

NMFS Southwest Fisheries Science Center

**Agency Report to the Technical Subcommittee
of the Canada-U.S. Groundfish Committee**

May, 2006

**Edited by John Field
with contributions from Anne Allen and Janet Mason**

A. AGENCY OVERVIEW

The Southwest Fisheries Science Center (SWFSC) conducts fisheries and marine mammal research at three laboratories in California. Activities are primarily in support of the Pacific Fishery Management Council, the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), as well as a number of international fisheries commissions and conventions. The deputy director of the SWFSC is Dr. Norman Bartoo, and the Science Director is Dr. William Fox. A considerable amount of expertise on groundfish research, assessment, and management resides within all three SWFSC laboratories, and all have supported the essential needs of the NMFS and the PFMC for groundfish (and other west coast federally managed species) for over 25 years. Laboratory scientists from the Fisheries Ecology Division (FED) in Santa Cruz have been members of the PFMC's Groundfish Management Team (GMT) every year since its inception in 1977, and scientists from all three labs are regular and active members of the PFMC's Scientific and Statistical Committee (SSC) and other management teams and advisory bodies.

The Center is headquartered in La Jolla, which hosts three divisions that conduct research on a wide range of Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats; the Antarctic Ecosystem Research Division (led by Dr. Rennie Holt), the Protected Resources Division (led by Dr. Stephen Reilly), and the Fisheries Resources Division (led by Dr. Roger Hewitt). The Fisheries Resources Division (FRD) conducts research on groundfish, large pelagic fishes (tunas, billfish and sharks), and small coastal pelagic fishes (anchovy, sardine and mackerel), and is the primary source of groundfish-related research in the La Jolla Laboratory. The La Jolla laboratory is also the primary source of federal support for the California Cooperative Oceanic Fisheries Investigations surveys that have taken place along most of the California coast since 1951, conducting integrated research on the physical, chemical and biological makeup of the California Current. Researchers at the La Jolla lab have primary responsibility for ichthyoplankton collections, studies of species abundance and distribution (including responses to climate variability), systematics, and the application of early life history information to stock assessments.

The Fisheries Ecology Division (FED), located in Santa Cruz and directed by Dr. Churchill Grimes, comprises two research branches. The Fisheries Branch (led by Dr. Peter Adams) conducts research (and stock assessments) in salmon population analysis, economics, groundfish, and fishery oceanography. The Ecology branch (led by Dr. Susan Sogard) conducts research on the early life history of fishes; salmon ocean and estuarine ecology; habitat ecology; and molecular ecology of fishes. Specific objectives of FED groundfish programs include: (1) collecting and developing information useful in assessing and managing groundfish stocks; (2) conducting stock assessments, and improving upon stock assessment methods, to provide a basis for harvest management decisions for the PFMC; (3) characterizing and mapping biotic and abiotic components of groundfish habitats, including structure-forming invertebrates; (4) disseminating information, research findings and associated advice to the fishery management and scientific communities; and (4) provide professional services (many of which fall in the above categories) at all levels, including inter-agency, state, national and international working groups. FED research is conducted in collaboration with researchers from several universities (i.e., Center for Stock Assessment Research (CSTAR), a partnership with the University of

California Santa Cruz; University of California Santa Barbara; Moss Landing Marine Labs, and others), and in cooperation with California Department of Fish and Game, USGS, and the National Marine Protected Area Center Science Institute (housed at Santa Cruz lab). Research programs are augmented with funds from NMFS' Offices of Protected Resources and Habitat Conservation, NOAA's NURP, Sea Grant, NOS Sanctuary Program, and Ocean Exploration.

The Pacific Environmental Research Division (ERD), directed by Dr. Franklin Schwing, is located at the Pacific Fisheries Environmental Laboratory (PFEL) in Pacific Grove. The ERD is a primary source of environmental information to fisheries researchers and managers along the west coast, and provides science-based analyses, products, and information on environmental variability to meet the agency's research and management needs. The objectives of ERD are to: (1) provide appropriate science-based environmental analyses, products, and knowledge to the SWFSC and its fishery scientists and managers; (2) enhance the stewardship of marine populations in the California Current ecosystem, and other relevant marine ecosystems, by understanding and describing environmental variability, the processes driving this variability, and its effects on the production of living marine resources, ecosystem structure, and ecosystem function; and (3) provide science-based environmental data and products for fisheries research and management, to a diverse customer base of researchers, decision-makers, and the public. ERD also contributes oceanographic expertise to the groundfish programs within the SWFSC, including planning surveys and sampling strategies, conducting analyses of oceanographic data, and cooperating in the development and testing of environmental and biological indices that can be useful in preparing stock assessments.

B. MULTISPECIES STUDIES

Research

Ichthyoplankton Surveys

The FRD, in collaboration with state and academic partners, supports and maintains the CalCOFI ichthyoplankton time series. The longest such time series in existence, this dataset extends from 1951 to the present and has been used to study distribution and abundance changes of many fish species in relation to climate and ecosystem change in the California Current region. CalCOFI data have been used in recent assessments of bocaccio rockfish, and are currently being used in a model of shortbelly rockfish. Since 2002, CalCOFI stations off central California, last routinely sampled in 1984, have been re-occupied during the winter and spring cruises in order to provide improved geographic coverage during the principal reproductive season for Pacific sardine and many of the groundfish species such as rockfishes, greenlings, cabezon, and various flatfishes whose spawning distributions extend well north of Point Conception or are centered north of Point Conception. Other recent ichthyoplankton surveys include the Southern California Nearshore Ichthyoplankton survey (2004-2005), the Cowcod Conservation Area high resolution ichthyoplankton and oceanographic surveys (2002-2005) and the Marine Ecological Reserves survey (1998-1999). These surveys provide an efficient and cost-effective means for monitoring abundance trends of cowcod, bocaccio, and other fishes.

