INTRODUCTION

The Northwest Fisheries Science Center (NWFSC) has two teams of economists and social scientists who conduct research and data collections on a wide variety of topics related to management and conservation of Northwest marine resources and the marine ecosystem. The Economic Social Science Research Program (ESSR) in the Fishery Resource Analysis and Monitoring Division employs five economists in permanent positions and is assisted by a number of contractors. ESSR is focused primarily on research and data collection to support management of commercial and recreational fisheries. The Human Dimensions (HD) team is part of the Ecosystem Science Program in the Conservation Biology Division. The team includes two economists and two non-economist social scientists in permanent positions and is assisted by several contractors. In addition to providing research and data to support fishery management, the team conducts research on how human wellbeing and communities are impacted by the marine ecosystem and human activities in it, on implementation of ecosystem-based fishery management, and on conservation of protected resources including endangered species and marine mammals. Although the ESSR and HD teams are in different divisions, there is substantial overlap in topics of research and extensive collaboration between the teams.

This documents describe the research and data collection activities of the ESSR and HD teams and their partners and collaborators. The discussion in divided into topical sections on: Commercial Fisheries Economics, Recreational Fisheries Economics, Human Dimensions Social Science, Ecosystem Economics and Social Science, and Protected Resource Economics. The discussion describes current research and data collection activities, but also activities completed over the last few years to provide examples of the types and quality of work done by the NWFSC’s scientists.

COMMERCIAL FISHERIES ECONOMICS

The NWFSC commercial fisheries economic research involves substantial data collection efforts, analysis of catch share programs, and regional economics. Research and data collection support mandates for economic and distributional analyses in the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the National Environmental Policy Act (NEPA) and the Regulatory Flexibility Act (RFA). Efforts are focused primarily on federally-managed fisheries and the salmon fisheries co-managed with the states. Research is published in peer-reviewed journals, presented at conferences and to management bodies, and published in environmental impact statements and environmental assessments by the West Coast Regional Office and Pacific Fishery Management Council (PFMC).

Cost and Earnings Surveys

The NWFSC began collecting cost and earnings data from commercial fishing vessels in 2005. Initially the targeted population for the surveys was vessels involved in the groundfish fishery. The groundfish fishery has both limited entry (LE) and open access (OA) components. The LE sector is divided into limited entry trawl (for those fishers using trawl gear, such as bottom and pelagic trawl nets) and limited entry fixed gear (for those fishers using fixed gear, such as longlines, traps or pots). The OA component of the fishery allocates a portion of the allowable harvest to fishers targeting groundfish without limited entry permits. The targeted population for the first survey was all active commercial fishing vessels
holding a LE groundfish permit with a trawl endorsement, which totaled 143 vessels. Somewhat surprisingly to many involved, the first survey achieved a 63% response rate (Lian 2010).

Upon the success of the LE trawl survey, the targeted population for the surveys was increased over time. In 2007, the open access portion of the groundfish fishery was targeted along with vessels that harvested salmon with troll gear, which totaled 1,152 vessels (Lian 2012a). In 2009, the LE survey was expanded to include not only those vessels with a trawl endorsement, but also those vessels with a fixed gear endorsement. This change increased the size of the population to 255 vessels, which accounted for more than 80% of the value of West Coast groundfish landings (Lian 2012b). In 2010, the voluntary survey population increased once again when the OA survey expanded to include vessels that had at least one trip on which groundfish, salmon, crab or shrimp accounted for a majority of revenue. The LE fixed gear population was surveyed again in 2013 and 2016, and the OA population was surveyed, using the 2010 survey definition, in 2014 and early in 2017.

In January 2011, the West Coast groundfish trawl fishery transitioned to the West Coast Groundfish Trawl Catch Share Program. The West Coast Groundfish Trawl Catch Share Program consists of an individual fishing quota (IFQ) program for the shorebased trawl fleet, and cooperative programs for the at-sea mothership and catcher-processor fleets. The Economic Data Collection (EDC) Program was established as part of these new regulations to monitor the economic effects of the catch share program (Steiner, 2016). Annual economic data submissions are required from all fishery participants in four sectors: catcher vessels, motherships, catcher-processors, and first receivers and shorebased processors. An annual report is published summarizing data collected for each sector (Guldin et al. 2017; Steiner et al. 2017a; Steiner et al. 2017b; Warlick et al. 2017). Baseline, pre-catch share data, were submitted in 2011 for the 2009 and 2010 operating years. Data for the first year the fishery operated under the catch share program (2011) were submitted in 2012 and annually thereafter. The EDC Program is currently in the process of collecting 2016 data.

