Washington Contribution to the 2011 Meeting of the Technical Sub-Committee (TSC) of the Canada-US Groundfish Committee

May 3rd – 4th, 2011

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May 2011

Review of WDFW Groundfish Research, Assessment, and Management Activities in 2010

A. Puget Sound Area Activities

1. Puget Sound Groundfish Monitoring, Research, and Assessment *(Contact: Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Wayne Palsson 425-379-2313, Wayne.Palsson@dfw.wa.gov) Marine Fish Science Unit*

Staff of the Puget Sound Marine Fish Science (MFS) Unit includes Wayne Palsson, Robert Pacunski, Tony Parra, and Jim Beam. In addition, Courtney Adkins and Pete Sergeef work as MFS employees during the spring 2010 bottom trawl survey. Unit tasks are primarily supported by supplemental funds from the Washington State Legislature for the recovery of Puget Sound bottomfish populations. The main activities of the unit include the assessment of bottomfish populations in Puget Sound, the evaluation of bottomfish in marine reserves, and the development of conservation plans for species of interest. Groundfish in Puget Sound are managed under the auspices of the Puget Sound Groundfish Management Plan (Palsson, et al. 1998).

a. Rockfish Conservation Plan and Final Environmental Impact Statement

Twenty-eight species of rockfishes occur in the inland marine waters of Washington, here defined as Puget Sound. The Washington Department of Fish and Wildlife manages these species and the various commercial and recreational non-tribal fisheries that have either targeted rockfishes or have caught them incidentally to other targeted species. During the past two years, staff worked with fishers and citizens to create a Puget Sound Rockfish Conservation Plan. The plan was developed through the Washington State Environmental Policy Act, and a draft EIS was open for public comment in late 2009. Public comments were reviewed in early 2010 indicating a desire for more information and inclusion of the Neah Bay area in the plan. The DEIS was revised and a new comment period was held in the spring of 2010. Comments were reviewed and the plan revised during the remainder of 2010.

Highlights of the FEIS and Puget Sound Rockfish Conservation Plan are:

- Received 1,102 comments from 306 organizations or individuals.
- Geographic scope of plan was extended to include the Strait of Juan de Fuca from Cape Flattery east.
- Eight elements in the plan: Natural Production, Habitat Protection and Restoration; Fishery Management; Ecosystem; Monitoring Evaluation and Adaptive Management; Research; Outreach, Education and Ecotourism; and Enhancement (Artificial Habitat and Hatchery Production).

- Habitat Protection and Restoration: Develop a science based system of marine reserves that, with other actions, achieves the natural production objectives by protecting significant amounts of rockfish stocks, their habitats and ecosystems.

- Fishery Management: Improve system to report lost gear. Evaluate the potential effectiveness of voluntary and mandatory reporting and marking systems to prevent the accumulation of derelict gear to reduce rockfish mortality.

- Monitoring and Research: Forge partnerships with scientists & citizens to evaluate the effectiveness of conservation. WDFW co-sponsoring the Salish Sea Rockfish Research Workshop in June.

- Outreach, Education and Ecotourism: Added ecotourism to this element to capture importance of providing non-consumptive recreational opportunities.

- Enhancement: Achieve natural production objectives through use of hatchery production to rebuild depleted rockfish stocks; and artificial habitats consistent with the hierarchy of habitat protection and mitigation approaches.

b. ESA Petition for Five Deep-water Rockfishes

On April 28, 2010 NOAA Fisheries listed three species of rockfish under the auspices of the Endangered Species Act. This listed was put into effect on July 28, 2010. WDFW staff worked cooperatively to address the concerns over the listed species and together reviewed fisheries that might pose a threat to the rockfishes. WDFW responded and close or restricted several fisheries. The commercial bottom trawl, dogfish set net, and dogfish set line fisheries were closed by emergency regulation on July 27th, 2010 and permanent regulation changes were filed for consideration by the Washington Fish and Wildlife Commission. Earlier in the year, the Fish and Wildlife Commission acted to reduce the catch of ESA-listed rockfishes and other depressed rockfish stocks by prohibiting the retention of rockfish east of Port Angeles and prohibiting fishing for bottomfish in waters deeper than 120 feet east of Cape Flattery. The Commission also reduced the recreational rockfish limits in the Neah Bay area to only allowing six black or blue rockfishes per day. In the Sekiu area, a limit of one to three black rockfish depending upon the time of year. WDFW staff have been working to complete a Incidental Take Permit and Fishery Conservation Plan to address takes of the listed rockfishes by ongoing recreational and commercial fisheries.

c. 2008 San Juan Archipelago ROV survey

From 29 September to 26 November 2008, the MFS staff conducted an ROV survey of the rocky habitats within the San Juan Archipelago (SJA). The survey was designed using available high-resolution (1-5 m^2) geomorphic habitat maps developed by Dr. Gary Greene and his graduate students at the UCSB Moss Landing Marine Laboratories. These maps and some previous survey results provided a sampling frame of rocky habitats in the San Juan Islands. The survey area was stratified by depth along the 20-fathom contour to allow for comparisons to earlier

drop-camera surveys of the region. A total of 207 transects were completed, ranging in depth from the surface to 250 m (820 ft), with an average length of 320 m. The most common species observed were kelp greenling, copper rockfish, quillback rockfish, Puget Sound rockfish, lingcod, and juvenile gadids. Other species observed with the ROV were yelloweye rockfish, bocaccio, widow rockfish, greenstriped rockfish, tiger rockfish, black rockfish, yellowtail rockfish, and brown rockfish. Approximately 50 hours of videotape were collected during the survey. Review and analysis of the videotapes was completed at the end of the 2009. Initial results found 420,000 quillback rockfishes and 535,000 copper rockfishes occur in the SJA. Standard errors for these common species were less than 14%. A manuscript is being prepared describing the methods and population survey results.

