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 Marine Mammal and Turtle Division (formerly the Protected Resources Division, led by Dr. Lisa Ballance), and the Fisheries Resources Division (led by Acting Director Dale Sweetnam). 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 Fisheries Research Division 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 FRD 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 Dr. Toby Garfield 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

B1. Swimming capabilities of early life stages of rockfish

Investigators: Neosha Kashef (UCSC) and Susan Sogard (FED, SWFSC)

Understanding the mechanisms that affect larval dispersal is critical to management of marine populations. Rockfishes (*Sebastes* spp.) do not settle to benthic habitats immediately after metamorphosis, but instead remain in the water column for weeks to months. Movements of larvae and pelagic juveniles during their months at sea are largely unknown. It is traditionally thought that young rockfishes are planktonic, moving at the mercy of ocean currents, but this assumption is unverified. In this study swimming capabilities (critical speed) of larval and pelagic juvenile stages of six rockfish species (blue (*S. mystinus*), yellowtail (*S. flavidus*), brown (S. *auriculatus*), kelp (*S. atrovirens*), gopher (*S. carnatus*), and splitnose (S. *diploproa*)) are evaluated to determine their ability to behaviorally influence dispersal. Rockfish larvae have critical speeds of 0.5 – 1.8 cm s^{-1} (1-3 body lengths per second (bl s^{-1})) at parturition, whereas newly settled juveniles are capable of swimming 8.6 – 53.5 cm s^{-1} (5-9 bl s^{-1}). Swimming ability increases throughout ontogeny and postflexion rockfishes can swim faster than mean current speeds in waters off central California. Critical speeds for *Sebastes* spp. are substantially lower than those for larvae and juveniles of tropical species at similar body sizes. Rockfishes, however, have comparable swimming speeds to some tropical species at settlement, as rockfishes settle at larger sizes. The increasing ability of rockfishes to outswim currents during their pelagic phase, acting as nekton rather than plankton, may promote individual survival as well as enhance retention and long-distance dispersal – and thus swimming has important implications for population connectivity and sustainability.

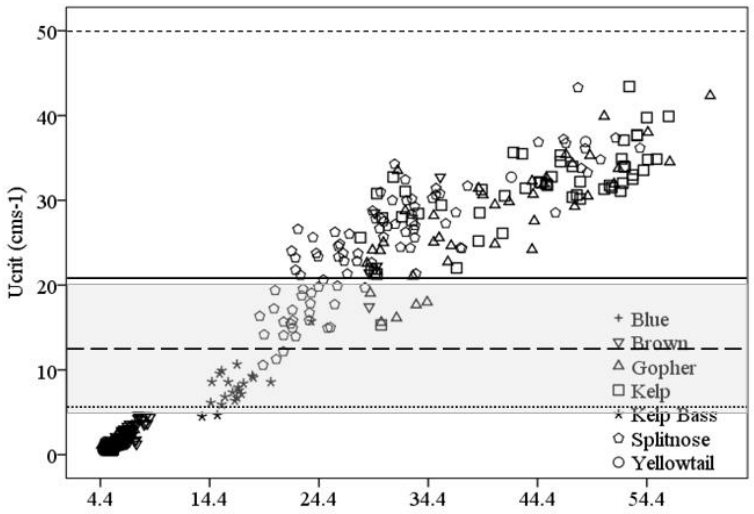

Figure B1. Relationship between absolute critical swimming speed (U_{crit}) and total length (TL) of *Sebastes* spp. throughout ontogeny from parturition to settlement. The shaded area represents current speeds between 5 and 20 cm s^{-1}, reported for Monterey Bay surface circulation by Breaker & Broenkow (1994) and the grey dashed line represents 50 cm s^{-1}, a typical speed for an upwelling jet (Largier *et al*. 1993, Rosenfeld et al. 1994, Kaplan et al. 2009). The dotted line represents a 3-week mean alongshore current speed at Terrace Point, CA (5.9 cm s^{-1}), the bold dashed line represents the 95-percentile for 33-hr filtered data (12.8 cm s^{-1}) and the solid line is the 95-percentile for 2-minute data (20.4 cm s^{-1}) (Kashef *et al*., 2014).

B2. Maternal influence on timing of parturition, fecundity, and larval quality in three shelf rockfishes (*Sebastes* spp.)

