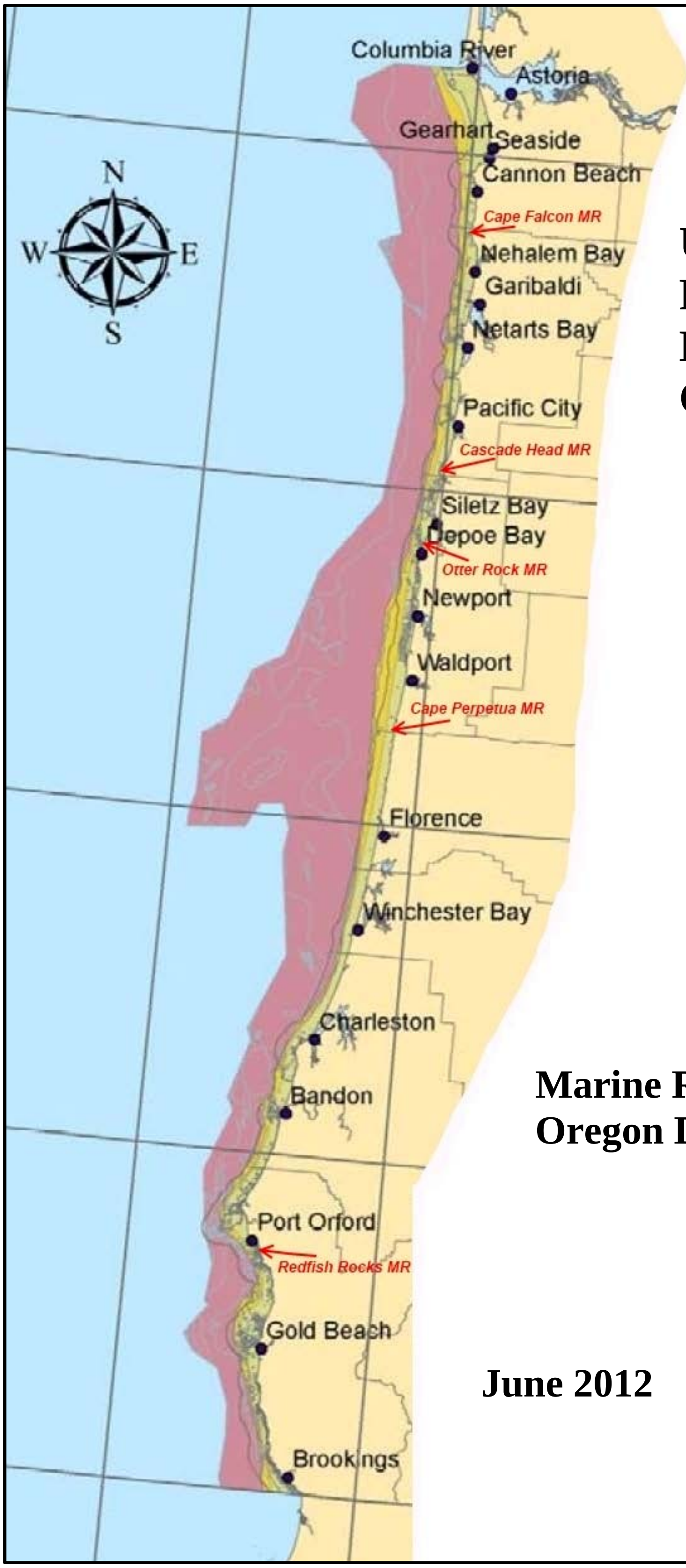

Using Spatial Analysis of Fisheries and Habitat Data to Evaluate Economic Effects of Oregon Marine Reserve Sites

Marine Resources Program
Oregon Department of Fish and Wildlife

June 2012

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PREFACE

This project was sponsored by the Oregon Department of Fish and Wildlife (ODFW). This report explains results from one human dimension investigative project being used to support ODFW's responsibilities to establish and monitor Oregon's system of marine reserve sites (MR's). A more thorough description of each of the studies and data collection projects for assessing human dimensions can be found in the Oregon Marine Reserves portal at the Oregon Ocean Information website: http://oregonocean.info/. This project's interim results were used by marine reserve community teams that were providing input on site design and management following passage of SB 1510 in 2012 which approved the addition of three marine reserves to the two pilot sites authorized by HB 3013 in 2009.

Project design and interim results were presented at two coordination meetings. The meetings were with the Ocean Policy and Advisory Council's Scientific and Technical Advisory Committee on April 25, 2011 and with fishery managers at the ODFW Marine Resource Program on October 4, 2011. Valuable suggestions were incorporated into final design and used in development of this report. The report was reviewed in draft form for the purpose of providing candid and critical comments that were to assist in making study results as sound as possible and to ensure that the report meets standards for objectivity, evidence, and responsiveness to the study charges. Although the reviewers have provided many useful comments and suggestions, they were not asked to endorse study findings and recommendations. The authors are solely responsible for making certain independent examination of this report was carried out in accordance with accustomed procedures and that review comments were carefully considered.

The authors' interpretations and conclusions should prove valuable for this project's purpose, but no absolute assurances can be given that the described results will be realized. Government legislation and policies, market circumstances, and other situations can affect the basis of assumptions in unpredictable ways and lead to unanticipated changes. The information should not be used for investment or operational decision making. The authors do not assume any liability for the information and shall not be responsible for any direct, indirect, special, incidental, or consequential damages in connection with the use of the information.

ACKNOWLEDGEMENTS

The project authors wish to recognize the project manager Melissa Murphy (Socio-Economic Analyst) and her supervisor Cristen Don (Marine Reserves Program Leader) for their guidance. Several data analysts at the Marine Reserves Program worked tirelessly to put together logbook and special survey response datasets: Michael Thompson, Daniel Crowther, and Erin Hall. Other Oregon Department of Fish and Wildlife (ODFW) Marine Resources Program staff had thoughtful contributions through attendance at one or both of two project design and status meetings. The attendance included: Caren Braby (Marine Resources Program Manager), Maggie Sommer (Technical and Data Services Section Manager), David Fox (Marine Resources Program Assistant Manager), Gway Kirchner and Troy Buell (groundfish fishery), Kelly Corbett (Dungeness crab fishery), Bob Hannah (shrimp fishery), Lynn Mattes (halibut fishery), Greg

Krutzikowsky (coastal pelagic fisheries), Michael Donnellan (marine habitat), Delia Kelly (ocean energy coordinator), and Eric Schindler (Program Manager, Ocean Recreational Boat Survey). The members of a Marine Reserves Social and Economic Work Group provided informal advice. There were three Work Group design and status meetings when the project was discussed. Work Group members in attendance at one or more of the meetings included: Gil Sylvia (Superintendent, Coastal Oregon Marine Experiment Station and OSU Department of Agricultural and Resource Economics professor), Michael Harte (previous OSU Marine Resource Management Program manager and OSU College of Ocean and Atmospheric Sciences economics professor), Flaxen Conway (current OSU Marine Resource Management Program manager), Randy Rosenberger (OSU Department of Forestry economics associate professor), Lori Cramer (OSU Department of Sociology associate professor), Mark Needham (OSU Department of Forestry geographer associate professor), Bill Jaeger (OSU Department of Agricultural and Resource Economics professor), Christine Broniak (previous ODFW economist), William Jenkins (current ODFW economist), Sarah Kruse (Ecotrust economist), and Hans Radtke (private natural resource economist). Many other individuals in government, academia, private consulting, and the commercial and recreational fishing industry provided input about candidate marine reserve area sites and/or data and methods that should be used to evaluate the sites. They deserve thanks, but in an anonymous fashion because permission was not sought for revealing their names.

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EXECUTIVE SUMMARY

Spatially defined fisheries and habitat data, and economic models were used to estimate economic consequences from displacing commercial and recreational harvest activities from within each site of Oregon's newly adopted marine reserve system. The results give the maximum economic risk to which ocean fisheries users and coastal communities would be exposed. The modeling was a simulation, cross sectional model not suited for determining biological nor human behavioral responses from ecological relationships and economic optimization theory (sometimes referred to as bioeconomic modeling) due to marine reserve sites (MR's) design and management alternatives. Best available information was used for statistical downscaling from known data and data relationships at reference area level to a discrete MR's level. Such an exercise assumes there is a continuum within the spatial block where the information was known. Yet spatially complex fish resources populating the reference area and MR's likely make such an assumption suspect. There is growing evidence for spatial and temporal fish species hotspots and it is unknown whether Oregon's system of MR's is congruent with this behavior. If any or all of the MR's were (were not) consistent hotspots, then using downscaling would understate (overstate) the economic consequences.

The following methodology was developed and applied to derive the displacement estimate:

1. Definitions were adopted for baseline commercial and recreational fishing activities that took place within MR's and reference areas. Commercial fishing logbook and other spatially defined information about MR's harvest activity was supplemented with interviews with local commercial fisherman, charter service operators, and recreational anglers.
2. The reference areas were chosen because they included the same harvest activity types and habitats as MR's and did not have spatial data limitations.
3. Available economic models with the potential to be useful for economic consequence estimates were researched.
4. Information about the likelihood of different fish species to occupy different habitat types was gathered and compiled for both reserve sites and reference areas.
5. Harvest levels were associated with habitat quantity and quality in the reference areas. It was assumed that the MR's habitat allowed for same harvest levels as reference areas.
6. Average economic consequence estimates for harvest activities at reference areas and MR's were calculated using existing commercial and recreational fishing economic model.
7. Models were generalized so that it could determine economic consequence estimates for different MR's designs and locations.

At the most basic level, the devised methods were to develop a regional economic impact (REI) spatial ratio estimator that would be applicable to the known physical characteristics of the sites. Those characteristics could be area size and habitats because of the availability of surficial geologic habitat (SGH) maps from the Oregon State University Active Tectonics and Seafloor Mapping Laboratory. The ratio estimator's numerator would be the economic effects generated from the fisheries harvests and the denominator would be likely fishing grounds habitat area. The numerator includes the composite effects of fisherman behavior to such influences as

weather, knowledge about the fishing grounds, marginal benefits/costs, and other skipper factors. The denominator would include the fish propensity to occupy the water column associated with different habitats. A fish exhibiting migratory behavior such as salmon would be assigned habitat area commensurate with wherever they were harvested rather than areas of particular habitat. A fish preferring certain habitat types such as rockfish would be assigned an area only for their proclivities to associate with a certain natural habitat type.

Species level onshore landed catch information was studied for possible inclusion in the model. State and federal required commercial fishing logbook data was reviewed to determine target fisheries that occurred within and nearby the MR's. There were discussions with fishery managers and input from fisherman groups about target fisheries. The discussions resulted in many onshore landed species such as deep water pelagics being excluded from model development.

Based on information about influences from California Current circulation patterns, two ocean regimes were used for the reference area habitat assignments. Cape Blanco is an approximate boundary for different fish resource behavior patterns. It was assumed fishery performance would be sufficiently dissimilar within the two regimes to justify the complexity.

The target fishery specific ratio estimator was applied to the measured habitat areas within the MR's to determine the estimated assessed (includes all target fisheries in a site's marine reserve and marine protected area (MPA) portion) and displaced (includes only the restricted target fisheries in the portions) fisheries REI for commercial and recreational fisheries in 2009 (Table ES.1). The sum of commercial and recreational fishing estimated assessed fisheries REI was $2.5 million and displaced fisheries REI was $816 thousand total personal income (includes the "multiplier" effect). Most likely, the actual impact would be lower as some displaced commercial fishing effort would be switched to other local areas or vessels would pursue substitute fisheries. A perspective of the REI calculation was provided using estimated REI from target fisheries in marine reserves that are harvested anywhere in the Territorial Sea and REI from all fisheries landed onshore statewide. The commercial fishing displaced REI is about 3.5 percent of Territorial Sea fishing grounds total REI and about one-tenth of that amount for all onshore landed fisheries REI. The recreational fishing displaced REI was 4.8 percent and 1.9 percent for the same two fishing grounds comparison areas.

Oregon's marine reserve system is relatively small patches among large ocean areas with similar fishing conditions. Since the system is less than 10 percent of the Territorial Sea (three nautical miles seaward of shoreline), it would seem likely that the 90 percent commercial harvesting and recreation angling area opportunities would provide satisfactory substitute fishing grounds. However, some individual fishermen may have experience with the bottom features and water conditions at these sites, and decide not to fish elsewhere given site management closures. If a commercial fishing operator or sport angler has previously fished in a designated area, economic theories would suggest that the fisher or angler believes that the area will give the highest catch rate or highest value catch for the costs of fishing. A closure to fishing in that familiar area could cause costs to increase, such as from a longer commuting distance to fishing grounds, or because of congestion from other fishers, catch per unit effort (CPUE) to decrease. This is likely to have some impact on the net returns earned by commercial fishers and recreational angler satisfaction.

Marine reserve harvest management rules may affect local governments and economies of each site's community of place, because they derive revenues from ocean uses. Fishing operations utilizing the sites would be expected to adjust to the marine reserve restrictions by fishing in other areas, and this will likely lessen some of the negative effects from having to avoid fishing at the reserve sites. If adjustments do not occur, then there would be possible reductions or redistribution of fishing revenues that ends up as revenue for local governments and economies.

Increased uses at MR such as for research could result in spending that would increase local economic activity. Marine reserves could attract additional visitors to the area. Increases in visitation to these sites could stem from the visitors' knowledge that they will be able to enjoy views of the reserve site from the shore, boat, or driving past the reserve while knowing that they will not be interrupted by fishing, crabbing, or other take activities. Additional economic activity would come directly from increased visitor spending at public owned marinas, RV parks, parking facilities, etc. Businesses that lease land and buildings or rely on local governments in other ways could be aided by increased visitor spending. MR's might have a positive impact on both the commercial and sport fisheries by helping to support fish populations. There have been assessment projects and model development for estimating this spillover effect from MR's around the world.

One way to portray marine reserve simulation model development is to look at it as a process that evolves depending on the information available and modeling results needed. The first stage is the deterministic model described in this report. Deterministic models are useful in providing some of the sideboards on expected economic responses – they can provide assurance that there will likely be limited impacts from restricting harvests, especially if the system is already overused. They can also characterize the buffering effects against uncertainty in environmental understandings of ecological functions, even if the system is not overexploited. Stochastic simulation based on fish recruitment variability would be a next advanced modeling stage. Multi-species ecosystems modeling with exogenous inputs for environmental drivers would be a penultimate stage. This project's model design incorporates habitat data, species/habitat associations, fisheries effort and catch, and economic effects data into the development of a static base model. A suggested future research project is for studying potential spillover effects and associated economic consequences using a more advanced stage of dynamic modeling.

The project goal was to assess economic consequences to ocean users and communities using REI measurements. A more thorough economic analysis would have used a total economic value (TEV) measurement approach that would have assessed consequences across an ocean resources use, non-extractive use, and non-use spectrum. There are issues for parameterizing TEV models, but other Oregon MR human dimension monitoring projects are gathering pertinent revealed and preference data that will assist in such models' specification. TEV is typically used in benefit-cost analysis (BCA) studies that involve environmental resources. At a society level accounting stance, a BCA would include valuations for not only extracting or disturbing natural resources, but also appreciating their non-use. The measurement unit is consistent across all types of positive and negative effects and therefore a net value can be derived. TEV analysis is the appropriate method to use when ecosystem services are the basis for quantitatively valuing marine reserve effects desired. The TEV analysis has the advantages for serving as a tool that fosters discussions with all stakeholders. The quantitative results of a TEV analysis can be challenged as resource non-use values can lose tangibility, but the discussions that include such benefits provide for better understandings and appreciation for the importance that ocean resources play in our lives. A TEV analysis approach is another recommend future research project.

Table ES.1
Regional Economic Impacts From Assessed and Displaced Commercial and Recreational Fisheries at Marine Reserve Sites in 2009

Harvest Area	Area Share of Terr. Sea	Assessed Fisheries REI Commercial	Assessed Fisheries REI Recreational	Assessed Fisheries REI Total	Displaced Fisheries REI Commercial	Displaced Fisheries REI Recreational	Displaced Fisheries REI Total
Marine Reserve Sites							
Cape Falcon	1.6%	509	38	547	182	29	211
Cascade Head	2.7%	466	394	860	154	94	248
Otter Rock	0.1%	17	21	38	16	21	38
Cape Perpetua	4.5%	801	94	895	217	35	252
Redfish Rocks	0.6%	114	28	141	42	25	67
Total	9.4%	1,907	575	2,482	612	204	816

Comparison Areas		REI Commercial	REI Recreational	REI Total	Assessed Share	Displaced Share
Territorial Sea	100.0%	17,725	4,275	22,000	11.3%	3.7%
Onshore Landed Fisheries		174,591	10,529	185,120	1.3%	0.4%

Notes:
1. Regional economic impacts (REI) measured in personal income thousand dollars at the coastwide economic level. It includes the "multiplier" effect. The REI for the state level economy would be higher because of where processing occurs and due to trade leakages at the coastal community level.
2. Only target fisheries within marine reserve sites (MR's) and Territorial Sea are assessed. The target fisheries applicable species assemblages are salmon, D. crab, sardine, sea urchin, halibut, and certain groundfish species caught nearshore. The list of target fisheries for each site is not the same.
3. Estimated harvest REI is the assessed fisheries economic contribution from both the marine reserve and marine protected area (MPA) portions of the MR. The estimates are from multiplying the fishery and habitat dependent ratio estimator times the amount of corresponding habitat in the MR and summing over the fisheries.
4. The displaced harvest REI excludes salmon and D. crab as they are allowed target fisheries in the MPA portion of MR. Sea urchin in Redfish Rocks is included as a displaced harvest in the MPA portions.
5. REI for displaced fisheries are likely to be less than shown as fishers will adjust to the restrictions and adopt new fishing grounds, albeit fishing costs may increase from increased transit distances and changed catch per effort. Also not included in the REI estimates are spillover effects from possible changed stock abundances that might increase catch per effort.
6. All fisheries use 2009 harvests for development of the habitat ratio estimator except salmon fisheries which uses 2010 harvests. Year 2009 salmon fishery is a data aberration because the fishery was essentially closed south of Cape Falcon. Year 2010 harvests were moderate, but representative of decade 2000's averages when salmon disaster years 2006 and 2008 as well as 2009 harvests are omitted.
7. Recreational crabbing is not included in the REI estimates. Recreational bank and dive fishing modes for finfish are not included in the REI estimates.
8. Recreational coastwide landings comparison area REI is based on trips for Oregon ocean recreational salmon, bottomfish, halibut, tuna, and dive fisheries.

Source: Study.

GLOSSARY

Acronyms

BCA	benefit-cost analysis
CPUE	catch per unit effort
CROOS	Collaborative Research on Oregon Ocean Salmon
EEZ	Exclusive Economic Zone
FEAM	Fishery Economic Assessment Model
fm	fathoms
FMP	fishery management plan
GCS	graphical coordinate system
GPS	geographical positioning system
IMPLAN®	IMpact Analysis for PLANning
MPA	marine protected area
MR's	marine reserve sites
MRFSS	Marine Recreational Fisheries Statistics Survey
MSP	marine spatial planning
NEV	net economic value
NOAA	National Oceanic and Atmospheric Administration
OCS	outer continental shelf
ODFW	Oregon Department of Fish and Wildlife
ODLCD	Oregon Department of Land Conservation and Development
ORBS	Ocean Recreational Boat Survey
PacFIN	Pacific Coast Fisheries Information Network
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
RCA	Rockfish Conservation Area
REI	regional economic impact
ROV	remote operating vehicle
RRMR	Redfish Rocks Marine Reserve
SGH	surficial geologic habitat

TRG	The Research Group, LLC
TEV	total economic value

<u>Terms</u>

marine reserve system in Oregon	Ocean areas within the Territorial Sea set aside for research and effectiveness monitoring. Oregon's five legislatively recognized areas will have unique management specifications for non-take zones (titled marine reserve area) and selective take zones (titled marine protective area).
spillover effect	Increased recreational angler effort and commercial catch outside of a marine reserve site (MR) due to increased fish production from ecological functions occurring within marine sites.
economic consequences	An economic contribution metric that relates to a short-term perspective for how an industry is represented in the local economy. If there is a change in the economy's industry activity, there may very well be adjustments in the longer term that may cause increased economic contributions. For example, a tourism business start-up may replace a fishing industry business closure.
regional economic impact (REI)	Economic contribution and REI are different concepts, but in this report the two terms are used interchangeably. A stricter use of the term "contribution" would be for an economic activity that exists. The use of the term "impact" would be when an economic activity is to be subtracted or added. It is the share of the regional economy supported by the expenditures made by the industry being analyzed. It can be expressed in terms of a variety of metrics.
net economic value (NEV)	NEV is measured by the most someone is willing to give up in other goods and services less the actual costs in order to obtain a good, service, or state of the world.
economic metric	The economic contribution measurement selected for this study is personal income. It could just as well been other metrics that would describe the same economic direct and secondary effects, but in a different dimension. Other example metrics are business output (analogous but different than sales), value added, personal income, and jobs.
downscaling	Using a known event's data relationships in a large reference area for defining an event at an included local area.
Territorial Sea	three nautical miles seaward of shoreline
deterministic simulation model	Model relationships assume a closed, steady-state system in which no randomness is involved in the development of future states of the system.

stochastic simulation model	Model relationships assume an open system where randomness can be introduced over time. This is the probabilistic counterpart to deterministic processes which can only evolve in one way. Results are often expressed as probabilities.
lithology	The types of rocks or sediment at the sea benthic layer (i.e. bottom). The rocks or sediment provide different habitat attributes for fish species. The attributes are directly related to many species' reproductive strategies, particularly larvae dispersal. The benthic layer also contains nutrients important in fisheries, a wide array of microscopic life, a variety of suspended materials, and sharp energy gradients. It is also the sink for many anthropogenic substances released into the environment.
morphology	The study of shapes or forms.
continental margin	The area of seabed extending seaward from shoreline past the continental shelf and continental slope where the ocean is relatively shallow compared with open deep water ocean. The seaward extent of the continental shelf is sometimes approximated to be the 100 fm depth contour.
nearshore	The part of the continental shelf closest to shoreline and includes an intertidal zone. The seaward extent is approximated to be the 30 fm depth contour.
personal income	Income accruing to households in the form of net earnings from wages, salaries, proprietorship income, etc. For example, it would include the contract payments based on share of catch value that is made to a commercial fishing vessel crewman and the net income after operating and fixed expenses for the vessel owner.
multiplier effect	The economic effects from subsequent rounds of spending (indirect and induced effects) that occur before money has leaked from the economy. For example, it includes the net earnings from jobs and business owner income where commercial fishing vessels purchase goods and services. It also includes the net earnings gained from businesses receiving the share of household spending that can be attributed to income from the fishing industry.

