NMFS Southwest Fisheries Science Center

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, as well as a number of international fisheries commissions and conventions. The Deputy Director of the SWFSC is Dr. Norman Bartoo, and the Science Director is Dr. William Fox. A considerable amount of expertise on groundfish research, assessment, and management resides within all three SWFSC laboratories, and all have supported the essential needs of the NMFS and the PFMC for groundfish (and other west coast federally managed species) for over 25 years. Laboratory scientists from the Santa Cruz Lab have been members of the PFMC's Groundfish Management Team (GMT) every year since its inception in 1977, and scientists from all three labs are regular and active members of the PFMC's Scientific and Statistical Committee (SSC) and other management teams and advisory bodies.

The Center is headquartered in La Jolla, which hosts three divisions that conduct research on a wide range of Pacific and Antarctic fish, marine mammals, sea turtles, and marine habitats; the Antarctic Ecosystem Research Division (led by Dr. Rennie Holt) , the Protected Resources Division (led by Dr. Stephen Reilly), and the Fisheries Resources Division (led by Dr. Roger Hewitt). The Fisheries Resources Division conducts research on groundfish, large pelagic fishes (tunas, billfish and sharks), and small coastal pelagic fishes (anchovy, sardine and mackerel), and is the primary source of groundfish-related research in the La Jolla Laboratory. The La Jolla laboratory is also the primary source of federal support for the California Cooperative Oceanic and Fishery Investigations surveys that have taken place along most of the California coast since 1951, conducting integrated research on the physical, chemical and biological makeup of the California Current. 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 Santa Cruz Laboratory (SCL), directed by Dr. Churchill Grimes, relocated from Tiburon, California in December 2000. The lab is comprised of two primary research branches, the Fisheries Branch (led by Dr. Peter Adams) leads research in salmon population analysis, economics, groundfish analysis, and fishery oceanography, and the Ecology branch (led by Dr. Susan Sogard) which leads research into early life history, salmon ocean and estuarine ecology, habitat ecology, and molecular ecology. Of the teams most directly involved in groundfish research, Dr. Alec MacCall leads the groundfish analysis team, Dr. Steve Ralston leads the fishery oceanography team, Ms. Mary Yoklavich leads the habitat ecology team, and Dr. Susan Sogard leads the early life history team. Specific objectives of Santa Cruz Lab groundfish programs include collecting and developing information useful in assessing and managing groundfish stocks (including both fishery-dependent and fishery-independent information, ecological and oceanographic studies), conducting stock assessments to provide a basis for harvest management decisions for the PFMC, disseminate information, research findings and associated advice to the fishery management community, and provide professional services (many of which fall in the above categories) at all levels, including inter-agency, national and international working groups. Cooperative relationships also include the National Marine Protected Area Center Science Institute (housed at the lab), and the Center for Stock Assessment Research (CSTAR), a partnership with the University of California Santa Cruz.

The Pacific Fisheries Environmental Laboratory (PFEL), directed by Dr. Franklin Schwing, is located in Pacific Grove. The PFEL 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 PFEL 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. PFEL also contributes oceanographic expertise to the groundfish programs within the SWFSC, particularly at the Santa Cruz Lab. This includes planning surveys and sampling strategies, conducting analyses of oceanographic data in the context of characterizing groundfish habitat and its spatial and temporal variability, 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

Icthyoplankton Surveys

The CalCOFI ichthyoplankton time series has been used to study distribution and abundance changes of many fish species in relation to climate and ecosystem change in the California Current region. CalCOFI data have been used in recent assessments of bocaccio and cowcod rockfishes, and can provide fishery-independent time series information for many other groundfish species. Since 2002 CalCOFI stations off central California, last routinely sampled in 1984, have been re-occupied during the winter and spring cruises in order to provide improved geographic coverage during the principal reproductive season for Pacific sardine and groundfish species including rockfishes, greenlings, cabezon, and various flatfishes. Similar surveys include the Southern California Nearshore Ichthyoplankton survey (ongoing), the Cowcod Conservation Area high resolution ichthyoplankton and oceanographic surveys (2002-2005) and the Marine Ecological Reserves survey (1998-1999).