d. 2010 ROV Stereoscopic Survey of the San Juan Islands

MFS staff planned and began a new ROV survey of the San Juan Archipelago during in fall of 2010 based upon the success of earlier ROV survey. The survey design was based on a stereoscopic approach, similar to a systematic survey, that aimed to survey all depth strata and habitats with one tool. The survey grid included 168 stations and also allowed for adaptive stations to be occupied when ESA listed rockfishes or high densities of rockfishes were observed. The goal is to produce population assessments for all benthic marine fishes occurring across all habitat types (i.e., rocky and unconsolidated seafloors). Stereoscopic statistical methods will be used to analyze the fish and habitat data. Results from the fish analyses will be compared those from a stratified habitat-based ROV survey of the SJI in 2008 and recent bottom trawl surveys to examine differences in density, species composition, and size produced by the different survey designs. Portions of the survey were also conducted at night and a 48 hour study was conducted over the same transect line every 6 six hours corresponding to slack current conditions. The survey began in late September and continued through the remainder of the year. In contrast to the 2008 survey, equipment problems and poor weather prolonged the survey into 2011.

e. Continued investigation of the 2006 Recruitment Event of Young-of-the-Year Rockfishes in Puget Sound

During 2010, MFS staff reoccupied dive sites surveyed in 2006 that documented a remarkable settlement of post-larval, young-of-the-year (YOY) rockfishes in the inland waters of Washington. As in 2007-2009, divers observed very few YOY rockfish at the eighteen index sites in Central and Southern Puget Sound in 2008. Large numbers of now 2+ year-old copper and quillback rockfish were observed on adult habitats adjacent to several of the nearshore YOY sites. Also in 2009, MFS staff observed what appears to be an immigration of 2+ year- old black rockfish to Puget Sound and the San Juan Islands. MFS staff hypothesize that these fish are emigrating from waters along the Washington coast and western Strait of Juan de Fuca where large numbers of juvenile pelagic rockfishes were observed during the 2006 recruitment event. Divers are also following the recruitment of copper and quillback rockfishes that occurred in 2008 in Hood Canal.

f. Low Dissolved Oxygen Conditions at Sund Rocks Marine Reserve

MFS investigated a minor fish kill in Hood Canal that occurred in late September 2010. Hood Canal is a fjord connected to Puget Sound in the north and extending 100 km to the south. 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, and these low concentrations have been attributed to naturally poor circulation resulting from low estuarine flow and bottom water replacement. Between 2002 and 2006, low DO concentrations have become chronic, extending into nearshore waters and possibly becoming worse due to eutrophication. Mass mortality events of fishes and invertebrates (Fish Kills) in 1926 and 1963 likely have resulted from poor water quality in this fjord naturally prone to hypoxia. Marine Fish Science staff has been conducting regular surveys at the Sund Rock Marine Reserve Site since 2001, with additional surveys conducted when extreme hypoxic conditions arise. Monitoring at this site by MFS staff continued in 2010 to detect potential impacts to fish populations inhabiting the local area.

During 2010, oceanographers did not observe any replenishment of bottom waters of Hood Canal with oxygenated waters from the Pacific Ocean. Dissolved oxygen in Hood Canal continued to decline during the spring summer in the deepest waters which was in contrast to previous patterns when the middle water was the first to become hypoxic. Unusual fish behaviors were observed in early September when near surface oxygen concentrations were at 2 mg/L. By mid September, near surface oxygen concentrations were near 1 mg/L and fish were concentrated near the surface. On September 21st, southerly winds advected surface waters to the north and upwelled hypoxic waters to the surface.

On 21 September at 0630 at Hoodsport, MFS staff observed dead and dying spotted prawns on the shore and thousands of prawns and fish swimming along the water's edge. We inspected beaches at Potlatch, the Cushman Boat Ramp, Hoodsport Public Beach to the Hoodsport Hatchery, and Sund Rock Conservation Area. We found hundreds to thousands of dead shrimp and hundreds of fishes among the sites. We received a report from a citizen that dead shrimp were on the beach just south of Lilliwap. As we drove to Lilliwap from Hoosport, we saw thousands of spotted prawn along many sections of beach, especially south of Sund Rock. We noted, as did Ron Filgar-Barnes of the Skokomish Natural Resources office, that many fish and prawns were found dead in freshwater inlets along the beach. He also reported that there were no obvious mortalities at Union. On 22 September, we inspected a beach 2 miles north of Hoodsport and found hundreds of dead fish and spot prawns from the previous day. Interestingly, most dead fish were intertidal and shallow gunnels, pricklebacks, and sculpins. While the prawns looked fresh, most were in the shade during the day and in relatively good condition from the previous' days mortality event.

On 21 September, we conducted on dive at the Sund Rock Conservation Area. On our offshore to onshore transect, we found virtually all fish were in depths less than 20'. Most fish were at the Grotto in extremely dense schools and aggregations exceeding several hundred. Most were resting on the bottom or just above it and were oriented into the current and showing obvious buccal respiration. Lingcod and wolf-eel were also showing marked respiration and most wolf-eel were completely out of their dens as were several octopus. We saw one dead blackeye goby.

At this time the oxygen minimum was 0.3 mg/L at 45' and was above 1 mg/L in waters shallower than 22'.

