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. Recentlyn Dr. Francisco Werner was appointed to the position of SWFSC Director and the Deputy Director is Kristen Koch. All three SWFSC laboratories have supported the essential needs of the National Marine Fisheries Service (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 SWFSC 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 laboratory 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. Stephen Ralston) 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, 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.

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

The Ichthyoplankton Ecology (directed by William Watson) and Molecular Ecology (directed by John Hyde) Programs within FRD collaborated to conduct two research projects in 2010 on the early life history of rockfish (*Sebastes* spp.) species in the Southern California Bight. Both projects utilized ethanol-preserved larvae collected during ichthyoplankton surveys within and around the Cowcod Conservation Area (CCA) in February 2002-2005 (Figure 1).

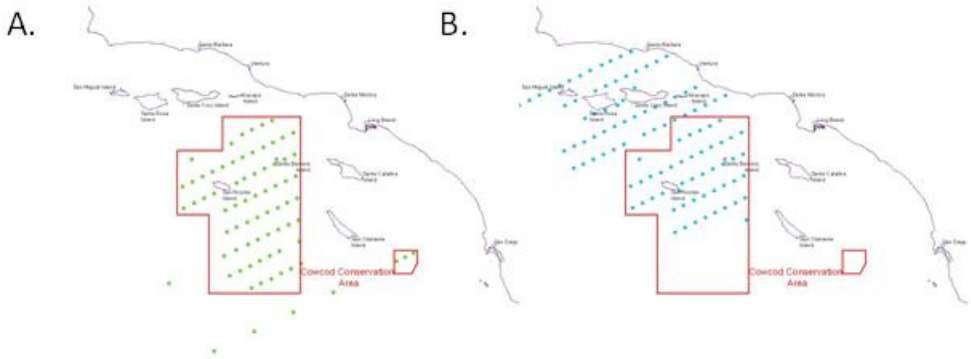

Figure 1. Location of ichthyoplankton sampling stations with and around the Cowcod Conservation Area (delineated by red polygons) in **A.** 2002, 2003, 2004 and **B.** 2005.

The first line of research focused on genetic identification of rockfish larvae. From a morphological perspective, it is possible to identify with certainty the larvae of six rockfish species; the others can be identified only to genus. Elucidation of the identity of members of this species complex is paramount for understanding rockfish population ecology, assemblage dynamics, and taxonomy, and for informing stock assessments. To identify rockfish to the species level, the *cytochrome* b mitochondrial gene was sequenced from individual larvae and matched to a particular species following the techniques of Hyde and Vetter (2007). Preliminary results based on sequences for 796 (of 3466) individuals collected at 36 (of 67) sample stations

from the 2002 CCA survey indicate that the *Sebastes* spp. complex contains a minimum of 26 species (Figure 2). Future research will determine spatial patterning of the rockfish species and whether assemblage composition varies among sample years.

