# Mapping a Path to Sustainable Utilization of Bay Clam Resources in Oregon's 21$^{st}$ Century Estuaries:

## An Investigation into the Potential of Oregon's Commercial Bay Clam Fishery

Photo by Dr. Bradley Stevens


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**Report to the Oregon Department of Fish and Wildlife and the Oregon Commercial Bay Clam Industry**


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## Executive Summary

### Study Motivation and Purpose

Recently, Oregon's commercial bay clam resources have been the focus of efforts by commercial shellfish fishermen to expand production and marketing. As a fishery which has recently transitioned from "developmental" status under the management of Oregon's Developmental Fisheries Program (DFP) to "developed" limited entry (rights-based) status, the commercial bay clam dive industry faces new challenges and opportunities in science, management, and economic development. The bay clam species harvested for commercial use in Oregon consist of the gaper or empire (*Tresus capax*), cockle (*Clinocardium nuttalli*), littleneck (*Venerupis staminea*), butter (*Saxidomus giganteus*), and softshell (*Mya arenaria*) clams.

The Oregon Administrative Rule (OAR) 635-006-0810 states that a "'developed fishery' means a fishery where the level of participation, catch, and effort indicate the fishery has approached optimum sustained yield and/or there is sufficient biological information, information on harvest methods, gear types, and markets to develop a long-term management plan for the species." The State of Oregon requires developmental fisheries to meet these scientific and management standards before transitioning to developed status. Oregon's commercial bay clam dive fishery, however, may not have completely fulfilled these legislative criteria before transitioning into developed limited entry.

This study was commissioned and funded by the Coastal Oregon Marine Experiment Station (COMES) to 1) identify the scientific and management issues constraining the advancement of the Oregon bay clam commercial industry, 2) explore scientific, management, and economic opportunities for the enhancement of the fishery, 3) outline and suggest mechanisms to develop stock and biological information, obtain funding, and manage the fishery at sustainable levels, and 4) provide a comprehensive framework for the development of a bay clam fishery management plan. Additionally, this report succeeds a recent draft of the new Oregon Nearshore Strategy (by the Oregon Department of Fish and Wildlife's (ODFW) Marine Resources Program (2005)) that recommends ODFW provide greater attention to developing and achieving stock assessments for shellfish as well as develop more capable fisheries management methods – two important aspects of this bay clam fishery study.

This report provides a synthesis of political, social, and scientific information regarding the current status and future potential of the Oregon bay clam commercial fishery and addresses the following topics: regulation and management, allocation, ecology and biology, estuarine water quality, stock assessments, economics, funding, applied Geographic Information Science (GIS), examples of relevant management from other states and countries, and related issues including markets, aquaculture, non-indigenous species, and regulatory enforcement. The presentation of these issues provides a framework for developing and implementing a bay clam fishery management plan. Cost-effective and cooperative management act as guiding concepts in developing the report's structure, analysis, and recommendations.

## Key Issues

Key science and management problems of the industry include: 1) out-dated and incomplete bay clam resource stock assessments and limited ecological and biological understanding of the resource, 2) mechanical harvest restrictions in all but two Oregon bays (restricting the development of low cost harvesting techniques), 3) the lack of a comprehensive management plan, 4) inadequate market development, 5) harvest levels below optimal yield (OY), 6) insufficient water quality monitoring, and 7) limited research and management funding.

***Stock Assessments:*** Out-dated and incomplete bay clam resource stock assessments of Oregon's estuaries create a major hurdle for advancing Oregon's bay clamming industry. Oregon State University (OSU) Sea Grant compiled the last coast-wide assessment in the 1970s. Tillamook Bay received one comprehensive assessment in the mid-1990s and Coos Bay received a limited subtidal site survey in 2004.

***Biology and Ecology:*** Several questions regarding the ecological value of Oregon bay clams need to be addressed to ensure rational resource management. Public good benefits such as the contribution of bay clams to water quality may be significant. These benefits are not currently quantified. Oregon legislation requires that State resource management achieve an optimal balance of public good, commercial, and recreational benefits to all user groups of the State (ORS 496.012 and ORS 506.109). It is important to consider these benefits when determining socially optimal harvest levels of bay clams (The North Carolina Division of Marine Fisheries, August 2001).

Currently, the five commercial bay clams are essentially managed as a group, with the exception of gaper clams that have a seasonal harvest. Biological and ecological research is necessary to determine whether different species of bay clams require different management frameworks or harvest seasons to ensure their sustainability.

***Geography:*** Currently, mechanical harvest is only permitted in Tillamook and Coos bays. Limited mechanical harvest and precautionary quotas due to insufficient stock assessment data cannot sustain the livelihoods of all 15 commercial bay clam permit holders.

***Funding:*** A lack of personnel and equipment due to insufficient funding has resulted in inadequate management of the Oregon commercial bay clam fishery. Attaining and sustaining funds is one of the greatest challenges for the Oregon bay clam fishery. Moreover, funding for bay clam stock assessments is a major issue for the commercial industry's success. Funds are not set-aside specifically for these assessments.

***Management:*** The intent of the Developmental Fisheries Program (DFP) is to promote and guide biological and economic research for the advancement of developmental fisheries. This study finds that the commercial bay clam fishery left DFP prematurely and unprepared as a State-classified developed limited entry fishery. As a result, the ODFW Marine Resources Program lacks the information, goals, and strategies for effectively managing this bay clam fishery. Furthermore, the fishery lacks a developed fishery management plan.

***Property Rights:*** Although the bay clam fishery is now classified as a rights-based limited entry fishery, it has not yet defined major industry goals and objectives in order to create and modify property rights accordingly.

***Undeveloped Markets:*** Currently, principal markets for commercial Oregon bay clams are bait and aquarium. A human consumption market is not well developed. In combination with low catch quotas, insufficient market development poses a major economic hindrance to the industry.

## Key Findings

**1)** This report identifies primary fisheries management costs and defines potential funding sources and strategies to cover these costs, such as cost-sharing partnerships for research and management.

*Suggested financial assistance ranking for bay clam fishery management includes:*

1) Oregon recreational shellfish license revenues
2) Industry cost recovery
3) Partnerships with the Tillamook Bay National Estuary Program (TEP) and the Coos Bay South Slough National Estuarine Research Reserve (NERR)
4) Sea Grant and university funding and partnerships

An assessment of the Oregon Department of Fish and Wildlife (ODFW), the Oregon Department of Agriculture (ODA), and the Oregon State Police (OSP) operation costs and budgets should consider the need for updated bay assessments and the possibility of funding bay assessments with new State shellfish license revenues. A portion of State shellfish license revenue could be allocated to the assessment of an Oregon bay and its benthic community annually.

Assessment costs may be covered in-full or partially through a portion of the State shellfish license revenues. Other sources should be arranged to cover remaining costs, particularly for years that may have fewer recreational license holders, and thus less State revenue. For example, partnerships with Tillamook Bay's National Estuary Program (NEP) and Coos Bay's South Slough National Estuarine Research Reserve (NERR) may help defray assessment costs in these bays.

**2)** In order to regulate the bay clam resource adequately, ODFW must acquire stock assessment data. This report recommends a rotational spatial commercial harvest strategy that incorporates the use of catch per unit effort data (CPUE) to update stock assessments. Rotational harvest methods are common in shellfish fishery management worldwide, and could benefit the Oregon bay clam industry. In addition, CPUE data could be considered a tool for stock assessment, assuming that certain conditions are met. The application of a spatial context to the collection of catch and effort data improves data reliability as an index of stock abundance. When a spatial context is applied to improve CPUE for stock assessment, fisheries that target sedentary or nearly-sessile animals are sound candidates due to their inherently stable spatial nature.

Through an intensive baseline survey of the bay clam resource and the establishment of strategic methods for future fishery dependent surveys, it may be possible to determine the sustainability of harvest levels of this fishery without expensive, ongoing traditional stock assessments.

The following four-part strategy provides a framework for bay clam stock assessments in Oregon. Parts one and two of this strategy are intended as one-time events. Parts three and four are ongoing.

1) Perform a comprehensive baseline stock assessment of bay clams in all major harvesting bays, particularly Tillamook and Coos bays.
2) Design a rotational spatial dive harvest strategy that considers catch per unit effort (CPUE) in order to update baseline assessments scientifically.
3) Implement the rotational spatial dive harvest strategy with the industry and employ a scientific analyst to evaluate the resource data and help set harvest levels.
4) Employ operational observers to monitor system protocols of the strategy a few times per year with fishermen during field harvest.

The combination of an updated, comprehensive stock assessment and ongoing, strategic rotational harvests should provide ODFW with significant biological resource data for fishery management purposes. These fishermen-dependent harvest data allow ODFW to obtain scientifically valid data without spending the time and money to personally conduct the fieldwork. If information points to healthy and resilient stocks, sustainable yields for the fishery may be increased. Higher yields should mean greater industry and State revenues, and possibly opportunities for further fishery development.

**3)** Attention to market conditions and opportunities, particularly the establishment of a human consumption market, will provide improved economic opportunities for this fishery. Some strategies for market development include:

-Unite bay clam marketing efforts with oysters and the greater “Oregon Seafood” umbrella. A smart segue for bay clams into the human consumption market may be through market ties of another more popular shellfish species in Oregon, such as the oyster.

-Work with the Oregon State University (OSU) Seafood Lab and Community Seafood Initiative in Astoria, Oregon on recipes to develop human consumption markets and market strategies.

-Introduce and promote bay clams to the human consumption market at local seafood festivals. Throughout the year, and particularly during warmer seasons, Oregon abounds with festivals and fairs. Farmers’ Markets and supermarket tasting booths also provide opportunities to showcase bay clams and potential recipes to the public.

-Market the industry as a local low-impact, low-bycatch, sustainable fishery. Consumers are increasingly interested in knowing where their food comes from and the impacts of its harvest.

-Use tourism to help the industry. Ecotourism and ecologically-friendly tourism is expanding globally. Many people travel to Oregon in search of a vast and beautiful countryside and coastline. The bay clam industry may find a niche in this tourist draw to Oregon by promoting the bay clam resource and its sustainable management at tourist locations, such as coastal hotels.

*Softshells, gapers, and the market*

The Oregon industry may find it economically efficient to increase softshell harvests and establish a human consumption market for softshells in Oregon and throughout the West Coast. Softshell clams have done very well as a human consumption commodity on the East Coast.

Another market option involves gaper clams and an extension of their harvest season. Bay clam fishermen claim to observe gapers in abundance during the gaper off-season and would like to meet the strong bait and aquarium market demand for gaper clams during this time. Biological research into gaper stock stability may show that an extension of the gaper season is a sustainable possibility for the commercial industry.

**4)** Ecosystem based fishery management (EBFM), is taking precedence over traditional, single-species management. In order to keep pace with this change, the US Commission on Ocean Policy (USCOP, 2004) advises that present and future fishery management plans tailor their objectives to achieve some level of EBFM. The conservative size and fishing effort of Oregon’s commercial bay clam industry should help ease a transition to ecosystem-based management. By setting small achievable objectives and incorporating ecological information into management of a resource on a step-by-step basis, managers can begin development of an ecologically-based management strategy.

**5)** This report provides a range of economic scenarios to demonstrate possibilities for the Oregon commercial bay clam industry given different market and harvest conditions. These scenarios help illustrate the economic potential of the industry in best-case and worse-case scenarios. The objective is to provide some insight into the economics of developing bay clam markets and increasing total allowable catch (TAC). Scenarios show that millions in revenue may be possible for this currently low-revenue industry (2004 industry ex-vessel revenue was $77,321) with the right set of circumstances.

**6)** This report discusses future institutional arrangement possibilities for the bay clam fishery including an individual transferable quota (ITQ) system and co-management.

**7)** Geographic Information Science (GIS) technology is an important technology in studying and managing coastal and marine environments. Now used worldwide, it provides powerful tools to monitor, map, analyze, visualize, and model coastal and marine environments. The organizational capabilities of GIS database systems should prove extremely helpful when managing a spatial harvest strategy and other fishery data issues. Additionally, the visual creations provide managers interactive maps they can share with fishermen when discussing complex management issues. Conveying information through imagery is an important communicative tool.

**8)** Finally, this report addresses future management issues for the bay clam industry. These issues consist of aquaculture, non-indigenous species, and enforcement. The report's general conclusions regarding these issues include:

> -Aquaculture is a potential expansion option for the bay clam industry. The possibility of its practice for bay clams in Oregon should be explored.
>
> -Implications of the introduction and spread of non-indigenous species on the West Coast likely involve economic hardship for several fishing industries, including Oregon's burgeoning bay clam industry. Precautionary monitoring of Oregon's estuaries for non-indigenous species problems could save the State and its industries significant costs and help secure a sustainable future.
>
> -To ensure that all Oregon resource users receive maximum benefits of the bay clam resource, recreational enforcement will likely need to increase. The costs and benefits of increased recreational enforcement are unknown, however, and a cost analysis should be performed to help provide insight into future enforcement needs and strategies.

This report makes 37 recommendations generated from study findings. Some key recommendations follow.

## Key Recommendations

- The Oregon commercial bay clam dive industry requires more science and market research. In particular, the industry requires the development of a long-term fishery management plan, which this report may assist in developing.
- Oregon State management agencies are at full capacity for funding, personnel, and time. In order for the small-scale, low revenue Oregon bay clam industry to progress, fishermen will have to play a larger role in the management process. The industry will likely need to devise a funding scheme involving a compilation of industry-based funding (cost recovery) methods as well as funding from other sources, such as Tillamook and Coos bays' estuary programs, NGOs, universities, and tribes.
- Use rotational spatial harvest methods and CPUE to help update needed information on bay clam abundances and distributions within Oregon bays. Consult the four-part strategy (consisting of cost-effective and cooperative methods) presented in this report as an option to achieve bay clam stock assessments in Oregon.
- Revisit the management practicality of current limits on bays open for mechanical harvest, mechanical harvest quotas, and the lack of hand-harvest quotas.
- Promote and develop a human consumption Oregon bay clam market (refer to this report's market strategies).
- Define bay clam industry goals in order to design appropriate and constructive property rights to help the industry realize its full potential as a new limited entry fishery.
- Address resource and permit allocation issues early in the industry's new limited entry phase to help the industry meet its potential.

This study finds that small-scale fishery management does not necessarily require less work and funding than that of large-scale fishery management. In order to develop a comprehensive yet workable fishery management plan for a small-scale fishery like the Oregon commercial bay clam dive industry, managers must address completely multiple fishery resource-use issues, often with the constraint of limited traditional financial resources. Creative and cooperative management systems are essential to the successful management of small-scale fisheries like the Oregon commercial bay clam industry.

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## CHAPTER V



**LIST of FIGURES, TABLES, and MODEL**

LIST of ACRONYMS

| | |
|---|---|
| **ORS** | **Oregon Revised Statutes** |
| **OAR** | **Oregon Administrative Rules** |
| **OFWC** | **Oregon Fish and Wildlife Commission** |
| **ODFW** | **Oregon Department of Fish and Wildlife** |
| **MRP** | **Marine Resources Program** |
| **DFP** | **Developmental Fisheries Program** |
| **DFB** | **Developmental Fisheries Board** |
| **ODA** | **Oregon Department of Agriculture** |
| **OSP** | **Oregon State Police** |
| **EBFM** | **Ecosystem Based Fisheries Management** |
| **GIS** | **Geographic Information Science** |
| **GPS** | **Global Positioning System** |

# CHAPTER I
# Introduction

## 1.1 Introduction

The future expansion and success of Oregon's commercial bay clam dive industry depends on the actions taken over the next few years. As a newly-transitioned fishery from "developmental" status (under the management of Oregon's Developmental Fisheries Program) to "developed" limited entry, the industry faces new challenges and opportunities in science, management, and economic development. In the case of the bay clam fishery, a limited entry management system means a rights-based fishery with individual bay quotas for each clam species and a capped number of industry permits.

Recently, Oregon's bay clam resources have gathered increased attention from commercial shellfish fishermen as having potential for a larger industry in Oregon estuaries (Sylvia and Munro Mann pers com 2004; Metcalfe 2003). The bay clam species harvested for commercial use in Oregon consist of the gaper or empire (*Tresus capax*), cockle (*Clinocardium nuttalli*), littleneck (*Venerupis staminea*), butter (*Saxidomus giganteus*), and softshell (*Mya arenaria*) clams (Developmental Fisheries Board 2004; Hancock et al. 1979). The divers of an established bay clam enterprise, Klam King Clams, in Coos Bay claim to observe resource potential (i.e., great abundances) for significantly higher sustainable commercial bay clam quotas than the present quotas that rely on data from partial surveys in the 1970s and 1990s (Metcalfe 2003). Other shellfish fishermen along the Oregon coast feel similarly and would like to help collect the data necessary to establish updated quotas (Developmental Fisheries Board meeting, November 2004; Alm pers com 2005).

In 2005, the Oregon commercial dive bay clam fishery requested the Developmental Fisheries Program (DFP) Board to recommend to the Oregon Fish and Wildlife Commission (OFWC) that the industry shift from "developmental" to a limited entry fishery, with transferable permits. (See Table 1 for the industry's proposed limited entry provisions and the DFP Board's recommendation to the Commission.) Members of the Board voiced that the commercial bay clam industry seemed to be nearing the point of "developed" (Developmental Fisheries Board meeting, November 2004); however, the fishery had neither approached optimum sustained yield nor acquired adequate information to develop a long-term management plan.

The State of Oregon requires developmental fisheries, or fisheries aiming to develop the commercial harvest of "underutilized food fish species" (ORS 506.450), to meet a set of scientific and management standards before transitioning to developed status. The Oregon Administrative Rule (OAR) 635-006-0810 states that a "'developed fishery' means a fishery where the level of participation, catch, and effort indicate the fishery has approached optimum sustained yield and/or there is sufficient biological information, information on harvest methods, gear types, and markets to develop a long-term management plan for the species." Curiously, although Oregon's commercial bay clam dive fishery did not fulfill these legislative criteria, the 2005 proposal passed.

Now classified as a developed limited entry fishery, the Marine Resources Program of the Oregon Department of Fish and Wildlife (ODFW) manages the bay clam industry (Figure 1). As with the industry's management under the Developmental Fisheries Program, OFWC continues to govern the industry's rules, and a total of 15 commercial permits are available to issue. Key science and management problems of the industry, cited from Developmental Fisheries Board meetings during 2004 and 2005, continue to include 1) out-dated and incomplete bay clam resource stock assessments and limited ecological and biological understanding of the resource, 2) mechanical harvest restrictions in all but two Oregon bays (restricting the development of low cost harvesting techniques), 3) the lack of a comprehensive management plan, 4) inadequate market development, 5) harvest levels below optimal yield (OY), 6) insufficient water quality monitoring, and 7) limited research and management funding.

**Commercial Bay Clam Dive Fishery Institutional Framework**

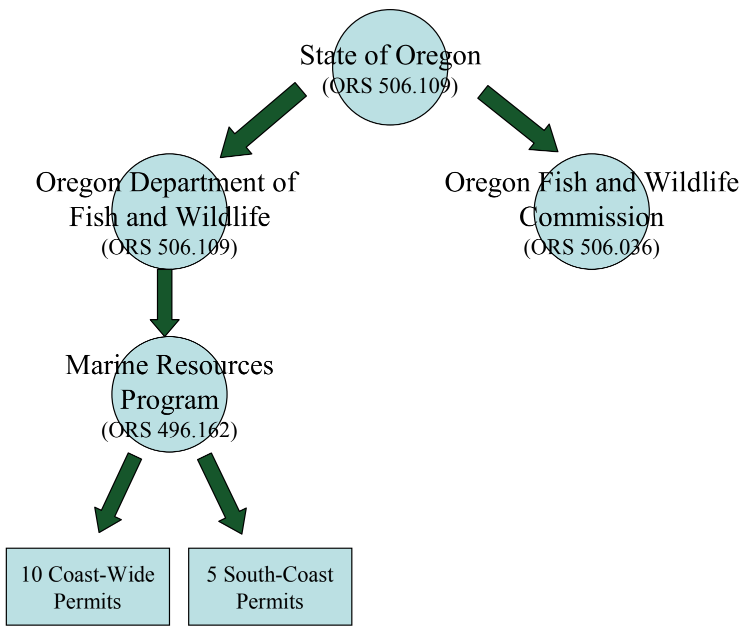



**Figure 1.** Commercial Bay Clam Dive Fishery Institutional Framework.

## 1.2 Study Purpose

This study was commissioned and funded by the Coastal Oregon Marine Experiment Station (COMES) to 1) identify the scientific and management issues constraining the advancement of the Oregon bay clam commercial industry, 2) explore scientific, management, and economic opportunities for the enhancement of the fishery, 3) outline and suggest mechanisms to attain stock and biological information, obtain funding, and manage the fishery at different stages of development, and 4) provide a comprehensive framework for the development of a bay clam fishery management plan.

### 1.2.1 Additional relevance of study

This report succeeds a recent draft of the new Oregon Nearshore Strategy by the Oregon Department of Fish and Wildlife's (ODFW) Marine Resources Program (2005). The mission of the new strategy "is to promote actions that will conserve ecological functions and nearshore marine resources to provide long-term ecological, economic, and social benefits for current and future generations of Oregonians." The Nearshore Strategy identifies Oregon's principal species and habitats that lack necessary management attention in order that conservation efforts are implemented to ensure their sustainability. The strategy currently does not include estuarine species; however it calls for the inclusion of these species in successive versions of the strategy. The Nearshore Strategy recommends ODFW provide greater attention to developing and achieving stock assessments for shellfish as well as develop more capable fisheries management methods, two important aspects of this bay clam fishery study.

## 1.3 Key Problems and Challenges

*Stock Assessments*

Out-dated and incomplete bay clam resource stock assessments of Oregon's estuaries create a major hurdle for advancing Oregon's bay clamming industry. It is scientifically and ecologically impractical to measure Oregon's bay clam stock potential without up-to-date and ongoing stock assessment data collection. Oregon State University (OSU) Sea Grant compiled the last coast-wide assessment in 1979 (Hancock et al. 1979). Since the 1970s, Tillamook Bay received one comprehensive assessment (Golden et al. 1998) and Coos Bay received a limited subtidal site survey specifically to raise bay clam fishing quotas in 2004 by the Oregon Department of Fish and Wildlife (ODFW). Comprehensive stock assessments for bay clam resources of the major Oregon estuaries are estimated to cost between $500,000 and $1,000,000, if not more (Sylvia pers com 2004; DeWitt pers com 2005). This study presents strategies for cost-effective stock assessments where fishermen and scientists will work cooperatively.

*Funding for Stock Assessments*

Funding for bay clam stock assessments is a major issue for the commercial industry's success. The industry needs comprehensive and regular stock assessments of bay clams to potentially raise quotas to effective levels for industry growth. Funds, however, are not set-aside specifically for these assessments. The Oregon Department of Fish and Wildlife (ODFW) must put their financial resources to many uses, and there is little funding for the bay clam fishery resource. This study discusses possible strategies for industry to conduct comprehensive stock assessments.

*Management*

The intent of the Developmental Fisheries Program (DFP) is to promote and guide biological and economic research for the advancement of developmental fisheries. This study finds that the commercial bay clam fishery left DFP prematurely and unprepared as a State-classified developed limited entry fishery. As a result, the ODFW Marine Resources Program lacks the information, goals, and strategies for effectively managing this bay clam fishery. Furthermore, the fishery lacks a developed fishery management plan.

Although the bay clam industry is a small-scale fishery, its resource management issues are not necessarily less complex than those of large-scale fisheries. Effective management of this industry requires time and research into issues such as biology and stock abundance, harvest practices, estuarine policies and management (e.g., water quality), markets, and resource allocation. However, inadequate industry revenues make funding these management needs a challenge.

*Property Rights*
Property rights provide fishermen a secure claim to a stream of benefits emerging from harvest of a fishery resource. These rights can be tailored to meet specific industry goals. Although the bay clam fishery is now classified as a rights-based limited entry fishery, it has not yet defined major industry goals and objectives in order to create and modify property rights accordingly. This study provides a description of property rights, potential features comprising a right, and the associated industry benefits.

*Undeveloped Markets*
Currently, principal markets for commercial Oregon bay clams are bait and aquarium. A human consumption market is not yet established. A human consumption market could raise demand for commercial bay clams and command higher prices per pound. This study presents a range of economic scenarios using harvest data and potential human consumption market prices.

## 1.4 Study Justification and Intent

Oregon's Wildlife Policy (ORS 496.012) requires the State to manage its wildlife resources for the conservation of indigenous species and for optimum social, recreational, and economic benefits. The policy requires the State to make decisions for the benefit of wildlife resources and for the best utilization of these resources by all user groups. Additionally, ORS 506.109 requires the State of Oregon to manage its food fish to provide optimum social, recreational, commercial, and economic benefits. (See the "Statutes' Table" in the Appendix.) Classified as both wildlife and food fish resources, Oregon bay clams fall under the legislation of both statutes.

This report provides a synthesis of political, social, and scientific information regarding the current status and future potential of the Oregon bay clam commercial fishery. This study addresses the following industry topics: existing regulation and management, allocation, ecology/biology, estuarine water quality, stock assessments, economics, funding, Geographic Information Science (GIS), management examples from other states and countries, and related issues including markets, aquaculture, non-indigenous species, and regulation enforcement. The presentation of these issues provides a framework for developing and implementing a bay clam fishery management plan. Cost-effective and cooperative management strategies are the foundation for the structure of the report and its recommendations, and they are fundamental concepts underpinning each section.

In addition to a synthesis, this study provides a variety of economic and management scenarios for the industry in order to demonstrate to the State and the industry its economic potential while ensuring its sustainability.

### 1.4.1 Guiding study objectives

1. *To determine whether the goals of legislative statutes are being satisfied as they pertain to the Oregon bay clam resource.*
2. *To analyze management goals and explore alternative approaches consistent with legislative statutes.*
3. *To determine viable management and funding alternatives, including a cost-effective stock assessment approach.*
4. *To identify principal areas of needed scientific research.*
5. *To provide information and analysis needed to advance industry development.*
6. *To provide ideas and information for developing and implementing a comprehensive fishery management plan.*

Many topics of this report overlap, demonstrating the complexity and interconnectedness inherent to resource and fishery management. This study supplies a background overview of the bay clam resource and fishery in Chapter II. Chapter III provides an analysis of current industry constraints that challenge its transition into a developed, limited entry fishery and presents mechanisms and strategies for the short- and mid-term to address the identified constraints and challenges. Long-term potential of the bay clam dive fishery is addressed in Chapter IV. Chapter V summarizes the study's major findings and provides recommendations.

# CHAPTER II
# Background: Oregon Bay Clam Resource and Industry

### Chapter Introduction
This chapter provides background to the Oregon bay clam resource and fishery, including a biological overview, geographical background, resource harvest history, economic trends, and status of the industry.

## 2.1 History of the Bay Clam Resource and Industry

### 2.1.1 Commercial fishing
Commercial collection of bay clams from Oregon estuaries has occurred for many decades. Hancock et al. (1979) cite data from commercial landings of bay clams back to 1941. Commercial harvests of subtidal bay clams began in Coos Bay in the 1960s with the introduction of mechanical equipment (Hancock et al. 1979). In the 1970s, fishermen used efficient mechanical dredging gear for experimental bay harvests. The gear's high level of efficiency caused concern among the Oregon Department of Fish and Wildlife (ODFW) for maintaining sustainable bay clam stocks, particularly stocks of gaper clams that exhibit sporadic recruitment. Therefore, ODFW banned mechanical dredging and only permitted commercial hand harvest of bay clams until the mid-1990s, when dive harvest began (ODFW 2004). The mid-1990s introduction of dive gear as a harvesting aide increased subtidal harvests dramatically, as did the authorization of a mechanical tool for subtidal harvests in Tillamook and Coos bays. Since 1996, subtidal landings have averaged 98.5% of the commercial bay clam harvest in Oregon (ODFW 2004).

In 1996, the bay clam dive fishery was one of the first fisheries to be classified under the Developmental Fisheries Program (DFP) as a "developmental fishery." Although the fishery had a significant history, insufficient biological and ecological data and poorly developed management institutions could not justify status as a developed dive fishery (OAR 635-006-0810).

As a developmental fishery, the Oregon Fish and Wildlife Commission (OFWC) in consultation with the DFP Board of ODFW managed Oregon's commercial bay clam dive fishery (Figure 2).

**Former Institutional Framework of the Commercial Bay Clam Dive Fishery**

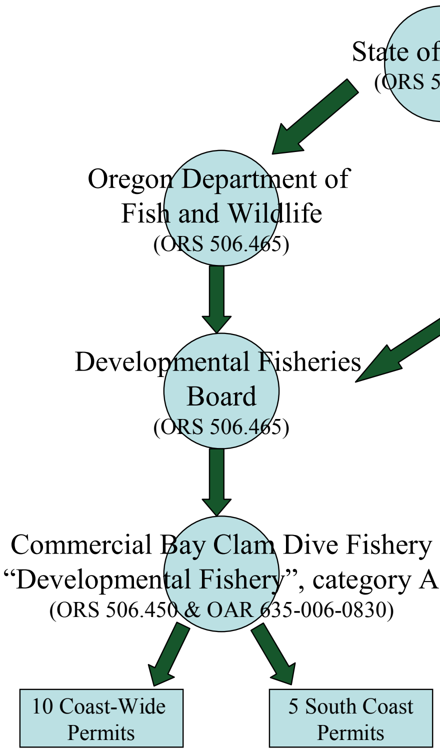



**Figure 2.** Former Institutional Framework of the Commercial Bay Clam Dive Fishery.

Under DFP, the fishery was permitted to commercially harvest in the subtidal zone. Given limited biological and ecological information, however, only precautionary fishing efforts and harvest levels were allowed. Thus, a major constraint to the development of the bay clam dive fishery was, and continues to be, a lack of resource information that may support larger harvests and a more sustainable fishery.

### 2.1.2 Subsistence and recreational fishing

Non-commercial clamming has occurred along the Oregon coast for thousands of years, first by Native Americans, and more recently by European settlers. Since the beginning of European settlement in Oregon less than two centuries ago, non-commercial clam fishing has grown concurrently with increasing coastal community populations. A 1954 study by Marriage demonstrated that non-commercial, or recreational, harvests of Oregon's bay clams far surpassed intertidal commercial harvests. In the 1970's, a study by the ODFW showed that recreational clam harvests comprise at least 90% of the total take from tidal flats (Hancock et al. 1979).

The recreational sector's impact on Oregon bay clam resources should not be underestimated when considering the potential expansion of Oregon's commercial bay clam industry. Coleman et al. (2004) researched recreational landing percentages on a national level for the US fishing industry. The Coleman study found US recreational fishery landings to be notably higher than those demonstrated by previous studies, and warns managers not to underestimate recreational impacts on fisheries resources. Standing alone, a recreational permit with modest daily quotas appears quite innocuous to the greater fishing industry; however, recreational permits are unlimited in availability and hundreds of permits may be in use at the same time. Therefore, recreational landings for a resource can quickly accumulate. Unfortunately, recreational harvests have not been as closely documented as commercial harvests. Recreational harvests need to be better understood as part of the plan managing bay clam resources and addressing commercial harvest issues.

## 2.2 Who are the Players?

### 2.2.1 State agency programs and authorities

Multiple state agencies have jurisdiction over Oregon's coastal and estuarine environments. Management responsibilities of these agencies include conserving fish and wildlife resources, monitoring water quality, and enforcing rules and regulations. Oregon's legislative statutes, or Oregon Revised Statutes (ORSs), characterize the jurisdictions and authorities of state agencies. Oregon Administrative Rules (OARs) describe agency policies and programs. State agencies adopt and use these rules to implement legislative statutes. See the Appendix "Statutes' Table" for the primary ORSs and OARs related to managing Oregon commercial bay clams and the industry.

The following state agency programs are the main authorities involved with the protection and management of Oregon bay clams. Refer to Figure 1 for an institutional schematic of the Oregon commercial bay clam industry.

Oregon Fish and Wildlife Commission (OFWC)

The Oregon Fish and Wildlife Commission (OFWC) develops policies for managing and protecting Oregon's fish and wildlife resources. OFWC institutes seasons, procedures, and harvest limits for commercial and recreational take. In consultation with the Developmental Fisheries Board, OFWC manages developmental fishery resources and components of the Developmental Fisheries Program.

Oregon Department of Fish and Wildlife (ODFW)

The Oregon Department of Fish and Wildlife (ODFW) is responsible for implementing policies and conducting day-to-day management and conservation of Oregon's fish and wildlife resources.

ODFW Marine Resources Program (MRP)

The ODFW Marine Resources Program (MRP) is responsible for the "assessment, management, and sustainability of Oregon's marine habitat, biological resources and fisheries" (Burke 2004).

Developmental Fisheries Program (DFP)

The Marine Resources Program administers the Developmental Fisheries Program (DFP). DFP provides a management process for the exploration of fishery resources and their potential commercial development by pioneering fishermen, while protecting the long-term sustainability of the fishery resources. The commercial bay clam industry recently shifted from “developmental” to limited entry, and is no longer managed under this program.

- Developmental Fisheries Board (DFB)
  The Developmental Fisheries Board (DFB) of DFP provides consultation to OFWC regarding developmental fishery species, commercial harvest programs, methods of data collection, and developed harvest systems. The DFB holds quarterly public meetings to discuss developmental fishery issues with stakeholders.

Oregon Department of Agriculture (ODA)
The Oregon Department of Agriculture’s (ODA) Shellfish Program, within the Food Safety Division, monitors the water quality of bays and tests for toxins. ODA is responsible for leasing and regulating oyster plots for aquaculture.

Oregon State Police (OSP)
The Oregon State Police (OSP) enforce the rules and regulations set by OFWC and ODA, such as harvest limits and toxin closures, respectively.