Juvenile Surveys

Since 1983, the FED has conducted an annual survey of the distribution and abundance of pelagic juvenile rockfishes, with the goal of providing data for forecasting future recruitment to rockfish and other species, and to otherwise monitor the physical and biological environment. A number of west coast groundfish stock assessments (e.g., Pacific whiting, widow rockfish, and chilipepper rockfish) have used this pelagic juvenile index to estimate recruitment strength of year classes. In 2004, the geographic coverage of the pelagic juvenile rockfish mid-water trawl survey was expanded substantially, with the addition of new sample lines off of southern and northern California, from San Clemente Island to Point Delgada. This increased the effective latitudinal range of the survey from 180 to 800 km, representing a four-fold increase in coverage. In addition, for the last four years efforts to calibrate survey methods have been ongoing with the Pacific Whiting Conservation Cooperative (PWCC)/Northwest Fisheries Science Center (NWFSC) survey.

During 2005, pelagic juvenile rockfish catches in the core part of the survey area were at an all time low. However, with the new data available from the expanded survey coverage in 2005 (spanning San Diego, CA to Westport, WA when the PWCC/NWFSC data are included), two types of shifts in distribution were revealed. Specifically, species characterized by a more southerly geographic range (e.g., bocaccio, shortbelly, and squarespot rockfish) were caught in relatively large numbers south of Point Conception. Conversely, species with more northerly distributions (widow, canary, and yellowtail rockfish) were caught in moderate numbers north of Cape Mendocino. The near absence of fish in the core survey area then, seemed to be associated with a redistribution of fish, both to the north and the south, as well as overall lower abundances. This work, and greater comparisons of the SWFSC and PWCC/NWFSC paired tow survey results (with respect to catch rates, geographic distribution and species composition) will be reported in Sakuma et al. (in review).

In addition, FED is continuing a long-term monitoring survey of recently settled juvenile blue, yellowtail, and black rockfishes, using scuba in nearshore subtidal habitat off northern California for the last 21 years (Laidig et al. in press) and most recently off central California since 2001. While mean annual abundance is highly variable (0.01 - 181 fish/min), trends in the abundance index were similar for the three species, and sea level anomalies as well as nearshore temperatures had the strongest relationship with relative changes in abundance. The annual abundance index for juvenile yellowtail rockfish was also positively correlated with year-class strength of adult yellowtail rockfish, indicating the utility of juvenile abundance surveys for assessment and management purposes.

Deeper shelf substrates used as nursery habitat by age-0 rockfishes will be examined in a new project evaluating essential fish habitat for newly settled fishes. Methods of trapping, otter trawling, drop camera surveys, scuba diving censuses and ROV censuses will be employed in a two-year study starting in June, 2006. All habitat types within a depth zone of 20 to 100 m in Monterey Bay will be examined. Preliminary results from 2005 suggest clear depth and spatial patterns in habitat use, and additional differences between the distribution of age-0 and age-1 cohorts. Low relief mud/sand substrates appear to have nursery value for newly settled rockfishes of several species, with later migration to the high relief rocky substrates typically recognized as adult habitat.

Adult Surveys

The FRD's Advanced Sampling Technologies and In-Situ Survey groups are currently using three technologies combined with industry partnership to form a novel, non-lethal survey to better survey some rockfish species off southern California. Multi-beam sonar measurements are used for habitat characterization, multi-frequency echosounder measurements are used for mapping rockfish aggregations and facilitating remote species identification, and ROV video observations are used to validate the acoustical habitat classification and species identification. Rockfish and their habitats were mapped throughout the Southern California Bight from the NOAA Ship David Starr Jordan (Nov. 2004 and Feb. 2005) and the sportfishing vessel Outer Limits (Jan. and Mar. 2006). A cruise report from these efforts includes acoustic estimates of the habitats, and dispersions and relative abundances of some rockfish species in this area. Site fidelity, diel vertical migratory behavior, and temporal variations in biomass on inter-hourly, daily, weekly, and monthly scales were also documented. The frequency-specific sound scatter from six different rockfish species was measured in-situ and as a function of water depth. This will ultimately be used to acoustically discriminate among taxa, and to scale the total acoustic energy. David Demer presented the results of this investigation at the ICES Working Group on Fisheries Acoustics, Science and Technology in April 2006 in Hobart, Tasmania, and a manuscript is in preparation. Further development of survey methods, including the design of purpose-built small-craft, is ongoing.

In support of this work, efforts have been ongoing to improve the accuracy of target strength estimates that are used to convert integrated acoustic backscattering coefficient data to fish densities. Measurements of the sound scattering spectra from bocaccio rockfish were made at Hubbs SeaWorld Research Institute, and additional experimental measurements (including water pressure manipulation to simulate large depths) will soon be made using a new hyperbaric sound scattering chamber. The 1000-liter tank has been developed over the last year by the SWFSC. The tank will be used to make broad bandwidth measurements of the total sound scattering cross-sections of rockfish that can be used to better interpret survey data from multi-frequency echosounders. Sound signatures will improve the apportioning of total sound scatter to that from rockfish and other cohabitant species.

