

References

- Barsky, K. (1990). History of the Commercial California Halibut Fishery. *The California Halibut, Paralichthys californicus, Resource and Fisheries*. C. W. Haugen. Sacramento, California Department of Fish and Game. Fish Bulletin vol. 174, pp. 217–27.
- Bjørndal, T., G. A. Knapp and A. Lem (2003). *Salmon—A Study of Global Supply and Demand*. Rome, FAO.
- Breman, J., Ed. (2002). *Marine geography: GIS for the oceans and seas*. Redlands, ESRI Press.
- Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed Method Approaches*. Thousand Oaks, Sage Publications.
- Davis, A. and C. Bailey (1996). "Common in Custom, Uncommon in Advantage: Common Property, Local Elites, and Alternative Approaches to Fisheries Management." *Society and Natural Resources* 9: pp. 251–65.
- Deweese, C. M. (2004). Sea Urchin Fisheries: A California Perspective. *Sea Urchins: Fisheries and ecology—Proceedings of the International Conference on Sea Urchin Fisheries and Aquaculture 2003*. J. M. Lawrence and O. Guzmán. Lancaster, PA, DEStech Publications, Inc.: pp. 37–55.
- Deweese, C. M., K. Sortais, M. J. Krachey, S. C. Hackett and D. G. Hankin (2004). "Costs and management options evaluated in Dungeness crab fishery." *California Agriculture* 58(4): pp. 186–93.
- Diamond, S. and M. Vojkovich (1990). Estimating Total Effort in the Gill and Entangling Net Fishery for California Halibut. *The California Halibut, Paralichthys californicus, Resource and Fisheries*. C. W. Haugen. Sacramento, California Department of Fish and Game. vol. 174: pp. 265–79.
- Fricke, P. (1994). Guidelines and Principles For Social Impact Assessment. The Interorganizational Committee on Guidelines and Principles for Social Impact Assessment. Silver Spring, MD, U.S. Department of Commerce. NOAA Technical Memorandum NMFS-F/SPO-16.
- Greene, H.G., Bizzarro, J.J., Herbert, I., Erdey, M., Lopez, H., Murai, L., Watt, S., Tilden, J., Levey, M. 2003. Final Report: *Essential Fish Habitat Characterization and Mapping of California Continental Margin. For Pacific States Marine Fisheries Commission, Job No. 574.02*. Center for Habitat Studies, Moss Landing Marine Laboratories, Moss Landing, CA.
- Hackett, S. C., M. J. Krachey, C. M. Deweese and D. G. Hankin (2003). "An economic overview of Dungeness crab (*Cancer magister*) processing in California." *CalCOFI Report* 44: pp. 86–93.
- Hansen, D. (2003). Estimating Costs in the California Commercial Salmon Fishery. *Agricultural and Resource Economics*. Davis, University of California.
- Hill, K. and Schneider, N. Historical Logbook Databases from California's Commercial Passenger Fishing Vessel (Partyboat) Fishery, 1936–97. December 1999. SIO Reference 99-19. <http://repositories.cdlib.org/sio/reference/99-19>
- Kruse, G. H., N. Bez, A. Booth, M. W. Dorn, S. Hills, R. N. Lipcius, D. Pelletier, C. Roy, S. J. Smith and D. Witherell, Eds. (2001). *Spatial processes and management of marine populations*. Fairbanks, University of Alaska Sea Grant.

- Langdon-Pollock, J. (2004). West Coast Marine Fishing Community Descriptions. Portland, OR, Pacific States Marine Fisheries Commission.
- Leet, W. S., C. M. Dewees and C. W. Haugen, Eds. (1992). *California's Living Marine Resources and Their Utilization*. Davis, California Seagrant Program.
- Leet, W. S., C. M. Dewees, R. Klingbeil and E. Larson, Eds. (2001). *California's Living Marine Resources: A Status Report*. Berkeley, University of California Agriculture and Natural Resources.
- Leeworthy, V. R. and P. C. Wiley (2001). National Survey on Recreation and the Environment 2000: Current Participation Patterns in Marine Recreation. Silver Spring, MD, NOAA, NOS.
- Lenarz, W. H. (1987). A history of California rockfish fisheries. *Proceedings of the International Rockfish Symposium (October 1986, Anchorage, Alaska)*, Sea Grant Report No. 87-2, May 1987, Anchorage, University of Alaska: pp. 35–41.
- Leslie, H., M. Ruckelshaus, I. R. Ball, S. Andelman and H. P. Possingham (2003). "Using Siting Algorithms in the Design of Marine Reserve Networks". *Ecological Applications* 13(1 Supplement): pp. S185–S198.
- Maine, R. A., B. Cam and D. A. Davis-Case (1996). Participatory analysis, monitoring and evaluation for fishing communities: A manual. Rome, FAO.
- McEvoy, A. F. (1990). *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850–1980*. Cambridge, Cambridge University Press.
- Monmonier, M. (1996). *How to Lie with Maps*. Chicago, University of Chicago Press.
- NOAA National Centers for Coastal Ocean Science (NCCOS) (2003). A Biogeographic Assessment off North/Central California: To Support the Joint Management Plan Review for Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries: Phase I—Marine Fishes, Birds and Mammals. Prepared by NCCOS's Biogeography Team in cooperation with the National Marine Sanctuary Program. Silver Spring, MD, NOAA NCCOS.
- Northwest Fisheries Science Center West Coast Groundfish Observer Program (2003). Initial Data Report and Summary Analyses. Seattle, NWFSC: pp. 26
- Pattison, D., D. d. Reis and H. Smillie (2004). An Inventory of GIS-based Decision-Support Tools for MPAs. Maryland, National Marine Protected Areas Center.
- Pomeroy, C. and M. Dalton (2003). Socioeconomics of the Moss Landing Commercial Fishing Industry: Report to the Monterey County Office of Economic Development. Monterey, Monterey County Office of Economic Development.
- Pomeroy, C. and M. FitzSimmons (2001). Socioeconomic Organization of the California Market Squid Fishery: Assessment for Optimal Resource Management. California Sea Grant Final Project Report. Santa Cruz, University of Santa Cruz.
- Rojas-Burke, J. (2005). Crabbing boom brings fears of bust. *The Oregonian*. 21 February 2005. Portland: p. A1.
- Scholz, A., K. Bouzon, R. Fujita, N. Benjamin, N. Woodling, P. Black, and C. Steinback, "Participatory socioeconomic analysis: Drawing on fishermen's knowledge for marine protected area planning in California," *Marine Policy* vol. 28, no. 4, pp. 335–49.
- Smith, M. D. and J. E. Wilen (2003). "Economic Impacts of Marine Reserves: The Importance of Spatial Behavior." *Journal of Environmental Economics and Management* 46(2): pp. 183–206.

- Squire, J., James L. and S. E. Smith (1977). *Anglers' Guide to the United States Pacific Coast: Marine Fish, Fishing grounds, and Facilities*. Seattle, NOAA.
- Starr, R. M., J. M. Cope and L. A. Kerr (2002). *Trends in Fisheries and Fishery Resources Associated with the Monterey Bay National Marine Sanctuary from 1981–2000*. La Jolla, California Sea Grant College Program.
- St. Martin, K. (2001). "Making Space for Community Resource Management in Fisheries." *Annals of the Association of American Geographers* 91(1): pp. 122–42.
- United States Department of Commerce (1980). Final Environmental Impact Statement on the Proposed Point Reyes-Farallones National Marine Sanctuary. Washington, DC, NOAA National Ocean Service.
- United States Department of Commerce (1989). Final Environmental Impact Statement and Management Plan for the Proposed Cordell Bank National Marine Sanctuary. Washington, DC, NOAA National Ocean Service.
- Vojkovich, M. (1998). "The California Fishery for Market Squid (*Loligo Opalescens*)."
CalCOFI Report 39: pp. 55–60.
- Weinberg, K.L., M.E. Wilkins, F.R. Shaw, and M. Zimmermann, "The 2001 Pacific West Coast bottom trawl survey of groundfish resources. Estimates of distribution, abundance, and length and age composition." NOAA Technical Memorandum NMFS-AFSC-128. Alaska Fisheries Science Center, Seattle.
- Wild, P. (1990). The Central California Experience: A Case History of California Set Net Laws and Regulations. *The California Halibut, Paralichthys californicus, Resource and Fisheries*. C. W. Haugen. Sacramento, California Department of Fish and Game. vol. 174, pp. 321–40.
- Wright, D. and A. Scholz, Eds. (2005). *Place Matters: Geospatial Tools for Marine Science, Conservation, and Management in the Pacific Northwest*. Corvallis, OR, Oregon State University Press.