I. INTRODUCTION

The "Oregon Marine Reserve Policy Recommendations" developed and approved by the Ocean Policy Advisory Council (OPAC 2008) acknowledged that socioeconomic effects should be considered in site design and subsequent site evaluations. Site design instructions gave equal weight for fulfilling biodiversity and marine organism abundance objectives, and avoiding significant adverse social and economic impacts on ocean users and coastal communities. This raised an issue of whether socioeconomic data spatial resolution and existing economic models were sufficient to carry out the instructions (see OPAC STAC (2009) for a description of these concerns). For example, some commercial fisheries required logbooks that identified catch locations (such as Dungeness crab), but others (such as salmon) did not. There is good information about geographically aggregated recreational ocean boat effort and catch, but it does not include comprehensive data points about fishing locations. Also, the annual collection of recreational ocean boat effort and catch does not extend to estuary nor bank fishing. It became clear upon review of fisheries and other ocean use data sources that the spatial resolution was not going to be sufficient to estimate uses that might be displaced for a particular site design. The other concerns about sufficiency of socioeconomic data to be used in the design process was the short time frame allowed for establishing the two pilot sites and the predictability about whether there would be a legislative decision to establish additional sites. These exigencies held back decisions for making arrangements to undertake a full-blown data collection and bioeconomic model development project that would provide normative results for the test of avoiding significant adverse socioeconomic impacts.

There have been many studies about data and simulation model types that should be used in marine reserve site (MR) design (for example see Sanchirico and Wilen (2001) and Grafton et al. (2005)), but the OPAC process for design immediacy and the high cost for simulation model development precluded using other than best available information. It would <u>not</u> have been a wise budgetary decision to embark on an expensive bioeconomic model development project if the OPAC guidance for providing a system of sites was somehow curtailed through legislature action or inaction. It was decided to use existing data assumptions and relevant economic models to provide information about adverse impacts. In addition, it was decided to undertake a parallel program to acquire socioeconomic data that could be used both for a monitoring plan baseline database and for development of a proper future bioeconomic simulation models. If the parallel program data compilations became available during the site design process, then the information would be used in the decision making procedures.

The following describes the project purpose.

<u>Project Purpose</u>

- Assist in the development of one component within the socio-economic section of an MR monitoring plan to test the significance of social and economic impacts on ocean users and coastal communities.
- Assist in public policy making concerned with establishing and managing MR's.
- Improve understanding of economic relationships with marine resources so as to benefit non-MR approaches to conservation management.

Project Goal

- Develop a spatial ratio estimator model to evaluate MR designs' economic consequences to ocean users and communities.

Project Objectives

- Determine maximum economic risk for establishing MR's by showing economic consequences to ocean users and communities from displacing all target fisheries commercial and recreational harvesting activities.
- Provide a tool to assess economic consequences to ocean users and communities from: 1) partially altering harvesting activities at MR's, and 2) providing baseline information for assessing ecological spillover effects at neighboring fishing grounds.

There were many data and methodological issues faced in the design and conduct of the study (see Connor et al. (2007) for expanded discussion of marine protected area (MPA) economic analysis frameworks). Some of the issues were left unresolved at the conclusion of the project. A separate report chapter offers recommendations for addressing the unresolved issues.

- Is data spatial resolution sufficient to discern existing harvesting activities for certain fisheries affected by management of MR's?
- Are target fisheries species associated habitat inventories complete?
- Is there adequate understanding about target fisheries species ecological production functions for making prospective predictions?
- Available fishing industry economic models are static and assumptions are necessary for dynamic applicability.
- Any information about participant behavior as a result from changed management will have to be stated rather than revealed preference.
- Whether MR and reference areas' harvesting is fully prosecuted for available fish resources and is evenly distributed across the associated habitat types that support the fish resources.

The project design was governed by the project goal, and results should prove helpful in at least characterizing baseline conditions. There are other ocean resource uses and impact projects such as wave and wind energy development projects, seabed cable installations, and others that could draw upon the modeling approach and results.

This report is organized to first present in Chapter II the background material on bioeconomic modeling techniques applied to sites that are data rich and have longevity. Trends towards equilibrium after no-take management was instituted can be discerned at those mature sites. The third chapter explains the methods for calculating the spatial ratio estimator. Modeling results are provided and limitations are explained in the fourth chapter. The last chapter provides recommendations abut future research. An appendix explains the evaluation of predicted harvests and actual harvests for selected species in one target fishery at one MR. There are many other appendices containing data sets used in the model. Descriptive metadata and the datasets in electronic format are available from the authors.

II. MODEL DEVELOPMENT BACKGROUND

Marine reserve science has been illuminated by theoretical and empirical modeling of ever increasing complexity (Gaines et al. 2010). Single species stock assessments for fisheries resources have progressed from Schafer catch-effort models to dynamic pool models, delay difference models, and full stock synthesis models with spatial partitioning and Bayesian statistical approaches to account for variability in parameter estimation. Ecologists and fisheries biologists have converged on more ecosystems based multi-species models that take into account trophic dynamics, large scale ecosystems and coastal processes. The newer methods attempt to simulate ecosystems, which can be complex and still lack sufficient detail about stock dynamics of individual species. World-wide, scientists and managers are implementing or at least evaluating the use of marine reserves to conserve biodiversity and productivity of marine species. Conservation goals vary from protecting biodiversity and stock structure to enhancing or recovering heavily exploited fisheries. Establishing a marine reserve or a network of marine reserves is challenging as it involves balancing conservation goals and objectives against social and economic ones.

Initiatives to implement systems of marine reserves in the United States have led to development of bioeconomic models to help decision makers and stakeholders evaluate different options for size and placement of marine reserves as well as monitor post-reserve effects. Model development was reviewed in Grafton et al. (2005). Bioeconomic models are used to study processes within the reserve and harvested areas. Early modeling efforts were attempted using deterministic models with a set of initial assumptions on parameters and then explicit algebraic solutions to determine effects such as the relative benefits of reserves in terms of discounted values on harvesting in exploited areas and associated costs (Holland and Brazee 1996). These models indicated that the larger the short-term harvest loss due to a reserve, or the greater the discount rate, the smaller were reserve benefits. Reserves did help if exploitation rates were very high prior to the establishment of a marine reserve. The authors also concluded that if management was effective through other means, then reserves were redundant. Hannesson (1998) came to similar conclusions for migratory fish, stating that reserves would have to be very large – on the par with a very controlled fishery, and would require 70 to 80 percent of the area to be set aside. Brown and Roughgarden (1997) modeled two-stage life cycles where space limits expansion, adults are non-migratory, and larvae contribute to a common pool available to both reserves and open areas. The authors concluded that many nursery areas and one harvest area was recommended to optimize harvest. Their model permitted economic evaluation of lost habitats. Conrad (1999) introduced stochastic modeling of marine reserve effects on recruitment. His modeling efforts suggest that variation in abundance is less in a reserve than in fished areas and that the smaller the sanctuary, the more variable the population becomes. He compared results with deterministic models and found that the stochastic model implied reserve sizes of 40 to 60 percent had the ability to lower the variation in the fished area as well.

In a subsequent study to his seminal work published in 2005, Grafton et al. (2006) identify a resilience effect of marine reserves. The authors use theoretical modeling to show a buffering effect occurs against environmental shocks and other forms of uncertainty. This would mean there can be positive economic payoffs even if harvesting is optimal and the fisheries are not overexploited. The buffering effect advantages may become more important because climate change impacts on fish stock variability are not yet fully understood. Fishery management harvest sustainability models may understate the uncertainty when annual catch limits are set. Marine reserves will provide the "insurance" of stock protections if environmental and other uncertainties inherent in biological systems are not taken into account to control either fishing effort or harvests in exploited areas.

The above mentioned literature and other instructions about bioeconomic modeling found in OPAC STAC (2009) provide sound explanations about methods for determining marine reserve short and long-term economic consequences. Given the immediacy to generate economic consequences information, available secondary information such as from commercial fishing logbook were supplemented with agency fishery manager experts' judgment and local knowledge to develop a spatial ratio estimator model. The model's design does not incorporate a bioeconomic modeling approach that would more thoroughly show long-term effects from post marine reserve implementation. Recommendations are provided about how future research could apply the more advanced modeling techniques to Oregon's system of marine reserve sites (MR's).

III. METHODS

A. Overview

The project purpose was to provide recreational and commercial fisheries economic consequences information in a rapid assessment context for the OPAC recommended marine reserve site (MR) selection and design process.[1] It was an admission at site design process initiation that the information being supplied could be questioned for its accuracy and uncertainty, but it would be the best available information given time and cost limitations for undertaking a more thorough quantitative assessment and analysis.[2] Best available information was used for statistical downscaling from known data and data relationships at reference area level to a discrete MR's level. Such an exercise assumes there is a continuum within the spatial block where the information was known. Yet spatially complex fish resources populating the reference area and MR's likely make such an assumption suspect. There is growing evidence for spatial and temporal fish species hotspots and it is unknown whether Oregon's system of MR's is congruent with this behavior. If any or all of the MR's were (were not) consistent hotspots, then using downscaling would understate (overstate) the economic consequences.

The best available information also did not provide for a model specification that would predict biological or human behavioral responses from marine reserve management alternatives. Smith and Wilen (2003) recount that the support of marine reserves for spatial biological processes in exploited systems should not overlook the behavior changes of fishermen in response to management if economic effects are to be disclosed. (They used a case study for the sea urchin fishery in northern California to develop a spatially explicit and dynamic bioeconomic model.) An existing commercial and recreational regional economic impact (REI) model did exist from TRG (2011a) and TRG (2011b), but even scaled effects from using the model would only provide snapshot impacts. What is needed is an accompanying analysis for economic long-term effects that includes parameters for positive and negative biological and use changes. A model that had outputs for net economic value (NEV) that included opportunity costs was not available, which meant that NEV for market and non-market terms used in a cost-benefit framework would not be possible. (See Appendix D for a discussion on NEV and REI economic measurement concepts.) Other economic analysis tools such as the calculation of cost-effectiveness where objective quantifications for maximizing biological responses and minimizing economic impacts were also not applied.

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1. Rapid assessments are a common ethnographic technique used when social scientists do not have the time and budget resource to collect existing fish resource use data and how those uses are given added value in local communities and in higher level economies (Bernard 2006). Instead primary data is gathered during short visits by social science experts. Both observations and local participants interviews are taken. As much secondary data is collected as possible about the fisheries. The data is synthesized and compiled in descriptive and cognitive frameworks so that improved decisions can be made about fisheries conservation and management.
2. Separate studies sponsored by ODFW and Oregon Department of Land Conservation and Development (ODLCD) and undertaken by Ecotrust (Hesselgrave et al. 2011) and Steinback et al. (2010) were reviewed for adequacy for developing a spatial fishery economic model. This would have precluded development of the new model described in this report. It was determined that the level of fishery spatial resolution that could be released would be inadequate for marine reserve site investigative purposes. The OPAC Scientific and Technical Advisory Committee review of this study is in OPAC STAC (2012).

A straightforward way to generate measures of economic consequences was needed. It would have to assume a steady-state situation for imposing no-take and selective-take management at the MR's. The methodology had to be quick, simple, and efficient. It had to be transparent, reproducible, and scalable to a larger area than just the ocean patches that might be set aside for marine reserves. This would allow realizations for economic effect importance as compared to NEV measurement assessments. The outputs must allow for identification of potential conditions that heighten or attenuate the exposure of the community to the marine reserve impacts.

At the most basic level, the method was to devise an REI spatial ratio estimator that would be relatable to the known physical characteristics of the sites. Known characteristics would include area size and habitats because of the availability of surficial geologic habitat (SGH) maps (OSU 2011). Arcsoft Software could be used to capture the physical measures for where all of Oregon recreational and commercial fisheries occur or at any designated subarea within the information's geographical resolution limits. The ratio estimator's numerator would be the economic effects generated from the fisheries harvests and the denominator would be likely fishing grounds habitat area. The ratio's numerator includes the composite effects of fisherman behavior to such influences as weather, knowledge about the fishing grounds, marginal benefits/costs, and other skipper factors. The ratio's denominator would include the fish propensity to occupy the water column associated with different habitats. A fish exhibiting migratory behavior such as salmon would be assigned habitat area commensurate with the where they were harvested rather than areas of particular habitat. A fish preferring habitat types such as rockfish would be assigned area only the associated type's habitat area.

Based on information about influences from California Current circulation patterns, two ocean regimes were used for the reference area habitat assignments. Cape Blanco is an approximate boundary for different fish resource behavior patterns (OPAC STAC 2008). It was assumed fishery performance would be sufficiently dissimilar within the two regimes to justify the complexity.

There were discussions with Oregon Department of Fish and Wildlife (ODFW) fishery managers and input from fisherman groups about target fisheries that occurred within and nearby the MR's. Applicable logbook information was scrutinized. Species level onshore landed catch information was studied for possible inclusion in the model. The discussions and research resulted in many species such as deep water pelagics being excluded from model development.

A depiction of the ratio estimator's derivation is shown in Figure III.1. For the example of commercial fisheries, fish ticket data provides harvest volume and direct economic value information by ports within the two ocean regimes. It was assumed the harvests occurred somewhere in the port's adjoining ocean regimes reference area as allowed by fishery regulations. Moreover, some species would only be found in areas of certain single or combination of habitats. (The results of the involved assignment of catch-area and habitat type are shown in Appendix C.) The area for that particular species "home" habitat within open fishing grounds could be calculated. The harvests direct economic value could be transformed into community effects measurement units using existing economic models. The ratio of economic effects and harvest area habitat in the reference area was assumed to apply to the MR's known proportion of habitat types.

For the example of recreational fisheries, trips for declared target fisheries that take place within marine reserves were related to bathymetric limits seaward to 40 fm and each port's likely north-south steaming limits. Salmon declared trips were assumed to take place anywhere within the reference area and bottomfishing or combination trips were assumed to take place at rocky habitats within the reference area.

The data and other studies used in developing displaced commercial and recreational harvests are shown in Table III.1. MR area size and proportion of habitat types within sites is shown in Table III.2. The existing REI models which had complexities for providing the detailed factors necessary for calculating REI by MR target fisheries is described in TRG (2011a) and TRG (2011b). The factors used to translate commercial and recreational harvest information to REI information are shown in Appendix B. The likely target fisheries to be affected by MR designation are shown in Table III.3. The assigned reference area habitat for the selected target species is shown in Table III.4.

The following steps summarize the model design considerations.

1. Definitions were adopted for baseline commercial and recreational fishing activities that took place within MR's and reference areas. Commercial fishing logbook and other spatially defined information about MR harvest activity was supplemented with interviews with local commercial fisherman, charter service operators, and recreational anglers.
2. The reference areas were chosen because they included the same harvest activity types and habitats as MR's and did not have spatial data limitations.
3. Available economic models with the potential to be useful for economic consequence estimates were researched.
4. Information about the likelihood of different fish species to occupy different habitat types was gathered and compiled for both reserve sites and reference areas.
5. Harvest levels were associated with habitat quantity and quality in the reference areas. It was assumed that the MR habitat allowed for same harvest levels as reference areas.
6. Average economic consequence estimates for harvest activities at reference areas and MR's were calculated using existing commercial and recreational fishing economic model.
7. Models were generalized so that it could determine economic consequence estimates for different MR designs and locations.

B. Habitat and Fisheries Spatial Analysis

The biological part of this analysis is simple and makes the assumption that species assemblages are associated with certain habitat types, or in the case of fish with migratory behavior like salmon, are associated with all habitat types. A simple habitat classification is used to discriminate areas off the Oregon coast consisting of rocky, gravel, and unconsolidated habitat types. Using fishery information and the literature, species assemblages were linked to these habitat types. Habitat types by area of interest were calculated in square km. Species catch per habitat area were then calculated and a range developed based on the fisheries sector and variation in catches.

1. Habitat Classification

Simplification of habitat type information from OSU (2011) was made for purposes of the analysis. ArcGIS® software was used to create fisheries/species habitat areas that corresponding to bathymetric and latitudinal boundaries associated with sub-divisions of the eco-region off the Oregon Coast (Figure III.2). Boundaries of latitude were at the California/Oregon border (42 degrees North latitude), just north of Cape Blanco (43 degrees North latitude), and at the Oregon/Washington border (46 degrees 15 minutes North latitude).

The lithology classifications were grouped into three bottom types: 1) unconsolidated, which included sand and mud; 2) rocky, which included large rocks, bedrock, boulders, and cobble, and 3) gravel. If mixtures were indicated in the SGH habitat classification, the primary habitat was used to combine into the three types. For example if mud/rock was the classification, the type was coded as unconsolidated. If it was boulders/mud, then the type was coded as rock. Cobble was classified with rock whereas previous investigators have classified it as unconsolidated. Re-doing the classification was discussed, but it was felt that was not necessary as cobble represents a very small fraction of habitats compared to other classifications. Also, older analysis indicates that these classifications are on a spectrum from consolidated to unconsolidated structures and cobble is adjacent to both boulders but also associated with mud, midway between unconsolidated and rock environments. On Heceta Bank studies in much deeper water, cobble and mud seem to be in close proximity (Nasby-Lucas et al. 2002). In shallower habitats, cobble is often found with boulders or on bedrock, so cobble was combined with rock.

At the eco-region scale, areas were divided into northern and southern areas or bio-regions, separated at a management boundary line at 43 degrees North latitude near Cape Blanco. Other areas were formed using bathymetric limits depending on target fisheries, biogeography science, fishery management, and habitat spatial data. Modeling evaluation areas were used to compare predicted and actual catch, including the Redfish Rocks Marine Reserve (RRMR) (Appendix E).

Habitat areas used in analyzing commercial catch data were estimated from shoreline to the Territorial Sea boundary, north and south of 43 degrees North latitude and from the shoreline to 20 fm, 30 fm, 40 fm, and 75 fm contours using Pacific Fishery Management Council (PFMC) Rockfish Conservation Area (RCA) fishery management boundaries. Finally, areas were calculated from the shore line out to the limits of the SGH layer and to the Exclusive Economic Zone (EEZ) boundary, both areas also split by the 43 degrees North latitude boundary. Habitat areas for the recreational charter boat bottom fish fishery were calculated for shoreline out to 20 and 40 fm contours for the major Ocean Recreational Boat Survey (ORBS) fishing ports.

The five MR's totaled about 316 square km of classified habitat compared to 3,253 square km of classified habitat within the Territorial Sea, or a little less than 10 percent (Table III.2). While nearly 71 percent of the territorial seas lie north of 43 degrees North latitude, this area consists of four percent rocky subtidal habitat, compared to about 12 percent south of 43 degrees. Looking at it differently, the area south of 43 degrees North latitude contains about 3.5 percent of the state's total rocky subtidal habitat while 2.9 percent of the state's total lies to the north.

2. Species and Habitat Associations

Biological modeling was based on: 1) marine reserve indicator species, 2) affiliated species that are not uniquely found at MR's, and 3) species that have little or no presence within the boundaries of the two pilot MR's and three proposed MR's. They were selected based on catch records, knowledge of their life history strategies and distribution, and degree of habitat association. Using the literature and information about species, their fisheries and habitats inside and outside of the marine reserves marine protected area (MPA), species were classified into different assemblages. Habitat associations were identified for 91 species (Appendix C). The primary sources of biological information included the Ecology of Marine Fishes of California and Adjacent Waters (Allen et al. 2006), Probably More Than You Want to Know About the Fishes of the Pacific Coast (Love 1996), Life History Information for Selected California Fishes (California Department of Fish and Game 2010), and the Rockfishes of the Northeast Pacific (Love et al. 2002).

3. Target Fisheries Assessed

The data sources used to assess likely MR target fisheries are shown on Table III.1 and the adopted target fisheries affected by MR designation are shown in Table III.3. The target fishery categories are recreational bottomfish, combination, and salmon for charter and private boat; and, commercial salmon, crab, sardine, sea urchin, halibut, and nearshore rockfish, roundfish, and flatfish. There may be other minor target fisheries at MR's omitted in the list because the project purpose was to show economic risk magnitudes and not be a complete census. For example, intertidal and bank fishing were not assessed. The following describes investigated results by target fishery.

a. Nearshore Groundfish Commercial Fishery

Using the State mandated nearshore fishery logbook results, starting nearshore block centers were located to assign harvests by species to blocks. Logbook records were aligned with fish ticket records for those trips with valid logbook entries. Only the first starting block of a trip was used even though subsequent catches may have occurred in other blocks. (ODFW is developing software to adjust catches between different blocks that may have been fished on the same trip.) Adjustments are necessary when some species are landed but not hailed on the logbook. Apportionment algorithms are needed when effort is used to allocate species by fishing block location. The distribution of catches by block did not change appreciably when only the first block was used to characterize catch distribution within the nearshore grid.

These records were aggregated by nearshore grid block number by permit type and port group. Once assembled, these data were adjusted according to species assignments to habitat types. There were 10 habitat layers consisting of shapes encompassing the nearshore grid for various combinations of shore to depth stratum including shore to the Territorial Sea boundary north and south of 43 degrees North latitude. Additional shapes encompassing nearshore grids were made for the MR's. Catch adjustments were made for catches occurring within each nearshore grid which crossed a habitat layer boundary by multiplying the block total catch for a given species by the proportion of habitat associated with a particular species within the habitat layer boundary. If no habitat of the type associated with a particular species was in a block containing catch of that species, the proportion of total area inside of the boundary was used to adjust catches and values.

Statistical and distributional characteristics of the catches within the nearshore grid and catch per habitat type were examined. A range of expected values of catch per habitat area were estimated for areas to the north and south of 43 degrees North latitude. Initially this was computed on a nearshore grid block basis and then by larger areas to reduce variability. A separate file was created that contained catch and value data by species for landing records that did not have logbook data associated with the landing. These files were used to expand logbook data on a port group basis.

Nine species or species groups made up more than 99 percent of the hailed catch in the nearshore hook and line and pot fisheries (does include tier sablefish fishery or halibut setline fisheries). Five of these species were singled out for more detailed spatial analysis, including black rockfish, lingcod, cabezon, greenling, and blue rockfish which made up more than 90 percent of the hailed catch.

Initial distributions of catch vs. percent rocky habitat area had multi-modal distributions. Using black rockfish as an example, catches and percentage rocky habitat did not appear to be strongly correlated. The catches north of 43 degrees North latitude appeared to be associated with slightly lower percentages of rocky habitat per grid cell compared to catches taken in nearshore grid blocks south of 43 degrees North latitude. There appears to be a higher percent of rocky habitat south of 43 degrees North latitude. Catch per habitat area was highly variable. In an example for black rockfish, extremely high catch per square km were realized along the south coast.

ODFW fishery managers indicated that catch locations the first two years of the nearshore logbook program were often reported by reef or geographic location (e.g. Three Arch Rock, Orford Reef, etc.). Catches were assigned a block closest to the geographic location. In subsequent years, fishers would report by block location closest to the reef fished so there may have been some binning of catches into a few blocks. Finally, in some areas, catches may be concentrated in just a few "hotspot" blocks.

In order to come up with a more reasonable estimate for expected production rates per rocky habitat area, the rocky habitat area associated with latitudinal boundaries of port groups and with the shore to 20 fm SGH layer was calculated. This resulted in six areas associated with the six port groups.