Investigators: David Stafford (UCSC) and Susan Sogard (FED, SWFSC)

Differences in maternal investment and reproductive timing can have important consequences for offspring survival. Prior studies on nearshore rockfishes have shown significant effects of maternal age and size on timing of parturition, fecundity, and larval quality, offering advantages to population persistence of maintaining age diversity in rockfish populations. In this study, reproduction in chilipepper, *Sebastes goodei*, widow rockfish, *Sebastes entomelas* and yellowtail rockfish, *Sebastes flavidus* was examined to determine whether age- and size-related effects on maternal investment and reproductive timing are exhibited in deeper-dwelling species of this genus. Parturition dates were derived from fine-scale staging of pre-parturition embryos from gravid females. Measurements of embryonic energy reserves (oil globule and yolk), indicators of condition, were used to estimate depletion rates and test for maternal age- and size-effects on larval quality. For widow and yellowtail rockfish, larger or older rockfish gave birth earlier in the parturition season than younger, smaller fishes. Maternal factors of weight, length or age were positively correlated to absolute and relative (weight-specific) fecundity in all species. A trade-off was observed between egg size and fecundity among species, with chilipepper displaying larger egg size and lower fecundity relative to widow and yellowtail rockfish. Embryonic reserves were weakly but significantly related to age only in chilipepper, with embryos from larger, older mothers having larger oil globules. Since strength of maternal effects varies among *Sebastes* species, information on maternal influence can assist managers in identifying species

most likely to benefit from the protection of age structure afforded by marine reserves or other fisheries regulations.

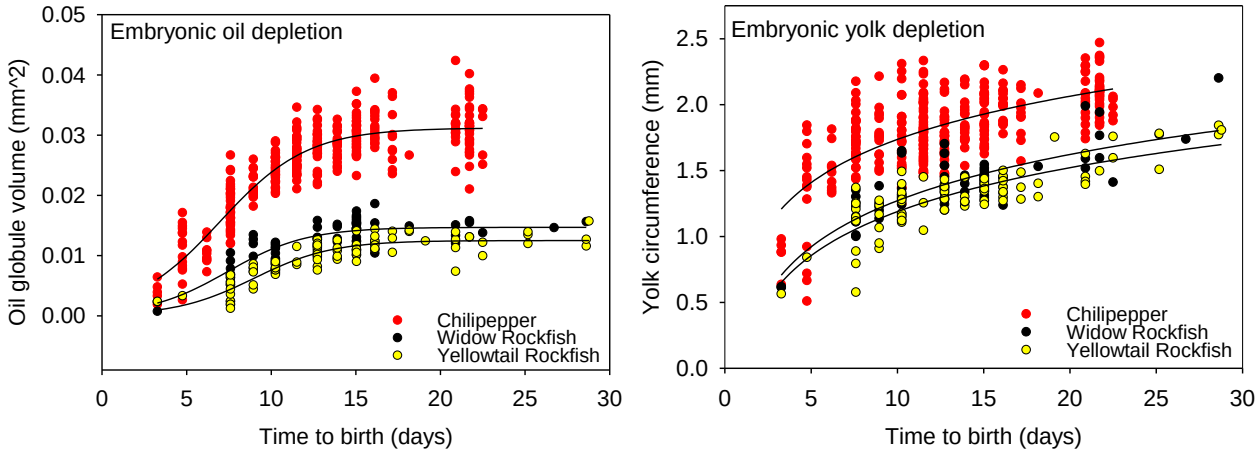

Figure B2. Energy reserve depletion of oil globule (left) and yolk (right) during embryogenesis of chilipepper, widow, and yellowtail rockfish. Each three species displayed a sigmoidal trend in depletion of oil reserves and a logarithmic depletion of yolk (Stafford *et al*., in press).

