Capturing Local Knowledge for Cooperative Fisheries Management Using a Participatory Geographic Information System (GIS) Approach in Port Orford, Oregon.

by
Victoria A. Wedell

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

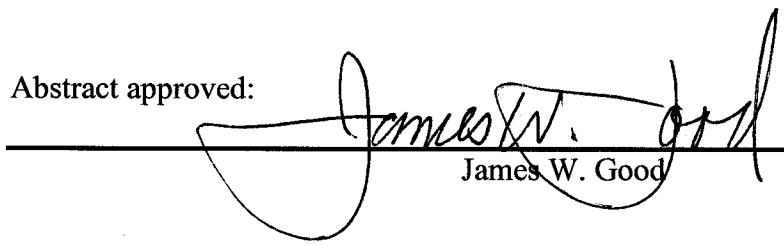
Master of Science

Presented December 3, 2004
Commencement June 2005

AN ABSTRACT OF THE THESIS OF

Victoria A. Wedell for the degree of Master of Science in Marine Resource Management presented on December 3, 2004.
Title: Capturing Local Knowledge for Cooperative Fisheries Management Using a Participatory Geographic Information System (GIS) Approach in Port Orford, Oregon.

Abstract approved:



James W. Good

This study demonstrates the utility of combining available scientific data with local ecological knowledge in a Geographic Information System (GIS) to support community-based fisheries management. The approach used provides both the framework for capturing important ecological, economic and social information relevant to marine fisheries management, and also offers coastal citizens a process for active participation in management discussions about their local nearshore marine environment. Thirty-three Local Knowledge Interviews (LKIs) were completed with commercial fishermen and recreational users with knowledge and experience observing the nearshore environment. Drawing on acetate overlays on basemaps of navigational charts and bathymetric contours, ocean users delineated areas of personal and observed human uses and locations of specific fish, invertebrate and plant communities. The individual maps were digitized and subsequently aggregated into thematic maps that represent the highest levels of correspondence among interviewees. This participatory GIS process for developing an ecological inventory of the distribution of marine species and human activities provides a more comprehensive understanding of the nearshore marine environment and its human uses than existing scientific data alone. The accompanying maps created also lay the groundwork for more in-depth economic studies and spatial analyses to support long-term community-based management planning.

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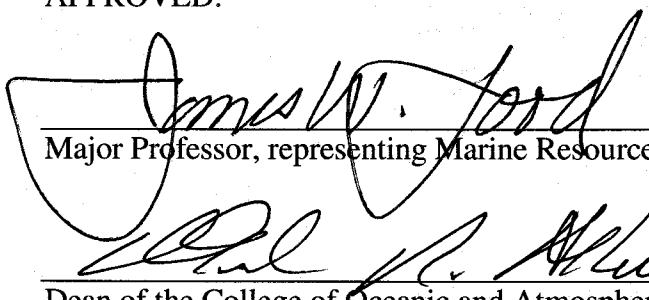

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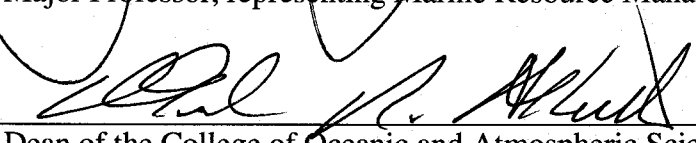

Dean of the College of Oceanic and Atmospheric Sciences

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Victoria A. Wedell

Victoria A. Wedell, Author

ACKNOWLEDGEMENTS

My sincere appreciation goes out to the community of Port Orford. Thank you for sharing your insights, knowledge, and experiences with me. You are what made this work possible.

Thank you to Charles Steinback and Ecotrust for considerable technical support developing the spatial analyses and community inventory maps.

My thanks to the members of my committee, Jim Good, Astrid Scholz, Dawn Wright, and Scott Heppell, for your assistance and guidance in the completion of this thesis. I respect and admire all of you immensely.

Thank you to Laura Anderson, David Revell, and Leesa Cobb. Your dedication, energy, and vision for the future are unparalleled.

Most of all, for his tireless encouragement and unwavering support in all I do, I am forever grateful to my husband Justin Tenke. You continually inspire me to be a better person!

This thesis was prepared by Victoria A. Wedell OSU/CIMRS under grant #NA17FE1526 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

TABLE OF CONTENTS

	Page
Introduction	1
Background and Literature Review	4
U.S. Fisheries Management and its Evolution	4
The Magnuson-Stevens Act of 1976: Americanizing U.S. Fisheries	5
The Sustainable Fisheries Act of 1996	7
Defining a Fishing Community	9
Assessing Impacts to Fishing Communities	12
Fisheries Management on the West Coast	16
The West Coast Groundfish Crisis	18
Conflict in the Fisheries Management Process	21
Community-Based Fisheries Management and the Roles of Local Knowledge and Participatory GIS	24
Local Fisheries Knowledge in Fisheries Management	27
Participatory GIS to Compile Local Fishing Knowledge	32
Port Orford, Oregon—A Small 'Fishing-dependent" Community	36
Location	37
Fishing Employment in Port Orford and the West Coast Groundfish Crisis	40
Port Infrastucture and Facilities	42
Research Design and Methods	45
Ethnographic Methods to Develop and Maintain Community Support	46
Data Collection Process	50
Materials and Methods Development	50
Human Subjects Research Approval	56
Introducing GIS to the Port Orford Community	57
Participant Recruitment	57
Conducting Local Knowledge Interviews	59

TABLE OF CONTENTS (Continued)

	Page
Data Compilation and Spatial Analysis	61
Community-Level Validation of Maps	63
Storage of and Access to Port Orford's Local Knowledge	64
Utility of Local Knowledge for Community-based Fisheries Management	65
Results and Discussion	67
Gaining Community Support	67
Integration of Science and Local Knowledge	71
Port Orford Involvement in Commercial Fisheries	74
Groundfish	77
Black Cod	78
Salmon	80
Dungeness Crab	82
Halibut	84
Port Orford Involvement in Recreational Activities	84
Future Analyses	87
Implications for Community-based Management in Port Orford	90
Community and Port Profiling	92
Planning for Fisheries Infrastructure	93
Evaluating Area-based Fisheries Management Strategies	96
Habitat Protection	98
Economic Sustainability	99
Non-extractive Use Values	102
Conclusion and Recommendations	105
Bibliography	109
Appendices	117

LIST OF FIGURES

Figure	Page
1. Conflict Triangle Diagram.....	22
2. Photo of the POORT Office.....	36
3. Map of Oregon Showing Port Orford and Other Coastal Communities....	39
4. Air Photo of Port Orford.....	39
5. Map of Oregon's Territorial Sea.....	40
6. Photo of the Port of Port Orford Dock and Hoists	44
7. Percent of LKI Participants and their Number of Target Fisheries.....	75
8. Percent of LKI Participants Targeting Specific Fisheries.....	75
9. Graph of Port Orford Monthly Landings for 2000.....	76

LIST OF TABLES

Table		Page
1.	Characteristics of TEK and Scientific Ecological Knowledge (NOAA Fisheries, 2004a).....	28
2.	Statistics of Port Orford Community Involvement in the GDOP.....	42
3.	Materials for Local Knowledge Interview Process.....	51
4.	Spatial Research and Management Questions Developed by POORT.....	52
5.	Attribute Categories and Example Values from LKI Database.....	62
6.	Port Orford Community Members Participating in Local Knowledge Interviews.....	68
7.	Local Knowledge Interview Participant's Self-identified Professional/Activity Categories and Average Experience.....	68
8.	Port Orford Commercial Fishermen Participating in LKIs.....	70
9.	Subset of Data Layers for Port Orford Community Mapping Project's Database.....	73

LIST OF APPENDICES

Appendix	Page
A. Port Orford Community Profile.....	118
B. POORT Confidentiality Agreement.....	139
C. Human Subjects Research Informed Consent Document.....	141
D. Flyer for the Port Orford Community Mapping Project.....	144
E. Local Knowledge Interview Questions.....	146
F. LKI's Species, Resources and Activities List.....	148
G. Ecotrust GIS Analysis Methods.....	150
H1-H6. Draft Maps from the Port Orford Community Mapping Project....	156

DEDICATION

This work is dedicated to my Pa, Richard Louis Bartunek. He was one of the most amazing people I know with respect to local knowledge about a special place. In his case, it is three acres of land and a body of water called the West Arm of Lake Nippissing in Ontario, Canada. Our family has benefited in countless ways from his knowledge and experience and his great sense of humor about life. He is much of the reason that I felt inspired to do the work that is contained in this report.

CAPTURING LOCAL KNOWLEDGE FOR COOPERATIVE FISHERIES MANAGEMENT USING A PARTICIPATORY GEOGRAPHIC INFORMATION SYSTEM (GIS) APPROACH IN PORT ORFORD, OREGON

INTRODUCTION

The adoption of the Sustainable Fisheries Act (SFA) in 1996 represented a major policy shift in how fisheries were to be managed in the United States. A new focus on fishing communities was mandated, which requires improved knowledge of traditional fishing grounds and the unique socioeconomic characteristics of fishing communities that are only attainable through the local fisheries knowledge of communities. Some fishing communities, such as Port Orford, Oregon, are utilizing GIS to integrate local fisheries knowledge with scientific information to document the geography of fishing communities and evaluate the impacts of fisheries management strategies from a community perspective. Traditionally, fisheries data used for management are collected and analyzed at scales that obscure the real ecological heterogeneity of habitat types and the social heterogeneity of communities and their territories of use. These data and associated management methods, along with other 1970s and 1980s programs designed to rapidly "Americanize" U.S. Exclusive Economic Zone (EEZ) fisheries, have increasingly led to poorly managed fisheries, overfishing of some stocks, excessive bycatch in some fisheries, overcapitalization of the fleet and overcapacity for fishing, and intense conflicts between different resource users and between fishers and managers. With passage of the SFA, new emphases were placed on taking precautionary approach to management, the protection of essential fish habitat, and the consideration of the impacts of management decisions on fishing communities. Fishery managers today must incorporate spatial considerations and scales and new kinds of information in order to assess how policy decisions will affect both the biophysical condition of fish habitat and the socioeconomic conditions of fishing communities. Implementing these new requirements, however, has been a considerable challenge for fishery managers and is only now beginning to be addressed in meaningful ways. Port Orford is one small fishing community trying to change its role and responsibilities in fisheries

management on the West Coast by participating in a study to document and integrate local fishing knowledge in geographic context.

The Port Orford community mapping project described here was a collaborative effort involving resources from several non-profit organizations and both federal and state agencies. The Cooperative Institute for Marine Resources Studies, a joint NOAA Fisheries and Oregon State University program, provided funding that allowed the author to design and conduct the study. NOAA Fisheries and the Oregon Department of Land Conservation and Development provided additional funding. Three non-governmental organizations provided human and technical resources essential to the study. The entire project team consisted of:

- Laura Anderson – The Port Orford Ocean Resource Team
- Leesa Cobb – The Port Orford Ocean Resource Team
- David Revell –The Surfrider Foundation, Oregon Chapter
- Markus Mead – The Surfrider Foundation, Oregon Chapter
- Sarah Klain – Ecotrust
- Charles Steinback – Ecotrust
- Mike Mertens – Ecotrust

The author developed the interview protocols to document qualitative and spatially explicit information about participation in local fisheries and recreational uses and the ecology of the marine environment. She was also the lead interviewer and transcribed all the local knowledge interviews. Project team members from both the Port Orford Ocean Resource Team (POORT) and the Surfrider Foundation participated in the interview process for double-coverage during the recording of interview information. The Surfrider Foundation representatives also provided outreach to the recreational interests in Port Orford for participation in the study and provided some technical

assistance digitizing spatially explicit local knowledge in a GIS. An Ecotrust consultant also provided assistance in digitization. Ecotrust was contracted to develop and implement the spatial analysis of the interview information to create aggregate maps representing the distribution and intensity of some commercial and recreational uses of the environment around Port Orford. The author and the POORT and Surfrider Foundation representatives conducted the community validation workshop. The author analyzed the resulting information to identify potential management strategies of benefit to the development of the Port Orford fishing community.

This thesis is organized as follows. In the Background and Literature Review chapter, the author develops the national, regional, and local context for this study. She examines the changing national priorities in federal fisheries management, especially the increased focus on assessing the impacts to fishing communities of management decisions. In this chapter, the author also examines relevant research on the role of local knowledge and GIS in community-based fisheries management and the potential contributions they have to fisheries management in general. The Research Design and Methods chapter contains the details of the entire Port Orford Community Mapping Project methodology, rather than only the discussion of the author's contribution to the project. In this chapter, the author also examines the utility of the process and data for supporting community-based management goals. The Results and Discussion chapter contains the author's discussion of the products of the community mapping project and the associated qualitative information that describe the community of Port Orford's involvement in marine fisheries and recreation. In this chapter, the author also examines the practical implications of the Port Orford Community Mapping Project for attaining community-based fisheries management objectives, including community profiling and evaluating area-based and quota management strategies. The Conclusions chapter contains a summary of the findings of the study and the author's suggestions for improving the role of co-management systems and local knowledge and community mapping in fisheries policies.

BACKGROUND AND LITERATURE REVIEW

U.S. Fisheries Management and its Evolution

Over the past several decades, fisheries management has undergone great changes in its policy and management focus. Values of fisheries have shifted from a primary focus on fisheries as food production systems to fisheries as part of marine ecosystems that are intimately tied to the socioeconomic systems of humans. The current contraction of the fishing industry is occurring after a period of deliberate expansion and growth during the 1970s and 1980s that was motivated by visions of the sea as an inexhaustible supply of protein for human use and by competition with foreign vessels (Hanna 2000). The resulting overcapacity and overfishing, combined with poor ocean conditions and incomplete science, are responsible for some of the diminished fish populations occurring throughout American waters (The Heinz Center 2000). Values of marine resources for recreational use, aesthetic enjoyment, and biodiversity now compete more strongly with values for commercial uses. The current goals of fisheries management are to attain sustainable fisheries and communities with strong economies that contribute to healthy ecosystems.

In its simplest sense, sustainable use of resources means that the resource can be used in perpetuity. Fishing is sustainable when it operates over the long-term in a way that does not cause undesirable changes in ecological or economic productivity, biological diversity, or ecosystem structure or function (NRC 1999). Fisheries managers are currently challenged to rebuild fish stocks and attain sustainable fisheries with complex legislatives mandates to: maximize sustainable yield, use the best scientific information available, make equitable decisions among fishermen in different states, protect essential fish habitat, eliminate bycatch, and minimize economic impacts to fishing communities. The predominant method for assessing changes in individual fish stocks, which forms the basis of harvest guidelines, depends on field survey data incorporated into numerical models that aggregate single-species survey data and measures of fishing effort across a theoretically homogeneous landscape. However, neither fishing behavior nor fish habitat is homogeneous at those scales.