Catches hailed vs. landings without logbooks were summed to profile catch by port group and estimate compliance rates for the five species. Catch per habitat area (pounds per square km) were adjusted to reduce the amount of non-reported catches that were estimated to be seaward of

20 fm. Catch per habitat area demonstrated an interesting reversal in rates north and south of 43 degrees North latitude in comparison on catch per habitat area based on nearshore grid summaries. Overall catches per habitat area were lower than on a rocky habitat per grid basis. The reversal in trend (higher rates now appearing in the north vs. south) can be attributed to the fact that high catches concentrated in a few blocks were now being divided by a larger habitat area in the south and a smaller habitat area in the north – there is more rocky habitat in port group areas south of 43 degrees North latitude. The central coast (Newport, port group) also has a significant amount of rocky habitat, but commercial nearshore catches are much lower compared to Tillamook (north) and port groups south of 43 degrees North latitude (Port Orford and Brookings).

b. Other Commercial Fisheries Occurring in Nearshore Waters

Commercial limited entry trawl starting locations were used to bin data by associating the starting location with centroid location data. Binned data were then prepared for spatial analysis using ArcGIS®. The marine spatial planning (MSP) grid was obtained from the Department of Land Conservation and Development. The grid subdivides U.S. Minerals Management Service outer continental shelf (OCS) blocks into smaller one mile by one mile blocks. The MSP grid also extends coverage inside of the OCS to the territorial seas and near coastal terrestrial environments. Using ArcGIS®, the grid was copied and set to use an Albers graphical coordinate system (GCS) and projection. Centroid locations were then calculated in decimal degrees for each of the grid blocks to provide a latitude and longitude for the center of each block location. Catches and values per habitat area for species associated habitats were estimated based on the larger spatial scales (e.g. shore to limits of Territorial Sea or to a bathymetric limit north and south of 43 degrees North latitude).

Pink shrimp logbook catch data from 2005, 2006, and 2009 were summed into bins in 10 fm increments by eight half degree bins and one quarter degree bin in front of the Columbia River for a total of 108 bins. Data bins were then prepared for spatial analysis in ArcGIS®. Years 2008 and 2007 were missing key data and were not included. High catch areas were found from about 50 fm to 100 fm consistent with historical fishery and catch distributions (Hannah 1995). Shrimp catches in the central and north coast areas were found to be associated with a high percentage of mud bottom or sand and mud bottom types. Shrimp grounds are known to vary from year to year in both latitude and bathymetric range within limits.

The logbook program is relatively new for the Dungeness crab fishery in Oregon. ODFW provided a limited analysis of catches which occurred inside of MR's based on one year's logbook data. The spatial explicit data was not made available for further analysis in this project.

Other logbook program results were reviewed and non-spatial data sources were consulted for salmon, Pacific sardine, sea urchin, shellfish, and halibut. Fishery managers and local fishery participant knowledge was combined with special study information to make habitat associations for these other species.

c. Recreational Fisheries

Recreational data distribution was based on ORBS data and observed fishing range of charter boats from major ports (Schindler et al. 2008). Catch per unit area of habitat type area was estimated for those species having a particular habitat association. Only trips designated for the target fisheries salmon, bottomfish, or combination were included in the analysis. This screening resulted in parsing trips designated for the target fisheries halibut and tuna. ORBS data were used to provide average weight data for several species for use in converting retained fish numbers to landed weight.

Table III.1
Fishery Data Sources Used to Assess Marine Reserve Target Fisheries

Source	Spatial Resolution	Owner
Commercial Use		
• Fish tickets	No	ODFW
• Logbook crab, nearshore groundfish, trawl groundfish, shrimp, sardine, sea urchin, halibut and shellfish	Yes	ODFW
• Salmon troll	Yes	CROOS Program
• Agency fishery managers	Yes	Managers
• Interviews with impacted fishermen	Yes	Fishermen
Recreational Use		
• ORBS ocean	No	ODFW
• MRFSS ocean bank and estuary boat and bank	old data	PSMFC
• Sport Observer Program	No	ODFW
• Interviews with charter and recreational fishermen	Yes	ODFW
Habitat		
• OSU surficial geologic habitat (SGH) maps	Yes	OSU
• Special studies		
• Experiential knowledge		

Source: Study.

Table III.2
Habitat Type Area Size for Territorial Sea and Marine Reserve Sites

	Size (sq km)	Share of Territorial Sea	Habitat Type: Rocky	Gravel	Unconsolidated	Total
Territorial Sea	3,252.90	100.0%	6.5%	0.6%	92.9%	100.0%
North Regime	2,296.26	100.0%	4.1%	0.8%	95.1%	100.0%
South Regime	956.63	100.0%	12.2%	0.2%	87.6%	100.0%
Marine Reserve Sites						
Cape Falcon	55.20	1.6%	1.2%	0.0%	98.8%	100.0%
MPA	22.40	0.6%	0.0%	0.0%	100.0%	100.0%
MR	32.80	1.0%	1.9%	0.0%	98.1%	100.0%
Cascade Head	90.70	2.7%	18.8%	0.4%	80.8%	100.0%
MPA	60.80	1.9%	21.0%	0.5%	78.5%	100.0%
MR	29.90	0.8%	13.6%	0.3%	86.1%	100.0%
Otter Rock	3.35	0.1%	29.4%	0.0%	70.6%	100.0%
MPA						
MR	3.35	0.1%	29.4%	0.0%	70.6%	100.0%
Cape Perpetua	144.90	4.5%	0.8%	0.1%	99.1%	100.0%
MPA	108.10	3.3%	0.6%	0.0%	99.4%	100.0%
MR	36.80	1.1%	1.3%	0.2%	98.5%	100.0%
Redfish Rocks	21.70	0.6%	14.8%	0.1%	85.1%	100.0%
MPA	14.92	0.4%	3.3%	0.0%	96.7%	100.0%
MR	6.78	0.2%	37.1%	0.3%	62.6%	100.0%
Total marine reserve sites	315.85	9.4%	7.2%	0.1%	92.7%	100.0%
MPA	206.22	6.2%	6.9%	0.1%	93.0%	100.0%
MR	109.63	3.2%	7.7%	0.2%	92.2%	100.0%

Sources: Habitat areas are from Oregon State University Active Tectonics and Seafloor Mapping Lab surficial geologic habitat (SGH) maps Version 3.0.

Table III.3
Marine Reserve Site Target Fisheries

Marine Reserve Site	Target Fisheries Prohibited	
	Recreational	Commercial
Cape Falcon		
MPA		halibut, rockfish, roundfish, flatfish, sardine, crab set in designated gravel substrate
Seaward	crab and salmon allowed; bottomfishing prohibited	
Shoreside	all from shore allowed, fishing from boat prohibited	
MR	all prohibited	salmon, crab, halibut, rockfish, roundfish, flatfish, sardine
Cascade Head		
MPA		
West	crab and salmon allowed; bottomfishing prohibited	halibut, rockfish, roundfish, flatfish
North	crab and salmon allowed; bottomfishing prohibited except if accessed via Salmon River – groundfish using hook-and-line from private, non-chartered, boats is allowed.	halibut, rockfish, roundfish, flatfish
South	all allowed	all allowed, except trawl gear prohibited
MR	all prohibited	salmon, crab, halibut, rockfish, roundfish, flatfish
Otter Rock		
MPA	n/a	n/a
MR	all prohibited	salmon, crab, halibut, rockfish, roundfish, flatfish
Cape Perpetua		
MPA		
North	crab and salmon allowed; bottomfishing prohibited from boat; all angling from shore allowed	halibut, rockfish, roundfish, flatfish
Southeast	crab, salmon and bottomfishing allowed	all allowed, except trawl gear prohibited; all forage fishing prohibited
Seabird	all allowed	only forage fish prohibited
MR	all prohibited	salmon, crab, halibut, rockfish, roundfish, flatfish
Redfish Rocks		
MPA	crab and salmon allowed; bottomfishing prohibited	sea urchin, halibut, rockfish, roundfish, flatfish
MR	all boat fishing prohibited; bank angling prohibited; intertidal harvest allowed	salmon, crab, sea urchin, halibut, rockfish, roundfish, flatfish

Notes: 1. Target fishery categories assessed are recreational bottomfish, combo, and salmon for charter and private boat; and, commercial salmon, crab, sardine, sea urchin, halibut, and nearshore rockfish, roundfish, and flatfish. There may be other minor target fisheries at marine reserve sites omitted in the list because project purpose was to show economic risk magnitudes and not be a complete census. For example, intertidal and bank fishing were not assessed.

2. Taking of other ocean resources such as kelp, invertebrates, or wildlife species are prohibited at marine reserve sites. Other ocean use development, such as oil exploration and energy (for example wave and wind) generation is also prohibited. Non-fisheries ocean uses were not assessed in this project.

Source: Study.

Table III.4
Habitat Size in Reference Areas for Commercial and Recreational Target Fisheries

	Habitat Area (square kilometers)											
	North Regime						South Regime					
Target Fisheries	Assumptions	U	G	U+G	R	P	Assumptions	U	G	U+G	R	P
Commercial												
1. Salmon	Shore to SGH	34,515	164	34,679	2,432	37,111	Shore to SGH	7,096	2.10	7,098	238	7,335
2. D. crab	Shore to 75 fm	9,630	122	9,752	1,196	10,948	Shore to 75 fm	1,801	2.10	1,803	155	1,958
3. P. sardines	30 fm to SGH	6,755	0.05	6,756	85	6,840						
4. Sea urchin	Territorial Sea	2,183	18	2,201	95	2,296	Territorial Sea	838	2.10	840	116	957
5. Halibut	Shore to 75 fm	9,630	122	9,752	1,196	10,948	Shore to 75 fm	1,801	2.10	1,803	155	1,958
7. GF rockfish, nearshore	Shore to 30 fm	2,284	18	2,302	94	2,396	Shore to 20 fm	375	1.50	377	93	469
8. GF roundfish, nearshore	Shore to 30 fm	2,284	18	2,302	94	2,396	Shore to 20 fm	375	1.50	377	93	469
9. GF flatfish, nearshore	Shore to 30 fm	2,284	18	2,302	94	2,396	Shore to 20 fm	375	1.50	377	93	469
Recreational												
All trip types	Shore to 40 fm	3,715	45	3,760	167	3,927	Shore to 40 fm	853	37	890	161	1,051
	Shore to 20 fm	1,326	3	1,329	82	1,411	Shore to 20 fm	375	1	377	93	469

Notes: 1. Legend:

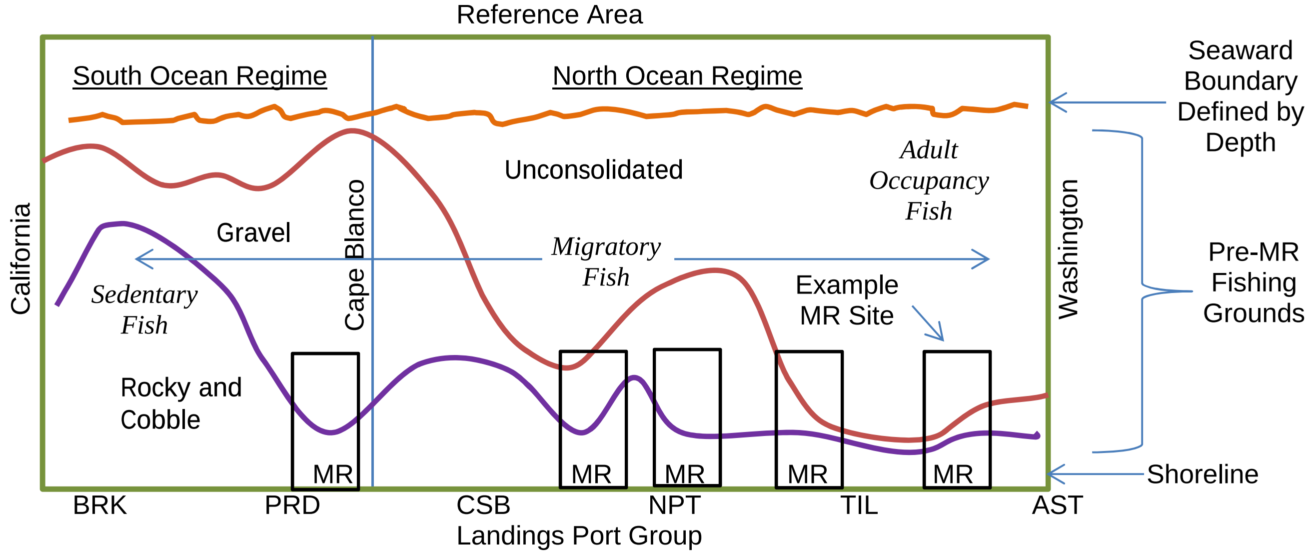
Ocean regimes: N North (Astoria, Tillamook, Newport, Coos Bay)
S South (Port Orford, Brookings)

Habitats: U Unconsolidated
R Rocky
G Gravel
P Pelagic/unrelated

2. The habitat areas are cut from surficial geologic habitat (SGH) maps from OSU (2011).
3. Seaward boundary and other area deductions different for each target fishery due to fishery management considerations, logbook program data for typical maximum depth, Essential Fish Habitat or other purpose closed fishing areas, or experiential knowledge about harvest practices.
4. Habitat area size within reference area assigned to target fisheries relied on biogeography science, and agency fishery managers and local fishing participant knowledge.

Source: Study.

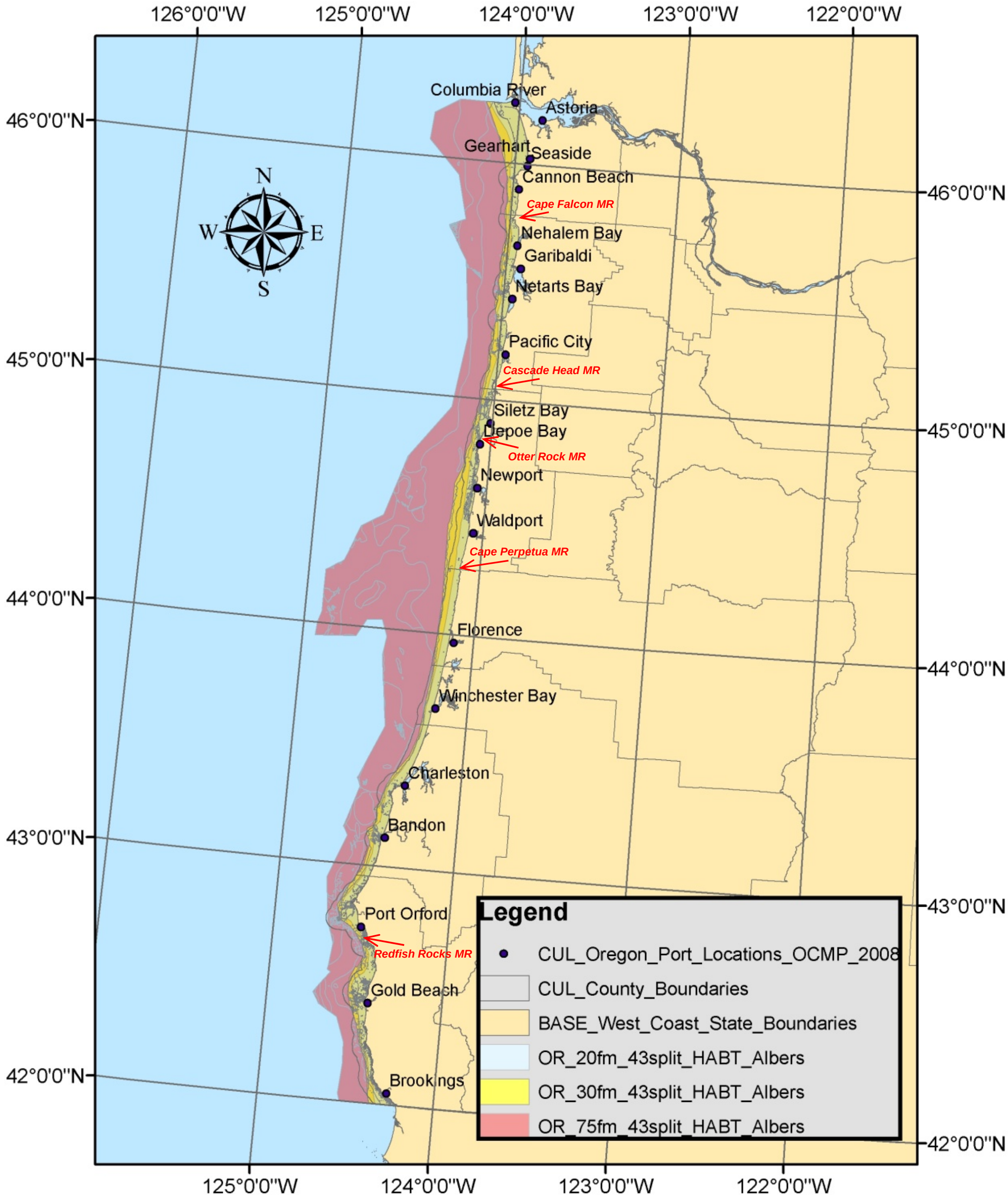
Figure III.1
Depiction of Reference Area Used to Develop Spatial
Ratio Estimator for Marine Reserve Target Fisheries



Notes:
1. Depiction does not portray actual size dimensions.
2. Seaward boundary and other area deductions different for each target fishery due to fishery management considerations, logbook program data for typical maximum depth, Essential Fish Habitat or other purpose closed fishing areas, or experiential knowledge about harvest practices.
3. Habitat area size within reference area assigned to target fisheries relied on biogeography science, and agency fishery managers and local fishing participant knowledge.

Source: Study.

Figure III.2
Habitat Layers From Shoreline to 20, 30, and 75 Fm Contours



Notes: Summaries of different habitat types were made for regions north and south of 43° and for different seaward depth boundaries. The depth boundaries correspond to RCA fishery management specifications and other fishing grounds area deduction considerations.
Source: Study using OSU (2011) data.

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IV. RESULTS

A. Economic Consequences

The ratio estimator was applied to the measured habitat areas within the marine reserve sites (MR's) to determine the estimated direct use values (Table IV.1). The direct use values served as inputs to an economic model to provide regional economic impacts (REI) for commercial fisheries (Table IV.2) and REI for recreational fisheries in 2009 (Table IV.3). These two results tables compare each of the five MR's potential displaced fisheries REI to: 1) REI from marine reserve target fisheries taking place in the Territorial Sea, 2) REI from onshore landed fisheries, and 3) REI from adjacent port group onshore landed fisheries. To assess the upper bound on the impacts, the REI for all target fisheries in both the marine reserve portion and marine protected area (MPA) portion of MR's was calculated. The estimated REI from the assessment was $2.5 million total personal income in 2009. Then the estimated displaced catch and resulting REI that occurs within the reserve sites were calculated. The estimate for total annual personal income from the displaced catch at the five sites is $816 thousand in 2009. Most likely, the actual impact would be lower as some displaced commercial fishing effort would be switched to other local areas, or vessels would pursue substitute fisheries. The Territorial Sea commercial and recreational economic activity is estimated at approximately $22.0 million annually. This means about a 3.7 percent marine reserve displacement in commercial and recreational fishing economic effects from all fishing in the Territorial Sea. The total REI from commercial onshore landings in 2009 was $175 million which means the five sites could have 0.4 percent displacement of commercial fishing economic effects.

Oregon's marine reserve system is relatively small patches among large ocean areas with similar fishing conditions. Since the system is less than 10 percent of the Territorial Sea (three nautical miles seaward of shoreline), it would seem likely that the 90 percent commercial harvesting and recreation angling area opportunities would provide satisfactory substitute fishing grounds. However, some individual fishermen may have experience with the bottom features and water conditions at these sites, and decide not to fish elsewhere given site management closures. If a commercial fishing operator or sport angler has previously fished in a designated area, economic theories would suggest that the fisher or angler believes that the area will give the highest catch rate or highest value catch for the costs of fishing. A closure to fishing in that familiar area could cause costs to increase, such as from a longer commuting distance to fishing grounds, or because of congestion from other fishers, catch per unit effort (CPUE) to decrease. This is likely to have some impact on the net returns earned by commercial fishers and recreational angler satisfaction.

Marine reserve harvest management rules may affect local governments and economies of each site's community of place, because they derive revenues from ocean uses. Fishing operations utilizing the sites would be expected to adjust to the marine reserve restrictions by fishing in other areas, and this will likely lessen some of the negative effects from having to avoid fishing at the reserve sites. If adjustments do not occur, then there would be possible reductions or redistribution of fishing revenues that ends up as revenue for local governments and economies.

Increased uses at MR's such as for research could result in spending that would increase local economic activity. Marine reserves could attract additional visitors to the area. Increases in visitation to these sites could stem from the visitors' knowledge that they will be able to enjoy views of the reserve site from the shore, boat, or driving past the reserve while knowing that they will not be interrupted by fishing, crabbing, or other take activities. Additional economic activity would come directly from increased visitor spending at public owned marinas, RV parks, parking facilities, etc. Businesses that lease land and buildings or rely on local governments in other ways could be aided by increased visitor spending.

MR's might have a positive impact on both the commercial and sport fisheries by helping to support fish populations. There have been assessment projects and model development for estimating this spillover effect from MR's around the world, and determining the spillover effects and economic impacts associated with this effect is a suggested future research project.

1. Local Government Economic Impacts

Marine reserve harvest management rules may affect units of local government which derive revenues from ocean uses. This could include port and other special districts, cities, and counties. Revenues could be enhanced by additional visitors that are attracted to MR's. The attraction might include being able to observe wildlife without conflicts that could come from extractive uses of the sites. The additional revenues would come directly from increased visitor spending at public owned marinas, RV parks, parking facilities, etc. The additional revenues could also come indirectly from businesses that lease land and buildings or rely on local governments in other ways that are made more viable by the increased visitor spending. The management and research at MR's can also bring new money into regional economies. The management and research activities would require purchase of locally offered goods and services. The purchases could be from both public entities and the private sector. Ultimately the spending would allow asset creation that would enhance local tax bases.

Recreational and commercial fishing restricted at the MR's may cause revenues to be reduced or possibly displaced to other local governments. It is expected that some fishing operations will adjust to the marine reserves by fishing in alternate spots, and that this will mitigate some of the negative effects from having to avoid some fishing grounds. Baseline assessment fishing information was generated for the Marine Reserve Community Teams during their deliberations for size and locations. The information was both for areawide fishing activity and estimates for fishing activity within the MR's being deliberated. The possible reductions or redistribution of fishing revenues will change commercial harvester and recreational angler spending that ends up as revenue for local governments.

It is difficult to provide reliable quantitative estimates for local government fee and tax revenue changes due to establishing the MR's. However, it can be presumed the effects are relatively minor given the low proportional change in total Territorial Sea economic activity. Additional information about business impacts and local government revenues that come from precluding certain extractive uses at the sites will be more available as monitoring plans for the MR's are carried out.

2. Public Economic Impacts

The public could be affected by the adoption of rules to manage the sites. All commercial fishing and recreational fishing, crabbing, clamming, hunting and gathering seaweed will be prohibited in the MR subtidal portions of the marine reserves. Recreational and commercial fishing for some fisheries such as the Dungeness crab fishery will be allowed in the MPA portions of the MR's, but sea urchin, halibut and groundfish fisheries are prohibited in the MPA portions. In addition, some segments of the marine reserve coastal shoreline inter-tidal habitats are also excluded from taking uses. Certain commercial fishing gear has drift distances and there would have to be a user voluntarily imposed fishing buffer around reserves so as the gear drift would not cross the boundaries.

The sites are mostly distant from recreational boat access points, but stakeholder anecdotal testimony noted that some trips for salmon and bottomfishing target fisheries do occur. The boats either must transit long distances to reach the MR's and/or there are nearby fishing grounds with habitat features and water condition similar to the MR's. There is also bank access recreational finfish and shellfish fishing at the sites. The degree of higher angler preference for fishing at the MR as compared to substitute sites is unknown. There was no consistent data to draw upon for determining the number of trips that might occur within the site boundaries.

