Assessment of Benefits and Costs Associated with Shellfish Production and Restoration in Puget Sound

Final

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Pacific Shellfish Institute

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Contents

1 Introduction

In this report we describe the suite of economic, social, and environmental benefits and costs associated with shellfish production and restoration in Puget Sound using information derived from a literature review, stakeholder focus groups, and quantitative and qualitative analyses. The objective of this report is to provide a comprehensive outline of these costs and benefits in order to support informed decision making regarding environmentally sustainable shellfish production and economically sustainable shellfish restoration. A review of the literature and public press makes it clear that there is not a consensus regarding the pros and cons of shellfish production and restoration on nearshore lands. We attempt in this report to objectively inform this debate. There are several limitations to this report, including the difficulty of placing a dollar value on all the benefits and costs identified. Therefore, while this report provides a monetary value assessment of some of the recognized benefits and costs, the balance of these is outlined qualitatively.

2 Economic Benefits

2.1 Industry Revenues Reported in Aggregate Levels

According to the Canadian Aquaculture Industry Alliance (2008) shellfish are bought and consumed for their nutritional benefits as well as their taste. They are healthy sources of protein, rich in vitamins and minerals, low in fat and a good source of omega-3 fatty acids. The value of the industry that serves regional, national, and international demand for shellfish is significant. Washington is the leading producer of farmed bivalve shellfish in the United States, generating an estimated $77 million in sales and accounting for 86 percent of the West Coast's production in the year 2000. According to Washington Department of Fish and Wildlife (WDFW, 2009), harvest of Puget Sound farmed shellfish (clams, mussel, geoduck, oyster, and scallops) has ranged from 3.8 million pounds in 1970 to 11.4 million pounds in 2008. All Washington farmed shellfish harvest (Puget Sound and Coastal Washington) has ranged from 7.6 million pounds in 1970 to 5.6 million pounds in 2008 with an estimated 2006 ex-vessel value of $107 million.

In addition to primary sales of the raw, unshucked product, there are further economic benefits from secondary products and services (e.g., shucking and packing houses, transport, manufacture of prepared oyster products and retail sales) (NOAA Restoration Center undated). In addition, the commercial shellfish industry is the second largest private-sector employer in both Mason and Pacific counties, supporting more than 1,200 jobs and an estimated total payroll that exceeds $27 million. In some areas of the state, shellfish fisheries and cultivating operations also contribute to public revenues through licensing and lease fees. According to a 2002 Mason County Shellfish Industry Update (Economic Development Council of Mason County, 2002), in 2001 there were 120 harvesters involved in the industry as compared to 31 in Jefferson County, 17 in Kitsap County, 15 in Grays Harbor County and 11 in Clallam County. Gross sales in Mason County in 2001 were estimated at $32.2 million (the tribes accounted for approximately 19 percent of the total). Of the total dollar volume, 69 percent came from firms generating over $1 million worth of production; the tribes accounted for an estimated 19 percent of the total; 8 percent came from firms producing between $100,000 and $1 million; and the remaining 4 percent came from firms producing less than $100,000. The industry also supported 534 direct full-time jobs and 91 additional indirect jobs, and resulted in $3.3 million in total payroll. Smaller entities such as the Drayton Harbor Community Oyster Farm in Whatcom County have generated average annual revenue from oyster sales of $14,000 for the period of 2004 through 2008 (Burke et al, 2009).

2.2 Economic Impact to the Region from Shellfish Harvest

More than two decades ago, Bonacker and Cheney (1988) described the state of knowledge of Washington's shellfish industry as follows: "We are weakest in the area of economics. Data on aquaculture production costs, revenues, etc. are very limited." Little has changed in the intervening years. To begin to address this data gap, NEI (2009) conducted a preliminary revenue and expenditure analysis of commercial shellfish farms in Little Skookum (Manila clams) and Totten Inlet (mussels and oysters). The analysis is a first step toward developing a more comprehensive cross-sectional economic survey of shellfish growers, the findings of which can be used to estimate a production function[1] and build an input-output model for the Washington state shellfish industry. In addition, survey data could provide a basis for estimating the producer surplus generated by the industry. NEI worked with Little Skookum Shellfish Growers to better understand the expense categories that would form the basis of the grower survey. The expense categories were generalized where appropriate to all forms of shellfish production. Growers were solicited for their feedback on whether or not the categories were representative of expenses for their business. In order to get quality responses, growers who showed support for economic research relevant to their business were identified to participate in the test survey. In order to best test the survey instrument, growers of different species were selected. Three firms, in addition to LSSG, participated in the survey.

The preliminary survey results were intended to help refine the questions that were asked and indicate areas that may need more in-depth questions. Revenue data were also collected as part of the survey. Table 1 shows the percent of total revenue by product for each grower surveyed. The products represented are clams, geoducks and oysters, but they have been relabeled products A, B and C in no particular order to protect the respondents' privacy. The total revenue of each firm exceeded $1 million. Of the firms surveyed, revenue from the largest product ranged from 82 to 96 percent. The growers surveyed tended to have one major product and at least one other product. One firm did have a substantial second product that accounted for 18 percent of its revenue.

Table 1. Percent of total Revenue by Product

	Company			
	1	2	3	4
Product A	0%	3%	4%	18%
Product B	4%	5%	96%	82%
Product C	96%	91%	0%	0%

Source: Northern Economics, Inc .Grower's Survey 2009.

The results of the revenue portion of the survey pose a challenge for the industry wide survey. Clearly, many growers will have mixed revenue if all of the participants in this small survey do. Developing production functions for the production of each species will require that costs for each species be tied to that species where possible and that other expenses be attributed based on something like the percentage of revenue.