Juvenile Surveys

Since 1983 the Groundfish Analysis Team of the SCL has used the NOAA R/V David Starr Jordan to conduct an annual survey of the distribution and abundance of pelagic juvenile rockfishes. The goal of the survey is to provide an information base for forecasting future recruitment to rockfish and other groundfish fisheries, particularly as rockfish and other species (such as Pacific hake) exhibit extreme variability in recruitment. A number of west coast groundfish stock assessments (e.g., Pacific whiting, widow rockfish, chilipepper rockfish) have used this pelagic juvenile index to estimate recruitment strength of year classes. An improvement in rockfish reproductive success, following the extended period of poor survival that occurred during the mid-1990s and the likely 1999 regime shift, appears obvious from the results of this survey. Although the abundance of juvenile rockfish was low in 2003 (as is normal for El Nino conditions), in 2004 they rebounded to values that are generally above their long-term means (Figure 1). In 2004 the geographic coverage of the pelagic juvenile rockfish mid-water trawl survey was expanded substantially, with the addition of new sample lines off of southern and northern California, from San Clemente Island to Point Delgada. This increased the effective latitudinal range of the survey from 180 to 800 km, representing a four-fold increase in coverage. The survey's expansion was made possible due to an increased allocation of shiptime, and changing from a design-based estimation scheme to a model-based GLM that includes year, station, and calendar date effects. In addition, for the last three years Groundfish Analysis staff have coordinated survey sampling efforts with the Pacific Whiting Conservation Cooperative (funded by the NWFSC).

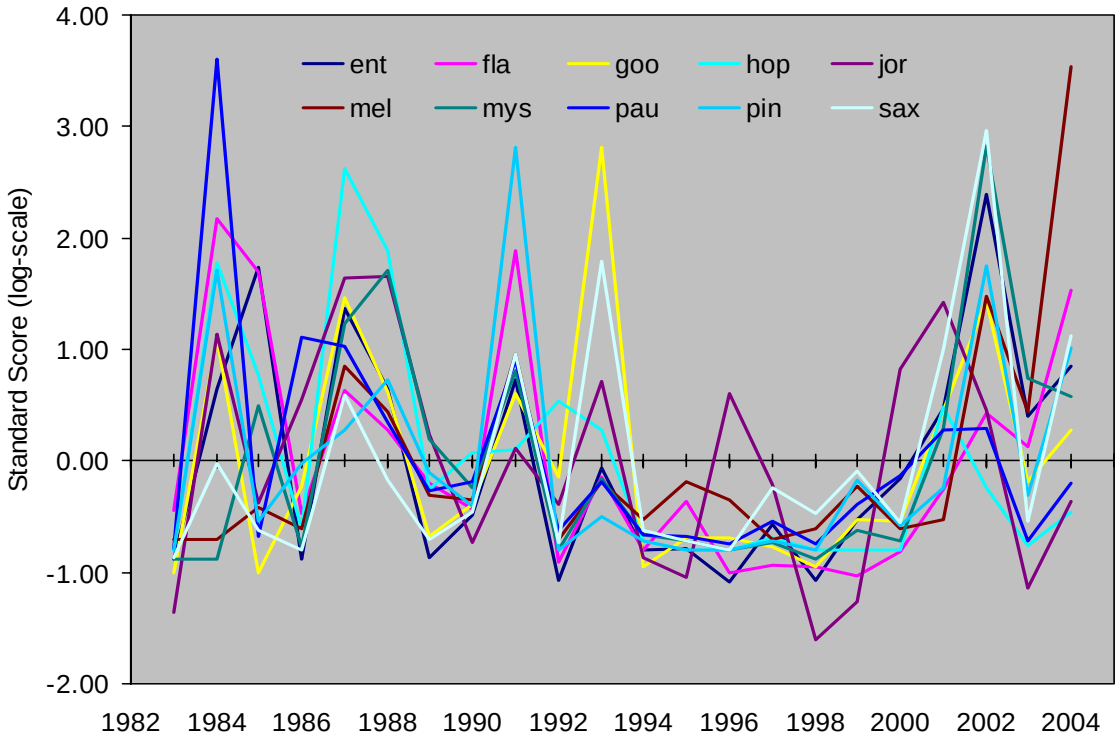

Figure 1: Time series of pelagic juvenile rockfish abundance in the SCL midwater trawl survey (results here are unadjusted for interannual differences in age composition).

Adult Surveys

In an effort to obtain a comprehensive understanding of the central California groundfish community and groundfish ecology, the Santa Cruz Lab has used Stock Assessment Improvement Program (SAIP) funding to continue the groundfish ecology surveys that began in late 2001. Cooperative research funding of the survey has allowed full monthly coverage for three consecutive years. The survey utilizes chartered commercial trawl and longline vessels using standardized gear, and typically operates over a wide range of depths throughout the Monterey Bay region. The primary objectives of the survey are to obtain detailed seasonal information on annual cycles, including species location and co-occurrence, maturation, and age validation. One potentially serious problem was identified early in these efforts, wherein it was noted that blackgill rockfish can easily be mistaken as darkblotched rockfish (an overfished stock) in fisheries samples. Additionally, evidence of multiple spawning has been documented in several species of rockfish, having previously been documented only for bocaccio. Tagging studies of nearshore species and skates has continued, including the deployment and monitoring of acoustic tags in gopher rockfish. The SCL molecular ecology and genetics team is also colleting tissue samples from rockfish and other species from this survey to evaluate population structure in a number of species. Finally, elasmobranch specimens have been provided to researchers at the Moss Landing Marine Laboratory, where studies of growth, maturity and food habits are ongoing.

