Washington Contribution to the 2016 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2015-April 2016

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I. Agency Overview

The WDFW Marine Fish Science (MFS) Unit is broadly separated into two groups that deal with distinct geographic regions, though there is some overlap of senior staff. Staff of the Puget Sound Marine Fish Science (PSMFS) Unit during the reporting period included Dayv Lowry, Robert Pacunski, Larry LeClair, Todd Sandell, Jen Blaine, Adam Lindquist, Lisa Hillier, Andrea Hennings, Mike Burger, Jim Beam, Casey Wilkinson, Chris Fanshier, Will Dezan, Amanda Philips, Phil Campbell, and Erin Wright. In addition, Courtney Adkins and Peter Sergeeff work as PSMFS employees during the annual spring bottom trawl survey. The PSMFS Unit is also overseen by Theresa Tsou and supported by Phil Weyland (programming and data systems) and Kari Fenske (statistics and stock assessment).

Unit tasks are primarily supported by supplemental funds from the Washington State Legislature for the recovery of Puget Sound bottomfish populations, and secondarily by a suite of collaborative external grants. The main activities of the unit include the assessment of bottomfish and forage fish populations in Puget Sound, the evaluation of bottomfish in marine reserves and other fishery-restricted areas, 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) and management has become increasingly sensitive to the ESA-listing of canary and yelloweye rockfish, and bocaccio, in Puget Sound since 2010 (National marine Fisheries Service 2010).

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Puget Sound Ecosystem Monitoring Program (PSEMP) *(Contact: Jim West 360-902-2842, james.west@dfw.wa.gov)*.

Staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Lorna Wargo, Brad Speidel, John Pahutski, Bob Le Goff, Brian Walker, Donna Downs, Jamie Fuller, and Vicky Okimura. Seasonal and project staff include Michael Sinclair, Robert Davis, Jennifer Simpson, Grace Thornton, and Kristen Hinton. Unit tasks are supported through a combination of state general and federal funds. Long-standing activities of the unit include the assessment of groundfish populations off Washington coast, the monitoring of groundfish commercial landings, and the rockfish tagging project. More recently, unit activity has expanded to include forage fish management and research. The CMFS Unit is also overseen by Theresa Tsou and supported by Phil Weyland and Kari Fenske.

The MFS Unit contributes technical support for coastal groundfish and forage fish management via participation on the Groundfish Management Team (GMT), the Coastal Pelagics Management Team (CPSMT), 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 and the CPSMT in the Stock

Assessment and Fishery Evaluation (SAFE) document. Additional regional fishery management support is provided by Michele Culver, Corey Niles, Heather Reed, and Carol Henry.

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Groundfish Management, Monitoring, Research, and Assessment (*Contact: Theresa Tsou 360-902-2855, tien-shui.tsou@dfw.wa.gov; Lorna Wargo 360- 249-1221 lorna.wargo@dfw.wa.gov; Corey Niles, 360-249-1223, corey.niles@dfw.wa.gov), Regional Fisheries Management)*.
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II. Surveys

Puget Sound Bottom Trawl – Since 1987, WDFW has conducted bottom trawl surveys in Puget Sound—defined as all marine waters of the State of Washington east of a line running due north from the mouth of the Sekiu River in the Strait of Juan de Fuca—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 their initiation. Surveys in 1987, 1989, and 1991 were synoptic surveys of the entire Puget Sound. From 1994-1997 and 2000-2007, surveys were annual, stratified-random surveys focusing on individual sub-basins. Starting in 2008, surveys became synoptic again, sampling annually at fixed index sites throughout Puget Sound.

The specific objectives of the annual "Index" trawl survey are to estimate the relative abundance, species composition, and biological characteristics of bottomfish species at pre-selected, permanent index stations. Key species of interest include Pacific Cod, Walleye Pollock, Pacific Whiting (Hake), English Sole, North Pacific Spiny Dogfish, and skates, but all species of fishes and invertebrates are identified and recorded. For the "Index" survey, the study area is subdivided into eight regions (eastern Strait of Juan de Fuca, western Strait of Juan de Fuca, San Juan Islands, Gulf of Bellingham, Whidbey Island sub-basin, central Puget Sound, Hood Canal, and South Puget Sound) and four depth strata ("S"= 5-20 fa, "T"= 21-40 fa, "U"= 41-60 fa, "V"= >60 fa), and 51 index (fixed) stations throughout the study area are sampled each spring (late April-early June) (Figure 1).

These index stations were originally selected from trawl stations sampled during previous trawl survey efforts at randomized locations throughout Puget Sound. Station selection was based on known trawlability and other logistical concerns and was informed by previously obtained biological data. Stations are named using a four-letter system with the first two letters designating the region, the third letter indicating the sub-region, or position within the region (north, south, mid), and the final letter designating the depth stratum. The index stations have remained relatively consistent since 2008, with a few exceptions: starting in 2009, 5 stations were added to make the current 51-station design; in 2012 and 2013, stations in the shallowest stratum (S) were not surveyed because of concerns from NOAA about impacts to juvenile salmonids; and in 2014 and 2015, stations JEWU and CSNV, respectively, were moved slightly to accommodate concerns raised by fiber-optic cable companies.

The trawling procedure of the survey has remained largely consistent. The 57-foot F/V CHASINA is the chartered sampling vessel, and it is equipped with an agency-owned 400-mesh Eastern bottom trawl fitted with a 1.25 inch codend liner. The net is towed at each station for a distance of ~0.40 nautical miles at a speed of 1-3 knots, and the tows last approximately 11

minutes. The resulting catch is identified to the lowest taxonomic level possible, weighed, counted, and most of the catch is returned to the sea. The density of fish at each station is determined by dividing the catch numbers or weight by the area sampled by the net. Some of the catch is taken for biological samples that are sampled on deck or preserved for laboratory analysis.

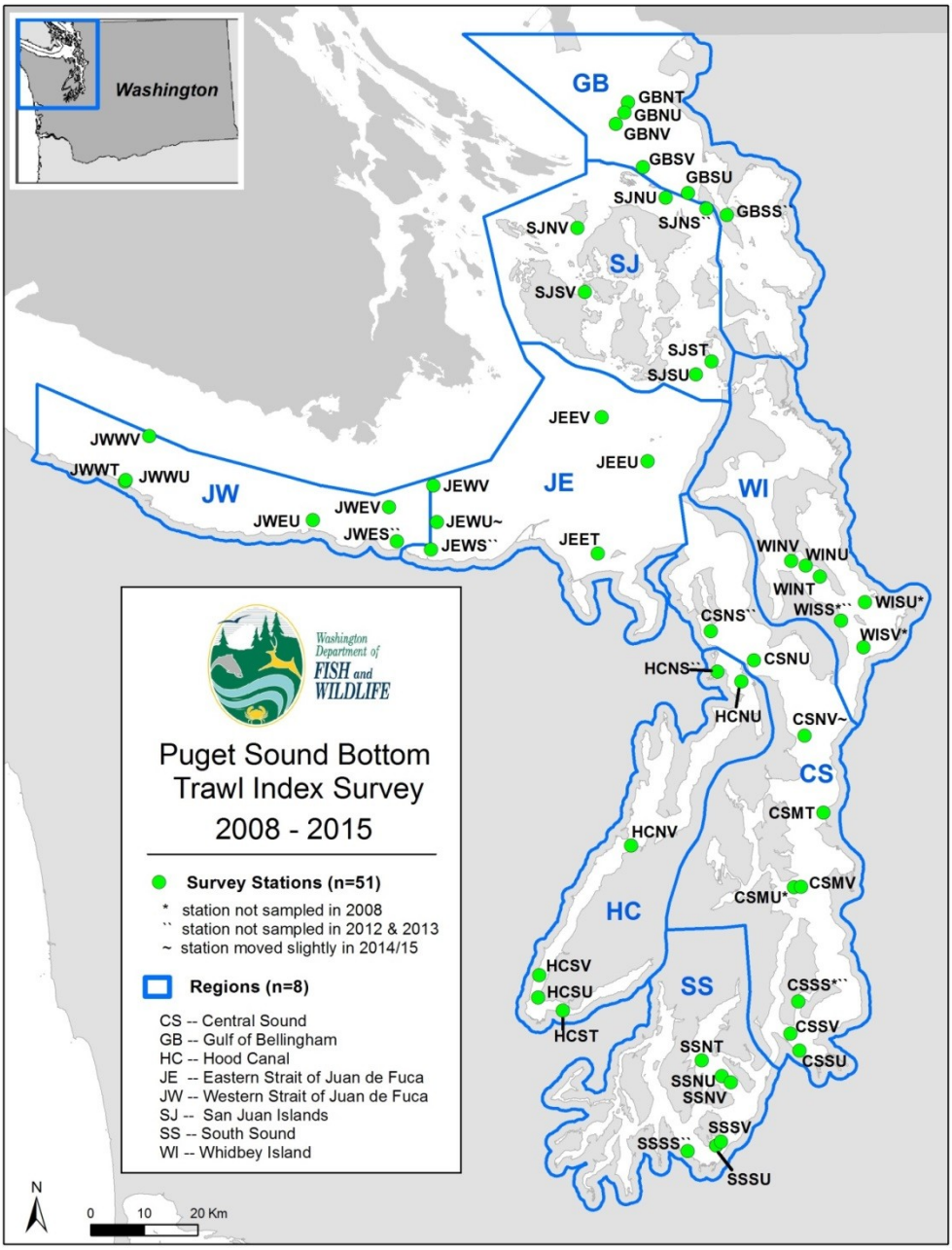

Figure 1. Trawl site locations for the Index survey design sampled in 2015

From 2008 to 2013, two trawl samples were collected at each station and were spaced several hundred meters apart to be close to each other but not directly overlapping. However, based on the similarity of catches in these paired tows at most stations, and in the interest of minimizing bottomfish mortality associated with the trawl survey, we altered our protocol in 2014. After the first tow is completed, the processed catch is compared to the average catch at that station since

2008. If the species comprising the majority (>75% by weight) of the tow falls within the previous years' average, no second tow is conducted at that station. If it is determined that the species composition was substantially different than expected, only then is a second tow conducted. This greatly improved the efficiency of the survey, as only 6 stations in 2014 and 4 stations in 2015 required a second tow. This newly gained efficiency has allowed us to institute two new sampling programs: vertical plankton tows, and gastric lavage/stomach collection on large predatory species (Pacific Cod, Spiny Dogfish, Lingcod, Walleye Pollock, Pacific Whiting/Hake). We also included the addition of bottom-contact sensors to the footrope to improve our understanding of net performance and increase the accuracy of density estimates from the trawl, and a mini-CTD on the headrope to collect water quality data at each trawl station and provide more accurate depth readings.

