

**Washington Contribution to the 2004 Meeting of the  
Technical Sub-Committee (TSC) of the Canada-US Groundfish  
Committee**

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# **Review of Agency Groundfish Research, Assessment, and Management**

## **A. Puget Sound Area Activities**

### **1. Puget Sound Management Activities**

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#### **Recreational Catch Estimation**

In 2003, and continuing into 2004, we have spent considerable effort improving our catch estimation procedures for recreational fisheries for groundfish. In coastal waters we have instituted a monthly catch report. Landings by species in both numbers and weight are reported for each month between March and September (fishing effort is very low in the other months). The report is due one month after the period of fishing; i.e. landings in March are reported by the end of April. Estimates of discards are also included. The reports are posted on the Pacific States Marine Fisheries Commission RecFIN web site which is <http://www.psmfc.org/recfin/data.htm>.

In Puget Sound we have instituted a new survey technique using a telephone survey to estimate fishing effort and an angler interview program to estimate catch rates, species composition and gather biological data. The telephone survey is based on fishing licenses where a random survey of license holders are telephoned at two month intervals and asked to describe their saltwater fishing trips during the previous two months. Through our new electronic license system (WILD) we know the total number of fishing licenses sold. By combining the total number of licenses and the average number of fishing trips per license holder we can estimate fishing effort by area. The effort estimates are expanded by the interview results to account for unlicensed anglers and CPUE estimates are applied to determine total catch. Estimates of fishing effort and catch are made for two month intervals. Estimates of discards are also provided.

During the telephone survey we estimate fishing areas for all marine waters of Washington thus providing a check on the amount of fishing effort in coastal areas during months when the coastal sampling program is not active.

The present program, in both Puget Sound and coastal areas, is limited to boat based fishing. Estimates of catch and effort from shore, pier and jetty fishing are not being made currently. This is a hole in the catch estimation that we hope to address in the upcoming years.

The number, species, size and fate of fish discarded in recreational fisheries is becoming an increasingly important component in management of recreational fisheries. Until recently, we have estimated the number of fish discarded without knowing their mortality rate or weight. We are now in the process of obtaining this information.

Our efforts include placing observers on charter vessels to closely observe the fish that are discarded. Additionally we are asking anglers when they return to shore about their discards. Part of the interview process includes showing anglers color photos and asking them to identify the number and species discarded.

We are now asking anglers about the depth of water where discarded fish were captured. Due to time constraints during the interview process, we cannot determine the depth for each fish discarded. Rather we ask anglers whether most of the discarded catch was caught in waters deeper or shallower than 60 feet. We are currently developing mortality estimates by species, or species groupings, for depths greater or less than 60 feet. We intend to apply these mortality estimates by depth to estimate mortality of the discarded catch. Note that the 60-foot depth level was chosen on little information and we would welcome suggestions for a more appropriate depth level.

We are also attempting to measure discarded groundfish seen during observed fishing trips. Additionally, we are asking selected anglers the reason for discard- i.e. the fish was too small, undesirable etc.

We are placing our initial emphasis on the discard of lingcod. Recreational fisheries for lingcod are an important factor in management and considerable numbers of lingcod are discarded.

### **Sixgill Shark Studies**

In 2003, we instituted a study of sixgill sharks in Puget Sound. Current regulations prohibit the retention of sixgills in Puget Sound and there is interest in allowing both commercial and recreational fisheries for this species. Harvest is not allowed as we have insufficient information to establish any sort of a management plan or set an acceptable level of harvest.

As part of the study we tagged sharks in Puget Sound during the spring and summer of 2003. Sharks were caught by longline gear (except one caught by trawling and one caught by sport fishing gear). The tags used were FLOY disk tags applied to the dorsal fin. We plan to revisit the initial tagging area during the summer of 2004 and tag more fish and look for recaptures.

To date we have caught 140 sixgill sharks, tagged 129 and dissected 11. None of the dissected sharks was mature. Muscle and liver tissues from the dissected sharks were sampled for analysis for chemical contaminants.

As a sidelight to this project, we attempted to tag sixgill sharks in Willapa Bay, along the southern coast of Washington. While we did not catch any sixgill sharks we did encounter sevengill sharks in the bay. According to local fishermen, the sevengills enter the bay during the summer months and the protected waters may be used as a birthing/nursery area. During August and September of 2003 we caught 28 sevengill sharks in 8 days of fishing. 24 fish were tagged and released.

### **Rockfish in Puget Sound**

The Department of Fish and Wildlife has undertaken a major effort to develop conservation/rebuilding plan for rockfish in Puget Sound. This effort was initiated at the request Governor, who asked the agency to develop plans for all groundfish species in Puget Sound by the end of 2004. After consultation, we all agreed that that task was too large to be accomplished in the allowed time and that rockfish were the species most in need of improved management. During 2004 we will be developing rebuilding plans for rockfish and we intend to draw heavily on the work done in California and British Columbia for inshore rockfish.

### **Dogfish Sharks**

During 2003 and early 2004 we continued our management interest in dogfish shark. A key part of this was collaboration with Dept of Fish and Oceans to re-examine the harvest model currently in use for the “inside” waters of British Columbia and Washington State. A major output of the joint work was a presentation at the annual meeting of the AAAS in Seattle during February 2004.

As part of our continuing efforts on dogfish the Department of Fish and Oceans, the University of Washington and the Washington Department of Fish and Wildlife are planning a symposium of dogfish sharks to be held during April 2005 at the University of Washington in Seattle. Preliminary plans call for sessions on the following topics:

1. Age, growth and reproductive biology of dogfish
2. Ecosystem impacts of increasing or decreasing dogfish populations
3. Dogfish management throughout the world- unfortunately a series of case failures
4. Stock identification and/or movement studies
5. Fisheries biology of dogfish

### **Pacific Herring**

In January 2004, NOAA-Fisheries received a petition from a number of environmental groups to list the “stock” of herring that spawn in the vicinity of Cherry Point as threatened or endangered under the U.S. Endangered Species Act. NOAA-Fisheries has not yet acted on this petition but should do so by the spring of 2004.

The group of herring that spawn near Cherry Point has undergone a dramatic and consistent decline in abundance over the past 15 years. Combined with the shrinking abundance the age composition has been compressed with few spawning fish over the age of 4 years.

**Ecosystem Management** *Contact: Mary Lou Mills (360) 902-2834)*

The Georgia Basin/Puget trough/Willamette Valley Eco-regional assessment is close to being released. The eco-regional assessment assembled data throughout the eco-region and used the SITES algorithm to select areas of high biodiversity. These areas are most relevant to efforts aimed at protecting biodiversity and associated land use decisions. The ECA has been a collaborative project among various state and provincial organizations and The Nature

Conservancy. The next eco-region that will be looked at is the North Coast area including the offshore waters.