#### 2.2.2 The Oregon bay clam commercial dive industry
The Oregon bay clam commercial dive industry is managed as a limited entry fishery under the authority of ODFW’s Marine Resources Program and OFWC. The industry consists of 15 permit holders, 10 coast-wide and 5 South-coast. This commercial dive industry harvests bay clams exclusively from subtidal areas of bays.

### 2.3 Biology of the Bay Clam Resource

#### 2.3.1 Ecological similarities, differences, and subsequent management implications
Oregon’s five commercial bay clam species (gaper or empire clams (*Tresus capax*), cockle clams (*Clinocardium nuttalli*), littleneck clams (*Venerupis staminea*), butter clams (*Saxidomus giganteus*), and softshell clams (*Mya arenaria*)) share several ecological similarities. Example similarities include their use of suspension feeding mechanisms, ability to live in comparable substrate types, lifetime longevities near 15 years and generation times of approximately 1.5 to 3 years, corresponding predators, and sexual spawning by broadcasting their eggs and sperm into the water column. (For images of these bay clams and more biological information, see Appendix section “Bay Clam Biologies and Life Histories.”)

All bay clams are important contributors to the ecological health and function of estuaries, improving water quality and providing nursery habitat for many organisms. These bivalves play essential roles in the recycling and filtering of nutrients and energy in estuarine ecosystems. As suspension feeders they act as a filtering system within bays, decreasing turbidity and algae concentrations in the water column. Studies have shown that suspension feeding bivalves like bay clams improve water clarity and cycle nutrients to the benthic environment and can promote the growth of seagrass beds (Joergensen

1990; Peterson and Heck 1999). The depth and width of an estuary as well as the location of bay clams within the estuary influence the extent of the bivalves' contribution to water quality (Gerritsen et al. 1994). Studies within Chesapeake Bay indicate that based on bivalve abundance, filtering capacities, and water mixing parameters, bivalves could consume more than 50% of the primary production in shallow fresh to low salinity estuarine areas; however this consumption of primary production reduces with depth (The North Carolina Division of Marine Fisheries, August 2001).

There are ecological differences between Oregon bay clams as well. For example, softshells are more concentrated in low-salinity intertidal flats of upper estuaries, whereas cockles, gapers, butters, and littlenecks tend to thrive in high-salinity subtidal and intertidal areas of bay areas closer to ocean inlets. If softshells become a greater commercial industry target, this difference in habitat location could affect softshell clam management. Another ecological difference is in the spawning success of gapers. Hancock et al. (1979) and Robinson and Breese (1982) report that gaper clams are less resilient and successful spawners than the other commercial clams. In effect, gaper clams are assigned a six month no harvest season to protect their spawning success. All other commercial bay clams can be fished year round. However, some scientists contend that the ecological arguments for the gaper season are not adequately substantiated (see section "3.1.2 Mixed stock management, bay clam seasons, and recruitment").

**2.3.2 Bay clam densities**

Figure 3 presents average bay clam densities. These data represent an average density from Tillamook and Coos bays, which have received the most comprehensive and frequent bay clam surveys. Data were extrapolated from per square meter densities within subtidal regions of these two bays. See Appendix section "Bay Clam Biologies and Life Histories" for more information on these clams.

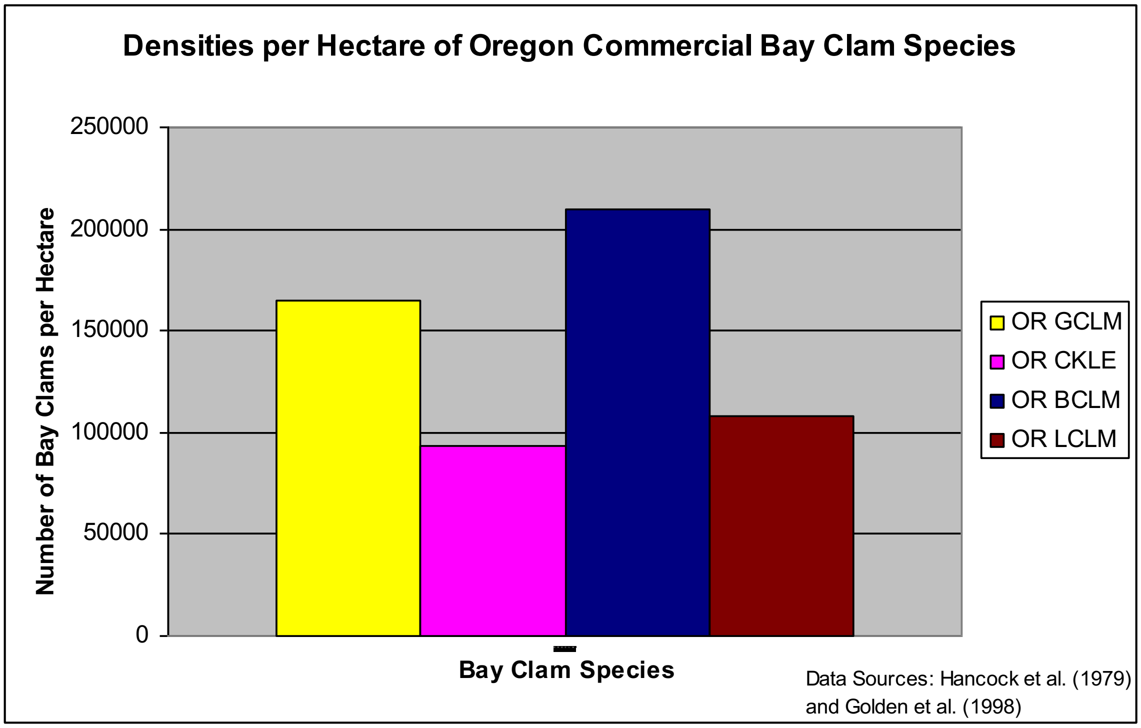



**Figure 3.** Densities per Hectare of Oregon Commercial Bay Clam Species. GCLM = gaper clam, CKLE = cockle clam, BCLM = butter clam, LCLM = littleneck clam. Softshell clams are not included in this graph due to limited survey and harvest data.

The following literature sources provide some of the most comprehensive biological, life history, and/or stock abundance information on Oregon bay clams: Coan et al. 2000; Eckert 2003; Emmett et al. 1991; Golden et al. 1998; Grantham, Eckert, and Shanks 2003; Griffin 1995; Hancock et al. 1979; and Johnson 1990. Full references for these sources may be found under "Literature Sources" at the end of this report.

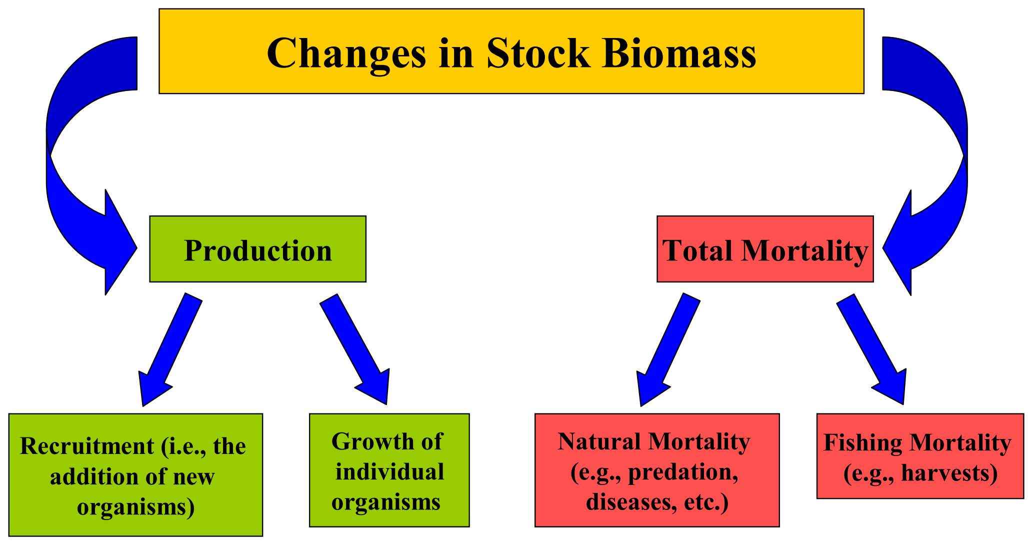
## 2.4 Stock Assessments

### 2.4.1 Why perform stock assessments?

A stock is considered a group of organisms of one species that exhibit similar production characteristics such as recruitment, growth rate, and natural and fishing mortality rates. Stock organisms inhabit the same geographic region; therefore a stock may include one or more populations of the same species depending on the populations' geographic range and relationship to one another in regards to production characteristics. Stock assessments are a key element of the fishery management process. A primary objective of a stock assessment plan is to collect biological information on a resource (e.g., distribution and density data; recruitment success, etc.) necessary for managers to make quantitative predictions about fish populations and establish sustainable total allowable catch (TAC) for a fishery (Hilborn and Walters 1992; Gertseva pers com 2005).

### 2.4.2 Understanding stock biomass

The size of a stock's biomass depends on four main factors: recruitment, growth, natural mortality, and fishing mortality. Recruitment refers to the naturally occurring replenishment of new organisms to a stock, and growth refers to the physical increase in biomass of individual organisms within that stock. Together, recruitment and growth comprise a stock's production. Natural mortality is the loss of stock biomass due to natural causes of death, such as predation and disease. Fishing mortality is the loss of stock biomass due to fishing harvests. Natural mortality and fishing mortality comprise a stock's total mortality (see Figure 4).




Stocks increase in biomass when production (i.e., recruitment and growth) exceeds total mortality (i.e., natural mortality and fishing mortality) and stocks decrease in biomass when total mortality exceeds production. Stock biomass remains steady when production equals total mortality.

**Figure 4.** Changes in Stock Biomass. A stock's biomass changes in size due to factors of increase such as recruitment and growth, and factors of decrease such as natural mortality and fishing mortality.

Sustainable harvests target a stock's surplus production, allowing the principal production to replace natural deaths and maintain a healthy stock size. Surplus production, or the amount of stock production that exceeds losses to natural mortality, is expressed as: Production – Natural Mortality = Surplus Production.

The complexities of natural systems make measurements of stock size a challenge. In particular, the aquatic nature of marine and estuarine systems is more difficult for humans to access than many terrain environments. Scientists face greater difficulties measuring parameters, higher costs, and more uncertainty. Equations are used to quantitatively estimate the magnitude of a stock's recruitment, growth, natural mortality, and fishing mortality.

For instance, the equation $Z = M + F$ (i.e., Z is total mortality, M is natural mortality, and F is fishing mortality) expresses a relationship between total, natural, and fishing mortality. Natural mortality measurements are difficult to make and scientists often assume constant natural mortality of a stock. However, fishing mortality is a more tangible measurement due to catch data records and can be calculated with the equation $F = q * f$, where q is the catchability coefficient and f is fishing effort. Total mortality can be determined from the slope of a catch curve. If two components of the equation $Z = M + F$ are known, like fishing mortality (F) and total mortality (Z), the third component, natural mortality (M), can be calculated using simple algebra.

**2.4.3 Stock assessment process**

The stock assessment process is used to measure the size of a fishery stock, understand dynamic stock processes, and help determine harvest strategies that meet management plan objectives (Gertseva pers com 2005). Catch data, abundance data, and other biological data are input into a population model to determine stock status and yield (Methot pers com 2005). Fishing logbooks and observers provide catch data that include age/size data of the stock. Resource surveys and fishery catch per unit effort (CPUE) provide abundance data, also including age/size data of the stock. Biological data includes information on age, growth, and maturity of the stock. Stock assessment methodology typically includes the following components: 1) data collection; 2) data analysis; 3) model development; 4) model relation to data collected (through statistical analysis); 5) development of short- and long-term stock projections; and finally 6) information for managers.

The main data sources available for finfish stock information are commercial catches, research surveys, and tagging studies (Hilborn and Walters 1992; Gertseva pers com 2005). Commercial harvests and research surveys are the most relevant data sources for bay clam stock information.

Components of the commercial catch data source include on-board observers, logbooks, and landing records.

- Observers make record of the catch, bycatch, etc., while on-board vessels. Observers can collect good quality data; however they are expensive to hire and many fishermen find them intrusive.
- Logbooks are much less expensive and intrusive ways to collect important stock data. Fishermen record their catch amounts, catch species, harvest times, and harvest locations, as well as other information. However, logbook data validation is a challenge for regulatory agencies. Fishermen may modify their actual catch data to avoid regulatory complications and concerns for the fishery.
- Landing records, or port samplings, occur after fishermen dock and unload their catch. Completion of these records is also an inexpensive and easy way to collect important stock information. However, like log books, data forging is an issue for regulatory agencies.

Research surveys often occur independently from commercial catch outings, although these surveys may coincide with fishermen harvests in order for researchers to use fishermen's boats and reduce their research vessel costs – a form of cooperative research discussed at the end of this chapter (National Research Council 2004). Research surveys may sample visually with high-resolution aerial surveys of tideflats or other appropriate sampling, or research surveys may use fishing gear to conduct a more refined survey of a stock. In the case of Oregon subtidal bay clam stocks, researchers commonly use dive gear in order to survey organisms. Once all survey data are collected, researchers use the data to conduct an analysis and estimate the size and distribution of the stock. Other research and educated deductions may be used to make assumptions for some research parameters or to characterize biological and harvest relationships (Gertseva pers com 2005).

### 2.4.4 Bay clam stock knowledge

Oregon State University (OSU) Sea Grant and the Oregon Department of Fish and Wildlife (ODFW) conducted a comprehensive study of Oregon's estuarine subtidal bay clam stocks in the 1970s (Hancock et al. 1979). Golden et al. (1998) conducted a comprehensive follow-up biological inventory of Tillamook Bay's intertidal and subtidal benthic invertebrates in the 1990s. Biomass estimates demonstrated that subtidal areas support the majority of bay clams and are an important brood stock for the bay's intertidal areas. In 2004, ODFW surveyed a portion of Coos Bay's subtidal areas to determine whether bay clam populations could support higher harvest quotas (McCrae pers com 2005). Tillamook and Coos bays have received the most recent bay clam surveys driven by the concentration of bay clam harvesting pressure in these two estuaries. However, Oregon bay clam stock assessment data are deficient for resource management purposes and a comprehensive plan for stock assessments within these and other bays is needed. (See Chapter III and particularly section "3.5 Cooperative and Cost-Effective Stock Assessments" for more detail on stock assessment needs and mechanisms to address these needs.)

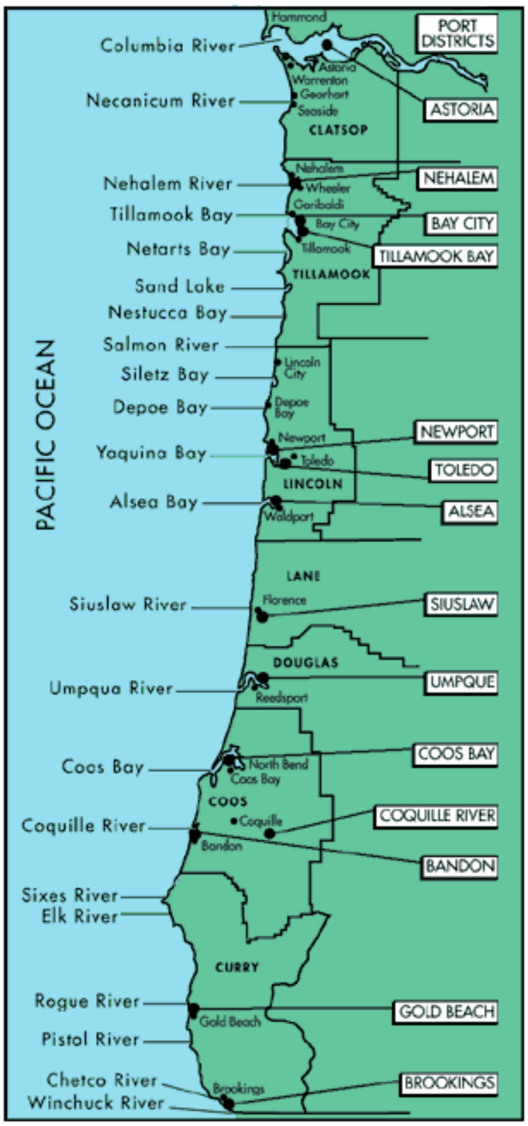
## 2.5 Geography of the Bay Clam Resource

### 2.5.1 Oregon coast and estuaries

According to Hancock et al. (1979), Tillamook, Yaquina, and Coos bays are three estuaries with the greatest potential in Oregon for commercial bay clam fisheries. Currently, Tillamook and Coos are the most heavily harvested estuaries. Tillamook and Coos estuaries each have an established local estuarine management program, the Tillamook National Estuary Program (NEP) and the South Slough National Estuarine Research Reserve (NERR), respectively. These programs could be used to update data collection and monitoring programs. Both bays have significant size, receive regular water quality monitoring, and are open for mechanical bay clam harvest, which is an efficient harvest technology (i.e., a small hand-held device that targets individual clams and harvests them one at a time). Mechanical quotas are set in Tillamook and Coos bays using recent resource surveys of the 1990s and 2000s and catch data. Most other Oregon bays received their last resource assessments in the 1970s.

The Lower Columbia River estuary, although large in area, is not a prime target for the bay clam dive industry due to large amounts of commercial and recreational boat traffic, water quality concerns, and high flow dynamics that challenge divers (Hunter pers com 2005; McCrae pers com 2005). (See Figure 5 for more Oregon bay information.)

**Oregon Coast and Estuary Map with Table**




| Oregon Estuaries (22 total) | Location on Oregon Coast | Area (in hectares) | Open to Commercial Bay Clam Harvest (OAR 635-005-0020) | Permission for Mechanical Harvest |
|---|---|---|---|---|
| Lower Columbia River | Astoria | 32,703.2 | Open | No |
| Necanicum River | Seaside | 182.5 | Open | No |
| Nehalem River | Nehalem | 1,112.5 | Open | No |
| Tillamook Bay | Tillamook and Garibaldi | 3,729.6 | Open | Yes |
| Netarts Bay | Netarts | 1,110.1 | Not open, except for cockles | No |
| Sand Lake | Sand Lake | 363 | Open | No |
| Nestucca Bay | Pacific City | 475.8 | Not open | No |
| Salmon River | Otis | 177.3 | Not open | No |
| Siletz Bay | Lincoln City | 591.2 | Not open | No |
| Depoe Bay | Depoe Bay | 10.1 | Open | No |
| Yaquina Bay | Newport | 1,751.9 | Open | No |
| Alsea Bay | Waldport | 1,018.2 | Open | No |
| Siuslaw River | Florence | 1,238.3 | Open | No |
| Umpqua River | Reedsport and | 2,648.3 | Open | No |

| | | | | |
|---|---|---|---|---|
| | Winchester | | | |
| Coos Bay | Coos Bay and North Bend | 5,401.8 | Open | Yes |
| Coquille River | Bandon, Coquille, and Myrtle Point | 437.9 | Open | No |
| Sixes River | Sixes | 133.5 | Open | No |
| Elk River | Port Orford | 117.4 | Open | No |
| Rogue River | Gold Beach | 356.1 | Open | No |
| Pistol River | Pistol River | 93.1 | Open | No |
| Chetco River | Brookings | 69.2 | Open | No |
| Winchuck River | Oregon – California border | 52.6 | Open | No |

**Figure 5.** Oregon Coast and Estuary Map with Table. Sources: Oregon Estuary Plan Book (2005) and Oregon Coastal Atlas (2005)

The total area in hectares of all 22 Oregon estuaries is 53,773.6 (132,877 acres), and 21,070.4 hectares (52,066 acres) excluding the Lower Columbia River.

### 2.5.2 Estuary closures to commercial harvest

In the mid-1980s, the Oregon Fish and Wildlife Commission (OFWC) closed bay clam commercial harvest in Nestucca Bay, Salmon River, Siletz Bay, and Netarts Bay (except for the commercial harvest of cockles) due to user conflicts between recreational and commercial fishermen. Recreational fishermen argued that the clam abundances in these bays could not support both commercial and recreational harvests; therefore, except for commercial harvests of abundant cockle populations in Netarts Bay, recreational fishermen requested a ban on commercial activity (Hunter pers com 2005; McCrae pers com 2005).

Commercial permit holders may harvest all open bays for clams throughout the year, or until bay quotas are met (discussed below). Gaper clams are an exception to this year-round harvest and have a closed season from January through June.

### 2.5.3 Mechanical harvest and commercial quotas

Tillamook and Coos bays have received the most frequent resource surveys of all Oregon bays since the 1970s. Resource surveys allow the Oregon Department of Fish and Wildlife (ODFW) to monitor Tillamook and Coos bays for sustainable commercial bay clam harvests, and consequently ODFW permits mechanical harvest in these two bays (McCrae pers com 2005). However, the use of efficient mechanical harvest equipment raises concerns for the potential over-exploitation of bay clam stocks in these bays; therefore, ODFW establishes commercial bay clam quotas for Tillamook and Coos bays. Only high-effort, precautionary hand-harvest methods are allowed for commercial harvest in other Oregon bays, which lack frequent resource assessments. Accordingly, these non-mechanical harvest bays contribute only a small amount to statewide commercial landings (see Figure 6). Tillamook and Coos bays represent over 99% of the total statewide harvest, with Tillamook Bay contributing almost four times more to commercial bay clam harvests than Coos Bay (see Figure 6).

With the exception of a commercial dive quota for cockles in Netarts Bay of 8,000 pounds (OAR 635-006-1015), commercial bay clam quotas are not established in bays that prohibit mechanical harvest. Precautionary hand-harvest methods maintain low harvests in these bays. The Netarts Bay quota is established by ODFW due to a user group conflict between recreational and commercial fishermen more than a scientifically-based ecological concern. The commercial quota on cockles ensures recreational fishermen the replacement of intertidal cockle stocks by abundant subtidal brood stocks (Hunter pers com 2005).

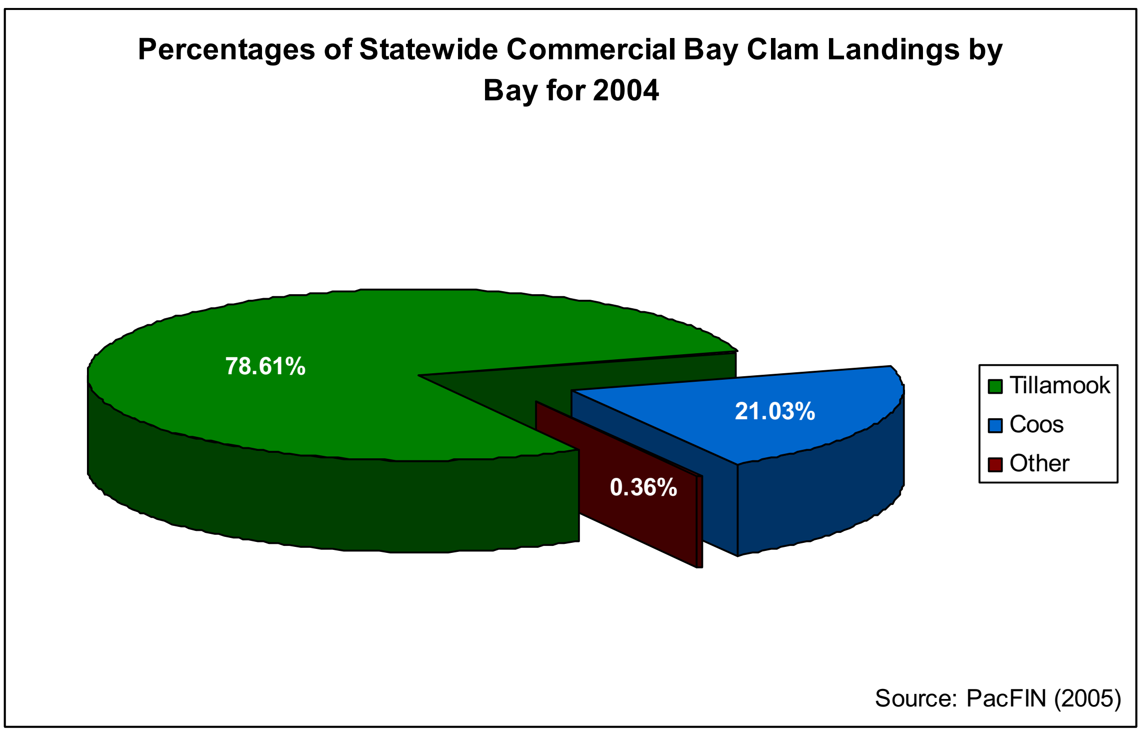



**Figure 6.** Percentages of Statewide Commercial Bay Clam Landings by Bay for 2004.

## 2.6 Fishery Economics

This section provides an overview of Oregon's commercial bay clam fishery landings, ex-vessel price trends, and ex-vessel revenue trends between the years 1995 and 2004. Fishery management costs are also addressed.

### 2.6.1 Ten-year financial and landing history of industry (1995-2004)

The following ex-vessel prices and revenues are adjusted for inflation with the National Aeronautics and Space Administration (NASA) Gross Domestic Product (GDP) Inflation Calculator based on 2004 values. These are all state-wide values. Softshell clams are not included in any graphs due to low and inconsistent commercial landings during the years 1995-2004 (PacFIN 2005).

Oregon cockle clams dominate statewide landings for all years but 1998 and 2003 (see Figure 7). For these two years, Tillamook Bay fishermen focused more strongly on butter clam harvests due to their high abundances in some bay regions (Alm pers com 2005). Tillamook Bay supplies the majority percent of statewide landings of cockles, with a small percentage coming from Coos Bay. In 2004, however, Coos Bay provided just over 20% of the statewide cockle landings, its highest percentage contribution during the ten year period.

Gaper clam landings have increased and remained steady since 2002. Since 1999, Tillamook Bay and Coos Bay have alternated as leading bays for their contributions to statewide gaper landings. Coos Bay provided close to 83% of statewide landings in 2004. Prior to 1999, Tillamook and Yaquina bays provided the majority of gaper statewide landings, with Yaquina Bay's last significant landings in 1996.

Butter clam landings spiked to over 90,000 pounds in 2003. During that year fishermen found dense stocks of butter clams in Tillamook Bay (allowing for a harvest rate of about 150 lbs/hr) and decided to focus on butter clam landings (Alm pers com 2005). Butter clam landings returned to lower figures, just under 40,000 pounds in 2004, as cockles became the main target of fishermen again.

Since 1999, littleneck clams have had the lowest statewide landings of the four bay clam species. Tillamook Bay has provided nearly all statewide littleneck landings during the ten-year span. The Oregon coast marks the southern range of littleneck bay clams' distribution, which may help explain the lower landings (D'Andrea pers com 2006).

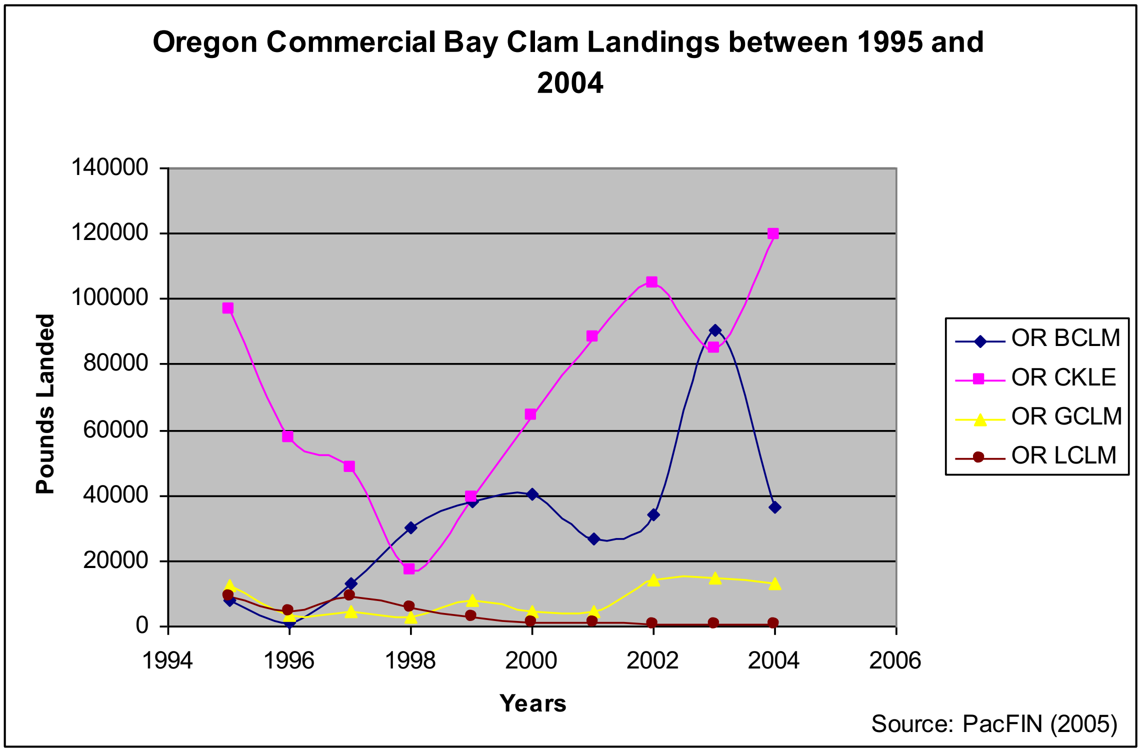



**Figure 7.** Oregon Commercial Bay Clam Landings between 1995 and 2004. BCLM = butter clam, CKLE = cockle clam, GCLM = gaper clam, LCLM = littleneck clam.

Oregon littleneck clams have commanded relatively high prices (ranging from approximately $1.60 to $2.65/lb) in comparison to the other commercial bay clams (Figure 8). These higher littleneck prices are due to their human consumption market. The other three bay clams are primarily sold as bait at lower prices.

Cockle and butter clams have demonstrated fairly consistent ex-vessel prices per pound over the past ten years, both averaging under $0.50/lb. Gaper clams, which are sought in the aquarium and bait markets for their high fat content (Alm pers com 2005), commanded close to $1/lb in 2004, and fluctuated between $0.35 and $0.80/lb from 1995 to 2003.

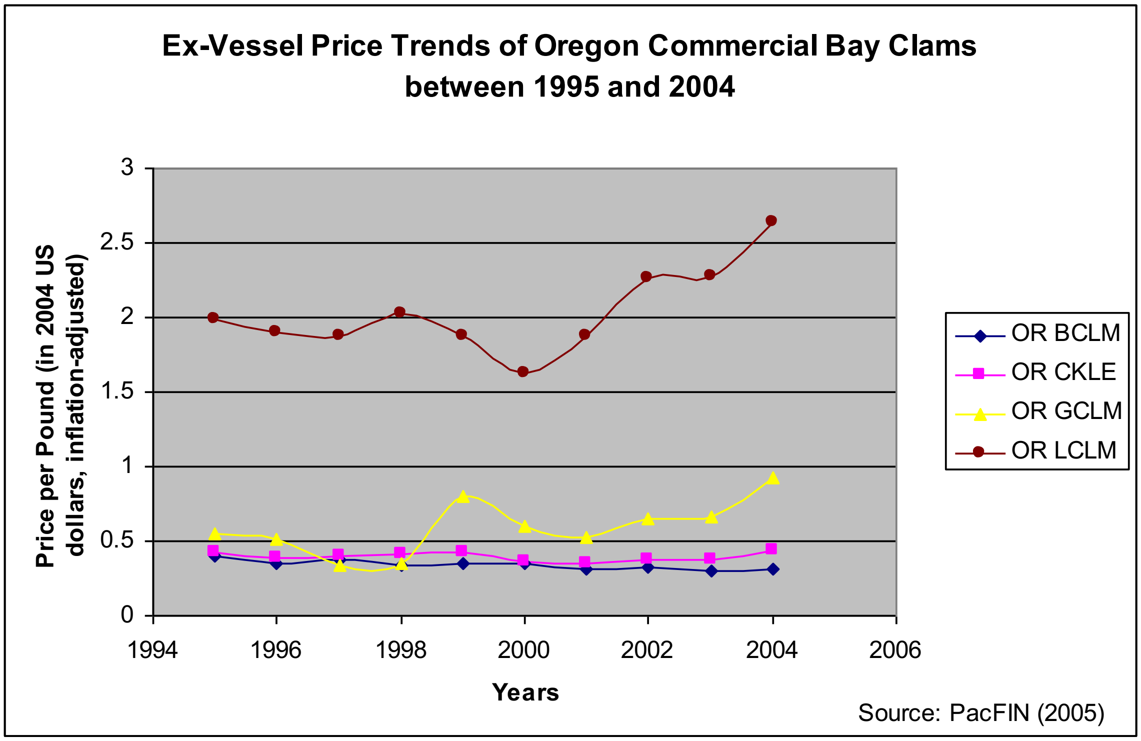



**Figure 8.** Ex-Vessel Price Trends of Oregon Commercial Bay Clams between 1995 and 2004. BCLM = butter clam, CKLE = cockle clam, GCLM = gaper clam, LCLM = littleneck clam.

Oregon cockles bring in the greatest ex-vessel revenues given their high landings and well-established bait and aquarium markets. Since 2000, littlenecks have contributed only a small percentage to statewide revenues due to water quality issues and reduced commercial access to littleneck habitat (Alm pers com 2005) (see Figure 9).

Since 2002, gaper clam ex-vessel revenues have increased, correlating with an increase in landings and ex-vessel prices per pound. Butter clam revenue trends closely mirror their landing trends due to fairly stable ex-vessel price trends over the past ten years.

