Washington Contribution to the 2006 Meeting of the Technical Sub-Committee (TSC) of the Canada-US Groundfish Committee

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Otter Crest, Oregon

Review of Agency Groundfish Research, Assessment, and Management

A. Puget Sound Area Activities

1. Research on Cowsharks in Washington *Contact: Greg Bargmann (360) 902-2825)*
The Department of Fish and Wildlife, in collaboration with the National Marine Fisheries Service, has been conducting research on sixgill sharks (*Hexanchus griseus*) in Puget Sound and sevengill sharks (*Nototy nchus maculatus*) in coastal estuaries. Longline fishing gear was deployed from chartered vessels to capture, measure and tag the animals. Both visual external tags and internal acoustical (VEMCO) tags have been used.

The sixgill sharks caught in Puget Sound have all been juveniles, despite extensive efforts to locate mature fish. The acoustical tags reveal a pattern of residency in a small area within Puget Sound for months.

Sevengills have been caught and tagged in Willapa Bay in 2003 and 2005, and in Gray's Harbor in 2005. Both immature and mature fish have been caught. The results from the acoustical tagging indicate some movement between the two coastal estuaries. Tagged fish seemed to be resident in the estuaries through the summer and early fall then left in a sudden movement out of the bay. Tagged fish have been detected off of Oregon and California and in Puget Sound. We plan to resume the tagging for one final year in 2006.

Detection of movement patterns has been hampered by the lack of access to detections made by the POST system.

2. Puget Sound Groundfish Monitoring, Research, and Assessment *(Contributed by Wayne Palsson, Marine Fish Science Unit (425) 379-2313, palsswap@dfw.wa.gov)*

Staff of the Puget Sound Marine Fish Science Unit includes Wayne Palsson, Robert Pacunski, Tony Parra, Jim Beam, and Ocean Eveningsong. 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 Assessment and 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.

A major effort was undertaken this year to assess the status and biology of rockfishes in Puget Sound. A draft document was nearing completion in the spring of 2006 that included the results of most sampling programs reviewed below.

Puget Sound Marine Habitat Studies

Wayne Palsson and Robert Pacunski collaborated with Professors Don Gunderson of the University of Washington and Gary Greene of Moss Landing Marine Labs in a Washington Sea Grant study to examine the distribution of marine fishes in relation to the distribution of different sea floor habitats in the San Juan Archipelago that were mapped by Dr. Greene through the NOAA/CCS and other grants. San Juan Channel was mapped with a high-resolution multi-beam echosounder that collected detailed bathymetric and back-scatter information (Figure 1). This mulitbeam bathymetry and bottom type information provided the survey frame for the Sea Grant study. During the 2004 field season, we used a Phantom 2+2HD ROV to survey the diversity of rocky, coarse, and fine sediment habitats in San Juan Channel. We found strong community associations with each substrate type. As expected, rockfish and lingcod were almost exclusively associated with rocky habitats. During the second year of study in 2005, we conducted 87 ROV transects in San Juan Channel and focused exclusively on rocky habitats to tease apart exactly how rockfish and lingcod are associated with different rocky habitat features. As in 2004, we were successful in deploying the ROV with a depressor weight and conducting transects as deep as 500 feet and in current speeds of 1.5 knots. Both seasons' data are being analyzed and written up for peer-reviewed publications.