Ecosystem-based management prescribed by the U.S. Commission on Ocean Policy (USCOP) and the Pew Oceans Commission is a necessary challenge for fisheries managers. It can be argued that the Sustainable Fishing Act of 1996 (SFA) allows for ecosystem approaches to management, but does not force it. The SFA calls for the improved management of several ecosystem components, including eliminating bycatch, protecting fish habitat and providing for the sustained participation of fishing communities. Ecosystem-based measures are needed, such as studies of system components and interrelationships, assessment and ranking of stressors, and development of comprehensive plans that include all components of fisheries and other regional concerns (USCOP 2004). Ecosystem approaches to management promotes that both the human and biological components of fisheries be brought together in one analysis when considering fisheries interactions with resources and activities.

The Magnuson-Stevens Act of 1976 – Americanizing U.S. Fisheries

The Magnuson Stevens Fishery Conservation and Management Act of 1976 (herein after referred to as the Magnuson-Stevens Act or MSA) is the Nation's principal piece of fisheries legislation and is the single most important factor that shaped the current American fishing industry and many of the fisheries challenges that are present today. The MSA promoted the redistribution of fishery resources from foreign to domestic fleets and the expansion of domestic catches to reduce the reliance on imported seafood. It designated the area from 3-200 miles offshore the U.S. Fisheries Conservation Area (FCA). The FCA was later declared the U.S. Exclusive Economic Zone (EEZ) through an executive order signed by President Ronald Reagan in 1983. The MSA also created a system of eight Regional Fishery Management Councils. The Councils were intended to manage the conservation and allocation of fishery resources within eight biogeographic regions of U.S. waters. The council process and the composition of its membership were intended to provide the public access to and oversight of the Nation's living marine resources. However, the council system was

not prepared to deal with the intense competing American interests, the overcapacity, and the diminished fish stocks that resulted from Americanizing the fishing industry.

In the 1950s and 1960s, the American people considered the ocean to be the new frontier of resource development. Foreign catch in U.S. waters was exceeding American catch and, from 1958-1968, seafood imports had increased from 37 to 76 percent of the total U.S. seafood supply (The Heinz Center 2000). The United States government became dedicated to helping the American fishing industry expand its capacity for fish production and to reducing foreign fishing opportunities off the west and east coasts of the country. The call for increasing American harvest of fish stocks was implemented through federal sponsorship of vessel construction loans, tax-deferred vessel repair and construction programs, fuel tax relief, gear replacement funds, market expansion programs and technical assistance programs (The Heinz Center 2000). Exemplifying this attitude, Senator Warren Magnuson of Washington, who later became a principal sponsor of the MSA, addressed a 1968 conference on the future of the U.S. fishing industry and said:

> "You have no time to form study committees. You have no time for biologically researching the animal...Your time must be devoted to determining how we can get out and catch fish. Every activity...whether by the federal or state governments, should be primarily programmed to that goal. Let us not study our resources to death, let us harvest them" (The Heinz Center 2000).

In 1969, the federal Commission on Marine Science, Engineering and Resources, also known as the Stratton Commission, comprehensively reviewed the United States' coastal and ocean policy and published *Our Nation and the Sea: A Plan for Ocean Action.* The "Stratton Report," as it has become known, emphasized a national interest in fishery rehabilitation, development, and expansion to create national wealth and to meet the world demand for food. The Stratton Report also noted the need to better coordinate management authority between the states and federal

government by creating a single independent agency to manage American fisheries. President Nixon created the National Marine Fisheries Service, now called NOAA Fisheries, in the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce. NOAA Fisheries' management responsibilities involve reviewing, approving or disapproving, implementing, and enforcing fishery management recommendations of the eight regional fishery management councils.

By the 1980s and 1990s it became apparent that "too many boats were chasing too few fish" and societal values had changed (Witherell 2004). High levels of fishing capacity led to pressures on the Regional Fishery Management Councils to keep catch levels high and access to the resources open. Changing environmental conditions, such as the El Niños that decreased ocean productivity for extended periods, resulted in further pressures to protect fish stocks and fisheries. Fishery yields had leveled off or declined nationwide, and it became clear to managers that entry into fisheries had to be limited. By the 1990s, the domestic fleet had developed to the point of full or overcapacity and social impacts were beginning to be taken more seriously. Coastal populations had also grown during this time, as did the stresses that they put on the marine environment. Diverse user groups continued to battle over equitable allocation of fishery resources for commercial, recreational, and environmental purposes. This combination of factors prompted major changes to the Magnuson-Stevens Act.

The Sustainable Fisheries Act of 1996

A new era in U.S. fisheries management began in 1996 when Congress passed the Sustainable Fisheries Act (SFA), which revised the Magnuson-Stevens Act to reflect the changing conservation values of the nation. The SFA includes a challenging set of mandates, in addition to those previously stated, to end overfishing and rebuild overfished fisheries while continuously achieving the optimum yield for each fishery. The legislation added three additional national standards to the seven existing standards that govern the Councils' development of Fishery Management Plans

(FMPs). The newest national standards are to reduce and minimize mortality of bycatch; to promote the safety of human life at sea; and to assess and minimize management impacts to coastal fishing communities. The SFA also added the requirement for the Councils to 1) designate and describe essential fish habitat (EFH) and the adverse effects to it from both fishing and non-fishing activities, and to 2) recommend actions to minimize adverse effects and identify conservation and enhancement measures. EFH is defined as "the waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (Wallace et al. 1999). The SFA demonstrated the new direction of federal fisheries management to consider ecologic, economic, and social sustainability.

Some of the management objectives set out in the national standards are compatible only when implemented in a truly precautionary fashion, previous to significant harvests or investments in capital. Precautionary measures are those that are taken before there is scientific certainty to protect against an undesired outcome. However, the fishery managers are not in a position to be proactive; they have significant challenges before them. For example, to meet the objective of rebuilding fish stocks, the fishery managers use fishery restrictions that increase social and economic risks to participants and communities. Conversely, reducing risks to communities can increase risks to the resources and to future generations. No single management measure can reduce risk to one component without increasing risks to another component of the system, at least in the short-term.

Sustainability is a balancing act between use and conservation, biology and economy, communities and individuals, and variability and stability. Fishery managers need clear biological and socioeconomic objectives and priorities, measurable criteria, and sufficient data at appropriate scales to be able to assess their achievement of the goals of sustainable ecosystems, fisheries, or communities. To develop the appropriate mix

of management strategies, fishery managers must also be able to identify the risks of management measures and evaluate them for different alternatives.

With specific regard to this research and to fishing communities like Port Orford, the National Standard 8 of the SFA demonstrates the need for a stronger emphasis on communities and socioeconomic concerns without compromising conservation. Specifically, National Standard 8 states that:

> "Conservation and management measures shall, consistent with the conservation requirements of this Act, take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities" (NMFS 2002).

Promoting sustainable communities is a broad fisheries goal that has not had specific management objectives identified. Some possible objectives could include: to maximize employment, maximize income, maximize profit, or minimize variability in income. For Port Orford, one could argue that participation in diverse fisheries is an important objective for community sustainability. However, it is likely that each fishing community will have a different set of objectives important to its sustained participation in fisheries. Evaluating these objectives requires knowledge about the baseline condition of the fishing community and its dependence on various fishery resources. Without new tools and new information, managers are unable to holistically and systematically consider the unique environmental, social, and economic trade-offs needed to assess impacts to communities as required in the SFA.

Defining a Fishing Community. In the last ten years, many researchers and mangers have been looking into the definition and practical application of the terms 'fishing community' and 'fishing dependency.' Some fisheries management strategies such as

co-management and community quota systems require an explicitly defined community. The Sustainable Fisheries Act defines a fishing community as:

> "a community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such a community" (Hall-Arber et al. 2002).

However, the SFA does not define what constitutes "substantially dependent on or substantially engaged in" fishing or seafood processing, although it is usually related to the employment and income of those "vessel owners, operators and crew, and U.S. processors" located in the community. It could also be argued that the members of fishing families, the port management and other local industries are dependent on commercial fishing, although they may not be evaluated in this narrow definition.

Regional fishery management councils interpret the legislation to imply a geographic, or place-based, definition of a fishing community (PFMC 2002). However, other definitions such as gear-based fishing communities or communities divided along target-species groupings may also be valid in certain cases. A rule of thumb for identifying fishing dependent communities determined that fifteen percent direct fishing employment could be one measure to quantify fishing-dependence, although admitted that the percentage is arbitrary (Jacob et al. 2001). Limitations with the measurement of direct fishing employment include the lack of differentiation between forestry and fishing employment in census data; the granularity of census data (i.e., county-level) obscures many communities (PFMC 2002) and (Langdon-Pollock 2004); and severe underestimation of direct fishing employment using census methods (Jacob et al. 2002). However, census and employment data may be useful for describing the background socioeconomic condition of the area, including the cost of living, and poverty and education levels (McCay et al. 2000). The benefit of using census data is its accessibility and consistency, which is important for standardization

purposes (Langdon-Pollock 2004). Using a definition grounded in a geographical location simplifies data collection for some components of a fishing community, while falling short on others.

Hall-Arber et al. (2002) argues that ports are not economic isolates, but are members of a regional network associated with a natural resource region. Geographic distribution of secondary industries along the coast and the relative isolation of communities to this sector also affect how a fishing community experiences policy changes. Langdon-Pollock (2004) states "It is assumed that smaller, more remote communities have fewer economic choices, influencing the way in which they depend on the local industry" (p. 15). This study used the following parameters to qualify a city as isolated: 1) having a population less than 1,900 people, 2) located not near a major highway, and 3) located at least 35 miles away from a city with a population over 20,000 people. Port Orford meets two of the three criteria, but does not qualify as isolated because Highway 101 runs through the town (as it runs down the entire Oregon Coast). Consequently, other coastal communities like Port Orford are not considered isolated by this criterion. However, communities could be isolated from the sea in addition to being isolated by land.

Other research has suggested that a model for defining a fishing community could involve a threshold percentage of total labor or total income *combined* with a multiplier effect based on the forward and backwards economic linkages to other industries (Jacob et al. 2001). However, quantifying multipliers is an even greater challenge than accurately quantifying a threshold percentage of income or labor. While describing West Coast fishing communities, Langdon-Pollock (2004) found that creating a fishing dependency index was impractical given the current availability of information. Hall-Arber et al. (2002) determined that simple economic assessments are inadequate, and even harmful when applied to some specific cases.

Other efforts to identify fishing communities and fishing dependence more qualitatively are in the beginning stages. McCay and Cieri (2000), Hall-Arber (2002) and Langdon-Pollock (2004) developed port-profiling approaches for examining social and economic linkages important in indicating a community's degree of vulnerability to regulatory changes. Port profiles are used to examine patterns of contracts, characteristics of community culture and institutions, local residents' views about their way of life and fisheries management, zoning and planning issues, the complexity of fishing infrastructure, and the degree of gentrification or specialization. To assess the degree of specialization or diversification of fisheries participation, managers need to also have knowledge of the community's fleet composition, percent of commercial and recreational use, size of vessels, target fisheries, harvesting strategies and gear types used. Qualitative measures are more difficult to compare across communities, but provide the breadth and depth of knowledge needed to begin to assess changes to communities' structure and function.

It is impossible for fisheries management to attain goals, such as National Standard 8, without a clear understanding of what constitutes a fishing community. Often the members of the community hold the most important information needed to characterize fishing communities. In all of the port profiling cases discussed above, the authors used interviews with community members to collect the baseline information. Fishing communities are as diverse as the individuals in them and finding one set of criteria is a difficult endeavor. However, defining fishing-dependent communities is the first step needed to adequately identify and assess adverse impacts of fisheries policy changes to these communities.

Assessing Impacts to Fishing Communities. Although National Standard 8 specifies that fishery managers must, to the extent practicable, provide for the sustained participation of fishing communities and minimize adverse economic impacts to them, it is not the only mandate to this end. With the passage of the National

Environmental Policy Act (NEPA) in 1969, the federal government, including NOAA Fisheries, is mandated to assess the impacts of federal decisions on the natural and social environments through the preparation of environmental impact statements (EISs). In addition, the MSA has requirements that fishery managers examine the socioeconomic and cultural impacts to fishing communities of implementing limited entry programs. The primary challenges to assessing impacts to communities are inadequate data and resources for turning the data into useful information.

Under NEPA, the socioeconomic impacts of federal actions alone do not require an EIS. However, an EIS may incorporate a Social Impact Assessment (SIA) to understand the connections between the natural and social environments and assessing impacts to a community's quality of life (U.S. GSA n.d.). An SIA is the traditional method used to gauge the social consequences of alternative fishery management actions or policies to fishing communities. It is not the same as an economic impact analysis, which assesses whether economic benefits of a federal action outweigh the costs and focuses more on resource supply and demand, prices and jobs (NOAA Fisheries 1991). Executive Order 12898 puts an additional emphasis on including SIAs in EISs with the goal of determining any "disproportional and adverse" impacts to low income or minority populations (NMFS 1995). In either social or economic analyses, the goals are to characterize the existing state of affairs, to forecast how things may change for a given action or policy, and to develop ways of mitigating adverse impacts to affected populations or communities.

The Magnuson-Stevens Act also has a variety of requirements related to social, cultural, and economic issues for fishermen and their communities in addition to National Standard 8. For example, section 303(b)(6) of the MSA states that limited entry programs require an examination of:

> "(A) present participation in the fishery, (B) historical fishing practices in, and dependence on, the fishery, (C) the economics of the fishery, (D) the capability of fishing vessels used in the fishery to engage in other fisheries, (E) the cultural and social framework relevant to the fishery and any affected fishing communities, and (F) any other relevant considerations" (NOAA Fisheries, 2003).

In addition, Section 303(a)(9) on preparation of Fishery Impact Statements notes that fishery managers:

> "shall assess, specify, and describe the likely effects, if any, of the conservation and management measures on--(A) participants in the fisheries and fishing communities affected by the plan or amendment; and (B) participants in the fisheries conducted in adjacent areas under the authority of another Council, after consultation with such Council and representatives of those participants" (NOAA Fisheries, 2003).