It can be assumed some of the fishing activity will simply be displaced to another area or another fishery. The marine reserves are relatively small patches among large ocean expanses of water of similar fishing qualities. However, some fisherman may be experienced with the bottom features and water conditions at the sites, and elect to not fish elsewhere due to the site closures. If a sport angler or commercial fishing operator has previously fished in a designated area, rational economic behavior would suggest that the fisher believes that the area will give the highest catch rate or highest value catch for the costs of fishing. When there is a fishing closure in that familiar area, costs could be increased or CPUE could be decreased as a result. This is likely to have some impact on recreational angler satisfaction and the net returns earned by commercial fishers. The degree of the reduction of these impacts is the subject of further study, but information is not currently available on the exact costs to the commercial fishery of the marine reserve designation. If any landings are eliminated, there would be associated impacts on the processing industry and commercial fishers in terms of personal income.

Despite the impacts of displaced fishing opportunity, the marine reserves might also have a positive impact on both the sport and commercial fisheries by helping to support fish populations. There have been assessment projects and model development for estimating this spillover effect from MR's around the world, but time and resources prevented model development for judging what this effect might be for the sites. The displaced economic effects, such as for higher commercial and recreational angler costs incurred for fishing at substitute sites was also not assessed. Determining the spillover effects and marginal cost impacts will receive attention in the monitoring plans for the sites.

Marine reserves can enhance economic activities in nearby communities from attracting more visitors and from being sites were management and research activities are occurring. The public is attracted to these sites knowing just viewing as well as touring them by boat or diving will not be interrupted by fishing, crabbing, or other take activities. The increased number of visitors and management/research activities will increase spending in the area. The increased activity and spending would be especially welcome to businesses during wintertime months when tourism wanes. The incremental increase in traffic and pedestrian counts during the summertime months might be considered in some local areas as a congestion impact. It would depend on a person's perceptions whether the change in activities from being a harvest area to a no-take zone is a positive or negative impact.

B. Results Discussion

The analysis attempts to be inclusive by incorporating available fisheries data from as many fishery sectors that may be affected by closures related to marine reserves and MPA's. The ability to spatially analyze fishery data is important for evaluating potential effects such as reduced opportunity and/or displacement that might be expected from a closure. This analysis was challenging given the different spatial resolutions in which data are collected and/or portrayed and the amount and type of data available by fishery sector.

Input data for nearshore commercial fixed gear logbooks used a one mile nearshore grid starting block. Commercial limited entry trawl catch locations begin with the start of a trawl haul and may have a higher resolution related to the accuracy of the on-board geographical positioning system (GPS) systems used to acquire latitude and longitude information for the haul record. Less resolution may be implied for trawl hauls given that actual catches are made over a much larger spatial frame than point data associated with the start of the haul.

In addition, different fisheries sectors have different compliance rates and accuracy levels associated with logbook data while other sectors have no logbook data at all (for example, the recreational charter boat fishery). Having a summary frame for like the marine spatial planning (MSP) grid would help ensure that data from different sources can be analyzed using a consistent spatial scale and resolution (assuming source data has sufficient resolution).

Modeling of desired outputs using different spatial scales has provided some insight as to the impacts of resolution or spatial scale bias. With nearshore logbook data, the range of catch per habitat area changed dramatically when estimates were based on a nearshore grid block scale (one square mile) compared to a much larger scale using shore to 20 fm by port group assemblage of nearshore blocks (72 to 160 square miles). Higher resolution data summarized on a smaller spatial scale may reflect more of the natural patchiness and distributional patterns of fish associated with rocky bottom habitat. In a previous study by the Oregon Department of Fish and Wildlife (ODFW) (Fox et al. 1999), diver observed densities of rockfish ranged from about 10,000 per square km to over 900,000 per square km. About 26 percent of transects had no rockfish over rocky bottom habitats.

When data was grouped into port group habitat areas, some interesting differences between port groups appeared. Tillamook, Port Orford, and Brookings port groups all had fairly high catches of black rockfish. While Tillamook had only three percent rocky habitat from shore to 20 fm and the south coast ports had 24 percent (Port Orford) and 17 percent (Brookings), catch per habitat area was estimated to be much higher within the Tillamook port group. Catch rates are dependent on biomass and exploitation rates which have been estimated on a much larger spatial scale for black rockfish, but not for local areas. If exploitation rates are relatively low, contemporary trip limits and seasonal catch may be achievable by fishing only a few 'favorite' spots during the season. Catch per habitat area would then be low in areas with a high amount of rocky bottom habitat compared to areas with less rocky habitat. If exploitation rates are high overall, it may mean that there are areas of localized depletion. The current black rockfish assessment suggests that exploitation rates are relatively low for black rockfish on a coast wide basis (Sampson 2007). The catch per habitat area of the recreational fleet has not been examined in any great detail, although there is available information from the Oregon Sport Observer Program. The recreational catch is significant, especially along the central coast. Any interpretation of spatial characteristics of the catch vis-á-vis a stock assessment within a local area would require accounting of the catch by all fishery sectors.

Simple relationships were used to associate species and habitats. Correlation of catch data with gross habitat morphology may not show habitat and species relationships at higher resolution (smaller spatial scales). Exploitation rates and biomass may influence fishing opportunities and may cause bias when catch and habitat summaries are examined at within a large spatial scale. More detailed habitat features than used in this study and fish density data from remote operating vehicle (ROV) and scuba transect observations reveal species and habitat correlation (Donnellan et al. 2008; Fox et al. 1999). Even with a broadly distributed species like ocean shrimp, it was apparent that the unconsolidated class of habitat might be misleading. Sand alone was a poor indicator of high shrimp abundance in several areas of the north – central coast. Mud seemed to be an important component, either in a mix with sand or by itself in the 50 to 100 fm range.

In spite of these shortcomings, the broader categories used in this analysis (i.e. multiple port groups) resulted in more stability in year to year expected catch per habitat area for fish associated with rocky habitat – reducing variation seen at smaller spatial scales. Between port group differences raise interesting questions about fleet behavior, the impact of compliance rates, and local stock status.

Table IV.1
Economic Model Inputs From Assessed and Displaced Commercial
Fishing and Recreational Angling at Marine Reserve Sites in 2009

		Commercial Volume						
Harvest Area	Recreational Trips	Total	Salmon	D. crab	Sardine	Sea urchin	Halibut	Nearshore Groundfish
Marine Reserve Sites								
Cape Falcon								
Assessed	718	480,698	755	97,996	359,029	0	1,160	21,757
Displaced	517	83,388	0	60,471	0	0	1,160	21,757
Cascade Head								
Assessed	5,474	209,177	1,257	133,234	0	0	1,585	73,102
Displaced	1,307	81,374	0	42,046	0	0	1,288	38,040
Otter Rock								
Assessed	289	7,716	45	4,186	0	0	50	3,435
Displaced	289	7,671	0	4,186	0	0	50	3,435
Cape Perpetua								
Assessed	1,853	339,543	2,111	274,732	0	0	3,253	59,447
Displaced	607	106,862	0	69,398	0	0	1,481	35,984
Redfish Rocks								
Assessed	556	64,901	133	32,499	0	18,795	123	13,351
Displaced	488	23,851	0	8,110	0	342	386	15,013
Total								
Assessed	8,890	1,102,035	4,302	542,648	359,029	18,795	6,169	171,093
Displaced	3,209	303,146	0	184,210	0	342	4,364	114,230

Notes:
1. Recreational trips are expressed in angler days. Commercial volume is expressed as harvest round pounds.
2. Nearshore groundfish includes rockfish, roundfish, and flatfish.
3. Estimated recreational effort and commercial harvest are the assessed fisheries economic model inputs from both the marine reserve and marine protected area (MPA) portions of the MR. The estimates are from multiplying the target fishery and habitat dependent ratio estimator times the amount of corresponding habitat in the MR and summing over the fisheries. The displaced harvest excludes salmon and D. crab as they are allowed target fisheries in the MPA portion of an MR. Sea urchin in Redfish Rocks and sardines in Cape Falcon are included as a displaced harvest in the MPA portions.

Source: Study.

Table IV.2
Regional Economic Impacts From Commercial Fisheries at Marine Reserve Sites, Territorial Sea, and All Onshore Landed Fisheries in 2009

		Displaced Fisheries REI			
			Share		
Harvest Area	Assessed Fisheries REI	Amount	Territorial Sea	Onshore Landed Fisheries	Port Group
Marine Reserve Sites					
Cape Falcon	509	182			0.25% AST
Cascade Head	466	154			4.58% TIL
Otter Rock	17	16			0.03% NPT
Cape Perpetua	801	217			0.44% NPT
Redfish Rocks	114	42			0.35% BRK
Total	1,907	612	3.45%	0.35%	
Comparison Areas					
Territorial Sea	17,725				
Onshore Landed Fisheries	174,591				
Astoria group (AST)	74,019				
Tillamook group (TIL)	3,361				
Newport group (NPT)	49,010				
Coos Bay group (CSB)	36,231				
Brookings group (BRK)	11,971				

Notes:
1. Regional economic impacts (REI) measured in personal income thousand dollars at the coastwide economic level. It includes the "multiplier" effect. The REI for the state level economy would be higher because of where processing occurs and due to trade leakages at the coastal community level.
2. Only target fisheries within marine reserve sites (MR's) and Territorial Sea are assessed. The target fisheries applicable species assemblages are salmon, D. crab, sardine, sea urchin, halibut, and certain groundfish species caught nearshore. The list of target fisheries for each site is not the same.
3. Estimated harvest REI is the assessed fisheries economic contribution from both the marine reserve and marine protected area (MPA) portions of the MR. The estimates are from multiplying the fishery and habitat dependent ratio estimator times the amount of corresponding habitat in the MR and summing over the fisheries.
4. The displaced harvest REI excludes salmon and D. crab as they are allowed target fisheries in the MPA portion of MR. Sea urchin in Redfish Rocks and sardine in Cape Falcon are included as a displaced harvest in the MPA portions.
5. REI for displaced fisheries are likely to be less than shown as fishers will adjust to the restrictions and adopt new fishing grounds, albeit fishing costs may increase from increased transit distances and changed catch per effort. Also not included in the REI estimates are spillover effects from possible changed stock abundances that might increase catch per effort.
6. All fisheries use 2009 harvests for development of the habitat ratio estimator except salmon fisheries which uses 2010 harvests. Year 2009 salmon fishery is a data aberration because the fishery was essentially closed south of Cape Falcon. Year 2010 harvests were moderate, but representative of decade 2000's averages when salmon disaster years 2006 and 2008 as well as 2009 harvests are omitted.

Source: Study.

Table IV.3
Regional Economic Impacts From Recreational Angling at Marine Reserve Sites, Territorial Sea, and Coastwide Ocean and Bay Fishing Areas in 2009

		Displaced Fisheries REI			
	Assessed		Share		
	Fisheries		Territorial	Onshore Land-	Port
Harvest Area	REI	Amount	Sea	ed Fisheries	Group
Marine Reserve Sites					
Cape Falcon	38	29			3.40% AST
Cascade Head	394	94			6.17% TIL
Otter Rock	21	21			0.42% NPT
Cape Perpetua	94	35			0.68% NPT
Redfish Rocks	28	25			1.72% BRK
Total	575	204	4.76%	1.93%	
Comparison Areas					
Territorial Sea	4,275				
Coastwide Angling	10,529				
Astoria group (AST)	849				
Tillamook group (TIL)	1,516				
Newport group (NPT)	5,133				
Coos Bay group (CSB)	1,568				
Brookings group (BRK)	1,463				

Notes: 1. Regional economic impacts (REI) measured in personal income thousand dollars at the coastwide economic level. It includes the "multiplier" effect.
2. Table IV.2 notes apply to this table.
3. REI for salmon are based on Year 2010 instead of Year 2009. Year 2009 was closed south of Cape Falcon. Year 2010 had a good number of open days and landings were about average in the middle to late 2000's if the closure years of 2006, 2008, and 2009 are omitted.
4. Recreational crabbing is not included in the REI estimates. Recreational bank and dive fishing modes for finfish are not included in the REI estimates.
5. Recreational coastwide landings comparison area REI is based on trips for Oregon ocean recreational salmon, bottomfish, halibut, tuna, and dive fisheries.

Source: Study.

V. RECOMMENDATIONS

This project's analysis is a spatial habitat based fishery displacement model which incorporates simple species assemblage and habitat relationships, and species distribution based on fisheries data, science literature, and experiential knowledge. Regional economic impacts (REI) are based on fleet dynamics and a coastal economy assessment model. Potential lost opportunities can be directly measured and weighed against remaining opportunities to evaluate placement of no-take or restricted fishing areas. Once established, the network of marine reserves and marine protected areas (MPA's) will be monitored for changes in comparison with references sites outside of the marine reserve site (MR). Data from these monitoring studies, improved habitat data and other coastal processes studies will be used to evaluate their size and placement against design goals and objectives. Additional data may be used in more complex models to add additional tiers of analysis to the simpler base model. Some of the areas for improvement may include the following.

Spatial Analysis:

- Where spatial information is available, simple impact modeling using historical data might be sufficient to evaluate immediate effects of marine reserves or be used to in site selection. The approach taken in this analysis might be taken a step further by using historical catch per habitat area estimates and applying them to other areas to estimate potential production rates in unfished areas. In addition, where discrete biomass estimates can be made for more localized areas, spatial analysis of catches might provide insight into rates of exploitation. Accurate logbook records for both commercial fishing and charter service vessels would be very valuable for this type of analysis and can compare favorably with fishery independent survey data (Fox and Starr 1996).

- Use of the marine spatial planning (MSP) grid is recommended to try and provide a consistent framework for analyzing fishery data. Because of differences in how fishery catch data are recorded along with how the fishery operates (fish attracted to gear over small spatial scale vs. fish swept by trawl gear over a larger spatial scale), some analysis of input data over various spatial scales is recommended to determine impact on results.

Model Design:

- One way to portray marine reserve simulation model development is to look at it as a process that evolves depending on the information available and modeling results needed (Grafton et al. 2005). The first stage is the deterministic model described in this report. Deterministic models are useful in providing some of the sideboards on expected economic responses – they can provide assurance that there will likely be limited impacts from restricting harvests, especially if the system is already overused. They can also characterize the buffering effects against uncertainty in environmental understandings of ecological functions, even if the system is not overexploited. Spatial ecological function and user behavior models may help characterize effort redistribution and impacts as well as help evaluate reserve placement/management for the flow of adults and larvae (biological changes). Stochastic simulation based on fish recruitment variability would be a next advanced modeling stage. Multi-species ecosystems modeling with exogenous inputs for environmental drivers would be a penultimate stage. This project's model design incorporates habitat data, species/habitat associations, fisheries effort and catch, and economic effects data into the development of a static base model. A suggested future research project is for studying potential spillover effects and associated economic consequences using a more advanced stage of dynamic modeling.

- Dynamic and stochastic elements used to simulate population trends or larval distribution outcomes could be developed to provide base model inputs. Other efforts (MarineMap® static evaluations or dynamic optimization (Marxan®) could also provide biological/economic model inputs. A system of models should inform choices by facilitating display and selection of alternatives. MarineMap® is one choice, ArcGIS® and CommunityViz® may be appropriate alternative software.

Habitat Association:

- Oregon's nearshore is being mapped and classified using multi-beam bathymetric imaging and backscatter data by the Oregon State University Active Tectonics and Seafloor Mapping Lab. Habitat layers used in this project's core model should be updated using this new data.

- Simple groupings of a more complex classification of lithology are used. Species associations should be validated by comparing results with known distributions from fishery and survey data.

- Finer scale species and habitat data modeled by Oregon State University and Washington State University. Correlation between species and habitats would likely be improved for those niche seeking species if a finer spatial scale was used. Data from dive and remote operating vehicle (ROV) studies are the primary source for developing more discriminating species/habitat association models.

Population Dynamics:

- Larval transport models will inform marine reserve placement effects. If spatial and quantitative metrics are available for predicting abundance of future adults based on larval distribution patterns, future expectations of catch per habitat area could be deduced and incorporated in the economic model. Stock assessment data can also help scale adult population levels and trends and provide stochastic variation in levels of future recruitments which can also be incorporated into the model.

Ecosystem Dynamics:

- The Northern California Current Ecosystem has been used to model interactions between fisheries and trophic dynamics of many of the key species inhabiting the coast. An example ecosystem model is called Atlantis (Kaplan 2012). As knowledge of species interactions is gained by studying changes in predators and prey inside and outside of reserve areas, finer scale modeling of nearshore species interactions may be accomplished. This type of modeling would contribute information about the buffering effects MR's can have against uncertainty in environmental understandings. Scenario analysis of future large and small scale trends suggested by these models could be used as inputs and incorporated into the base model.

Marine Reserve and Marine Protected Area Monitoring:

- Area closures or area restrictions and their potential impact on resources and fleet behavior need spatial analysis on a smaller spatial scale than is usually accomplished by fisheries management. There seems to be quite a bit of fisheries data available from many of the potentially affected sectors that could be used in spatial analysis.

- Some improvements to ensuring adequate data would be to 1) try and coordinate data collection functions within the Oregon Department of Fish and Wildlife (ODFW), 2) look for ways to improve commercial fishing logbook data collection (data quality, ease of collection, compliance rates) and institute charter service logbook program, and 3) try to prepare a data frame for consistent spatial analysis.

- After vetting the data vs. spatial scale for each fishery sector along with identifying key habitat and species associations, use a simple spatial model to look at impacts and in time, extend that model to look at other factors such as fleet behavior, effects of recruitment and biomass, and environmental influences. Use the simple model to determine impacts from questions about local stock conditions (i.e. what is the significance of higher than average catch rates in some port group areas?).

Ecosystems Services and Other Economic Valuation Approaches:

- Less often measured values might be incorporated into a spatial extension of the base model for analysis. Spatially explicit weighted measures of ecosystems services or other value system (non-consumptive values) could be developed and applied as site selection criteria evaluated along with fishery data in the biological/economic model. The project goal was to assess economic consequences to ocean users and communities using REI measurements. A more thorough economic analysis would have used a total economic value (TEV) measurement approach that would have assessed consequences across an ocean resources use, non-extractive use, and non-use spectrum (Appendix D). There are issues for parameterizing TEV models, but other Oregon MR human dimension monitoring projects are gathering pertinent revealed and preference data that will assist in such models' specification. TEV is typically used in benefit-cost analysis (BCA) studies that involve environmental resources. At a society level accounting stance, a BCA would include valuations for not only extracting or disturbing natural resources, but also appreciating their non-use. The measurement unit is consistent across all types of positive and negative effects and therefore a net value can be derived. TEV analysis is the appropriate method to use when ecosystem services are the bases for quantitatively valuing marine reserve effects desired (Freeman et al. 2011). The TEV analysis has the advantages for serving as a tool that fosters discussions with all stakeholders. The quantitative results of a TEV analysis can be challenged as resource non-use values can lose tangibility, but the discussions that include such benefits provide for better understandings and appreciation for the importance that ocean resources play in our lives.

VI. BIBLIOGRAPHY

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APPENDIX A

Target Fisheries Per Assigned Habitat Area

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Table A.1
Target Fisheries Commercial Catch Per Assigned Habitat Area

		Commercial Catch (pounds)		Species Assemblage Catch Per Habitat Area (pounds/sq. km.)									
				North Regime					South Regime				
Species Assemblages	Habitat	North	South	U	G	U+G	R	P	U	G	U+G	R	P
A. Applicable													
1. Salmon	P	540,656	48,942					15					7
2. D. crab	U	18,416,690	3,437,611	1,912					1,909				
3. P. sardines	P	47,357,065	0					6,923					n/a
4. Sea urchin	R	11,024	739,804				116					6,355	
5. Halibut	U+G	220,682	12,979			23					7		
7. GF rockfish, nearshore	R	76,562	249,510				817					2,691	
8. GF roundfish, nearshore	R	188,401	155,177				2,010					1,673	
9. GF flatfish, nearshore	U	892,486	9,767	391					26				
Subtotal		67,327,071	4,610,288										
B. Inapplicable													
6. GF sablefish		6,110,963	1,173,818										
10. Pink shrimp		21,056,209	1,097,139										
11. Albacore tuna		9,998,951	72,743										
12. Hagfish		778,876	0										
13. GF rockfish, shelf/slope		713,471	52,789										
14. GF roundfish, shelf/slope		111,431	0										
15. GF flatfish, shelf/slope		26,252,692	1,915,327										
16. GF midwater, other		66,197,271	287,016										
17. Other fish species		236,059	76										
18. Other invertebrates		489,292	2,412										
19. Marine algae and plants		0	0										
Subtotal		131,945,215	4,601,320										
Total A and B		199,272,286	9,211,609										
C. Marine Reserve Indicator Species													
2. D. crab	U	18,416,690	3,437,611	1,912					1,909				
4. Sea urchin	R	11,024	739,804				116					6,355	
7. GF rockfish, nearshore	R	76,364	249,340				815					2,689	
8. GF roundfish, nearshore	R	188,401	155,177				2,010					1,673	
9. GF flatfish, nearshore	U	522,254	2,057	229					5				
Subtotal		19,214,733	4,583,989										

Notes:
1. Applicable species assemblages are those affected by restricted management in marine reserve portion or marine protected areas (MPA) portion of a marine reserve site (MR). Inapplicable species assemblages are those not likely caught in MR or MPA target fisheries. Indicator species are the subset of applicable that are likely included in MR only target fisheries.
2. Catch for all fisheries is Year 2009, except salmon is Year 2010. Year 2009 salmon was closed south of Cape Falcon. Year 2010 had a good number of open days and landings were about average in the middle to late 2000's if the closure years of 2006, 2008, and 2009 are omitted.
3. Commercial non-salmon harvest is from PacFIN vdrfd data, March 2010 extraction (species composition adjusted) and not annual vessel summary data (market category unadjusted), and salmon is from PacFIN annual vessel summary data, July 2011 extraction. Salmon is filtered for only troll gear, and other species are filtered for ocean catch areas. Nearshore groundfish groups are filtered by species.
4. Legend:
   Ocean regimes (assumed delivery port groups):
   North (Astoria, Tillamook, Newport, Coos Bay), South (Port Orford, Brookings)
   Habitats:
   U Unconsolidated
   R Rocky
   G Gravel
   P Pelagic/unrelated

Source: Study.

Table A.2
Target Fisheries Recreational Trips Per Assigned Habitat Area

			Recreational Trips		Trips Per Habitat Area									
					North Regime					South Regime				
Trip Type	Habitat	Boat Type	North	South	U	G	U+G	R	P	U	G	U+G	R	P
A. Applicable														
Bottomfish	R	Charter	26,399	4,341				159					27	
	R	Private	14,490	19,626				87					122	
Combination	R	Charter	1,159	37				7					0.2	
	R	Private	4,808	876				29					5	
Salmon	P	Charter	3,786	33					1					0.03
	P	Private	37,475	5,155					10					5
Dive	P	Charter	44	0										
	P	Private	241	202										
Non-Fishing	P	Charter	8	2										
	P	Private	6,069	2,564										
Subtotal		Charter	38,741	4,578										
		Private	86,746	28,298										
B. Inapplicable														
Halibut		Charter	2,063	93										
		Private	8,332	339										
Tuna		Charter	2,392	290										
		Private	7,242	429										
Subtotal		Charter	4,455	383										
		Private	15,574	768										
Total A and B		Charter	43,196	4,961										
		Private	102,319	29,066										
C. Marine Reserve Indicator Trips														
Dive	P	Charter	44	0										
	P	Private	241	202										
Non-Fishing	P	Charter	8	2										
	P	Private	6,069	2,564										
Subtotal		Charter	52	2										
		Private	6,310	2,766										

Notes: 1. Legend:
Ocean regimes (assumed embarking port groups):
North (Astoria, Tillamook, Newport, Coos Bay)
South (Port Orford, Brookings)
Habitats: U Unconsolidated
R Rocky
G Gravel
P Pelagic/unrelated

Source: Study.