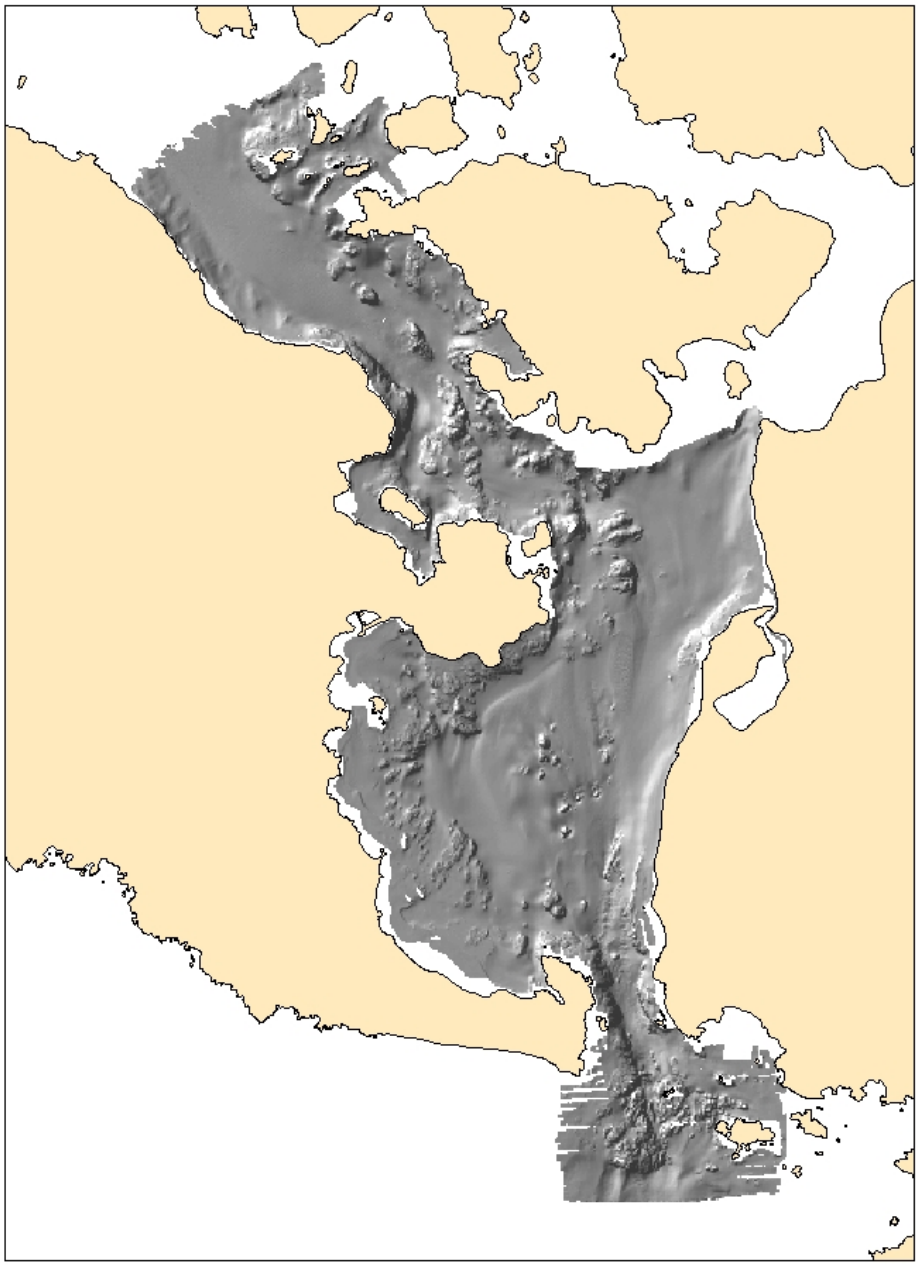

Figure 1. Hillshaded bathymetry of San Juan Channel.

Evaluation of No-Take Refuges for Rocky Habitat Fishes

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.

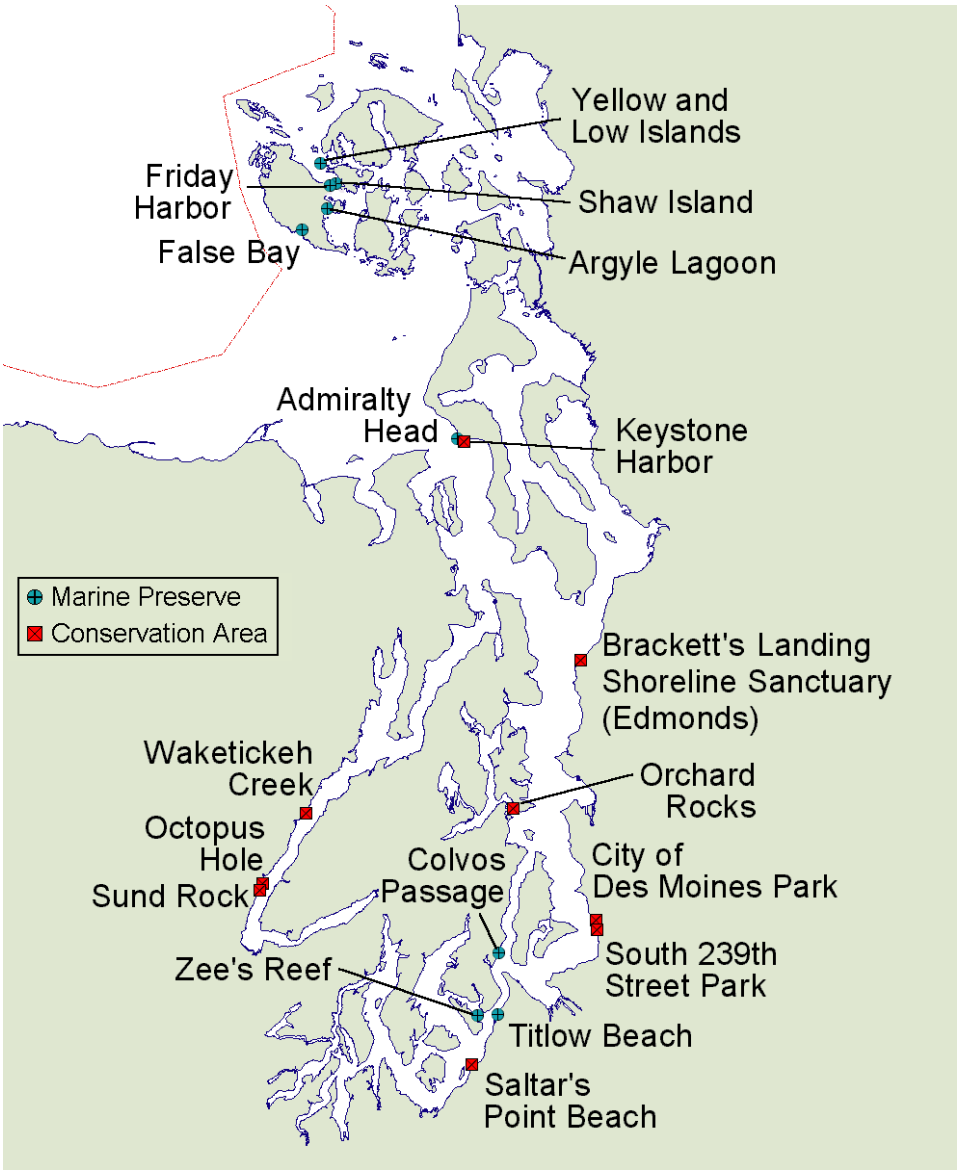

Figure 2. WDFW non-tribal marine reserves in Puget Sound. Conservation Areas are fully-protected, Marine Preserves are partially-protected.

Specific monitoring activities in 2005 included surveying many of the Puget Sound reserves and comparable fished sites. Several reserves in central Puget Sound were visited six times during 2005 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 2004. The reserve at Colvos Passage was also monitored during the same survey series.

We have not subjected the 2004-5 marine reserve data to detailed analysis, but the observations will likely corroborate earlier analyses showing that lingcod have dramatically increased in many of the marine reserves and that rockfish have either declined or showed little improvement over time. The increase in lingcod abundance may be best demonstrated by the long-term reserve study in the San Juan Archipelago where lingcod densities are twice as dense inside marine reserves as in comparable fished areas (Figure 3). While the density continues to increase inside the marine reserves, densities have decreased in the fished areas after a multi-year pattern of increase.