Although it is clear that the mandate exists, it is less certain that fishery managers can implement this standard without improved data or resources. The Pacific Fishery Management Council readily admits on their Community website that they lack substantive information on fishing communities and the resources to complete this research comprehensively:

> "Not much information on fishing communities has been systematically gathered. One reason for this is because most funding for fisheries management goes towards assessing fish stocks. For example, the National Marine Fisheries Service's 2002 budget requests more than $200.8 million for biological fisheries research, compared to $3.4 million for economics, statistics, and other social research" (PFMC 2002).

Several challenges exist for fishery managers or the councils attempting to collect and effectively utilize data on fishing communities. Exactly what data are needed and acceptable to management? Who should be collecting and

maintaining the data, scientists or fishermen?[1] Where and at what scale are data collected? How are those data collected and transformed into information? An additional difficulty is that fishing businesses and communities continue to adapt and evolve in order to stay competitive with changing regulations, markets and environmental conditions, and thus change the baseline conditions from which managers measure change and impacts.

Not only does fisheries management lack substantive data on fishing communities, the data collected are at such a granular scale that it is ineffective at showing the landscape of a fishing community. In a recent study to describe West Coast fishing communities, the scale of demographic data collection was limited to counties to reduce the amount of data fishery managers would have to consider and interviews were conducted with only one person from each county (Langdon-Pollock 2004). A similar spatial argument applies for the identification and minimization of impacts to fish habitat. The large statistical areas used by the groundfish fishery managers to record fishing effort and the areas from the stock assessment models used to assess stock size are too large to see the heterogeneous landscape of fishing communities and habitat (St. Martin 2001). Similar to the methodology used to conduct the Port Orford Community Mapping Project, NOAA Fisheries is developing a project that uses local knowledge interviews to produce GIS maps for the Essential Fish Habitat Environmental Impact Statement(Abbott-Jamieson et al. 2003). Essential fish habitat is tied to life stages of fishes and is therefore, at smaller spatial scales than the range of the species. Habitat maps generated by fishermen will be overlaid with those generated by biologists to ensure that the appropriate areas are targeted in a habitat management context. Other genetic research projects are aimed at collecting

[1] The term "fishermen" is used throughout this document rather than the more scholarly "fishers" or "fisherperson" because this is the terminology that people in the fishing profession of both genders use to refer to themselves and their colleagues.

information at reduced spatial scales to identify potential sub-populations of species. In practice, neither fishing communities, nor essential fish habitat, nor impacts to them can be assessed without the proper kind and scale of socioeconomic data.

NOAA Fisheries and other entities are examining new ways to meet the federal mandates for socioeconomic impact analysis. The agency is exploring a conceptual model for predicting the social impact of fisheries management action alternatives using a limited set of qualitative and quantitative indicators to streamline the Social Impact Analysis process (Abbott-Jamieson et al. 2003). Although it is not a peer-reviewed publication, the Final Report of the Groundfish Fleet Restructuring Information and Analysis (GFR) Project was an innovative GIS project that attempted to further resolve the scale of federal fisheries landings information (Scholz et al. 2005). The distribution of catch areas was linked to homeport communities through vessel information. The impacts of various spatial management and capacity reduction scenarios could then be analyzed for individual ports. The increase in national focus on defining fishing communities and fishing dependency and efforts to collect baseline data at smaller spatial scales are signals that the federal government is trying to respond to the mandates of NEPA and MSA.

Fisheries Management on the West Coast

The Regional Fishery Management Councils set up by the MSA are intended to represent the variety of interests and stakeholders in a decentralized, democratic structure. They make public policy fishery management decisions through command and control management using notice-and-comment rulemaking processes. Typically, managers take a complex situation like the West Coast groundfish crisis and break it down into its component parts (harvest policies, fleet reduction, stock assessment and monitoring, allocation, bycatch, and marketing). They attempt to

solve these issues independently across a very large jurisdictional area with limited staff and finances.

Mounting problems within the council system prompted NOAA to recommend the separation of conservation and allocation decisions in fishery management in the 1980s, a recommendation that is echoed in the recent U.S. Commission on Ocean Policy Report. Poorly resolved areas of authority and responsibility between NOAA Fisheries and the regional councils, interference in council actions through congressional or constituent pressures, and the failure to fund the management system at a level commensurate with its expanding responsibilities caused some of the fisheries management problems experienced today (Eagle et al. 2003). This division of conservation and allocation is intended to reduce the constituent pressures on council decisions to designate one or another harvest level. Allocation disputes take up much of the time and energy of the council system and may impede its ability to effectively respond to changing political, economic, and social conditions with timely, appropriate management strategies.

The Pacific Fishery Management Council (PFMC) has regional authority over federally managed marine species in Washington, Idaho, Oregon and California and is responsible for conservation and sustainable management of Pacific marine fish stocks and habitat, while balancing a variety of human needs. For approximately 80 years, groundfish were managed independently by the states of Washington, Oregon and California. With the enactment of the Magnuson-Stevens Act in 1976, the states and the PFMC jointly managed the fishery until the development and implementation of the Pacific Groundfish Fishery Management Plan (FMP) in 1982, at which time the PFMC became the lead authority. FMPs form the basis for Council management of fish stocks. In addition to the groundfish plan, the PFMC has plans for Pacific coast salmon and coastal pelagic species, and is developing a plan for highly migratory species on the West Coast.

The PFMC manages over 80 different species of groundfish, which are targeted using a variety of gears including fish pots, hook and line gear, and various types of trawl. This leads to gear conflicts and competition. The pot fishery mainly targets black cod[2] and hook and line gear targets black cod, lingcod and rockfish. Trawls target certain groundfish species complexes such as: deepwater slope species for bottom trawls, bottom rockfish for roller trawl, nearshore flatfish for mud gear, and widow rockfish and whiting for midwater trawl (Witherell 2004). Commercial fisheries for groundfish management are divided into three primary sectors: limited entry trawl, limited entry fixed gear, and open access. "Limited entry" refers to the component of a fishery that requires a permit for a vessel to be allowed to participate in a given fishery. This is in contrast to "open access" where no permit is required. In open access fisheries, a portion of the total allowable catch is allocated to those vessels with no permit.

The West Coast Groundfish Crisis

In January 2000, the Secretary of Commerce declared the West Coast Groundfish Fishery a national crisis. Witherall (2004) summarizes the causes of the groundfish decline in three main categories: 1) science-based decisions inappropriate for the life history characteristics of groundfish, 2) poor ocean conditions amplifying the naturally low productivity of these fish species, and 3) incomplete accounting for the total fishing-related mortality due to bycatch and discards at sea. NOAA Fisheries Q&A on the Status of West Coast Groundfish lists a variety of additional issues responsible for the crisis in the groundfish fishery including: inadequate scientific data, overcapacity, overfishing, and the mandate to develop and implement rebuilding plans which must restrict fishing opportunities (NOAA Fisheries 2004e). These combined issues produced a major West Coast groundfish crisis with biological, economic, and social consequences.

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[2] "Black cod" is the term used by Port Orford commercial fishermen when referring to the species *Anoplopoma fimbria* that is commonly known as sablefish in the scientific community. This report utilizes the term black cod because of the focus on local knowledge.

In the late 1970s and early 1980s, domestic groundfish landings were stable and increasing and groundfish stocks appeared healthy. In fact, groundfish landings peaked in 1982 at 116,000 metric tons and remained around 92,000 metric tons for several years (Witherell 2004). Facing little information on the sustainability of groundfish stocks, PFMC set allowable biological catches (ABCs) that were based on the amount of historical catches and capped harvest at the current level at that time. Things were about to change quickly for the West Coast commercial groundfish industry.

An overall decline in groundfish landings occurred from 1982 to 1999. During this time commercial ex-vessel groundfish revenues decreased by 47 percent from $100.2 million to $52.9 million (in 1999 dollars) in spite of a 12 percent increase in commercial landings (Witherell 2004). Rockfish of the genus *Sebastes* and flatfish, which together accounted for between 50-60 percent of groundfish landings, declined severely in landings and revenue. Concurrently, recreational fisheries were also switching from salmon to rockfish and lingcod as target species. Since 1999, nine West Coast groundfish stocks have been declared overfished[3]: bocaccio *(Sebastes paucispinis)*, canary rockfish *(Sebastes pinniger)*, cowcod *(Sebastes levis)*, darkblotched rockfish *(Sebastes crameri)*, widow rockfish *(Sebastes entomelas)*, yelloweye rockfish *(Sebastes ruberrimus)*, lingcod *(Ophiodon elongates)*, Pacific ocean perch *(Sebastes alutus)*, and Pacific whiting *(Merluccius productus)*. Most of the depleted stocks are species often caught at depths coincident with the continental shelf, and are known as "shelf species." Port Orford fishermen target six out of nine groundfish species declared overfished by PFMC and have lost the opportunity to fish for these species, although they perceive some of them as locally abundant. In 2000, the PFMC separated out the major rockfish species and divided the rest into assemblages to improve data collection and management.

[3] As defined by the Pacific Fishery Management Council, a species is declared "overfished" when it is determined to have less than 25% of its virgin (unfished) biomass left in the fishery.

Underreported bycatch and discarding on trawl vessels were partially responsible for the miscalculation of the groundfish biomass that caused management to implement harvest restrictions for the entire groundfish fleet, including the fixed gear and open access sectors (Witherell 2004). The Council applied quota reductions throughout the 1990s to bring harvest levels in line with acceptable biological catches for individual species and assemblages. The PFMC shortened the limit on footrope diameter for roller trawls, intending to keep this gear away from rocky areas important to the declining rockfish species. The Council provided an incentive to fish with mid-water trawls by giving higher trip limits to this gear type. A fifty percent capacity reduction plan for the entire groundfish fleet was introduced in 2000 (PFMC 2000). In reality, the capacity reduction was targeted at trawlers and no small vessels are eligible for the vessel buyback program. For 2002, PFMC revised bycatch rates for several species in the limited entry trawl fishery and also prohibited retention of yelloweye rockfish in both the limited entry fixed gear and open access sectors. For 2003, the Council continued to restrict groundfish harvest levels and introduced a new management regime that included area and season restrictions, including a depth-based restriction to seasonally move fisheries that catch overfished stocks out of the depth zones between 100-250 fathoms (PFMC 2002). The area closure has changed in shape over time, although the relative impacts of these changes to communities have not been evaluated.

Overfished groundfish stocks, dramatic harvest restrictions, declining revenues, and capacity reduction measures have differentially impacted fishing communities along the Oregon coast. Many Port Orford fishermen feel that their fixed gear small vessel fleet has been penalized for detrimental impacts caused by the large vessel trawl fleet, while it is those vessels that are being compensated through the vessel buyback program. Fixed gear and open access sectors can no longer target canary or yelloweye rockfish while the trawlers are allowed some as bycatch, although at drastically reduced levels. Although the entire fishery is in decline and all gear sectors have to be

restricted in order for stocks to rebuild, the fixed gear fleet of Port Orford interprets the resulting conservation measures as socially inequitable management decisions.

Conflict in the Fisheries Management Process

It is not surprising that fisheries management decisions are rife with conflict. Fisheries management issues are both highly complex and controversial. Daniels and Walker (2001) suggest that in order to make progress in these kinds of environmental policy decisions, three important facets of conflict should be addressed: the relationships of the participants; the process for making decisions; and the actual substantive aspects of the outcome. Their Conflict Triangle diagram is a useful tool to evaluate the benefits and challenges of various management approaches to fisheries policy development (Figure 1). Although the substantive aspects of public policy are focused on most often (the tip of the iceberg), it is arguable that the process and relationship issues offer the most potential for improvement in spite of high levels of conflict.

A problem often cited by Oregon's fishing communities is their superficial involvement in the Council process (Conway et al. 2002). Influence of social considerations on a management plan can be affected by: 1) a social impact assessment (SIA) if one is prepared by the Regional Council; 2) public testimony; and 3) the character of individual Council membership (Buck et al. 1995). While there appear to be sufficient opportunities for the public to become involved in the Council process, several challenges exist for meaningful public involvement. These problems include: the accessibility of meetings, time and knowledge needed to provide input at the right stage, and the perception that decisions are predetermined and that viewpoints are easily dismissed (Eagle et al. 2003).

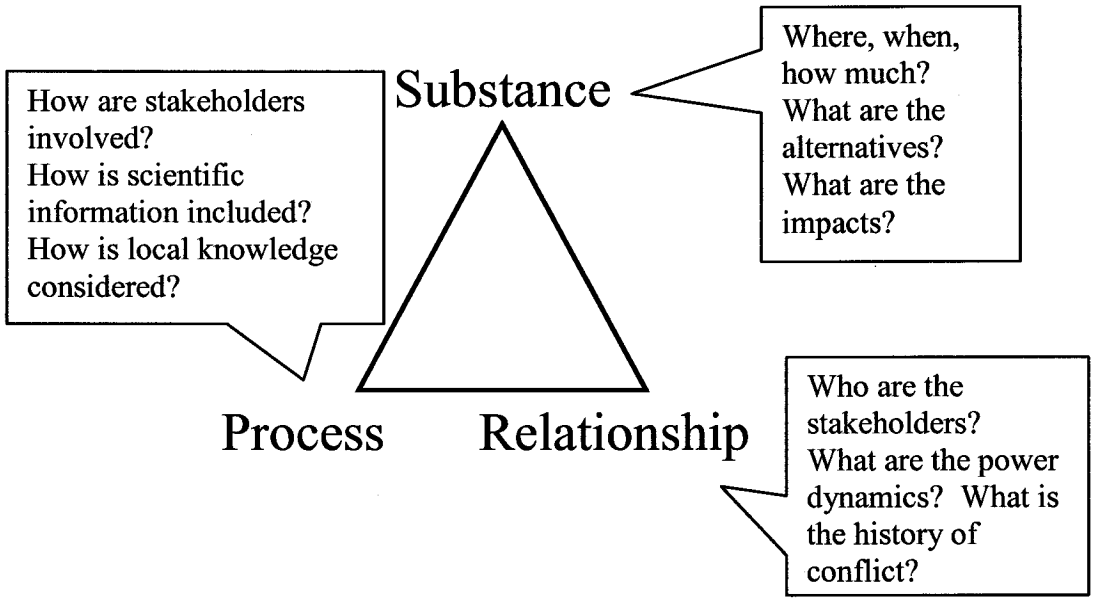

Figure 1: Daniels and Walker (2001) Conflict Triangle

The logistics of Council meetings add to the marginalization of small fishing communities. The venue for council meetings can be anywhere in California, Oregon or Washington and is often a considerable distance from fishermen's homeport. For example, even a PFMC meeting in Portland, Oregon is about a six-hour drive from Port Orford and would require travel and lodging costs to attend a several-day meeting. This makes attendance difficult and prohibitively expensive for some fishermen.