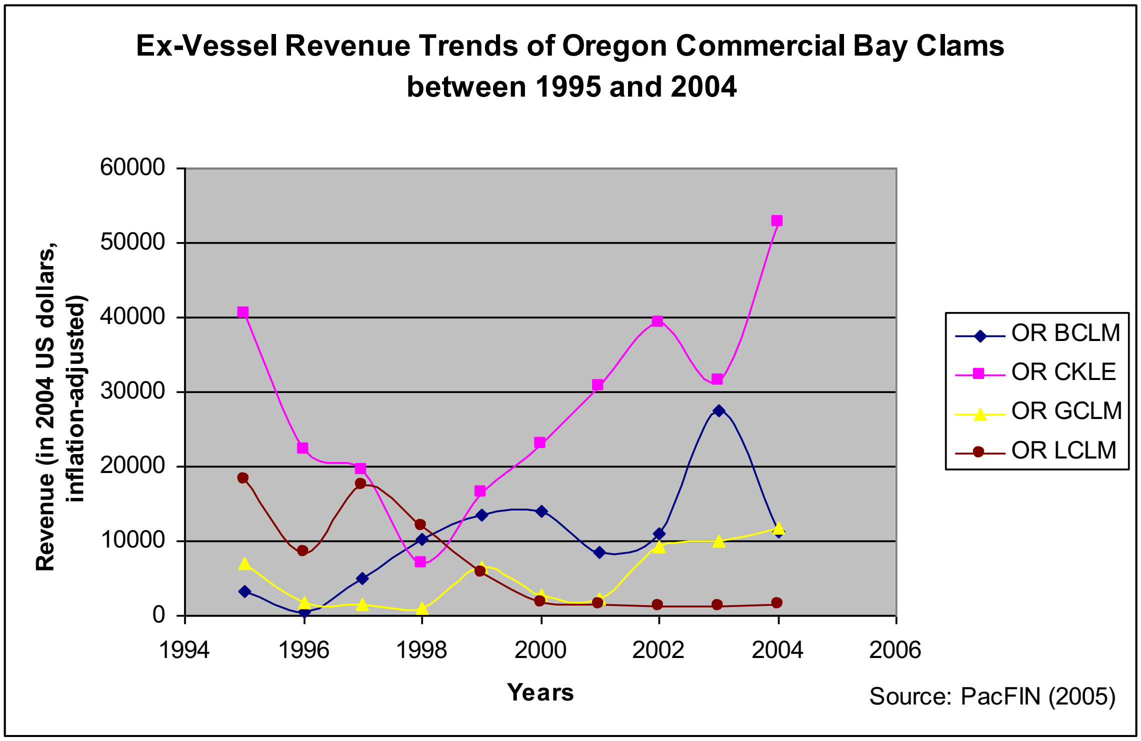



**Figure 9.** Ex-Vessel Revenue Trends of Oregon Commercial Bay Clams between 1995 and 2004. BCLM = butter clam, CKLE = cockle clam, GCLM = gaper clam, LCLM = littleneck clam.

These graphs demonstrate a ten-year trend of industry landings, ex-vessel prices, and ex-vessel revenues. Ex-vessel prices differ significantly for bay clams sold for bait and aquarium use versus human consumption. However, the cockle, a bay clam sold primarily for bait and aquarium use, has almost consistently contributed the most to industry revenues between the years of 1995 to 2004. The cockle clam's considerable contribution to revenue is due to its high ex-vessel landings. (See section "4.1.1 Economic scenarios" for a discussion of potential future economic scenarios based on these data and different assumptions about markets and landings. Also see Appendix section "10-Year Landing, Price, and Revenue Trends of Oregon and Washington Clams" for a comparison of Oregon and Washington industries.)

### 2.6.2 Management costs of the bay clam industry

The principal management costs of the bay clam industry include biological resource assessments and water quality monitoring. Fish ticket administration, data processing, and permitting procedures also require attention from agency personnel.

The Oregon Fish and Wildlife Commission (OFWC) controls State moneys for Oregon's fishery resources and industries. The Oregon Department of Fish and Wildlife (ODFW) is responsible for the costs of developmental fishery biological resource assessments and management costs associated with fish tickets, data processing, and permitting. ODA is responsible for the costs of water quality monitoring. The fishing industry occasionally shares in the costs of resource surveying by loaning fishing boats and dive equipment, and by aiding in the collection of resource data. For example, fishermen helped with bay clam surveys in Tillamook Bay in the 1990s and in Coos Bay in 2004 (Golden et al. 1998; Developmental Fisheries Board meeting 2004).

### 2.6.3 Economic trade-offs

A goal of fisheries management is to find an optimal balance across time of resource allocation and use between commercial, recreational, and ecosystem services (public goods). One way to analyze a "balance" between resource-users is to understand the economic trade-offs. For example, if more bay clam resource is allocated to the commercial fishery harvest, rather than remaining an ecologically-functioning public good, what will be the effect on estuarine water quality? A significant reduction in bay clam populations in estuaries due to higher quotas/harvests may have an adverse affect on bay water quality, and may require other measures for managing costly water quality. (See section "3.1.1 Contribution to water quality" for further discussion of water quality as a public good.) One cannot assume that higher industry revenues (e.g., due to greater harvests) equate to economic gain overall. Losses to other users need be addressed in order to perform an accurate cost-benefit analysis.

## 2.7 The Industry Today: Present Status

### 2.7.1 Fishing rights allocation

Before the industry shifted to limited entry, ODFW's Developmental Fisheries Program (DFP) allocated developmental bay clam dive permits through permit fees. Each permit holder paid an annual fee of $75 to attain and maintain a dive fishery permit, which was non-transferable, and its associated commercial fishing rights. A lottery was held for permits if the number of applicants exceeded the number of available permits.

Individual and vessel permits were available with a total of 15 bay clam dive fishery permit holders: 10 coast-wide and 5 South-coast permits (Developmental Fisheries Board meeting, 2004). Coast-wide permit holders were allowed harvesting privileges in all open bays along the Oregon coast. South-coast permit holders could only harvest within open bays south of Heceta Head. (See Appendix section "Developmental Fisheries Permits" for conditions and formatting of a 2005 permit and Oregon dive gear log.)

Fishing rights are allocated similarly now that the limited entry fishery is managed by ODFW's Marine Resources Program. The main difference is that these fishing rights are considered property rights that provide fishermen a secure claim to a stream of benefits emerging from the harvest of the resource, and permit holders no longer pay an annual fee of $75. The transition of the fishery from developmental to limited entry has allowed holders of the 15 developmental fishery permits to become holders of the 15 limited entry permits.

### 2.7.2 Transition to a developed status

As a limited entry fishery, bay clam fishermen's permits are deemed property, meaning they carry monetary value like other personal property, and can be considered part of the fishermen's assets. In addition, the permits will have transferability later in 2006, a characteristic that encourages economic efficiency.

The following table (Table 1) outlines the final proposal for limited entry, developed by the bay clam industry and the DFP and submitted to the OFWC for approval. Conflicts of interest between north coast fishermen, south coast fishermen, and the Developmental Fisheries Board (DFB) led to several discussions about the parameters of prior limited entry proposals before consensus was reached.

OFWC reviews proposals for their consistency with legislative statutes and rules and makes certain fisheries meet requirements for transition to developed status. OFWC accepted this proposal in November 2005 with the amendment that minimum landings will be required to allow permits to be transferred. Landing requirement amounts will be discussed by OFWC in 2006 (Hunter pers com 2005; McCrae pers com 2005).

**Table 1.** The Final Limited Entry Proposal.
Outline of proposed limited entry provisions for the bay clam dive fishery, as recommended by the Developmental Fisheries Board, 8/18/2005.

| | Proposal recommended by DF Board | Other options to consider | Relevant OAR |
|---|---|---|---|
| Definition | • Include only five major species: cockle, butter, gaper, littleneck, softshell | • Limited Entry includes harvest of all species of clams by dive gear from subtidal areas in estuaries. | 635-006-1010 (1) |
| Requirement for permit | • Limited entry permit is needed to harvest bay clams, from subtidal areas, using dive gear.<br>• Allows only two divers off a vessel in the water at any one time<br>• 10 permits allowed for harvest in all open estuaries, (all current coast-wide DF permits).<br>• 5 permits allowed for harvest in all open estuaries south of Heceta Head (all current south coast DF permits).<br>• Permit issued to individual or vessel. May change designation at the beginning of a year. | | 635-006-1015 (1)(l) |
| Permit fee | • $75 | | 635-006-1025 (10) |

| | | | |
|---|---|---|---|
| Eligibility for permit | • An individual or vessel is eligible for a coast-wide LE permit if they had a coast-wide Developmental Fisheries bay clam dive permit in 2005 (and met renewal requirements).<br><br>• An individual or vessel is eligible for a south-coast LE permit if they had a south-coast permit in 2005 (and met renewal requirements). | | 635-006-1035 (10) |
| Transfer provisions | • Fully transferable (no landing requirements)<br><br>• Transfers allowed in the event of a death of the permit holder. | • Transfers allowed if landings were made totaling 3,000 lb in three of the last five years. | 635-006-1095 (10) |
| Renewal of permits | • Annual renewal requirements of 5 landing of 100 lb or a total of 2,500 lb.<br><br>• In the case of a death of the permit holder, renewal requirements are waived for the year. | • No renewal requirements. | 635-006-1075 (1)(j) |
| Logbooks | • Logbooks required<br>• Must submit for renewal | | 635-006-1110 (3) and 635-006-1075 (1)(j)(C) |
| Other regulations | • Add existing bycatch provisions, closed areas, size limits, and quotas to bay clam OARs<br>• Remove above from devo. fish OAR's. | | 635-005-0020 & 635-005-0030 & new number |

## 2.8 Cooperative Research

### 2.8.1 A new era of cooperative research

In the US and abroad, centralized, government-staffed research has been the leading method for acquiring scientific information for fisheries management. Today, cooperative research approaches for acquiring scientific data are becoming increasingly common. Cooperative research involves other parties in the research process in order to increase scientific understanding of fishery resources, improve cost-effectiveness, build communication pathways and trust between stakeholders, and enhance overall management of the fishery resource. Commercial and recreational fishermen, industry groups, nongovernmental organizations (NGOs), universities, Sea Grant, and other State resource agencies represent several parties that can provide unique skills and experiences for cooperative research. Participation levels vary among parties depending on a project's objectives, design, and incentives for involvement (National Research Council 2004).

Incentive-based approaches are shown to improve and strengthen a cooperative fisheries management process (Grafton et al. 2005). Positive incentives for motivating fishermen to be involved with research include improvement of the science, financial compensation, prestige and material awards for the best information, potential for additional harvest, and participation in the collection of information that affects management of the fishery resource (Hilborn and Walters 1992; National Research Council 2004). This research involvement can empower fishermen and subsequently increase their investment in the conservation of the resource (National Research Council 2004).

# CHAPTER III
# Industry Challenges and Alternative Strategies

**Chapter Introduction**
This chapter addresses the constraints and challenges facing the commercial bay clam industry, and provides mechanisms and strategies for management. These mechanisms are intended to deal with the current constraints on the industry and address these impediments in the short- and mid-term (i.e., within the next few years). Long-term industry potentials are addressed in Chapter IV.

## 3.1 Improving Biological Science with Biological Solutions

### 3.1.1 Contribution to water quality
Bivalves are known to help maintain water quality by filtering suspended particles and pollutants out of the water column (Joergensen 1990; Dame 1993; Peterson and Heck 1999). What is not well quantified for Oregon bay clams is their marginal economic value at different levels of stock to support healthy estuarine ecosystems. Public good benefits such as the contribution of bay clams to water quality may be significant. Oregon legislation requires that State resource management achieve an optimal balance of public good, commercial, and recreational benefits to all user groups of the State (ORS 496.012 and ORS 506.109). It is important to consider these benefits when determining socially optimal harvest levels of bay clams (The North Carolina Division of Marine Fisheries, August 2001).

The Puget Sound Action Team reports that standard bivalve filtering rates range between 6 and 26 gallons of water a day. Species, size, location within bays, and other factors contribute to bivalve filtering rates. Oysters have high filtering rates, with a mature oyster filtering up to 55 gallons of water a day. Riisgard (2001) examines methods used to measure bivalve filtering rates and includes a filtration rate found by Meyhofer (1985) for the cockle, *Clinocardium nuttalii*. This rate may be applied to cockle populations within Oregon bays to determine their filter rate and estimate their contribution to water quality.

Several questions regarding the ecological value of Oregon bay clams need to be addressed to ensure rational resource management. Questions include: What is the level of filtering by bay clams in Oregon estuaries today? What is the public benefit of water quality associated with these filter feeders? If fishermen harvest the bay clam resource to a level of one-half pristine biomass (assuming pristine biomass is known), what is the effect on water quality? Is the relationship linear – nonlinear? What other factors need observation in order to understand bay clam biomass affects on water quality? In consideration of the recreational harvest of bay clams, what are the commercial harvest tradeoffs? Legislative standards request knowledge of these public good issues for optimal management. Additionally, these questions are key considerations for ecosystem-based management, discussed further below.

### 3.1.2 Mixed stock management, bay clam seasons, and recruitment

Currently, the five commercial bay clams are essentially managed as a group, with the exception of gaper clams that have a seasonal harvest. The known ecological similarities of the five species suggest that their general management as a mixed stock ecological group may be sufficient (Hancock et al. 1979); however, further biological and ecological research will determine whether certain bay clam species require different management frameworks or set harvest seasons to ensure their sustainability.

Gaper clams, *Tresus capax*, are the only Oregon commercial bay clams with an established six-month commercial fishing season open from July 1 through December 31 (OAR 635-005-0020). As discussed by Hancock et al. (1979) and Robinson and Breese (1982), gaper clams are winter to early spring spawners and sporadic recruiters. In response, ODFW established a closed season. The four other commercially-fished bay clam species are considered more resilient and successful spawners and may be fished year-round (Hancock et al. 1979).

Many bay clam fishermen claim gaper clams are a resilient species and do not need off-season protection. They believe that in some cases gaper clams are too abundant and may out-compete butter clams for space (Alm pers com 2005). Fishermen argue that harvest size limits on gaper clams are adequate to protect spawning stock. Moreover, the aquarium and bait markets need gaper clams year-round, and Oregon bay clam fishermen would like to meet this market demand to support industry's development (Alm pers com 2005).

Fishermen have also observed that the process of harvesting other bay clams during the gaper off-season is a disruptive process for gapers. These clams coexist in the same benthic habitat; therefore, the take of one type of clam affects adjacent clams. Regardless of the precautionary season to protect gaper populations, fishermen report that the disrupted gaper clams often become prey to predators like crab, and yet their populations are still thriving. These observations lead fishermen to believe that a harvest of gapers during these spawning months would not fundamentally threaten population abundance. Biologists have yet to investigate this theory.

Essentially, Oregon bay clam recruitment (i.e., the addition of new individuals to a population) is inadequately understood and further research is required for effective commercial management. Commonly, clam recruitment data are collected weeks after spat settlement, and grabs or hand dredges are used in the field to take samples from the surface sediment at several sites. Samples are then sieved and spat counted. Additionally, spat settled on filamentous algae or artificial substrates can be counted to measure recruitment (Gosling 2003). Recruitment sampling generally occurs on an annual basis (Bradbury pers com 2006).

An additional component of bay clam recruitment knowledge is to understand the extent of larval transport between bays (D'Andrea pers com 2006). West coast bays open to the dynamic ocean environment experience mixed tidal fluxes that transport bay-produced larvae within and outside of bays. Since planktonic larval stages can last from a few days to months (Brink 2001), some degree of larval transport by tides and currents is certain, but how far these larvae are transported is unknown (Roegner et al. 2003; Shanks and Brink 2005; D'Andrea pers com 2006).

### 3.1.3 Developing ecosystem based fishery management (EBFM) approaches

Ecosystem based fishery management (EBFM) is fundamentally different than single-species based fisheries management. Rather than focusing solely on the life history and biological attributes of a single target species, EBFM uses what is biologically known about the target fish as well as their interactions within the greater ecosystem in order to manage the fishery. The approach of EBFM gives greater weight to integrated, holistic management and recognizes the importance of resource and ecosystem sustainability (Kalo et al. 2002; Pikitch et al. 2004; USCOP 2004). The goal of EBFM is to manage target resources more effectively by understanding their roles in the broader ecosystem.

The desire to achieve EBFM is an admirable one; however, the inherent complexity of this management scheme is overwhelming. The necessary processes and protocols to achieve successful EBFM are not well-defined or well-known. Nonetheless, a new era of ecosystem approaches is taking precedence over the more traditional, single-species management. In order to keep pace with this change, the US Commission on Ocean Policy (USCOP) advises that present and future fishery management plans tailor their objectives to achieve some level of EBFM (USCOP 2004).

The conservative size and fishing effort of Oregon's commercial bay clam industry should help ease a transition to ecosystem-based management. The fishery's stocks are considered healthy – not depleted by over-harvest – and bay environments have not been compromised by invasive fishing equipment, therefore allowing an ecosystem management approach to develop without the challenges of unstable stocks and degraded habitat. In addition, the nearly-sessile condition of bay clams in a benthic estuarine habitat allows for the advantage of a fairly stabile sampling environment in comparison to the dynamic ocean environment of many pelagic fish species. Sampling stability benefits the bay clam fishery's candidacy for EBFM because ecological observations such as sediment type, seagrass presence, and water clarity can be quite simple to monitor and record during single-species surveys.

In November 2005, the Chesapeake Bay Program accepted a fisheries ecosystem planning document as the structure for the program's shift from single-species fisheries management to an ecosystem based multi-species approach for the bay and coastal area. The Chesapeake Fisheries Ecosystem Plan Technical Advisory Panel developed the document, "Fisheries Ecosystem Planning for Chesapeake Bay" (FEP), with support of the National Oceanic and Atmospheric Administration (NOAA) Chesapeake Bay Office. Oysters are one of the species that will receive priority development for ecosystem based fishery management plans within the Chesapeake Bay Program.

By setting small achievable objectives and incorporating ecological information into management of a resource on a step-by-step basis, managers can begin development of an ecologically-based management strategy. Inclusion of simple ecological observations with bay clam surveys can start the collection of potentially valuable ecological data sets. These ecological data may not be used for management initially, but with time and understanding of EBFM, managers may find these data sets valuable for management of the bay clam resource. More familiar single-species management strategies will predominate, however, until ecosystem management strategies are developed and implemented.

### 3.1.4 Models and management: using models to understand ecological structure

Ecological modeling is a method to test for ecological stability and species' interactions (Dambacher 2003). Ortiz and Wolff (2002) recommend the use of models to assess sustainability of benthic fisheries management practices, particularly for multispecies fisheries like Oregon's five-specie bay clam industry. (See Appendix section "Ecological Modeling" for a multi-species bay clam modeling schematic and information about ecological community modeling.)

Ecological models are not necessary tools to manage single fishery harvests; however, managers should be thinking about ecosystem components for longer-term management. As more data are collected on the resource and surrounding ecosystem such as during stock assessment, this biological information can be used to calibrate model parameters. Ecological models provide a way to address questions regarding ecosystem components, and may be useful and cost-effective management tools for Oregon's bay clam fishery.

## 3.2 Geography: Estuarine Harvest Constraints and Possibilities

Currently, limited mechanical harvest areas and precautionary quotas cannot sustain the livelihoods of all commercial bay clam permit holders. Managers need to revisit the management practicality of current limits on bays open for mechanical harvest, mechanical harvest quotas, and the lack of hand-harvest quotas.

### 3.2.1 Increasing mechanical quotas

An implemented stock assessment strategy (such as the one discussed below) monitors the bay clam resource and allows for controlled examination of estuarine potential. For example, higher bay clam quotas in Tillamook and Coos bays could be explored by raising bay clam quotas in conservative increments (and here the term "conservative" is emphasized) and monitoring stock response to these higher harvests. These higher harvests may generate more revenue that can pay for additional water quality monitoring sites, and thus open more regions to commercial harvest.

### 3.2.2 Expanding mechanical harvest

The permission to mechanically harvest in Yaquina Bay, and the security of good water quality, could give Yaquina a similar commercial potential to that of Tillamook and Coos bays once sustainability issues of mechanical harvest are addressed. Mechanical harvests in Yaquina Bay may face some obstacles including conflicting uses with oyster industry, boat traffic, and various recreational and commercial activities as well. Updated resource assessments of other bays may indicate potential to support mechanical harvests.

## 3.3 Funding Management Costs

A lack of personnel and equipment, due to insufficient funding, can result in inadequate management of fisheries. Attaining and sustaining these funds is one of the greatest challenges for the Oregon bay clam fishery. This section identifies primary fisheries management costs and defines potential funding sources and strategies to cover these costs, such as cost-sharing partnerships for research and management. When appropriate, this section specifies costs and funding strategies pertaining to Oregon's commercial bay clam fishery.

### 3.3.1 Fisheries management costs

The costs of fisheries management may be grouped into the following categories (Arnason et al. 2000):

1) Management and Administration
2) Research
3) Enforcement

**How do these costs relate to Oregon?**

1) The formulation of Oregon's central legislation for fishery management has been completed. Costs for amendments occur periodically. For instance, Senate Bill 597 amended legislation for recreational shellfish management in 2003.

Generally, Oregon's fundamental fishery management policy and rules have been developed and implemented. Yet, management policy and rules are occasionally amended; therefore, costs to develop and implement these modifications are periodic.

2) Effective fisheries management requires regular and ongoing biological/ecological and economic research. Many small-scale fisheries in Oregon, like the bay clam fishery, lack adequate research. Two substantial biological/ecological research costs are 1) resource stock assessments by ODFW and 2) water quality monitoring by ODA.

*Stock assessment costs*

For a full-assessment of one bay, cost estimates are between $100,000 and $200,000, and for a coast-wide assessment of the bays, cost estimates are between $500,000 and $1 million (Hunter pers com 2005; Johnson pers com 2005; Sylvia pers com 2004). These are very rough estimates. A detailed and realistic cost estimate will include labor costs, materials and equipment, and funds for analysis.

*Water quality monitoring costs*

The Oregon Department of Agriculture (ODA) monitors bay waters for toxins. Each water quality sample costs ODA $35. The number of samples needed depends on a bay area's extent. In order to expand or add harvesting areas within bays, the costs of water quality testing for these new sites must be covered. In 2004, 1,920 commercial water quality samples cost ODA $67,200 (Cannon pers com 2005; ODA, Food Safety Division, Shellfish Program Budget 2004).

In addition to current monitoring costs, water quality budgets should consider increased monitoring costs for domoic acid and paralytic shellfish poison (PSP), particularly with any development of Oregon bay clam human consumption markets. Some Oregon bay clam species, especially butter and cockle clams, are quite susceptible to building high toxicity levels in their tissues (RaLonde 1996; D'Andrea pers com 2006).

3) The enforcement of fishery management statutes and rules by the Oregon State Police (OSP) is a regular and ongoing cost.

### 3.3.2 Potential Sources of Funding and Cost-Sharing

#### Federal

Federal funding provides different degrees of financial support to State management programs. In the case of Oregon's small developmental fisheries program and the individual fisheries within the program, obtaining direct aid from a federal source is unlikely. The developmental fisheries program is more likely to attain indirect federal funding, subsequent to federal aid reaching the State level. Once funding is within the State, it can be allocated appropriately to various state programs. Management proposals submitted to federal grant agencies may result in some financial support for developmental fisheries.

Two federally-based programs in Oregon, the CZMA's National Estuarine Research Reserve System (NERRS) South Slough program at Coos Bay and the National Estuary Program (NEP) at Tillamook Bay, are opportunities for commercial and recreational bay clam fisheries research and management. Objectives of these two programs may parallel the research and management needs of the State and industry. Additionally, these programs may be willing to partner with the State and the industry to find ways to meet the needs of all parties.

#### Regional

Regional aid opportunities from the Pacific Fishery Management Council are unlikely. The intention of the congressionally-funded council is to benefit domestic fishing within the 200-mile US Exclusive Economic Zone (EEZ), not within estuarine areas of the State. Therefore, neither funding nor other management aid should be expected from this council for a State-regulated, estuarine-based fishery.

#### State

In addition to federally-funded State programs like the Coastal Zone Management Program (CZMP), Oregon State programs receive financial support from the tax-generated General Fund. General funds are allocated to various State programs including ODFW, ODA, and OSP in order for these programs to perform their necessary operations.

In 2003, Senate Bill 597 amended the Oregon Revised Statutes (ORSs) to establish recreational shellfish license fees, specifically intended to address shellfish resource management costs. Oregon recreational shellfish license fees are allocated among ODFW, ODA, and OSP. License revenues in 2004 exceeded $1 million (Hunter pers com 2005). In regards to possible State funding sources for the bay clam industry, the new shellfish license revenue appears the most likely and applicable candidate source.

Public goods' association with management inherently links government responsibility to management services of these goods (Arnason, Hannesson, and Schrank 2000). Some degree of funding for bay clam management services may be a requisite role for the State; however, it is uncertain which State agency is responsible.

**Industry (cost recovery idea)**
Industry responsibility for fishery research and management costs, or what is referred to as "cost recovery," is an increasingly common trend seen today in the US and abroad (Arbuckle and Drummond 2000; Arnason, Hannesson, and Schrank 2000; Cox 2000; Scott 2000; National Research Council 2004; Sizemore pers com 2005) and should be considered an option for the Oregon dive bay clam industry. Cost recovery is generally required in response to creating wealth-generating privileges and property rights in the fishery (Sylvia pers com 2005).

Cost recovery implies that those directly benefiting from management of a fishery are responsible for paying for that management. It is argued that the main beneficiaries of industry management are the commercial fishermen; therefore, it is the fishermen who pay the majority of "attributable" costs for management. Industries may use different methods of generating the funding they need for cost recovery including set-aside funds, landing taxes, or directly contributing to some fund (or use a combination of all three methods). (See Appendix section "Funding Sources" for more information on these industry methods.)

The Oregon bay clam industry was not responsible for funding its management as a fishery of the Developmental Fisheries Program (DFP); funding for DFP fisheries is the responsibility of the State and fishermen participation in research is requested to help defray costs. However, by transitioning into limited entry, or another developed fishery system that incorporates a wealth-generating asset (the permit), cost recovery should be examined as a funding option for the industry. Nonetheless, in order to create a successful cost-recovery program, the presently low-revenue bay clam industry will need to increase its annual landings and profitability. The question is: how much growth and management planning does the industry need to prepare for a cost recovery system?

How does cost recovery increase efficiency and cost-effectiveness in fisheries management? Cost recovery creates an incentive for efficiency and cost-effectiveness because fishermen assume the primary responsibility for fisheries management costs. Fishermen strive to get the greatest benefit they can from their financial investment. This industry push for smart management likely leads to greater industry participation and a cooperative management approach to fishery management, as observed in countries such as New Zealand and Australia. The National Research Council's 2004 report, "Cooperative Research in the National Marine Fisheries Service," encourages this trend of industry-based funding.

Increased involvement by the industry in resource management may prove a conflict of interests between the industry and the public regarding resource-use objectives (Arnason, Hannesson, and Schrank 2000). Thus, prior to the implementation of a cost recovery system, strategies to avoid and resolve such potential conflicts should be prepared.

The remainder of this section focuses on cost-sharing possibilities through partnerships and cooperative research.

***Cost-Sharing through Partnerships and Cooperative Research with Nongovernmental Organizations (NGOs), Universities, and Indigenous Groups***

Organizations use strategic partnerships to achieve common objectives with greater efficiency and cost-effectiveness. Partnerships between institutions have different levels of participation; they may be as simple as sharing datasets or as involved as joint data collection and analysis. Partnerships may involve direct exchange of funds or they may be cost-sharing agreements, where each entity provides assistance by sharing people, research equipment, or data.

The Oregon bay clam industry will need to develop a strategic approach to evaluate potential beneficial partnerships. One approach is to: 1) take inventory of Oregon organizations, universities, and/or tribes with similar resource and management objectives, 2) identify the types of research needed by the groups (e.g., biological, economic; steps and goals of current projects) and evaluate synergies and mutual benefits, 3) consider ventures that will benefit both parties, and 4) propose a partnership idea or potential joint research venture to a strong candidate group.

**Nongovernmental Organizations (NGOs)**

Nongovernmental organizations (NGOs) are private, not-for-profit organizations that attain a majority of their funding through grants and members' contributions; therefore, finding cost-effective solutions to their missions is essential. Cost-sharing partnerships provide one such cost-effective opportunity.

*A Potential NGO Cost-Sharing Partnership*

ODFW could evaluate potential partnerships with several Oregon environmental NGOs. In particular, NGOs concerned with salmon may be potential partners. Salmon sustainability is an important issue and receives significant financial support from government. Estuaries are vital habitats for salmon and bay clams. Bay clams use estuaries for at least the majority of their life cycles. Most juvenile salmon use estuaries as nursery grounds before migrating into the marine environment; and adult salmon migrate through estuaries en route to their freshwater river spawning grounds. Estuarine ecology is important for the successful management of both bay clams and salmon, and the data collection for managing these organisms, particularly related to ecosystem issues, may be similar. Understanding these common needs is an important step in developing mutually beneficial partnerships.

Additionally, federal and state agencies interested in estuarine science and management may be potential collaborative research partners. For instance, the Environmental Protection Agency (EPA) conducts ecological and biological monitoring of Oregon bays. ODFW and the EPA may realize research efficiencies by coordinating data collection.

**Universities**
Implementation of cooperative partnerships between universities, government, and industry may reduce expenses of research processes. Programs such as Sea Grant that advocate the enhancement of university-government partnerships are essential to the development of marine policy and resource management in the US and abroad. Sea Grant researchers and outreach specialists promote institutional collaborations for improved marine coastal research and management, and Sea Grant provides resource managers with information and tools needed for effective management.

In regards to funding the Oregon bay clam industry, Sea Grant might help support a pilot management project, but Sea Grant is not likely to provide ongoing financial aid. For ongoing assistance, cost-sharing and partnerships with other entities is a more appropriate approach.

University students represent a resource that may assist financially-limited state agencies with data collection necessary for management decisions. Universities may also function as facilitators between industry and government or assist industry-led projects in order to achieve credibility. In return, these cooperative opportunities provide students training, networking, and exposure to real resource management problems. Cooperative research can empower those not typically involved in the research process including industry and students.

**Indigenous Groups**
Indigenous groups may appreciate the suggestion of cooperative research projects that aim to ensure resource sustainability, and may want to participate.

**Community Involvement**
Community participation occurs through the recreational bay clam fishery. Since the implementation of the 2003 Senate Bill 597, recreational fishermen pay license fees for their permits, and these revenues are deposited into a shellfish fund. Further incorporation of the community through community education events and/or seafood marketing strategies at annual festivals could generate additional support.

**Volunteerism**
Creel surveys serve as a way to gather recreational fishing data from the community as they dig bay clams from intertidal flats. Community volunteers may help to run these surveys as a community service.

**Tourism**
Tourists events hosted out of coastal hotels, like coordinated clam digs and clam bakes, may prove a means of gathering more intertidal bay clam data as well as funds for management needs through tourist fees.

(See sections "3.5.6 Surveying recreational-take areas" and "3.6.1 Human consumption market potential and marketing strategies" for more information on community involvement, volunteerism, and tourism.)

### 3.3.3 Suggested ranking for financial assistance and discussion

1) Oregon recreational shellfish license revenues
2) Industry cost recovery
3) Partnerships with the Tillamook Bay National Estuary Program (TEP) and the Coos Bay South Slough National Estuarine Research Reserve (NERR)
4) Sea Grant and university funding and partnerships

An assessment of ODFW, ODA, and OSP operation costs and budgets should consider the need for updated bay assessments and the possibility of funding bay assessments with new State shellfish license revenues. A portion of State shellfish license revenue could be allocated to the assessment of an Oregon bay and its benthic community annually. Bay assessments may need to occur rotationally, in order that every few years, depending on the number of bays within the rotation, a bay receives an updated assessment. Annual bay surveys should include assessments of bay clam stocks for the development of a fishery management plan and quota modifications.

Assessment costs may be covered in-full or partially through a portion of the State shellfish license revenues. Other sources should be arranged to cover remaining costs, particularly for years that may have fewer recreational license holders, and thus less State revenue. For example, partnerships with Tillamook Bay's National Estuary Program (NEP) and Coos Bay's South Slough National Estuarine Research Reserve (NERR) may help defray assessment costs of these two larger bays.

## 3.4 Rotational Strategies for Harvests and Surveys

Many molluscan shellfish fisheries are managed on a rotational basis. Rotational harvest closes harvest areas for a year or more in order for them to recover and increase productivity (Robinson 1995). This gives the seed stock time to grow larger and more plentiful – closer to market sizes – and better withstand incidental mortality from breakage and burial during harvest (Newell 1991). Hilborn and Walters (1992) argue that for many ecosystems, periodic disruptions (e.g., El Nino events; hurricanes) are more natural than sustained system disturbances, and many fish stocks should tolerate rotational harvests better than sustained harvest pressure. In addition to providing recuperative periods resulting in better growth and lower mortality of the clams, rotational methods are relatively simple management techniques (Hilborn and Walters 1992; Robinson 1995; Hart 2003). However, problems may occur with this method when: 1) there is not enough harvesting area to set aside from harvesting pressure (Hilborn and

Walters 1992; Robinson 1995), or 2) managers assume the set aside areas will not suffer losses from pollution, disease, or weather (Robinson 1995).

Rotational harvesting can work in conjunction with a rotational surveying schedule. When an area is “rotated-out,” or set aside from harvest pressure for some time frame, a post-harvest survey can occur in the area to help determine when it should be harvested again (Hilborn and Walters 1992). This post-harvest survey method is successfully practiced in Washington’s commercial geoduck (*Panopea abrupta*) fishery (Sizemore pers com 2005).

