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 Director is Dr. Francisco Werner and the Deputy Director is Kristen Koch. 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), the Groundfish Management Team, 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 only source of groundfish research at the La Jolla facility. 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 much 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. Steve Lindley, comprises two research branches. The Fisheries Branch (led by Michael Mohr) conducts research and stock assessments in salmon population analysis, economics, groundfish, and fishery oceanography of salmonids and groundfish. The Ecology branch (led by Dr. Susan Sogard) conducts research on the early life history of fishes, salmonid ocean and estuarine ecology, habitat ecology, and the molecular ecology of fishes. Specific objectives of the 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 at 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) providing professional services (many of which fall into the above categories) at all levels, including inter-agency, state, national and international working groups. An FED economist represents the SWFSC on the Pacific Council's Groundfish Management Team.

The Environmental Research Division (ERD) is led by Acting Director Dr. Steven Bograd and 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. The 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

Genetic research on larval rockfish at the SWFSC

In 2011 the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division collaborated on a study to better discern the spatial distribution of spawning locations of different rockfish species within and around the Southern California Bight. To achieve this goal, we anlayzed ichthyoplankton samples collected in February 2005 (0502 JD) within a grid of stations that stretched north to Point Conception and south to within the Cowcod Conservation Area. Because it is often difficult to discern to species larval rockfishes based on morphology, samples were preserved in ethanol to enable identification using genetic sequencing.

We sorted 5022 rockfish larvae from the 95 0502JD stations and sequenced ~600 bp of mitochondrial *cytochrome b* from 2592 individual larvae of uncertain identity. We compared these sequences to rockfish species of known identity (Hyde and Vetter 2007) and found larvae from 34 rockfish species. Numerically, the assemblage was by far dominated by four small species (*Sebsates jordani*, *S. hopkinsi*, *S. wilsoni*, and *S. ensifer*) that were historically not targeted by fishers. However, there were also over 100 larvae of each of three targeted rockfishes (*S. rufus*, *S. paucispinis*, and *S. mystinus*; Figure B1, Panel A-C), thus providing information on spawning distribution of these species. Notably, we found 28 *S. levis* larvae (Figure B1, Panel D) and hence identified essential fish habitat for this commercially important species. In addition to single-species analysis, evaluation of rockfish diversity patterns provided insight on the biogeographic patterns of rockfish assemblages in the oceanographically variable Southern California Bight (Figure B2). At present, we are completing a small number of additional genetic identifications in stations where larva were initially subsampled and conducting statistical analyses. We anticipate completing and submitting a manuscript based on the 0502JD rockfish assemblage data by October 2012.

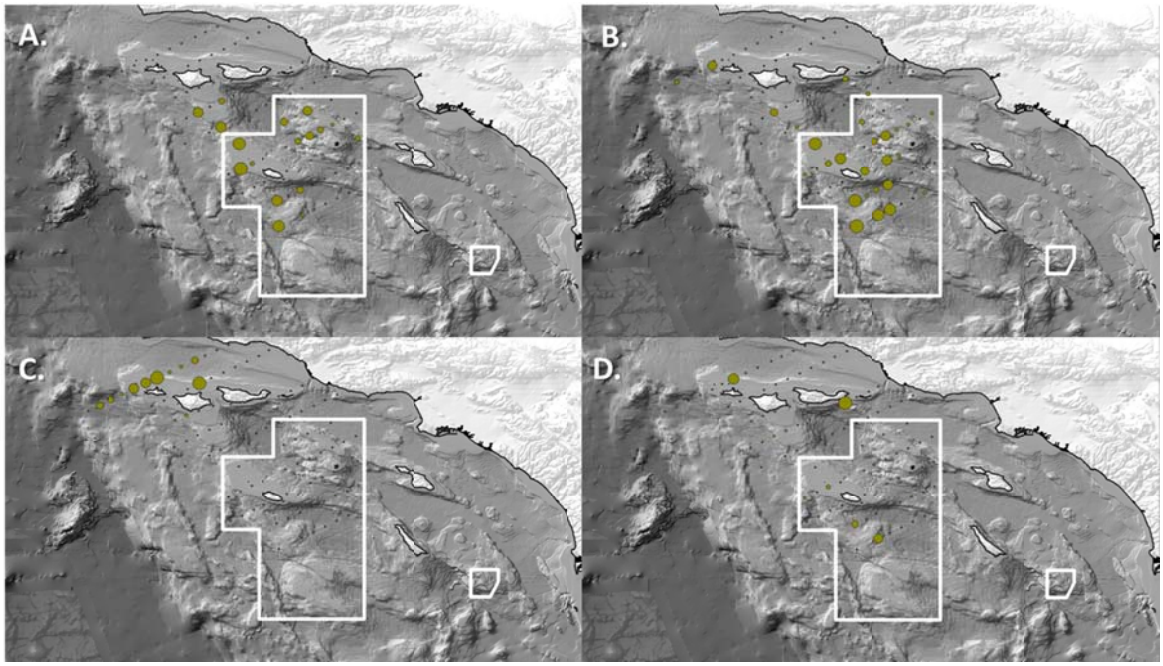

Figure B1. Distribution and abundance of **A.** *S. rufus* (range: 0 – 29 per stations), **B.** *S. paucispinis* (range: 0 - 14), **C.** *S. mystinus* (range: 0 – 23), and **D.** *S. levis* (range: 0 - 8) larvae from the 0502JD cruise.