The development and adoption of fishery management plans is so complex and lengthy that unpaid participants find it difficult to provide input at the correct stages (Eagle et al. 2003). For example, NOAA Fisheries lists at least 61 different steps to develop and adopt fishery management plans and actions (Gade et al. 2002). Public testimony is the primary way that constituents interact with the Council. However, NOAA Fisheries reported that public testimony reflects individual judgments of people affected by the decision, are not presented in a systematic and scientifically

verifiable manner, and therefore cannot be used in a predictive or evaluative way, as is needed for Environmental Impact Statements (NMFS 1995). Several council members in Eagle et al. (2003) reported that the council does not give much weight to public testimony. Many Oregon fishermen feel the Council's decision has already been made before the public meeting ever begins and therefore feel powerless to affect management decisions (Conway et al. 2002). "The public testimony process at the Council makes you cynical. When you get stepped on, you are hesitant to make the effort. I've given up hope" (Interview 758). Communication during the council process does not foster careful deliberation of citizen input and is the source of much contention for the fishing industry.

Many members of the Port Orford fishing community do not perceive their interests as being adequately represented by the interests on the Pacific Fishery Management Council (PFMC). A recent study of the composition of regional fishery management councils agreed that ninety percent of the appointed fishing representatives reported that "they were appointed to represent, and did represent, a particular sector of the fishing industry" (p. 26) (Eagle et al. 2003). The PFMC's fourteen voting members include state fishery managers, a NOAA Fisheries representative, Treaty Indian tribes, and eight private citizens. Of the eight private citizens, six are recreational interests and two are commercial interests (Witherall 2004). The two commercial fishing representatives are from large trawl vessels, which have little in common with the fixed-gear small-scale fleet of Port Orford. Although the Council should not be expected to have representation of every port under its jurisdiction, the commercial interests are biased towards sectors of the industry with which the members identify. The issue of representation is a large complaint of the Council system in general, as many of the council members themselves believe that the councils do not fully reflect or represent all public constituencies, particularly environmental interests (Eagle et al. 2003).

The fisheries management system has been slow to adopt its plans to accommodate the new national standards and the changes imposed by the 1996 Sustainable Fisheries Act. The relationship between the fishing industry and fishing managers in Oregon is characterized by blame, distrust, and stereotyping (Conway et al. 2002) and fishermen often perceive a lack of respect from scientists and managers. New incentives are needed to help groundfish management make the transition to new goals and objectives such as National Standard 8 (Hanna 2000). Community based fisheries management systems can help address mandates determined by the Sustainable Fisheries Act (SFA) and help find common ground between fishing communities and fisheries management. Community-based management and co-management can improve and challenge the existing management system to incorporate local fisheries knowledge and to consider community-scale impacts.

Community-Based Fisheries Management and the Roles of Local Knowledge and Participatory GIS

Community-based and co-managed fisheries systems are ones in which the community has greater responsibility and authority for managing public fisheries resources. The desired outcomes of fisheries co-management, as with consultative management, are appropriate, efficient, and equitable management decisions that insure the sustainability of the resources. Pinkerton (1989) states that the three secondary goals of co-management— decentralized regulatory authority, community-based development, and participatory democracy—are potential ways to achieve primary benefits and thus can be end goals themselves. The overall goal is still sustainable resources and communities, but the scale of focus changes to a more localized area of stewardship using community knowledge.

Decentralizing regulatory authority involves various degrees of delegation of responsibility and authority to the fishing community, thus altering the traditional roles of industry and government (McCay et al. 1996). Potential supporting

management functions that communities could undertake jointly with federal and state management are data gathering and analysis, harvest regulation, and/or harvest allocation. Co-management can alter the relationship between fishing communities and fisheries mangers by instituting a shared decision-making process. Collaboration places value on mutual learning and joint responsibility, and therefore has the potential to increase social capacity for decision-making and empowerment of communities (Pomeroy et al. 1994).

A second goal of co-management systems is community-based development. Several management functions can contribute to opportunities for fishing communities to contribute to their own development. However, Pinkerton (1989) asserts that enhancement, planning and habitat protection are some of the main ways that communities begin contributing. The goal is not to sacrifice the environment for the sake of the community, but to craft policies in a way that values the long-time knowledge and expertise of community members who have a vested interest in the continued health of the ecosystem that supports local economies. Increased participation and responsibility promotes increased stewardship ethics because there is a sense of ownership of the process and pride in contributing to sustainable development.

The third goal is to reduce conflict through a process of participatory democracy. The assumption here is that increased participation in management will reduce conflict and opposition because of increased social legitimacy of policy and regulatory decisions. McCay et. al (1996) stated that "there are good reasons to argue that early, systematic and meaningful participation of representatives of user groups in the management process can create the kind of vested interest that works for, not against the collective good" (p.241). The different ways that the public can be involved ranges from requesting information to assessing and recommending solutions to involvement in the final decision (Weiner et al. 2002). This continuum can also be

thought of as a progression of increasing shared power and trust, from cooperation to collaboration (Daniels et al. 2001). An example of this distinction is the level of industry participation in joint research projects. In a cooperative project, a fishing vessel is contracted as a platform from which to conduct a scientific experiment. In contrast, in a collaborative project, the scientist and fisherman would work together in the actual conception, design and implementation of the project.

Socially legitimate environmental policy processes enable public participation and provide opportunities for management to tailor actions and policies to meet local needs while attaining conservation objectives (Daniels et al. 2001). Community-based management provides an open framework for improving communication in fisheries management and encourages collaborative and innovative management strategies to address the unique environmental, economic and social conditions at a manageable geographic scale (Anderson 2001). Direct community participation in developing GIS data that integrates their collective knowledge is one way to improve the fishery management process at the local level and make the community's knowledge visible using GIS (St.Martin 2004). Improved participatory processes, improved substantive information, and new relationships can bridge the scientific and management gaps and help break the impasse in the conflict between government and industry.

Pinkerton (1989) describes the "completeness" of fisheries co-management systems based on the number of potential management functions that industry can perform in collaboration with fishery managers and scientists. The seven potential management functions described by Pinkerton include:

1) Data gathering and analysis to understanding the state of the resource as the basis for sound decisions (including obtaining research funding);
2) Logistical harvest decisions (who, what, where, when, and how fish are caught);

3) Harvest allocation decisions (how much can be fished by whom) to allow equitable access;
4) Habitat and water quality protection;
5) Enforcement of regulations and practices;
6) Enhancement and long-term planning (where to concentrate management efforts for the future); and
7) Broad policy decision-making.

She states that many incomplete co-management systems can evolve into more complete co-management systems, but also that some systems "may have achieved all that is appropriate or feasible in a particular situation" (p. 6). POORT is already engaged in the first cooperative management function in Pinkerton's list, data gathering and analysis, and is doing so to better understand the condition of the resources and the patterns of use in the local area. Local knowledge interviews produced important information for evaluating alternatives for the other management functions of habitat protection, long-term planning, and for evaluating the alternatives for logistical harvest decisions.

Local Fisheries Knowledge in Fisheries Management

The perceived polarity between "scientific knowledge" and "traditional or local ecological knowledge" is an artificial construction of the current era. It was not until the late 1700s that theoretical knowledge and practical knowledge were categorized and separated (Nader 1996). Although local ecological knowledge differs from scientific knowledge, they also have similarities (Table 1). Traditional ecological knowledge and conventional science both 1) acquire data through empirical observations; 2) observe, compare and classify; 3) see nature as a system of relationships; and 4) work towards acquisition of objective knowledge (Hipwell 1998). However, it has become common for Western theoretical science to consider itself "superior" in some way to indigenous knowledge and to the knowledge of the laypeople from the same society (Nader 1996). It may be that the fishery managers

and the fishing industry are just interpreting the complexity of fisheries dynamics from two different perspectives, as linear and non-linear systems (Smith 1996). IN any case, opening up the dialog to include a discussion of different knowledge paradigms may be the beginning of many opportunities for mutual learning. It would seem that modern science and traditional and local knowledge are all just different "ways of knowing," a continuation of the historic human effort to understand and give meaning to the world.

Table 1: Characteristics of TEK and Scientific Ecological Knowledge

Traditional Ecological Knowledge	**Scientific Ecological Knowledge**
Mainly qualitative (although counting may be used, other modes of measurement and analysis are central)	Mainly quantitative (strong preference for quantitative measurement and analysis)
Emphasizes intuitive and informal modes of knowing	Emphasis is on formal inductive and deductive logic, although intuition can play a role
Views nature holistically as more than the sum of its parts and includes a spiritual aspect	Tries to explain nature by identifying limited sets of principles or laws, as do chemists and physicists. Specifically excludes a spiritual aspect.
Mind and matter typically considered together	Mind and matter often separated
Includes moral values	Ideally value free
Based on observations & accumulation of facts by trial and error	Systematic, deliberate accumulation of fact through experimentation
Based on data generated by resource users themselves	Based on data generated by specialized researchers
Based on long time-series information in one locality (diachronic data)	Based on short time-series information over a large area (synchronic data)
Primarily concerned with local interest and needs	Concerned with principals of general interest and applicability [i.e., theory]
Tries to control nature to benefit specific human interests	Tries to control nature to benefit specific human interests

Traditional ecological knowledge (TEK) is a term first coined in the 1980s and has been described using many terms including, "indigenous ecological knowledge," "indigenous technical knowledge" and "folk knowledge" (Hipwell 1998). Many concepts of TEK include self-management of the resources and knowledge that is closely tied to social or spiritual aspects of culture (Stevenson 1996). Anthropological studies of TEK are relatively recent as compared to studies of traditional knowledge of agriculture or botany (Berkes 1993). The common thread of all the terms for TEK is that the knowledge is of a localized place and it is passed down through time through social and cultural practices.

Non-indigenous or laypeople also have knowledge about the ecology of local areas that is accumulated by experience and shared throughout generations. *Local* ecological knowledge (LEK) is the terminology used to differentiate ecological knowledge of a non-indigenous society that can be acquired over a single lifetime as well as over several generations. Local fisheries knowledge (LFK) is a particular type of local knowledge acquired through experiences and observations made during fishing and related activities. LFK may include knowledge of: local distribution of fishes and habitats, ecological interactions, local fishing businesses, social dynamics of fishing, fishing communities' territories of use, local economics and networks of regional economies of which communities are a part, and local fishing culture (Hall-Arber et al. 2002). NOAA Fisheries recently defined LFK as "knowledge about commercial, subsistence, and recreational marine fishing/harvest, including the marine environment and species; fishing culture and society; fishing technology and practices; and business and economic aspects of fishing" (NMFS 2004). LFK can be possessed communally or individually and is tied to a specific place and is locally significant (NOAA Fisheries, 2004d). Fishing communities' knowledge of territories of use and species distribution is included in LFK. Because the process described in this research documents the knowledge of a contemporary commercial fishing

community and includes both ecological and socioeconomic knowledge, this project involves the communication of local fisheries knowledge.

Several researchers have categorized the differences between TEK and conventional science (Johnson 1992; Berkes 1993; Stevenson 1996). Theoretical knowledge is associated with particular methodologies that validate information through experimental processes. Traditional or local ecological knowledge is associated with people's knowledge of the ecological relationships of a place, which is developed and validated through experience and transmitted by social and cultural means. Unfortunately these differences have been cited as reasons enough to dismiss local ecological knowledge in resource management (Johannes 1993).

Are the differences between local knowledge and scientific information so vast that the two types of information cannot truly be integrated into one management system? The benefits of local fisheries knowledge include increased spatial resolution of information, more holistic and qualitative analysis, and diachronic data (small area/long time periods) (Hipwell 1998). Incorporating LFK with fisheries management provides substantive information to fishery managers consider when making controversial and complex fisheries management decisions. The NOAA Fisheries web site states that traditional and local ecological knowledge positively contribute to the fishery decision-making processes:

> "Local ecological knowledge and traditional ecological knowledge can enhance fisheries science and management, particularly as it contributes information about species range, diet, behavior, seasonal patterns, habitats, and fishing gear. It can support existing scientific knowledge, draw attention to inconsistencies between the two, and provide information that can lead to the creation of testable hypotheses and collaborative research" (NOAA Fisheries, 2004b).

NOAA Fisheries has demonstrated increasing recognition of the value of social and economic local knowledge by increasing the investment in social scientists and socioeconomic and anthropological research at regional offices and science centers. For, example, the Senior Social Scientist of NOAA Fisheries recently led a session on "Integrating Local Fisheries Knowledge" at the 2004 Annual Meeting of the Society for Applied Anthropology in Dallas, Texas. The Port Orford Community Mapping Project was presented as an example of integrating scientific and local knowledge systems using GIS. NOAA Fisheries is also currently developing a Community and Port Profile Database (of which Port Orford is a part) (Karma Norman, Northwest Fisheries Science Center, pers. comm., 2004) and piloting a local fisheries knowledge project in New England states (NOAA Fisheries, 2004c). The Essential Fish Habitat Draft Environmental Impact Statement will utilize habitat maps generated by fishermen overlayed with those generated by biologists to ensure that the appropriate areas are targeted in habitat management context (Abbott-Jamieson et al. 2003). Fisheries managers are realizing the value of local fisheries knowledge in crafting socially legitimate policy decisions.

Utilizing LFK in fisheries management demonstrates a movement towards improved recognition of local knowledge systems and potential for mutual learning, which fosters an improved relationship between industry and management (Dale 1989). Some fishing communities are looking to provide information that can be helpful in analyzing the ecological and socioeconomic impacts of fisheries policy and regulatory decisions. By incorporating local knowledge, fisheries management will be better positioned to consider the unique trade-offs needed to create sustainable fishing communities. The information collected through local knowledge interviews can be used to support both traditional and more co-operative fisheries management.

One goal of community-based fisheries management is to enable the current management system to consider the holistic local knowledge about the resource

ecosystem. Some researchers argue that revealing local knowledge to managers relinquishes power to the resource management agency rather than empowering the local community (Johannes 1993). Communities are providing local knowledge to increase their local participation in and shared responsibility for science and management activities for fisheries. Increasing the collaborative potential between diverse groups of people is a central tenet of co-management and community-based management. Community-based management provides fishing communities with an appropriate management context in which to use methods to document and utilize local knowledge for resource management.