The FED has continued monthly industry-cooperative groundfish ecology surveys at numerous sites off central California, at depths 20 m to the continental slope. Both bottom trawl and longline gear are used from a commercial fishing vessel; these surveys began in late 2001, although coverage has been incomplete for much of 2005. Fish count, size, sex, age, and reproductive state are recorded, along with depth and environmental variables. From these data, we estimate fecundity, spawning season, seasonal distributions, sex and size ratios within different areas, population age structure, and size frequencies. This life history information is being used to improve management of groundfish species (especially those for which we have little knowledge).

Economic Studies

The FED's Economics Team is developing a model of fishery dynamics using 1981-2005 vessel- and trip-specific data for all West coast commercial fisheries (including groundfish). The model is intended to: (1) analyze patterns of fishing behavior across space and time, (2) identify

biological, economic, regulatory and environmental factors underlying these behavioral changes, and (3) evaluate the cumulative effects of these changes on fishing communities.

Stock Assessment Support

Both the FRD and the FED regularly produce stock assessments of groundfish for the PFMC and support stock assessment science through the maintenance of data systems and the development of new analytical techniques. The FED works closely with the California Department of Fish and Game (CDFG) to coordinate port sampling efforts and to maintain the CALCOM database, which serves as the source of the data provided to PacFIN by the State of California. The system provides port sampling biologists with Internet access to the database, so that data are entered directly in real time.

Through our liaison with CDFG, the FED also recently acquired a massive amount of historical California landings data on microfiche and original paper. These data have immense value for stock assessment and habitat evaluation purposes, and the FED recently initiated a process of contracting for the digitization of these records, which will be done through the designated contractor for the NESDIS Climate Data Modernization Program. The microfiche contain information on monthly California catches by 10-minute block from 1931 to 1968. Previous work with the California Department of Fish and Game resulted in gaining access to similar data for 1969-1981, so that the final database (1931-present) created by this CDMP project will triple the length of the currently available historical catch time series (currently 1982-present).

The FED has also been involved in a simulation study to test how relative weighting among likelihood components affects assessment results. The simulation framework includes a population-fishery simulation model, an assessment model, and comparisons of assessment results between true and estimated biomass, depletion rates and recruitment parameters. In the assessment model, within-component likelihood weighting is used for age composition data and CPUE indices. The simulation results indicate that when equal weights are used for all likelihood components, the assessment models generally under-estimate depletion rates (the estimated current biomass was higher than the true biomass), under-estimated recruitment potentials (smaller h values than the true value), and have more variable population trajectories. The assessment results were much closer to the true values when the likelihood for age composition was down-weighted to about 10% of the original values.

C. BY SPECIES, BY AGENCY

Nearshore Rockfish

Research

The FED Early Life History Team continues to evaluate sources of variability in the fitness characteristics of individual larval rockfish, such as the initial size of larvae at parturition, bioenergetic condition as indexed by oil reserves, initial swimming capabilities, growth rates and mortality. The team has also conducted experiments testing for multiple paternity in rockfish broods. Maternal age appears to play an important role in larval success (growth and survival) for some species but not others. Age also appears to influence the timing of parturition,

suggesting that older mothers fertilize their eggs earlier than younger mothers. The strength of some of these maternal effects appears to be related to seasonal patterns of parturition timing.

Assessment

FED biologists were involved in supporting three assessments for nearshore rockfish performed in the 2005 PFMC stock assessment cycle, although all of these were led by authors from other agencies or entities. These include gopher rockfish (*Sebastes carnatus*, Key et al. 2005), California scorpionfish (*Scorpaena guttata*, Maunder et al. 2005) and kelp greenling (*Hexagrammos decagrammos*, Cope and MacCall 2005). The results from the gopher rockfish assessment (which was restricted to California waters north of Point Conception) was based on suggest that this stock is well above target biomass levels. California scorpionfish was assessed for the first time in 2005, and the assessment estimated the 2005 biomass to be at 80% of its unfished level. The status of kelp rockfish could not be ascertained in the southern (California) region due to a paucity of data and apparent inconsistencies in data that did exist, an assessment of the Oregon stock suggested that kelp greenling are close to target levels in that region.

Shelf Rockfish

Research

The SWFSC FRD Genetics team has pioneered the development of automated molecular ID of eggs and larvae from RFLPs to Multiplex PCR and finally gene arrays. Presently they have a 20+ species gene array that covers most species encountered in the CalCOFI grid. One new molecular genetic species identification method uses DNA-specific probes and optical detection to identify larval rockfish samples in real-time (hours, not months), at sea (Fig. 2). This method improves our observations by allowing for real-time adaptive sampling, and gives us a better understanding of the early life history of over-fished rockfish stocks. The FED is also involved in understanding temporal and genetic population structure in several rockfish species, and developing multilocus genotypes for the identification of northeastern Pacific rockfish.