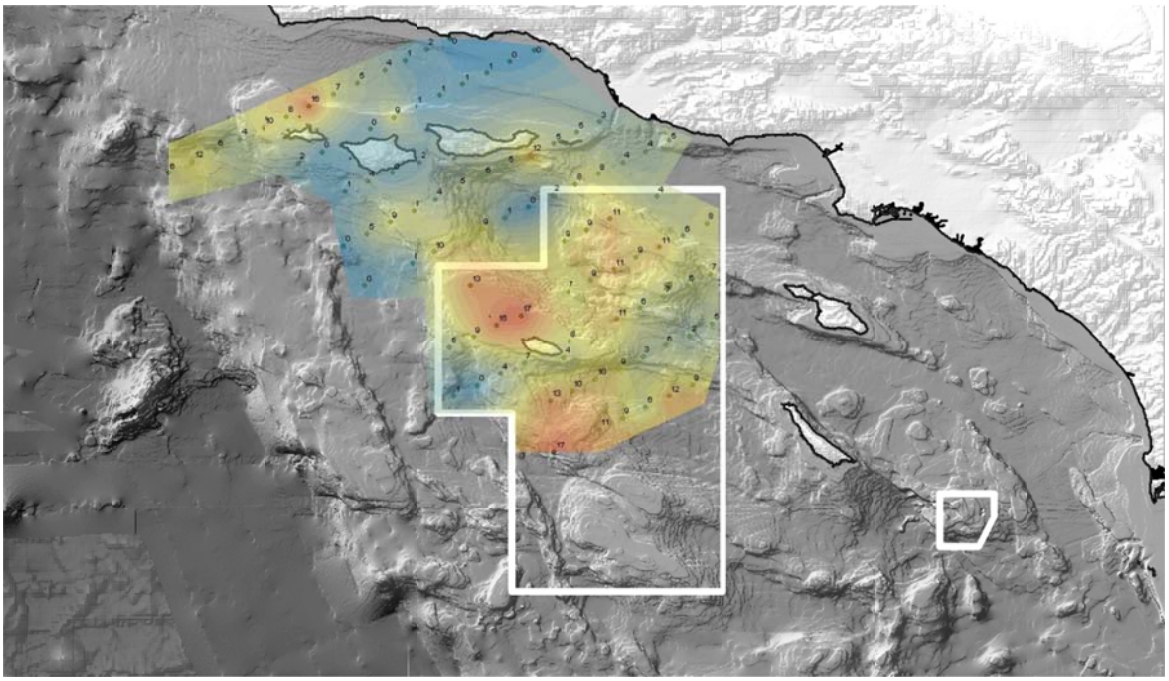
Figure B2. Rockfish species richness (no. species per station) from the 0502JD cruise. Labels depict the total number of species at a station and colors are krig-based image plots where red depicts high, and blue low, values.

In addition to the 0502JD data, we completed sorting 41 of 46 ethanol-preserved samples from the 0501NH CalCOFI cruise. Our goal is to eventually build a rockfish larval time-series from ethanol-preserved CalCOFI samples (1998-present). Initially, however, to evaluate CalCOFI rockfish sampling

efficacy, we will conduct genetic identification on the 0501NH sample and compare patterns of rockfish distribution and abundance to the fine-grained 0502JD samples. Preliminary results for this study should be available in 2012.

Juvenile Surveys

The Groundfish Analysis Team at FED has conducted an annual midwater trawl survey for juvenile rockfish and other pelagic nekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile rockfish for fisheries oceanography studies and for developing indices of year class strength for stock assessments, although many other commercially and ecologically important species are captured and enumerated as well. The results here summarize trends in the core area since 1990, as not all species were consistently identified in earlier years. From 1983 through 2008 cruises took place on the NOAA ship David Starr Jordan, but since 2009 a series of different ships has been utilized; in 2011 the cruise took place onboard the F/V Excalibur and had limited temporal and spatial coverage relative to the post-2003 period. The data for the 2011 survey presented here are preliminary, and the analysis does not account for potential differences in catchability among vessels (although see Sakuma et al. 2006). Although this survey has sampled a greater spatial area from 2004 onward (roughly Cape Mendocino to the U.S./Mexico border), the results presented here focus on the core survey area (corresponding to the region just south of Monterey Bay to just north of Point Reyes, CA) as the length of the time series leads to more informative insights. Results from the expanded survey area will be developed for future reports. A spatial analysis of the distribution of key taxa for the core area is also in development (Santora *et al*., in prep) and should be published during 2012.

The standardized anomalies from the log of mean catch rates are shown by year for six key forage species and assemblages that are sampled in this survey (Figure B3). Most are considered to be well sampled, although the survey was not designed to accurately sample either krill or coastal pelagic species which have variable depth distributions, and those numbers should be considered with caution. Trends in 2010 and 2011 were of increasing abundance for the species and assemblages that tend to do better with cool and productive conditions, including juvenile rockfish, juvenile Pacific hake, market squid and krill. In 2011, juvenile rockfish, market squid, and other groundfish (such as Pacific hake, shown, and Pacific sanddabs, not shown) were at their highest levels since the early 2000s. By contrast, the coastal pelagic forage species (adult northern anchovy and Pacific sardine) were at low levels in 2009 and 2010, although this is likely a greater reflection of their local availability and ocean conditions rather than their coastwide or regional abundance. As with past reports (e.g., Bjorkstedt *et al*. 2010), the trends observed in these six indicators are consistent with trends across a broader suite of taxa within this region, with the first and second components (of a principle components analysis) explaining 39% and 14% of the variance in the data respectively (representing strong covariance among young-of-the-year groundfish, cephalopods and euphausiids, which in turn tend to be negatively correlated with coastal pelagic and mesopelagic fishes). As with the 2010 results, the 2011 survey continued to indicate a return to conditions similar to those seen in the early 1990s and early 2000s. The groundfish analysis team is also in the process of finalizing a manuscript that characterizes the relationship between juvenile rockfish abundance and environmental factors (particularly relative sea level height) from the period 1983 through 2010 (Ralston *et al*, in prep).