Appendix A—Methods

Before detailing the methods used in the various segments of our analysis, it is useful to describe and discuss the data sources used and their limitations. It is important to note that virtually none of these data sets were designed to address some of the issues of central interest to the sanctuaries in the context of the JMPR process, especially the questions of spatial extent and intensity of fishing effort by different gear types, and also the relative importance of particular ocean areas for various commercial and recreational fisheries.

Some of our analysis, especially the use of local expert knowledge to characterize the fishing grounds in the study area, is directly motivated by these limitations, and we outline the methods used in this analysis in the remainder of this appendix.

Available data sources and their limitations

In general, data used for the sanctuaries profile fall into two main categories:

- a) fishery-dependent data
- b) fishery-independent data

A) FISHERY DEPENDENT DATA

These are data collected as part of the normal operation of fisheries. They typically involve a degree of self-reporting by fishermen and other participants in the fishing industry and are reported as part of the associated regulatory requirements.

1) CDFG logbooks for all commercial fisheries of interest in sanctuaries' waters

We used the following logbooks in our analysis:

- groundfish trawl fishery (1981–2003)
- shrimp and prawn trawl and trap (1987–2003)
- live bait (1975–2001)
- squid (1999–2003)
- Northern and Southern sea urchins (1980–2003)

We did not request or analyze logbooks for the sea cucumber fishery, the offshore longline drift fishery, or drift gillnet fisheries, which—in the assessment of the fishermen on the sanctuaries' working groups³⁵—are not relevant for the JMPR initiative. We obtained and assessed the livebait and urchin logbooks, but determined that the information they provided wasn't suitable for an evaluation of fishing grounds.

Typically, logbooks are filled out by vessel operators and periodically sent to CDFG where they are entered into a database. Logbook data vary considerably over time and by fishery, and are of variable spatial and temporal resolution. For example, the squid logbooks are very detailed, containing point data on sea surface temperature, direction the vessel is fishing in, and wattage of the lights used. This information is mandatory on an individual vessel level for all years of operation. By contrast, the live bait logs are voluntary and report catch in “scoops,” which lack a common conversion factor.

³⁵ In addition to the joint Fishing working group of the CB/GFNMS, we worked closely with the fishermen on the MBNMS Special MPA working group (www.sanctuaries.noaa.gov/jointplan/mb_mpa.html).

³⁶ Kevin T. Hill and Niklas Schneider. Historical Logbook Databases from California's Commercial Passenger Fishing Vessel (Partyboat) Fishery, 1936–97. December 1999. SIO Reference 99-19. <http://repositories.cdlib.org/sio/reference/99-19>

2) Line item Commercial Passenger Fishing Vessel (CPFV) logbooks, 1936–2001

CPFV operators are required to fill out logbooks for each trip, including the number of passengers, areas visited, and number and types of species caught. It is important to note that species identification of rockfishes was not required until the late 1990s, and as of today only some species of rockfish are required to be identified. An extensive analysis, including standardization of the historical data, has been conducted by CDFG staff,³⁶ which we augmented with more recent data.

3) Line item CDFG landing receipts for all fisheries, 1981–2003

Landing receipts are filled out by fish buyers and submitted to CDFG where they are entered into a database. Records contain codes for species caught, gear type, and location (by statistical block). For some of the most important local fisheries, notably Dungeness crab and salmon, they are the only data available for characterizing the fishery. While this is one of the largest datasets available, it is complicated by changes to the block structure used for recording landings, as well as to the gear and species codes over time. Furthermore, the logbook information on block origin of catch for the Dungeness crab and salmon fisheries is widely known to be inaccurate. This leads to some strikingly counterintuitive results and necessitates additional analysis for specifying catch locations and distribution of fishing effort.

B) FISHERY INDEPENDENT DATA

These are data that are collected by various state and federal agencies for a variety of purposes associated with fishery management, notably enforcement and stock assessments.

4) West Coast Groundfish Observer Program, 2001–03

This dataset covers three years of NOAA Fisheries observers in the federally managed groundfish fishery and contains temporal and spatial observations for both trawl and fixed-gear fleets. In principle, these records could be compared to the logbook and landing receipts as a gauge of accuracy and could also be used to constrain the fishing grounds of the groundfish fleets. Since we only had access to a truncated and incomplete dataset, however, we were not able to harness the observer data to their fullest capacity and omitted them from the analysis.

5) CDFG sportfishing sampling and observer data

There are observer data and sampling data for the charter boat fleet, as well as for private and shoreside recreational anglers. Considering these in turn, observer data exist for the CPFV fleet in several ports in the study area for the years 1990–98. Observer data can be used to verify the CPFV logbooks and to compare the implied fishing grounds. The CPFV fleet is also surveyed as part of the Marine Recreational Fisheries Statistical Surveys (MRFSS), which are conducted by the Pacific States Marine Fisheries Commission's (PSMFC) RecFIN (Recreational Fisheries Information Network) program. These annual surveys include phone interviews and dockside surveys and comprise data on recreational fishing catch, effort, and economic information. Telephone interviews are conducted with fishers in coastal counties to estimate angler trips, while intercept surveys at fishing sites estimate catch rates and species composition. These data have been collected since 1979, with several gaps arising from funding constraints. There are several quality issues with the MRFSS data due to the high variability of results, making the information difficult

to interpret and rather contentious when used in allocation decisions at the Pacific Fishery Management Council. It is, however, the only comprehensive source of data available and provides at least an impression of the pertinent trends over the last 23 years. Using customized queries of the RecFIN data,³⁷ we compiled summary statistics of non-CPFV fishing modes for the study area and the entire state. Since the MRFSS data contain no spatial information about catch location other than the access point or boat launch, they were of limited utility in our analysis.

³⁷ www.recfin.org/data.htm

As of January 2004, the MRFSS in California became the California Recreational Fishery Survey and is now providing more spatially-explicit catch and effort estimates. Data from this effort were not available in time to be considered in this study.

6) NMFS trawl surveys, 1977–2001

We obtained the slope and shelf surveys conducted by NOAA Fisheries for all years available (1977–2001). Although conducted with trawl gear, these surveys provide perhaps the only comprehensive survey of species distributions on the coast, and can be interpreted to yield habitat ranges for the commercial species of interest. This, in turn, is useful for constraining the footprint of commercial fishing fleets.

³⁸ Pacific Coast Groundfish Essential Fish Habitat Project (2004). Consolidated GIS Data Volume 1: Physical and Biological Data. Seattle, WA, Terralogic GIS NOAA Fisheries Northwest Region Pacific States Marine Fisheries Commission.

7) Habitat classifications

As part of the NOAA Northwest Region's project to describe groundfish Essential Fish Habitat, a comprehensive habitat classification exercise compiled a coastwide GIS database of habitat classifications.³⁸ These data can be used to relate fishing effort to habitat types, and also to constrain particular gear types.

8) Historical maps of fishing grounds

Before the widespread use of geographic information systems (GIS), there were several earlier attempts to map the fishing grounds in sanctuary waters that can be used as references and comparisons for the project. These include the Environmental Impact Statement of the MBNMS designation document, and an anglers guide produced by NOAA based on interviews with fishermen.³⁹

³⁹ Squire, J., James L. and S. E. Smith (1977). *Anglers' Guide to the United States Pacific Coast: Marine Fish, Fishing grounds, and Facilities*. Seattle, NOAA.

9) Habitat data

We imported digital data layers from the Pacific Coast Groundfish Essential Fish Habitat Project⁴⁰ into the JMPR GIS, both in vector and raster formats. The latter facilitates the fast loading of a habitat classification layer in the software interface that we use for expert knowledge interviews with fishermen and for interactive demonstrations during presentations and meetings. Also included in the habitat information, in addition to more than 30 classes of benthic features, is high resolution bathymetry (at 10-meter intervals).

⁴⁰ Pacific Coast Groundfish Essential Fish Habitat Project (2004). Consolidated GIS Data Volume 1: Physical and Biological Data. Seattle, WA, Terralogic GIS NOAA Fisheries Northwest Region Pacific States Marine Fisheries Commission.

10) Other data sources

In addition to these datasets, we evaluated the feasibility of using aerial data from periodic U.S. Coast Guard enforcement flights for characterizing the fishing grounds. Due to current record keeping practices and the use of flight protocols that are geared more towards enforcement rather than research surveys, there is no existing dataset that we could use in our analysis. In principle, however, overflight data remain a potential source of information on the extent of fishing grounds and the use patterns of fishermen and other users of the marine environment.