Ecosystem Research

Santa Cruz Lab personnel have also been involved in ecosystem modeling, through participation in a National Center for Ecological Analysis and Synthesis (NCEAS) working group on ecosystem modeling and management, presentation of preliminary model results to the PFMC SSC and at national and international forum, and have publications forthcoming based on dynamic simulations of the Northern California Current ecosystem. Additionally, Santa Cruz Lab personnel were involved with a PICES Study Group investigating Fisheries and Ecosystem Responses to Recent Regime Shifts (FERRRS), which reported to the U.S. Government in October 2004. Santa Cruz Lab personnel analyzed multivariate long-term patterns of variability in ocean conditions by integrating the likelihood response surface over all possible two-wavelet deterministic models. The result identifies new patterns of potential regime shifts in the northeastern Pacific. Results were presented to the PICES FERRRS Study Group, and are being prepared for publication

2. Stock Assessment Support

Both the La Jolla and the Santa Cruz Lab regularly produce stock assessments of groundfish for the PFMC (recent groundfish assessments are described in more detail in the species summaries), and support stock assessment science through the maintenance of data systems and the development of new analytical techniques. The SCL works closely with the California Department of Fish and Game (CDFG) to coordinate port sampling efforts and to maintain the CALCOM database, which serves as the source of the data feeds provided to PacFIN by the State of California. The system provides port sampling biologists with Internet access to the database, so that monitoring data is entered directly in real time. Recently completed efforts included new expansions of landings and port sampling information that eliminate aggregate species and "unknown" categories. Although the resulting estimates are similar to older estimates for major species, they have improved the information content of estimates for minor species, several of which are being assessed for the first time in 2005.

Through our liaison with CDFG the SCL also recently acquired a massive amount of historical California landings data on microfiche and original paper. These records include high quality landings receipts from 1969- to the present (75,000 pages, good quality), landings receipts 1950-1968 from paper output (85,000 pages, poor quality), species landings summaries 1931-1949 by 10-minute block origin (9,000 pages, poor quality), and San Francisco area trawler catch and effort by block from 1924-1939 (on paper, 3 boxes). These data have immense value for stock assessment and habitat evaluation (e.g., EFH) purposes. CDFG recently relocated electronic records of the 1969-present data, which should ultimately extend the PacFIN database back to 1969, which is being enthusiastically received by the assessment community. The earlier data (landings receipts 1950-1968) are also especially valuable, and would extend the PacFIN database back to 1950. However, the poor image quality prevents use of optical character

recognition (OCR), so the data must be keyed by hand. The SCL is currently trying to obtain cost estimates and looking for alternative funding sources for this effort, which will likely exceed $100,000.

The SCL has also developed a flexible computing package to do GLM analyses incorporating several delta-distributions, a variety of diagnostics, and jackknife estimation of precision, and has offered to contribute this package to the NMFS Stock Assessment Toolbox. Similarly, SCL scientists developed an AIC-based diagnostic methodology for identifying appropriate probability distributions for use in GLM analyses, as diagnostics recommended in existing literature were often shown to be insufficient. Finally, the SCL maintains an otolith archive representing nearly 400,000 roundfish, rockfish and flatfish collected over the past 40 years. These samples are used for stock assessment (including several first-time assessments being conducted in 2005), as well as for biological research. These archived otoliths may offer opportunities for distinguishing between the newly-discovered "species" of vermilion rockfish in historical landings, based on morphological or size-at-age differences, and perhaps genetic analysis of residual tissues. Recently, samples from these archives have been used by for age determinations of long-lived rockfish using bomb radiocarbon.

C. BY SPECIES, BY AGENCY

2. Nearshore Rockfish

i. Research

The SCL Early Life History Team conducts ecological research applicable to understanding factors driving population regulation during early larval and juvenile stages in rockfish and other species. Recent research has included studies of nearshore rockfish species to assess variability in the fitness characteristics of individual larval rockfish and determine sources of variability, such as the initial size of larvae at parturition, bioenergetic condition as indexed by oil reserves, initial swimming capabilities, growth rates and mortality. One clear tradeoff identified thus far is that species that release larvae early in winter (such as black and blue rockfish), have relatively small larvae that are well provisioned with oil reserves. By contrast, larvae of late spring spawners (such as gopher and kelp rockfish) have minimal oil reserves but are larger in body size. These strategies are potentially explained as an adaptive response to oceanographic conditions; larvae released in early winter may require high lipid stores to allow survival under poor or sporadic feeding conditions, whereas larvae released during the upwelling season may have a more reliable prey base but more vulnerability to predators or other threats (which would be mitigated by improved swimming capabilities). Laboratory experiments have also been used to test the hypothesis that older females producing larvae that grow and survive better than larvae from younger mothers. Prior studies have demonstrated that this is true for black rockfish, and

preliminary results suggest that this is also true for blue rockfish, another winter spawner, but results are less distinctive for spring and summer spawners.