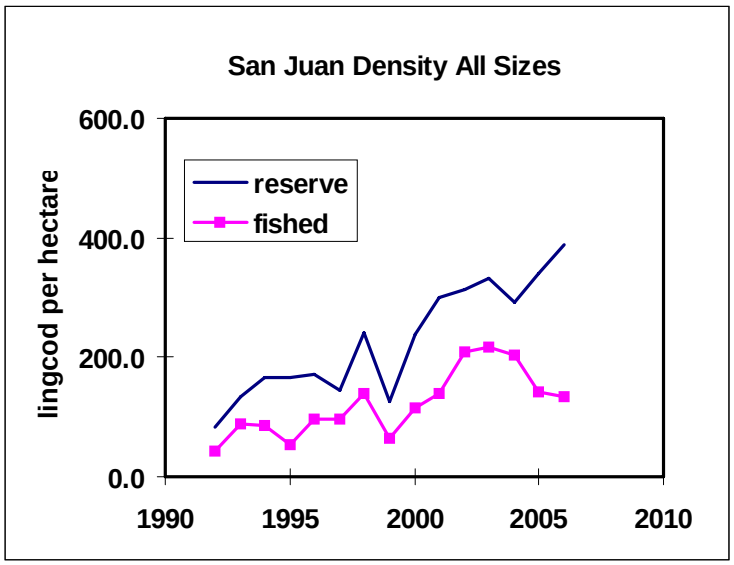

Figure 3. Winter scuba density estimates from two reserved and fished area transects in San Juan Channel.

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 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 4 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 and 2004 low DO events, 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. 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 2 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.

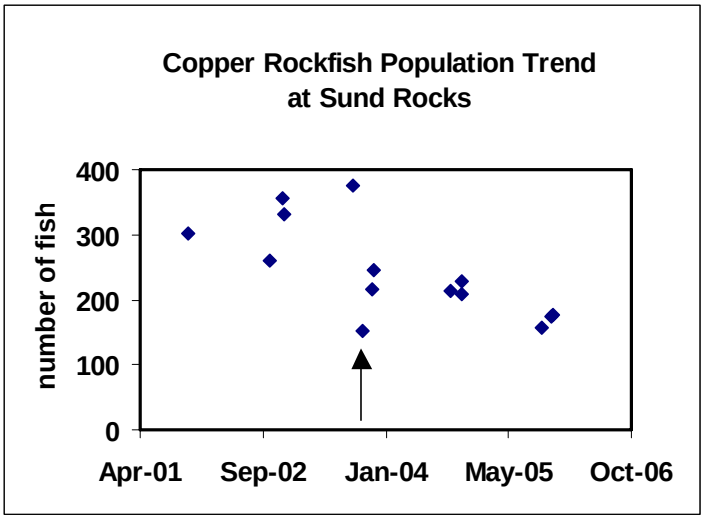

Figure 4. Scuba counts of copper rockfish at Sund Rocks prior to, during, and after the October 2003 fish kill.

Second Tacoma 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 was created at Toliva Shoal in spring 2005 that tested the effectiveness of adding small, quarried rock on or near extisting artificial habitat composed of large boulders and concrete deployed for attracting adult rockfish (Figure 5).

Monitoring at the bridge site included conducting scuba transects in the shallow waters (<100 ft) at planned anchor sites and conducting towed video transects at planned anchor, rip-rap, and bridge tower locations. Pre-construction surveys revealed that most rockfish and lingcod were distributed along old bridge rubble and natural hardpan habitats on the eastern side of the Narrows. Now that the towers have been erected and the anchors removed, after-construction comparisons will be made from transects conducted during early 2006.

Pre-construction scuba transects at Toliva Shoal, found that most rockfish and lingcod were sparsely distributed on previously deployed, large-rock artificial habitats composed of concrete and quarried boulders. Initial surveys after deployment of small, quarried rock found sub-adult rockfish sparsely distributed on newly created habitat in greater numbers than on comparable

transects that were not affected by new construction. Extensive surveys will continue for the next two years to determine the effectiveness of creating a small rock habitat for rockfishes on top of or away from an existing artificial habitat composed of large rocks targeting adult rockfish and lingcod.