APPENDIX B

Economic Modeling Factors

Table B.1
Equations for the Fisheries and Habitat Economic Model

Commercial Fishing Economic Model

$$M_{n,o} = \left[\sum_{i,j}^{a1+a2} S_{i,o} \cdot L_{a,j,o} - \sum_{f,g}^{a2} S_{f,o} \cdot L_{a,g,o} \right] \cdot R_i$$

where: *M* = MR's estimated displaced commercial fishing (REI) for total site area less REI for allowed fisheries in MPA portion of site
S = target fisheries' catch (pounds) per assigned habitat area (sq. km) in reference area
L = habitat area (sq. km) in the MR for the MR portion (*a1*) and MPA portion (*a2*)
R= economic factor (REI measured by total personal income per pound) for a particular target fishery at the Oregon Coast economic level
n = one of five MR's in a particular
o = ocean regime
a1 = MR portion in MR *n* where harvesting is prohibited for all target fisheries
a2 = MPA portion in MR *n* where harvesting is allowed for certain target fisheries
i = target fisheries' species assemblage with
j = assigned habitat area for the species assemblage
f = target fisheries allowed in MPA portion with
g = assigned habitat area for the species assemblage

Recreational Fishing Economic Model

$$U_{n,o} = \left[\sum_{k,w}^{a1+a2} T_{k,w,o} \cdot L_{a,o} - \sum_{h,w}^{a2} T_{h,w,o} \cdot L_{a,o} \right] \cdot V_{k,w}$$

where: *U* = MR's estimated displaced recreational fishing (REI) for total site area less REI for allowed fisheries in MPA portion of site
T = angler trips per habitat areas (sq. km) taken by residents or non-residents
L = habitat area (sq. km) in the MR for the MR portion (*a1*) and MPA portion (*a2*)
V = economic factor (REI measured by total personal income per trip) for a particular target fishery at the Oregon Coast economic level
k = target fisheries (salmon, bottomfishing, or combination)
a1 = MR portion in MR *n*
a2 = MPA portion in MR *n*
k = target fisheries
w = fishing mode (charter or private)
h = target fisheries allowed in MPA

Total Economic Model

$$B = \sum_{n,o} (M_{n,o} + U_{n,o})$$

where: *B* = estimated displaced commercial and recreational fishing REI summed for MR's found in the two ocean regimes

Source: Study using results from TRG (2011a) and TRG (2011b).

Table B.2
Economic Modeling Factors for Commercial Fisheries in 2009

FEAM Group No	Resources	Resource Distribution	Landed Round Pounds and Vessel Revenue: Volume	Value	Aggregate Price	Adjusted Price	Price Adjust	Hauled Round Pounds or Revenue: Hauled In	Hauled Out	Net Processed	Product Yield	Processor Costs and Sales Price Per Finished Pound: Raw	Labor	Other	Contri-bution	Sales Price
Oregon 2009																
1	Troll Coho		150,425	266,839	1.77	1.77			54	150,371	0.87	2.04	0.15	0.17	0.40	2.76
2	Troll Chinook		17,616	76,696	4.35	4.35			2,018	15,598	0.87	5.00	0.15	0.12	0.40	5.67
4	Albacore Tuna		10,071,694	10,179,246	1.01	1.01			20,950	10,050,744	0.85	1.19	0.20	0.06	0.40	1.85
5	GN/PS Coho		870,519	1,043,026	1.20	1.20				870,519	0.80	1.50	0.25	0.17	0.40	2.32
6	GN/PS Fall Chinook	67%	836,609	1,437,426	1.72	1.72	*			836,609	0.80	2.15	0.25	0.18	0.40	2.98
7	GN/PS Tule	22%	267,236	125,437	0.47	0.47	*			267,236	0.75	0.63	0.25	0.17	0.40	1.45
9	Pink/Steel/Chum/Sock		30,783	16,701	0.54	0.54				30,783	0.80	0.68	0.25	0.89	0.40	2.22
11	GN/PS Spring Chinook	11%	138,604	577,798	4.17	4.17	*			138,604	0.80	5.21	0.25	0.31	0.40	6.17
12	Sturgeon		177,422	345,871	1.95	1.95				177,422	0.64	3.05	0.25	0.12	0.40	3.82
13	Pacific Halibut		233,665	670,446	2.87	2.87			3,894	229,771	0.74	3.88	0.15	0.13	0.40	4.56
14	Cod/Rockfish		5,040,001	3,282,980	0.65	0.65			223,319	4,816,682	0.29	2.25	0.25	0.18	0.40	3.08
15	Sole/Flounder		26,705,590	8,468,239	0.32	0.32			1,118,576	25,587,014	0.24	1.32	0.38	0.09	0.40	2.19
16	Blackcod Trawl		4,427,726	8,222,957	1.86	1.86			259,990	4,167,736	0.55	3.38	0.25	0.11	0.40	4.14
17	Blackcod Fixed Gear		2,857,055	7,696,258	2.69	2.69			444,302	2,412,753	0.55	4.90	0.25	0.30	0.40	5.85
19	Pink Shrimp		22,153,348	6,813,417	0.31	0.31			548,570	21,604,779	0.31	0.99	0.25	0.35	0.40	1.99
20	Dungeness Crab		21,854,301	42,404,127	1.94	1.94			1,856,310	19,997,991	0.58	3.35	0.61	0.12	0.40	4.48
23	Herring/Sardine		47,372,506	5,293,962	0.11	0.11				47,372,506	0.95	0.12	0.15	0.20	0.19	0.66
24	Shark/Skates		2,368,191	463,660	0.20	0.20			32,837	2,335,354	0.50	0.39	0.25	0.10	0.40	1.14
25	Smelt/Shad/Mack $		1,499,191	933,135	0.62	1.00	*		704	932,431	1.00	1.00	0.15	0.10	0.40	1.65
26	Sea Urchin		751,043	342,394	0.46	0.46				751,043	0.07	6.51	0.75	0.87	0.40	8.53
33	Whiting-Surimi/shore	38%	23,777,061	1,404,177	0.059	0.059			6,177,403	17,599,658	0.25	0.24	0.17	0.25	0.10	0.76
37	Whiting H&G/shore	62%	39,210,864	2,315,636	0.059	0.059			9,266,105	29,944,760	0.61	0.10	0.10	0.08	0.19	0.47
38	Fish Meal	70%	73,070,542							73,070,542	0.10	0.00	0.04	0.09	0.10	0.23
	Total		283,881,992	102,380,428												
	Oregon Landings		210,811,450	102,380,428												

Table B.2 (cont.)

FEAM Group No	Resources	Processor Revenue	FEAM Price	FEAM Marginal Impacts Processor/ Buyer	FEAM Marginal Impacts Harvester	FEAM Marginal Impacts Total	Current Year Price Adjusted Marginal Impacts Factor	Current Year Price Adjusted Marginal Impacts Harvester	Current Year Price Adjusted Marginal Impacts Total	Adjusted Total Impacts Local	Adjusted Total Impacts State	State Level Economic Factor
Oregon 2009												
1	Troll Coho	360,936	1.77	0.86	2.50	3.37	1.00	2.51	3.37		450,569	1.00
2	Troll Chinook	77,001	4.35	0.80	6.44	7.25	1.00	6.45	7.25		113,598	
4	Albacore Tuna	15,796,540	1.01	0.83	1.27	2.10	1.00	1.27	2.10		18,831,645	
5	GN/PS Coho	1,614,086	1.20	0.92	1.45	2.36	1.00	1.45	2.37		1,834,469	
6	GN/PS Fall Chinook	1,992,935	1.71	0.92	2.23	3.16	1.00	2.24	3.16		2,353,354	
7	GN/PS Tule	289,787	0.47	0.86	0.29	1.15	1.00	0.29	1.15		273,426	
9	Pink/Steel/Chum/Sock	54,626	0.54	0.79	2.48	3.27	1.00	2.49	3.28		89,907	
11	GN/PS Spring Chinook	684,246	4.21	1.01	6.14	7.15	0.99	6.08	7.09		874,576	
12	Sturgeon	433,305	1.95	0.79	2.48	3.27	1.00	2.48	3.27		516,236	
13	Pacific Halibut	774,894	2.87	0.70	4.14	4.84	1.00	4.14	4.84		1,006,314	
14	Cod/Rockfish	4,296,888	0.65	0.33	0.91	1.24	1.00	0.91	1.24		5,570,841	
15	Sole/Flounder	13,456,112	0.32	0.31	0.42	0.73	0.99	0.42	0.73		17,260,034	
16	Blackcod Trawl	9,482,231	1.86	0.59	2.82	3.42	1.00	2.82	3.41		13,420,686	
17	Blackcod Fixed Gear	7,760,073	2.69	0.69	3.78	4.47	1.00	3.79	4.48		11,379,704	
19	Pink Shrimp	13,342,182	0.31	0.39	0.37	0.76	0.99	0.37	0.76		14,927,034	
20	Dungeness Crab	51,908,993	1.94	0.96	2.70	3.66	1.00	2.70	3.66		71,196,602	
23	Herring/Sardine	29,596,058	0.11	0.64	0.14	0.79	1.02	0.14	0.78		32,979,995	
24	Shark/Skates	1,332,988	0.20	0.54	0.22	0.76	0.98	0.22	0.76		1,592,076	
25	Smelt/Shad/Mack $	1,538,511	1.00	0.92	1.40	2.32	1.00	1.40	2.32		1,926,737	
26	Sea Urchin	448,591	0.46	0.16	0.57	0.74	0.99	0.56	0.72		484,550	
33	Whiting-Surimi/shore	3,327,320	0.06	0.15	0.08	0.23	0.98	0.08	0.23		4,896,315	
37	Whiting H&G/shore	8,526,949	0.06	0.31	0.08	0.39	0.98	0.08	0.39		13,658,163	
38	Fish Meal	1,680,622	0.00	0.03	0.00	0.03	1.00	0.00	0.03		1,950,983	
	Total	168,775,873									217,587,813	

Notes:
1. Fish meal pounds are the average lost yield from cod/rockfish, sole/flounder, blackcod, sharks/skates, and onshore whiting.
2. The asterisk in the landing price adjustment column means price is either from other source material or economic impacts are calculated using revenue rather than landed pounds.
3. FEAM prices and marginal impacts are from 2009 model that uses 2007 response coefficients.
4. Landings do not include private aquaculture.
5. The factor for adjusting between marginal and average economic contribution is 0.89.
6. Distant water economic contributions are not shown.
7. Small amounts of salmon reported as midwater trawl at mid-coast ports with no value are shown with smelt/shad/mackerel group.
8. The economic modeling factors are shown at the State economy level. The area economies factor need to be applied to adjust the factors to the coastwide economy level. The coastwide adjustment factor is 0.83, and the port areas are Astoria 0.88, Tillamook 0.78, Newport 0.90, Coos Bay 0.77, and Brookings 0.74.

Source: PacFIN March 2010 extraction; and study for adjustments and economic contributions.

Table B.3
Economic Modeling Factors for Recreational Fisheries in 2009

Target Fishery	Trips		Expenditures		Economic Contributions		Economic Contribution Per Trip Factors	
	Charter	Private	Charter	Private	Charter	Private	Charter	Private
Coastwide								
Bottomfish	30,740	34,117	177.82	70.71	3,319,892	1,566,859	108.00	45.93
Halibut	2,156	8,671	349.16	70.71	457,232	398,211	212.07	45.93
Tuna	2,682	7,671	349.16	70.71	568,827	352,312	212.07	45.93
Salmon	10,370	61,473	232.94	58.40	1,467,205	2,331,841	141.48	37.93
Combination	2,155	10,377	232.94	58.40	304,855	393,633	141.48	37.93

Notes:
1. Economic contributions are expressed as personal income in 2009 dollars.
2. Economic contributions are for trip variable cost, and include average of resident and non-resident.
3. Expenditures and economic contributions per angler day are adjusted to dollar year 2009 using the GDP implicit price deflator developed by the U.S. Bureau of Economic Analysis.
4. Economic contributions are at the coastwide economic level.

Source: Study using results from TRG (2011b).

APPENDIX C

Biological and Habitat Classifications

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APPENDIX C
BIOLOGICAL AND HABITAT CLASSIFICATIONS

1. Biological and Habitat Classifications

Eighteen different species or species assemblages were identified for the analysis (Table C.1). For the purpose of this report the term assemblage refers to either a single species of interest or a group of species. Assemblages 1-5 and 7-9 make up those species that have some importance to the marine reserves by their presence within them and to fisheries that might be excluded from harvesting them when the 'no-take' regulations go into effect. This group is defined as "applicable" species assemblages. Assemblages numbered 6, and 10-18 make up are defined as "inapplicable" as they are either not present in significant numbers or there is very little fishing activity for them within the reserves.

Assemblage 1 included species of salmon caught off the Oregon coast. Assemblage 2 consisted of only one species – Dungeness crab. Assemblage 3 also consisted of one species, the Pacific Sardine. All of these species occur within and outside of the reserve/marine protected areas (MPA's) to varying degrees. Dungeness crab and salmon species are important to both commercial and recreational fisheries. The Pacific sardine is important to Oregon's commercial fisheries. Assemblage 4 consists of two sea urchin species important to commercial divers in Oregon's shallow nearshore ocean. Assemblage 5 consists of Pacific halibut and is another important commercial and recreational species caught in shallow water and on the continental shelf to greater depths. Juvenile or maturing sablefish may be taken in shallow water. Assemblage 7 is composed of an assortment of rockfish and other fish, mostly sedentary in nature, which inhabit the nearshore. Many of these species are also marine reserve/MPA evaluation indicator species. Assemblage 8 is represented by lingcod, greenling and cabezon. These species tend to be somewhat sedentary and associated with rocky bottom habitats in the nearshore. They are also classified as roundfish under the groundfish Fisheries Management Plan (FMP). Assemblage 9 consists of shallow water flatfish species. These species are mostly associated with sand and mud bottom habitats and have a broader home range than the more sedentary nearshore rockfish and roundfish species.

The single species in Assemblage 6 is the sablefish which is an important deepwater groundfish species, which used to be taken in shallow water by trawlers. Although juvenile sablefish are found in shallow water, there is little catch coming from the nearshore in recent history. Assemblages 9-12 are made up of individual species, including sablefish, pink shrimp, albacore tuna and hagfish. Assemblage 13 represents rockfish living outside of the nearshore on shelf and slope habitats. Assemblage 14 consists of other roundfish found on the shelf and slope. Likewise, Assemblage 15 is made up of flatfish found on shelf and slope. Assemblage 16 consists of midwater groundfish, while 17 and 18 are made up of other fish and other invertebrates respectively.

Auxiliary information was also provided as an aid to interpreting results.

> **Indicator species** were identified as those species with significance for ecological and fisheries reasons. All have been found in nearshore coastal waters and within marine reserve boundaries. In addition, some have broader bathymetric distributions and also

occur in deeper water or over a variety of habitats. Key invertebrates species that have fisheries and are located within marine reserves are the Dungeness crab and the red sea urchin. Several species of rockfish, cabezon, kelp greenling, and lingcod support nearshore fisheries and are commonly found within reef areas inside marine reserves.

Bio-region - The species data were also coded by regional structure for all groundfish species and some non-groundfish fish and invertebrates. The bio-region classification identifies nearshore (N), shelf/slope (S/S), and deep water (D) benthic areas. The classification (NG) is for non-groundfish species.

Bio-geography - Species were also classified as to their general life history strategy. These strategies include sedentary (S), occupancy of a habitat during the adult stage of life (A), migratory or pass-through (P) or unassociated (U).

Habitat Association - Species were also classified as to their habitat association by major habitat features including, sand (S), gravel (G), rock (R), pelagic (P), rocky intertidal (I), and mud (M). Habitat associations and bathymetric extent were developed from the literature and were in more detail than what was used in the model.

2. Recreational Fisheries Habitat Areas

Recreational fisheries habitat areas for the recreational fisheries were calculated for shoreline out to 20 and 40 fm contours for the major Ocean Recreational Boat Survey (ORBS) identified fishing ports. Oregon Department of Fish and Wildlife (ODFW) fishery managers, charter boat operators, and private anglers were consulted about maximum distance traveled from the major ports (Table C.2). Using this information, the fishing grounds reference area associated with the included target fisheries was adopted (Figure C.3). The habitat amounts within the commercial and recreational fishing reference areas are shown in Table C.3.

3. Quality Assurance Analysis

ArcGIS® shape files were created in two different ways. Some of the shapes benefited from more precise ArcEditor® procedures whereby shapes representing clips of surficial geologic habitat (SGH) layers were made from existing polygon type shape files authored by ODFW and the Oregon Department of Land Conservation and Development (ODLCD). Earlier shapes were created ArcView® using a 1:250,000 projection and heads up digitizing of shapes over existing polygons and polylines. These shapes were used to clip the SGH layer to extract habitat data. A repeated measures type analysis was conducted, repeating this process to determine the error associated with heads up shape file creation. In addition shapes created in this fashion were compared to similar shapes created using the more accurate method.

The SGH layer (Version 3) will undoubtedly be updated, as superior multi-beam imaging and habitat classification methods are being employed by OSU's Tectonics and Seafloor Mapping Lab to create new habitat layers for Oregon's territorial seas. Where preliminary data were available, comparisons were made between old and newer data sets used to estimate area of similar habitats for some of the marine reserve/MPA sites.

Catch per habitat area was computed for selected nearshore species. Where detailed spatial information was available, additional statistical analysis was done to characterize the distributional characteristics of catches (Table C.4). The effects of spatial resolution were evaluated by looking at habitat and species correlations taken from map data gridded by nearshore fishing blocks. These data were compared with independent survey data of much higher resolution.

Differences between 'heads-up' methods of shape file creation and the more precise methods employed by ODFW were minor. Most differences were less than one percent, with the exception of the shoreline to 30 fm shape north of 43 degrees North latitude gravel habitat category, although this was a very small amount of habitat.

Repeated creation of shape files using the 'heads-up' method of digitizing also resulted in very low rates of error. All SGH group types had standard errors of less than a 0.1 percent. Even though errors appeared to be low, ODFW's revised shapes were used for most of the areas of interest except for larger shapes (Exclusive Economic Zone (EEZ) and total SGH layers north and south of 43 degrees North latitude) and for the recreational charter boat fishing areas.

Future revisions to the SGH layers will likely have more of an effect on the calculated areas of rocky, gravel, and unconsolidated habitat types. Preliminary data collected for the most recent marine reserve site (MR) evaluation process were compared to habitat data created using the SGH Version 3 layer. There were slight differences in the amount of rocky habitat present in each of the areas. More differences were seen between gravel and sand areas.

Table C.1
Species Assessed and Spatial Analysis Model Treatment

Species Name	Species Group	Assem-blage	Habitat	Bio-region	Bio-geog	Indic ator	Manage ment	Assess-ment	SGH Group	Depth Range (m)	Source	Comments	FMP	Management Area
Chinook Salmon	Salmon	1	P, R	NG	M		O,f,s	yes 2009					Pacific Coast Salmon FMP	WOC
Chum Salmon	Salmon	1	P	NG	M		O,f,s						Pacific Coast Salmon FMP	
Coho Salmon	Salmon	1	P, R	NG	M		O,f,s	yes 2009					Pacific Coast Salmon FMP	WOC
Pink Salmon	Salmon	1	P	NG	M		O,f,s						Pacific Coast Salmon FMP	
Steelhead	Salmon	1	P	NG	U		O,f,s						Pacific Coast Salmon FMP	
Dungeness Crab	Invertebrate	2	S, G	NG	A	I	s							
Pacific Sardine	Other Species	3	P	NG	M		P,f,s	yes 2009					Coastal Pelagic Species FMP	BC, WOC, Mex.
Purple Urchin	Invertebrate	4	R, I	NG	S		s		ROCKY		Personal obs.			
Red Urchin	Invertebrate	4	R	NG	S	I	s		ROCKY		Personal obs.			
Pacific Halibut	Other Species	5	S, G	NG	M		C,f,s	yes 2009	UNCON,GRAVEL				PFMC Catch Sharing Plan	Ak, BC, Wa, Or.
Sablefish	Roundfish	6		D	U		G	yes 2007	UNCON		Love et al. (2002)		Groundfish FMP	WOC
Buffalo Sculpin	Other Species	7	R	N	S		f,s		ROCKY		Allen et al. (2006)			
Irish Lord	Other Species	7	R	N	S		f,s		ROCKY		Allen et al. (2006)			
Pile Surfperch	Other Species	7	S,R	NG	A		s		ROCKY	3-18 m	Love et al. (2002)			
Redtail Surfperch	Other Species	7	S	NG	A		s		UNCON		Love et al. (2002)			
Rock Greenling	Other Species	7	R	N	S		f,s		ROCKY		Allen et al. (2006); CDFG (2010)			
Sculpin Unsp.	Other Species	7	R	N	S				ROCKY		CDFG (2010); Lamb and Handby (2005)			
Striped Surfperch	Other Species	7	S,R	NG	A		s		UNCON,ROCKY	3-21 m	CDFG (2010); Love et al. (2002)			
Surfperch Spp.	Other Species	7	S,R	NG	A		s		UNCON,ROCKY		Love et al. (2002)			
Unknown. Sculpin/Greenling Spp.	Other Species	7	R	N	S				ROCKY	inshore to 250 m	CDFG (2010); Love et al. (2002)			
Wolf Eel	Other Species	7	R	N	S				ROCKY	inshore to 600 m	Love et al. (2002)			
Black and Yellow Rockfish	Rockfish	7	R	N	S		G,f,s		ROCKY	< 18 m	Love et al. (2002); Allen et al. (2006); CDFG (2010)		Groundfish FMP	
Black Rockfish	Rockfish	7	R	N	M	I	G,f,s	yes 2007	ROCKY	inshore to 55 m	Allen et al. (2006); CDFG (2010); Love et al. (2002)		Groundfish FMP	Or. Ca.
Blue Rockfish	Rockfish	7	R	N	M	I	G,f,s	yes 2007	ROCKY	5-90 m	Allen et al. (2006); CDFG (2010); Love et al. (2002)		Groundfish FMP	Ca.
Brown Rockfish	Rockfish	7	R	N	S	I	G,f,s		ROCKY	0-120 m	Love et al. (2002)		Groundfish FMP	
China Rockfish	Rockfish	7	R	N	S	I	G,f,s		ROCKY	3-128 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	
Copper Rockfish	Rockfish	7	R	N	S	I	G,f,s		ROCKY	inshore to 90 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	
Gopher Rockfish	Rockfish	7	R	N	S	I	G,f,s	yes 2005	ROCKY	12-80 m	Love et al. (2002); Allen et al. (2006); CDFG (2010)		Groundfish FMP	Ca.
Grass Rockfish	Rockfish	7	R	N	S	I	G,f,s		ROCKY	inshore to 46 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	
Quillback Rockfish	Rockfish	7	R	N	S	I	G,f,s		ROCKY	41-60 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	
Cabezon	Roundfish	8	R	N	S	I	G,f,s	yes 2009	ROCKY	inshore to 250 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	Or. Ca.
Kelp Greenling	Roundfish	8	R	N	~~M~~ S	I	G,f,s	yes 2005	ROCKY	inshore to 150 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	Or. Ca.
Lingcod	Roundfish	8	R	N, S/S	M	I	G	yes 2009	ROCKY6	inshore to 1,400 m	Love et al. (2002); CDFG (2010)		Groundfish FMP	WOC
English Sole	Flatfish	9	S	N, S/S	M		G	yes 2007	UNCON	46-137 m	Love et al. (2002)		Groundfish FMP	WOC
Pacific Sanddab	Flatfish	9	S	N, S/S	A	I	G		UNCON	46-137 m	Love et al. (2002)		Groundfish FMP	
Sand Sole	Flatfish	9	S	N, S/S	A	I	G		UNCON	1-91 m	Love et al. (2002)		Groundfish FMP	
Starry Flounder	Flatfish	9	S	N, S/S	A	I	G	yes 2005	UNCON	2-46 m	Love et al. (2002)		Groundfish FMP	WOC
Pink Shrimp	Invertebrate	10		NG	U		s							
Albacore Tuna	Highly Migratory	11	P	NG	U		H	yes 2006 and 2008					Highly Migratory Species FMP	NPO, SPO
Hagfish	Other Species	12	S, G	NG	U		s							
Bank Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	90 to 360 m	Love et al. (2002)		Groundfish FMP	
Bocaccio	Rockfish	13	R	S/S	S		G	yes 2009	ROCKY	50 to 250 m	Love et al. (2002)	Schooling, with excursions above bottom	Groundfish FMP	Cape Blanco - Ca.
Canary Rockfish	Rockfish	13	R	N, S/S	M		G	yes 2009	ROCKY	80-200 m	Love et al. (2002)		Groundfish FMP	WOC
Chilipepper	Rockfish	13	R	S/S	S		G	yes 2007	ROCKY	>182 m	Love et al. (2002)	Schooling, with excursions above bottom	Groundfish FMP	Or. Ca.
Darkblotched Rockfish	Rockfish	13	S,R	S/S	M		G	yes 2009	ROCKY,UNCON	140-210 m	Love et al. (2002)	Mud near rocks	Groundfish FMP	WOC
Greenspotted Rockfish	Rockfish	13	S,R	S/S	S		G		ROCKY,UNCON	60-240 m	Love et al. (2002)	Mud and rocks	Groundfish FMP	
Greenstriped Rockfish	Rockfish	13	S,R	S/S	M		G	yes 2009	ROCKY,UNCON	100-250 m	Love et al. (2002)	Mud and rocks	Groundfish FMP	WOC

Table C.1 (cont.)