ii. Assessment

Personnel at the SCL 2003 assessed black rockfish, and the stock appears to be in relatively healthy condition. The SCL provided technical advice for a California sheephead stock assessment in 2004; although not a Council-managed species, sheephead interacts with the southern California groundfish fishery. Sheephead is a hermaphroditic species, and although current fishing intensity is near 50% SPR for females, male SPR may be closer to 10%.

Two assessments for nearshore rockfish initiated in 2004 are approaching completion for the 2005 PFMC biennial management cycle; gopher rockfish (led by CDFG, with participation by SCL), and kelp greenling (led by Jason Cope, UW, with participation from the SCL. Preliminary results from the gopher rockfish assessment suggest that this stock is well above target biomass levels.

3. Shelf Rockfish

i. Research

The genetics program at the La Jolla Laboratory has developed many genetic markers for groundfish, is working to determine stock structure and dispersal distances, and helps with the design of MPA networks. Recently, the program has been attempting to resolve the discovery of many new cryptic species pairs that will greatly impede valid stock assessments until we can resolve the issue. Examples include rougheye, Pacific Ocean perch, dusky, vermillion, and stripetail rockfish. The laboratory also houses a collection of over 20,000 groundfish tissue samples, which includes virtually all extant rockfish species and DNA extracted from museum specimens. In addition, SWFSC Genetics has pioneered the development of automated molecular ID of eggs and larvae from RFLPs to Multiplex PCR and finally gene arrays. Presently they have a 20+ species gene array that covers most species encountered in the CalCOFI grid. One new molecular genetic species identification method uses DNA-specific probes and optical detection to identify larval rockfish samples to species in real-time (hours, not months), at sea (Figure 2). This method improves our observations by allowing for real-time adaptive sampling, and gives us a better understanding of the early life history of overfished rockfish stocks.

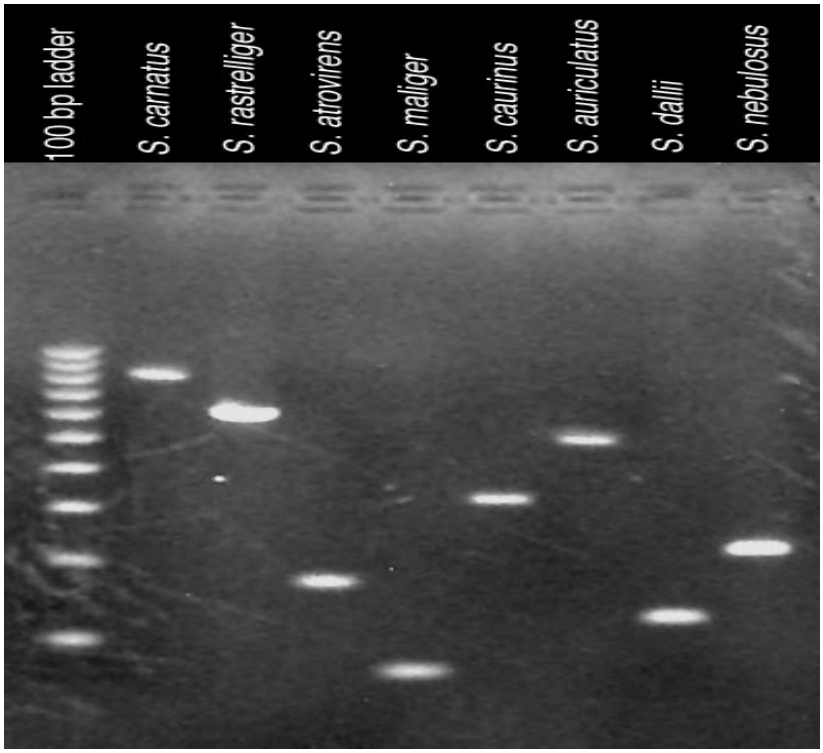

Figure 2. Agarose minigel of *Sebastes* (pteropodus) identification PCR

In cooperation with the NWFSC, the La Jolla Lab FRD has developed statistical techniques for analysis of bomb radiocarbon data and have completed several projects to assess ageing error of black and canary rockfish, using bomb radiocarbon and stable isotopes (papers submitted in 2004). Currently these methods are being applied to other rockfish species.