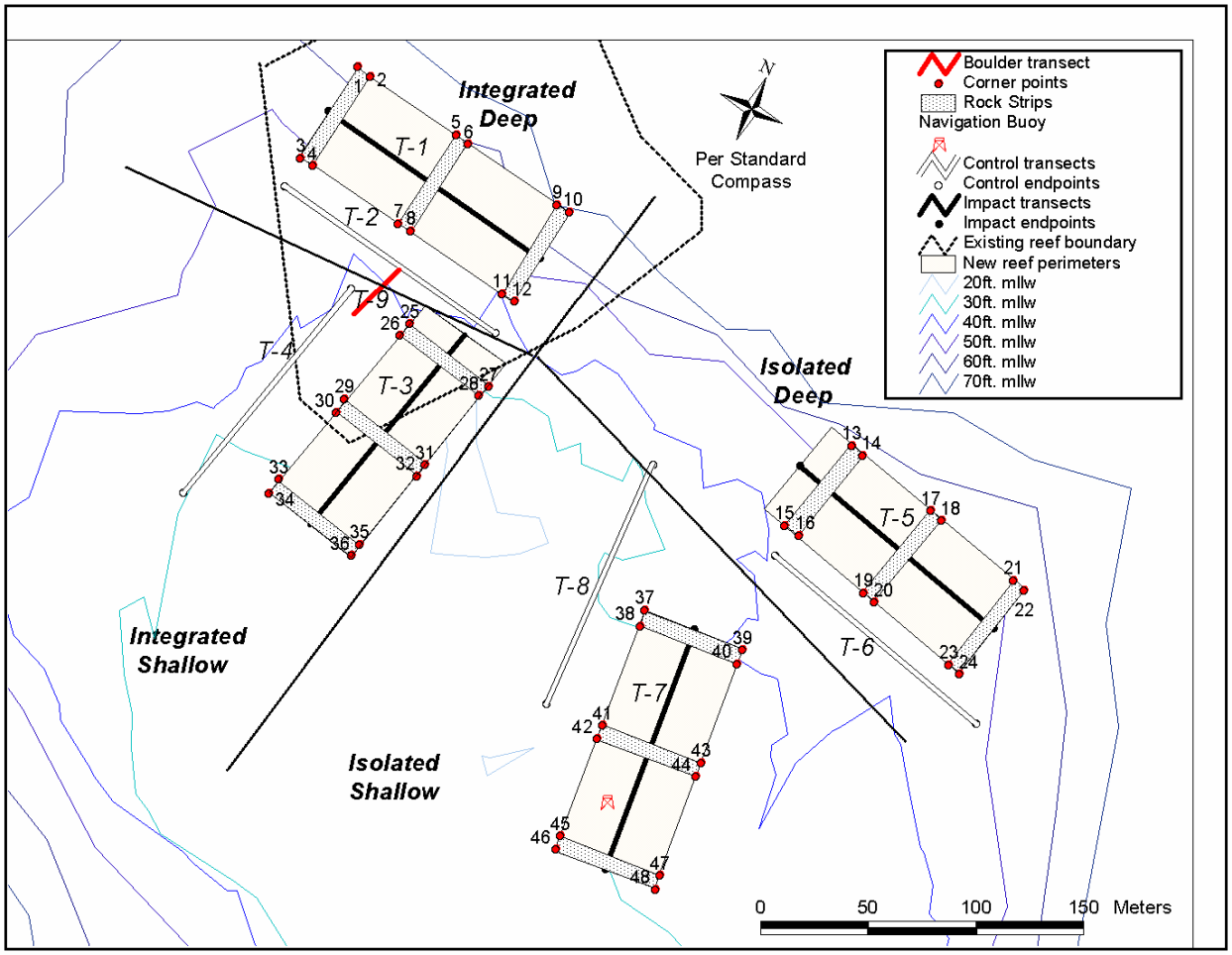

Figure 5. Deployed quarry rock for juvenile rockfishes at Toliva Shoal.

2004 Bottom Trawl Survey of Northern Puget Sound

In 2005, WDFW conducted a synoptic bottom trawl survey in the waters south of Port Townsend including central and southern Puget Sound, the Whidbey Basin, and Hood Canal. The goals and objectives of this survey were to estimate the abundance and describe the distribution of recreational and commercial groundfish and macro-invertebrate 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 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 subregions. The area sampled at each station was measured with 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 168 of 170 planned trawl stations were occupied and completed.

The trawl surveys conducted at irregular intervals since 1987 have provided the basis to compare population trends in the inland marine waters over the past two decades. Statistical analysis has shown that fish communities sharply differ between the inland waters north of Port Townsend from those south of Port Townsend. In North Puget Sound, total biomass has not changed dramatically since 1987 (Figure 6) but the species composition has changed from having fewer dogfish and other species and having higher proportions of flatfishes. In South Sound, total biomass was substantially reduced during 1989-91, but increased to levels comparable to 1987 afterwards (Figure 7). Spotted ratfish have been increasing, seemingly at the expense of codfishes and dogfish.

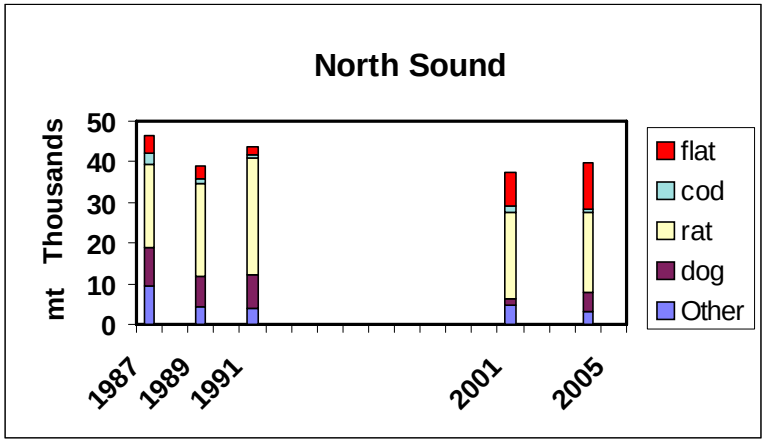

Figure 6. Estimated biomass (metric tons) of flatfishes, codfishes, ratfish, dogfish, and other groundfish in North Puget Sound resulting from bottom trawl surveys.

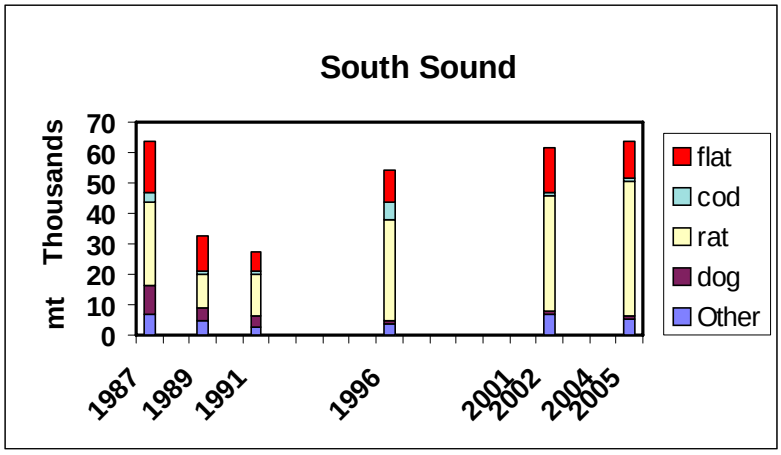

Figure 7. Estimated biomass (metric tons) of flatfishes, codfishes, ratfish, dogfish, and other groundfish in South Puget Sound resulting from bottom trawl surveys.