We documented 29 nominal species of marine fish and at least 3 species of invertebrates that perished during this fish kill. The occurrence of rockfish, lingcod, and wolf-eel in shallow water when oxygen concentrations are less than 2 mg/L in shallow water is consistent with our previous published work. The second day of the kill was more geographically extensive than the first day covering 5.7 miles of shoreline. We observed 880 dead fish and several thousand spotted prawns along the approximately one half mile of shoreline that we checked. This rough sampling rate suggests that 10,000 fish many more prawns died during this event. Most fish were deep-water and sand oriented species likely showing that the hypoxic waters caused these species to be displaced to shallow water as waters with depleted oxygen rose to the surface. In particular, blackbelly eelpout, greenstriped rockfish, Dover sole, and rex sole have not been previously documented in our list of species affected by hypoxia. The eel-like gunnels typical of intertidal and shallow subtidal depths also perished showing their vulnerability to hypoxic waters at the surface. Fortunately, only a few rockfishes suffered mortality, and the strong recruitment of copper and quillback rockfishes from 2008 still appears to be intact.

g. Bottom Trawl Surveys of Puget Sound

Since 1987, WDFW has conducted bottom trawl surveys in Puget Sound that have proven invaluable as a fisheries-independent indicator of population abundance for fishes living on unconsolidated habitats. These surveys have been conducted at irregular intervals and at different scales since 1987. Early surveys between 1987 and 1991 were synoptic surveys of the entire Puget Sound, later were stratified, random surveys focusing on individual sub-basins, and beginning in 2008 became synoptic again with stations at fixed sites.

From May th through June 11th, 2010, WDFW conducted a bottom trawl survey to assess the abundance of groundfishes in the inland marine waters of Washington (Puget Sound). The survey area was divided into Puget Sound's oceanographic basins including the Eastern and Western Strait of Juan de Fuca, San Juan Archipelago, Strait of Georgia, Whidbey Basin, Central Puget Sound, Southern Puget Sound, and Hood Canal. The goal of the survey was to detect long-term changes in abundance of fishes living on or near the bottom and to characterize the structure of the fish communities. The specific objectives of this survey were to estimate the relative abundance, species composition, and biological characteristics of groundfish species at pre-selected, permanent index stations. Key species of interest include Pacific cod, walleye pollock, Pacific whiting, English sole, spiny dogfish, and skates, but all species of fishes and invertebrates will be identified and recorded.

This survey was the third "Index" survey of Puget Sound, a departure from the stratified – random designs use prior to 2008. This new design is used to assess changes in the relative abundance of key groundfish species because reoccupying fixed stations will minimize the variation in sea floor and habitat and provide more powerful inter-annual comparisons. For the new survey design, we divided each oceanographic basin into two geographic components (north and south or east and west) for representative coverage. We selected previously trawled stations within each component area from pre-existing depth zones such that one station would be

occupied between depths of 30 to 240 feet, from 240 to 360 feet, and greater than 360 feet. Two replicate trawl samples were collected at each stations and were spaced several hundred meters apart to be close to each other but not directly over the first trawl location. We occupied 51 index stations during 2009 among eight oceanographic basins, two geographic component areas, and three depth zones (8 x 2 x 3). An additional set of three stations was planned for the central portion of Central Puget Sound to better represent this elongate basin.

While WDWF adopted a new survey design, the trawling procedure of the survey was similar to previous WDFW trawl surveys (Palsson et al. 2002, 2003). The 58-foot *F.V. Chasina* was the chartered sampling vessel, and it was equipped with an agency-owned 400-mesh Eastern bottom trawl fitted with a 1.25 inch codend liner. The net was towed at each station for a distance of 0.40 nautical miles at a speed of 1-3 knots, and the tows lasted approximately 12 minutes. Net openings ranged from 8 to 14 m depending upon depth and the amount of cable towing the net. The resulting catch was identified to species, weighed and enumerated, and most of the catch was returned to the sea. The density of fish at each station was determined by dividing the catch numbers or weight by the area sampled by the net. Some of the catch was taken for biological samples that were sampled on deck or preserved laboratory analysis.

During the 22 survey days, we occupied 51 stations and conducted 102 bottom trawls (Figure 1). Some 100,000 individual fish among 89 species weighing 14 mt were collected. Spotted ratfish, English sole, and walleye pollock were the most common species in the samples in terms of weight, but this year, Pacific cod were the eighth-most abundant species. The cod measured between 18 to 64 cm and averaged 28 cm in total length, corresponding to a fish beginning its second year of life. The cod were present in all basins and the pattern suggests a strong 2008 year class. The climate of 2008 was one of the coldest since the mid-1970s supporting the idea that for two decades, cod have been limited in abundance by a warm climate.

h. Marine Reserve Monitoring: Evaluation of No-Take Refuges for Rocky Habitat Fishes

WDFW has developed a system of 24 fully and partially protected marine reserves in Puget Sound, fourteen of which are significant for groundfish resources. As the system has expanded, MFS staff regularly monitors a core of the marine reserve sites on a frequent basis and visit other subtidal reserves on a periodic basis. This monitoring effort builds upon field research at many of these sites that was begun as early as 1986. The fieldwork consists primarily of scuba divers using standardized techniques to conduct visual censuses along a fixed strip transect at central Puget Sound sites or of the site “footprint” at south Puget Sound sites. Along with estimating fish density, divers measure individual fish, and in the case of lingcod, quantify nesting activity. Specific monitoring activities in 2010 included surveying a number of the Puget Sound reserves and comparable fished sites. Several reserves in central Puget Sound were visited six times during 2010 as an extension of a study initiated in 1995 that takes advantage of previous information collected at Orchard Rocks. Prior to 1998 when Orchard Rocks was declared a fully protected reserve, MFS staff conducted monitoring in 1986, 1987, and from 1995-1997. With the addition of a new fished-site treatment located 1 nm across the channel at Point Glover, the newly created Orchard Rocks refuge in a formerly monitored fished area provided MFS staff with an excellent opportunity to evaluate the before and after impacts of refuge creation with a comparable fished-site treatment. Monitoring at Zee’s Reef and Colvos Passage that began in

2002 continued with six surveys conducted in 2009. Several of the sites showed a marked increase in the number of 2+ year-old copper and quillback rockfish at most sites, although brown rockfish continue to be the dominant species at most of the central Puget Sound sites, whereas a more even distribution of the three species was seen at the southern sites.

MFS staff also conducted scuba surveys at established sites in San Juan channel to examine the nesting success of lingcod in marine reserve and fished areas. An analysis of the data collected in 2009 and in the past several years shows that lingcod at the marine reserve sites continue to be larger, more abundant, and have higher nest densities than fish at non-reserve (i.e., fished) sites.

h. Groundfish Trend Analysis

MFS staff began assembling historical catch and survey information to review the status of groundfish stocks in Puget Sound. Because inconsistent catch data have been collected over time lacking species composition, total catch, age composition, and other desirable attributes, demographic stock assessments and other population modeling are not possible for Puget Sound stocks. MFS began identifying and evaluating data limited techniques including DCAC, catch forecasting, and other trend analysis. The results will be ready in 2011.

i. Neah Bay Groundfish Management

The management of recreational and commercial groundfish fisheries were reviewed at the request of the Washington Fish and Wildlife Commission. The area lies east of Cape Flattery and west of the Sekiu area. The Washington Department of Fish and Wildlife (WDFW) held three public meetings during the summer of 2010 to discuss draft management alternatives and objectives for marine fish fisheries in the western Strait of Juan de Fuca. The draft proposals presented during the meetings were developed with input from an ad hoc citizen advisory group formed earlier this year and address recreational and commercial management of marine fish in waters stretching from the mouth of the Sekiu River west to the Bonilla-Tatoosh line in Marine Area 4 (Neah Bay). WDFW met with the ad hoc advisory group following the public meetings to discuss the comments received and to review additional material that WDFW staff developed in response to public input. Several alternatives to management were developed ranging from status quo to eliminating commercial fisheries for groundfish, reducing recreational catch limits and creating large marine reserves for bottomfish. New information added to the WDFW web site to provide more information on the members of the ad hoc focus group, more specific location information on the proposed closed areas and more habitat and biological information about the area under consideration. In addition to the new material, WDFW has revised Alternative 1 to include the proposed closure of commercial fisheries that have been inactive in the Neah Bay area. These commercial fishery closures were discussed with stakeholders during a separate process but were not originally included under the draft alternatives for public review.

The proposals and new information are available on WDFW's website at http://wdfw.wa.gov/conservation/fisheries/marinearea4/

WDFW staff briefed the Washington Fish and Wildlife Commission – a nine-member citizen panel that sets policy for department – on the revised alternatives and management objectives

during the commission's December meeting in Olympia. A public hearing on the draft proposals also occurred at the December commission meeting. WDFW accepted comments through December 4, 2010. The Commission will consider and act on the alternatives during it February 2011 meetiung.

j. Other Activities

Tony Parra initiated a collaborative effort to describe a newly observed ecological phenomenon of small sculpins cleaning inside the mouths of lingcod. During surveys of marine reserves where larger lingcod are more common, WDWF divers have observed lingcod with their mouths agape. Further observations and photography found several species of sculpins inside the mouths or on the heads of the lingcod. While cleaner fish ecology has been described in several coral reef communities, the possible occurrence of these relationships in cold temperate communities underscores the subtle ecosystem relationships that need to be understood for ecosystem management.

Wayne Palsson was invited to an experts' workshop evaluating the impacts and methods to monitor tidal energy generation in the United States. This workshop was sponsored by the Department of Energy, Battelle Northwest, and the University of Washington. With the development of a pilot tidal energy project in Admiralty Inlet, the was an impending need to identify issues and approaches to monitoring prior to the initiation of the project. The proceedings documenting knowledge to date, rating potential impacts, and methods to monitor impacts is forthcoming.

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

Annual herring spawning biomass was estimated in Washington in 2010 using spawn deposition surveys. WDFW Fish Program staff based in the Mill Creek, La Conner, and Point Whitney offices currently conduct these assessment surveys of all adult herring stocks in Washington's inside waters annually. Stock assessment activities for the 2011 spawning season are in progress.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2010 is 7,960 tons (see table below). The cumulative total is a considerable decrease from the 2009 total of 13,423 tons, less than half the recent peak of 17,765 tons in 2006, and also less than the mean cumulative total for the previous ten year (2000-2009) period of 14,115 tons.

The combined biomass of south/central Puget Sound (including Hood Canal) stocks in 2010 of 5,400 tons was the lowest estimated cumulative spawning biomass for this region since 1992. Cumulative biomass of north Puget Sound stocks, excluding the Cherry Point stock, in 2010 remained at a low level of abundance with a slight increase compared to 2009. The spawning biomass of the Cherry Point stock continued a negative trend in abundance in 2010, estimated to be only 774 tons, the lowest on record since estimates began in 1973. Estimated herring spawning activity for the Strait of Juan de Fuca region was also down in 2010, with an estimated spawning biomass of only 101 tons.

PUGET SOUND HERRING SPAWNING BIOMASS ESTIMATES (SHORT TONS) BY STOCK AND REGION, 2001-2010

	YEAR									
	2010	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Squaxin Pass	510	817	1025	557	755	436	828	2201	3150	1597
Purdy	500	125	496							
Wollochet Bay	11	359	45	35	27	67	52	152	106	133
Quartermaster Harbor	143	843	491	441	987	756	727	930	416	1320
Port Orchard-Port Madison	350	1755	1186	1589	2112	1958	700	1085	878	2007
South Hood Canal	214	156	223	70	244	210	176	207	166	187
Quilcene Bay	2012	3064	2531	2372	2530	1125	2342	916	2585	2091
Port Gamble	433	1064	208	826	774	1372	1257	1064	1812	1779
Kilisut Harbor	0	0	0	24	54	170	184	448	774	612
Port Susan	152	251	345	643	321	157	429	450	775	587
Holmes Harbor	673	1045	686	572	1297	498	673	678	573	275
Skagit Bay	402	1027	1342	1236	2826	1169	1245	2983	2215	2170
South-Central Puget Sound Total	5400	10506	8578	8365	11927	7918	8613	11114	13450	12758
Fidalgo Bay	103	15	156	159	323	231	339	569	865	944
Samish/Portage Bay	649	320	409	348	412	218	351	299	496	470
Int. San Juan Is.	24	0	60	33	285	41	67	72	158	219
N.W. San Juan Is.	0	0	0	0	0	0	0	13	131	62
Semiahmoo Bay	909	990	662	1124	1277	870	629	1087	1012	1098
Cherry Point	774	1341	1352	2169	2216	2010	1734	1611	1330	1241
North Puget Sound Total	2459	2666	2639	3833	4513	3370	3120	3651	3992	4034
Discovery Bay	26	205	248	42	1325	33	252	207	148	137
Dungeness/Sequim Bay	75	46	69	34	0	0	22	44	131	93
Strait of Juan de Fuca Total	101	251	317	76	1325	33	274	251	279	230
Puget Sound Total	7960	13423	11534	12274	17765	11321	12007	15016	17721	17022

3. Puget Sound Ambient Monitoring Program (PSAMP) *(Contact: Jim West 360- 902-2842, James.West@dfw.wa.gov)*

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.

B. Coastal Groundfish Monitoring, Research, and Assessment (*Theresa Tsou 360-920-2855, tien-shui.tsout@dfw.wa.gov; Farron Wallace 360-902-2712, Farron.Wallace@dfw.wa.gov) Marine Fish Science Unit*

Staff of the coastal Marine Fish Science (MFS) Unit includes Farron Wallace, Henry Cheng, Lorna Wargo, John Pahutski, Bob Le Goff, Donna Downs, Victoria Okimura, and Brian Walker. Unit tasks are primarily supported by the combination of state general and federal funds. The main activities of the unit include the assessment of groundfish populations off Washington coast, the monitoring of groundfish commercial landings, and the tagging project.

1. Black Rockfish Tagging Study (*Contact: Farron Wallace, 360-902-2712, Farron.Wallace@dfw.wa.gov; Lorna Wargo 360-249-1221, Lorna.Wargo@dfw.wa.gov*)

During 2010, a Washington Department of Fish and Wildlife Progress report "Summary of the Coastal Black Rockfish Tagging program" was completed. This report compiled nearly 30 years of black rockfish tagging studies, and is intended to serve as a key reference document describing changes in research objectives and methods that evolved over time as research built upon earlier studies.

In Washington State, the first black rockfish tagging project began in 1981. Since then, there were several major changes to objectives and scope of the project. These changes were reflected in the distribution of tagging effort over time. Between 1981 and 1985, black rockfish were tagged and released in selected areas located within the usual recreational fishing areas off the ports of Ilwaco, Westport and Neah Bay aboard both Department and recreational charter vessels. Between 1986 and 1990, an effort was made to allocate tagging effort in a random fashion throughout coastal waters fished by the Washington recreational fleet. Beginning in 1998, the study area was constrained to the central Washington coast in areas within the operation range of the Westport Charter. Between 1998 and 2000, distribution of tagging effort was based on the knowledge of the charter vessel captain and tagging crew to distribute tags "proportionally" to the resource in this area. In an effort to formalize methods and provide greater consistency in effort distribution through time, rocky habitat was identified and geo-referenced. Beginning in 2001, using this information, tagging effort was weighted proportionately and distributed relative to the amount of rocky habitat found in each 2-degree latitudinal block.

Tag release and recovery statistics reflected changes in research goals, objectives, and funding in both number of releases and in spatial distribution of the tagged fish releases. Between 1981 and 1990 a total of 52,042 fish were tagged with three-inch Floy FD-68B T-end spaghetti anchor tag of which 1,962 were recovered. In the early part of the study (1981-1985) tag recoveries were entirely dependent on voluntary returns. A catch sampling program was initiated in 1986 and continued through 1992 in an effort to recover tagged black rockfish from both the recreational and commercial fishery. Tagged black rockfish were also recovered through voluntary returns. Although the catch sampling program ended in 1992, voluntary returns continued through 1997. Beginning in 1998, fish were internally tagged with Code Wire Tags (CWT) or Passive Integrated Transponder (PIT) tags. A catch sampling program was again initiated to sample

recreational catch for tags caught from the central Washington coast. Because these tags are not visible, there are no voluntary recoveries.

Tagged black rockfish have been part of the recreational catch for nearly three decades with some tagged fish recovered after more than 15 years at large. As a consequence of tag loss, fishing and natural mortality, and immigration and emigration tags from all release groups show a significant declining recovery rate through time. Although, the largest proportion of tag recoveries occurred near the area of release, data clearly show that tag recoveries could occur at extended distances from the release area. However, there was a declining tag recovery trend with increasing distance from release area.

Although tagging objectives and methods have varied through time, tagging information has provided key information to determine population dynamics for the Coastal Washington black rockfish stock located between Cape Falcon, Oregon and Cape Flattery, Washington. Continuation of a data collection program that measures biomass or population trends such as the current tagging program is essential for monitoring the health of this important coastal resource and for supporting future stock assessment of this species. Much consideration has been taken to ensure proper evaluation of these data. Importantly, changes in spatial and temporal distribution of tag releases and the spatial-temporal changes in the fisheries need to be considered for proper interpretation of tag recovery rates and movement patterns.

The black rockfish tagging program was last reviewed in 2008 based on program costs and its efficacy in providing information needed for sustainable ecosystem management. An overall conclusion was that there was an urgent need to develop a long term monitoring program with greater spatial extent for multiple fish species to support Washington State fisheries management. The review recommended the use of fixed stations for capture and recapture of all fish species along the entire Washington coast using PIT tags. The experiment was first conducted in spring of 2009 and will continue through 2012 when an evaluation and comparison of study results will be preformed. The new study design is hoped to provide unbiased biological information on spatial movement and growth for multiple fish species commonly caught in the recreational fishery. It will also improve validity and reliability of estimates on abundance trends. Current protocols for tag release and recovery will continue.

2. Underwater Remotely Operated Vehicle Survey *(Contact: Farron Wallace, 360-902-2712, Farron.Wallace@dfw.wa.gov)*

Information from the WDFW/ International Pacific Halibut Commission (IPHC) cooperative survey has been incorporated into the Pacific Fishery Management Council's yelloweye rockfish stock assessment since 2001. Unfortunately, the survey catch rate information has varied substantially among years making the population trend information difficult to interpret. In an effort to better understand IPHC survey covariates, WDFW conducted a video survey of IPHC rockfish stations located off the Washington coast. The objectives of the survey were to gather data to establish habitat associations and explore catch rates of rockfish across time and area using ROV survey technology. This information will improve our knowledge and capability to develop a more efficient and cost effective way to survey rockfish populations in areas not

accessible to traditional survey techniques and do not induce mortality. A long-term no-take monitoring survey program will significantly contribute to rockfish population status determination. These data will inform stock assessments that will in turn inform fishery managers to develop effective management measures to promote conservation of this valuable living resource.

We made over 2,300 fish observations of 36 species or species groups, fifteen of which were rockfish. Rockfish were encountered most frequently and found in highest density on most transects relative to other species. Several invertebrates such as sea urchins and feather stars were encountered most frequently and had highest densities among all other invertebrates. The primary habitat found among transects was gravel and sand as secondary habitat interspersed with boulders that were found in stacked piles or scattered. Many of the rockfish species including yelloweye, rosethorn, sharpchin/stripetail grouping, tiger, canary and yellowtail rockfish were found largely associated with or near boulder habitat.

Our study suggested that there may be diurnal effects on the relative survey abundance for a number of rockfish species. For canary, unidentified juvenile rockfish, unidentified adult and rosethorn rockfish we found higher survey abundance during day light hours compared with nighttime. For sharpchin/stripetail rockfish we found highest abundance at dawn and dusk. However, due to the low number of observations for many other rockfish or other groundfish species it was difficult small to draw conclusion. Yelloweye rockfish, tiger rockfish, yellowtail rockfish, lingcod, sculpin and unidentified flatfish density was variable and without apparent diurnal pattern.

Visual survey methodology has a number of advantages and disadvantages for surveying rockfish, which have been well chronicled in this study and elsewhere. Some of the disadvantages include: 1) difficulties in fish identification, particularly for small fish or fish with cryptic coloration, 2) the potential for attraction or repulsion from the submersible, 3) variation in detection due to habitat type; for example, due to reduced visibility when the submersible maneuvered off bottom to avoid large boulders, or the failure to detect fish hiding behind boulders, 4) possible bias in collecting length measurements and 5) the limitation of the technique to quantifying the density of benthic species found in close proximity to the bottom. The advantages of the technique include the ability to: 1) sample in habitats that are inaccessible to other survey methods, 2) observe in-situ fish behavior, and 3) observe the distribution of fish and fish-habitat associations on a fine scale. It is also particularly valuable where additional mortality is not compatible with conservation for species and/or for species poorly sampled by trawl gear, such as yelloweye rockfish.

Given limited funding, expense is a major consideration in developing any groundfish survey. We found that costs associated with this survey were at least five times more expensive than the traditional longline survey methods for surveying the same nine study sites (IPHC rockfish stations) that were examined in this study. In the future, however, these costs could be substantially reduced by employing smaller vessels and crew than that used in this survey. This approach has been previously demonstrated to be effective by WDFW which recently completed several small-vessel ROV surveys near the San Juan Islands in Puget Sound. It is unclear how effective this approach would be in coastal waters given more extreme weather conditions and

survey depths are greater than 60 fathoms. If no-take surveys are required we should must consider exploring less expensive ROV survey approaches and/or other no-take survey methods such as self-releasing pots.

This study has demonstrated that visual transect surveys could provide a unique no-take alternative method for estimating rockfish biomass in habitats not accessible to conventional survey tools. Whatever survey method is applied it is clear that relatively large-scale no-take surveys are needed to assess bottomfish densities in habitats that are not accessible to trawl survey gear. The low density and patchy distribution of yelloweye and many other rockfish species must be taken into consideration for developing a meaningful abundance time series that will be responsive to changes in abundance and useful to population dynamics models. Further study among several study sites and habitats will be required to better inform development of survey methods and measure the degree of possible bias associated with diel movement and avoidance behavior. Additionally, research that provides insight into the seasonal and/or social behavior patterns associated with prey or mating will be necessary to fully understand or interpret abundance estimates. Standardization will be required for any bottom tending survey gear such as video, setlines, pots or trawl. Because most groundfish species are habitat-specific in their distribution, careful survey design will be necessary to ensure precise and unbiased estimates of abundance. If direct observation surveys such as the present study were conducted on a routine basis, a time-series of yelloweye rockfish density data could be used to develop an index of the trend in abundance. Such an index would be indispensible information that could be incorporate into a demographic model of the yelloweye rockfish population for stock assessment analysis.

3. Stock assessment on data poor fisheries *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

MacCall (2009) proposed a depletion–corrected average catch (DCAC) method to estimate the sustainable yield of data-poor fisheries. The distribution and the expectation of sustainable yield from this method is currently estimated and bias corrected from simulation, requiring assumptions for total catch of the time series, and the independent normal distributions of relative decline in abundance, tuning adjustment, and natural mortality rate. In the proposed analytical DCAC method, uncertainty stemming from variation in the annual catch series is incorporated into the DCAC method to correct the estimates of sustainable yield uncertainty. It can correct the bias of the estimate of sustainable yield analytically without simulation. The distribution and expectation of sustainable yield are derived from a Taylor series approximation. Both DCAC simulation and the proposed analytical method results agreed well with each other in two examples from redfish and widow rockfish fisheries. Variation in annual catch does not affect the DCAC expectation but does affect the probability density of sustainable yield distribution. An advantage of the proposed method is that it can identify the proportion of the variance from each random variable. The proposed method can assist stock assessment experts in developing reasonable assumptions for the distribution of natural mortality. Thus, it can help fisheries scientists better understand the DCAC method and develop statistically defensible assumptions for managing data poor fisheries.

Publication:

Cheng, Y.W. 2011. Correcting bias and estimating uncertainty in sustainable yields from the depletion-corrected average catch (DCAC) method, WDFW research report series, in press.

4. Forecasting method on data poor recreational fisheries in Pacific Coast *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

For numerous, small, data-poor recreational and commercial fisheries in Washington State, and similar fisheries around the world, there is a need for alternative, low cost stock assessment and catch forecasting tools to enable fisheries management performance indicators to be developed. Seasonal autoregressive integrated moving average (SARIMA) models are proposed to model the monthly catch of six data-poor and one data-rich recreational rockfish fisheries off the coast of Washington State. The forecasting results of the black rockfish catch in 2009-2011 agree with the forecasting results of existing abundance forecasting trends from Stock Synthesis II model. Both black and blue rockfish fisheries monthly catches are significantly ($P<0.05$) correlated with previous monthly catch, as observed from the fitted autoregressive parameters. Monthly catch from fisheries on all seven rockfish species are affected by the previous catch within the same year, as observed from the fitted moving average parameters. Yellowtail and blue rockfish fisheries catches are affected by the number of boat trips, but this is not true for fisheries on the other five species. The estimated seasonal moving average parameters imply that both copper and yellowtail rockfish fisheries are difficult to rebuild if they are over-exploited. Comparison of the annual forecasted catch based on SARIMA and traditional time series models shows that monthly catch should be used to model with SARIMA if data is available. From the model validation results, SARIMA model can be an alternative, low cost and reliable forecasting tool for both data rich and poor fisheries.

Publication

Cheng, Y.W. 2011. Predicting the catch of data-poor recreational rockfish fisheries off the coast of Washington State using SARIMAX models, WDFW report series, under external review.

5. Aging method of spiny dogfish *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

North Pacific spiny dogfish (S*qualus suckleyi*, Girard 1854) are aged with annuli count on the second dorsal spine. As this spine grows, enamel at the distal tip is worn away producing a zone of missing annuli. Sixty-seven male and 115 female dogfish specimens were randomly selected from captured specimens taken off the Washington coast in 2005-2006 and their fork lengths measured and spines taken. For the second dorsal spine from each specimen, five measurements were recorded. These measurements permit the estimation of the missing annuli count before the "no wear point" based on the known statistical distribution of annuli count after the "no wear point." Three diameter measurements were then modeled with nonlinear mixed effects (NLME) models that treated the number of missing annuli count as random effects. Resulting models were compared against Ketchen's (1975) "no wear point" method. The estimated missing annuli count and the measured spine base diameter fits well with the assumptions of an existing von Bertalanffy growth curve for this species. Ketchen's method produced an apparent underestimate

of the mean missing annuli count for all dogfish with spine diameter at the no wear point less than 1.2 mm and greater than 4.6 mm. The NLME models provide an alternative method to estimate the missing annuli count of north Pacific spiny dogfish based on both sound biological and statistical properties.
At present, we have implemented the proposed statistical aging methods of the mussing annuli count in North Pacific spiny dogfish on all the data since 2005.

Publication:
Cheng, Y.W. 2011. Modelling the missing annuli count in North Pacific spiny dogfish (S*qualus suckleyi*) by nonlinear mixed effects models, International Journal of Applied Mathematics and Statistics, *in press*.

6. Inverse prediction in length-length conversion *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

Inverse prediction is a common method used in ecology, marine fish stock assessment, forest research, and many other biological fields. It is unlikely, however, that inverse prediction is unbiased if data is not available for refitting. I propose an inverse prediction method to estimate the linear regression coefficient in the absence of an intercept, along with 95% confidence intervals. The proposed method uses the linear regression estimate, its standard deviation, and basic data statistics. The proposed method provides results closer to actual known values and can also estimate the variance of the slope of inverse regression.

The proposed method has been used to obtain the fork length and total length conversion of spiny dogfish.

Publication:
Cheng, Y.W. 2010. Inverse prediction for fish length-length conversion, Fisheries Research, 106:112-114.

7. Stereological sampling protocol *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

Stereology is a spatial version of sampling theory. It was initially developed in biology and materials science as a quick way of analyzing three-dimensional solid materials from information visible on a two-dimensional plane section through the material. Stereological methods are almost “assumption free”. This means we do not need know the spatial distribution of habitats within the target survey area. In addition, it may be bias, inaccurate or change with time. Examples from Monte Carlo integration of a surface with points generated by random and systematic sampling are given. Extension to high dimensions, e.g., the spatial and diurnal scale in fisheries and salmon redd survey, are provided. Comparison of the assumptions and restrictions of fishery and stereological survey samplings are discussed. Edge effect and bias correction are illustrated with fishery examples, IPHC longline rockfish survey and groundfish bottom travel survey. With the combination of stereology and other existing survey methods, e.g., stratified sampling or adaptive sampling, it can provide extra unbiased spatial survey

designs that can help fishery managers and scientists to reduce the transportation cost and staff time.