## **2. Puget Sound Groundfish Monitoring, Research, and Assessment**

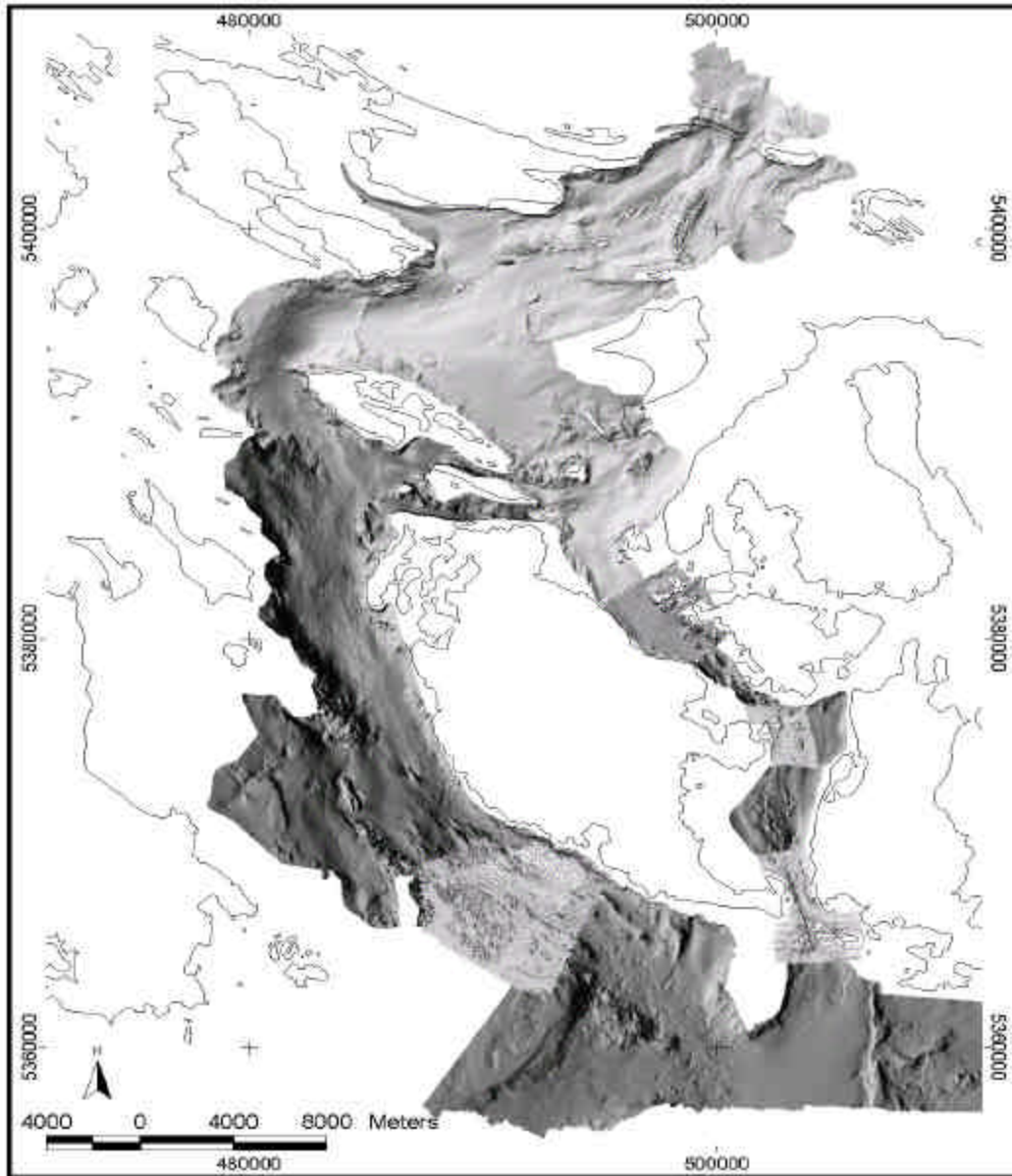
*(Contact: Wayne Palsson, Marine Fish Science Unit (425) 379-2313, palsswap@dfw.wa.gov)*

The Puget Sound staff of the Marine Fish Science Unit includes Wayne Palsson, Robert Pacunski, Tony Parra, Karl Mueller, and Jim Beam. Their tasks are primarily supported by supplemental funds from the Washington State Legislature for the recovery of Puget Sound bottomfish populations. Most of the work of the staff is associated with the Puget Sound Ambient Monitoring Program (PSAMP) and is tasked by the Puget Sound Action Team. The main activities of the unit include the assessment of bottomfish populations in Puget Sound and the evaluation of bottomfish in marine reserves. This year, additional grants and contracts were received for special studies regarding marine fish habitat modifications and marine reserves in Puget Sound.

### **Puget Sound Marine Habitat Studies**

Wayne Palsson is collaborating with Professor Gary Greene and his students who are mapping the San Juan Archipelago with a multi-beam echosounder. A grant has been funded by NOAA's Center for Coastal Services to further augment surveys collecting detailed bathymetric and backscatter data (Figure 1). As maps are developed and habitats are identified, trawl, video and ROV surveys will be correlated with fish abundance. In late 2002, Robert Pacunski and Jim Beam collaborated with Greene and Janet Tilden in an ROV survey funded by the National Undersea Research Program with the purpose of examining specific identified habitats and the associated fish fauna. In 2003, Pacunski and Palsson collaborated with Janet in the interpretation of the video tapes that were used to verify habitat classifications and develop data on fish and habitat associations. Most of remaining deep-water habitats were mapped in the San Juan Archipelago and the data are being processed.

Wayne Palsson collaborated with Professors Don Gunderson of the University of Washington and Gary Green of Moss Landing Marine Labs in successfully obtaining a Washington Sea Grant to examine the distribution of marine fishes in relation to the distribution of different sea floor habitats that were mapped Dr. Greene through the NOAA/CCS and other grants. The work will make use of the ROV at Friday Harbor Laboratories, scuba transects, and other quantitative methods to estimate the densities of juvenile and adult rockfishes, lingcod, and greenling in San Juan Channel. These densities will be mapped by life history phase in relation to the different habitat types and in relation to the marine reserves that already exist in San Juan Channel. With the work commencing in 2004 and ending in 2005, a model of fish and habitat associations will be developed for the study area and will be used to evaluate the performance of the reserves.



**Figure 1.** Preliminary map of the western San Juan Archipelago depicting backscatter data from multibeam surveys (Courtesy of Gary Greene, MLML).

### **Evaluation of No-Take Refuges for Reef Fish Management**

WDFW has developed a system of 18 fully and partially protected marine reserves in Puget Sound (Figure 2). As the system has expanded, MFSU staff has developed a plan to monitor a core series of the marine reserves on a frequent basis and visit other subtidal reserves on a periodic basis. This plan builds upon field research at many of these sites that was begun as early as 1986. The field work primarily consists of scuba divers' conducting visual censuses along strip transects. Along with estimating fish density, divers' measure individual fish and in the case of lingcod, quantify nesting activity.



**Figure 2.** WDFW non-tribal marine reserves in Puget Sound. Conservation Areas are fully-protected, Marine Preserves are partially-protected.

Specific monitoring activities in 2003 included surveying many of the Puget Sound reserves and comparable fished sites. Several reserves in central Puget Sound were visited six times during 2003 as an extension of a study initiated in 1999 that takes advantage of the previous information collected at Orchard Rocks. This site was declared as a fully-protected reserve in 1998 but was a fished site monitored in 1986, 1987, and from 1995-1997. With the addition of a new fished site treatment at Point Glover, the newly created refuge in a formerly monitored fished area is an excellent opportunity to evaluate the before and after impacts of refuge creation with a comparable fished site treatment. WDFW also created several new reserves in 2002. These included subtidal reserves at Admiralty Head and Keystone Jetty in Admiralty Inlet and Zee's Reef in Southern Puget Sound. Monitoring was initiated at Zee's Reef in 2002 with six surveys

conducted again in 2003. The reserve at Colvos Passage was also monitored during the same survey series.