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Breitburg, D. 2002. Effects of hypoxia, and the balance between hypoxia and enrichment, on coastal fishes and fisheries. Estuaries 25:767-781.

Collias, E.E., N. McGary, and C.A. Barnes. 1974. Atlas of Physical and Chemical Properties of Puget Sound and Its Approaches. Wash. Sea Grant..

Warner, M.J., M. Kawase, and J.A. Newton. 2002. Recent Studies of the overturning circulation in Hood Canal. 2001 Puget Sound Research Conference Proceedings. Puget Sound Action Team, Olympia.

3. Herring Stock Assessment *Contact: Kurt Stick (360) 466-4345 ext 243)*

Annual herring spawning biomass is estimated for known herring populations in Washington waters using spawn deposition and/or acoustic-trawl surveys. The Washington Department of Fish and Wildlife recognizes nineteen different herring stocks in Puget Sound and two coastal stocks, based primarily on timing and location of spawning activity. Estimates were made for all recognized stocks in 2005. Stock assessment activities for the 2006 spawning season are in progress.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2005 is 11,321 tons (Table 1 and Figure 8). The cumulative abundance of spawning herring in Puget Sound has decreased since 2002, when it totaled 17,721 tons. The Puget Sound total reflects the recent trend exhibited by the combined biomass of south/central Puget Sound herring stocks; an increase from 1997 to 2002, followed by a decrease through 2005.

Cumulative biomass of North Puget Sound stocks has remained at a low level of abundance, primarily due to the continued critical status of the Cherry Point herring stock. The Cherry Point

stock increased slightly in 2005 to 2,010 tons, continuing an observed annual increase since a low of 808 tons in 2000. The Cherry Point stock ranged from 3,100 to nearly 15,000 tons between 1973 and 1995. Recent research has suggested that the Cherry Point stock is genetically distinct from other Puget Sound and British Columbia herring stocks. However, it did not meet the Endangered Species Act criteria in a 2005 review by NOAA for protection as a Distinct Population Segment.

Herring spawning biomass for the Strait of Juan de Fuca region is also at a very low level of abundance. The Discovery Bay herring stock is the primary component of this region and has decreased dramatically and steadily since the late 1980's, after a peak estimate of 3,200 tons in 1980. However, surveys to date in 2006 indicate a significant increase in spawning biomass for this stock.

Estimated herring spawning biomass for 2005 for coastal stocks (Willapa Bay and Grays Harbor) was higher than that estimated for 2004, but abundance is relatively low compared to previous years (Table 1).

Additional information about herring management and stock status is available the WDFW web site at: http://wdfw.wa.gov/fish/papers/herring_status_report/index.htm

Table 1. Washington state herring spawning biomass estimates by stock and region, 1996-2005.

HERRING SPAWNING BIOMASS ESTIMATES (SHORT TONS) BY STOCK AND REGION, 1996-2005.
(blanks indicate no surveys done that year)

	YEAR									
	2005	**2004**	**2003**	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**	**1996**
Squaxin Pass	436	828	2201	3150	1597	371	474	68	149	374
Wollochet Bay	67	52	152	106	133	142				
Quartermaster Harbor	756	727	930	416	1320	743	1257	947	1402	805
Port Orchard-Port Madison	1958	700	1085	878	2007	1756	2006	489	360	806
South Hood Canal	210	176	207	166	187	140	516	101	226	239
Quilcene Bay	1125	2342	916	2585	2091	2426	2464	1152	465	328
Port Gamble	1372	1257	1064	1812	1779	2459	1664	971	1419	2058
Kilisut Harbor	170	184	448	774	612	107	802	311	307	380
Port Susan	157	429	450	775	587	785	545	2084	828	110
Holmes Harbor	498	673	678	573	275	281	175	464	530	336
Skagit Bay	1169	1245	2983	2215	2170	646	905	209	893	736
South-Central Puget Sound Total	7918	8613	11114	13450	12758	9856	10808	6796	6579	6172
Fidalgo Bay	231	339	569	865	944	737	1005	844	929	590
Samish/Portage Bay	218	351	299	496	470	196	555	643	509	636
Int. San Juan Is.	41	67	72	158	219	128	197		30	277
N.W. San Juan Is.	0	0	13	131	62	90		107	79	53
Semiahmoo Bay	870	629	1087	1012	1098	926	868	919	621	1219
Cherry Point	2010	1734	1611	1330	1241	808	1266	1322	1574	3095
North Puget Sound Total	3370	3120	3651	3992	4034	2885	3891	3835	3742	5870
Discovery Bay	33	252	207	148	137	159	307	0	199	747
Dungeness/Sequim Bay	0	22	44	131	93	138	352	112	158	180
Strait of Juan de Fuca Total	33	274	251	279	230	297	659	112	357	927
Puget Sound Total	11321	12007	15016	17721	17022	13038	15358	10743	10678	12969
Grays Harbor	15	33	129	87	77	166	297	77		
Willapa Bay	145	0*	398	389	150	345	397	57	144	
*partial survey coverage										
Coast Total	160	33	527	476	227	511	694	134	144	

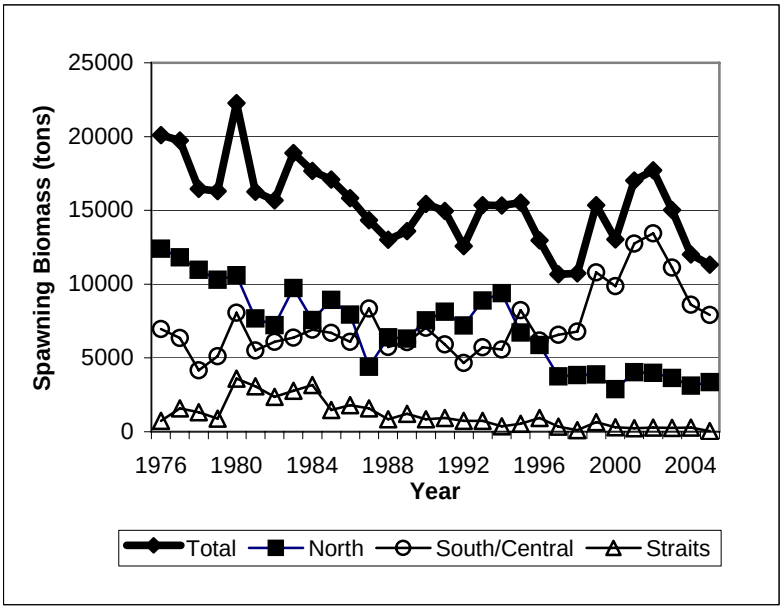

Figure 8. Estimated Puget Sound herring spawning biomass, 1976-2005.