DATA QUALITY

For each dataset, we distinguish between thematic, temporal and spatial resolutions. Our approach is to generate a baseline for subsequent analyses by comparing datasets against each other, according to those variables. Then, we assess the accuracy and confidence of using the landing receipts to characterize the thematic variables of the ports and of the spatial representations of fishing effort. For example, using the trawl logbooks, we can identify which vessels in the CDFG landing receipts participate in the groundfish trawl fishery. For those vessels, we can then summarize from both datasets the amount of pounds landed per port—by species, gear type, and year. By comparing these summarized figures we have found that there is 99% correlation between the logbook and landing receipt data sets in terms of landings and revenues, but a considerably poorer match in terms of spatial specificity. This is largely due to problems with the landing receipt data.

We develop a spatial index to indicate the level of confidence for our determination of the fishing grounds for each fishery profile in this report. For each of the spatial resolutions that we use per fishing grounds map, we can then tie the thematic and temporal variables that are associated with each resolution. The rankings can be categorized into five types:

1. Latitude and longitude coordinates, as reported by on-board observers (West Coast Groundfish Observer Program)
2. Areas drawn by fishers that indicate the relative economic importance specific to a fishery (Local Knowledge)
3. Latitude and longitude coordinates reported by fishers (Logbooks)
4. CDFG block reported by fishermen (Logbooks)
5. CDFG block reported by licensed fish buyer/processor (Landing Receipts)

Since our analysis relies on the combination and interpretation of multiple datasets, we did this in recognition of the fact that information presented on maps is frequently taken at face value, with few readers scrutinizing the meta-data or methods descriptions.⁴¹ We therefore include on each map a reference to the relevant dataset. Where relevant, we also include a visual reminder of the extent of our local knowledge sample (see Map 3, Appendix E). All this is done in an attempt to enable the casual viewer of the information presented in maps to gauge the relative quality of the data used in the analysis. In some cases, fishery logbooks with poor compliance and sporadic records or landing receipts with poor spatial resolution may be the only sources of information available. Stakeholders and decision-makers may wish to distinguish these data layers in the final GIS from those for fisheries that are described by datasets with better thematic, spatial and temporal resolution, and/or by multiple, independent datasets. For example, since the groundfish fishery is described by detailed logbooks, landings receipts, and fishery-independent observer data, the associated data layers are likely to be of higher quality.

⁴¹ Monmonier, M. (1996). *How to Lie with Maps*. Chicago, University of Chicago Press.

Methods used

In this section we describe the methods used in the various interlocking parts of our analysis. We begin with an overview, and then describe the component parts in turn:

- a) Spatial analysis of fishing grounds
- b) Local knowledge interviews for characterizing fishing grounds
- c) Port characterizations

OVERVIEW

Conceptually, the goal of this analysis is to arrive at an accurate characterization of the fishing grounds and to link them—through associated landing and revenue information—with the ports adjacent to the sanctuaries. Portside, this forms the basis for gear and fishery specific profiles of fishing activity off the coast of North-central California, including assessments of the importance of sanctuary waters to particular ports or fleets. Essentially, the approach consists of “layering” all available data sources for each fishery and/or species, and constraining them with the most reliable spatial information. It may be useful to think of the project as a spatially explicit version of Starr et al.’s assessment of fishery resources in the MBNMS⁴²—updated, extended to the entire Jmpr area, and organized in a geographic information system—and as the socioeconomic companion piece to the biogeographic assessment of the sanctuaries by NOAA’s National Center for Coastal Ocean Science (2003).

⁴² Starr, R. M., J. M. Cope and L. A. Kerr (2002). *Trends in Fisheries and Fishery Resources Associated with the Monterey Bay National Marine Sanctuary from 1981–2000*. La Jolla, California Sea Grant College Program.

In general, the analytical framework we developed for this analysis has three important characteristics that make it both innovative and somewhat complex. It is *participatory*, relying on fishermen’s knowledge and direction for significant parts of the socioeconomic assessment; it utilizes a range of *quantitative and qualitative data*; and it is *spatially explicit* and designed to be compatible with a range of spatial ecosystem models, as well as with spatial siting algorithms.

Considering the three characteristics of the analysis in turn, the *participatory approach* grows out of the working group structure of the Jmpr process itself,⁴³ in which representatives from interest groups and stakeholders—including the fishing community—deliberate and recommend potential changes to sanctuary management plans alongside representatives from the conservation and scientific communities and the public at large. These working groups report formally to the Sanctuary Advisory Councils and have identified detailed strategies for revising the management plans. Since the recommendation for this socioeconomic assessment came out of two of these working groups, the fishermen-members of these working groups were actively involved in this project and served as expert witnesses, reviewers and co-investigators.

⁴³ For an overview of the working groups, see www.sanctuaries.nos.noaa.gov/jointplan/issue.html

Functionally, their involvement is facilitated through periodic project updates and working sessions during the regular meetings of the working groups. For example, after having compiled a list of possible logbook datasets to use in the analysis, we solicited suggestions from the Fishing Activities Working Group as to which fisheries to focus on, resulting in the elimination of several fisheries (see discussion under Data Sources). As described below, fishermen from both working groups served as expert witnesses for validating the CDFG data used in the analysis and for describing the fishing grounds off the North-central California coast. They also provided guidance on the level of port, species, and gear detail to consider in the analysis.⁴⁴

⁴⁴ Presentations made during these meetings may be found at the project website; please see “learn more” at www.ecotrust.org/jmpr.

The socioeconomic assessment utilizes both *quantitative and qualitative data*, using the latter both for triangulation and to flesh out the port profiles through a narrative analysis of fishery participation, regulatory history, and processing capacity. The main activities for collecting this qualitative information, in addition to working group meetings, were archival research, literature reviews, and fieldwork conducted during the spring and summer of 2004. The latter combines semi-structured interviews with portside observations. The field methodology is adapted from a local knowledge pilot project conducted jointly with Environmental Defense and the Pacific Coast Federation of Fishermen's Associations⁴⁵ and utilizes the OceanMap spatial software interface for collecting and standardizing respondents' information about regional fishing grounds, activity and use patterns, and the relative economic importance of ocean areas.

⁴⁶ Scholz, A., K. Bouzon, R. Fujita, N. Benjamin, N. Woodling, P. Black, and C. Steinback, "Participatory socioeconomic analysis: Drawing on fishermen's knowledge for marine protected area planning in California," *Marine Policy* vol. 28, no. 4, pp. 335–49.

⁴⁷ Notably NOAA National Centers for Coastal Ocean Science (NCCOS) (2003). A Biogeographic Assessment off North/Central California: To Support the Joint Management Plan Review for Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries: Phase I—Marine Fishes, Birds and Mammals. Prepared by NCCOS's Biogeography Team in cooperation with the National Marine Sanctuary Program. Silver Spring, MD, NOAA NCCOS.

⁴⁷ Pattison, D., D. d. Reis and H. Smillie (2004). An Inventory of GIS-based Decision-Support Tools for MPAs. Maryland, National Marine Protected Areas Center: p. 20.

⁴⁸ For example, see the discussion in Leslie, H., M. Ruckelshaus, I. R. Ball, S. Andelman and H. P. Possingham (2003). "Using Siting Algorithms in the Design of Marine Reserve Networks". *Ecological Applications* 13(1 Supplement): pp. S185–S198.

⁴⁹ Breman, J., Ed. (2002). *Marine geography: GIS for the oceans and seas*. Redlands, ESRI Press.

Kruse, G. H., N. Bez, A. Booth, M. W. Dorn, S. Hills, R. N. Lipcius, D. Pelletier, C. Roy, S. J. Smith and D. Witherell, Eds. (2001). *Spatial processes and management of marine populations*. Fairbanks, University of Alaska Sea Grant.

Wright, D. and A. Scholz, Eds. (2005). *Place Matters: Geospatial Tools for Marine Science, Conservation, and Management in the Pacific Northwest*. Corvallis, OR, Oregon State University Press.

Other qualitative data not pertaining to the fishing grounds are captured in a geo-referenced relational database that forms part of the geographic information system. It is thus possible to access qualitative observations, e.g. about the changes in a particular port following the closure of a marine business, in conjunction with statistics about the number and type of fishing vessels, landings, revenues, and so on. While quantitative data provide most of the raw material for the socioeconomic assessment, data quality issues and gaps associated with them elevate the utility of the qualitative data beyond mere context. It would be desirable to deepen and expand the qualitative analysis in future research.

Finally, in order to ensure the compatibility of socioeconomic information with existing ecosystem and oceanographic information prepared for the JMPR process,⁴⁶ the project design is deliberately *spatially explicit*. Our spatial analysis involves both standard, geospatial interpretations of already geo-referenced data, where available, and novel spatial analysis using a variety of interpretive and overlay techniques as well as secondary datasets in the case of non-spatial data or data with poor spatial resolution. For example, some of the logbooks contain point locations, allowing for very detailed spatial analysis, while other datasets are so poorly geo-referenced as to be counterintuitive, as discussed in the previous section. Our approach to spatial analysis also makes possible the integration of socioeconomic objectives into subsequent decision-support tools such as simulated annealing tools.⁴⁷ Although existing siting algorithms tend to focus on ecological and conservation objectives,⁴⁸ they could potentially be expanded to incorporate socioeconomic objective functions. This would effectively enable stakeholders and decision-makers to jointly consider and optimize ecological and socioeconomic goals associated with area-based marine management measures.