The marine reserve monitoring studies conducted in the San Juan Islands, Hood Canal, and Central Puget Sound were analyzed and the results presented at the 2003 Georgia Basin/Puget Sound Research Conference held in Vancouver, B.C. The results confirmed those previously reported that most marine reserves had higher densities of copper rockfish and lingcod than comparable and nearby fished areas. These fishes were also larger in the long-term reserve at Edmonds (Brackett's Landing) than at the fished areas. In Hood Canal, where the existing reserves amount to almost 20% of the available nearshore rocky habitat, increasing sizes of copper rockfish have been observed since 1996 at a site set aside as a reserve in 1994. However, recent comparisons among fished and reserves sites has found similar size compositions between reserve and fished area treatments. The densities of copper rockfish are significantly greater in the Hood Canal reserves than the fished area. In the San Juan Islands, rockfish and lingcod densities in the reserves are also greater than at nearby fished areas, but there have not been any discernable trends in size or density for copper rockfish over a span of ten years of monitoring and 12 years after reserve creation. For lingcod at these sites, the winter-time densities are substantially greater than in fished areas, but densities in both reserve and fished area treatments have been increasing. At Orchard Rocks, the central Sound reserve created in 1998, there has not been any increase in copper rockfish abundance, but lingcod abundance has increased.

The analysis also found a major change at the long-term reserve at Edmonds. The study site once harbored a large school of large copper rockfish that accounted for a high estimated reproductive advantage for the long-term reserve compared to fished areas. Since 1999, this school has disappeared with a resulting decrease in the density of copper rockfish at the site. During the same period, lingcod abundance has dramatically increased simultaneously with the decline in copper rockfish. While a number of competing hypotheses can not be ruled out to explain these patterns, the shift to a site dominated by large piscivores may reflect a shift in the trophic dynamics of the reserve. Co-incidentally, a new study on the ecological succession and trophic dynamics in Puget Sound reserves was initiated in 2002 (See Below).

### **Ecological Succession and Trophic Cascades in Puget Sound Marine Reserves**

With major funding from the Conservation and Re-investment Act Fund, administered by the U.S. Dept. of the Interior, the MFSU received a grant to examine the prey and predator relationships the array of long-term and newer reserves within Puget Sound as well as nearby fished areas. Karl Mueller is the lead biologist for this project. The grant was initially developed for a three-year study but was cut back to 1.25 years during the first year. The amended work plan therefore included the following objectives: 1.) Develop protocols for monitoring prey species in an array of old and new marine reserves, 2.) Implement biodiversity monitoring in a range of old to new reserves, 3.) Interface biodiversity monitoring with existing surveys for managed species, and 4.) Review predator-prey literature for northwest rocky habitat species, identify data gaps, and recommend further studies. We completed or made progress on all of these goals during 2003. Protocols for monitoring unclassified species in marine reserves were developed during a pilot study completed in September 2003. Several transect and quadrat sampling techniques were



tested using scuba visual census methods, and we selected a 0.5 m<sup>2</sup> quadrat placed randomly within rocky habitats to estimate the density of small supra-benthic fishes and invertebrates that are known prey items of rockfish, lingcod, and other predaceous bottomfish. By December 2003, we completed the first season (“Fall”) of biodiversity monitoring using the methods developed during the pilot study, and we collected at least 30 samples from each of seven reserves and four fished areas. These sampling activities were conducted while other WDFW scuba teams surveyed the same sites for lingcod, rockfish and other, larger rocky habitat fishes. Finally during 2003, we conducted a literature survey to identify existing knowledge on diet, abundance, trends, and succession of marine species.

### **Low Dissolved Oxygen Conditions at Sund Rocks Marine Reserve**

Hood Canal is a fjord connected to Puget Sound in the north and extending 100 km to the south (Figure 1). The steep sides of the canal extend to depths of 180 m in the north and range to depths of over 125 m for most of the water body. Hood Canal is one of the water bodies identified in the Pew Ocean Commission report as a hypoxic dead zone. Dissolved oxygen (DO) concentrations of less than 2 mg/l have been observed for decades in deep and shallow waters in the southern portion of the canal (Warner et al. 2002; Collias 1974), and these low concentrations have been attributed to naturally poor circulation resulting from low estuarine flow and bottom water replacement. In recent years, low DO concentrations have become chronic, extending into nearshore waters and possibly becoming worse due to eutrophication (J. Newton, Wash. Dept. of Ecology, pers. comm). Mass mortality events of fishes and invertebrates (Fish Kills) in 1926 and 1963 likely have resulted from poor water quality.

Beginning in 2001, WDFW began surveying marine fishes with respect to depth at the Sund Rocks Reserve. Two discrete and prominent rocky habitats located north and south of each other were surveyed independently. A team of three divers conducted the visual surveys. One diver swam the 9 m isobath and oriented the two recording divers along the longitudinal axis of each survey area. The two divers swam along predetermined depth zones and identified, counted, and measured key fish species along the rocky outcropping. The divers swam close together to coordinate their observations and not double count fishes. Total length measurements to the nearest 10 cm meter were made with the aid of a graduated plastic rod.

DO concentrations were obtained from the Washington Department of Ecology’s Marine Water Monitoring group, the University of Washington’s PRISM program, and citizen monitors with the Hood Canal Salmon Enhancement Group. The data were collected by calibrated continuous oxygen sensors or with water samples and subsequent laboratory titration.

Dive surveys at both the North and South Sund Rocks sites in November 2001 found that copper rockfish were distributed evenly from a depth of 5 m to a depth of 20 m and were generally not present in depths of less than 5 m. Monthly monitoring by WDOE revealed that DO concentrations were at least 3 mg/l in waters shallower than 20 m. In October 2002, we found rockfish were almost exclusively concentrated in depths of less than 7 m during a period when DO concentrations were greater than 5 mg/l in shallow water and less than 2 mg/l at greater depths.

Rockfish were distributed evenly to 20 m in depth again by November 2002 when rains restored circulation and DO concentrations were once again greater than 4 mg/l in the nearshore zone. During the 2002 low DO event, dead fish were not observed. On October 10, 2003, a fish kill was observed along the western edge of southern Hood Canal. WDFW divers observed dozens of dead copper rockfish, 24 other fish species, and many invertebrates along the shore and during census dives. Eighty dead copper rockfish were measured and they tended to be smaller than the live fish observed during the survey dives. The dive surveys also revealed that only half of the previous counts of copper rockfish were present (Figure 7). These numbers remained low during the subsequent November survey.

These field observations revealed that copper rockfish are hypoxia intolerant and cannot tolerate DO concentrations below 3 mg/l. The observed avoidance behavior is similar to the response of other marine fishes to low dissolved oxygen in Chesapeake Bay and other coastal waters where low dissolved oxygen limits the amount of available habitat (Breitburg 2002). The widespread occurrence of poor water quality in southern Hood Canal has many ramifications for sustainable fisheries pursued by tribal and recreational fishers and for the location and design of marine reserves in the area. Further work is planned for determining the causes of worsening water quality and the impact on marine resources.