2.3 Potential Commercial Markets for Shellfish

In addition to the existing shellfish industry, there is also potential to develop markets that use shellfish for other purposes besides food, such as chicken grit (ground-up shells fed to chickens to help their gizzards digest food and to provide calcium for egg shells), calcium carbonate food

[1] As with any other industry, the output (i.e., harvest) of a shellfish farming operation is a function of many variable and fixed inputs applied in the production process. Production output is dependent upon biological and environmental factors, as well as on capital, labor, management skills and the technology used. The relationship between inputs and output is referred to as the production function.

supplements, and even as mulch for growing lavender. With a grant from King County, Puget Sound Restoration Fund (PSRF) and other partners are exploring the potential for some of these product lines in Quartermaster Harbor in Puget Sound. The research team is assessing the potential to produce native mussels for compost/chicken feed as well as for local consumption. Shucked oyster shell could also provide an ideal material with which to protect shorelines because the shell becomes tightly packed and is lighter than traditional shoreline protection materials (i.e., limestone rock).

Finally, shellfish also support a major recreational fishery in which people derive pleasure from an outdoor experience that offers them the opportunity to harvest, prepare, and eat their own "catch." Thousands of local residents and visitors enjoy digging shellfish at local beaches and shoreline environments (U.S. Environmental Protection Agency 2006). The recreational value of shellfish (including crab and shrimp) is estimated to be $43/day (TWC, 2008). No estimates exist for the value of recreational harvest for bivalves alone but can be generated through the modeling of expenditures by residents and non-residents to engage in this activity.

3 Environmental Benefits

3.1 Overall Ecosystem Benefits

Shellfish are integral components of the coastal ecosystem, so much so that some ecologists view oyster beds as outstanding communities of the estuary. Research suggests that shellfish provide several environmental benefits or ecosystem services (in addition to the commercial and recreation harvest). First, shellfish enhance water quality by concentrated deposition of feces and pseudofeces (particles collected on the oyster gills that is not use as food) (Newell 2004; Newell et al. 2005). Increased biodeposition of organic matter in sediments leads to increased bacterial denitrification, which can help to remove nitrogen from estuarine systems. The associated bacteria in sediments of an oyster bed can remove 20 percent or more of the nitrogen in oyster wastes, using the same process that is used in modern wastewater treatment plants (Shumway et al. 2003). Further, filter-feeding shellfish not only remove nitrogen from the water column, they also incorporate a high proportion of it into their tissues. When shellfish are harvested, the nitrogen is removed from the system (Shumway et al. 2003). For example, shellfish may reduce the release of ammonium resulting from sediment diagenetic processes and also favor the conversion of ammonium to nitrate, an essential step before denitrification (Cerco and Noel, 2005). These difficult-to-quantify, higher-order water quality effects are neglected in looking only at nitrogen removal through harvest. By mediating water column phytoplankton dynamics and denitrification, shellfish are also likely to reduce excess nutrients that stimulate excessive plant growth in coastal waters, which often leads to low dissolved oxygen levels (hypoxia) as the phytoplankton die, a serious environmental problem in many aquatic ecosystems worldwide (Atlantic States Marine Fisheries Commission 2007). In addition, it has been shown that shellfish can enhance water clarity, allowing sufficient light penetration to support expansion of seagrass habitat (Newell and Koch 2004), an important estuarine "nursery area," where juvenile invertebrates and fish are protected from predators. Finally, shellfish may also play a role in sequestering carbon in the calcium carbonate of shells, thereby reducing concentration of a greenhouse gas (Hickey 2008; Peterson and Lipcius 2003). In general, because they are filter feeders, shellfish can greatly influence nutrient cycling in estuarine systems and maintain the stability of the ecosystem (NOAA Restoration Center undated). As noted above, oysters filter large amounts of phytoplankton and detritus (small organic particles) from the water column. As grazers of phytoplankton and other particles, these filter feeders couple, or join, the oyster reef to the water column. Some of the organic components resulting from shellfish metabolism serve as a nutrient source for benthic infauna, some enters the microbial loop, and some re-enters the water column. This flux or cycling of carbon, nitrogen and other essential materials is vital for the continuity and stability of any living system and acts to keep the system in balance (NOAA Restoration Center undated; Peabody and Griffin 2008).

3.2 Water Quality Benefits

Steinberg and Hampden (2009)d an estimate for nitrogen removal through shellfish harvest in from Oakland Bay, Washington to be 11.7 MT/year, which represents 0.87 percent of the total nitrogen loading from all sources (i.e. The watershed, wastewater, marine and precipitation) or 5.0 percent of the total load from sources excluding marine. Shellfish nitrogen removal was found to be 62 MT/year (0.04 percent of the total nitrogen load), or 0.26 percent of the total load from sources excluding marine. Steinberg and Hampden note that their set of calculations does not include shellfish impacts on water quality, other than through harvest. Using this information, Burke (2009) attempted to estimate the dollar value of the associate ecosystem service of water quality enhancement related to shellfish harvest. Rather than controlling at the source (e.g. through agricultural best practices), or controlling discharges (e.g. at wastewater treatment plants [WWTPs]) shellfish remove nitrogen from the receiving waters, a relatively new concept. One reason to explore removing N from the receiving waters as a method to control water quality is that it may provide a least cost solution to tertiary treatment of wastewater treatment plant effluent. Controlling point sources and treating effluent becomes relatively more costly, because they both face increasing marginal costs.

The cost of removing N using treatment at a waste water treatment plant increases with the volume of nitrogen being removed. For example, in 2005, 370 million pounds of nitrogen were introduced into the Chesapeake Bay, more than twice the restoration target of 175 million pounds (Chesapeake Bay Program 2006). Accordingly, to ameliorate N pollution (and its effects) in the Bay, the Chesapeake Bay 2000 agreement mandated 48 percent reductions in nitrogen loads from point sources to the Bay and its tributaries (based on 1990 input levels). This agreement has resulted in increasingly stringent effluent discharge limits for wastewater utilities discharging into the Chesapeake Bay watershed; down to as low as 3 mg/L total nitrogen by January 1, 2011. The capital cost to achieve this level of treatment by point sources discharging into Chesapeake Bay is estimated to be several billion dollars (Nutrient Reduction Technology Cost Task Force, 2002).