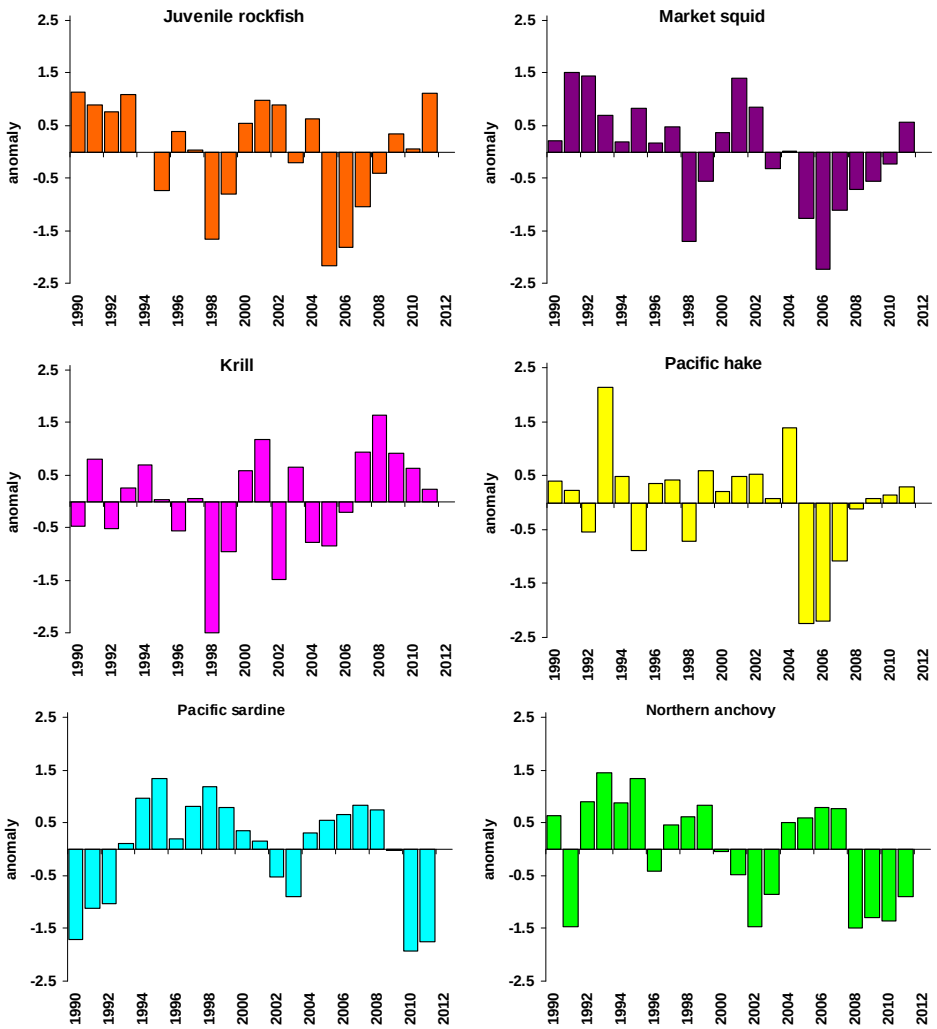

Figure B3: Long-term standardized anomalies of several of the most frequently encountered pelagic forage species from the central California rockfish recruitment survey in the core region (1990-2011 period only, not all taxa were recorded from 1983-1989).

Adult Surveys

Pilot Survey for Nearshore Groundfish

Stock assessments of west coast groundfish rely on size and age data from fishery-independent surveys to estimate the relative strength of cohorts and individual growth rates, two essential factors for determining stock productivity. Fishery-independent trawl surveys on the U.S. west coast are designed to sample species associated with low-relief shelf and slope habitats. Many nearshore groundfish species are not available to the trawl survey due to depth and habitat restrictions, but are primary targets of both recreational and commercial (e.g. live fish) fisheries. FED scientists aim to fill a gap in fishery-independent sampling of west coast groundfish by evaluating a collaborative, fishery-independent trap

survey design for species associated with nearshore and untrawlable habitats. The project was funded through the NMFS FY12 Cooperative Research Internal RFP process, and we are in the process of soliciting bids and acquiring necessary permits.

C. BY SPECIES, BY AGENCY

3. Shelf Rockfish

i. Research

Two recent publications (Buonaccorsi *et al*. 2011 & 2012) deal with a range-wide genetic study of *Sebastes paucispinis* using both anonymous and gene-associated microsatellite markers. Despite an increase in sample size and marker coverage there was no significant signal for genetic stock structure. In collaboration with researchers at USC, UCM, and Juniata College we have been work working to sequence the genomes and transcriptomes of *S. rubrivinctus* and *S. nigrocinctus.* SWFSC (FRD) is acting in a sample support and advising role on this project while the other collaborators do the majority of the sequencing and annotation.