In 2015, WDFW conducted the 8th Index trawl survey of Puget Sound from April 27 through June 1, splitting boat time with PSEMP's biennial trawl survey. During our 14 survey days, we occupied all 51 stations and conducted 55 bottom trawls. An estimated 20,300 individual fish among 77 species weighing 7.7 mt were collected (2014: 25,700 fish; 78 species; 7.8 mt). Similar to 2014, Spotted Ratfish constituted 57% of the total fish catch by weight and 25% of the total number of individual fish, followed by English Sole at 17% and 23%, respectively. The remaining fish species contributed 5% or less to the fish catch weight and 7% or less to the total number of individual fish. For invertebrates, an estimated 9,500 individuals from 67 different species/taxa weighing 1.8 mt were caught in 2015, compared to 10,800 individuals from 76 species/taxa weighing 1.7 mt caught in 2014. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 46% and 20% of the total invertebrate catch weight. By number of individuals, Alaskan Pink Shrimp and Dungeness Crab comprised 25% and 15%, respectively, of the invertebrate catch. The remaining species contributed 9% or less to the total invertebrate catch by weight or by number.

Pacific Eulachon was the only confirmed ESA-listed species encountered during the 2015 survey; 24 individuals were caught (up from 6 in 2014), and genetic samples were collected for each in accordance with the Section 10 permit for the trawl survey. One juvenile rockfish that was tentatively identified as a Canary was also caught; a genetic sample was collected and will be used to confirm identification.

Catches of three key Gadiformes species decreased in the 2015 survey compared to the 2014 survey: Pacific Cod, Walleye Pollock, and Pacific Whiting (Hake). In 2015, we caught 43 individual Pacific Cod weighing a total of 75 kg, compared to 2014's 88 individuals totaling 86 kg. Similar to previous years, Pacific Cod were primarily found in the western Strait of Juan de Fuca; in fact 65% of the total number of cod was caught at just one station north of Port Angeles. Walleye Pollock catch in 2015 consisted of an estimated 810 individuals weighing a total of 114 kg, compared to 1460 individuals totaling 277 kg in 2014. The steepest decline occurred in the western Strait of Juan de Fuca, in which our pollock catch dropped 97% by both weight and number. Lastly, Pacific Whiting (Hake) catch decreased from an estimated 1557 individuals weighing a total of 72 kg in 2014 to 450 individuals totaling 25 kg in 2015, with the largest declines occurring in the Whidbey Island region (90% drop in individuals, 84% in weight).

In contrast with the gadids noted above, North Pacific Spiny Dogfish were encountered at the highest rates since 2008. In the 2015 survey, we caught 246 individuals weighing a total of 387 kg, compared to the 2014 survey in which we caught just 34 individuals totaling 35 kg. Dogfish

were most prevalent in the Gulf of Bellingham region (40% of the total individuals; 46% of the total weight), followed by the western and eastern Straits of Juan de Fuca and the San Juan Islands. Few dogfish were encountered in the rest of Puget Sound.

The 2016 Index bottom trawl survey is scheduled to occur from May 2 - May 26.

Threatened and Endangered species surveys at Naval Installations – The U.S. Navy controls multiple restricted areas throughout Puget Sound that have been exempted from rockfish critical habitat designation by the NMFS. The Navy maintaining an Integrated Natural Resource Management Plan (INRMP) is a prerequisite, however, to fulfill the requirements that authorize these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at NBK-Bremerton and NUWC-Keyport in 2013, the WDFW's PSMFS Unit entered into a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NASWI-Crescent Harbor, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NUWC-Keyport, NAVSTA-Everett. These surveys, which expanded on the 2013 surveys, were conducted during 2014-15 and included ROV, scuba, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted, which concluded that: no ESA-listed rockfish were observed; no deep-water critical habitat (>30m) for adult rockfish was present; and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do exist within the surveyed areas. These nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect methods in 2016-17. The deep-water surveys concluded in 2015.

The WDFW's PSMFS Unit has also entered into a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NASWI-Crescent Harbor, NASWI-Lake Hancock, NAVMAG-Indian Island, NBK-Bangor, Manchester Fuel Depot, NAVSTA-Everett. Monthly sampling at each installation began in May 2015 and will continue through the summer of 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. A summary of the results from 2015 sampling was included with the rockfish final reports. The only ESA-listed fish captured in beach seine conducted in 2015 were Puget Sound Chinook Salmon, Puget Sound Steelhead, Hood Canal Summer Chum Salmon, and Bull Trout. Regarding timing and abundance, juvenile salmonids and forage fish species generally followed trends previously documented in similar reports, which supports the work windows outlined in the WAC. In 2016-17 samples taken from these ESA-listed fish will be processed to determine stock of origin, using both genetic markers and coded wire tags.

Annual Pacific Herring Assessment in Puget Sound – Annual herring spawning biomass was estimated in Washington in 2015 using spawn deposition surveys. WDFW staff based in the Mill Creek, La Conner, Olympia, and Port Townsend offices conduct these assessment surveys of all 21 known herring stocks in Puget Sound and Hood Canal waters annually from January to June.

The herring spawning biomass estimate for all Puget Sound stocks combined in 2015 is 13,246 tons (Table 1). The cumulative total is an increase from the 2014 total of 9,796 tons and higher than the mean cumulative total for the previous ten year (2006-2015) period of 11,658 tons. The increase in driven in part by increases in the Quilcene Harbor stock (Hood Canal), estimated at

4,097 tons in 2015, the highest spawning biomass for this stock since 2011. The other stock in this region, South Hood Canal, also increased from 112 tons in 2014 to 282 tons in 2015.

Table 1. Pacific Herring spawning biomass estimates (short tons) in Puget Sound by stock and year

STOCK	YEAR									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Squaxin Pass	755	557	1,025	824	510	565	589	554	394	324
Purdy			496	125	500	711	135	260	83	32
Wollochet Bay	27	35	45	360	11	21	31	10	39	0
Quartermaster Harbor	987	441	491	843	143	96	108	157	44	55
Elliot Bay							290	214	29	135
Port Orchard-Port Madison	2,112	1,589	1,186	1,768	350	123	217	184	90	92
Port Gamble	774	826	208	1,064	433	1,464	404	273	170	345
Kilisut Harbor	54	24	0	0	0	0	0	0	5	0
Port Susan	321	643	345	252	152	138	61	29	68	70
Holmes Harbor	1,297	572	686	1,045	673	3,003	678	585	459	456
Totals for South and Central Puget Sound	**6,327**	**4,687**	**4,482**	**6,281**	**2,772**	**6,121**	**2,513**	**2,266**	**1,381**	**1,509**
Skagit Bay	2,826	1,236	1,342	1,036	402	469	443	454	294	285
Fidalgo Bay	323	159	156	15	103	119	89	100	221	80
Samish/Portage Bay	412	348	409	320	649	387	430	693	778	559
Int. San Juan Islands	285	33	60	0	24	0	5	0	5	38
NW San Juan Islands	0	0	0	0	0	0	0			
Semiahmoo Bay	1,277	1,124	662	990	909	1,605	879	569	2,828	5,852
Cherry Point	2,216	2,169	1,352	1,341	774	1,301	1,120	908	1,003	524
Totals for North Puget Sound/SJI	**7,339**	**5,069**	**3,981**	**3,702**	**2,861**	**3,881**	**2,966**	**2,724**	**5,129**	**7,338**
South Hood Canal	244	70	223	156	214	156	264	199	112	282
Quilcene Bay	2,530	2,372	2,531	3,064	2,012	4,443	2,626	2,072	3,097	4,097
Totals for Hood Canal	**2,774**	**2,442**	**2,754**	**3,220**	**2,226**	**4,599**	**2,890**	**2,271**	**3,209**	**4,379**
Discovery Bay	1,325	42	248	205	26	0	105	0	5	12
Dungeness/Sequim Bay	0	34	69	46	75	104	43	71	72	8
Totals for Straight of Juan de Fuca	**1,325**	**76**	**317**	**251**	**101**	**104**	**148**	**71**	**77**	**20**
Annual Totals	**17,765**	**12,274**	**11,534**	**13,454**	**7,960**	**14,705**	**8,517**	**7,332**	**9,796**	**13,246**

The combined spawning biomass of South/Central Puget Sound herring stocks in 2015 of 1,509 tons is a slight increase from 2014, when the cumulative spawning biomass for this region was 1,381 tons. A number of stocks in the region that were previously at relatively large abundances are now at low levels, particularly the Port Orchard-Port Madison, Port Susan, Holmes Harbor and Quartermaster Harbor stocks.