A) SPATIAL ANALYSIS OF FISHING GROUNDS

We spatially interpret all geo-referenced data sets at their recorded spatial resolution, using standard GIS techniques.⁴⁹ For squid logbooks, for example, this results in point specific fishing effort locations, associated with directional and fishing intensity information (e.g. wattage of lights used to attract squid). For other fisheries, this direct interpretation is fraught with data artifacts and challenges. For example, two commercially important fisheries in the study area — crab and salmon — are only described by landing receipts, necessitating the collection of additional data for

characterizing their fishing grounds. While these are spatially coded to a grid of blocks developed by CDFG, several problems arise from periodic re-categorization of these blocks over time and the reporting habits of the fish buyers who are responsible for filing out the landing receipts. For example, an analysis of crab landings suggests that the vast majority of Dungeness crabs in California are caught far offshore, in depths over 2,000 fathoms—deeper than where crabs are known to live and deeper than the trap-hauling capacity on a typical fishing vessel in the region.

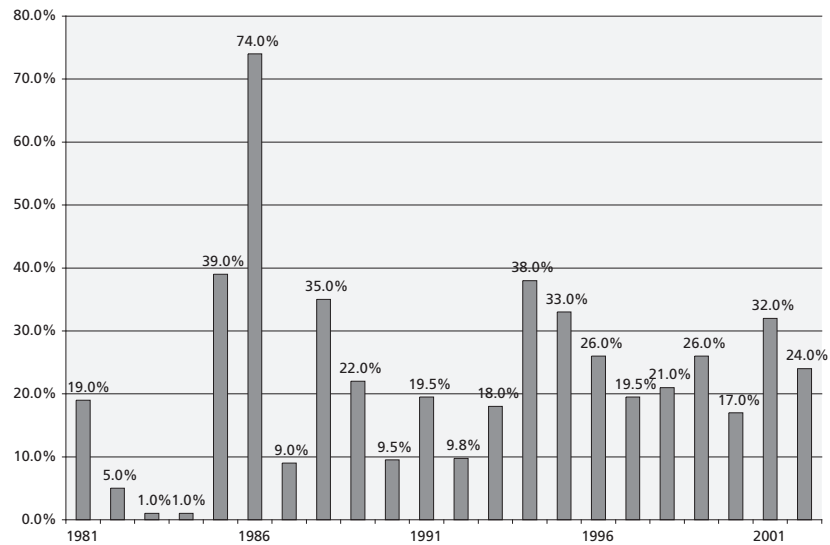
According to the fishermen on the Fishing Activities Working Group, this may be an artifact of local buyers putting in the same block number irrespective of what the fishermen tell them about their fishing locations. Furthermore, adding to the analytical challenges, these offshore blocks include the smaller (10-minute) inshore blocks and were apparently created in the 1980s to accommodate fisheries with larger ranges, notably trawlers.⁵⁰ Similar artifacts of the landing receipts exist in the squid and salmon fisheries, where again the vast majority of fishing effort is attributed, spatially, to areas where it is known not to occur.

For fisheries described by multiple fishery-dependent and independent data sets, we compile composite maps of the fishing grounds that serve as the basis for our valuation analysis. To do this, we first evaluate the spatial accuracy of block entries within landing receipts against logbook records, using two methods: 1) directly comparing each landing receipt to the corresponding logbook record, where available, and 2) comparing summarized results. Accuracy, in this case, refers to matching records in both logbooks and landing receipts, and so reflects only the internal consistency of the datasets rather than their geographic accuracy as to where fishing actually occurred.

Based on our analysis of the groundfish fishery, there are two common types of error and an average of less than 30% correlation between the two datasets: either the block entry is generalized in the landing receipts, or different blocks are entered in the landing receipts and in the corresponding logbook entry or entries. With regard to the former, the accuracy of block entries in landing receipts increases over time (Figure 52), and the percentage of block entries containing accurate block identification numbers approaches 40%.

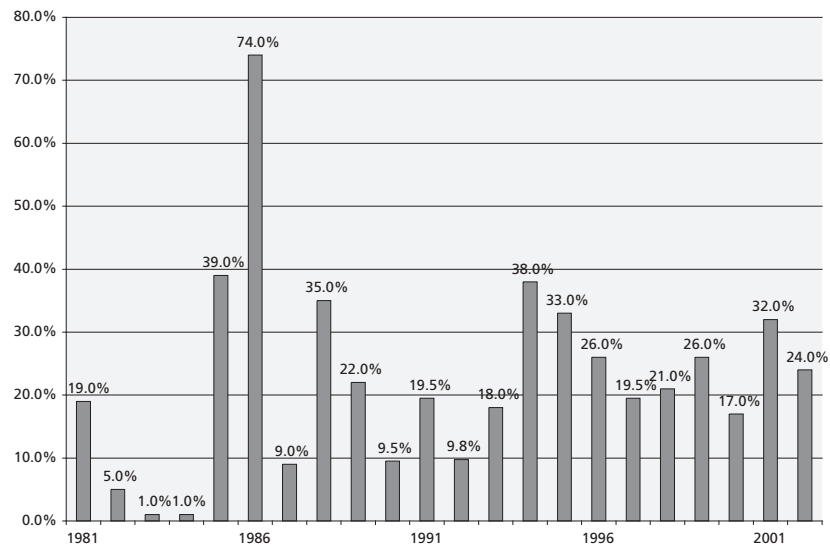
⁵⁰ Paul Reilly, pers. comm., 21 April 2004; Connie Ryan, pers. comm., 8 December 2004

Figure 52. Percentage of CDFG landing receipt records with correct block ID, 1981–2003



In terms of the spatial correspondence between landing blocks and logbook data, there are several kinds of mismatches. Since there can be several logbook entries for each landing receipt (in the groundfish trawl fishery, logbook entries are made for each tow, and several tows combine to a landing receipt), blocks can match exactly, partially, or not at all. Considering even partial matches as a match, the percentage of correspondence between landing receipts and logbook records is consistently below 40%, with the notable exception of 1986 (Figure 53). Fishermen on the fishing working groups suggested that this may be related to more accurate recording in advance of the limited entry regime implemented in the groundfish fishery.

Figure 53. Percentage correspondences between groundfish logbooks and landing receipts, 1981–2003



Due to a narrow spatial extent for fishery-independent data and the lack of coverage for particular gear types, we are not able to perform the necessary correlations to

adequately characterize the fishing grounds for these fisheries. We rely instead on fishery-dependant data—logbook reports—to map the groundfish trawl fisheries. Several fishery-independent data sources help circumscribe the fishing grounds. For example, as discussed above, groundfish observers in both the mobile- and fixed-gear sectors record dates and locations of fishing activities independently of the logbooks.⁵¹ Also, the NFMS trawl surveys, although conducted with trawl gear and thus not representative of non-trawl fisheries, record all species encountered.⁵² Another useful dataset consists of habitat classifications for California waters, such as those generated by the groundfish EFH project, which can be combined with species-habitat linkages from the literature to provide another characterization of the maximum extent of the fishing grounds.⁵³ We anticipate combining these and other fishery-independent data sources to construct composites of potential “forage areas” for each fishery, i.e. the fishing grounds as captured by the various datasets.

B) LOCAL KNOWLEDGE INTERVIEWS FOR CHARACTERIZING FISHING GROUNDS

For fisheries where there are few or no additional data sets, either fishery-dependent or fishery-independent, available to help characterize the fishing grounds, we use a technique for eliciting local expert knowledge to augment our understanding of the local fisheries. We apply this technique to the following six fisheries:

- albacore tuna
- California halibut
- Dungeness crab
- rockfish hook-and-line
- salmon
- squid

The fishermen’s knowledge of the fishing grounds is perhaps the single most important contribution to characterizing the fishing grounds for the purposes of the socioeconomic profile. Given the size of the study area, an approach such as the 1’ grid used for the socioeconomic analysis in the Channel Islands marine reserves process is not feasible.

Instead, we devise a data collection protocol that we utilize for incorporating data from our expert knowledge interviews. The result is a composite, weighted surface of the fishing grounds over which we then distribute the landings (pounds and revenues) recorded in the landing receipts associated with the ports adjacent to the grounds. Effectively, this entails redistributing the landings information currently associated with the artifacts of the landing receipts, notably the blocks that indicate fishing effort is taking place “off the deep end” of the continental shelf, into the fishing grounds as described by expert knowledge and fishery-independent data.