B3. Ecosystem indicators for the Central California Coast, May-June 2013

Investigators: John Field and Keith Sakuma, Fisheries Ecology Division, SWFSC

The Fisheries Ecology Division of the SWFSC has conducted an annual midwater trawl survey for juvenile rockfish and other pelagic micronekton along the Central California coast in late spring (May-June) since 1983. The survey targets pelagic juvenile (pelagic age 0) rockfish for fisheries oceanography studies and stock assessments, while simultaneously monitoring the micronekton forage assemblage (including other juvenile fishes, krill, coastal pelagic species, and mesopelagic species) and collecting oceanographic information. A recent manuscript by Ralston *et al*. (2013) describes the results from the first 28 years of the survey with respect to young-of-the-year (YOY) abundance in the core area. Standardized catch rate time series for ten species were developed from delta-GLM models that include main effects for year, station, and calendar date. The results show that interannual fluctuations of all ten species are strongly coherent but highly variable, demonstrating both high- and low-frequency components. A similarly coherent result is observed in the size composition of fish, with large fish associated with elevated catch rates. A comparison of PC1 from the juvenile rockfish abundance trends with recruitments from five rockfish stock assessments shows that the results compare favorably, but perhaps not as robustly as would be ideal, to the stock assessment estimates of year class strength. An examination of oceanographic factors associated with year-to-year variability indicates that sea level anomalies in the months preceding the survey are best correlated with high recruitment. Specifically, equatorward anomalies in the alongshore flow field in early winter are associated with elevated survival, while poleward anomalies (often associated with El Nino events) are associated with poor recruitment.

As the Ralston manuscript only included trends through 2010, we have updated that figure to reflect recruitment trends through 2013 (Figure B3). Most of the period since 2010 has been associated with higher productivity for the species and assemblages that tend to do better with cool, high productivity and high transport conditions, including juvenile rockfish, market squid and krill. In particular, the 2013 survey was associated with extremely high rockfish catches throughout both the core area and the expanded survey region, with the highest overall juvenile rockfish catches in the time series. Catches of more regularly encountered YOY groundfish, such as Pacific hake, were also at high (albeit, not record) levels (see Wells *et al*. 2013 for trends in other forage species). These observations were consistent with high reported catches of YOY rockfish and other groundfish in power plant impingement surveys, from scuba divers conducting a range of scuba surveys, and from commercial and recreational fishermen. Other papers report on the relationship between fronts and juvenile rockfish catches (Sakuma *et al*. 2013), on the anomalous coastwide distribution of YOY rockfish during the mid-2000s (Ralston and Stewart 2012) and on the relationships between YOY rockfish, YOY flatfish and other micronekton abundance and seabird productivity in central California (Santora *et al*. 2013).