Species Name	Species Group	Assem-blage	Habitat	Bio-region	Bio-geog	Indic ator	Manage ment	Assess-ment	SGH Group	Depth Range (m)	Source	Comments	FMP	Management Area
Juvenile Rockfish spp.	Rockfish	13	R	S/S	M		G		ROCKY		Love et al. (2002)	Pelagic at first, then move to substrate with structure or relief	Groundfish FMP	
Pacific Ocean Perch	Rockfish	13	R	S/S	S		G	yes 2009	ROCKY	90-825	Love et al. (2002)	Seasonal movement on shelf summer slope winter	Groundfish FMP	Wa. Or.
Redbanded Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	150 to 350	Love et al. (2002)		Groundfish FMP	
Redstripe Rockfish	Rockfish	13	R	S/S	M		G		ROCKY	150 to 275	Love et al. (2002)		Groundfish FMP	
Rosethorn Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	180 to 350	Love et al. (2002)		Groundfish FMP	
Rougheye Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	150 to 450	Love et al. (2002)		Groundfish FMP	
Sharpchin Rockfish	Rockfish	13	R	S/S	M		G		ROCKY	100 to 300	Love et al. (2002)		Groundfish FMP	
Shelf Rockfish Nor. Unsp.	Rockfish	13	R	S/S	S		G		ROCKY				Groundfish FMP	
Silvergrey Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	100 to 300	Love et al. (2002)		Groundfish FMP	
Slope Rockfish Nor. Unsp.	Rockfish	13	R	S/S	S		G		ROCKY				Groundfish FMP	
Splitnose Rockfish	Rockfish	13	R	S/S	M		G	yes 2009	UNCON,ROCKY	215 to 350	Love et al. (2002)	Mud and Rocks	Groundfish FMP	WOC
Stripetail Rockfish	Rockfish	13	S,R	S/S	S		G		UNCON,ROCKY	100 to 200	Love et al. (2002)	Mud, rocks, shell	Groundfish FMP	
Tiger Rockfish	Rockfish	13	R	N, S/S	S	I	G,f,s		ROCKY				Groundfish FMP	
Unknown Rockfish Spp.	Rockfish	13	R	S/S	S		G		ROCKY				Groundfish FMP	
Vermillion Rockfish	Rockfish	13	R	N, S/S	S	I	G,f,s	yes 2005	ROCKY				Groundfish FMP	Ca.
Widow Rockfish	Rockfish	13	R	S/S	M		G	yes 2009	ROCKY				Groundfish FMP	WOC
Yelloweye Rockfish	Rockfish	13	R	N, S/S	S	I	G	yes 2009	ROCKY				Groundfish FMP	WOC
Yellowmouth Rockfish	Rockfish	13	R	S/S	S		G		ROCKY	180-275 m	Love et al. (2002)		Groundfish FMP	
Yellowtail Rockfish	Rockfish	13	R	S/S	M	I	G	yes 2004	ROCKY				Groundfish FMP	WOC
Pacific Cod	Roundfish	14		S/S	U		G						Groundfish FMP	
Arrowtooth Flounder	Flatfish	15	S	D	A		G	yes 2007	UNCON				Groundfish FMP	S. BC Wa, Or. N.Ca.
Butter Sole	Flatfish	15	S	S/S	A		G		UNCON				Groundfish FMP	
Curlfin Sole	Flatfish	15	S	S/S	A		G		UNCON				Groundfish FMP	
Dover Sole	Flatfish	15	S	D	M		G	yes 2005	UNCON				Groundfish FMP	WOC
Flathead Sole	Flatfish	15	S	S/S	A		G		UNCON				Groundfish FMP	
Other Flatfish	Flatfish	15	S	S/S	A		G		UNCON				Groundfish FMP	
Petrale Sole	Flatfish	15	S	S/S	M		G	yes 2008	UNCON				Groundfish FMP	WOC
Rex Sole	Flatfish	15	S	S/S	A	I	G		UNCON,ROCKY				Groundfish FMP	
Rock Sole	Flatfish	15	S,R	S/S	A		G		UNCON				Groundfish FMP	
Spiny Dogfish	Shark	15	S	S/S	A		G		UNCON	0-914 m	Love et al. (2002)		Groundfish FMP	
Big Skate	Skate	15	S	S/S	A		G		UNCON		CDFG (2010)		Groundfish FMP	
Longnose Skate	Skate	15	S	S/S	A		G	yes 2007	UNCON		CDFG (2010)		Groundfish FMP	WOC
Unsp. Skate	Skate	15	S	S/S	A	I	G		UNCON		CDFG (2010)		Groundfish FMP	
Unsp. Grenadiers	Grenadier	16	S	D	U		G				Allen et al. (2006); Wakefield et al. (2005)		Groundfish FMP	
Other Groundfish	Other Species	16	S	S/S	A		G		UNCON				Groundfish FMP	
Ratfish	Ratfish	16	S,R		S		G		UNCON,ROCKY	6-18 m Canada	Love et al. (2002)		Groundfish FMP	
Spotted Ratfish	Ratfish	16	R		S		G		ROCKY				Groundfish FMP	
Aurora Rockfish	Rockfish	16	S,G,R	D	S		G		ROCKY,UNCON	300-500 m	Love et al. (2002)		Groundfish FMP	
Blackgill Rockfish	Rockfish	16	R	D	S		G	yes 2005	ROCKY	250-600 m	Love et al. (2002)		Groundfish FMP	WOC(mostly Ca.)
Shortraker Rockfish	Rockfish	16	R	D	S		G		ROCKY	300-500 m	Love et al. (2002)		Groundfish FMP	
Thornyheads	Rockfish	16	S,R	D	M		G	yes 2005	ROCKY,UNCON				Groundfish FMP	WOC
Pacific Whiting	Roundfish	16	P	S/S	U		G	yes 2008					Groundfish FMP	BC, WOC
Other Shark	Shark	16	P	NG	U		G						Groundfish FMP?	
Shark Unsp.	Shark	16	P	NG	U		G						Groundfish FMP?	
Soupfin Shark	Shark	16	P		U		G						Groundfish FMP	
Unknown Shark Spp.	Shark	16	P	NG	U		G						Groundfish FMP ?	
White Shark	Shark	16	P	NG	U		X						Prohibited Commercial HMS FMP	
Chub Mackerel(aka Pacific)	Coastal Pelagic	17	P	NG	A		P						Coastal Pelagic Species FMP	
Jack Mackerel	Coastal Pelagic	17	P	NG	M		P						Coastal Pelagic Species FMP	
Northern Anchovy	Coastal Pelagic	17	P	NG	U		P,s						Coastal Pelagic Species FMP	
Pacific Mackerel	Coastal Pelagic	17	P	NG	M		P						Coastal Pelagic Species FMP	
Pacific Sand Lance	Coastal Pelagic	17	P	NG	U		P						Coastal Pelagic Species FMP	
Blue Shark	Highly Migratory	17	P	NG	~~A~~ U		H	yes 2008					Highly Migratory Species FMP	NPO
Bluefin Tuna	Highly Migratory	17	P	NG	~~A~~ U		H	yes 2008					Highly Migratory Species FMP	NPO
Dolphinfish	Highly Migratory	17	P	NG	U		H						Highly Migratory Species FMP	
Shortfin Mako Shark	Highly Migratory	17	P	NG	U		H						Highly Migratory Species FMP	
Eulachon	Other Species	17	P	NG	U									
Green Sturgeon	Other Species	17	S	N	M		s							
Jack Smelt	Other Species	17	S	NG	U		s							
Jack, Yellowtail	Other Species	17	P	NG	~~M~~ U									

Table C.1 (cont.)

Species Name	Species Group	Assem-blage	Habitat	Bio-region	Bio-geog	Indicator	Management	Assess-ment	SGH Group	Depth Range (m)	Source	Comments	FMP	Management Area
Misc. Fish	Other Species	17	S	NG	A				UNCON					
Misc. Fish/Animals	Other Species	17	I	NG	A				ALL					
Pacific Herring	Other Species	17	P	NG	U		s							
Pacific Tomcod	Other Species	17	S	NG	U									
Shad Unsp.	Other Species	17	S	NG	U		s		UNCON		Love et al. (2002)			
Smelt Unsp.	Other Species	17	S	NG	U		s		UNCON		Love et al. (2002)			
Striped Bass	Other Species	17	S,R	NG	U		s		ALL		Love et al. (2002)			
Surf Smelt	Other Species	17	S	NG	U		s		UNCON		Love et al. (2002)			
Unknown Mackerel/Tuna Spp.	Other Species	17	P	NG	M		Z						(Confuses CPH and HMS)	
Yellowtail	Other Species	17	R	S/S	~~S~~ U									
Barnacles spp.	Invertebrate	18	I	NG	S		s							
Basket Cockle	Invertebrate	18	~~I~~ S,M	NG	S		s		UNCON		CDFG (2010); Personal obs.			
Blue Mud Shrimp	Invertebrate	18	~~I~~ S,M	NG	S		s		UNCON		Personal obs.; CDFG (2010)			
Butter Clams	Invertebrate	18	~~I~~ S,M	NG	S		s							
California Mussel	Invertebrate	18	I	NG	S		s							
California Sea Cucumber	Invertebrate	18	S, G, R, I	NG	S		s							
Chittons spp.	Invertebrate	18	I	NG	S		s							
Echinoderm Unsp.	Invertebrate	18	R	NG	S		s		ROCKY		Personal obs.			
Gaper Clam	Invertebrate	18	S,I	NG	S		s		UNCON		CDFG (2010); Personal obs.			
Ghost Shrimp	Invertebrate	18	~~I~~ S,M	NG	S		s		UNCON		CDFG (2010); Personal obs.			
Hermit Crabs spp.	Invertebrate	18		NG	S		s							
Humbolt Squid	Invertebrate	18	P	NG	M		s							
Limpets spp.	Invertebrate	18	I	NG	S		s		ROCKY		CDFG (2010)			
Market Squid	Invertebrate	18	P	NG	A		P,s						Coastal Pelagic Species FMP	
Mole Crab	Invertebrate	18	S	NG	S		s							
Moon Snail	Invertebrate	18	S	NG	S		s							
Native Littleneck	Invertebrate	18	~~I~~ S,M	NG	S		s		UNCON (COBBLE)		CDFG (2010)			
Ochre Sea Star	Invertebrate	18	I	NG	S		s							
Octopus Unsp.	Invertebrate	18	R	NG	A		s		ROCKY,UNCON		CDFG (2010)			
Other Shrimp	Invertebrate	18	S	NG	S		s		UNCON		CDFG (2010)			
Purple Rock Crab	Invertebrate	18	I	NG	S		s							
Razor Clam	Invertebrate	18	S	NG	S		s							
Rock Crab	Invertebrate	18	S,R	NG	A		s		ALL		CDFG (2010); Morris et al. (1980)			
Sea Anemonies spp.	Invertebrate	18	R, I	NG	S		s							
Sea Stars spp.	Invertebrate	18	R, I	NG	S		s							
Top Snails spp.	Invertebrate	18	I	NG	S		s							
Turbin Snails spp.	Invertebrate	18	I	NG	S		s							
Unsp. Squid	Invertebrate	18	P	NG	A		s							
White Plumose Anemone	Invertebrate	18	R	NG	S		s							
Sea Palm	Marine Algae	19	I	NG	S		s							
Surf Grass	Marine Plant	19	I, R	NG	S		s							

Notes:

1. Harvests include Oregon 2009 landings from ocean catch area only. Recreational harvest is fish.
2. Legend:
   Habitat: S = Sand, G = Gravel, R = Rock, P = Pelagic, I = Rocky intertidal, M = Mud
   Bio-region: N = Nearshore, S/S = Shelf/Slope, D = Deep water, NG = Nongroundfish
   Bio-geography: S = Sedentary, A = Adult occupancy, M = Migratory pass-through, U = Unassociated
   Indicator: I = Marine reserve indicator species
   Management: G = Groundfish FMP, O = Pacific Coast Salmon FMP, P = Coastal Pelagic Species FMP,
   H = Highly Migratory Species FMP, C = PFMC Catch Sharing Plan, X = Prohibited
   HMS FMP, Z = CPH and HMS, f = federal, s = state (overlapping federal and state management shown as "f,s")
3. Species not shown in the table that are state managed fisheries included: box and tanner crabs, crayfish, intertidal animals, oysters, and scallops. Some species are state managed for inland harvests: herring, anchovy, and shad.
4. NOAA Fisheries has performed additional West Coast stock assessments for species not usually harvested in Oregon marine waters: cowcod, shortbelly rockfish, and scorpionfish.
5. Lingcod are associated with hard and soft bottom habitats. Rocky habitat was assumed since adult lingcod tend to be in rocky habitats in shallow water and soft habitats in deeper water.
6. Layers within SGH group habitats are: rocky (boulder, cobble, rock, rock/boulder, rock/gravel, rock/sand, rock/shell); gravel (gravel, gravel/mud, gravel/rock, gravel/sand); unconsolidated (mud, mud/sand, sand, sand/boulder, sand/gravel, sand/mud, sand/rock, sand/shell, shell).

Table C.2
Adjusted Boundaries and Maximum Distance From Ports Used to
Create Shape Files for Recreational Fishing Operational Areas

	Maximum Distance North			Maximum Distance South		
Port	Nautical Miles	Placename	Latitude (dec deg)	Nautical Miles	Placename	Latitude (dec deg)
Garibaldi	26	Tillamook Head	46.0000000	23	Off Straub St. Park	45.1833333
Pacific City	11	N. of Cape Lookout	45.3666667	2	Off Straub St. Park	45.1833333
Depoe Bay	27	Cape Kiwanda	45.2500000	5	Otter Rock	44.7219667
Newport	9	N. of Otter Rock	44.7620000	24	Cape Perpetua	44.2100000
Charleston	0	CB Harbor Entrance	43.3570000	18	Coquille Point	43.0666667
Bandon	14	Cape Arago (CB Harbor)	43.3570000	3	Coquille Point	43.0666667
Port Orford	6	Cape Blanco	42.8333333	6	Humbug Mt.	42.6440167
Gold Beach	7	North of Nisika B.	42.5333333	6	Cape Sebastian	42.3166667
Brookings	13	Crook Point	42.2666667	3	CA/OR Border	42.0000000

Source: Study.

Table C.3
Marine Reserve, Reference Area, and Comparison Area's Habitat Size
by Type Used to Asses Commercial and Recreational Target Fisheries

		Area in Square Km			
		Rocky	Gravel	Unconsolidated	No Habitat
Marine Reserves and Marine Protected Areas	Cape Falcon MR	0.61	-	41.10	0.01
	Cape Falcon MPA: Seaward	-	-	9.61	-
	Cape Falcon MPA: Shoreside	0.00	-	0.52	-
	Cascade Head MR	3.49	0.08	21.99	0.04
	Cascade Head MPA North	0.30	0.21	31.36	0.01
	Cascade Head MPA South	12.40	0.07	13.02	0.00
	Cascade Head MPA West	0.04	-	3.30	-
	Otter Rock Marine Reserve	0.91	-	2.19	0.04
	Cape Perpetua MR	0.49	0.08	36.29	0.03
	Cape Perpetua MPA North	0.34	-	29.07	0.03
	Cape Perpetua MPA South-East	0.35	-	20.78	0.06
	Cape Perpetua Seabird MPA	-	-	57.52	-
	Redfish Rocks MR	2.52	0.02	4.24	0.05
	Redfish Rocks MPA	0.44	-	12.79	-
Larger Areas of Interest					
	North of Blanco Territorial Sea	95.2	17.6	2,192.2	1.6
	South of Blanco Territorial Sea	116.2	2.1	836.4	1.7
	Grand Total Territorial Sea	211.4	19.7	3,028.7	3.4
	North of Blanco 20 fm	83.1	2.9	1,346.6	1.7
	South of Blanco 20 fm	92.3	1.5	373.5	1.7
	Grand Total 20 fm	175.4	4.4	1,720.1	3.4
	North of Blanco 30 fm	94.5	17.4	2,295.8	1.7
	South of Blanco 30 fm	104.2	2.0	608.0	1.7
	Grand Total 30 fm	198.7	19.4	2,903.8	3.4
	North of Blanco 40 fm	152.5	44.4	3,513.0	1.7
	South of Blanco 40 fm	109.8	2.1	861.1	1.7
	Grand Total 40 fm	262.3	46.5	4,374.1	3.4
	North of Blanco 75 fm	1,194.8	122.0	9,639.7	1.7
	South of Blanco 75 fm	154.2	2.1	1,797.7	1.7
	Grand Total 75 fm	1,349.0	124.1	11,437.4	3.4
	North of Blanco SGH	2,432.44	164.21	34,514.81	--
	South of Blanco SGH	237.73	2.10	7,095.65	--
	Grand Total SGH	2,670.16	166.31	41,610.46	--
	North of Blanco EEZ	2,432.44	164.21	122,638.94	--
	South of Blanco EEZ	237.73	2.10	40,626.99	--
	Grand Total EEZ	2,670.16	166.31	163,265.93	--
Recreational Bottom Charter Boat Areas					
	Shore to 20 fm - Garibaldi	326.73	8.52	0.61	--
	Shore to 40 fm - Garibaldi	829.31	12.29	6.62	--
	Shore to 20 fm - Pacific City	71.32	2.63	0.29	--
	Shore to 40 fm - Pacific City	175.68	3.91	0.35	--
	Shore to 20 fm - Depoe Bay	160.68	32.73	1.97	--
	Shore to 40 fm - Depoe Bay	499.39	44.33	2.58	--
	Shore to 20 fm - Newport	199.18	31.00	0.14	--
	Shore to 40 fm - Newport	897.35	41.85	0.21	--
	Shore to 20 fm - Charleston	106.28	14.92	0.05	--
	Shore to 40 fm - Charleston	192.39	63.39	34.75	--
	Shore to 20 fm - Port Orford	61.39	38.87	0.79	--
	Shore to 40 fm - Port Orford	138.71	47.52	1.13	--
	Shore to 20 fm - Gold Beach	106.59	23.96	0.22	--
	Shore to 40 fm - Gold Beach	232.84	27.16	0.28	--
	Shore to 20 fm - Brookings	75.12	21.17	0.19	--
	Shore to 40 fm - Brookings	177.19	21.91	0.19	--

Source: Study.

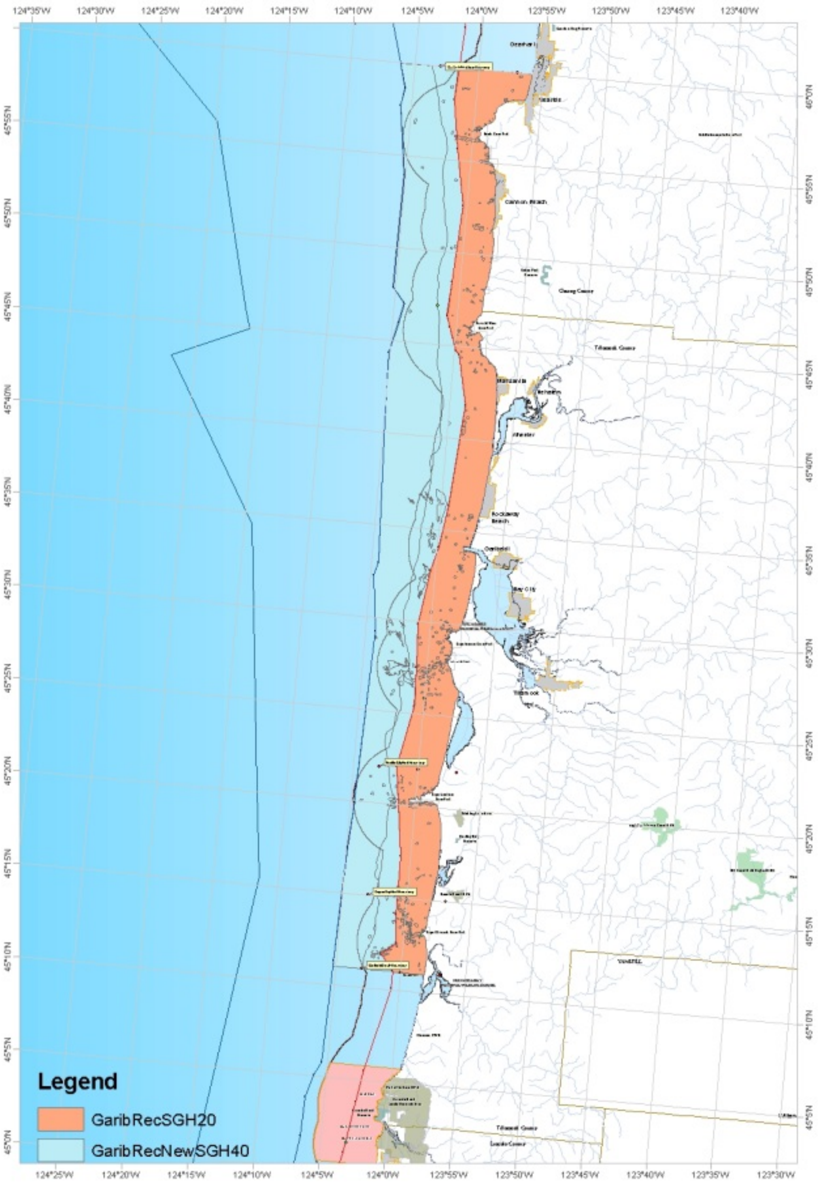
Table C.4
Top Ranked Nearshore Non-Trawl Groundfish Species Logbook Hails From 2004 to 2009

Species	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing	Sum	%	Cum %
Black Rockfish	1,068.5	2,440.44	78.28	972	0	25,431	0	1,038,612	56.1%	56.1%
Lingcod	287.0	631.90	20.27	972	0	7,656	0	278,915	15.1%	71.2%
Cabezon	231.6	773.06	24.80	972	0	15,618	0	225,121	12.2%	83.3%
Greenling	172.6	574.90	18.44	972	0	8,924	0	167,787	9.1%	92.4%
Unspecified Nearshore Rockfish	53.6	194.48	6.24	972	0	2,810	0	52,106	2.8%	95.2%
Blue Rockfish	27.8	124.54	4.00	972	0	2,607	0	26,988	1.5%	96.7%
Vermillion Rockfish	19.1	56.04	1.80	972	0	695	0	18,581	1.0%	97.7%
China Rockfish	15.7	69.27	2.22	972	0	1,351	0	15,239	0.8%	98.5%
Yellowtail Rockfish	14.0	123.52	3.96	972	0	2,649	0	13,610	0.7%	99.2%
All other species	-	-	-	972	0	-	0	14,255	0.8%	100.0%
Total All Years								1,851,214		

Notes: Data summed across all nearshore blocks that had any species hailed in them. All hailed catches occurred between the shore and 75 fm. Hail weight in pounds.
Source: Study.