Some assumptions are made when redistributing the landings into the fishing grounds based on local knowledge. Since landings are derived from the ports that are adjacent to the sanctuary boundaries, based on the northern and southern landing ports indicated by the fishermen that participated, we acknowledge that the assumption that all these landings associated with the ports adjacent to the

⁵¹ Northwest Fisheries Science Center West Coast Groundfish Observer Program (2003). Initial Data Report and Summary Analyses. Seattle, NWFSC: pp. 26.

⁵² Pacific Coast Groundfish Essential Fish Habitat Project (2004). Consolidated GIS Data Volume 1: Physical and Biological Data. Seattle, WA, Terralogic GIS NOAA Fisheries Northwest Region Pacific States Marine Fisheries Commission

⁵³ Weinberg K.L., M.E. Wilkins, F.R. Shaw, and M. Zimmermann, “The 2001 Pacific West Coast bottom trawl survey of groundfish resources. Estimates of distribution, abundance, and length and age composition.” NOAA Technical Memorandum NMFS-AFSC-128. Alaska Fisheries Science Center, Seattle.

sanctuaries is probably not true. Although we do not know what percent of the landings in a port can be directly associated with an area at this time, we hope this will be corrected once there is complete coverage and increased sampling based on local knowledge for the entire state.

During the summer of 2004, Ecotrust staff met with the fishermen-members of the two sanctuary working groups to review spatial interpretations of the CDFG logbook and landing receipt data, and to collect information on the extent and location of the local fishing grounds. We tested and then implemented the following data collection protocol with the Fishing Activities Working Group at a meeting in San Francisco:

- Using electronic and paper nautical charts of the area, fishermen are asked to identify, by fishery, the maximum extent north, south, east and west they would forage or target a specie(s).
- They are then asked to identify, within this maximum forage area, which areas are of critical economic importance, over their cumulative fishing experience, and to rank these using a weighted percentage—an imaginary “bag of 100 pennies” that they distribute over the fishing grounds;
- Based on the areas the fisherman have identified, they are then asked about the northern and southern range of ports that they would land their catch, and specific ports within that range.

⁵⁴ Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed Method Approaches*. Thousand Oaks, Sage Publications.

The sampling strategy is thus purposive,⁵⁴ using the members of the Fishing Activities Working Group as expert witnesses, who—by virtue of serving as the designated fishing community representatives on the sanctuary working groups—are responsible for helping to construct accurate depictions of the fishing grounds. Given their shared understanding of the importance of accurate socioeconomic information, and their role in requesting this socioeconomic profile, there is comparatively little scope for strategic behavior. The fishermen also help identify others who are not on the working group but have in-depth knowledge of the key local fisheries.

We assume that the members of the Fishing Activities Working Group, by virtue of the public selection and nomination process that led to their appointment, are fairly representative of the local fishery. Between them and additional knowledgeable fishermen identified by them, we believe that the resulting fishing ground maps would not change significantly in extent or relative value if we expanded the sample. This, however, is impossible to determine definitively, short of conducting a census of the fleet. This method could be improved by stratifying the fishermen in each fishery by ranges of total annual average landings and selecting randomly from within each stratum to conduct the fishing ground exercise. This would rest on the assumption that the most successful fishermen are also the most knowledgeable.

Table 14 contains a summary profile of the fishermen who participated in the local knowledge segment of this project.

Table 14. Profile of fishermen respondents

| 1 | Number of fishermen interviewed (<i>n</i>) | 19 | | | | | | | | | | | | | | | | | | | | | |
|------------------------|--|--|----------------------|--------------------|---------------|--------------------|--------|-----|----------------|----|---------|------------------|-----|-----|------------------------|----|-----|---------|----|-----|-------|-----|-----|
| 2 | Average age | 57 years | | | | | | | | | | | | | | | | | | | | | |
| 3 | Average fishing experience | 32 years (<i>n</i> =18) | | | | | | | | | | | | | | | | | | | | | |
| 4 | Cumulative fishing experience | 570 years (<i>n</i> =18) | | | | | | | | | | | | | | | | | | | | | |
| 5 | Average number of days at sea (per year) | 132 days (<i>n</i> =15) | | | | | | | | | | | | | | | | | | | | | |
| 6 | Percentage of family income derived from fishing | <table border="1"> <thead> <tr> <th>Percentage of income</th> <th>No. of respondents</th> </tr> </thead> <tbody> <tr> <td><25%</td> <td>4</td> </tr> <tr> <td>25–50%</td> <td>4</td> </tr> <tr> <td>51–75%</td> <td>1</td> </tr> <tr> <td>76–100%</td> <td>10</td> </tr> </tbody> </table> | Percentage of income | No. of respondents | <25% | 4 | 25–50% | 4 | 51–75% | 1 | 76–100% | 10 | | | | | | | | | | | |
| Percentage of income | No. of respondents | | | | | | | | | | | | | | | | | | | | | | |
| <25% | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 25–50% | 4 | | | | | | | | | | | | | | | | | | | | | | |
| 51–75% | 1 | | | | | | | | | | | | | | | | | | | | | | |
| 76–100% | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Percentage of study-area landings and revenues of six fisheries made by respondents, 1981–2003 | <table border="1"> <thead> <tr> <th>Fishery</th> <th>Landings</th> <th>Revenues</th> </tr> </thead> <tbody> <tr> <td>California halibut</td> <td>3%</td> <td>3%</td> </tr> <tr> <td>Dungeness crab</td> <td>8%</td> <td>8%</td> </tr> <tr> <td>Groundfish trawl</td> <td>5%</td> <td>5%</td> </tr> <tr> <td>Rockfish hook-and-line</td> <td>4%</td> <td>5%</td> </tr> <tr> <td>Salmon</td> <td>2%</td> <td>2%</td> </tr> <tr> <td>Squid</td> <td>66%</td> <td>61%</td> </tr> </tbody> </table> | Fishery | Landings | Revenues | California halibut | 3% | 3% | Dungeness crab | 8% | 8% | Groundfish trawl | 5% | 5% | Rockfish hook-and-line | 4% | 5% | Salmon | 2% | 2% | Squid | 66% | 61% |
| Fishery | Landings | Revenues | | | | | | | | | | | | | | | | | | | | | |
| California halibut | 3% | 3% | | | | | | | | | | | | | | | | | | | | | |
| Dungeness crab | 8% | 8% | | | | | | | | | | | | | | | | | | | | | |
| Groundfish trawl | 5% | 5% | | | | | | | | | | | | | | | | | | | | | |
| Rockfish hook-and-line | 4% | 5% | | | | | | | | | | | | | | | | | | | | | |
| Salmon | 2% | 2% | | | | | | | | | | | | | | | | | | | | | |
| Squid | 66% | 61% | | | | | | | | | | | | | | | | | | | | | |
| 8 | Average and maximum percentages of Dungeness crab revenues made by respondents in study-area ports, 1981–2003 | <table border="1"> <thead> <tr> <th>Port group</th> <th>Avg. revenues</th> <th>Max. revenues</th> </tr> </thead> <tbody> <tr> <td>Bodega Bay Area</td> <td>21%</td> <td>66%</td> </tr> <tr> <td>Bodega Bay</td> <td>5%</td> <td>13%</td> </tr> <tr> <td>Half Moon Bay</td> <td>16%</td> <td>38%</td> </tr> <tr> <td>San Francisco</td> <td>5%</td> <td>11%</td> </tr> <tr> <td>SF Area</td> <td>5%</td> <td>38%</td> </tr> </tbody> </table> | Port group | Avg. revenues | Max. revenues | Bodega Bay Area | 21% | 66% | Bodega Bay | 5% | 13% | Half Moon Bay | 16% | 38% | San Francisco | 5% | 11% | SF Area | 5% | 38% | | | |
| Port group | Avg. revenues | Max. revenues | | | | | | | | | | | | | | | | | | | | | |
| Bodega Bay Area | 21% | 66% | | | | | | | | | | | | | | | | | | | | | |
| Bodega Bay | 5% | 13% | | | | | | | | | | | | | | | | | | | | | |
| Half Moon Bay | 16% | 38% | | | | | | | | | | | | | | | | | | | | | |
| San Francisco | 5% | 11% | | | | | | | | | | | | | | | | | | | | | |
| SF Area | 5% | 38% | | | | | | | | | | | | | | | | | | | | | |
| 9 | Average and maximum percentages of halibut revenues made by respondents in study-area ports, 1981–2003 | <table border="1"> <thead> <tr> <th>Port group</th> <th>Avg. revenues</th> <th>Max. revenues</th> </tr> </thead> <tbody> <tr> <td>Bodega Bay Area</td> <td>22%</td> <td>71%</td> </tr> <tr> <td>Bodega Bay</td> <td>0%</td> <td>6%</td> </tr> <tr> <td>Half Moon Bay</td> <td>9%</td> <td>35%</td> </tr> <tr> <td>San Francisco</td> <td>0%</td> <td>0%</td> </tr> <tr> <td>SF Area</td> <td>1%</td> <td>6%</td> </tr> </tbody> </table> | Port group | Avg. revenues | Max. revenues | Bodega Bay Area | 22% | 71% | Bodega Bay | 0% | 6% | Half Moon Bay | 9% | 35% | San Francisco | 0% | 0% | SF Area | 1% | 6% | | | |
| Port group | Avg. revenues | Max. revenues | | | | | | | | | | | | | | | | | | | | | |
| Bodega Bay Area | 22% | 71% | | | | | | | | | | | | | | | | | | | | | |
| Bodega Bay | 0% | 6% | | | | | | | | | | | | | | | | | | | | | |
| Half Moon Bay | 9% | 35% | | | | | | | | | | | | | | | | | | | | | |
| San Francisco | 0% | 0% | | | | | | | | | | | | | | | | | | | | | |
| SF Area | 1% | 6% | | | | | | | | | | | | | | | | | | | | | |