### 3.4.1 Where are rotational harvest methods used?

Rotational harvest methods are common in shellfish fishery management worldwide. Rhode Island manages their bay quahog (*Mercenaria mercenaria*) fishery with a rotational harvest system (Rhode Island Division of Fish and Wildlife, August 2004), and the Maine softshell (*Mya arenaria*) fishery manages their clam flats using rotational methods (Newell 1991; Sampson pers com 2005). Maine towns using this rotational management system yield 15% greater clam harvests than clam yields of unmanaged towns (Newell 1991). The Atlantic sea scallop (*Placopecten magellanicus*) fishery off the northeastern US used rotational closures within Georges Bank to successfully assist management of the sea scallops (Hart 2003), and new rotational closures are planned for future sea scallop management in this area (Hart 2003; National Marine Fisheries Service, May 2004). Additionally, the New Zealand Southern Scallop Fishery uses a rotational fishing regime with great success (Arbuckle and Drummond 2000).

In Washington, the commercial geoduck fishery uses rotational methods for harvesting and surveying geoduck bay clams (Bradbury pers com 2005; Sizemore pers com 2005). Washington State controls the commercial geoduck fishery with a detailed bed-by-bed rotational management strategy. Large amounts of industry revenue pay into the State treasury annually for ongoing spatial management by the State (Sizemore pers com 2005).

### 3.4.2 Rotational spatial harvest in the Washington commercial geoduck fishery

The Washington commercial geoduck fishery works on a harvest quota system, publicly auctioning harvest quotas to private individuals or companies. The total allowable catch (TAC) for a particular bay area is converted into its equivalence in leased tracts, and these tracts are distributed to fishermen through auctions. Washington State managers recommend that distinct regions of bay clam habitat be given different TACs (Bradbury et al. 2000). Before harvest, surveys are conducted in each tract and a percentage, below 100, of the estimated biomass is auctioned. Lessees may choose not to harvest the total percentage auctioned of the tract in order that their catch per unit effort (CPUE) remain cost-effective.

Once harvest concludes on a tract, that tract enters a recovery period and may not be re-harvested until tract biomass reaches its pre-harvest level. This full-recovery stipulation results in a tract rotation. Tract recovery time is influenced by tract location within the bay, extent of tract harvest, pollution and environmental conditions, etc. Ultimately, fastrecovery tracts are revisited more often than slow-recovery tracts, and are economically more profitable. Monitoring tract recovery times allows for spatial tracking of recovery rates within bays (Sizemore pers com 2005).

### 3.4.3 How is a rotational method determined and used?

Harvest rotation is primarily based on empirical data of a bed recovery time to the average pre-fishing density. If a population is experiencing positive environmental conditions, good recruitment may shorten the rotation time between harvest areas, whereas if conditions turn adverse (e.g., warming sea temperatures, hypoxic waters, increase in diseases, etc.), recruitment may be affected and population recovery may be extended. In order to decide on appropriate harvest rates and rotations for a population, it is imperative to understand the biology of the organism and collect information on population parameters including natural mortality, growth, and recruitment. It is also important to have data on baseline abundances and abundance trends through time as well as empirical population recovery data. Finally, when bed recovery does not occur as expected, managers must anticipate changes to the established harvest rotation (e.g., adaptive strategies).

In Washington, the harvest rotation of geoducks has a theoretical basis in their deterministic, age-structured equilibrium yield model, which recommends an annual harvest rate of 2.7% of the exploitable geoduck biomass (Sizemore pers com 2005). Bradbury et al. (2000) describe the details of this equilibrium yield model in their geoduck stock assessment document.

### 3.4.4 Catch per unit effort (CPUE) to estimate abundance

Catch per unit effort (CPUE) can be used as a proxy to estimate stock abundance when an industry cannot afford frequent biological surveys. (By multiplying CPUE by total effort, the result is total catch.) Assuming CPUE is related to stock abundance, managers may analyze fluctuations in CPUE to draw conclusions about changes in stock abundances. The use of CPUE to collect biological information on stocks is particularly important for low-revenue industries, like Oregon's commercial bay clam fishery, that cannot afford comprehensive biological surveys on a regular basis. CPUE provides a valuable estimate of stock abundances when used wisely and with consideration of potential complexities (Food and Agriculture Organization of the United Nations (FAO), February 2005). The following two sections recognize the primary limitations of CPUE and address the use of CPUE as a reliable estimate of stock abundance with consideration of its restrictions.

### 3.4.5 CPUE limitations

Managers must consider limitations of the application of CPUE as a proxy for stock abundance. The first problem involves the assumption that dive fishermen randomly harvest different parts of a target bay, providing a significant and unbiased cross-section of CPUE within that bay. Based on this assumption, these CPUE trends are used to estimate an accurate stock distribution and abundance. Often, however, this is not the case in many fisheries. Rather, bay clam fishermen target high-density pockets of clams within bays in order to harvest at maximum CPUE (Alm pers com 2005; Bradbury pers com 2005, Metcalfe pers com 2005). Once an area is harvested to a level of inefficient

CPUE (e.g., less than 150 lbs/hr for some Oregon bay clam fishermen), fishermen often move to new high-density areas to maintain efficient CPUE levels (Alm pers com 2005). Therefore, CPUE data are not derived from unbiased harvest samplings within the bay, nor are the data representing true reductions in stock abundances (Hilborn and Walters 1992).

While high-density pockets continue to be targeted and CPUE levels remain steady, managers will assume a sustainable fishing effort. Only when high-density pockets are harvested down to lower density levels and fishermen return to harvest these areas will the CPUE data reflect decreases in stock abundance. This first sign of reduced stock abundance may not occur quickly enough for effective management measures to protect the stock. Hilborn and Walters (1992) refer to this relationship of steady CPUE and declining abundance as hyperstability and a common problem for fisheries that rely on CPUE data.

Market prices also complicate the use of CPUE as an accurate proxy for stock abundance. Fishermen tend to harvest with greater effort when market prices are highest. For example, CPUE trends of abalone fisheries in Australia closely parallel market demand throughout the year. Holiday seasons command higher ex-vessel prices for abalone, particularly in Japanese markets; therefore, to supply the market and take advantage of higher economic gains, abalone fishermen harvest the stocks to a greater extent (Bradbury pers com 2005). Higher prices can motivate fishermen to harvest less-than-ideal areas such as places that are difficult to access or low-density areas if the financial return makes the increased effort worth their time. Managers may misinterpret decreasing CPUE data (greater effort for a standard amount of fish) as a sign of decreasing stock abundance, when in truth increasing prices motivate fishermen to harvest normally "substandard" areas for profitable economic returns.

A final problem with CPUE commonly occurs during the early stages of a new fishery. As fishermen improve their harvesting skills and buy efficient harvesting equipment, CPUE often increases. Managers may interpret changes in CPUE data with increasing stock abundance, when in reality fishermen are becoming more efficient harvesters (Hilborn and Walters 1992; Bradbury pers com 2005). New technology also creates problems. As fishermen implement technological advances in their fishery, their effort is reduced to harvest a standard amount of fish. Therefore, CPUE increases in relation to technology, not necessarily stock abundance (Bradbury pers com 2005; Sylvia pers com 2005).

### 3.4.6 Improving CPUE abundance estimates; applying a spatial harvest context

With respect to CPUE data limitations, CPUE data could be considered a reasonable tool for stock assessment, especially for low-revenue industries that cannot pay for regular comprehensive biological surveys. Fishery trends are commonly expressed through the use of estimated CPUE and recurring, effective effort (Food and Agriculture Organization of the United Nations (FAO), February 2005). To increase the efficacy of CPUE data as an estimate of stock abundance, assumptions about CPUE data must be identified and measured, and the CPUE sampling scheme should include areas outside typically targeted harvest regions (particularly if harvesters concentrate on high-density population areas). The additional harvests outside of typical harvest grounds investigate the relationship of different stock abundances and reduce some bias of the CPUE data collection in order to enhance its statistical quality (Sylvia pers com 2005). However, there must be incentive for fishermen to go to less-appealing sites for harvest; the National Research Council (2004) argues that financial compensation incentives work effectively.

The application of a spatial framework to the collection of catch and effort data improves data reliability as a stock abundance proxy (Hilborn and Walters 1992). When a fishing area is spatially defined and linked with CPUE data to improve stock assessment, fisheries that target sedentary or nearly-sessile animals are sound candidates due to their inherently stable spatial nature.

Hilborn and Walters (1992) describe the need for managers to map and analyze catch and effort data as a first step to improving use of CPUE as an abundance proxy. Mapped data may be analyzed in terms of catch, effort, and area to understand stock concentrations and distribution (Hilborn and Walters 1992). Goodwin (pers com 2005) suggests joining commercial dive harvests with data surveying through the use of spatial strategies. Survey data would be recorded in fishermen logbooks during harvests and on fish tickets, which are submitted to the State. Target bays would be divided into defined segments, determined by initial analyses of mapped CPUE. The spatial harvesting scheme would track CPUE between designated segments and through time for stock assessment purposes (Harte pers com 2005). Additionally, the schematic strategies used would have a relatively simple design so as not to hinder or complicate harvest by fishermen. (See section "4.3.2 Proposed spatial harvest rotation scheme in GIS: an example in Tillamook Bay" for example imagery of a spatial dive harvest schematic.)

Designated harvest areas may not need to be symmetrical or identical in size and shape for this strategy to be effective; however, there should be valid reasoning behind segment design and placement within bays that intends to support data monitoring and analysis needs. The design of this sampling scheme should take fishermen's knowledge into consideration before a final draft is implemented, as the industry will be the principal data collectors.

### 3.4.7 Rotational spatial harvest in Oregon

The fieldwork component of this proposed rotational dive strategy is designed to attain scientifically-valid data solely by fishermen during fishery harvests. Surveying bay clam stocks during the harvesting process minimizes extra assessment costs. Oregon could benefit from a rotational method such as Washington's strategy, allowing harvest in a designated area only when that area achieves a certain density biomass. Managers would decide upon a strategy that maximizes management goals. For example, what percentage of the estimated biomass should be harvested in a designated area? What are the benefits and costs of harvesting an area completely and leaving little to no biomass as compared to harvesting an area down to 20%, for instance, of its estimated biomass? How do the recovery rates compare, and which recovery rate works best within the strategy's rotational timeline given the harvest technologies? It is important to consider the contributions of adjacent areas to harvested areas, as they may be capable of replenishing the harvested areas through spat settlement, and allow for higher percent harvests. Therefore, how many designated areas are within a bay system? If there are many, longer recovery times may be possible for areas before they are targeted for harvest areas. If there are few designated areas, rotation time between an area's harvest periods may be quite short (e.g., on the order of one year). In such a case, an area must recover quickly to pre-harvest levels, which means its harvest percentage should probably be lower than that of an area with a long period of recovery time (e.g., on the order of three years).

### 3.4.8 Management without rotation

Non-rotational methods are also used to successfully manage shellfish fisheries. The recreational geoduck clam fishery in Washington manages stocks with a quota system rather than rotation due to social interests. Recreational fishermen are more concerned with having unlimited access to preferred mudflats throughout the year than maximizing geoduck stocks through rotational methods. Since harvest objectives of recreational fishermen are for sport, they are quite different than objectives of commercial fishermen who are more concerned with maximizing harvests and profits. Thus, commercial fishermen of bay clam and oyster fisheries in Washington are generally supportive of rotational systems in order to maximize industry stocks, whereas recreational fishermen prefer non-rotational methods (Bradbury pers com 2005).

Crab and shrimp industries of the U.S. commonly use quota systems to manage for stock sustainability (Bradbury pers com 2005; NOAA Fisheries, URL). Crab and shrimp mobility allows these organisms to travel across benthic environments as adults; therefore, they can repopulate harvested areas more quickly than their sessile counterparts (e.g., clams and oysters) that are limited to repopulating primarily through new production and growth (i.e., larvae settlement and development within harvested areas). Hilborn and Walters (1992) claim that the recuperation periods provided by rotational harvest strategies work well to help sustain populations of sedentary, long-lived species.

With regard to ecosystem management, however, damage to other benthic organisms and structures during non-rotational harvests should be considered in the recovery of associated mobile shellfish. Additional study may show that rotational strategies provide advantages to the ecosystem's productivity and recovery.

### 3.4.9 Incorporating enhancement into rotation

Reseeding areas with spat (enhancement) is an option to incorporate into rotational strategies to increase area recovery time and annual harvests. Enhancement speeds the recuperation period of harvested areas and allows them to re-enter rotation more quickly through the assurance of spat settlement. This process is very similar to agricultural practices on land. The basic enhancement protocol is as follows: 1) harvest an area to a certain level of pre-harvest biomass, 2) reseed (enhance) with spat (collected from areas recognized for high recruitment), 3) allow a recuperation period for spat to develop and grow into harvestable adults, and 4) re-harvest the area and repeat the enhancement process (Harte pers com 2005).

Enhancement may require additional capital investment and raise permitting issues beyond basic wild-harvest management; however, the practice is not as intensive as some types of aquaculture that require the development of hard structures and rigorous monitoring. In New Zealand's Southern Scallop Fishery, the benefit of reseeding with rotation is clear, as reseeded stock can contribute up to ninety percent of a year's harvest (Challenger Scallop Enhancement Company Limited, June 2005). A key question is whether enhancement could similarly benefit Oregon's commercial bay clam industry.

## 3.5 Cooperative and Cost-Effective Stock Assessments

This section addresses stock assessment constraints and proposes the development of cost-effective and cooperative solutions for conducting stock assessments.

### 3.5.1 Stock assessment challenges

Existing Oregon bay clam stock data are incomplete and out-dated, yet stock assessments are necessary for developing information on resource distribution and abundance to maintain and advance the fishery. There are five species of Oregon commercial bay clams, and therefore five stocks to assess. Key challenges for conducting stock assessments include funding and developing cooperative assessment strategies that are scientifically valid and cost-effective.

### 3.5.2 Validating the science

For cooperative stock assessments, or assessments where government agencies are not the sole responsible party for collection of resource data, scientific validation of data is a major obstacle (Developmental Fisheries Board 2004). In Oregon, commercial bay clam fishermen have expressed interest in helping with bay clam data collection while they harvest; however, the State is unsure how to scientifically validate their data collection. What protocols must fishermen follow for ODFW to accept their data as scientifically valid? One option is to use a "fail-safe" scientifically valid data collection strategy, like a rotational harvest strategy. Such an approach should not require the presence of a scientific authority during data collection.

The use of scientific authorities for science validation increases management costs. A key question is: who should pay for the costs of scientifically validated data collection (whatever the method of collection)? Fishermen? The State? Counties and towns? Or, should this be a shared payment between stakeholders? Suggested strategies to address these questions follow.

### 3.5.3 Strategy recommendation for achieving stock assessments

Through an intensive baseline survey of the bay clam resource and the establishment of strategic methods for future fishery dependent surveys, it may be possible to determine the sustainability of harvest levels of this fishery without expensive, ongoing traditional stock assessments.

The following four-part strategy provides a framework for bay clam stock assessments in Oregon. Parts one and two of this strategy are intended as one-time events. Parts three and four are ongoing.

1) Perform a comprehensive baseline stock assessment of bay clams in all major harvesting bays, particularly Tillamook and Coos bays.

Possible methods for baseline stock assessments within subtidal and intertidal bay areas are described in Hancock et al. (1979), Griffin (1995), and Golden et al. (1998).

*Possible funding sources for this one-time initial assessment strategy cost:*
-State revenues from the new recreational shellfish license fees
-Special state legislation
-Sea Grant aid
-Assistance financially and/or operationally from Tillamook Bay's National Estuary Program (NEP) and the South Slough National Estuarine Research Reserve (NERR) at Coos Bay for assessments of their respective bays
-Industry assistance; defraying assessment costs by providing vessels, dive gear, and other research equipment

The Nearshore Strategy of ODFW's Marine Resources Program (2005) encourages the State to aid in survey costs for biological assessments. Moreover, it is the responsibility of the State to ensure that biological data is collected for management needs.

2) Design a rotational spatial dive harvest strategy that considers catch per unit effort (CPUE) in order to update baseline assessments scientifically.

Assessment scientists will need to participate in the design of the rotational spatial dive harvest methodology. It is imperative that this method be scientifically sound and appropriate (considering CPUE within each defined spatial area of the schematic) in order that it updates baseline assessments without the need for supplemental surveys. A statistically-designed methodology will help provide quantitative evaluation of fishery dependent data and verify data integrity.

Additionally, the methods must consider harvest practices of fishermen since fishermen will be the sole collectors of assessment information. Fishermen need assurances from the State that their hard work will be recognized for management decisions. State-fishermen working relationships would be harmed if there was inadequate communication and diverging expectations. To avoid these types of problems, all elements of the process, complete with expectations, should be detailed in a formal contract prior to implementing the strategy.

*Possible funding sources for this one-time design cost:*
-State revenues from the new recreational shellfish license fees
-Sea Grant aid

3) Implement the rotational spatial dive harvest strategy with the industry and employ a scientific analyst to evaluate the resource data and help set harvest levels.

The field component of the rotational spatial dive harvest strategy would be conducted by the industry. Industry-collected data would need evaluation by a scientist analyst in order to verify data application to management concerns, watch for trends, and set appropriate harvest levels. (See section "4.3.2 Proposed spatial harvest rotation scheme in GIS: an example in Tillamook Bay" for information on how to update stock information in a GIS with the rotational spatial dive harvest strategy.)

*Possible funding sources for this ongoing cost:*
-Cost recovery by the industry
-State revenues from the new recreational shellfish license fees (supplemental)

4) Employ operational observers to monitor system protocols of the strategy a few times per year with fishermen during field harvest.

The field component of the rotational spatial dive harvest strategy will need protocol monitoring by operational observers a few time every year. The observers will note any operational difficulties or inconsistencies within the system and provide fishermen protocol guidance. This monitoring process, in combination with a methodology that can be statistically-verified, ensures greater accuracy in the data collection.

*Possible funding sources for this ongoing cost:*
-Cost recovery by the industry
-State revenues from the new recreational shellfish license fees (supplemental)
-Assistance from Tillamook Bay's National Estuary Program (NEP) and the South Slough National Estuarine Research Reserve (NERR) at Coos Bay for protocol monitoring at their respective bays

**3.5.4 Discussion of stock assessments and rotational dive harvests**
In order to regulate the bay clam resource adequately, ODFW must acquire stock assessment data. The combination of an updated, comprehensive stock assessment and ongoing, strategic rotational harvests should provide ODFW with significant biological resource data for fishery management purposes. Stock assessments provide intensive information on stock abundances and distributions at certain points in time, whereas the spatially-based harvest data provides a structured representation of harvest data over time. These fishermen-dependent harvest data allow ODFW to obtain scientifically valid data without spending the time and money to personally conduct the fieldwork. Furthermore, the spatial system of harvest should work well for the bay clam industry because bay clams are nearly sessile. Ultimately, these spatial yield data should give ODFW a reasonable estimate of the bays' bay clam stocks in order to make informed management decisions. If information points to healthy and resilient stocks, sustainable yields for the fishery may be increased. Higher yields should mean greater industry and State revenues, and possibly opportunities for further fishery development.

### 3.5.5 Discussion of funding

In New Zealand's Individual Transferable Quota (ITQ) shellfish fisheries, fishermen pay for the fishery science they need through cost recovery fees based on their ITQ holding. Typically, private consulting firms bid on scientific-observer positions for assessments (Sampson pers com 2005). Cost recovery is suggested for the Oregon bay clam dive industry as well. State revenues, Sea Grant aid, and assistance from the Tillamook NEP and South Slough NERR are other primary funding sources to consider. (See section "3.3.2 Potential Sources of Funding and Cost-Sharing.")

The idea of university graduate students serving as operational observers for low or no pay (in order to receive experience in this facet of fisheries management) has been explored and deemed unlikely. This unlikelihood is due to reasons like distance of universities from the major harvesting bays (e.g., Tillamook and Coos) and the fact that observer positions are not research-oriented. For a graduate student who needs a thesis-based project, an observing job may not provide the necessary research possibilities for a thesis. Additionally, students graduate; therefore, new student observers will need training, which takes time. It is also possible that student interest or availability for work will be absent some years.

### 3.5.6 Surveying recreational-take areas

Creel surveys are a simple means for regulators to collect recreational harvest information from harvesters on site. These surveys are not intended to inconvenience recreational harvesters – they involve only a quick interview about the day's catch as harvesters leave tideflats. Typically, creel surveys collect information on the total weight and number of each species harvested in order to determine a catch per unit effort (CPUE, or pounds caught per harvester-day). These surveys may ask for additional information depending on the data needs of the surveyors. For instance, it may be useful to note how many harvested bay clams have broken shells or the number of harvesters in each digging party (Bradbury pers com 2005).

Washington State uses creel surveys and aerial surveys as their two principal field activities to estimate recreational harvest of clams and oysters. Creel surveys are used to determine CPUE and aerial surveys are used to estimate total effort, or total harvester-days. Appendix 1 of the Washington Department of Fish and Wildlife's (WDFW) Bivalve Management Plan (December 2002) presents the sampling design and methods used for these surveys.

## 3.6 Economic Constraints and Options

This section defines some economic constraints on the industry and suggests some market opportunities for the industry to explore in the short-term. See Chapter IV for potential future economic scenarios of the industry given successful market development.

Low catch quotas and insufficient market development pose major economic hindrances to the industry. With the implementation of stock assessments (through the strategy presented above), the industry's total allowable catch (TAC) may be raised. Attention to market conditions and opportunities, particularly the establishment of a human consumption market, will provide improved economic opportunities for this fishery.

### 3.6.1 Human consumption market potential and marketing strategies

Economically, human consumption markets typically command higher prices per pound for fishery resources than bait markets. However, Oregon's main markets for bay clams are bait and aquarium (Alm pers com 2005). So, why is the industry not harvesting Oregon bay clams for human consumption? Several reasons are expressed by stakeholders including: 1) larger East Coast bay clam industries sell human consumption clams to Oregon very inexpensively; 2) a human consumption market for fresh, local bay clams is not developed in Oregon; and 3) the additional effort (e.g., stricter water quality and storage guidelines) involved with harvesting human consumption quality bay clams discourages Oregon fishermen, particularly if financial compensation is not proportional to the additional effort (due to an undeveloped human consumption market). These reasons are cyclical and interwoven, making the main marketing problem difficult to identify.

*Strategies*

Through promotion and development of a human consumption Oregon bay clam market, the industry should receive greater economic returns on their catch. A number of strategies for market development follow.

1) Unite bay clam marketing efforts with oysters and the greater "Oregon Seafood" umbrella. The bay clam industry has not yet taken advantage of Oregon's robust seafood market. A smart segue for bay clams into the human consumption market may be through the market ties of another more popular shellfish species in Oregon, such as the oyster. The human consumption market knowledge of oyster fishermen could assist bay clam fishermen with their entrance into the market. Oyster and bay clam fishermen may find that by developing united marketing strategies they can increase economic returns for both industries. For example, the geoduck and horse clam industries of British Columbia founded the Underwater Harvesters Association (UHA) and have had great success with management and markets due to their association. The UHA includes major wholesalers of clams as well (Underwater Harvesters Association, URL). A similar association may work towards improving markets for Oregon bay clam and oyster industries.

2) Work with the Oregon State University (OSU) Seafood Lab and Community Seafood Initiative in Astoria, Oregon on recipes that will entice a market outside of bait and aquarium. The OSU Seafood Lab experimented with Oregon bay clams in 2004 and found potential for quality seafood recipes (Sylvia pers com 2004; Metcalfe pers com 2005). Further study into Oregon bay clam recipes could provide the bay clam industry a sound recipe portfolio for the human consumption market.

3) Introduce and promote bay clams to the human consumption market at local seafood festivals. Throughout the year, and particularly during warmer seasons, Oregon abounds with festivals and fairs. These events are opportunities to showcase bay clams to the human consumption market.

Some potential Oregon festivals and fairs to consider:
-Astoria-Warrenton Crab & Seafood Festival
-Newport Seafood & Wine Festival
-Newport Clambake & Seafood Barbeque
-Chowder, Blues & Brews Festival (Florence)
-Charleston Seafood Festival
-Portland Rose Festival
-Bite of Oregon (Portland)
-Oregon Brewers Festival (Portland)
-Oregon State Fair (Salem)
-Oregon Wine and Food Festival
-Mt. Angel Oktoberfest
-Eugene Celebration
-Salem Art Fair & Festival
-Oregon Ag Fest (Salem)

Farmers' Markets and supermarket tasting booths also provide opportunities to showcase bay clams and potential recipes; both venues can display bay clam recipes and provide tasting samples to the shopping public. In addition, by polling the public during advertising events on their interest in accessing fresh clams at market, supermarkets should respond by making fresh clams available to their customers.

4) Market the industry as a local low-impact, low-bycatch, sustainable fishery. Consumers are increasingly interested in knowing where their food comes from and the impacts of its harvest. The commercial bay clam industry is one of few commercial industries that can claim it is a low-impact, low-bycatch sustainable fishery. The industry should capitalize on these positive aspects in the human consumption market. Furthermore, consumers should know that their purchase supports local Oregon economies and State resource management agencies.

5) Use tourism to help the industry. The idea of ecotourism, or ecologically-friendly toursim, is expanding globally. Many people travel to Oregon in search of a vast and beautiful countryside and coastline. The bay clam industry may find a niche in this tourist draw to Oregon by promoting the bay clam resource and its sustainable management at tourist locations, such as coastal hotels.

For example, coastal Oregon hotels could host eco-friendly bay clamming events within nearby bays. These events would conclude with a seafood dining experience incorporating the clams harvested on that day. Participating tourists would pay a fee that encompasses the costs of a recreational shellfish license, transportation between hotel and bay, hotel restaurant preparation of food, and a donation to the State's bay clam and estuary program. Therefore, proceeds of the event would compensate the hotel and also be used for State resource assessments, in particular bay clam assessments. Since tourist fees will help the State pay for costly resource assessments, the event can be marketed as an eco-friendly affair.

These options demonstrate a variety of opportunities to showcase bay clams as a human consumption fish food and build their markets in Oregon. Concurrently, these marketing options may help raise awareness about the Oregon bay clam resource and the importance of sustainable fishing practices in Oregon.

*Softshells*

Softshell clams live in the upper reaches of Oregon estuaries. Few of these softshell areas are open for commercial harvest due to a lack of water quality monitoring in the upper reaches, and thus softshells are the least harvested of the five commercial bay clam species. Softshells, however, are a popular human consumption clam, particularly on the East Coast, and should be considered a strong market opportunity for Oregon.

Langan (pers com 2005) suggests that the Oregon industry should aim to increase softshell harvests and establish a human consumption market in Oregon and throughout the West Coast because it has done very well as a human consumption commodity on the East Coast. Langan also recommends that Oregon consider increasing softshell harvest to supplement to East Coast markets during times of harvest closures. For example, in the spring and summer of 2005, many softshell areas on the East Coast were closed to harvest due to toxic red tides. Meanwhile, markets still demanded the softshell resource. Fishermen, processors, supermarkets, restaurants, and consumers on the East Coast depend on significant softshell landings throughout the year. When landings are banned for a reason like red tide closures, an available West Coast source provides a high-demand resource for this East Coast market. The challenge is timing the Oregon landings to coincide with the sporadic nature of softshell landing closures on the East Coast. If Oregon decides to increase softshell landings, a steady market in addition to a sporadic East Coast demand would have to be established to secure the business.

*Gapers*

Gapers are the only commercial bay clam species in Oregon with a harvest season. Their off-season lasts from January 1 to June 30 to protect the spawning stock (McCrae pers com 2005). The bait and aquarium markets, however, request gaper clams all year (Alm pers com 2005). Bay clam fishermen observe gaper clams in abundance during off-season months and believe that further study of their spawning success will show that healthy stocks can be sustained with a year-round harvest (Alm pers com 2005; Metcalfe pers com 2005). An extended gaper season is another market possibility for the commercial industry.

## 3.7 The Limited Entry Fishery

A limited entry fishery is a type of developed fishery (OAR 635-006-0810). Limited entry, in the case of bay clams, means a fishery with individual bay quotas for each of the five species of clams and a capped number of industry permits.

As a limited entry fishery, the fishery remains with the same number of participants and catch level as set during its developmental stage. The main difference is that now industry permits are recognized as a property right, which gives the fishery greater security. With a transferability attribute, these permits may be sold or transferred. The ability to transfer permits increases economic efficiency in the fishery.

### 3.7.1 Property rights

Before fishermen enter a fishery and invest in costly fishing materials and permits, they need assurances from regulatory sectors that their business investments will be respected and secured. In fisheries, property rights provide fishermen secure claim to a stream of benefits emerging from the harvest of a resource. Property rights are a means to protect industry participants' access to a fishery resource while protecting the fishery resource from over-fishing due to over-capacity by the industry. The number of fishermen allowed to harvest a particular resource is capped; therefore, the right to harvest that resource is assigned a secure economic value. Holders of fishery property rights are permitted to harvest a resource and receive the corresponding flow of benefits, while those without rights to the resource cannot harvest and benefit directly.

Property rights can be tailored to meet specific needs or goals of an industry. Property rights may be comprised of at least six characteristics: 1) exclusivity, 2) duration, 3) transferability, 4) flexibility, 5) divisibility, and 6) security, or quality of title (Scott 2000) (see Appendix section "Property Right Characteristics" for more detail). These characteristics increase the value of the right and affect behaviors of the holder, such as enhancing an owner's stewardship over the resource and increasing his investment in the industry. Additionally, the composition and weight of these characteristics within a property right can be modified to meet different objectives, for instance, improving economic efficiency (Edwards 2000).

As a newly-developed limited entry fishery, bay clam industry goals need to be well defined in order that appropriate and constructive property rights can be designed to help the industry realize its full potential. Furthermore, the State should make known its legal responsibilities and obligations for guidance.

### 3.7.2 Transition to limited entry

What does it mean to transition from a developmental fishery to a limited entry fishery?

Developmental fishery

- Stock assessments are erratic and incomplete; stock abundances are not well known.
- Harvest levels are suspected to be below optimal yield (OY). (Stock assessments are used to determine optimal yields.)
- Harvest programs (e.g., season, gear, size limits, bycatch restrictions, and closed areas) are inadequate.
- Participation by fishermen is variable.
- The Developmental Fisheries Board develops management recommendations for the Oregon Fish and Wildlife Commission.
- Markets are undeveloped.
- Permits are non-transferable.

- Fishery lacks a long-term management plan.

Limited entry fishery (rights-based fishery)

- Stock assessments are periodic and consistent; stock abundances are estimated with reasonable confidence and monitored for changes over time.
- Harvest levels are at, or near, optimal yield (OY).
- Harvest programs (e.g., season, gear, size limits, bycatch restrictions, and closed areas) are established.
- Permits are stable.
- Industry is an active participant in research and management.
- Markets are well established.
- Permits are transferable.
- The fishery is guided by a long-term management plan (Developmental Fisheries Board 2005).

The commercial bay clam fishery transitioned from developmental to limited entry before meeting many of the criteria outlined by the Developmental Fisheries Program (DFP) above. It seems this premature management decision was made to reduce administrative responsibilities of DFP for the small-scale industry and not because the industry was officially ready to transition (Munro Mann pers com 2005). Therefore, although this industry is now managed as a limited entry fishery, its true development stage is still closer to "developmental." The industry requires more science and market research, and it especially requires the development of a long-term fishery management plan, which this report may assist in developing.

## 3.8 Institutional and Management Constraints

### 3.8.1 A management plan for the industry

In comparison to the management framework for Washington's established geoduck industry (Washington State Department of Natural Resources, May 2001) and New Zealand's Southern Scallop Fishery (Arbuckle and Drummond 2000), the management framework for Oregon's very small commercial bay clam fishery is inadequate. It lacks 1) routine and complete biological assessments and 2) a fishery management plan for the commercial harvest of bay clams (as well as recreational harvests) that include goals and objectives for rational management strategies, evaluation, and periodic revision.

Inadequate objectives limit effective management. As a new limited entry fishery, formulating a central set of goals is imperative to the industry's success. These goals should address the main constraints impairing the industry's advancement and the need for strategy development to address these constraints – strategies such as conducting biological assessments to optimize harvests and developing a comprehensive fishery management plan.

### 3.8.2 Fisheries rights allocation

The rationale for allocation of rights is a primary issue for managers and fishermen, and it can be a highly controversial component of the developing process of a rights-based management system (Edwards 2000; Harte pers com 2005). A common approach for the allocation of fishing rights is to distribute quotas to fishermen with a history of catch over a certain period of time. Lotteries, auctions, equal allocation, and priority ranking are other allocation methods (Edwards 2000). When designing an opportune allocation system for a fishery, the goals of the industry must be clear. Optimum allocation strategies will differ for industries with different goals, such as strong community-based goals versus goals of maximizing economic efficiency.

When the industry was managed as a developmental industry, Oregon's commercial bay clam permit holders paid ODFW an annual fee of $75 per fishing permit and made minimum landings each year to maintain their commercial fishing rights (Developmental Fisheries Board meeting, 2004). Now a limited entry fishery, the number of available permits, 15, remains the same. Holders of developmental bay clam permits were given priority allocation to new developed fishing rights due to their industry history (Munro Mann 2005). However, was this allocation of limited entry permits the optimum method for the industry? (See Appendix section "Allocation of Rights.")

Some argue that many developmental bay clam fishermen should not have been given priority access to the limited entry permits, particularly if these fishermen were just making their qualifying landings each year and keeping their permits away from fishermen that would put greater effort into advancing the industry (Alm pers com 2005; Brown pers com 2005). Did these fishermen deserve immediate allocation of the secure, developed right when the fishery transitioned? Should qualifying landings have been higher during the industry's time in DFP? Should they be raised now that the right is developed? Should fewer permits be made available to spark competition and drive economic value of the permit and industry? If so, how many permits are optimal, and how should the fewer number be allocated? Should permits come with a stipulation that the collection of science data by fishermen is necessary for participation in the small-scale fishery? Industry participation is important to help defray expensive management costs. Additionally, incentives are a key issue for motivating fishermen to be involved with research and expand the industry into new areas. What incentive approaches should be used to help advance this fishery? Would a quota system of resource allocation work more optimally for this industry than a permit system? And, how should managers address resource allocation issues between the commercial and recreational fisheries, if at all? Greater understanding of subtidal and intertidal stock interactions will help managers answer allocation questions between fisheries.

These questions raise important allocation issues to consider when addressing industry goals. These issues were not attended to during the industry's time as a developmental fishery, and so they should be handled early in the industry's new limited entry phase to help the industry meet its potential.

## 3.9 Establishing Management Goals

The Washington State Department of Natural Resources (May 2001) states the following management goals in the State's commercial geoduck fishery management plan:

1) “To ensure biological sustainability of geoduck populations and minimize impacts to the marine environment”
2) “To encourage a stable and orderly harvest”
3) “To provide maximum benefits of geoduck resources to the citizens of the State”
4) “To minimize adverse impacts to shoreline residents”
5) “To ensure effective enforcement of the State harvest”

This list provides one example of management goals for a commercial bay clam fishery; however, these goals are quite broad and lack specific objectives that must be met in order to achieve the larger goals. Smaller more explicit objectives provide an effective means to help meet industry goals. These objectives are essential for structuring a path and framework for achieving the greater goals.

Oregon’s bay clam industry lacked a set of well-defined management goals as a developmental fishery, and continues to lack a set of goals as a limited entry entity. The formulation of an appropriate list of goals and objectives for the developmental bay clam fishery may be aided by following the guiding principles of the Oregon Revised Statutes (ORSs) and Oregon Administrative Rules (OARs) that regard shellfish fisheries. Additionally, industry interests should be considered in the formulation of these goals and objectives.

Other sources include Fisheries Western Australia (November 1999) and the Challenger Scallop Enhancement Company Limited (June 2005). These documents provide templates for 1) designing a successful developing fisheries process and 2) a comprehensive fisheries management plan, respectively. Full references for these sources may be found under “Literature Sources” at the end of this report.

# CHAPTER IV
# Industry Potential

**Chapter Introduction**
This chapter offers options for the industry to explore its full potential economically, biologically, geographically, and institutionally.

## 4.1 Geographic and Economic Options

With the advancement of the bay clam industry economically and institutionally, the potential of mechanical harvest in Oregon bays other than Tillamook and Coos, which permit mechanical harvest, should be explored as a sustainable option for industry expansion. In particular, the permission of mechanical harvest in Yaquina Bay should be explored as an industry option. Hancock et al. (1979) found bay clam stocks in Yaquina comparable to those of Tillamook and Coos bays. By resolving issues of water quality and monitoring and eliminating restrictions on mechanical harvest in Yaquina Bay, the estuary may support increased commercial harvests in the future. The inclusion of Yaquina Bay as a commercial industry target may increase industry landings and revenue significantly (see the following section "4.1.1 Economic scenarios").

Considering the established estuarine management programs at Tillamook and Coos bays (e.g., the Tillamook National Estuary Program (NEP) and the South Slough National Estuarine Research Reserve (NERR) at Coos Bay), Hatfield Marine Science Center in Newport, Oregon may one day host an estuarine management program for Yaquina Bay. The research of a Yaquina Bay management program would likely aid management needs of the bay clam industry as well.

### 4.1.1 Economic scenarios
The following economic scenarios provide a range of possibilities for the Oregon commercial bay clam industry given different market and harvest conditions. These scenarios help illustrate the economic potential of the industry in best-case scenarios when markets are developed, bay management constraints are lifted, landings meet high percentages of estimated exploitable biomass, and all commercial bay clam species are harvested. These scenarios also illustrate industry potential when conditions are less than ideal. The objective of these scenarios is to provide some insight into the economic results of developing bay clam markets and harvestable bays and increasing total allowable catch (TAC).

**Harvest rate**
Kachemak Bay, Alaska's commercial hardshell clam fishery (including littlenecks, cockles, and butter clams) harvests clams at rates ranging from 5 to 13% of legal-sized biomass estimates (Alaska Department of Fish and Game, URL). The annual harvest rate in Washington for native littlenecks (*Protothaca staminae*) on public tidelands is 25% of the surveyed exploitable biomass of a beach; for manila clams (*Venerupis philippinarum*), the annual harvest rate is 33% of the surveyed exploitable biomass of a beach (Bradbury pers com 2005). The recommended annual harvest rate for butter clams

(*Saxidomus giganteus*) in Washington ranges between 8 to 13% of exploitable biomass (Bradbury pers com 2005). Clams living at the lower latitudes of their habitat reaches grow more quickly than clams found at more northerly latitudes, and thus harvest rates typically increase accordingly (Harte pers com 2005; Sampson pers com 2005; Alaska Department of Fish and Game, URL).

Catch quotas are usually established by setting the target harvesting rate equal to the rate of natural mortality (F = M). The natural annual mortality rate for Oregon bay clams is likely near 20% (Sampson per com 2005). Given this insight and the harvest rates of comparable clams in the northern states of Alaska and Washington, the following scenarios assign a general harvest rate of 20% to the five commercial Oregon bay clams. This rate is an average estimate, however, and may be higher for some of the Oregon species (like littlenecks) and lower for others (like butters).

**Biomass**
Biomass estimates for clams within Oregon bays are based on out-dated and incomplete data; however, in order to provide a viable range of economic scenarios for the industry, these older estimates are used for developing these scenarios.

**Ex-vessel price**
In the following scenarios, various ex-vessel prices are used depending on the situation. Ex-vessel prices are based on data from Oregon and the East Coast, and consider different markets such as bait and aquarium and human consumption.

**The current scenario**
In 2004, 169,010 total pounds were landed for four Oregon commercial bay clams: butters, cockles, gapers, and littlenecks. Softshell clams are not included due to very low commercial landings. Each of the four bay clams contributed 36,169lbs, 119,406 lbs, 12,825 lbs, and 610lbs, respectively to the total, and as percentages, these contributions are 21.4%, 70.6%, 7.6%, and 0.4%, respectively. The majority of these landings came from Tillamook and Coos bays. The total revenue in 2004 was $77,321 and prices ranged from $0.40 to $2.63/lb.

**The greatest scenario**
*Scenario 1:* Harvest within Tillamook, Yaquina, and Coos bays. Hancock et al. (1979) determined the following total pounds of clams of commercial size (exploitable biomass) for Tillamook, Yaquina, and Coos bays for gapers, cockles, littlenecks, and butters. Softshells are not taken into consideration in scenario 1 and 2.
Tillamook total: 5,317,400 lbs
Yaquina total: 9,235,000 lbs
Coos total: 1,692,500 lbs
Total exploitable biomass for all three bays: 16,244,900 lbs
TAC (20% of exploitable biomass): 3,248,980 lbs
**Total revenue for scenario 1 using the best market price for OR bay clams in the past 10 years ($2.63/lb for littleneck clams in 2004): $8,544,817**

This total revenue is more than 110 times the total revenue of 2004 ($77,321). In relation to the average total revenue of years 1995-2004 ($51,127), this total revenue is more than 167 times this average revenue.

However, a very high ex-vessel price is used in this scenario and unrealistic for all commercial Oregon bay clams. In 2005, the human consumption ex-vessel price for softshell clams in the shell in Massachusetts was $2.00 per pound and more. Roach and Whittaker (pers com 2006) of the Massachusetts Division of Marine Fisheries expect a price of $2.00/lb and more for softshells again in 2006.
**Using an ex-vessel price of $2.00/lb for scenario 1, total revenue is: $6,497,960**
This total revenue is approximately 84 times greater than the total revenue of 2004.

The average ex-vessel human consumption price for some quahog varieties in Massachusetts is $1.75/lb (in the shell). Small varieties are often more desirable than larger, tougher clams and command the highest prices, nearing $2.60/lb (Roach pers com 2006; Whittaker pers com 2006).
**Using an ex-vessel price of $1.75/lb for scenario 1, total revenue is: $5,685,715**
This total revenue is almost 74 times greater than the total revenue of 2004.

The Woods Hole Oceanographic Institution (WHOI) Sea Grant Program reports an ex-vessel price of $1.25/lb for softshells in the late 1990s.
**Using an ex-vessel price of $1.25/lb for scenario 1, total revenue is: $4,061,225**
This total revenue is more than 52 times the total revenue of 2004.

It is important to recognize that ex-vessel prices are variable in relation to season, supply, and the economy (Roach pers com 2006). Ex-vessel prices of this scenario are used in more scenarios below.

Clearly, with the consideration of exploitable biomass in all Oregon bays open to bay clam harvest, these potential revenues would be even greater (see scenario 1B). Unfortunately, biomass data are not available; therefore, a total revenue scenario with consideration of all open bays would be highly speculative.

One way to estimate total revenue is with a ratio system using available data. New data could then be extrapolated based on that ratio. For Tillamook, Yaquina, and Coos bays, the total pounds of clams of commercial size were averaged. Then, the areas (in hectares) of these three bays were averaged. A ratio of 1,493 lbs of clams of commercial size per hectare was found. Using the known areas (in hectares) of all the other open bays, this ratio can be used to estimate the pounds of clams of commercial size in these bays.

*Scenario 1B:* There are 15 other Oregon estuaries open for bay clam harvest, though only non-mechanical methods are permitted. Excluding the large Lower Columbia River, which has a great deal of boat traffic and problems with pollution, there are 14 open bays with a total area of 7,832.7 hectares. This area should yield 11,694,221 pounds of commercially viable bay clams, based on the ratio described above. The TAC for these clams (20% of exploitable biomass) is 2,338,844 lbs. Combining this number with the

TAC of 3,248,980 lbs from scenario 1 (20% of exploitable biomass of 16,244,900 lbs), the new TAC is 5,587,824 lbs.
**Using this new TAC and a market price of $2.63/lb, total revenue is: $14,695,977**
**Using an ex-vessel price of $2.00/lb, total revenue is: $11,175,648**
**Using an ex-vessel price of $1.75/lb, total revenue is: $9,778,692**
**Using an ex-vessel price of $1.25/lb, total revenue is: $6,984,780**
These total revenues range from approximately 90 to 190 times the total revenue of 2004. (See scenario 1 above for source information on these ex-vessel prices.)

Netarts Bay (1,110.1 hectares) is closed to the harvest of all bay clams except for cockles. Potential cockle harvest from Netarts was not calculated into scenario 1B. If a commercially viable cockle harvest could be estimated for Netarts and applied to scenario 1B, the estimated revenue values would increase accordingly. Additionally, if the bays closed for harvest were opened and harvested to their potential, the coast-wide total revenue for bay clams could increase significantly. Not including Netarts, there are three closed bays to harvest totaling 1,244.3 hectares; using the above density estimates, these bays could supply an additional 1,857,740 lbs of bay clams or more. (See section "2.5 Geography of the Bay Clam Resource" for more information.)

*Scenario 2:* Harvest within Tillamook and Coos bays only.
Total exploitable biomass for the two bays: 7,009,900 lbs
TAC (20% of exploitable biomass): 1,401,980 lbs
**Using this new TAC and a market price of $2.63/lb, total revenue is: $3,687,207**
**Using an ex-vessel price of $2.00/lb, total revenue is: $2,803,960**
**Using an ex-vessel price of $1.75/lb, total revenue is: $2,453,465**
**Using an ex-vessel price of $1.25/lb, total revenue is: $1,752,475**
These total revenues range from approximately 23 to 48 times the total revenue of 2004. (See scenario 1 above for source information on these ex-vessel prices.)

*Scenario 3:* Harvest within Tillamook and Coos bays only, considering softshells. This scenario uses data from Hancock et al. (1979), and assumes that all available softshell biomass is exploitable. This biomass estimate is conservative. Adequate softshell data lacks for all the bays. More current and complete surveys will likely show a greater exploitable biomass, and therefore greater TAC and total revenue.
Total exploitable biomass for the two bays: 7,147,900 lbs
TAC (20% of exploitable biomass): 1,429,580 lbs
**Using this new TAC and a market price of $2.63/lb, total revenue is: $3,759,795**
**Using an ex-vessel price of $2.00/lb, total revenue is: $2,859,160**
**Using an ex-vessel price of $1.75/lb, total revenue is: $2,501,765**
**Using an ex-vessel price of $1.25/lb, total revenue is: $1,786,975**
These total revenues range from approximately 23 to 49 times the total revenue of 2004. (See scenario 1 above for source information on these ex-vessel prices.)

**The short-term scenario**
The following scenarios, 4 through 7, aim to demonstrate short-term economic options for the industry by applying more optimum prices to current bay clam harvest levels (e.g.,

development of a human consumption market). These scenarios do not consider changes in TAC.

*Scenario 4:* Using the currently harvested biomass (169,010 lbs) and best price for each of the four bay clams in the last ten years, what is the total revenue? (See section "2.6 Fishery Economics" for ex-vessel prices.)
**Total revenue: $80,410**
Total revenue in 2004: $77,321
Difference in revenue: $3,089

*Scenario 5:* Using the currently harvested biomass and best human consumption price of $2.63/lb for two of the four bay clams (butters and littlenecks), and the best price in the last ten years for cockles and gapers, what is the total revenue?
**Total revenue: $161,068**
The difference in revenue (from 2004 revenue) is $83,747.

*Scenario 6:* Using the currently harvested biomass and prices of $2.63/lb for littlenecks, $2.00/lb for gapers, $1.75/lb for cockles, and $1.25/lb for butters, what is the total revenue?
**Total revenue: $281,426**
The difference in revenue (from 2004 total revenue) is $204,105.

*Scenario 7:* Using the currently harvested biomass and prices of $2.63/lb for littlenecks and $2.00/lb for gapers, cockles, and butters, what is the total revenue?
**Total revenue: $336,800**
The difference in revenue (from 2004 total revenue) is $259,479.

Noticeably, by increasing harvests and maintaining prices these short-term scenario revenues should increase accordingly.

**4.1.2 Economic conclusions**
By raising market prices from bait to those of human consumption, total revenues change drastically. An effort to establish a stronger human consumption market for Oregon bay clams could prove an economically efficient investment. As seen in scenario 5, by bringing just one other bay clam species into a human consumption market at the biomass landing levels of 2004, it may be possible to more than double the industry's annual revenue. By bringing all harvested clams into a human consumption market at individual market prices, total revenue increases more than 3.6 times (see scenario 6). However, costs of any extra time, labor, and equipment to harvest bay clams for human consumption are not taken into account in these scenarios. A cost-analysis should provide a more realistic value of economic return to the industry if these clams are harvested for human consumption.

Additionally, these scenarios do not take into account clam biomass density issues within bays. Estuaries do not have consistent clam density throughout their benthic environments. Bay clams congregate in areas with the most ecologically-desirable characteristics. Bay clam fishermen are aware of this fact and aim to maintain efficient catch per unit effort (CPUE) levels by targeting high-density pockets of clams within bays (Alm pers com 2005; Bradbury pers com 2005, Metcalfe pers com 2005). High density areas may provide higher sustainable harvest rates than low density areas. Rather than a 20% harvest rate, a high density pocket may be able to sustain a harvest rate closer to 40%. Conversely, a very low density area may only sustain a harvest rate of 5% or lower. Therefore, biomass density distributions within bays are important to consider for determining harvest rates, and density surveying should be a component of bay clam stock assessments.

Scenarios 1, 1B, 2, and 3 do not take into account hectares of "open" or "restricted" areas (OAR 635-005-0001) within bays, which are determined by the Oregon Department of Agriculture (ODA), for calculations of available commercial bay clam biomass. For these scenarios, consideration of open harvest areas may change the available exploitable bay clam biomass values, and thus total possible revenues.

See OAR 635-005-0001 and OAR 635-005-0002 for legislation on Oregon clams sold as bait and for human consumption.

## 4.2 Institutional

### 4.2.1 Individual Transferable Quota (ITQ) system

Assuming the Oregon bay clam dive fishery successfully operates within the developed limited entry system, the fishery could evaluate other management systems including an Individual Transferable Quota (ITQ) system. Fishermen of ITQ systems are assigned a certain percentage of the total allowable catch (TAC) that they may fish for a particular season. Once an ITQ fisherman reaches his quota, his fishing season is over. With a limited entry permit, individual fishermen may fish until the TAC is met by the industry. The transferability characteristic of ITQ systems promotes economic efficiency within a fishery. Less efficient fishermen are able to sell their quotas to more efficient fishermen (Harte pers com 2005). (See Appendix section "The Pros and Cons of ITQs".)

### 4.2.2 Fishery co-management

After a period of time under a limited entry system, the fishery may decide to try alternative forms of management, such as co-management or power-sharing between government and the industry. Co-management recognizes the importance of government collaboration with fishermen in the decision-making process in order to build greater local stewardship of the resource and improve communication between sectors. Overall, the government is less involved in management and fishermen accept more responsibility and authority over the resource's management (Pomeroy 2005). The key to successful co-management of a fishery is to make certain that the rules of fishermen rights and responsibilities are clear, appropriate, and enforceable from the beginning of new institutional arrangements (Harte pers com 2005).

Although co-management systems are a sort of devolution from a permit system, they can work well for a fishery depending upon its set objectives and needs. For example, in the long-term, co-management systems are more economical since fishermen accept many of the administration and enforcement responsibilities once covered by government.

A successful example of co-management is observed in the Underwater Harvesters Association (UHA), which is comprised of British Columbia (BC) geoduck and horse clam industries. The UHA has worked to successfully co-manage the Canadian West Coast fishery since 1981 (Underwater Harvesters Association, URL).

Enhancement practices are sometimes used in co-management systems to help ensure fisheries sustainability. The Underwater Harvesters Association (UHA) began enhancing BC geoduck populations in 1994 and developing enhancement techniques and technology for the future success of the fishery. The geoduck and horse clam industries fund all costs of this successful program via their association (Underwater Harvesters Association, URL).

### 4.3 Geographic Information Science (GIS) and Management

Geographic Information Science (GIS) technology is an important technology in studying and managing coastal and marine environments. Now used worldwide, it provides powerful tools to monitor, map, analyze, visualize, and model coastal and marine environments. GIS allows managers to collect and store environmental data at different spatial and temporal scales, map the data for exploratory analysis and interpretation, edit and manage the data, and visualize the data in a wide variety of ways through the integration of multiple datasets. Krause et al. (2004) argue that the key advantage of using GIS for coastal management is its "ability to store, retrieve, and handle large datasets of very heterogeneous origin and to represent these in visual format." Green et al. (2000) claim GIS has major benefits for all types of environmental management since it can store information gathered in long-term monitoring programs and secure this knowledge from one generation of researchers and managers to the next. Moreover, remote sensing imagery can be integrated into a GIS, adding information layers cost-effectively.

The effectiveness of GIS tools for management depends on the quality of data (i.e., accurate, detailed, and thorough data collection) as well as the availability of information and the geometric accuracy (Krause et al. 2004). Remotely sensed data is also represented in various levels of spatial detail and resolution. When using remotely sensed data to guide management decisions, managers must understand that differences in resolution can affect the results of landscape analysis (Krause et al. 2004). For example, fine-scale coastal management issues should not be addressed with 30-meter resolution Landsat imagery. In a fine-scale case, it is likely more appropriate to use remotely sensed data from a higher resolution source, like the IKONOS satellite with 1-meter resolution.

There are definite expenses associated with GIS management, such as purchasing software packages and covering labor costs (e.g., creating GIS maps; managing the database). Users of GIS management systems should find, however, that these expenses are quickly recovered, particularly if multiple resources are managed under one system.

Effective resource management requires continual collection, processing, and analysis of data. Resource management also requires very current resource information in order for managers to make informed and effective resource decisions. The adaptability of GIS makes it an excellent tool for the dynamic and often complex field of resource management.

#### 4.3.1 Example GIS imagery of Oregon bays for management needs

GIS allows users to digitally create and layer point, line, and polygon imagery with remotely-sensed imagery (e.g., aerial photographs; satellite images) in order to add or highlight features. These newly created features can then be queried for spatial information to help with management decisions. An example of this GIS capability is shown in Figure 10 below. Digitized polygons were created atop a geo-referenced ortho-quad photo of Coos Bay to highlight intertidal habitat of South Slough National Estuarine Research Reserve (NERR). Color infrared and natural color photographs of South Slough at low tide aided the delineation of the intertidal habitat polygons. The intertidal polygons are geospatially-referenced in relation to the ortho-quad photo; therefore, the polygons may be spatially-analyzed for resource management. For instance, with an estimated average density of intertidal bay clams in South Slough and a GIS-calculated amount of intertidal area, managers may quantify an estimate of intertidal bay clam abundance. Abundance data are important for stock assessments.

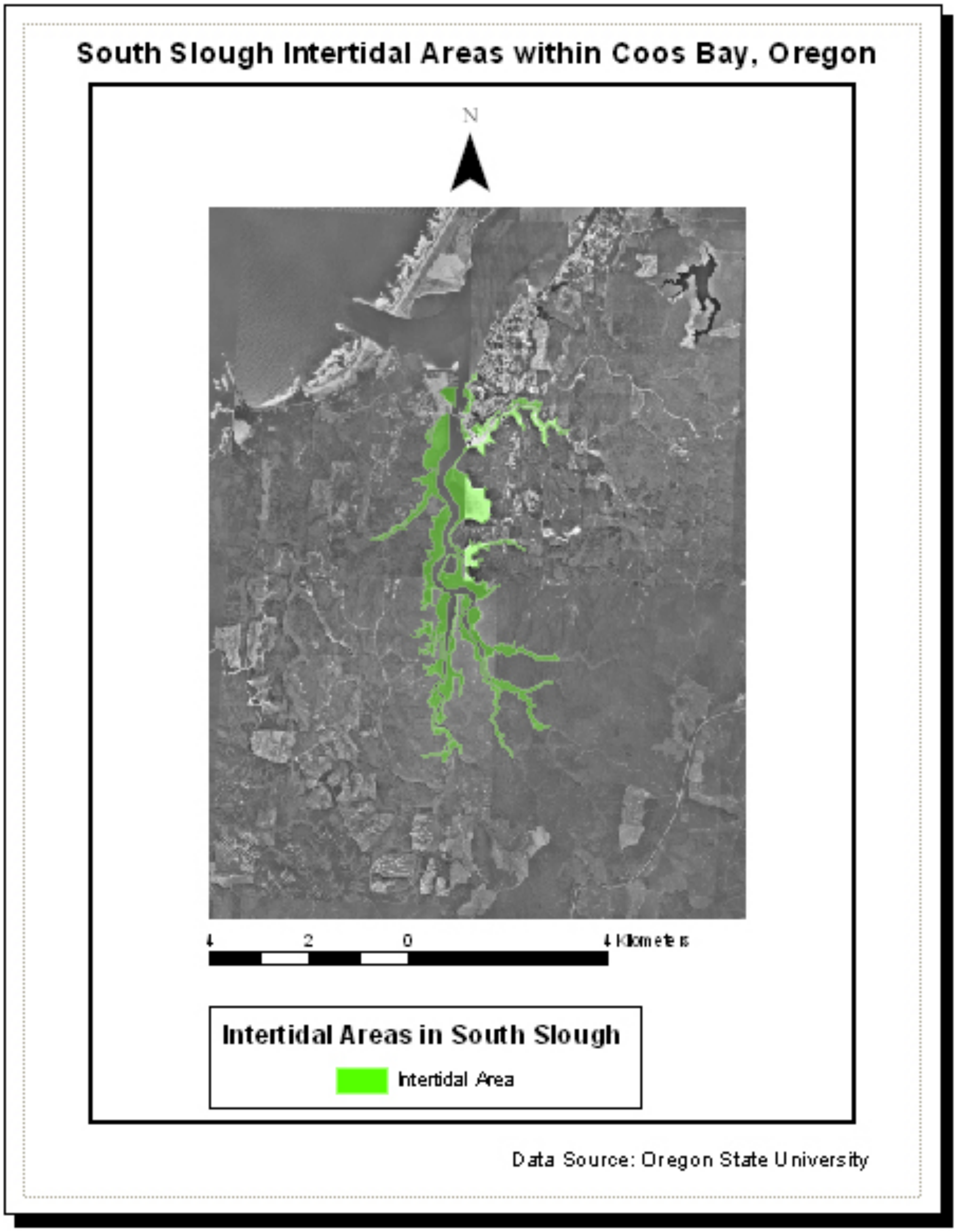



**Figure 10.** South Slough Intertidal Areas within Coos Bay, Oregon.

Another example of this GIS function is illustrated in Figure 11. Oyster lease plots and eelgrass areas are depicted as GIS imagery atop an ortho-quad photo of Tillamook Bay. Hancock et al. (1979) observed a strong correlation between the presence of highly-productive bay clam areas and eelgrass beds, particularly in Tillamook Bay. Fewer bay clams were observed in eelgrass beds of very high density than in areas of moderate eelgrass density. If a definite correlation between eelgrass density and clam density is drawn, a particular level of eelgrass presence may be used as an indicator for highly-productive clam beds. Remotely-sensed imagery of eelgrass areas within bays can be imported into GIS to address management issues concerning bay clam abundances.

The enlarged GIS image within Figure 11 highlights an eelgrass area within an oyster lease plot in Tillamook Bay. Although eelgrass may indicate bay clam presence, commercial bay clam fishermen cannot harvest in oyster lease areas. Therefore, if a management goal aims to make more productive bay clam areas available for wild commercial harvest, managers may use these data to identify areas of high bay clam abundance and shift oyster lease plots outside of these areas. On the other hand, managers may decide to keep these productive eelgrass areas protected from commercial harvest disturbances. Identified eelgrass beds could become reserves for bay clams and other estuarine fauna.

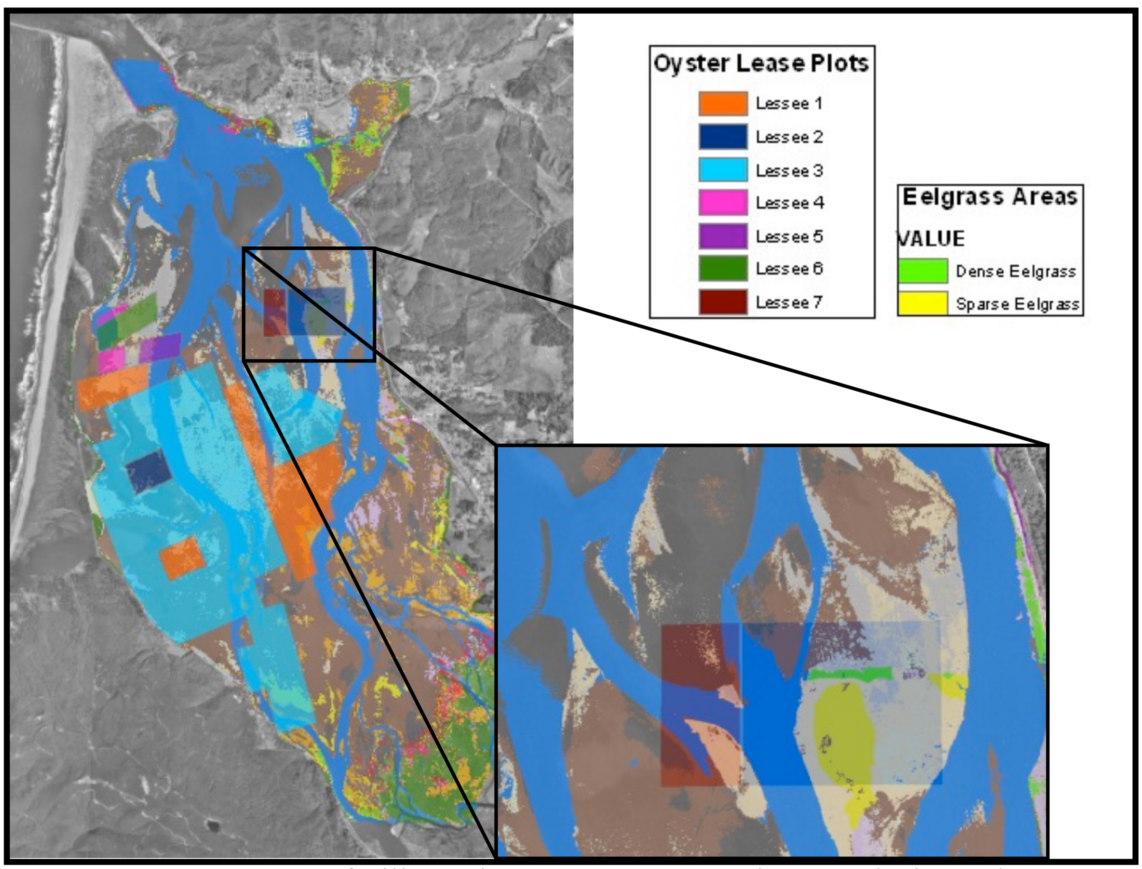
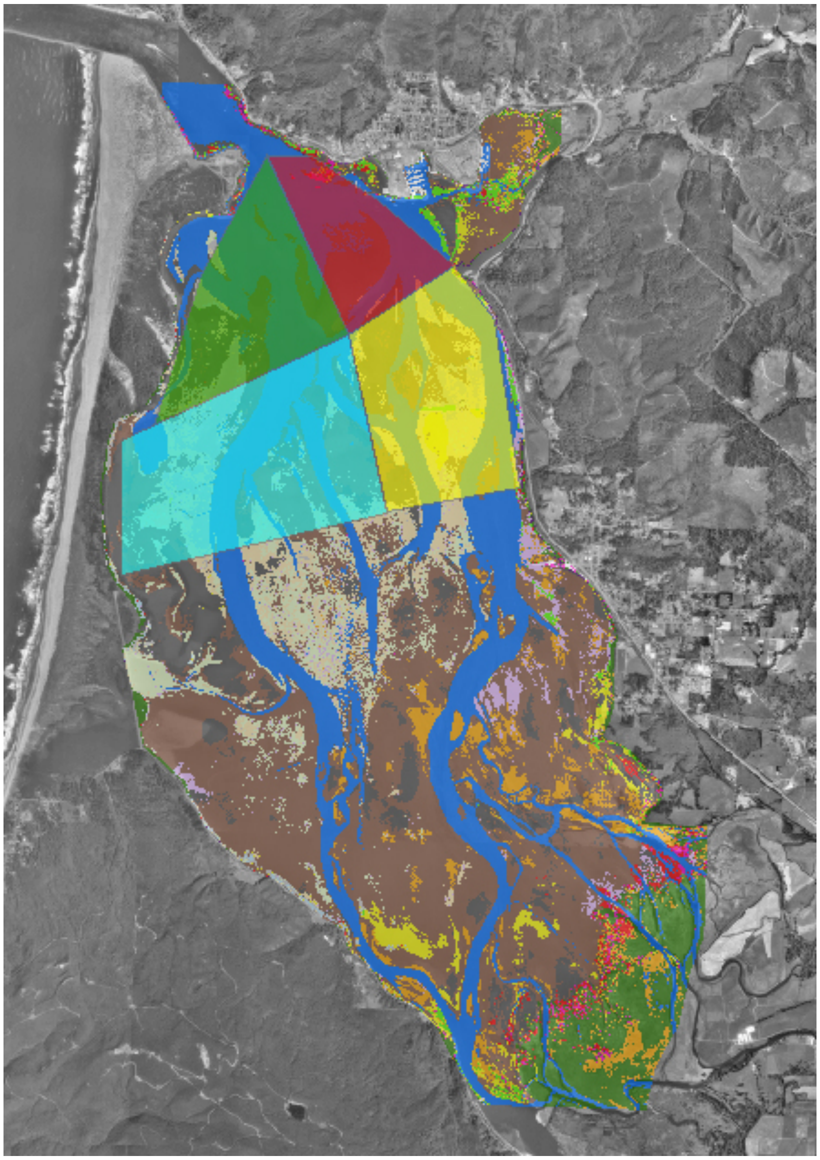



**Figure 11.** GIS Imagery of Tillamook Bay Oyster Lease Plots Overlaying Eelgrass Areas.

**4.3.2 Proposed spatial harvest rotation scheme in GIS: an example in Tillamook Bay**
Figures 12, 13, and 14 illustrate how GIS can aid the management of a spatial harvest rotation scheme, discussed in Chapter III. Figure 12 shows four polygons representing possible spatial harvest areas in Tillamook Bay. Managers can track catch per unit effort

(CPUE) within these harvest areas as fishermen collect their catch (Figure 13). These CPUE data can be added to an attribute table within the GIS (Figure 14). Continuous harvest data updates may be easily added to a GIS database while reducing the paperwork component. GIS records may be printed periodically for a hardcopy record. At the end of every harvest year, GIS-stored data may be used for analysis to determine appropriate total allowable catches (TACs) for the following year.



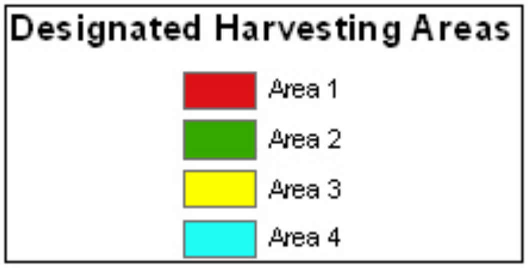



**Figure 12.** Potential Designated Harvest Areas in Tillamook Bay.

In the example presented in Figure 13, bar graphs within different harvest areas represent total pounds caught of cockles, gapers, butters, littlenecks, and softshells, respectively. Updating these harvest levels within the layer attribute table automatically modifies the bar graphs. The layer property table provides other display options for these data, such as pie charts and graduated colors. The adaptability of the GIS layer attribute and property tables allows users to display data at different levels of detail. For example, harvest levels may be divided into various time frames, like weeks, months, or years; harvest amounts of certain bay clam species may be displayed separately from other species, or linked to another attribute, like sediment type; and the effort, or number of harvester-days, in an area may be symbolized on the map image as well. These pieces of information may be viewed together or separately for analysis purposes.

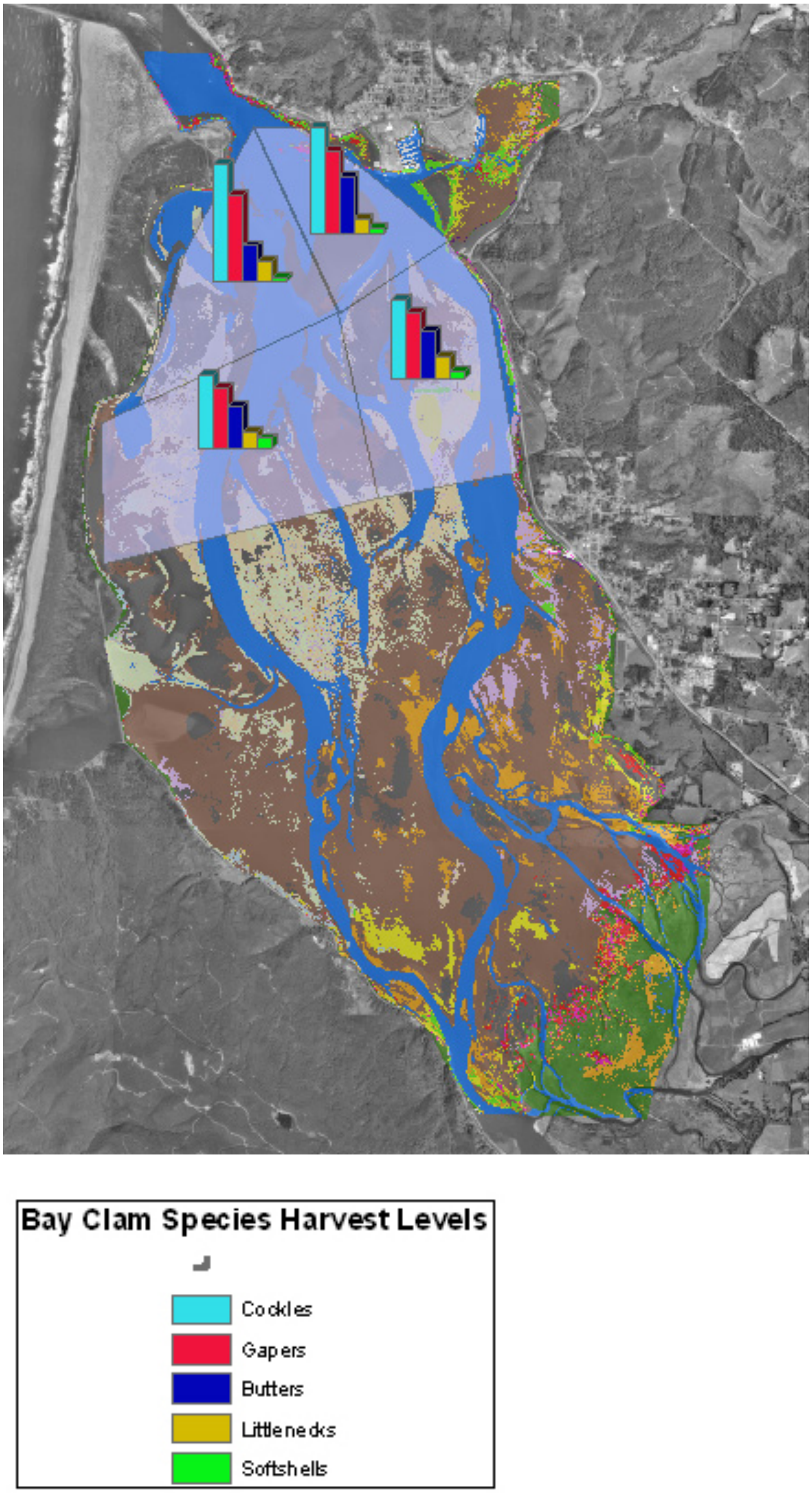



**Figure 13.** Potential Bay Clam Species Harvest Levels.

The organizational capabilities of GIS database systems should prove extremely helpful when managing a spatial harvest strategy and other fishery data issues. Additionally, the visual creations provide managers interactive maps they can share with fishermen when discussing complex management issues. Conveying information through imagery is an important communicative tool.

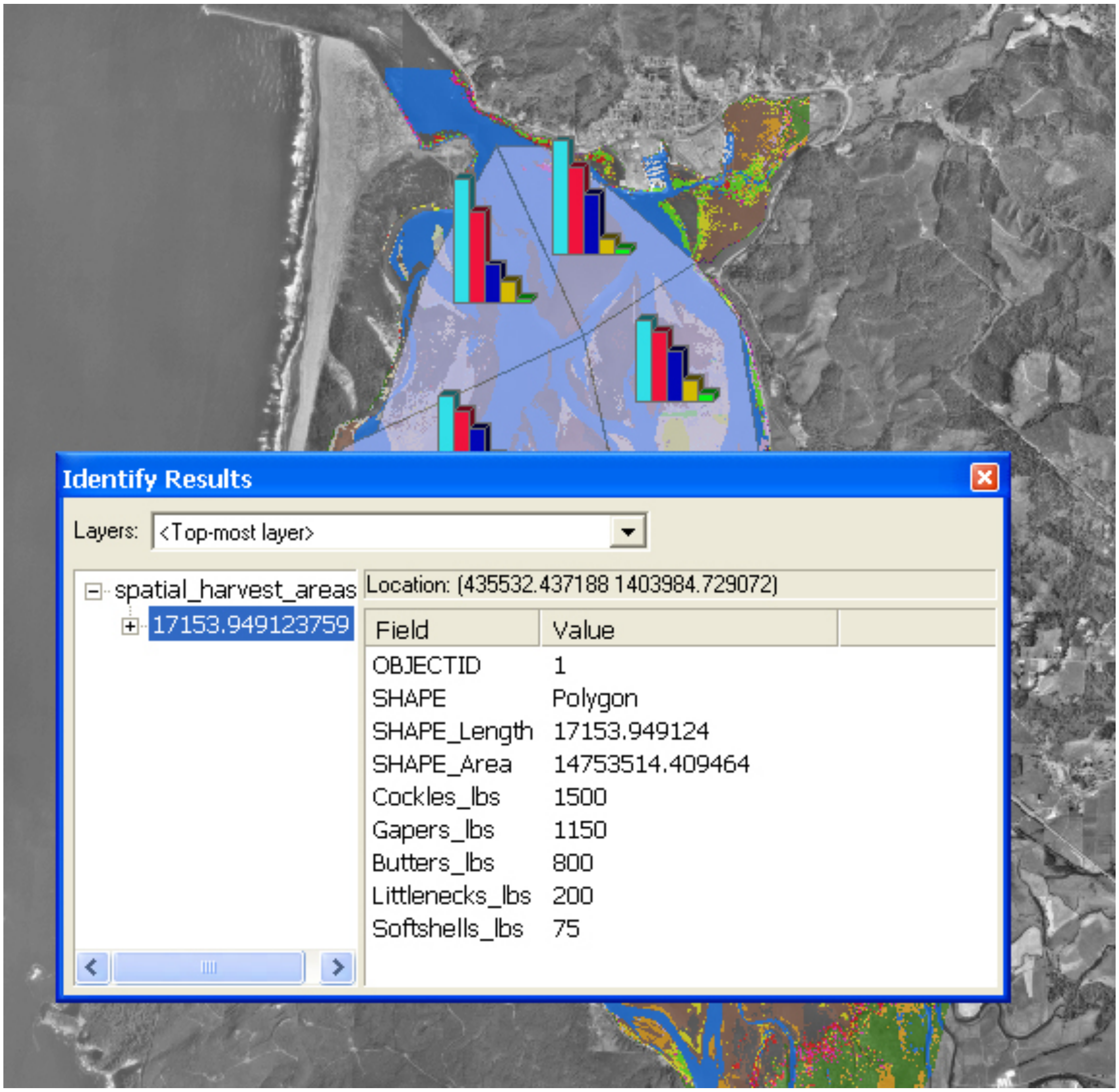



**Figure 14.** Numerical Expression of Harvest (in pounds) of Bay Clams. These data represent harvest levels for one spatial designation in Tillamook Bay (information accessed using the Identify tool in ArcMap).

### 4.3.3 Global Positioning System (GPS) technology and GIS

Global Positioning System (GPS) technology is a satellite navigation system that can be used to establish spatial sampling schematics in bays. Fishermen can use GPS to locate designated harvesting areas in their boats. A major advantage of GPS data is that they can be easily imported into a GIS. GPS point data, along with their associated yield data, can be used to build upon stock assessment data stored and visualized via GIS. Additionally, fish ticket data can expand to include either GPS information on catch or at least a general description of where the yield was caught within the bay (e.g., the northwest section of the bay between buoys x and y).

## 4.4 Future Management Issues

### 4.4.1 Bay clam aquaculture

Aquaculture is becoming the "future" of fisheries. Worldwide aquaculture practices have been undergoing refinements for decades. Technological gains and improved shellfish growing techniques of the past few decades give current aquaculture practices a greater certainty and sophistication (Dore 1991; Anderson 2002; Nunes et al. 2003). Successful examples may be used as aquaculture models. Bay clam aquaculture is one potential option for industry expansion in Oregon, if not ultimately an inevitable one.

Economically, the market demand and price for bay clams needs to be relatively high before an investment in aquaculture can be considered economically viable. The value of the individual clam on the market needs to be greater than the cost of rearing it via aquaculture practices (Newell 1991). An economic analysis should be performed before the onset of a bay clam aquaculture endeavor.

Shellfish aquaculture is potentially one of the most sustainable forms of mariculture because: 1) it is largely extensive and 2) it requires no artificial food input (the animals obtain all their nutrition from phytoplankton, microphytobenthos, and different types of organic detritus) (Nunes et al. 2003). Like traditional harvests, pollution is a constraint to successful shellfish aquaculture practices. In addition to regulations that protect water quality, depuration plants are used to combat pollution problems (Newell 1991).

Currently in Oregon, oyster farmers control lease areas within bays (see Figure 11). A problem for bay clam aquaculture is the competition for space of leased intertidal areas with oyster farmers. Oysters are a more profitable industry than bay clams at present, so they are given preference for lease space. One way to determine the economic efficiency of bay clam aquaculture is to allow co-aquaculture and the buying and selling of leases.

Enhancement or seeding practices are commonly used in shellfish industries around the world as well. The Underwater Harvesters Association (UHA) began enhancing BC geoduck populations in 1994 and developing enhancement techniques and technology for the future success of the fishery. The commercial abalone fishery of New South Wales, Australia uses enhancement techniques to increase the State's sustainable total allowable catch (TAC) of abalone (NSW Department of Primary Industries, URL).

Bay clam aquaculture should be strongly considered as an option for the Oregon commercial bay clam industry, particularly to help combat estuarine eutrophication, or nutrient-loading. Aquaculture of filtering organisms within bays can increase bay filtration and reduce the adverse effects of nutrient loading into bays (Langan pers com

2005). If the filtration of bays by molluscan shellfish is a public good, should the public subsidize aquaculture?

Questions to consider: Can bay clams and oysters be farmed together? Why must the aquaculture lease areas for one type of shellfish exclude the possibility of the other? By including bay clam aquaculture practices in some oyster lease areas, the aquaculture potential for the bay clam resource can be examined.

Aquaculture is a potential expansion option for the bay clam industry. The possibility of its practice for bay clams in Oregon should be explored.

### 4.4.2 Non-indigenous species

On a global scale, species introductions are an inevitable problem for estuaries, particularly port bays with a great deal of international traffic. Oregon's estuaries currently face invasions by over 100 non-indigenous species. Non-indigenous species, sometimes referred to as invasive species, are generally defined as organisms that do not naturally occur in a specific area, and whose introduction to that area may cause environmental and economic harm.

The purple varnish clam, the European green crab, and *Spartina alterniflora* are three example species invasions in or near Oregon estuaries (Yamada 2003 – Introduced Species in Oregon Estuaries, URL). Implications of the purple varnish clam's introduction on the ecology of Oregon estuaries are currently unknown, and potential ecological effects of the introduction should be monitored with caution.

The European green crab, *Carcinus maenas*, was introduced into Oregon's estuaries via ballast water, and likely dissipated further through subsequent current transport of larvae. The green crab is an effective predator, particularly of softshell clams. In Maine, declines in softshell clam production coincided with an increase in green crab populations (Welch 1969). One green crab is capable of consuming up to 15 softshell clams in one day (Spear 1953). The softshell clam is an introduced species to Oregon as well, from the United States' East Coast; however, its non-predatory nature may not raise as much concern for its potential harm as a non-indigenous species like the green crab. In fact, this bay clam is commercially harvested on the West Coast and considered to have potential for additional industry expansion. Although the softshell clam's introduction to Oregon has not yet proved damaging, this species should be monitored for any influences it has on Oregon biology, habitat, and ecology. What may seem like insignificant changes now could become larger issues in the future.

*Spartina alterniflora*, a salt marsh grass native to the East Coast of the United States, is rapidly invading Pacific Northwest estuaries (Western Aquatic Plant Management Society, URL). *S. alterniflora* is a productive, rhizomatous perennial grass of the intertidal zone capable of colonizing a broad range of substrates and tolerating a wide range of environmental conditions (Callaway and Josselyn 1992; Western Aquatic Plant Management Society, URL). Once established initially by seed, the robust grass spreads outward in the form of circular clones using rhizomes. These clones combine to form contiguous meadows (2001 *Spartina* Management Plan for Willapa Bay, URL). Dense root beds and tall grass shoots trap sediments and threaten to fundamentally change the natural make-up of Pacific Northwest estuaries physically and ecologically (Willapa Bay, URL). Dense root structures of *S. alterniflora* inhibit the abundance of large burrowing organisms, like clams, in the sediments (Talley and Levin 2001). On the West Coast, Levin and Hewitt (1998) found mean infaunal densities in a marsh invaded by *S. alterniflora* to be three times less than densities of an adjacent mudflat and marsh with native vegetation.

Willapa Bay, Washington had its first introduction of non-indigenous *S. alterniflora*, also known as smooth cordgrass, in an 1894 shipment of eastern oyster spat originating from the East Coast. The plant became well established throughout the bay between the years of 1945 and 1988 (Sayce 1988). Today the invasive salt marsh grass has encroached onto much of the bay's intertidal shellfish habitat and is continuing to spread, thus threatening Willapa Bay's profitable oyster industry. Though not yet observed in Oregon estuaries, the nature of *S. alterniflora* is to spread, and Oregon intertidal areas must be watched for its arrival in order that removal strategies are rapidly implemented. As *S. alterniflora's* migration continues throughout Pacific Northwest estuaries, vital habitat for commercially important fish, shellfish, and their prey is greatly altered. Introduction of this grass into Oregon estuaries should be closely monitored for prevention, as it is a major threat to the ecological integrity of Oregon's estuarine intertidal flats, shellfish, and overall ecosystem health.

Implications of the introduction and spread of non-indigenous species on the West Coast likely involve economic hardship for several fishing industries, including Oregon's burgeoning bay clam industry. Precautionary monitoring of Oregon's estuaries for non-indigenous species problems could save the State and its industries significant costs and help secure a sustainable future.

**4.4.3 Enforcement**

Industry fishermen believe their fishing activity compliance with commercial regulation is substantially monitored by Oregon's shellfish regulating enforcement, the Oregon State Police (OSP). Further, in towns bordering Tillamook Bay, a general public concern for ecological impacts of commercial fishing results in frequent inquiries by local enforcers about fishermen's activities (Alm pers com 2005).

Enforcement of recreational regulations is significantly undersupplied by OSP, however (Alm pers com 2005). Recreational shellfish digging is very widespread along Oregon's estuarine intertidal areas. Thousands of participants make regulation of recreational activity inherently more difficult to enforce than relatively contained commercial activity with a total of 15 participants. Yet, without sufficient regulation, intertidal bay clam resources may be over-exploited, possibly hindering the potential of the bay clam resource for the commercial industry as well as the public.

To ensure that all Oregon resource users receive maximum benefits of the bay clam resource, recreational enforcement will likely need to increase. The costs and benefits of increased recreational enforcement are unknown, however, and a cost analysis should be performed to help provide insight into future enforcement needs. Again the question of responsibility and funding is fundamental: who should perform this cost analysis and who should pay for it? OSP now shares the new recreational shellfish license revenues with ODFW and ODA. This money may be allocated to perform a cost analysis study as well as strengthen shellfish enforcement activity. It may be in the interest of all three agencies to contribute funds to a cost analysis study.

# CHAPTER V
# Conclusions and Recommendations

## 5.1 Suggestions and Recommendations

**Improving Biological Science with Biological Solutions** (Section 3.1)
**(1)** Several questions regarding the ecological value of Oregon bay clams need be addressed to ensure intelligent resource management. These questions are key considerations for ecosystem-based management as well. By setting small, achievable objectives and incorporating additional ecological information into the management of a resource step-by-step, managers can begin development of an ecologically-based management strategy.

**(2)** Public good benefits such as the contribution of bay clams to water quality may be significant. Oregon legislation requires that State resource management achieve an optimal balance of public good, commercial, and recreational benefits to all user groups of the State (ORS 496.012 and ORS 506.109). It is important to consider these benefits when determining socially optimal harvest levels of bay clams. As a public good, the cost of water quality testing should be primarily the State's responsibility. The industry, however, should help defray a portion of testing costs as harvesters of the bay clam resource and direct users of the good.

**(3)** The current system of mixed stock management should be reviewed. Further biological and ecological research will determine whether certain bay clam species require different management frameworks or set harvest seasons to ensure their sustainability.

**(4)** The spawning success of gaper clams, *Tresus capax*, requires further study to determine whether a six-month harvest season is necessary. Essentially, Oregon bay clam recruitment (i.e., the addition of new individuals to a population) is inadequately understood, and further research is required for effective commercial management.

> *Suggestion: Initiate a trial year or two of year-round gaper harvest. Track harvest landings throughout the year(s) for later analysis. Compare monthly landings within the former open harvest season to the landing of other years in order to measure for differences. If harvest levels in these "open" months seem to taper, it is likely that the six-month off-season is a necessary conservation tool for this species. If harvest levels remain steady, continue the full-year harvest with the stipulation that a six-month season will be enforced for precautionary reasons if landing data shows that the population may be diminishing. Research into extended gaper clam harvest may be designed to explore cooperative research between fishermen and scientists as well.*

**(5)** Ecological models provide a way to address questions regarding ecosystem components, and may be a useful and cost-effective management tool for Oregon's bay clam fishery in the future.

**Geography: Estuarine Harvest Constraints and Possibilities** (Section 3.2)
**(6)** Managers need to revisit the practicality of current limits on bays open for mechanical harvest, mechanical harvest quotas, and the lack of hand-harvest quotas.

**Funding: Management Costs and Attaining Funding** (Section 3.3)
**(7)** Suggested ranking for financial assistance:
1) Oregon recreational shellfish license revenues
2) Industry cost recovery
3) Partnerships with the Tillamook Bay National Estuary Program (TEP) and the Coos Bay South Slough National Estuarine Research Reserve (NERR)
4) Sea Grant and university funding and partnerships

**(8)** Oregon State management agencies are at full capacity for funding, personnel, and time. In order for the small-scale, low revenue Oregon bay clam industry to progress, fishermen will have to play a larger part in the management process. The industry will likely need to devise a funding scheme involving a compilation of industry-based funding (cost recovery) methods as well as funding from other sources, such as Tillamook and Coos bays' estuary programs, NGOs, universities, and tribes.

> *Suggestion: Professors at state and community colleges throughout Oregon, particularly marine-oriented schools and coastal-based colleges, should seek opportunities for their students to conduct research needed by the State for resource management. University involvement may occur at a course-level, supervised by a head professor, or at a level of individual graduate research. University students (undergraduate and graduate) are a constant resource in continuous need of scientific experience, and opportunities to conduct real, necessary research. Students provide an opportunity to assist industry-led research with the scientific validity needed for data approval by government agencies. Scientific standards set by universities act as parameters for the scientific integrity of student projects; thus, these standards act as checks and balances for the scientific integrity of university-industry projects.*

**(9)** State agencies should embark on a collaborative (and cost-effective) approach to coordinate all the available data on benthic estuarine organisms and determine the status of these organisms in Oregon's estuary ecosystems.

**Rotational Strategies for Harvests and Surveys** (Section 3.4)
**(10)** Rotational harvest methods are used successfully in shellfish fishery management worldwide and should be considered for the Oregon commercial bay clam fishery.

**(11)** Catch per unit effort (CPUE) can be used as a proxy to estimate stock abundance when an industry cannot afford frequent biological surveys. Respecting CPUE data limitations, these data should be considered a reasonable tool for stock assessment, especially for low-revenue industries that cannot pay for regular comprehensive biological surveys. The application of a spatial context to the collection of catch and effort data improves data reliability as a stock abundance proxy. When a spatial context is applied to improve CPUE for stock assessment, fisheries that target sedentary or nearly-sessile animals are sound candidates due to their inherently stable spatial nature. The use of spatial harvest methods should help update needed information on bay clam abundances and distributions within Oregon bays in order that regulators may set appropriate limits on harvest and effort.

**(12)** Oregon could benefit from a rotational method such as Washington State's strategy, allowing harvest in a designated area only when that area achieves a certain density biomass. Managers must decide upon a strategy that maximizes management goals.

**(13)** Reseeding areas with spat (enhancement) is an option to incorporate into rotational strategies to increase area recovery time and annual harvests.

**Cooperative and Cost-Effective Stock Assessments** (Section 3.5)
**(14)** In order to regulate the bay clam resource adequately, ODFW must acquire stock assessment data. The combination of an updated, comprehensive stock assessment and ongoing, strategic rotational harvests should provide ODFW significant biological resource data for fishery management purposes. Through an intensive baseline survey of the bay clam resource and the establishment of strategic methods for future fishery dependent surveys, it may be possible to determine the sustainability of harvest levels of this fishery without expensive, ongoing traditional stock assessments.

**(15)** A four-part strategy (consisting of cost-effective and cooperative methods) provides a framework for bay clam stock assessments in Oregon:
1) Perform a comprehensive baseline stock assessment of bay clams in all major harvesting bays, particularly Tillamook and Coos bays.
2) Design a rotational spatial dive harvest strategy that considers catch per unit effort (CPUE) in order to update baseline assessments scientifically.
3) Implement the rotational spatial dive harvest strategy with the industry and employ a scientific analyst to evaluate the resource data and help set harvest levels.
4) Employ operational observers to monitor system protocols of the strategy a few times per year with fishermen during field harvest.

**(16)** Regular annual creel surveys are a simple means for regulators to collect recreational harvest information from harvesters on site, and help determine CPUE of bay clams and other bivalves on Oregon tideflats.

**Economic Constraints and Options** (Section 3.6)
**(17)** Insufficient market development poses major economic hindrances to the industry. Through promotion and development of a human consumption Oregon bay clam market, the industry should receive greater economic returns on their catch. A number of strategies for market development are presented.
1) Unite bay clam marketing efforts with oysters and the greater "Oregon Seafood" umbrella.

2) Work with the Oregon State University (OSU) Seafood Lab and Community Seafood Initiative in Astoria on recipes that will entice a market outside of bait and aquarium.
3) Introduce and promote bay clams to the human consumption market at local seafood festivals, Farmers' Markets, and supermarket tasting booths.
4) Market the industry as a local low-impact, low-bycatch, sustainable fishery.
5) Use tourism to help the industry.

**(18)** Develop a softshell clam human consumption market in Oregon. Consider harvest closure on the East Coast due to red tides and other issues and provide supplements for those markets.

**(19)** Consider an extended gaper season as a market possibility for the commercial industry.

**The Limited Entry Fishery** (Section 3.7)
**(20)** As a newly-developed limited entry fishery, bay clam industry goals need to be well defined in order that appropriate and constructive property rights can be designed to help the industry realize its full potential. Lacking the transferability characteristic, property rights are not as valuable. Assigning transferability to permits in 2006 is important for the advancement of the commercial bay clam fishery.

**(21)** Although this industry is now managed as a limited entry fishery, its true development stage is still closer to "developmental." The industry requires more science and market research, and it especially requires the development of a long-term fishery management plan, which this report should help draft. Research responsibilities should be assigned to every limited entry permit.

**Institutional and Management Constraints** (Section 3.8)
**(22)** As a new limited entry fishery, formulating a central set of goals is imperative to the industry's success. These goals should address the main constraints impairing the industry's advancement and the need for strategy development to address these constraints – strategies such as conducting biological assessments to set optimal harvests and developing a comprehensive fishery management plan.

**(23)** Allocation issues were not closely addressed during the industry's time as a developmental fishery. They should be addressed early in the industry's new limited entry phase to help the industry meet its socioeconomic potential. Higher minimum landings and fewer available permits would create greater competition between fishermen and be a driver of resource and industry development.

**Establishing Management Goals** (Section 3.9)
**(24)** Oregon's bay clam industry lacked a set of well-defined management goals as a developmental fishery, and continues to lack goals as a limited entry entity. The formulation of an appropriate list of goals and objectives for the developmental bay clam fishery may be aided by following the guiding principles of the Oregon Revised Statutes (ORSs) and Oregon Administrative Rules (OARs) that regard shellfish fisheries.

Furthermore, industry interests should also be consulted in the formulation of these goals and objectives.

**Geographic and Economic Options** (Section 4.1)
**(25)** By raising market prices from bait and aquarium to those of human consumption, total revenues change drastically. Scenarios show that millions in revenue may be possible for this currently low-revenue industry with the right set of circumstances. An effort to establish a stronger human consumption market for Oregon bay clams could prove an economically smart investment.

**(26)** The expansion of harvestable areas may allow for greater economic advancement of the industry and should be considered.

**Institutional** (Section 4.2)
**(27)** Future institutional arrangements should be considered for the bay clam fishery, such as an individual transferable quota (ITQ) system or co-management.

**GIS and Management** (Section 4.3)
**(28)** The organizational capabilities of Geographic Information Science (GIS) database systems should prove extremely helpful when managing a spatial harvest strategy and other fishery data issues. Additionally, the visual creations provide managers interactive maps they can share with fishermen when discussing management complex issues. Conveying information through imagery is an important communications tool.

**Future Management Issues** (Section 4.4)
**(29)** Aquaculture is a potential expansion option for the bay clam industry. Enhancement practices may also prove beneficial for the industry. The possibility of aquaculture for bay clams in Oregon should be explored.

**(30)** Regular monitoring of Oregon's estuaries for non-indigenous species problems could provide managers a chance to act proactively near the beginning of species introductions. Subsequently, the State and its industries could save significant costs due to invasions and help secure a sustainable future.

**(31)** To ensure that all Oregon resource users receive maximum benefits of the bay clam resource, recreational enforcement will likely need to increase.

**Additional Management Recommendations** *(pertaining to sections 3.7 through 3.9 as well as the Developmental Fisheries Program (DFP))*
**(32)** In order for a fishery's time in the Developmental Fisheries Program (DFP) to be effective, the industry and DFP together, need to set well-defined goals and objectives for the fishery. Prior to this step, DFP must define parameters to how a fishery moves from a developmental classification to a developed industry. DFP should develop and implement a program protocol (e.g., steps or phases within the program; a set timeline with possible sunset provision; goal of a fishery management plan before a fishery transitions into a developed industry) for moving developmental fisheries through the program. The

protocol should be made clear to the fishermen within the program and all DFP board members in order that relevant and attainable goals are set for the fishery that fit within the DFP structure. Program parameters and a protocol need to be in place providing a framework in order that developmental fisheries can set appropriate and effective goals.

**(33)** The DFP should set an initial time limit on the developmental fisheries management process. Sunset provisions on management decisions may be useful tools as well. If after a review period a second term in the DFP is decided, this second term may come with different developmental stipulations, such as a cost-recovery scheme for management costs and biological assessments.

**(34)** Program and industry protocols must allow for adaptability as new information is learned about the industry resource and management strategies.

**(35)** Before a fishery transitions into limited entry, it must work with the DFP to develop a fishery management plan.

**(36)** The creation of an association of statewide bay clam fishery fishermen could provide an opportunity for fishermen to discuss developmental issues such as biological information needs and market development outside of Developmental Fisheries Board (DFB) meetings. These discussions would allow fishermen to address issues prior to DFB meetings and prepare to articulate their ideas or concerns to the DFB. An association chairman should be appointed by the fishermen to facilitate these meetings.

**(37)** The creation of a Web-based clearinghouse for information on potential funding sources and partners for stakeholders of fisheries within DFP could prove useful and easily accessible and updated. Links to important Web sites with information about proposal writing could be of great use to stakeholders in pursuit of funding.

## 5.2 Summary and Conclusions

As a newly-transitioned fishery from "developmental" status (under the management of Oregon's Developmental Fisheries Program) to "developed" limited entry, the Oregon commercial dive bay clam industry faces new challenges and opportunities in science, management, and economic development. The future expansion and success of Oregon's commercial bay clam dive industry depends on the actions taken over the next few years. Key science and management challenges of the industry include 1) out-dated and incomplete bay clam resource stock assessments and limited ecological and biological understanding of the resource, 2) mechanical harvest restrictions in all but two Oregon bays (restricting the development of low cost harvesting techniques), 3) the lack of a comprehensive management plan, 4) inadequate market development, 5) harvest levels below optimal yield (OY), 6) insufficient water quality monitoring, and 7) limited research and management funding.

This report provides a synthesis of political, social, and scientific information regarding the current status and future potential of the Oregon bay clam commercial fishery. Many topics of this report overlap, demonstrating the complexity and interconnectedness inherent to resource and fishery management. Cost-effective and cooperative management strategies are the foundation for the structure of the report and its recommendations, and they are fundamental concepts underpinning each section. In addition to a synthesis, this study provides a variety of economic and management scenarios for the industry in order to demonstrate to the State and the industry its economic potential while ensuring its sustainability. A key purpose of this report is to provide a framework for developing and implementing a bay clam fishery management plan.

This study finds that small-scale fishery management does not necessarily require less work and funding than that of large-scale fishery management. In order to develop a comprehensive fishery management plan for a small-scale fishery like the Oregon bay clam industry, managers must still address multiple fishery resource-use issues, yet with the burden of inadequate financial resources. Thus, creative and cooperative management systems are essential to the successful management of small-scale fisheries.

Inherently, small-scale fisheries must contend with the issue of public goods. This report discusses the impact of harvest on the public good known as “water quality” and what that means for the public and industry economically. Once a particular level of harvest occurs, what is the marginal value of removing another bay clam in regards to its affect on water quality? Several questions regarding the ecological value of Oregon bay clams need to be addressed to ensure rational resource management, and achieve an optimal balance of public good, commercial, and recreational benefits to all user groups of the State.

The question of “who pays?” is raised several times throughout this report. The importance of addressing financial responsibility for fisheries management cannot be understated. Who pays for repeated water quality testing? Who pays for regular bay clam resource stock assessments? The State (the public)? The industry? Securing sufficient, long-term funding is essential to achieving successful fisheries management and covering its myriad ongoing costs. Funding sources and options may range from industry cost recovery to NGO partnerships.

A lack of inter-agency coordination and cooperation complicates the handling of regulatory details. The Oregon Department of Fish and Wildlife (ODFW) and the Oregon Department of Agriculture (ODA) should focus on more cooperative management of small-scale fisheries. Complicated and intense regulatory frameworks create challenges for managing small fisheries and developing successful management institutions that comply with numerous regulations.

The development of industry assets will encourage fishermen participants to coalesce. Lacking the transferability characteristic, however, bay clam fishery property rights are not as valuable. Assigning transferability in 2006 is important for the advancement of the commercial bay clam fishery.

Mixed-species fisheries, such as the commercial bay clam industry, are more complicated to track for sustainable catch than single-species fisheries (Edwards 2000). This is due to factors such as ecological variability, distribution of species, rates of productivity, and changes in abundance. The challenge of balancing catch with quota for a mixed-species fishery is an important issue for this industry in the long-term.

## Literature Sources


**Alaska Department of Fish and Game.** URL, http://www.adfg.state.ak.us/ (Accessed on 11/15/2005)

**Anderson, J.** 2002. Aquaculture and the future: why fisheries economists should care. Marine Resource Economics 17: 133-151.

**Arbuckle, M. and K. Drummond.** 2000. Evolution of self-governance within a harvesting system governed by individual transferable quota. In: Shotton, R. (Ed.), Use of property rights in fisheries management, FAO Fisheries Technical Paper 404/2. Rome, pp. 370-382.

**Arnason, R., R. Hannesson, and W. E. Schrank.** 2000. Costs of fisheries management: the cases of Iceland, Norway and Newfoundland. Marine Policy 24(3):233-244.

**Bradbury, A., B. Sizemore, D. Rothaus, and M. Ulrich.** 2000. Stock assessment of subtidal geoduck clams *(Panopea abrupta)* in Washington. Fish Management Division, Marine Resources Unit. 59pp.

**Brink, L. A.** 2001. Mollusca: Bivalvia. In: Shanks, A. L. (Ed.) An Identification Guide to the Larval Marine Invertebrates of the Pacific Northwest. Corvallis: Oregon State University Press., pp. 129-149.

**Burke, P. M.** 2004. Oregon Department of Fish and Wildlife-Marine Resources Program. Marine Resources Program.

**Callaway, C. C., and M. N. Josselyn.** 1992. The introduction and spread of smooth cordgrass (*Spartina alterniflora*) in South San Francisco Bay. Estuaries 15: 218-226.

**Castillo, G. C., P. A. Rossignol.** 2000. Absence of Overall Feedback in a Benthic Estuarine Community: a system potential buffered from impacts of biological invasions. Estuaries 23: 275-291.

**Challenger Scallop Enhancement Company Limited.** June 2005. Southern Scallop Fishery Draft Fisheries Plan. Nelson, New Zealand.

**Coan, E. V., et al.** Bivalve Seashells of Western North America: Marine Bivalve Mollusks from Arctic Alaska to Baja California. The Santa Barbara Museum of Natural History, 2000.

**Coleman, F. C., W. F. Figueira, J. S. Ueland, L. B. Crowder.** 2004. The Impact of United States Recreational Fisheries on Marine Fish Populations. Science 305:1958-1960.

**Cox, A.** 2000. Cost recovery in fisheries management: the Australian experience. ABARE Conference Paper. URL, http://oregonstate.edu/dept/IIFET/2000/papers/cox2.pdf (Accessed on 8/23/2005)

**Dambacher, J. M., H. W. Li, P. A. Rossignol.** 2003. Qualitative predictions in model ecosystems. Ecological Modelling 161:79-93.

**Dambacher, J. M., H.-K. Luh, H. W. Li, P. A. Rossignol.** 2003. Qualitative stability and ambiguity in model ecosystems. The American Naturalist 161:876-888.

**Dame, R. F.** Bivalve Filter Feeders in Estuarine and Coastal Ecosystem Processes. New York: Springer-Verlag, 1993.

**Developmental Fisheries Board.** 2004/2005 meetings.

**Dore, I.** Shellfish: A Guide to Oysters, Mussels, Scallops, Clams and Similar Products for the Commercial User. New York: Van Nostrand Reinhold, 1991.

**Eckert, G. L.** 2003. Effects of the planktonic period on marine population fluctuations. Ecology 84(2): 372-383.
**Edwards, M.** 2000. The administration of fisheries managed by property rights. In: Shotton, R. (Ed.), Use of property rights in fisheries management, FAO Fisheries Technical Paper 404/1. Rome, pp. 75-88.
**Emmett, R., S. L. Stone, S. A. Hinton, and M. E. Monaco.** 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries. Volume II: Species life history summaries. Strategic Environmental Assessments Division. 329pp. ELMR Rep. No. 8. NOAA/NOS.
**Fisheries Western Australia.** November 1999. Developing New Fisheries in Western Australia: A guide to applicants for developing fisheries. Perth, Western Australia.
**Food and Agriculture Organization of the United Nations (FAO).** February 2005. FAO FishCode-STF-SEAFDEC Regional Workshop on the Improvement of Fishery Data and Information Collection Systems. URL, http://www.fao.org/figis/servlet/static?xml=STF_proj.xml&dom=org&xp_nav=4,1,1 (Accessed on 9/15/2005)
**Gerritsen, J., A. F. Holland, and D. E. Irvine.** 1994. Suspension-feeding bivalves and the fate of primary production: An estuarine model applied to Chesapeake Bay. Estuaries 17(2): 404-416.
**Golden, J. T., et al.** A Biological Inventory of Benthic Invertebrates in Tillamook Bay. Oregon Department of Fish and Wildlife, Marine Resources Program. 1998.
**Gosling, E.** Bivalve Molluscs: Biology, Ecology and Culture. Oxford: Fishing New Books, 2003.
**Grafton, R. Q. et al.** 2005. Incentive-based approaches to sustainable fisheries. Economics and Environment Network Working Paper, Australian National University. EEN0501.
**Grantham, B., G. L. Eckert, and A. L. Shanks.** 2003. Dispersal potential of marine invertebrates in diverse habitats. Ecological Applications 13(1): S108-S116.
**Green, E. P., Mumby, P.J., Edwards, A. J., Clark, C. D.** 2000. Remote sensing handbook for tropical coastal management. Coastal Management Sourcebooks 3. UNESCO, Paris.
**Griffin, K. F.** 1995. Identification and distribution of subtidal and intertidal shellfish populations in Tillamook Bay, Oregon. Mater's project report. Oregon State University.
**Hancock, D. R., T. F. Gaumer, G. B. Willeke, G. P. Robart, and J. Flynn.** 1979. Subtidal clam populations: Distribution, abundance, and ecology. Oregon State University Sea Grant Program. ORESU-T-79-002.
**Hart, D. R.** 2003. Yield- and biomass-per-recruit analysis for rotational fisheries, with an application to the Atlantic sea scallop (*Placopecten magellanicus*). Fish.Bull. 101: 44-57.
**Hilborn, R. and C. J. Walters.** Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Boston: Kluwer Academic Publishers, 1992.
**Jessup, C. M. et al.** 2004. Big questions, small worlds: microbial model systems in ecology. Trends in Ecology and Evolution. In review.
**Joergensen, C. B.** 1990 Bivalve filter feeding: Hydrodynamics, bioenergetics, physiology and ecology. Olsen and Olsen, Fredensborg (Denmark). 140pp.
**Johnson, John A.** Clam Digging and Crabbing in Oregon. Waldport: Adventure North Publishing Co., 1990.

**Kalo, J. J., R. G. Hildreth, A. Rieser, D. R. Christie, and J. L. Jacobson.** Coastal and Ocean Law: Cases and Materials. Second Edition. St.Paul: West Group, 2002.
**Krause, G., M. Bock, S. Weiers, and G. Braun.** 2004. Mapping Land-Cover and Mangrove Structures with Remote Sensing Techniques: a contribution to a synoptic GIS in support of coastal management in North Brazil. Environmental Management 34: 429-440.
**Levin, L. A., and J. Hewitt.** 1998. Macrobenthos of *Spartina foliosa* (Pacific cordgrass) salt marshes in Southern California: community structure and comparison to a Pacific mudflat and a *Spartina alterniflora* (Atlantic smooth cordgrass) marsh. Estuaries 21: 129-144.
**Levins, R.** 1966. The strategy of model building in population biology. American Scientist 54:421-431.
**Marine Fish Conservation Network, The.** Individual Fishing Quotas: Potential and Risk. URL, http://www.conservefish.org/site/capitolhill/ifqbrochure-final-lowres.pdf (Accessed on 2/25/2005)
**Metcalfe, R. J.** 2003. Klam King Clams. Enterprise description (grey literature).
**Meyhofer, E.** 1985. Comparative pumping rates in suspension-feeding bivalves. Mar Biol 85: 137-142.
**National Marine Fisheries Service.** May 2004. B. Stock Assessment for Atlantic Sea Scallops *(Placopecten magellanicus)*. Northeast Fisheries Science Center, National Marine Fisheries Service. Woods Hole, MA. 125p.
**National Research Council.** Cooperative Research in the National Marine Fisheries Service. Washington, DC: The National Academy Press, 2004.
**NSW Department of Primary Industries.** URL, http://www.dpi.nsw.gov.au/fisheries (Accessed on 10/26/2005).
**Newell, C. R.** 1991. The soft-shell clam *Mya arenaria* (Linnaeus) in North America. In: Menzel, W. (Ed.), Estuarine and Marine Bivalve Mollusk Culture. Boca Raton: CRC Press, Inc., pp. 1-10.
**NOAA Fisheries.** URL http://www.nmfs.noaa.gov/ (Accessed on 11/02/2005)
**North Carolina Division of Marine Fisheries, The.** August 2001. North Carolina hard clam fishery management plan. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. Morehead City, NC. 158p.
**Nunes, J. P. et al.** 2003. A model for sustainable management of shellfish polyculture in coastal bays. Aquaculture 219: 257-277.
**Oregon Department of Fish and Wildlife (ODFW).** 2004. Review of Commercial Bay Clam Dive Fishery and Regulations. Marine Resources Program.
**Oregon Department of Fish and Wildlife (ODFW).** 2005. Oregon's Nearshore Marine Resources Management Strategy (Draft). Marine Resources Program.
**Ortiz, M.** 2003. Qualitative modeling of the kelp forest of *Lessonia nigrescens* Bory (Laminariales: Phaeophyta) in eulittoral marine ecosystems of the south-east Pacific: an approach to management plan assessment. Aquaculture. 220:423-436.
**Ortiz, M., and M. Wolff.** 2002. Application of loop analysis to benthic systems in northern Chile for the elaboration of sustainable management strategies. Marine Ecology Progress Series. 242:15-27.
**Pacific Fisheries Information Network (PacFIN).** 2005. Data provided through The Research Group. Corvallis, Oregon.

**Peterson, B. J. and K. L. Heck Jr.** 1999. The potential for suspension feeding bivalves to increase seagrass productivity. Journal of Experimental Marine Biology and Ecology 240:37-52.
**Pikitch, E. K., et al.** 2004. Ecosystem-Based Fishery Management. Science 305:346-347.
**Pomeroy, R.** 2005. Fisheries co-management: a fact sheet for Connecticut fishermen. Connecticut Sea Grant Extension.
**RaLonde, R.** 1996. Paralytic Shellfish Poisoning: The Alaska Problem. Marine Resources 8. URL, http://72.14.203.104/search?q=cache:L1E3IZcidngJ:www.uaf.edu/seagrant/issues/PSP/PSP.pdf+How+Toxic+are+Alaska%27s,+clam&hl=en&gl=us&ct=clnk&cd=2 (Accessed on 11/06/2005)
**Rhode Island Division of Fish and Wildlife, The.** August 2004. Rhode Island Fisheries Stock Status, An Overview 2004. The Rhode Island Division of Fish and Wildlife. Jamestown, RI. 21p.
**Riisgard, H. U.** 2001. On measurement of filtration rates in bivalves – the stony road to reliable data: review and interpretation. Mar Ecol Prog Ser 211: 275-291.
**Robinson, A. M. and W. P. Breese.** 1982. The spawning season of four species of clams in Oregon. Journal of Shellfish Research 2(1):55-57.
**Robinson, S. M. C.** 1995. Clam enhancement trails in the Bay of Fundy. URL, http://www.mar.dfo-mpo.gc.ca/science/review/e/pdf/clam_enhancement.pdf (Accessed on 9/01/2005)
**Roegner, G. C., D. A. Armstrong, B. M. Hickey, A. L. Shanks.** 2003. Ocean distribution of Dungeness crab megalopae and recruitment patterns to estuaries in southern Washington State. Estuaries 26: 1058-1070.
**Sayce, K.** 1988. Introduced cordgrass, *Spartina alterniflora* Loisel in saltmarshes and tidelands of Willapa Bay, Washington. USFWS contract #FWSI-87058 (TS).
**Scott, A.** 2000. Moving through the narrows: from open access to ITQs and self-government. In: Shotton, R. (Ed.), Use of property rights in fisheries management, FAO Fisheries Technical Paper 404/1. Rome, pp. 105-117.
**Shanks, A. L. and L. Brink.** 2005. Upwelling, downwelling, and cross-shelf transport of bivalve larvae: test of a hypothesis. Mar. Ecol. Prog. Ser. 302: 1-12.
***Spartina* Management Plan for Willapa Bay, 2001.** URL, http://www.willapabay.org/~coastal/nospartina/control_program/mgmtplans/2001WillapaBay.pdf (Accessed on 11/20/2004)
**Spear, H. S.** 1953. Green crab studies at Roothhay Harbor, Maine. Pages 48-52 in Proc. 4th Annu. Conf. Clam Res., Maine Dep. Sea and Shore Fish., Boothbay Harbor.
**Talley, T. S., and L. A. Levin.** 2001. Modification of sediments and macrofauna by an invasive marsh plant. Biological Invasions 3: 51-68.
**Taylor, P. J.** 2000. Socio-ecological webs and sites of sociality: Levins' strategy of model building revisited. Biology and Philosophy. 15(2):197-210.
**"The Tragedy of the Oceans,"** The Economist, 19 March 1994, pp. 23-25.
**Underwater Harvesters Association.** URL, http://www.geoduck.org/ (Accessed on 10/26/2005)

**U.S. Commission on Ocean Policy (USCOP)**. 2004. Preliminary Report of the U.S. Commission on Ocean Policy, Governor's Draft. (U.S. Commission on Ocean Policy, Washington, DC, April 2004).
**Washington Department of Fish and Wildlife.** December 2002. Bivalve Region 8 Management Plan for 2003. URL, http://www.pnptc.org/PNPTC_Web_data/Publications/Management_Plans/2003_Plans/Region_8_Bivalve_Finl.doc (Accessed on 1/20/2005)
**Washington State Department of Natural Resources.** May 2001. The State of Washington Commercial Geoduck Fishery Management Plan. DNR Aquatic Resources Division, WDNR. Available from Department of Natural Resources, Seattle.
**Washington State Department of Natural Resources.** URL, http://www.dnr.wa.gov/htdocs/adm/comm/fs04_176.htm (Assessed on 3/01/2005)
**Welch, W. R.** 1969. Changes in abundance of the green crab, *Carinus maenas* (L.), in relation to recent temperature changes. U.S. Fish Wildl. Serv., Fish. Bull. 67:337-345.
**Western Aquatic Plant Management Society.** URL, http://www.wapms.org/plants/spartina.html (Accessed on 11/20/2004)
**Willapa Bay.** URL, http://www.willapabay.org/~coastal/nospartina/ (Accessed on 10/20/2004)
**Woods Hole Oceanographic Institution (WHOI) Sea Grant Program.** URL, http://www.whoi.edu/seagrant/education/bulletins/clam.html (Accessed on 11/14/2005)
**Yamada 2003 – Introduced Species in Oregon Estuaries.** URL, http://science.oregonstate.edu/~yamadas/ (Accessed on 11/05/2004)

**Personal Communications** (cited within report and listed alphabetically)
Doug Alm (fisherman), 2005
Alex Bradbury – (Recreational shellfish management, WDFW), 2005 and 2006
Ralph Brown (Curry County Commissioner), 2005
Deb Cannon (ODA), 2005
Tony D'Andrea (OSU), 2006
Ted DeWitt (EPA), 2005
Vladlena Gertseva (OSU), 2005
Robert Goodwin – (WA Sea Grant Program at UW; School of Marine Affairs), 2005
Michael Harte (OSU – MRM), 2005
Matt Hunter (current ODFW Estuary and Shellfish Project Leader), 2005
John Johnson (former ODFW Estuary and Clam Specialist), 2005
Richard Langan – (CINEMAR/CICEET, University of New Hampshire), 2005
Jean McCrae (ODFW), 2005
Robert Metcalfe (fisherman), 2005
Richard Methot (NOAA Fisheries), 2005
Heather Munro Mann (DFP), 2004 and 2005
David Roach (Massachusetts Division of Marine Fisheries), 2006
Phil Rossignol (OSU), 2005
David Sampson (OSU and COMES), 2005
Bob Sizemore (WDFW), 2005
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David Whittaker (Massachusetts Division of Marine Fisheries), 2006

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Onno Husing (OCZMA), 2005
Sans Miles (fisherman), 2005
Steve Rumrill (South Slough NERR), 2005
Nathan Schumaker (EPA), 2005
Grant Thompson (NOAA Fisheries), 2005
Terry Thompson (Lincoln County Commissioner), 2004
Mitch Vance (ODFW), 2005
Brett Wiedoff (ODFW), 2005
Georgia York (OCZMA), 2005

# Appendix

**Bay Clam Biologies and Life Histories**

**Cockle Clam (*Clinocardium nuttalli*)**

Source: http://whatcomshellfish.wsu.edu/shellfish_harvesting.htm (Accessed on 8/29/2005)

Shell: Whitish to brown shell, sometimes mottled; eminent radial ribs, distinct from other OR bay clams.
Size: Length up to 12cm; average length 5-9cm
Ecology/Habitat: Found in substrates ranging from muddy to rocky mixtures; burrow to shallow depths of only 15cm, or found on surface of substrate. Intertidal and subtidal; high abundances at mouths of bays. Found coastally on beaches and to depths of 110fm. Prefer high salinities.
Feeding: Suspension feeder
Predators: Sea stars, birds, and humans. Larvae may fall prey to other suspension feeders and fish.
Generation time: 2 years
Reproduction: Separate sexes (male and female) spawn by releasing sperm and eggs into the water column (broadcast spawning).
Longevity: 15 years
Range: San Diego, CA to Bering Sea; also found in Japan.

**Gaper Clam (*Tresus capax*)**

Source: http://www.nwmarinelife.com/htmlswimmers/t_capax.html (Accessed on 8/29/2005)

Shell: Chalky white shell with brown, flaking periostracum and smooth concentric rings.
Size: Length up to 25.5cm; average length 10-13cm
Ecology/Habitat: Prefer muddy to fine sand substrates; burrow to depths of 61cm. Intertidal and subtidal; found in high abundances at mouths of bays.
Feeding: Suspension feeder
Predators: Sea stars, crabs, birds, drilling gastropods, and humans. Larvae may fall prey to other suspension feeders and fish.
Generation time: 3-4 years
Reproduction: Separate sexes (male and female) spawn by releasing sperm and eggs into the water column (broadcast spawning). Spawning occurs primarily from late January through April.
Longevity: 16 years
Range: San Francisco, CA to Kodiak, AK

**Littleneck Clam (*Venerupis staminea*)**

Source: http://whatcomshellfish.wsu.edu/shellfish_harvesting.htm (Accessed on 8/29/2005)

Shell: Light-colored shell (whitish or sometimes a little darker); both radial and concentric rings, distinct from other OR bay clams.
Size: Length up to 8cm
Ecology/Habitat: Found often in coarse sand mixed with small rocks in the intertidal, but range from mud to cobble sediments, and to depths of 20fm. Prefer high salinities (greater than 30ppt).
Feeding: Suspension feeder
Predators: Birds, drilling gastropods, and humans. Larvae may fall prey to other suspension feeders and fish.
Generation time: 1.5 years
Reproduction: Separate sexes (male and female) spawn by releasing sperm and eggs into the water column (broadcast spawning). Spawning occurs primarily from March through August.
Longevity: 10-16 years
Range: Socorro Islands, Mexico to Aleutian Islands, AK

**Butter Clam (*Saxidomus giganteus*)**

Source: http://whatcomshellfish.wsu.edu/shellfish_harvesting.htm Accessed on 8/29/2005)

Shell: Whitish shell, or sometimes dark blue or black; close, irregular-sized concentric ribs.
Size: Length up to 12.5cm; average length 7.5-10cm
Ecology/Habitat: Live in a wide variety of substrates; prefer a porous mixture of sand, mud, and broken shell/small rocks.
Feeding: Suspension feeder
Predators: Birds, fishes, drilling gastropods, and humans. Larvae may fall prey to other suspension feeders and fish.
Generation time: 3-4 years
Reproduction: Separate sexes (male and female) spawn by releasing sperm and eggs into the water column (broadcast spawning). Spawning occurs primarily from February to July.
Longevity: 10-20 years

Range: Monterey, CA to Aleutian Islands, AK

**Softshell Clam (*Mya arenaria*)**


Source:
http://www.biopix.dk/Species.asp?Language=de&Searchtext=Mya%20arenaria&Category=Bloeddyr
(Accessed on 8/29/2005)

Shell: Brittle white shell with grey or darker periostracum and smooth concentric ribs.
Size: Length up to 12.5cm; average length 5-10cm
Ecology/Habitat: Very adaptable and tolerant of extreme anaerobic conditions as well as pollution and low salinity. Live on and in intertidal flats of upper estuaries.
Feeding: Suspension feeder
Predators: Terrestrial animals, birds, and humans. Larvae may fall prey to other suspension feeders and fish.
Generation time: 2-5 years
Reproduction: Separate sexes (male and female) spawn by releasing sperm and eggs into the water column. Spawning occurs once or twice annually, typically in spring and early fall (sometime between March and September). Larvae may disperse successfully greater than 10km.
Longevity: 10-20 years
Range: San Diego, CA to Vancouver Island, BC; introduced specie of West Coast US; native to East Coast US and Europe.

**10-Year Landing, Price, and Revenue Trends of Oregon and Washington Clams**

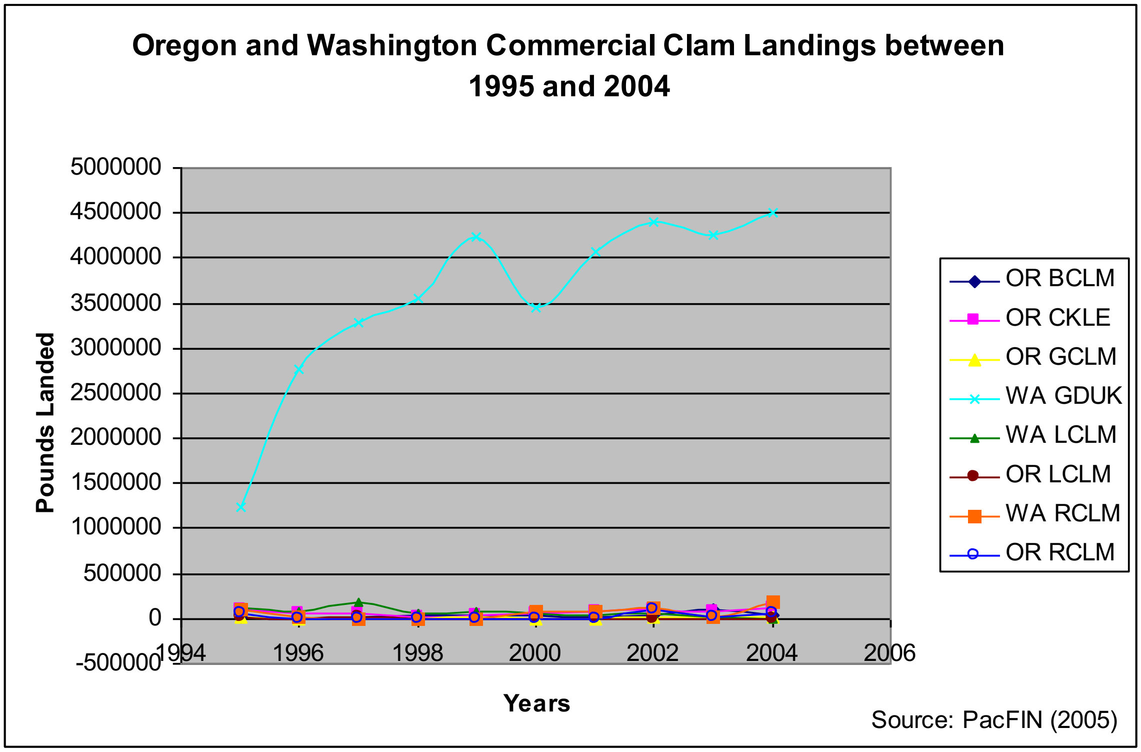


**Figure 1X.** Oregon and Washington Commercial Clam Landings between 1995 and 2004. Data Source: PacFIN.

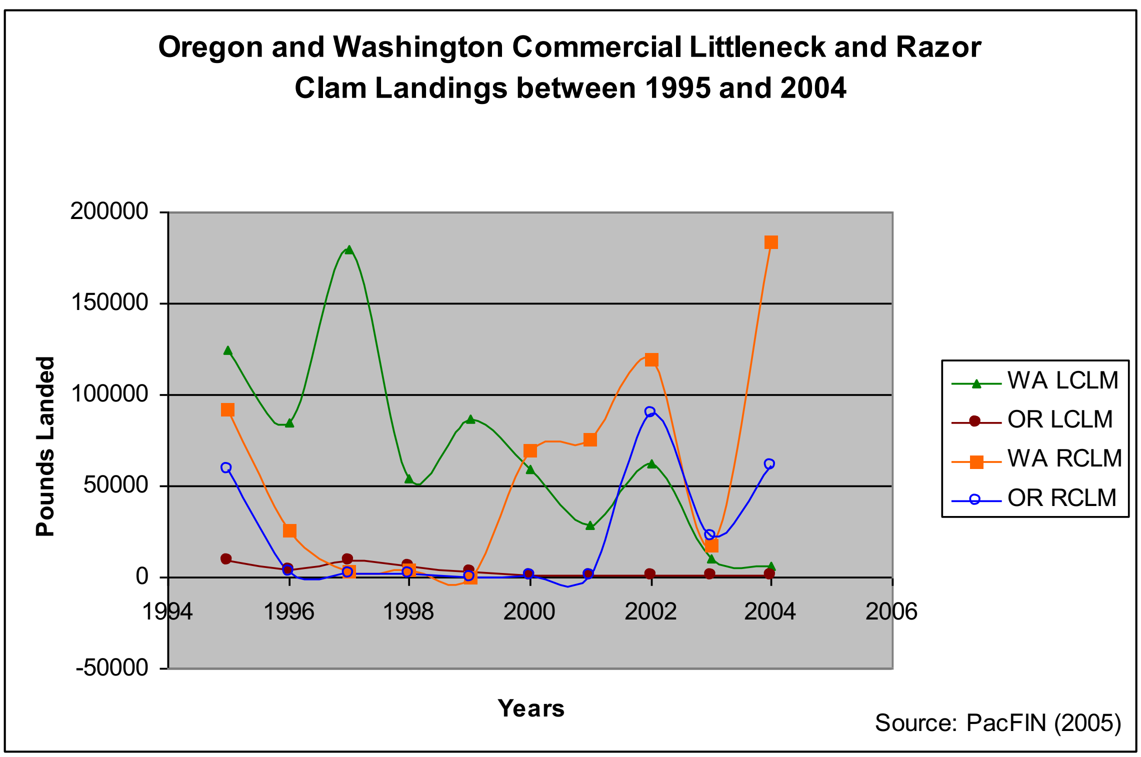

**Figure 2X.** Oregon and Washington Commercial Littleneck and Razor Clam Landings between 1995 and 2004. Note that razor clams are not a bay clam species. Data Source: PacFIN.

The well-established human consumption market for Washington geoducks in the US and abroad, primarily Asia, commands very high prices per pound for these clams relative to the other graphed species (see Figure 3X). Oregon razor clams are the second to highest priced commercial clams in Oregon and Washington. In 1999, Washington beach closures for domoic acid resulted in a zero price value for razor clams.

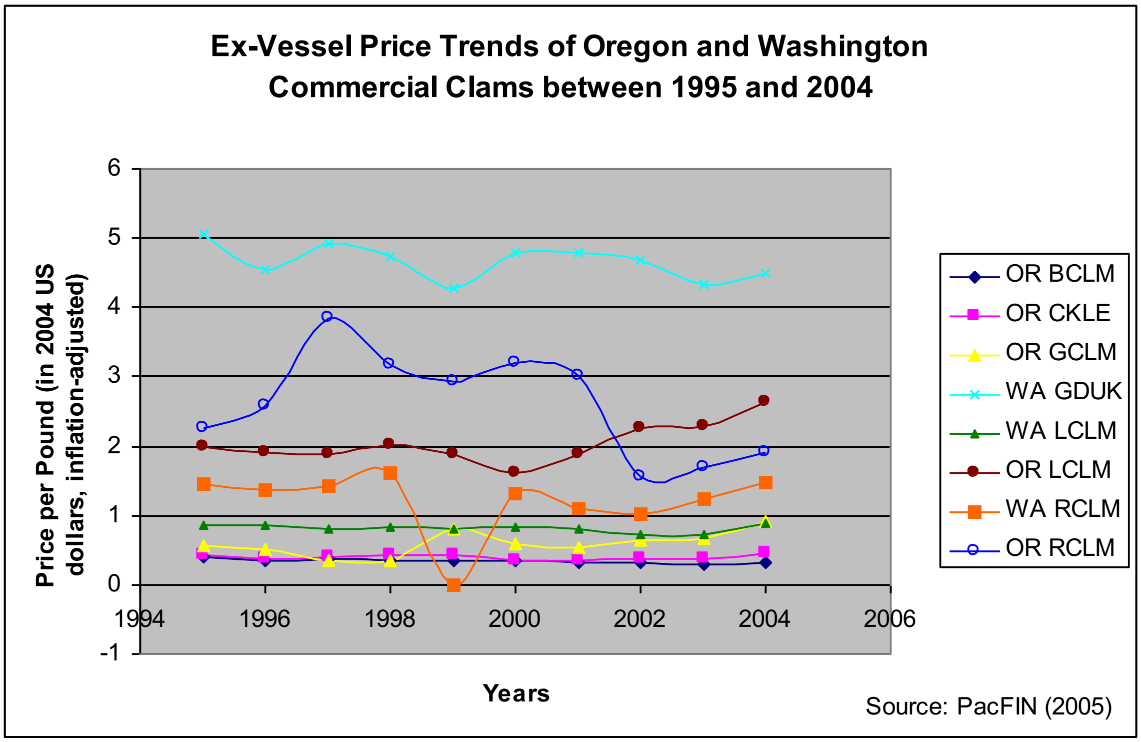


**Figure 3X.** Ex-Vessel Price Trends of Oregon and Washington Commercial Clams between 1995 and 2004. BCLM = butter clam, CKLE = cockle clam, GCLM = gaper clam, GDUK = geoduck, LCLM = littleneck clam, RCLM = razor clam. Softshell clams are not included in this graph due to low and inconsistent commercial landings during the years 1995-2004. California's commercial landings of bay and razor clams are too low to illustrate in this graph; moreover, any reported landings of these species from California are likely bycatch by non-target fisheries. Data Source: PacFIN.

Oregon littleneck prices typically fall between Oregon and Washington razor clam prices, and often more than double Washington littleneck prices (see Figure 4X).

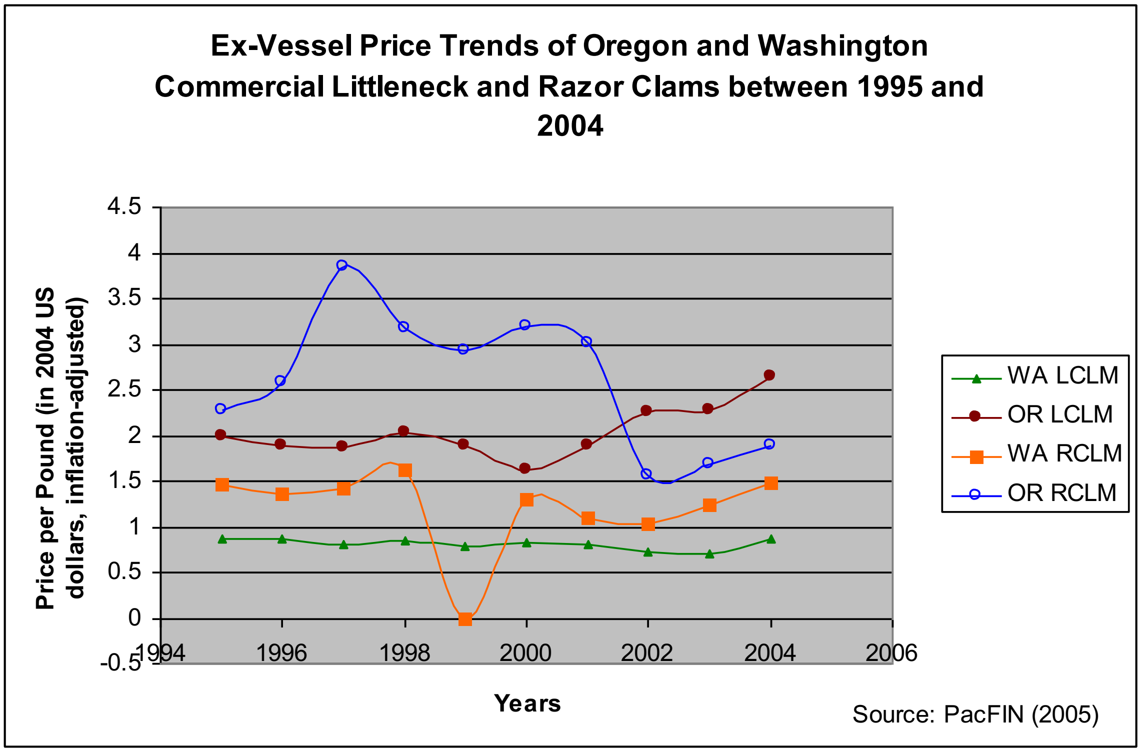


**Figure 4X.** Ex-Vessel Price Trends of Oregon and Washington Commercial Littleneck and Razor Clams between 1995 and 2004. LCLM = littleneck clam and RCLM = razor clam. Note that razor clams are not a bay clam species. Data Source: PacFIN.

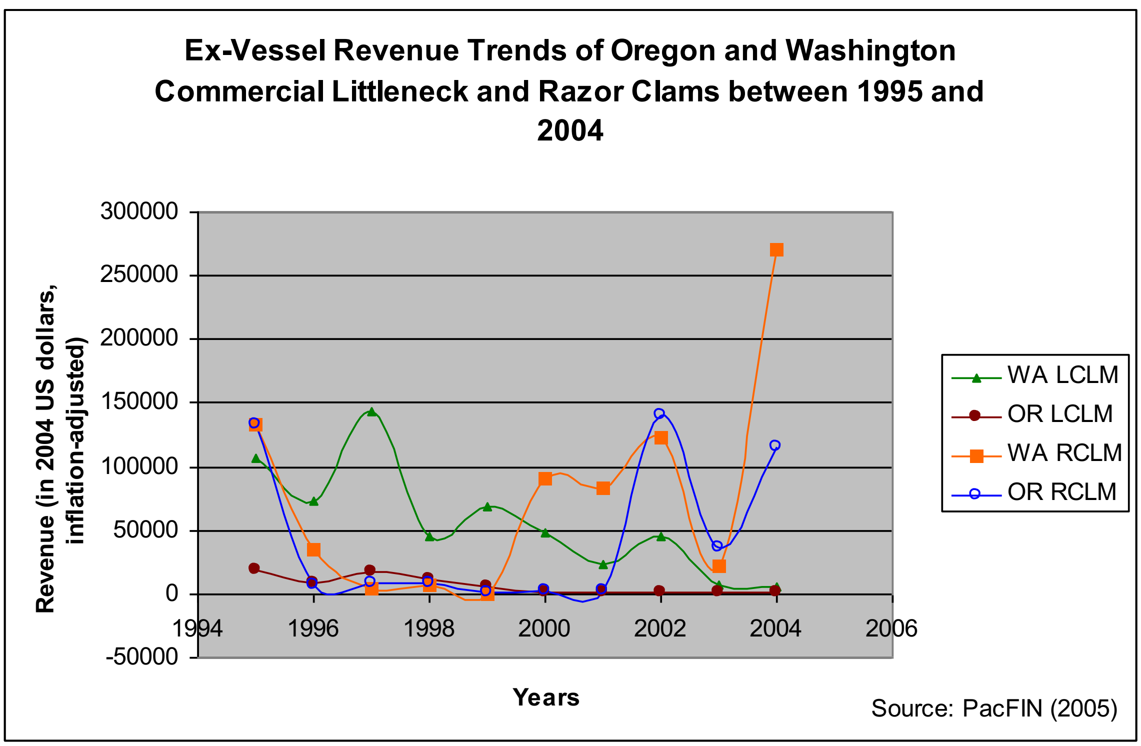

**Figure 5X.** Ex-Vessel Revenue Trends of Oregon and Washington Commercial Littleneck and Razor Clams between 1995 and 2004. Note that razor clams are not a bay clam species. Data Source: PacFIN.

## Developmental Fisheries Permits

Example Developmental Fisheries Permit (coast-wide) for 2005:

Under the authority of OAR's 635-05-0016, 635-06-900, and 635-06-020 the F/V Breanna (Doc. No. OR537YP ) is authorized to harvest and land cockle, butter, gaper, native littleneck, or softshell clams from Oregon estuaries using mechanical gear. This permission is subject to the following provisions:

1. The permit is not transferable and must be readily available during harvest and sale of catch.

2. A legible log of catch (target and incidental), effort, area of catch, and other information as required in the instructions must be recorded on the logbook provided by the Department. Log information is to be entered before off loading of clams is completed. Log sheets are to be returned to an ODFW office within 10 days past the end of each month clams are harvested.

3. ODFW observers shall have the opportunity to be on board the harvest vessel at the option of the Department for the purposes of collecting scientific data on the catch.

4. The Department shall have the opportunity to collect biological data from the harvest allowed under the permit.

5. Size Limit: The minimum size limit for cockle clams is 2 1/4 inches and 4 inches for gaper clam.

6. Annual Quotas: In **Netarts Bay**, there is an annual quota of 8,000 pounds for cockle clams. In **Tillamook Bay**, the annual quotas are: 90,000 pounds for cockle clams, 200,000 pounds for butter clams, 55,000 pounds for gaper clams, and 20,000 for native littleneck clams. In **Coos Bay**, the annual quotas are: 4,000 pounds for cockle clams, 3,000 for butter clams, 5,000 pounds for gaper clams, and 500 lbs for native littleneck clams.

7. Gear restrictions: Bay clams must be harvested subtidally using dive gear by hand or hand powered tools. Except, mechanical gear is allowed in Tillamook and Coos Bays with the following restrictions. Mechanical gear is restricted to the use of a hand-held, manually operated water jet or "stinger"controlled from under water by the diver, with a nozzle no larger than 3/4 inches inside diameter. The mechanical gear may not be powered by a pump larger than 5.5 horse power .

8. Not more than 2 divers operating from any one boat may be in the water at the same time and no more than 2 persons without permits may be on board.

9. Area restrictions: Open areas are subject to closures by Oregon Department of Agriculture.
   In **Tillamook Bay**, the following areas are closed to the commercial harvest of clams:
   1) the" Ghost Hole"-from the floating toilet site, south to Sandstone Point and 500 feet westward from the Highway 101 shoreline;
   2) the area east of a line connecting the Coast Guard tower on the north jetty and buoy marker 13; and
   3) an area 100 feet around and including the recreational clam harvest area near Kincheloe Point.

   In **Netarts Bay**, the following areas are closed to the commercial harvest of cockle clams:

1) an area extending 500 feet to the north adjacent to OSU's shellfish reserve and across the entire width of the bay; and

2) Commercial harvesters will avoid areas of heavy recreational harvest.

In **Coos Bay**, dive harvest must occur in depths greater than 10 feet from mean lower low water. The area of South Slough east of the Charleston bridge is closed to subtidal harvest.

The following estuarine areas are closed to the commercial harvest of bay clams: All state parks south of Tillamook Head, Netarts Bay (except for the harvest of cockles), Little Nestucca Bay, Big Nestucca Bay, Salmon River & Bay, Siletz River & Bay, South Slough National Estuarine Sanctuary (Coos Bay) and shellfish reserves in Netarts and Yaquina bays.

10. By-catch limits: All catch other than bay clams must be returned to the water immediately.

11. Seasons: The open season for gaper clams is July 1 through December 31, except an incidental catch allowance of one gaper for every eight butter clams, or 25 pounds of gaper clams per 100 pounds of butter clams, whichever allows the greater gaper clam incidental catch, is allowed from January through June. The open season for other bay clams is all year.

12. Any clams harvested and sold for bait purposes must be visibly dyed with a Department approved dye. Dyeing must occur before the time of docking of the vessel used in harvesting.

13. Clams must be sold within 48 hours of harvest or leaving the digging area, whichever comes last.

14. Renewal of this permit is subject to meeting the minimum annual landing requirements of 5 landings of bay clams from Oregon estuaries of at least 100 pounds each or an annual total of at least 2500 pounds. **In addition, logs of fishing activity must be turned into an ODFW office by December 31.**

15. The permit is subject to revocation for failure to abide by the conditions of the permit, violation of other fishing regulations or other valid reason.

16. The permit expires December 31, 2005.

____________________________ 1/1/05

For Director Date

Oregon Department of Fish and Wildlife

The South-coast Developmental Fisheries Permit is very similar to the coast-wide, but it only authorizes harvest of commercial bay clams from Oregon estuaries south of Heceta Head.

ODFW Oregon dive gear example log sheet:

**OREGON DIVE GEAR LOG**

Mail To:
ODFW
2040 SE Marine Science Dr.
Newport, OR 97365

Permit Holder ______________________

Oregon or Federal
Vessel No. ______________________

Estuary ______________________

Port of Landing ______________________

Buyer ______________________

| Date | Diver | Ave. Depth | Gear: hand | Gear: mechanical | Number of Dives | Down Time (hrs) | Location/Landmark | Species | Species | Species |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Loran or Lat./Lon. | Est. Lbs | Est. Lbs | Est. Lbs |
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Remarks:

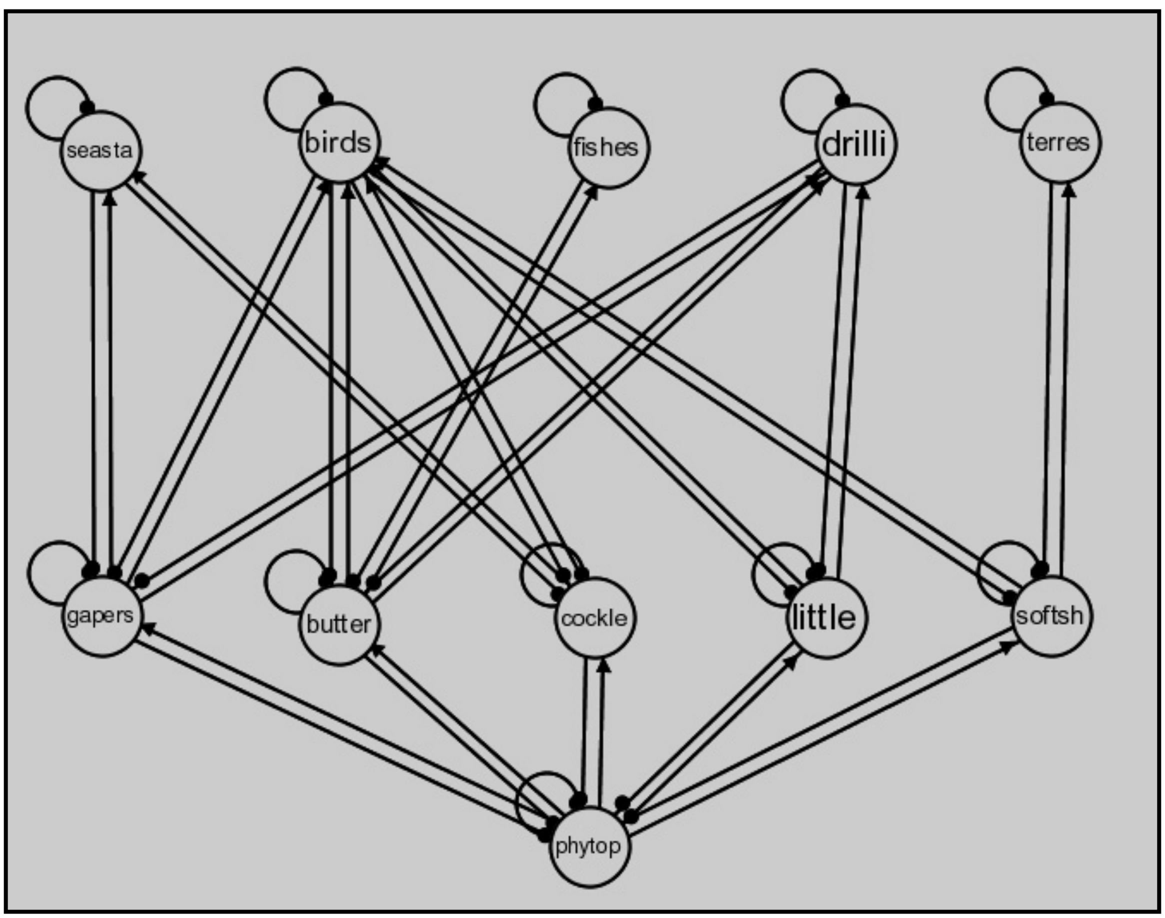
______________________
Signed

## Ecological Modeling

In the design of a qualitative model, simplicity is vital (Ortiz 2003; Rossignol pers com 2005). The more complex a model, the less likely it can be applied to successfully answer an ecological question. Therefore, simplicity within ecological models is fundamental to making stronger predictions for a more general range of questions (Jessup et al. 2004, in review; Rossignol pers com 2005).

Levins (1966) raises the concern that modelers tend to sacrifice qualitative understanding of an ecological system in pursuit of precise measurements of system components, although qualitative understanding of whole ecological systems is essential to the development of rational research questions and the advanced study of ecological system behavior (Dambacher et al. 2003). Dambacher et al. (2003) advocates the use of qualitative models to help progress science's overall understanding of ecological systems more quickly than the lengthy and costly endeavor of quantitatively piecing together a multitude of ecological components.

For cases when biological and ecological information of system components is lacking, qualitative depictions of ecosystem interactions are a cost-effective method to provide financially-limited agencies guidance through complicated resource-use decisions. Given the limited quantified biological data available for Oregon bay clams, it is unrealistic to expect the design of useful quantitative models; however, qualitative models of known predator-prey interactions have the potential to provide important predictions (Dambacher et al. 2003) that may help with tough management decisions.




Model 1. This ecological model was created in PowerPlay and is called a digraph. It depicts a simple bay clam predator-prey system within an Oregon estuary. Beginning at the bottom of the digraph and reading

up from left to right, the eleven system variables are: 1) phytoplankton, 2) gapers (*Tresus capax*), 3) butters (*Saxidomus giganteus*), 4) cockles (*Clinocardium nuttalli*), 5) littlenecks (*Venerupis staminea*), 6) softshells (*Mya arenaria*), 7) seastars, 8) birds, 9) fishes, 10) drilling gastropods, and 11) terrestrial animals. Variable 1 comprises the food source of the five fished bay clam species, variables 2 through 6 comprise the five fished bay clam species, and variables 7 through 11 comprise the known bay clam predators.

Dambacher et al. (2003) show evidence that understanding the structure of a community allows one to "know its theoretical potential for predictability." This suggests the application of qualitative ecological community models as reliability tests for quantitative models and manipulation experiments. Qualitative models may be used to help sift apart quantitative model and experiment accuracies from other study error (Dambacher et al. 2003).

Qualitative modeling demonstrates an alternative scientific mechanism to quantitative models in order to assess and characterize different options for adaptive management under a holistic and incorporative capacity. Yet, it is important to realize the limitations of these qualitative models; they represent unrealistic circumstances because they do not integrate physical aspects into their systems. This is an integrative management challenge that ecosystem based fisheries management (EBFM) continues to address (Kalo et al. 2002; Ortiz 2003; Pikitch et al. 2004; USCOP 2004). Although greater information assimilation is called for by EBFM (USCOP 2004), Ortiz (2003) claims it is a difficult task to integrate these physical factors into qualitative models and maintain system stability.

Nonetheless, by first understanding the species' interactions within a simplified estuarine ecosystem, managers can conservatively add additional parameters to the model. Variables from areas such as economics, politics, and the social sciences should ultimately be woven into these models to enhance the system's intricate extent and develop greater model realism (Taylor 2000; Ortiz 2003). Taylor (2000) suggests that model building is open to negotiation; nothing is off-limits as a potential variable. Dambacher et al. (2003) agree that it is possible to include human-induced variables (e.g., management decisions, social considerations, economic constraints), that may influence the behavior of ecological systems, into qualitative models.

Models with these human-based incorporations may be used to answer important management questions regarding resource conservation in a more holistic way, as called for by EBFM (Kalo et al. 2002; Ortiz 2003; Pikitch et al. 2004; USCOP 2004). For example, in an attempt to protect a resource, an ecosystem model design may include a regulatory agency restricting a fishery from harvesting one particular life stage of the target species. Another version of that model may have the regulatory agency intervening in the survival of juveniles, rather than restricting the fishery from harvest. These two models could be run to determine which management strategy provides the more favorable outcome. These types of human-based interactions within ecological systems are important scenarios to model. Several studies (Castillo and Rossignol 2000; Dambacher et al. 2002; Ortiz and Wolff 2002; Dambacher et al. 2003; Ortiz 2003) demonstrate that the creation and application of qualitative models can be of great use in the study of ecological systems and promoting a more holistic approach to estuarine fishery management.

**Funding Sources**

*Federal*

- Congressional mandates and federal grants
    - The U.S. Commission on Ocean Policy's (USCOP) final 2004 report contained 212 recommendations for facilitating the federal government in the development and implementation of a more thorough and integrated national ocean policy in cooperation with states and local institutions. To achieve these recommendations, the current annual federal funding for NOAA and its partners must more than double.
    - States participating in the Coastal Zone Management Act (CZMA), like Oregon, receive federal grants for their coastal zone management programs. The Coastal States Organization recommends increasing these available grant funds.
        - The CZMA also supports the National Estuarine Research Reserve System (NERRS). Participating estuarine areas, like South Slough of Coos Bay, Oregon, receive federal grants for management-oriented research, coastal data collection and monitoring, and educational outreach purposes.
    - Amendments to the Clean Water Act in 1987 established the National Estuary Program (NEP) as a federal Environmental Protection Agency (EPA) program. Tillamook Bay, Oregon is one of 28 NEPs, established to improve management of water quality and living resources, such as shellfish, within the estuary. NEPs are funded through a varying conglomerate of sources, including EPA funding through Section 320 of the Clean Water Act, EPA funding through non Section 320 funding options (federal grants), federal non-EPA funding, State funding, local funding, and non-governmental funding.
    - National Oceanic and Atmospheric Administration (NOAA) and National Marine Fisheries Service (NMFS) grants
    - National Science Foundation (NSF) research grants

*Regional*

- Pacific Fishery Management Council
    - This council, funded by Congress, is crafted to benefit domestic and foreign fishing within the 200-mile US Exclusive Economic Zone (EEZ).

*State*

- General Fund
    - The General Fund is the principal fund for supporting a state's operations. State taxes generate the revenues for this fund.
- Recreational shellfish license revenues (SB 597)

    - Senate Bill 597 amended the Oregon Revised Statutes (ORSs) regarding recreational licenses for taking shellfish in 2003. ORS 497.121 now grants the Commission authorization to issue residents and nonresidents shellfish licenses for certain fees (e.g., resident annual license, $6.50; nonresident annual license, $16.50; and nonresident three-day license, $9). Monies received by the Commission for the sale of these licenses are deposited in the Marine Shellfish Subaccount and used by the Oregon Department of Fish and Wildlife (ODFW), the Oregon Department of Agriculture (ODA), and the Oregon State Police (OSP) for shellfish-related programs (ORS 496.303).

*Industry (cost-recovery idea)*

- Industry set-aside funds
    - These are industry contributions placed in a trust or account by the industry to accrue interest and grow. Contributions can be deposited into the trust year-round, for instance, by arranging some fraction of industry landing revenue to go directly into the fund.
- Landing taxes
    - These are simply State taxes on industry landings. These taxes should be allocated specifically to address management and research needs.
- Direct industry contributions
    - These are out-of-pocket contributions made by individuals of the industry for the industry. These contributions may be deposited into an industry account to financially mature, or applied directly to a pending industry cost.

*Nongovernmental Organizations (NGOs)*

- Cooperative research
    - Nongovernmental organizations (NGOs) concerned with environmental issues in Oregon may be cooperative research partners.

*Universities*

- Cooperative research
    - Sea Grant, a university-based program of NOAA, promotes institutional collaborations for the improved management of many marine coastal themes, such as fisheries, ecosystems and habitats, and coastal communities and economies. Sea Grant researchers and outreach specialists can provide resource managers with the information and tools for effective management and also offer technical assistance to aid coastal communities.
    - Student involvement at graduate and undergraduate levels

*Indigenous Groups*

- Cooperative research
    - Indigenous groups within Oregon have strong interest in sustaining coastal resources. These groups may be cooperative research partners.

*Community Involvement, Volunteerism, and Tourism*

- Community involvement
  - Community participation occurs through the recreational bay clam fishery. Since the implementation of Senate Bill 597 in 2004, recreational fishermen pay license fees for their permits, and these revenues are deposited into a shellfish fund. Further incorporation of the community through community education events and/or seafood marketing strategies at annual festivals could generate additional support.
- Volunteerism
  - Creel surveys serve as a way to gather recreational fishing data from the community as they dig bay clams from intertidal flats. Community volunteers may help to run these surveys as a community service.
- Tourism
  - Tourists events hosted out of coastal hotels, like coordinated clam digs and clam bakes, may prove a means of gathering more intertidal bay clam data as well as funds for management needs through tourist fees. (See the Stock Assessment section and Marketing section for more information on community involvement, volunteerism, and tourism.)

## Property Right Characteristics

Property rights may be comprised of at least six characteristics: 1) exclusivity, 2) duration, 3) transferability, 4) flexibility, 5) divisibility, and 6) security, or quality of title (Scott 2000). The composition and weight of these characteristics within a property right can be modified to meet different objectives.

The extent of the *exclusivity* feature depends upon the number of fishermen with overlapping portions of their right to the resource. A right has greater exclusivity when fewer fishermen compete for access to the resource. Exclusivity may help create incentives for fishermen to conserve the fishing resource. Those holding the rights may try to coordinate their fishing practices to effectively conserve the resource and maximize yields.

The *duration* characteristic of a property right can influence a fisherman's incentive to make long-term investments. Renewal costs are reduced and uncertainty declines when a right has a fairly permanent duration. Long durations increase the quality of the right and thus the length of a fisherman's investment.

*Transferability* enables efficient fishermen who most-value the right to buy out other fishermen from the industry, thus increasing overall industry efficiency.

*Flexibility* of a right allows fishermen to set personal objectives and structure their operations accordingly.

A *divisibility* attribute allows fishermen to either divide their quota into smaller amounts in order to transfer portions to other fishermen, or it gives fishermen the ability to divide their rights into new, more specified rights.

A high *quality of title* creates incentive for fishermen to invest in the fishery and maintain the industry's overall quality because the right is decided and firmly fixed. This security of rights encourages long-term investments in the fishery.

For more detailed information on these characteristics, see Scott's "Moving through the narrows: from open access to ITQs and self-government" (2000).

**The Pros and Cons of ITQs**
(The Marine Fish Conservation Network, URL)

***Pros:***
-The theory behind ITQs is that once access rights are made more secure, the stewardship of the resource will increase, thereby promoting sustainability of the fish population.
-Fishermen may catch their quota any time during a fishing season, at their own pace.
-Transferability leads to greater economic efficiency of the fishery. If the goal is to maximize economic efficiency, then an ITQ system may be the best choice.
-For ITQs, the TAC is one of the main conservation tools; therefore, stock assessments are performed regularly.

***Cons:***
-A poorly regulated ITQ system could promote "high-grading," a manner by which fishermen discard low-value fish of their target species in order to continue to fish and make a quota with only high-value fish, or other cheating. This is an unlikely scenario for bay clam fishermen in Oregon because they use a very selective harvesting system that allows them to choose the most marketable clams initially.
-Some managers are concerned that ITQ systems may discourage conservation efforts in a fishery because the fishermen are often allocated their quota shares based on the efficiency of their fishing history. The health and vitality of marine ecosystems may be sacrificed by fishermen's fishing practices in order that they meet their quotas. However, because fishermen quotas are proportional to the Total Allowable Catch (TAC), conservation efforts should not be threatened as long as a sustainable TAC is assigned to the fishery.
-The transferability characteristic of an ITQ system allows an industry to attain greater economic efficiency, yet it also raises concerns about the possibility of a monopolized industry when large-scale fishermen or companies buy-out all the available quotas from smaller fishermen entities, and thus threaten the public trust to the resource. The justification of this monopoly concern depends on the fishery. For instance, the reduction of capacity of a fishery does not necessarily mean a monopoly effect is occurring. The distribution of quota ownership among remaining quota holders must be considered. A monopoly effect occurs when one quota holder has exclusive ownership of the resource. If a certain level of ownership is distributed among more than one holder, a monopoly is not occurring. If a fishery management goal is to avoid a monopoly industry, a quota

share cap for any one quota holder should be stipulated in the management plan, and limits on quota allocation discussed.
-Those wanting to enter an ITQ fishery may find it more expensive given the market that is set in place, but easier to actually enter the fishery because of tradability of rights.
-ITQ systems can be complicated and sophisticated systems. They require a well-organized management plan and administration to be carried-out effectively (Harte pers com 2005).
-ITQ systems are more difficult to enforce than some other systems. Greater enforcement means more necessary funding for stronger enforcement plans and more personnel (Harte pers com 2005).
-Some managers are concerned that ITQs inhibit an ecosystem-based approach to fisheries management. However, as long as the appropriate environmental regulations are set and a fishery's TAC accounts for ecosystem constraints, ITQ systems will not hold back ecosystem-based management.
-A strong market is necessary to drive ITQ systems to efficiency.
-Funding and time must be allocated regularly to assessments of the fishery stock biomass.

The surf clam and ocean quahog fisheries off New Jersey have demonstrated that transferable quotas increase the economic efficiency of a fishery and reduce the number of vessels in the fishery. The number of fishing vessels of the surf clam and ocean quahog fisheries declined by 74 and 40 percent, respectively, and the number of shareholders declined by 17 percent for surf clams and 34 percent for ocean quahogs (Edwards 2000).

Edwards (2000) defines the components of an ITQ system to include: 1) sustainability, 2) enforcement, 3) administrative systems (to make sure the catch balances the held quota), 4) allocation of rights (commercial and non-commercial), 5) resource rentals and cost recovery, and 6) economic and social issues.

**Allocation of Rights**

The initial allocation of rights has a high potential for controversy and should be given careful consideration in the design of a rights-based management system (Harte pers com 2005). There are some key questions and objectives to consider when designing an opportune rights allocation system for a fishery.

1) How will rights be delivered to fishermen: sold, given away, or a combination of both? (Currently, ODFW collects an annual fee from bay clam fishermen for them to hold developmental bay clam fishery permits.)
2) For rights that are given away, who is eligible and how is eligibility determined?
3) How are rights allocated after eligibility is determined?
4) Do restrictions condition the rights (e.g., vessel size or gear type)?

Important criteria to consider when determining eligibility are *sustainability, community and social objectives, economic efficiency, and equity*.

A key management objective of fisheries is to sustain stocks. Sustainability objectives should be met through gear restrictions, total allowable catch (TAC) and effort limits, and area and season restrictions – not through the allocation of rights to fishermen.

Unless a community is slightly dependent on or engages in a particular fishery, community and social objectives need not be part of the eligibility criteria. Currently, the bay clam fishery is not playing a strong economic role in Oregon's coastal communities. The broad interpretation of community and social benefits also makes it difficult to use them as a consideration when determining eligibility.

Economic efficiency is a process that occurs after the allocation of rights, not prior to their allocation. Therefore, this criterion may not be useful for determining eligibility. It is possible to create a certain distribution of wealth among fishermen with an initial allocation of rights; however, the efficiency of the industry is not realized until after an allocation has occurred and the fishing process ensues.

Equity or fairness during the distribution of rights may be the most applicable principle of the four criteria. Procedural fairness and fairness during any redistribution of rights, so as to minimize wealth redistribution, are general, yet important concerns. Concerning fairness, the rights allocation of each fisherman may be based on each fisherman's portion of: 1) total profits from the fishery, 2) total investment in the fishery, 3) catch from the fishery, and 4) effort in the fishery.

The use of catch history over a certain period of time is a common tactic for allocating fishing rights among fishermen in a new stage of the industry (Edwards 2000). Lotteries, auctions, equal allocation, and priority ranking are other allocation methods to contemplate. For example, the Washington commercial geoduck fishery has an annual auction of fishing rights. The fishery generated $60 million in the last ten years by publicly auctioning its harvest quotas. Half this revenue is used for management of Washington State-owned aquatic lands, and the other half pays for aquatic land restoration and development of public access to aquatic lands in Washington (Washington State Department of Natural Resources, URL; Sizemore pers com 2005).

**Statutes' Table*:** Summary of Oregon's General Shellfish Statutes and Laws.

| **WILDLIFE** | |
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| **ORS 496.004, ORS 506.011**<br>Definitions of interest | "'Manage' means to protect, preserve, propagate, promote, utilize and control wildlife."<br><br>"'Optimum level' means wildlife population levels that provide self-sustaining species as well as taking, nonconsumptive and recreational opportunities."<br><br>"'Shellfish' includes but is not limited to abalone, clams, crabs, crayfish or crawfish, mussels, oysters, piddocks, scallops and shrimp." |

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| | "'Wildlife' means fish, shellfish, wild birds, amphibians and reptiles, feral swine as defined by State Department of Agriculture rule and other wild mammals." |
| **ORS 496.012**<br>Wildlife policy | Requires the State of Oregon to manage wildlife for the conservation of indigenous species and for optimum social, recreational, and economic benefits; decisions for the benefit of wildlife resources and for the best utilization of wildlife resources by all user groups. |
| **COMMERCIAL FISHING AND FISHERIES** | |
| **ORS 506.006, ORS 506.028**<br>Definitions of interest | "'Commercial purposes' means taking food fish with any gear unlawful for angling, or taking or possessing food fish in excess of the limits permitted for personal use, or taking, fishing for, handling, processing, or otherwise disposing of or dealing in food fish with the intent of disposing of such food fish or parts thereof for profit, or by sale, barter or trade, in commercial channels."<br><br>"'Conservation' means providing for the utilization and management of the food fish of Oregon to protect the ultimate supply for present and future generations, preventing waste and implementing a sound management program for sustained economic, recreational and esthetic benefits."<br><br>"'Fishing gear' means any appliance or device intended for or capable of being used to take food fish except by angling."<br><br>"'Personal use' means taking or fishing for food fish by angling or by such other means and with such gear as the commission may authorize for fishing for personal use, or possessing the same for the use of the person fishing for, taking or possessing the same and not for sale or barter."<br><br>"'Waters of this state' means all waters over which the State of Oregon has jurisdiction, or joint or other jurisdiction with any other state or government, including waters of the Pacific Ocean and all bays, inlets, lakes, rivers and streams within or forming the boundaries of this state." |
| **ORS 506.036**<br>Jurisdiction of commission; duty to protect and propagate fish | Grants the State Fish and Wildlife Commission "exclusive jurisdiction over all fish, shellfish, and other animals living intertidally on the bottom, within the water of this state." Delegates to the commission the "duty of protection, preservation, propagation, cultivation, development and promotion of all fishes under its jurisdiction." |
| **ORS 506.050**<br>Federal and state fish cultural operations and scientific investigations; commission to propagate fish and to stock waters | Gives the Commission permission to conduct fish aquaculture operations and scientific examinations in the waters of this state. |
| **ORS 506.109**<br>Food fish management policy | Requires the State to manage food fish to provide the optimum social, recreational, commercial, and economic benefits.<br>"(7) To develop and implement a program for optimizing |

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| | the return of Oregon food fish for Oregon's recreational and commercial fisheries." |
| **ORS 506.129**<br>Establishing seasons, amounts and manner of taking food fish; rules. | Instructs the Commission to institute seasons, quantities and methods of taking food fish; grants power to impose rules. |
| <br>**COMMERCIAL FISH MONEYS; RECEIPTS AND EXPENDITURES** | |
| **ORS 506.306**<br>Collecting moneys under commercial fishing laws; disposition of receipts and fines | Orders the Commission to collect all moneys paid to the state for the commercial fishing industry and to deposit these moneys in the Commercial Fisheries Fund. |
| **ORS 506.321**<br>Acceptance and use of gifts of money and property to commission | Allows the Commission to "accept gifts of money, lands or other property and use" these gifts for the fishery resource. |
| <br>**FEDERAL AID AND PROJECTS** | |
| **ORS 506.405**<br>Powers of commission regarding federal aid for fish and fisheries. | Authorizes the Commission to enter into federal contracts to aid fish and fisheries; may accept federal funding contributions. |
| <br>**DEVELOPMENTAL FISHERY** | |
| **ORS 506.450, OAR 635-006-0810**<br>Definitions of interest | "'Developmental fishery' means activity for the development of commercial taking of an underutilized food fish species. The State Fish and Wildlife Commission by rule shall determine those species of food fish that are underutilized."<br><br>"'Developed fishery' means a fishery where the level of participation, catch, and effort indicate the fishery has approached optimum sustained yield and/or there is sufficient biological information, information on harvest methods, gear types, and markets to develop a long-term management plan for the species."<br><br>"'Developmental fisheries species' means food fish species adopted by the Commission to be managed under the Developmental Fisheries Program." |
| **ORS 506.455**<br>Policy | Directs the State "to institute a management system for developmental fishery resources that addresses both long term commercial and biological values and that protects the long term sustainability of those resources through planned commercial development when appropriate." |
| **ORS 506.460**<br>Developmental fishery species harvest programs; biological surveys; permits; fees | Gives the Commission, in consultation with the Developmental Fisheries Board, control of the developmental fishery resources and program components. |
| **ORS 506.465**<br>Developmental Fisheries Board; members; qualifications; expenses | Explains the Board's establishment in the State Department of Fish and Wildlife and member composition of the Board, appointed by the Commission. |
| <br>**COMMERCIAL FISHING LAW ENFORCEMENT** | |
| **ORS 506.501**<br>Jurisdiction and authority to enforce commercial fishing laws | Grants the Commission "jurisdiction and authority to enforce the commercial fishing laws." |
| **ORS 506.506** | Permits the "Commission to employ only such deputy fish |

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| Intent of ORS 506.511 and 506.516 | wardens as are agreed necessary or expedient among the commission, the Governor, and the Superintendent of State Police"; instructs that the Department of State Police enforce the laws of commercial fishing, "so far as is economical and practicable." |
| **ORS 622.010 to ORS 622.992** | Explains Oregon Department of Agriculture's (ODA) powers and all powers necessary and proper to insure sanitary conditions in the production and distribution of shellfish. |
| **OAR 603-100-0000, OAR 603-100-0010, OAR 603-100-0030** | ODA's rules relating to shellfish sanitation. |
| **OAR 635-006-0800 to OAR 635-006-0950** | Oregon Department of Fish and Wildlife's (ODFW) rules relating specifically to the Developmental Fisheries Board. |
| **Senate Bill 597 - Amendments** | |
| **ORS 497.121** | Amended. Gives the Commission authorization to issue residents and nonresidents shellfish licenses for fees. |
| **ORS 496.303** | Amended. "(9) The Marine Shellfish Subaccount is established in the Fish and Wildlife Account. Interest earnings on moneys in the subaccount shall be credited to the subaccount. All moneys received by the commission from the sale of resident and nonresident shellfish licenses pursuant to ORS 497.121 shall be deposited in the subaccount. Moneys in the subaccount shall be used for the protection and enhancement of shellfish for recreational purposes, including shellfish sanitation costs and the cost of enforcement of wildlife laws pertaining to the taking of shellfish." |
| **Native Fish Conservation Policy** | |
| **OAR 635-007-0502** | Presents a basis for managing fisheries, hatcheries, and ecological habitats in balance with sustainable production of naturally produced native fish; intends to conserve and restore native fish as well as keep opportunities for fisheries and other societal resource uses appropriately unconstrained; implementation through conservation plans. |

Key: Oregon Revised Statutes (ORSs), Oregon Administrative Rules (OARs)

*NOTE: This table summarizes some primary State statutes related to shellfish and the issues within this report. Please refer to the listed Web site addresses below for a more complete view of these and other related statutes.

*The above statute information is provided by the Legislative Counsel Committee of the Oregon Legislative Assembly and made available on the Internet. The official record copy is the printed published copy of the Oregon Revised Statutes (ORS). Oregon Administrative Rules (OARs) are also noted (can be found on the Internet).*

**http://www.leg.state.or.us/ors/496.html**

**http://www.leg.state.or.us/ors/506.html**

**http://www.leg.state.or.us/ors/622.html**

**http://arcweb.sos.state.or.us/rules/OARS_600/OAR_603/603_100.html**

**http://arcweb.sos.state.or.us/rules/OARS_600/OAR_635/635_006.html**

**http://hmsc.oregonstate.edu/odfw/regs/laws/ShellfishLicenseSB597.pdf (Senate Bill 597)**

**http://arcweb.sos.state.or.us/rules/OARS_600/OAR_635/635_007.html (Native Fish Conservation Policy)**