Figure C.1
Maps for Recreational Fisheries Reference Areas

Garibaldi



Pacific City and Depoe Bay

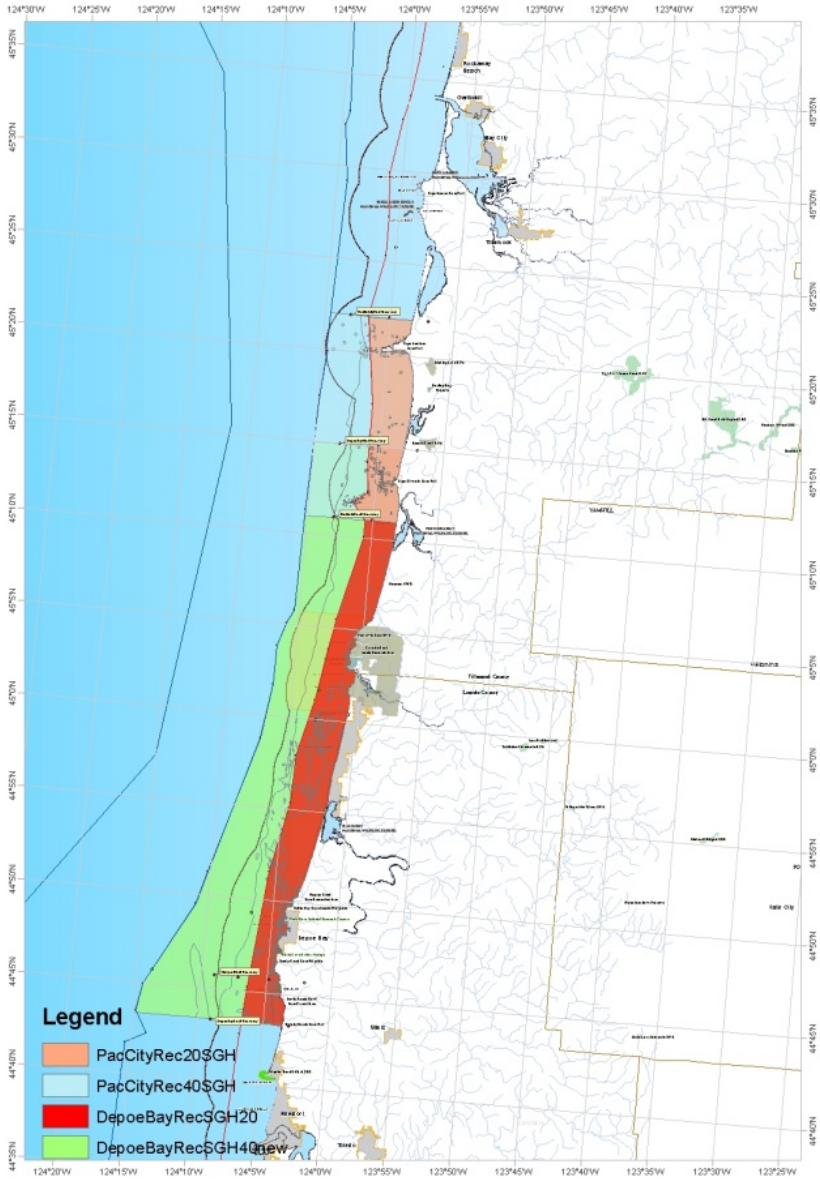
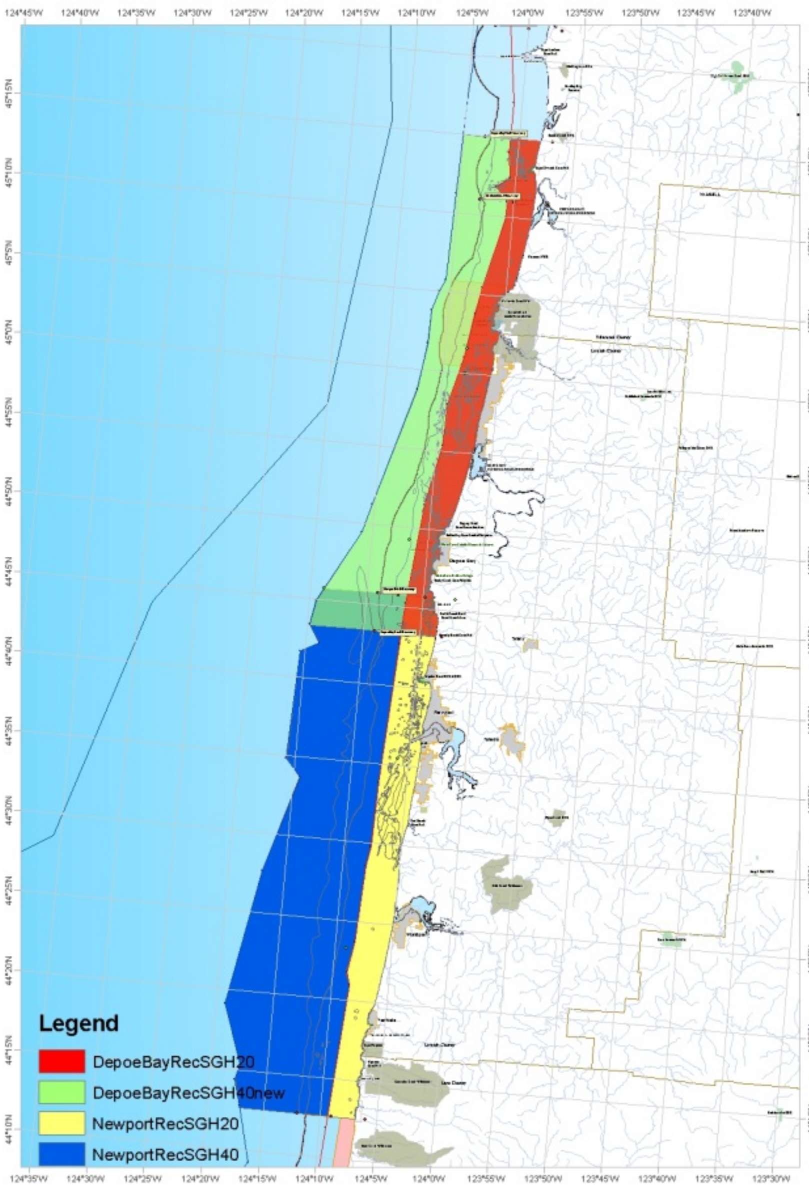


Figure C.1 (cont.)

Depoe Bay and Newport



Charleston/Bandon

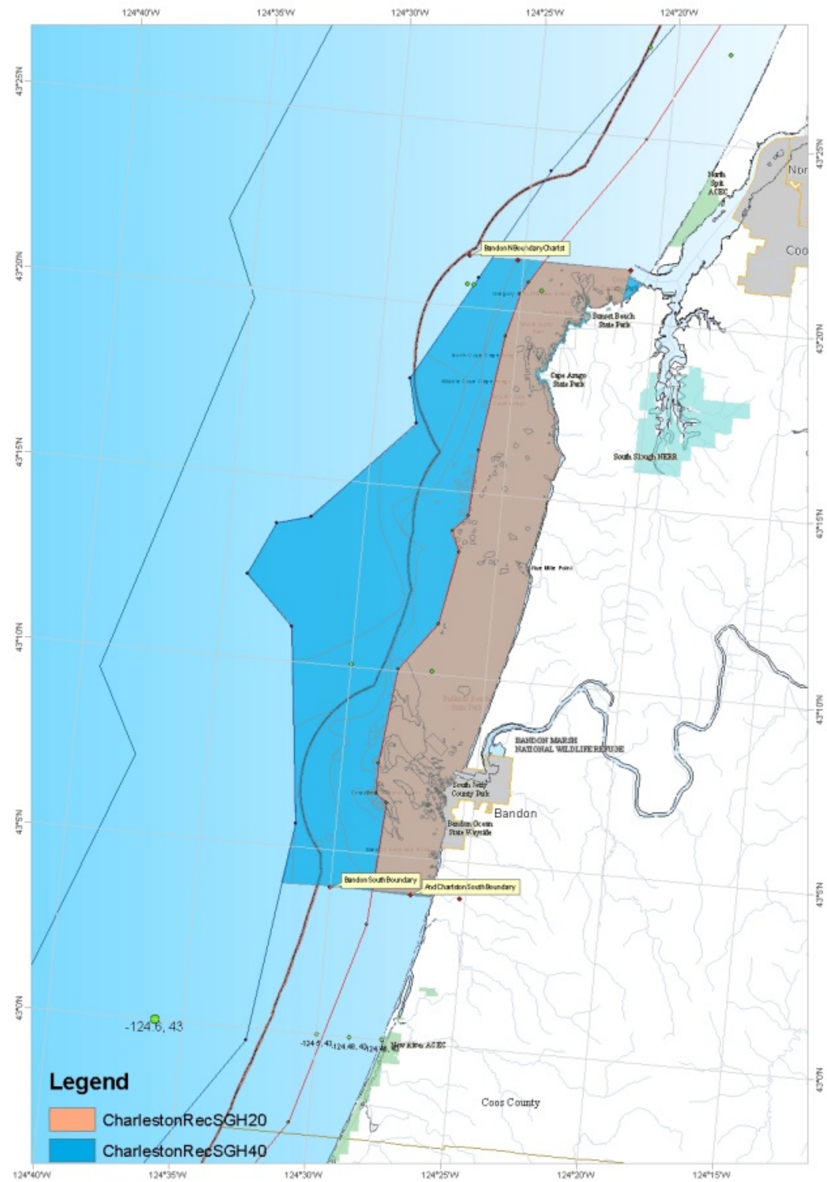
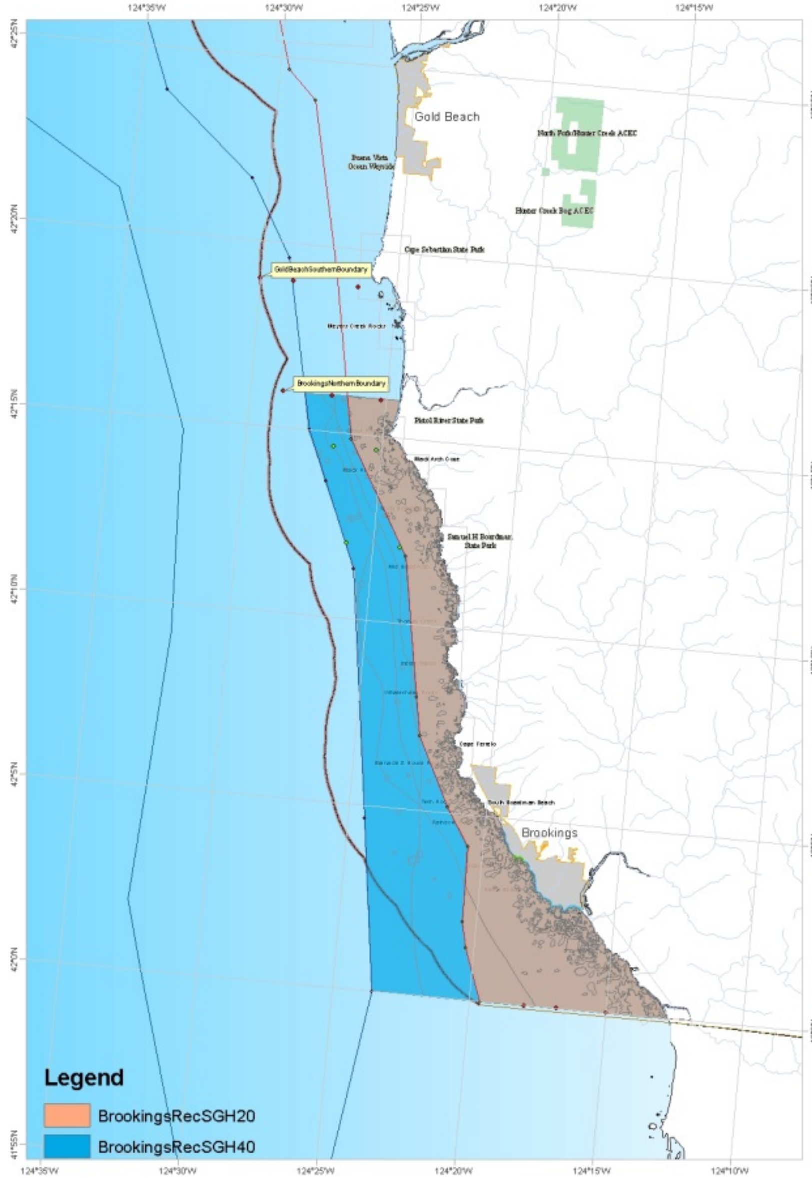


Figure C.1 (cont.)

Brookings



Notes: 1. Shaded ocean areas show depths of 20 and 40 fathoms.
Source: Study.

APPENDIX D

Economic Value Measurement Concepts

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APPENDIX D
ECONOMIC VALUE MEASUREMENT CONCEPTS

1. Background

Fishery resources in Oregon provide all types of values to society. This includes values that can be measured by those that use the resources as well as values people place on the fish resource without using it (Pendleton 2009). Measuring values for the non-users is much more difficult because there are no traditional market exchanges. The non-users have to be asked hypothetically about the value. For this marine reserve study, only values by extractive users are considered, and further, only one of two economic analysis approaches is applied. The user value measure not considered is net economic value (NEV) and the user value considered is regional economic contribution, sometimes called regional economic impact (REI).[1] Both provide dollar estimates, but have quite different meaning. This appendix's next section distinguishes the difference in NEV and REI methods and the third section describes NEV methods in a total economic value (TEV) context. TEV means it includes NEV by users and non-users and it means there can be NEV gains and NEV losses.

2. Regional Economic Impact Measurements

a. Differences in Net Economic Value and Regional Economic Impact

The NEV of the fishery resource can be defined as people's willingness to give up resources of value to have the fishery resource. A common mistake that is often made in economic analysis is to include the costs associated with using the fishery resource (e.g. vessel costs for the commercial fishery and travel costs for the recreational fishery) as part of the NEV from the resource. These associated costs, or expenditures, are instead the source of local or REI's associated with use of the fishery. The NEV must represent the value of the fishery resource itself, and not the value for obtaining or enjoying fish resource.

Another way to view the difference between NEV and REI is to consider NEV as the net loss to society if the resource were no longer available. Suppose that a specific ocean fishery were no longer available, then fishermen would have to either fish somewhere else or engage in some other activity. The money spent before the fishery was restricted would not necessarily be lost to the financial economy - in fact it could be spent in some other way for commodities. But the value received from fishing at that specific location would be lost. It cannot be assumed that one

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1. NEV is the economic surpluses for a good or service in excess of the cost of obtaining it. The economic surpluses can come from producers or consumers. The producer surplus in the commercial sector is the difference between the market value of a good or service, such as the ex-vessel value of harvests, and its production cost. The producer surplus in the fishing industry is from firms participating in harvesting, distribution, and processing activities. However, some economic studies will carry producer surplus estimates to the sale of fish at the wholesale and retail levels. For consumer surplus in the commercial sector, the surplus is the difference between what people would pay and the actual price for the seafood. For producer surplus in the recreational fishing sector, the surplus is from businesses providing services for anglers, such as charter boats and lodges. The consumer surplus is the extra value that anglers would be willing to pay for the angling experience less the actual costs for the experience.

ocean location's fishing is preferred over (had greater value than) those of the other location, or the first site would not have been utilized in the first place. The net between the value for the chosen fishery versus other fisheries or activities would be a loss to society. The change in expenditures or associated impacts on community personal income or jobs for the first fishery would be a loss to the economy, but would be a gain due to some other fishing location or activity. REI, therefore, describes the local or regional effects associated with any specific area chosen for fishing restrictions.

The measurement calculation for REI in this report is personal income. Corresponding measures for full time equivalent jobs may be developed by assuming the personal income is a person's average wage and salary or proprietors net income. It can be assumed in the Pacific Northwest that $35,000 is a reasonable estimate for a per job factor.[1]

The above example should make it clear why local economies are often more concerned about REI than NEV, especially when the economic values are in the form of consumer surplus. If anglers are willing to pay some amount of money over and above their costs, but don't actually have to pay, the consumers get to take that surplus or value home with them in the form of "unextracted" income. It is not immediately obvious to local businesses that the consumer surplus generated from any specific fishery has any impact on the local economy. On the other hand, money spent on lodging, food, supplies, guides, etc., has a direct impact on local businesses and on personal income in the local area.

It is clear that NEV and REI are two distinct measures, and each is useful for different purposes. NEV's are important if the goal is to allocate society's resources efficiently. REI's are important in assessing the distributional impacts of the different allocation possibilities on the financial economies of areas. It may often be the case that society will want to invest in a less valuable resource because the local area or economy that holds the resource is in need of economic development. Nevertheless, having the information on economic value will tell society how much they are giving up in order to achieve the redistribution of economic activity or development. Some of the REI may be new to an area; some of these may be considered a transfer from one region or industry to another.

b. Regional Economic Contribution Modeling Methodology

Economic analysis studies when REI is to be the measurement start with assessing the direct effects of local spending from the industry activity being studied. Direct effects capture the consequences of businesses selling goods and services directly to the study industry participants. In addition to these direct effects, economic analysis also reports on the secondary effects from local spending through the use of multipliers. The concept of a multiplier is that an initial amount of spending will also have successive re-spending rounds using the new money brought into an economy. The added spending means the economic contribution will be greater than the

1. County average annual earnings per job are computed by dividing the economies all industry earnings estimates by total full-time and part-time jobs estimates. Average earnings per job within industries involving more part-time work is lower than industries involving more full-time work, although there could be little difference in the underlying wage of full-time workers. Since average earnings per job are just a simple average, it does not account for variations in the distribution of earnings among high-pay vs. low-pay jobs.

initial amount. These secondary effects assess the impacts on backward linked industries that sell goods or services to the studied industry-related businesses (indirect effects) and the impacts from household spending of income earned at the local businesses (induced effects). The total business spending changes is sometimes called changed business "output." A portion of the output from businesses will be what those businesses need for purchasing, manufacturing, and/or providing services for the sold product. Those costs will include wages and salaries and proprietorship profits (or income). For example, Figure D.1 shows the relationship between output and income that accrues from successive re-spending rounds of the new money brought into an economy. Figure D.2 has a cumulative view of how local businesses first supply goods and services to the external economy's demand, and the leakage of the new money out of the local economy as it circulates between businesses and is re-spent by local households. The households receive a portion of the new money via employment at the businesses where studied industry participants spending occurs.

For this study, input-output models for Oregon's coastal counties were used from the IMPLAN system.[1] IMPLAN is a widely used regional economic modeling system originally developed by the USDA Forest Service. If economic contribution was to be calculated for the state or U.S. level economy, different multipliers would have to be extracted from the IMPLAN system.

Angler spending in retail categories must be bridged and margined to IMPLAN sectors to fashion and correctly apply multipliers. This action may allocate some of the spending to producer sectors that are not represented in the regional economy.

It is necessary to state the geographic scope of the economy being assessed for the studied fishing industry's activity. For example, angler trip spending can include spending at home, en/route, and at the destination. The size of the region being analyzed will determine whether a particular region is receiving purchases. Unless the industry being analyzed is bringing "new money" into the economy, economic analysis studies should exclude its spending. Economic analysis attempts to identify spending that would be lost to the region being studied in the absence of the studied industry activity. Such a "with versus without" analysis requires considerable knowledge of industry activity purposes and potential substitution behaviors to assess which spending would be lost if the project or policy did not occur. For the example of angler spending, residents within the area being studied may spend the same amount of money on another form of entertainment if denied fishery access. In the absence of this type investigation, the assumed spending can be characterized as being business sales that are "stirred up" in the local economy.

1. The multiplier effects are calculated using economic response coefficients generated from the IMPLAN input-output model. IMPLAN models are available for various U.S. geographic levels, states, national economy, and international economies. The models are distributed by IMPLAN Group LLC, 16740 Birkdale Commons Parkway, Suite 212, Huntersville, NC 28078.

The economic contribution measurement selected for this study is personal income. It could just have well been other metrics that would describe the same economic direct and secondary effects, but in a different dimension. The definitions for the other dimensions are:

- **Value added** includes labor income as well as profits and rents and indirect business taxes. Value added is the preferred measure of the contribution of an activity or industry to gross state product as it measures the value added by that activity/industry net of the costs of all non-labor inputs to production.
- **Output** represent the business sales in the region with the exception that sales in the trade sector (wholesale and retail) are only the margins on the sales. Therefore, they exclude the cost of goods sold.
- **Income** is measured as net earnings which includes wages and salaries, payroll benefits, and income of sole proprietors.
- **Jobs** are not full time equivalents but include full and part time jobs, consistent with employment estimates of the U.S. Bureau of Economic Analysis.

A criticism of regional economic contribution modeling is that it tends to overstate actual economic impacts because it assumes that all possible adjustments to disturbance are instantaneous and permanent, and that individual responses to disturbances are limited. People who lose a job, for example, are assumed to stay unemployed. In reality people and businesses adjust over time, as they consider and try alternative occupations, technologies, and locations. Economic changes created by the alternatives can be "short-run" or "long-run." Short-run describes the effects of construction or other temporary spending that typically lasts for less than a few years while industry adjusts to the changes.