| | | | | |
|----|--|-------------------|----------------------|----------------------|
| 10 | Average and maximum percentages of groundfish trawl revenues made by respondents in study-area ports, 1981–2003 | Port group | Avg. revenues | Max. revenues |
| | | Bodega Bay Area | 3% | 83% |
| | | Bodega Bay | 0% | 3% |
| | | Half Moon Bay | 25% | 41% |
| | | San Francisco | 0% | 0% |
| | | SF Area | 8% | 100% |
| 11 | Average and maximum percentages of rockfish hook-and-line revenues made by respondents in study-area ports, 1981–2003 | Port group | Avg. revenues | Max. revenues |
| | | Bodega Bay Area | 37% | 99% |
| | | Bodega Bay | 9% | 25% |
| | | Half Moon Bay | 1% | 16% |
| | | San Francisco | 2% | 10% |
| | | SF Area | 4% | 54% |
| 12 | Average and maximum percentages of salmon revenues made by respondents in study-area ports, 1981–2003 | Port group | Avg. revenues | Max. revenues |
| | | Bodega Bay Area | 1% | 6% |
| | | Bodega Bay | 3% | 5% |
| | | Half Moon Bay | 2% | 6% |
| | | San Francisco | 2% | 3% |
| | | SF Area | 0% | 2% |
| 13 | Average and maximum percentages of squid revenues made by respondents in study-area ports, 1981–2003 | Port group | Avg. revenues | Max. revenues |
| | | Bodega Bay Area | 0% | 0% |
| | | Bodega Bay | 9% | 100% |
| | | Half Moon Bay | 63% | 100% |
| | | San Francisco | 17% | 100% |
| | | SF Area | 0% | 0% |

While there are no hard and fast measures of the amount of fishing expertise or length of participation in the fishery that constitutes a local knowledge expert, the fishermen who participated in this study have an impressive depth of knowledge and have demonstrated success in the local fisheries. The first five rows of Table 8 are self-explanatory. The sixth row contains a classification of the respondents by the percentage that fishing constitutes of their families' incomes. As is readily apparent, a majority of the respondents are full-time fishermen who derive more than 75% of their families' income from fishing.

The remainder of the table details their relative fishing success, as a proxy for assessing what proportion of the local fleet and each fishery our sample represented. Row seven shows the average percentage of study-area landings and revenues for each fishery accounted for by the respondents. These figures are obtained by summarizing the landings each fisherman made for these various species in the five study-area ports during the period 1981–2003. For example, respondents accounted for 8% of total Dungeness crab landings and revenues in study-area ports and more than 60% of squid landings and revenues.

When considered on their own, these proportions are not very informative. A more detailed picture emerges when considering the relative contribution of the fishermen to the fishery *in each port* of the study area. This is captured in rows 8–13. For example, the fishermen we interviewed accounted for, on average over the time period from 1981 to 2004, 21% of Dungeness crab landings by revenue in Bodega Bay, and 5% in San Francisco. Since the averages mask the peaks and troughs in the time series, it is useful to consider the *maximum* percentage achieved by the respondents. In the Dungeness crab, there was a year when our fishermen sample accounted for 66% of all Dungeness crab landed (by revenue) in Bodega Bay, and 38% in San Francisco. Again, there are no precedents for what degree of fishing success, by proportion of local or regional landings and revenues, constitutes expertise. Given, however, that the sample accounts for a substantial or even a majority of landings and/or revenues in some of the fisheries that are most lacking in spatially specific, fishery-independent data, we are cautiously optimistic that the fishing ground maps resulting from this local knowledge exercise are indeed representative.

It is important to note that the sample is centered on the area from Bodega Bay to Half Moon Bay, and the resulting fishing ground depictions are most reliable for that area. We verified this in a meeting with the sanctuaries' working groups, whose fishermen-members pointed out that relatively more important fishing grounds are located off Monterey and Moss Landing, which are the tails of the geographic distribution identified by the fishermen. It stands to reason, therefore, that the fishing grounds depicted in our analysis represent one of several overlapping distributions spanning the coast of California. An expansion of this approach to other parts of the coast, replicating the protocol used in this study, would result in a comprehensive coverage of the fishing grounds.

Map 2. Comprehensive Coverage of Fisheries

(A color version of this map appears in Appendix E.)



We analyze the information provided by the fishermen to evaluate the distribution of catch per fishery based on spatially specific information collected through local knowledge interviews. This information is used to extrapolate landings data from CDFG landing receipts and attribute a proportion of the total catch to any given location within the fishing grounds, using the following steps:

1. Determining the Fishing Grounds

Through a set of local knowledge interviews conducted along the North-central California coast, fishermen are asked to identify their fishing grounds for a specific fishery. In order to determine the fishing grounds G for any given fishery, the fishing grounds identified by the fishermen (i.e. the area of all the shapes, j) is summarized. Each fisherman f interviewed, identifies his/her fishing grounds G_f , per fishery as one or more shapes $G_f = \sum j$, where $j = 1, \dots, n$. The number of shapes differs for each respondent and by fishery. If there is only one shape, then $G_f = j$.

Each shape j in fisherman's f 's fishing grounds is then converted to a grid with a 100m-cell size. For example, in the Dungeness crab fishery, each shape identified by a fisherman now equals some multiple of 100m cells, so the total number of cells in one shape, $C_j = n$, where $n = 1, \dots, C$. The crab fishing grounds for each fisherman G_f , is now represented by the total number of cells for all of his/her shapes:

$$G_f = \sum_{n=1}^j C_j$$

But, in order to normalize each shape by the total area, the entire crab fishing grounds G_{crab} , need to be determined. This will be used in a later step that effectively weights the response according to the relative size of the respondent's fishing footprint to the composite fishing grounds. The composite fishing grounds G_{crab} , is based on all the shapes provided by all fishermen, and it is necessary to account for the possible overlap of shapes identified by multiple fishermen. This is done by expressing whether a cell exists for j in any given location (cell) through the following equation:

$$G = \sum b$$

Where b = result of the Boolean expression:
does j exist for any i for location x, y . 1 = true, 0 = false.

If we were to just sum the number of cells of every j , identified by every f , the resulting sum would not be for a unique x, y location and count multiple occurrences in the same location. In other words, the fishing grounds of any one fisherman G_f , are smaller or equal to the total grounds for that fishery.

2. Determining the Relative Economic Importance (REI)

Each respondent allocates a budget, Ω , of 100 "pennies," representing his or her total effort for that fishery by allocating some portion of pennies, P_j to each shape, j , on their fishing grounds, G_f , such that $\sum P_j = 100$. Each shape j is now associated with a distinct number of cells, C_j , and a weight, P_j .

The value of each cell in the shape is then the number of pennies allocated to the shape divided by the number of cells in the shape. So as not to overstate the relative importance of cells associated with shapes identified by fishermen who reported smaller fishing grounds (thus concentrating value in a sub-section of the composite grounds, G), we multiply the value of each cell (P_j/C_j), by the number of cells for that fisherman's grounds, G_f , divided by the total number of cells in the composite fishing grounds for the entire shape (G_f/G). This weights the response according to the relative size of the respondent's fishing footprint, C_j , to the composite fishing grounds, G , or normalizes by the total area.