The EDC Program supplanted the voluntary cost earnings surveys for the LE trawl sector and has enhanced the quantity and quality of economic information available for analysis and management. The voluntary survey only collected data from catcher vessels that delivered shoreside, therefore no cost and earnings data were available for catcher vessels that delivered to motherships, nor from catcher-processors, motherships, or shorebased processors. Additionally, in contrast to the voluntary survey, response rates for the EDC Program have been over 95%, except for the two years prior to the implementation of the catch share program when response rates were 88-93% for the catcher vessel survey and 67-78% for the shorebased processors. The response rate for catcher-processors and motherships has always been 100%. This comprehensive information for all sectors has enabled quantitative analysis that was not previously possible, including comparisons at the levels of target species, homeport, state, and vessel size, making more refined information available for management decisions.

**Catch shares**

The West Coast has two of the sixteen catch share programs currently operating in the United States. The Limited Entry Fixed Gear Sablefish Primary Fishery (also called tier limit or permit stacking program) was fully established as an individual transferrable quota program in 2001, and the West Coast Groundfish Trawl Catch Share Program was established in 2011. The NWFSC has conducted analyses through national working groups on catch share performance indicators (Brinson and Thunberg 2016), catch share markets and data availability (Holland et al. 2015b), and productivity change in catch share fisheries (Walden et al. 2014; Thunberg et al. 2015).
Prior to its implementation, the NWFSC estimated the likely effects of the West Coast Groundfish Trawl Catch Share Program. Research by Lian et al. (2010) estimated that an individual fishing quota program would result in a 50%–66% reduction in the number of participating vessels and an annual harvesting cost savings of $18–$22 million (based on 2004 price and cost estimates). The environmental impact statement for the program, conducted by the PFMC and National Marine Fisheries Service (NMFS) (2010), relied heavily on these findings to design the program and estimate the likely impacts of it.

The NWFSC played a leading role in the MSA-mandated 5 year review of the West Coast Groundfish Trawl Catch Share Program. With data collected via the EDC Program, supplemented by data from a variety of additional sources, the review team compiled a report that evaluates progress of the program toward its goals and objectives. The economics section of the report evaluates the program’s performance on goals such as “increase net economic benefits”, “create individual economic stability”, “provide for a viable, profitable, and efficient groundfish fishery”, “increase operational flexibility”, “promote measureable economic and employment benefits”, “provide quality product for the consumer”, and “increase safety in the fishery” (PFMC and NMFS 2017). Many of these topics will be developed into in-depth research papers in the future.

In addition, the NWFSC has conducted a variety of studies evaluating the effects of catch share programs on various outcomes. Holland and Jannot (2012) look at the potential for bycatch risk pools to reduce the financial risk of unexpected bycatch events for fishermen, as well as the moral hazard and adverse selection problems that they can create. Jannot and Holland (2013) attempt to empirically identify the ecological and fishing drivers of bycatch in the groundfish fishery. Holland and Norman (2015) and Holland (2016) discuss many aspects of the development and functioning of the IFQ market system. They conclude that, in many ways, the quota market is not yet mature and is not functioning perfectly efficiently. Steiner and Holland (working paper) studied a provision of the catch share program that allows fixed gear vessels to fish with trawl quota and find that vessels fishing with trawl gear are more profitable per pound of constraining quota species than fixed gear vessels. Steiner and Russell (working paper) find that crew members are working fewer days and annual wages have increased since the implementation of the West Coast Groundfish Trawl Catch Share Program. Leonard and Steiner (2017) develop counterfactual revenues and costs for the groundfish fleet and used an input–output model to estimate the change in income and employment for the West Coast as a whole and for 12 different port areas as a result of the catch share program. They find that alternative assumptions regarding the distribution of quota payments substantially changed conclusions about the economic impacts of the IFQ program. Holland, Steiner, and Warlick (2017) determine that the value of the quota distributed to quota share owners as a result of 2003 permit/vessel buyback outweighs the cost of servicing the buyback loan. For the Limited Entry Fixed Gear Sablefish Primary Fishery, Pfeiffer and Gratz (2016) evaluate the effects of the catch share program on vessels’ propensity to take trips in stormy weather, which is higher risk. Overall, catch shares caused the average annual rate of fishing on high wind days to decrease by 79%, evidence that institutional changes can significantly reduce individual, voluntary risk exposure and result in safer fisheries.

