensions.

Table 13. Treaty Gillnet Fisheries, Harvests and Values

Year	Chinook				Chum			
	Number	Weight (lbs.)	Value ($)	Value (2014 $)	Number	Weight (lbs.)	Value ($)	Value (2014 $)
2004	3,546	66,763	$ 98,978.70	$ 120,118.77	9,600	98,776	$ 22,582.40	$ 27,405.59
2005	2,297	43,692	$ 51,397.45	$ 60,436.47	5,804	68,908	$ 11,145.60	$ 13,105.72
2006	3,758	74,664	$ 126,400.75	$ 144,198.81	4,070	48,879	$ 12,219.75	$ 13,940.37
2007	2,483	48,435	$ 107,752.65	$ 119,746.20	598	7,529	$ 2,635.15	$ 2,928.46
2008	1,880	37,621	$ 98,521.45	$ 107,390.13	2,070	25,523	$ 17,823.90	$ 19,428.37
2009	2,512	41,078	$ 69,170.35	$ 74,820.88	4,397	47,357	$ 18,673.95	$ 20,199.42
2010	3,403	60,509	$ 150,774.10	$ 161,123.52	8,938	102,415	$ 51,246.23	$ 54,763.87
2011	6,417	99,397	$ 247,601.25	$ 259,244.22	17,207	157,068	$ 133,601.40	$ 139,883.75
2012	3,994	69,436	$ 159,014.30	$ 163,554.93	11,670	160,984	$ 63,400.95	$ 65,211.35
2013	2,909	44,554	$ 113,160.80	$ 114,683.28	11,976	129,494	$ 64,830.35	$ 65,702.58

Year	Coho				Steelhead			
	Number	Weight (lbs.)	Value ($)	Value (2014 $)	Number	Weight (lbs.)	Value ($)	Value (2014 $)
2004	18,093	188,515	$ 149,186.55	$ 181,050.12	6,742	62,764	$ 91,986.30	$ 111,632.92
2005	23,428	227,083	$ 238,765.85	$ 280,756.42	4,992	48,150	$ 73,128.50	$ 85,989.25
2006	8,746	95,214	$ 121,596.10	$ 138,717.63	3,404	30,539	$ 53,420.15	$ 60,942.06
2007	8,927	86,456	$ 123,886.25	$ 137,675.57	3,975	41,957	$ 73,310.75	$ 81,470.70
2008	10,208	118,125	$ 178,925.20	$ 195,031.64	1,467	16,041	$ 28,373.40	$ 30,927.51
2009	28,487	290,499	$ 309,595.00	$ 334,885.81	697	6,981	$ 12,918.15	$ 13,973.43
2010	25,347	269,972	$ 362,965.90	$ 387,880.56	1,837	15,770	$ 30,334.95	$ 32,417.20
2011	27,982	268,188	$ 453,254.89	$ 474,568.33	3,341	31,463	$ 68,226.55	$ 71,434.77
2012	30,693	276,388	$ 487,363.04	$ 501,279.61	2,880	25,510	$ 61,700.80	$ 63,462.66
2013	21,962	196,791	$ 423,560.00	$ 429,258.62	1,955	19,045	$ 44,696.75	$ 45,298.10

Table 13. Treaty Gillnet Fisheries, Harvests and Values (continued)

	White Sturgeon				Total Value of
Year	Number	Weight (lbs.)	Value ($)	Value (2014 $)	Fisheries (2014 $)
2004	1,544	47,115	$ 104,502.25	$ 126,822.05	$ 567,029.45
2005	3,374	79,860	$ 173,544.75	$ 204,065.21	$ 644,353.07
2006	2,918	64,821	$ 138,778.35	$ 158,319.25	$ 516,118.12
2007	1,766	40,881	$ 91,211.85	$ 101,364.30	$ 443,185.23
2008	3,206	69,947	$ 183,032.40	$ 199,508.56	$ 552,286.21
2009	1,373	32,133	$ 79,046.75	$ 85,504.08	$ 529,383.62
2010	1,125	27,262	$ 61,051.10	$ 65,241.76	$ 701,426.91
2011	947	24,348	$ 70,444.65	$ 73,757.17	$ 1,018,888.24
2012	598	17,176	$ 51,846.50	$ 53,326.97	$ 846,835.52
2013	726	22,280	$ 66,748.25	$ 67,646.29	$ 722,588.87

Source: QDFi Database, 2015

Average values per pound for the ocean troll fisheries (Chinook and coho salmon) were not reported for 2005. Values per pound from 2004 and 2006 to 2013 were adjusted to 2014 dollars and averaged to develop a proxy value for 2005. The average value of Chinook per pound for these years is $5.08; the average value of coho per pound for these years is $2.04 (Table 14).

Table 14. Treaty Ocean Salmon Troll Fisheries, Average Values

Year	Chinook		Coho	
	$/lb	2014 $/lb	$/lb	2014 $/lb
2004	$ 3.50	$ 4.25	$ 2.00	$ 2.43
2006	$ 4.46	$ 5.09	$ 1.78	$ 2.09
2007	$ 3.75	$ 4.17	$ 1.46	$ 1.62
2008	$ 6.60	$ 7.19	$ 1.84	$ 2.01
2009	$ 3.29	$ 3.56	$ 1.10	$ 1.19
2010	$ 4.88	$ 5.21	$ 2.17	$ 2.32
2011	$ 4.65	$ 4.87	$ 2.21	$ 2.31
2012	$ 5.31	$ 5.46	$ 1.84	$ 1.89
2013	$ 5.88	$ 5.96	$ 2.44	$ 2.47
Average		**$ 5.08**		**$ 2.04**

Source: QDFi Database, 2015

Values for the commercial ocean salmon troll fisheries, by year, were adjusted to 2014 dollars and summed to determine an annual total. Averaging yearly totals for 2004 to 2013, the yearly average value of the ocean salmon troll fisheries was estimated at $71,392 (Table 15).

Table 15. Treaty Ocean Salmon Troll Fisheries, Harvests and Values

Year	Chinook					Coho					Total Value of Fisheries (2014 $)
	Number	Weight (lbs.)	Avg $/lb.	Value $	Value (2014 $)	Number	Weight (lbs.)	Avg $/lb	Value $	Value (2014 $)	
2004	237	729	$ 3.50	$ 2,551.50	$ 3,096.45	170	978	$ 2.00	$ 1,956.00	$ 2,373.77	$ 5,470.22
2005	3,113	21,059	$ 5.08		$ 106,979.72	578	4,465	$ 2.04		$ 9,108.60	$ 116,088.32
2006	200	2,359	$ 4.46	$ 10,521.14	$ 12,002.59	165	1,432	$ 1.78	$ 2,548.96	$ 2,907.87	$ 14,910.46
2007	367	3,468	$ 3.75	$ 13,005.00	$ 14,452.54	1,039	5,185	$ 1.46	$ 7,570.10	$ 8,412.70	$ 22,865.24
2008	437	4,958	$ 6.60	$ 32,722.80	$ 35,668.43	591	4,905	$ 1.84	$ 9,025.20	$ 9,837.63	$ 45,506.06
2009	432	5,132	$ 3.29	$ 16,884.28	$ 18,263.56	4,039	16,064	$ 1.10	$ 17,670.40	$ 19,113.89	$ 37,377.45
2010	2,519	27,966	$ 4.88	$ 136,474.08	$ 145,841.92	1,988	17,362	$ 2.17	$ 37,675.54	$ 40,261.66	$ 186,103.58
2011	1,944	26,080	$ 4.65	$ 121,272.00	$ 126,974.58	719	4,638	$ 2.21	$ 10,249.98	$ 10,731.97	$ 137,706.55
2012	1,456	15,929	$ 5.31	$ 84,582.99	$ 86,998.24	1,080	5,465	$ 1.84	$ 10,055.60	$ 10,342.74	$ 97,340.98
2013	616	6,447	$ 5.88	$ 37,908.36	$ 38,418.38	997	4,908	$ 2.44	$ 11,975.52	$ 12,136.64	$ 50,555.02

Source: QDFi Database, 2015

The QDFi provided numbers, whole weights and values for the Treaty commercial marine fisheries from 2004 to 2013. Values for the Treaty commercial marine fisheries (Table 16), by year, were adjusted to 2014 dollars and summed to determine a yearly total. Yearly totals for the period were then averaged to estimate a yearly value at $1,065,982 for the halibut, sablefish, lingcod, rockfish and sardine fisheries.

Table 16. Treaty Marine Fisheries, Harvests and Values

Year	All Marine Fisheries (except salmonids) Weight (lbs.)	Value $	Total ($2014)
2004	437,512	$ 1,007,094	$ 1,222,191
2005	351,014	$ 770,710	$ 906,251
2006	406,641	$ 931,074	$ 1,062,176
2007	264,308	$ 716,889	$ 796,684
2008	346,625	$ 1,029,249	$ 1,121,900
2009	424,084	$ 1,153,673	$ 1,247,917
2010	300,456	$ 927,530	$ 991,197
2011	260,040	$ 1,177,262	$ 1,232,621
2012	3,127,701	$ 1,402,130	$ 1,441,982
2013	1,459,616	$ 628,451	$ 636,897
Yearly Average (2014 $)			***$ 1,065,982***

Source: QDFi Database, 2015

The QDFi provided total whole weights for the commercial harvest of Dungeness crab from 2004 to 2013. Values per pound were not reported for 2004 to 2010; WDFW reported prices for these years were used as proxies. Values per pound were calculated by dividing the number of landed pounds of Dungeness crab in Grays Harbor County by the total value reported by WDFW for Grays Harbor County for the year (IEc, 2014b). Total values of the Treaty Dungeness crab harvests, by year, were calculated by multiplying total whole weights by the values per pound. The yearly average value of the Treaty Dungeness crab harvest was estimated at $6,794,288 (Table 17).

Table 17. Treaty Dungeness Crab Fishery, Harvests and Values

Year	Whole Weight (lbs.)	Value (2014 $)
2004	1,486,853	$ 3,306,849
2005	3,188,806	$ 5,340,507
2006	1,371,961	$ 2,513,995
2007	2,956,441	$ 7,378,899
2008	2,061,477	$ 5,886,188
2009	3,004,009	$ 7,742,326
2010	2,771,881	$ 7,276,738
2011	3,254,288	$ 9,296,054
2012	2,019,549	$ 8,375,747
2013	3,694,925	$ 10,825,580
	Yearly Average	***$ 6,794,288***

Sources: QDFi Database, 2015; IEc, 2014b

The QDFi provided data for the whole weights of the commercial harvests of razor clams for 2004 to 2013. Values per pound were not reported; WDFW reported prices for the period were used as proxies. Values per pound were calculated by dividing the number of landed pounds of razor clams in Grays Harbor County by the total values reported by WDFW for Grays Harbor County for a year (IEc, 2014b). Total values of the Treaty commercial razor clam harvests, by year, were calculated by multiplying total whole weights by values per pound. The yearly average value of the Treaty commercial razor clam harvest was estimated at $637,364 (Table 18).

Table 18. Treaty Commercial Razor Clam Fishery, Harvests and Values

	Jetty to Copalis		North of Copalis				
Year	Number	Whole Weight (lbs.)	Number	Whole Weight (lbs.)	Total Whole Weight (lbs.)	Price per pound (2014 $)	QIN Total Value (2014 $)
2004	635,064	170,508	556,042	150,104	320,612	$ 1.81	$ 580,011
2005	694,148	170,314	766,433	169,057	339,371	$ 1.87	$ 633,961
2006	447,129	135,605	431,766	118,323	253,928	$ 1.70	$ 432,132
2007	459,676	123,351	599,912	156,850	280,201	$ 1.71	$ 478,060
2008	920,840	263,801	97,432	27,742	291,543	$ 1.89	$ 549,967
2009	471,592	129,296	388,269	114,349	243,645	$ 1.74	$ 423,346
2010	725,704	227,872	361,184	104,537	332,409	$ 1.86	$ 618,172
2011	824,054	189,666	594,208	143,047	332,713	$ 1.99	$ 661,408
2012	547,807	138,791	662,695	169,780	308,571	$ 2.13	$ 656,464
2013	847,831	236,886	1,141,124	294,825	531,711	$ 2.52	$ 1,340,121
						Yearly Average (2014 $)	***$ 637,364***

Sources: QDFi Database, 2015; IEc, 2014b

Note: 'Jetty to Copalis' is the stretch of beach between the north jetty at the harbor entrance and the Copalis River. 'North of Copalis' is the stretch of beach between the Copalis River and the north end of Kalaloch Beach.

Yearly average values for the Treaty commercial fisheries are summarized in Table 19. Total yearly average value of the Treaty commercial fisheries was estimated at $9,223,236.

Table 19. Yearly Average Value of Treaty Commercial Fisheries, 2004-2013

Fishery	Yearly Average ($2014)
River Gillnet	$ 654,210
Ocean Troll	$ 71,392
Marine Fish	$ 1,065,982
Dungeness Crab	$ 6,794,288
Razor Clam	$ 637,364
Total Fisheries	***$ 9,223,236***

Source: Resource Dimensions, 2015

To estimate the economic impact of the Treaty commercial razor clam fishery to the local and regional economies, data provided by the QDFi reported in Tables 18 and 19 supplied inputs for IMPLAN sub-models. Table 20 summarizes the value of production for the Treaty commercial razor clam fishery at $1.1 million in 2013. Considering indirect and induced effects associated with this production, the total economic impact of the Treaty commercial razor clam fishery was estimated to have been more than $1.5 million in 2013. Total employment (direct and secondary) associated with the fishery in the region was estimated by the model at 24.1 FTE jobs with labor income of more than $700,000, and an average annual earnings per FTE of $29,000. Given the nature of this fishery, the FTE equivalent likely represents several times more actual diggers than is reflected in Table 20.

Table 20. Economic Impact of the Treaty Razor Clam Fishery, 2013 ($2014)

Impact Type	Output	Employment	Income	Value Added
Direct Effect	$ 1,060,304	20.4	$ 530,454	$ 597,941
Indirect Effect	$ 166,542	1.2	$ 75,435	$ 90,842
Induced Effect	$ 313,337	2.5	$ 94,556	$ 204,316
Total Effect	$ 1,540,182	24.1	$ 700,445	$ 893,100

Source: Resource Dimensions, 2015

Pink shrimp was mentioned as potential Treaty commercial fishery by several interviewees. To understand the potential value of this fishery, per active state fishing license, the commercial coastal pink shrimp catch in Washington from 2004 to 2013 was examined. The average value of landings per license over this time is $198,415 (Table 21).

Table 21. Yearly Average Value of the Coastal Pink Shrimp Fishery per License ($2014)

Year	Metric Tons	Pound Equivalent	Avg Ex-Vessel Price Per Pound	Total value	Total value (2014 $)	Active Licenses	Value Per License (2014 $)
2004	2,440	5,379,273	$ 0.36	$ 1,936,538	$ 2,350,148	20	$ 117,507
2005	2,842	6,265,530	$ 0.41	$ 2,568,867	$ 3,020,641	16	$ 188,790
2006	2,804	6,181,754	$ 0.33	$ 2,039,979	$ 2,327,221	16	$ 145,451
2007	1,517	3,344,409	$ 0.46	$ 1,538,428	$ 1,709,665	13	$ 131,513
2008	2,843	6,267,735	$ 0.53	$ 3,321,899	$ 3,620,929	17	$ 212,996
2009	3,180	7,010,692	$ 0.31	$ 2,173,314	$ 2,350,852	16	$ 146,928
2010	4,296	9,471,048	$ 0.33	$ 3,125,446	$ 3,339,982	20	$ 166,999
2011	4,088	9,012,487	$ 0.48	$ 4,325,994	$ 4,529,415	14	$ 323,530
2012	4,225	9,314,520	$ 0.47	$ 4,377,824	$ 4,502,832	16	$ 281,427
2013	6,020	13,271,812	$ 0.42	$ 5,574,161	$ 5,649,157	21	$ 269,007
Annual Average							***$ 198,415***

Source: WDFW, 2014a

The QDFi provided the number of QIN vessels per fishery per year (Table 22). On average from 2004 to 2013, there were 13 ocean vessels per year for the ocean salmon, halibut, rockfish, sardine and sablefish fisheries; and 22 crab vessels per year.

Table 22. QIN Vessels by Fishery

Year	Ocean Vessels	Crab Vessels
2004	13	15
2005	12	26
2006	12	21
2007	10	22
2008	15	25
2009	16	24
2010	13	21
2011	13	21
2012	12	21
2013	9	21
Average	12.5	21.7

Source: QDFi Database, 2015

6.2.1 Commercial Fishing Employment

The QDFi (Table 23) provided the number of Treaty fishers and their helpers per fishery per year.[22] On average from 2004 to 2013, there were 123 fishers per year in the gillnet fisheries; five fishers per year in the ocean salmon fisheries; 13 fishers per year in the halibut, rockfish, sardine and sablefish fisheries; and 23 crab fishers per year. Gillnet fisheries data is reported for Areas 2A, 2B, 2C, 2D and 72F (the Grays Harbor system).

[22] The count of Gillnet Fishers does not include deckhands or helpers.

Table 23. Treaty Commercial Fishers and Helpers, by Fishery

Year	Gillnet Fishers	Ocean Fishers [1]	Ocean Fishers [2]	Sardine Fishers	Crab Fishers
2004	107	1	13		17
2005	123	0	12		25
2006	139	6	12		22
2007	111	4	10		24
2008	143	5	15		28
2009	111	3	16		26
2010	112	16	13		23
2011	111	6	13		23
2012	141	5	11	1	23
2013	132	4	8	1	23
Average	123	5	12.3	1	23.4

Source: QDFi Database, 2015

[1] Ocean Fishers – Salmon

[2] Ocean Fishers – Halibut, Rockfish, Sablefish

Treaty commercial fishers employ helpers for fishing. These duties consist of the driving of the boat, helping with nets or bait, etc. Interviewees were asked to report the number of helpers they typically employ in a season, and how these helpers are compensated.

Commercial gillnetters interviewed report that they either fish alone, or employ one or two helpers. The number of helpers is dependent on factors including workload needs, age of the licensed fisher, or if the licensed fisher wants to use a fishing trip for an educational purpose. Crab fishers typically employ an average of three helpers, based on workload needs (i.e. crab fishing process).

All interviewees reported that they compensate helpers through an agreed-upon percent of the value of the daily or seasonal catch. These percentages range from 10% to 50%, and are typically based on the helper's experience.

6.2.2 QIN Fisheries Management Activities

Fisheries and related marine resources off the Pacific coast are co-managed under a comprehensive and complex mixture of tribal, state, and federal jurisdictions. Together these governments are responsible for managing natural resources and the regulation of fisheries within their jurisdictions. Their responsibilities include working cooperatively to develop policies and programs with the goal of maintaining the long-term productivity of the fisheries.

The QDFi provides the QIN with technical and scientific expertise, information, stewardship, guidance and enforcement of fisheries harvested by QIN members. Expenditures aligned with the provision of these services were nearly $6.6 million in 2014, with an annual average of about $6.2 million over the five-year period 2010-2014 (Table 24).

Spending data was disaggregated, by expenditure class, into seven sectors, and input into the IMPLAN base model. Results estimate employment directly attributable to QDFi fisheries management activities totaled 28.2 FTE jobs, for which $1.7 million of direct wages and salaries were received by those directly employed in fisheries management activities (e.g., technical specialists, scientists, researchers, tagging, monitoring, engineering, research, education and outreach activities, field technicians, hatchery staff, administrative personnel, etc.).

Table 24. QIN Fisheries Management Expenditures, 2010-2014

Year	Total Expenditure
2010	$ 5,520,936
2011	$ 6,007,078
2012	$ 7,135,305
2013	$ 5,566,540
2014	$ 6,577,493
5 year total	$ 30,807,353
5 year avg	$ 6,161,471

Source: QDFi Database, 2015

6.2.3 Economic Impacts of Treaty Fisheries-based Activities on Grays Harbor County, 2013

Table 25 indicates the Treaty commercial fishers, Quinault Pride Seafood I, and QIN fishery management activities (i.e. fisheries-based activities) generated the following economic impacts for the local and regional economies in 2013 (reported in $2014 dollars):[23]

- 264.5 direct jobs generated by the Treaty commercial fishers, Quinault Pride Seafood I, and QIN fishery management activities. Purchases made by these individuals supported an additional 45.7 induced jobs in the region.

- 45.5 indirect jobs were supported by $9.67 million of local purchases made by businesses supplying services to these business activities.

- $8.8 million of direct wages and salaries were received by the 264.5 directly employed by Treaty commercial fishery-based activities. Re-spending of this income created an additional $1.67 million of income and consumption expenditures in Washington, principally in Grays Harbor County. Those holding indirect jobs received $1.8 million in indirect income.

- Businesses providing services to Treaty commercial fishers, Quinault Pride Seafood I, and QIN fishery management activities received $28.8 million of revenues.

Given the complexities of estimating the full extent of tax impacts generated by Treaty fisheries-based activities, we limit the discussion to those economic impacts reflected in Table 25.

[23] Revenue and expenditure data for Quinault Pride Seafood I are presented in Section 6.5.1.

Table 25. Summary of Economic Impacts Generated by Fisheries-based Activities 2013 ($2014)

Grays Harbor County	Treaty Commercial Fishing	Quinault Pride Seafood I	Fisheries Management	TOTAL
Jobs				
Direct	225.3	11.0	28.2	264.5
Indirect	7.3	33.8	4.4	45.5
Induced	29.3	7.9	8.5	45.7
Total	**261.9**	**52.7**	**41.1**	**355.7**
Personal Income				
Direct	$ 6,581,291	$ 531,316	$ 1,718,792	$ 8,831,399
Indirect	$ 474,714	$ 1,206,849	$ 159,387	$ 1,840,950
Induced	$ 1,112,120	$ 271,371	$ 289,843	$ 1,673,334
Total	**$ 8,168,125**	**$ 2,009,536**	**$ 2,168,022**	**$ 12,345,683**
Business Revenue	$ 15,225,573	$ 9,344,265	$ 4,188,514	**$ 28,758,352**
Local Purchases	$ 7,241,233	$ 696,028	$ 1,736,342	**$ 9,673,603**

Source: Resource Dimensions, 2015

6.2.4 Projected Economic Impacts of Treaty Fisheries-based Activities on Grays Harbor County, 2020 – 2022

To evaluate the economic impacts under each of the three scenarios detailed in Section 4.5, we begin with the Base Scenario, which is built upon the original IMPLAN sub-model and assumes no changes from activities in 2013 (i.e., growth, expansion, decline, etc.) for Treaty commercial fisheries, QIN commercial aquaculture, Quinault Pride Seafood I and II, or QIN fisheries management activities.[24]

Table 26 indicates the Base Case Scenario economic impacts projected for the local and regional economies over the three-year period 2020-2022 (reported in 2014 dollars):

- An average of 289.3 direct jobs generated by the Treaty commercial fishers, QIN commercial aquaculture, Quinault Pride Seafood operations, and QIN fishery management activities. Purchases made by these individuals supporting an additional average of 58.6 induced jobs in the region.

- An average of 70.1 indirect jobs supporting a total of some $37.9 million in local purchases made by businesses supplying services to these activities.

- Nearly $34.6 million of direct wages and salaries would be received by an annual average of 289.3 directly employed by Treaty fisheries-based activities. Re-spending of this income would create an additional $6.9 million of income and consumption expenditures in Washington, principally in Grays Harbor County. Those holding indirect jobs would receive some $9.3 million in indirect income.

- Businesses providing services to fisheries-based activities would receive some $116.5 million of revenues.

Again, we have not included related tax impacts generated by Treaty fisheries-based activities in the presentation of projected economic impacts reflected in Table 26.

[24] Revenues and expenditure data for Quinault Pride Seafood II are presented in Section 6.5.1. Assumed revenues and expenditures for the QIN commercial aquaculture pilot project are explained in Section 6.5.5.

Table 26. Summary of Economic Impacts Generated by Treaty Fisheries-based Activities, 2020-2022

Grays Harbor County	Treaty Commercial Fishing	Quinault Pride Seafood I	Quinault Pride Seafood II	QIN Commercial Aquaculture	Fisheries Management	TOTAL
Jobs						
Direct	234.7	11.8	6.1	4.0	32.7	289.3
Indirect	8.5	36.9	19.1	0.2	5.4	70.1
Induced	34.1	8.6	4.5	1.1	10.3	58.6
Total	**277.3**	**57.3**	**29.7**	**5.3**	**48.4**	**418**
Personal Income						
Direct	$ 23,655,410	$ 1,986,359	$ 1,023,296	$ 768,607	$ 7,164,091	$ 34,597,763
Indirect	$ 1,706,286	$ 4,514,036	$ 2,336,671	$ 28,467	$ 688,488	$ 9,273,948
Induced	$ 3,997,341	$ 1,014,875	$ 524,751	$ 124,983	$ 1,213,264	$ 6,875,214
Total	**$ 29,359,037**	**$ 7,515,270**	**$ 3,884,718**	**$ 922,057**	**$ 9,065,843**	**$ 50,746,925**
Business Revenue	$ 50,654,332	$ 30,611,540	$ 15,818,031	$ 1,468,806	$ 17,959,603	**$ 116,512,313**
Local Purchases	$ 26,027,466	$ 2,594,673	$ 1,336,661	$ 802,851	$ 7,114,149	**$ 37,875,800**

Source: Resource Dimensions, 2015

6.2.5 Scenario-based Changes in Economic Impacts Generated by Treaty Fisheries-based Activities on Grays Harbor County, 2020 – 2022

To estimate the changes in economic contributions under each scenario, we begin with Base Case Scenario models for the period 2020 to 2022 for Treaty fisheries-based activities and accordingly adjust each to estimate changes in local and regional economy impacts resulting from activity levels expected under each scenario (Section 4.5). Tables 27, 28 and 29 show the economic impacts, as changes in contributions to the local and regional economy for 2020 to 2022 by scenario. As mentioned previously, the related tax impacts generated by these activities are not presented.

Scenario 1: Table 27 indicates the change in economic contributions by Treaty commercial fishers, QIN commercial aquaculture, Quinault Pride Seafood I and II, and QIN fishery management activities to the local and regional economy for 2020 to 2022:

- An average three-year decrease of 69.7 direct jobs in Treaty fisheries-based activities; nearly 90% of these direct job losses will be by Treaty commercial fishers. Resulting purchases made by the remaining 219.6 individuals would support an average of 43.6 induced jobs in the region (a loss of 15 induced jobs).

- An average three-year decrease of 20.9 indirect jobs resulting in an estimated $8.1 million decrease in purchases made by businesses supplying services to these activities.

- A three-year total decline of $8.8 million in direct wages and salaries from Base Case Scenario 2020-2022 was estimated for the 219.6 directly employed by Treaty fisheries-based activities. Re-spending of remaining income will create an estimated additional $5.1 million of income and consumption expenditures in Washington, principally in Grays Harbor County (a $1.8 million decrease for the period as shown in Table 27). A three-year total decrease of 20.9 indirect jobs and some $2.3 million in related income from the Base Case Scenario 2020-2022 was estimated.

- Businesses providing services to Treaty fisheries-based activities can expect to receive $24.2 million less in revenues.

- Given requirements to maintain and restore the affected fisheries we estimate little if any changes will occur with the 48.4 jobs (direct, indirect and induced) in QIN fisheries management. All other Treaty fisheries-related jobs are expected to be affected, with an estimated average annual loss of 105.6 jobs over 2020 to 2022.

Table 27. Scenario 1: Summary of Changes in Economic Contributions by Treaty Fisheries-based Activities, 2020-2022

Grays Harbor County	Treaty Commercial Fishing	Quinault Pride Seafood I	Quinault Pride Seafood II	QIN Commercial Aquaculture	TOTAL
Jobs					
Direct	60.7	4.8	2.5	1.7	69.7
Indirect	-2.8	15.8	7.8	0.1	20.9
Induced	9	3.7	1.8	0.5	15
Total	**66.9**	**24.3**	**12.1**	**2.3**	**105.6**
Personal Income					
Direct	$ 7,233,232	$ 845,736	$ 416,584	$ 312,900	$ 8,808,452
Indirect	$ (566,683)	$ 1,923,536	$ 951,259	$ 11,589	$ 2,319,701
Induced	$ 1,064,001	$ 432,353	$ 213,626	$ 50,881	$ 1,760,861
Total	**$ 7,730,550**	**$ 3,201,625**	**$ 1,581,469**	**$ 375,369**	**$ 12,889,013**
Business Revenue	$ 4,144,638	$ 13,046,667	$ 6,439,521	$ 597,951	**$ 24,228,776**
Local Purchases	$ 6,107,529	$ 1,098,742	$ 544,155	$ 326,841	**$ 8,077,267**

Source: Resource Dimensions, 2015

Scenario 2: Table 28 indicates the changes in economic contributions by Treaty fisheries-based activities to the local and regional economy for 2020 to 2022:

- An average three-year decrease of 78.9 direct jobs in Treaty fisheries-based activities; nearly 90% of these direct job losses will be by Treaty commercial fishers. Resulting purchases made by the remaining 201.4 individuals would support an average of 42.4 induced jobs in the region (a loss of 16.2 induced jobs).

- An average three-year decrease of 21.4 indirect jobs resulting in an estimated $8.9 million decrease in purchases made by businesses supplying services to these activities.

- A three-year total decline of $9.6 million in direct wages and salaries from Base Case Scenario 2020-2022 was estimated for the 210.4 directly employed by Treaty fisheries-based activities. Re-spending of remaining income will create an estimated additional $4.9 million of income and consumption expenditures in Washington, principally in Grays Harbor County (a $1.9 million decrease for the period as shown in Table 28). A three-year total decrease of 21.4 indirect jobs and some $2.4 million in related income from the Base Case Scenario was estimated.

- Over the period 2020-2022, businesses providing services to these activities can expect to receive $26.2 million less in revenues.

- Given requirements to maintain and restore the affected fisheries we estimate little if any changes will occur with those 48.4 jobs (direct, indirect and induced) in QIN fisheries management. All other Treaty fisheries-related jobs are expected to be affected, with an estimated average annual loss of 116.5 jobs over the three-year period.

Table 28. Scenario 2: Summary of Changes in Economic Contributions by Treaty Fisheries-based Activities, 2020-2022

Grays Harbor County	Treaty Commercial Fishing	Quinault Pride Seafood I	Quinault Pride Seafood II	QIN Commercial Aquaculture	TOTAL
Jobs					
Direct	69.9	4.8	2.5	1.7	78.9
Indirect	-2.3	15.8	7.8	0.1	21.4
Induced	10.2	3.7	1.8	0.5	16.2
Total	**77.8**	**24.3**	**12.1**	**2.3**	**116.5**
Personal Income					
Direct	$ 7,980,849	$ 845,736	$ 416,584	$ 312,900	$ 9,556,068
Indirect	$ (460,181)	$ 1,923,536	$ 951,259	$ 11,589	$ 2,426,203
Induced	$ 1,197,249	$ 432,353	$ 213,626	$ 50,881	$ 1,894,109
Total	**$ 8,717,917**	**$ 3,201,625**	**$ 1,581,469**	**$ 375,369**	**$ 13,876,381**
Business Revenue	$ 6,136,702	$ 13,046,667	$ 6,439,521	$ 597,951	**$ 26,220,840**
Local Purchases	$ 6,946,059	$ 1,098,742	$ 544,155	$ 326,841	**$ 8,915,797**

Source: Resource Dimensions, 2015

Scenario 3: Table 29 presents the changes in economic contributions by Treaty fisheries-based activities to the local and regional economies for 2020 to 2022:

- An average three-year decrease of 104.6 direct jobs in Treaty fisheries-based activities; over 90% of these direct job losses will be by Treaty commercial fishers. Resulting purchases made by the remaining 184.7 individuals would support an average of 38.7 induced jobs in the region (a loss of 19.9 induced jobs).

- An average three-year decrease of 27.2 indirect jobs resulting in an estimated $12.6 million decrease in purchases made by businesses supplying services to these activities.

- A three-year total decline of $11.2 million in direct wages and salaries from Base Case Scenario 2020-2022 was estimated for the 184.7 directly employed by Treaty fisheries-based activities. Re-spending of remaining income will create an estimated additional $4.5 million of income and consumption expenditures in Washington, principally in Grays Harbor County (a $2.3 million decrease for the period as shown in Table 29). A three-year total decrease of 27.2 indirect jobs and some $3.6 million in related income from the Base Case Scenario was estimated.

- Over the period 2020-2022, businesses providing services to Treaty fisheries-based activities can expect to receive $40.7 million less in revenues.
- Given requirements to maintain and restore the affected fisheries we estimate little if any changes will occur with those 48.4 jobs (direct, indirect and induced) in QIN fisheries management. All other Treaty fisheries-related jobs are expected to be affected, with an estimated average annual loss of 151.7 jobs over the three-year period.

Table 29. Scenario 3: Summary of Changes in Economic Contributions by Treaty Fisheries-based Activities, 2020-2022

Grays Harbor County	Treaty Commercial Fishing	Quinault Pride Seafood I	Quinault Pride Seafood II	QIN Commercial Aquaculture	TOTAL
Jobs					
Direct	95.6	4.8	2.5	1.7	104.6
Indirect	3.5	15.8	7.8	0.1	27.2
Induced	13.9	3.7	1.8	0.5	19.9
Total	**113**	**24.3**	**12.1**	**2.3**	**151.7**
Personal Income					
Direct	$ 9,644,848	$ 845,736	$ 416,584	$ 312,900	$ 11,220,067
Indirect	$ 696,724	$ 1,923,536	$ 951,259	$ 11,589	$ 3,583,107
Induced	$ 1,629,943	$ 432,353	$ 213,626	$ 50,881	$ 2,326,803
Total	**$ 11,971,514**	**$ 3,201,625**	**$ 1,581,469**	**$ 375,369**	**$ 17,129,978**
Business Revenue	$ 20,649,621	$ 13,046,667	$ 6,439,521	$ 597,951	**$ 40,733,760**
Local Purchases	$ 10,612,386	$ 1,098,742	$ 544,155	$ 326,841	**$ 12,582,123**

Source: Resource Dimensions, 2015

6.3 Subsistence Harvest of Seafood

The costs to replace the calories and protein provided by the subsistence harvest of seafood in the case of an oil spill, harvest closure, etc., were calculated using the market replacement method. **As described in Sections 1.2 and 2.3, the analysis in this section does not value – monetarily or otherwise – the cultural and spiritual aspects of tribal members' exercise of Treaty-reserved fishing rights.**

The market replacement method consisted of eight steps:

1. Estimating the whole weights of the subsistence harvest of seafood;
2. Estimating the meat yield of the seafood;
3. Estimating the weights of edible meats of the seafood;
4. Determining the amounts of calories and protein provided by the seafood;
5. Selecting the most likely substitutes for the seafood;
6. Determining the caloric and protein content, and market prices, of these substitutes;
7. Calculating weights of these substitutes that provide an equivalent amount of calories and protein to the seafood; and
8. Calculating the costs of the substitutes to obtain equivalent amounts of calories and protein.

The QDFi provided data from 2004 to 2013 on the whole weights of the Dungeness crab, the numbers of razor clams, and the whole weights of the halibut, lingcod, and rockfish harvested for subsistence. Data on the whole weights of the razor clams, by year, were estimated by multiplying the average weight per clam by area taken for the commercial harvest by the total number taken for the subsistence harvest.

No subsistence data is tracked by the QDFi for the ocean salmon troll fisheries (Chinook and coho salmon) or the gillnet fisheries (Chinook, chum, and coho salmon; steelhead, and white sturgeon). The whole weights of the subsistence harvest for these fisheries were estimated at three levels of subsistence as percentages of the commercial harvest: 5%, 10%, and 20% of the whole weights of the commercial catch of each fishery. These hypothetical scenarios were developed using information reported by interviewees, who were asked the percentage of their/their family's diets met by the subsistence harvest of seafood. Thus, the total whole weights of the commercial harvest for each year, by fishery, were multiplied by the three levels (i.e. 0.05, 0.10 and 0.20) to estimate the subsistence harvests.

The total commercial whole weight for each Grays Harbor system gillnet fishery, by year, was calculated by summing the whole weights caught from each Area (i.e. Chehalis River Areas 2A, 2D, 2A1, and 72B; Humptulips River 2C and 72F).

The average whole weights for each fishery were calculated from 2004 to 2013. Table 30 presents the yearly average total weights of the subsistence harvest of Chinook and coho salmon. Table 31 presents the yearly average total weights of the subsistence harvest for all fisheries.

Table 30. Yearly Average Total Weights of Subsistence Harvests, Chinook and coho, 2004-2013

Subsistence Fishery	10 year Average (lbs.)
Troll Fisheries	
Chinook	
5%	570.64
10%	1,141.27
20%	2,282.54
Coho	
5%	327.01
10%	654.02
20%	1,308.04
Gillnet Fisheries	
Chinook	
5%	2,930.75
10%	5,861.49
20%	11,722.98
Coho	
5%	10,086.15
10%	20,172.31
20%	40,344.61
Total Fisheries	
Chinook	
5%	3,501.39
10%	7,002.76
20%	14,005.52
Coho	
5%	10,413.16
10%	20,826.33
20%	41,652.65

Sources: QDFi Database, 2015; Resource Dimensions, 2015

Table 31. Yearly Average Total Weights of Subsistence Harvests, 2004-2013

Subsistence Fishery	Annual average total weight of subsistence harvest (lbs.)
Shellfish	
Dungeness crab	23,529.00
Razor clam	68,752.00
Marine Fish	
Halibut	13,143.00
Lingcod	887.00
Rockfish	3,896.00
Gillnet Fisheries	
Chum	
5%	4,234.66
10%	8,469.33
20%	16,938.65
Steelhead	
5%	1,491.10
10%	2,982.20
20%	5,964.40
Sturgeon	
5%	2,129.12
10%	4,258.23
20%	8,516.46
Troll and Gillnet Fisheries	
Chinook	
5%	3,501.39
10%	7,002.76
20%	14,005.52
Coho	
5%	10,413.16
10%	20,826.33
20%	41,652.65

Sources: QDFi Database, 2015; Resource Dimensions, 2015

The USDA, Agricultural Research Service, National Nutrient Database for Standard Reference, was accessed to retrieve caloric and protein data for the seafood. Caloric content and protein content per serving size of 100 grams was extrapolated to a serving size of one pound (1.0 pound is equivalent to 453.6 grams) (Table 32).

Table 32. Caloric and Protein Content of Seafood

	Caloric Content		Protein Content	
Subsistence Seafood	kcal/100 g serving	kcal/453.6 g	g/100 g serving	g/453.6 g
Razor clam	86	390.10	14.67	66.54
Dungeness crab	86	390.10	17.41	78.97
Chinook salmon	179	811.94	19.93	90.40
Chum salmon	120	544.32	20.14	91.36
Coho salmon	146	662.26	21.62	98.07
Steelhead	119	539.78	20.48	92.90
White sturgeon	105	476.28	16.14	73.21
Halibut	111	503.50	22.54	102.24
Lingcod	85	385.56	17.66	80.11
Rockfish	90	408.24	18.36	83.28

Source: USDA, Agricultural Research Service, 2014

The meat yield of seafood, or the amount of edible meat as a percent of the whole weight, were retrieved from Crapo, Paust and Babbit (2004). Fish are assumed to be dressed, with the head on. The meat yield of a razor clam, from whole to edible meat is estimated at 44%, and from raw meat to cooked meat at 60%. Thus, the edible, cooked meat as percent of the whole weight of razor clams is 26% (Table 33).

Table 33. Meat Yields of Seafood

Subsistence Seafood	Meat Yield
Razor clam	26%
Dungeness crab	25%
Chinook salmon	88%
Chum salmon	89%
Coho salmon	92%
Steelhead	88%
White sturgeon	85%
Halibut	88%
Lingcod	90%
Rockfish	88%

Source: Crapo, Paust and Babbit, 2004

The pounds of edible meats supplied by the subsistence harvest of seafood on a yearly average basis were determined by multiplying yearly average whole weights versus meat yield factors. The total pounds of edible meat were multiplied by the caloric content and protein content of one pound of each seafood to estimate the yearly average total calories and total grams of protein provided by the subsistence harvest (Tables 34 and 35).

Table 34. Yearly Average Calories Provided by Subsistence Harvest

Subsistence Seafood	Avg Subsistence Harvest (whole weight, lbs)	Meat Yield Factor	Edible Meat (lbs)	Caloric content (kcal/1.00 lb.)	Avg Total Calories of Subsistence Harvest
Razor clam	68,752	0.26	17,876	390.10	6,973,169
Dungeness crab	23,529	0.25	5,882	390.10	2,294,642
Halibut	13,143	0.88	11,566	503.50	5,823,354
Lingcod	887	0.90	798	385.56	307,793
Rockfish	3,896	0.88	3,428	408.24	1,399,643
Chinook salmon					
5%	3,501	0.88	3,081	811.94	2,501,781
10%	7,003	0.88	6,162	811.94	5,003,547
20%	14,006	0.88	12,325	811.94	10,007,094
Chum salmon					
5%	4,235	0.89	3,769	544.32	2,051,459
10%	8,469	0.89	7,538	544.32	4,102,923
20%	16,939	0.89	15,075	544.32	8,205,841
Coho salmon					
5%	10,413	0.92	9,580	662.26	6,344,483
10%	20,826	0.92	19,160	662.26	12,688,973
20%	41,653	0.92	38,320	662.26	25,377,940
Steelhead					
5%	1,491	0.88	1,312	539.78	708,287
10%	2,982	0.88	2,624	539.78	1,416,575
20%	5,964	0.88	5,249	539.78	2,833,149
White sturgeon					
5%	2,129	0.85	1,810	476.28	861,949
10%	4,258	0.85	3,619	476.28	1,723,893
20%	8,516	0.85	7,239	476.28	3,447,787

Source: Resource Dimensions, 2015

Table 35. Yearly Average Protein Provided by Subsistence Harvest

Subsistence Seafood	Avg Subsistence Harvest (whole weight, lbs)	Meat Yield Factor	Edible Meat (lbs)	Protein Content (g/1.00 lb.)	Avg Total Protein (g) of Subsistence Harvest
Razor clam	68,752	0.26	17,876	66.54	1,189,493
Dungeness crab	23,529	0.25	5,882	78.97	464,532
Halibut	13,143	0.88	11,566	102.24	1,182,508
Lingcod	887	0.90	798	80.11	63,948
Rockfish	3,896	0.88	3,428	83.28	285,527
Chinook salmon					
5%	3,501	0.88	3,081	90.40	278,550
10%	7,003	0.88	6,162	90.40	557,099
20%	14,006	0.88	12,325	90.40	1,114,198
Chum salmon					
5%	4,235	0.89	3,769	91.36	344,303
10%	8,469	0.89	7,538	91.36	688,607
20%	16,939	0.89	15,075	91.36	1,377,214
Coho salmon					
5%	10,413	0.92	9,580	98.07	939,505
10%	20,826	0.92	19,160	98.07	1,879,011
20%	41,653	0.92	38,320	98.07	3,758,021
Steelhead					
5%	1,491	0.88	1,312	92.90	121,897
10%	2,982	0.88	2,624	92.90	243,794
20%	5,964	0.88	5,249	92.90	487,587
White sturgeon					
5%	2,129	0.85	1,810	73.21	132,494
10%	4,258	0.85	3,619	73.21	264,987
20%	8,516	0.85	7,239	73.21	529,974

Source: Resource Dimensions, 2015

Table 36 summarizes total calories and total protein provided by the subsistence catch, by scenario.

Table 36. Yearly Average Calories and Protein Provided by Subsistence Harvest

Calories / Protein	Yearly Average
Total Calories	
5% Level	29,266,560
10% Level	41,734,511
20% Level	66,670,411
Total Protein	
5% Level	5,002,757
10% Level	6,819,506
20% Level	10,453,002

Source: Resource Dimensions, 2015

Ground beef, chicken and ham were selected as likely substitutes for the subsistence harvest of seafood. Table 37 below provides the caloric and protein content of these substitutes.

Seafood sold at the grocery store was not selected as a substitute for the subsistence harvest of seafood for three reasons. First, the Quinault people prefer salmon from the Reservation for its taste and quality. For example, one commercial fisher stated that he "*doesn't take fish from the Chehalis River system, I prefer Quinault salmon*". Another commercial fisher explained that, *"tribal members do not take home fish from the Chehalis, because the fish eat different bugs*" (affecting taste). Second, it is assumed that the grocery store cost of seafood is prohibitive. For example, the prices per pound of the substitute foods are considerably lower than the prices per pound for seafood at the grocery store. Third, standard USDA price data is not reported for seafood.

Table 37. Calorie and Protein of Substitutes

	Caloric Content		Protein Content	
Substitute Food	kcal/100 g serving)	kcal/453.6 g	g/100 g serving)	g/453.6 g
Ground beef	254	1,152.14	17.17	77.88
Chicken	239	1,084.10	27.30	123.83
Ham	178	807.41	22.62	102.60

Source: USDA, Agricultural Research Service, 2014
Note: Ground beef is assumed 80% lean; chicken is assumed broilers or fryers, roasted; ham is assumed regular (11% fat), roasted.

Average prices for ground beef, chicken and ham for urban areas in the American West over December 2013 to November 2014 are provided in Table 38 below.

Table 38. 12 Month Average Prices for Substitutes

Price per 1.00 lb.	Ground beef	Chicken	Ham
Dec-13	$ 3.954	$ 1.625	$ 3.172
Jan-14	$ 3.991	$ 1.610	$ 3.315
Feb-14	$ 3.996	$ 1.487	$ 3.360
Mar-14	$ 4.150	$ 1.679	$ 3.479
Apr-14	$ 4.316	$ 1.624	$ 3.374
May-14	$ 4.328	$ 1.704	$ 3.531
Jun-14	$ 4.258	$ 1.548	$ 3.594
Jul-14	$ 4.339	$ 1.593	$ 3.666
Aug-14	$ 4.445	$ 1.694	$ 3.776
Sep-14	$ 4.590	$ 1.683	$ 3.896
Oct-14	$ 4.617	$ 1.586	$ 3.916
Nov-14	$ 4.743	$ 1.501	$ 3.696
Average	**$ 4.31**	**$ 1.61**	**$ 3.56**

Source: BLS, 2015.

We assume that each substitute replaces one-third (i.e. an equal allotment) of the total calories and grams of protein supplied by the yearly average subsistence harvest of seafood. The pounds of each substitute required were found by dividing the allotments by the calories or grams of protein provided by one pound of each substitute. The cost to purchase the equivalent weights of these substitute foods, by level, was calculated using the average prices per pound reported in Table 38.[25]

The total population relying on the subsistence harvest for a portion of their dietary needs was estimated to determine the costs per person to purchase the substitutes. Two assumptions were made (1) the population is confined to QIN members residing in Grays Harbor and Jefferson Counties (either on- or off-Reservation); and (2) 25% of this population does not consume seafood from the subsistence harvest. This population was estimated to number 1,380; thus, the costs per person were estimated by dividing the total prices for calories and protein, by 1,380.

At the 20% estimated subsistence harvest level, the cost to replace the caloric equivalent provided by the seafood was estimated to be $155.16 per person per year. The cost to replace the protein equivalent provided by the seafood was estimated to be $260.16 per person per year.

The percent of these 'new' costs to replace the subsistence harvest as a percent of income was estimated to illuminate the effect on individuals and families. The per capita income reported for the Reservation from the 2009-2013 American Community Survey is $15,160 ($15,364 in 2014 dollars) (USCB, 2013a).

[25] A full accounting of the costs to replace the subsistence harvest of seafood would include the costs of traveling to a store to purchase the substitutes. To calculate these costs, a survey of purchasing habits and distance traveled to a store is required, which is beyond the timeline and scope of this analysis. However, it is important to note that costs beyond merely the costs of the substitutes would be incurred at the individual level. Note that the Reservation is more than 40 miles from the nearest supermarket.

Thus, at the 20% estimated subsistence harvest level, the cost to replace the caloric equivalent provided by the seafood represents of 1.01% of total income per person; for an equivalent amount of protein the figure rises to 1.69% of total income per person. Tables 39 and 40 provide the costs to replace the total calories and protein provided by the subsistence harvest of seafood.

Table 39. Costs to Replace Calories Provided by Subsistence Harvest of Seafood

5% Level *Total Calories* *29,266,559.60*

Kcal to replace	Substitute	Caloric content (kcal/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
9,755,519.87	Ground Beef (1/3)	1,152.14	8,467.27	$ 4.31	$ 36,493.95	1,380	$ 26.44	
9,755,519.87	Chicken (1/3)	1,084.10	8,998.69	$ 1.61	$ 14,487.90	1,380	$ 10.50	
9,755,519.87	Ham (1/3)	807.41	12,082.52	$ 3.56	$ 43,013.76	1,380	$ 31.17	
							$ 68.11	***Total per capita cost***
							0.44%	***Percent per capita income***

10% Level *Total Calories* *41,734,511.35*

Kcal to replace	Substitute	Caloric content (kcal/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
13,911,503.78	Ground Beef (1/3)	1,152.14	12,074.45	$ 4.31	$ 52,040.87	1,380	$ 37.71	
13,911,503.78	Chicken (1/3)	1,084.10	12,832.26	$ 1.61	$ 20,659.94	1,380	$ 14.97	
13,911,503.78	Ham (1/3)	807.41	17,229.83	$ 3.56	$ 61,338.20	1,380	$ 44.45	
							$ 97.13	***Total per capita cost***
							0.63%	***Percent per capita income***

20% Level *Total Calories* *66,670,411.32*

Kcal to replace	Substitute	Caloric content (kcal/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
22,223,470.44	Ground Beef (1/3)	1,152.14	19,288.80	$ 4.31	$ 83,134.71	1,380	$ 60.24	
22,223,470.44	Chicken (1/3)	1,084.10	20,499.39	$ 1.61	$ 33,004.02	1,380	$ 23.92	
22,223,470.44	Ham (1/3)	807.41	27,524.46	$ 3.56	$ 97,987.08	1,380	$ 71.01	
							$ 155.16	***Total per capita cost***
							1.01%	***Percent per capita income***

Source: Resource Dimensions, 2015

Table 40. Costs to Replace Protein Provided by Subsistence Harvest of Seafood

5% Level *Total Protein (g)* *5,002,757.28*

Protein to replace	Substitute	Protein content (g/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
1,667,585.76	Ground Beef (1/3)	77.88	21,411.39	$ 4.31	$ 92,283.09	1,380	$ 66.87	
1,667,585.76	Chicken (1/3)	123.83	13,466.43	$ 1.61	$ 21,680.95	1,380	$ 15.71	
1,667,585.76	Ham (1/3)	102.60	16,252.59	$ 3.56	$ 57,859.21	1,380	$ 41.93	
							$ 124.51	***Total per capita cost***
							0.81%	***Percent per capita income***

10% Level *Total Protein (g)* *6,819,505.89*

Protein to replace	Substitute	Protein content (g/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
2,273,168.63	Ground Beef (1/3)	77.88	29,186.92	$ 4.31	$125,795.64	1,380	$ 91.16	
2,273,168.63	Chicken (1/3)	123.83	18,356.76	$ 1.61	$ 29,554.38	1,380	$ 21.42	
2,273,168.63	Ham (1/3)	102.60	22,154.71	$ 3.56	$ 78,870.76	1,380	$ 57.15	
							$ 169.73	***Total per capita cost***
							1.10%	***Percent per capita income***

20% Level *Total Protein (g)* *10,453,001.89*

Protein to replace	Substitute	Protein content (g/1.00 lb.)	Lbs. needed to replace	Avg price per lb.	Total cost to replace	Population	Cost/person to replace	
3,484,333.96	Ground Beef (1/3)	77.88	44,737.99	$ 4.31	$192,820.72	1,380	$ 139.73	
3,484,333.96	Chicken (1/3)	123.83	28,137.41	$ 1.61	$ 45,301.23	1,380	$ 32.83	
3,484,333.96	Ham (1/3)	102.60	33,958.94	$ 3.56	$120,893.83	1,380	$ 87.60	
							$ 260.16	***Total per capita cost***
							1.69%	***Percent per capita income***

Source: Resource Dimensions, 2015

6.4 WEAVING WITH PLANT MATERIALS

6.4.1 Sweetgrass gathering overview

As reported in interviews with grass gatherers and weavers, sweetgrass stems can be harvested between June and August, but are most often harvested in July and August. Sweetgrass is a perennial, and dying back can begin as early as August. Stems harvested early are known to be too soft for use, while those harvested late are known to be too brittle. Stems are harvested when the tide is fully out, or during low tide (Shebitz and Crandall, 2012).

Sweetgrass stems are always pulled from the roots and rhizomes – the stems are not cut. Stems from the same plant are gathered only once per season. Non-published data has shown that sweetgrass is not adversely affected if a recovery period of more than one year between harvests on the same plant is allowed, or if less than 25% of the stems in a patch are harvested annually. Further, cutting has a negative effect on stem height and density for at least one year after cutting (Shebitz and Crandall, 2012).

Interviewees explained that sweetgrass stems are rinsed with tidewater in the gathering area, and once leaves are removed, the stems are bundled. Stems are then more carefully washed at home to remove contaminants and improve appearance. Clean stems are hang-dried or dried flat.

Interviewees also reported that desirable qualities include longer and thicker stems (as stems shrink after drying), and stem quality (color and suppleness). The stems of female sweetgrass plants are reported to be more flexible, and thus easier to use

Estimates of the yearly average number of QIN members gathering sweetgrass stems ranged from 20 to 40 people; however, it was noted that some people gather for those unable to.[26] There are 30 adults on the most current weavers list (weavers known to QIN staff). Interviewees explained that basket weaving instruction, which requires sweetgrass stems as an instructional material, is currently offered for Taholah High School students. An estimated 50 to 60 students have participated in the class each year, for the last several years.

Interviewees reported an average of gathering one bundle of sweetgrass stems per year, or roughly 15 to 40 pounds of cleaned and dried stems. The gathering, cleaning, drying, and bundling process was reported to take four to six hours, on average.

6.4.2 Economic values

Dried sweetgrass stems are used in a variety of woven products, including in baskets, jewelry and for clothing (ceremonial or regalia). Some baskets and jewelry are sold. However, interviewees reported that the majority of the products, estimated at 75%, are not sold, but are instead used for ceremonial or display purposes only. There were no reports of woven clothing being sold.

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[26] Interviewees report permits are required for plant material gathering, but not all permit holders gather every year.

As described in Sections 1.2, 2.3 and 6.3, the analysis in this section does not value – monetarily or otherwise – the cultural and spiritual aspects of QIN members' exercise of Treaty-reserved gathering rights.

One interviewee reported that weaving is a full-time job for her, and that she is the only full-time QIN weaver she knows of. However, it was reported by several interviewees that historically many QIN weavers depended on incomes from commercial woven products as a primary or secondary source of income. Today weaving for sale is almost universally a secondary source of income.

It was estimated by interviewees that about 15 to 20 QIN members weave products for sale, and that on average each weaver sells five to seven baskets per year. Woven products are typically marketed via word-of-mouth, at a holiday bazaar, at the Quinault Beach Resort & Casino, and online.

Determining estimates for the price of woven products is complicated. Prices are dependent on materials, size, the nature of the good, craftsmanship, and the renown of the weaver. Interviewees estimated the typical hourly wage for a weaver to be about $20.

Weaving a necklace was typically estimated to require about two hours of labor, and selling in a range from $75 to $120. Weaving a set of earrings was estimated to require about three hours of labor, and selling for about $160.

Basket prices vary significantly by materials and size. For example at the high end, a 6" tall, 9" diameter basket sold for $1,500. A basket made partly from sweetgrass, for example 4" tall and 6" in diameter was estimated to be $75 to $100. Such a basket requires about three hours of weaving

To estimate the yearly commercial value of woven goods made in part by sweetgrass stems, several assumptions are required: (1) that 20 weavers are weaving every year; (2) that each weaver sells seven baskets per year, three necklaces per year and three sets of earrings per year; and (3) that each basket is sold for $100, each necklace is sold for $100, and each set of earrings is sold for $160.

Under these assumptions, the yearly commercial value of baskets, necklaces and earrings was estimated to be $14,000, $6,000 and $9,600, respectively. Thus, the total commercial value of products woven with sweetgrass stems by QIN members was estimated at $29,600.

Interviewees unanimously reported that they believe that oiling of the salt marsh in Grays Harbor would either physically prevent them from or dissuade them from gathering sweetgrass and cattail stems in Bowerman Basin, or, that the stems would be damaged from oil contamination rendering them useless. Interviewees report that oil contamination would be exceedingly difficult to clean from the stems, and that oil contamination would mottle the color of the stems. Most interviewees believe that oil contamination would cause the plants to die off.

The conditional technique used by DOE for spill cleanup of medium oils in a salt marsh is to cut the contaminated vegetation back. It is assumed that this technique would be applied to sweetgrass and cattail plants if oiled (DOE, 2013a)

Oil contamination of the salt marsh in Scenarios 1, 2 and 3 could result in losses of $29,600 for each year of environmental impact. These losses could be attributable to a disinterest in gathering contaminated grasses, or, from no sweetgrass stems to gather.

6.5 SELECT QIN-OWNED BUSINESS AND ECONOMY IMPACTS

Revenues and expenditures for select QIN-owned businesses are presented in this section. This encompasses those established or emergent businesses that could be most directly affected in Scenarios 1, 2 and 3. The seven select QIN-owned businesses are the Quinault Beach Resort & Casino; the newly acquired Ramada Inn at Ocean Shores; Quinault Pride Seafood I (Taholah) and the branch of Quinault Pride Seafood II at Westport – aka 'Jolly Roger'; Q-Mart I (Ocean Shores) and Q-Mart II (Aberdeen); and the Maritime Resort in Ocean Shores (Table 41). Geographic locations of these businesses are displayed in Figure 11.

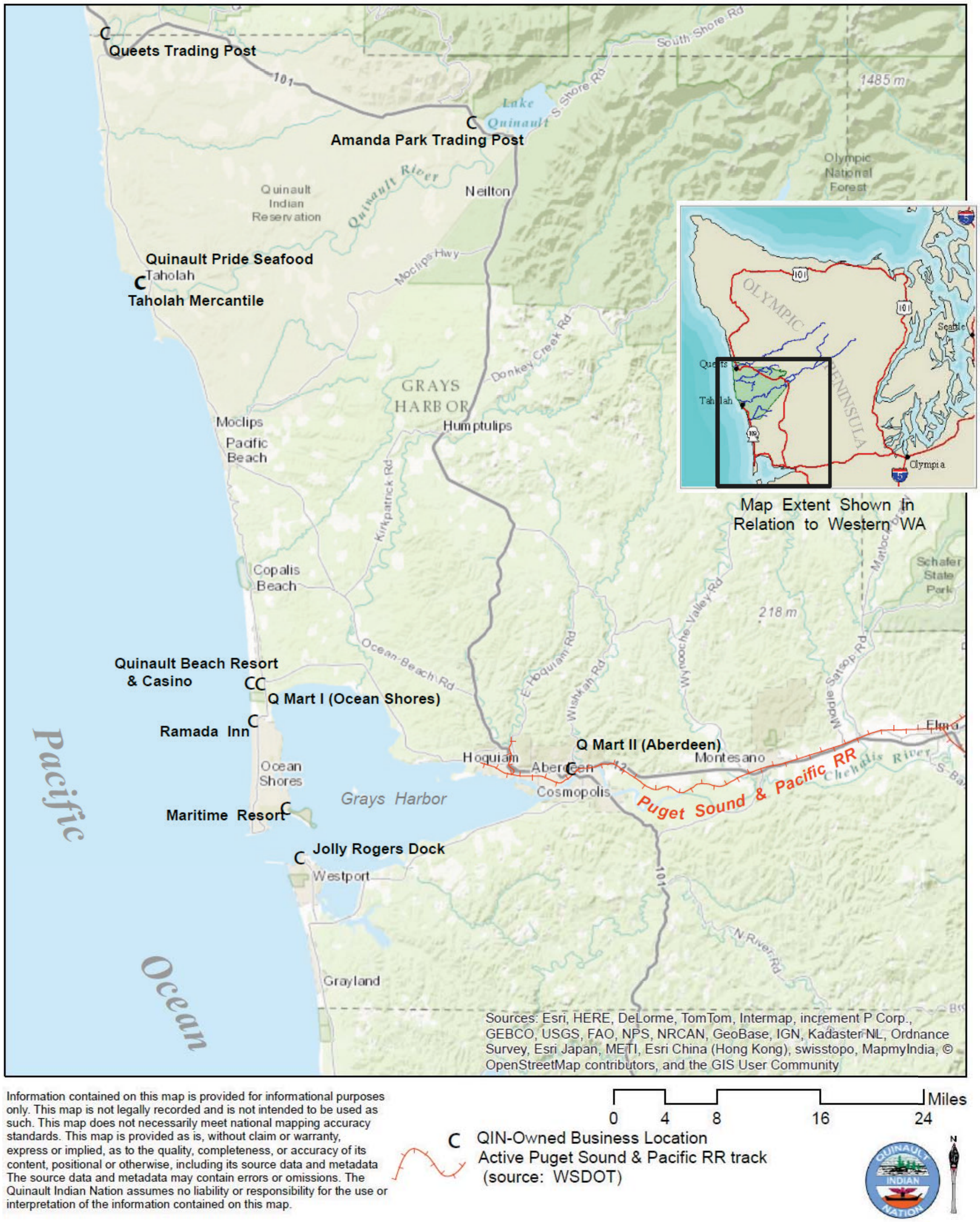
In addition, the revenues and expenditures attributable to a potential pilot project for QIN commercial aquaculture are discussed.

Table 41. Select QIN-owned Businesses

QIN-owned Business	Location
Maritime Resort	Ocean Shores
Q-Mart I	Ocean Shores
Q-Mart II	Aberdeen
Quinault Beach Resort & Casino	Ocean Shores
Quinault Pride Seafood I	Taholah
Quinault Pride Seafood II	Westport
Ramada Inn	Ocean Shores

Source: Resource Dimensions, 2015

Figure 11. Locations of QIN-owned businesses



Source: QDNR GIS Program, 2015. Note: QIN timber enterprise not shown.

6.5.1 Select QIN-owned business revenues and expenditures

Revenues for the six select QIN-owned businesses operating in Fiscal Year (FY) 2014, totaling $57,633,812, are reported in Table 42.

Table 42. Select QIN-owned Businesses Revenues, 2014

QIN-owned Business	2014
Maritime Resort	$ 99,709
Quinault Beach Resort & Casino	$ 36,301,327
Quinault Pride Seafood I	$ 10,859,406
Quinault Pride Seafood II	$ 636,189
Q-Mart I	$ 2,290,080
Q-Mart II	$ 7,447,101
Total	***$ 57,633,812***

Source: QIN, 2015c

AARG was calculated for the four businesses operating over 2009 to 2013 to examine trends in revenue (adjusted to 2014 dollars). Q-Mart I had the highest AARG over that time at 109%, driven by strong years in 2010 and 2011 (Table 43).

Table 43. Select QIN-owned Businesses Revenue Trends

QIN-owned Business	2009	2010	2011	2012	2013	AARG
Maritime Resort	$ 60,741	$ 63,437	$ 74,794	$ 79,889	$ 87,394	9.6%
Beach Resort & Casino	$ 28,692,308	$ 29,413,318	$ 31,041,114	$ 32,345,505	$ 33,927,777	4.3%
Quinault Pride Seafood I	$ 11,572,180	$ 16,293,796	$ 17,753,587	$ 9,531,900	$ 14,022,202	12.6%
Q-Mart I	$ 577,979	$ 2,580,043	$ 3,186,684	$ 958,094	$ 2,289,826	109.7%

Source: QIN, 2014

Revenue projections for Q-Mart II are limited in that the business was started in 2012. Revenue for Q-Mart II was $260,622 in 2012, increasing to $5.9 million in 2013 and $7.4 million in 2014 (2014 dollars). Revenues for the Quinault Pride Seafood II are projected to increase from $6,659,415 in FY 2015, to $6,759,306 in FY 2016, to $6,860,696 in FY 2017, and to $6,963,606 in FY 2018, for an AARG of 1.50% (QIN, 2015b). Revenues for the Ramada Inn at Ocean Shores are expected to increase from $846,904 in year 1 of operations, to $859,608 and $872,502 in years 2 and 3 (also an AARG of 1.50%) (QIN, 2015a).

Total expenditures for the six QIN-owned businesses operating in FY 2014, totaling $53,083,385, are reported in Table 44.

Table 44. Select QIN-owned Businesses Direct Expenditures, 2014

QIN-owned Business		2014
Maritime Resort	$	172,226
Quinault Beach Resort & Casino	$	31,996,388
Quinault Pride Seafood I	$	10,900,608
Quinault Pride Seafood II	$	578,384
Q-Mart I	$	2,272,888
Q-Mart II	$	7,162,891
Total	***$***	***53,083,385***

Source: QIN, 2015c

Expenditures for the Ramada Inn at Ocean Shores are expected to increase from $696,091 in year 1 of operations, to $706,532 and $717,130 in years 2 and 3 (an AARG of 1.50%) (QIN, 2015a).

6.5.2 Economic Impacts of Select QIN-owned Businesses on Grays Harbor County

As Table 45 indicates, four select QIN-owned businesses (the Quinault Beach Resort & Casino, Maritime Resort, and Q-Marts I and II) generated the following economic impacts for the local and regional economies in 2013:[27]

- 404 direct jobs generated by the Quinault Beach Resort & Casino, Maritime Resort, and the two Q-Mart stores. Purchases made by these 404 individuals supported an additional 86.5 induced jobs in the region.
- 61.5 indirect jobs were supported by $22.4 million of local purchases made by businesses supplying services to the four select QIN-owned businesses.
- $18.7 million of direct wages and salaries were received by the 404 directly employed by the four businesses. Re-spending of this income created an additional $3.3 million of income and consumption expenditures in Washington, principally in Grays Harbor County. Those holding indirect jobs received $2.5 million in indirect income.
- Businesses providing services to the four businesses received $55.9 million of revenues.

As with the economic impact evaluation for Treaty fisheries-based activities, tax impacts are not described.

[27] The economic impacts of Quinault Pride Seafood I and II are included in the economic impacts discussed in Section 6.2, as they were included under the umbrella of Treaty fisheries-based activities.

Table 45. Summary of Economic Impacts Generated by Select QIN-owned Businesses 2013 ($2014)

Grays Harbor County	Quinault Beach Resort & Casino	Maritime Resort	Q-Marts I & II	TOTAL
Jobs				
Direct	385.4	0.9	17.7	404.0
Indirect	60.7	0.0	0.8	61.5
Induced	83.7	0.1	2.7	86.5
Total	**529.8**	**1.0**	**21.2**	**552.0**
Personal Income				
Direct	$ 18,026,838	$ 27,470	$ 677,664	$ 18,731,972
Indirect	$ 2,430,987	$ 1,834	$ 28,742	$ 2,461,563
Induced	$ 3,195,752	$ 4,571	$ 104,081	$ 3,304,404
Total	**$ 23,653,577**	**$ 33,875**	**$ 810,487**	**$ 24,497,939**
Business Revenue	$ 54,920,823	$ 94,052	$ 908,258	**$ 55,923,133**
Local Purchases	$ 21,479,391	$ 66,981	$ 876,257	**$ 22,422,629**

Source: Resource Dimensions, 2015

6.5.3 Economic Impacts of QIN-owned Businesses on Grays Harbor County, 2020 – 2022

To estimate the changes in economic contributions in Scenarios 1, 2 and 3, we begin with the Base Case Scenario model for the period 2020 to 2022 for the select QIN-owned businesses and accordingly adjust each IMPLAN sub-model to estimate changes in local and regional economy impacts resulting from activity levels expected under each scenario. The Base Case Scenario model is built upon the original sub-model and incorporates only revenue and expenditure changes from known 2013 operations for the select QIN-owned businesses. The Ramada Inn at Ocean Shores is included in 2020 to 2022 analyses.

Base Case Scenario: Table 46 indicates the economic impacts projected for the local and regional economy from 2020 to 2022.

- An average of 421.3 direct jobs generated by the select QIN-owned businesses. Purchases made by these individuals supporting an additional average of 90.3 induced jobs in the region.
- An average of 63.9 indirect jobs supporting a total of some $73.3 million in local purchases made by businesses supplying services to the select QIN-owned businesses from 2020 to 2022.
- $60.7 million of direct wages and salaries would be received by an annual average of 421.3 directly employed by the select QIN-owned businesses. Re-spending of this income would

create an additional $10.7 million of income and consumption expenditures in Washington, principally in Grays Harbor County. Those holding indirect jobs would receive some $7.8 million in indirect income.

- Businesses providing services to the select QIN-owned businesses would receive some $205 million of revenues.

Related tax impacts generated by the select QIN-owned business activities are not reported.

Table 46. Summary of Economic Impacts Generated by Select QIN-owned Businesses, 2020-2022

Grays Harbor County	Quinault Beach Resort & Casino	Maritime Resort	Q-Marts I & II	TOTAL
Jobs				
Direct	385.4	0.7	27.2	421.3
Indirect	60.4	0.0	2.4	63.9
Induced	83.4	0.1	5.6	90.3
Total	**529.2**	**0.8**	**35.2**	**575.5**
Personal Income				
Direct	$ 55,624,344	$ 69,748	$ 4,156,150	$ 60,682,819
Indirect	$ 7,400,414	$ 4,657	$ 264,887	$ 7,803,300
Induced	$ 9,844,102	$ 11,605	$ 660,952	$ 10,662,893
Total	**$ 72,868,859**	**$ 86,010**	**$ 5,081,989**	**$ 79,149,012**
Business Revenue	$ 189,441,062	$ 281,244	$ 12,092,342	**$ 205,000,308**
Local Purchases	$ 66,300,145	$ 170,067	$ 5,743,858	**$ 73,347,265**

Source: Resource Dimensions, 2015

6.5.4 Scenario-based Changes in Economic Contributions Generated by Select QIN-owned Businesses on Grays Harbor County, 2020 – 2022

Tables 47 and 48 present the economic impacts as changes in contributions from the Base Case (Table 46) to the local and regional economy from 2020 to 2022. Related tax impacts generated by the select QIN-owned businesses are not presented in these discussions or tables.

Scenario 1: Table 47 indicates the changes in economic contributions by select QIN-owned businesses to the local and regional economy from 2020 to 2022:

- An average three-year decrease of 9.6 direct jobs in select QIN-owned businesses. Resulting purchases made by the remaining 411.7 individuals would support an average of 88.3 induced jobs in the region (a loss of 2 induced jobs).

- An average three-year decrease indirect jobs results in an estimated $2.3 million decrease in purchases made by businesses supplying services to the select QIN-owned businesses.
- A three-year total decline of $1.5 million in direct wages and salaries from Base Case Scenario 2020-2022 was estimated for the 411.7 directly employed by the select QIN-owned businesses. Re-spending of remaining income will create an estimated additional $10.4 million of income and consumption expenditures in Washington, principally in Grays Harbor County ($243,432 decrease for the period as shown in Table 47). A three-year total decrease of one indirect job and some $82,000 in related income from the Base Case Scenario 2020-2022 was estimated.
- Over the period 2020 to 2022, businesses providing services to the select QIN-owned businesses can expect to receive $4.8 million less in revenues.
- Under the conditions of Scenario 1, we estimate minor impacts to the Quinault Beach Resort & Casino's and the Ramada Inn's operations, thus all related jobs. Given the prominence of these local employers, the overall economic impacts under Scenario 1 are the least severe for the select QIN-owned businesses, with an estimated average annual loss of 12.5 jobs over 2020 to 2022.

Table 47. Scenario 1: Summary of Changes in Economic Contributions to Grays Harbor County by Select QIN-owned Businesses, 2020-2022

Grays Harbor County	Maritime Resort	Q-Marts I & II	TOTAL
Jobs			
Direct	0.1	9.5	9.6
Indirect	0	1	1
Induced	0	2	2
Total	**0.1**	**12.4**	**12.5**
Personal Income			
Direct	$ 13,515	$ 1,529,202	$ 1,542,717
Indirect	$ 902	$ 81,170	$ 82,072
Induced	$ 2,249	$ 241,184	$ 243,432
Total	**$ 16,666**	**$ 1,851,555**	**$ 1,868,221**
Business Revenue	$ 54,496	$ 4,713,517	**$ 4,768,013**
Local Purchases	$ 32,953	$ 2,222,576	**$ 2,255,530**

Source: Resource Dimensions, 2015

Scenarios 2 and 3: These two scenarios are expected to affect the select QIN-owned businesses in very similar ways. Thus, the changes in economic contributions by these businesses are the same in Scenarios 2 and 3. Table 48 displays the changes in economic contributions by select QIN-owned businesses to the local and regional economies from 2020 to 2022:

- An average three-year decrease of 56.7 direct jobs in the select QIN-owned businesses; nearly 80% of these direct job losses will be at the Quinault Beach Resort & Casino. Resulting purchases made by the remaining 364.6 individuals would support an average of 77.8 induced jobs in the region (a loss of 12.5 induced jobs).

- An average three-year decrease of 8.5 indirect jobs results in an estimated $10.9 million decrease in purchases made by businesses supplying services to the select QIN-owned businesses.

- A three-year total decline of $8.6 million in direct wages and salaries from Base Case Scenario 2020-2022 was estimated for the 364.6 directly employed by the select QIN-owned businesses. Re-spending of remaining income will create an estimated additional $9.2 million of income and consumption expenditures in Washington, principally in Grays Harbor County (about a $1.5 million decrease for the period as shown in Table 48). A three-year total decrease of 8.5 indirect jobs and some $1.0 million in related income from the Base Case Scenario 2020-2022 was estimated

- Over the period 2020 to 2022, businesses providing services to the select QIN-owned businesses can expect to receive $29.8 million less in revenues.

- The similarities in general economy effects associated with spill Scenarios 2 and 3 are realized in the estimated average annual loss of 77.7 jobs from 2020 to 2022.

Table 48. Scenarios 2 and 3: Summary of Changes in Economic Contributions to Grays Harbor County by Select QIN-owned Businesses, 2020-2022

Grays Harbor County	Quinault Beach Resort & Casino	Maritime Resort	Q-Marts I & II	Ramada Inn	TOTAL
Jobs					
Direct	45.3	0.1	9.6	1.7	56.7
Indirect	7.1	0	1.2	0.2	8.5
Induced	9.8	0	2.5	0.2	12.5
Total	**62.2**	**0.1**	**13.3**	**2.1**	**77.7**
Personal Income					
Direct	$ 6,543,815	$ 13,515	$ 1,896,950	$ 178,361	$ 8,632,640
Indirect	$ 870,607	$ 902	$ 118,729	$ 28,565	$ 1,018,804
Induced	$ 1,158,090	$ 2,249	$ 305,557	$ 31,328	$ 1,497,223
Total	**$ 8,572,512**	**$ 16,666**	**$ 2,321,236**	**$ 238,254**	**$ 11,148,667**
Business Revenue	$ 22,293,476	$ 54,496	$ 6,749,274	$ 682,500	**$ 29,779,746**
Local Purchases	$ 7,799,749	$ 32,953	$ 2,825,902	$ 242,761	**$ 10,901,365**

Source: Resource Dimensions, 2015

6.5.5 Potential QIN commercial aquaculture pilot project and potential economic impacts

The QIN is considering a commercial aquaculture pilot project for growing Pacific oysters on tidelands in Grays Harbor. The project would first be instituted on 80 acres of tidelands, and the oysters likely would be grown using stake and line and bottom cultures. Marketable Pacific oysters would not be produced until at least the third year of operations (Pacific oysters require at least two years of growth to reach a size desirable for the majority of the market).[28]

To understand potential revenues for an operation of this size, average Pacific oyster values per pound for Grays Harbor County were calculated from 2004 to 2013 (using figures reported by WDFW), and multiplied versus assumed productivity. The average value per pound for Pacific oysters is $3.41 (Table 49).

[28] Pacific oysters can be used for the half-shell market at one year of growth; however two years of growth is assumed for production in this analysis.

Table 49. Average Pacific Oyster Harvest and Value, Grays Harbor County ($2014)

Year	Harvest (round lbs.)	Value ($2014)	
2004	1,378,664	$	5,362,290
2005	1,339,464	$	4,498,958
2006	1,428,407	$	4,795,239
2007	1,470,898	$	4,722,114
2008	1,045,443	$	3,519,614
2009	1,123,869	$	3,886,081
2010	1,030,586	$	3,533,584
2011	1,804,434	$	6,134,273
2012	1,740,822	$	5,908,801
2013	1,565,904	$	5,187,446
Average	*1,392,849*	*$*	*4,754,840*
Average price/round lbs.		**$**	**3.41**

Source: IEc, 2014a

Production of Pacific oysters on tidelands in Grays Harbor County is estimated to be 800 gallons per acre (Plauche & Carr, 2014). This an approximate yield of 6,672 round pounds of Pacific oysters per acre, assuming the density of water.[29] Thus, the estimated value of Pacific oysters harvested per acre $22,751 at $3.41 per pound. If all 80 acres in the pilot project are producing the average yield, the total value every other year (starting in the third year of operations, and assuming a two-year growing cycle) is estimated at $1,820,098.

Expenditures to farm the 80 acres on the pilot project were estimated using survey data from shellfish farming expenditures reported by Northern Economics (2013). To estimate the total expenditure for each expenditure category, average spending per farmed acre was adjusted to 2014 dollars and then multiplied by 80 (pilot project acres). Project expenditures were estimated to be $426,431 annually (Table 50).

[29] To estimate the round pounds of oysters yielded per acre, the gallons of oysters per acre was multiplied by 8.34 lbs./gallon (assuming the density of oysters equals the density of water) to convert from a volume to a mass.

Table 50. Estimated Total Expenditures for QIN Commercial Aquaculture Pilot Project

Expenditure category	Per acre ratio of spending	Average spending per farmed acre (2014 $)	Total spending (2014 $)
Total		**$ 5,330.39**	**$ 426,431.20**
Payroll	29%	$ 1,545.81	$ 123,665
Other Spending	21%	$ 1,119.38	$ 89,550
Seed and Shellfish	18%	$ 959.47	$ 76,758
Capital	10%	$ 533.04	$ 42,643
Freight	6%	$ 319.82	$ 25,586
Benefits	5%	$ 266.52	$ 21,322
Federal	4%	$ 213.22	$ 17,058
Gas/Fuel	2%	$ 106.61	$ 8,529
Leases	2%	$ 106.61	$ 8,529
Insurance	2%	$ 106.61	$ 8,529
State and Local	1%	$ 53.30	$ 4,264

Sources: Northern Economics, 2013; Resource Dimensions, 2015

Table 51 illustrates the economic impact that would have been produced by the QIN commercial aquaculture pilot project for the local and regional economy in 2013:

- About 4 direct jobs would be generated by the project. Purchases made by these individuals would support one induced job in the region.
- The equivalent of one part-time indirect job would be supported by $221,224 in local purchases made by businesses supplying services to the project.
- $211,590 of direct wages and salaries would be received by those directly employed by the project. Re-spending of this income would create an additional $34,473 of income and consumption expenditures in Washington, principally in Grays Harbor County. About $8,300 would be generated in indirect income to those holding indirect jobs.
- Businesses providing services to the project would have received $443,448 in revenues.

Table 51. Projected Economic Impacts of QIN Commercial Aquaculture Pilot Project

Grays Harbor County		QIN Commercial Aquaculture
Jobs		
Direct		3.8
Indirect		0.2
Induced		0.9
Total		**4.9**
Personal Income		
Direct	$	211,590
Indirect	$	8,333
Induced	$	34,473
Total	**$**	**254,396**
Business Revenue	**$**	**443,448**
Local Purchases	**$**	**221,224**

Source: Resource Dimensions, 2015

6.6 Rail and Marine Vessel Traffic Impacts

Potential losses to Treaty commercial fishers resulting from rail and marine vessel transport of oils, and from lost or damaged fishing gear are explored in this section using case studies. Note, while subsistence fishing is not considered here these impacts are likely to impart similar losses to Treaty subsistence fishers.

6.6.1 Rail traffic impacts

Rail transport of oils could affect any Treaty commercial fisher who needs to cross the railway to reach his/her fishing area or who must cross the railway to transport catch to the processor. From interviews, it is understood that this conflict would be most relevant for those with fishing areas near Montesano. These fishers must cross the railway potentially several times per day to transport their catch.

Rail traffic is problematic in two respects. First, it could potentially delay fishers from reaching their fishing areas because of regular operations or a derailment, and with no net in the water no revenue is generated. This could cause fishers to miss the most productive fishing times (slack tides, per interviewees). Second, in terms of transporting catch, delays at crossings would increase the time the catch is remaining exposed to the elements in crates, potentially affecting whether the catch is purchased by the processor, and the value of the catch.

At current writing (March 2015) there is no cumulative RTIA for the proposed projects, precluding a more exacting analysis of potential waits at railroad crossings. The only document concerning rail traffic impacts is for the GHRT project. This analysis assumes one train per day is added to current operations (rather than 3.75 new trains per day as projected cumulatively for the three projects at full build-out). Further, the study area of the GHRT document is confined to intersections in Hoquiam, and is thus not relevant for this case study (HDR, 2014b).

We consider how rail transport of crude oil can affect the gillnet fisheries on the Chehalis River, using 2013 data. The 2013 total value of the gillnet fisheries in Areas 2A, 2A1 and 72B (Chinook, chum and coho salmon, steelhead and white sturgeon) was $381,533 (2013 dollars) (QDFi Database, 2015). To estimate the average value per fisher-day, we assume 50 Treaty commercial fishers (the maximum number permitted to fish these Areas), fishing an average of 30 days per year (the average number of days fished in these Areas per year as reported by interviewees). The yearly average value per fisher in these Areas was estimated at $7,631; thus, an average value of $254 per fisher-day in 2013.

To illustrate the effects of these impacts on fishing, the example of a 10% reduction in the ability to fish or to transport catch due to delays at railroad crossings, and a direct relationship of fishing or delivery abilities to catch was assumed. A 10% reduction in the yearly average value of landings from these Areas per fisher was estimated to be a loss of $763, or about 5.0% of the per capita income reported for the Reservation in 2013 dollars (USCB, 2013a).

6.6.2 Marine vessel traffic impacts

Transport of oils is expected to occur via barge or tanker. These vessels require the assistance of tugboats to navigate Grays Harbor. At the time of this writing (March 2015), no cumulative VTIA exists for the proposed projects, complicating a risk analysis of potential navigational conflicts.

Using the method described in Section 6.6.1, we consider how marine vessel traffic can impact the gillnet fisheries on the Chehalis River, using 2013 data. The 2013 total value of the gillnet fisheries in Areas 2A and 2D (Chinook, chum and coho salmon, steelhead and white sturgeon) was $442,072 (2013 dollars) (QDFi Database, 2015). To estimate the average value per fisher-day, we assume 50 Treaty commercial fishers (the maximum number permitted to fish these Areas) fishing an average of 30 days per year, (the average number of days fished in these Areas per year reported by interviewees). The yearly average value per fisher in these Areas was estimated to be $8,841; thus an average value of $295 per fisher-day in 2013.

Using the method described in Section 6.6.1, we consider how marine vessel traffic can impact the gillnet fisheries on the Chehalis River, using 2013 data. The 2013 total value of the gillnet fisheries in Areas 2A and 2D (Chinook, chum and coho salmon, steelhead and white sturgeon) was $442,072 (2013 dollars) (QDFi Database, 2015). To estimate the average value per fisher-day, we assume 50 Treaty commercial fishers fishing an average of 30 days per year. The yearly average value per fisher in these Areas was estimated to be $8,841; thus an average value of $295 per fisher-day.

To illustrate the effects of these impacts on fishing, a 5% reduction in the ability to fish, and a direct relationship of fishing ability to catch was assumed. A 5% reduction in the yearly average value of landings from these Areas per fisher was estimated to be a loss of $442, or about 2.9% of the per capita income reported for the Reservation in 2013 dollars (USCB, 2013a).

6.6.3 Lost or damaged fishing gear replacement

The costs of replacing fishing gear lost or damaged due to marine vessel transport of crude oil can be estimated by adding new gear costs to the opportunity costs of foregone revenue from not fishing and the value of time needed to prepare new gear. Revenue from fish in a damaged net or crabs in the pot with no buoy is also lost.

Interviewees unanimously reported that oiled nets have decreased effectiveness and are not useable. Nets severed by propellers may be limited in usefulness or never recovered. Nets are the most significant expenditure for Treaty gillnetters by a wide margin. Further, interviewees reported one's ability to purchase and ready a new net in time to resume fishing for a season could be questionable, depending on the type of net used and the process for readying the net for fishing.

Interviewees reported a range of costs for their nets; hanging was done by the fisher or hired out at a labor cost of $100 for a few hours' work.[30] Treaty gillnetters replace their nets on different cycles; on average the average annual cost of a net, plus line, hanging, etc. was estimated at $2,500.

Three types of economic loss are tied to lost crab pots – the value of the pots, the value of the crab, and the time needed to prepare the pots for use. Treaty crab fishers reported that the cost of one new crab pot, including rope, buoy and bait jar is $235. Crab fishers typically replace a portion of their pots every year. The time needed to prepare, for example, 100 new pots, including painting and rigging, is roughly one full week of work for the fisher (40 to 50 hours).

Total Treaty crab fisher-days for the 2013 crab season were 577; median crab fishing days per crab fisher was 25 (QDFi Database, 2015). There were 23 crab fishers licensed for 2013 season. The total value of the 2013 crab fishery was $10,681,865 (QDFi Database, 2015); thus, an average value of $18,513 per fisher-day. As an example, assuming 25 deployed pots are lost, at $235 per pot, the lost value is $5,875.

The loss of the pots is roughly one-third of the average value per fisher-day (1/75 of the 2013 season's average revenue). Depending on how many pots are fished per day, the lost pots can have a significant impact on daily revenues, carrying forward until the pots are replaced. In the case of the 2013 season wherein median fishing days per fisher were 25, there is limited opportunity to significantly recoup lost revenue.

[30] Interviewees reported that fisheries sometimes have short openings, for example two days. Time spent preparing a net for use, and the time required to hang a net varies significantly depending on the type and size of net used. Combined times to accomplish these tasks can range from several hours to multiple days of work.

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Appendices

Appendix A. NAICS to IMPLAN bridge table for economic sectors used in impact models

Table A-1. NAICS to IMPLAN bridge table for economic sectors used in impact models

Economy Sector	Economy Industry Name	NAICS Code	NAICS Industry Name	IMPLAN Code	IMPLAN Sector
Construction - Marine	Marine Related Construction	237120 237990	Oil & Gas Pipeline & Related Structures Other Heavy & Civil Engineering Constr.	58	Construction of other new nonresidential structures
Marine Resources	Fish Hatcheries & Aquaculture	112511 112512	Finfish Farming & Fish Hatcheries Shellfish Farming	14	Animal production, except cattle, poultry, eggs
	Fishing	114111 114112	Finfish Fishing Shellfish Fishing	17	Commercial Fishing
	Management & Research	924120	Administration of Conservation Pgms	375	Environmental and misc. technical consulting services
		325411	Medicinal and Botanical Manufacturing	132	Fish liver oils, medicinal, uncompounded
	Commercial fishing equip/supply	423830	Industrial Machinery & Equipment	417	Commercial and industrial machinery and equipment repair and maintenance
	Fishing net materials	314999	Misc. Textile Products	85	All other textile products
	Seafood Processing	311710 311712	Seafood Canning Fresh & Frozen Seafood Processing	61	Seafood product preparation & packaging
	Fish Merchants	424420 424460	Frozen Fish Wholesalers Fish and Seafood Merchant	319	Wholesale trade
	Seafood Markets	445220	Fish and Seafood Markets	400	Retail - Food & beverage
Ship & Boat Building and Repair	Boat Building/Repair Ship Building/Repair	336612 336611	Boat Building & Repair Ship Building & Repair	354 363	Boat Building Ship building & repairing
Tourism & Recreation (Coastal)	Boat Dealers	441222	Boat Dealers	396	Retail - motor vehicles & parts
	Eating & Drinking Places	722110 722111 722112 722113	Full Service Restaurants Limited Service Eating Places Cafés Snack & Nonalcoholic Beverage	501 502 503	Food services & drinking places
	Lodging/Accommodations	721110 721191	Hotels & Motels B&Bs / Inns	411 412	Hotels & motels; incl. casino hotels Other accommodations
	Marinas	713930	Marinas	409	Amusement parks, arcades & gambling
	RV Parks & Campsites Rec/Vacation Camps	721211 721214	RV Parks & Recreational Camps Rec Camps (except Campgrounds)	412	Other accommodations
	Scenic Water Tours	487210	Scenic & Sightseeing Transp., Water	338	Scenic & sightseeing transp. & support

(Continued)

Table A-1. NAICS to IMPLAN bridge table for economic sectors used in impact models (continued)

Economy Sector	Economy Industry Name	NAICS Code	NAICS Industry Name	IMPLAN Code	IMPLAN Sector
Tourism & Recreation (Coastal)	Sporting Goods - Retail & Supply	451110	Sporting Goods Stores	328	Retail Goods: Sporting Goods
		339920	Equipment Mfg.	311	Sporting & athletic goods manufacturing
		423910	Sporting Goods - Supply, Wholesale	319	Wholesale trade
	Amusement & Recreation Services	487990	Scenic & Sightseeing Transp., Other.	338	Scenic & sightseeing transp. & support
		611620	Sports & Recreation Instruction	393	Other educational services
		532292	Recreation Goods Rental	363	Gen & Cons. Goods rental (excl. video)
		713990	Other Amusement & Recreation Svcs	410	Other amusement & recreation industries
	Zoos & Aquaria	712130	Zoos & Botanical Gardens	406	Museums, historical sites, zoos & parks
		712190	Nature Parks & Similar		
Transportation - Marine	Deep Sea Freight Transportation	483111	Deep Sea Freight Transportation	334	Water transportation
		483113	Coastal & Great Lakes Freight Trans		
	Marine Passenger Transport	483112	Deep Sea Passenger Transportation	334	Water transportation
		483114	Coastal & Great Lakes Freight Trans		
	Marine Transportation Services	488310	Port & Harbor Operations	338	Scenic & sightseeing transportation & support activities
		488320	Marine Cargo Handling		
		488330	Navigational Services to Shipping		
		488390	Other Support Act. for Water Transp.		
	Search & Nav. Equip.	334511	Search, Detection, Nav. Guidance, Aero. & Naut. System & Inst. Manuf.	315	Search, detection, & navigational instrument manufacturing
	Warehousing	493110	General Warehousing & Storage	340	Warehousing & Storage
		493120	Refrigerated Warehousing & Storage		
		493130	Farm Product Warehousing & Storage		

Sources: Resource Dimensions, 2015 adapted with guidance from Colgan, C.S. 2007. A Guide to the Measurement of the Market Data for the Ocean and Coastal Economy in the National Ocean Economics Program. National Ocean Economics Program, January 2007; IMPLAN Sector descriptions and NAICS bridge for the 536 IMPLAN sector scheme.

Note: To estimate county-level economic contributions or impacts with IMPLAN, it was necessary to disaggregate county-level data into 27 sectors. This was done using this "bridge table," adapted from Colgan (2007). The last two columns are the IMPLAN industry sector assignments used to estimate the economic contributions of QIN fisher-based and other QIN business activities.

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