The FED is currently developing a study in to estimate the spawning biomass of bocaccio in the southern California Bight based on larval production. In an effort to compliment the traditional stock assessment analysis, larval abundance data collected during routine CalCOFI surveys and enhanced ichthyoplankton sampling surveys in the Cowcod Conservation Area (CCA) were summarized. Bocaccio larvae were sub-sampled, aged, and a probability transition matrix developed to estimate age composition from the area-wide length composition. Spawning seasonality was estimated from long-term patterns of availability in the CalCOFI survey from 1950 to the present. Lastly, adult female weight-specific fecundity was estimated by sampling mature fish in 2002 from Ensenada (Mexico), which when combined with the larval production data, yielded estimates of total age-1+ biomass of bocaccio. Results from the larval production analysis are in general agreement with the traditional stock assessment, although uncertainty in estimates of weight-specific fecundity and the incidence of repeat spawning remain high.

The FED also developed a model of shortbelly rockfish, an essentially unexploited species due to small size and poor quality of flesh, for research purposes. Shortbelly rockfish are one of the most abundant rockfish species in the California Current, and are a key forage species for many piscivorous fish, birds, and marine mammals. Although catch data are extremely limited, other

sources of information suggest that the population has undergone significant fluctuations in abundance over the last several decades, presumably in response to variations in environmental conditions. As this stock might be considered the equivalent of a “control” rockfish population, the results may provide insight into the potential causes and consequences of natural population variability on both exploited and non-exploited rockfish populations throughout the California Current.

In cooperation with the NWFSC, the FRD has developed statistical techniques for analysis of bomb radiocarbon data and have completed several projects to assess ageing error of black and canary rockfish, using bomb radiocarbon and stable isotopes. Currently, these methods are being applied to other rockfish species.

The FED also is comparing results from direct-observation and video transects using an occupied submersible with those from bottom longline methods to determine abundance, size and species composition, catchability coefficients and selectivity, and appropriate conversion factors for relative and absolute abundance of groundfish shelf species off central California. Quantitative transect methods, collection of accurate visual observation and navigation data, database management and analysis follow protocols based on past experience with in situ methods. This study includes participation by a commercial longline fisherman. These results should contribute to improved assessments of groundfish stocks in untrawlable habitat off California.

Assessments

The FED conducted an update of the 2003 bocaccio rockfish assessment, which used the original Stock Synthesis model (MacCall 2005). In addition to new length frequency data, new data points were included from both the triennial survey and the CALCOFI larval abundance index, both of which suggested an increasing upwards trajectory for the stock. The estimated spawning output from the base model in 2005 was 10.7% of the estimated unfished level, and catches in recent years have been less than recent OY levels. The rebuilding analysis that followed the updated assessment found that the probability of further long term declines in bocaccio abundance were negligibly small, and that the expected (50% probability) year of rebuilding under status quo harvest rates was 2024.

The FED conducted a unique fishery-independent assessment of cowcod off southern California (Yoklavich et al. In Prep.). In 2002, cowcod were surveyed within the Cowcod Conservation Areas (CCAs) using non-extractive methodologies and direct observations during 95 dives from a research submersible over ten major offshore rocky banks (all longtime fishing sites). This survey was restricted to high and low relief rock substrata within a depth range of 75-300 m, which represented likely cowcod habitats. A line-transect analysis of the count of cowcods, their perpendicular distances from the track line, length of survey tracks, and area of each bank was used to estimate total number of fish in the study area. Several sources of uncertainty were evaluated and accounted for in the resulting estimates of abundance and biomass. This first ever fishery independent assessment for a rockfish species off southern California was well vetted by an independent CIE review panel and the PFMC cowcod STAR panel. It suggested that a time-series of results from such visual surveys is critical to evaluate a trend in cowcod biomass with respect to increased time of protection within the CCAs. Research is ongoing to assess the accuracy of visual underwater estimates of size and distance from submersibles; comparisons are

being made between actual measurements (from fish either caught on a longline or replicas placed on the seafloor) and those estimated using paired lasers on the submersible.

The FRD took the lead in conducting the 2005 cowcod stock assessment, which included only two primary data sources. These sources included a recreational CPUE time series and the direct-observation line transect survey conducted by researchers at FED (described above). The assessment estimated that the 2005 spawning biomass was 18% of unfished levels, within a range of 14 to 21% depending on the value assumed for steepness, a considerably more optimistic result than the 1999 assessment. The corresponding rebuilding analysis (Piner 2005b) also estimated that rebuilding to target levels could occur faster than earlier thought, although rebuilding times were still expected to last 60 to 80 years. However it was also noted that rebuilding scenarios are extremely uncertain for this data-poor species. Moreover, there is widespread concern about the ability to monitor the stock, and consequently to evaluate progress towards rebuilding in the future

The FED conducted a full assessment of widow rockfish in 2005 (He et al. 2005). In addition to including the new data from 2003 to 2004, this assessment added a new index of relative abundance based on the triennial survey. The base model estimated that spawning output in 2004 was 31% of the unexploited level, above the Council's overfished threshold. Further, spawning output in the base model was estimated to have never dropped below the 25% overfished threshold. Alternative model runs, which were considered to be only slightly less plausible than the base model, however, indicated that the stock could have been below B25%. The 2005 rebuilding analysis indicated that the stock was much closer to reaching a rebuilt biomass than previously estimated, with target dates of rebuilding within approximately 10 years (depending upon harvest rates).