In collaboration with the University of Washington, the NWFSC also conducts research on the potential impacts of IFQ programs on shorebased processors. The West Coast Groundfish Trawl Catch Share Program provides a unique opportunity to contribute in this area for two reasons. First, the catch share program allocated 20% of the Pacific whiting harvesting quota to eligible processors. Second, the EDC Program collects detailed information on costs and earnings from all first receivers and shorebased processors participating in the catch share program. Guldin and Anderson (under review) extend analysis in the 5 year review and EDC reports to explore observed changes to shoreside Pacific whiting processors in the years surrounding implementation of catch shares relative to predicted outcomes. The
potential impacts of allocating harvesting quota to the processing sector are examined in Guldin and Anderson (working paper).

**Regional Economics**

The Center has developed a model that is heavily used by the PFMC for salmon and groundfish-related management measures and has led to additional regional economic research projects. The regional economic efforts rely heavily on our cost earnings surveys of both the commercial and recreational charter participants. These data provide costs by type of expenditure, earnings per employee, and processor margins.

The NWFSC’s Input-Output model for Pacific Coast Fisheries (IO-PAC) is designed to estimate the changes in economic contributions and economic impacts resulting from policy, environmental, or other changes that affect fishery harvest. IO-PAC was built by customizing the Impact Analysis for Planning (IMPLAN) regional input-output software. The original methodology employed in developing this model was similar to that used in the Northeast Fisheries Science Center’s Northeast Region Commercial Fishing Input-Output Model (Steinback and Thunberg 2006). The development and design of IO-PAC is documented in detail in Leonard and Watson (2011). Updates to the model were subsequently documented in PFMC and NMFS (2015). The model is currently used by the PFMC to estimate economic impacts of groundfish and salmon-related management measures. Additionally, the model has been used in conjunction with ecological models to estimate the economic impacts of alternative management scenarios (Kaplan and Leonard 2012).

In addition to the IO-PAC model, the Center has collaborated on or led several regional economic projects. We collaborated with personnel of the Alaska Fishery Science Center to develop a multiregional computable general equilibrium model (Seung, et al. 2014). Leonard and Steiner (2017) estimated the initial economic impacts of the IFQ program for the trawl groundfish fishery. Estimates of income and employment changers were made for 12 different port areas on the West Coast. The IO-PAC model is being used to predict the economic impacts of large salmon troll fishery closures in 2017.

**RECREATIONAL FISHERIES ECONOMICS**

The goal of the recreational economics group at the NWFSC is to produce information about the recreational fishing sector for the Pacific Fishery Management Council, the NMFS West Coast Regional Office, the Puget Sound Partnership, charter businesses, anglers, and the interested public. The NWFSC is focused primarily on saltwater recreational fisheries in Washington and Oregon while the Southwest Fisheries Science Center (SWFSC) focuses on recreational fisheries in California.

Saltwater recreational fisheries primarily occur in non-federal waters (zero to three nautical miles off the coast) in the Northwest and are managed by the states of Washington and Oregon. Inter-state coordination is facilitated through the Pacific States Marine Fisheries Commission. The Pacific Fishery Management Council and NOAA Fisheries manage fisheries that occur within federal waters (three to 200 nautical miles off the coast). Management of these fisheries is separated into four fishery management plans: coastal pelagic species, groundfish species, highly migratory species, and salmon species.