The SWFSC FRD genetics and physiology group has begun a study of post release mortality, health, and behavior of rockfish species suffering from barotrauma injuries and released using descending devices. Animals were captured primarily from depths between 140-180 m, externally tagged with Vemco V9AP acoustic tags, and descended to depths between 40-70 m for release. In total 48 animals were tagged and released (*12 S. paucispinis, 12, S. rufus, 12 S. crocotulus, 9 S. levis, 3 S. constellatus*). External injury was assessed prior to tagging and behavior at release was recorded for subsequent analyses. Tag data is being collected over the course of 6 months and these data will be used to assess levels of immediate and delayed mortality as well as monitor shifts in behavior (horizontal and vertical movement, gross activity) over the course of the study. In addition to the tagging data samples (heart, rete mirable, head kidney) were taken from 4 species (*S. paucispinis, S. crocotulus, S. rufus, and S. constellatus*) to examine histologically for barotrauma injury. Planned work includes examining gene expression and health of fish subjected to simulated capture and release using a hyperbaric chamber.

ii. Assessments

Full stock assessments were conducted for widow rockfish (*Sebastes entomelas*, He *et al*. 2012), greenspotted rockfish (*Sebastes chlorostictus*, Dick *et al*. 2012), and blackgill rockfish (Field and Pearson 2012, see Slope Rockfish section). An update assessment and rebuilding analysis were conducted for bocaccio (*Sebastes paucispinis*, Field 2012a and 2012b). A status report for cowcod stock was also conducted in 2011 (Dick 2011).

In the 2011 widow rockfish stock assessment, all data and model structures were reanalyzed and reexamined and the assessment was reviewed by a STAR panel in July 2011. A revised version of the assessment was again reviewed by the Mop-up panel in October 2011. The assessment results from the Mop-up panel indicated that the stock was rebuilt in 2011, with stock depletion at 51.1% of unfished level. However, great uncertainties existed in the assessment, especially in the area of estimating stock-recruitment relationship because of insufficient data.

Greenspotted rockfish in California waters was fully assessed for the first time in 2011. The stock was modeled as two separate stocks (north and south of Point Conception). Data from commercial and recreational fisheries as well fishery-independent surveys were used in the assessment. Both assessment models are single sexed, since no evidence of sexual dimorphism in growth was found. The assessment

models estimated that the stock is at 37% of unexploited level south of Point of Conception, and at 31% of its unexploited level north of Point Conception. Sustainable yield estimates for Oregon and Washington were calculated using MacCall's Depletion-Corrected Average Catch method.

Update assessment for bocaccio used the 2009 stock assessment model but included new data from 2009 and 2011. The model suggested an unprecedented strong recruitment in 2010, which has an overly strong influence on the model results. Based on this result and the guidance provided by the SSC, an alternative assessment model was developed. The stock was estimated to be at 26% of unfished level in 2011. Rebuilding analysis for bocaccio provided range of reference points for management considerations.

FED scientists are also actively working on developing methods of assessing data-poor stocks and will present their findings to a Methodological Review Panel in June 2012. Included in the review are: a review of methods to generate prior probability distributions for parameters used in several models (e.g. natural mortality, FMSY/M, BMSY/B0, and current stock status). Improvements to model specifications used for depletion-based stock reduction analysis (DB-SRA), Bayesian extensions to DB-SRA, including an age-structured model with a generalized stock-recruitment relationship. The review is intended to provide a comprehensive evaluation of approaches for assessment of data-moderate (tier 2) stocks in the PFMC's Groundfish FMP. Assessments using an extended DB-SRA approach have the potential to raise the tier level of stocks to data-moderate. Status determinations of data moderate stocks are considered more certain than those of data-poor stocks, which under the Council's current ABC control rule will allow an increase in ABC due to a reduction in scientific uncertainty. In addition to methodological developments , FED scientists are developing indices of relative abundance from existing recreational data to help inform these new data-poor methods. Data from dockside surveys have been formatted into a relational database that facilitates development of CPUE indices for stocks important to recreational fisheries. Data are available at a county-level resolution, and a standardized indices will be developed for three regions (Southern California Bight, Central California, Northern California / Oregon).

FED scientists are also exploring surplus production functions which incorporate different time lags for recruited biomass and natural mortality. This project is a collaboration with E. Aalto, a Ph.D. Candidate from the University of California at Davis. Lagged production models often assume (implicitly) that all factors affecting net production (recruitment, deaths, etc.) depend on biomass a fixed number of years before the current time step. In many applications, it is preferable to specify one lag for recruitment (e.g. age at maturity), but to define replacement biomass in terms of more recent population size. A potential bias in yield estimates is introduced by ignoring differences in lag times between recruitment and mortality. An ongoing study aims to quantify the magnitude of this bias under a variety of assumptions about life history characteristics, fishing intensity, and stock status.

