# Northwest Fisheries Science Center

# National Marine Fisheries Service


# Agency Report to the Technical Subcommittee

# of the Canada-U.S. Groundfish Committee

**April 2010**

## Review of Agency Groundfish Research, Assessments, and Management

### A. Agency Overview

The Northwest Fisheries Science Center (NWFSC) provides scientific and technical support to the National Marine Fisheries Service (NMFS) for management and conservation of the Northwest region's marine and anadromous resources. The Center conducts research in cooperation with other federal and state agencies and academic institutions. Five divisions, Conservation Biology, Environmental Conservation, Fish Ecology, Resource Enhancement and Utilization Technologies, and Fishery Resource Analysis and Monitoring, conduct applied research to resolve problems that threaten marine resources or that deter their use. The Center's main facility and laboratories are located in Seattle. Other Center research facilities are located in Pasco, Big Beef Creek, Mukilteo, and Manchester, Washington; Newport, Hammond, and Clatskanie, Oregon; and Kodiak, Alaska.

**The Fishery Resource Analysis and Monitoring Division** (FRAMD) is the source for most of the research reported by the NWFSC to the Technical Subcommittee of the Canada-US Groundfish Committee. The FRAMD works in partnership with state and federal resource agencies, universities, and the groundfish industry to achieve a coordinated groundfish program for the West Coast.

FRAMD consists of a multi-disciplinary team with expertise in fishery biology, stock assessment, economics, mathematical modeling, statistics, computer science, and field sampling techniques. Members of this program are stationed at the NWFSC facilities in Seattle and in Newport, Oregon, with some Observer Program staff located in California. Together, they work to develop and provide scientific information necessary for managing West Coast marine fisheries and strive to provide useful and reliable stock assessment data with which fishery managers can set ecologically safe and economically valuable harvest levels. FRAM researchers develop models for managing multi-species fisheries; design programs to provide information on the extent and characteristics of bycatch in commercial fisheries as they look at methods to reduce fisheries bycatch; characterize essential habitats for key groundfish species; and employ advanced technologies for new assessments.

During 2009, FRAMD continued to: implement a West Coast observer program; build a survey program that conducts West Coast groundfish acoustic and trawl surveys previously conducted by the AFSC; develop new technologies for surveying fish populations, particularly in untrawlable areas; and expand its stock assessment, economics, and habitat research. Significant progress continues in all programs.

For more information on FRAMD and groundfish investigations, contact the Division Director, Dr. M. Elizabeth Clarke at Elizabeth.Clarke@noaa.gov, (206) 860-3381.

**Other Divisions at the NWFSC are:**

**The Conservation Biology Division** is responsible for characterizing the major components of biodiversity in living marine resources, using the latest genetic and quantitative methods. It also has responsibility for identifying factors that pose risks to these components and the mechanisms that limit natural productivity. The Division's multi-disciplinary approach draws on expertise in the fields of population genetics, population dynamics, and ecology.

**The Environmental Conservation Division** (ECD) conducts nationwide research on the effects of chemical pollution and harmful algal blooms on habitat quality and fisheries resources. ECD is also a leader in NMFS' National Marine Mammal Health and Stranding Response Program's bio-monitoring and quality assurances projects.

**The Fish Ecology Division**'s role is to understand the complex ecological linkages among important marine and anadromous fishery resources in the Pacific Northwest and their habitats. The Division particularly places emphasis on investigating the myriad biotic and abiotic factors that control growth, distribution, and survival of important species and on the processes driving population fluctuations.

**The Resource Enhancement and Utilization Technologies Division** draws together multi-disciplinary groups to address existing and developing challenges of captive rearing of salmon and other marine fish, improved hatchery practices, smolt quality, disease control, and developing technologies for full utilization of bycatch and fish processing waste.

For more information on Northwest Fisheries Science Center programs, contact the Center Director, Dr. Usha Varanasi at Usha.Varanasi@noaa.gov, (206) 860-3200.

## B. Multi-species Studies

### 1. Research

#### a) Estimating the NWFSC survey trawl herding and footrope escapement

Data collected during the NWFSC trawl survey are the primary source of fishery-independent data included in stock assessments and are vital in determining current and projected stock size. The survey produces annual swept-area biomass estimates that are calculated using the area swept by the trawl to estimate the density of fish; these estimates are then expanded to the full survey area. Understanding the distance and width that the trawl is effectively fishing is important for producing an accurate calculation of the area swept in relation to the capture of a particular species. Currently, area swept is calculated using the distance over which the net is determined to be on the bottom and the width between the wings of the net. However, previous experiments describe herding over areas greater than the portion of the trawl between the wings. If fish are actively avoiding or being herded by the trawl net, the effective area swept may be smaller or larger, respectively, resulting in the need to modify the area-swept calculation.

In 2009, the NWFSC undertook a pilot study to use video to examine the trawl warps (the cable running from the trawl doors to the wing extension of the footrope) while the Aberdeen Trawl was fishing under standard procedures. The video camera work was conducted aboard the F/V Raven between August 22 and 24. A combination of historical NMFS survey catch data and fishermen's knowledge of the fishing grounds was used to locate areas where the project was likely to find target flatfish species. An underwater video camera was attached at each of three different positions along the starboard warp of the survey net to try to observe trawl performance along this portion of the gear, generally, and to capture visual evidence of herding, specifically.

The first priority was to position the video camera system at several locations above the 90-foot section of the lower bridle or sweep closest to the trawl wing. The plan was to fly the camera and light frame from the upper cable bridle. This has been done successfully by the Alaska Fisheries Science Center. To start, representative video was collected from 3 points along the 90' section of sweep. The second priority was to position the video camera system at several locations above the 90-foot section of the bridle or sweep closest to the trawl door. This portion of the sweep has no upper bridle. The plan was to fly the camera and light frame from a 200-ft long Spectra line that ran from the door end of the sweep to the leading edge of the upper starboard wing. This has also been done successfully by the Alaska Fisheries Science Center, but is much more difficult to "dial in." As with priority one, we collected representative video from 3 points along this 90-foot section of sweep. The third priority was to collect video observations of fish behavior in association with the trawl doors.

Initial emphasis was placed on obtaining adequate views of the target areas of the sweeps. Once we began to collect adequate video, we closed the trawl codend and began sampling to provide groundtruthing for the video. Post processing the video is currently underway to determine: 1) the number of fish that go over or under mud gear versus the

number herded, 2) direction of herding, 3) changes in performance during hall back, 4) when the sweeps contact the bottom and how consistent is contact over the 200-foot interval, and 5) fish behavior around doors.

Closer examination of the video footage is currently underway to collect information on the movement and behavior of fish in response to the warps, and data from this will be used to provide information for stock assessments and to plan a more extensive project to address this issue in the future, if possible.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

**b) U.S. west coast temporal and regional summer groundfish assemblages: 1977 to 2008**

Investigators: J. Cope and M. Haltuch

Multispecies interactions are increasingly being considered when developing sustainable fisheries practices for the U.S. west coast groundfish fishery, highlighting the need for identification of spatial and temporal groundfish assemblages. Previous groundfish assemblage analyses using fishery independent survey data have either focused on particular groups (i.e. *Sebastes*) or limited geographic regions within the groundfish fishery and have not used the most recently available data. We use hierarchical and non-hierarchical agglomerative clustering methods on presence-absence and log+1 transformed CPUE data to identify groundfish assemblages for the full spatial extent of the west coast groundfish triennial survey from years 1977-2001. Persistent and predictable co-occurring assemblages were detected by both methods through most years of the survey, while the magnitude at which species were caught together was also investigated. Members of an assemblage may therefore occur together, but not necessarily at the same magnitudes. These findings are relevant to marine resource managers because they can be directly applied to formulating bycatch models and in evaluating the implementations of spatial management measures, such as marine protected areas.

For more information, please contact Dr. Jason Cope at Jason.Cope@noaa.gov

**c) Using meso-habitat information to improve abundance estimates for West Coast groundfish: a test case at Heceta Bank, Oregon**

Historical *in situ* observations of benthic fishes and invertebrates represent an opportunity for establishing fishery-independent benchmark estimates of abundance from specific time points and in both trawlable and untrawlable habitats. Depending on the original intended purpose of a given study, the direct count data may be non-random in nature. The objective of this research is to show how a new method for treating such data was used by combining *in situ* fish observation data and a habitat map to estimate fish abundance. We evaluated whether increased resolution of habitat information could improve the precision of population estimates. For this study we used an existing and previously published data set from Heceta Bank, Oregon. Heceta Bank is one of the

largest rocky banks along the US west coast containing a diverse array of habitats supporting numerous species of commercially important groundfish, including a diverse assemblage of rockfishes (*Sebastes*). We looked at fish observations relative to the variables of habitat type, depth, backscatter intensity and relative elevation (i.e., topographic position index [tpi]) and post-stratified the data according to levels of sampling effort. We also looked at two levels of habitat detail: four habitat types, and "hard" vs "soft" substrate. We then calculated the density and variance of fish species for each habitat type and then estimated fish abundance for a select group of groundfish species. Based on these results it appears that improved precision of more geographically comprehensive abundance estimates may be achieved through pre-survey stratification based on currently available habitat information.

For more information please contact Julia Clemons at Julia.Clemons@noaa.gov

**d) Demersal fish species composition and biomass in relation to the oxygen minimum zone along the U.S. West Coast**

The goal of this research is to provide information of use to fisheries manager to aid in assessment of fish populations in the face of future climate changes. Various models driven by increased greenhouse gases and higher temperatures predict a decline in oceanic dissolved oxygen (DO) as a result of greater stratification and reduced ventilation of waters below the thermocline. Since spreading of low oxygen waters is currently underway and predicted to increase, understanding the impacts on higher trophic levels is essential. Shoaling of the oxygen minimum zone (OMZ) is expected to produce complex ecosystem-level changes in the California Current System Direct hypoxia-related effects are expected on demersal fish and benthic invertebrate species depending on their oxic requirements where the OMZ contacts the continental margin. The onshore movement of the OMZ could lead to habitat compression for species with higher oxygen requirements while perhaps allowing expansion of species tolerant of low bottom DO concentrations. These events need to be considered when managing our nation's fisheries.

In 2009, the NWFSC sampled a range of oxygen conditions extending from the upper to the lower limit of the OMZ as well as across the boundaries of the OMZ. We collected data on the composition, distribution, and biomass of demersal groundfish species in relation to bottom oxygen concentration within the Eastern North Pacific OMZ along the U.S. West Coast from May 23 – July 27, 2009 (pass 1) and August 26 – Oct. 25, 2009 (pass 2). We measured bottom oxygen concentrations on 192 tows conducted during the first half of the 2009 West Coast Groundfish Bottom Trawl Survey (WCGBTS) and 182 tows conducted during the second half of the survey. Our preliminary results indicate that DO ranged from 0.07 to 3.88 ml $l^{-1}$ during pass 1 with 128 stations experiencing hypoxic conditions (DO < 1.43 ml $l^{-1}$). During pass 2, near bottom DO ranged from 0.08 to 4.33 ml $l^{-1}$ with 104 stations located in hypoxic waters. Throughout this project, the NWFSC has collaborated with a group of physical oceanographers at Oregon State University to develop procedures and protocols for integrating the collection of oceanographic quality temperature, salinity, and dissolved oxygen data into the WCGBTS. Figure 1 shows bottom DO levels in the northern portion of the study site during both the first and second

half of the survey. Hypoxic levels are seen at greater depths along the DO minimum zone during both periods, with an apparent shoreward movement of low DO waters during the second portion of the survey (August – October).

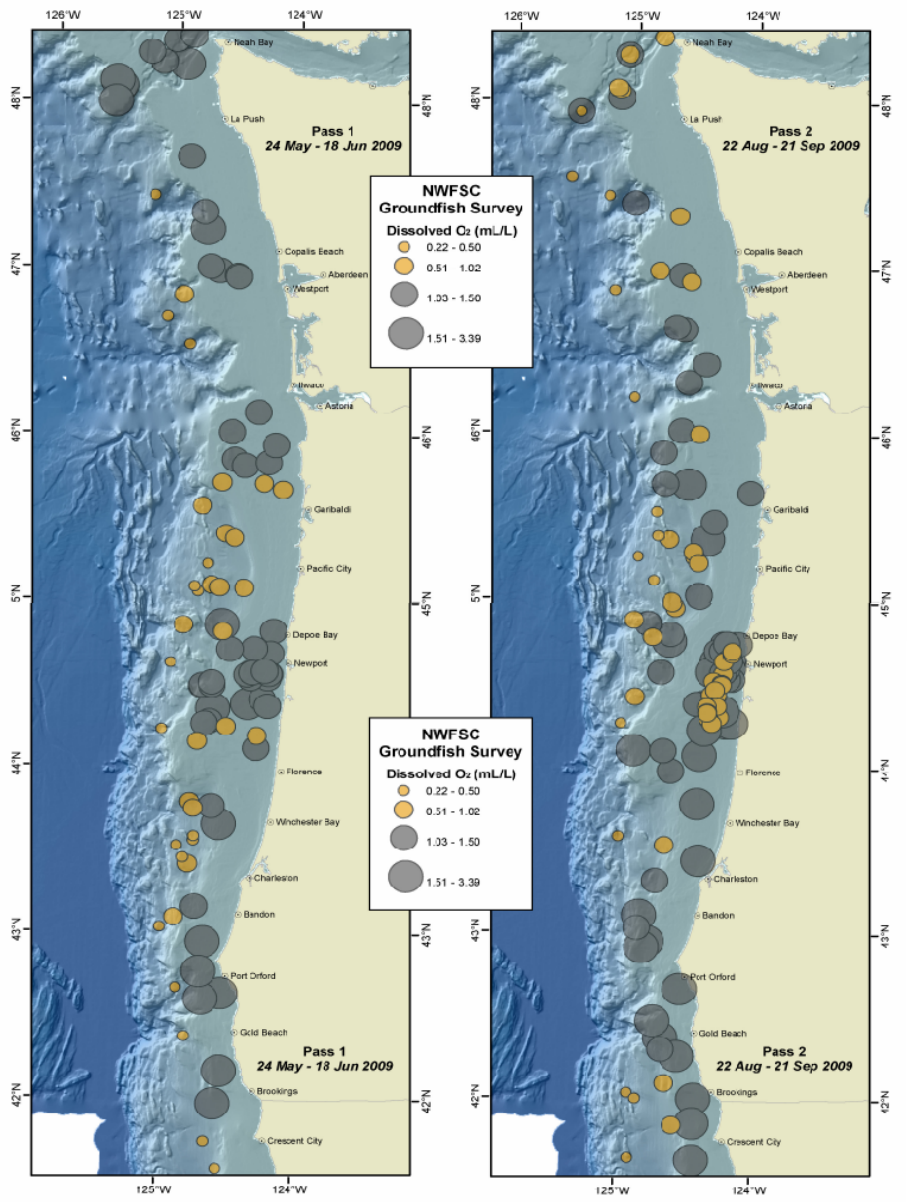



Figure 1. 2009 sampling station by survey pass: North of Crescent City. The size of the circles are proportional to the concentration of bottom DO (ml $l^{-1}$) and clearly show low oxygen in deep water within the DO minimum zone as well as low oxygen at shallower depths offshore of Newport Oregon. Low DO appeared to move shoreward as the summer progressed.

For more information, contact Aimee Keller at (206) 795-5860, Aimee.Keller@noaa.gov.

**e) Development of a Quantitative Optic Trawl Analysis System (QUOTAS)**

The goal of this research effort is to improve accuracy and reduce uncertainty of fish stock assessments by developing a non-lethal, efficient method of gathering data on important management species over wide areas via a deployed integrated optical camera system (Figure 2). The priorities for FY09/10 were: 1) to test a single unit consisting of camera, laser diodes, and flash (CLF) components and build a benchtop prototype; 2) to assemble a complete prototype using 6 cameras; and 3) to integrate the 6 camera system into the cod end of a trawl net and test in trawling operation. The funds were secured in a competitive bid contract which was awarded to GSA vendor Sound and Sea Technologies in Seattle. The camera and laser diode components are undergoing preliminary testing and trials. The design for the flash circuitry will quickly follow for the benchtop prototype. This NWFSC effort supports the national Advanced Sampling Technology Working Group initiative to improve NMFS's ability to monitor protected marine resources without using conventional, lethal trawling methods.

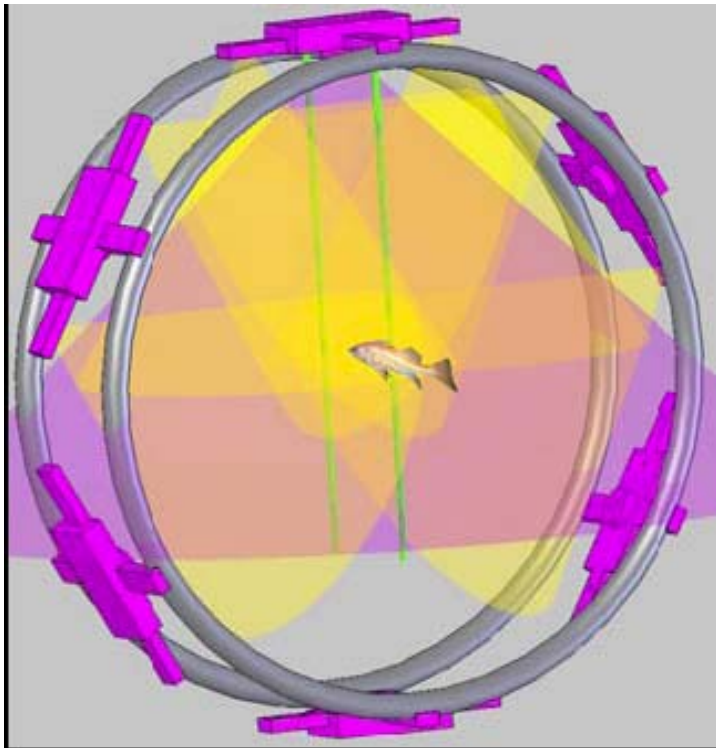


Figure 2. Diagram illustrating the configuration of the QUOTAS. A total of 6 CLF units will be activated in a group of 3 to illuminate sequentially the sample volume bounded by the ring frame. The laser pair on each CLF will be used to size the illuminated targets.

For more information please contact Victor Simon at: Victor.Simon@noaa.gov

**f) Demersal fish abundance in relation to an offshore hypoxic zone along the U.S. west coast**

In August 2009, as part of the West Coast Groundfish Bottom Trawl Survey, FRAMD examined the abundance of benthic organisms in a known hypoxic area off the Oregon

coast. Since 2002, seasonal hypoxia has been observed extending over an area greater than 700 $km^2$ offshore of Newport, Oregon. Although observed each summer, the intensity of hypoxia has varied with the greatest temporal and spatial extent noted in 2006. The Northwest Fisheries Science Center annually conducts a groundfish survey from Washington to California (55 to 1,280 m) using a stratified random design. A few stations generally fall within the hypoxic area and in 2006 FRAMD observed exceedingly low fish biomass here. Consequently in August 2009, FRAMD dedicated 3-days of the groundfish survey to examining the abundance of demersal fish and invertebrates within the hypoxic zone in greater detail, as was initially done in 2007. Working collaboratively with colleagues from Oregon State University, we identified the geographic extent of the 2009 hypoxic zone. A Seabird SBE19-plus was attached to the trawl gear to monitor oxygen concentration during each tow. We sampled 14 stations along 2 depth contours (70 and 80 m) and additionally measured bottom DO via 31 CTD casts within the sampling area off OR. All catch was identified and weighed with stomach and tissue samples taken from selected species. Dungeness crabs from each tow were measured, weighed and assigned a condition code. During the 3-day survey, bottom oxygen concentrations at all stations ranged from 0.55 to 1.48 ml $l^{-1}$ and was hypoxic along 12 tow tracks. Preliminary results indicate that total catch (kg) and bottom dissolved oxygen (DO, ml $l^{-1}$) levels for 2009 were significantly related as seen for all depths combined and (Figure 3).

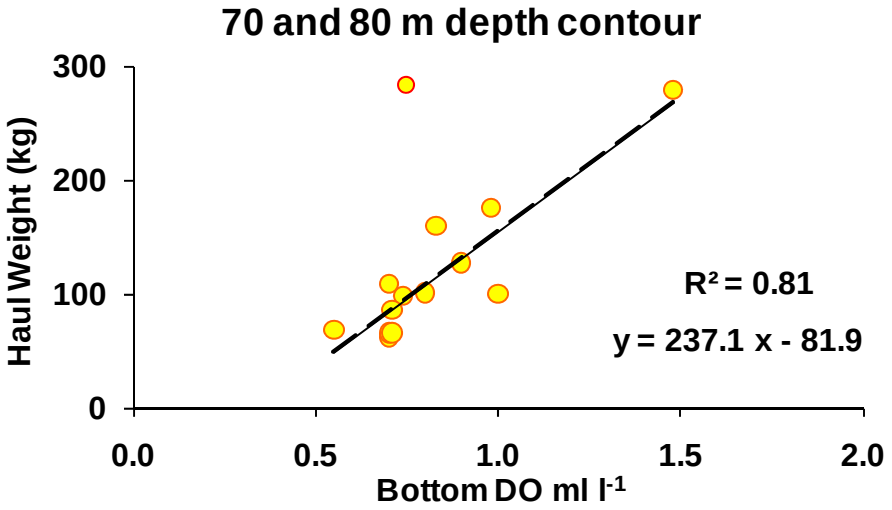



Figure 3. Relationship between haul catch (kg) and mean bottom oxygen concentration (DO, ml $l^{-1}$) along the tow track within the hypoxic zone.

For more information please contact Dr. Aimee Keller at Aimee.Keller@noaa.gov.

**g) Accuracy of sex determination for northeastern Pacific Ocean thornyheads (*Sebastolobus altivelis* and *S. alascanus*)**

Determining the sex of thornyheads (*Sebastolobus alascanus* and *S. altivelis*) can be difficult under field conditions. We assessed our ability to correctly assign sex in the field

by comparing results from field observations to results obtained in the laboratory through both macroscopic and microscopic examination of gonads. Sex of longspine thornyheads was more difficult to determine than that of shortspine thornyheads and correct determination of sex was significantly related to size. By restricting the minimum size of thornyheads to 18 cm for macroscopic determination of sex we reduced the number of fish with misidentified gender by approximately 65%.