Participatory GIS to Compile Local Fishing Knowledge

Public participation GIS (PPGIS) expands GIS science into a framework for effective communication about spatial information of a local place and offers processes that promote active community participation in crafting solutions to local problems (Schroeder 1997). By definition, PPGIS is a bridge concept that looks at the practice of using GIS in a social setting (Schroeder 1997). Since the development of the first GIS in the mid-1960s, its increasing use by community organizations has been made more feasible as costs declined, user interfaces improved, and a trend towards a more human-centric vision of GIS developed (Craig et al. 2002). Communities are now using GIS to develop consensus of a geographical representation of a particular place and to communicate their local knowledge of that place to other people. Participatory GIS also offers communities a framework to integrate local knowledge and conventional science. PPGIS products and processes can be a starting point for meaningful community participation in collaborative science and management, although the challenge of implementation often comes down to a matter of scale.

The term "scale" has several meanings and confusing terminology; it can refer to the geographic extent of something, the spatial resolution of a representation, or to the scale of a map (Longley et al. 2001). The scale of the geographic extent of an

observation indicates the amount of area that it covers. A large-scale activity covers a large area, whereas a small-scale activity covers a relatively small area. The same terminology is used to describe the extent or scope of fiscal and human resources for an activity. For example, a small-scale fishing fleet may require less people and capital to operate. When discussing the spatial resolution of a map (i.e., the level of spatial detail represented), the terminology gets confusing. To clarify, the author uses "fine-scaled" to refer to maps that display records at a high level of detail or resolution and that represent very small objects. The author uses "coarse-scaled" or "granular" when referring to maps do not record small objects and have low resolution or spatial detail. The map scale is the representative fraction that is the ratio between map units and on-the-ground units of measurement.

The scale of scientific information feeds into the development of management options. Local knowledge is place-specific knowledge and tends to necessitate the use of finer-scale maps that focus in on a discreet area. The use of GIS technology in a community can help develop consensus of a common vision of place (Kyem 1998). Participatory GIS projects make visible communities' geography and ecological knowledge and can put this geography at the center of discussions about management strategies and community development (St.Martin 2001). However, the current usefulness of fine-scale local knowledge is constrained by existing scientific and management mechanisms. In an example from Newfoundland, Canada, locations derived from fishermen's knowledge of viable fisheries closures was not able to be considered by fishery managers because the refined scale was incompatible with the coarse scale of traditional fisheries data collection and analysis (Macnab 2002). Managers were unable to evaluate the effect of the closures on harvest levels because the unit of analysis was not compatible. However, there is a trend towards refining the current scale of fisheries data collection and analysis to evaluate how management decisions may impact fishing communities.

Public participation GIS provide an opportunity to integrate diverse forms of knowledge and scientific information. Public participation GIS to engage fishermen in management discussions was demonstrated in California where local fisheries knowledge was used to conduct a socioeconomic study of marine protected areas (MPAs) (Scholz et. al 2004). The Channel Islands National Marine Sanctuary also collected and analyzed spatially explicit local knowledge when evaluating marine reserves as a tool for marine resource management (Kronman et al. 2000). The participatory GIS process allows local knowledge to be put in a format useful for environmental impact assessments and other management applications (Johannes 1993).

Participatory GIS in a fisheries policy setting contributes to the community-based fisheries management goals of increased participatory democracy and to the decentralization of management responsibilities. PPGIS can be used by a community to establish a common vision of their place of interest that can serve as the basis for deliberation about public problems (Kyem 1998). Weiner et al. (2002) states that GIS technology enables citizens to understand and prioritize issues, consider alternatives, and reach viable conclusions. GIS in public participation settings has the potential to empower communities to develop consensus about their environment, resolve disagreements and difficulties, and allow them to actively participate in long-term planning (Craig et al. 2002). The process of collecting spatial information and making it available to managers also demonstrates shared responsibility and interest in mutual learning. Increasing the level of community involvement in decision-making processes may also reduce conflict in fisheries management decisions and increase social legitimacy in fisheries policy development.

A danger of any GIS, but especially poignant with participatory GIS, is that the products could be perceived as valid even if the data supporting them are not accurate (Schroeder 1997). Very simply, it would seem that presenting local fisheries

knowledge in a spatial database format lends credibility to the information. Johannes (1993) asserted that more effort is needed to determine the validity of local knowledge and that while local "observations of natural phenomena maybe acute, the conclusions drawn from them may not be accurate." Ground truthing information through additional research could verify the accuracy of spatially explicit local knowledge. There are other techniques, such as measures or indicators of data quality, which can be included on any map products. For example, the Sea Floor Mapping Lab at Oregon State University developed an indirect assessment of thematic map accuracy for their EFH habitat maps (Romsos et al. 2005). These kinds of "error maps" provide the context for the displayed data and inform the readers about the relative degree of uncertainty of the data used to map the themes.

Although some community organizations have the resources to develop GIS capacity in-house, this is rare in small communities because of limited human and fiscal resources (Sawicki et al. 2002). Benefits of in-house GIS arrangements are local control of access and use of the data. However, many communities do not fully utilize GIS functionality or the advanced spatial analysis capabilities (Weiner et al. 2002). Internet GIS data portals such as the Oregon Coastal Atlas (a web-based portal jointly managed by the Oregon Ocean-Coastal Management Program, Oregon State University, and Ecotrust) can provide an option for finding common ground between controlling access and promoting the use of PPGIS data (Haddad et al. 2005). In this project, the use of individual data layers can be password-restricted until such time that the community is ready to share or use it (Oregon Ocean-Coastal Management Program, 2000). Community organizations need to be using the GIS software often enough to justify the investment in the equipment and training. Also, the additional cost of collecting, maintaining and updating databases needs careful consideration. When participatory GIS work is done in conjunction with universities, government agencies or non-profit organizations, communities may focus on asking the right

questions rather than spending time and money to learn how to use the tool (Sawicki et al. 2002).

Port Orford, Oregon—A Small 'Fishing-dependent' Community

In 2000, Port Orford began exploring how a community-based framework and comprehensive strategic plan could improve the understanding and management of their local fisheries and recreational uses. Through a non-profit organization called the Port Orford Ocean Resources Team (POORT), science and management questions are being addressed at the scale of a single fishing community. In March 2003, the POORT established a local office (Figure 2) on the street going down to the dock and harbor. Since then, the office has become a hub for community members and scientists to get information and to find assistance for cooperative research projects. Two initial steps are being taken concurrently to facilitate the evolution of a functional community-based management structure in Port Orford: education and empowerment of local stakeholders to contribute to sustainable solutions, and preliminary assessment of the biological, economic, and social health of Port Orford's nearshore resources.

Figure 2: POORT's Office (V.Wedell)

Under POORT's guidance, the Port Orford Community Mapping Project examined this relatively small fishing community on the South Coast of Oregon with a particular eye as to how it utilizes the ocean area for commercial and recreational uses. Through the local knowledge interviews, qualitative and spatially explicit information were collected that describes some of the changes occurring in this small-scale fishing community. The following information is an excerpt of the Port Orford Fishing Community Profile that the author completed, of which a majority was included in the Northwest Fisheries Science Center's short form fishing community profile (Appendix A), which is discussed in more detail in the Results and Discussion chapter in the section on community and port profiling.

Location

Established in 1851, Port Orford was one of the first Euroamerican settlements on the Oregon Coast and has depended on natural resource extraction throughout its history. The original port facility dates back to 1856, with the port district being formed in 1911. Logging and lumber milling of Port Orford cedar supported the community for many years, reaching a peak during the 1930s. Currently, the port's only commodity is local seafood. Port Orford's maritime history includes about 40 fishing families, with some having third generation fishermen with over 50 years of cumulative knowledge passed down through the generations (Anderson 2001).

Port Orford meets two out of the three isolation criteria used by Langdon-Pollock (2004) to study West Coast fishing communities. Port Orford is disqualified because it is located on a major highway, Oregon state route 101. Port Orford has a recorded population of 1,153 (U.S. Census 2000), which is below the 1,900 maximum used in this study. This port is located more than 35 miles away from a major population center; it is approximately 50 miles south of the nearest large population center of Coos Bay/Charleston/North Bend (combined population of ~26,000) and about a

three and a half hour (160-mile) drive to Eugene (population 137,893; 2000 Census), the closest interior city (Figure 3).

This fishing town is situated within a semi-enclosed ocean embayment, unlike most other Oregon ports, which are located within estuary harbors or along river channels (Figure 4). Large sand bars outside the nearest ports of Bandon to the north and Gold Beach to the south, both about 25 miles away, make water-borne transportation into these ports potentially dangerous to the small fishing vessels of Port Orford, especially during poor weather conditions (Interview 193). The relative geographic isolation of Port Orford may contribute to the town's sense of cohesion and community.

Just 10 miles north of Port Orford, Cape Blanco is a prominent oceanographic feature in the California Current system, separating two distinct oceanographic regions of the Northeast Pacific Ocean (Mackas et al. 2002). The ocean area in front of Port Orford exhibits some characteristics of both these regions. Generally, eastern boundary currents like the California Current induce strong upwelling conditions in the nearshore area and support diverse and abundant marine life including fishes, invertebrates, marine birds and marine mammals. The continental shelf is quite narrow along this section of the Oregon coast, providing the Port Orford fleet access to both nearshore and deeper shelf fish species that would typically be out of range for smaller sized vessels like those in the Port Orford fleet.

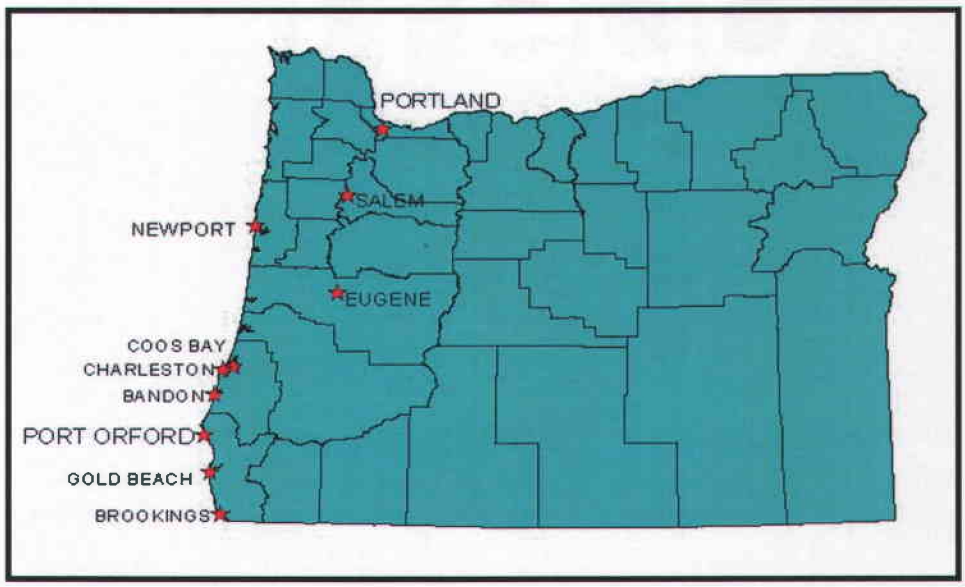

Figure 3: Map of Oregon showing Port Orford and other coastal communities.

Figure 4: Air Photo of Port Orford (City of Port Orford)

The Orford and Blanco Reefs are marine extensions of the cape's rocky headlands, and together, consist of about seven miles of rocky reef and bull kelp (*Nereocystis*) habitat. Several reef features including Fox Rock of Orford Reef break the surface of the water to form small islands that extend the three-mile limit of state jurisdiction to include most of the nearshore reef area near Port Orford. This is evident in Figure 5, provided by the Oregon Coastal Management Program (OCMP). This extension of the Territorial Sea means the inclusion of some deep-water shelf habitat, extending out to 100 fathoms. Small pocket beaches enclosed north and south by rocky headlands make for a diverse range of nearshore benthic and shoreline habitats.

Figure 5: Oregon's Territorial Sea (OCMP)

Fishing Industry Employment in Port Orford and the Groundfish Crisis

Port Orford is very much a fishing community, supporting about forty local fishing families (Anderson 2001). The relative proportion of fishing-related employment has statutory and management implications as set out by National Standard 8 of the 1996 Sustainable Fishing Act. However, the estimates of local fishing employment vary considerably, from as high as thirty percent to as low as less than seven percent, as reported by Scholz (2003) and the U.S. Census (2000), respectively. Anderson (2001) reports that depending on the season, the community has between 100-150 people

directly or indirectly involved in the day-to-day activities of commercial fishing, which would represent about ten to fifteen percent of the estimated 2000 population. Radtke and Davis (1997) reported that the port brings 226 commercial fishing-related jobs, representing twenty-two percent of the estimated population in 1996 (U.S. Census Bureau). If employment estimates determine relative fishing dependency, apparent dilution of dependency will occur with increases in non-fishing proportion of populations. In Port Orford, this dilution could result from the immigration of California retirees to the area or with the reduction in fishing employment, such as those moving out of the industry due to lack of fishing opportunity because of the groundfish crisis.

The Port Orford fishing community received more than $800,000 in direct payments from the Groundfish Disaster Outreach Program (GDOP) from 2000-2004, indicating a high level of dependency on the groundfish fishery. With federal appropriation funds, the GDOP worked primarily with two other agencies to aid in transitioning people affected by the groundfish disaster into new careers. The Oregon Employment Department administered the Groundfish Transition Income and the coastal Workforce Investment Agencies provided the actual training for new careers. In Port Orford, the target recipients for the transition income are boat owners and their spouses, deckhands, shore-side baiters, and processor employees from recently closed Premium Pacific Seafood Company (Table 2).

Unique to the Port Orford fishing community are the displaced shore-side baiting crew. A traditional longline vessel's crew baits the longline gear onboard the actual vessel while at sea. However, Port Orford vessels are too small to have room onboard to bait tubs. 'Tub gear' is used in Port Orford and is named so because of the metal tubs that contain the wound up line with hooks and bait. The shore side baiting crews,

Table 2: Statistics of Port Orford Community Involvement in the GDOP.

GDOP Retraining in Port Orford (2000-2004)	**Number of People**
Vessel owners and captains	3
Fishermen's wives	13
Deckhands	17
Shore side baiters and processor employees	16
TOTAL	**49**

who are often family members of fishermen, baited tubs seasonally from March thru August until decreasing groundfish quota eliminated the need for their services. With limited opportunities available in Port Orford, many of these people continue to struggle to find jobs. Of the 49 applicants, 29 have completed their transition successfully into new careers, which include dog grooming, nursing aides, truck driving, and mechanical work. Not everyone from Port Orford who participated in the GDOP was successful in transitioning to a new career. Challenges identified by the GDOP Outreach Peer in Port Orford include: willingness to relocate, no GED or high school diploma, no driver's license, and drugs and alcohol abuse (Leesa Cobb, pers. comm. 2003). The accessibility of other employment opportunities another important factor that affects how relatively dependent a fishing community is on commercial fishing.