4. Slope Rockfish

I Research

We are conducting a focused study of maturity patterns for blackgill rockfish (*Sebastes melanostomus*) to better inform future stock assessments. Analysis of existing data has suggested unusual patterns of maturity stages throughout the spawning season that are consistent with observations of "prolonged adolescence" in other species of deepwater Sebastes. Specifically, we found unusually high numbers of stage 2 females (stage 2 equates to unfertilized oocytes) throughout, and following, the "typical" spawning (parturition) period that ranges from January through April, when one would expect those fish to move through fertilization, eyed larvae, and then spent stages. To further evaluate these findings, ovarian samples collected in collaboration with The Nature Conservancy (TNC) and fishermen in Morro Bay from 2010 through 212 have been macroscopically staged, with a subset processed for histological

analyses. Histological analysis from an initial subset of 75 blackgill rockfish ovarian tissue samples collected between June 2010 and April 2011 indicate that the high proportion of stage 2 females collected year round is likely a result both of errors in macroscopic staging and anomalous ovarian development. The most frequent discrepancy between macroscopic and histological staging was with spent or resting ovaries being macroscopically identified as being in early stages of development. Through histological examination, atretic oocytes, which might appear with the naked eye to be developing, were visible, as were microscopic structures indicative of oocyte ovulation (post-ovulatory follicles). Comparison of fresh, preserved, and histologically processed ovaries may help provide indicators of atresia that could be detected macroscopically. Additionally, ovaries from 3 females appeared to be undergoing abortive maturation, with 30-80% of the developing oocytes being resorbed. All three females were smaller than the estimated L95 (42.4 cm), and two were around the L50 (33 cm), suggesting these females were in an adolescent phase. Histological examination from more individuals will help to determine the prevalence of these abortive maturation events and their effect on production of the population.

ii. Assessments

The Fisheries Ecology Division completed a full assessment of the status of blackgill rockfish (*Sebastes melanostomus*) for the Conception and Monterey INPFC areas, using data from 1950 through 2010. The resource is modeled as a single stock. Landings peaked in the mid-1980s at just over 1000 tons, but have declined to a value of approximately 100 to 150 tons in recent years. The base case model assumes a steepness of 0.76 and a natural mortality rate of 0.063 (females) and 0.065 (males), with model results highly sensitive to the assumed value for M. Due to the very slow growth, relative scarcity of age data, and high degree of ageing error, annual recruitments were not estimated for this assessment, rather recruitment is assumed to be deterministic. Results indicate that the spawning output of blackgill rockfish was at high levels in the mid-1970s; began to decline steeply in the late 1970s through the 1980s (consistent with the rapid development and growth of the targeted fishery); and reached a low of approximately 18% of the unfished level in the mid- 1990s. Since that time, catches have declined and spawning output has increased such that the current estimated larval production is 30% of the unfished level. The base model estimates recent SPR rates variable but very close to the target levels (e.g. 0.62 in 2008, approximately 0.46 in 2009, and 2010). Exploitation rates are estimated to have ranged from 1.2 to 2.3% over recent years. Age estimates are highly uncertain, and this species has proven very difficult to age. Conducting cross reads with other laboratories, as well as consideration of alternative age validation and bias evaluation methods, are important factors for future efforts. Similarly, historical catches remain uncertain for this stock due to the likely spatial patterns of fishery development for this species (a deeply distributed species generally encountered in offshore waters). Efforts to analyze spatially explicit historical catch data are ongoing.

D. OTHER RELATED STUDIES

D.1. SWFSC FED Current Habitat Activities

The SWFSC/FED Habitat Ecology Team conducts research in response to the mandates of the Magnuson-Stevens Reauthorization Act of 2006, with a focus on deep-water California demersal communities. Our goal is to provide sound scientific information to ensure the sustainability of marine fisheries and the effective management of marine ecosystems, with objectives to: (1) improve stock assessments, especially of overfished rockfish species in complex habitats; (2) characterize fish and habitat associations to improve EFH identification and conservation; (3) contribute to MPA design & monitoring and to Coastal and Marine Spatial Planning; and (4) understand the significance of deep-sea coral as groundfish habitat. The habitat team uses a variety of survey tools and approaches to improve assessments of demersal fishes, macro-invertebrates (including members of deep-water coral

communities), and associated seafloor habitats in water depths from 20 to 900 meters off central and southern California. Habitat-specific distribution and densities of juvenile and adult life stages of numerous Pacific Coast demersal species have been determined from non-extractive, visual surveys conducted with remotely operated vehicles (ROV), manned submersibles, scuba, and towed cameras, coupled with seafloor maps of the continental shelf and upper slope off California. These surveys have resulted in habitat-specific assemblage analyses on multiple spatial scales; fishery-independent stock assessments; baseline monitoring of MPAs; documentation of marine debris on the seafloor; and predictive models of the distribution and abundance of deepsea coral communities.

Underwater Technologies to Survey West Coast Groundfishes

The FED Habitat Ecology Team recently completed a survey of demersal fishes in southern California using Nuytco's occupied *Dual Deepworker* submersible (Figure D1). This survey is part of a "calibration study" to understand the capabilities of various technologies and methods to assess West Coast groundfishes. All data from this survey are being analyzed to estimate abundance, size composition, biomass, and species diversity of demersal fish assemblages in untrawlable rocky habitats. Our results will be compared with those from two other studies conducted with an autonomous underwater vehicle (AUV; NWFSC) and a remotely operated vehicle (ROV) coupled with hydroacoustics (SWFSC). The results of this comparison will assist in our selection of survey tools to improve assessments of those species residing in high relief untrawlable habitats **(**for more details see **http://swfsc.noaa.gov/HabitatEcology/).**

Figure D1. Two-person submersible *Dual Deepworker* being launched off the F/V *Velero* during a survey of demersal fishes and habitats on the Footprint seamount in the Southern California Bight.

