NMFS Southwest Fisheries Science Center

Agency Report to the Technical Subcommittee

of the Canada-U.S. Groundfish Committee

April 2008

Edited by John Field with contributions
from David Demer, John Hyde, and William Watson

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 acting Science Director is Dr. Norman Bartoo, and the acting deputy director is Dr. Frank Schwing. All three SWFSC laboratories have supported the essential needs of the NMFS and the Pacific Fishery Management Council (PFMC) for groundfish, including as 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. Lisa Ballance), 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 (CalCOFI) surveys that have taken place along most of the California coast since 1951. 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 advice to the fishery management and scientific communities; and (5) provide professional services (many of which fall in the above categories) at all levels, including inter-agency, state, national and international working groups.

The 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

1. Research

Ichthyoplankton Surveys
The CalCOFI ichthyoplankton time series, the longest such time series in existence, dates 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 and shortbelly rockfishes, and may provide fishery-independent time series information for many other groundfish species. 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 are centered north of Point Conception.

Over the 57+ years of the CalCOFI time series substantial advances have been made in ichthyoplankton identifications and many species identifiable only to the level of genus or above in earlier years now are identified to species. To increase the consistency of identifications through the time series, a project to systematically work back through the archived CalCOFI ichthyoplankton samples to bring all identifications up to current standards has been completed for samples collected during the first nine months of 1969 and from 1972 to the present. In addition, we have begun re-identifying fish eggs collected in the CalCOFI bongo net samples, and are adding the count data for eggs of Pacific whiting (hake) and jack and Pacific mackerels to the database. Egg re-identifications have been completed for samples collected from 1992 to the present and we continue to work back through the time series for both eggs and larvae. A data report for the Southern California Nearshore Ichthyoplankton survey (2004-2005) was published in 2007 (Watson et al. 2007) and a study is currently underway to identify all the rockfish larvae collected during the CCA surveys. To date, visual and molecular identifications have been completed for about half the rockfish larvae collected during the 2002 CCA survey, representing 26 species.

Finally, larvae of most of the rockfish species cannot be reliably identified to species using standard visual techniques. However, one side of each bongo net sample collected during the

Cowcod Conservation Area (CCA) surveys was preserved in ethanol, thus these larvae can be identified using molecular techniques. Currently, about 60% of the "unidentified rockfish" larvae collected during the 2001 CCA survey have been identified, representing 27 species and dominated by squarespot and swordspine rockfishes. The results of this work will greatly enhance the number of species identified in such surveys and assist in the validation of pigment/morphology-based identifications.

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 have historically used this pelagic juvenile index to estimate impending recruitment. In 2004 the geographic coverage of the SWC 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. As in 2005 and 2006, pelagic juvenile rockfish catches in the core part of the survey area were at very low levels in 2007, with some evidence of a redistribution of fish to the north and the south.

The Early Life History Team is continuing studies of essential fish habitat for newly settled rockfish in Monterey Bay. Using methods of trapping, otter trawling, drop camera surveys, scuba diving censuses and ROV censuses, we are examining a range of habitat types and depths from 20 to 100m. Ongoing poor recruitment trends have limited our attempts to use video methods of censuses, although trawling and trapping methods have revealed spatial patterns in settlement, with higher densities of YOY rockfish in southern Monterey Bay relative to the north, and higher densities in deeper regions relative to shallow. 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 Advanced Survey Technology (AST) and In-Situ Survey groups have made operational a Collaborative Optically-assisted Acoustic Survey Technique (COAST) to survey rockfish and evaluate their biotic and abiotic requirements for habitat. The COAST can provide estimates of biomass and dispersion by species, throughout the Southern California Bight (SCB), with practical sampling effort (Fig. 1). The techniques were developed in 2003/04 from the Commercial Passenger Fishing Vessel (CPFV) Outer Limits; applied throughout the Southern California Bight (SCB) in 2004/05 and 2007 (COAST07), largely from NOAA Ship David Starr Jordan. The COAST will provide a time-series of data for improving rockfish stock assessments. Efforts are underway to also apply the COAST to rockfish off central California.