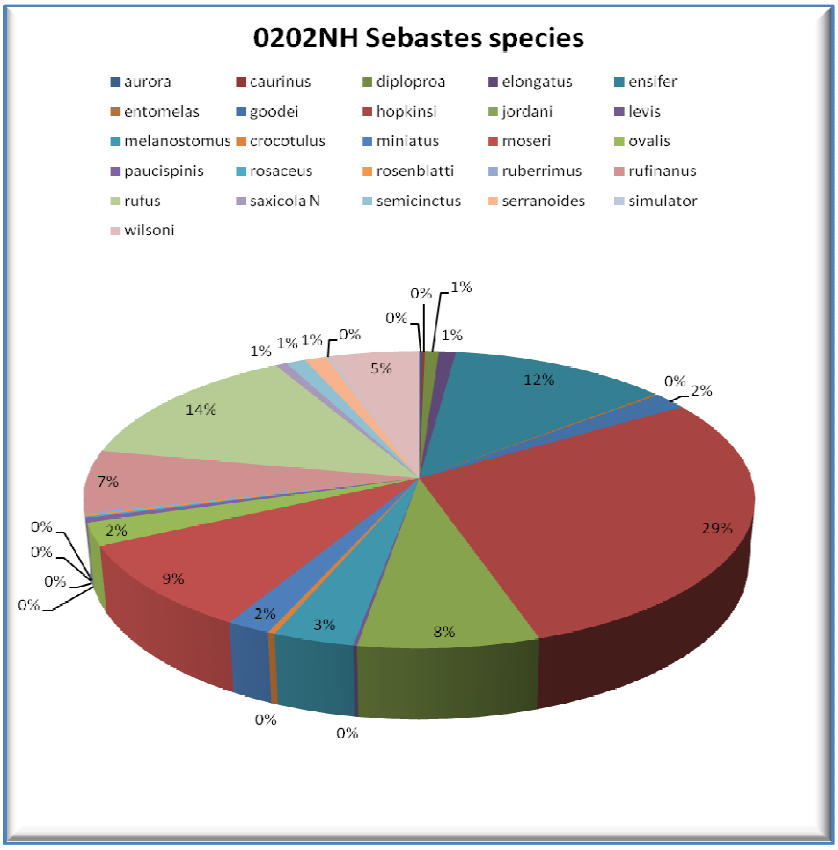

Figure 2. Larval rockfish species composition in the Cowcod Conservation Area, February 2002.

The second part of the rockfish genetic research investigated stock structure of cowcod (*Sebastes levis*). This research was motivated by results of genetic and otolith microchemistry analyses of adult cowcod rockfish suggesting that there are distinct cowcod populations north and south of Point Conception and that there may be genetic separation between inshore and offshore populations within the Southern California Bight (Simon et al. 2010). To investigate population genetic structure of cowcod within the Southern California Bight the mitochondrial control region was sequenced and genetic structure compared between individual cowcod larvae collected inshore and offshore during the 2002 CCA survey relative to the boundary identified by Simon et al. (2010) (Figure 3) . Thirty-three cowcod larvae were collected from 17 sample stations in 2002 and separated *a priori* into inshore (stations 28, 29, 48, 49, and 51) and offshore (stations 5, 13, 14, 16, 17, 31, 42, 43, 54, 64, 72) groups. Results of Analysis of Molecular Variance indicated that there was no genetic difference between the two groups. Future analysis of samples from the CCA (2003-2005) should provide a more robust test of genetic distinctiveness of inshore and offshore cowcod populations if more specimens are found from inshore stations.