For more information please contact Erica Fruh at Erica.Fruh@noaa.gov

**h) Catch composition in the NMFS west coast bottom trawl survey as a predictor of habitat complexity**

For many assessments of west coast fish stocks, an annual bottom trawl survey is the main source of fishery-independent information on biomass trends. Unfortunately, these biomass estimates are made under the assumption that densities of fish observed in the trawl catches are uniform across all benthic habitats. From *in situ* habitat studies, we know however that density can vary significantly in relation to various habitat types. The recent availability of coast wide maps of surficial geologic habitat off the west coast has provided the opportunity to explore trawl survey catch rates in the context of seafloor characteristics. For this study, we compared catch-per-unit-effort data for select species of demersal fishes and benthic invertebrates to the habitat types encountered during the trawl. These trawls were conducted between 2003 and 2009 by the Northwest Fisheries Science Center as part of an annual trawl survey of commercially important groundfishes. The species used in this analysis were chosen due to their ubiquitous distributions and strong affinities to certain benthic habitat types – either soft, unconsolidated sediments or hard, rocky outcrops. We hypothesize that for trawls that encounter a variety of habitats, the catch composition will reflect those changes in habitat type. For instance, we expect to see species with affinities to hard, rocky habitats if the trawl crosses those types of habitat. If our hypothesis is correct, we hope to develop a model using catch composition as a predictor of greater habitat complexity, particularly in areas where habitat information is lacking.

For more information please contact Curt Whitmire at Curt.Whitmire@NOAA.gov

i**) Reproductive parasitism of lithodid crabs by snailfishes off the western U.S.**

Snailfish (Family Liparidae) are probably the most broadly distributed family of marine fishes, occurring in temperate and cold ocean waters from intertidal to depths below 7,700 m. Some snailfishes of the genus *Careproctus* have the unique reproductive strategy of depositing their eggs in the branchial chambers of large lithodid crabs, probably via an ovipositor. The relationship has been described as parasitic, with effects on crabs ranging from no obvious damage to major gill compression and necrosis of half (an entire side) of the gills. Records of carcinophily consist of observations of eggs (and/or larvae) in crabs, but generally the fish involved are unidentified because the eggs have no distinguishing features, and snailfish are too similar in morphology to allow identification of embryos. West Coast U.S. occurrences have been reported.

We initiated a pilot study during the 2007 NWFSC groundfish trawl surveys to collect data on the presence of snailfish eggs in the branchial chambers of crabs captured in the survey trawls, to identify adult snailfishes collected on the survey, to use genetic methods to match eggs to adults, and to initiate further studies of carcinophily. We included a non-lithodid group of crabs with potential commercial value, tanner crabs of the genus *Chionoecetes*, but 807 crabs were checked for the presence of snailfish eggs and none were found. Snailfish eggs were found in three different lithodid species out of six that were collected and checked in 2007. The study was continued in 2008 and 2009 checking only lithodid species for egg masses. Five different lithodid species out of the ten that were collected in 2008 had egg masses, three of which (*Paralithodes rathbuni*, *Paralomis multispina*, and *Glyptolithodes cristatipes*) were the first recorded instances of parasitism. Five different lithodid species out of the seven that were collected in 2009 had egg masses. At least seven different species of snailfish in three genera were collected during the 2007 survey, including one (*Paraliparis pectoralis*) that is rare in collections. Visual analysis of the egg masses suggests there are at least two different liparid species depositing their eggs in crabs. The most common species collected was *C. melanurus.* Females collected had ovarian eggs ranging from undeveloped to 4.9 mm in size, suggesting that spawning may be protracted, even if periodic. Genetic analysis of egg masses and tissue samples taken from adult snailfish to identify which species laid the eggs was completed for 2007 samples. All of the egg masses were determined to belong to just one species, *C. melanurus*. Information on the relative frequency of occurrence of parasitism was determined for 2007 and 2008, and the rates for each year, respectively, were as follows: *Lopholithodes foraminatus* 12.9% and 4%; *Lithodes couesi* 2.1% (2007); *Paralithodes californiensus* 7.2% and 6%; *G. cristatipes* 9% (2008); *P. rathbuni* 1% (2008), and *P. multispina* 1% (2008). Genetic analysis of egg masses is underway for 2008 and 2009. This work will both help clarify the natural history of two groups of species distributed worldwide: snailfishes and lithodid crabs, and, we hope, lead to clarification of the evolution of this unique behavior.

For more information please contact Keith Bosley at Keith.Bosley@noaa.gov

**j) Estimates of Pacific halibut bycatch and mortality in IPHC Area 2A in 2008 West Coast**

During 2009, the estimate of Pacific halibut bycatch and mortality in the bottom trawl fishery was updated through the calendar year 2008. The estimate of halibut bycatch and mortality in the bottom trawl fishery is based upon the method developed in the Pikitch et al. (1998) paper and the report for 1999 (Wallace, 2000) with the addition of using halibut condition as recorded by the West Coast Groundfish Observer Program (WCGOP). This analysis used halibut bycatch rates observed during the 2008 calendar year from WCGOP. These rates are stratified by season, depth, latitude, and level of arrowtooth flounder catch; then multiplied by the amount of trawl effort in each stratum, which was derived from the 2008 Oregon and Washington trawl logbooks.

For more information please contact John Wallace at John.Wallace@noaa.gov

**k) Length-based reference points for data-limited situations: applications and restrictions**

Investigators: J. Cope and A. Punt

Current fisheries management policies generally require assessing stock status, a difficult task when population and fisheries data are limited. Froese (2004) offered three simple metrics ($P_{mat}$, $P_{opt}$, $P_{mega}$) based on catch length compositions by which to monitor population status relative to exploitation. They are intended to avoid growth and recruitment overfishing, but there was no quantitative linkage to stock status and calculation of future sustainable catches. We attempt to make this connection by exploring the relationship of these measures (collectively referred to as $P_x$) to fishing mortality and spawning biomass. The relationships are compared specifically to current target (0.4 $SB_0$) and limit (0.25 $SB_0$) reference points used for the U.S. west coast groundfish fishery using simulations based on a deterministic age-structured population dynamics model. Sensitivity is explored to fishery selectivity, life history traits and recruitment compensation (steepness). Each $P_x$ measure showed a wide range of possible values depending on fishery selectivity, steepness, and the ratio of the length at maturity ($L_{mat}$) to the optimal fishing length ($L_{opt}$). The values of $P_x$ suggested by Froese (2004) as being compatible with sustainable fishing are not always sufficient to insure stock protection from overfishing. Moreover, values for $P_x$ cannot be interpreted adequately without knowledge of the selectivity pattern. A new measure, $P_{obj}$ (the sum of $P_{mat}$, $P_{opt}$, and $P_{mega}$) is introduced to distinguish selectivity patterns and construct a decision tree to develop indicators of stock status. Heuristic indicator values are presented to demonstrate the utility of this approach. Although several caveats remain, this approach builds on the recommendations of Froese (2004) by giving further guidance related to interpreting catch length composition data under variable fishery conditions without collecting additional information. It also provides a link to developing harvest control rules to inform proactive fisheries management under data-limited conditions.

For more information, please contact Dr. Jason Cope at Jason.Cope@noaa.gov

**l) Drawing the lines: Resolving fishery management units with simple fisheries data**

Investigators: J. Cope and A. Punt

The task of assessing marine resources should begin with defining management units. Often this step is overlooked or defined at temporal scales irrelevant to management needs. Additionally, traditional methods to define stock structure can be data intensive and/or cost prohibitive and thus not available for emerging or data-limited fisheries. We present an approach that uses commonly available fisheries data (catch and effort) to delineate management units for dynamically independent populations. Spatially-explicit standardized indices of abundance are grouped using a two-step partitioning cluster analysis that includes abundance index uncertainty. This 'management unit estimator' (MUE) is tested via simulation and found generally to recover the true number of management units across data of different temporal length, sample size, and quality.

Management units are then determined for four species with varying ecologies, fishery histories, and data issues that exemplify the challenges of applying this method to messy data sets. Defining management units via relative abundance incorporates changes in population connectivity in relation to current removals and environmental conditions, and creates consistency of index use within assessments. The two-step clustering approach is simple and widely applicable to situations wherein the clustering metric contains uncertainty.

For more information, please contact Dr. Jason Cope at Jason.Cope@noaa.gov

**m) Feeding ecology of juvenile rockfish off Oregon and Washington as indicated by diet and stable isotope analysis**

Investigators undertook a study of the feeding habits of juvenile rockfish (genus *Sebastes*) collected off Oregon and Washington during GLOBEC (2002) and NOAA Predator (2006) surveys. The predominant species collected in both years were darkblotched (*S. crameri*), canary (*S. pinniger*), yellowtail (*S. flavidus*), and widow (*S. entomelas*) rockfishes. Analysis of gut contents by % number revealed that darkblotched rockfish had a high degree of variability in their diets, consisting of gelatinous zooplankton (2002), several life-history stages of euphausiids (2006), as well as hyperiid amphipods and copepods (2002, 2006). Canary, yellowtail, and widow rockfishes had a high degree of dietary overlap, because of common utilization of copepods and euphausiids. There was less overlap in diets between species when % wet weight was examined, with only canary and widow rockfish showing significant similarities (2006). Additionally, nitrogen stable isotope analyses confirmed that there was a 1.5‰ difference between years, and all fish from the same year were feeding at nearly the same trophic level. In both years, carbon signatures were of an off-shore origin, and darkblotched were enriched relative to all other species. Non-metric multidimensional scaling revealed significant differences in diet with increasing distance from shore. Taken together, these results advance our understanding of some of the important environmental factors that affect young-of-the-year rockfish during their pelagic phase.

For more information, please contact Keith Bosley at Keith.Bosley@noaa.gov

**n) Taxonomic and genetic identification of fisheries bycatch of deep-sea corals during the 2009 West Coast Groundfish Bottom Trawl Survey**

The purpose of this project is to contribute to ongoing efforts toward establishing a voucher collection for deep-sea corals from the West Coast. Deep-sea corals are often components of trawling bycatch, though their brittle skeleton and slow growth make them particularly vulnerable to such impacts. An understanding of their population structure is critical to ascertaining the effects of habitat loss and genetic connections among distant populations, both of which are important to the 2006 Magnuson-Stevens Act directive and the NMFS federal mandate. An initial species inventory of deep-sea corals off the United States coastline is a necessary first step toward a comprehensive understanding of the ecology and distribution of this diverse species assemblage;

however, the taxonomic identification of corals to the species level is often problematic. In some cases morphologically similar specimens may only be distinguished from one another using microscopic skeletal structures. In other cases, the taxonomic delineations of some families are so confused that accurate species-level designations are currently impossible. The use of genetic information combined with morphology is likely the best approach to decipher evolutionary patterns in these species. In FY2009 we received funding from the NOAA Deep-Sea Coral Research and Technology Program to support the collection of coral specimens during the 2009 West Coast Groundfish Survey, as well as DNA sequencing of specimens from previous years (2007-2008) of the same surveys. In addition, we began creating scanning electron microscope (SEM) images of some of the specimens, which will be linked to the original specimen for our Voucher Collection. These SEM images will help morphological taxonomists identify the species collected in these surveys. The linked DNA data, SEM images, and morphologically verified specimens will serve not only as an essential resource for coral researchers and other stakeholders, but also as a foundation for future research efforts at the Northwest Fisheries Science Center (NWFSC) aimed at understanding the biogeography and ecology of coral species in these deep-sea communities.

Initial DNA sequencing of the 2007-2008 specimens has been completed, and preliminary analyses are underway. Various species of sea pens make up the bulk of the specimens collected, but there are also a number of gorgonian corals in the collections as well. A significant number of those gorgonians fall into a group putatively identified as *Swiftia* spp., but the taxonomy of this group is equivocal. Given the numbers of *Swiftia* found in the trawls, we began by concentrating our efforts with this difficult group. SEM images from several *Swiftia* specimens have been produced and initial sequence information suggests there may be phylogenetic associations relating to colony morphology. We are in contact with a morphological taxonomist (Beth Horvath) at the Santa Barbara Museum of Natural History, who will assist in determining species-level designations for these specimens.

For more information, please contact Ewann Berntson at Ewann.Berntson@noaa.gov

**2. Stock Assessment**

**a) Stock assessment model development**

Stock Synthesis (SS) is an assessment model in the class termed integrated analysis. SS is built with a population sub-model that simulates a stock's growth and mortality processes, an observation sub-model to estimate expected values for various types of data, and a statistical sub-model to characterize the data's goodness of fit and to obtain best-fitting parameters with associated variance. It includes a rich feature set including age- and size-based population dynamics and the ability to specify observational phenomena, such as ageing imprecision. Model parameters can vary randomly or across time blocks or can be specified as functions of environmental data. SS includes routines to estimate MSY and exploitation levels that correspond to various standard fishery management targets. It supports assessments spanning several geographic areas and can

use tag-recapture data. A customizable harvest policy is used to conduct a forecast in the final phase of running the model. The model is coded in ADMB (www.admb-project.org). SS is now in version 3 (SS_v3) and is included in the NOAA Fisheries Assessment Toolbox (http://nft.nefsc.noaa.gov/) incorporating a graphical user interface developed by Alan Seaver (NEFSC).

In 2009, usage of SS expanded significantly in the Atlantic. It is now being used for assessments of reef fish and pelagic fish in the Southeast, pink shrimp in the Gulf of Mexico, tunas and billfishes in the international Atlantic, surfclam and dogfish in the Northeast, and northern hake off France. In support of this expanded usage, several features were added to bridge the transition from strictly age-based assessments.

For more information, please contact Richard Methot at Richard.Methot@noaa.gov

**b) Deriving objective data weighting for age- and length-composition data in stock assessments using post-model and simulation results**

Integrated age-length structured stock assessment models derive estimates of management quantities by fitting to multiple sources of observed data, including indices of abundance, and age and length compositions. The relative weighting of these likelihood components is often an important contributor to uncertainty, but there is currently no clear objective approach to determine these weights. Model "tuning" is often applied, with the goal of achieving internal consistency between assumed data weighting and model fit. Tuning relies on reasonable starting values for input sample sizes to appropriately allocate lack of fit to process and observation error. Focusing on age- and length-composition observations from trawl survey data, we compare the effective sample sizes derived from assessment models fit to actual data in 2005 and 2007 with theoretical effective sample sizes based on simulation. We find that effective sample size is best represented as a function of both the number of fish and the number of hauls sampled. We develop guidelines for tuning of these data sources that should increase objectivity and reliability of stock assessment model results.

For more information please contact Dr. Ian Stewart at Ian.Stewart@noaa.gov

**c) The Promise and pitfalls of using climate data in fish stock assessment**

Investigators: Melissa A. Haltuch, André E. Punt

Concurrent declines in demersal fish stock abundances and shifts in long-term average environmental conditions in the Pacific have been well documented. Furthermore, highly variable stock-recruitment curves indicate environmental or other factors affect recruitment to fisheries. Thus, management advice that ignores environmental forcing of recruitment may cause stocks to be over- or under-harvested. The efficacy of including environmental impacts on recruitment in management models is important if stock assessment methods are to consider ecosystem interactions. Simulation testing is used to determine the statistical power of currently-used stock assessment methods to correctly

identify long-term decadal-scale environmental forcing of recruitment. The ability of the stock assessment methods to balance type I and type II error rates suggests that methods used most commonly in practice tend to lead to lower total error rates. In this study, the promise of integrating environmental data directly into stock assessments is outweighed by the pitfall of high type I error rates, suggesting that the conventional means of avoiding spurious correlation are insufficient.

For more information, contact Dr. Melissa Haltuch at Melissa.Haltuch@noaa.gov

**d) Growth variability of the splitnose rockfish (*Sebastes diploproa*) in the Northeast Pacific Ocean: pattern revisited**

Investigators: V. Gertseva, J. Cope and S. E. Matson

Understanding patterns of somatic growth within populations greatly contributes to fisheries stock assessment and helps determine the proper model structure. Splitnose rockfish was reported as having a striking pattern of latitudinal growth variability from studies conducted in the 1980s. We investigated variation in growth parameters of splitnose rockfish by latitude using recent data from the NOAA Fisheries Groundfish Survey (2003-2008), current ageing techniques and advanced modeling and statistical methods to provide an updated understanding of growth along this species' latitudinal range. Age data generated from sectioned otoliths were fit to a von Bertalanffy growth function incorporating ageing error. Growth parameters were estimated for each of five International North Pacific Fisheries Commission areas along the U.S. west coast. Generalized linear models and Akaike's Information Criteria were used to evaluate hypotheses for growth parameter relationship with latitude. We found that splitnose rockfish exhibited a cline in asymptotic length ($L_\infty$) with $L_\infty$ increasing with rising latitude. We also found that although the growth coefficient ($k$) was smallest in the Conception INPFC area, there was no apparent cline along the coast; a northward cline in $k$ has previously been reported in the literature. We propose that differences in fishing intensity could be responsible for cline in $L_\infty$, as higher fishing pressure in the south could skew the size distribution of the population in that region, and reduce southern $L_\infty$ estimates. We also attribute slower growth in the Conception area to the oceanographic characteristics and low productivity of the area south of Point Conception.

For more information, contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

**e) Lessons learned in incorporating spatial dynamics in west coast groundfish stock assessments**

Investigators: J. Cope and I. Stewart

The recognition of low dispersal rates, spatially variable biological traits, differential fishing pressure, and heterogeneous habitats has highlighted the need to incorporate smaller-scale population dynamics into larger-scale stock assessment areas. Spatial considerations are often avoided because of data limitations or poor understanding of key

parameters (e.g. movement). The Pacific Fishery Management Council's biennial assessment cycle yielded a range of methods employed to address spatial structure in 2009 stock assessments and management. We illustrate this range with results for two species, cabezon (*Scorpaenichthys marmoratus*) and yelloweye rockfish (*Sebastes ruberrimus*). In each case, data availability and life history information led to different approaches to spatial structure and therefore information about stock status and reference points for fishery management. We suggest that "going spatial" provided needed insight into population dynamics and offer some general conclusions about making reasonable spatial modeling choices for management-oriented stock assessments.

For more information, please contact Dr. Jason Cope at Jason.Cope@noaa.gov

**f) The relationship between MSY fishing rates ($F_{MSY}$) and productivity indices**

Investigators: W. Patrick, J. Cope, and R. Methot

The 2009 revision of the National Standard 1 Guidelines describe a hierarchal approach to prescribing precautionary catch recommendations (i.e., Overfishing Limit (OFL) ≥ Acceptable Biological Catch (ABC) ≥ Annual Catch Limit). This research focuses on the specification of the ABC, which is the scientific recommendation for a level of catch that would prevent overfishing. To do this, it must take into account any scientific knowledge about the stock, and uncertainty in the estimate of OFL (where OFL = $F_{MSY}$ * current biomass). The $F_{MSY}$ is typically based on proxies and incompletely accounts for all biological factors that could influence the true $F_{MSY}$. It has been proposed that indices of stock productivity, which potentially consider more factors than are directly accounted for in $F_{MSY}$ proxy calculations, could contribute to the scaling of the buffer between OFL and ABC. In extreme data-poor situations, it is possible that a productivity measure could be the sole source of information with which to set ABC relative to historical catch levels. As a first step, we investigated the strength of the relationship between productivity indices and commonly used measures of $F_{MSY}$. The goal is to determine if productivity measures could serve as a proxy for $F_{MSY}$ in data-poor situations and could provide useful supplementary information for scaling ABC relative to OFL even in more data-rich situations.

For more information, please contact Dr. Jason Cope at Jason.Cope@noaa.gov

**g) Reconciling stock assessment and management scales under conditions of spatially-varying catch histories**

Investigators: J. Cope and A. Punt

Spatial homogeneity is often the exception, not the rule, for many marine populations. Data limitations or biological knowledge gaps, though, often drive the assumption of limited stock structuring. Such mismatch of management units and biological stock structure may compromise management goals. Spatial considerations thus remain a major challenge in providing managers with the best information for responsible and responsive management. This study offers a quantitatively evaluation of spatial stock structure

assumptions on the performance of stock assessments relative to management scales. Catch histories, not biological differences, are used to create stock structure. Simulation testing is based on an operating model of 'true' population states of nature that vary only in catch history across 9 regions. Stock assessments under various data scenarios are then performed on regions either as one aggregated assessment, or at finer area scales defined by zonal catch differences. The median absolute relative error of the terminal spawning biomass depletion is used as a performance statistic. One area stock assessments demonstrated low bias and high precision under all catch scenarios when stock structure is ignored, but perform poorly when applied to areas with differing regional catch histories. Separate area assessments grouped by zonal catch differences performed best under these circumstances, despite lower data quality, indicating the importance of identifying stock structure for management purposes. We suggest a focus on explicitly defining management units prior to conducting stock assessments with a concomitant resolve to increase data provisions at the resolution of management needs.

For more information, please contact Dr. Jason M. Cope at Jason.Cope@noaa.gov

**h) Analysis of fishery-independent hook and line-based data for use in the stock assessment of bocaccio rockfish (*Sebastes paucispinis*)**

Investigators J.H. Harms, J.R. Wallace, and I.J. Stewart

Fishery-independent surveys are an important source of information for stock assessment and management worldwide. Research surveys often use trawl gear to capture commercially valuable species and calculate indices of relative abundance or density. However, many species of interest do not occur in direct contact with the bottom, or occur in areas where high-relief habitat precludes trawl operation. This research was undertaken during a standardized hook and line survey for rockfish conducted by NOAA Fisheries' Northwest Fisheries Science Center in the Southern California Bight. The survey uses fishing gear similar to that used in many recreational fisheries to sample approximately 120 locations covering a wide range of depths and habitats. To provide an example of how these data can be analyzed for direct inclusion in stock assessments, we standardize catch rates of bocaccio rockfish from 2004 – 2008 using a Bayesian Generalized Linear Model to account for site, fishing time, survey vessel, angler, and other statistically significant effects. Results indicate that the bocaccio stock vulnerable to this survey in the Southern California Bight has shown a relatively flat trend over recent years. Length-frequency distributions indicate the presence of several strong cohorts that should be detectable in future stock assessments of bocaccio for use in U.S. West Coast groundfish management. This survey is the only available tuning index for the adult portion of the bocaccio population in recent years as historically-used recreational catch per unit effort indices have been compromised due to changes in bag limits and other management restrictions.