Regional economic contribution modeling (a type of modeling more often termed REI modeling) is an appropriate methodological approach for understanding key relationships, such as effects across broad economic sectors from investment incentives to promote an industry activity. However, the quantitative results do not provide a complete picture of an industry activity effects on a region. For example, it does not show project feasibility. A project can be unprofitable and still show positive economic contributions through its spending. Government agencies public financing incentives for establishing a private sector business will be interested in the long-term success of an industry activity in order to derive the expected returns in jobs and other financing program objectives.

Second, the economic modeling does not show fiscal impacts such as the effects on government services and revenues. Local governments may have to finance new roads, schools, buildings and other infrastructure to accommodate the new industry activity. Residents may have to endure crowding costs (such as increased traffic) if there is under capacity in infrastructure. Third, economic modeling uses in a prospective analysis may not address lag structures of the studied industry expenditures (time relationships between expenditures and economics impacts). Lagging may occur if there is a business start-up horizon that requires regional economy adjustment.

Finally, economic contribution modeling does not show social impacts on residents.[1] Current housing stock value may increase, especially if the economy is already growing and the anticipated impact is comparatively large. The value may make shelter costs unaffordable to current residents. Use of regional economic contribution modeling results in local government policy making should at least acknowledge its limitations and more appropriately be accompanied by additional fiscal and social analyses.

3. Total Economic Value Measurement

The TEV measurement across an ocean resources use spectrum is depicted in Figure D.3. TEV is typically used in benefit-cost analysis (BCA) studies that involve environmental resources. The accounting of benefits in a BCA would include valuations for not only extracting or disturbing natural resources, but also appreciating their non-use. The accounting for costs in a BCA would include opportunity costs, such as for the next best use of the investment being studied. The TEV measure for ocean resource use reflects what society is willing to pay or accept for one more unit of usage minus the cost to access the ocean resource times the demand for the use. It includes all economic producer and consumer surpluses. For the example of calculating producer surplus from commercial fishing, the economic value is business profits less an expected rate of return on vessel assets and less compensation for alternative expected returns on labor. Determining ocean resource economic value when there are prices and cost information available is tedious but doable, however establishing economic values for the right side of the usage spectrum on the figure is much more difficult. Economists apply a variety of procedures in an attempt to elicit a dollar amount for restoring or just preserving ocean resources, such as asking a person's willingness to pay extra on a utility bill or choosing between preservation and another activity that has a known value. Even though TEV analysis methods and modeling results become somewhat abstract, they are still worthwhile for discussion purposes. The discussions provide an understanding and appreciation for the importance that ocean resources play in our lives. Leaving out the non-use benefits as well as opportunity costs during economic analysis exercises will tend to undervalue marine reserve functions, and therefore provide incomplete valuation information used in policy decision making processes.

TEV would be the proper measurement for addressing the need for quantitative information about the net economic effects from establishing marine reserves. Figure D.4 itemizes what might be gains and losses in TEV as applied to a marine reserve site (MR). TEV methods provide the consistent units whereby the sum of benefits minus the costs applied over a relevant time period will generate a net economic effect quantity.

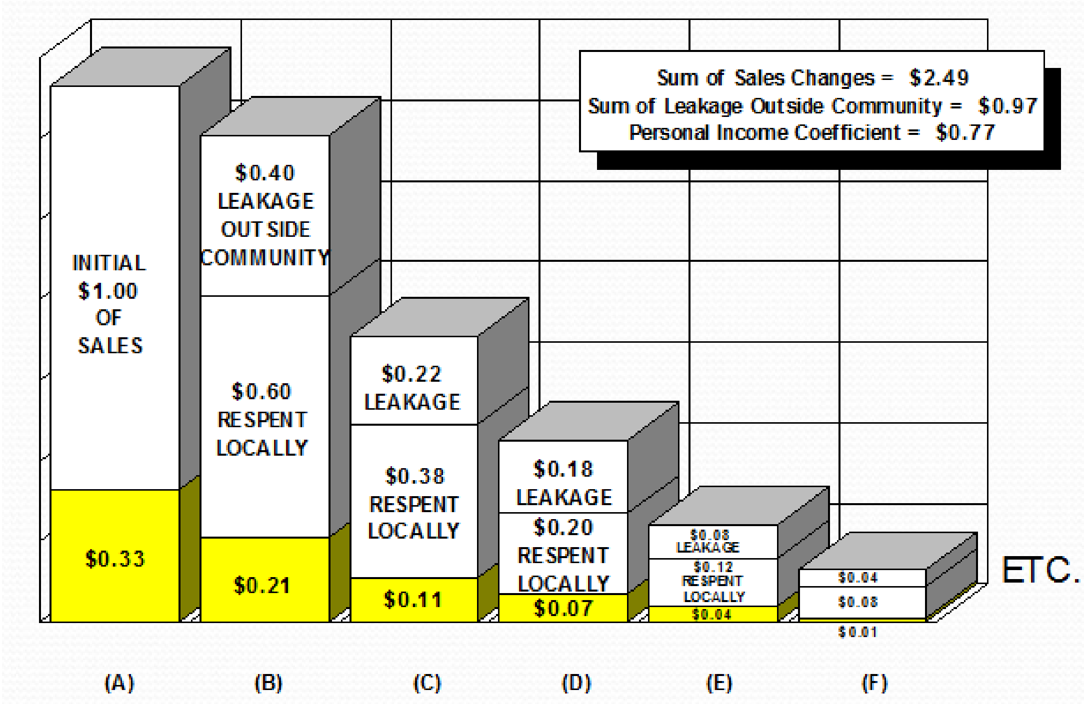
There is a substantial body of literature on the ecological benefits of marine reserves, and a lesser but growing published studies about the bioeconomic modeling of marine reserves. The challenge becomes specifying parameters in the TEV models and calibrating them to the marine

1. There are accepted methodological practices for conducting social impact assessments just as there are for regional economic impact analysis. They are directed more at finding distributional impacts across households and demographics. For example, economic impact analysis may show net job growth, but there may be winner and loser individuals in the calculation for net. The experience and training of those employed in the negatively impacted sector may not qualify individuals for jobs in the positively impacted sector. A subset of a social impact analysis is a social equity analysis where historically disadvantaged and vulnerable groups are examined.

reserves unique situation. Using rules-of-thumb and borrowing results from other studies where primary data collection occurred may provide adequate prospective information to assist in understanding how marine reserve net economic effects may play out. However, such approaches based on a TEV model may not provide the reliable solutions needed for policy making. The approach would foster criticism about modeling results appropriateness and be of lesser usefulness than if the weak approach was not developed. If the mathematical approach is used, sufficient study resources should be mustered to acquire through surveys and ecological investigations the necessary parameterization data.

The design of TEV models would be confined to assessing the objectives for which Oregon's marine reserve system was established. Those objectives (paraphrased in the Introduction section of this report) were not to cause spillover or buffering benefits. Knowing those benefits might be relevant to decision makers weighing future policy decisions about the implementation plans for Oregon's system, but it would be extra knowledge because the location, size, and spacing of the Oregon system would have been different if spillover and buffering objectives were to be satisfied. Applying TEV methods can provide the organizational approaches to find out if initial objectives are being satisfied and identifying were there might be unintended (positive or negative) consequences. In such cases, there needs to be the flexibility to adapt management plans to address consequences.

Figure D.1
Output and Personal Income Multipliers



Notes: 1. The shaded portion of the bars shows output (sales) that goes to households in terms of wages, salaries, and proprietorship profits. The shaded portion when summed over respending is called total personal income.

Source: Radtke and Davis (1994).

Figure D.2
Linkage Model of the Regional Economy

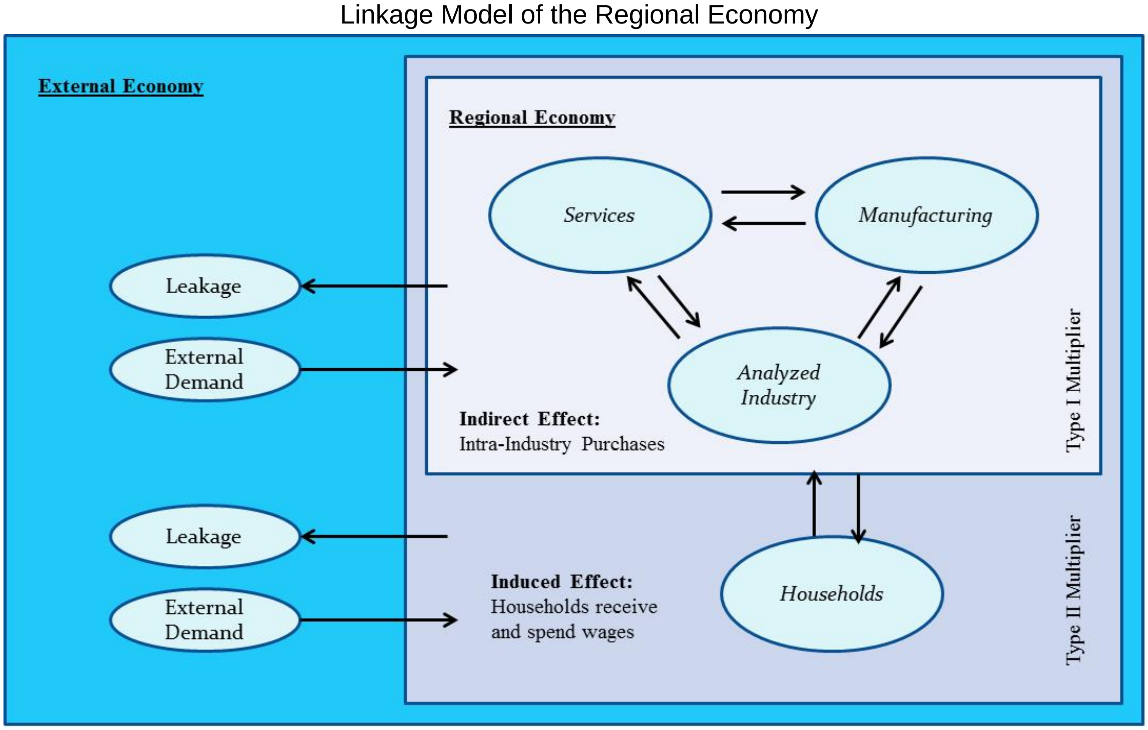
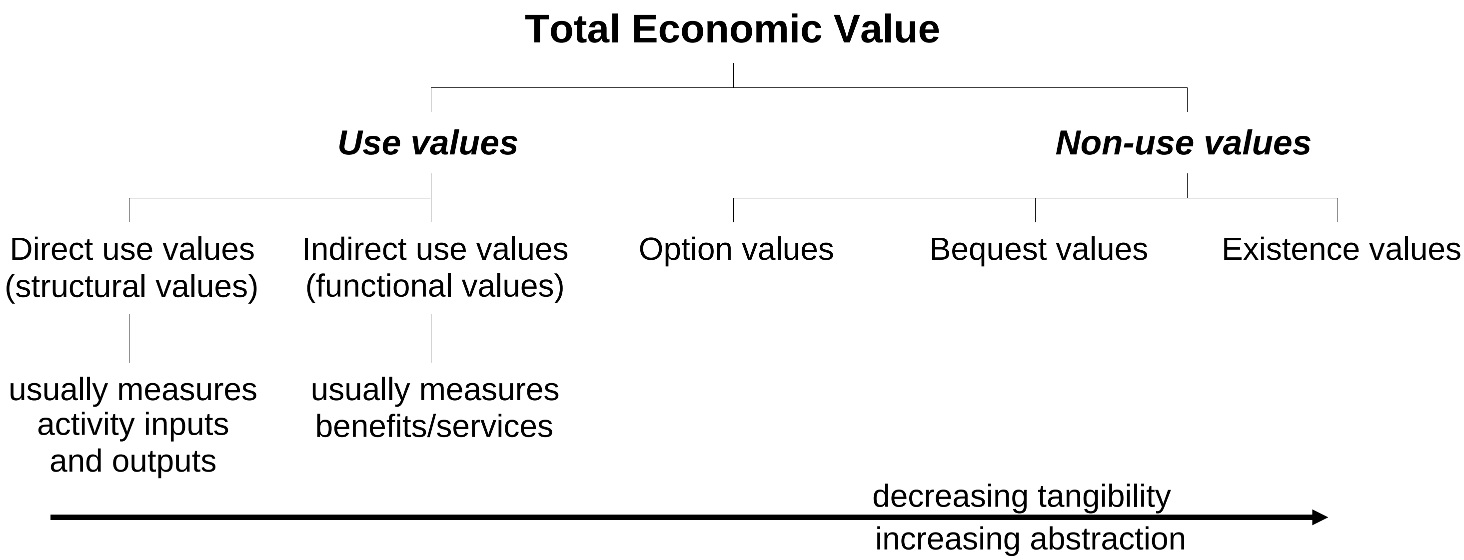


Figure D.3
Total Economic Value Measurements



Notes: 1. Total economic value (TEV) includes both use and non-use values.
- Use values include direct use (both consumptive, i.e. fishing, and non-consumptive, i.e. observing) and indirect use (sustaining species and other non-direct ecosystem services, i.e. provisioning (e.g. water to scrub pollution), regulating (e.g. regulation of climate), cultural (e.g. spiritual values), and supporting (e.g. soil formation)).
- Non-use values include option values, bequest values, and existence values.

2. There may be unknown values to be discovered in the future, i.e. genetic material (e.g. new cure for cancer).
3. Valuation is easiest for finding in direct-use values, quite difficult for finding in indirect-use values, and very difficult finding in non-use values.

Source: Adapted from Peterson and Randall (1984).

Figure D.4
Net Economic Consequences of Marine Reserves

Net economic value changes (benefits minus costs)

1. Example Benefits
   a. Spillover benefits in fishing opportunity within harvest areas through increased catch and increased CPUE measured by changes to commercial economic rent and recreational willingness-to-pay
   b. Ecotourism increases
   c. Biodiscovery
   d. Existence value
2. Example Costs
   a. Displaced fishing opportunity for commercial and recreational sectors.
   b. Ecotourism decreases
   c. Potential impacts to other uses such as mineral exploration or ocean energy development

Notes: The example benefits for biodiscovery may arise from the protection of genetic material for possible future development of commercially valuable product. The value of preserving this future option is likely to be significant, but is difficult to estimate.
Source: Study.

APPENDIX E

Evaluation of Predicted Displaced Harvests

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APPENDIX E
EVALUATION OF PREDICTED DISPLACED HARVESTS

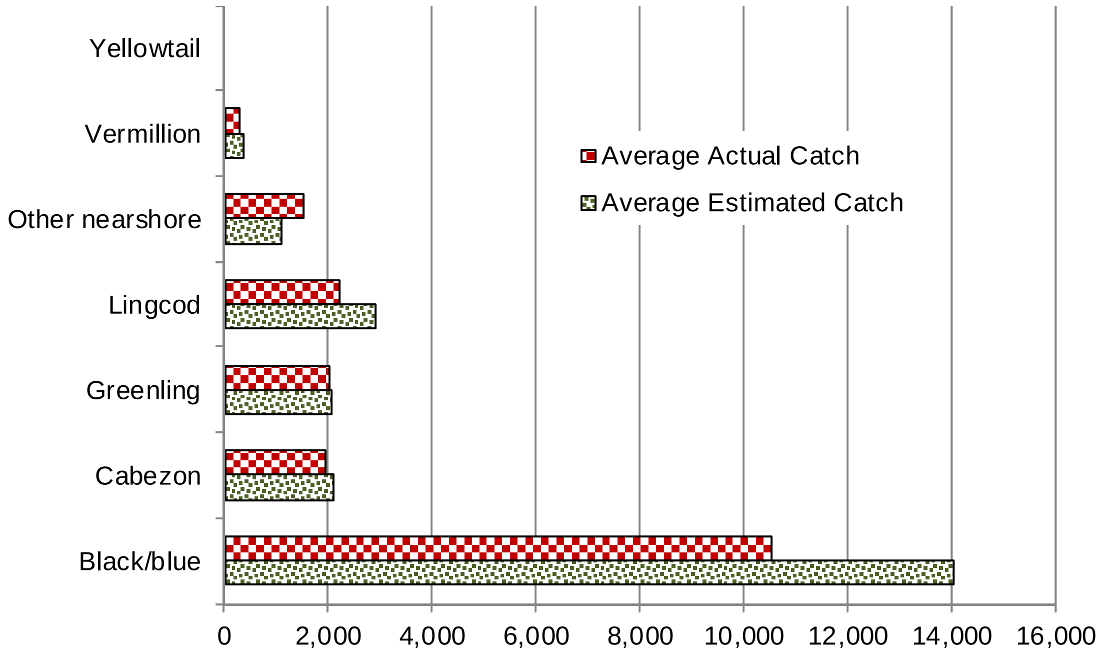
State nearshore fisheries logbook records could be compared to the model's predicted catch for nearshore groundfish at marine reserve sites (MR's). This evaluation was applied at the Redfish Rocks Marine Reserve (RRMR) site for selected species. The analysis of the nearshore logbook program records for years 2004 to 2008 did find recorded harvests that were adjusted for compliance and corrected using fish ticket information to be lower for some species than the predicted harvests. Overall, the actual was 18 percent less than predicted harvest using the study ratio estimator for the species analyzed in 2009 (Figures E.1 and E.2). Other fisheries logbook programs (such as Dungeness crab and sea urchins) were not used for an evaluation.

Comparison analysis elsewhere along the Coast where nearshore logbook compilations provided adequate spatial coverage resulted in similar difference (positive or negative) envelope around predicted harvest. There was not sufficient nearshore logbook program spatial coverage to evaluate all MR's. The inference from this evaluation's spot checking is that the confidence envelope was similar. However, using bootstrapping to determine the modeling results distribution should use a more rigorous random sampling method for selecting logbook program comparison sites. It is unknown if this inference would apply to other target fisheries predicted harvests.

An interpretation of the RRMR site's nearshore groundfish predicted results is that it would correctly be high for both the commercial fishing sector and the recreational fishing sector. The reference area used for developing the commercial fishing ratio estimators included open fishing grounds shoreward of the Rockfish Conservation Area (RCA) boundary extending from Cape Blanco to the Oregon-California border. This area includes long commuting distances for fleets from the three ports that primarily utilize these fishing grounds for the included target fisheries. The disbursed area harvesting may have higher catch per unit effort (CPUE) than the more easily accessed MR. The Port Orford fleet vessels facing inclement weather conditions or wanting to keep steaming costs low would fish closer to the port and may cause local depletions.

The referenced area used for the recreational angling was approximately 15 miles north and south of Brookings. Many charter service and private boats use these fishing grounds. On the other hand, private boat launching at the Port of Brookings is inconvenient and expensive which hinders access to the MR. There are charter service boats that depart from Gold Beach which do travel north and fish the Port Orford area. However, a Brookings reference area ratio estimator probably is high for the MR application.

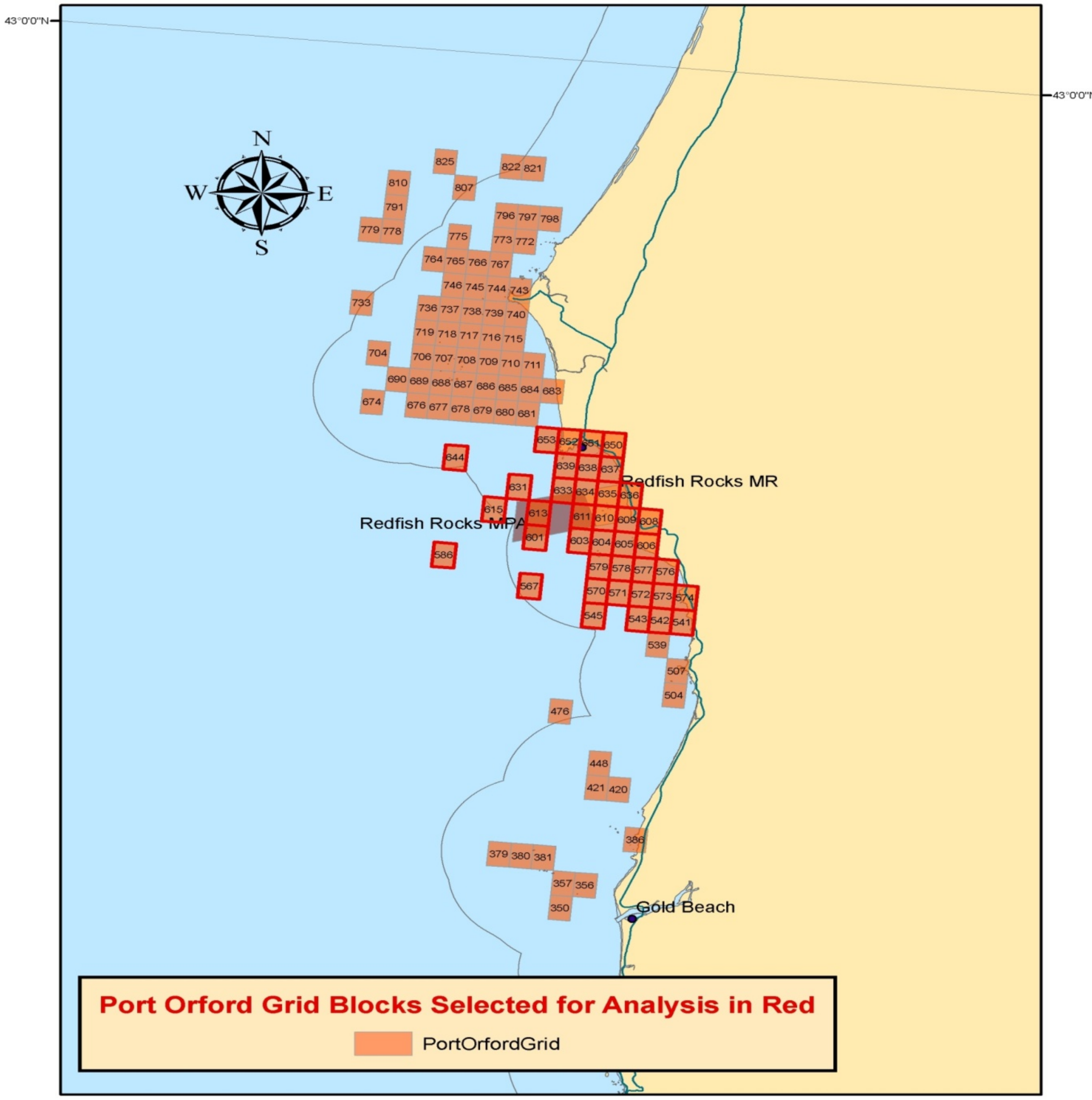
Figure E.1
Redfish Rocks Marine Reserve Actual Versus Estimated Harvest for Selected Species



Notes: 1. Actual is from nearshore logbook program data.
2. The average is for the years 2004 through 2009.
3. The harvest is for the marine reserve portion of the marine reserve site (MR).

Source: Jim Golden, personal communication, April 2012.

Figure E.2
Port Orford Nearshore Logbook Program Grid Blocks Selected for Determining Actual Harvest



Notes: 1. Actual catch determined from using average catch per area in selected grid blocks and the marine reserve sites (MR's) total area.

Source: Jim Golden, personal communication, April 2012.

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