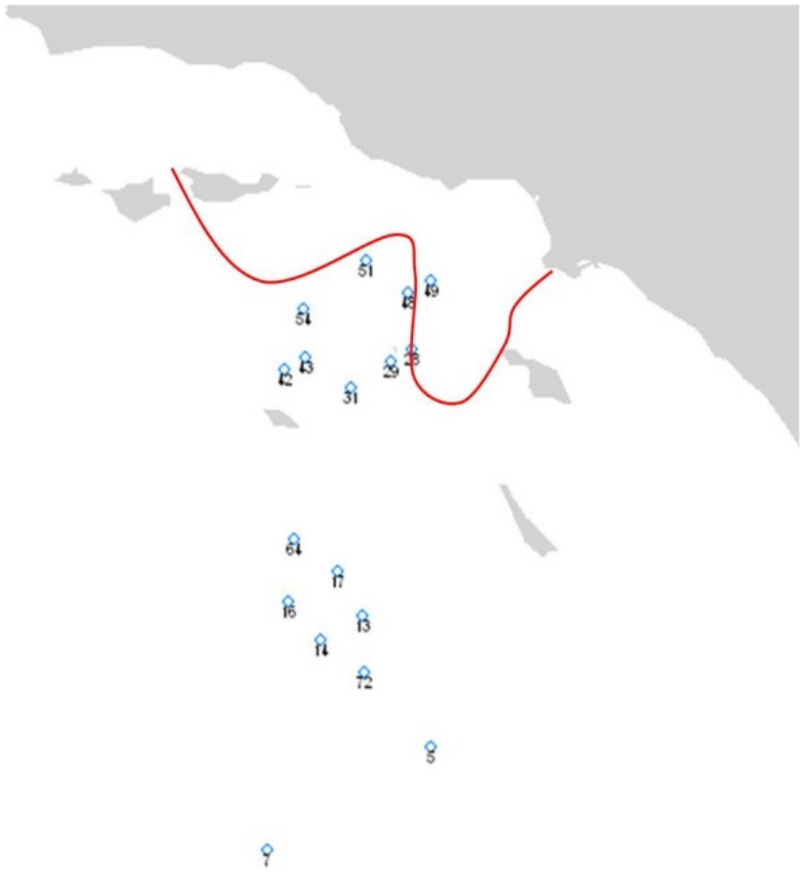

Figure 3. Station locations where at least one cowcod larva was collected during 2002 CCA surveys. Numbers next to stations depict station identity (order occupied). The red line depicts a potential boundary identified by Simon et al. (2010) that may separate inshore and offshore cowcod stocks within the Southern California Bight.

Juvenile Surveys

The FED at the SWFSC completed the 28th year of its annual May-June survey of the distribution and abundance of pelagic juvenile rockfishes aboard the Canadian F/V Frosti. This marked the first time the midwater trawl survey was completed on a contracted private vessel, the result of a budgetary shortfall within NOAA's Office of Marine and Aviation Operations (OMAO). Objectives of the survey include collecting data for use in estimating future recruitment to rockfish and other groundfish stocks, and otherwise monitoring the general state of the physical and biological environment (including krill, other forage fish, and oceanographic conditions).

The SWFSC midwater trawl survey data are usually coupled with comparable data collected by the Northwest Fisheries Science Center (NWFSC) to provide a coastwide view of pelagic juvenile rockfish distribution and abundance. However, because a survey was not conducted by the NWFSC in 2010, coastwide indices of abundance for 2010 could not be developed for use in groundfish stock assessments. Nonetheless, three species that are well-sampled by the SWFSC survey (i.e., *Sebastes hopkinsi*, *S. jordani*, and *S. paucisipinis*) have distributions that are

sufficiently far to the south that the absence of information from the northern portion of the survey frame did not hamper year-class estimation. The catch rate of bocaccio (*S. paucispinis*), an overfished species, has been trending upwards since 2006, with 2010 yielding the highest value in the 10-year time series (Figure 4); catch rates of the two other species in 2010 were unremarkable.

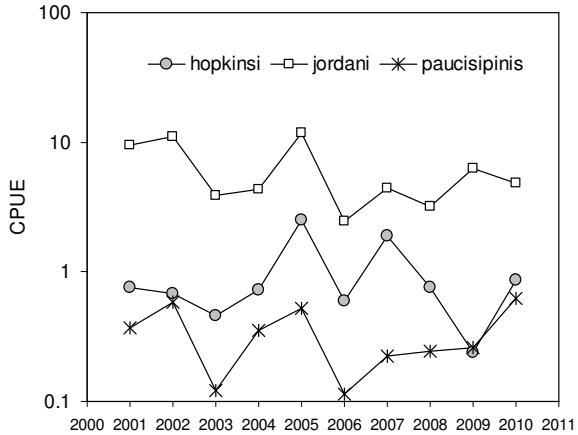

Figure 4. Standardized catch rates of three southerly distributed species taken in the SWFSC pelagic juvenile rockfish midwater trawl survey.

When considering the long term time series of forage species catches within the core area of the SWFSC survey (36°30'–38°20' N lat.), it is evident that two basic species assemblages occur within the central California region during May-June. Specifically, a principal components analysis of 15 well-sampled taxa reveals that an assemblage consisting of young-of-the-year (YOY) groundfish, market squid, YOY octopus, sergestid shrimp, California smoothtongue, and krill is inversely related to an assemblage that is composed of deep-scattering layer species and clupeoids (Figure 5). This fundamental dichotomy in forage availability accounted for 37% of the total variation in abundance of the 15 taxa considered. Broadly speaking it represents an assemblage dominated by cooler water shelf species versus warmer water oceanic species.