### **Second Narrows Bridge Mitigation Study**

In March 2003, the Washington Department of Transportation (WSDOT) and the Washington Department of Fish and Wildlife (WDFW) established a contract to fulfill part of the terms of the mitigation agreement for the construction of a second bridge at Tacoma Narrows, connecting Tacoma with the Kitsap Peninsula across Puget Sound. The contract establishes that staff from WDFW will conduct sampling at the bridge site to determine the impacts of the disruptive activities associated with the construction of the bridge upon marine fish communities at the bridge site. Primary areas of interest include the two caisson and pier sites, the proposed anchor sites, and the rip-rap fields that will be placed at the footings of the existing and new tower piers. As part of the mitigation, a new artificial habitat will be created at Toliva Shoal. This habitat will be configured as a structure that will potentially attract juvenile rockfishes and improve the existing artificial rocky habitat that was intended to attract adult rockfishes and lingcod.

The first quarter of work was focused upon obtaining video and diving observations at the SNB site before construction activities began disrupting the existing habitats. A plan was submitted to WSDOT detailing the plan for the construction of a juvenile reef at Toliva Shoal as a mitigation measure for the bridge construction. Third quarter activities included indexing videotapes collected during the first quarter, developing protocols to analyze those tapes, and beginning to quantify the habitat, fishes, and invertebrates in those tapes. The fourth quarter of work was focused upon obtaining video and diving observations in the vicinity of the SNB construction site, and establishing line transects to evaluate the proposed juvenile rockfish habitat at Toliva Shoal.

### **Wolf-eel Life History SCUBA Surveys**

Field work was concluded in 2002 on a study of wolf-eel *Anarrhichthys ocellatus* in Puget Sound. While this is an identified species managed under the Puget Sound Groundfish Management Plan (Palsson et al. 1998), little is known about their life history, population status, or vulnerability to fishing. As a result of this study, the Fish and Wildlife Commission closed the harvest of wolf-eel in all Puget Sound waters. The basic study was initiated at two sites in South Puget Sound known to have wolf-eel colonies. Scuba transects were established at each site and individual den locations mapped. These sites at Day Island and Sunrise Beach, lie at the southern and northern ends of the Tacoma Narrows, respectively, and are separated by a distance of approximately 7 nautical miles. A monthly dive schedule was developed to gain information on den occupancy, consistency of counts, and basic biological observations. Individual wolf-eels were anesthetized with clove oil and marked by implanting visible elastomer tags *in-situ* in the lip region of the animal. In addition, naturally occurring marks were used to identify non-tagged fish. During the survey dives, 35 mm still and digital video cameras were used to capture high quality images of both tagged and non-tagged wolf eels. These spotting patterns around the eyes of wolf eels along with scars and color are unique and were used as natural marks to identify individuals. By identifying individual animals it was possible to track den and mate fidelity during the year and among spawning seasons.

The methods and interim results were presented by Tony Parra in a paper titled “Abundance, Mate, and Den Fidelity of Wolf-eel (*Anarrichthys ocellatus*) in Puget Sound, Washington which was published in the conference proceedings in 2002 ([www.psat.wa.gov](http://www.psat.wa.gov)). Differences in mate fidelity between sites were observed for the over two years, with wolf-eels at Day Island exhibiting lower fidelity rates than those at Sunrise Beach. We observed a considerable decline in mate and den fidelity through subsequent spawning seasons at both survey sites. Only one of the original eight pairs that were observed at the beginning of the study remained together and five of twenty-one individuals remained in the same den throughout the duration of the study. Our results contrast with total mate and site fidelity resulting from captive observations and the generally accepted belief that wolf-eels mate for life. Factors that may contribute to a decline in mate and site fidelity of wolf-eels include the harvest management of competing and prey base species. Pacific giant octopuses have been observed displacing wolf-eels from their dens and we have observed evidence of such occurrences at our study sites.

Work in 2003 was aimed at refining the use of natural marks for the identification of individual wolf-eel. Tony Parra developed a matrix of spot and scar patterns and catalog of individuals akin to those used by marine mammalogists for the identification of humpback and orca whales. In addition, Parra had several independent observers use the catalog and a series of photographs to determine the consistency of using these marks. Initial results indicated that 80% of the individuals were consistently recognized by the observers. Further development of the catalogue of recognition marks will occur with a subsequent reanalysis of mate and den fidelity determinations.

### **Quantitative Video Surveys for Assessing Rocky Habitat Fishes**

Since 1994, Marine Fish Science staff has been conducting quantitative video surveys of nearshore rocky habitats in order to estimate population abundances of rockfishes, lingcod,

greenlings, and other rocky habitat species. The survey was originally designed as the Video-Acoustic Technique (VAT) that consisted of a quantitative video camera to survey fishes within 2 m of the bottomfish and a scientific echosounder to survey fishes in the water column above rocky habitats. Beginning in 2002, the acoustic portion of the survey was dropped because of spending reductions. The remaining Video Assessment Techniques is based upon the area-swept method of quantitative surveys. The camera mounted on a platform is anchored at randomly-selected sites on identified rocky habitats. The camera is panned three times during the deployment and the video information is taped. The visual range of the camera is the radius of the area sampled by the camera and the fishes identified and enumerated during the last pan are used with the area to determine a density. The density observations are averaged and then multiplied by the amount of nearshore rocky habitat in the region.

Analysis of video data collected in the past and the estimation of population abundance has been limited by difficulties in estimating the visual range of video plots. Since 1998, two parallel lasers mounted on the camera aid in the determination of the visual range, but range estimates beyond three meters and during previous surveys is difficult and comparisons between observers and with previous determinations of the visual range have resulted in differences between 0.5 m and 1.5 m. Robert Pacunski led an effort in 2003 to develop criteria and tests of the observer's ability to determine visual range. A series of grids and plots were set up underwater around the video platform to measure the visual acuity of the camera. In separate tests without the grid field, wooden fish models were placed around the camera at random but known locations within and outside of the expected range of the camera without the knowledge of the observers. Their observations were then compared to the known locations. Generally, observer agreement was good within 3 m of the camera but became progressively poor to 6 m, which was near the functional limit of the camera. These tests will be refined in the future and past video range determinations will be reviewed for consistency before final population estimates are made.

### **2003 Trawl Survey of the Strait of Juan de Fuca**

With support of the PSAMP, sufficient resources were pooled with Supplemental Recovery Funds to stage and execute an extensive survey of benthic fish populations in the Washington Strait of Juan de Fuca and portions of the Canadian Strait. The eastern WA and BC Strait was surveyed in 2000 but the western portion of the Washington Strait has never been adequately surveyed. The WDFW conducted a bottom trawl survey in four sub regions of the Strait during spring 2003. The goals and objectives of this survey were to estimate the abundance and describe the distribution of recreational and commercial groundfish and macroinvertebrate species, collect biological information from key species, and evaluate the relationship of abundance and distribution of key species to oceanographic features and the need for transboundary management. The sub regions included the eastern WA Strait (JE), the eastern BC Strait (CJ), Discovery Bay (DB), and the western WA Strait (JW).

The chartered *F.V. Chasina* was used as the sampling vessel which towed a 400 mesh Eastern net fitted with a 3 cm codend liner. Stations were selected with a stratified random approach based upon four depth zones for each of the sub regions. The area sampled at each station was measured with a differential GPS and known net width openings. The catch from each trawl was

identified, weighed, and enumerated, and the weights and numbers of each species were divided by the area sampled to estimate species densities. Abundance will be estimated by averaging station densities within each stratum and multiplying these by the stratum area.