For more information, please contact John Harms at John.Harms@noaa.gov

## C. By Species, by Agency

The PFMC currently operates under a biennial schedule for the development of stock assessments and management guidance. Table 1 lists the species for which full assessments were conducted in 2009 and the dates of the Stock Assessment Review (STAR) Panels convened to review those assessments. Summaries for assessments conducted by the NWFCS are included in the following sections.

Table 1. 2009 Review Schedule for Full Groundfish Assessments.

| STAR PANEL | STOCK | AUTHOR(S) | STAR PANEL DATES | STAR PANEL LOCATION |
|---|---|---|---|---|
| 1 | Pacific whiting | Owen Hamel<br>Ian Stewart | February 3 - 6 | Seattle, WA |
| 2 | Petrale sole<br>Splitnose rockfish | Melissa Haltuch<br>Vlada Gertseva | May 4-8 | Hatfield Marine Science Center<br>Barry Fisher Bldg., Room 101,<br>2032 SE Oregon State University Drive, Newport, OR 97365 |
| Updates | Pacific Ocean Perch<br>Canary Rockfish<br>Darkblotched rockfish<br>Cowcod | Owen Hamel<br>Ian Stewart<br>John Wallace<br>E. J. Dick | June 10-11 | PFMC Council Meeting<br>Spokane, WA |
| 3 | Bocaccio<br>Widow | John Field<br>Xi He | July 13-17 | Southwest Fisheries Science Center<br>110 Shaffer Road<br>Santa Cruz, CA 95060 |
| 4 | Lingcod<br>Cabezon | Owen Hamel<br>Jason Cope | July 27-31 | Seattle, WA |
| 5 | Yelloweye rockfish<br>Greenstriped rockfish | Ian Stewart<br>Alan Hicks | August 3-7 | Seattle, WA |

## 1. Shelf Rockfish - West Coast

### a) Stock assessments

Full assessments of yelloweye rockfish, widow rockfish, bocaccio and greenstriped rockfish were conducted in 2009. Updates of the 2007 canary rockfish and cowcod rockfish assessments were also conducted in 2009.

### Canary rockfish - update

The 2009 updated assessment reports the status of the canary rockfish (*Sebastes pinniger*) resource off the coast of the United States from southern California to the U.S. - Canadian border using data through 2008. As in 2007, the resource is modeled as a single stock. The historical period (<1981) of the catch history for canary rockfish has been substantially revised for this updated assessment. Historical reconstruction estimates from efforts by CDFG and NOAA scientists were made available and replaced existing estimates which dated back to the 2005 and earlier assessments. These older estimates assumed a constant percentage of canary rockfish in the total California landings, whereas the improved estimates now available allowed for changes in this percentage over time and fishing areas accounting for shifts in the fishery and the lower occurrence of canary in Southern California waters. The net result of this revision was a 24% reduction in the total estimated canary catch from 1916-2006 with most of this reduction occurring prior to 1968. The remaining model data sources are unchanged, but updated to reflect the most recent data collected since the 2007 assessment.

As in 2007, the base case assessment model includes parameter uncertainty from a variety of sources, but underestimates the considerable uncertainty in recent trend and current stock status. For this reason, in addition to asymptotic confidence intervals (based upon the model's analytical estimate of the variance near the converged solution), two alternate states of nature regarding stock productivity (via the steepness parameter of the stock-recruitment relationship) are presented. The base case model (steepness = 0.51) is considered to be twice as likely as the two alternate states (steepness = 0.35, 0.72) based on the results of a 2007 meta-analysis of west coast rockfish (M. Dorn, personal communication). In order to best capture this source of uncertainty, all three states of nature will again be used as probability-weighted input to the rebuilding analysis. Given the change in this update caused by the revised historical California catch estimates, future assessments are likely to be sensitive to additional revised estimates from ongoing efforts in Oregon and Washington should they prove appreciably different from the time-series used here.

The updated data resulted in a slightly more pessimistic view of the recent stock recovery trajectory, just inside the lower 95% confidence interval from the 2007 assessment. Addition of the fully revised catch history reduced the scale of the entire time-series estimate of spawning biomass by an average of 14% (19% in the first 10 years of the

series and 47% in the last 10). The central portion of the time-series estimates remained largely unchanged (~1960-1990). Based on the revised catch series, canary rockfish were very lightly exploited until the early 1940's, when catches increased and a decline in biomass began. The spawning biomass experienced an accelerated rate of decline during the late 1970s, and finally reached a minimum (12% of unexploited, slightly below the estimate of 13% from the 2007 assessment) in the mid-1990s. The canary rockfish spawning stock biomass is estimated to have been gradually increasing since that time, in response to reductions in harvest and above average recruitment in the preceding decade. However, this trend is very uncertain. The estimated relative depletion level in 2007 is 21.7% (below the estimate of 32.4% from the 2007 assessment) and 23.7% in 2009 (~95% asymptotic interval: 16-28%, ~75% interval based on the range of states of nature: 9-40%), corresponding to 6,170 mt (5,642 in 2007, 54% of the 2007 estimate of 10,544 mt). The base model asymptotic interval for 2009 spawning biomass remains broad: 4,385-7,955 mt, and the states of nature interval: 2,459-10,244. After a period of above average recruitments, recent year-class strengths (1997-2008) have generally been low, with only 4 of the 12 years (1999, 2001, 2006, and 2007) producing large estimated recruitments. Because of the limited number of years they have been observed, the strengths of the 2006-2007 year classes are subject to greater uncertainty than other strong recruitment events in the last 30 years. As the larger recruitments from the late 1980s and early 1990s move through the population in future projections, the effects of recent poor recruitment may tend to slow the rate of recovery.

The abundance of canary rockfish was estimated to have dropped below the *SB40%* management target in 1983 and the overfished threshold in 1990. In hindsight, the spawning stock biomass passed through the target and threshold levels at a time when the annual catch was averaging more than twice the current estimate of the MSY. The stock remains slightly below the overfished threshold (unlike the 2007 estimate), although the spawning stock biomass still appears to have been increasing since 1999. The degree of increase is very sensitive to the value for steepness (state of nature), and is projected to slow as recent (and largely below average) recruitments begin to contribute to the spawning biomass. Fishing mortality rates in excess of the current F-target for rockfish of *SPR50%* are estimated to have begun in the late 1970s and persisted through 1999. Recent management actions appear to have curtailed the rate of removal such that overfishing has not occurred since 1999, and recent SPR values are in excess of 70% (> 90% since 2003). Relative exploitation rates (catch/biomass of age-5 and older fish) are estimated to have been less than 1% since 2001. Following the 1999 declaration that the canary rockfish stock was overfished, the canary OY was reduced by over 70% in 2000 and by the same margin again over the next three years. Managers employed several tools in an effort to constrain catches to these dramatically lower targets. These included: reductions in trip/bag limits for canary and co-occurring species, the institution of spatial closures, and new gear restrictions intended to reduce trawling in rocky shelf habitats and the coincident catch of rockfish in shelf flatfish trawls. In recent years, the total mortality has been slightly above the OY (higher in retrospect based on current methods used for total mortality estimates), but well below the ABC. Since the overfished determination in 1999, the total 9-year catch (749 mt) has been 14% above the sum of the OYs for 2000-2006. This level of removals represents only 34% of the sum of the ABCs for that period.

The total 2008 catch (40.5 mt) is <1% of the peak catch that occurred in the early 1980s. Current medium-term forecasts predict slow increases in abundance and available catch, with OY values for 2011 and 2012 lower than those predicted from the 2007 assessment.

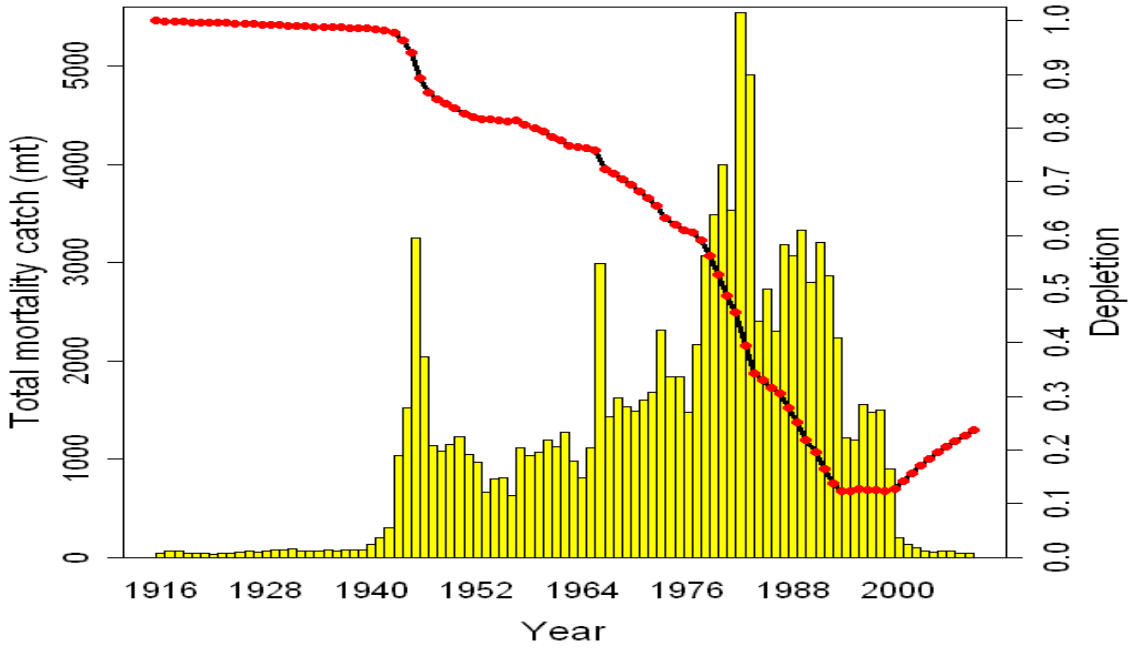



Figure 4. Level of estimated depletion (line) and total catch (bars) for canary rockfish, 1916-2009.

**Canary rockfish:** The complete versions of: Status of the U.S. Canary Rockfish Resource in 2009 (Update of 2007 assessment model) and Rebuilding Analysis for Canary Rockfish Based on the 2009 Updated Stock Assessment can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on the canary rockfish assessment please contact Dr. Ian Stewart at Ian.Stewart@noaa.gov

**Greenstriped rockfish**

This assessment reports the status of the greenstriped rockfish (*Sebastes elongatus*) resource off the continental coast of the United States from the U.S.-Canadian border in the north to the U.S.-Mexican border in the south. Within the assessment area the resource is treated as a single stock due to the lack of biological and genetic data supporting the presence of multiple stocks, although greenstriped rockfish from Southern California may exhibit different growth and maturity patterns.

Greenstriped rockfish have not often been targeted by any fishery, mainly due to its small size and short product shelf life, thus discards as well as landings are an important component of the total fishing mortality on the stock. The majority of landings of

greenstriped rockfish have occurred in the trawl fishery, but a small proportion has been observed in recreational fisheries and even smaller amounts in hook and line and net fisheries. Discards have been higher than 77% in trawl fisheries and near 99% in fixed gear fisheries. This introduces a considerable amount of uncertainty in the total fishing mortality for greenstriped rockfish because discards are rarely reported, and are estimated from observed landings. Annual landings of greenstriped rockfish were less than 60 mt until the mid 1960s when foreign trawl fleets began fishing in U.S. waters. Subsequently, the development of the domestic fleet replaced the foreign fleets and resulted in increased landings and discards, peaking in the mid 1980s before dropping to very low levels with the implementation of management measures in the late 1990s.

The assessment for greenstriped rockfish showed that the stock in the U.S. West Coast is currently at 81% of its unexploited level and, therefore, is not overfished. The spawning output reached a low in the late 1990s before beginning to increase throughout the last decade. The estimated depletion has remained above the 40% of unfished spawning output target and it is unlikely that the stock has ever fallen below this threshold. However, throughout the 1970s, 1980s, and 1990s the exploitation rate and *SPR* have generally increased and occasionally exceeded current estimates of the harvest rate limit ($SPR_{50\%}$). More recently, though, low exploitation rates on greenstriped rockfish in the last decade and evidence of recent above average recruitment is resulting in an increase in spawning output to near unexploited levels. The annual total removals (landings plus discards) and estimated depletion for greenstriped rockfish are presented in Figure 5.

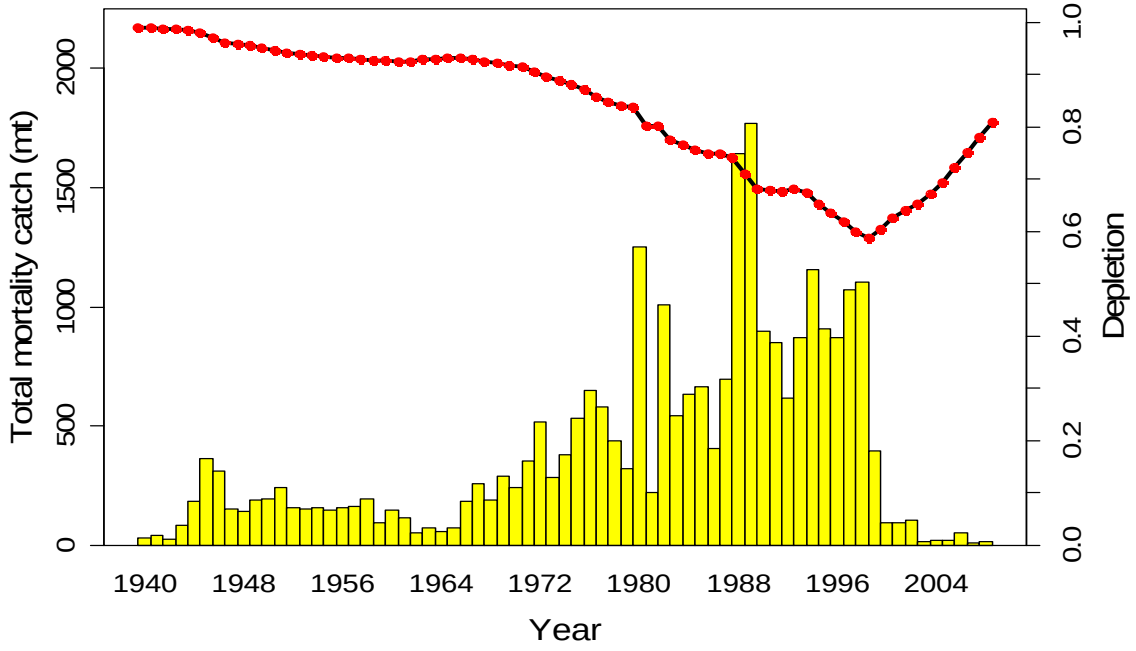



Figure 5. The time-series of total removals (bars) and estimated depletion (line) for greenstriped rockfish, 1940–2009.

**Greenstriped rockfish:** The complete version of "Status of greenstriped rockfish (*Sebastes elongatus*) along the outer coast of California, Oregon, and Washington" can be found online at: http://www.pcouncil.org/groundfish/stock-assessments/

For more information on the greenstriped rockfish assessment, please contact Allan Hicks at Allan.Hicks@noaa.gov.

**Yelloweye rockfish**

The 2009 assessment reports the status of the yelloweye rockfish (*Sebastes ruberrimus*) resource off the coast of the United States from southern California to the U.S.-Canadian border using data through 2008. The resource is modeled as a single stock, but with three explicit spatial areas: Washington, Oregon and California. Each area is modeled simultaneously with its own unique catch history and fishing fleets (recreational and commercial) but the dynamics follow the current understanding of yelloweye stock structure: large stocks linked via a common stock-recruit relationship with negligible adult movement among areas.

Yelloweye rockfish catches were estimated from a variety of sources, but are very uncertain due to the relatively small contribution of yelloweye to rockfish market categories and the relatively large scale of recreational removals. Catches include estimates of discarding after 2001 when management restrictions resulted in nearly all yelloweye caught by recreational and commercial fishermen being discarded at sea. Estimated catches increased gradually throughout the first half of the 20th century, with the exception of a brief period of higher removals around World War II. Catches peaked in 1982 at 421 mt, with removals in excess of 200 mt estimated for all years between 1977 and 1997. Uncertainty in catches is treated explicitly throughout this analysis. The model data sources include catch, length- and age-frequency data from six state-specific recreational and commercial fishing fleets. Biological data are derived from both port and on-board observer sampling programs. Yelloweye catch in the IPHC long-line survey for Pacific halibut is also included via an index of relative abundance for Washington and for Oregon as well as length- and age-frequency data. Oregon recreational charter observer data from discarded yelloweye were used to construct a recent index of relative abundance (2004-2008) and length-frequency observations. The National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center (NWFSC) trawl survey relative biomass indices and information from biological sampling, as well as the triennial trawl survey are included. Externally estimated model parameters, including those defining weight-length, maturity, and fecundity relationships, are revised from values used in previous assessments. The assessment explicitly accounts for the small degree of dimorphic growth as well as markedly different exploitation histories among geographic areas (Washington, Oregon and California). Due to sparse and poorly informative age- and length-frequency data, recruitment is modeled as a deterministic process. Key parameters including natural mortality, stock-recruitment steepness and all growth parameters are estimated.

Although the base case assessment model captures some uncertainty via asymptotic intervals, uncertainty from two sources is reported through alternate states of nature bracketing the base case results and included explicitly in the decision table. The magnitude of the estimated catch time-series was found to have a large influence on the perception of current stock size and the estimate of steepness of the stock-recruit relationship was closely linked to the projected recovery rates. Alternate values of each were selected to bracket the best estimates with marginal probabilities one-half as likely. For historical catch these values, 75% and 150% of the estimated catch series prior to 2000, were subjective, but reflect both the lack of a comprehensive catch reconstruction in Washington and the change in likelihood of the fit to data sources over a reasonable range of catch levels. For steepness the 12.5th and 87.5th percentiles were calculated from the likelihood profile as a proxy for the probability distribution about this point estimate. The most optimistic and pessimistic of the nine combinations from these two axes (weighted 6.25% each relative to 25% for the best estimate on each dimension) are reported in this document and all combinations used to provide a more realistic degree of uncertainty for future projections, decision tables and rebuilding analyses.

A fecundity relationship is used for yelloweye specifying that spawning output per unit weight increases with fish weight; therefore all reference to spawning output is in terms of eggs produced, instead of spawning biomass. Yelloweye rockfish are estimated to have been lightly exploited until the mid-1970's, when catches increased and a rapid decline in biomass and spawning output began. The relative spawning output reached a minimum of 15.8% of unexploited levels (slightly above the estimate of 12.1% from the 2007 assessment) in 2000. Yelloweye rockfish spawning output is estimated to have been gradually increasing since that time in response to large reductions in harvest. Although the relative trend in spawning output is quite robust to uncertainty in the estimated removals, the spawning output trajectory on an absolute scale is very sensitive. The estimated relative depletion level in 2007 is 19.2% (slightly above the estimate of 16.4% from the 2007 assessment) and 20.3% in 2009 (states of nature: 17.3-23.5%), corresponding to 201.5 million eggs. The range over states of nature reflects the very large uncertainty in the absolute scale of the estimated time-series for spawning output: 128.3-353.0 million eggs. The aggregate spawning output estimates mask the spatial heterogeneity included via the area-specific dynamics: relative spawning output has differed markedly among the three states, with California having the largest spawning output at unexploited equilibrium, followed by Oregon and then Washington. Currently, Oregon is estimated to have the largest spawning output, followed by California, then Washington. Relative depletion also varies dramatically by state, with California estimated to be at 16.4% of unexploited conditions, Oregon, 22.5%, and Washington, 27.3%.

The coast-wide abundance of yelloweye rockfish was estimated to have dropped below the *SB40%* management target in 1989 and the overfished threshold in 1994. In hindsight, the spawning output passed through the target and threshold levels with annual catch averaging almost five times the current estimate of the *MSY*. The coast-wide stock remains below the overfished threshold, although the spawning output is estimated to have been increasing since 2000 in response to reductions in harvest. The degree of

increase is largely insensitive to the magnitude of historical catch and only moderately sensitive to the value for steepness, but the absolute scale of the population reflects alternate removal series very closely. Fishing mortality rates are estimated to have been in excess of the current *F*-target for rockfish of *SPR50%* from 1976 through 1999. Recent management actions have curtailed the rate such that recent SPR values are in excess of 60% over the last eight years. Relative exploitation rates (catch/biomass of age-8 and older fish) are estimated to have been at or less than 1% after 2001. Before 2000, yelloweye rockfish were managed as part of the *Sebastes* Complex, which included all *Sebastes* species without individual assessments, ABCs and OYs. In 2000, the *Sebastes* Complex was divided into three depth-based groups (north and south of 40° 10' N. latitude), and yelloweye rockfish were managed as part of the minor shelf rockfish group until 2002. Since then, there has been species-specific management, and total catch has been below both the ABC and OY for yelloweye each year. These catch levels represent a 95% reduction from average catches observed in the 1980s and 1990s. Managers have constrained catches by eliminating all retention of yelloweye rockfish in both commercial and recreational fisheries, instituting broad spatial closures (some specifically for moving fixed-gear fleets away from known areas of yelloweye abundance), and creating new gear restrictions intended to reduce trawling in rocky shelf habitats and the coincident catch of rockfish in shelf flatfish trawls. Since 2002, the total 6-year catch (88.5 mt) has been only 63% of the sum of the OYs for 2002-2008 and only 29% of the sum of the ABCs for that period. The total 2008 catch (16.7 mt) is estimated to be just 4% of the peak annual catch that occurred in the early 1980s.

Data for yelloweye rockfish are sparse and relatively uninformative, especially regarding current trend. Historical catches are very uncertain, as yelloweye comprise a small percentage of overall rockfish removals and actual species-composition samples are infrequently available for historical analyses. Currently available fishery-independent indices of abundance are imprecise and not highly informative. It is unclear whether increased rates of recovery (or lack thereof) will be detectable without more precise survey methods applied over broad portions of the coast. Fishery data are also unlikely to produce conclusive information about the stock for the foreseeable future, due to lack of retention and active avoidance of yelloweye among all fleets. For these reasons, it is unlikely that the major uncertainties in this assessment will soon be resolved.