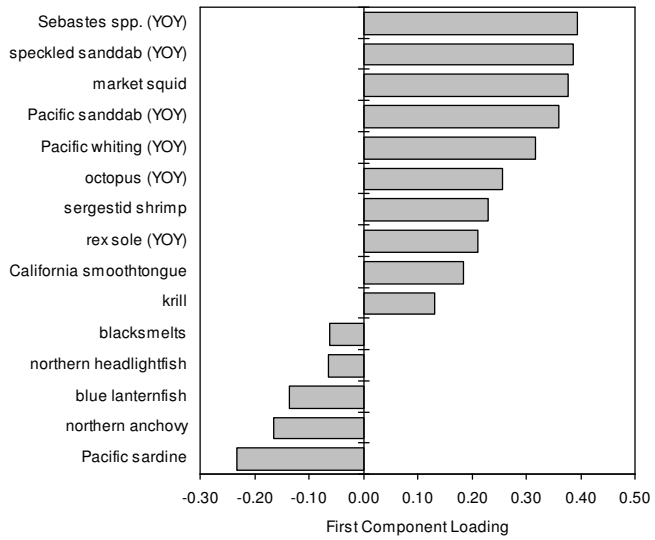

Figure 5. Loadings of 15 different taxa on the first principal component derived from an analysis of co-variation of SWFSC midwater trawl catches of forage species over the period 1990-2010.

It is illuminating to examine interannual variation in the availability of these two assemblages to the SWFSC survey by plotting the first principal component score over the last 21 years (Figure 6). The figure shows strong negative first component scores for 2005 and 2006, representing increased relative abundances of mesopelagics and clupeoids in those years. Since then, however, midwater trawl catches have been shifting back to the shelf-associated YOY groundfish assemblage. The survey catch composition in 2010 showed an increased abundance of krill, market squid, and YOY rockfish.

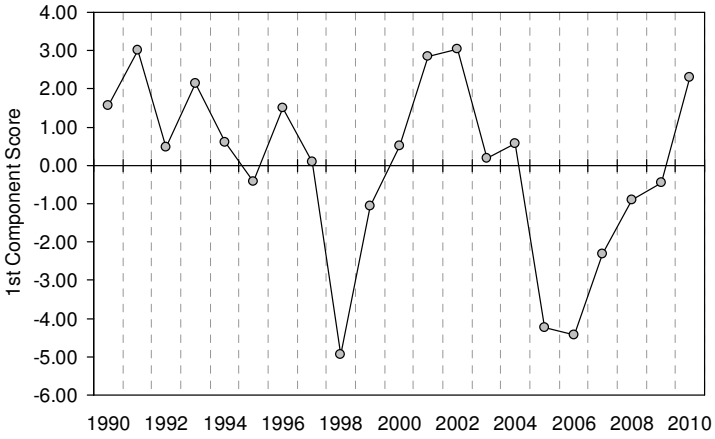

Figure 6. Time plot of the first principal component score obtained from an analysis of fifteen different forage species sampled by the SWFSC midwater trawl survey in the central California region. Positive values indicate that survey catches were largely comprised of YOY groundfish and other shelf-associated taxa (positive loadings in Figure 5); negative values are due to increased catches of mesopelagics and clupeoids.

Comparison of Pre-Recruit Indices

A publication by SWFSC scientists evaluated the efficacy of forecasting impending year class strength of bocaccio in order to better evaluate likely catches in recreational and commercial fisheries and to monitor rebuilding success (Field et al. 2010b). Accurate indices of the strength of incoming year classes both improve stock assessment estimates of future (near term) abundance trends, as well as aid regulators in making management decisions during those infrequent periods of high abundance of young fish. The study evaluated four datasets that provide estimates of impending year class strength in the southern and central California region (impingement data from power plant cooling systems, juvenile trawl survey, delta submersible survey, and recreational pier fishery catches), and evaluated their relative performance in the early detection of strong year classes. All surveys had predictive power for this highly variable populatio, although the study also found that because the fish recruit to the fishery at such a small size and age, pre-recruit indices provided only a relatively small (1-2 year) lead time with respect to informing managers of likely changes in productivity and consequent encounter and catch rates.