The cumulative biomass of North Puget Sound stocks again increased dramatically in 2015 (7,338 tons) in comparison with 2014 (5,129 tons), which was also an increase from 2013 (2,724 tons). This was primarily the result of a robust year for the Semiahmoo Bay stock, which increased from 2,828 tons in 2014 to 5,582 in 2015. However, the spawning biomass of the Cherry Point stock decreased by roughly half in 2015 (524 tons) from the 2014 cumulative total (1,003 tons). This stock, which is genetically distinct from other herring stocks in Puget Sound and British Columbia, continues to be at critically low levels of abundance. Estimated herring

spawning activity for the Strait of Juan de Fuca region also declined dramatically in 2015 (20 tons) in comparison with 2014 (77 tons), and remains at a very low level of abundance.

Rockfish surveys on the Washington outer coast – The focus of the fall 2015 cruise season was to experiment with longline gear in nearshore waters (inside 30 fathoms [55 m]) to target benthic rockfishes. The WDFW has been considering longline gear as a potential option for future nearshore rockfish surveys and currently conducts offshore longline surveys for Yelloweye Rockfish. Previously, the existing rod-and-reel survey for Black Rockfish had been modified to accommodate the need for information on additional rockfish species that inhabit nearshore waters. Issues with fishing tackle selection and general concerns about gear standardization with rod-and-reel surveys prompted the effort to begin experimentation with longline gear in nearshore waters. One spring cruise in 2015 was dedicated to longline experimentation, and it was immediately apparent that the longline gear would be a viable option for targeting the additional focal rockfish species. In September of 2015 a five-day pilot survey that utilized fixed longline gear to target nearshore groundfish species was completed. The specific objectives of this survey were to:

1. Deploy conventional fixed (tub gear) longline gear in nearshore waters, using a modified version of the standard IPHC survey gear. Key gear differences were hook size, gangion size and material, and bait used.
2. Target Blue/Deacon Rockfish, China Rockfish, Copper Rockfish, Quillback Rockfish, Tiger Rockfish, Vermilion Rockfish, Yelloweye Rockfish, Cabezon, and Kelp Greenling
3. Investigate suitable locations to deploy the gear in order to catch a wide variety of demersal rockfish, especially China Rockfish.
4. Collect biological information such as length, sex, weight, and otoliths from all retained fish. Retain all rockfish, cabezon, and kelp greenling.
5. Deploy a CTD at all fishing locations.
6. Tag and release any encountered Yelloweye Rockfish
7. Choose locations where rod-and-reel gear could sample in conjunction with the longline for gear comparison.

September was chosen for this pilot survey due to vessel availability, logistical reasons (followed by offshore yelloweye survey), weather, and staff availably. The first good weather opportunity after mid-September was chosen to begin work.

The longline gear developed for this survey was modified from the standardized gear that the IPHC uses for their annual halibut surveys. IPHC gear consists of a weighted mainline with 16/0 circle hooks affixed by a #72 gangion line 24-28 inches in length. Gangions are tied to the mainline and hooks are attached to loops tied at the end of the gangions. Hooks are baited with #2 semi-bright chum salmon. The mainline is broken into units of length called “skates” which are 1800’sections with gangions spaced at 18’ intervals to accommodate 100 hooks per skate. Each skate can be attached to another so that mainline length can vary from 1800’ to any desired length. The ends of each set (multiple skates combined) receive a length of anchor line followed by a 40-60 lb fishermen type anchor and then a buoy line varying in length (based on depth) attached to a surface buoy array. A 10 lb lead is attached at the junction of each skate. WDFW began modification experiments with this gear in 2013 on yelloweye surveys to target smaller sized fish.

The modified gear included identical mainline lengths and hook spacing, but smaller 12/0 and 14/0 circle hooks baited with squid were used with smaller #60 hard lay gangions 24-28 inches in length. Squid was used as bait because the smaller hooks do not hold pieces of salmon very well and squid is a typical bait choice for longline fishermen that target rockfish. 14/0 hooks were chosen over the 12/0 hooks because there seemed to be more fish dropping off of the line with the 12/0 hooks. This experimental gear was changed again just before fall 2015 to experiment with a different type of gangion for this nearshore pilot study. The #60 hard lay gangions would kink easily and break. A different type of gangion material (nylon) that is more pliable (soft lay) was used instead to address this issue. The use of weights (end anchors and mainline lengths) were kept the same except the mainline weights (10 lb lead) were placed mid-skate since sets were only going to be one skate in length. In summary, gear used for this survey was standard IPHC mainline material and length units with soft lay #60 nylon gangions, 14/0 Mustad circle hooks, and American squid.

Three hours was estimated as sufficient soak time to provide good catch rates, limit lingcod predation on hooked fish, and allow for logistical needs of travel and bottom familiarization while deploying gear each day. Soak time is defined as the elapsed time between deployment of the first anchor and the beginning of retrieval of the buoy line for any given set.

Five general fishing areas (Figure 2) were identified as survey areas to investigate and deploy gear over the five day survey. These areas were identified as potential target species habitat by looking at species compositions from previous rod and reel survey locations. Objectives for the 2014 and 2015 rod and reel surveys included searching for undocumented rockfish habitat and targeting a broader list of focal species. This information showed particular areas where demersal rockfish encounters could be expected. Within each of the daily areas, skipper and WDFW staff discretion were applied in identifying exact set locations at a rate of four to five sets of one skate each per day.

Data collected at each station in the 2015 survey included set start and stop GPS locations, set depth ranges, set and haul times, 100 percent hook by hook tally of catch identified as close to species level as possible, and status of unoccupied hooks such as empty or baited. Biological information was collected from retained and released fish; released fish were measured and retained fish were measured, weighed, sexed, and dissected for otoliths. A CTD was deployed at each set location immediately before set retrieval to collect temperature, depth, salinity, dissolved oxygen and chlorophyll measurements. All data was immediately logged electronically as gear was set and hauled. Biological information from retained fish was collected during the mid-cruise weather day and after the cruise in port. The cruise data was housed in a master MS Access database for all WDFW coastal longline surveys.

The five planned fishing areas were sampled over five charter days (Table 2) with 23 individual locations (sets) fished at 4-5 sets per day. Individual sets (Table 3) ranged in depth from 7-24 fathoms (13-44 meters). The cruise started out of Westport, WA to begin sampling at Pt. Grenville, moving north each day to the next fishing area. The cruise was completed in Makah Bay with one bad weather day spent in La Push mid-way through the trip. Before gear deployment each day, time was spent getting familiarized with reef structures at specific locations identified from rod-reel survey data to determine suitability for longline fishing operations. Specific locations and set orientations were chosen based on rugosity, previous rod-

reel catch rates and compositions, safety, and reef size and shape. The gear was set to maximize hard substrate coverage yet minimize potential snagging on steep pinnacle structures.

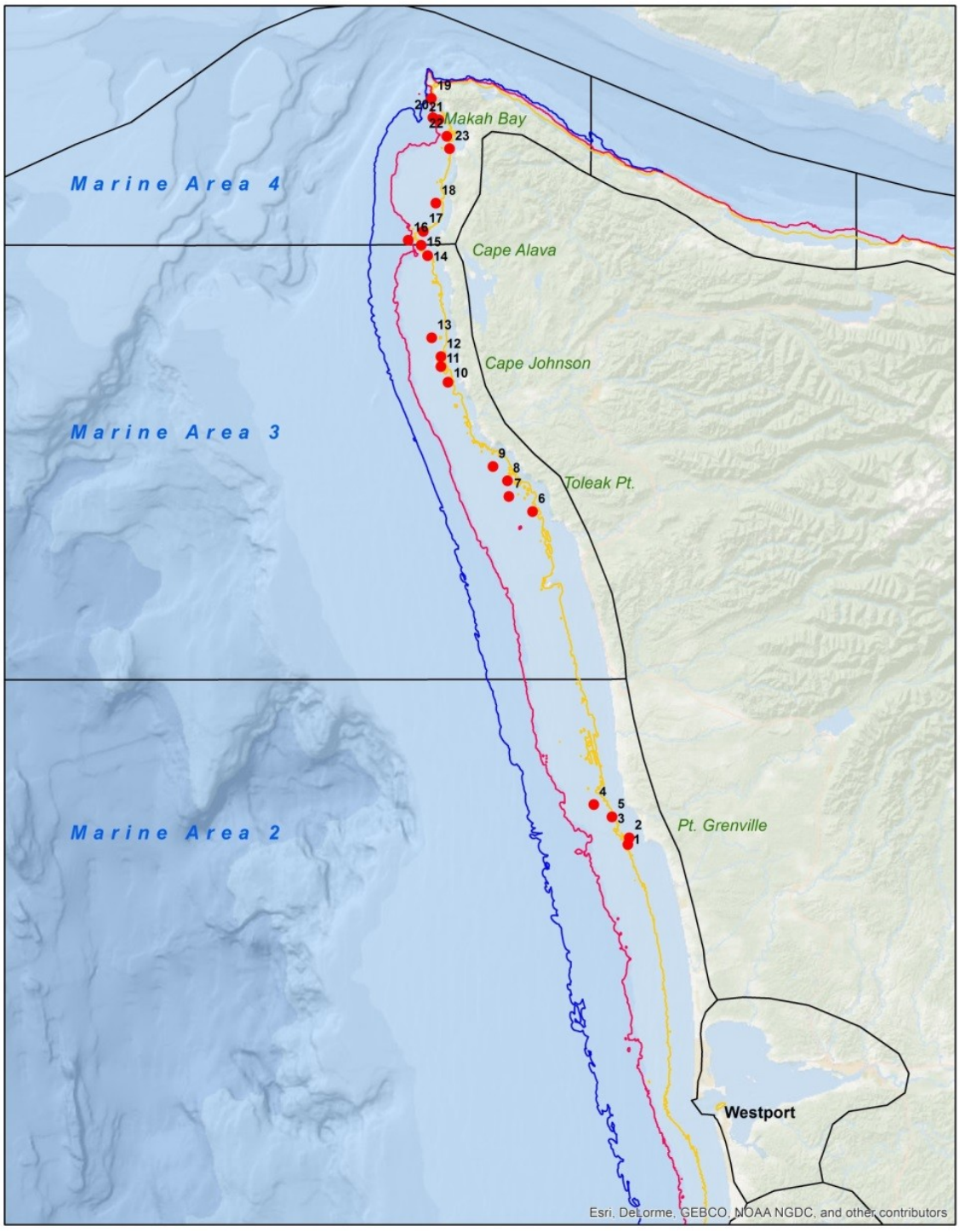

Figure 2. Longline set locations for all fished areas.