A total of 120 of 125 planned trawl stations were occupied and completed. Twenty-seven stations were occupied in British Columbia and 93 stations were sampled in the WA. There were 202 living taxa identified including 91 species of fish and 111 species of invertebrates. There were over 2,800 records of species catch which comprised a catch weight of almost 18 mt and represented 267,000 individuals. Canadian collections resulted in 4.8 mt of specimens including 40,000 individuals and 118 taxa. Almost 75,000 individual fish were collected from all areas and these weighed 14 mt. Spotted ratfish, spiny dogfish, walleye pollock, and Pacific cod were the four most frequently captured species. There was a series of samples collected for later analysis or archives. These collections included almost 725 fin clips for the genetic analysis of lingcod, quillback rockfish, copper rockfish, cabezon, spiny dogfish, walleye pollock, Pacific whiting and Pacific cod. Samples of up to 25 English sole and starry flounder were retained for laboratory analysis from each trawl sample. Approximately 27 species of specimens were collected for positive fish identification at a permanent museum collection. Vessel space offered to Canadian scientific staff was declined.

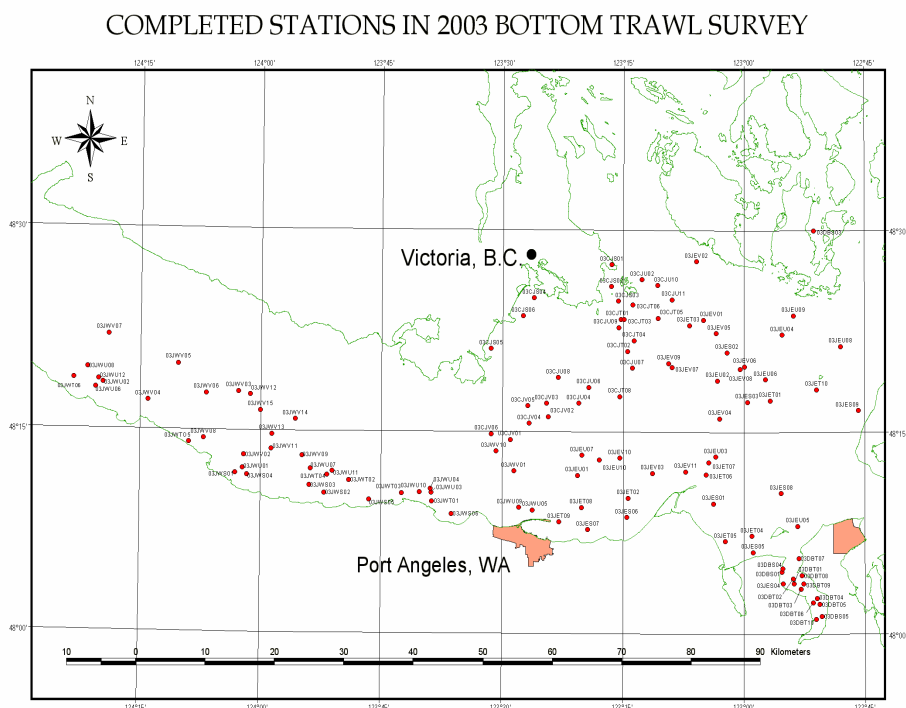


Figure 3. Completed bottom trawl stations for the 2003 bottom trawl survey.

### ***Analysis of Past Transboundary Trawl Surveys***

A retrospective analysis was conducted for the bottom trawl surveys that were conducted by WDFW between 1997 and 2001 in the Washington and British Columbian southern Strait of Georgia, San Juan Islands, and eastern Strait of Juan de Fuca. The survey goals were to estimate the abundance of demersal fishes and macroinvertebrates in the Washington and adjacent British Columbian portions of the transboundary waters. The spring-time surveys consisted of trawling at stations that were stratified by depth and selected on a systematic or random basis. At each station, a research bottom trawl fitted with a fine-mesh codend liner was towed from a chartered fishing vessel for approximately 10 minutes at a speed of 1.5 to 2 knots. In all, 210 trawls were conducted in Washington portions of the survey area, and 156 stations were occupied in the British Columbian portion.

In 1997 and 2000, extensive and synoptic surveys of the Washington and British Columbian Straits of Georgia and Juan de Fuca revealed that fish biomass was roughly distributed between the two areas in proportion to the area surveyed. However, individual species were not proportionately distributed. Species with affinities to shallow and unconsolidated sand and mud substrates were relatively more abundant in the Washington survey area where these habitats were more frequent. Species frequenting harder substrates were correspondingly more common in the British Columbian and San Juan regions where these habitats were more common. Groundfish populations increased in the Washington Strait of Georgia from 11,000 mt in 1997 to 18,000 mt in 2001. A long-term declining trend in total fish abundance was evident in the Washington Strait of Juan de Fuca.

Several distinct patterns in transboundary distributions were observed that have implications for coordinated fisheries management between the United States and Canada. In the Strait of Georgia, the deep Malaspina Trough confines shallow-water species to the rim around the basin. These species are less likely to be encountered by trans-border fisheries. Deep-water species, however, were distributed along the international border making them vulnerable to fisheries on either side of the border. The banks and troughs of the eastern Strait of Juan de Fuca presented a different pattern of species distributions. Shallow and deep-water species were distributed on either side of the international boundary making them both likely to be encountered by transboundary fisheries.

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### **3. Herring Stock Assessment**

*Contact: Kurt Stick (360) 466-4345 ext 243)*

Herring spawning biomass estimates were completed for nineteen spawning grounds in Puget Sound and two coastal grounds in 2003. Stock assessment field work for the 2004 spawning season is in progress. Spawning biomass is estimated for each area by spawn deposition surveys and/or acoustic-trawl surveys.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2003 is 15,016 tons. This total is lower than the cumulative estimate for 2001 and 2002, but is relatively high for the last ten years. Population size for most stocks in central and south Puget Sound are currently considered to be at average or above average levels compared to the previous 25 year mean. As has been the case for several years, the Cherry Point and Discovery Bay stocks are the primary significant Puget Sound stocks that continue to be at critically low levels of abundance.

The combined total for Willapa Bay was just over 500 tons. Additional coastal herring spawning grounds surveyed in 2003 were located in Grays Harbor and were similar to 2002.

### **4. Puget Sound Ambient Monitoring Program (PSAMP)**

*Contact: Sandie O'Neill (360) 902-2843*

#### **Ongoing Studies of PCBs in Puget Sound Fishes**

The Puget Sound Ambient Monitoring Program (PSAMP) is a multi-agency effort to monitor the health of Puget Sound. The Washington Department of Fish and Wildlife participates by monitoring contaminant level in Puget Sound fishes. PSAMP has an ongoing monitoring program to assess contaminants of PCBs and other contaminants in Puget Sound fishes. To date, PCBs have been measured in edible muscle tissue of adult English sole (*Pleuronectes vetulus*), demersal rockfish (*Sebastes* spp.), chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon and whole body concentrations of Pacific herring (*Clupea pallasii*) to determine if concentrations reflected environmental exposure from the geographic areas in which they reside. English sole from urban bays accumulated higher concentrations of PCBs than from near- or non-urban bays and concentrations in tissue and sediments were positively correlated. Highest PCB concentrations in rockfish were also observed in fish from urban bays. PCBs accumulated in older males but not in older females, who likely lose PCBs during reproduction with transfer of nutrients (lipids) to larvae. Higher PCB concentrations were also observed in Pacific herring, from the central Puget Sound basin where most of the urban bays are located, suggesting that PCBs present in discrete areas of marine sediments can be transported to the pelagic food web, distant from their source. Possible transport mechanisms include maternal transfer of PCBs from benthic feeding biota. PCBs were also detected in Pacific salmon with higher concentrations in

chinook than coho. PCBs in adult coho returning to rivers in Puget Sound were highest in the central basin followed by the southern and northern basins.