Harvest Impacts on Seabirds

Scientists from the FED published a manuscript linking the abundance and productivity of YOY rockfish to seabird breeding success (Field et al. 2010a), based on abundance time series from the FED juvenile rockfish survey and a comparable time series of seabird breeding success from the Farallon Islands (collected by PRBO Conservation Science). As juvenile rockfish are important prey to seabirds in the California Current, Field et al. quantified relationships between observed juvenile rockfish relative abundance and seabird productivity, used fisheries stock assessment approaches to estimate the relative abundance of juvenile rockfish in the absence of fishing, and compared the differences in seabird productivity that would have resulted without rockfish fisheries. Basic results showed that while the relative abundance of juvenile rockfish has declined to approximately 50% of the estimated unfished biomass, seabirds achieved 75% to 95% of the estimated un-impacted levels of productivity, depending upon the species of bird and various model assumptions.

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 Commission (PSMFC) and the California Department of Fish and Game (CDFG) to coordinate port sampling efforts and to maintain the California Commercial (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 landings estimation, the FED has 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. This yea,r E.J.

Dick resigned his seat on the Council's GMT and he was replaced by Rosemary Kosaka, an economist with the FED in Santa Cruz.

Model-Based Estimation of California Groundfish Landings

Estimation of species-specific landed catch can be challenging, particularly for mixed-species fisheries with limited sampling effort. Understanding uncertainty in those estimates is also critical to numerous management-related processes, e.g. stock assessment, specification of harvest levels, and catch monitoring. A framework for estimating landings and associated uncertainty was developed by Ole Shelton (University of California, Santa Cruz) and SWFSC staff (Shelton *et al*., In review). Bayesian hierarchical models for species compositions were developed and tested using data from California's commercial sampling programs. Combined with estimates of total landed weight by stratum, the models produce posterior distributions of species-specific landings for observed and unobserved strata.

Current Assessments

This is an "on" year for the Council's biennial stock-assessment cycle and FED scientists are engaged in five stock assessments, including full stock assessments of widow rockfish (Xi He), blackgill rockfish (John Field), and greenspotted rockfish (E.J. Dick). In addition, Field and Dick are completing updated assessments of bocaccio and cowcod, respectively, both of which are overfished stocks that are under rebuilding plans.

FED scientists have also been actively working on developing methods of assessing data-poor stocks and presented their findings to a Stock Assessment Review Panel in April. Included in the review were: depletion-corrected average catch (DCAC), depletion-based stock reduction analysis (DB-SRA), extended DB-SRA, and stock assessment based on fitting length-compositions only. The PFMC had adopted overfishing limits, acceptable biological catches (ABCs), and annual catch limits for ~50 groundfish stocks in 2010 that were based on the DB-SRA and, to a lesser extent, DCAC methodologies. The review was intended to provide a comprehensive evaluation of these two approaches using both simulated data and paired comparisons with results from data-rich stock assessments. In addition, enhancements to DB-SRA, including fitting CPUE time series developed by E.J. Dick and Alec MacCall, were evaluated by the review panel. 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. Extended DB-SRA is now a Bayesian approach, with DB-SRA providing a prior distribution. The abundance indexes provide an ability to update the prior distribution of final depletion. The new approach has been applied to several stocks for which data-rich assessments exist as a "ground truth" with good success.

California Cooperative Groundfish Survey

The FED has participated in the commercial groundfish market sampling program since 1978. The CalCOM database, website, and most programs used to process data were created and

maintained by our staff in close cooperation with Brenda Erwin (PSMFC, Belmont, CA). This year, we are beginning the first major overhaul of the system since 1997. These changes will improve website access to the data, improve error checking, have better documentation, and will include significant improvements to the programs used to process the data. We hope to complete the work by the end of 2012.