Using the replacement cost methodology, Burke (2009) estimated water quality benefits from shellfish harvest by multiplying the per pound treatment facility life cycle costs by the estimate of the pounds of nitrogen removed by shellfish harvesting estimated at 25,787 pounds of nitrogen per year removed in Oakland Bay (Steinberg and Hampden, 2009). The water quality benefit can be thought of as the investment needed in nitrogen removal technology that can replace the nitrogen removed by shellfish harvest.

A range of benefits is to be expected, because the actual benefit depends on many factors: capacity, concentration targets in the effluent, nitrogen removal technology used, upgrade feasibility, etc. For example, the costs of nitrogen removal technology increase as the concentration levels on the effluent decrease—these increasing marginal costs of nitrogen removal technology means, using the replacement cost valuation methodology, the water quality benefit will increase as regulations, like the NPDES, require reductions in concentrations of nitrogen. As shown in Table 2 Burke (2009) estimated water quality benefits to be in the range of $25,300 to $815,400 annually. These estimates of annual benefit represent a range of capital investment from $144,900 to $7,465,300.

An estimate of the water quality benefit from shellfish harvesting most applicable to Oakland Bay, WA is based on the data of N removal obtained from the City of Shelton (bolded in Table 2). Using life-cycle costs data from the City of Shelton, the annual water quality benefit of shellfish harvest from Oakland Bay is estimated to be $77,100. This estimate is based on capital costs only; the estimate of O&M costs was not available. The $77,100 benefit represents a capital investment of $884,400.

Other estimates of the potential water quality benefit of shellfish removal in Oakland Bay can be developed using cost data from other sources—for example, the benefit estimate based on the case study from the Environmental Protection Agency of the wastewater treatment plant with the capacity and concentration levels most closely approximating the City of Shelton's wastewater treatment plant. The Kalispell WWTP located in Kalispell Montana treats 3.0 MGD to a concentration of 10.6 mg/L nitrogen, a close approximation to the City of Shelton's wastewater treatment plant which treats 3.3 million gallons per day to 10.0mg/L concentration of nitrogen. The estimated annual water quality benefit based on the Kalispell WWTP case study is $42,500, representing a capital investment of $431,800.

Or, if the City of Shelton were considering treating effluent to achieve lower concentrations of nitrogen, then another case study from the EPA study could be used. The Fiesta Village wastewater treatment plant located In Lee County Florida is similar in size to the City of Shelton's wastewater treatment plant and treats the water to a much lower concentration of nitrogen, 1.7mg/L. The annual water quality benefit is estimated to be $123,300 representing a capital investment of $1,144,600.

Table 2. Estimates of Water Quality Benefit from Shellfish Harvest (2007 $ in 000s)

Study/ Source of Data	Name of Case Study	Reason for Selecting	Annual Life-Cycle	Annual Capital	Annual O&M	Total Capital
			($ 000s)	($ 000s)	($ 000s)	($ 000s)
EPA	Central Johnston County WWTP Smithfield, NC	Minimum per unit value from the EPA report	$25.3	$12.6	$12.6	$144.9
EPA	Kalispell advances WWTP, Kalispell, Montana	Design criteria close fit to the City of Shelton	$42.5	$37.6	$4.9	$431.8
City of Shelton	**City of Shelton WWTP, Shelton WA**	**Site of the study**	**$77.1**	**$77.1**	**N/A**	**$884.4**
EPA	Fiesta Village Advanced WWTP, Lee County Florida	Maximum from the EPA report	$123.3	$99.8	$23.5	$1,144.6
LOTT	1994 upgrade, Olympia WA	Located near the study site	$194.9	$194.9	N/A	$2,236.0
CBF	4.0MGD from 8.0mg/L to 5.0mg/	Capacity equals City of Shelton, suggest costs for further upgrades	$266.1	$197.8	$68.3	$2,268.6
LOTT	2017 planned upgrade, Olympia WA	Located near study cite suggests benefit for larger WWTP	$650.9	$650.9	N/A	$7,465.3
CBF	4.0MGD from 5.0mg/L to 3.0mg/L	Capacity equals City of Shelton, suggest costs for further upgrades	$815.4	$499.0	$316.4	$5,723.2

Source: ENTRIX calculations

Two other benefits estimates are based on data from the sewer utilities of the cities of Lacey, Olympia, Tumwater, and Thurston Counties (LOTT). These benefits estimates can help frame the magnitude of benefit to LOTT if it were possible to expand shellfish harvesting to Oakland Bay's scale in Budd Inlet, where LOTT discharges its effluent. The cost data from LOTT provide an example of how costs increase as nitrogen concentration levels are reduced. Using the 1994 life-cycle cost data, the water quality benefit of shellfish harvest is $194,900, representing $2,236,000 in capital costs. The life-cycle cost data for the planned 2017 LOTT upgrade, with further reduction in nitrogen concentrations, results in a benefit estimate of $650,900 and a capital investment of $7,465,300. These data provide an example of how the water quality benefits of shellfish harvest will increase as lower and lower concentration levels of nitrogen are required. The marginal costs of nitrogen removal increase as concentration levels in effluent decrease, which will change the water quality benefit calculations.

The two benefits estimates based on the Chesapeake Bay Foundation cost data provide another example of increasing marginal costs. The Chesapeake Bay Foundation cost data are based on the assumption that nitrogen concentration levels would be reduced first from 8.0 mg/L to 5.0 mg/L and then from 5.0 mg/L to 3.0 mg/L for a wastewater treatment plant with a 4.0 million galls per day capacity. The annual water quality benefits, based on these two assumptions, are $266,100 and $815,400, respectively. These annual benefits represent a capital investment of $2,268,600 and $5,723,200, respectively.

Native shellfish restoration efforts also affect water quality issues, though unlike shellfish aquaculture where shellfish are removed from the watershed at harvest the removal of nutrients at harvest is not a prime consideration for such activities. As native oyster beds increase in size and ecological complexity, however, a suite of other benefits will likely emerge. Foremost is the potential through benthic pelagic coupling for native oysters to help facilitate nitrification and denitrification processes. Recent work suggests that complex habitats associated with oyster beds may significantly enhance ecosystem services related to nitrogen sequestration in estuaries subject to high nutrient loading (Cornwall et al., 2011). These processes have not been demonstrated in native oyster beds and remain a prime focus with renewed interest to better define and characterize.