Each cell for every given shape is now represented by the relative economic importance value normalized by the total area, or V .

$$V_j = (P_j/C_j) * (G_f/G)$$

Where:

P = the economic importance value

C = the number of cells

j = the shape

G = the total number of cells in the entire fishery

G_f = the total number of cells in the fishing grounds of one fisherman

Consider this example:

For this example there are only two respondents. Collectively they have drawn five shapes: respondent A has identified three shapes and respondent B has identified two shapes. They have each allocated their budget of pennies accordingly.

Respondent A identifies three shapes, which cover 50, 100 and 10 cells, respectively. She then weighs them 20, 75, and 5 pennies each, for a total penny budget of 100.

| Shape j | No. of cells C_j | No. of pennies P_j | Value per cell (P_j/C_j) |
|-----------------------------|-----------------------|-------------------------|-------------------------------|
| $j_{A,1}$ | 50 | 20 | $20/50 = 0.4$ |
| $j_{A,2}$ | 100 | 75 | $75/100 = 0.75$ |
| $j_{A,3}$ | 10 | 5 | $5/10 = 0.5$ |
| A's total grounds $G_{f,A}$ | 160 cells | 100 pennies | |

Respondent B identifies two shapes, which cover 20, and 100, respectively. He then weighs them 80 and 20 pennies each, for a total penny budget of 100.

| Shape j | No. of cells C_j | No. of pennies P_j | Value per cell (P_j/C_j) |
|-----------------------------|-----------------------|-------------------------|-------------------------------|
| $j_{B,1}$ | 20 | 80 | $80/20 = 4$ |
| $j_{B,2}$ | 100 | 20 | $20/100 = 0.2$ |
| B's total grounds $G_{f,B}$ | 120 cells | 100 pennies | |

All of respondent B's first shape ($j_{B,1}$), overlaps with a portion of respondent A's second shape ($j_{A,2}$). The total number of cells in the composite fishing grounds, G , thus equals 260. In order to account for the relative size of each respondent's fishing footprint, $C_{(j)}$, to the composite fishing grounds, G , the value per cell (P_j/C_j) is multiplied by the number of cells for that shape, divided by the total number of cells in the composite fishing grounds (C_j/G).

Respondent A

| Shape j | Value per cell (P_j/C_j) | Relative Economic Importance Value $V_j = (P_j/C_j) * (G_{f,A}/G)$ |
|-----------|---------------------------------|---|
| $j_{A,1}$ | 20/50 = 0.4 | 0.4 * 0.6 = 0.24 |
| $j_{A,2}$ | 75/100 = 0.75 | 0.75 * 0.6 = 0.45 |
| $j_{A,3}$ | 5/10 = 0.5 | 0.5 * 0.6 = 0.3 |

Respondent B

| Shape j | Value per cell (P_j/C_j) | Relative Economic Importance Value $V_j = (P_j/C_j) * (G_{f,B}/G)$ |
|-----------|---------------------------------|---|
| $j_{B,1}$ | 80/20 = 4 | 4 * 0.46 = 1.84 |
| $j_{B,2}$ | 20/100 = 0.2 | 0.2 * 0.46 = 0.092 |

For each cell shared between the two shapes, such that $C_{sA,2} = C_{sB,1}$, the relative economic importance value of the cell is the sum of the values assigned by each fisherman whose shapes (i.e. fishing grounds) overlap in that cell.

$$O_{x,y} = \sum_{n=1}^i V_{x,y}$$

Where O = the sum of all V s for any given location (cell).

So for the 20 cells in respondent B's shape ($j_{B,1}$), with a REI value of 1.84, which overlap with 20 of the 100 cells in respondent A's shape ($j_{A,2}$), with a REI value of 0.45, the aggregate value equals 2.29.

The aggregate value, O , is the share of the total fishing effort budget, $B = i * 100$, where $i = 2$ for this example, that is apportioned to $O_{x,y}$. In the case of our example, 2.29 pennies out of a total of 200 would get assigned to each of the 20 cells where there is overlap. The remaining area that comprises the rest of the fishing grounds is assigned the REI values that are calculated for each cell for each shape, $O_{x,y} = V_{x,y}$.

3. Apportioning the Values from the CDFG Landing Receipts

The final step to this process is to apportion the values, total pounds or revenue from the CDFG landing receipts to the fishing grounds defined by our respondents. An apportioning cell value, R , is determined for each location based on dividing the sum of all V s for any given location, O , by the sum of all O s.

$$R_{x,y} = O_{x,y} / \sum O$$

| Shape j | No. of Cells C_j | $O_{x,y}$ | $O_{x,y} * C_j$ | $R_{x,y}$ |
|---------------------------------|--------------------|-----------|-----------------|-----------|
| $j_{A,1}$ | 50 | 0.240 | 12.0 | 0.00226 |
| $j_{A,2}$ | 80 | 0.450 | 36.0 | 0.00424 |
| $j_{A,3}$ | 10 | 0.300 | 3.0 | 0.00283 |
| $j_{B,2}$ | 100 | 0.092 | 9.2 | 0.00087 |
| $j_{A,2}$ & $j_{B,1}$ (overlap) | 20 | 2.290 | 45.8 | 0.02160 |

Because the values for each fishery are attributed to the landing ports in the landing receipts, we derive landings values for those ports indicated by sample respondents and distribute those values into the fishing grounds. Since the study area of this analysis is focused on GFNMS and CBNMS, the ports that are of interest are those that are adjacent to the sanctuary waters. Those ports are classified, into 5 classes/groups, Bodega Bay Area, Bodega Bay, San Francisco, San Francisco Area, and Half Moon Bay (Princeton) (see Appendix C for a list of ports grouped into these classes). For each fishery, the total pounds and revenue are summarized for ports within the study area. This summarized value is then apportioned to the fishing grounds on a per cell basis or x,y location based on the following equation:

$$R_{x,y} * \text{landings} = a_{x,y}$$

Where:

a = the value (in pounds or dollars) of landings from that fishery apportioned to a particular cell

R = the proportional value by which to multiply total catch

Validating this analysis over and beyond the buy-in of the fishermen, stakeholders and decision-makers who are poised to use the resulting fishing ground maps in their deliberations is complicated by the characteristics of the available data. One reviewer suggested comparing our frequency distribution of economic hotspots with the relative distribution of CDFG landing blocks in the same area. That would work only if the majority of the catch of a species is reported in the smaller, 10-minute blocks. Unfortunately that is precisely not the case. For example, over 80% of the Dungeness crab landed in San Francisco is reported at the four-digit block level (No. 1038 in this case), and there is no way of ascertaining how representative the residual landings are that are reported in the smaller blocks.

C) PORT CHARACTERIZATION

In order to characterize the ports and port groups in the study area, we augment information about landings and revenues available from the CDFG data sets with census data, qualitative descriptions of fishing infrastructure, changes in the industry, and regulatory developments over time. The latter rests on literature reviews, archival research, and new fieldwork, which is typically conducted in conjunction with fieldwork designed to groundtruth and validate the spatial analysis. Given resource and time constraints, a thorough analysis of the kind available for Moss Landing⁵⁶ was beyond the scope of this project but remains a desirable product for the study area. Similarly, the JMPR process and future updates to this socioeconomic profile will benefit from the comprehensive effort underway at NOAA Fisheries, the “Joint

⁵⁶ Pomeroy, C. and M. Dalton (2003). Socioeconomics of the Moss Landing Commercial Fishing Industry: Report to the Monterey County Office of Economic Development. Monterey, Monterey County Office of Economic Development: p. 134.

⁵⁷ Karma Norman, pers. comm., 6 January 2005.

Project for Fishing Community Profiles in the Western States,” results from which are expected to be forthcoming in spring 2005.⁵⁷

Building on an existing Ecotrust database resulting from a prior project on the groundfish fleet, we compile information on fishery participation, port infrastructure, history of processor capacity and fishing regulations in a spatially referenced (by port and/or ocean area) relational database. This database includes observations from port visits, interviews with port managers, information provided by the fishermen-members of the working groups, and relevant literature. We conducted field work in the summer of 2004 to obtain current counts of processing capacity and related marine business infrastructure, and conducted follow-up phone calls with harbor and port personnel during the early spring of 2005.