Based on our on-going monitoring results, Sandra O'Neill presented a paper at the Workshop on Contaminants in Fish held in San Diego in January 2004, highlighting the factors affecting PCB accumulation in fishes.

We have been developed a graphic conceptual model of PCBs in the Puget Sound food web that describes major trophic pathways in the Puget Sound/ Georgia Basin (PS/GB) marine ecosystem, through which PCBs might bio-accumulate or bio-magnify. Jim West presented this model at the 2003 Research Georgia Basin/Puget Sound held in Vancouver in the spring of 2003. This Lower Trophic Level sub-model identifies potential pathways among plants, invertebrates, and lower vertebrates, and comprises three modules: (1) a graphic image of the lower trophic levels food web (LTLFW Module) illustrating major ecological groups in the PS/GB ecosystem, and their trophic connections ("who eats whom"). (2) A text outline that describes assumptions and provides explanations of groupings and suggestions for indicator or representative species. (3) A spreadsheet that describes major pathways for uptake and elimination of PCBs within organisms. These descriptions are used to apply what we think are the dominant uptake and elimination pathways for each group in (2). Our intention is to link this Lower Trophic Submodel with two other submodels developed during the PCB Workshop held in September 2002, one dealing with loadings and abiotic transfer mechanisms, and the other with PCB pathways among higher trophic levels (birds, marine mammals, and humans).

### **English sole Home Range Tracking Study**

A collaborative between NMFS and WDFW to study the home range of English sole by acoustically tracking fish with surgically implanted sonic tags is on-going in Eagle Harbor. Based on laboratory studies completed Spring 2003, we decided to implant the tags on the eyed side of the fish.

English sole are suitable as a sentinel species for studies on effects of contaminants because they are broadly distributed in benthic habitats along the Pacific Coast where both juveniles and adults can contact contaminated sediment. Tagging studies have shown that, with the exception of a winter spawning migration and subsequent return to feeding grounds, adult English sole show site fidelity, tending to remain in Puget Sound bays for most of the year. Significant correlations between liver disease and other adverse health effects in English sole and chemical contaminants in sediments at the sites where these fish are captured support the hypothesis of high site fidelity. However, the home range is unknown, and better information on home ranges and habitat utilization is needed to adequately characterize relationships between sediment contaminant exposure and fish health.

A two-year study was therefore initiated in the summer of 2003 to document movements by adult English sole tagged with acoustic transmitters. Twenty fish captured by trawling in Eagle Harbor, a small, contaminated bay, were implanted with transmitters and released at the site of capture, and another 20 will be tagged in April 2004. Stationary receivers equipped with omni-directional hydrophones were deployed to monitor fish moving in and out of Eagle Harbor. Individual fish moving within Eagle Harbor



were also determined by active tracking from a small boat using a portable receiver with both directional and omni-directional hydrophones. 45% of the fish left the bay within 2 weeks of their release date and did not return. Fish that stayed in the bay generally remained near the areas where they were captured. When the study is complete, the data will help refine estimates of home range, habitat use, and migration timing of English sole so we can better understand their exposure to contaminated sediments.

Results of this Study were presented by Sandra O'Neill at the Western Groundfish Conference in Victoria B.C. in February 2004, and will be presented by Stephen Quinnell at the Northwestern SEATAC conference to be held in Port Townsend Washington, April 2004.

### **Study on Contaminants in Prey of Killer Whales**

WDFW is working on a collaborative project with NOAA Fisheries to assess contaminant concentrations in known prey of killer whales, especially salmon species. We will be collecting 5 species of salmon from several locations along the west coast to determine whether fish returning to northern rivers (e.g. Skeena) have higher contaminant body burden than those returning to southern rivers (e.g., Fraser, Skagit, Columbia). Additionally, we will measure the nutritional quality of whole body samples of these salmon samples. The analyses will include caloric content, proximate composition, lipid analyses and lipid class profiles.

### **Analysis of Rockfish Growth Patterns**

Identifying and quantifying spatial patterns in population structure of temperate marine fishes is important for their management. Two species of demersal rockfish, quillback (*Sebastes maliger*), and copper rockfish (*S. caurinus*) have been important components of the commercial and recreational fisheries in the inland marine and estuarine waters of Puget Sound and Georgia Basin for the past 70 years. Populations of these long-lived, demersal carnivores are in serious decline. We used length-at-age (LAA) and a condition factor (CF) to identify specific patterns unique to oceanographic basins in these inland waters, comparing them with an oceanic population. For quillback rockfish, we observed the greatest LAA from oceanic samples, followed by fish significantly smaller-at-age from GB and still smaller from PS. This pattern was almost reversed for copper rockfish, with greatest LAA from oceanic and PS samples, and smallest from GB. For CF, we were only able to compare quillback rockfish from GB and PS, wherein PS quillbacks exhibited a lower CF than the Georgia Basin population. This difference was driven mostly by female rockfish from Puget Sound, which exhibited a significantly lower condition factor (CF) than Puget Sound males (not true between the sexes in the Georgia Basin), as well as a significantly lower CF than females from Georgia Basin. We discuss the significance of these findings, especially related to management of these species, as well as three potential factors that could have contributed to the patterns we observed: 1) basin-specific environmental or habitat-related factors (e.g., productivity, temperature, salinity and depth -- copper rockfish occupied significantly shallower depths than quillbacks), 2) pressures from fishing, and 3) effects on growth from toxic contaminants in Puget Sound, the most highly urbanized or industrialized of the basins we studied.

These results were presented by Jim West at a Lingcod and Rockfish Workshop held in Friday Harbor on September 25 – 27, 2003 and at the Western Groundfish Conference held in Victoria B.C. in February 2004.

## **B. Coastal Area Activities**

### **1. Coastal Groundfish Management**

*Contact: Michele Robinson (360) 249-1211*

#### **Council Activities**

The Department contributes technical support for coastal groundfish management issues via participation on the Groundfish Management Team (GMT), the Scientific and Statistical Committee (SSC), and the Habitat Steering Group (HSG) of the Pacific Fishery Management Council (PFMC). The Department is also represented on the Scientific and Statistical Committee and Groundfish Plan Team of the North Pacific Fishery Management Council. Landings and fishery management descriptions for PFMC-managed groundfish are summarized annually by the GMT in the Stock Assessment and Fishery Evaluation (SAFE) document.

#### **Biennial Management for 2005-06**

The Pacific Fishery Management Council has transitioned to a biennial management cycle for groundfish, beginning with 2005. The Council initiated this management cycle in November 2003, with preliminary decisions scheduled for April 2004, and final adoption of management measures in June. This results in 2005 being an “off year” for management, other than considerations for inseason adjustments. The biennial cycle also moves the assessment schedule such that 2004 is an “off year” for assessments, and 2005 will have an ambitious round of assessments that would be used for management in 2007-08.

#### **2005-06 Management Considerations**

The Pacific Council is considering exploring alternatives for regional management for canary, yelloweye, and black rockfish, and lingcod, rather than continuing with a coastwide management approach for 2005 and 2006. The acceptable biological catch (ABC) would likely remain coastwide unless there is genetic stock separation data available, with regional harvest guidelines or optimum yields (OYs) for management purposes. NMFS observer data for the trawl fishery and fixed gear fisheries is expected to be presented to the Pacific Council in April 2004 with preliminary management measures for West Coast commercial groundfish fisheries.

Relative to state recreational fisheries, the Department has held public meetings to solicit input on recreational management measures for 2005 and 2006. Input so far has indicated support for remaining at status quo—a 15 groundfish bag limit, with a sublimit of 10 rockfish, and 2 lingcod with a minimum size limit of 24", and no retention of canary or yelloweye rockfish.

## **Exempted Fishing Permits (EFPs)**

The Department sponsored three EFPs in 2003 and plans to continue them in 2004. These EFPs include a trawl fishery targeting arrowtooth flounder, a longline fishery targeting spiny dogfish, and a midwater trawl fishery targeting pollock. The arrowtooth flounder EFP is based in Bellingham and Blaine, and takes place from May through August. Six vessels have participated in the EFP for the past three years; however, as a result of a federal buyback program that was implemented in November 2003, there will be only three vessels participating this year.

The spiny dogfish EFP is also based out of Bellingham during the months of February through May. There are three vessels that qualified to participate in the dogfish EFP, but only one vessel has chosen to do so.

The pollock EFP is based out of Westport and will have two participating vessels this year. In 2003, this EFP was scheduled for April through June, but there were only three EFP trips taken in the month of May. This EFP was terminated early as a result of higher than anticipated catches of Pacific whiting (~ 33% compared to < 10% in 2002). It was determined that pollock can be targeted more cleanly in the late summer; therefore, this EFP will occur from July through September this year.

The Department has initiated an effort to accommodate the arrowtooth flounder fishery in the federal fishing regulations, beginning in 2005, so an EFP would not be needed to access arrowtooth. The Pacific Fishery Management Council is currently considering this alternative. The results of the 2001 and 2002 arrowtooth flounder EFPs have been published, and a final 2003 arrowtooth flounder EFP report will be available in April. A report on the spiny dogfish EFP is expected to be completed by September.

## **2. Coastal Sardine Management**

*(Contributed by Michele Robinson, (360) 249-1211 and Brian Culver, (360) 249-1205)*

### **Experimental Purse Seine Fishery for Sardines**

In Washington, sardines are managed under the Emerging Commercial Fishery provisions, which provide for the harvest of a newly classified species, or harvest of a previously classified species in a new area or by new means. From 2000 through 2002, the Washington Department of Fish and Wildlife had trial purse seine fisheries for Pacific sardines, under which the number of participants cannot be limited. Following an extensive public process which included establishing and meeting with a formal Sardine Advisory Board, the Director decided to advance the sardine fishery to an experimental fishery in 2003, under the Emerging Commercial Fisheries legislation, which mandates that permits be limited.

Pacific sardines are managed under the Pacific Fishery Management Council's Coastal Pelagic Species (CPS) fishery management plan. The Pacific Council develops and adopts a coastwide annual harvest guideline, which is then allocated between the two areas which take into account

the biological and ecological impacts of harvesting forage fish. Earlier this year, the Pacific Council adopted an interim allocation regime with plans to develop a long-term allocation strategy over the next year.

The Northwest sardine fishery has rapidly expanded over the past few years, which was the primary reason the Department decided to convert from a trial to an experimental fishery. Oregon began its limited developmental fishery in 1999, which yielded 771 mt in sardine landings. Since then, the Northwest landings have increased with Oregon catching 22,711 mt and Washington landing another 15,212 mt, for a total of 37,923 mt in 2002. In 2003, the overall coastwide harvest guideline decreased slightly to 110,908 mt (from 118,442 mt in 2002), producing a northern allocation of 36,969 mt.

There were 17 fishermen who met all of the criteria necessary to obtain a Washington sardine experimental fishery permit in 2003. Out of the 17 permit holders, 10 made landings this year, for a total of 11,604 mt sardines landed into Washington. This is a decrease from the previous year (15,212 mt); it has been suggested that the decline in landings was the result of a slow startup, rather than fish availability. The size of the average landing was 40 mt.

Sixty-seven percent of the sardines landed were caught in waters adjacent to the Washington coast. This is an increase over past years in which about 43% of the sardines landed were caught off Washington. Sardines are landed into two coastal ports—Westport and Ilwaco. Westport is located on the south side of Grays Harbor and Ilwaco is located on the northern shore of the Columbia River. In 2003, 88% of the sardines were landed into the port of Ilwaco.

The Department provided observer coverage for the fishery and averaged about 24% coverage overall. Observers collected total catch data including species, amount, and condition, and noted whether the fish were released or landed. Bycatch included Chinook and coho salmon, spiny dogfish, blue shark, and other species of fish.

Department staff also collected and processed biological samples. Otoliths were extracted and sent to the Department's lab in Olympia for age-reading. Data collected on the samples include standard lengths, individual weights, sex, and maturity.

### **3. Coastal Groundfish Monitoring, Research, and Assessment**

#### **Coastal Lingcod Stock Assessment for PFMC Contact: Tom Jagielo (360) 902-2837**

In 2003, WDFW provided an updated coastwide lingcod stock assessment for the Pacific Fishery Management Council (PFMC). The assessment applies to lingcod (*Ophiodon elongatus*) in the full Pacific Fishery Management Council (PFMC) management zone (the US-Vancouver, Columbia, Eureka, Monterey, and Conception INPFC areas). Separate assessment models were constructed to describe population trends in the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

Over the last two decades, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (62%) coast. In recent years (1998-2002), commercial fishery restrictions constrained the trawl portion of the catch to 54% and 45% for the northern and southern coast, respectively. In 2002, coastwide commercial landings totaled 223 mt and were distributed as follows by INPFC area: U.S.-Vancouver 63 mt (22%), Columbia 52 mt (30%), Eureka 63 mt (27%), Monterey 35 mt (16%), Conception 10 mt (5%).

Recreational catch in southern waters has declined dramatically since catch peaked in 1980 at 2,226 mt. In contrast, recreational fisheries in northern waters catch peaked at only 236 mt in 1994 and in 2002, 127 mt was landed.

Historically, recreational landings have comprised a larger proportion of the total landings for the southern area, compared to the northern area. In recent years, the recreational portion of the total landings has increased substantially in both the southern and northern areas. In 2002, recreational fisheries harvested 83% of the total lingcod catch in the south and 52% in the north.

The new assessment updates the previous coastwide assessment (Jagiello et al. 2000) and is implemented in Coleraine using the executable code COLERA20.EXE (Hilborn et al. 2000). Coleraine is a statistical catch-at-age model programmed in AD Model Builder with a Microsoft Excel user interface.

A revised lingcod rebuilding analysis was prepared using the updated assessment results. The following table provides projected yield (mt) under the model allowing for domed fishery selectivity. Yields are shown for probability of recovery values ranging from  $P=0.5$  to  $P=0.9$ , and for the 40-10 and ABC rules.

| Model     | Year | P= .5 | P= .6 | P= .7 | P= .8 | P= .9 | Yr=Tmid | F=0 | 40-10 Rule | ABC Rule |
|-----------|------|-------|-------|-------|-------|-------|---------|-----|------------|----------|
| Coastwide | 2004 | 2825  | 2781  | 2732  | 2680  | 2609  | 2815    | 0   | 2674       | 3091     |
|           | 2005 | 2677  | 2636  | 2588  | 2538  | 2467  | 2668    | 0   | 2694       | 2922     |
|           | 2006 | 2497  | 2459  | 2414  | 2367  | 2299  | 2489    | 0   | 2618       | 2716     |
|           | 2007 | 2339  | 2303  | 2261  | 2216  | 2150  | 2331    | 0   | 2511       | 2540     |
|           | 2008 | 2250  | 2216  | 2175  | 2132  | 2069  | 2243    | 0   | 2437       | 2438     |
| North     | 2004 | 2055  | 2055  | 2055  | 2055  | 2055  | 2055    | 0   | 2055       | 2055     |
|           | 2005 | 1874  | 1874  | 1874  | 1874  | 1874  | 1874    | 0   | 1874       | 1874     |
|           | 2006 | 1694  | 1694  | 1694  | 1694  | 1694  | 1694    | 0   | 1694       | 1694     |
|           | 2007 | 1540  | 1540  | 1540  | 1540  | 1540  | 1540    | 0   | 1540       | 1540     |
|           | 2008 | 1451  | 1451  | 1451  | 1451  | 1451  | 1451    | 0   | 1451       | 1451     |
| South     | 2004 | 769   | 726   | 676   | 625   | 554   | 760     | 0   | 618        | 1036     |
|           | 2005 | 804   | 762   | 714   | 664   | 594   | 795     | 0   | 821        | 1048     |
|           | 2006 | 803   | 764   | 719   | 672   | 605   | 794     | 0   | 924        | 1021     |
|           | 2007 | 799   | 763   | 721   | 675   | 610   | 791     | 0   | 971        | 1000     |
|           | 2008 | 800   | 765   | 725   | 682   | 618   | 792     | 0   | 987        | 987      |

## Evaluation of In-Situ Survey Methods for Demersal Groundfish

Contact: Tom Jagiello (360) 902-2837.

In October of 2003, WDFW conducted further in-situ survey methodology development work using the new 3-Beam Quantitative Measurement System (3-Beam QMS). The 3-Beam QMS was affixed to the submersible Delta in a forward looking aspect. The operation was conducted on the RV Velero IV in the Channel Islands National Marine Sanctuary. Over a five day period, scientific colleagues from several federal and state agencies were invited to participate as we surveyed targets of known size for empirical verification of the systems performance in “real-world” conditions. In 2003, the system was upgraded to incorporate in-situ navigational capabilities using an Attitude Heading Reference System (AHRS), and measurement of the transect distance traveled using a Doppler Velocity Log (DVL).

### **Density of Demersal Groundfish in Untrawlable Habitat of the US-Vancouver INPFC Area**

*Contact: Tom Jagielo (360) 902-2837*

Demersal groundfish densities were estimated by conducting a visual strip-transect survey via manned submersible on the continental shelf off Washington. The purpose of this study was to estimate the density of selected groundfish species in habitats not accessible to NMFS trawl survey gear, and to field test a new 3-Beam Quantitative Measurement System. Emphasis was placed on Yelloweye rockfish (*Sebastes ruberimus*), a species recently deemed to be overfished by the Pacific Fishery Management Council.

Nominally untrawlable habitat of the shallow (55-183m) stratum of the US-Vancouver INPFC area was used as the primary spatial sampling frame. Submersible transects were completed at 50 randomly selected dive sites selected *a priori* from a sampling grid prepared as an overlay to the spatial sampling frame. Bottom micro-habitat type was visually characterized for the sampled transects. The density of selected demersal groundfish species was estimated for the untrawlable habitat. Submersible survey density estimates for the untrawlable habitat were contrasted with recent trawl survey density estimates derived from trawlable habitat. Yelloweye rockfish densities were used to derive an estimate of biomass for comparison with a recent PFMC stock assessment.

A manuscript containing the results of this study is near completion and will be submitted to a journal shortly.

Preliminary interpretation on stable isotopic data of yelloweye rockfish otoliths *Contact: Farron Wallace (360) 249-4628)*

In 2003 we analyzed 200 aragonite powder samples of otoliths of yelloweye rockfish (*Sebastes ruberrimus*) from the Washington (WA) and Oregon (OR) coast. For each otolith, one sample was taken from the nucleus (the starting time of otolith growth), and the other taken from the fifth annual zones of the otolith surface (assuming the year 5 in life history). Data of otolith nuclei will provide information on the natal development and spawning stock separation of the fish, whereas the isotopic signatures of age-1 and age-5 will indicate the behavior of the fish over the sampling period.

During the mass spectrometer analysis, three samples were failed because of the small amount of aragonite powder material. Overall, the  $\delta^{13}\text{C}$  values of 197 otoliths of yelloweye rockfish ranged

from -6.5 to -0.1 ‰ VPDB, whereas the  $\delta^{18}\text{O}$  values of the same otoliths ranged from -0.5 to 2.2 ‰ VPDB. Isotopic values of otolith nuclei between WA and OR samples were slightly different (*t*-test, *p* = 0.72 for  $\delta^{13}\text{C}$ , and *p* = 0.10 for  $\delta^{18}\text{O}$ ). However, the isotopic values of the fifth annual zones between the two areas were significantly different (*t*-test, *P* < 0.0001 for  $\delta^{13}\text{C}$ , and *p* < 0.0001 for  $\delta^{18}\text{O}$ ).

Combination of  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  data showed no isotopic differences in otolith nuclei, suggesting there might be a single spawning stock for yelloweye rockfish along the WA and OR coast. For WA samples, there are distinct isotopic differences between samples from otolith nuclei and the fifth annual zones, indicating yelloweye rockfish might move to other habitat as they grew from age-1 to age-5. Similar isotopic trends or signatures were found in OR otoliths. Nevertheless, as compared within the fifth annual otolith zones between WA and OR samples, there were clear differences in  $\delta^{13}\text{C}$ , but not in  $\delta^{18}\text{O}$  variations, suggesting that the food sources or composition of the two areas are slightly different.

In conclusion, the isotopic signatures from otolith nuclei showed there might be a single spawning stock for yelloweye rockfish along the WA and OR coast. From age-1 to age-5, the fish might change their habitat or associated bottom substrates for food.

### **Black Rockfish Tagging study**

*Contact: Farron Wallace (360) 249-4628)*

Since 1998, WDFW has conducted a multi-year mark-recapture survey near Westport Washington, the principal location of recreational landings of black rockfish along the Washington coast. The survey design involves five annual releases, and seven years of tag-recovery monitoring in the sport fishery. Approximately 2-3 thousand fish are released annually on pinnacles distributed throughout the area fished by the Westport charter fishing fleet. Each fish is tagged with two coded wire tags (CWT) placed in the opercular musculature: one on each side of the fishes head. The tags are marked to allow for identification of specific individuals upon subsequent recapture. No tag shedding or tag related mortality was observed during holding experiments during 1998 and 1999.

On an annual basis, roughly 40% of the total Westport recreational black rockfish catch is sampled for tags by passing fish carcasses through a CWT tube detector. Cooperation of the charter boat industry has been very good and has enabled us to achieve the high sample proportion of the total number of fish landed (including those filleted at sea). Mark-recapture data will be used to produce estimates of abundance, survival, and mortality for black rockfish in the Westport coastal area. Population parameter estimates will be incorporated into the next black rockfish age structured model.

Data analyses show the importance of tagging as many fish as possible each year, and conducting an accurate and thorough sampling of as large a proportion of the catch as possible for tags. Study results so far are quite promising and efforts may be expanded to include the entire Washington coast in subsequent segments.