Table 2. Summary of deployed effort and catch by date and area.

Date	Survey Area	Marine Area*	Locations Fished	Hooks Deployed	Fish Caught	Fish Species Caught
9/22/2015	Pt. Grenville	2	4	497	19	6
9/23/2015	Toleak Pt.	3	4	396	30	8
9/25/2015	Cape Johnson	3	4	400	57	8
9/26/2015	Cape Alava	3/4	5	498	80	11
9/27/2015	Makah Bay	4	5	503	61	12

* WDFW recreational punchcard area

Table 3. Summary of set details and total catch.

Set	Date	Survey Area	Skates Set	Hooks	Soak Time (min)	Fish Caught	Fish Species Caught	Start Depth (ftm)	Start Depth (m)	End Depth (ftm)	End Depth (m)
1	9/22/2015	Pt. Grenville	1	98	185	0	0	9	16	10	18
2	9/22/2015	Pt. Grenville	1	99	194	0	0	8	15	7	13
3	9/22/2015	Pt. Grenville	1	100	210	2	2	10	18	11	20
4	9/22/2015	Pt. Grenville	1	100	228	12	5	15	27	15	27
5	9/22/2015	Pt. Grenville	1	100	79	4	3	10	18	10	18
6	9/23/2015	Toleak Pt.	1	100	182	1	1	10	18	12	22
7	9/23/2015	Toleak Pt.	1	97	197	11	4	14	26	14	26
8	9/23/2015	Toleak Pt.	1	99	209	10	4	15	27	15	27
9	9/23/2015	Toleak Pt.	1	100	220	6	4	17	31	16	29
10	9/25/2015	Cape Johnson	1	100	179	28	6	14	26	16	29
11	9/25/2015	Cape Johnson	1	99	200	9	3	15	27	15	27
12	9/25/2015	Cape Johnson	1	100	213	8	4	14	26	13	24
13	9/25/2015	Cape Johnson	1	101	229	12	5	18	33	18	33
14	9/26/2015	Cape Alava	1	99	198	21	4	9	16	9	16
15	9/26/2015	Cape Alava	1	101	232	9	3	8	15	9	16
16	9/26/2015	Cape Alava	1	100	246	29	9	22	40	17	31
17	9/26/2015	Cape Alava	1	97	257	9	3	11	20	8	15
18	9/26/2015	Cape Alava	1	101	274	12	5	16	29	14	26
19	9/27/2015	Makah Bay	1	102	180	17	6	16	29	21	38
20	9/27/2015	Makah Bay	1	99	203	19	7	16	29	24	44
21	9/27/2015	Makah Bay	1	100	233	12	3	13	24	17	31
22	9/27/2015	Makah Bay	1	101	251	5	3	12	22	11	20
23	9/27/2015	Makah Bay	1	101	267	9	3	10	18	10	18

In total, 254 hooks were occupied at the rail upon retrieval for an overall hook occupancy rate of 11.1%. Hook occupancy rates varied from zero catch to 30% for individual sets. Catch rates were very low at Pt. Grenville with an overall catch rate of 4.4%; sand flea predation was suspected due to the quantity of empty hooks (no remaining bait attached) recorded at the rail. Seventeen different fish species were caught over the 5 sampling days, including 10 different rockfish species. Catch rates increased (Table 4) and number of species encountered increased (Figures 3-5) as the sampling progressed northward. Highest catch rates and species diversity were seen at Cape Alava and Makah Bay. Cabezon and China Rockfish were the most frequently caught species, comprising almost half of the total catch. Fifty-eight percent of the

total catch was rockfish. Kelp Greenling were the only target species not encountered during sampling.

Table 4. CPUE and average CPUE (bold numbers) by area for rockfish, cabezon, and lingcod. CPUE reported as ratio of total catch by set to number of hook soak hours.

Area - Set	ck Rockfish	ue Rockfish	bezon	nary Rockfish	ina Rockfish	pper Rockfish	ngcod	illback Rockfish	ger Rockfish	rmilion Rockfish	lloweye Rockfish	llowtail Rockfish
Pt. Grenville	**0.0104**		**0.0029**	**0.0026**			**0.0086**					
3			0.0029				0.0029					
4	0.0132			0.0026			0.0079					
5	0.0076						0.0152					
Toleak Pt.	**0.0076**		**0.0083**	**0.0029**	**0.0126**						**0.0027**	
6			0.0033									
7	0.0031		0.0157		0.0126							
8	0.0116		0.0116	0.0029								
9	0.0082		0.0027								0.0027	
Cape Johnson	**0.0111**	**0.0156**	**0.0163**	**0.0026**	**0.0064**	**0.0040**	**0.0034**					
10	0.0302	0.0235	0.0201		0.0101	0.0067	0.0034					
11	0.0061		0.0182									
12	0.0028		0.0141		0.0028	0.0028						
13	0.0052	0.0078	0.0130	0.0026		0.0026						
Cape Alava	**0.0122**	**0.0049**	**0.0115**	**0.0024**	**0.0239**	**0.0043**	**0.0041**	**0.0083**	**0.0024**	**0.0024**	**0.0022**	
14			0.0153		0.0367	0.0061	0.0061					
15			0.0051		0.0154		0.0026					
16	0.0122	0.0049	0.0098	0.0024	0.0195		0.0049	0.0122	0.0024	0.0024		
17			0.0144			0.0024	0.0048					
18			0.0130			0.0043	0.0022	0.0043			0.0022	
Makah Bay	**0.0025**	**0.0177**	**0.0057**	**0.0209**	**0.0128**	**0.0023**	**0.0033**	**0.0060**		**0.0068**	**0.0030**	**0.0033**
19		0.0294	0.0033		0.0131		0.0033			0.0033		0.0033
20		0.0060		0.0209	0.0060			0.0060		0.0119	0.0030	
21	0.0026				0.0232					0.0052		
22	0.0024		0.0071			0.0024						
23			0.0067		0.0089	0.0022						
Average	**0.0088**	**0.0143**	**0.0104**	**0.0063**	**0.0148**	**0.0037**	**0.0053**	**0.0075**	**0.0024**	**0.0057**	**0.0026**	**0.0033**

Biological information was collected from all encountered catch excluding invertebrates (Figure 6). All rockfish and Cabezon were retained with the exception of two Cabezon and one Blue Rockfish that were lost at the rail. Otoliths, lengths, sex, and weights were collected from all retained fish where complete specimens were retained. All fish during the cruise were scanned for previously implanted tags, but no previously tagged fish were encountered. Three Yelloweye Rockfish were tagged with external Floy tags and internal pit tags before release. Tissue samples were collected from the three encountered yelloweye and 50 encountered china rockfish for DNA analysis.

Gear deployment for all sets was successful with no gear loss or significant bottom hang up. Soak times varied from 3 to 4.6 hours with each successive set for the day soaking longer than the previous set. Set 5 for the trip was an exception to this; set 5 was a repeat of set 3 but

modified with mainline floats meant to investigate potential sand flea predation on baits. Although the soak time was only 80 minutes on set 5, more than twice as many baits were retained and catch rates were higher. Bait retention increased as the survey progressed northward with the most bait retention recorded in Makah Bay. No lingcod predation was noticed on any of the catch.

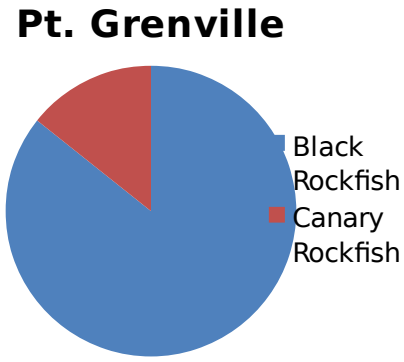

Figure 3. Rockfish catch composition for Pt. Grenville.

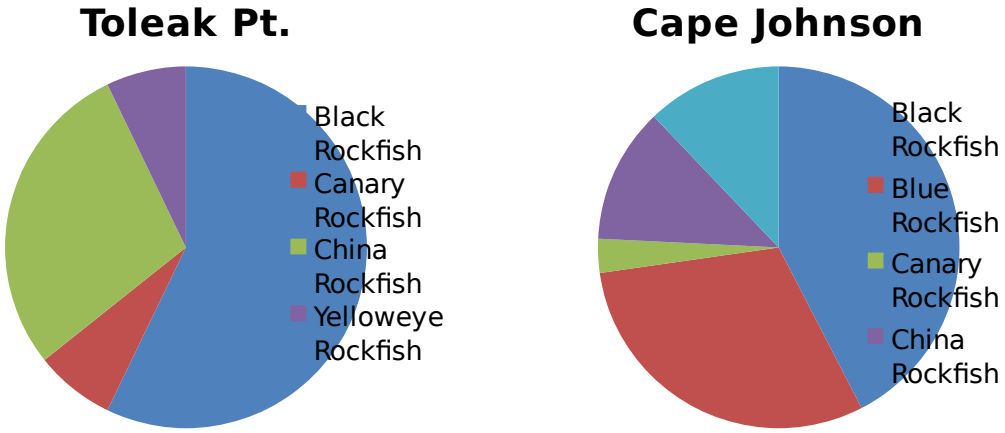

Figure 4. Rockfish catch composition for fishing areas near La Push.

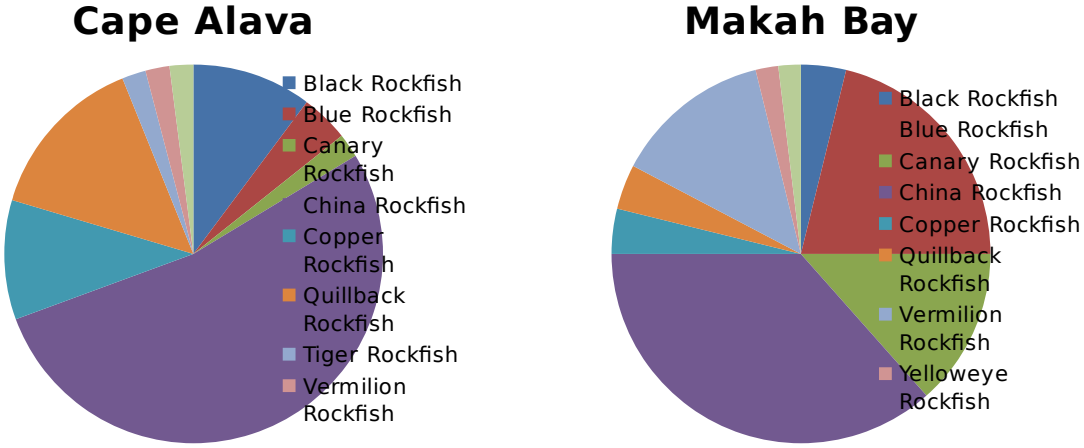

Figure 5. Rockfish catch composition for north coast fishing areas.

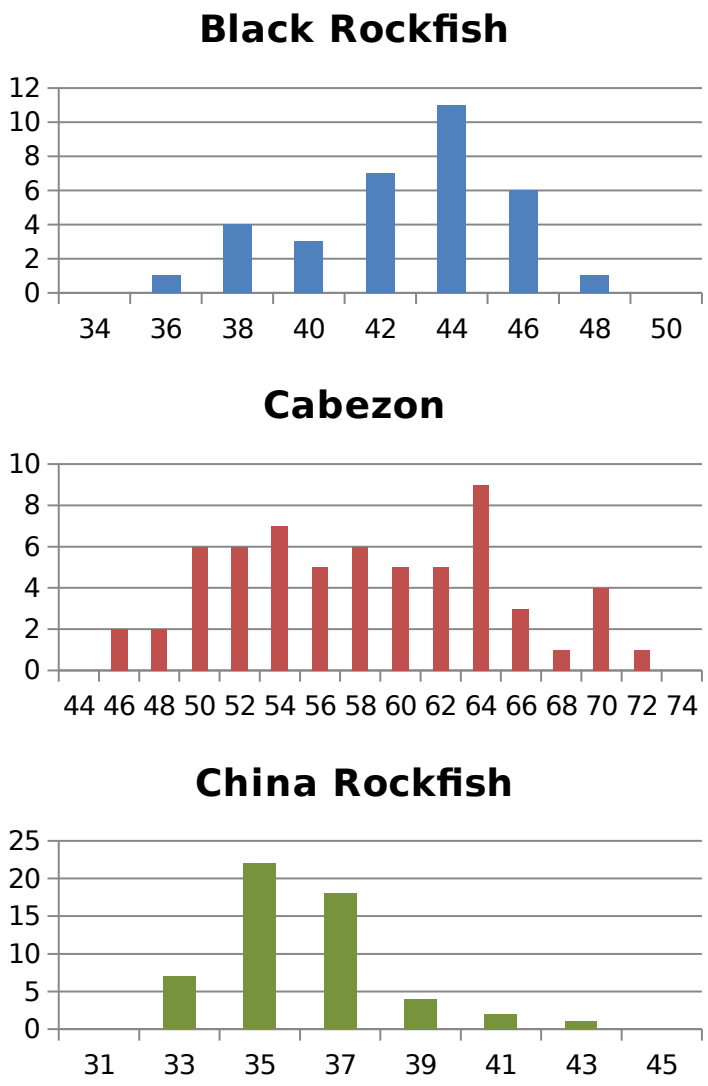

Figure 6. Length frequencies for the most encountered fish species.

Toward a synoptic approach to reconstructing west coast groundfish historical removals – Quantifying the removal time series of a stock is an essential input to a variety of stock assessment methods and catch-based management. But estimating removals is really hard. Sampling protocols, fishery diversity, catch versus landing location, dead discards, and species identification are just some of the complications that vary across time and space. Given that most groundfish stocks are distributed coast-wide and a complete time series of removals is needed, this project aims to coordinate approaches across the states of Washington, Oregon and California to confront removal reconstruction challenges and establish common practices. Both California and Oregon have attempted historical removal reconstructions, while Washington is just beginning the process. We use the Washington effort to focus on six groundfish species that vary in the difficulty of estimating removal histories: Black, Canary, and Rougheye rockfishes, Petrale Sole, Sablefish, and Lingcod. The Washington reconstruction is compared to the approaches taken for the same species in Oregon and California with the goal of matching reconstruction protocols across states to the extent possible. Lastly, uncertainty levels across

periods, species and states are established. This is a new feature of all three removal reconstructions which will improve treatment of uncertainty in future stock assessments.

III. Reserves

Marine reserve monitoring and evaluation – Due to changes in program priorities and staffing limitations brought on by intensive ROV survey work, very little directed monitoring of marine protected areas and reserves has occurred in Puget Sound since 2011 and no monitoring activities were conducted in 2015. A systematic evaluation of data from SCUBA-based surveys collected between 2000 and 2010 is nearing completion and six sites for which sufficient data are available are being used to evaluate reserve efficacy.

Preliminary results indicate that site-specific variation in average fish size, biomass, and density are all significant factors influencing long-term trends in these variables. Despite this, significant trends toward more, larger fish are apparent for Lingcod, Copper Rockfish, and Quillback Rockfish at some locations. Notable recruitment pulses are also clearly apparent at multiple sites, specifically for rockfishes during 2006. For most species and locations it appears that a 15-yar evaluation period simply doesn't represent a long enough time frame to observe significant changes in abundance, biomass, and density, given the level of noise observed in these parameters. Planning has begun to replicate these studies at longer intervals (e.g., 20 years, 30 years).

Over the next six months Larry LeClair, Lisa Hillier, and Dayv Lowry will be drafting a report on these six sites that includes, as an appendix, data from other sites surveyed during the evaluation period for which data collection was more sparse.

IV. Review of Agency Groundfish Research, Assessment, and Management

A. Hagfish

The Washington Hagfish commercial fishery – Opened in 2005 under developmental regulations, the Washington hagfish fishery is small in scale, exporting hagfish for both frozen and live-fish food markets in Korea. Management of the Washington hagfish fishery is challenged by a lack of life history information, partial controls, and high participant turnover. Active fishery monitoring and sampling began in 2009. Due to limited agency resources, only fishery dependent data programs have been developed to inform management, including logbooks, fish receiving tickets and biological sampling of catch. Current efforts intend to focus on refining and improving these programs, including improving systematic sampling, developing species composition protocols, shifting to use the maturity scale developed by Martini (2013). Interest in conducting a study similar to research conducted in California (Tanaka, 2014) to evaluate escapement relative to barrel dewatering-hole size exists but will depend on funding availability.

The Washington hagfish fishery operates by rule only in offshore waters deeper than 50 fathoms. It is also regulated under open access provisions. Figure 7 presents annual landings by state since 2000. However, landings don't necessarily represent where fishing actually occurred. Washington licensed fishers can fish federal waters off Oregon and land that catch into Washington. Vessels that freeze at sea are particularly able to advantage themselves this way. Live hagfish vessels typically fish grounds closer to their home port. The fishery catches predominantly Pacific Hagfish (*Eptatretus stoutii*). Occasionally, Black Hagfish (*Eptatretus deani*) are landed incidentally. Landings data cannot distinguish between species as only one code exists for hagfish. Hagfish are caught in long-lined barrels (Figure 8); rules

limit each fisher to 100. The barrels are constructed from olive oil or pickle barrels modified with an entrance tunnel and dewatering holes. Average soak time is 21 hours.