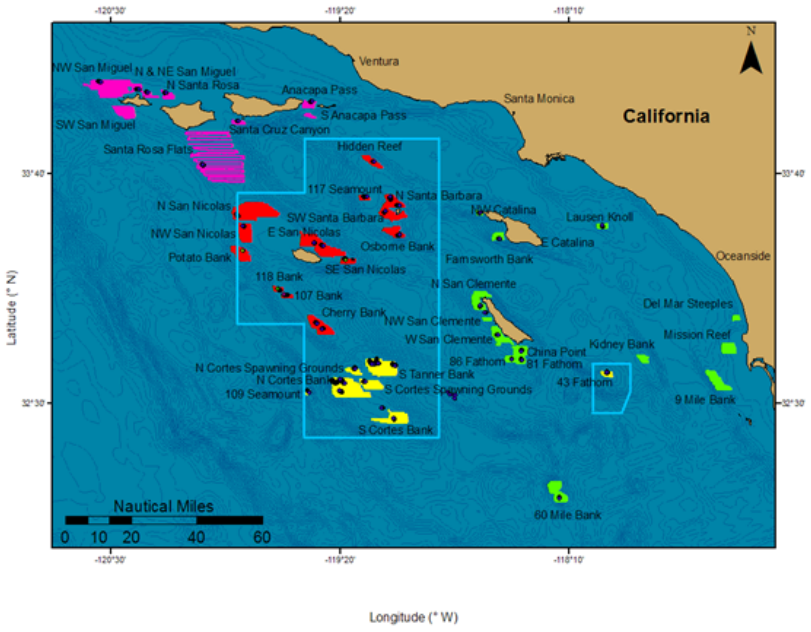


Figure 1. Sites for the COAST07 survey of rockfish in the SCB. COAST07 was conducted in four legs, each approximately 15 days in duration: Leg I, 8/26-9/9 (yellow); Leg II, 9/13-9/27 (red); Leg III, 10/1-10/15 (purple); and Leg IV, 10/19-10/31 (green). Most of the multi-frequency echosounder surveys (lines) and ROV transects (black dots) were conducted from the NOAA Ship David Starr Jordan. A few sights were completed with acoustic and optical observations from the CPFV Outer Limits. Indicated with light blue lines are the boundaries of the Cowcod Conservation Area.

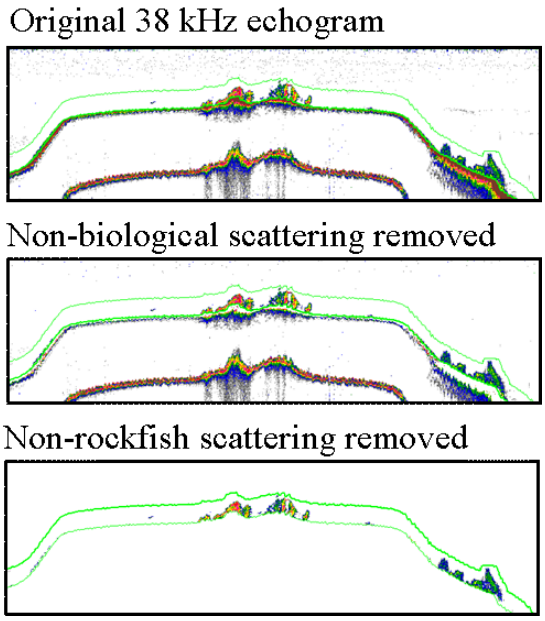


Figure 2. Volume backscattering strength data (Sv; dB) from multi-frequency echosounders is used to detect and classify rockfish near the seafloor.

Throughout COAST07, acoustical volume backscattering strengths (Sv; dB re 1 m) and in-situ target strengths (TS; dB 1 m2) were measured continuously by four Simrad EK60 echo sounders configured with 38, 70, 120, and 200 kHz hull-mounted transducers. Then, video and high-resolution still images of the rockfish were collected using cameras deployed on a remotely operated vehicle (ROV). In each of 42 sites surveyed, a three-dimensional seafloor was visualized by interpolating the bottom detections from the 38 kHz echo sounder to render a surface. Empirical relationships between the multi-frequency Sv were used to remotely identify and separate the scatterer taxa (i.e. large fish, small fish, and zooplankton; e.g. Fig. 2). Signals from the rockfish were thus extracted from the echograms and their distributions were overlaid on the rendering of the seafloor. Using these geographically-referenced files to navigate the ROV, optical images were obtained to characterize the fish species and their sizes, and also to validate acoustical seabed classifications. At the conclusion of each survey segment or day, a CTD was deployed in the area to profile the temperature, salinity, and sound speed within each survey location.

Additional optical surveys were conducted during December 2007 through April 2008, with the aid of partners in the sportfishing industry, to fill in missing data at a few sites. The goals were to examine the species compositions and length distributions of bocaccio (*Sebastes paucispinis*), cowcod (*S. levis*), vermilion (*S. miniatus*) and bank rockfish (*S. rufus*) at all sites. Results have been widely disseminated, and manuscripts detailing the methods and results of the COAST04/05 and COAST07 surveys are in preparation.

2. Stock Assessment Support

The Fisheries Ecology Division (FED) is currently the SWFSC lead for stock assessments of groundfish for the PFMC, and supports 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. In addition to maintaining the CalCOM database and supporting port sampling and sample expansion efforts, the FED has also participated in the PFMC process since it's inception. Staff scientists have been represented on the Groundfish Management Team (GMT) in every year since it's establishment, and have also been active participants in the Scientific and Statistical Committee (SSC) for the PFMC.

C. BY SPECIES, BY AGENCY

2. Nearshore Rockfish

Research

The Early Life History Team continues to conduct research 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. 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. We are currently expanding these studies to additional species common in deeper habitats. This issue is widely recognized by researchers and assessment scientists as important in evaluating the productivity and sustainability of West Coast groundfish fisheries, and insights gained from ongoing research will be incorporated into scientific assessments and management advice as it becomes available. In addition to research examining maternal effects, we have completed experiments testing for multiple paternity in kelp rockfish, with the finding that multiple paternity appears to be common.

Assessment

In 2007, FED biologists assisted in the development of a blue rockfish (*Sebastes mystinus*) stock assessment led by the California Department of Fish and Game (Key et al. 2008). The 2008 assessment indicated that increased catches in the 1970s resulted in a continuous decline in spawning biomass through the early 1990s. Spawning biomass was estimated to have reached a minimum (10% of unexploited) in 1994 and 1995; with a constant increase since that time, such that the current relative depletion level in 2007 is 30% of the unfished. The base model estimated that the stock could support an MSY of 275 metric tons. Although the assessment was fairly data poor and several key uncertainties were characterized in the assessment, including expected results from ongoing genetic studies that suggest that "blue rockfish" may in fact be represented by two closely-related species.

3. Shelf Rockfish

Research

Ongoing efforts are underway to develop a spawning biomass point estimate of bocaccio (*Sebastes paucispinis*) in the southern California Bight (SCB) using data collected during standard winter CalCOFI surveys and enhanced ichthyoplankton sampling surveys (Figure 3). Standard and enhanced ichthyoplankton sampling conducted during 2002 and 2003 were used to generate independent estimates of spawning biomass in those two years through the analysis of larval catch curves. Larval production was then linked to spawner biomass based on information obtained from adult fish recently collected in Ensenada, Mexico (i.e., maturity and fecundity data). The results will be evaluated in the next full bocaccio rockfish stock assessment

Assessments

In the 2007 stock assessment cycle, the FED conducted full stock assessments of cowcod and chilipepper rockfish, and updated assessments of bocaccio and widow rockfish. Updated rebuilding analyses were also developed for cowcod, bocaccio and widow rockfish. All assessments and rebuilding analyses are available on the Pacific Fishery Management Council website, at http://www.pcouncil.org/groundfish/gfstocks.html.

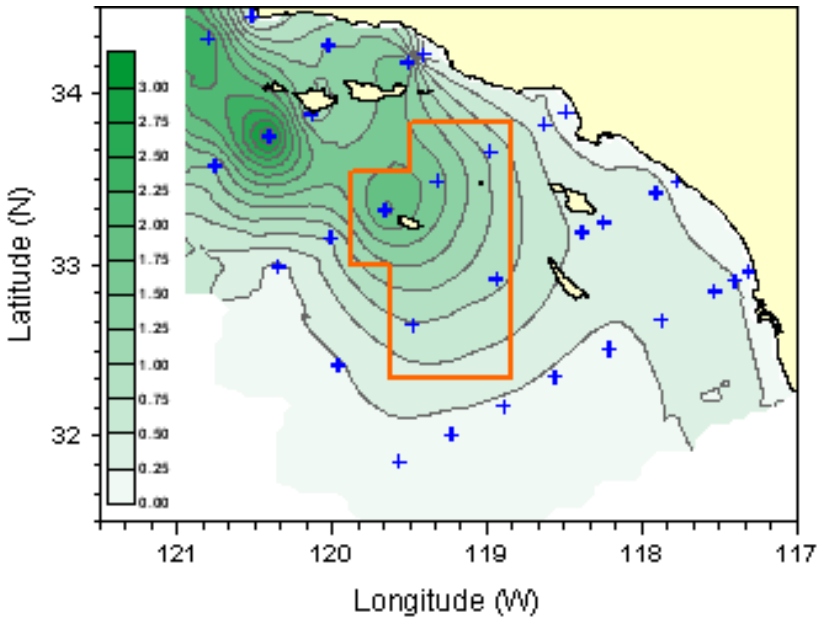


Figure 3: Historical distribution of bocaccio larval abundance (# ≅ 10 m^{-2}) from the CalCOFI database. Shown are contours of the estimated station effects from a Δ-lognormal GLM, with blue "+" symbols indicating actual station locations. The Cowcod Conservation Area is delimited by the orange polygon.

A full assessment of cowcod (*Sebastes levis*) rockfish was recommended by the PFMC SSC following the discussion of some corrections and refinements to the updated 2005 model. These corrections caused the estimate of the 2005 estimate of depletion to drop from 17.8% to 9.4%. A major effort was also initiated to refine the historical catch data and to improve on the means by which visual survey estimates of cowcod were incorporated into the model. The model was developed in Stock Synthesis II (SS2), the modeling platform used for most west coast groundfish assessments. The final model estimated the 2007 spawning biomass to be approximately 4.6% of the unfished level (Dick et al. 2008). For this stock in particular, there is an urgent need for an informative abundance index that can monitor the recovery of this stock, as past relative abundance information was derived from recreational CPUE time series which are now truncated due to a ban on retention and the establishment of the Cowcod Conservation Areas (CCAs) to rebuild the stock.

Chilipepper rockfish (*S. goodei*) have been one of the most important commercial target species in California waters since the 1880s. Although the last stock assessment (in 1998) found that the stock was above target levels, landing have plummeted to a fraction of their former magnitude over the last ten years, due to management measures implemented to rebuild bocaccio and other rockfish of abundance. The 2007 assessment found that although the biomass through the early and mid 1990s was at low levels (close to, but above, the existing overfished threshold), the

spawning biomass of chilipepper rockfish increased substantially in recent years, due to a strong 1999 year class as well as greatly reduced harvest rates in commercial and recreational fisheries (Field 2008). The base model result suggests a spawning biomass of 23,889 tons in 2006, corresponding to approximately 70% of the unfished spawning biomass and representing a near tripling of spawning biomass from the late 1990s.

The bocaccio (*S. paucispinis*) rockfish assessment was conducted primarily as an "update," which follows the methodology, assumptions and modeling platform (SS1) of the 2003 bocaccio assessment. The updated assessment estimated that the stock has continued to increase in abundance, due to both declining exploitation rates and a very strong 1999 year class, which appears to have been followed by a moderately strong 2003 year class. Recent management has been achieving total removals well below target levels, and far below maximum levels. A full assessment of bocaccio rockfish will be conducted in 2009.

The last full assessment of widow (*S. entomelas*) rockfish was conducted in 2005 using an age-based population model written in ADMB (He et al. 2006). The 2007 assessment applied the same assessment model and data compiling procedures, with new data from 2005 and 2006 including catches, age composition, and CPUE time series. The updated assessment results suggest that the stock may be approaching its rebuilding target (40% of the assumed unfished biomass level). The SSC of the PFMC recommended that the ability to classify this stock as "rebuilt" would be greatly enhanced if it was based on a full assessment, and the FED is currently undertaking this effort, including an exploration of the use of the Stock Synthesis 2 (SS2), which may be better able to handle the apparent area-specific growth rates.

7. Flatfish

Research
A manuscript on the age, growth, life history and fisheries for sand sole (*Psettichthys melanostictus*) was published (Pearson and McNally 2005), presenting a comprehensive evaluation of recently developed life history information for this species. From some 250 otoliths, the oldest fish was found to be age 8, with most fish found to be between 2 and 4 years old. Sand sole were thus found to be a relatively fast-growing, short lived species; available data also suggested a latitudinal gradient in growth rate. Although landings are relatively modest, the value of sand sole landings is high relative to most other West Coast flatfish. Maturity, growth, and life history studies of starry flounder, rex sole and sanddabs are also ongoing.

D. OTHER RELATED STUDIES

1. Western Groundfish Conference

The Fisheries Ecology Division co-hosted the Fifteenth Western Groundfish Conference, a meeting of over 200 participants representing state and federal fishery agencies, regional management councils, universities, conservation groups, and fishing and other marine industries. The meeting was held in Santa Cruz, CA in February of 2008, at the Coconut Grove Conference

Center. Other co-sponsors included the California Department of Fish and Game, the University of California Santa Cruz, and the Monterey Bay National Marine Sanctuary, and many others. The conference included oral and poster sessions on stock assessment, management targets and thresholds, advanced survey technology, ecosystem analysis, marine protected areas, habitat characterization, and general fishery biology. This conference is the only such meeting in the United States, and is the best venue for groundfish biologists to interact with colleagues from the fishing industry, the government, and universities. Dr. Alan Longhurst presented the keynote address entitled "The Sustainability Myth," challenging scientists and fishermen to reflect on the broad and cumulative impacts of fishing on marine ecosystems. The lecture was followed by an interactive panel of regional fishermen, scientists, and fisheries managers who discussed their perceptions of sustainability and the state of regional fisheries with conference participants.

2. Historical Catch Reconstruction

The Fisheries Ecology Division's Groundfish Analysis Team completed work on a California commercial landings database covering 1931 to 2007 based on California Department of Fish and Game (CDFG) records that had been available only in microfiche format. This spatially explicit landings information from 1931 through 1968 were recovered using funds and services provided by the NESDIS Climate Database Modernization Program (CDMP). The recovered data, when combined with more recent landings estimates from the California Cooperative Groundfish Survey from 1969-2007, forms one of the longest detailed catch records in the U.S. The 1931-68 period includes monthly summaries of catches by 10-minute geographic blocks. These data are now openly available to the public for use in stock assessments and monitoring of climate effects. This effort will provide historical catch information with a high degree of spatial resolution, which will be tremendously useful in both stock assessments and ecosystem models based on understanding past and future consequences of spatial exploitation patterns.

In addition to these data recovery efforts, FED staff have been involved in an ongoing effort to examine the reliability of more recent commercial groundfish landings estimates, together with staff from the Pacific States Marine Fisheries Commission and the California Department of Fish and Game. This effort represents a comprehensive examination of potential problems with species misidentification, landing receipt errors and unusual patterns in landings. Conclusions indicate that most landings estimates (by volume) have been at least somewhat reliable, although some problems are difficult to resolve. For example, catch histories for as many as 27 rarely or infrequently encountered Sebastes species in California waters are considered to be unreliable (Pearson et al., in prep), which will make meaningful assessments of vulnerability to overexploiation and the setting of appropriate total catch limits difficult.

The landings reliability assessment, as well as the historical catch reconstruction effort, are also critically important to the ongoing effort by the SSC of the PFMC to reconstruct consistent catch histories at the species level for west coast groundfish, particularly for rockfish (*Sebastes* species), which have typically been reported as a small number of market categories with a broad (and often time-varying) species composition.

3. Molecular Genetics in La Jolla

The La Jolla laboratory of the SWFSC houses a collection of over 20,000 groundfish tissue samples, which includes virtually all extant rockfish species. These samples have enabled the recent completion of a comprehensive and robust phylogenetic hypothesis for the genus (Hyde and Vetter 2007). Additionally, scientists in the genetics program have developed many genetic markers for groundfish, and have been working to determine stock structure and dispersal distances, examine mating systems, increase the species resolution of ichthyoplankton surveys, and are helping with the design of MPA networks.

The comprehensive phylogeny for Sebastes provided evidence for a cryptic species pair within the currently recognized vermilion rockfish (*S. miniatus*). The validity of this assertion was tested using a combined genetic and morphologic study (Hyde et al. 2008a). The results of this study strongly supported the existence of two species and a tentative name (*S. crocotulus*, "sunset rockfish") has been applied to the new species. A formal description of *S. crocotulus* is currently in preparation (Hyde in prep.) and will be submitted within the next few months. *S. crocotulus* and *S. miniatus* are separated primarily by depth and *S. miniatus* has a much broader geographic distribution. *S. miniatus* occurs from at least Vancouver Island, Canada to Punta Baja, Mexico and is found primarily shallower than 100 m. *S. crocotulus* is found from Monterey, CA to Punta Colnett, Mexico but is most abundant within the Southern California Bight, deeper than 100 m. The two species can be reliably separated by gill-raker counts and are significantly different at several morphometric characters.

Following the above study, a study of genetic connectivity between populations of *S. miniatus* was initiated (Hyde and Vetter in prep). A high-degree of genetic heterogeneity was observed among sample locations. Analyses supported a moderate genetic break across Point Conception with weaker breaks observed across Cape Blanco and possibly Cape Mendocino. There was a strong relationship between increasing genetic and geographic distance. The slope of this relationship was used to calculate larval dispersal values. The results suggest limited larval dispersal for vermilion rockfish, similar in magnitude to dispersal values obtained from our previous studies on brown, copper, and grass rockfish. These results are extremely valuable when designing MPA's to manage this and similar species.

Additionally important to the proper management of exploited species, particularly highly fecund, r-selected fishes, which often show strong discrepancies between census and effective population sizes, such as Sebastes spp., is the understanding of mating systems. Paternity analysis was performed on a phylogenetically and ecologically diverse sample of Sebastes species, with multiple paternity found in 14 of the 35 broods and 10 of the 17 examined species (Hyde et al. 2008b). This finding suggests that this polyandrous mating system is not a rare event within a single species and is likely common throughout the genus. Additionally we found that at least 3 sires can contribute paternity to a single brood. Hyde et al. (2008b) suggest that multiple paternity may be a form of bet hedging that serves to maximize genetic diversity within broods and that, regardless of the selective value at the level of individual fitness, the net effect at the population level may be a genetic buffer to the consequences of overexploitation.

4. 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 and Yoklavich, in press.); 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). During a two week cruise along the Central California coast in November 2007, FED researchers spent time in Cordell Bank, Monterey Bay and off Point Sur, using the ROV to identify and map distribution of young-of-year rockfishes.

5. 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). This 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. The project is currently focused on the relationship between fishery behavior and port-level fishery infrastructure. Related efforts include the development of a Bayesian approach to estimating technical efficiency in the limited entry groundfish trawl fleet, in which an analysis is currently focused on the effects of the 2003 trawl vessel buyback program on technical efficiency in that fishery.

The Economics Team is also working in collaboration with the Environmental Research Division on an analysis of the economic effects of the Rockfish Conservation Areas on the groundfish trawl fleet. The ERD has expanded it's mapping of groundfish trawling to cover all of California's offshore waters out to 700 fathoms. Data consists of start and end locations of all tows from trawl logbooks from 1977 to 2005 linked to landings receipts for weight of market species. This year maps were created of the distribution and density of species from the trawl fishery for years before and during rockfish conservation area closures. Files of the 25 different RCA boundaries from 2002 to 2005 were created to overlay these maps. These data are being analyzed to quantify changes in fishing location and effort of the limited entry trawl fleet resulting from the RCA closures, including the spatial distribution of trawling by vessels from each port. This project will include analysis of (a) adaptations made by West coast groundfish trawlers in terms of movement between fisheries, and (b) adaptations by California groundfish trawlers in terms of spatial redistribution of effort and changes in fishing strategies.

6. MPA Center working groups

Currently a number of small working groups are being supported MPA Science Center Working Group on MPAs and Fisheries Science. One such group is the Density ratio working group. The premise of this collaboration is the recognition that marine reserves introduce several new sources of uncertainty to traditional fisheries stock assessment and management, requiring new tools for managers. For relatively data rich species, concerns have been raised regarding the impact of increasing spatial heterogeneity in population abundance and demographics. However for data poor stocks and assemblages (such as most California nearshore fisheries), it is possible that such heterogeneity could be used to provide guidance to management. For example, the relative abundance of target species in the fished area relative to the unfished area, and use a control rule analogous to the State of California's existing 60-20 rule to restrict catch or season when the density outside the MPA falls below ~60% of the density within MPAs. The rule could use the average densities of several representative species that could be adequately monitored (with separate OY's for assessed species). Cooperative surveys to develop relative abundance indices could improve industry acceptance as well as supplement survey funding. Although management system based on ratios of fished to unfished densities is appealingly simple in concept, a number of details need to be thoroughly evaluated before such an approach might be applied. The current working group is addressing several key questions regarding the feasibility of such an approach, based primarily on simulations of the effectiveness of such an approach using a simple management strategy evaluation (MSE).

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2007 - PRESENT

1. Primary Literature Publications

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., and **M. M. Yoklavich**. 2007. Multiscale habitat associations of deepwater demersal fishes off central California. Fishery Bulletin 105(2):168-179.

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

Conti, S. G., **B. D. Maurer**, M. A. Drawbridge, and **D. A. Demer**. 2007. Measurements of total scattering spectra from bocaccio (*Sebastes paucispinis*). Fish. Bull. 105:153-157.

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., K. Baltz, A.J. Phillips, and W.A. Walker. 2007. Range expansion and trophic interactions of the jumbo squid, *Dosidicus gigas*, in the California Current. California Cooperative Oceanic and Fisheries Investigations Reports 48: 131-146.

Field, J.C., E.J. Dick, M. Key, **M. Lowry**, Y. Lucero, **A. MacCall, D. Pearson, S. Ralston**, W. Sydeman, and J. Thayer. 2007. Population dynamics of an unexploited rockfish, *Sebastes jordani*, in the California Current. pp 451-472 in J. Heifetz, J. Dicosimo, A.J. Gharrett, M.S. Love, V. M. O'connell and R.D. Stanley (editors) Proceedings of the Lowell-Wakefield Symposium on the Biology, Assessment and Management of North Pacific Rockfish. University of Alaska Sea Grant: Anchorage, Alaska.

Fisher, R., **S.M. Sogard**, and S.A. Berkeley. 2007. Trade-offs between size and energy reserves reflect alternative strategies for optimizing larval survival potential in rockfish. Mar. Ecol. Prog. Ser. 344:257-270.

Francis, R. C., M. A. Hixon, M. E. Clarke, S. A. Murawski, and **S. Ralston**. In press. Ten commandments for ecosystem-based fisheries scientists. Fisheries.

Holloway, G., and **D. Tomberlin**. 2007. Bayesian Ranking and Selection of Fishing Boat Efficiencies. Marine Resource Economics 21:407-424.

Hyde, J. R., Kimbrell, C. A., Budrick, J. E.**, Lynn, E. A., and Vetter, R. D.** 2008a. Cryptic speciation in the vermilion rockfish (Sebastes miniatus) and the role of bathymetry in the speciation process. Mol. Ecol. 17:1122-1136.

Hyde, J. R., Kimbrell, C., Robertson, L., Clifford, K**., Lynn, E., and Vetter, R. D.** 2008b. Multiple paternity and the maintenance of genetic diversity in the live-bearing rockfishes, genus Sebastes. Mar. Ecol. Prog. Ser. 357:245-253.

Hyde, J. R. and R. D. Vetter. 2007. The origin, evolution, and diversification of rockfishes of the genus Sebastes (Cuvier). Mol. Phylo. Evol. 44:490-811.

Laidig, T. E., J. R. Chess, and D. F. Howard. 2007. Long term trends in annual abundance of juvenile rockfish (*Sebastes spp.*) off northern California and possible mechanisms for the variation. Fisheries Bulletin 105: 39-48.

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.

Mills, K. L., **S. Ralston**, **T. Laidig**, and W. J. Sydeman. 2007. 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. 2007. Identification of northeastern Pacific rockfish using multilocus nuclear DNA genotypes. Transactions of the American Fisheries Society 136: 272-280.

Pearson, D.E., and S.V.G. McNally. 2005 (published in 2007). Age, growth, life history, and fisheries of the sand sole, Psettichthys melanostictus. Marine Fisheries Review 67(4):9-18.

Pearson, D.E., B. Erwin and M. Key. In prep. Reliability of California's Groundfish Landings Estimates.

Phillips, A. J., **S. Ralston**, R. D. Brodeur, T. D. Auth, R. L. Emmett, C. Johnson, and V. G. Wespestad. 2007. Northward shift in the location of spawning and recruitment of Pacific hake (*Merluccius productus*) in the northern California Current. CalCOFI Reports 48.

Pinkard, D. R., J. L. Butler, and **D. A. Demer**. In prep. Diversity, community structure and substrate and depth preferences of rockfish in the Southern California Bight.

Punt, A.E., and **S. Ralston**. 2007. A management strategy evaluation of rebuilding revision rules for overfished rockfish stocks. In J. Heifetz, J. Dicosimo, A.J. Gharrett, M.S. Love, V. M. O'connell and R.D. Stanley (editors) Proceedings of the Lowell-Wakefield Symposium on the Biology, Assessment and Management of North Pacific Rockfish. University of Alaska Sea Grant: Anchorage, Alaska.

Ralston, S., and M. R. O'Farrell. 2007. Spatial variation in fishing intensity and its effect on yield. Can. J. Fish. Aquat. Sci. 65(4):588-599.

Sakuma, K. M., S. Ralston, and D. A. Roberts. 2007. High-frequency patterns in abundance of larval Pacific hake, Merluccius productus, and rockfish, Sebastes spp., at a single fixed station off central California. Fisheries Oceanography 16(4):383-394.

Sogard, S.M., S.A. Berkeley, and R. Fisher (in press). Maternal effects in rockfishes (Sebastes spp.): a comparison among species. Mar. Ecol. Prog. Ser.

Sogard, S.M., **E. Gilbert-Horvath**, **E.C. Anderson**, **R. Fisher**, S.A. Berkeley, and **J.C. Garza**. 2008. Multiple paternity in viviparous kelp rockfish, Sebastes atrovirens. Env. Biol. Fish. 81:7-13.

Stewart, I. J., and **K. R. Piner**. 2007. Simulation of the estimation of the functional form of ageing bias in an integrated stock assessment of canary rockfish using bomb radiocarbon based ages. Mar. Fresh. Res. 58(10):905-913.

Yoklavich, M. M., M. S. Love, and **K. A. Forney**. 2007. A fishery-independent assessment of an overfished rockfish stock, cowcod (Sebastes levis), using direct observations from an occupied submersible. Canadian Journal of Fisheries and Aquatic Sciences 64(12):1795-1804.

2. Other Publications

Dick, E.J., S. Ralston and D. Pearson. 2008 Status of cowcod, *Sebastes levis*, in the Southern California Bight. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

Field, J.C. 2008. Status of the Chilipepper rockfish, *Sebastes goodei*, in 2007. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

Field, J.C., E.J. Dick and A.D. MacCall. 2007. Stock assessment model for the shortbelly rockfish, Sebastes jordani, in the California Current. NOAA Technical Memorandum NMFS/SWFSC 405. 83pp.

He, X., D. Pearson, E.J. Dick, J. Field, S. Ralston, and A.D. MacCall. 2008. Status of the Widow Rockfish Resource in 2007. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

Key, M.**, A.D. MacCall, J.C. Field,** D. Aseltine-Neilson and K. Lynn. 2008. The 2007 Assessment of Blue Rockfish (*Sebastes mystinus*) in California. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

MacCall, A.D. 2008. Status of bocaccio off of California in 2007. In: Status of the Pacific Coast Groundfish Fishery Through 2007, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses Portland, OR: Pacific Fishery Management Council.

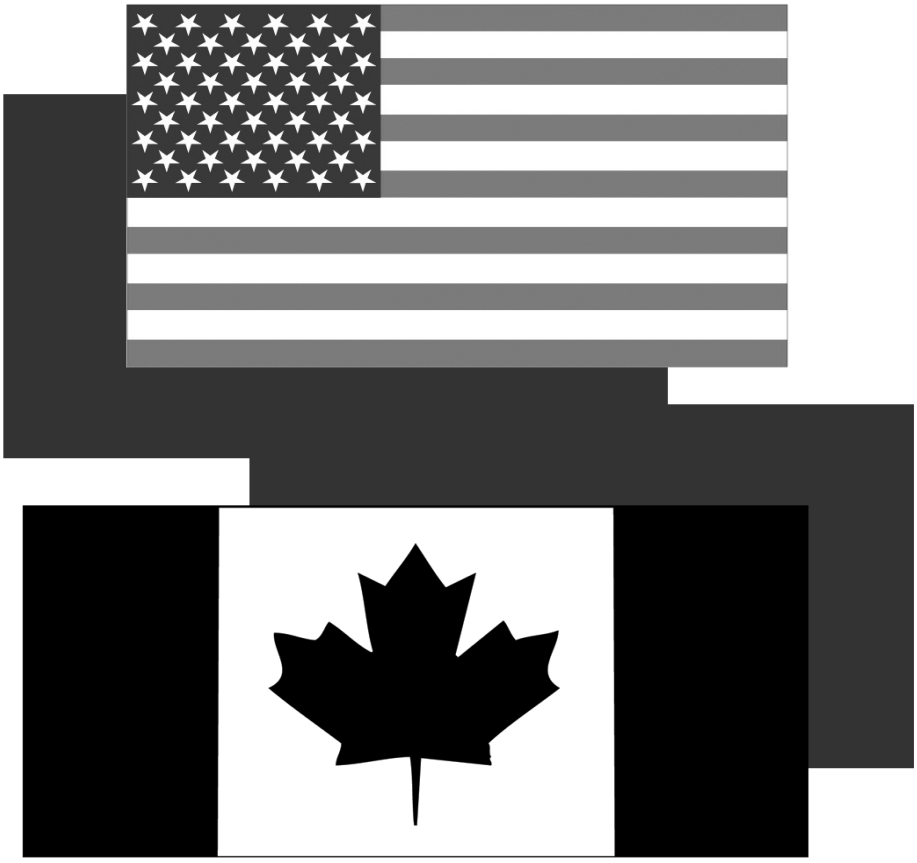
Watson, W., **S. M. Manion**, and **R. L. Charter**. 2007. Ichthyoplankton and station data for oblique (bongo net) plankton tows taken during a survey of shallow coastal waters of the Southern California Bight in 2004 and 2005. U. S. Dep. Commer. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-410. 63p.

Report of the Technical Subcommittee of the Canada-United States Groundfish Committee

Forty-Ninth Annual Meeting of the TSC

May 6-7, 2008

Seattle, Washington



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

Compiled by the Pacific States Marine Fisheries Commission