The FED conducted an assessment for vermillion rockfish for the first time in 2005, with separate models for the stocks north and south of Point Conception. One consideration in this assessment was the building evidence from genetic research, which suggests that vermillion rockfish may be two species, as nothing is known about biological differences among the two species. The models suggested upward trends for vermillion rockfish since approximately 1990, with the depletion levels for both stocks generally above target levels for most model formulations. However, as the model exhibited high sensitivity to modest changes in data or assumptions, the assessment was not accepted by the Scientific and Statistical Committee (SSC) as being suitable for the provision of quantitative management advice.

Flatfish

Research

A paper on the growth and life history of sand sole is in preparation. Maturity, growth, and life history studies of starry flounder, rex sole and sanddabs are also ongoing, based primarily on data and specimens collected in the Central California Cooperative Groundfish Ecology Survey.

Assessment

The U.S. West Coast starry flounder stock was assessed for the first time in 2005 (Ralston 2006), with an assumption of separate biological populations north and south of the California/Oregon border. The assessment was based on catch data, relative abundance indices derived from trawl logbook data, and an index of age-1 abundance from trawl surveys in the San Francisco Bay and Sacramento-San Joaquin River estuary. Unlike most other groundfish stock assessments, no age- or length-composition data were available for use the assessment. Both the northern and southern populations are estimated to be above the target level of 40% of virgin spawning biomass (44% of SB0 in Washington-Oregon and 62% in California), although the paucity of data for this species contributes to substantial uncertainty around these levels. One of the most significant areas of uncertainty in the assessment is the estimate of natural mortality rate, which was quite high (0.30 yr⁻¹ for females and 0.45 yr⁻¹ for males).

D. OTHER RELATED STUDIES

Fish Culture and Enhancement

The SWFSC FRD has maintained over 10 species of rockfish in the experimental aquarium and has succeeded in getting some to mate, brood, and produce viable larvae. Larvae have been reared (not without difficulty) to the juvenile stage and papers describing larval and juvenile morphology have been produced. Collaborations with Hubbs-SeaWorld Research Institute and oil companies have resulted in establishment of captive brood stocks of bocaccio, vermilion, and cowcod. Currently, several species of rockfish are housed in the aquarium, although no experiments are associated with them at this time.

Trawl Location Mapping

The ERD has continued to develop a GIS demonstration of trawl location mapping with improved resolution. Trawl lines based on the start and endpoints of individual trawls from California logbook database were mapped for Central California for 1997-2002 and all of California for 2003 and 2004, and summarized with roughly 3 square km resolution. Associated information such as tow hours, date, and port was retained and integrated with pounds landed by species. Maps detailing the distribution of species and trawling effort are being analyzed to understand the effects of past regulatory actions, including the consequences of implementing rockfish conservation areas on the spatial distribution of fisheries effort.

Integration of Marine Protected Areas and Fisheries Science and Management

The Santa Cruz Laboratory and the National Marine Protected Areas Science Institute have continued their support of the Science Integration of Marine Protected Areas and Fishery Management Working Group through 2005 and into 2006. The entire working group has met twice, and the three principal working group teams have met frequently throughout the past year in working sessions to review progress and develop results. These groups include the MPA/ecosystem team, charged with using models and other means to identify and evaluate the trade-offs of different fishery management measures; the connectivity team, with a focus on the development of tools to identify connectivity patterns at the ecosystem scale and the natural

heritage team, with a focus on developing measurable objectives for the design and evaluation of MPAs implemented for natural heritage purposes.

SWFSC/Santa Cruz Lab Groundfish Habitat Ecology Program

The FED has an ongoing research program to implement legislative mandates with respect to Essential Fish Habitat (EFH) and Stock Assessment Improvement for West coast groundfish. This program uses a range of tools, including research submersibles, laser line scan system, and multibeam and side scan sonar. In addition to the Cowcod Conservation Area surveys and the gear intercalibration research described in the Assessments section for shelf rockfish, other ongoing projects include: 1) an evaluation of patterns in groundfish distribution and abundance and seafloor habitats at a range of spatial scales, being conducted in collaboration with USGS (Anderson et al. 2005; Anderson and Yoklavich, In Prep.); 2) characterizing benthic invertebrates that form habitat on deep banks off southern and central California, with special reference to deep sea coral communities (Tissot et al. 2006); 3) an evaluation of the potential for laser line scan (LLS) systems to serve as a bridge between high resolution, limited coverage video survey tools (e.g., remotely-operated vehicle (ROV), occupied submersible, towed sled) and lower resolution, higher coverage acoustic technologies (e.g., multibeam and sidescan sonar) (Amend et al. In Press).

Groundfish Economics

The FED's Economics Team is conducting research to estimate technical efficiency in the West coast groundfish fishery. This research involves use of Bayesian methods to characterize a production function that accounts for both the highly stochastic environment of commercial fisheries and the effect of boat-specific unobservables such as skipper skill, and provides a framework for assessing the impact of regulations on vessel efficiency.

Concerns regarding overfished groundfish stocks have led to drastic regulatory changes, including highly restrictive OYs and vessel landings limits, an industry-funded buyback program, and sweeping closures on the continental shelf. The Economics Team is conducting a retrospective analysis of the effects of these regulations on trawlers who exited the fishery as well as those who continue to participate. This project is being conducted in collaboration with ERD, whose Trawl Location Mapping Study (D2 above) is well suited to exploring changes in fishing strategies and the spatial distribution in fishing activity over time.