Following publication of the shortbelly rockfish larval production paper (Ralston et al. 2003), the Santa Cruz and La Jolla Labs are cooperatively developing a study in to estimate the spawning biomass of bocaccio in the southern California Bight. This study will utilize growth, maturity, and fecundity information data obtained from sampling female bocaccio at the Ensenada fish market, coupled with CalCOFI and CCA enhanced ichthyoplankton sampling of bocaccio larvae. Results of the analysis should compliment the stock assessment of bocaccio that will be conducted in the coming year. Preliminary results indicate that in southern California larger/older females release larvae at least twice during the spawning season.

Finally, results from an analysis of spatial patterns of recruitment variability based on port-specific catch at age data showed broad spatial coherence in rockfish recruitment events for winter-spawning shelf rockfish (chilipepper, widow, and yellowtail) along the US and Canadian west coast, which will help to alleviate concerns about the more restricted spatial scale of the juvenile recruit survey in prior years.

ii. Assessments

The La Jolla laboratory is currently the lead for the ongoing (2005) cowcod stock assessment. Past assessments included the first cowcod assessment in 1999, and assessments of blackgill and cabezon. The Santa Cruz Lab habitat ecology team has led the development of a new fishery independent survey method for cowcod, using direct observations from an occupied submersible. The study surveyed demersal juvenile and adult cowcod using a one-sided line-transect method and direct visual observations made during dives in an occupied research submersible (Delta). The survey was conducted over eight major offshore rocky banks inside the two newly established Cowcod Conservation Areas (CCAs) off of southern California, all of which are longtime recreational and commercial fishing sites. A review of this survey method for cowcod was hosted by the La Jolla Fisheries Research Division (FRD) in December 2004, with the intent of advising the cowcod stock assessment team on how to use the new information. The draft assessment of cowcod has been completed and will be presented May 9-13, 2005 in Long Beach at the regional office, where the direct observation survey results will be considered further.

In 2003 Bocaccio was re-assessed by the SCL following a 2002 assessment that found that bocaccio were at an extremely low population size (<10% historical abundance), and had led to very restrictive groundfish management in California (as well as a petition for ESA listing). Anecdotal evidence of a strong 1999 year class was poorly supported by the data in 2002, but was prominent in the 2003 assessment, resulting in an increased estimate of productivity in 2003. Bocaccio is scheduled for an "update" assessment in 2005, work on this assessment is currently ongoing. The 2003 assessment also included the application of a newly developed a method for recreational CPUE estimation which draws inferences regarding fishing locations from the mix of species that is caught, allowing non-relevant fishing trips to be excluded from the analysis (Figure 3).

Widow rockfish was also assessed in 2003, and found to be at slightly under 25% of the historical SPR. This stock will be assessed again in 2005, although the assessment is scheduled as an update, the use of a new Bayesian one-tailed prior on steepness may merit a full review. Although genetic evidence suggests that Vermillion rockfish may in fact be two distinct species, the California stock is being assessed for the first time in 2005. Preliminary results so far suggest the stock is at or above target biomass levels. Rebuilding plans for both widow and bocaccio (as well as cowcod) were developed in 2003, and will be reevaluated in 2005. Steve Ralston and Alec MacCall are also actively engaged in the development of options for establishing quantitative criteria for assessing the progress towards rebuilding for the PFMC. Additionally, an assessment of shortbelly rockfish, an unexploited stock, is currently in progress. As this stock might be considered the equivalent of a "control" rockfish population, the results of this assessment should be informative with regard to the understanding the potential causes and consequences of natural population variability on exploited rockfish populations throughout the California Current