Development of Predictive Models to Relate Population Abundance of Rockfishes and Habitats

FED Habitat Ecology Team members are developing statistical models that predict densities and biomass of demersal fish species in untrawlable areas, and are coupling these models with broad-scale seafloor

habitat maps in a geographical-information-systems (GIS) environment to spatially predict fish densities/biomass on a regional basis. We are basing these models on fish data (identification, counts, sizes) collected during visual surveys conducted from manned submersibles off central California (Figure D2), and on a number of associated habitat variables (e.g., depth, substratum type, patch size and configuration). Spatial data sets are being compiled and the most up-to-date multibeam sonar data sets are being synthesized to provide a bathymetric base layer to support the spatially predictive models. These results will provide managers, policy makers, and the public with information that can be used in the conservation and management of sustainable marine resources (both the fisheries and associated habitats). Development of models of co-occurring species and associated habitats will have application to ecosystem-based management, providing information needed to manage a more complete demersal fish community. By including measures of spatial variability, this work will advance our understanding of the ecological processes that influence demersal fish distribution and abundance.

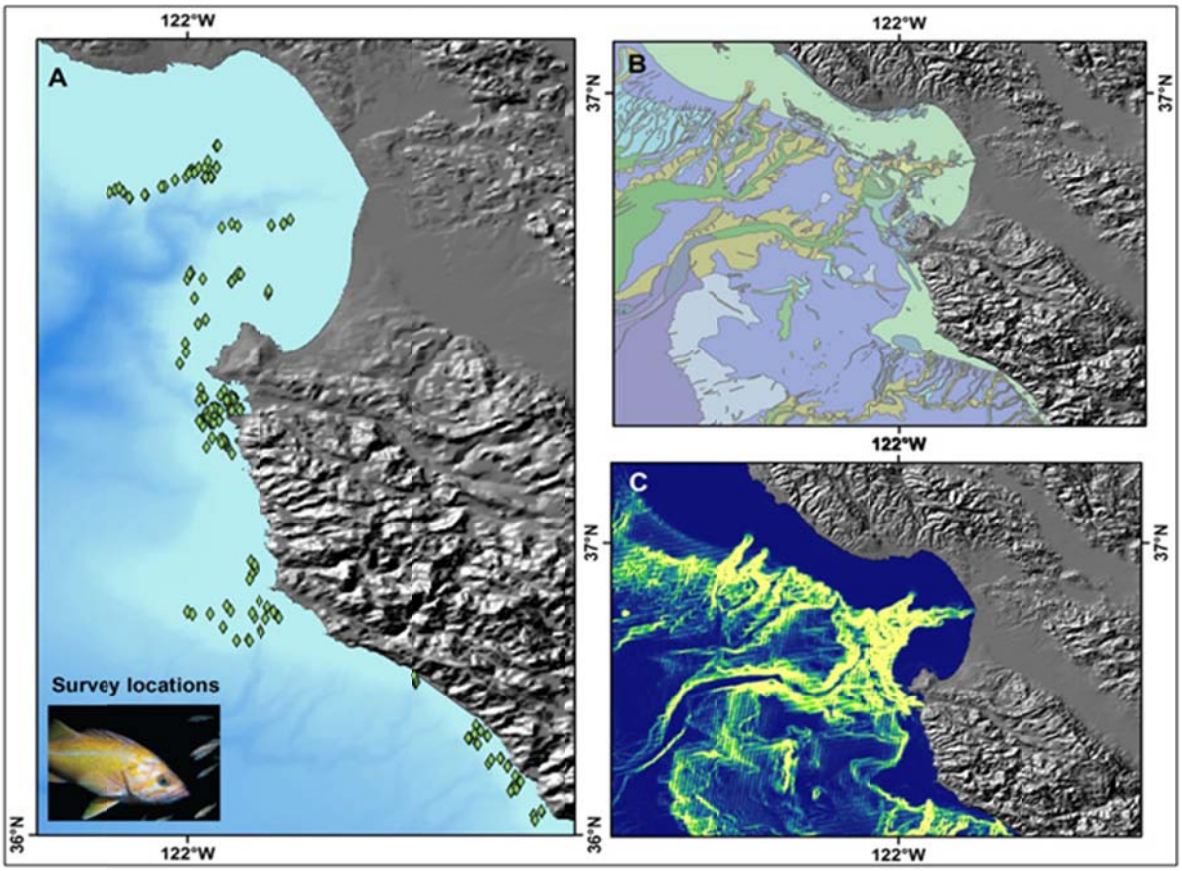

Figure D2. Spatial data sets compiled to support predictive modeling, including (A) map of submersible survey locations, (B) benthic habitat map, and (C) multibeam-derived product (e.g., habitat complexity, or rugosity).

Predicting Distribution of Benthic Macro-invertebrates

As part of the California Seafloor Mapping Project (CSMP), the FED Habitat Ecology team continues to collaborate with USGS and others to create a suite of maps detailing seafloor morphology and geology and characterizing potential benthic habitats derived from high-resolution multibeam sonar data. These efforts are being conducted coastwide, from the Oregon-California border to Mexico. We are using a towed camera sled to groundtruth these data and to survey biological components of the habitats. From

presence/absence of macro-invertebrates associated with specific sediment types, depth, and latitude, we have developed multivariate models using logistic regression to predict the distribution of various species. Coupling these results with spatial information on bottom type and depth, we have created maps of probability of occurrence of these important components of seafloor communities (Krigsman *et al*. 2012). These maps will provide managers, policy makers, and the public with information that can be used in the conservation and management of sustainable marine resources.

Deep-Sea Coral Communities and Fisheries Habitats off California

The FED Habitat Ecology Team has developed a research program to assess deep-sea coral communities associated with fisheries habitats off California. An underwater survey of corals, sponges, and associated habitats and fishes was conducted on Piggy Bank Seamount in Southern California using direct observations from a remotely operated vehicle (ROV; Yoklavich *et al*. 2011), From this survey, we found that this underwater mountain supports very high densities and a remarkable diversity of deep-sea corals and sponges. At least 26 different taxa of corals and 26 different taxa of sponges occur on rocky, mixed, and soft sediment at depths from 275 to 900 m. The high densities and diversity of these corals and sponges could reflect the wide range of habitats and depths of our survey. Whatever the reason, these communities occur inside a new Marine Reserve and will continue to receive protection from any type of fishing that impacts the seafloor. With such protection, the Piggy Bank seamount very likely will serve as a source of young corals and sponges that may repopulate surrounding rocky banks. Our characterization provides the baseline for future monitoring of change to this community and for evaluation of the effectiveness of the new MPA. In Fall of 2012 we will survey corals off northern California and southern Oregon at depths up to 1000 meters in areas of high coral bycatch from the commercial trawl fishery. This study will be conducted using an ROV (depth capability to 1,000 m) and the Seabed AUV (depth cabability to 2,000 m). Our research on deepsea corals will assist in (1) understanding those factors that influence settlement and distribution of corals in the deep sea; (2) informing the Pacific Council's management of Essential Fish Habitat; (3) addressing petitions for conservation; and (4) NOAA's Coastal and Marine Spatial Planning processes.

NMFS Southwest Regional Habitat Initiative in the Southern California Bight

As part of NMFS new Habitat Blueprint to improve habitat for fisheries, marine life, and coastal communities, the SWFSC and SW Region have initiated a 5-year plan to evaluate change in biodiversity, abundance, and size composition of demersal fish stocks and in their habitat following the closure of selected areas of the Southern California Bight to bottom-contact fishing gear. This study will significantly enhance our understanding of the effectiveness of habitat conservation measures on rebuilding commercially valuable fish stocks and on the demersal communities of which they are a part. This information will help NMFS to tailor management measures that meet its conservation mandates more efficiently and with less economic impact.

D.2. SWFSC FED Economics Team Activities

A paper co-authored by members of FED's Economics Team was accepted for publication in Marine Policy (Mason et al., in press). The paper compares the spatial distribution of groundfish trawl effort in California before and after establishment of the Rockfish Conservation Area. Results indicate some concentration of effort along parts of the closed area boundaries, suggesting the "fishing the line" behavior noted in the marine reserve literature. However other possible explanations also exist for this behavior, including the effects of coincident changes in other regulations and changing bioeconomic conditions.

The FED's Economics Team is hosting a workshop on "Productivity Change under Catch Shares" on June 11-13, 2012 in Santa Cruz. The workshop will include presentations by academic and government economists on methods of measuring productivity change. The workshop is funded by NMFS Economics and Social Analysis Division in Silver Spring, which is also providing funding for an economist from each Science Center to attend the workshop. Workshop proceedings will be published in late 2012.

The FED's Economics Team provided input into the design of a nationwide economic survey of marine recreational anglers sponsored by NMFS. The survey, which was completed in 2011, provides data that will be used to estimate the impacts of marine recreational fishing (including groundfish) on employment and income in California and other states.

D.3 Environmental Research Division (ERD) Trawl intensity mapping

The Environmental Research Division (ERD) completed maps showing the intensity of bottom trawling off California. Data from California trawl logbooks from 1997 to 2009 was summarized into periods before and after the development in 2003 of the Rockfish Conservation Areas (RCAs) that closed specific depths to trawling. These maps are being used in the Pacific Council's review of Essential Fish Habitat areas in California. Maps of species density from California commercial trawling landings for aggregated years are being developed from the same data source.

The Environmental Research Division (ERD) collaborated with the Fisheries Economics Team to analyze the effects of the Rockfish Conservation Areas (RCAs) on California's groundfish trawl fleet using 1997-2009 trawl logbook data and landings receipts. They grouped California groundfish trawlers by their level of effort within the closed area prior to the closure in order to compare effort changes between groups before and after the closure. Results suggest that the RCA may have a small effect on the level of fishing effort in California's trawl fishery. Spatial distribution of effort before and after RCA implementation suggests some concentration of effort along parts of the closed area boundaries. This pattern suggests the "fishing the line" behavior noted in the marine reserve literature, but other possible explanations exist, including the effects of coincident changes in other regulations and changing bioeconomic conditions. Effort changes around a marine reserve: the case of the California Rockfish Conservation Area (in Press 2012) Marine Policy.

D.4 FED Historical Catch Reconstruction

Currently, spatially explicit catch data exists for many California commercial landings as recorded in the California Department of Fish and Game (CDFG) blocks (10' latitude x 10' longitude grid resolution), and comparable historical catch records were recently recovered from microfiche and paper records with support from the (now defunct) NOAA Climate Data Modernization Program. These data were used to help aid in the first round of catch reconstruction efforts for California groundfish (Ralston *et al*. 2010), and since early 2011 we have initialized efforts to error check, refine and analyze these data in a spatial context, which is allowing us to utilize these important data to their full potential. Our initial efforts have focused on groundfish landings in California waters, particularly rockfish and sablefish landings in the Southern California Bight due to the unique biogeography of the region and our perception of the spatial expansion of the southern California fishery based on anecdotal accounts. Moreover, this is a region that is facing considerably complex and controversial issues regarding the consequences of large-scale area closures (rockfish conservation areas, cowcod conservation areas) on the ability to conduct stock assessments of overfished rockfish populations (e.g., cowcod, bocaccio). By stratifying habitat areas by depths at which fisheries for different groundfish target species have taken place (e.g,. 0 to 600 meters for rockfish, 100 to 1200 meters for sablefish) we have been able to develop preliminary results that include estimates of legacy groundfish landings as a function of available habitat, a suite of geostatistical analyses, and evaluation of the spatial pattern of fisheries development (Figure D3). These results are

consistent with the expectation that the distance between catch locations and ports has increased through time, and that both distance from port and depth are critical in explaining fishery development patterns.

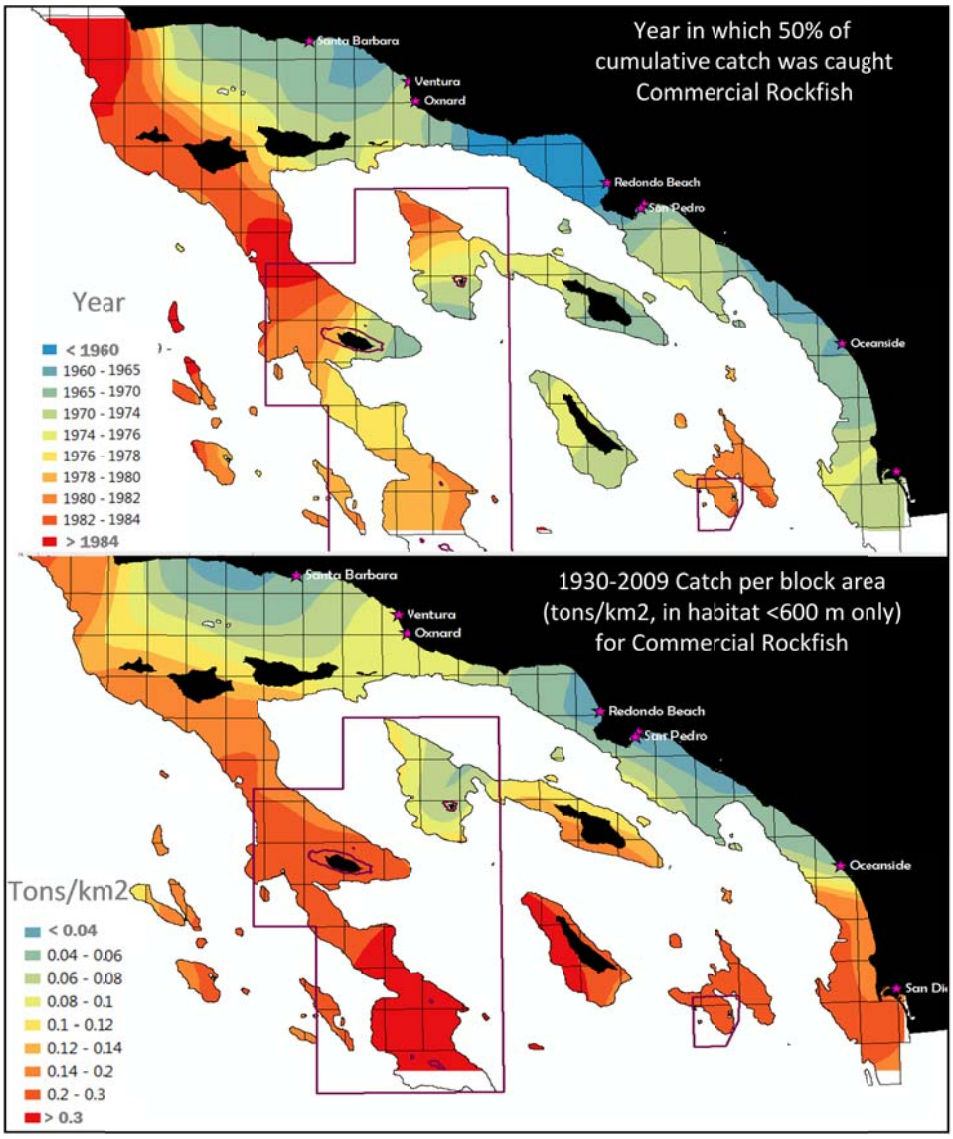

Figure D3: Preliminary results for rockfish (all *Sebastes* spp.) historical commercial landings in the southern California Bight, showing the year in which 50% of the total cumulative catch was caught (top) and the total cumulative catch per unit of habitat area (bottom). The Cowcod Conservation Areas (areas in which fishing is prohibited and bottom-contact survey data do not exist) is denoted in magenta.

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2011 – PRESENT

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2. Other Publications

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