Appendix B—List of ports considered in the analysis

Ports are all those towns and places that appear in the CDFG landing statistics as having landing receipts recorded to them. Some inland towns and cities appear as ports because they show up in landing receipts in cases where fisherman have so-called transfer tickets to take fish home and/or sell directly to the public (e.g. farmers' markets). Landings associated with these "ports" are typically very small and are based on the groupings provided by CDFG. In addition to actual ports on the coast, these include several inland towns and cities where fishermen and brokers who use transfer licenses live. (We grouped all small ports in the two coastal counties of Sonoma and Marin in the Great Bodega Bay Area, and all the small ports in counties ringing the San Francisco Bay [e.g. Napa, Solano, Contra Costa, Alameda, and San Mateo] in the Greater San Francisco Area.)

| | | |
|-------------------------------------|-----------------------------------|---------------------|
| Bodega Bay | Greater San Francisco Area | Pinole |
| San Francisco | Alameda | Pittsburg |
| Half Moon Bay (Princeton) | Alamo | Pleasanton |
| Greater Bodega Bay Area | Albany | Point Montara |
| Bolinas | Alviso | Point San Pedro |
| Corte Madera | Antioch | Redwood City |
| Dillon Beach | Benicia | Richmond |
| Drakes Bay | Berkeley | Rio Vista |
| Forrest Knolls | Brentwood | Rockaway Beach |
| Greenbrae | Burlingame | Rodeo |
| Hamlet | Campbell | San Bruno |
| Healdsburg | China Camp | San Jose |
| Inverness | Concord | San Leandro |
| Jenner | Crockett | San Mateo |
| Kentfield | Daly City | Sausalito |
| Marconi | Danville | South San Francisco |
| Marshall | El Sobrante | Suisun City |
| Mill Valley | Emeryville | Sunnyville |
| Muir Beach | Fairfield | Vacaville |
| Nicasio | Farallone Island | Vallejo |
| Novato | Foster City | Yountville |
| Occidental | Fremont | |
| Petaluma | Glen Cove | |
| Point Reyes | Hayward | |
| San Quentin | Lafayette | |
| San Rafael | Livermore | |
| Santa Rosa | Los Altos | |
| Sebastopol | Martinez | |
| Sonoma | Martins Beach | |
| Stewarts | McNears Point | |
| Stinson Beach | Moss Beach | |
| Tiburon | Mountain View | |
| Timber Cove | Napa | |
| Tomaes Bay | Newark | |
| Windsor | Oakland | |
| | Oakley | |
| | Pacifica | |
| | Palo Alto | |
| | Pescadero | |
| | Pigeon Point | |

Appendix C—List of species considered in analysis, and their groupings

ABALONE:

Abalone
Black Abalone
Flat Abalone
Green Abalone
Pink Abalone
Pinto Abalone
Red Abalone
Threaded Abalone
White Abalone

CALIFORNIA HALIBUT

COASTAL PELAGIC SPECIES (CPS):

Deepbody Anchovy
Northern Anchovy
Slough Anchovy
Bullet Mackerel
Jack Mackerel
Pacific Mackerel
Unspecified Mackerel
Juvenile Sardine
Pacific Sardine
Pacific Saury

CRAB:

Box Crab
Brown Rock Crab
Crab Claws
Dungeness Crab
King Crab
Pelagic Red Crab
Red Rock Crab
Rock Crab Unspecified
Sand Crab
Shore Crab
Spider Crab
Tanner Crab
Yellow Rock Crab

GROUNDFISH:

(Nearshore rockfish are managed by the state and listed separately.)

Flounder (flatfish):

Arrowtooth Flounder
Starry Flounder
Unspecified Flounder

Lingcod (roundfish)

Other Rockfish:

Group Deepwater Reds Rockfish
Group Red Rockfish

Group Small Rockfish
Unspecified Rockfish

Pacific Hake – Whiting (roundfish)

Sablefish (roundfish)

Sanddab (flatfish):

Longfin Sanddab
Pacific Sanddab
Sanddab
Speckled Sanddab

Shelf Rockfish:

Bocaccio Rockfish
Bronzespotted Rockfish
Canary Rockfish
Chameleon Rockfish
Chilipepper Rockfish
Cowcod Rockfish
Flag Rockfish
Greenblotched Rockfish
Greenspotted Rockfish
Greenstriped Rockfish
Honeycomb Rockfish
Mexican Rockfish
Pink Rockfish
Pinkrose Rockfish
Rosethorn Rockfish
Rosy Rockfish
Speckled Rockfish
Squarespot Rockfish
Starry Rockfish
Stripetail Rockfish
Swordspine Rockfish
Vermilion Rockfish
Yelloweye Rockfish
Yellowtail Rockfish
Group Bocaccio-Chilipepper
Group Canary – Vermilion
Group Rosefish Rockfish
Group Shelf Rockfish

Slope Rockfish:

Aurora Rockfish
Bank Rockfish
Blackgill Rockfish
Darkblotched Rockfish
Pacific Ocean Perch
Redbanded Rockfish
Splitnose Rockfish
Widow Rockfish
Group Slope Rockfish

Sole (flatfish):

Bigmouth Sole
 Butter Sole
 C-O Sole
 Dover Sole
 English Sole
 Fantail Sole
 Petrale Sole
 Rex Sole
 Rock Sole
 Sand Sole
 Slender Sole
 Tongue Sole
 Unspecified Sole

Thornyhead (roundfish):

Longspine Thornyhead
 Shortspine Thornyhead
 Thornyheads

HERRING:

Herring
 Herring Roe on Kelp
 Pacific Herring
 Round Herring

LOBSTER:

California Spiny Lobster

NEARSHORE FISHERY MANAGEMENT

PLAN SPECIES:

Black Rockfish
 Black-and-yellow Rockfish
 Blue Rockfish
 Brown Rockfish
 Cabezon
 Calico Rockfish
 California Scorpionfish
 California Sheephead
 China Rockfish
 Copper Rockfish
 Gopher Rockfish
 Grass Rockfish
 Kelp Greenling
 Kelp Rockfish
 Monkeyface Prickleback
 Olive Rockfish
 Quillback Rockfish
 Rock Greenling
 Treefish

PRAWN:

Golden Prawn
 Ridgeback Prawn
 Spot Prawn

SALMON:

Chinook Salmon
 Open Water Salmon
 Rainbow Trout Salmon

SHARK:

Basking Shark
 Bigeye Thresher Shark
 Blacktip Shark
 Blue Shark
 Brown Smoothhound Shark
 Cow Shark
 Dusky Shark
 Gray Smoothhound Shark
 Horn Shark
 Leopard Shark
 Pacific Shark
 Pacific Angel Shark
 Pelagic Thresher Shark
 Salmon Shark
 Sevengill Shark
 Shortfin Mako Shark
 Sixgill Shark
 Smooth Hammerhead Shark
 Soupfin Shark
 Spiny Dogfish
 Swell Shark
 Thresher Shark
 Unspecified Shark
 White Shark

SHRIMP:

Brine Shrimp
 Coonstriped Shrimp
 Ghost Shrimp
 Mantis Shrimp
 Pacific Ocean Shrimp
 Red Rock Shrimp
 Unspecified Shrimp

SQUID:

Jumbo Squid
 Market Squid

SWORDFISH

TUNA:

Albacore Tuna
 Bigeye Tuna
 Blackfin Tuna
 Bluefin Tuna
 Longfin Tuna
 Skipjack Black Tuna
 Skipjack Tuna
 Unspecified Tuna
 Yellowfin Tuna

URCHIN:

Purple Sea Urchin
 Red Urchin
 White Urchin

Appendix D— Gear types considered in the analysis

Bottom Trawl:

Balloon Trawl
Beam Trawl
Bottom Trawl
Danish—Scottish Seine
Double—Rigged Trawl
Pair Trawl
Paranzella
Single—Rigged Trawl
Trawl Net
Trawl with Roller Gear
Trawl with Footrope >8" in Diameter
Trawl with Footrope <8" in Diameter

Diving:

Diving
Diving—Abalone Iron
Diving—Hooks (Sea Urchins)

Hook-and-line:

Hook-and-line
Horizontal Set Line
Jig—Bait
Jig—Bait (Albacore)
Live Bait
Mooching (Salmon)
Set Longline
Vertical Hook-and-line – Portuguese
Longline
Vertical Set Line

Midwater Trawl:

Midwater Trawl

Miscellaneous Gear:

Cast Net
Dredge
Fish Pump
Hand Pump
Hand Take
Harpoon – Spear
Hoop Net – Crab-Rings
Kelp Barge – Shearing
Pelagic Trawl
Raft – Lines for Herring Roe on Kelp
Rakes – Forks
Spear

Net:

Dip Net
Drift Gill Net
Entangling Nets
Lift Net
Net
Set Gill Net
Trammel Net

Seine:

Beach Seine
Brail—Dip Net or A-Frame
Drum Seine
Encircling Nets
Half Ring
Lampara Net
Purse Seine

Trap:

Crab or Lobster Trap
Entrapping
Fish Trap
Fyke Net
Prawn Trap
Shrimp Net—Chinese Type
Traps—Seattle Type (Sablefish)

Troll:

Troll (Albacore)
Troll (Ground or Other Fish)
Troll (Salmon)
Troll Longline