NWFSC economists collect data from recreational fishermen and charter businesses to help understand the economics of the recreational sector. There are no existing external data sources that are well suited to estimate angler behavioral models or that contain cost earnings data for the recreational charter fleet. NMFS does not fund regularly-scheduled data collections of social or economic data relating to
recreational fishing in the Northwest, with the exception of the national expenditure survey conducted by NMFS Office of Science and Technology’s Marine Recreational Fishing Expenditure Survey (Lovell et al. 2013). Instead, NWFSC economists fund data collection efforts through the NMFS Office of Science and Technology’s annual RFP funding competition. This includes surveys of anglers conducted in 2007 (Anderson and Lee 2013a), a survey of shellfish harvesters conducted in 2013 (Anderson and Plummer 2016), and a survey of saltwater charter fishing businesses conducted in 2013 (Leonard 2016). In addition, two data collection efforts will be completed within the next year: a discrete choice experiment of saltwater anglers in Washington, Oregon, and California – a project with SWFSC economists; and a survey of hatchery and wild steelhead anglers in Washington.

Data from the charter fishing survey (Leonard 2016) have been combined with trip expenditures from the NMFS Office of Science and Technology’s Marine Recreational Fishing Expenditure Survey (Lovell et al. 2013) to estimate the economic contribution of the recreational fishery for the Pacific Council’s biennial harvest specifications (Pacific Fishery Management Council 2015).

Recreational demand for saltwater fishing in Oregon and Washington and recreational shellfish harvesting in Puget Sound have been estimated using nonmarket valuation methods. The discrete choice experiment data from the previous angler survey (Anderson and Lee 2013a) was used to estimate mixed logit models highlighting angler preferences for hatchery and wild salmon (Anderson and Lee 2013b), examining the effect of potential conservation-related closures for rockfish (Anderson et al. 2013), and exploring the value of increased eelgrass habitat to salmon anglers as component of a food web model (Plummer et al. 2012). The contingent behavior data from the survey of Puget Sound shellfish harvesters (Anderson and Plummer 2016) have been used to estimate an incomplete demand system, providing trip demand under different types of environmental closures (Anderson and Plummer 2017).

The recreational surveys also form the basis for a bioeconomic model that is currently being developed at the NWFSC. The bioeconomic model integrates existing estimates of recreational demand (Anderson and Lee 2013b) with current stock assessments for a number of recreational species of importance. In particular, the model is intended to predict the effect of changes in management or changes in abundance on angler effort and economic values.

**HUMAN DIMENSIONS SOCIAL SCIENCE**

The status and sustainability of West Coast fishing communities is a key focus of research by the Human Dimensions (HD) team at the NWFSC, reflecting the National Standard 8 mandate within the MSA “...to take into account the importance of fishery resources to fishing communities in order to provide for their sustained participation; and to the extent practicable, minimize adverse economic impacts.” (16 U.S.C 1851 §301 (a)(8)) Since 2005, the NWFSC has maintained two Social Scientist positions focused on fisheries-oriented social research and human dimensions analyses. Beginning in 2013, the addition of a Washington Sea Grant Social Science Liaison position to the NWFSC’s Ecosystem Science Program allowed for an expansion of human dimensions foci. These scientists have generally developed research projects rooted in social science disciplines other than economics, thereby enhancing NWFSC economics with social data collection efforts and human dimensions perspectives in several areas of interest to West Coast fisheries and marine resource management. HD approaches at the NWFSC inform fisheries policy development in the West Coast region, marine spatial planning at the regional and state levels, and allow for integration into ecosystem-oriented collaborative research with biophysical scientists.
Primary foci include communities and fishery management, and the development of measures of human wellbeing and vulnerability in West Coast ecosystem contexts, and Puget Sound region research.

**Fishing Communities and Fishery Management**

The NWFSC has, for many years, maintained a research focus on quantitative approaches to assessing the strength of community connections to fishing (Sepez et al. 2006; Sepez et al. 2007). Identifying the West Coast communities that may require social impact considerations in the context of fisheries management actions has allowed for nationally standardized profiles of these West Coast communities (Norman et al. 2007), and nationally standardized metrics for a variety of social vulnerabilities and pressures on communities linked to commercial fishing ([http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/map](http://www.st.nmfs.noaa.gov/humandimensions/social-indicators/map)).