Current medium-term forecasts predict increases in coast-wide abundance under the SPR=71.9% rebuilding strategy, however these increases are largely driven by the California and Oregon portions of the stock. In fact, the Washington portion is projected to remain at current levels under recent allocation of catch; however, this result is likely to be sensitive to future revision of the estimated Washington historical catch series. The estimated OY values for 2011 and 2012 are larger (20.9, 21.2) than those predicted from the 2007 rebuilding analysis (13.9, 14.2).

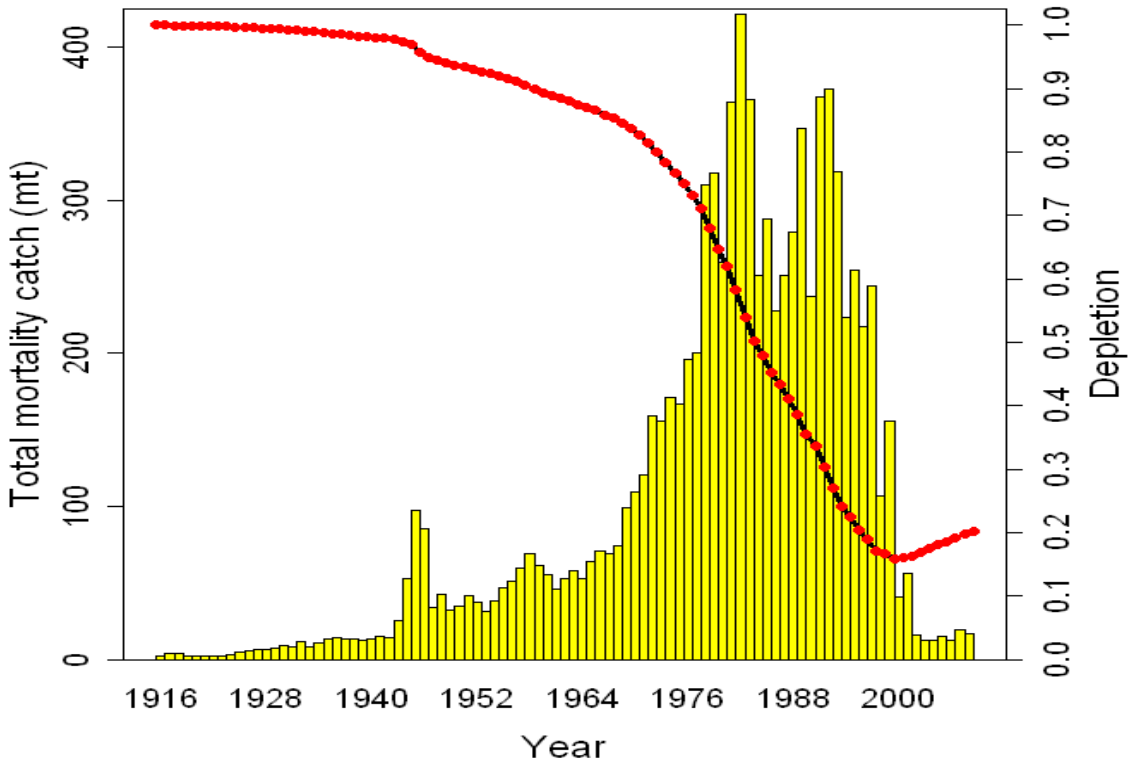



Figure 6. Level of estimated depletion (line) and total catch (bars) for yelloweye rockfish, 1916-2009.

**Yelloweye rockfish:** The complete versions of: Status of the U.S. Yelloweye Rockfish Resource in 2009 and Rebuilding Analysis for Yelloweye Rockfish Based on the 2009 Stock Assessment can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on the yelloweye rockfish assessment please contact Dr. Ian Stewart at Ian.Stewart@noaa.gov

**Widow rockfish:** The widow rockfish assessment was conducted by the Southwest Fisheries Science Center (SWFSC). The complete version of: Status of the widow rockfish resource in 2009 can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

**Bocaccio:** The bocaccio assessment was conducted by the SWFSC. The complete version of: Status of bocaccio, *Sebastes paucispinis*, in the Conception, Monterey and Eureka INPFC areas for 2009
http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

**Cowcod:** The cowcod update was conducted by the SWFSC. The complete version of: Updated status of cowcod, *Sebastes levis*, in the Southern California Bight can be viewed online at:
http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

**2. Slope Rockfish**

**a) Stock assessments**

Slope rockfish assessments conducted during 2009 included an update of the 2007 darkblotched rockfish assessment, a second update of the 2005 Pacific ocean perch assessment, and a full assessment of splitnose rockfish.

**Darkblotched rockfish -update**

This assessment applies to the darkblotched rockfish (*Sebastes crameri*) for the combined U.S. Vancouver, Columbia, Eureka and Monterey INPFC areas. The largest landings (removals between 2,300 and 4,200 metric tons) of darkblotched were taken from 1966-1968, primarily by foreign vessels. From 1969 to 1981, the fishery proceeded with more moderate landings of between 200 and 1,000 mt per year, with the foreign fishery ending in 1977. A second peak in landings occurred between 1982 and 1993, with landings exceeding 1,100 mt in 10 of 12 years, reaching over 2,400 mt in 1987. Management measures reduced landings to below 950 mt since 1994, below 400 mt since 1999, and below 200 mt in recent years. This update used the SS model, version 3.03a and data through 2008. Based on this assessment, darkblotched rockfish on the West Coast remain below the overfished threshold, but the spawning biomass appears to have increased steadily over the past 7 or 8 years to 27.5% of the unfished level. Since 2001, overfishing occurred only once, with estimated catch exceeding the ABC by 12 mt (5.0%) in 2004.

A number of sources of uncertainty were explicitly included in this assessment. For example, allowance was made for uncertainty in natural mortality and the parameters of the stock-recruitment relationship. There were also other sources of uncertainty that were not included in the current model, including the degree of connection between the stocks of darkblotched rockfish off British Columbia and those in PFMC waters; the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of darkblotched rockfish; and gender-based differences in survival. With the stock extending northwards into Canadian waters, management and assessment of stock status might be improved through greater cooperation with British Columbia.

The recruitment pattern for darkblotched rockfish is similar to that of many rockfish species, with highly variable recruitment from year to year. With a few exceptions, the 1980s and 1990s provided rather poor year-classes compared with average historical recruitment levels. Although the 1999 and 2000 year-classes appear to be two of the four largest year-classes since 1975, they are only now reaching the age of 50% maturity, and will not be fully mature for another decade (when their fecundity will also be over 3 times what it is now). As a result, the full impact of these recruits will not be felt for

years to come. The exploitation rate (percent of biomass taken) on fully-selected animals peaked historically near 14% in the intensive foreign fishery of the mid-1960's. The exploitation rate dropped by the late 1960's, but increased slowly and steadily from the late 1970's to 1987, at roughly 15%, and stayed high until 1998, with the continuing decline in exploitable biomass. Over the past 10 years the exploitation rate has fallen from a peak of 16% in 1998 to under 2%. This stock remains overfished and a rebuilding analysis was conducted. Recent recruitment and levels of depletion are presented in Figure 7.

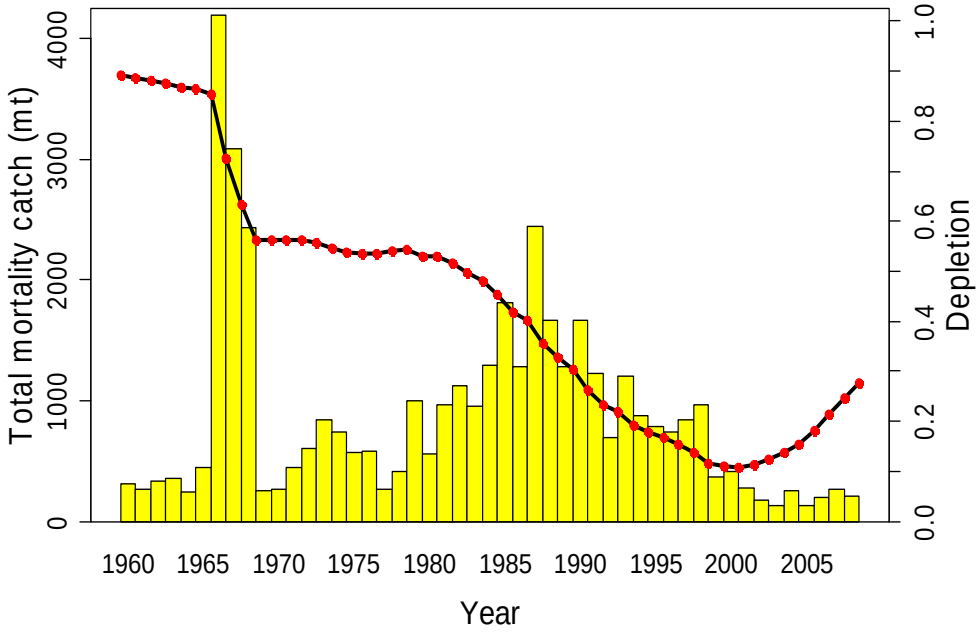



Figure 7. Level of depletion (line) and total catch (bars) for darkblotched rockfish, 1960-2009.

**Darkblotched rockfish:** The complete version of: Status and Future Prospects for the Darkblotched Rockfish Resource in Waters off Washington, Oregon, and California as Updated in 2009 can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on this assessment contact John Wallace at: John.Wallace@noaa.gov.

**Pacific ocean perch - update**

This assessment update applies to the Pacific ocean perch (*Sebastes alutus*) (POP) species of rockfish for the combined U.S. Vancouver and Columbia INPFC areas. Catches are characterized by large removals of between 5,000 and 20,000 mt during the mid-1960's, primarily by foreign vessels. The fishery proceeded with more moderate

removals of between 1,100 and 2,200 metric tons per year from 1969 through 1994, with the foreign fishery ending in 1977. Management measures further reduced landings to below 900 metric tons by 1995, with subsequent landings falling steadily until reaching between 60 and 150 metric tons per year from 2002 through 2008. Total catch, including discard, is estimated to be between 80 and 180 metric tons since 2002. This assessment is an update and uses the same model as in the 2003, 2005 and 2007 assessments, a forward projection age-structured model. New data and changes to the data used in the previous assessment are as follows. Catch data for 2002-2006 were updated using total mortality estimates from the observer program. New catch data were added for 2007 and 2008. The 2007 and 2008 NWFSC slope survey indices were added. Fishery age compositions from 2004-2006 were updated, with new 2008 age compositions added. 2007 length compositions were used in place of age compositions on account of substantial issues with the quality of age assignments for that year of data. The 2001-2006 NWFSC slope survey age compositions were recalculated, and the 2008 compositions added. Due to the ageing issues mentioned above, the 2007 NWFSC slope survey length compositions were used in place of age compositions.

A number of sources of uncertainty are explicitly included in this assessment. For example, allowance is made for uncertainty in natural mortality, the parameters of the stock-recruitment relationship, and the survey catchability coefficients. However, sensitivity analyses based upon alternative model structures / data set choices in the 2003 and 2005 assessments suggest that the overall uncertainty may be greater than that predicted by a single model specification. There are also other sources of uncertainty that are not included in the current model. These include the degree of connection between the stocks of Pacific ocean perch off British Columbia and those in PFMC waters; the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of Pacific ocean perch; gender differences in growth and survival; a possible nonlinear relationship between individual spawner biomass and effective spawning output and a more complicated relationship between age and maturity. A reference case was selected which adequately captures the range for those sources of uncertainty considered in the model. Bayesian posterior distributions based on the reference case were estimated for key management and rebuilding variables. These distributions best reflect the uncertainty in this analysis, and are suitable for probabilistic decision making.

For West Coast rockfish, a stock is considered overfished when it is below 25% of virgin spawning biomass. Currently, the spawning stock is believed to be near 30% of the unfished level; roughly 50% higher than the low of 20% reached in 1997. Despite the modest rate of increase over the last decade, POP is expected to reach the rebuilding target (40% of the unfished level) within the next 10-12 years. POP has not been subject to overfishing since 2000. Although catches were generally near or below harvest guidelines during the 1990s, the current assessment suggests that exploitation rates throughout most of the 1980s and 90s were higher than those identified in more recent assessments as sustainable. POP are essentially managed on a regional basis, as they occur almost exclusively off of Oregon and Washington for the West Coast. Management and assessment of stock status might be improved through greater cooperation with

British Columbia, as the stock extends northward into Canadian waters. Recent catch and levels of depletion are presented in Figure 8.

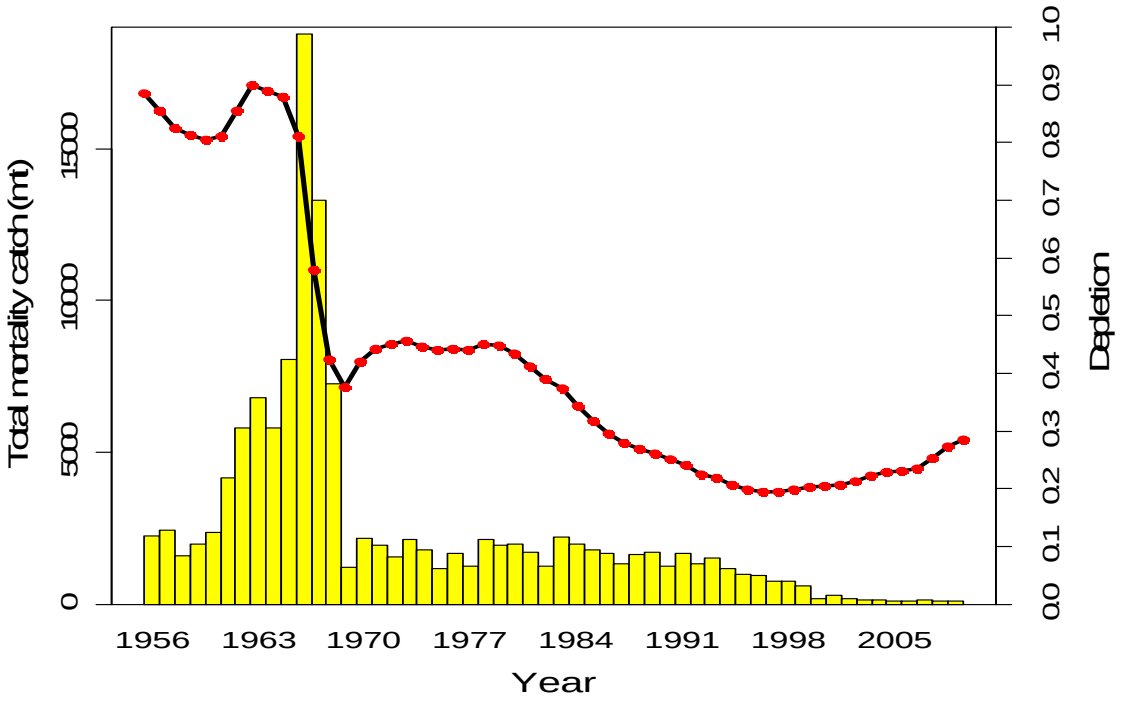



Figure 8. Level of catch (bars) and depletion (line) for Pacific ocean perch, 1950-2009.

**Pacific Ocean Perch:** The complete version of: Status and Future Prospects for the Pacific Ocean Perch Resource in Waters off Washington and Oregon as Assessed in 2009 can be viewed at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on this assessment contact Dr. Owen Hamel at: Owen.Hamel@noaa.gov.

**Splitnose rockfish**

This assessment reports the status of the splitnose rockfish (*Sebastes diploproa*) resource off the continental coast of the United States from the U.S.-Canadian border in the north to the U.S.-Mexican border in the south. Within the assessment area the resource is treated as a single stock due to the lack of biological and genetic data supporting the presence of multiple stocks. Nevertheless, management decisions on a coast-wide population need to account for effort concentration, since abundance is higher in some areas such as off central California.

Splitnose rockfish have not been targeted by commercial fisheries, but have historically been taken as bycatch in the fishery for Pacific ocean perch, a species with which splitnose rockfish co-occurs, and fisheries for mixed slope rockfish or other deepwater

targets. Trawl landings on average comprise 90% of annual catches, with 80% of fish landed in California. Only 10% of splitnose rockfish on average are caught by non-trawl commercial fisheries. The vast majority of non-trawl landings are caught by net gear, and only a small portion is caught by hook-and-line in the sablefish fishery. This species is rarely taken in the recreational fishery. Because of their small size, splitnose rockfish have a limited market and are often discarded. Over the last twenty years, trawl discard rates ranged between 27% and 80% of the total catch. Landings peaked in the 1960s, when foreign trawl fleets operated in U.S. waters, and reached 5,313 mt in 1967. The highest catch by domestic fleets was in 1998, when 1,526 mt of splitnose rockfish was landed. For the last ten years landings were relatively low and ranged between 65 and 274 mt.

The assessment shows that the stock of splitnose rockfish in the U.S. West Coast is currently at 66% of its unexploited level and, therefore, not overfished. As estimated in 2009, the spawning output showed a small decline prior to 1950, when splitnose rockfish were lightly exploited using mostly non-trawl gear with zero discard. With the development of the Pacific ocean perch fishery, spawning output of splitnose rockfish began to decline and exhibited a sharp drop in the 1960s, when foreign trawl fleets targeted Pacific ocean perch in the current U.S. EEZ. In the 1980s and 1990s splitnose rockfish spawning biomass continued to decrease as a result of relatively low recruitment and removal by domestic trawl and non-trawl fisheries, with a large portion of trawl catches being discarded. The spawning biomass reached its lowest level (35.8% of its unexploited level) after large domestic removals in 1998, when the increased availability of splitnose rockfish led to higher than usual catches. Since 1999 however, the splitnose spawning output is estimated to have increased in response to below-average removals and above-average recruitment during the last decade. The time-series of recent total removals (landings plus discards) and estimated depletion for splitnose rockfish are presented in Figure 9.

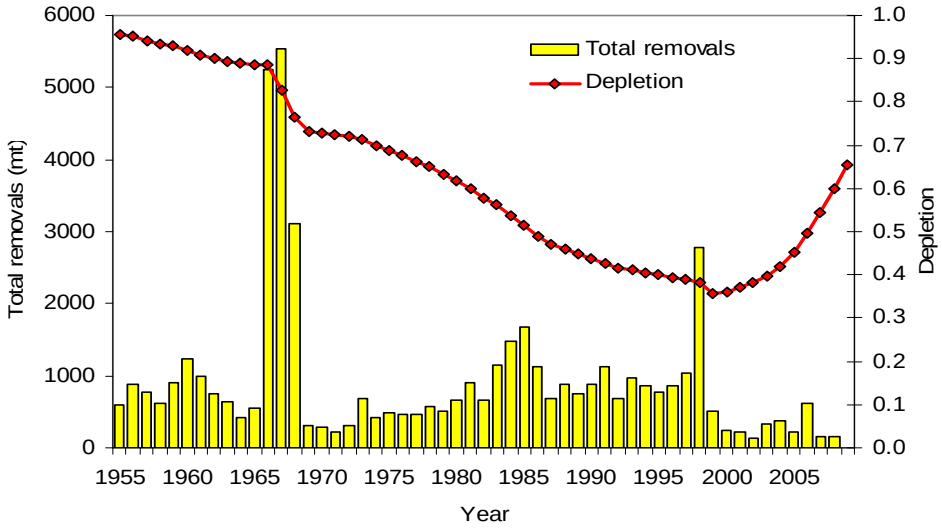



Figure 9. The time-series of recent total removals (bars) and estimated depletion (line) for splitnose rockfish, 1955-2009.

**Splitnose rockfish:** The complete version of "Status of the U.S. splitnose rockfish resource in 2009" can be found online at: http://www.pcouncil.org/groundfish/stock-assessments/

For more information on the splitnose rockfish assessment, contact Dr. Vladlena Gertseva at Vladlena.Gertseva@noaa.gov

## 3. Flatfish

### a) Stock assessment

### Petrale sole

This assessment reports the status of the petrale sole (*Eopsetta jordani*) resource off the coast of California, Oregon, and Washington using data through 2008. While petrale sole are modeled as a single stock, the spatial aspects of the coast-wide population are addressed through geographic separation of data sources/fleets where possible and consideration of residual patterns that may be a result of inherent stock structure. There is currently no genetic evidence suggesting distinct biological stocks of petrale sole off the U.S. coast. The limited tagging data available to describe adult movement suggests that petrale sole may have some homing ability for deepwater spawning sites but also have the ability to move long distances between spawning sites and seasonally.

The earliest catches of petrale sole are reported in 1876 in California and 1884 in Oregon. Recent annual catches during 1981–2008 range between 1,244–2,854 mt (Figure 10). Petrale sole are almost exclusively caught by trawl fleets. Non-trawl gears contribute less than 2% of the catches. Based on the previous 2005 assessment, subsequent OYs were reduced due to 2,499 mt. From the inception of the fishery through the war years, the vast majority of catches occurred between March and October (the summer fishery), when the stock is dispersed over the continental shelf. The post-World War II period witnessed a steady decline in the amount and proportion of annual catches occurring during the summer months (March-October). Conversely, petrale catch during the winter season (November–February), when the fishery targets spawning aggregations, has exhibited a steadily increasing trend since the 1940's. Since the mid-1980s, catches during the winter months have been roughly equivalent to or exceeded catches throughout the remainder of the year (Figure 10).

Petrale sole were lightly exploited during the early 1900s but by the 1950s the fishery was well developed and showing clear signs of depletion and declines in catches and biomass (Figure 10). The rate of decline in spawning biomass accelerated through the 1930s–1970s reaching minimums generally around or below 10% of the unexploited levels during the 1980s and 1990s. The petrale sole spawning stock biomass is estimated to have increased slightly from the late 1990s, peaking in 2005, in response to above average recruitment. However, this increasing trend has reversed since the 2005 assessment and the stock has been declining, most likely due to strong year classes

having passed through the fishery. The estimated relative depletion level in 2009 is 11.6% (~95% asymptotic interval: ±4.8%, ~ 75% interval based on the range of states of nature: 9.4-13.8%), corresponding to 2,937.6 mt (~95% asymptotic interval: ±832.7 mt, states of nature interval: 2,407.8-3,468.1 mt) of female spawning biomass in the base model. The base model indicates that the spawning biomass has been below 25% of the unfished level continuously since 1953.