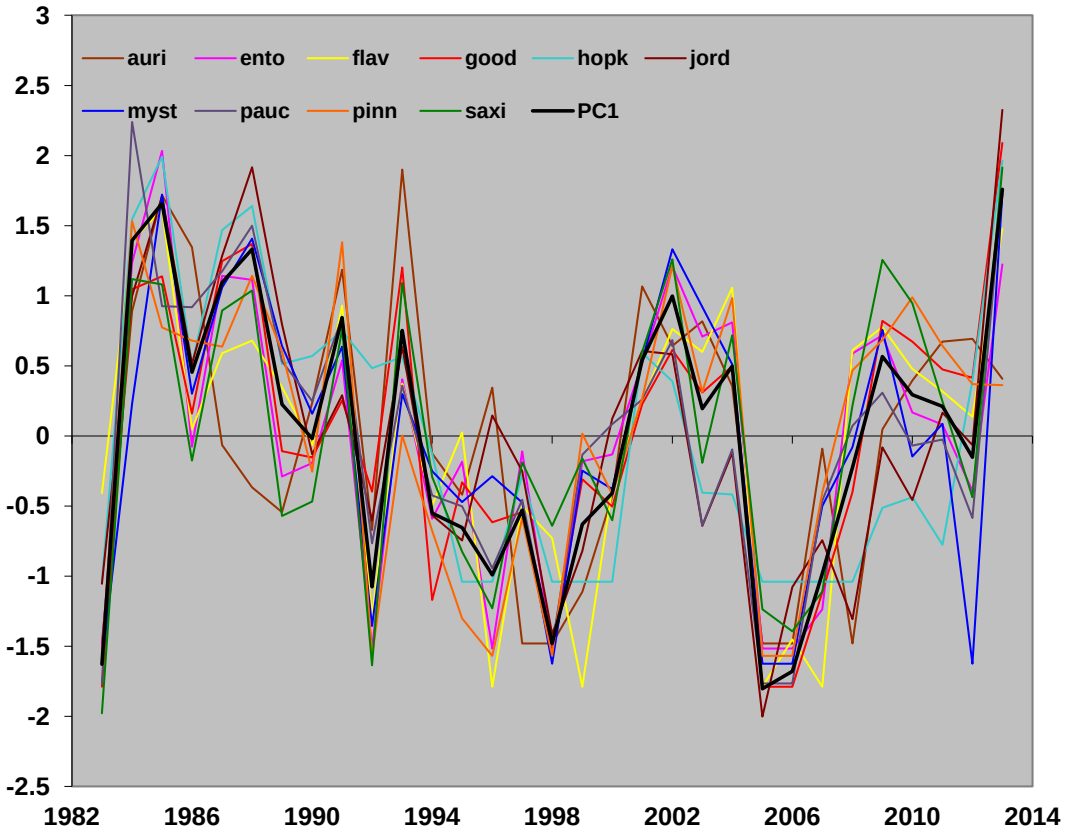

Figure B3: Standardized anomalies from Delta-GLM year effects for the ten most abundant rockfish (Sebastes) species in the Central California region (updated from Ralston *et al*. 2013)

B4. Research on larval rockfish at the SWFSC

Over the past year (2013-14) the Ichthyoplankton Ecology and Molecular Ecology labs within the Fisheries Resources Division in La Jolla continued to conduct molecular identification on larval rockfishes collected from CalCOFI cruises. The overall aim of this research is to develop a species-specific larval rockfish time-series and then use this data to evaluate how spawning patterns of different rockfishes responded to environmental factors and the presence of rockfish conservation areas in Southern California between 1997 and the present. Methodologically, the project involves sorting rockfishes (which can mostly only be identified to the genus level based on morphology) from ethanol-preserved plankton samples, sequencing mitochondrial DNA from individual larvae and matching larval sequences to those from adults that have previously been identified to species. We are initially focusing on winter CalCOFI cruises because rockfish larvae are more abundant in this relative to other seasons. During the past year we sorted larva from winter cruises in 2002-2005 and 2011 and genetically identified all 445 larvae from 2005 cruise. Twenty-eight species were found in winter 2005 (Figure B4a). We are currently in the process of identifying larvae from the winter 2011 cruise and are preparing a manuscript evaluating how rockfish assemblage structure changes spatially within Southern California based on relatively coarse-scale CalCOFI and fine-scale Cowcod Conservation Area (CCA; Figure B4b) sampling in 2005 (larvae from the 2005 CCA cruise were all genetically identified in 2012). In addition, we received funding from NOAA's Fisheries and the Environment program to work on this project; this award should accelerate greatly the rates of production and analysis of the rockfish genetic data.

In addition to the molecular identification-based research, we have continued updating larval fish identifications from historic CalCOFI surveys to current taxonomic standards. We currently have completed all surveys from 1966 to 2011, and are working on samples collected during 1965 in addition to completing processing of 2012 and 2013 samples. This provides to date a nearly 50-year time-series of larval abundances of the rockfish species visually identifiable as larvae (*Sebastes aurora, S. diploproa, S. goodei, S. jordani, S. levis, S. paucispinis*).