4. Puget Sound Ambient Monitoring Program (PSAMP) *Contact: Sandie O'Neill (360) 902-2843*

The Washington Department of Fish and Wildlife continues to be a key component of the Puget Sound Ambient Monitoring Program Project (PSAMP), a multi-agency effort to assess the health of Puget Sound. To assess how the health of the Sound is affected by chemical contamination of it's fish, the PSAMP Fish Component monitors "legacy" pollutants like PCBs and DDTs that persist in the ecosystem despite restrictions in their use, PAHs, which are compounds associated with petroleum and with combustion, heavy metals, and emerging toxics like PBDEs that are used as flame retardants.

5. Puget Sound Marine Fish Research *Contact Larry LeClair (360) 902-2767*

Trans-generational Marking of Viviparous Marine Fish in Puget Sound, Washington
(Contact: Larry LeClair, Marine Fish Science, 360 902-2767, leclalll@dfw.wa.gov)

Investigators at the Washington Department of Fish and Wildlife continued experimenting with the use of elemental strontium as a means to mark the otoliths of viviparous marine fish larvae prior to birth. Laboratory trials with captive perch and rockfish have shown that a single intramuscular injection of strontium into gestating adults is sufficient to produce a lifelong strontium mark in the otoliths of larvae prior to parturition, thus providing a potential method for directly estimating retention and dispersion rates from local populations.

The first field trials are now underway at Point Heyer, Washington with brown rockfish (*Sebastes auriculatus*). To date, over 80 gestating females have been injected and released *in situ*, and 150 injection cohort juveniles have been recovered and assayed for the presence of elevated Sr. A single marked otolith was found among the 150 juveniles captured.

Use of Microsatellite DNA and Pedigree Analysis to Test For Self-recruitment in an Isolated Population of Brown Rockfish in Puget Sound, Washington
(Contact: Larry LeClair, Marine Fish Science, 360 902-2767, leclalll@dfw.wa.gov)

This collaborative study between the Washington Department of Fish and Wildlife and the University of Washington is aimed at using genetic markers to identify progeny of resident adult brown rockfish among juveniles sampled at an isolated reef near Point Heyer, Washington. Non-lethal *in situ* sampling using tissue clipped from the dorsal lobe of the caudal fin are being used to genotype individuals at 12 microsatellite loci. To date, 137 adults, estimated to be about one third of the total adult population, have been sampled and genotyped. Genotypes from 118 juveniles have been obtained. Preliminary results using a maximum likelihood estimation approach indicate self-recruitment to be about 15%; however, low genetic variability and higher than expected genotyping error has lead to some ambiguity in assigning parent-offspring-sib relationships. Additional marker loci with greater allelic richness and reduced genotyping error were developed in 2005 and will be used to assay existing and future collections from Point Heyer and adjacent areas. Results are expected to be directly applicable to the design and placement of MPA's in Puget Sound and elsewhere.

Allozyme and Microsatellite DNA Analysis of Lingcod From Puget Sound, Washington, and Adjoining Waters
(Contact: Larry LeClair, Marine Fish Science, 360 902-2767, leclalll@dfw.wa.gov)

Allozymes and microsatellite DNA were used to examine genetic connectivity among lingcod populations in Puget Sound and between Puget Sound and the outer coast. No significant differences in allele frequencies were detected, though multidimensional ordination suggested minor differences between Puget Sound and the outer coast. A manuscript was submitted to the Transactions of the American Fisheries Society is currently under revision.

B. Coastal Area Activities

1. Coastal Groundfish Management *(Contact Michele Culver, (360) 249-1211 or Brian Culver, (360) 249-1205)*

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 Teams 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.

2. Coastal Groundfish Monitoring, Research, and Assessment

Black Rockfish Tagging Study *Contact: Eric Eisenhardt (360) 249-1208*
In 1998, WDFW began 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 annual releases of coded wire tagged (CWT) fish and recovery of tagged carcasses from the recreational fishery, both of which are currently on going. From 1998 to 2001, WDFW's R/V Corliss was used to capture, tag and release 2,622, 3,478, 2,779 and 3,200 black rockfish annually. Since 2002, commercial charter vessels have been used, including F/V Hula Girl, F/V Slammer and F/V Tequila Too. A total of 4,089 black rockfish were caught, tagged and released in 2002, 6,744 in 2003, 5,981 in 2004, and 3,716 in 2005. In 2004, passive integrated transponder (PIT) tags were used to reduce the labor need to read and match recovered tags. In 2005, all tagged fish released were tagged with both CWTs and PIT tags, which will allow estimation of PIT tag loss rates (since CWT loss rates are already known).

Fish are released on pinnacles distributed throughout the area fished by the Westport charter fishing fleet. Each CWT tagged fish had two tags placed in the opercular musculature: one on each side of each fish's head. The tags were 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, 1999 and 2003. PIT tags are injected into the throat

patch musculature, and appear to have excellent retention and very low to non-existent shedding rates.

On an annual basis, roughly 40% of the total Westport recreational black rockfish catch is sampled for tags by passing fish carcasses through a metal detector tube (Northwest Marine Technologies R8000).