This new proposed has been applying to Pacific euchelon and Puget Sound rockfish ROV sampling.

Publication:
Cheng, Y.W. 2011. An alternative sampling approach for spatial fishery survey based on stereology. *In* Quinn, T.J., II, Ianelli, J.N., Cadrin, S.X., Wespestad, V., and Barbeaux, S.J. Report on a Workshop on Spatial Structure and Dynamics of Walleye Pollock in the Bering Sea, Seattle WA, July 2009. NOAA Processed Report, in press.

8. Collection of juvenile rockfish *(Contact: Yuk Win Cheng 360-902-2689, chengywc@dfw.wa.gov)*

Some populations of rockfish (*Sebastes*) species in the Puget Sound have been listed as Species of Concern by the State of Washington or under the US Federal Endangered Species Act, but very little is known about juvenile rockfish settlement and abundance trend, or their interaction with other fish species in Puget Sound. For fishery managers to develop management practices that accelerate the recovery of over-fished areas they need an understanding of the spatial and temporal trends in juvenile rockfish distribution and abundance as well as cost-effective recruitment monitoring techniques.

In 2005, a pilot experiment was conducted by the Washington Department of Fish and Wildlife to collect juvenile sea cucumber *(Parastichopus californicus*). The collector (Cheng and Hillier, 2011) is made of a commercial of oyster cultch bag filled with Pacific oyster (*Crassostrea gigas*) shell. Accidentally, we collected 11 juvenile rockfish and their sizes ranged from 45 m to 70 mm. From the collection results, it is clear that location, depth, and substrate influence the settlement of juvenile rockfish. The proposed collector can be used as a cost effective tool to define rockfish nursery areas and in addition, oyster shells can possible be used to enhance rockfish habitat. Further experimental design was suggested to test the effectiveness of different type of collectors.

Publication:
Cheng, Y.W. and Hillier, L. (2011). Use of Pacific oyster *Crassostrea gigas* (Thunberg 1793) shell to collect juvenile sea cucumber *Parastichopus californicus* (Stimpson 1857), *Journal of Shellfish Research*, 30:1-5.

9. Study of Eulachon Smelt (Thaleichthyus pacificus) off the coast of Washington State to Determine Bycatch Reduction Strategies in the Shrimp Trawl Fishery
(*Contact: Lorna Wargo 360-249-1221, Lorna.Wargo@dfw.wa.gov*)

In 2010 the National Marine Fisheries Service listed the southern DPS (Distinct Population Segment) *Thaleichthyus pacificus*, also known as "eulachon" as threatened under the Endangered Species Act. Bycatch of eulachon in commercial fisheries, including the Washington ocean shrimp (*Pandalus jordani*) trawl fishery was identified as a moderate threat to

the eulachon population. Bycatch rates of eulachon in the Washington ocean shrimp trawl fishery are unknown. Limited data exists for eulachon bycatch in the Oregon and California shrimp trawl fisheries through their participation in the National Marine Fisheries Service's West Coast Groundfish Observer Program, and from Oregon evaluations of biological reduction devices (BRD).

Landings in the Washington ocean shrimp trawl fishery have declined over the past two decades, however, the fishery has provided a relatively stable opportunity compared to other commercial trawl fisheries during this time. Management of the shrimp trawl fishery is achieved through a fixed season with rules governing mesh size, shrimp size, and BRD's. The trawl fleet operates out of two coastal ports and supports processors in each. The average annual total direct value of the fishery is about $3 million and whereas, the average direct value to individual fishers was about $60K up to 2000, since then the average has been over $100K per fisher due to the declining numbers of participants. In 2008, the direct value per fisher was approximately $200K. Closing the data gap will allow fishery managers to better understand and estimate bycatch in the shrimp trawl fishery. This information is important to ensure conservation needs for eulachon and other species are met while reducing the potential for lost fishing opportunity. Specifically, this project seeks to determine the rate of catch of non-targeted species including eulachon in the Washington ocean-shrimp trawl fishery and collect eulachon for biological and genetic sampling.

Observers will be deployed from Westport and Ilwaco, Washington to observe onboard Washington licensed shrimp trawl vessels engaged in routine commercial fishing activity. For each trip during the fishery season, Washington licensed shrimp trawlers will be required to notify WDFW at least 24-hours in advance of leaving port. A dedicated cell phone will be used for this purpose and monitored by the project assistant. The project lead will schedule observer coverage for selected vessels. Since the number of active vessels can vary considerably weekly and monthly, selection for observer coverage will be on an opportunistic basis. Observers will be deployed on vessels in the order that notification is received and cycle through the fleet within constraints posed by over-time schedule limits, safety concerns or other factors.

Data will be collected to allow stratification by a variety of characteristics. Data collected by observers will include fish ticket numbers for each trip; and for each tow: location, depth, vessel speed, start and end time, estimated total catch weight, weight of discard by category, species composition of discard categories, weight of shrimp retained, weight of fish retained by category, catch of prohibited or protected species, and biological and genetic samples of eulachon**.** To the extent possible, at-sea data collection protocols will follow those outlined in the NMFS West Coast Groundfish Observer Program Manual.

To date, the project lead and four observers have been hired, undergone training and are ready to be deployed. Preseason meetings, one an Ilwaco and one at Westport were held with shrimpers to review project objectives and requirements. The pink shrimp fishery season opened April 1, but due to inclement weather and an initial strike by shrimpers for a better price, no fishing has yet occurred from Washington ports.

C. Coastal Groundfish Management *(Contact: Corey Niles, 360-249-1223, Corey.Niles@dfw.wa.gov), Intergovernmental Resource Management*

Activities Related to Pacific Fishery Management Council

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.