Note that the PFMC chose to change the proxy harvest rate and relative biomass reference points after the final acceptance of this stock assessment. The previously defined reference points are: $B_{msy}$ target of B40%, the MSST of B25%, and the $F_{msy}$ proxy of F40%. Documents from the STAR panel review of this assessment, the PFMC SSC and council decisions describe the process that lead to a redefinition of the proxy harvest rate and relative biomass reference points such that the $B_{msy}$ target is now B25%, the MSST is B12.5%, and the $F_{msy}$ proxy is F30%. Petrale sole are considered overfished under these reference points and catches have been restricted for 2009 and 2010 and a rebuilding plan for petrale sole is complete.

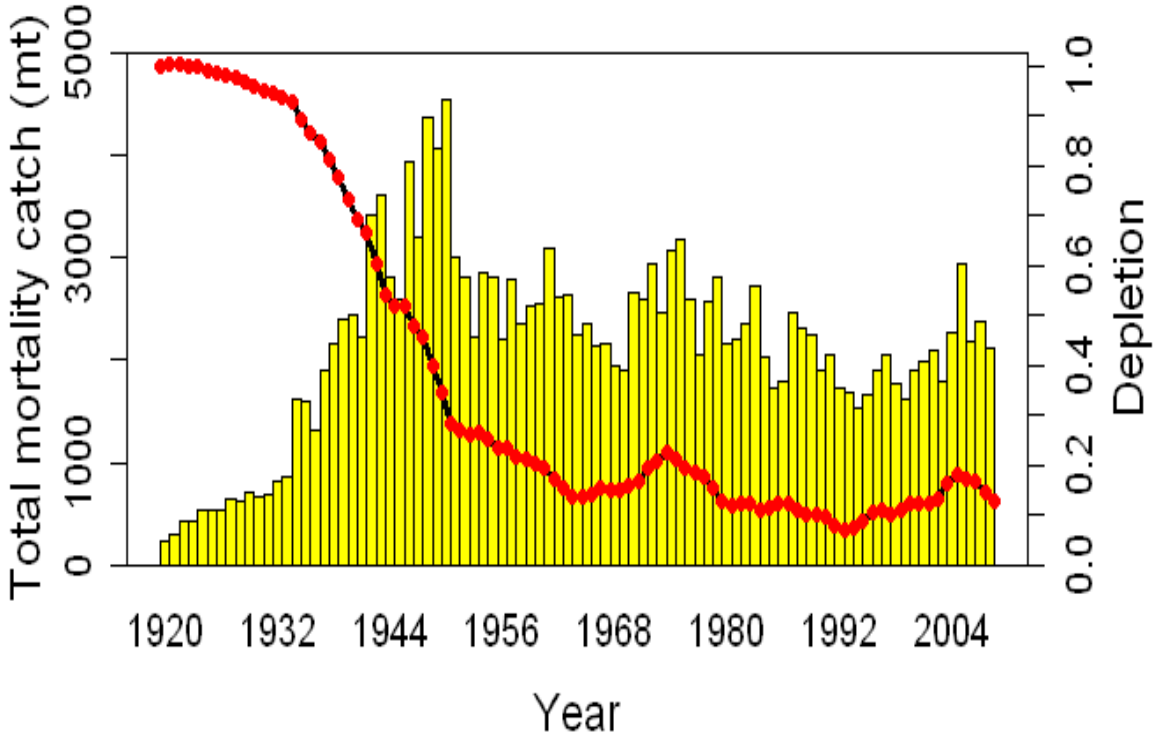



Figure 10. Time series of depletion (line) and catch (bars) for petrale sole.

**Petrale sole:** The complete version of: Status of the U.S. petrale sole resource in 2009 can be viewed online at: http://www.pcouncil.org/groundfish/gfstocks.html

For more information on the petrale sole assessment, contact Dr. Melissa Haltuch at Melissa.Haltuch@noaa.gov

**4. Pacific hake**

**a) Stock assessments**

There were two stock assessments used for Pacific hake management in 2010. One developed by Dr. Steve Martell (University of British Columbia), which was endorsed by the Pacific Fishery Management Council's (PFMC) Stock Assessment Review (STAR) process, and an update of the 2009 stock assessment conducted by the Northwest Fisheries Science Center (NWFSC; Stewart and Hamel, 2010). The Scientific and Statistical Committee (SSC) was unable to reach consensus regarding which model formulation reflected the best available science for Pacific whiting this year and was consequently forced to put both models forward as best available science without assigning weights to either.

Both assessment models estimated that the Pacific hake spawning stock biomass has declined in recent years following the decline of the very strong 1999 year-class and is currently in the precautionary zone (below the $SB_{40\%}$ target and above the $SB_{25\%}$ overfished threshold). The resulting optimal yield (OY; the target catch, which is then partitioned 73.88% to the U.S. fishery and 26.12% to the Canadian fishery) values for 2010 from the two models were 186,000 mt (NWFSC) and 550,000 mt (Martell). These values are less than the corresponding values reported in the assessment documents (224,975 mt and 617,700 mt respectively) because those values would lead to predictions of stock depletion to below $0.25B_0$ in 2011. If the NWFSC model is correct, and a catch exceeding 186,000 mt is taken, the stock is predicted to drop below the overfished threshold. In contrast, if the Martell model is correct, taking a catch of 186,000t will lead to forgone yield. The SSC emphasized that the assessment of whiting was highly uncertain; there is uncertainty regarding which model is better, uncertainty regarding which data sources are best included in assessments of whiting, and uncertainty due to the presence of a new but voracious predator species (Humboldt squid).

Based on the SSC's recommendations, the Pacific Council adopted an OY for 2010 of 262,500 mt and an allowable biological catch (ABC, the overfishing limit) of 455,550 mt. Under the terms of the U.S. – Canada Pacific whiting treaty, the U.S. allocation equates to 193,935 mt. The National Marine Fisheries Service is negotiating with the treaty tribes for their 2010 allocation, which will be set aside from the U.S. OY. The Council also decided to set aside 3,000 mt of Pacific whiting yield to accommodate incidental bycatch in non - whiting fisheries and research catch this year. The whiting sector allocations (i.e., 24% to motherships, 34% to catcher - processors, and 42% to shoreside whiting) will be decided once the treaty allocation is decided. The next Pacific hake assessment process will be conducted in early 2011.

**Pacific hake:** The two Pacific hake stock assessments can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on the Pacific hake assessment please contact Dr. Ian Stewart at Ian.Stewart@noaa.gov.

**5. Other species**

**a) Stock assessments**

**Cabezon**

This is the third full assessment of the population status of cabezon (*Scorpaenichthys marmoratus*) off the west coast of the United States. The first assessment was for a state-wide California cabezon stock in the year 2003 (Cope et al. 2004). The second assessment (Cope and Punt 2006) considered two sub-stocks (the northern California sub-stock (NCS) and the southern California sub-stock (SCS)), demarcated at Point Conception, CA. The current assessment retains the two California sub-stocks, also evaluating the population as a coast-wide California stock (CAS), and extends the assessment to a third sub-stock for cabezon in the waters off of Oregon (ORS). Separation of these spatial sub-stocks is based on distinguishing localized population dynamics, preliminary population genetics results, and is supported by spatial differences in the fishery (the NCS has been the primary area from which removals have occurred), the ecology of nearshore groundfish species, and is consistent with current state management needs.

Cabezon removals were assigned to six fleets in each California sub-stock (two commercial and four recreational) and four fleets in Oregon (two commercial and two recreational) for each sub-stock because each of these fleets targets a different component of the population. The California time series begin in 1916, with the onset of commercial landings, while Oregon begins in 1973, with the start of the recreational fishery. Historical recreational removals for California were based on the reconstruction used in Cope and Punt (2006), while the staff of the Oregon Department of Fish and Wildlife supplied the historical Oregon recreational time series. Historically, vessel-based recreational catch (private and charter) has been the primary reported source of biomass removals of cabezon. Commercial catch has become a major source of removals in the last 15 years because of the developing live-fish fishery in both California and southern Oregon (Figures 11-13). Commercial discard mortality, assumed negligible in the last assessment, is included in this assessment. Because cabezon are caught primarily in the nearshore fishery and are believed to not suffer from barotrauma, discard mortality is assumed to be low.

Cabezon were lightly exploited until the 1940s in California, particularly in northern California (Figure 11). Catches began to increase in southern California in the 1960s (Figure 12). This increase in catch caused a relatively large decline in spawning biomass. In Oregon, the take of cabezon did not begin in earnest until the 1970s, which in turn has

also caused a decline in spawning biomass (Figure 13). The estimated depletion levels for NCS and SCS are 45% (± 7%) and 60% (± 14%), respectively. Estimated depletion for ORS sub-stocks is 52% (± 10%). Greatest uncertainty is found in the smaller SCS and ORS sub-stocks.

Though much of the declines in cabezon populations correspond to removals by the recreational fishery sectors, the added impact of the live-fish fishery is also witnessed in declines through the mid- to late-1990s in all sub-stocks.

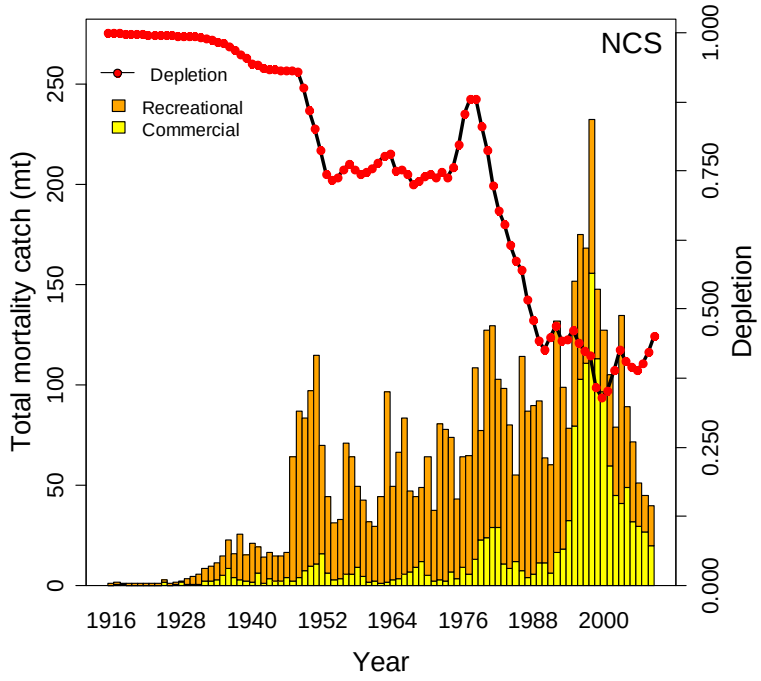



Figure 11. Time series of removals (bars) for commercial and recreational fisheries and estimated depletion (line) for the northern California cabezon stock (NCS), 1916-2009.

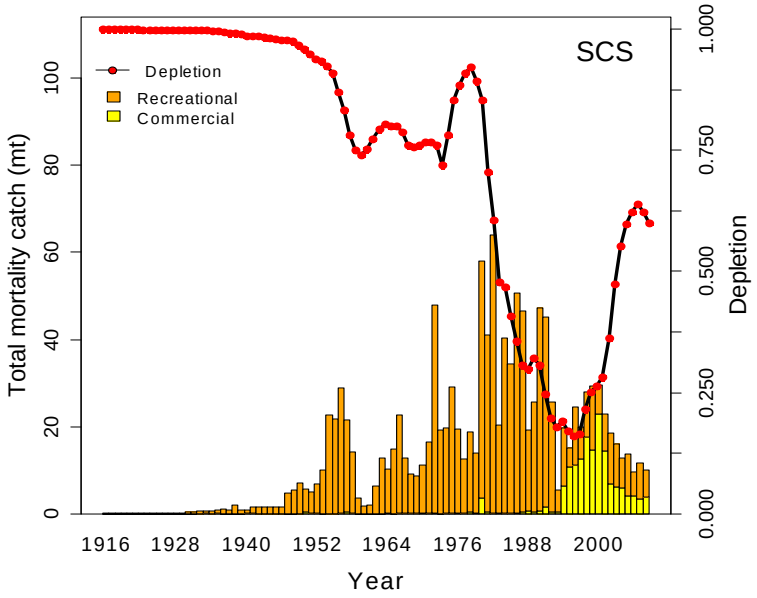



Figure 12. Time series of total removals (bars) for the commercial and recreational fisheries and estimated depletion (line) for the southern California cabezon stock (SCS), 1916-2009.

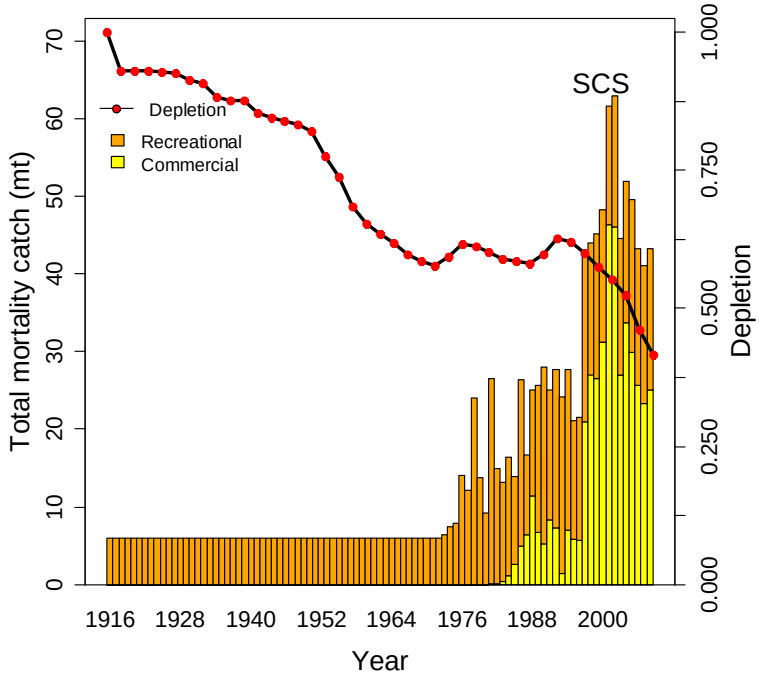



Figure 13. Time series of total removals (bars) for the commercial (yellow) and recreational fisheries (orange) and estimated depletion (line) for the Oregon cabezon stock (ORS), 1916-2009.

**Cabezon:** The complete version of: Status of Cabezon (*Scorpaenichthys marmoratus*) in California and Oregon Waters as Assessed in 2009 can be viewed online at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on the cabezon assessment, contact Dr. Jason Cope at Jason.Cope@noaa.gov

**Lingcod**

This assessment applies to lingcod (*Ophiodon elongatus*) off the West Coast of the United States, and is conducted as two separate assessments of (1) lingcod off of Washington and Oregon (the North stock), and lingcod off of California (the South stock). The largest landings off California were 2,749 mt in 1980 (nearly equally divided between the commercial and recreational fleets). For Washington/Oregon, the largest landings were 3,443 mt in 1983 (with over 90% of the landings coming from the commercial fleet). Landings exceeded 1,400 mt for the years 1971-1991 in the South and the years 1973-1994 in the North. Landings have declined significantly over the past two decades, with the average landings over the past 10 years being 298 mt in the North and 405 mt in the South. For each stock, two fisheries are modeled: the commercial fishery and the recreational fishery. Landings are included from 1928-2008, with equilibrium landings estimated for the commercial fisheries prior to 1928. Since the fishery off of California developed earlier, the equilibrium catches are an order of magnitude higher there (341 metric tons (mt) in California vs. 36 mt for Washington/Oregon). Catch (total mortality) is similar to landings for most of the time series. However, discard rates and therefore estimates of mortality due to discard for the commercial fishery have been quite high relative to landed catch in recent years due to regulations.

This assessment used the Stock Synthesis (SS) model, version 3.03a. Lingcod has been modeled using various age-structured forward-projection models since the mid-1990s. The previous assessment was conducted in 2005 in SS2. Data used in the base models for the current assessment include the following: Commercial and recreational landings data from 1928-2008, with information on prior catch informing the "equilibrium" landings level; Commercial discard rates from 2002-2007; Triennial survey indices for the years 1980-2004 (every 3$^{rd}$ year); NWFSC survey indices for the years 2003-2008; commercial logbook CPUE indices for the years 1976-1997 (North) or 1978-1997 (South); PSMFC Dockside (recreational) boat survey index 1980-1989, 1993-1997 (South); Commercial length composition data for 1965-2008 (North) or 1978-2008 (South); Commercial discard length composition data for 2003-2007 (North) and 2004-2007 (South); Recreational length composition data for 1993-2008 (North) or 1987-2008 (South); Triennial length composition data for 1986-2004 (North) or 1989-2004 (South); NWFSC length composition data for 2003-2008. Age data were available and used in sensitivities but not in the base models due to issues with outliers and possible aging bias. The data used in sensitivities include: Commercial conditional age-at-length data for 1980-2008 (North) and 1987-2008 (South); Recreational conditional age-at-length data for 1999-

2008 (North); Triennial conditional age-at-length data for 1992-2004 (North) or 1995-2004 (South); NWFSC survey conditional age-at-length data for 2003-2008.

A number of sources of uncertainty were explicitly included in this assessment. There were also other sources of uncertainty that were not included in the current model, including the degree of connection between the two lingcod stocks and also between the northern stock and the stock off British Columbia; the effect of the PDO, ENSO and other climatic variables on recruitment, growth and survival of lingcod. A reference case was selected based on extensive model testing and an attempt was made to balance the sources of uncertainty. In addition, an attempt was made to make the North and South models as equivalent as possible. In this regard, fixed and estimated parameters are largely the same for the two assessments. The data supporting the assessment of the Northern stock is of somewhat higher quality and is more consistent than those for the Southern stock, thus the results of the assessment for the Southern stock are more uncertain, especially regarding the current depletion level.

For West Coast rockfish, a stock is considered overfished when it is below 25% of virgin spawning biomass. Currently, the spawning stock is believed to be near 70% of the unfished level in both the Northern and Southern stocks. Lingcod has not been subject to overfishing since 2003. Management and assessment of stock status might be improved through greater cooperation with British Columbia, as the stock extends northward into Canadian waters. Recent catch and levels of depletion are presented in Figures 14 and 15.

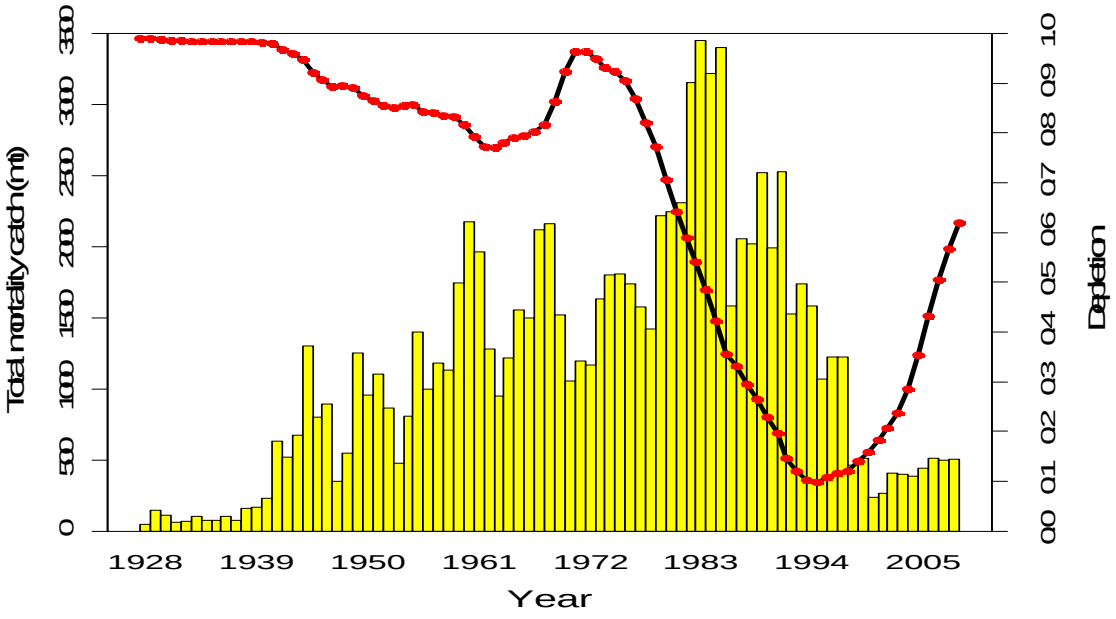



Figure 14. Level of catch (bars) and depletion (line) for lingcod North of 42ºN, 1928-2009.

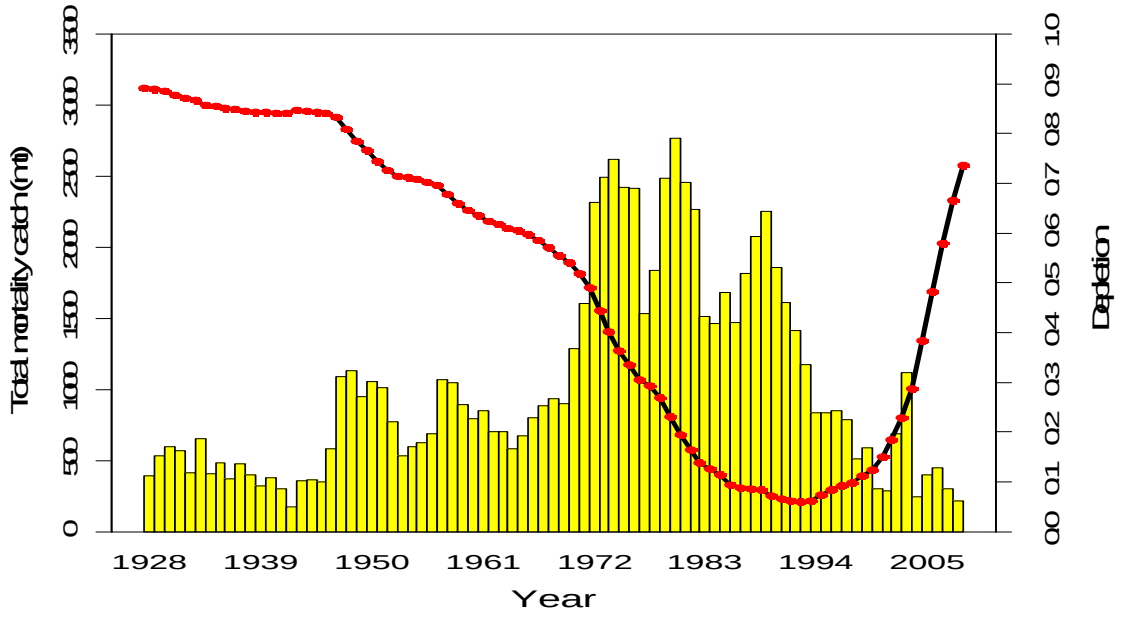



Figure 15. Level of catch (bars) and depletion (line) for lingcod South of 42ºN, 1928-2009.