Yelloweye Rockfish Stock Assessment for PFMC *Contact: Farron Wallace (360) 249-4628*

A stock assessment was prepared reporting the status of the yelloweye rockfish (*Sebastes ruberrimus*) resource off the west coast of the United States, from the Mexican border to Canadian border. This stock is treated as a single coastwide population as in the previous two assessments (Wallace *et al*. 2005, Methot *et al*. 2002) and as separate sub-populations in area models for Washington, Oregon and California.

Catches
NMFS and State personnel expended a significant amount of effort to provide the best possible historical accounting of landings prior to 1983. These estimates are considered to be a significant improvement over previous catch time series for California, Oregon and Washington. This resulted in decreasing total catch between 1955-2005 for the coastwide recreational fishery by 667 mt and increasing the commercial landings by 1,674 mt (compared to the 2005 assessment). Discard was assumed to have not occurred prior to enactment of strict harvest policies beginning in 2002 and is currently estimated from a variety of sources. By 2004, all three States instituted regulations that did not allow yelloweye retention in the recreational fishery and most commercial fisheries. Discard between 2002 and 2004 may not be well estimated due to an overall lack of sampling coverage during establishment of restrictions to decrease catch.

Data and assessment
The first and second full assessments for yelloweye rockfish were conducted in 2001 (Wallace 2001) and 2002 (Methot *et al*. 2002), respectively. Both assessments were length-based models and used an earlier version of the Stock Synthesis program (Methot 1989). Wallace (2001) conducted separate area assessments for the Northern California and Oregon areas. Methot *et al*. (2002) incorporated Washington catch, recreational abundance indices, and age data, and treated the stock as one single assemblage of the W-O-C coast. The 2005 assessment (Wallace *et al*. 2005) provided an update of the 2002 assessment incorporating a revised catch time series and employed the Stock Synthesis 2 (SS2) modeling framework to estimate model parameters and management quantities. Abundance indices were not revisited and little new composition data were available. All of the assessments concluded that ending spawning biomass was less than 25% of unfished.

This current (2006) assessment reevaluated all of the available coast-wide catch and effort information, and reformulates all of the indices of abundance. The IPHC survey index of abundance, a revised historical catch time series from 1955-1982 and new age, length and size composition data were also incorporated. The SS2 modeling framework is again used to estimate model parameters for a coastwide model and for separate area models for W-O-C. Additionally, natural mortality was estimated within the coastwide model to be 0.036 and was

assumed to be 0.036 in all area specific models. This compares to natural mortality estimates of 0.02 and 0.033 (in development) used in the SE Alaska, U.S. and British Columbia, Ca, respectively. Natural mortality was assumed to be 0.045 in the previous two assessments.

Since natural mortality is confounded with selectivity in age-structured models we explored the trade-off between natural mortality and selectivity relative to our ability to estimate selectivity parameters. Because of the lack of age and length composition information especially for older, larger individuals we concluded that we did not have sufficient data to allow us to satisfactorily estimate the descending limb of a double logistic selectivity curve and chose to assume a logistic form for all models. This model form assumes that all ages and sizes of fish are available to the fishery with no refugia for the largest individuals in the population.

In agreement with previous assessment(s), yelloweye rockfish biomass is considered to be at historic low levels with spawning biomass less than 25% of unfished in all models.

Unresolved problems and major uncertainties

As in the previous assessments, the sparseness of the size and age composition data and the lack of a relevant fishery-independent survey has limited the model's ability to properly assess the status of the resource. This is especially apparent in the Washington model where the wholesale lack of data resulted in our inability to obtain a converged model without placing significant restraints and assumptions within the model relative to the area-specific models for California and Oregon. Further, due to catch restrictions since 2002, catch-per-unit-effort (CPUE) data no longer reflect the real changes in population abundance, and discard estimates are highly uncertain.

Research and Data Needs

Additional effort to collect age and maturity data is essential for improved population assessment. Collection of these data can only be accomplished through research studies and/or by onboard observers because this species is now prohibited. In 2006, IPHC and WDFW scientists are conducting a study to increase our knowledge of current stock biomass off Washington coast. Loss of the study due to declining OY will have significant detrimental effects on our ability to adequately assess this stock in the future. We strongly urge Management to make this study the highest priority. Increased effort toward habitat mapping and in-situ observation of behavior will provide information on the essential habitat and distribution for this species.

Alternative survey such as the in-situ 2002 US Vancouver submersible survey in untrawlable habitat is required for future assessment of yelloweye rebuilding status. This study has demonstrated that submersible visual transect surveys can provide a unique alternative method for estimating demersal fish biomass in habitats not accessible to conventional survey tools. For example, because of the low frequency of yelloweye rockfish encountered in the NMFS shelf trawl survey tows, those data were not considered a reliable indicator of abundance and were not used in the 2002 yelloweye stock assessment for PFMC (Methot *et al.* 2002). Results from this study support this conclusion and illustrate the need for large-scale surveys to assess bottomfish densities in habitats that are not accessible to trawl survey gear. Further, stratified random sampling designs should be employed with sample sizes sufficient to ensure acceptable levels of statistical power (Jagielo *et al.* 2003). At present, the in-situ visual transect submersible survey

method appears to be a useful tool for this purpose, and the utility of this method will likely improve further with technological advances such as the 3-Beam Quantitative Measurement System (QMS).

Lingcod Stock Assessment for PFMC *Contact: Tom Jagielo (360) 791-9089*

A stock assessment was conducted for 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.

Commercial Landings.
Commercial lingcod catch history in California waters is available beginning 1916 (personal communication Brenda Erwin, PSMFC) and averaged 428 mt between 1916 and 1955. Commercial lingcod landings in Oregon were first reported in 1950 (Mark Freeman, personal communication) and averaged 264 mt between 1950 and 1953. Washington commercial lingcod landings were first reported in 1937 (anonymous, 1956, WDFW report) and averaged 106 mt until 1955.