Port Infrastructure and Facilities

Of Oregon's 23 public ports, the Port of Port Orford is one of the smallest ports in size (its taxing district comprises just 150 square miles), but it is relatively large in

terms of economic contribution to the community. Radtke and Davis (1997) estimated that the port brings $4,310,000 of personal income and 226 jobs, with 96 percent of both from fishing-related income and employment. They also estimate that the port generates $915,000 in state and local taxes, from industries closely linked to the port's activities. Between 2000-2004, the average value per ton of commercial catch landed in Port Orford was $3,443, compared to the average value of $741 for the rest of the Oregon ports (International 2004). This is due to the increase in the live rockfish market, a low-volume and high-value fishery, in which about 30 Port Orford vessels participate. Live rockfish are sold for between $2.00 per pound for Copper rockfish (over 2 pounds) to $7.00 for Grass rockfish. The relatively high landings value of Port Orford in comparison to other Oregon ports is also due in part to the high-volume, low-value landings of other Oregon ports, including whiting in Newport and Astoria and sardines in Astoria.

Port Orford has minimal infrastructure. There are facilities and services that include a dock and jetty, two commercial hoists, one sport crane, dry moorage area and parking spaces, minimal land and buildings for lease, beach access and restrooms and showers. The commercial hoists and limited moorage in the Port of Port Orford constrains the Port Orford commercial fishing fleet in both vessel size and number of vessels (Figure 6). Vessels must meet the weight and dimensional requirements of the commercial hoists that lift them in and out of the water to dry moorage. The vessels in the Port Orford are restricted to a maximum length of 44 feet and a maximum width of 15 feet and no more than 44,000 pounds (Private Public Service Site, 2004a). These requirements effectively homogenize the fleet's predominant vessel size class. In addition, all vessels must be fitted with special hooks in order to connect to the hoist. This contributes to the predominantly commercial use of the port, as most recreational vessels have not been fitted with hooks. Small vessel size restricts the range and duration of fishing trips, especially during adverse weather, and results in

somewhat discreet traditional fishing grounds for most species except the highly migratory Albacore tuna. The fishing community of Port Orford is a uniquely homogeneous small-scale port on the South Coast of Oregon with relatively traditional fishing grounds determined by vessel size and capacity.

Figure 6: Photo of Port Orford Dock and Hoists (V. Wedell)

RESEARCH DESIGN AND METHODS

"Not everything that can be counted counts,
and not everything that counts can be counted."
~Albert Einstein

The research discussed in this report tested a process to map local fisheries knowledge in the community of Port Orford, Oregon. The process was designed to develop community support, collect local knowledge about the marine environment, aggregate individuals' knowledge and validate the resulting map representations of collective fisheries knowledge of the places important to the community of Port Orford. The methodology used here included participant observation, informal and formal discussions, and semi-structured interviews with a variety of community members, especially commercial fishermen. This served as a basis for systematically capturing ethnographic data, such as local fisheries knowledge, that cannot be ascertained by literature review or scientific analysis.

In support of POORT efforts, the goal of the community mapping project was to map local fisheries knowledge of the Port Orford Reef area using participatory GIS. Specific objectives were to:

1. Develop community support for the project, especially the trust and cooperation of the fishermen and their families and partners;
2. Develop and administer a survey and process to draw out relevant spatially-explicit biological and economic information and qualitative data about local participation in Port Orford fisheries;
3. Using these survey data, develop and validate aggregated maps that describe important fisheries from the local community fishing perspective; and
4. Conduct a preliminary analysis of the implications of these data for establishing community-based management of locally important fisheries.

Ethnographic Methods to Develop and Maintain Community Support

Ethnography is a social science method developed within cultural anthropology for studying communities in natural settings (GAO 2003) and typically involves a combination of observation, interviewing, and long-term contact with the subject of study (No Doubt Research 2003). Ethnographic data collection processes are often reflexive, meaning that the fieldwork is dynamic and changes as the project evolves (No Doubt Research 2003). Initial interviews and observations are used to fine-tune the research instruments and redirect the research process itself. New knowledge and information are used not only for understanding and explaining the research, but also for adjusting the approach, design, and methods for a more effective study. Ethnographic methods are exploratory and are appropriate for studying issues or problems that are not readily amenable to traditional quantitative or experimental methods alone, such as studying the spatial patterns and socioeconomic linkages of fishing communities like Port Orford.

Although commonly used to understand indigenous cultures, ethnography can also be used to inform the design, implementation, and evaluation of public programs and federal actions (GAO 2003). For example, the GAO (2003) reports that NOAA Fisheries uses ethnographic methods with fishing communities to gauge the potential social and cultural consequences of alternative fishery management actions or policies on local communities. Similarly, the local knowledge interviews and informal and formal discussions with community members undertaken as part of this study provided an opportunity to collect qualitative and spatially-explicit information that is not available in scientific literature or governmental reports.

Asking fishermen to share their knowledge about their use of traditional fishing grounds is often controversial because of the historically conflict-ridden relationship

between participants and managers of the fishing industry. Trust is an important element that must be proactively addressed and kept at the forefront of both formal and informal discussions. Acknowledging and respecting the real and perceived power dynamics that currently exist between the fishing industry and fisheries management is also critical. Therefore, developing community support for sharing local fisheries knowledge is essential for the success of implementing community mapping projects like the one undertaken here. To foster cooperation and candid communication, and to build community support, effective ways of dealing with trust and power needed to be incorporated into the interview and GIS mapping methodologies.

Ensuring local control of the process and development and use of the map products was also vital to establishing and maintaining community support for the project. It was important that the project be a successful and positive experience for participants and for POORT, rather than trying to push to get the last data point, or by sharing data when POORT was not ready. People were encouraged to only share information with which they were comfortable. One principal way to communicate sensitivity of the concern of data misuse was to sign a confidentiality agreement (Appendix B) and informed consent document (Appendix C) at the outset of the interview process (discussed in detail in the following section on Data Collection). This committed researchers to protect the anonymity and the proprietary nature of information to the extent practicable under law. Random identification numbers provided anonymity of individual information and spatial representations. Except for the results of the pilot interview where permission was obtained, no individual information was ever shown in a public setting. Contact information was taken only so that the interviewees could be contacted to arrange for the follow-up verification interview. The random identification number referenced an individual's local knowledge, and appeared on the map overlays, interview notes, and in the computer records. Individual data were securely stored and were not accessible to any person other than the interviewer and

the contractors who input the information into the computer. After all information was collected and verified from all interviews, the acetate maps and written information were either returned to the participant or destroyed. Issues of access, representation, privacy, and confidentiality were incorporated into the process, as they were important to gaining and keeping the community's trust and contributed to the success of gaining community support for participatory GIS.

Long-term contact with a community is another common characteristic of ethnography, allowing the researcher to experience the regular patterns and routines of those being researched (No Doubt Research 2003). Extended stays in Port Orford provided the opportunity to observe activities during different fishing seasons and to develop social relationships with people in the community. Developing a personal relationship with the Port Orford fishing community was essential to their decision to trust the author and research team with collecting and mapping their personal knowledge of fishing and fisheries. The foundation of cooperation involved developing personal relationships with the fishing community, continually collaborating with respected community leaders, and focusing on local ownership of the process and the products of the community mapping project.

Close collaboration with respected community leaders was one of the most important elements of building community support for the mapping project. Probably the most important relationship was developed with the POORT's Communications Coordinator, Leesa Cobb, who is a member of a Port Orford fishing family with roots in both logging and ranching. Her participation in and support of the community mapping project was essential for the project's success. With respect to ethnographic study methods, she would be considered both the "gatekeeper" and the author's "key informant" for the community (No Doubt Research 2003). Gatekeepers help researchers gain access to the community of interest. Key informants are those persons who know the "inside scoop" and can help direct the researcher to other

knowledgeable community members. Her personal knowledge of the dynamics of fishing in Port Orford and her personal relationships with the fishermen, their families and partners was invaluable to learning about Port Orford. Getting her approval and assistance was integral to gaining the trust and cooperation of the local fishing community members.

POORT's Project Manager, Laura Anderson, was another important community leader who collaborated with the research. Although she has never commercially fished from Port Orford, Anderson has personal experience in Oregon commercial fishing with her family, and her practical and academic knowledge has helped guide the development of POORT and the implementation of the cooperative research projects that they have executed. Through her independent consulting business, she manages POORT contracts and fiscal resources and provides POORT with valuable administration and management assistance. Over the last four years, she has developed a good working relationship with Port Orford fishermen and has credibility with the community that enhanced the development and implementation of the Port Orford Community Mapping Project.

Over the two years of project development and implementation, the author was integrated into the Port Orford community by attending and participating in several community events, spending time in town working from the POORT office, visiting local restaurants and bars, staying in local hotels and inns, and frequenting the dock and shops. Learning about the intricacies of this unique commercial fishing port and the community that depends on it occurred through personal observation and discussions with local people. Formal presentations at POORT planning and informational meetings provided another way to develop strong working relationships with the Port Orford community. The interests expressed by the Port Orford fishing community in both formal and informal discussions guided the topics covered in the

meetings. Examples of meeting topics include marine reserves and protected areas, quota management systems, and GIS technology and processes.

Data Collection Process

The author used several examples of participatory GIS from the literature to create a unique data collection process for the Port Orford Community Mapping Project (Macnab 2002, Kronman et al. 2000, and Scholz et al. 2004). The goal of the project was to test the protocols for collecting, analyzing, and presenting local knowledge using GIS. Focusing this research on the development of the unique mapping process, rather than on the substantive data or set of maps that were derived from the process, was a strategic decision that was intended to preserve local control of the data until the community was comfortable with sharing them. The interviewing and mapping process was an iterative data collection process to ensure that each interviewee was given the opportunity to check for accuracy and to provide an opportunity to make necessary corrections to the spatial and qualitative data collected and represented. Macnab (2002) also suggests that individual user areas could be documented very accurately using a global positioning system and extensive field surveys, although this could be expensive and time consuming. A semi-structured interview and participatory GIS methodology was developed, which documented local knowledge about the status and spatial distribution of marine resources and human activities important to the Port Orford community. The local knowledge was recorded using a database template during interviews and was later combined with spatial layers generated from the interviewees' hand-drawn map layers, creating individual GIS databases for each of the 33 interviews.

Materials and Methods Development

The Port Orford Community Mapping Project process began with creation of the basemaps, draft interview questions, a general GIS framework, and supporting

materials for the interview process. Both materials and methods for the local knowledge interviews were tailored to fit into the frames of reference of participants, so as to facilitate their communication of local knowledge (Table 3). All materials and methods evolved during the development and implementation of the project. Most important, a pilot interview provided an opportunity to refine the interview questions and process, and to improve upon the original design of the supporting materials. For example, the pilot interview took over four hours to complete, a huge time commitment for volunteers. To reduce the amount of time required for participants to be interviewed, improvements were made to the questions, basemaps, and the database template.

Table 3: Materials for Local Knowledge Interview Process

Confidentiality Agreement and Informed Consent Document
Interview questions
Checklist of activities/species/resources
Interview response spreadsheet
Four large size (36"x36") basemaps
1:120,000 "Coos Bay to Gold Beach"
1:40,000 "Port Orford Nautical Chart"
1:24,000 "North of Port"
1:24,000 "South of Port"
Acetate overlays, scissors, and masking tape
Colored wax pencils
Tissue eraser
Identification guides

The initial development of the interview instrument and GIS database template was guided by the research and management questions generated by the Advisory Board and the Science Advisory Committee (Table 4) and by two examples of ethnographic surveys: one for the Channel Islands National Marine Sanctuary (Kronman et al.

2000) and one for mapping fishermen's knowledge for marine protected area planning in California (Scholz et al. 2004). The Port Orford Community Mapping Project focused on determining the distribution of biological resources and commercial and recreational human activities. The project also tested a method of documenting the relative socioeconomic value of areas for fisheries. Research projects are already being developed and implemented by POORT to answer some additional questions, including identifying if some fish species are residents of the Orford Reef, the movement patterns of species, and gear selectivity.

Table 4: Spatial Research and Management Questions Developed by POORT

1. What are the distribution, abundance and diversity of species near Port Orford?
2. What are the distributions of recreational and commercial effort and socioeconomic value?
3. Are some species residents? What are their movement patterns?
4. What is the catch per unit effort of different fishing gear types?
5. What is the correlation between habitat and species distribution, abundance, and diversity?
6. Are spatial management strategies appropriate for Port Orford? What kind and where might they be located?

In order to represent the diverse interests of the entire Port Orford community, rather than only commercial fishermen, the maps and questions were designed to facilitate communication of local knowledge in general. Similar to the Channel Islands survey, the protocol and materials were flexible enough to facilitate interviews with variety of audiences. People of different professions or recreational activities see the nearshore and ocean areas in different ways. For example, surfers and beachcombers had more detailed knowledge of the shoreline and beaches, whereas a groundfish fisherman had detailed knowledge of underwater rock structures, including ledges and high spots. In Scholz et al. (2004), commercial fishermen were asked a series of questions on four core areas in a semi-structured format. The Port Orford Community Mapping Project's interview process was modeled after this "free flowing (style of)

conversations guided by a set of specific questions" (p. 5) (Scholz et al. 2004). This allowed the participant the freedom to elaborate on topics of choice and promoted naturalness of the discussion of the resource and activity categories.

Kronman et al. (2000) also provided a model for collecting a user profile as part of the local knowledge interview questions. This helped categorize the interview participants for later analysis. In this first part of the interview, the age, sex, profession/recreation and primary activities of the interviewee was recorded along with their number of years experience in their chosen activity or profession in the Port Orford area. Several people identified themselves by more than one category, such as commercial fishermen who also enjoyed surfing, or someone who recreationally fished from a kayak. In a few instances, two or more interviewees chose to conduct their interview together. The participants were asked to select a representative for the demographic analysis. Knowing the number of interviewees, their mean age and mean number of years experience can add validity to mapped and qualitative data.

In the Channel Islands survey, information was divided into twenty-four resource or activity categories, whereas the Port Orford Community Mapping Project had a list of over 80. The database format was established based on the resource and activity themes and designed to facilitate data storage, retrieval, and analysis. Although this wealth of information provides the Port Orford community with a very comprehensive baseline inventory, it was costly in terms of interview and digitization time.