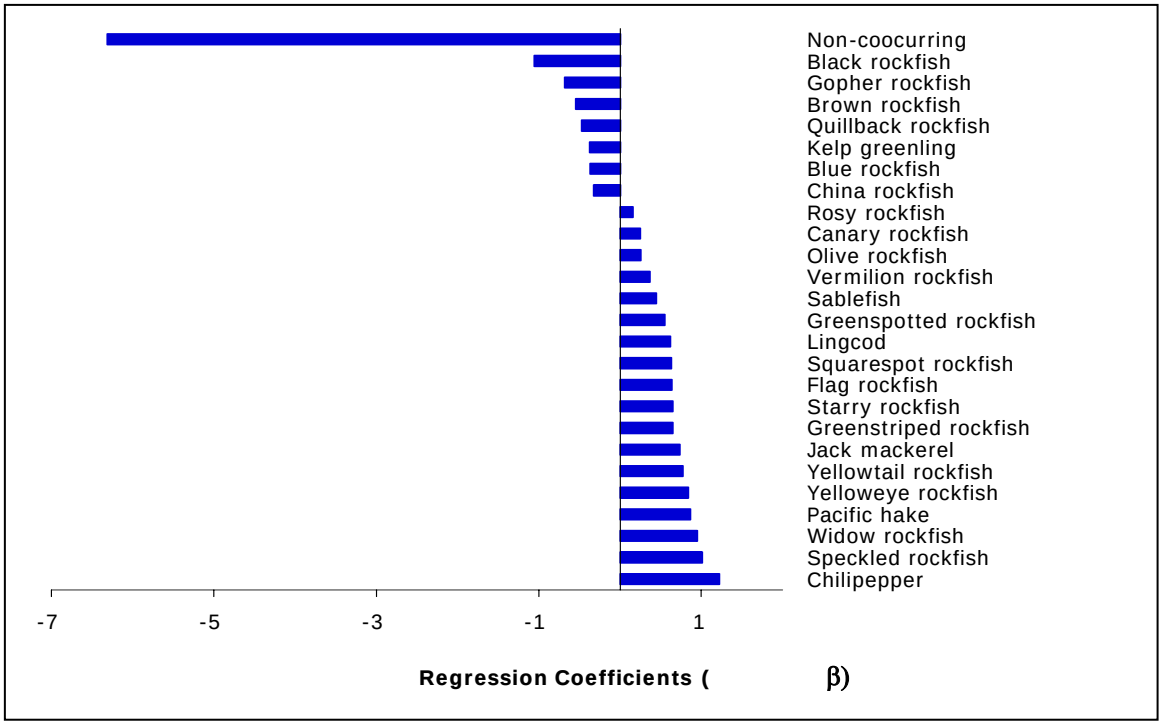

Figure 3: Species-based subsetting classifies each trip by probability of encountering target, as target switching is a major problem in interpreting recreational CPUE.

6. Sablefish

i. Research

Publication of a study initiated jointly by SCL and AFSC researchers reviewed substantial complications in the ageing of sablefish, based on otoliths retrieved from fish that had been injected with oxytetracycline (OTC) and subsequently been at liberty for known durations. The findings suggest that some improvements could be achieved by detailed knowledge of growth characteristics of different morphological types.

7. Flatfish

i. Research

A paper on the growth and life history of sand sole is in preparation. Maturity, growth, and life history studies of starry flounder, rex sole and sanddabs are also ongoing, based

primarily on data and specimens collected in the Central California Cooperative Groundfish Ecology Survey.

ii. Assessment

A stock assessment for starry flounder was initiated in 2004 and recently underwent STAR panel review. The final assessment is in preparation. This was the first assessment ever for starry flounder, and results suggest that although the stock is currently near target levels, biomass levels of the southern stock have recently been close to (or below) overfished levels, largely in response to environmental factors. In particular, recruitment for the southern stock appears to be strongly linked with streamflow to San Francisco Bay

D. OTHER RELATED STUDIES

1. Acoustical/Optical Survey of Rockfish Habitat and Abundance

The La Jolla Center Advanced Sampling Technologies and In-Situ Survey groups are currently using three technologies combined with industry partnership to form a novel, non-lethal survey method for overfished stocks and to better survey rockfish off the California coast. Multi-beam sonar measurements are used for habitat characterization, multi-frequency echosounder measurements are used for mapping rockfish aggregations and facilitating remote species identification, and ROV video observations are used to validate the acoustical habitat classification and species identification.

In the past year rockfish and their habitats were mapped using this technique at ten different locations. Rockfish at one of these sites, the Forty-three Fathom Spot (Fig. 1), were monitored for site fidelity, diel vertical migratory behavior, and temporal variations in biomass on inter-hourly, daily, weekly, and monthly scales. Also at this location, the frequency specific sound scatter from six different rockfish species were measured in-situ and as a function of water depth. These target strength data will ultimately be used to acoustically discriminate animal taxa, and to scale the total acoustic energy scattered from rockfish to estimate their biomass density. Other work includes the use of an instrumented small craft for efficient routine monitoring, the use of an Autonomous Underwater Vehicle (AUV) for species identification, and the use of instrumented buoys for characterization of environmental factors.