The NWFSC has also developed a longitudinal social study of the coast-wide community of fishermen and others linked to the groundfish trawl fishery (e.g., those involved in harvesting, processing, support services) ([https://www.nwfsc.noaa.gov/research/divisions/cb/ecosystem/humandim/groundfish-study.cfm](https://www.nwfsc.noaa.gov/research/divisions/cb/ecosystem/humandim/groundfish-study.cfm)). The study was designed to measure social changes in fishing communities resulting from the implementation of a new catch shares program specific to the West Coast Trawl Groundfish and Whiting Fleets. A coast-wide survey was implemented in 2010, 2012, and again in 2016, capturing periods both before and after the 2011 implementation of catch shares management system (Russel et al. 2014; Russell et al. 2016). The survey was administered in most cases through in-person interviews which collected responses to specific standardized questions. These interviews also allowed for the collection of qualitative information through recordings of conversations with respondents, which NWFSC scientists then transcribed and analyzed using qualitative analysis techniques. The longitudinal survey has enabled an assessment of social and economic effects on a range of direct and indirect participants in the groundfish catch share fishery and the communities they live in, and provided a key source of data for the mandated five-year review of the catch share system. Social data collected in these communities, as well as the application of social analyses, have been valuable in evaluating catch shares management approaches currently employed in the groundfish trawl fishery (Colburn et al. in press; Holland and Norman 2015; PFMC & NMFS 2017).

The NWFSC has an ongoing project (Voices of the West Coast) to collect oral histories from West Coast fishery participants. Oral histories are collected via audio and video equipment, transcribed by the researchers, and uploaded by the principal investigator. Participants are found through attendance at festivals and events, as well as through referrals, and previous contacts. Among other things, the project has provided insights on the shifting roles of women vis-à-vis policy changes (Calhoun et al. 2016) and the lack of generational recruitment into the fishing industry, frequently invoked as the “greying of the fleet” (Silva et. al. in progress).

**Measures of Human Wellbeing and Vulnerability in West Coast Ecosystem Contexts**

A key focus in recent years has been developing measures of human wellbeing and community vulnerability, in both fisheries management and broader ecosystem assessment contexts. The development of a set of community-level indices of vulnerability and community-level connections to fishing was included in the Human Dimensions of the California Current Integrated Ecosystem Assessment (Breslow et al. 2014) and in the WA state marine spatial plan (Poe et al. 2015a). Puget Sound research on cultural ecosystem services and sense of place has informed a similar ecosystem framework employed by the Puget Sound Partnership (Poe et al. 2016), and NWFSC scientists are adapting their community vulnerability indices so that they can be applied within research on harmful
algal bloom events. NWFSC scientists have creatively used both existing and new data to develop wellbeing measures related to non-commercial personal use of harvest (Poe et al. 2015b; Pitchon and Norman 2012; Howard et al. 2013). HD researchers will augment both the community-level indices and the research on personal use of harvest with a coast-wide fisheries participation survey recently administered.

NWFSC helped develop and participated in the Social Wellbeing Indicators for Marine Management (SWIMM) working group. The SWIMM group surveyed prior ecosystem-oriented human dimensions indicators in order to operationalize human wellbeing definitions and indicators for the California Current (Breslow et al. 2016), conceptualize the California Current as a socio-ecological system (Levin et al. 2015, Levin et al. 2016), identify social concepts important to integrated conservation (Hicks et al. 2016), and advise on how human dimensions indicators and social science more generally might be evaluated in natural resource management contexts (Charnley et al. 2017). NWFSC scientists are currently collaborating in employing the frameworks developed in SWIMM to link the human dimensions elements of the California Current Integrated Ecosystem Assessment (CCIEA) to the human activities components.

**Puget Sound Research**

Non-economic social science research at the NWFSC has also focused on the human dimensions of protected species and resources, particularly in the Puget Sound region. NWFSC social scientists surveyed the Puget Sound-based whale watching industry in anticipation of any proposed whale interaction regulatory shifts for Southern Resident Killer Whales (Russell and Ruff 2014). The NWFSC’s interests in researching and sustaining Puget Sound protected species in both marine and freshwater habitats led to the development of Puget Sound-wide social surveys on environmental knowledge, attitudes and beliefs (Norman et al. 2016; Safford et al. 2014), research on Puget Sound social norms and conservation targets (Levin et al. 2015), traditional environmental knowledge in the Sound (Beaudreau et al. 2011), and sociological analyses of salmon restoration strategies (Safford and Norman 2011a; Safford and Norman 2011b). Building on a framework for including cultural dimensions in conservation-oriented research (Poe et al. 2014), ongoing Puget Sound work is centered on the Sound’s tribal communities and cultural aspects of ocean acidification, particularly in terms of shellfish harvest practices (Poe et al. 2016). Human dimension research on social vulnerability to ocean acidification will be integrated into an interdisciplinary project recommended for 2018 funding under NOAA’s Regional Vulnerability Assessments for Ocean Acidification program.