Laminated basemaps served as the foundation for the interviews and were extremely important for relaying the spatial components of local knowledge. Using these maps to collect and display local knowledge was a natural outflow from fishermen's experience using nautical charts for navigation. Much of this methodology is from Macnab (2002), who used digital topographic maps to develop prototype basemaps

depicting most of the community's harvest area and several local place names, or "toponyms." The basemaps displayed the relevant National Oceanic and Atmospheric Administration nautical charts, the latest bathymetric data (C. Goldfinger, pers. comm. 2003) displayed as both depth contours and shading, and some local place names. Academics and professional scientists almost always record data on depth in meters. However, depth contours were labeled in fathoms to better relate the maps with the fishermen's experience of using nautical charts, which display depths in fathoms. Customizing data to meet fishermen's needs and worldview fosters clear communication.

Four basemaps were needed to cover the Port Orford study area. The smallest scale basemap (i.e., covers the largest amount of area) was 1:120,000 and displayed the South Coast of Oregon from Coos Bay in the north to Gold Beach in the south. However, through interviews, it was learned that these maps did not show the complete extent of the Port Orford fleet's fishing activity. Albacore tuna, black cod, and salmon are fished beyond the area represented on the maps. For logistical purposes, limits of Port Orford study area had to be defined. Coos Bay and Gold Beach were chosen because most of the Port Orford fishing activities occur within this latitudinal range. Two of the basemaps were larger scale (1:20,000) representing the marine area closer to the port of Port Orford, from north of Cape Blanco to Sisters Rock at Frankport, Oregon. One basemap was modeled after the scale used on the Port Orford nautical chart, 1:40,000. Interviewees were encouraged to utilize any base map that met their needs. Most used three, but several only used the two larger-scale maps due to their need for higher resolution.

Putting toponyms on the basemap of the study area helped orient interview participants to the areas covered by the maps, and therefore facilitated more effective communication. Toponyms also give a sense of familiarity and ownership of the process to the interviewee. The obvious major nearshore rock structures were labeled,

including: Orford and Blanco Reefs, Redfish Rocks, Island Rock, and Sisters Rock. Locating and delineating other local places required additional assistance from the local fishermen and interview participants. There was consistency of local knowledge about safe passageways between the rocks (e.g., the Big Hole, the Little Hole, and Hell's Gate). Fishermen who target the same species referred to the same places such as the High Spot, the Banana, and the Canyon. The utility of toponyms was not limited to enhancing communication; they also improved the data transcription and digitization processes.

After conducting a few interviews, an ad-hoc focus group was convened to delineate the spatial extent of the most commonly referenced local places. This small group discussion took place at the Hallmark fish shack down on the dock and involved approximately 6-8 Port Orford fishermen. They were asked to provide a consensus as to where and how big an area they were talking about when they would say, for example, "the Banana," or any other of these local places. The focus group participants drew on layers of acetate taped on top of the laminated basemaps created previously. From this discussion, 20-25 "standard" polygons were collected and used in creating the GIS databases.

Having standard polygons allowed the interview process to proceed more quickly because each interviewee did not have to draw these places on the maps. An abbreviation for the location was documented in the interview template next to the appropriate species or activity and the actual spatial representation, or polygon, was incorporated during the data digitization process. Although these polygons were not standardized in the traditional scientific sense, each interviewee had the opportunity to amend their draft maps in the follow-up interview. A review and clearance process was used to validate the data collected.

Human Subjects Research Approval

In order to administer the interviews as part of the author's graduate research, the Oregon State University Institutional Review Board (IRB) had to approve the research methods. The research community has a responsibility to ensure that the treatment of human participants meets the highest ethical standards. An academic research project involving human participants requires review and approval by the IRB before any recruitment or fieldwork may begin. The approval number for this research was IRB Protocol No. 2271.

The IRB approval process for the Port Orford Community Mapping Project involved the submission of an application that adequately described the project, the intended participant population, the methods and procedures, the potential risks and benefits, and the processes for maintaining anonymity and confidentiality and for obtaining Informed Consent. The application also included the actual materials used to recruit interview participants, the survey instrument and the Informed Consent Document (Appendix B). Each participant had to read and sign the Informed Consent document to participate in this research. The participant's signature indicated that the research study has been thoroughly explained to them, that all their questions had been answered, and that they voluntarily agreed to take part in the study. Each interviewee received a copy of this form for their personal records. Every Informed Consent Document was turned in to the IRB at the conclusion of the research project.

All researchers that were to participate in the interview process were required to be trained through the IRB. Leesa Cobb, Laura Anderson, David Revell, the author's academic advisor, and the author all completed an online tutorial in the ethical treatment of human participants in research. Proof of completion was submitted to the IRB for review and approval as part of the application package.

Introducing GIS to the Port Orford Community

Two POORT planning meetings in 2003 were used to introduce and demonstrate the participatory GIS process to be used in the Port Orford Community Mapping Project. At the first meeting, the basic concepts of computer mapping and GIS were introduced, resulting in a valuable discussion of the different types of spatial data and the uses and limitations of GIS. The proposed method of conducting local knowledge interviews was also presented. A local commercial fisherman with over 25 years experience fishing from Port Orford volunteered to participate in a pilot interview. At the second planning meeting, the full pilot interview process and derived information layers were presented to the POORT Advisory Board. To further demonstrate how local knowledge is translated into a GIS layer, a group exercise was conducted to document the navigation routes in and out of the dock. After some healthy deliberation, general consensus was reached that for the community to have input into local fisheries management decisions, relevant information had to be collected and put into a format that would ultimately be digestible to fisheries managers. From that point forward, the Port Orford Community Mapping project became a priority for POORT.

Participant Recruitment

In contrast to more traditional scientific research, where a statistically-significant representative sample of a much larger population is sought, many ethnographic studies do not lend themselves to random sampling and the associated statistical methods. These ethnographic studies use survey methods to collect, analyze and study members of a population. Whereas the goal of a census survey is to interact with every member of the population, the goal of a sample survey is to obtain a large enough sample of participants that "saturation" of knowledge is reached (No Doubt Research 2003). Saturation occurs when additional interviews would not contribute additional knowledge to the data collection effort. For this project, a sample survey was used to select interviewees from the Port Orford community. Fiscal and time

constraints are often the other limiting factors for conducting a sample survey instead of a census, as it was with the Port Orford Community Mapping Project. Sample surveys can have advantages provided they are properly designed and conducted.

The goal of this sampling strategy was to target the most knowledgeable people, but to be inclusive of the community-at-large. Non-probability purposive sampling methods were used to recruit most of the participants for interviews. Whereas probability sampling involves the random selection of participants, non-probability sampling does not (Trochim 2002). In purposive sampling, researchers have one or more specific predefined groups they are seeking to have represented in their sample (Trochim 2002). The methods used for the Port Orford Community Mapping Project targeted people who had direct experiential knowledge about the coastal and ocean resources in the Port Orford area. The sampling from the mapping project was intended to balance obtaining buy-in from the local community and collecting the most accurate data possible.

There are many subcategories of purposive sampling, of which a combination of expert, snowballing, and heterogeneity sampling approaches were used in this application. Expert sampling involves assembling a sample of people with known or demonstrable experience and expertise in some area. Expert sampling started with volunteers from the POORT Advisory Board and community members who attended POORT community meetings. These individuals were primarily commercial fishermen, although also included fishery scientists. Leesa Cobb also helped identify other experts who were not at the POORT meetings, such as port management personnel and fish buyers in Port Orford. She was very cognizant of knowledgeable community members due to being a long-time Port Orford resident and fisherman's wife.

"Snowball" sampling occurred when interview participants were identified through suggestions made by interviewees or the gatekeeper (No Doubt Research 2003). A local veteran surfer and three members of a local fishing family were identified through snowball sampling. In a small community like Port Orford, word-of-mouth can also be a successful sampling method. Two participants contacted the POORT through a flyer (Appendix D) that was posted at the Port Orford dock and in the *Port Orford Today!* (Downtown Fun Zone, 2003). Another person who is a local beachcomber stopped by the POORT office, was curious about the newly formed organization, and decided to volunteer his expertise and time. The author recruited a local resident who enjoyed watching wildlife during an informal discussion conducted during a hike at the Port Orford Heads State Park.

Flexibility in participant recruitment promoted a truly community-based approach to the design and implementation of the mapping project. Heterogeneity sampling is when all opinions or views are sought and when one is not concerned about representing these views proportionately. A cross-section of the community provides representation of a cross-section of values including: extractive and non-extractive use values, and scientific and recreational values. Community representation was the reason for naming the project the Port Orford Community Mapping Project.

Conducting Local Knowledge Interviews

The author was the primary interviewer for the 33 semi-structured interviews and follow-up interviews, although one of the four IRB-trained team members was also present for each initial interview. The author and a consultant documented the information through handwritten notes on a standard database template. Double coverage of interview notes provided a crosscheck for when the author transcribed the interview information into a excel spreadsheet.

The interview process occurred mainly in four steps (Appendix E):

1) Demographic and vessel information, if applicable, were obtained.
2) The interviewees identified the locations of their primary ocean-related activities. If the primary activity was commercial fishing, they were asked about what gear they used for each target species. Fishermen were also asked to assign a value of the relative economic importance of their fishing grounds.
3) The participants were asked to describe their personal observations of other species and human activities and to identify the location of these observations (Appendix F). Additional attributes were also documented at this time.
4) The interviewees were given the opportunity to talk about anything else important to them about the ecological, economic and/or social conditions of the study area. This 'open microphone' time helped identify the common themes of important issues to the community to help guide future community-based management efforts.

In order to capture the 33 interviews, flexibility to the schedules and responsibilities of the interviewees was vital. Two interviews had more than one person present at the interview. A local couple interviewed together because they always did their beachcombing and tidepooling together. A trio of commercial fishermen from one fishing family was also interviewed together. The author did not encounter any internal disagreement during these unconventional interviews and therefore included them in the analysis. The location of the initial and verification interviews varied. Most interviews were conducted in the facilities of the POORT office (Figure 2). However, some were conducted in a local café, at the dock, or at another place of work. The last interview was conducted in the middle of the night at the last minute because the interviewee decided to go tuna fishing early the next morning when the interview was originally scheduled. Not everyone who expressed interest in the local knowledge mapping project was actually interviewed due to scheduling conflicts and the good weather conditions that caused them to go out fishing instead. Because the

POORT office is located on the street heading towards the dock, follow-up with these and other experts was made easier.

Data Compilation and Spatial Analysis

The author coded the data on the acetate overlays and transcribed the interview notes into standardized excel spreadsheets. These spreadsheets became the GIS polygon attribute tables for each interview (Table 5). Other attributes were populated from the interviewers' notes, although not every category was filled in for each interview. To capture the spatial extent of the location of the resource and activity categories, location information was given to the interviewers in one of four ways: 1) directly drawn on the maps in wax pencils; 2) verbally referenced using a local place name; 3) using a depth or distance associations; or 4) using a species association. Each polygon was given a unique identifier and its own record in the database. The author and the Ecotrust and Surfrider consultants digitized polygons from the individual interviews and joined them with the excel databases to create individual digital map layers comprising all polygons assigned to the activity or species. Each interview generated anywhere from ten to fifty spatial data layers.

The author conducted one-hour follow up interviews with each participant to verify the integrity of the data transcription and conversion process. Every resource or activity theme was shown to the interviewee on the computer. The associated attributes of each theme were discussed in detail. Participants specified any necessary edits to the polygon areas and associated attributes. The author then incorporated these edits into the final GIS databases. Every interview was verified in this way.

Table 5: Attribute Categories and Example Values from LKI Database

Attribute Category	Examples of Attribute Value
Name of species or activity	Commercial fishing, surfing, sablefish
Alternate name of the species	Sea trout, ragmops
Species/activity descriptor	Female or male, large, spawning, nursery
Local name of the location area	Big hole, banana, hubbards creek
Area descriptor	North side, east side
Basemap utilized	120K, 40K, 24N, 24S
Percent of effort	1 to 100
Percent economic importance	1 to 100
Gear used	Longline, jig, pots, troll
Description of gear set up	150 pots
Current level of abundance	Abundant or not abundant
Trends	Increasing, decreasing, static
Trend descriptor	Size or abundance
Season	Spring, summer, fall, winter
Climatic patterns	Cyclic, intermittent, year-round
Target species	Dungeness crab, sablefish
Other communities' targeting	Bandon, Coos Bay
Associated species	Octopus, starfish
Habitat associations	Sand, mud, dark water, water temperature
Depth associations	30-50 fathoms

A non-profit organization, Ecotrust, provided integral technical support by conducting the spatial analysis that aggregated the individual interview databases and created the draft community inventory maps (Appendix G). Ecotrust converted vector data into 30-meter grids. Each grid cell was assigned a value of 1 for presence of the polygon area and 0 for its absence. Then, they took cumulative totals for each grid cell using an Arc macro language script, or AML. Ecotrust conducted a nearest neighbor analysis with a 6-cell focal mean to smooth the data. The data was then classified using an equal area distribution of 7 classes and re-categorized as low, medium, and high usage, with 1 equal to the lowest level use and 7 equal to the

highest. This categorization scheme gives an indication of the gradation of intensity of use of areas.

It was economically unfeasible for the POORT to have Ecotrust aggregate all the data layers for the first phase of the project. Six layers were chosen for initial aggregation. Recreational activity layers were combined together to produce a composite aggregate map of the intensity of all recreational uses in the Port Orford area. The recreational activities included: surfing, kayaking, diving, wind surfing, recreational fishing, shore fishing, whale watching, bird watching, and beachcombing.

Recreational fishing and shore fishing are differentiated by whether the people are fishing from a boat or from shore. The POORT chose salmon, Dungeness crab, halibut, and black cod as the commercially targeted species to aggregate in the first round of spatial analysis. These fisheries provided a good variety of species that are economically important to Port Orford. These fishes were also chosen because they were a less controversial or competitive subset of the whole Port Orford fishing portfolio. The community maps developed by Ecotrust displayed the spatial distribution and intensity of use of areas targeted for these species and recreational activities. Finally, an additional socioeconomic spatial analysis tested the process for representing the relative economic importance of areas targeted by commercial fishermen for black cod.

Community-Level Validation of Maps

In January 2004, the community inventory maps developed by Ecotrust were validated through an interactive workshop held in Port Orford. Participants could suggest changes to the maps in a few different ways; increasing or decreasing intensity of use in areas, or changing the spatial extent of the area represented as an area being targeted for recreational and commercial uses. The intent of the workshop

was to validate the information provided in the interviews and its interpretation on the maps showing commercial fishing grounds and recreational areas.