Observer Effects on Commercial Landing Estimates

In cooperation with the NWFSC, a study is underway to determine whether the presence of an observer on board commercial fishing vessels has an effect on the composition of commercial market samples. If an effect exists, it could adversely impact estimates of commercial landings that rely on the market samples. In addition, age and length compositions from the fishery could be affected. A draft of a manuscript is in preparation should be ready for review by early May. At this time, we have found that the presence of an observer onboard does not appear to affect market samples. We have determined that cooperation between the observer and port sampling programs could be improved, which we will work to achieve in the upcoming year.

C. BY SPECIES, BY AGENCY

3. Shelf Rockfish

i. Research

ii. Assessments

Groundfish Aging

Four species of rockfish were aged by Don Pearson and Lyndsey Lefebvre in support of upcoming stock assessments and other research activities (Table 1). Widow rockfish were obtained from the commercial fishery, with most samples from bycatch in the Pacific whiting fishery. Although the PSMFC has primary responsibility for aging chilipepper rockfish, samples from research and commercial samples were cross-aged by Don Pearson. Greenspotted rockfish from research and recreational samples were aged to support the upcoming assessment. To support the upcoming blackgill assessment, we developed age criteria for this species and aged approximately 3,000 fish. Due to the difficulty of aging this this long-lived rockfish, each fish was aged twice independently and then the ages were resolved. Approximately 10% of all fish from all species were aged a second time to allow development of aging error matrices.

Table 1. Number of fish aged at Santa Cruz Laboratory

SPECIES	NUMBER AGED	NUMBER REAGED
Greenspotted Rockfish	2,900	300
Widow Rockfish	3,100	200
Chilipepper	3,800	400
Blackgill Rockfish	3,100	300

4. Slope Rockfish

ii. Assessments

Work on the blackgill rockfish is underway for the 2011 stock assessment and review. To support the upcoming blackgill assessment, we developed age criteria for blackgill rockfish and aged approximately 3,000 fish (included in Table 1 above). Due to the difficulty of aging this species, each fish was aged twice independently and then the ages were resolved. Approximately 10% of all fish from all species were aged a second time to allow development of age error matrices. Studies of maturity (including histological examinations) and fecundity are also ongoing to improve the available life history and reproductive information regarding this species. Preliminary fecundity studies suggest that blackgill have a strong increase in relative fecundity with size. Histological studies are likely to be important for this species due to the late age at maturity, and some suggestion of reabsorbtion of early stage ovaries at smaller sizes (younger ages). The catch reconstruction effort has also led to changes in the perception of the catch history for this species, which may also influence the next assessment. The review panel for this assessment will take place in August, 2011.

D. OTHER RELATED STUDIES

3. SWFSC Current Habitat Activities

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 essential fish habitat (EFH) identification; (3) contribute to marine protected area (MPA) design & monitoring and to marine spatial planning; and (4) understand the significance of deep-sea coral habitats.

We use a variety of survey tools and approaches to improve our 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, laser line scan, 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 are being used in the California-NOAA-USGS Seafloor Mapping Program.

The FED Habitat Ecology Team recently co-convened a workshop *Comparative Assessment of Visual Survey Tools for Seafloor Communities*, held at Monterey Bay Aquarium Research Institute in Moss Landing, California 22-23 February 2011. The workshop was attended by 47 marine scientists and engineers from academic, government, and private groups in the U.S., Canada, and Australia, including representatives from all NMFS' Science Centers and Office of Science and Technology. Discussions focused on five types of underwater visual survey tools (AUVs, ROVs, manned subs, towed cameras, and scuba), and the capabilities, limitations, and tradeoffs in using these tools to conduct quantitative surveys. A workshop proceedings is being produced.