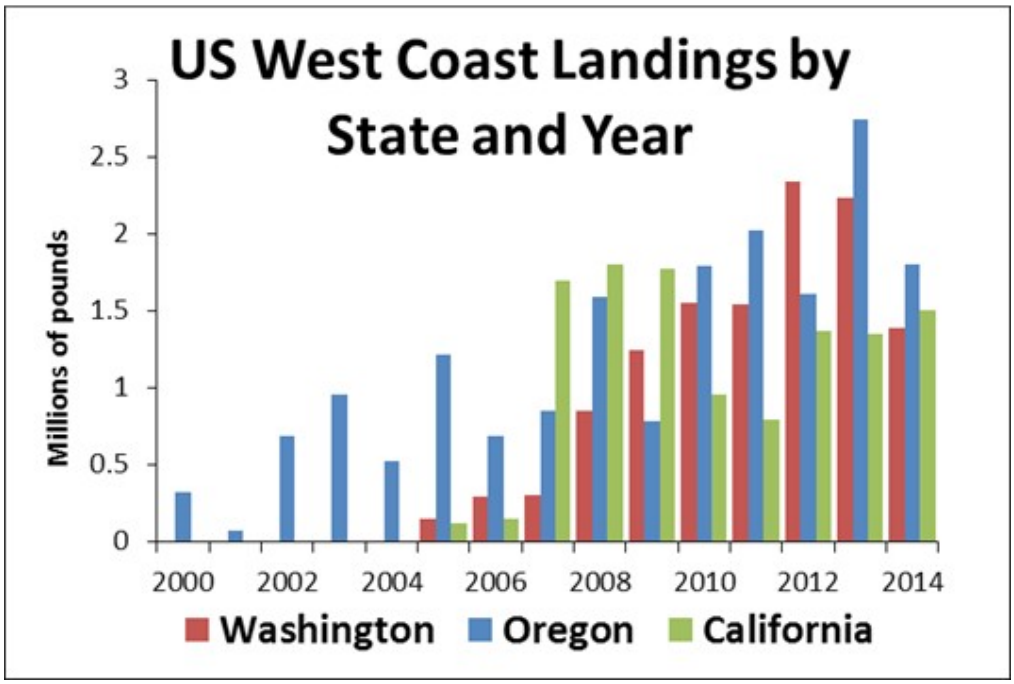

Figure 7. Hagfish Landings in pounds by Washington, Oregon, and California; 2000-2014.

Fishing location and catch per unit effort have been evaluated from logbook data (Figure 9). Fishing occurs on soft, muddy habitat. Pacific hagfish are predominant from 50 to 80 fathoms. Deeper sets, up to 300 fathoms, have been made to target Black Hagfish. Pacific and Black Hagfish ranges appear to overlap between 80 and 100 fathoms.

Figure 4 presents catch per unit effort (CPUE) for years with more than 100 sets by catch area. Median CPUE is about 4.5 pounds. Instances of high CPUE are evident; in these situations skippers reported "plugged" barrels.

Figure 1. Hagfish barrels used in the commercial fishery.

Length, weight, and maturity data have been collected from Pacific and Black Hagfish; however, only Pacific Hagfish data are reported here. Male and female hagfish present similar size distributions, ranging from 30 to 65 cm (Figure 10). The in-sample largest specimen was 78 cm male, the smallest a 25 cm female. By depth, male and female distribution is similar at the depths the fishery operates; none of the samples were from sets shallower than 59 fathoms (Figure 11). An evaluation of maturity suggests year-round spawning (Figure 12). Fecundity is low; the number of mature eggs rarely exceeds 10 to 12. Very few females with fully developed eggs and even fewer spent females have been sampled.

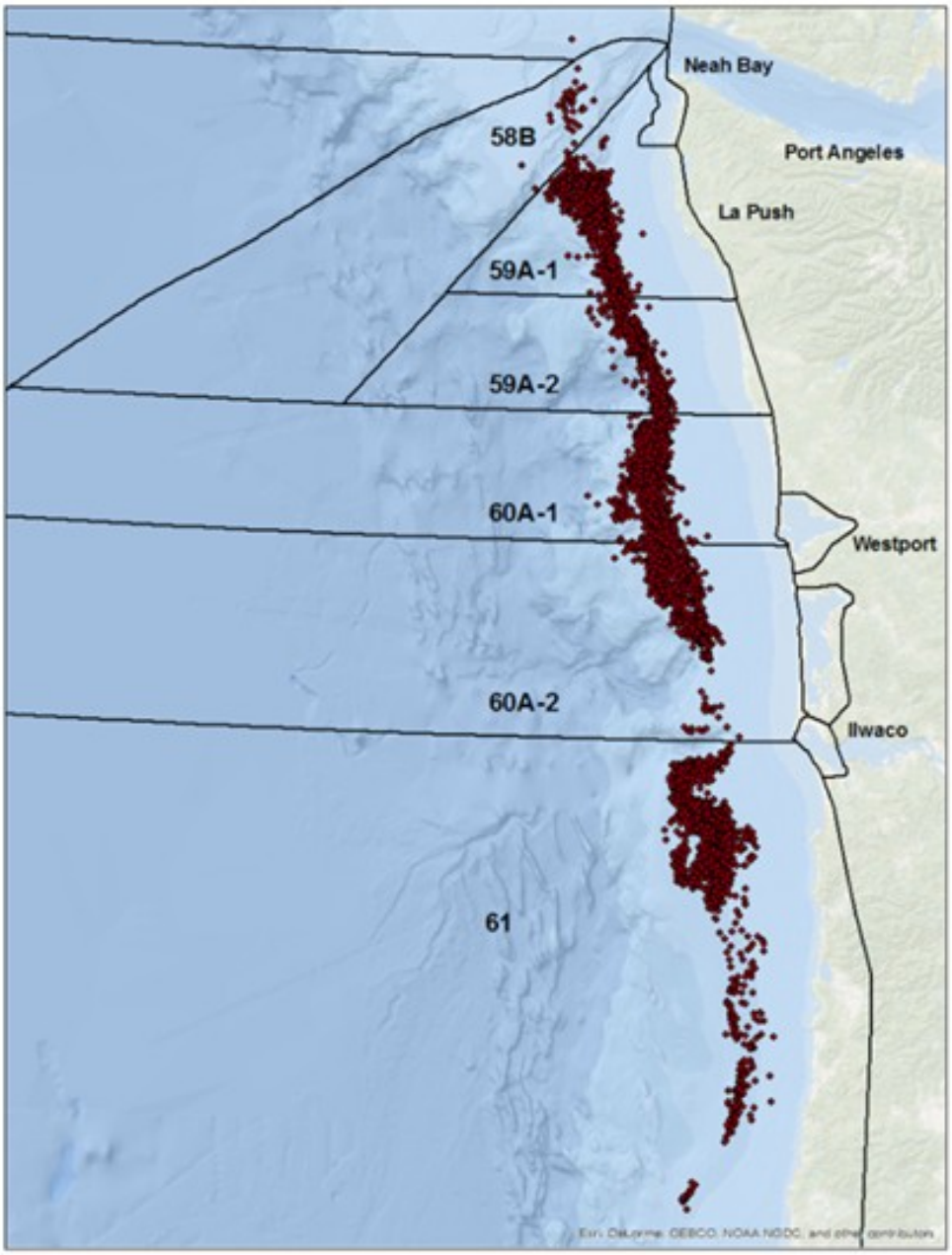

Figure 9. Hagfish fishing off WA and OR, from Washington logbooks, 2005-2014.

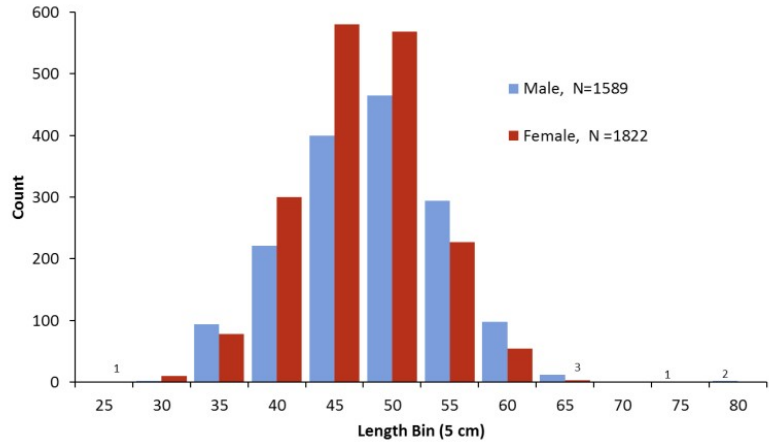

Figure 10. Length (cm), male and female Pacific Hagfish only.

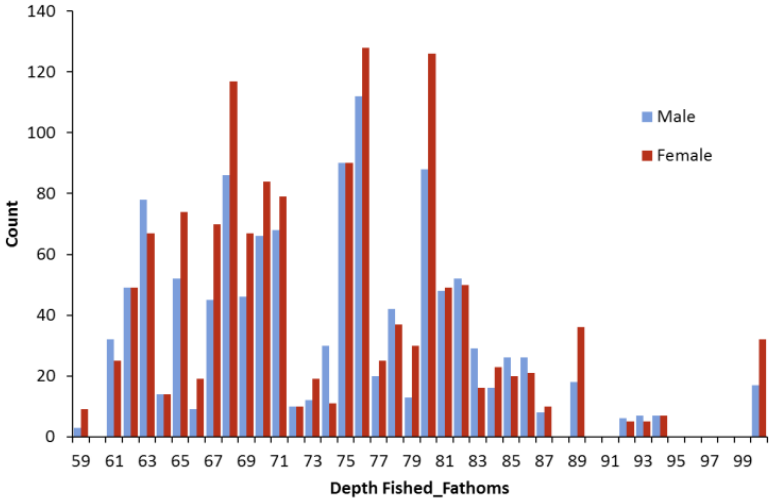

Figure 11. Distribution, by depth (fa), of male and female Pacific Hagfish.

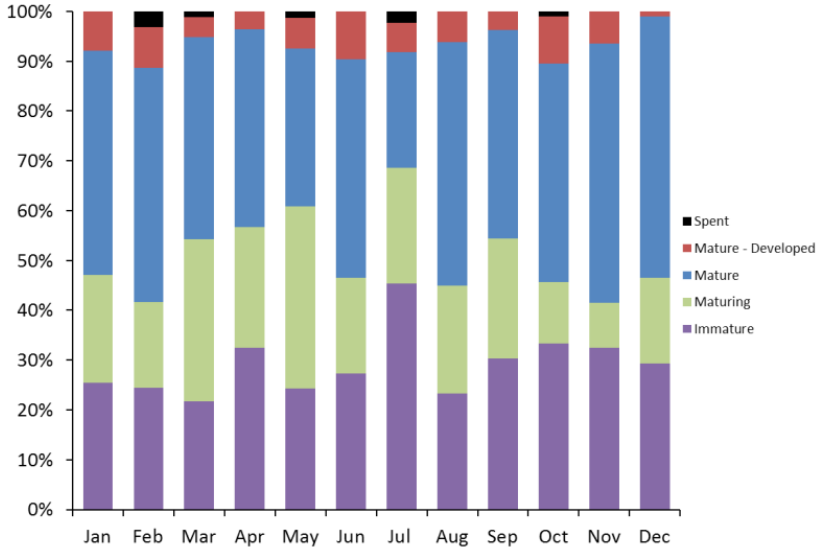

Figure 12. Female Pacific Hagfish maturity, proportion by month.

B. North Pacific Spiny Dogfish and other sharks

Lummi Nation dogfish fishery in northern Puget Sound – Directed commercial fishing for North Pacific Spiny Dogfish *Squalus suckleyi* was formally closed in Puget Sound in 2010 to protect ESA-listed rockfishes (Canary Rockfish, Yelloweye Rockfish, and Bocaccio) and their habitats. This included both State-sponsored and Tribal commercial fisheries. Prior to this closure, annual Sound-wide State harvest was below 500k lbs since 1997, though harvests as large as ~8.6M lbs once occurred (1979). By contrast, dogfish harvest in Puget Sound by Native American tribes peaked in 1996 at 159k lbs.

In 2014 the Lummi Nation initiated a directed drift- and set-gillnet fishery for dogfish in their Usual and Accustom Fishing Ground in northern Puget Sound. The harvest quota for this fishery was set at 250k lbs, 159k of which was taken in 2014 and 219k of which was taken in 2015. Harvest occurs predominantly from May-August, involves little to no reported bycatch, and tails off as fishers transition to targeting salmon in the fall.

In August of 2015 Lummi Nation biological staff collected biological data and fin clips from a representative sub-sample of sharks caught in two locations as part of the tribal fishery. Every one of these 100 sharks was female, and their average size was 87 cm. Many contained full-term embryos. Lummi biologist Breena Apgar-Kurtz confirmed that this was a representative sub-sample and that the "vast majority" of the harvest consisted of relatively large female sharks. The WDFW is currently working with the Lummi Nation to address conservation concerns associated with the size and sex composition of the catch.

Shark book -- Together with Dr. Shawn Larson of The Seattle Aquarium, Dayv Lowry will be co-editing a book entitled *Northeast Pacific Shark Biology, Research, and Conservation.* Planning for this undertaking began in November of 2015 and final author commitments were obtained in March of 2016. Topics covered will include regionally specific policy, current taxonomy and population trends, fisheries impacts/interactions, food web ecology, advances in aging techniques, genetic population identification, the role of captive husbandry programs in conservation, the economy of ecotourism, and future challenges to long-term conservation. Publication is expected in the summer of 2017 through Elsevier Scientific.

C. Skates

No specific, directed research or management to report.

D. Pacific Cod

Assigning individual Pacific Cod to population of origin along an isolation-by-distance gradient – Many marine species are characterized by an isolation-by-distance pattern (IBD), where more geographically distant samples are also more genetically differentiated. IBD patterns are problematic for management because population boundaries, and thus spatial management units, cannot be cleanly delineated. Assignment tests could potentially be used to identify population of origin, facilitating management by estimating seasonal migration patterns and distances, as well as detecting productive areas. However, most IBD patterns are shallow and assignment tests have little power. The team of Kristen Gruenthal and Lorenz Hauser at the University of Washington, Mike Canino at NOAA's Alaska Fisheries Science Center, and Dayv Lowry successfully applied restriction site associated DNA (RAD) sequencing toward stock identification in the Pacific Cod (*Gadus macrocephalus*), which exhibits nearly perfect IBD along the northeastern Pacific coast. Using 6,756 SNPs, they were able to reassign 95-100% of fish to their population of origin, with high confidence,

while still reproducing the strong IBD pattern found in earlier studies. Moreover, they were able to identify over 200 SNPs that may be under selection across the sampled range. These results lay the groundwork for future genetic stock identification and genetics-based management of Pacific cod. A manuscript details these results in current in preparation and expected to be complete by late summer 2016.

E. Walleye Pollock

No specific, directed research or management to report.

F. Pacific Whiting (Hake)

No specific, directed research or management to report.

G. Grenadiers

No specific, directed research or management to report.

H. Rockfishes

Participation in the Federal Rockfish Technical Recovery Team – Since 2012 Dayv Lowry and Bob Pacunski have served on NOAA's Rockfish Technical Recovery Team, which was charged with developing a detailed recovery plan for the three ESA-listed species in Puget Sound and the Strait of Georgia (Canary, Yelloweye, Bocaccio). The team met in person twice since April of 2015 and held several conference calls focused on delisting and down-listing criteria and polishing a version of the plan for public consideration. The draft plan underwent pre-public review by WDFW and other state agencies at large, tribal co-managers, and representatives at the Department of Fisheries and Oceans. Public review of the document was postponed in early 2016 due to the initiation of the five-year status review for these species by the Biological Review Team. A final plan will be finalized late in 2016, depending on the completion date for the five-year review and the outcome of a pending delisting decision (see below).

Genetic study on ESA-listed rockfish – In April of 2014 WDFW partnered with NOAA to conduct a two-year fishing study aimed at collecting genetic samples of ESA-listed rockfish (Dayv Lowry and Bob Pacunski are co-PI's). The study utilizes several local charter operators with experience fishing for these species prior to the closure of rockfish fisheries in Puget Sound. To date, the survey has obtained samples from over 60 Yelloweye Rockfish, over 70 Canary Rockfish, and 3 Bocaccio in the Puget Sound DPS, with collections occurring throughout the Sound (Figure 13). Many of these fish have been visibly tagged to aid in identification by divers and a remotely-operated vehicle (with one fish sighted by each method in 2015, and one additional fish sighted by each method in 2016).

Results from the genetic analysis strongly demonstrate that Canary Rockfish within the Puget Sound/Georgia Basin DPS are not genetically distinct from Canary Rockfish outside the DPS, and it a recommendation has been passed to the Biological Review Team conducting the five-year status review to delist this species. Yelloweye Rockfish, however, are genetically distinct within and outside the DPS boundary, and fish in Hood Canal also form a largely independent cluster. Additional samples collected from Canadian waters north of the current DPS boundary line have prompted a recommendation to extend this boundary to include more of Johnstone Strait and interior waters to the northern end of Vancouver Island. Listing status recommendations for Bocaccio were not made due to low sample size.

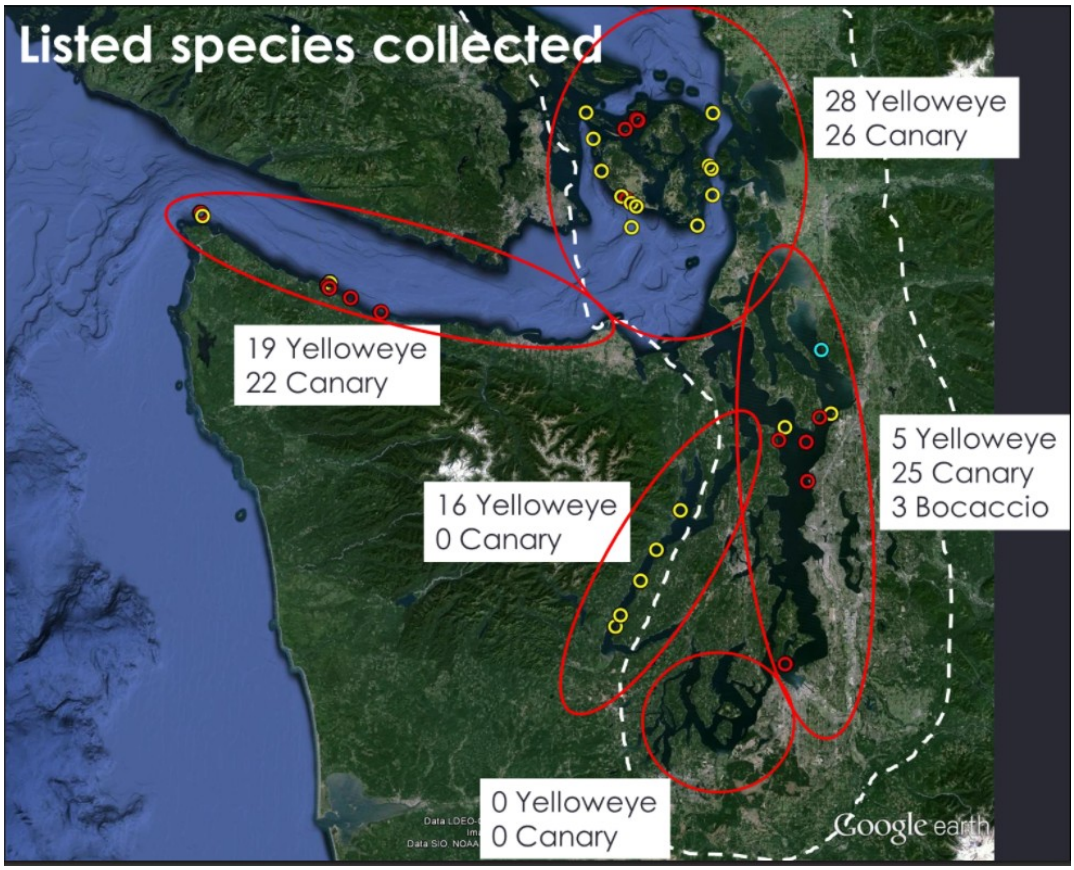

Figure 13. Total sample numbers for ESA-listed rockfish by region as of December 2015 for the Sound-wide genetic study.