Commercial landings peaked in 1985 at 3,129 mt in northern waters (Columbia and Vancouver INPFC areas) and in 1974 at 1,735 mt in southern waters (Eureka, Monterey and Conception INPFC Areas). Average catch between 1990-1997 declined 40 % and 35% since the 1980's in northern and southern waters, respectively. Under rebuilding management, commercial fishery restrictions in recent years (1998-present) reduced coastwide catches to an annual average of less than 225 mt.

From 1981-1997, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (63%) coast. In recent years (1998-2004), commercial fishery restrictions constrained the trawl portion of the commercial catch to 65% and 40% for the northern and southern coast, respectively. In 2004, coastwide commercial landings totaled 174 mt and were distributed as follows by INPFC area: U.S.-Vancouver (41.7 mt), Columbia (44.6 mt) , Eureka 39.5 mt), Monterey (33.2 mt), Conception (14.8 mt).

Recreational Landings.
Recreational fishers in California have targeted lingcod since the early 1940's. Catch averaged 65.3 mt annually between 1947-1954 (Leet et al., 1992). Recreational lingcod catch information is not available until 1977 for Oregon waters and averaged 52.3 mt annually between 1977 and 1979. Recreational lingcod catch in Washington was first estimated in 1967 to be 25.3 mt and annual catch estimates have been provided since 1975.

Recreational catch estimates were extracted from the RecFIN database for years 1980–1989 and 1993 to present for California waters. California recreational catch estimates for all other years were previously compiled in the 2000 lingcod assessment (Jagielo et al., 2000). Oregon recreational catch data were provided by ODFW (Don Bodenmiller personal communication). The recreational catch in Washington was provided by the WDFW Ocean Sampling Program.

Recreational catch in southern waters has declined since catch peaked in 1980 at 2,226 mt (Table 5, Figure 4). In contrast, recreational catch in northern waters peaked at 236 mt in 1994. Estimated coastwide recreational landings averaged 500 mt. from 1998-2004 and were 1175 mt. and 316 mt. in 2003 and 2004, respectively.

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 2004 recreational fisheries harvested 65% of the total lingcod catch coastwide.

Modeling Approach and Assessment Program
The 2006 assessment updated the previous coastwide assessment (Jagielo et al. 2003) and is implemented in Stock Synthesis II using the executable code SS2 version 1.19d (Methot 2005). As in the previous assessment, separate age structured models were constructed to analyze stock dynamics for the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

Unresolved Problems and Major Uncertainties
At the STAR Panel review (August 15-19, 2005) concern was raised regarding the apparent lack of evidence in the data for the northern (LCN) model estimates of high 1999 and 2000 year class strength. In particular, doubts were raised concerning the reliability of the 2001 and 2004 NMFS triennial survey estimates, in which these two year classes were abundant. Furthermore, the STAR Panel did not find compelling evidence from the fishery age composition data to corroborate the high year classes seen in those two surveys. As a result of these uncertainties, the lingcod assessment was recommended for further review at the follow-up STAR Panel meeting (September 26-30, 2005).

At the follow-up STAR Panel meeting, additional analyses and information were provided to document the LCN model estimates of high 1999 and 2000 year class strength. Additional model runs with sequential removal of the 2001 and 2004 NMFS trawl surveys, and age compositions from the commercial and recreational fisheries from 2000-2004 indicted that both survey and commercial data supported the two strong year classes. As a result, the STAT Team recommended and the STAR Panel approved the base LCN model for management.

The STAT team additionally notes that:

1) Uncertainty regarding stock status is higher for the southern area relative to the northern area, primarily because historical data from the southern area were sparse relative to the northern area. The time series of fishery age data available for the southern (LCS) model is short and samples sizes are small, resulting in greater uncertainty in the estimation of assessment parameters and stock productivity for the southern area. Age data for the NMFS trawl survey were sparse for both regions in early years, but particularly for the southern region. Recreational fishery catch at age data were not available for the southern region in 2003.

2) Management-implemented minimum size limits have resulted in limiting the utility of fishery information for estimation of recent stock recruitment in both regions, and fishery trip limits have compromised the utility of recent fishery CPUE data as viable indices of abundance.

Management Reference Points

The estimates of unfished spawning biomass (Bzero) were determined as the product of mean recruitment from 1956-2005 and the estimated Spawners Per Recruit. On a coastwide basis the lingcod population is fully rebuilt; estimated spawning biomass was 34,017 mt in 2005, which is 0.60 of the unfished spawning biomass estimate (52,850 mt). The estimated ratio of 2005 spawning biomass to unfished spawning biomass is higher in the north (0.87) compared to the south (0.24).

Spawning Stock Biomass

SS2 estimates of the coastwide female spawning stock biomass declined from 60,106 mt in 1956 to 6,004 mt in 1994, and subsequently increased to 34017 mt in 2005. Female spawning biomass depletion (B_0/B_t) fell to 0.11 in 1994 and subsequently increased to 0.64 in 2005.

Recruitment

The model estimate of virgin recruitment was higher for the northern area (3750 thousand age 0 fish) compared to the southern area (2503 thousand age 0 fish). Recruitments were generally similar in magnitude in both the north and south from 1972-1992, averaging 2008 in the north, and 2071 in the south. Subsequently, from 1993-2005, recruitments tended to be higher in the north, and averaged 4503 compared to 1309 for the same period in the south. Recent, historically strong, 1999 and 2000 year classes were estimated in the north.

Exploitation Status

In the northern area, the exploitation rate (catch/available biomass) peaked at 0.20 in 1991 and averaged 0.03 from 1956-1980, 0.12 from 1981-1997, and 0.02 from 1998-2005. Exploitation rates were generally higher in the southern area, peaking at 0.26 in 1989 and averaging 0.05 from 1956-1980, 0.20 from 1981-1997, and 0.10 from 1998-2005.

Recommendations: Research and Data Collection Needs

Emphasis should be placed on improving fishery age structure sampling size and geographical coverage in both regions. More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment.