NMFS Southwest Fisheries Science Center

Draft Agency Report to the Technical Subcommittee

of the Canada-U.S. Groundfish Committee

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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. George Watters) , the Protected Resources Division (led by Dr. Lisa Ballance), and the Fisheries Resources Division (led by Dr. Russ Vetter). 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 58+ 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, we are systematically working back through the archived CalCOFI ichthyoplankton samples to bring all identifications up to current standards; to date we have completed all samples collected from 1969 to the present. In addition, we are 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 1989 to the present and we continue to work back through the time series for both eggs and larvae.

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. From 2005-2007, pelagic juvenile rockfish catches in the core part of the survey area were at very low levels, with some evidence of a redistribution of fish to the north and the south in 2007. Catches in 2008 improved slightly relative to 2007, but overall rockfish catch remained lower than average. There is typically strong covariance among the ten most frequently encountered rockfish species in the survey. However in 2008 most of the rockfish observed were "northern" species such as widow, canary, and yellowtail rockfish, while the traditionally most abundant species in this region, particularly shortbelly rockfish, remained at record low levels. Market squid were also encountered at below average numbers in 2008, but had increased over the 2005-2007 period. By contrast, Pacific sardine numbers were down modestly in 2008, and northern anchovy numbers were down significantly, relative to the 2005-2007 period. The trends observed in these four indicators are consistent with trends across a number of other taxa, and ongoing efforts include characterizing these assemblages and their relationship to physical conditions in the California Current.

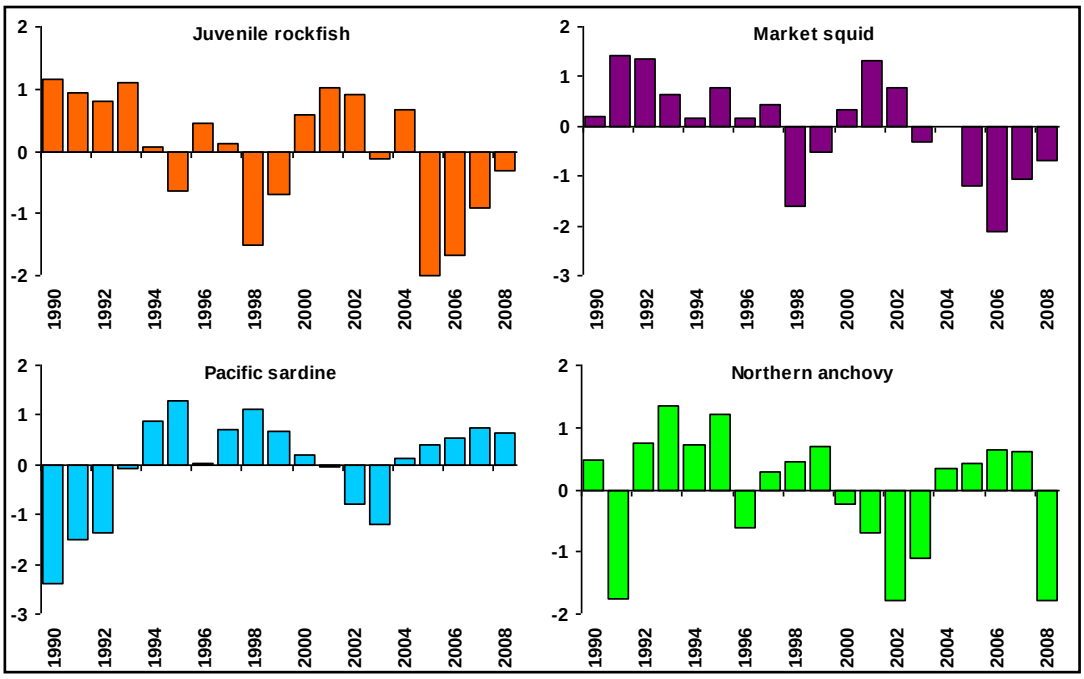


Figure 1. Standardized anomalies of the log of mean values by year for four key forage species that are well sampled in the SWFSC juvenile rockfish midwater trawl survey (figure reflects catches in the historical Central California core survey area only).

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 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.

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 Pacific States Marine Fisheries Council (PSMFC) and 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 its inception. FED staff scientists have been represented on the Groundfish Management Team (GMT) in every year since its establishment, and have also been active participants in the Scientific and Statistical Committee (SSC) for the PFMC.
Depletion-Corrected Average Catch

FED staff developed Depletion-Corrected Average Catch (DCAC), an extension of the potential yield formula, that provides robust estimates of sustainable yield for data-poor fisheries on long-lived species (MacCall, in review). The catch stream is divided into a sustainable yield component and an unsustainable "windfall" component associated with a one-time reduction in stock biomass. The size of the windfall is expressed as being equivalent to a number of years of sustainable production, in the form of a "windfall ratio." DCAC is the cumulative catch divided by the sum of the number of years in the catch series and this windfall ratio. Input information includes the sum of catches and associated number of years, the relative reduction in biomass during that period, the natural mortality rate (M, which should be less than 0.2), and the assumed ratio of F_{MSY} to M. These input values are expected to be approximate, and based on estimates of their imprecision, the uncertainty can be integrated by Monte Carlo exploration of DCAC values.

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. These studies were expanded in 2008 to additional species common in deeper habitats (Sogard et al., 2008). 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

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

Modeling the reproductive potential of rockfishes

Members of the FED Groundfish Analysis Team completed a meta-analysis of rockfish fecundity to better characterize the reproductive output of exploited populations. Results indicate that target harvest rates are sensitive to changes in relative fecundity with size, and that Bayesian hierarchical models are a useful tool to inform predictions of fecundity at size, quantify uncertainty about those predictions, and provide predictive distributions of model parameters for unobserved species. State dependent life history models for optimal resource allocation were also developed to evaluate potential mechanisms driving these trends. Patterns of growth, maturation and reproduction observed in rockfishes are consistent with the hypothesis of a trade-off between reproduction and natural mortality.

Estimating rockfish abundance based on larval production

Ongoing efforts are underway to develop a spawning biomass point estimate of bocaccio (*S. 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 by FED staff for use in the 2009 bocaccio rockfish stock assessment.

Sounds of Captive Rockfishes

The Advanced Survey Technologies group at the Southwest Fisheries Science Center has recently been investigating sound production in rockfishes. Sound production by many fish species has been studied extensively, but little is known about sound production by rockfishes (genus *Sebastes*), and only a few species have been reported to be soniferous. To determine if additional rockfish species produce sounds, passive acoustic recordings were made during 2007/08 at Hubbs-SeaWorld Research Institute and Southwest Fisheries Science Center in tanks containing bocaccio (*S. paucispinis*), cowcod (*S. levis*), starry rockfish (*S. constellatus*), and sunset rockfish (*S. crocotulus*). Data were collected using pre-amplified hydrophones (HTI-94-SSQ) and digitized at sample rates of 44,100 or 8,000 Hz (using an Edirol R-09 recorder, or Edirol UA-5 sound card and Ishmael software, respectively). Three distinct sounds were recorded in tanks containing only *S. paucispinis* and two of those sounds occurred at different

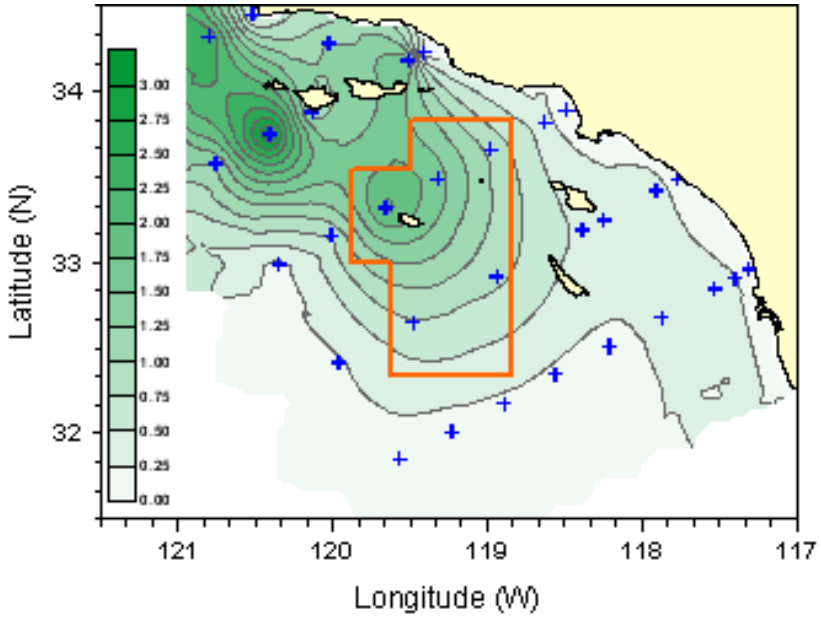


Figure 2: Historical distribution of bocaccio larval abundance (# ≅ 10 m^{-2}) from the CalCOFI database. Shown are contours of the estimated station effects from a Δ-lognormal GLM, with blue "+" symbols indicating actual station locations. The western Cowcod Conservation Area is delimited in orange.

rates during light and dark conditions (Širović and Demer, 2009). Their common characteristics were low frequency (below 800 Hz), short duration (<4 s), and low source levels (103-113 dB re: 1µPa at 1m). Also, there was evidence one or more other species produced sounds. These findings indicate that more rockfishes produce sounds than previously known.

Rockfish sounds and their potential use for population monitoring in the Southern California Bight

Southwest Fisheries Science Center is a leader in the development of non-lethal methods to assess and monitor the depleted rockfish stocks off Southern California. For example, data from multifrequency echosounders and underwater cameras have been combined to map the dispersions and estimate the abundances of rockfish at the historical fishing sites within this region. From August to October 2007, this ship-based technique was augmented with two passive-acoustic seabed recorders. One collected data at the 43 Fathom Bank for 46 d, while the other was serially deployed at 13 locations for shorter periods (1–8 d). Passive-acoustic data were analyzed for the presence of rockfish sounds. Potential sources of five pulsing sounds were identified from the optically estimated species compositions at each location, as well as from known rockfish recordings collected in aquaria. All sounds had a low frequency (900 Hz). Some were short individual pulses (0.1 s), while others were repetitive. A repetitive pulsing from bocaccio (*Sebastes paucispinis*) was the most commonly recorded sound and it occurred predominately at night. The daily calling rates at each site were quantitatively compared with the rockfish abundance estimates obtained from the active-acoustic survey, and they were positively correlated (Širović et al. 2009). These results suggest it may be feasible to use passive acoustic tools to efficiently monitor changes in rockfish populations.

A statistical-spectral method for echo classification

The frequency dependence of sound-scatter intensity is commonly exploited to classify fish, zooplankton and seabed observed in acoustic surveys. Although less utilized, techniques based on scattering statistics of echo amplitudes can also be used to extract information. For example, single-frequency echo statistics have been used to determine whether backscatter originates from single or multiple fish or from rough or smooth seabeds, and estimate scatterer sizes and densities. The efficacies of the amplitude-based techniques are challenged, however, by the usual requirement to group echo measurements to facilitate meaningful comparisons with model predictions. Groupings of data over space, time, or both, can combine scatter from multiple taxa or species, confounding the comparisons. Scientists in the Advanced Survey Technologies group at Southwest Fisheries Science Center have improved these methods with a hybrid, statistical-spectral method for target identification (SSID), which incorporates information contained in both the signal amplitudes and phases. The SSID uses multifrequency echo statistics from individual timespace intensities (pixels) to identify general scattering types, before applying model-based identification schemes for target identifications (Demer et al. 2009). The effectiveness of the SSID is demonstrated for fine-scale separation of scatter from demersal fish and the seabed and estimating seabed depth, within-beam slope, hardness and roughness, and the height of the dynamic acoustic dead zone.

Assessments

FED staff have led the development of stock assessments for three overfished rockfish species in 2009: bocaccio (*S. paucispinis*), widow rockfish (*S. entomelas*), and cowcod (*S. levis*). All three assessments with be finalized in mid- 2009 following critique by independent review panels and the Scientific and Statistical Committee of the PFMC. The widow rockfish assessment will be the first full assessment since 2005, and the bocaccio assessment will be the first full assessment since 2003. The cowcod assessment is an update of the 2007 full assessment.

Assessments of greenspotted rockfish (*S. chlorostictus*) and bronzespotted rockfish (*S. gilli*) are also in preparation, outside of the PFMC process. These are the first assessments of these two species. Greenspotted rockfish is not uncommon in commercial fisheries landings, and bronzespotted rockfish have similar life histories and habitat associations to cowcod. Assessments of these species provide an opportunity to apply recently developed methods in assessment of data-poor stocks.

D. OTHER RELATED STUDIES

1. Historical Catch Reconstruction and Evaluation of the Reliability of Landings Data

The Fisheries Ecology Division's Groundfish Analysis Team completed initial work to reconstruct historical commercial groundfish landings from 1916 through 1969, based on analysis of recently digitized California commercial landings data. Spatially explicit (CDF&G block) 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. This effort centered on fulfilling a Pacific Fishery Management Council request to develop a single methodology for estimating historical catches of groundfish to the species level for use in West Coast Groundfish Stock Assessments. Recreational catches of rockfish (*Sebastes* species) were also reconstructed in a parallel effort based on historical Commercial Passenger Fishing Vessel (CPFV) logbook data that exists back to 1936 and species composition information from both recent and historical monitoring programs. A draft document (Ralston et al. in prep) has been distributed to stock assessment authors for use in this year's stock assessments, and these data are expected to be highly influential in several assessments. FED staff, working together with PSMFC and CDF&G personnel, also examined the reliability of California's commercial groundfish landing estimates from 1969-2006. Landings estimates for most species were found to be generally reliable. Issues associated with species misidentification, landing receipt errors, and unusual patterns in landings were identified and described. A technical memorandum (Pearson et al., 2008) provides users of the data (e.g. stock assessors and managers) with species-specific accounts of data reliability.

2. Molecular Genetics

Recent genetic studies at Southwest Fisheries Science Center, Fisheries Resources Division, have revealed that the heavily exploited vermilion rockfish, *Sebastes miniatus*, is really a cryptic species pair (Hyde et al. 2008a). The splitting of this species impacts stock size estimates and draws attention to the unintended consequences of depth-based management policies. Distinct differences in exploitation level between the two species necessitated an evaluation of population structure and connectivity among regional management segments of the fishery.

Staff from the Fisheries Resources Division analyzed gene flow between populations and calculated larval dispersal values using 782 bp of DNA sequence data from the mitochondrial cytochrome b gene of 681 vermilion rockfish sampled from 16 sites between Kyuquot Sound, Canada and San Quintin, Mexico. Significant genetic heterogeneity was found among sample sites ($FST = 0.0742$, $p < 0.001$). Isolation by distance analysis produced a strong and significant correlation, suggesting that average larval dispersal distance is on the order of 10's of kilometers (Hyde and Vetter, Accepted). Analysis of molecular variance showed strong and significant partitioning of genetic variance across the biogeographic boundary at Point Conception ($FCT = 0.0923$, $p < 0.001$). Additional genetic barriers were found across Cape Mendocino, Punta Colnett, Santa Monica Bay, and along the coast of Washington. These genetic barriers conform to oceanographic compartments previously proposed for the California Current ecological geography province and suggest natural management units for this species at Cape Mendocino and Point Conception.

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. Fisheries Resources Division staff performed paternity analysis 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.

Staff from the Fisheries Ecology Division have been investigating population structure of several species of *Sebastes* - shortbelly, kelp, widow, blue and black rockfish - in the California Current using data from 14-17 microsatellite markers per species. These studies have revealed a general lack of population structure in the Central/Northern California portion of this ecosystem (Gilbert-Horvath et al. 2007; Petersen et al. in prep). However, in blue rockfish a substantial signal of population structure was confirmed to be due to the presence of two cryptic groups of blue rockfish with little gene flow between them. These groups have tentatively been referred to as incipient species and assigned the interim names blue-sided and blue-blotched rockfish. These two fishes were found to be broadly sympatric, with separation between them not geographically-based (Petersen et al., in revision).

Patterns of paternity are being assessed in several species of *Sebastes* through the analyses of larvae from broods of gravid fish collected in various surveys by Fisheries Ecology Division staff. Broods from approximately 30 females from five species- widow, chilipepper, yellowtail, shortbelly and kelp rockfish (Sogard et al. 2008). Analyses have used 6-9 microsatellite loci in samples of almost 100 larvae per female to detect and quantify multiple paternity. To date, multiple sires have been found to contribute to broods of females in all but one species, yellowtail rockfish, but substantial variation in frequency of multiple paternity were found and are under continuing investigation. Two NOAA Hollings Scholarship interns have assisted in the

genetic analyses of multiple paternity in these species and subsequently used the research experiences for senior theses at the University of Hawaii and Scripps College.

3. SWFSC Current Habitat Activities

The SWFSC currently has about 33 full-time-equivalent staff members that conduct research on marine habitats of over 110 stocks and species being tracked within four FMPs (i.e. Coastal Pelagic, Pacific Coast Groundfish, Pacific Coast Salmon, and Highly Migratory) of the PFMC. Most of this effort is focused on collecting habitat data and processing and converting these data into usable products. Over the last decade, SWFSC researchers also have been refining existing habitat survey methods and tools and developing new ones. SWFSC habitat research is designed to respond to the mandates of the Magnuson-Stevens Reauthorization Act of 2006 to characterize and protect EFH and to improve stock assessments, as well as to understand and predict the effects of climate and environmental change on fish populations and marine ecosystems at global to local scales. The goal is to provide sound scientific information for effective decision-making and ecosystem management.

Researchers at SWFSC have been using a variety of survey tools and approaches to improve our assessments of demersal fishes, macro-invertebrates (including deep-water coral communities and endangered white abalone), and associated seafloor habitats in relatively deep water off central and southern California. Habitat-specific distribution (Level 1 EFH) and densities (Level 2 EFH) of juvenile and adult life stages of a few of >90 species in the Pacific Coast Groundfish FMP have been determined from non-extractive, visual surveys conducted with remotely operated vehicles (ROV), a manned submersible, scuba, laser line scan, and high-definition drop cameras, often coupled with acoustic surveys and seafloor maps of the continental shelf and upper slope off California. These methods have resulted in habitat-specific assemblage analyses on multiple spatial scales; a fishery-independent stock assessment; baseline monitoring of MPAs, and are being used in the California-NOAA-USGS Seafloor Mapping Program.

A SWFSC/FED staff member serves as chair of a team of NMFS scientists that are developing NOAA NMFS' Marine Fisheries Habitat Assessment Improvement Plan (HAIP). The HAIP presents an evaluation of NMFS' current habitat science capabilities and unmet needs, and provides recommendations for addressing deficiencies in marine habitat research. This Plan will assist NMFS in meeting the mandates of the Magnuson-Stevens Reauthorization Act, and more specifically will help to improve identification of EFH, improve stock assessments by explicitly incorporating ecosystem and habitat considerations and spatial analyses, and contribute to Ecosystem-based Fishery Management and Integrated Ecosystem Assessments.

Scientists on the SWFSC/ FED Habitat Ecology Team have been surveying fish and habitats in depths to 365 m (1200 feet) off the California coast, making direct observations from the manned submersible Delta over the last 15 years. A new review paper "Twenty years of research on demersal communities using the Delta submersible in the Northeast Pacific", co-authored by Mary Yoklavich (SWFSC FED) and Tory O'Connell (Alaska Dep. Fish Game), has been published in the monograph "Marine Habitat Mapping Technology for Alaska" (eds. J. Reynolds and G. Greene). This is one of 17 scientific papers written by international experts on the topics

of remote sensing for broad-scale mapping, visual surveys for direct characterization of habitats and associated organisms, and examples of major habitat mapping programs. The publication will be useful to the broad community in marine resource management as well as researchers in Alaska and worldwide. This publication is available online at: http://seagrant.uaf.edu/bookstore/pubs/AK-SG-08-03.html.

Members of the SWFSC/FED Habitat Ecology Team completed the second year of monitoring MPAs in deep water off central California: 2008 IMPACT Submersible Baseline Survey. This program is funded by CA Ocean Protection Council, CA Dep. Fish Game, Sea Grant, and NMFS, and is a collaborative effort among researchers from SWFSC-FED, UC Cooperative Extension Sea Grant Program, Washington State University, UC Santa Barbara, and Stanford Research Institute Intl. They made 300 dives and conducted over 700 quantitative visual transects from the manned submersible Delta to survey all demersal fishes, structure-forming invertebrates, and habitats from 24 to 365 meters deep inside and out of eight newly designated MPAs in Monterey Bay and along the Big Sur coast. This multi-year baseline will be used in the future to critically evaluate the effectiveness of the new MPAs by assessing changes in the diversity, density, and size composition of species using seafloor habitats in these areas.

SWFSC/FED researchers presently have quantified the types and locations of marine debris found during submersible surveys of seafloor habitats. The extent of marine debris and its potential impacts on organisms living in deepwater habitats on the sea floor was largely unknown off California… until now. Commercial and recreational fishing activities were the primary source of debris. Most debris in this study was made of plastic, which likely will persist in the environment for many years. The most obvious negative impacts of the debris were from commercial traps and nets that continued to capture and kill organisms, such as crabs. On the other hand, debris also provided habitat to some fishes and large invertebrates. A manuscript on their findings is in review, and a public-service video, "Keepers of the Deep," has been screened at various film festivals and is available at (http://swfsc.noaa.gov/news.aspx?id=13064). This new video hopefully will increase public awareness of marine debris in deepwater habitats off California.

Habitat data and methods developed by the SWFSC/FED Habitat Ecology Team were used in the recent risk assessment and policy development for EFH of groundfishes on the West Coast. A SWFSC/FED biologist is a member of the PFMC Ad Hoc EFH Review Committee, which is a neutral advisory body comprised of diverse disciplines including scientists (federal, tribal, and academic), managers, the fishing industry, and non-governmental organizations. This Committee advises the Council on proposals to change designations of EFH, Habitat Areas of Particular Concern, and Ecologically Important Habitat Closed Areas, which have been implemented as part of the West Coast Groundfish EFH-EIS to identify and protect EFH and to mitigate for the adverse effects of groundfish fishing activities. The Groundfish FMP requires review and update of these designations during a periodic 5-year review process, and also allows for reviews as needed during interim periods.

4. 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 its 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. 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. To facilitate this analysis a manuscript has been drafted reviewing the history of groundfish trawl management, including trip limits and spatial closures. 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.

The Economics Team is conducting economic surveys of southern and northern California recreational anglers. Both surveys involve collection of data on angler fishing patterns, preferences, expenditures and demographics. In addition, conjoint methods are being used in the southern California survey to determine angler preferences for rockfish versus other species, and in the northern California survey to determine angler preferences for differing combinations of groundfish regulations (bag limits, area and season closures) The survey will be conducted in summer 2009.

5. MPA Center Density Ratio Working Group

The MPA Science Center and Fisheries Ecology Division have been wrapping up their efforts to evaluate the efficacy and policy implications of using marine protected areas as reference sites for data poor fisheries (such as nearshore groundfish). 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 data poor stocks and assemblages (such as most California nearshore fisheries), it is possible that the

resulting heterogeneity in stock abundance and distribution could be used to provide guidance to management, by adjusting catch or effort limits based on the relative abundance of target species in the fished area relative to the unfished area. Cooperative surveys to develop relative abundance indices could improve industry acceptance as well as supplement survey funding.

At the final meeting of the Density Ratio working group in Santa Barbara on February 23-24, 2009, several members of the group presented results that evaluated the feasibility of such methods using management strategy evaluations. Although these simulation studies have uncovered some potential problems in implementing such an approach, they generally suggest that it is tractable and may hold promise. Other members of the working group have been evaluating the institutional barriers that would challenge such management regimes, with a particular focus on how co-management systems for marine resources could be defined and implemented. Three meetings of this group, in addition to summer support for a graduate student, have been supported by the MPA Science Center over the last two years, but support has now been exhausted. Several members of the group have therefore begun to investigate alternative sources of funding to continue the effort. The meeting included participants from NOAA (FED/SWFSC and Channel Islands National Marine Sanctuary), the California Department of Fish and Game, the University of Washington, the University of California Santa Barbara, Hopkins Marine Station, Pew Charitable Trusts, Commonweal, and Environmental Defense.

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2008 – PRESENT

1. Primary Literature Publications

Black, B.A., G. W. Boehlert, and **M. M. Yoklavich.** 2008. Establishing climate–growth relationships for yelloweye rockfish (*Sebastes ruberrimus*) in the northeast Pacific using a dendrochronological approach. Fisheries Oceanography 17:368-379.

Botsford, L. W., D. R. Brumbaugh, **C. Grimes,** J. B. Kellner, J. Largier, **M. R. O'Farrell, S. Ralston,** E. Soulanille, and V. Wespestad. 2009. Connectivity, sustainability, and yield: bridging the gap between conventional fisheries management and marine protected areas. Reviews in Fish Biology and Fisheries 19(1):69-95.

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.

Demer, D.A., G.R. Cutter, J.S. Renfree and J.L. Butler. 2009. A statistical-spectral method for echo classification. ICES Journal of Marine Science, 66: In press.

Gilbert-Horvath, E. A., R. J. Larson, and **J. C. Garza**. 2006. Temporal recruitment patterns and gene flow in kelp rockfish (*Sebastes atrovirens*). Molecular Ecology 15(12):3801-3815.

Hamel, O., **K.R. Piner** and J. Wallace. 2008. A robust deterministic model describing the bomb radiocarbon bump for use in fish age validation. Transactions of the American Fisheries Society 137:852-859.

Hess, J.E., P. Moran and **R. Vetter.** A steep genetic cline in yellowtail rockfish, *Sebastes flavidus*, suggests limited dispersal across the Cape Mendocino faunal break. Submitted to Molecular Ecology.

Hyde, J. and R. Vetter. (Accepted). Population genetic structure in the redefined vermilion rockfish (*Sebastes miniatus*) indicates limited larval dispersal and reveals natural management units. Canadian Journal of Fisheries and Aquatic Sciences.

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

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

Laidig, T. E., K. M. Sakuma, J. R. Hyde, W. Watson, and C. Taylor Lawley**.** 2008. Identification, description, and daily growth of pelagic larval and juvenile squarespot rockfish, *Sebastes hopkinsi* (Family Sebastidae). CalCOFI Reports 49:212-221.

Laidig, T., D. Watters, and M. Yoklavich. Demersal fishes and habitat associations from visual surveys on the central California shelf. Coastal, Estuarine, and Shelf Science. (In Review).

Love, M.S. and **M. Yoklavich.** 2008. Habitat characteristics of juvenile cowcod, *Sebastes levis* (Scorpaenidae), in Southern California. Environmental Biology of Fishes 82:195-202.

Love, M.S., **M. Yoklavich,** and D.M. Schroeder. 2009. Demersal fish assemblages in the Southern California Bight based on visual surveys in deep water. Environmental Biology of Fishes 84:55-68.

MacCall, A.D. (in review). Depletion corrected average catch. ICES J. Mar. Sci.

O'Farrell, M., M. Yoklavich, and M. Love. Habitat and predator effects on dwarf rockfishes (*Sebastes* spp.): an information theoretic approach. Environmental Biology of Fishes (In Press).

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.

Ralston, S., and M. R. O'Farrell. 2008. Spatial variation in fishing intensity and its effect on yield. Canadian Journal of Fisheries and Aquatic Sciences 65(4):588-599.

Širović, A., G.R. Cutter, J.L. Butler and D.A. Demer. 2009. Rockfish sounds and their potential use for population monitoring in the Southern California Bight. ICES Journal of Marine Science, 66: In press.

Širović, A. and D.A. Demer. 2009. Sounds of captive rockfishes. Copeia, In press.

Sogard, S.M., S.A. Berkeley, and R. Fisher 2008. Maternal effects in rockfishes *Sebastes* spp.: a comparison among species. Marine Ecology Progress Series 360:227-236.

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*. Environmental Biology of Fishes 81:7-13.

Tomberlin, D., and G. Holloway**.** In press. Bayesian hierarchical estimation of technical efficiency in a fishery. Applied Economics Letters. Published online May 2008, print date not yet available.

Watters, D., M. Yoklavich, M. Love, and D. Schroeder**.** Assessing marine debris in deepwater seafloor habitats off CA. (In review for submission to Marine Pollution)

Wells, B.K., **J. Field**, J. Thayer, **C. Grimes**, **S. Bograd**, W. Sydeman, **F. Schwing**, and **R. Hewitt**. 2008. Untangling the relationships between climate, prey, and top predators in an ocean ecosystem. Marine Ecology Progress Series 364: 15-29.

Yoklavich, M. M. and V. O'Connell**.** 2008. Twenty years of research on demersal communities using the Delta submersible in the Northeast Pacific. In: J.R. Reynolds and H.G. Greene (eds.) Marine Habitat Mapping Technology for Alaska. Alaska Sea Grant College Program, University of Alaska Fairbanks. doi 10.4027/mhmta.2008. 10:143-155.

2. Other Publications

Baltz, K. 2008. Cruise report, NOAA Ship David Starr Jordan DS-07-03, May 4 - June 17, 2007: Rockfish recruitment assessment, Fisheries Ecology Division, NOAA NMFS SWFSC. National Marine Fisheries Service, Santa Cruz, California. 25 p. (Author not specified in document.)

Dick, E.J. 2009. Modeling the reproductive potential of rockfishes (*Sebastes* spp.). Ph.D. Dissertation, University of California, Santa Cruz.

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.

Dick, E.J. and S. Ralston. 2008. Cowcod Rebuilding Analysis. 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.

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.

MacCall, A.D. 2008. Bocaccio Rebuilding Analysis for 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.

Patrick, W.S., P. Spencer, O. Ormseth, J. Cope, **J. Field**, D. Kobayashi, T. Gedamke, E. Cortes, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. In prep. Using productivity and susceptibility indices to determine the vulnerability of a stock: Case studies from six U.S. fisheries. NOAA Technical Memorandum.

Pearson, D. E., B. Erwin, and M. Key**.** 2008. Reliability of California's groundfish landing estimates from 1969-2006. NOAA Technical Memorandum NMFS-SWFSC-431. 133 p.

Ralston, S., D. Pearson, J. Field and M. Key. In prep. Documentation of the California Commercial Catch Reconstruction Project. NOAA Technical Memorandum.

Starr, R., **M. Yoklavich**, et al. 2008. Monitoring MPAs in deep water off central California: 2007 IMPACT submersible baseline survey. CA Sea Grant College Program Publ. No. T-067, 22 p.

Yoklavich, M., et al. Marine Fisheries Habitat Assessment Improvement Plan – Report of the National Marine Fisheries Service HAIP Team. (In Review with HAIP Team)

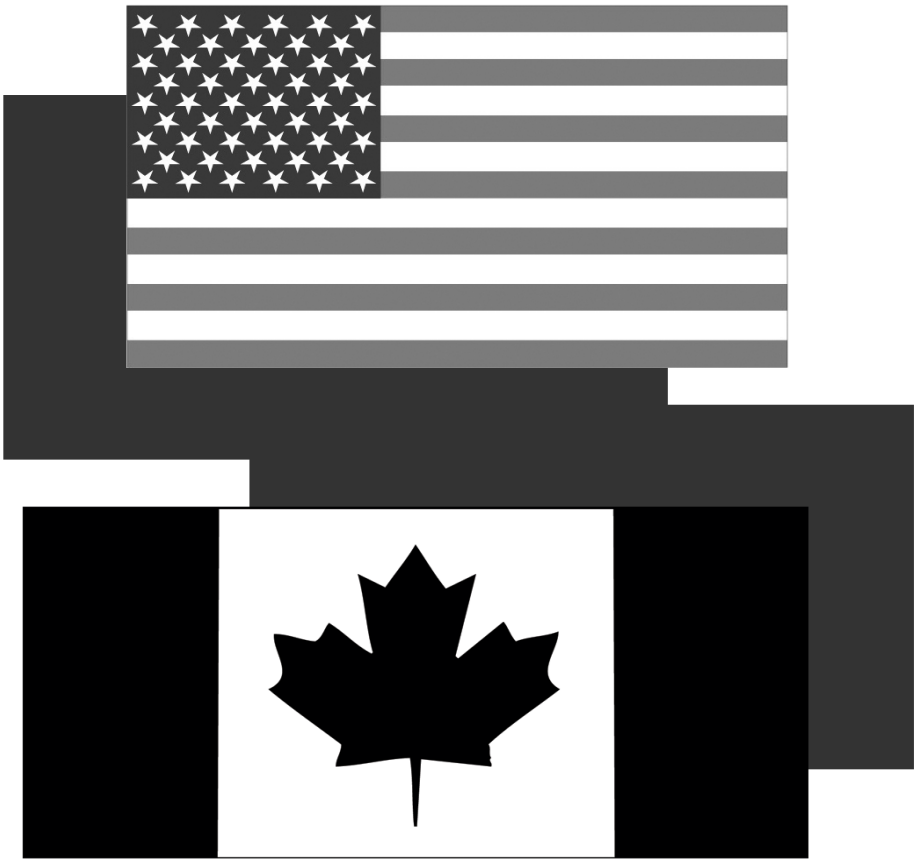
Yoklavich, M., D. Watters, and M. Love . 2008. Keepers of the Deep: deep water marine debris research off the CA coast. Available online (http://swfsc.noaa.gov/news.aspx?id=13064).

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

Fiftieth Annual Meeting of the TSC

May 5-6, 2009

Juneau, Alaska



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

Compiled by the Pacific States Marine Fisheries Commission