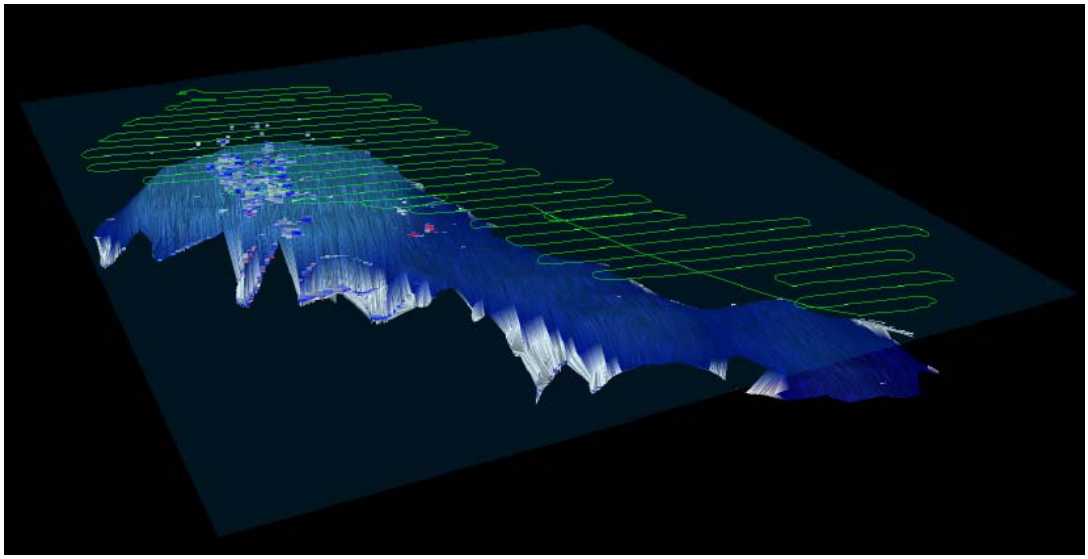

Figure 4. An acoustically-derived image of the bathymetry (surface) overlayed with rockfish aggregations (grey, blue, and red spots) at Forty-Three Fathom Bank, located approximately 45 n.mi. west of San Diego. The rockfish were identified using a multi-frequency delineation technique. The bathymetric surface was derived by interpolating the depth measurements recorded along the survey tracks (yellow lines) using the 38 kHz echosounder. Note that virtually all the rockfish are aggregated at the rocky high spot.

2. Groundfish Habitat Ecology

The SCL's Habitat Ecology team has developed a research program to respond to the Essential Fish Habitat (EFH) requirements of the MSFCMA. In addition to the *in situ* surveys of cowcod in the Cowcod Conservation Areas mentioned in the stock assessment section, the habitat team has evaluated the role of structure forming invertebrates in CCAs, by identifying over 500,000 organisms of 15 taxa seen in the CCA submersible survey. Efforts are ongoing to quantifying their density and size distributions relative to depth and substratum types, and quantifying associations between these organisms and their communities, particularly fishes. Among the products of this work have been the first descriptions of black corals (genus *Antipathes*) off southern California, including at least one new species to date. Interestingly, few organisms, and virtually no fishes, seem to be associated with these animals, suggesting that fishes are not intimately associated with structure-forming invertebrates in the areas surveyed. Other efforts have focused on using direct observation methods from an occupied submersible to survey fishes and habitats in tandem with bottom longline surveys, to compare direct observations with bottom longline methods for determining abundance, size and species composition, catchability coefficients and selectivity, and appropriate conversion factors for relative and absolute abundance. Finally, a post-doctoral fellowship funded jointly by the SCL and USGS Coastal and Marine Geology has generated research products and tools for evaluating the relationship between patterns in groundfish distribution and abundance and seafloor habitats at a range of spatial scales.

3. Trawl Location Mapping

The Pacific Grove Environmental Research Division has developed a GIS demonstration of trawl location mapping with improved resolution. Trawl lines based on the start and endpoints of 28,000 individual trawls from California logbook database were mapped for a test region in Central California. The density of trawling effort trawl lines was mapped on a 2-km grid for each year from 1997 to 2002. Associated information such as tow hours, date, port and pounds landed was retained with each line and used to create different maps. Landings by species from associated fish receipts matched to tows by California Department of Fish and Game were aggregated into 1-minute blocks (about 3sq km each, 100 per 10 minute fishing logbook block) to calculate catch per tow hour by species with much greater resolution than in the past. Maps detailing the distribution of trawling effort and landed species will provide detailed information to fisheries managers for the decision process for area closures. These maps also will provide information on how past regulatory actions, including rockfish conservation areas, have affected the spatial distribution of fishing effort and catch. The Environmental Research Division has been examining the relationship of environmental signals to time series of California commercial landings, including groundfish. Principal component analysis identified two signals closely related to sea surface temperature and southward wind stress that together describe over half the variability in commercial groundfish landings over the last 70 years.