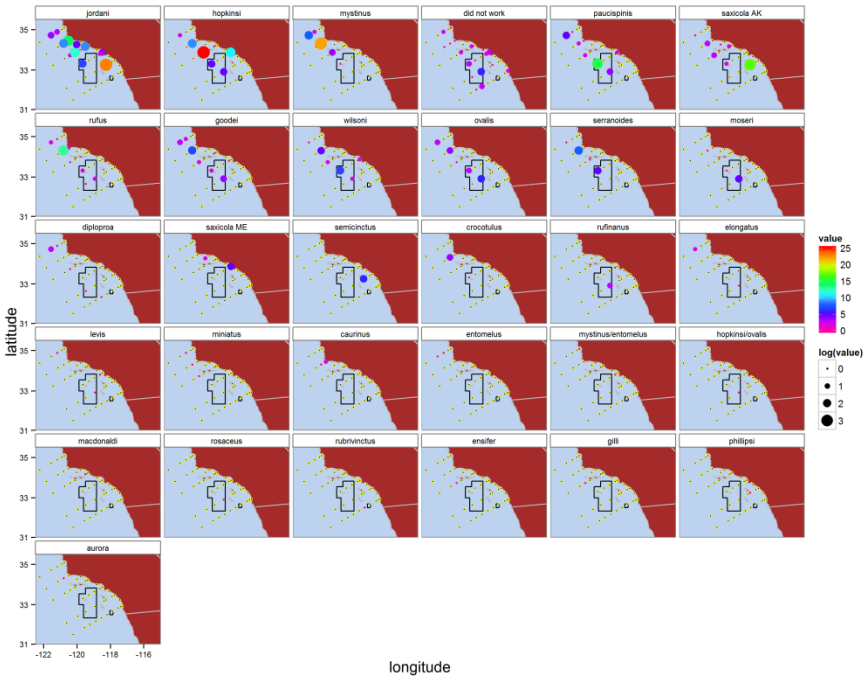

Figure B4a. Abundance of 28 species of rockfish larvae from the 2005 winter CalCOFI cruise. Species are ordered by their total abundance from all survey locations. Black outlines depicts the location of the Cowcod Conservation Areas within the Southern California Bight. Yellow circles depict locations where samples were collected. The size and color of circles corresponds to the abundance of each species.

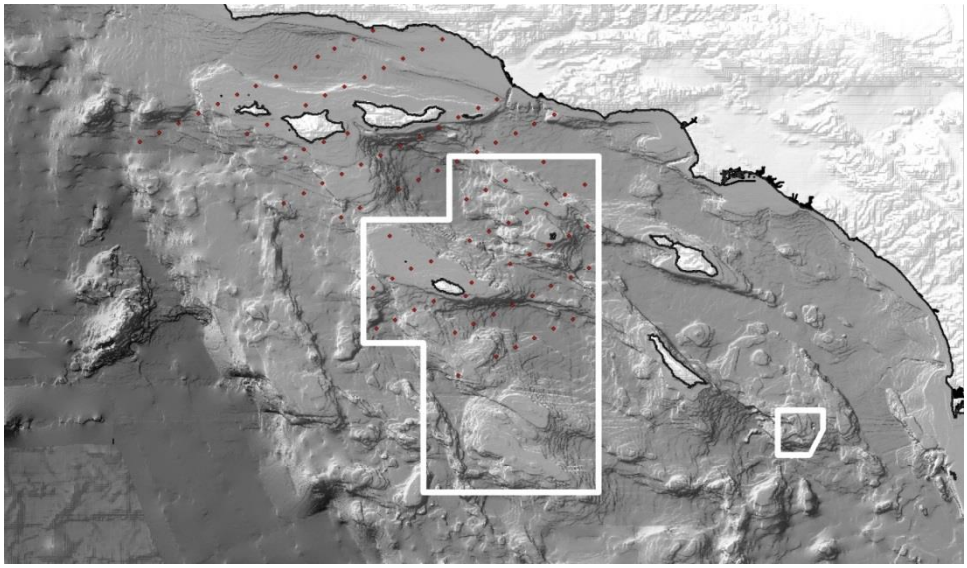

Figure B4b. Location of the 95 stations sampled within and around the western CCA during winter 2005.

C. BY SPECIES, BY AGENCY

C1. Nearshore rockfish stock assessments

Assessment scientists at the SWFSC contributed to the first "data-moderate" STAR panel held by the PFMC, resulting in approval of assessments for brown, China, and copper rockfishes (Cope et al. 2013). The data-moderate assessments improve upon catch-based estimators of sustainable yield that were previously applied to these stocks by incorporating indices of abundance to inform estimates of stock status. Stock status was found to vary by geographical region, but no stock was below the minimum stock size threshold.

C2. Shelf Rockfish

C2.a. Rockfish barotrauma and behavior research at SWFSC Lo Jolla Lab

The SWFSC Genetics and Physiology program continues to evaluate post-release survival of rockfish (*Sebastes* spp.) suffering from barotrauma and released using recompression devices. This work relies upon the use of externally attached acoustic tags equipped with depth and accelerometer sensors to send data to a receiver array that allows us to determine survival and behavior of released fish. Building upon previous work we expanded our receiver array at the 43 fathom bank to allow us to incorporate 3D tracking of individual fish in addition to the basic behavior and survival data that we were previously collecting. These tracking data will provide a rare insight into natural movements (horizontal and vertical) at fine temporal (~ 4min data points) and spatial (+/- a few meters) scales, allowing us to better understand habitat and foraging behavior which ultimately will inform capture probabilities in visual and acoustic based surveys. In addition to fish tracking, multiple oxygen as well as temperature & depth loggers are deployed between 80an 200m to characterize the seasonal incursion of hypoxic water into this important depth habitat for rockfishes in southern California and allow us to monitor behavior of fish in relation to oxygen saturation.