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2005 - PRESENT

1. Primary Publications

Aguilar, A., and J. C. Garza. 2005. Analysis of major histocompatibility complex class II Beta genes from rockfishes (genus *Sebastes*). *Journal of Fish Biology* 67:1021-1028.

Amend, M., M. Yoklavich, Y. Rhzanov, C. Grimes, and W. Wakefield. In Press. Mosaics of benthic habitats using laser line scan technology: it's in the details. In: Todd, B. and H.G. Greene (eds.) *Proceedings of GeoHab: Marine Geological and Biological Habitat Mapping*.

Anderson, T. J., M. M. Yoklavich, and S. L. Eittreim. 2005. Linking fine-scale groundfish distributions with large-scale seafloor maps: issues and challenges of combining biological and geological data. *American Fisheries Society Symposium* 41:667-678.

Anderson, T.J. and M.M. Yoklavich. In Prep. Multi-scale habitat associations of deep-water groundfishes in Monterey Bay, California.

Baskett, M., **M. Yoklavich**, and M. Love. 2006. Predation, competition, and the recovery of overexploited fish species in marine reserves. *Canadian Journal Fisheries and Aquatic Sciences* 63: 1214-1229.

Benet, D., D. E. Pearson, and E. J. Dick. In prep. Life history of greenspotted rockfish (*Sebastes chlorostictus*) in Central California.

Black, B.A., G. W. Boehlert, and **M. M. Yoklavich.** 2005. Using tree-ring crossdating techniques to validate age in longlived fishes. *Canadian Journal of Fisheries and Aquatic Sciences* 62:2277-2284.

Buonaccorsi, V. P., **C. A. Kimbrell, E. A. Lynn, and R. D. Vetter.** 2005. Limited realized dispersal and introgressive hybridization influence genetic structure and conservation strategies for brown rockfish, *Sebastes auriculatus*. *Conservation Genetics*. 6: 697-713.

Conti, S. G., Maurer, B., Drawbridge, M., and D. A. Demer. In press. Measurements of total scattering spectra of bocaccio rockfish (*Sebastes paucispinis*). *Fisheries Bulletin*

Copps, S., **M. Yoklavich**, G. Parkes, W. Wakefield, A. Bailey, H. G. Greene, and C. Goldfinger. (In Press). Applying habitat data to fishery management on the US West coast. In: Todd, B. and H.G. Greene (eds.) *Proceedings of GeoHab: Marine Geological and Biological Habitat Mapping*.

Field, J. C., and S. Ralston. 2005. Spatial variability in rockfish (*Sebastes spp.*) recruitment events in the California Current System. *Canadian Journal of Fisheries and Aquatic Sciences* 62: 2199-2210.

Field, J.C., R.C. Francis, and K. Aydin. 2006. Top-down modeling and bottom-up dynamics: linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. *Progress in Oceanography* 68:238-270.

Field, J. C., E. J. Dick, M. Key, **M. Lowry**, Y. Lucero, **A. MacCall**, **D. Pearson**, **S. Ralston**, W. Sydeman, and J. Thayer. In review. Population dynamics of an unexploited rockfish, *Sebastes jordani*, in the California Current. Proceedings of the 23rd Lowell Wakefield Symposium: Biology, Assessment, and Management of North Pacific Rockfishes.

Field, J.C., A.E. Punt, R.D. Methot and **C. Thomson**. In prep. Potential Impacts of MPAs on Fisheries Science and Stock Assessment, with Specific Reference to the Groundfish Fisheries off the West Coast of the U.S.

Fisher, R., S.M. Sogard, and S.A. Berkeley (in review). Trade-offs between size and energy reserves reflect alternative strategies for optimizing larval survival potential. *Oecologia*.

Gilbert-Horvath, E. A., R. J. Larson, and **J. C. Garza**. In review. Temporal recruitment patterns and genetic population structure in kelp rockfish (*Sebastes atrovirens*).

Gunderson, D. R. and **R. D. Vetter**. 2006. Temperate rocky reef fishes. In *Marine Metapopulations*, J. P. Kritzer and P. F. Sale, eds. San Diego: Elsevier Academic Press, pp. 70-117.

He, X., M. Mangel, and **A. MacCall**. In press. A prior for steepness based on an evolutionary persistence principle. *Fishery Bulletin*.

Holloway, G., and **D. Tomberlin**. In press. Bayesian ranking and selection of fishing boat efficiencies. *Marine Resource Economics*.

Holloway, G., **D. Tomberlin**, and X. Irz. 2005. Hierarchical Analysis of Production Efficiency in a Coastal Trawl Fishery. In A. Alberini and R. Scarpa, eds., *Applications of Simulation Methods in Environmental and Resource Economics*. Boston: Kluwer Academic Press.

Laidig, T. E., J. R. Chess, and D. F. Howard. In press. Long term trends in annual abundance of juvenile rockfish (*Sebastes spp.*) off northern California and possible mechanisms for the variation. *Fisheries Bulletin*.

Laidig, T.E., K.M. Sakuma, J. Hyde, W. Watson, and C. Taylor. In Prep. Identification, description, and daily growth of pelagic larval and juvenile squarespot rockfish, *Sebastes hopkinsi* (Family Sebastidae). *CalCOFI Rep.*

Love, M. S., D. M. Schroeder, **W. Lenarz**, **A. MacCall**, A. S. Bull, and L. Thorsteinson. In press. The unexpected utility of offshore marine structures in rebuilding an overfished species. *Fishery Bulletin*.

Mills, K. L., **S. Ralston**, **T. Laidig**, and W. J. Sydeman. In press. Functional response curves and the use of top predator diet as indicators of pelagic juvenile rockfish (*Sebastes* spp.) abundance in the California Current system. Fisheries Oceanography.

Pearse, D. E., L. Wooninck, C. A. Dean, and J. C. Garza. Submitted. Identification of northeastern Pacific rockfish (*Sebastes* spp.) using multilocus nuclear DNA genotypes.

Pearson, D.E., and S.V.G. McNally. In prep. Age, growth, life history, and fisheries of the sand sole (*Psettichthys melanostictus*) from central California.

Piner, K. R., M. A. Haltuch, and J. R. Wallace. 2005. A preliminary evaluation of the use of oxygen stable isotopes and the 1983 El Niño to assess ageing accuracy of black rockfish (*Sebastes melanops*). Fisheries Bulletin 103:553-558.

Piner, K.R., O.S. Hamel, J.L. Menkel, J.R. Wallace, and C. E. Huthchinson. 2005. Age validation of canary rockfish (*Sebastes pinniger*) from off the Oregon coast (USA) using the bomb radiocarbon method. Canadian Journal Fisheries Aquatic Sciences 62:1060-1066.

Punt, A.E., and **S. Ralston.** In review. A management strategy evaluation of rebuilding revision rules for overfished rockfish stocks. Proceedings of the 23rd Lowell Wakefield Symposium: Biology, Assessment, and Management of North Pacific Rockfishes.

Ralston, S., W. H. Lenarz, and D. P. Woodbury. In prep. Long-term variability in year-class strength of northern California rockfishes (*Sebastes* spp.) in relation to the larval ocean environment and young-of-the-year growth.

Sakuma, K. M., S. Ralston, and D. A. Roberts. In review. High-frequency patterns in abundance of larval Pacific hake, *Merluccius productus*, and rockfish, *Sebastes* spp., at a single fixed station of central California.

Sakuma, K. M., S. Ralston, and V. G. Wespestad. In review. Interannual and spatial variation in young-of-the-year rockfish, *Sebastes* spp.: expanding and coordinating the sampling frame.

Sakuma, K. M., C. A. Taylor, and **W. Watson.** 2005. Pigment variability in larval *Sebastes jordani* off central California. Journal of Fish Biology 67:510-520.

Sogard, S.M., E. Gilbert-Horvath, E.C. Anderson, R. Fisher, S.A. Berkeley, and J.C. Garza. In review. Multiple paternity in viviparous kelp rockfish, *Sebastes atrovirens*. Journal of Fish Biology.

Starr, R. M., V. O'Connell, **S. Ralston,** and L. Breaker. 2005. Use of acoustic tags to estimate natural mortality, spillover, and movements of lingcod (*Ophiodon elongatus*) in a marine reserve. Marine Technology Society Journal 39(1):19-30.

Tissot, B.N., **M.M. Yoklavich**, M.S. Love, K. York, and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral. *Fishery Bulletin* 104:167-181.

Tomberlin, D., X. Irz, and G. Holloway. In press. Bayesian estimation of technical efficiency in the Pacific Hake fishery. In *Proceedings of the North American Association of Fisheries Economists' Forum*. Corvallis, OR: International Institute for Fisheries Economics and Trade.

Watters, D.L., D.E. Kline, K.H. Coale, and G.M. Cailliet. In review. Radiometric Age Confirmation and Growth of a Deep Water Marine Fish Species: the Bank Rockfish, *Sebastes rufus*. *Fisheries Research*.

Yoklavich, M. and M. Love. 2005. Christmas tree corals: a new species discovered off southern California. *Current: The Journal of Marine Education* 21:27-30.

Yoklavich, M., M. Love, and **K. Forney**. In Prep. A fishery independent assessment of cowcod (*Sebastes levis*) in southern California's Cowcod Conservation Areas using direct observations from an occupied submersible.

2. Other Publications

Allen, L., **M. Yoklavich**, G. Cailliet, and M. Horn. 2006. Bays and Estuaries. 119-148. In: Allen, Horn, and Pondella (eds.) *The Ecology of Marine Fishes: California and Adjacent Waters*. UC Press.

Cope, J., and **A. D. MacCall**. 2005. Status of kelp greenling (*Hexagrammos decagrammus*) in Oregon and California waters as assessed in 2005. Pacific Fishery Management Council, Portland, Oregon.

Goldfinger, C., C. Romsos, J. Chaytor, **M. Yoklavich**, M. Amend, W. Wakefield, and L. Huffnagle. 2005. Multibeam sonar surveys and habitat mapping of the seafloor within the Cowcod Conservation Areas, Southern California Continental Borderland. Final Report to NOAA Fisheries, Santa Cruz Laboratory.

He, X., **D. E. Pearson**, **E. J. Dick**, **J. C. Field**, **S. Ralston**, and **A. D. MacCall**. 2005. Status of the widow rockfish resource in 2005. Pacific Fishery Management Council, Portland, Oregon.

He, X., A. Punt, **A. D. MacCall**, and **S. Ralston**. 2005. Rebuilding analysis for widow rockfish in 2005. Pacific Fishery Management Council, Portland, Oregon.

Key, M., **A. D. MacCall**, T. Bishop, and B. Leos. 2005. Stock assessment of the gopher rockfish (*Sebastes carnatus*). Pacific Fishery Management Council, Portland, Oregon.

Love, M. and **M. Yoklavich**. 2006. Deep Rock Habitats, 253-266. In: Allen, Horn, and Pondella (eds.) *The Ecology of Marine Fishes: California and Adjacent Waters*. UC Press.

MacCall, A. D. 2005. Assessment of vermilion rockfish in southern and northern California. Pacific Fishery Management Council, Portland, Oregon.

MacCall, A. D. 2005. Bocaccio rebuilding analysis for 2005. Pacific Fishery Management Council, Portland, Oregon.

MacCall, A. D. 2005. Status of bocaccio off California in 2005. Pacific Fishery Management Council, Portland, Oregon.

Maunder, M. N., J. T. Barnes, D. Aseltine-Nielson, and **A. D. MacCall.** 2005. The status of California scorpionfish (*Scorpaena guttata*) off southern California in 2004. Pacific Fishery Management Council, Portland, Oregon.

Moser, H. G. and **W. Watson.** 2006. Ichthyoplankton. p. 269-319 In: L. G. Allen, D. J. Pondella, and M. H. Horn (eds.) The ecology of marine fishes: California and adjacent waters. UC Press, Berkeley.

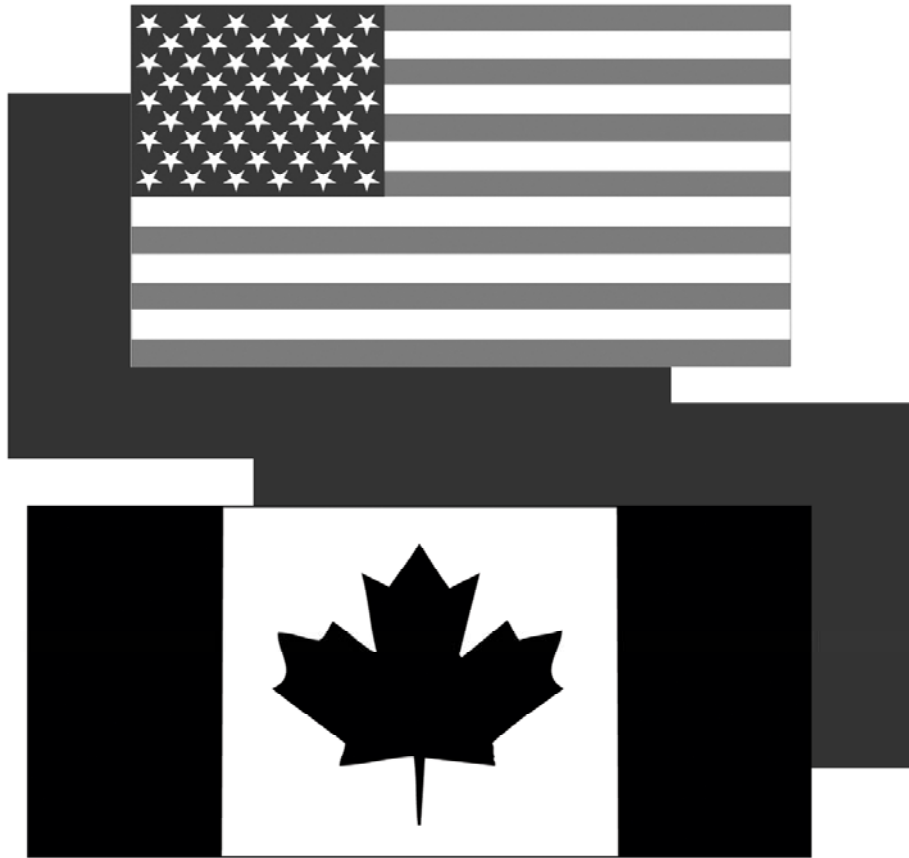
Piner, K., E. J. Dick, and **J. Field.** 2005. 2005 stock status of cowcod in the Southern California Bight and future prospects. Pacific Fishery Management Council, Portland, Oregon.

Pinkard, D. R., D. M. Kocak, and **J. B. Butler.** 2005. Use of a Video and Laser System to Quantify Transect Area for Remotely Operated Vehicle (ROV) Rockfish and Abalone Surveys. Proc. MTS/IEEE Oceans 2005, Washington, D.C., Sept. 2005.

Watson, W., R. L. Charter, and **S. M. Manion.** 2005. Ichthyoplankton and station data for surface (Manta) and oblique (Bongo) tows taken for California Cooperative Oceanic Fisheries Investigations survey cruises in 2004. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-384. 123 pp.

Yoklavich, M. 2005. Using video observations from submersibles and laser line scanners to survey benthic fishes, macro-invertebrates and habitat types in deepwater off California. 19-23. In: Somerton, D.A. and C.T. Glendhill (eds.) Report of the NMFS Workshop on Underwater Video Analysis. NOAA Tech. Memo. NMFS-F/SPO-68, 69 pp.

**Report of the Technical Subcommittee
of the
Canada-United States Groundfish Committee
Forty Seventh Annual Meeting of the TSC
May 2-3, 2006
Inn at Otter Crest
Otter Rock, Oregon**



**Appointed by the Second Conference on Coordination of
Fisheries Regulations between Canada and the United States**

Compiled by the Pacific States Marine Fisheries Commission