This September, we will be conducting comparative field studies of three underwater survey tools, specifically to evaluate the accuracy and precision of estimated densities and biomass of groundfish species in rocky areas and associated ecosystem information. Survey tools for this comparison include the Seabed AUV (NMFS NWFSC and PIFSC), Nuytco's Dual Deepworker submersible (SWFSC FED), and the Cooperative Optical Acoustic Survey Technique (COAST) (ROV and EK60 ecosounder; SWFSC FRD). In order to develop long-term surveys of those West Coast groundfish species that occur in untrawlable habitats (such as cowcod and yelloweye rockfishes), the performance, capability, and efficiency of these technologies must be assessed.

Using Habitat Information to Improve Stock Assessments

From our quantitative visual surveys, the FED Habitat Ecology team has developed an extensive database of habitat-specific fish abundance for over 100 species of demersal fishes off CA. Using this database, we are beginning to develop statistical models that predict densities of individual demersal fish species and multi-species fish assemblages over broad spatial scales. These models will be based on a number of associated habitat variables (e.g., depth, substratum type, patch size and configuration) and the densities of co-occurring fish species. These models will then be coupled with broad-scale seafloor habitat maps that are being developed for Calfornia.

The FED Habitat Ecology team also is using this database to evaluate the performance of two underwater survey vehicles (the *Delta* submersible and Phantom DS4 ROV). We compared habitat-specific densities estimated from the survey cameras of both vehicles and determined changes in fish behavior as potential reaction to the survey tools (Laidig et al. In Review). Similar species were seen in the visual surveys using each vehicle, but identification of species was more difficult using the ROV than using the submersible. Although fishes reacted to both vehicles, more fishes reacted to the ROV (51%) than to the submersible (18%). In general, fishes that occur higher off the bottom had a greater reaction to either vehicle than those fishes on the seafloor. Understanding survey biases, such as the ability to detect and identify various species and the behavioral response of the fishes to each vehicle, will result in improved survey design and interpretation, more accurate abundance estimates, and can help in selection of appropriate survey tools for specific species.

Predicting Distribution of Benthic Macro-invertebrates

As part of the California Seafloor Mapping Project (CSMP), the FED Habitat Ecology team has been collaborating 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. 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. In Review). 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.

NMFS' Marine Fisheries Habitat Assessment Improvement Plan (HAIP)

The FED Habitat Ecology Team led a group of NMFS scientists in development of the first nationally coordinated plan to focus on marine fisheries habitat science. There are ever-increasing demands being placed on marine habitats across many sectors of the U.S. economy, but the role of marine habitats in supporting fishery production and in providing other critical ecosystem services is poorly understood. Although habitat information is needed in almost every NMFS program, habitat science has received relatively little programmatic support compared to other disciplines. The recently published Habitat Assessment Improvement Plan (HAIP; NMFS, 2010; available at http://swfsc.noaa.gov/HabitatEcology) outlines current gaps in NMFS habitat science, steps to improve habitat assessments, and the need for an integrated, fully supported, national habitat science program. The HAIP will help NMFS meet mandated responsibilities to sustain marine fisheries and associated habitats, and will contribute to President Obama's new ocean policy. NMFS and all of its partners will benefit from and contribute to the success of the HAIP.

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. From preliminary observations, these areas are home to diverse and abundant assemblages of black corals, sea fans, *Lophelia*, and sponges in a myriad of types, colors, and sizes. Underwater surveys of corals, sponges, and associated habitats and fishes are being conducted on rocky banks in 20-900 m water depth using direct observations from a ROV, a manned submersible, and an autonomous underwater vehicle (AUV). Such data also are being retrieved from archived video of past visual surveys, all of which will contribute to a comprehensive deep-sea coral database. In addition, our Deepsea Coral and Sponge Image Database from our 2010 cruises off Southern California is available at http://swfsc.noaa.gov. This research 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. This is a collaborative effort among investigators from NOAA's National Marine Fisheries (SWFSC and NWFSC), University of

California Santa Barbara, and Monterey Bay Aquarium Research Institute, with additional funds from NOAA's Deepsea Coral Program.

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2008 – PRESENT

1. Primary Literature Publications

Black, BA, GW Boehlert, and **MM Yoklavich.** 2008. Establishing climate–growth relationships for yelloweye rockfish (*Sebastes ruberrimus*) in the northeast Pacific using a dendrochronological approach. Fish. Oceanogr. 17:368-379.