In FY14/15 we will deploy 40 tags on bocaccio (*S. paucispinis*) and 15 on cowcod (*S. levis*). A subset of these fish will be fitted with dissolved oxygen sensor tags to monitor fine-scale oxygen preferences. The survival estimates from our FY12/13 project are currently being considered by the management council for incorporation into management decisions. However, as sample size is still somewhat low there is a need to gather more data to refine these estimates cowcod.

Though precision of these mortality estimates needs to be improved, there is no question that in situ recompression confers a higher probability of survival than surface releases. As a proactive measure we have been working with CPFV captains and industry representatives to encourage the use of descending devices aboard all CPFV boats in California that target rockfish. As part of the outreach component we have partnered with other groups to produce a humorous and educational outreach video (https://www.youtube.com/watch?v=EiZFghwVOyI) which has been disseminated widely on the internet and used as an outreach video at several fishing trade shows.

C2.b. Stock assessments

FED staffs conducted stock assessments for cowcod (*S. levis*) and bocaccio (*S. paucispinis*) in 2013. A full stock assessment for cowcod (*Sebastes levis*) was conducted using a Bayesian extension of Depletion-Based Stock Reduction Analysis (DB-SRA). Four new indices of relative abundance were added to the assessment to infer recent trends in abundance and estimate overall stock productivity. The final cowcod model suggests that biomass has been increasing over the past decade, is currently near 34% of the unfished level, and is likely to rebuild within approximately the next ten years (Dick and MacCall 2013)

An update of the 2011 stock assessment of the bocaccio rockfish was conducted in 2013 (Field *et al*., 2013). The update included updated fishery and survey data from 2011 and 2012. It shows increasing trend of the stock biomass in recent years, with stock depletions changed from 24.9 percent in 2011 to 31.4 percent in 2013. Since the last full stock assessment was conducted in 2009, it is expected that a full assessment will be conducted in 2015. FED staffs started a new study to determine if otoliths from bocaccio rockfish can be used for estimating ages and growth in 2013, as no ageing data have been available to the past assessments of this species. The study shows promising results of otolith ageing for bocaccio, which will provide important data series for future assessments of this species.

C3. Flatfish stock assessments

A stock assessment of Pacific sanddab (*Citharichthys sordidus*) was conducted in 2013, and was reviewed by a STAR Panel (He *et al*., 2013). Because it was a first time that this species was assessed, extensive data collections and retrievals and laboratory works were conducted. This included field works on collecting samples for reproductive biology, and laboratory works on determining fecundity and maturity. Over 12,000 otoliths were examined to determine growth and ages of the species. The assessment model predicts that the spawning biomass was 96 percent of the unfished level at the start of 2013, well above the target biomass for flatfish stocks of 25 percent. However, there are major inconsistences between the estimates of biomass from the triennial and NWFSC surveys and the estimates of biomass from the assessment, with the assessment inferring that catchability for the surveys is substantially larger than 1. The SSC recommends that the assessment not be used for deciding harvest specifications. However, the information included in the assessment document is sufficient to conclude that the stock is well above the B_{SMY} proxy of 25 percent of the unfished level.

Research into the reproductive ecology of Pacific sanddabs has been ongoing since 2012 to support assessment activities. Pacific sanddab were collected between March 2012 and February 2014 from the Monterey Bay, and the reproductive cycle has been described based on visual, as well as more thorough histological, examination. Subsamples of ovarian tissue were collected to estimate batch fecundity, and a complimentary aquarium study demonstrated the biological capabilities for reproduction and provided samples for time-specific histological indicators of spawning. The current estimates of length at maturity were found to be considerably smaller than historical estimates. These and other results will be presented at the 2014 Flatfish Symposium in Seattle, WA.

D. OTHER RELATED STUDIES

D1. 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 deep sea coral communities.