4. Integration of Marine Protected Areas and Fisheries Science and Management

The Santa Cruz Laboratory and the National Marine Protected Areas Science Institute have convened a technical working group to develop the scientific information necessary to integrate MPAs and traditional fisheries management strategies. Prior to convening the working group, a NOAA planning committee was initiated, consisted of members representing the various line offices within NOAA, the Pacific Fishery Management Council (PFMC), and the MPA Federal Advisory Committee. The Science Integration working group held its inaugural meeting in October 2004 where it defined three main topics for review and analysis by individual teams. The topics were distilled from a longer list based upon their relevance, urgency, and tractability for MPA science integration. Three teams were formed to address separate topics and main objectives. These teams were (1) Fisheries – MPA/ecosystem team, charged with using models and other means to identify and evaluate the trade-offs of different fishery management measures (MPAs are one of them) in terms of common currencies for fisheries and ecosystems. This includes considerations of how an MPA would likely affect traditional fishery management science, such as stock assessment reference points. (2) Connectivity team, will develop tools to identify connectivity patterns at the ecosystem scale and to translate that information into the design of effective MPAs that meet the needs of fishermen and other stakeholders. (3) Natural heritage MPA team: develop guidance and measurable objectives for the design and evaluation of an MPA implemented for natural

heritage purposes. Discussions are ongoing among some members of the working group about adding a fourth team to identify institutional and legislative barriers to integration of MPAs and traditional fishery management, and develop strategies to overcome these barriers. The working group will continue participate in a series of focused workshops over a span of two years to discuss and define the critical concepts and issues, and use in-depth analysis and synthesis develop a rational approach for integration of the dominant, yet divergent, management approaches based in single species population dynamics versus multi-species ecosystem dynamics. This process is ultimately designed to address the need to derive ecosystem and fisheries level standards, reference points and control rules to evaluate the trade-offs (ecologically and economically) between MPA and other fisheries management strategies.

GROUNDFISH PUBLICATIONS OF THE SWFSC, 2004 - present

1. Primary Publications

Anderson, T., **M. Yoklavich**, and S. Eittreim. In Press. Linking fine-scale groundfish distributions with large-scale seafloor maps: issues and challenges of combining biological and geological data. In: P. Barnes and J. Thomas (eds). Benthic habitats and the effects of fishing. AFS Symposium 41, Bethesda, Maryland.

Amend, M., M. Yoklavich, Y. Rhzanov**, C. Grimes**, and W. Wakefield. In press. Mosaics of benthic habitats using laser line scan technology: it's in the details. In: B. Todd and H. G. Greene (eds.), Proceedings of GeoHab: Marine geological and biological habitat mapping (Moss Landing, California, 2002).

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

Berkeley, S. A., C. Chapman, and **S. M. Sogard**. 2004. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes melanops*. Ecology 85(5):1258-1264.

Black, B. A., G. W. Boehlert, and **M. M. Yoklavich**. In review. Using tree-ring crossdating techniques to validate age in longlived fishes.

Buonaccorsi, V. P., **C. Kimbrell**, **E. Lynn** and **R. D. Vetter**. In press. Limited realized dispersal and introgressive hybridization influence genetic structure and conservation strategies for brown rockfish, *Sebastes auriculatus.* Conservation Genetics

C. Hsieh, M.J. Allen, **J.R. Hunter**, R.N. Lea, **C. Reiss**, R. Rosenblatt, **P.E. Smith**, G. Sugihara, **W. Watson**. (submitted) A comparison of long-term trends and variability in populations of larvae of exploited and unexploited fishes in the Southern California region: a community approach. Progress in Oceanography.

Copps, S., **M. Yoklavich**, G. Parkes, W. Wakefield, A. Bailey, H. G. Greene, and C. Goldfinger. In review. Applying habitat data to fishery management on the US west coast. In: B. Todd and H. G. Greene (eds.), Proceedings of GeoHab: Marine geological and biological habitat mapping (Moss Landing, California, 2002).

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Dick, E. J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70:351-366.

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Field, J. C., R. C. Francis, and K. Aydin. In review. Top down modeling and bottom up dynamics: linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography.

Field, J. C., and **R. C. Francis**. In prep. Considering ecosystem-based fisheries management in the California Current.

Gunderson, D. and **R. D. Vetter**. Mtapopulation Structure in Temperate Rocky Reef Fishes. In press. In Marine Metapopulations. Kritzer, J. P and P. F. Sale (eds.) Academic Press.

He, X., M. Mangel, and **A. MacCall**. In review. A one-tailed prior for steepness based on an evolutionary persistence principle.

Kahn, R. G., **D. E. Pearson**, and **E. J. Dick**. In press. Comparison of standard length, fork length, and total length for measuring fish. Marine Fisheries Review.

Laidig, T. E., **K. M. Sakuma**, and J. A. Stannard. 2004. Description and growth of larval and pelagic juvenile pygmy rockfish (*Sebastes wilsoni*) (family Sebastidae). Fishery Bulletin 102(3):452-463.

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