**Lingcod:** The complete version of: Status and Future Prospects for the lingcod Resource in Waters off Washington and Oregon as Assessed in 2009 can be viewed at: http://www.pcouncil.org/groundfish/stock-assessments/current-stock-assessments/

For more information on this assessment contact Dr. Owen Hamel at: Owen.Hamel@noaa.gov.

**D. Other Related Studies**

**1. The PaCOOS, West Coast habitat data portal**

The PaCOOS Marine Habitat Data Portal was conceived in 2005 as a Local Data Access Center (LDAC) of the Integrated Ocean Observing System (IOOS). Funding for its development was provided by the NOAA IOOS Program through the FRAM Division of the Northwest Fisheries Science Center. The database and GIS system had its origin the data collected together for the West Coast Essential Fish Habitat Environmental Impact Statement, which was completed in 2005/2006. Maintained jointly by FRAM and Oregon State University, College of Oceanic and Atmospheric Sciences Seafloor Mapping Laboratory and in collaboration with PSMFC, the portal provides access to data (search, connection, and download), a visualization environment, and integrated navigation tools. The data portal houses an ever expanding array of information including but not limited to geological and geophysical data, benthic habitat maps, fisheries survey datasets, and ocean climatologies. Data access, which includes data searching and metadata

harvesting, is provided through IOOS Data Management and Communications (DMAC) compliant pathways such as OPeNDAP, OGC WMS, and ESRI ArcIMS map services. The portal's centerpiece is its unique map viewer environment (http://pacoos.coas.oregonstate.edu/), an online application that provides a map interface to data holdings with custom tools for data downloads and queries. There is a growing user base that includes local, state, and federal agencies within the California Current Large Marine Ecosystem.

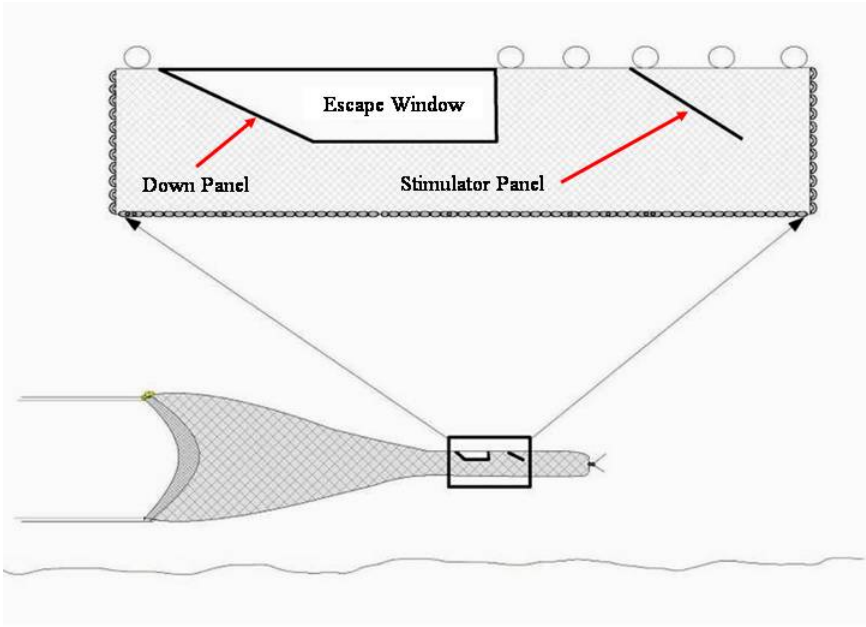
The functionality of the PaCOOS data portal is continually being improved and new data sets are being added. This year updates to survey information have been added and habitat information has been updated.

For more information, contact Elizabeth.Clarke@noaa.gov (206-860-3381) or Chris Goldfinger at gold@coas.oregonstate.edu (541-737-5214)

**2. Bycatch Reduction Research**

The Northwest Fisheries Science Center (NWFSC) sought funding in 2008 and 2009 to support staffing for a fishing gear technician in the NWFSC's Habitat and Conservation Engineering (H&CE) group within the NWFSC's Fishery Resource Analysis and Monitoring Division. Working with our fisheries research partner, the Pacific States Marine Fisheries Commission (PSMFC), the NWFSC hired a gear technician who is stationed at the NWFSC's field station in Newport, Oregon. This technician focuses on gear research, assists the group coordinator in the continued development of the NWFSC's bycatch reduction research, and collaborates with other NMFS and regional gear researchers.

In 2009, the NWFSC and PSMFC developed and began field testing of an open escape window bycatch reduction device (BRD) to reduce ESA-listed Chinook salmon and rockfish (genus *Sebastes*) bycatch (e.g., darkblotched, canary, and widow) in the Pacific whiting fishery (Figure 16). The development of this BRD benefited from extensive interactions with scientists, especially those from the Alaska Fisheries Science Center, commercial fishermen, and gear manufacturers working in the Pacific Northwest and Alaska. This BRD design consists of two mesh panels, positioned near the codend of a midwater trawl, which direct



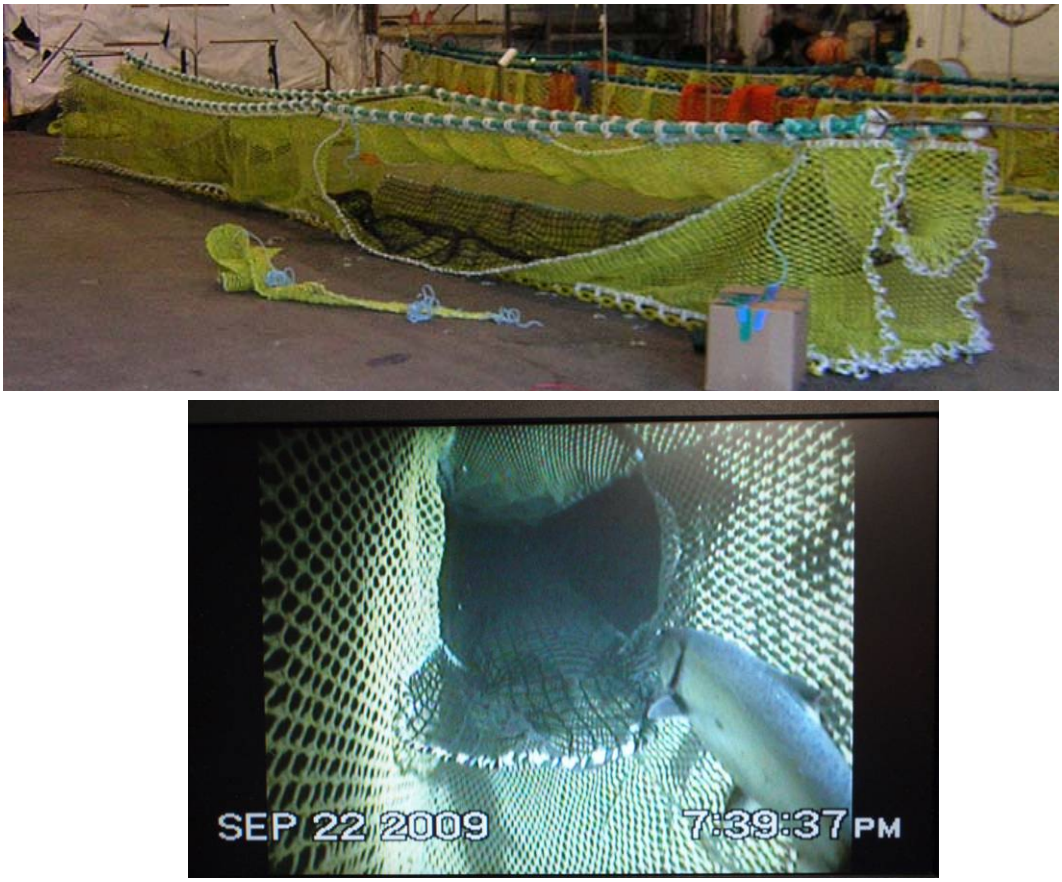



Figure 16. Schematic view of midwater trawl and open escape window bycatch reduction device (BRD) (top); completed BRD in net loft in Newport, Oregon (starboard escape panel removed) (middle); Chinook salmon (ca. 80 cm) approaching BRD's escape window (bottom).

actively swimming fish toward an open escape window on the top and upper sides of the net. This BRD is designed so that fish displaying strong swimming abilities (e.g., salmon and rockfish) can escape through the open windows, whereas fish exhibiting weak swimming abilities (e.g., Pacific whiting) will pass into the codend. During September 2009, the HC&E group conducted a five-day research cruise aboard a trawler engaged in the Pacific whiting fishery. Chinook salmon behavior within the BRD was documented with an autonomous video camera. A total of eight salmon were observed, with five salmon (> 62%) escaping via the BRD. Because trawling was conducted with an open codend and the video camera system could not record the total duration of every tow, we were unable to determine whether the remaining three salmon escaped using the BRD. Planning is currently underway to conduct further development and testing of the open escape window BRD concept in the Pacific whiting midwater trawl fishery as well as other Pacific coast trawl fisheries. Results from 2009 demonstrated the capability of the open escape window BRD to release Chinook salmon before capture. More extensive testing of the BRD under varied fishing conditions with successful results would be the

first step in applying this bycatch reduction concept in the Pacific whiting fishery. One recent fishing industry collaboration grew out of the NWFSC's interactions with the conservation engineering group at the Alaska Fisheries Science Center and regional net lofts in the Pacific Northwest. A resulting technology transfer was the development of a variation on the BRD by a Seattle area net loft and its testing in Alaska's walleye pollock fishery. Results from tests during 2009 and lessons learned are currently being exchanged between Pacific coast and Bering Sea gear technologists and will be applied in gear development for next year's field season.

In addition to the above work on flexible sorting grids, the NWFSC has continued work on two ongoing bycatch reduction research projects. The first ongoing project is collaboration with the gear research group at the Oregon Department of Fish and Wildlife (ODFW) and is focused on observations of fish behavior in the vicinity of the footrope of the bycatch-reducing selective flatfish trawl, using a dual-frequency identification sonar (DIDSON) ultrasonic camera. Reducing bycatch in commercial fishing gear requires an understanding of the behavior of fish interacting with the gear. The use of lights may confound observations of fish behavior in the proximity of fishing gear. The DIDSON uses ultrasound to form images of fish, as well as the gear, surrounding structures, and the seafloor. The DIDSON was used to examine diel behavior differences in roundfish along a 12-meter section of the footrope on the starboard wing of the flatfish trawl. During FY09, data extraction was completed for individual fish tracks from all of the archived DIDSON data collected in 2006 and 2007. Movements of individual roundfish were tracked, providing a continuous measurement of distance from the footrope. Analysis of fish tracks revealed that during the day, roundfish remained farther from the footrope, maintained a relatively constant distance, and showed less variation in direction. At night, fish approached the footrope at a sharper angle and displayed a more abrupt change in speed and direction. These behavioral differences suggest that herding efficiency and gear selectivity are different between day and night fishing.

In FY09, the NWFSC continued a pilot project to integrate seabed classification with commercial fishing activities to investigate whether this type of information would be useful in reducing bycatch in Pacific coast groundfish fisheries. This project is being conducted in the vicinity of Morro Bay, California as a collaboration between the NWFSC's HC&E group and West Coast Groundfish Observer Program, the Nature Conservancy, and Oregon State University's Active Tectonics and Seafloor Mapping Lab. The goal of the project is to capture bottom type using a Quester Tangent QTC VIEW simultaneously with bottom trawling. This project will consider questions such as, can high-quality data be collected during normal fishing operations to inform NMFS about bottom type with minimal impact on fishing operations, and will patterns in bycatch relate to specific seafloor classifications? Building on work completed in FY2008, this project entered a second phase of field work in September 2009, employing a newly installed dual frequency echosounder matched to a Quester Tangent QTC View 5.5 system. The field work for the phase II portion of the project will continue through February 2010.

For more information, contact Waldo Wakefield at Waldo.Wakefield@noaa.gov, (541) 867-0542 or Bob Hannah at Bob.W.Hannah@state.or.us, (541) 867-0300

**3. Cooperative Ageing Unit**

The Cooperative Ageing Project (CAP) provides direct support for U.S. West Coast groundfish stock assessments by providing ages derived primarily from otoliths. In 2009, CAP aged the following species: Dover sole, curlfin sole, petrale sole, canary rockfish, Pacific ocean perch, darkblotched rockfish, redbanded rockfish, splitnose rockfish, greenstriped rockfish, Pacific hake, and sablefish.

For more information, please contact Dr. Jim Hastie at Jim.Hastie@noaa.gov

**4. Resource Surveys**

**a) U.S. West Coast Groundfish Bottom Trawl Survey**

The NWFSC conducted its twelfth annual bottom trawl resource survey for groundfish off the coasts of Washington, Oregon, and California. The objective of the 2009 survey was to provide information on the distribution and relative abundance of demersal species within this region at depths from 30 to 700 fathoms. Other biological information necessary to assess the status of groundfish stocks (e.g. length, weight, sex and age structures) was collected throughout the survey period.

The NWFSC chartered commercial fishing vessels to conduct independent, replicate surveys using standardized trawl gear. Fishing vessels *Ms. Julie, Excalibur, Noah's Ark* and *Raven* were contracted to survey the area from Cape Flattery, WA to the Mexican border in Southern California, beginning in the later part of May and continuing through October. Each vessel was chartered for 11-12 weeks with the *Ms Julie* and *Noah's Ark* surveying the coast during the initial survey period from May to July. The *Excalibur,* and *Raven* operating in tandem, surveyed the coast during a second pass from mid-August to late October. The survey area was partitioned into ~12,000 adjacent cells of equal area (1.5 nm long. by 2.0 nm lat., Albers Equal Area projection) with each vessel assigned a primary subset of 188 randomly selected cells to sample. An Aberdeen-style net with a small mesh (1 1/2" stretch) liner in the codend was used for sampling. The survey followed a stratified random sampling scheme with 15-minute tows within 2 geographic strata (80% N of Pt. Conception, CA and 20% S) and 3 depth strata. The depth strata were: shallow (30-100 fms), middle (100-300 fms), and deep (300-700 fms). The sample design consisted of 752 sampling locations, with a minimum of 30 tows per strata.

In 2009, we also continued to utilize the FSCS data collection system with updated software applications, and wireless networking. Established NOAA national bottom trawl protocols were used throughout the survey. As in prior years, a series of special research projects were undertaken in cooperation with other NOAA groups and various Universities.

Additional data were collected during the trawl survey for collaborative research projects with several NMFS/academic colleagues: 1) Maternal effects on larval quality in rockfishes - Southwest Fisheries Science Center; 2) 1) Genetic variation in the natural population of sablefish and development of a genetic map for sablefish – University of Victoria, BC, Canada; 3) Preliminary work on mercury detection in selected species of groundfish off WA -Division of Environmental Health Washington State Department of Health; 4) Age, growth, and reproductive biology of the starry skate, *Raja stellulata* - Moss Landing Marine Laboratories; 5) Collection of Pacific black dogfish, *Centroscyllium nigrum* specimens - Moss Landing Marine Laboratories; 4) Feeding ecology of the roughtail skate, *Bathyraja trachura*.; 6) Collection of all unusual or unidentifiable skates, sharks, or chimaeras - Moss Landing Marine Laboratories; 7) Collection of biological data and specimens of the deepsea skates, *Bathyraja abyssicola*, and broad skates, *Amblyraja badia* - Moss Landing Marine Laboratories.

Several other research initiatives were undertaken by the Survey Team including: 1) Use of stable isotopes and feeding habits to examine the feeding ecology of rockfish (genus *Sebastes*); 2) Fin clip collection for various shelf rockfish species; 3) Collection of stomachs for selected species including: Pacific hake and various rockfish; 4) Collection and identification of cold water corals; 5) Determination of sexual parasitism of crabs (carcinophily) in the northeast Pacific Ocean; 6) Fish distribution in relation to bottom dissolved oxygen concentration in the oxygen minimum zone; 7) Video study observing the interaction of flatfish with trawl sweeps; 8) Fish distribution in relation to bottom dissolved oxygen concentrations in a known hypoxic area off OR; 9) Composition and abundance of benthic marine debris collected during the 2009 West Coast Groundfish Trawl Survey from May to October 2009; and 10) Collection of ovaries from Pacific hake and canary rockfish to assess maturity.

For more information please contact Dr. Aimee Keller at Aimee.Keller@noaa.gov.

**b) Autonomous Underwater Vehicle (AUV) Surveys**

The Northwest Fisheries Science Center (NWFSC), in collaboration with researchers at Woods Hole Oceanographic Institution (WHOI), and the Pacific Islands Fisheries Science Center is developing a SeaBED type Autonomous Underwater Vehicle (AUV) to overcome the difficulty of monitoring fish populations in rocky areas. Traditional fish monitoring techniques, such as trawls are of limited applicability in these areas due to the rugged nature of the terrain. Thus, to enhance our ability to adequately assess fishery species that use these habitats alternate technologies must be identified and evaluated for augmenting current fishery-independent assessment techniques. Hover-capable AUVs offer a unique tool that is appropriate for work in these types of habitat.

The SeaBED-class AUV is unlike more traditional AUV's in that its twin-hull design provides greatly enhanced stability for low-speed photographic surveys. Built by Woods Hole Oceanographic Institute (WHOI), SeaBED is designed to autonomously follow the terrain approximately 3-4 meters (m) above the sea floor, collecting high resolution color imagery while maintaining a forward speed of 0.25 – 0.5 m $sec^{-1}$. SeaBED is

approximately two meters long and weighs nearly two-hundred kilograms. It has two main pressure housings, a top hull and a bottom hull. With a maximum depth range of 2,000 m, and maximum single-dive time of 6 – 8 hours, SeaBED can be used to survey habitats ranging from shallow coral reefs to deep groundfish environments.

During several missions in both Hawaii and California, new camera configurations and new cameras were added and tested. An Imagenex Delta T multibeam sonar was also added to the vehicle to allow near bottom multibeam mapping. Research cruises are now being planned for spring and summer of 2010 during which the occurrence, distribution and abundance of coldwater corals and sponges in key areas of the west coast will be examined.

For more information, contact Dr. Elizabeth Clarke at Elizabeth.Clarke@noaa.gov

**c) Southern California hook-and-line survey**

In early Fall 2009, FRAM personnel conducted the sixth hook and line survey for shelf rockfish in the Southern California Bight (SCB). This project is a cooperative effort with Pacific States Marine Fisheries Commission (PSMFC) and the southern California sportfishing industry aimed at developing an annual index of relative abundance and time series of other biological information for structure-associated species of rockfish (genus *Sebastes*) such as bocaccio (*S. paucispinis*), greenspotted rockfish (*S. chlorostictus*), and the vermilion rockfish complex (e.g., *S. miniatus* and *S. crocotulus*) within the SCB.

The F/V *Aggressor* (Newport Beach, CA) and F/V *Mirage* (Port Hueneme, CA) were each chartered for 12 days of at-sea research, with nine biologists participating during the course of the survey. The two vessels sampled a total of 120 sites ranging from Point Arguello in the north to 60 Mile Bank in the south. Approximately 2,800 lengths, weights, fin clips, and otolith pairs were taken representing 34 different species of fish.

Several ancillary projects were also conducted during the course of the survey. This includes the deployment of non-lethal genetic tagging hooks designed by FRAM personnel. These hooks remove a small piece of tissue from a fish's mouth during a strike without bringing the animal to the surface, limiting mortality associated with barotrauma stress. Genetic microsatellite analysis uniquely "tags" each fish which can then be "recaptured" during subsequent deployments of the tagging hooks. A total of 392 of these hooks were used during the course of the 2009 hook and line survey. An underwater video system was deployed opportunistically at sites to gather imagery of the seafloor for future analyses correlating catch rates of key species with specific habitat types. This camera system has also been deployed in other applications including direct visual observations of pelagic fish schools to be compared with contemporaneous acoustic backscatter data.

Other ancillary projects conducted during the 2009 hook and line survey included the collection of tissue samples from bocaccio for stable isotope analysis to compare trophic feeding levels inside and outside of marine reserves and the preservation of several

rockfish and flatfish specimens for a genetic voucher program conducted by the University of Washington and for species identification training for the West Coast Observer Program.

For more information please contact John Harms at John.Harms@noaa.gov

**d) 2009 Joint U.S.-Canada hake acoustic survey and the processing of the collected data**

The Joint U.S./Canada Integrated acoustic and trawl survey was conducted from June 29 to Aug. 23, 2009 by the U.S. Team (NWFSC/FRAMD) on the NOAA ship *Miller Freeman*, and from Aug. 12 to Sep. 10, 2009 by the Canadian Team (DFO/PBS) on the *CCGS W.E. Ricker*. The data collected during the survey were processed to provide an estimate of the abundance and spatial distribution of the coastal Pacific hake stock shared by both countries. The survey covered the slope and shelf of the Pacific coast from approximately 35.7º N to 55.7ºN with acoustic transects spaced 10-20 nm apart. The U.S. team onboard the *Miller Freeman* surveyed up to 48.4ºN, and the Canadian team on the *Ricker* completed the region from 48.5ºN to 55.7ºN. The survey resulted in 121 transects with over 3,877 miles of acoustical transect. Pacific hake were observed from approximately 37ºN to 55º N (Dixon Entrance), close to the northern extent of the survey. Data were collected on 18-, 38-, 120-, and 200-kHz EK60 echo sounder on the *Miller Freeman*, and 38 and 120 kHz EK60 echosounder on the *Ricker*. Midwater and bottom trawls were conducted to verify size distribution and species composition and to obtain biological information (i.e. age composition, sex).

A total of 129 successful trawls (91 by U.S.) resulted in a total catch of 35,592 kg (28,672 kg from U.S.). One of the major findings is that a significant amount of Humboldt squid was found during the 2009 hake survey, with total catch weight of 28,137 kg (26,531 kg from U.S.). The data analysis was completed by Dec. 15 to provide necessary information to the hake stock assessment group. The estimated total biomass of Pacific hake was 1.46 million metric tons. The stock was dominated by hake with mean length about 40 cm (3-4 year old cohort). Due to the presence of Humboldt squid, the variance estimated with the method proposed by Jolly-Hampton was 16.3%, or about 50% more than that from the 2007 hake survey.

Also on the joint U.S./Canadian survey, the NWFSC Video Plankton Recorder (VPR) was used to give a complete picture of the plankton community, including gelatinous zooplankton not identifiable from net tows. The goal of this work is to identify plankton that affects acoustic backscatter during hake surveys.

Figure 17. NWFSC Digital Video Plankton Recorder

For more information, contact Dr. Dezhang Chu at Dezhang.Chu@noaa.gov

**e) Joint PWCC-NMFS hake pre-recruit survey**

A joint Pacific Whiting Conservation Cooperative and FRAMD pre-recruit survey was conducted in 2009 to determine the spatial distribution and abundance of young-of-year (YOY) Pacific hake along the U.S. West Coast. The survey was conducted from May 7 to June 8, 2009 and covered the area from 36º 30'N to 48ºN at 30 nm intervals. A minimum of 5 trawl stations were sampled on transects located at 30 nm intervals with stations located over waters between approximately 50 m and 1,000 m depth, with hauls taken over bottom depths of 50, 100, 200, 300, and 500 meters at each transect. The survey was conducted using the research gear and survey protocol developed by the NMFS Santa Cruz laboratory for surveys of juvenile rockfish (*Sebastes* spp.). The net has a 86' headrope length and was rigged to fish at 30 m depth. The net tapers from the opening to a cod-end of 1/2" mesh that is lined with a 3/8" mesh liner. Trawling is conducted at night with the headrope at 30 m at a speed of 2.2 to 2.5 kt. Trawl tow duration at depth is 15 minutes, counted from the time the net reaches the 30 m fishing depth.

All fish and invertebrates captured were identified to the lowest taxonomic level and enumerated. All hake caught were counted and measured and data summarized and transferred to the NWFSC within 3 months of the end of the survey. Rockfish collected were bagged, labeled, frozen and delivered to the NWFSC for identification. YOY Pacific hake numbers were found to be low, suggesting a relatively weaker year class

than in recent years. Additionally, spawning appears to have returned to a more southerly distribution.

For more information, contact Dr. Dezhang Chu at Dezhang.Chu@noaa.gov

**5. NOAA Program: Fisheries And The Environment (FATE)**

**Project Title:** Development of a Real-Time Tool for Predicting the Location of Pacific hake (*Merluccius productus*)

**Investigators:** Dr. Melissa Haltuch (NWFSC), Dr. Carrie Holt (DFO, Nanaimo), Dr. Elizabeth Clarke (NWFSC), and Dr André E. Punt (NWFSC)

Predicting species distributions has utility for survey planning. Specifically, if a tool were available to predict where the density of migratory target species was highest a few weeks before a survey is conducted (without using data on the species itself), survey effort could be distributed to minimize (expected) variance. The benefits of modifying designs for surveys which target a mix of species may be low. However, substantial benefits in terms of more precise estimates of abundance could be possible for surveys which target single species, such as the acoustic surveys for Pacific hake (*Merluccius productus*) off the west coasts of the U.S. and Canada. These surveys form a key basis for the stock assessment and hence management advice for this species (e.g. Helser and Martell 2007; Helser *et al.* 2008).

The spatial distribution of Pacific hake is known to exhibit inter-annual variation and this has consequences for monitoring, assessment, management and utilization of this species. Considerable research on Pacific hake has been undertaken (see, for example, the review by Ressler *et al*. 2007). For example, it is known that a larger proportion of the stock migrates into Canadian waters during El Niño events, apparently due to intensified northward transport during the period of active migration (Dorn 1995; Agostini *et al*. 2006), while ocean-basin scale regime shifts have also been used to explain inter-annual variability in migration (Benson *et al.* 2002; Field 2004). Changes in spatial distribution are explicitly accounted for in stock assessments for Pacific hake by allowing fishery selectivity for the U.S. and Canadian fleets to vary through time, but such changes do not directly impact how the fishery is monitored for assessment purposes.

The project addresses several of the aims of the FATE program. Specifically, the development of a modeling tool that can forecast species distributions on short time-scales using environmental data partially addresses the aim "to construct the next generation of forecasting tools". In addition, this tool will allow environmental data to be used when crafting management decisions and when planning surveys. The results of stock assessments should be more precise and reliable if surveys can be designed that are more precise than those currently undertaken. This is particularly relevant to Pacific hake which is a transboundary stock, the assessment of which has been contentious in recent years, and for which indices of abundance from acoustic surveys are the main sources of information on abundance.

For more information, contact Dr. Melissa Haltuch at Melissa.Haltuch@noaa.gov

## 6. Ecosystem Studies

### a) Fish Ecology Division Summary Report

The Fish Ecology Division conducted five monthly field surveys in 2009 for larval fishes using plankton nets and juvenile fishes using trawls. This was the most successful year to date, with all transects and 99 out of the 100 planned ichthyoplankton tows completed. All larval fish have been sorted and identified for 2009 and the juvenile fishes have been identified from all but the September cruise in 2009. Preliminary results have shown a substantial increase in the abundance of rockfishes in plankton nets and trawls in the last few years so that they dominate the fish composition presently. Due to the fact that there are potentially so many (>60) rockfish species present off the Oregon coast and that they are so difficult to visually differentiate at early stages, the division been working with Oregon State University geneticists to use genetic techniques to identify several thousand rockfish juveniles from 2005-2009. At least 24 species and several species groups have been identified in this analysis to date. Genetic techniques will soon be applied to larvae which are already sorted, measured, and preserved in alcohol. There have also been moderate increases in flatfish larvae/juveniles of several commercially important species. Perhaps the most striking change for 2009 was the finding of substantial numbers of Humboldt squid, a more tropical species, in the sampling area. Although observed every year squid were particularly abundant this past year. Division personnel are presently working on a manuscript which will document this finding and consider the potential impact of this voracious predator.

*Products:*

- Poster presentation at the 2009 annual Larval Fish Conference in Portland, OR (7/24/09) entitled, "An investigation of the response of fish larvae to decadal changes in environmental forcing factors off the Oregon coast." Toby D. Auth, Richard D. Brodeur, Heather L. Soulen, Lorenzo Ciannelli, and William T. Peterson.
- Poster presentation at the 2009 annual Larval Fish Conference in Portland, OR (7/24/09) entitled, "Winter Ichthyoplankton abundance: predictor of summer prey fields and ultimate survival of juvenile salmon?" Elizabeth A. Daly, Toby D. Auth, Richard D. Brodeur, and William T. Peterson.
- Oral presentation at the Gilbert Ichthyological Society meeting in Washington (10/09) entitled, "Genetic Identification of Larval/Juvenile *Sebastes* Samples for Stock Assessment" Johansson, M.L., T.A. Britt, C.A. Vanegas, M.N.C. Litz, J.R. Hyde J.R., M.A. Banks, and R.D. Brodeur.
- Oral presentation at the 2009 Annual PICES Conference in Jeju, Korea (10/09) entitled, "Ichthyoplankton as indicators of climate change and recruitment variability of marine fishes and salmon along the northwest coast of the US." Richard D. Brodeur, Toby D. Auth, Elizabeth A. Daly, and William T. Peterson.

- Auth, T.D. 2009. Importance of far-offshore sampling in evaluating the ichthyoplankton community in the northern California Current. *CalCOFI Rep.* 50:107-117.
- Phillips, A.J., R.D. Brodeur, and A.V. Suntsov. 2009. Micronekton community structure in the epipelagic zone of the northern California Current upwelling system. *Prog. Oceanogr*. 80:74-92.
- Parnel, M.M, R.L. Emmett, and R.D. Brodeur. 2008. Ichthyoplankton community in the Columbia River Plume off Oregon: effects of fluctuating oceanographic conditions. *Fish. Bull.*106:161-173.
- Toole, C.L., R.D. Brodeur, C.J. Donohoe, and D.F. Markle. MS. Seasonal and interannual variability in the community structure of small demersal fishes along the central Oregon coast. In revision to *Mar. Ecol. Prog. Ser.*
- Contributed multiyear data on juvenile fishes to a section of the North Pacific Marine Science Organization Ecosystem Status Report that will be published in 2010.

For more information, contact Dr. Rick Brodeur or Dr. R. Emmett at Rick.Brodeur@noaa.gov and Robert.Emmett@noaa.gov

**b) A Synthesis of diets and trophic overlap of marine species in the California Current**

A key step toward ecosystem-based management is to better understand how interactions within food webs affect species of commercial and conservation importance. The NWFSC compiled comprehensive diet information and food web analysis for major taxa within the California Current ecosystem, including fish, marine mammals, birds, and invertebrates (Dufault et al. 2009).

Dufault et al. (2009) synthesized 75 published diet studies from this ecosystem and calculated representative diets for each species or aggregated functional group. They assessed diet relatedness using hierarchical cluster analysis and calculated diet overlaps based on percent similarity index (PSI). Both analyses were performed on functional group data and also separately for each vertebrate species.

Cluster analysis identified distinct feeding guilds and revealed both intuitive and novel diet similarities between several species and functional groups. One intuitive example is that functional groups preying on euphausiids, a key forage species in the California Current, show a high amount of overlap. A novel example is the significant diet overlap of shallow small rockfish and baleen whales (e.g., grey whales [*Eschrichtius robustus*]), both of which consume large amounts of benthic invertebrates.

Functional groups were highly significant in explaining the PSI differences between species, which suggests that key ecological interactions will be preserved in ecosystem models that use these functional groups. A visual representation of the complete food web and calculation of food web statistics suggest that there are strong similarities

between the food webs of the California Current and the Benguela Current, a similar upwelling-driven eastern boundary current off the southwest coast of Africa.

For more information please contact Dr. Isaac Kaplan at Isaac.Kaplan@noaa.gov

**c) NOAA's Fisheries Service proposes federal protection for three Georgia Basin rockfish species**

NOAA's Fisheries Service proposed to list three populations of rockfish in Puget Sound and the Strait of Georgia for protection under the Endangered Species Act. A final decision on the three will be made in April 2010.

The Georgia Basin populations of two of the rockfish species – canary and yelloweye – are proposed for "threatened" status. A third rockfish species – bocaccio – is proposed as "endangered." An endangered species is at high risk of extinction; a threatened species is vulnerable to extinction in the near future and in need of protection.

Populations of all three rockfish species in the Georgia Basin, which encompasses Puget Sound and the Strait of Georgia, have been harvested at high levels, depleting their numbers. Rockfish, which are bottom dwellers, typically live long lives, and mature and reproduce slowly, making them especially vulnerable to overfishing.

Rockfish make up a substantial portion of the federally managed commercial bottomfish harvest off the West Coast, especially off the coast of California. Rockfish harvests in Puget Sound, by contrast, are managed by the state and the commercial catch there has been substantially restricted since the early 1990s, although there is still a small recreational harvest.

According to NOAA scientists, rockfish population growth has also been hampered by other fisheries unintentionally catching the stock and by environmental factors, such as loss of eelgrass beds, pollution and abandoned fishing gear that continues to catch fish.

If these rockfish are listed for Endangered Species Act protection next in 2010, the agency's initial focus would be on fishing practices in Puget Sound. There is currently a broad state and federal effort to improve the sound's water quality and nearshore habitat through the Puget Sound Partnership, which is aimed at conserving all marine life, including rockfish. Resident killer whales, Chinook salmon, chum salmon, steelhead and bull trout are already protected in the sound under the ESA.

The proposed listing is in response to a petition from an Olympia resident who asked the agency in 2007 to list Puget Sound populations of five species of rockfish. In addition to the three proposed today, the petition also included greenstriped and redstriped rockfish. Agency scientists have said the greenstriped and redstriped rockfish are at a "low risk" of extinction, and protection under the ESA was not needed at this time.

For more information on this action please see http://www.nwr.noaa.gov/Other-Marine

**d) Genetic evaluation of stock structure and population bottlenecks in the severely depleted cowcod**

Investigators: J. Hess, P. Chittaro, A. Elz, L. Gilbert-Horvath, J. Carlos Garza , V. Simon

Cowcod (*Sebastes levis*) range from Oregon to Baja California and are currently assumed to be one continuous population. Since 2004, it has been on the National Marine Fisheries Service "Species of Concern" list due to its dramatic decline in abundance (<3.4% - 16.3% of historical biomass). The following questions were addressed: 1) Are there population subdivisions within the species, specifically, between two marine biogeographic regions separated by Point Conception, and 2) Have cowcod populations experienced loss of genetic variation due to a reduction in population size? Sixteen variable microsatellite loci were genotyped and ~500 bp of the mitochondrial control region were sequenced for 294 fish distributed throughout the species range. We observed significant structure when fish were grouped into two regions separated by Point Conception (FST=0.066). However, upon further inspection, an individual-based spatial analysis using Bayesian cluster assignment of the microsatellite genotypes localized this genetic break further south (FST=0.092), corresponding to separation between a Channel Islands region versus the mainland. These results indicate a minimum of two management units in this species. In general, cowcod show low genetic diversity compared to other rockfishes. However, cowcod stocks do not appear to exhibit detectable loss in genetic variation, despite declines in abundance.

For more information please contact Paul Chittaro at Paul.Chittaro@noaa.gov

**e) Differential somatic growth rates and population subdivision of regions separated by Point Conception, CA, in a depleted rockfish, cowcod (*Sebastes levis*)**

Investigators: P. Chittaro, J. E. Hess, J. Carlos Garza, and V. Simon

Cowcod rockfish (*Sebastes levis*), a once commonly harvested (commercially and recreationally) species within Californian waters, was declared overfished in 2000, and added to the National Marine Fisheries Service Species of Concern list in 2004. To assist in the conservation of this species, we used otolith microchemistry and microstructure to obtain information related to population structure and the spatial variability of juvenile somatic growth. We hypothesized that a location of large upwelling near Point Conception, CA may act as a dispersal barrier for cowcod rockfish, resulting in population structure (currently, fisheries managers assume a single continuous population). If population structure is detected, we hypothesized that juvenile somatic growth rates would differ among populations owing to the different environments each population resides. To address these objectives we used archived collections of otoliths that were obtained throughout the species range. Using trace element concentrations from whole otoliths we identified two populations of cowcod rockfish that were separated at Point Conception. Further, based on otolith microstructural analyses we detected significant differences in juvenile somatic growth rates between these two populations.

These results suggest that a management approach, which considers two populations with differential growth rates, may better assist the rebuilding of this species.

For more information please contact Paul Chittaro at Paul.Chittaro@noaa.gov

## 7. Acoustic Modeling and Research

### a) Codend video camera system

One challenging but crucial element of fisheries acoustic surveys is to obtain accurate groundtruthing of the echo returns. However, it is extremely difficult, if not impossible, to determine the depth at which each species is caught. Therefore, it is problematic when multiple scattering layers are present. In addition, small organisms, such as siphonophores which are strong acoustic scatterers, are missed by regular midwater trawls. To address these issues and to achieve more objective interpretation of the acoustic data, Lisa Bonacci (FRAM acoustics team), along with Waldo Wakefield (Habitat), have constructed a Codend Video Camera System and conducted a pilot study during the summer of 2008 by mounting the system in the codend of an open midwater trawl which enabled us to look at several scattering layers during each tow. From the preliminary data analysis, it was found that this method appeared to provide improved knowledge of acoustic backscatter observed during fisheries acoustic surveys.

The camera system was used during the 2009 Hake survey where it provided non-extractive sampling and information on multiple scattering layers. It was particularly helpful in areas where hake and Humboldt squid were both present which made it difficult to assign species composition to some of the observed regions of backscatter. In some cases the camera system enabled scientists to find a layer of hake under a layer of Humboldt squid that would have been difficult to distinguish with only a closed net tow. Also, in some cases this system was able to be used in place of a bottom trawl in areas where potential bycatch was a concern. Overall, the camera system provided valuable groundtruthing information and will continue to be used during future hake acoustic surveys. Figure 18 presents an example of the analysis of a typical camera tow with analyzed results superimposed.

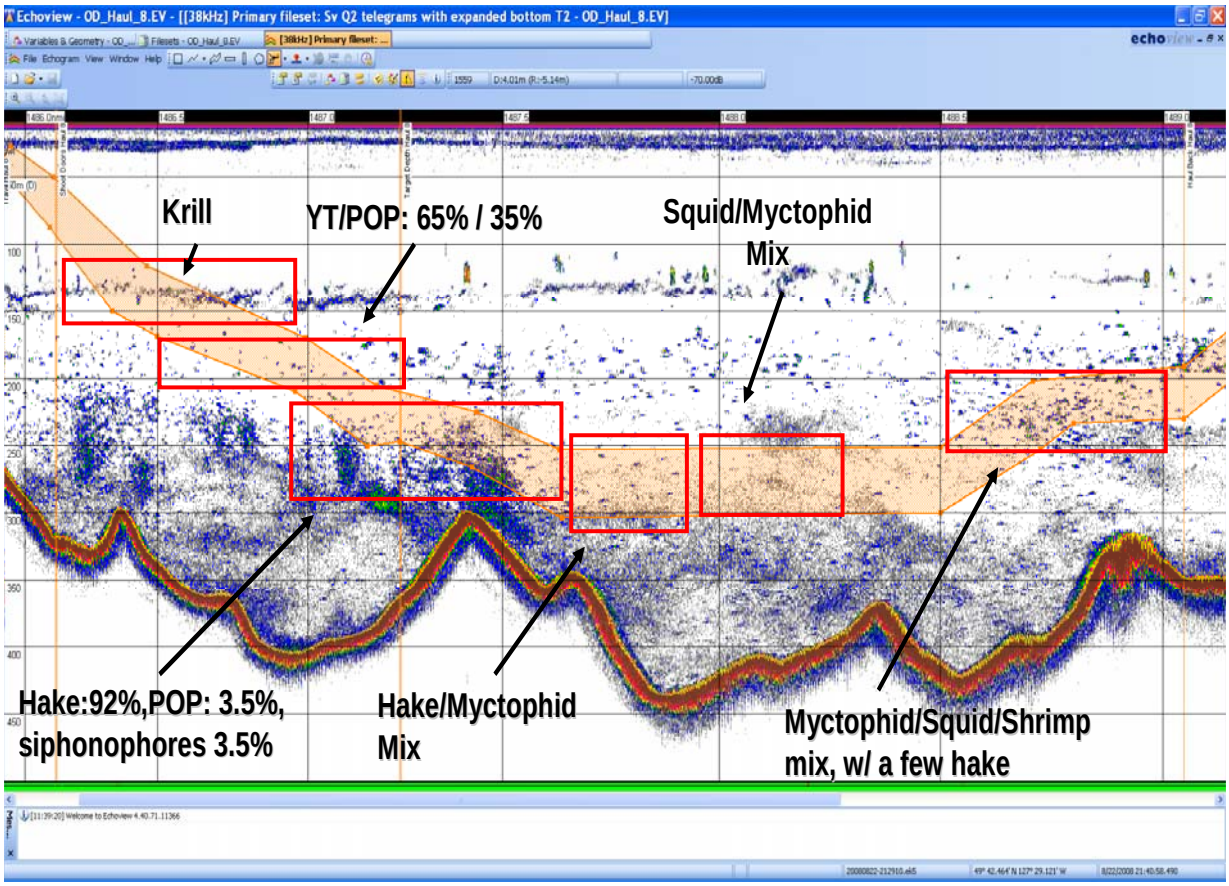



Figure 18. An example of an open-codend camera trawl with analyzed results superimposed. Shaded area represents the estimated area (lateral view) covered by trawl net during the trawl operation. The tow was actually conducted during 2008 Inter-vessel calibration (IVC) cruise.

This system was also used in March of 2009 during a pilot study lead by Lisa Bonacci with co-PI Waldo Wakefield to test the feasibility of using a survey method of acoustics and codend video camera system for widow rockfish (and other rockfish in untrawlable areas). Eleven sea days of field work took place on the F/V *Excalibur*. Sixteen successful tows were completed and more than 800 nautical miles of acoustic trackline data were collected. Review of video footage showed that fish could be clearly seen, identified, counted, and measured. Bycatch was minimal on most tows. Based on the sampling results, a set of future survey locations off of central and northern Oregon was identified. Additionally, the best time of day for towing was also determined. This appears to be a viable non-extractive survey method for widow rockfish. Future work will include pilot work at potential survey sites in the waters off of Washington and California.

For more information, contact Dr. Dezhang Chu at Dezhang.Chu@noaa.gov

**b) Acoustic Imaging Microtome System (AIMS)**

To quantify changes in swimbladder shape and volume of swimbladder-bearing fish relative to pressure changes, we propose to develop an Acoustic Microtome Imaging System (AMIS). The apparatus that holds the array and allows the array to slide along the Y-axis has been partially built. A 3D conceptual plot of the AIMS is illustrated in Figure 19. The design of the drive electronics is underway and will be completed by the end of FY 2010.

The expected outcomes from the proposed research include: (1) obtaining *in situ* and high resolution (~1mm) 3D acoustic images of fish swimbladders for both physoclistic and physostomous fish over a depth range from the sea surface to as deep as 300 m; (2) increasing our capability to size and possibly classify swimbladder-bearing fish remotely by means of acoustic resonance classification, (3) significantly strengthening our ability to model the target strengths of swimbladder-bearing fish at different depths and frequencies, and (4) improving the estimation accuracy and/or reducing the estimation uncertainty of the spatial and temporal density distributions, and population abundance of swimbladder-bearing fish.

The success of the AIMS will strengthen our ability to predict the target strength of swim bladder-bearing fish and consequently improve the accuracy of stock assessments performed by acoustics surveys.

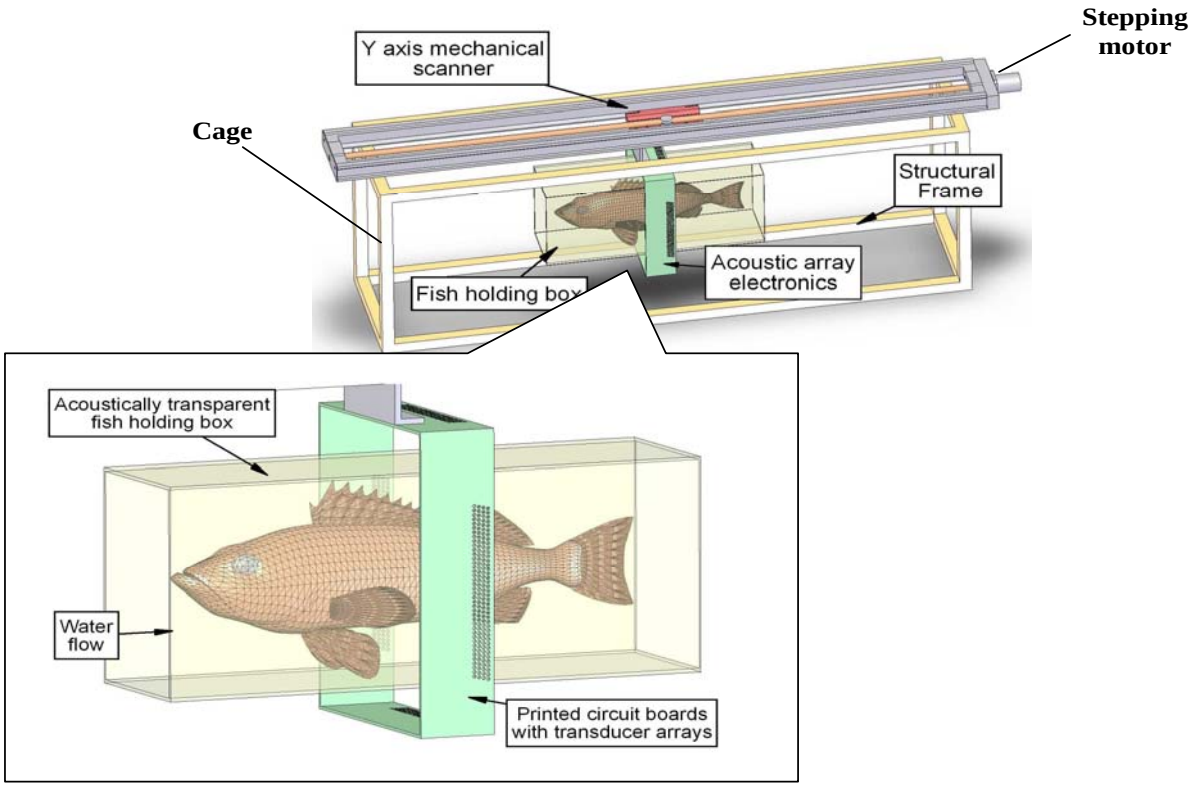



Figure 19. A 3-dimensional conceptual illustration of the Acoustic Imaging Microtome System (AIMS).

For more information please contact Dr. Dezhang Chu at Dezhang.Chu@noaa.gov

**c) Automated Shipboard Acoustic Calibration System (ASACS)**

This is a project funded by NMFS Advanced Sampling Technology Working Group (ASTWG). The objective of the project is to use state-of-art technologies to improve and expand data collected on existing surveys and to develop new technologies that could be used to initiate new surveys for monitoring groundfish. This project was initiated in early FY08 and tested during the 2008 Inter-vessel calibration (IVC) cruise. In 2009, we improved the system performance by updating both hardware and software. We added tension detection capability to the downrigger motor controllers and increased the wire measure resolution from 2.5 cm to 1 cm. We also revised our GUI based software to make it more flexible functionally and easier to operate. The acoustic calibrations were conducted in Elliott Bay before and after the 2009 Integrated Hake Acoustic and Trawl Survey. The on axis calibration was very easy. The sphere swing operation to map the beam pattern was challenging but was accomplished successfully (Figure 20).

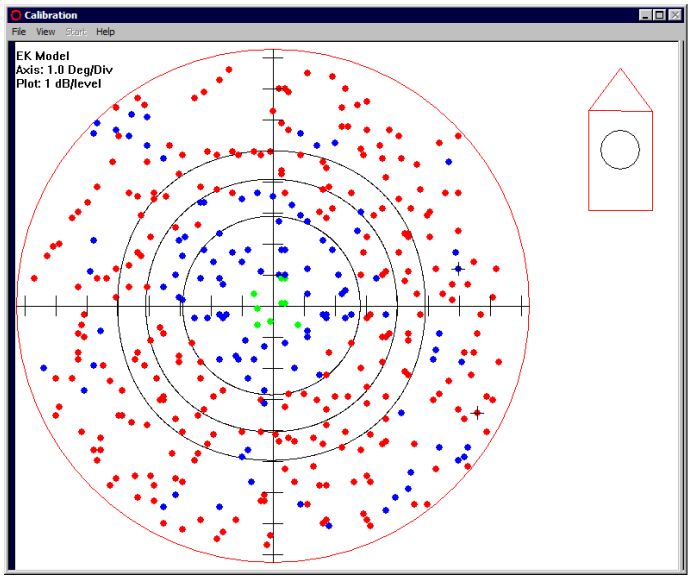



Figure 20. Field calibration swing results of the 18-kHz echosounder. The calibration sphere is a 64-mm diameter copper sphere. Blue dots represent the measured beampattern values that are below the current beampattern values while the red dots mean that the measured values are higher than the current beampattern values.

**d) Statistical characterization and classification of fish school clutter**

The long-term goal of this research is to transition our results into operational active acoustic systems for reducing false alarm rates due to fish clutter. A remaining key element toward transitioning our results to an operational system involves prediction of statistics of fish patch size. It will address an important issue for fisheries acoustics: to enumerate the fish based on the echo statistics, especially when fish distribution is

dispersed and only a few number of fish will be insonified simultaneous. It was found that beampattern can influence the echo statistics significantly and make the fish echo distribution strongly non-Rayleigh (Figure 21). In theory, the different probability density function (PDF) of fish echo can be used to determine the numerical density of fish acoustically.

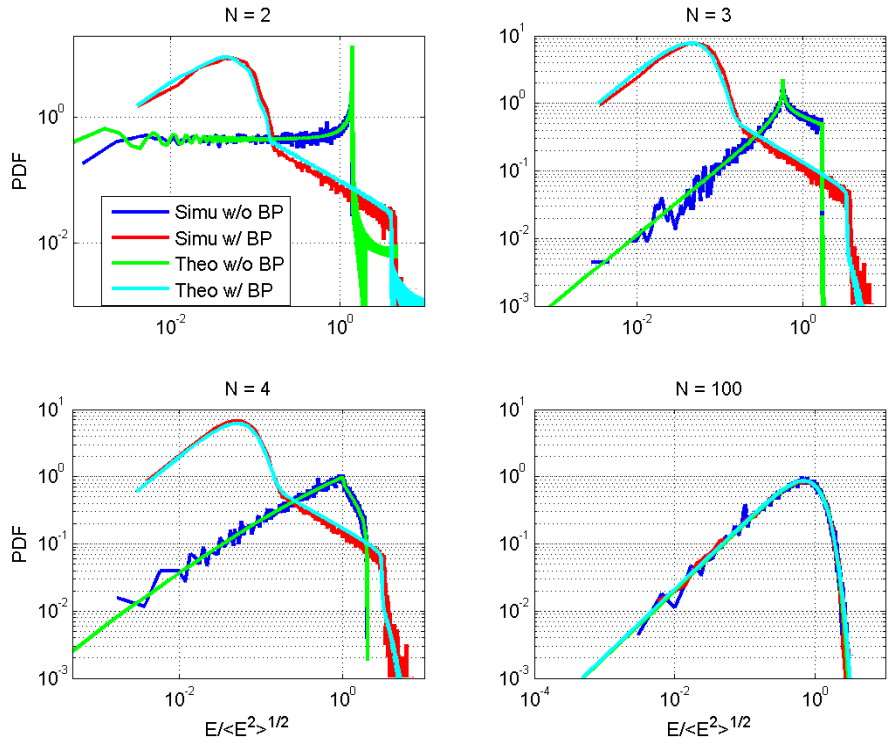



Figure 21. Numerical simulations and the theoretical predictions of echo probability density function (PDF) with and without beampattern effect. N is the number of targets in the acoustic beam, and E is the echo amplitude.

## 8. Economic Data Collection and Analysis

### a) Commercial Fishing Economic Cost-Earnings Data

During 2009, the West Coast limited entry trawl and limited entry fixed gear cost earnings surveys were fielded. Survey response rates of about 65% for limited entry trawl fleet and 55% for the limited entry fixed gear fleet were obtained. These data will be merged with data from other sources such as PacFIN landings data and vessel registration data to produce an updated cost earnings data set for the limited entry fleet. These data will be used to develop inputs for the regional economic model being developed by economists at the NWC, and to support a project to estimate potential changes in the generation and distribution of economic rent as the limited entry trawl fishery moves under a catch share management regime.

The NWC also continued working with the data collected in the previous limited entry trawl and limited entry fixed gear surveys. A study co-authored by NWC staff and two Iowa State University professors found that the number of vessels operating in the groundfish trawl fishery is likely to decrease by 50% to 66% when the groundfish trawl fishery is placed under a catch shares management regime, resulting in annual cost savings of $18 million to $22 million. This study was used in the Pacific Fishery Management Council's Trawl Rationalization EIS and published by Marine Resource Economics. This paper is available as Lian, C., R. Singh, and Q. Weninger, "Fleet Restructuring, Rent Generation, and the Design of Individual Fishing Quota Programs: Empirical Evidence from the Pacific Coast Groundfish Fishery", *Marine Resource Economics*, Volume 24, pp.329-359.

For more information please contact Dr. Carl Lian at Carl.Lian@noaa.gov

**b) Survey of the Economic Value of Sport Fishing**

During 2009, econometric models were estimated using the Washington and Oregon recreational angler survey data. The models show the effect of changes in catch by species, size, and bag limits on the value of a recreational fishing trip. In addition, changes in value predicted by this model serve as an input to a related model predicting participation in the fishery. The NWC is currently gathering fishery data that will be used as baseline data in model simulations.

A comparison of the effectiveness of experimental designs used in these types of surveys was conducted as part of the survey design and is currently under review.

For more information please contact Dr. Todd Lee at Todd.Lee@noaa.gov or Dr. Leif Anderson at Leif.Anderson@noaa.gov

**c) Regional Economic Impact Analysis**

The Input Output Model for Pacific Coast fisheries underwent a CIE review last October. The model is intended to calculate the backward-linked multiplier effects of changes in fishing harvest. Subsequent to the CIE review, the model was presented to the Scientific and Statistical Committee (SSC) of the Pacific Fishery Management Council. Both the CIE and SSC reviews were favorable, and the model is expected to be used for the Council's groundfish specification process during 2010. The documentation of the model that was presented at the CIE and SSC review will be modified and published as a NOAA technical memo.

There will be ongoing improvements to the model as additional data are made available. The second phase of development will be to incorporate recreational fishing into the model, and to expand the coverage of commercial fleets. Additionally, the model will be used as a starting point for the development of a computable general equilibrium model.

One source of new data will be the Western Community Survey, which is a survey of business and households in eight communities along the west coast. The survey will obtain data such as the location of expenditures by businesses and households, household income from marine related endeavors, extent of income from non-labor sources, and some more sociological questions about people's preferences and values for marine resources. Fielding of the survey began in January 2010 and will continue through March 2010.

For more information please contact Jerry Leonard at Jerry.Leonard@noaa.gov

**9. Observer Data Collection and Analysis**

The FRAM division's At-Sea Hake and West Coast Groundfish Observer Programs continued collecting fishery-dependent data during 2009 on groundfish fleets along the entire west coast.

**a) NWFSC U.S. West Coast At-Sea Hake Observer Program**

The At-Sea Hake Observer Program deploys two fisheries observers on each of fifteen at-sea Pacific hake processing vessels for every fishing day. Observer sea days exceeded 850 days at sea in 2009, a sharp decline from 1,500 sea days in 2008 as a result of a diminished hake quota. Due to low total catch limits on some bycatch species in this fishery, observer data are crucial to the successful management of the fishery. The 2009 season saw the introduction of bycatch quotas divided among the mothership, catcher-processor, and shoreside sectors. This change will allow management to end fishing for a specific sector if a bycatch allocation is reached, while the other sectors remain open to catch their respective hake quotas. Widow, darkblotched and canary rockfish species each have specific bycatch quotas for the hake fishery. The 2009 hake season was successfully fished to the total hake allocation without exceeding any of the specific bycatch caps.

Recent developments in the at-sea Pacific hake fishery have led to restrictions on several bycatch species which have changed the nature of this fishery and therefore the At-Sea Hake Observer Program (A-SHOP). Additionally, interest has increased about the type and quantity of data being collected by the observers and this has driven changes as well. The result is an increasingly complex work load, which now requires the observers to be more involved in making minute-by-minute decisions about their sampling, and to prioritize and manage their time. This increase in data collection has created new challenges for the observers and has required the program to make changes in the sampling protocols, as well as to modify the actual training of the observers. Historically the observers have collected vessel and haul information, species composition samples, marine mammal and endangered species samples and sighting data, and biological data on the target species. Recent additions to the data collection include an increase in species composition sample size from 33% to 50% for most tows, and a full haul census when there are large amounts of an overfished species present. Biological data, including age structures, are collected on nine rockfish species including: canary, yelloweye,

bocaccio, Pacific ocean perch, darkblotched, widow, yellowtail, rougheye and shortraker. Coded wire tag data and samples are collected from both Chinook and coho salmon and genetic samples are collected from all Chinook salmon and sturgeon. Occasionally, additional data for special projects are also collected. The A-SHOP is continually evolving and changing to help the observers adapt to this increased sampling demand and to help ensure that the highest quality data are collected, along with a reasonable maximum amount of data without causing observer fatigue.

For more information please contact Vanessa Tuttle at Vanessa.Tuttle@noaa.gov

**b) NWFSC West Coast Groundfish Observer Program**

During 2009, the West Coast Groundfish Observer Program deployed observers in bottom trawl and fixed-gear fisheries along the entire U.S. West Coast, exceeding 2,900 observer days at sea on over 300 vessels. The observer program currently conducts observation aboard vessels ranging in size from skiffs to large trawlers, which fish in depths ranging from less than 20 fm to more than 500 fm. The program observes both federally managed and state managed fisheries and in 2009, ten distinct fishery sectors were observed. In 2010, the observer program will begin covering the Washington Pink shrimp fishery (Oregon and Northern California pink shrimp fisheries have been covered since 2004, with the exception of 2006). Due to its unique data collection circumstances, the program continues to stress safety and data quality.

**c) Data and analytical reports**

The WCGOP collects at-sea data from limited-entry trawl and fixed-gear fisheries as well as from open access nearshore, prawn/shrimp, California halibut, and deep water fixed-gear fisheries. The WCGOP's goal is to improve total catch estimates by collecting information on the discarded catch (fish returned overboard at-sea) of west coast groundfish species. The data are used in assessing and managing a variety of groundfish species.

Summaries of data collected on observed trips are routinely published on the NWFSC web site. Several fleet-specific reports, which are detailed in the table below, were completed during the fall and winter of 2009.

| Report Title | Fisheries in Report | Date Range of Data |
|---|---|---|
| Data Report and Summary Analyses of the U.S. West Coast Limited Entry Groundfish Bottom Trawl Fishery, Oct 2009 | Limited Entry Groundfish Bottom Trawl | January 1, 2008 – April 30, 2009 |
| Data Report and Summary Analyses of the U.S. West Coast Non-Nearshore Fixed Gear Groundfish Fishery, | Limited Entry Sablefish-endorsed fixed gear, Limited entry non-sablefish-endorsed fixed-gear, open access fixed- | January 1, 2008 – April 30, 2009 |

| | | |
|---|---|---|
| Oct 2009 | gear | |
| Data Report and Summary Analyses of the U.S. West Coast Nearshore Fixed Gear Groundfish Fishery, Oct 2009 | California nearshore fixed-gear, Oregon nearshore fixed-gear | January 1, 2008 – April 30, 2009 |
| Data Report and Summary Analyses of the U.S. West Coast California Halibut Trawl Fishery, Oct 2009 | California halibut bottom trawl | January 1, 2008 – April 30, 2009 |
| Data Report and Summary Analyses of the California and Oregon Pink Shrimp Trawl Fisheries, Oct 2009 | California Pink Shrimp Trawl, Oregon Pink Shrimp Trawl | January 1, 2008 - December 31, 2009 |
| Estimated 2008 Discard and Total Catch of Selected Groundfish Species | Limited Entry Groundfish Bottom Trawl, Limited Entry Sablefish-endorsed fixed gear, Limited entry non-sablefish-endorsed fixed-gear, open access fixed-gear, California nearshore fixed-gear, Oregon nearshore fixed-gear, California halibut bottom trawl, California Pink Shrimp Trawl, Oregon Pink Shrimp Trawl, At-Sea Midwater Hake Trawl, Research catch, EFP catch, tribal, recreational | January 1, 2008 – December 31, 2008 |
| Observed and Estimated Total Bycatch of Salmon in the 2008 U.S. West Coast Groundfish Fisheries | Limited Entry Groundfish Bottom Trawl, Limited Entry Sablefish-endorsed fixed gear, Limited entry non-sablefish-endorsed fixed-gear, open access fixed-gear, California nearshore fixed-gear, Oregon nearshore fixed-gear, California halibut bottom trawl, California Pink Shrimp Trawl, Oregon Pink Shrimp Trawl | January 1, 2008 – December 31, 2008 |
| Observed and Estimated Total Bycatch of Green Sturgeon in the 2002-2008 U.S. West Coast Groundfish Fisheries | Limited Entry Groundfish Bottom Trawl, Limited Entry Sablefish-endorsed fixed gear, Limited entry non-sablefish-endorsed fixed-gear, open access fixed-gear, California nearshore fixed-gear, Oregon | January 1, 2002 – December 31, 2008 |

| | | |
|---|---|---|
| | nearshore fixed-gear, California halibut bottom trawl, California Pink Shrimp Trawl, Oregon Pink Shrimp Trawl | |
| Pacific Halibut Bycatch in IPHC Area 2A in the 2007 Groundfish Trawl Fishery. | Limited Entry Groundfish Bottom Trawl | January 1, 2008 – December 31, 2008 |
| Observed and Estimated Total Bycatch of Pacific Halibut in the 2002-2008 U.S. West Coast Groundfish Non-Nearshore Fixed Gear Fishery | Limited Entry Sablefish-endorsed fixed gear, Limited entry non-sablefish-endorsed fixed-gear, open access fixed-gear | January 1, 2002 – December 31, 2008 |

All reports can be obtained at:
http://www.nwfsc.noaa.gov/research/divisions/fram/observer/datareport/index.cfm.

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

**d) Tracking species range expansion as an indicator of climate change using observer data**

One possible consequence of climate change is an alteration in species distribution ranges. However, identifying such alterations can be difficult. Since 2001, the West Coast Groundfish Observer Program (WCGOP) has deployed fisheries observers year-round, along the contiguous West Coast of the United States. This has provided a large data set which can be used to track shifts in species distributions and help to identify the effects of oceanographic phenomena including climate change. To aid in identifying distribution pattern shifts, the WCGOP has recently added latitudinal and depth range parameters to its database. This enables the program to quickly identify any species found outside of its usual range and to monitor such occurrences to determine if they are anomalous or indicate a trend.

For more information, please contact Allen Cramer at Allen.Cramer@noaa.gov

**e) Observer-collected data for integrating seafloor classification with commercial fishing activities to potentially reduce bycatch in groundfish fisheries**

The NOAA NMFS Northwest Fisheries Science Center continued a pilot project initiated in spring 2008 to integrate seabed classification with commercial fishing activities to investigate if this type of information would be useful for reducing bycatch in west coast groundfish fisheries. This project is being conducted in the vicinity of Morro Bay, CA where the Nature Conservancy (TNC) has launched a project using a private fishing agreement with a longer-term goal for developing a more sustainable trawl fishery in the Central Coast. The project represents collaboration between the NWFSC's Habitat and Conservation Engineering group and the West Coast Groundfish Observer Program, The

Nature Conservancy, Oregon State University's Active Tectonics and Seafloor Mapping Lab, and the Quester Tangent Corporation. The goal of the project is to capture information about bottom habitat type using a Quester Tangent QTC VIEW system simultaneously with bottom trawling. Questions to be considered include: can high quality data be collected during normal fishing operations to gather information about bottom habitat type and have minimal interference with fishing operations; do patterns in bycatch relate to specific seafloor habitats and/or classifications; can seafloor data help assist with habitat mapping for west coast groundfish?

For more information, please contact Janell Majewski at Janell.Majewski@noaa.gov

**f) Bycatch trends over time in the limited entry groundfish fishery**

The West Coast Groundfish Observer Program (WCGOP) was initiated in the fall of 2001 with the goal of improving estimates of total catch and discard through at-sea observation of the groundfish fishery. The program has now collected a substantial amount of bycatch information, which is incorporated into management. Bycatch ratios are computed annually by the WCGOP program and are one of several components used to produce fleet-wide mortality estimates for groundfish species. Trends in observed bycatch and discard over time are evaluated for selected rockfish species, using bycatch ratios, fleet-wide mortality estimates, and the spatial distribution of discard.

For more information, please contact Marlene Bellman at Marlene.Bellman@noaa.gov

**10. Recent Publications**

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