D1.1 Underwater technologies to survey west coast groundfishes

The FED Habitat Ecology Team completed a final report (Yoklavich *et al*. 2013) 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. In addition to abundance and biomass estimates for demersal fishes surveyed with a manned submersible, preliminary comparisons are made between these data and those from an ROV survey conducted close to this time period at the same study site. The accuracy and precision of such results, and the extent of associated ecosystem information collected during such a survey, will be more fully evaluated in consideration of results from the NWFSC/PIFSC Seabed AUV and the SWFSC COAST methodologies, both of which were part of this study. Results from this comparative study will be useful in future surveys of groundfishes in habitats that are not adequately surveyed by bottom trawls, and can be used to develop long-term plans to assess some west coast groundfish species.

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.

D1.2. 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.

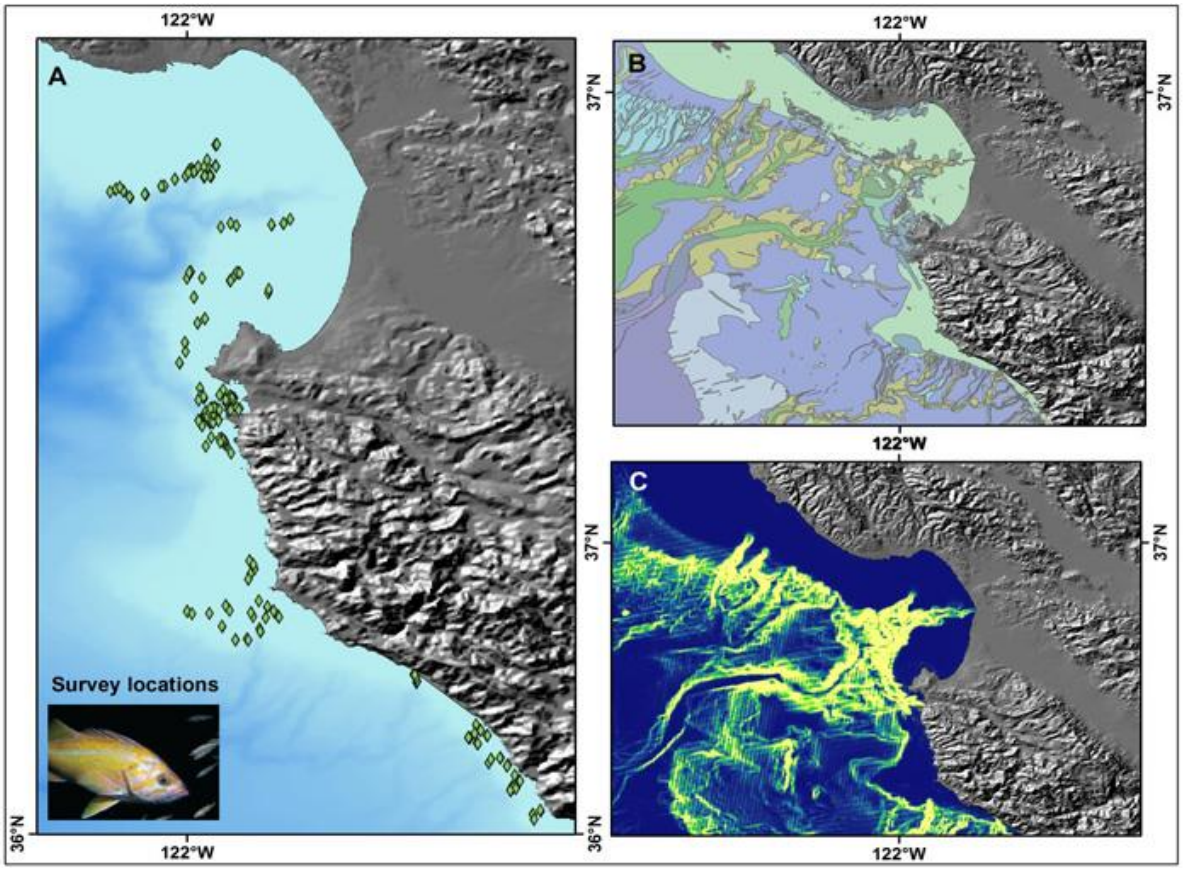

Figure D2. Spatial data sets compiled to support predictive modeling, including (A) map of submersible survey locations, (B) benthic habitat map, and (C) multibeam-derived product (e.g., habitat complexity, or rugosity).

D1.3. 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 have used 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. Members of the FED Habitat Ecology Team have completed a draft manuscript describing models that predict distribution of density and sizes of the black coral (Anthipathes dendrochristos) using covariates of ocean currents, water depth, and primary productivity. Describing the relationships of these corals and environmental factors helps in understanding the demersal community structure and function.