This workshop provided various forums for participants to propose edits in order to account for the differences in people's level of comfort making suggestion in front of a group. People could make suggestions verbally or in writing, individually or in small groups. Proposals for changes were then discussed with the larger group. People voted for agreement, disagreement, or abstention. Votes of abstention were just as important as votes of agreement and disagreement, as not everyone present had personal observations for the chosen target species or for the recreational activities. Conflicting suggestions from participants that could not be resolved were kept "as is." The agreed-upon edits need to be incorporated into the draft maps when additional funding is secured by POORT. On one map, no edits at all were suggested. In the final group discussion, the participants reached consensus that the process accurately represented their knowledge of the spatial extent and intensity of uses in the study area.

Storage of and Access to Port Orford's Local Knowledge

The interview participants made recommendations for immediate uses of the data and the protocols for sharing the resulting maps at the validation workshop. These recommendations were voted on by POORT members to further ensure local ownership of the process and products. The POORT office in Port Orford and the Terra Cognita GIS Lab at Oregon State University provided short-term secure storage for the data. Options for long-term storage of the GIS data include: the POORT office, the Oregon Coastal Atlas, or Ecotrust's Inforain Server. A permanent solution for secure data storage will be decided through a series of community meetings, the first of which outlined the above options.

Workshop participants also recommended immediate uses for the inventory and the level of disclosure. The participants unanimously voted to allow the maps to be published as part of this master's thesis and to be used in professional presentations such as the American Association for the Advancement of Science and the Society for Applied Anthropology Annual Meeting.

Utility of Local Knowledge for Community-based Fisheries Management

Local knowledge inventories, such as the Port Orford Community Mapping Project, provide both data and a process that builds capacity for a community to conduct community-based fisheries management. Using this consensus-building process to learn collaboratively, POORT is building social capacity for long-term resource planning and more participation into management decisions. Local knowledge interviews were a useful tool for developing a more comprehensive understanding of this unique fishing community, its resources, and its dependence on various areas. Mapping local knowledge is a process that can support fisheries management functions including data gathering and analysis, logistical harvest decisions, habitat and water quality protection, and long-term planning, including the identification of economic alternatives (Pinkerton 1989).

This community-based GIS process combined scientific and local knowledge and allowed researchers to collect high-resolution data on a local area. The improved scale of data collected can position the community to be able to assess the potential socioeconomic impacts of fisheries management strategies and communicate these impacts to state and federal fisheries management. GIS and rapid appraisal techniques provide an opportunity to document local knowledge important to fisheries management at scales appropriate for an individual fishing community and in formats acceptable to the fisheries management process (Scholz et al. 2004). Because of

inherent complexity, a comprehensive analysis of the social and economic impacts of fishing regulations will be impossible without new tools.

Using GIS and spatial representation of human uses, economic importance, and species distribution can guide area-based management strategies including: local area management and marine protected areas. This research project can be used to analyze the potential socioeconomic impacts to Port Orford from different spatial management strategies employed in the area. The different spatial management strategies that could be analyzed include: areas with gear limitations (e.g., a no-trawl zone) and exclusive territorial use rights by the Port Orford fleet (i.e., no non-Port Orford vessels). Addressing the community management question "Is there an area off Port Orford for marine protected areas?" remains a significant challenge.

RESULTS AND DISCUSSION

Gaining Community Support

The high level of participant involvement is one measure of support of the project from the Port Orford community. The local knowledge interviews included 36 individuals from the local community who utilize the Port Orford marine environment for their occupation or leisure activities (Table 6). The mean age of the participants was 51 years old. The interviewees had an average of over 20 years experience in their primary activity or profession. The male-female ratio was 31 to 5. The participant sample represented a diversity of professional and recreational categories of marine and coastal uses including: commercial and recreational fishing, surfing, kayaking, beachcombing, tidepooling, birding, whale and seal/sea lion watching, and professional and recreational diving (Table 7). The sample also included scientists, fish buyers and processors, and representatives from the port. The diversity of marine and coastal resource users interviewed demonstrates that the project represented a cross-section of the Port Orford community's values. Many people were not adequately represented by a single category. Every interviewee coming back for his or her follow-up validation interview demonstrated support. A large proportion of participants and other local people attended the POORT planning meetings and the final validation workshop. Success in gaining community support is also demonstrated by the fact that all the interviewees except one permitted their picture to be taken. By the end of the process, each interviewee wanted to be identified as a participant in the Port Orford Community Mapping Project.

How well does the survey represent the involvement of 1) the community-at-large, 2) the local fishing industry, and 3) the Port Orford commercial fishing fleet? The answer is not as simple as it may appear. By legal definition, a fishing community

"includes fishing vessel owners, operators, and crew and United States fish processors that are based in such a community." Does this mean that fisheries

Table 6: Port Orford Community Members
Participating in Local Knowledge Interviews

Local Knowledge Interview Participants	
Total number of people	36
Total number of interviews	33
Average age	51 years
Number of Men	31
Number of Women	5

Table 7: Local Knowledge Interview Participant's
Self-identified Professional/Activity Categories and Average Experience

Categories of Participants in Local Knowledge Interviews	**Number of People**	**Average Years Experience**
Port Orford commercial fishermen	24	25
Recreational fishermen	4	15
Surfers	5	15
Divers	3	15
Wildlife watchers/Beachcombers/Tidepoolers	4	13
Kayakers	1	12
Local fish buyers	4	13
Port of Port Orford affiliates	3	1
Oregon Department of Fish and Wildlife scientists	2	16

management must only assess impacts to those specific individuals? One could argue that the Port Orford's fishing families and port management personnel might also be substantially engaged with and dependent on commercial fishing. The community-at-large includes both the fishing and non-fishing populations. This survey sample represents 36 individuals from the community of 1,153 people, equivalent to approximately 3 percent of the total Port Orford community population.

The local fishing industry includes those people who directly participate in the harvesting, buying and processing sectors. Estimates of the fishing portion of a community are difficult to assess because of the difficulty of capturing the actual number of people with fishing-related employment. As previously stated, estimations of the percentage of fishing employment in Port Orford range from 7 to 30 percent. By these percentages, the twenty-four commercial fishermen and three local buyers interviewed could represent anywhere from 33 to 8 percent of the local commercial fishing industry.

The Port Orford fleet includes the owners/captains, deckhands, and shore-side baiters of the approximately forty vessels that homeport in Port Orford or at the dock. The survey had representatives from 50 percent of the Port Orford fishing vessels. Estimating that each vessel has about two to three people involved in actual fishing activity at any one time produces about 120 people as potential crew, including owner/captains. This is a high estimate, as some people in Port Orford own several vessels and crew may work for several owners. However, this estimate of crew does not include any estimate of the number of supporting shore-side baiters. The information in the commercial effort maps is most representative of the fishing fleet. The twenty-four fishermen interviewed represent at least 20 percent of the fishing portion of the Port Orford, using the estimate of approximately 120 crewmembers.

The twenty-four fishermen interviewed had a combined 524 years experience on the ocean and had a mean 25 years experience commercial fishing in Port Orford (Table 8). They work a *combined* total of over 2000 days/year, *averaging* over 120 days/year out at sea (includes four recently retired fishermen). Sixteen people were owners and/or captains of their own vessels and eight were deckhands, although some now have purchased their own vessel. Six of the twenty-two fishermen were the second-generation of fishermen in their families, and one was the third generation. This sample of fishermen represented approximately 50 percent of the vessels that homeport in Port Orford. Due to the homogenous nature of the Port Orford fleet in terms of vessel size and fisheries, 50 percent coverage of the forty vessels was an adequate representation of the vessels in the Port Orford fleet. Three representatives from the Port Orford buying/processing sector of the fishing industry participated. While most of their knowledge is not derived from direct at-sea observations, they possess a 'common knowledge' of fishing locations and have great insights into the overall picture of the economic activities of this port.

Table 8: Port Orford Commercial Fishermen Participating in Local Knowledge Interviews

Port Orford Commercial Fishermen Participating in Local Knowledge Interviews	
Port Orford vessels	20 vessels ~50 percent of fleet
Average vessel length	34 feet
Owners and/or captains	16
Deckhands	8
Total combined days/year on water currently	2021
Average days/year/person on water currently	119
Second-generation fishermen	6
Third-generation fishermen	1

The confidentiality and anonymity protections built into the process gave respondants confidence that the research project intended to protect the proprietary nature of the data. "Open microphone" time during the interviews provided people an opportunity to air other concerns and to communicate in a more conversational manner. The author had many very candid and frank conversations with participants throughout the interview process and in formal and informal discussions, providing insightful and valuable knowledge of the Port Orford area.

That few map changes were suggested at the validation workshop demonstrated the participants' satisfaction with the outcome and the process. The community group achieved consensus on distribution of areas targeted by Port Orford for commercial and recreational activities represented in the draft maps. It is important to note that the intention of the workshop was to validate the process and results from the interviews, which is different than "groundtruthing" the results. "Groundtruthing" the data would require a scientific comparison of statistically collected data on the actual locations of fishing and recreational activities.

Integration of Local Knowledge and Science

The overall goal of the Port Orford Community Mapping Project was to test the methodology for integrating local knowledge with scientific information using GIS in a social setting. The mapping project used a combination of local knowledge and scientific information to answer some of the spatially explicit scientific questions raised by POORT. The utility of this new spatial information to inform management is dependant on what level of uncertainty is acceptable to managers. New GIS tools are currently being developed and implemented that offer opportunities to further refine mapping processes and information storage and use.

The community inventory maps generated from local knowledge interviews demonstrates a successful process for integrating local fisheries knowledge and conventional scientific information from nautical charts and a bathymetric layer of the Oregon seafloor. Several scientific spatial data layers were compiled in the beginning of the Port Orford GIS development, although not all were utilized in the specific application of documenting the distribution of human uses (Table 9). These data included sampling locations of visual fish and urchin surveys and a two-meter resolution bathymetry of the Orford Reef documented by Oregon Department of Fish and Wildlife (ODFW), data layers obtained from the Oregon Coastal Atlas data portal (Haddad et al. 2005), and a distribution of geological substrate habitat from Dr. Chris Goldfinger's Seafloor Mapping Lab at Oregon State University. Conventional forms of data included in the Port Orford Community Mapping Project were NOAA nautical charts and a higher resolution (approximately 100 meter) bathymetric grid, also from the Seafloor Mapping Lab. The bathymetric grid was converted to fathoms and represented by depth contours for the community mapping project. Many participants' knowledge of areas targeted for commercial harvesting was described in terms of depth-associations. Deriving these local areas was possible because of the integration of local knowledge and conventional scientific information.

Table 9: Subset of Data Layers for Port Orford Community Mapping Project's Database

Data Layers	Creator	Location
NOAA Nautical Charts	NOAA Office of the Coast Survey	Valley Library, Oregon State University
Side Scan Sonar Bathymetry of Orford Reef	Marine Program, Oregon Department of Fish and Wildlife	Hatfield Marine Science Center, Newport, OR
Urchin Surveys	Marine Program, Oregon Department of Fish and Wildlife	Hatfield Marine Science Center, Newport, OR
Fish Surveys	Marine Program, Oregon Department of Fish and Wildlife	Hatfield Marine Science Center, Newport, OR
Multi Beam Bathymetry off Port Orford	Dr. Chris Goldfinger	Seafloor Mapping Lab, Oregon State University
Geologic Substrate off Port Orford	Dr. Chris Goldfinger	Seafloor Mapping Lab, Oregon State University
Oregon Shoreline	OR Oceans Resources Management Task Force	Oregon Coastal Atlas
Three-mile State Jurisdictional Boundary	OR Oceans Resources Management Task Force	Oregon Coastal Atlas
Digital Orthophotos Quarter Quadrangles	United States Geological Survey	Oregon Coastal Atlas
Oregon State Boundary	Bureau of Land Management	Oregon Geospatial Data Clearinghouse
Oregon Counties	Bureau of Land Management	Oregon Geospatial Data Clearinghouse
Oregon Highways	Oregon Department of Transportation	Oregon Geospatial Data Clearinghouse
Local Knowledge Interview Data Layers	POORT	POORT Office, Port Orford, Oregon
Distribution and Intensity of Port Orford Commercial Fishing Effort for Black Cod	Ecotrust	Ecotrust Office, Portland, Oregon
Distribution and Intensity of Port Orford Commercial Fishing Effort for Dungeness Crab	Ecotrust	Ecotrust Office, Portland, Oregon
Distribution and Intensity of Port Orford Commercial Fishing Effort for Salmon	Ecotrust	Ecotrust Office, Portland, Oregon
Distribution and Intensity of Port Orford Commercial Fishing Effort for Halibut	Ecotrust	Ecotrust Office, Portland, Oregon
Distribution and Intensity of Port Orford Effort for Recreational Activities	Ecotrust	Ecotrust Office, Portland, Oregon
Distribution and Relative Economic Importance of Areas for Targeting Black Cod	Ecotrust	Ecotrust Office, Portland, Oregon

Port Orford Involvement in Commercial Fisheries

Local knowledge interviews provided a baseline assessment of the sample population's local participation in commercial fisheries for 2004. Seventy-two percent of the 24 commercial fishermen interviewed currently participate in four to seven fisheries over a year of fishing activities (Figure 7). At present, this sample of the Port Orford fleet currently primarily targets salmon (86% of interviewees), Dungeness crab (82%), live rockfish (*Sebastes*) (73%), and sablefish (68%). However, albacore tuna (55%) and Pacific halibut (50%) are also important fisheries, with hagfish (23%) and urchins (14%) making up most of the remainder (Figure 8). Commercial fishing in Port Orford is a year-round profession (Figure 9). Fishing for live rockfish, traditional shelf rockfish, and sablefish are important summer fisheries. Salmon fishing occurs primarily throughout the summer and as the runs hit the North Beach area. The July halibut opener is apparent on the graph as well. Black cod are targeted in the winter months. Dungeness crab is predominantly a winter fishery, with landings peaking in December and January. Tuna fishing is variable, dependent on the water temperature gradient offshore. Hagfish were not landed during this year, although have grown in importance in the last several years. Port Orford fishermen continually change their target fisheries and harvest strategies throughout the year.

Because of the POORT's fiscal and time constraints and lack of technical expertise, Ecotrust was contracted to aggregate a small subset of the total number of locally important fisheries. It was most important POORT to test the validity of the interview and participatory GIS methodology first, rather than to select the most economically and socially important (and also most controversial) fishery, the groundfish fishery.