**ECOSYSTEM ECONOMICS AND SOCIAL SCIENCE**

A diverse array of research and data collection activities at the NWFSC support ecosystem-based fishery management (EBFM) and ecosystem science though many are not expressly focused on ecosystems and support other programmatic areas as well. NOAA Fisheries defines EBFM as a *systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals*. As described in the EBFM Policy and Road Map, NOAA Fisheries views EBFM as the means to meet a variety of existing legal mandates as opposed to an additional requirement for meeting them. The EBFM Road Map notes that many of the standards and objectives included in existing legislations are or can be accomplished as part of EBFM. This includes Magnuson-Stevens Fishery Conservation and Management Act (MSA) requirements for managing for
optimal yield, accounting for interrelated stocks, taking into account the importance of fishery resources to fishing communities, limiting bycatch, protecting essential fish habitat (EFH), protection of deep sea corals, conservation of target and non-target species and habitats, and rebuilding overfished stocks. Other legislation, including the Endangered Species (ESA), the Marine Mammal Protection Act (MMPA), and the National Environmental Policy Act (NEPA), also include requirements that create a demand for economic and social science data and analysis to support EBFM.

The NWFSC HD team is part of the Ecosystem Program in the Conservation Biology Division, and is integrated into ecosystem research activities such as the California Current Integrated Ecosystem Assessment (CCIEA) and work on conservation and recovery of endangered species and marine mammals. Many of the research and data collection activities contributing to EBFM were described in more detail in earlier sections of this document reflecting the overlap of EBFM with other topical research and management areas. These include the work on fishing communities detailed in the section on human dimensions social science, and the work on the economics of salmon and steelhead conservation and habitat restoration discussed below in the section on protected resources. In addition, the HD team conducts fishery management research focused on bycatch and on the interconnections between fisheries due to both ecological and human-related processes. Examples include: analysis of cooperative “risk pool” approaches to managing bycatch (Holland, 2010; Holland and Jannot 2012; Jannot and Holland 2013); comparisons of alternative management approaches for bycatch and discarding (Ono et. al. 2013, Little et. al. 2015); development of locations choice models in multispecies fisheries; management strategy evaluations of California Current fisheries using Atlantis ecosystem models (Kaplan and Leonard 2012, Kaplan, Holland and Fulton 2013); studies of how diversification impacts financial risk for fishers and how diversification is influenced by regulatory change (Kasperski and Holland 2012; Holland and Kasperski 2016; Holland et al. In Press); and modeling direct and indirect impacts of salmon fisheries closures that may affect a broader system of fisheries and fishermen due to cross-participation (Richerson and Holland 2017).

The CCIEA is the primary organizing framework for integrating and communicating NWFSC ecosystem economic and social science research. The NWFSC HD team is actively involved in the CCIEA contributing research and participating in the continuing development of the overall CCIEA as well as the national IEA program. Specific economic and social science contributions to the CCIEA include providing indicators and analysis of fishing community reliance and vulnerability trends, and studying the causes and impacts of diversification of fishers and fishing ports (Harvey and Garfield 2017). The CCIEA also tracks use of commercial fishery catch for personal consumption and sharing as part of efforts to understand non-pecuniary contributions of fisheries to human wellbeing (Poe et al. 2015b). Another component of the CCIEA is management strategy evaluation which includes analyses conducted with Atlantic Ecosystem models to evaluate the impacts of management approaches on both the ecological and human components of the California Current Ecosystem. Versions of the Atlantis model incorporate groundfish fleet dynamics models and input-output models derived from collaborations of NWFSC economists and ecosystem modelers. The CCIEA also includes basic indicators of human impacts and benefits such as fishery landings and value. An important function of the CCIEA is to evaluate conflicts between human uses of ecosystem resources. An example is assessing potential conflicts between fisheries and wave energy generation along the Oregon coast (Plummer and Feist 2016).