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Demer, DA, GR Cutter, JS Renfree, and JL Butler. 2009. A statistical-spectral method for echo classification". ICES Journal of Marine Science, 66: 1081–1090.

Dick, EJ, and AD MacCall. In press. Depletion-Based Stock Reduction Analysis: a catch-based method for determining sustainable yields for data-poor fish stocks. Fish. Res.

Field, JC, AD MacCall, RW Bradley, and WJ Sydeman. 2010a. Estimating the impacts of fishing on dependant predators: a case study in the California Current. Ecological Applications 20: 2223-2236.

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Field, JC, J Cope and M Key. 2010. A descriptive example of applying vulnerability evaluation criteria to California nearshore finfish species. Pages 235-245 in Managing Data-Poor Fisheries: Case Studies, Models & Solutions. California Sea Grant College Program Report No. T-070.

Harvey, C, **JC Field, SG Beyer and SM Sogard**. 2011. Modeling growth and reproduction of chilipepper rockfish under variable environmental conditions. 109:187-200.

He, X, S Ralston, and AD MacCall. 2011. Interactions of age-dependent mortality and selectivity in age-based stock assessment models. Fish. Bull. 109:198-216.

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

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

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52nd Annual Meeting of the TSC

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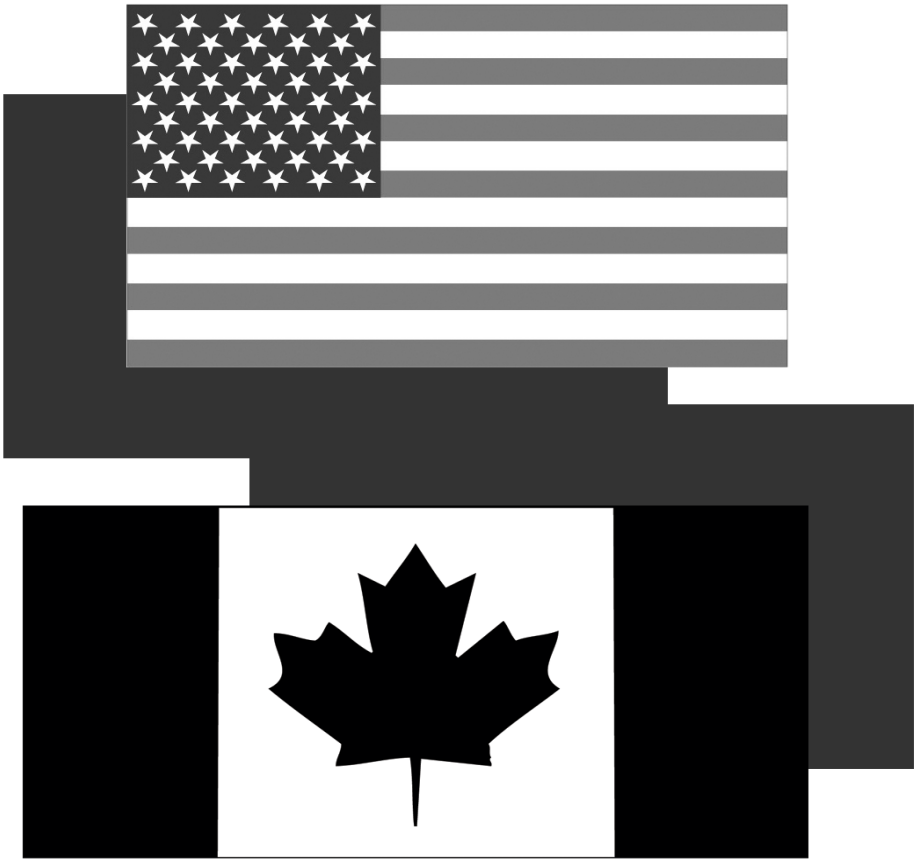

Appointed by the Second Conference on Coordination of Fisheries Regulations between Canada and the United States

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