D2. SWFSC FED Economics Team Activities

The FED's Economics Team is conducting research on how two major management interventions (introduction of the Rockfish Conservation Areas in 2003 and the transition to catch-share management in 2011) have affected the productivity of California's groundfish trawl fleet. The research focuses on whether productivity changes vary between large versus small vessels, northern versus southern vessels, and vessels with diversified versus non-diversified operations. Preliminary results of this research will be presented at the North American Productivity Workshop in Ottawa.

Landings receipts are an important source of data on West Coast commercial harvest but provide little information on location of fishing activity other than port of landing. Logbooks are required for Pacific groundfish trawl vessels and provide data on the spatial distribution of effort and catch for that fleet. Landings receipt and logbook data are used in complementary fashion by scientists and managers to determine the spatial origins of landed catch. More recently, vessel monitoring systems (VMS) based on satellite surveillance have been required for groundfish trawlers and other commercial fishing vessels. The FED Economics Team is conducting research that compares the consistency of lower-frequency spatial data from California trawl logbooks with higher-frequency positional data for the same vessel using VMS data. This research will provide a method for assessing the accuracy of self-reported spatial data. Additionally, augmenting landings receipts with VMS data may be a promising way to consider spatial behavior in fisheries for which logbooks are currently lacking. A manuscript regarding the methods and conclusions of this research is in prep.

The Economics Team is working with a NEFSC Woods Hole economist on a comparative study of the effects of the Pacific groundfish trawl and Atlantic sea scallop catch share programs on the distribution of landings across ports. The research focuses on the distributional impacts of catch shares relative to other major policy changes, how the distribution of fishing rights correlates

with the distribution of landings, and how distributional changes affect and are affected by effort shifts in related fisheries.

The FED's Economics Team completed an economic survey of California recreational anglers in April 2014 that provides data on groundfish trip expenditures, species preferences, and angler attitudes and behavior as they relate to groundfish regulations. The survey was designed in coordination with the California Department of Fish and Wildlife and groundfish biologists from FED and University of California, Santa Barbara. A survey report will be completed in late 2014.

E. GROUNDFISH PUBLICATIONS OF THE SWFSC, 2012 – PRESENT

E1. Primary Literature Publications

Beyer, S.G., Sogard, S.M., Harvey, C.J., and J.C. Field. In press. Variability in rockfish (*Sebastes* spp.) fecundity on the California coast: species contrasts, maternal size effects, and spatial differences. Environmental Biology of Fishes.

Butler, J. L., M. S. Love, and T. E. Laidig. 2012. A guide to the rockfishes, thornyheads, and scorpionfishes of the northeast Pacific. University of California Press. 185 p.

Carruthers, T.R., A.E. Punt, C. J. Walters, A. MacCall, M.K. McAllister, E.J. Dick, and J. Cope. 2014. Evaluating methods for setting catch limits in data-limited fisheries. Fisheries Research 153:48-68

Field, J.C., C. Elliger, K. Baltz, G. Gillespie, W.F. Gilly, I. Ruiz-Cooley, D. Pearse, J.S. Stewart, W. Matsubu and W. Walker. 2013. Foraging ecology and movement patterns of the Humboldt squid (*Dosidicus gigas*) in the California Current. Deep Sea Research II 95: 37–51.

Field, J C., S.Y. Litvin, A. Carlisle, J. S. Stewart, W. F. Gilly, and R. I. Ruiz-Cooley. 2014. Stable isotope analysis of Humboldt squid prey: Comment on Miller et al. (2013). Marine Ecology Progress Series 500:281-285.

Haltuch, M. A., O. S. Hamel, K. R. Piner, P. McDonald, C. R. Kastelle, and J. C. Field. 2013. A California Current bomb radiocarbon reference chronology and petrale sole (*Eopsetta jordani*) age validation. Canadian Journal of Fisheries and Aquatic Sciences 70(1):22-31.

Hess, J.E., P. Chittaro, A. Elz, E.A. Gilbert-Horvath, V. Simon and J.C. Garza. 2014. Cryptic population structure in the severely depleted cowcod, *Sebastes levis*. Canadian Journal of Fisheries and Aquatic Sciences 71(1):81-92.

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