3.3 Habitat Benefits

Shellfish also function as natural breakwaters that protect the shoreline against the erosive force of wind- and boat-generated waves, thereby reducing bank erosion, protecting fringing salt marsh, and decreasing loss of aquatic vegetation beds, such as eelgrass. Shellfish can be stabilizers of processes as well as shorelines. The literature also describes the functional role that shellfish play in estuaries. Some species of bivalve shellfish such as oysters and mussels form complex structures that provide refuge or hard substrate for other species of marine plants and animals to colonize, thereby enhancing biodiversity (Brumbaugh et al. 2006; NOAA Restoration Center undated). Shellfish are ecosystem engineers that create conditions that allow many other plant and animal species in estuaries and coastal bays to thrive (TNC, 2009). Perhaps most important from an ecosystem service perspective, certain types of shellfish offer the unique service of creating important habitats for other commercially or recreationally important species, particularly when they occur at high densities (Atlantic States Marine Fisheries Commission 2007). Bivalve shellfish can also help to structure benthic communities in other ways even when they do not provide the dominant physical structure. Shell, even at low densities, can provide nursery and nesting sites for fish and attachment points for macroalgae and a variety of invertebrates (TNC, 2009). On the Pacific coast, shells of the Pacific oyster placed at high density in the intertidal zone may provide excellent habitat for newly recruited Dungeness crab (Ruesink et al. 2005), for example. The structures used in shellfish aquaculture (racks, cages, nets, ropes, trays and lines) also provide habitat by providing surfaces for attachment of other organisms (Shumway et al. 2003).

Between 2005-2008, the Puget Sound Restoration Fund (PSRF) and Baywater, Inc assessed the costs and benefits of several years of enhancement activity in Liberty Bay, WA using Pacific oyster shell as a basement layer to increase the availability of emergent hard structure for native oyster settlement and subsequent recruitment. Increasing the quantity of emergent shell material in Liberty Bay had the overall effect of increasing native oyster density. The pilot project showed that the complex habitat associated with the creation of emergent substrate for settlement of native oysters can increase oyster abundance. Significant increases in abundance and species diversity of associated invertebrates, particularly epibenthic organisms (mainly harpacticoids), were also observed on emergent shell material.

4 Social Benefits

4.1 Traditional, Cultural, and Spiritual Benefits

Shellfish provide significant social and cultural benefits. For example, Bauer (2006) noted that razor clam harvesting, cleaning, cooking, eating and canning have been an important focus of family relationships and local culture in Washington coastal communities for many generations. To underscore this importance, Bauer provides a quote from Dan L. Ayres, Coastal Shellfish Lead Biologist, Washington Department of Fish and Wildlife: "The cultural significance of joining with friends or family to successfully brave the natural elements to take home a sport limit of fresh razor clams cannot be understated." In coastal communities throughout Washington State, shellfish are cultural icons, reflecting traditions and a way of life dating back generations (Brumbaugh et al. 2006). What's more, there is a growing recognition among the broader public that the livelihood of these individuals is an integral part of what is worth preserving in America's coastal areas (Wasserman and Womersley undated).

Harvesting of shellfish for food and cultural purposes is also a longstanding practice deeply rooted in some Tribal communities in the North Pacific (Kingzett and Salmon 2002). For thousands of years, the coastal indigenous peoples have relied on the sea for most of their needs, and today shellfish from tidal flats remain an essential subsistence food source for Tribes and First Nations (NOAA Fisheries Northwest Fisheries Science Center and Washington Sea Grant Program 2002). North American Tribes and First Nations still use the shells of mussels, clams, abalone and oysters to decorate woodcarvings and ceremonial apparel, as they did thousands of years ago (NOAA Northwest Fisheries Science Center and Washington Sea Grant Program 2002). Western Washington Tribes continue to use shellfish for subsistence, economic and ceremonial purposes (U.S. Environmental Protection Agency 2006), and the Tribes are closely involved in efforts to rebuild stocks of Puget Sound's native oysters (Kay 2008; Peter-Contesse and Peabody 2005). Moreover, shellfish grounds have become important to some Washington Tribes by affirming treaty rights that entitle them to fish and hunt for subsistence and commerce on traditional lands and water (Barry 2008).

4.2 Education Benefits

Shellfish production can also indirectly bring local environmental problems to the attention of nearby communities. In particular, community support and involvement in shellfish restoration and enhancement projects has also been shown to heighten public awareness of the need to rehabilitate and conserve marine and estuarine ecosystems. For example, Reynolds and Goldsborough (2008) argue that hands-on oyster reef restoration projects are not only complimentary to, but a critical component of, advancing a broader environmental policy agenda aimed at reducing nutrient loading in coastal waters. In addition, U.S. public health standards under which shellfish fisheries and aquaculture operate demand clean waters and commercial shellfish harvest can only take place in waters that have been certified under the National Shellfish Sanitation Program (Shumway et al. 2003). The standards of this program fostered the first estuarine/marine monitoring programs, and are the most stringent of all U.S. water quality classifications, far exceeding those required for swimming. As a result, the presence of shellfish fisheries and aquaculture often results in increased monitoring of environmental conditions of estuaries and coastal waters. Moreover, the economic hardships suffered by communities following closure of shellfish fisheries and culture operations due to water contamination have often provided the political impetus for improvement in sewage treatment plants or programs to fix local septic systems (Shumway et al. 2003).

4.3 Social Capital

Burke, Menzies, and Peabody (2009) assessed indirect social benefits of the Drayton Harbor Community Oyster Farm (DHCOF). This community oyster farm grows Pacific oysters with a focus on improving water quality in order to restore and sustain recreational, tribal, and commercial harvest. Identified indirect benefits illustrate that individuals and entities directly involved with the restoration of Drayton Harbor and the DHCOF are not the only beneficiaries of the operations of the farm. By involving local community members, DHCOF provides multiple cultural resource benefits (sometimes referred to in the literature are social capital or capacity building). Social capital can be thought of as the framework that supports the process of learning through interaction, and requires the formation of networking paths between agencies and sectors and well as between agencies and communities and individuals. Involvement in organizations and voluntary associations such as DHCOF has been linked to building an individual's political aptness and engagement in civic life by developing an individual's social network and fostering the transmittal of politically relevant information (La Duke Lake and Huckfeldt, 1998). The generation of this social capital leads to significant benefits for the greater community in the form of more effective governance, healthier social norms, reduced crime, broader public engagement, and economic development. Activities sponsored by the DHCOF in their public outreach and education efforts include the Open House and Oyster Feed (a community educational event that brings together 15 or more agencies to expose watershed residents to pollution problems in the watershed). Prior to the 2004 upgrade in Drayton Harbor, shellfish for the event was usually donated by industry members from other areas of Puget Sound. Once the bay was reopened, the DHCOF supplied locally grown oysters for the event. In collaboration with Trillium Corporation and Semihamoo resort, a shellfish festival called "Shuckin on the Spit" was held in 2002 and 2003. This festival was a fundraiser for the DHCOF and a public outreach event. Finally, Tide Flat Tours offered by PSRF in collaboration with Whatcom County provide educational tours of Drayton Harbor and the DHCOF. Tours initially focused on outreach to about 40 local decision makers including county and city land use planning commissioners, elected representatives, the city of Blaine Public Works staff, etc.

4.4 Non-Profit Organizational Support

In addition to these community-based shellfish restoration efforts, thousands of people participate each year in shellfish celebrations that raise money for non-profits, promote community engagement in local environmental issues, and segue nicely with the growing interest in local food and connecting people with local foods and traditions (U.S. Environmental Protection Agency 2006). A good example of such a celebration is the Annual West Coast Oyster Shucking Championship and Washington State Seafood Festival held in Shelton, Washington. "OysterFest" is the primary fund raising activity of the Shelton SKOOKUM Rotary Club Foundation, which uses the earnings to support a broad array of community organizations and events (Shelton SKOOKUM Rotary Club Foundation 2008). Nonprofit fundraisers for organizations focused on the health of Puget Sound almost all, without exception, feature locally grown shellfish. Clams and oysters embody what is still healthy and productive about this ecosystem and give people a tasty vision of why resources are designated towards environmental restoration and conservation (personal communication, Betsy Peabody, PSRF, 2009).

5 Economic Costs

5.1 Property Value Loss

The presence of a commercial shellfish operation on tidelands has the potential to have adverse effects on nearby residential properties. Some waterfront property owners in the South Sound region of Puget Sound have voiced concern that harvesting operations have a negative effect on their property values and visual aesthetic. These concerns range from the unsightliness of growbags, nets, and piles of shells to noise recreated by boats, barges, and hydraulic equipment. A review of the hedonic price methodology[2] literature suggests that the potential for discernable quantitative effects on property values exists, but this effect may be so specific to individual buyers or sellers that it was not discernable through key informant interviews with local realtors and county property assessors. Identifying specific numerical effects of shellfish production on property values will require a full-scale hedonic analysis that can account for specific property attributes including the negative and positive externalities associated with shellfish production. However, even with such a statistical analysis, the numerical effect may not be statistically significant from zero. The fact that so few informants noted a market effect could mean that there is no discernable market effect and that buyers who are concerned with commercial shellfish operations are replaced by buyers willing to tolerate or take advantage of these operations.

5.2 Shellfish Production and Restoration Fixed and Variable Costs

Economic costs include the expenses (fixed and variable operating and maintenance costs) incurred in the commercial growth and production of shellfish and the design and implementation of shellfish restoration and enhancement projects. Restoration project costs include several major elements: planning and project development; the cost of eyed oyster larvae and remote setting equipment; bottom cultch and placement material; other equipment and maintenance; transportation and vehicle costs; a baseline survey; the cost of a monitoring program; data analysis and interpretation; enforcement; infrastructure; labor; and project implementation (these costs reflect the management personnel expense needed to manage project activities) (Industrial Economics Inc., 1999). The Drayton Harbor Community Oyster Farm has been estimated to have cost $2,890,150 between 1990 and 2008 (Geoff Menzies, personal communication, 2009). Resources dedicated to enhancing mudflats in Liberty Bay with hard substrate totaled $294,000, or roughly $50,000 per acre enhanced. (PSRF, 2010).

As outlined in the study cited above in section 2.2 NEI (2009) conducted a revenue and expense preliminary test survey of four shellfish producers in South Puget Sound in order to design and implement a robust industry wide survey as part of a larger effort to generate a Washington State shellfish input output model. NEI (2009) found that the cost structure of Puget Sound shellfish producers is very different. Management salaries ranged from below 10 percent to over 20 percent of total costs. Tideland Lease costs also varied greatly from over 30 percent of total

[2] The hedonic price method is an indirect valuation approach that relies on observable market transactions to establish a monetary value for individual attributes of a home or property including environmental characteristics, proximity to tidelands used for commercial shellfish production, and views.

expense to zero. Table 3 shows the maximum, minimum and average of the largest expense categories as a percentage of total expenses.

The only expense category that did not have any response was "Water/Sewer." NEI recommended that this category remain in the survey because conversations with growers revealed that in general, shellfish operations tend to be rural because they must be at least three miles from sewage treatment plant outlets. This means that they tend to be on wells with agriculture permits with the ability to draw substantial volumes of water.

Table 3. Preliminary Survey Results – Percent of Total Revenue

Expense Category	Maximum Percent	Minimum Percent	Average
Growing/Harvest Crew	30	5	19
Managers/Executives	21	7	12
Tideland Leases	32	0	11
Growing/Harvest Supervisors	18	3	10
Amortization	20	0	5
Other Harvest	19	0	5
Depreciation Expense	6	0	4
Other Staff	6	0	3
Employee Medical	5	0	3
Capital Equipment	6	0	2
Freight	9	0	2
Processing - crew	9	0	2
Research and Development	7	0	2
Interest Expense	4	0	2
Business Taxes	4	0	2
Professional Dues and Subscriptions	2	1	1
General Liability	2	1	1
Legal and Admin	2	1	1
Repairs and Maintenance	2	0	1

Source: Northern Economics, Inc Grower's Survey, 2009.

The growers that were surveyed had clams or geoducks as their main revenue source. All growers produced more than one type of shellfish including oysters. The differences in the types of growers results in impressive differences across expense categories. The following discussion relates to the average across the expense categories. The largest average expense was the growing and harvesting crews, with a range between 5 and 30 percent of total expenses. Managers and executives were second, with a range between 7 and 21 percent. Tideland leases were the third largest expense even though some respondents did not have any tideland lease expenses. The fourth largest expense was Growing/Harvest supervisors, ranging from 3 to 18 percent. The largest expense in general for the shellfish growers surveyed is labor.

One firm contracts their harvest, so the labor costs there showed up in an "other" category. Issues like these differences in the way that growers perform their harvest will need to be dealt with in a larger survey. With a large enough sample, respondents that vary from the norm of hiring labor could be removed as outliers. The largest expense category that was not labor was medical costs for employees, which is still labor related. All other expense categories were less than 3 percent of total expenses. The next highest expense category was freight, even though only two firms listed freight expense. This raised questions about whether some firms did not include freight because their customers reimburse growers for freight or if they make deliveries themselves. The revised survey instrument should make explicit that only non-reimbursed freight charges should be recorded.

6 Environmental Costs

6.1 General Ecosystem Costs

While non-native shellfish species that are brought into new environments may indeed provide such valuable services as water column filtration, habitat creation for non-shellfish species and stabilization of estuarine sediments, they may also compete with native species, negatively affect food webs and bring in new diseases and other undesirable species (Brumbaugh et al. 2006). A recent non-peer reviewed Sierra Club Cascade Chapter (2009) memorandum suggests that based on recent research, Puget Sound native species are negatively affected by disturbance/alteration of the near shore habitat and aquatic vegetation, modifications of forage fish and rearing areas, removal of essential macrophytes (algae), ecological carrying capacity, accumulation of shellfish fecal deposits/organic matter in low flushing areas (like South Puget Sound), plastic pollution and the unlimited use of invasive species. The Sierra Club memorandum states that according to a Ruesink and Rowell Sea Grant presentation "eelgrass density is depressed in summer by space competition with geoducks. When geoduck are harvested, eelgrass shoot density drops by more than 70 percent" (pg. 10) and that Pentilla (2007) states that "standard aquaculture practices may have profound effects on the benthic ecology of Washington State's tidelands and the conservation of forage fish spawning areas, especially for herring" (pg. 10). Shellfish aquaculture may also result in changes in benthic community composition through a range of mechanisms, such as excessive partitioning of food resources, competition for space, and increased sediment deposition (Sequeira et al. 2008). Submerged and floating shellfish cultivation gear may also have negative impacts on essential marine habitats. For example, the physical disturbance caused by oyster cultivation gear may cause deterioration of eelgrass beds, an essential habitat for juvenile fish and shellfish (Getchis 2005). In addition, physical alteration to prospective geoduck aquaculture sites through grading and rock removal may result in damage to ecological functions (Washington Department of Ecology 2009). Mechanical harvesters, commonly used for clams, can create significant environmental stress, harming benthic plant life and other wild species (Brumbaugh et al. 2006; SeaChoice undated). [3]

There are also significant costs in terms of the potential risk of contaminating wild shellfish populations with cultured genes. With culture of a native species, this risk centers on the potential loss of natural genetic variation, which serves to buffer the population against natural selective forces (Straus, Crosson, and Vadopalas 2008). Moreover, diseases and parasites carried by hatchery seed may be introduced into areas where they currently do not exist, with a consequent deleterious effect on wild shellfish populations (Cross et al. 2008; Washington Department of Ecology 2009; Straus, Crosson, and Vadopalas 2008).

[3] Note that a recent NMFS Biological Opinion on commercial shellfish operations determined that shellfish operations are not likely to cause adverse impacts to the environment. It was a "No Jeopardy" opinion that concluded that while there were some adverse effects, they were offset by ecological services provided by shellfish.

7 Social Costs

7.1 Aesthetic and Nuisance Costs

It has been found that the extensive use of nets, docks, cages, and other gear by commercial shellfish producers may, in some cases, conflict with navigation, dredging, commercial and recreational fishing, swimming, and other uses of coastal waters and the adjoining shoreline. Moreover, commercial shellfish production may compete with shoreland property owners who value their shoreline vistas (see section 5.1). While farms are usually hidden below the waterline, at low tide much of the gear is exposed (Thacker 2006). Evans (1979) reports that among the complaints expressed by concerned citizens before the Kitsap County Board of Commissioners was that hydraulic harvesting of subtidal hardshell clams causes extraordinary amounts of broken clam shells to be washed up on nearby beaches, results in unacceptably high levels of turbidity (amount of suspended solid materials in the water), and is unacceptably noisy and interferes with the residential character of the area.

7.2 Public Health Costs

In addition, shellfish may potentially lead to significant human health issues if Washington State Department of Health harvest restrictions are not followed or enforced. In addition, toxins produced by harmful algae can be concentrated by shellfish through filter feeding to the point that the shellfish become dangerous or even deadly for humans to eat (NOAA Fisheries Northwest Fisheries Science Center and Washington Sea Grant Program 2002). Paralytic shellfish poisoning, neurotoxic shellfish poisoning, diarrhetic shellfish poisoning and amnesic shellfish poisoning are caused by eating scallops, mussels, clams, oysters and cockles contaminated with various toxins (Bauer 2006).

8 Conclusions

Using information derived from a literature review, stakeholder focus groups, and quantitative and qualitative analyses, this report summarizes a suite of economic, social, and environmental benefits and costs associated with shellfish production and restoration in Washington State. Both benefits and associated costs are outlined in **Table 4.**

While data on aquaculture production costs, revenues, etc. is very limited, the economic benefits of commercial shellfish production are considerable in Washington State. Washington is the leading producer of farmed bivalve shellfish in the United States. Farmed shellfish harvest in the state (Puget Sound and Coastal Washington) has increased from 7.6 million pounds in 1970 to 5.6 million pounds in 2008 with an estimated 2006 ex-vessel value of $107 million. Commercial enterprises generate revenue for the state through licensing and lease fees and contribute direct employment, secondary employment (e.g. shucking and packing houses, transport, manufacture of prepared oyster products and retail sales), and a number of other local economic impacts.

In addition to the existing shellfish industry, there is also potential to develop markets that use shellfish for other purposes besides food, such as chicken grit, calcium carbonate food supplements, and even as mulch for growing lavender.

Finally, shellfish also support a major recreational fishery in which people derive pleasure from an outdoor experience that offers them the opportunity to harvest, prepare, and eat their own "catch." Thousands of local residents and visitors enjoy digging shellfish at local beaches and shoreline environments. The recreational value of shellfish (including crab and shrimp) is estimated to be $43/day.

Research suggests that shellfish also provide several environmental benefits or ecosystem services (in addition to the commercial and recreation harvest), by enhancing water quality and providing essential habitat structure. Shellfish enhance water quality through increased biodeposition of organic matter in sediments leads to increased bacterial denitrification, which when harvested, can help to remove nitrogen from estuarine systems. Decreases in concentrations of particulate matter from water increases water transparency and primary productivity and decreases bacteria and pathogen concentration in water. Shellfish may also play a role in sequestering carbon in the calcium carbonate of shells, thereby reducing concentration of a greenhouse gas. Shellfish production and restoration can contribute to increasing abundance of natives species such as geoduck (commercial) and native oysters (restoration). Reintroduction of native shellfish species may also reduce the establishment of non-native shellfish species in Washington.

In addition to benefits to water quality, shellfish also function as natural breakwaters that protect the shoreline against the erosive force of wind- and boat-generated waves, thereby reducing bank erosion, protecting fringing salt marsh, and decreasing loss of aquatic vegetation beds, such as eelgrass. As ecosystem engineers, shellfish can create conditions that allow many other plant and animal species in estuaries and coastal bays to thrive, including other commercially or recreationally important species. Bivalve shellfish can help to structure benthic communities in other ways even when they do not provide the dominant physical structure, providing nursery and nesting sites for fish and attachment points for macroalgae and a variety of invertebrates.

The Liberty Bay case study showed that the complex habitat associated with the creation of emergent substrate for settlement of native oysters can increase oyster abundance. Significant increases in abundance and species diversity of associated invertebrates, particularly epibenthic organisms (mainly harpacticoids), were also observed on emergent shell material.

Shellfish also provide significant social and cultural benefits. Commercial production provides a sustainable, high protein food source for local communities. Indeed, shellfish culture has a long and vibrant history in Washington, and represent significant cultural heritage for communities and tribes alike. The iconic value and abundance of shellfish in Washington also create environmental education and stewardship opportunities, brining environmental problems to the attention of nearby communities. Community support and involvement in shellfish restoration and enhancement projects has been particularly effective in heightening public awareness of the need to rehabilitate and conserve marine and estuarine ecosystems. The Drayton Harbor Community Oyster Farm case study demonstrated that in addition to economic and environmental benefits, public investment in volunteerism has also provided the social capital necessary for effective government in the area.

While there are numerous benefits to shellfish cultivation and restoration, there are also economic, environmental, and social costs associated with these activities. In examining the fixed and variable operations and maintenance costs of commercial aquaculture operations, it was discovered that the cost structure and primary product among of Puget Sound shellfish producers differs greatly. These differences resulted in impressive variation across expense categories. The largest average expense for shellfish producers was for growing and harvesting crews, followed by managers and executives, tideland leases, and growing/harvest supervisors. Planning and implementation costs of restoration programs also incur significant economic costs. It is estimated that expenses associated with the Drayton Harbor Community Oyster Farm effort amounted to $2,890,150 between 1990 and 2008. Enhancing mudflats in Liberty Bay with hard substrate totaled $294,000, or roughly $50,000 per acre enhanced.

While non-native shellfish species that are brought into new environments may indeed provide valuable services such as water column filtration, habitat creation for non-shellfish species and stabilization of estuarine sediments, they may also modify the natural environment, compete with native species, negatively affect food webs and bring in new diseases and other undesirable or invasive species. There are also significant costs in terms of the potential risk of contaminating wild shellfish populations with cultured genes.

Commercial operations also often lead to attempts to preclude resident and transient predators (e.g. some shellfish growing areas utilize synthetic chemicals for control of "pests" such as burrowing shrimp) and impacts on species diversity and richness. There is also potential for introduction of chemical toxins into the water. Shellfish harvest can result in suspension of sediment, increase in concentrations of bacteria, nutrients and toxins. Bioaccumulation of toxins in shellfish may also serve to transfer toxic substances from water/sediments into the food chain.

In addition to economic and environmental costs, the presence of commercial shellfish operations on tidelands has the potential to have adverse effects on nearby residential properties and generate multi-use conflicts. Commercial shellfish production may compete with shoreland property owners who value their shoreline vistas and result in complaints from residents regarding shells debris, high levels of turbidity, and noise generated by commercial operations. In addition to perceived negative aesthetic impacts associated with commercial production, shellfish aquaculture can divide communities over private property rights (e.g. private land owners or lease holders receive a monetary benefit from utilizing a public resource). Extensive use of nets, docks, cages, and other gear by commercial shellfish producers may, in some cases, conflict with navigation, dredging, commercial and recreational fishing, swimming, and other uses of coastal waters and the adjoining shoreline.

Shellfish may also potentially lead to significant human health issues such as Paralytic shellfish poisoning, neurotoxic shellfish poisoning, diarrhetic shellfish poisoning and amnesic shellfish poisoning if Washington State Department of Health harvest restrictions are not followed or enforced.

Table 4. Benefits of Shellfish Production and Restoration

Benefits
Environmental
Decreases concentrations of particulate matter from water, which increases water transparency and primary productivity
Decreases bacteria and pathogen concentration in water
Harvest may result in nitrogen removal
Carbon sequestration
Native species utilized (e.g., geoduck)
Enhanced biodiversity
Reintroduction of native shellfish species may reduce non-native shellfish species
Economic
Direct employment
Secondary employment
Local economic impacts
State fees and license revenue
Social
Sustainable protein source
Local food source
Creates environmental education and stewardship opportunities
Traditional natural resource job creation
Maintains cultural heritage and Tribal rights
Existence/Iconic value
Improves public health

Table 5. Costs of Shellfish Production and Restoration

Costs
Environmental
Introduction of chemical toxins into the water, which impact other organisms
Modification to natural environment
Impacts on species diversity and richness
Attempts to preclude resident and transient predators
Bioaccumulation of toxins in shellfish may serve to transfer toxic substances from water/sediments into the food chain
Harvest can result in suspension of sediment, increase in concentrations of bacteria, nutrients and toxins
some shellfish growing areas utilize synthetic chemicals for “pest” control (e.g., burrowing shrimp)
Introduction of non-native species.
Economic
Planning and implementation costs of restoration programs
Fixed and variable operations and maintenance costs of commercial aquaculture operations
Social
Gear conflicts with other coastal water uses
Perceived negative aesthetic impacts associated with commercial production
Aquaculture can divide communities because of the private property rights (e.g. private land owners or lease holders receive a monetary benefit from utilizing a public resource (the marine environment)
Potential negative human health consequences

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Appendix A: Drayton Harbor Oyster Restoration Costs

Planning Efforts		cash	match	total
1990	subtotal	42	8	50
1991	subtotal	42	8	50
1992	subtotal	42	8	50
1993	subtotal	42	8	50
1994	subtotal	42	8	50
1995	subtotal	0	8	8
1996	subtotal	23	6	29
1997	subtotal	23	6	29
1998	subtotal	0	3	3
1999	subtotal	10	3	13
2000	subtotal	10	3	13
2001	subtotal	10	3	13
2002	subtotal	35	3	38
2003	subtotal	35	3	38
2004	subtotal	35	3	38
2005	subtotal	35	3	38
2006	subtotal	65	3	68
2007	subtotal	35	3	38
2008	subtotal	35	3	38
	Total	**561**	**93**	**654**

notes: Watershed planning from 1990 thru 1995, Shellfish district planning from 1996 thru 2008

Cash 99-2001 is the DH share of the CD grant to Chris and Julie. This also covered Portage and total was 56K

Water Quality Monitoring			$1,000 cash	match	total
1990			0	0	0
1991			0	0	0
1992	subtotal	WQ	25	0	25
1993			0	0	0
1994			0	0	0
1995	subtotal		30	0	30
1996	subtotal		5		5
1997	subtotal		58	0	58
1998	subtotal		5		5
1999	subtotal		15	0.75	15.75
2000	subtotal		25	0.75	25.75
2001	subtotal		25	0.75	25.75
2002	subtotal		35	2.35	37.35
2003	subtotal		35	1.6	36.6
2004	subtotal		22	0	22
2005	subtotal		23		23

2006	subtotal	17	0	17
2007	subtotal	18	0	18
2008	subtotal	68	0	68
	Total	**406**	**6**	**412**

Note: this includes all WQ monitoring programs with exception of those conducted thru PSRF

Special Projects		**$1,000 cash**	**match**	**total**
1990		0	0	0
1991		0	0	0
1992		0	0	0
1993		0	0	0
1994		20	0	20
1995	subtotal	20	0	20
1996	subtotal	55.5	0	55.5
1997	subtotal	219.5	63	282.5
1998	subtotal	42	2	44
1999	subtotal	5		5
2000	subtotal	75	0	75
2001		0	0	0
2002	subtotal	42	0	42
2003	subtotal	4	9	13
2004	subtotal	39.5	0	39.5
2005	subtotal	15		15
2006	subtotal	41.5	5	46.5
2007	subtotal	174	28	202
2008	subtotal	135	44	179
	Total	**888**	**151**	**1039**

Note: Special projects includes all applied field studies and pollution control projects Conducted outside of PSRF management.

Public Outreach				
1996	subtotal	38	3	41
1997	subtotal	13	0	13
1998	subtotal	0	0	0
1999	subtotal	8	2.5	10.5
2000	subtotal	8.5	3	11.5
2001	subtotal	8	2.5	10.5
2002	subtotal	8	2.5	10.5
	total	**83.5**	**13.5**	**97**

note(does not include PSRF outreach programs)

Community Oyster Farm	**$1,000 cash**	**match**	**total**
1990	0	0	0
1991	0	0	0

1992		0	0	0
1993		0	0	0
1994		0	0	0
1995		0	0	0
1996		0	0	0
1997		0	0	0
1998		0	0	0
1999	subtotal	7		7
2000	subtotal	16		16
2001	subtotal	71.2	29.4	100.6
2002	subtotal	60.5	31.4	91.9
2003	subtotal	40.9	49	89.9
2004	subtotal	31.9	5	36.9
2005	subtotal	82.7	17	93.7
2006	subtotal	87.7	25	112.7
2007	subtotal	44.8	32.5	77.3
2008	subtotal	52	12	64
	Total	**495**	**201**	**690**

Note: The Community Oyster Farm/PSRF is shown as one funding center or activity. This represents all of the funds that went through PSRF to Drayton Harbor restoration which includes outreach, water quality monitoring, special projects, and oyster farming. These are pulled out individually in the PSRF Breakdown worksheet.

Summary by Category

Activity		**$1,000 cash**	**match**	**total**	**%**
Planning	subtotal	561	93	654	23
WQ Monitoring	subtotal	406	6	412	14
Special Projects	subtotal	888	151	1039	36
DCOF	subtotal	495	201	696	24
Public Outreach	subtotal	83	14	97	3
	Total	**2433**	**465**	**2898**	