A major new research effort involving collaboration between the NWFSC HD team and several academic researchers supported by a grant from the National Science Foundation will evaluate human-induced connections between key state and federal fisheries in the California Current. The project will integrate models of fishing supply with models of the population dynamics of key fish stocks under environmental variability to create a coupled ecological-economic simulation model of West Coast fisheries. This
An integrated model will be used to consider how alternative management approaches may enhance or hamper the resilience of the system of fisheries and fishing communities by facilitating or restricting fishermen’s adaptive behavior. A key focus of this work is to understand how climate variability interacts with fishery management restrictions to influence behavior of fishers and ecosystem outcomes. This project has just begun its second year and has already produced modeling framework for quantifying and predicting responses and direct and indirect economic impacts of West Coast salmon fishery closures (Richerson and Holland 2017). A mail survey of 2800 commercial fishery participants coast wide was recently administered achieving a 50% response rate. Among other things the survey will provide data on non-pecuniary motivations for fishing that will be used to augment expected revenue in fishery participation modeling. It will also enable evaluation of how fisheries contribute to human wellbeing beyond providing income and will enable measurement and comparison of social capital across fishing communities following approaches applied in New England fisheries (Holland et. al. 2015).

PROTECTED RESOURCES ECONOMICS

NMFS is tasked with protecting and managing marine species listed under the Endangered Species Act (ESA) and the Marine Mammal Protection act (MMPA). There are 46 marine species (or distinct population segments) listed under the ESA and over 30 species of marine mammals protected by the MMPA in NOAA’s West Coast region. Salmon and steelhead (salmonids) are a primary focus of protected resources (PR) management in the West Coast region where 28 evolutionary significant units of salmonids from six species are listed under the ESA. Other ESA-listed species in the West Coast Region include killer whales, green sturgeon, eulachon, and yelloweye and bocaccio rockfish. The ESA listing process does not allow for economic considerations in listing decisions, but it is used after listings to quantify economic impacts of critical habitat designations. Economic analysis can also inform recovery planning and management decisions. Furthermore, federal management actions that impact protected species are subject to regulatory reviews under the National Environmental Policy Act (NEPA), and may involve consideration of costs and benefits under EO12866 and EO13563.

The HD team at NWFSC conducts research that informs protected resources recovery and ecosystem-based management decisions. Past research efforts by the HD team have informed protected species management. Anderson et al (2013a) used stated preference of saltwater angler preferences to estimate the welfare impacts of delaying recreational bottom-fishing aimed at reducing protected rockfish bycatch. The stated preference study results were also used to evaluate saltwater angler preferences for catching hatchery salmon, which can be kept up to a bag limit, and wild salmon, which may come from listed stocks and must be released (Anderson et. al. 2013b).

Each year tens of millions of dollars are allocated to habitat restoration for ESA-listed salmon in the PNW. An ongoing research effort in the HD team is developing models and tools to inform cost effective selection of salmon habitat restoration projects. Specifically, previously developed biophysical models from the Wenatchee Basin in Washington State were coupled to predict expected salmon recovery outcomes across spatially-explicit restoration action alternatives. This research effort is also investigating the implications of ecological thresholds, non-linear restoration costs, and climate change on cost effective prioritization. Planned research will investigate cost effective selection of restoration portfolios in a dynamic context and compare cost-effective prioritization across habitats and associated salmonid life stages.
Economists on the HD team are currently conducting a species-by-species gap analysis of PR science in the West Coast to identify gaps in the literature and opportunities to apply economic analysis to PR management. The HD team recently secured funds for two PR-related research projects whose proposals were informed by the preliminary gap analysis findings. The first project will conduct a stated preference study of Washington State steelhead anglers to investigate preferences for encountering wild and hatchery fish on fishing trips. The estimated preference parameters will be used to evaluate angler welfare changes under alternative conservation and hatchery management portfolios. Habitat restoration efforts are often targeted at multiple objectives, and protected recovery outcomes are frequently evaluated at the ecosystem level. The second funded research project will investigate the impact of restoration-based ecosystem service changes (e.g. floods and erosion control) on home values with a model that explains historical real estate transaction prices with property characteristics and environmental amenities, including those provided by habitat restoration. Other potential PR research topics include institutional analysis of interactions between listed species and the incentives facing salmon stakeholders, and valuation and prioritization of scientific data collection and modeling.

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