Developing an index of abundance for Yelloweye Rockfish (*Sebastes ruberrimus*) off the Washington coast – Yelloweye Rockfish (*Sebastes ruberrimus*) was declared overfished by the PFMC in 2002 and since has been a "choke species" limiting groundfish fishing opportunities along the U.S. west coast. One of the many challenges in monitoring and managing this stock is the lack of adequate fisheries-independent surveys. The conventional bottom trawl survey does not consistently sample Yelloweye Rockfish habitat; and the only survey used in the past assessments was the International Pacific Halibut Commission's fixed-station setline survey. For Yelloweye Rockfish caught by the IPHC survey off the Washington coast, more than 90% were from one single station off Cape Alava and the minimum size was 40 cm (older than 10 years old). The abundance trend derived from the IPHC survey is uninformative for the population in Washington waters, thus the need for another survey.

Since 2006, the Washington Department of Fish and Wildlife has been conducting pilot projects to identify the best location, season, and hook-size for constructing a representative Yelloweye Rockfish abundance index trend. Working together with Jason Cope from NOAA's FRAM Division, the CMFS Unit has conducted pilot projects, compared abundance trends, and is working toward future research recommendations. Surveys will continue in 2016.

Yelloweye Rockfish life history project – A collaborative, ongoing project involving the NWFSC, SWFSC, ODFW, and WDFW is collecting and analyzing data for a Yelloweye Rockfish life history project. Port samplers and survey teams are collecting Yelloweye Rockfish ovaries for fecundity and maturity estimates from WDFW port-sampled fish, the West Coast groundfish bottom trawl survey, southern California hook and line survey, and ODFW port sampled-fish. The goal is to complete a coast-wide analysis of Yelloweye Rockfish size and age at maturity, as well as look at temporal trends in maturity since the data span from 2002-2015. In addition, we hope to investigate spatial and temporal relationships in length, weight, age, and growth relationships with the available Yelloweye Rockfish data. We also have access to Yelloweye Rockfish genetic samples collected during 2004-2014 and, if we can secure funding, could look for potential shifts in genetic structure over the sampled period, as well as determine whether different stock structures are present.

Current collaborators and contributors who've helped with this project include: Melissa Head (NWFSC, project lead), Neosha Kashef & David Stafford (SWFSC), Kari Fenske & Robert Le Goff (WDFW), and Sheryl Flores (ODFW)

Lumping vs. splitting: Comparing two Black Rockfish assessment modelling options – Stock assessment models are constructed to estimate fish population abundance, but there is often uncertainty in the understanding of stock structure components such as the spatial extent of the population, movement rates, and sub-stock mixing. In addition, fish tend to ignore political boundaries between states, countries and other political divisions, leading to stock assessment models based on best estimates of stock structure within the confines of data availability, management boundaries, and management convenience. To examine the effects of 'model lumping' vs. 'model splitting' on estimates of biomass and management reference points, we compared results from two models of black rockfish off the west coast US: 1) A single area model using data from California, Oregon, and Washington and assumes spatially constant M and growth. This ignores potential spatial heterogeneity in growth and mortality; and 2) The three state-specific separate models, as conducted for the 2015 PFMC assessment cycle, with spawning output and total biomass for individual states summed for comparison to the single area model output. We found that the sum of predicted total biomass for the state-specific models was on average 28% greater than the predicted total biomass for the coast-wide model, though the population trends were otherwise similar. The single area coast-wide model estimated that the spawning depletion level has been at or very near to the management target of 40% depletion, whereas the individual state models varied, with Oregon above the target, Washington near the target, and California below the management target. As expected, a non-spatial coast-wide model cannot give area-specific details about management performance so for a species managed at regional levels and with potentially different fishing history and regulations, it is practical to assess the stock based on management boundaries.

I. Thornyheads

No specific, directed research or management to report.

J. Sablefish

An evaluation of the standard conversion factor for dressed sablefish: is it accurate? – Sablefish (*Anoplopoma fimbria*) is a high dollar-value species caught in the Eastern North Pacific Coast groundfish fishery, and is often landed dressed. The scale weight of dressed

sablefish is reported on fish receiving tickets and later converted to derive the equivalent whole weight. Fishery managers use the standard conversion factor of 1.6, but the accuracy of this value has been questioned due to varying cut types and seasonal spawning trends. Because inaccurate accounting can have a significant impact on annual commercial harvest limits, we collected fishery samples in 2015 to evaluate conversion factor accuracy for two commonly used cut styles, as well as the effect of seasonally related spawning condition on recovery rate. Sampling was stratified by quarter to produce the mean recovery rate at the 95% confidence interval.

Our data confirm the conversion factor is different between the rolled-cut (Figure 14) and slight angle-cut (Figure 15) types investigated, 1.54 and 1.57 respectively (Figure 16). Furthermore, data show seasonal differences, with Quarters 1 and 2 being characterized by a lower conversion factor than that of Quarters 3 and 4 for both J-cut types (Figure 17).

In conclusion the slight angle-cut is comparable to the standard conversion factor of 1.6. In contrast, the rolled-cut differs from the standard conversion factor slightly. Our data suggest two conversion factors are necessary for J-cut types and season. The idea of having two conversion factors is problematic. Further discussion between fishery managers is necessary to evaluate the impact resulting from a change to the conversion factor if one is implemented, or when and where to use the most appropriate factor if both are to be used.

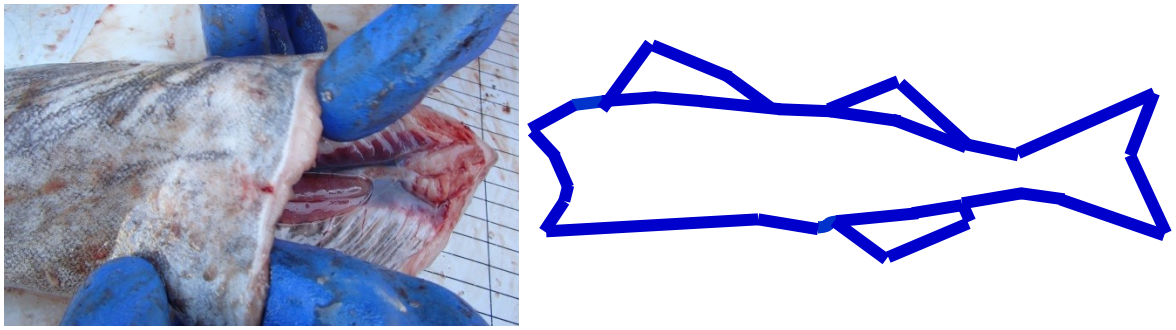

Figure 14. Rolled-cut: Fish laid on its side, cut started behind the pectoral fin and knife blade rolled toward the direction of the head and ended at the bony base; fish was flipped over and same cut made on its other side.

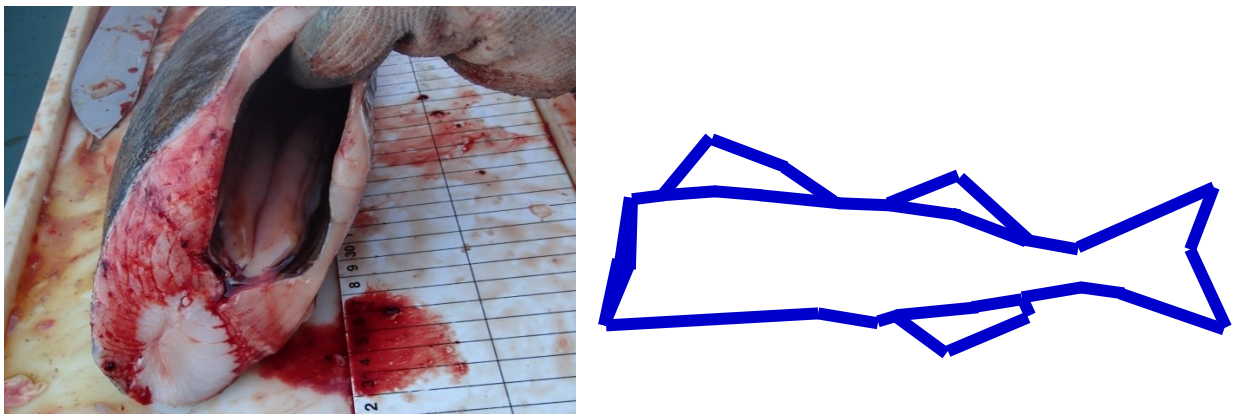

Figure 15. Slight angle-cut: The cut was made anterior of the origin of the first dorsal fin, fish belly side up, slight angle cut made to remove the head, gills, pelvic and pectoral fins.

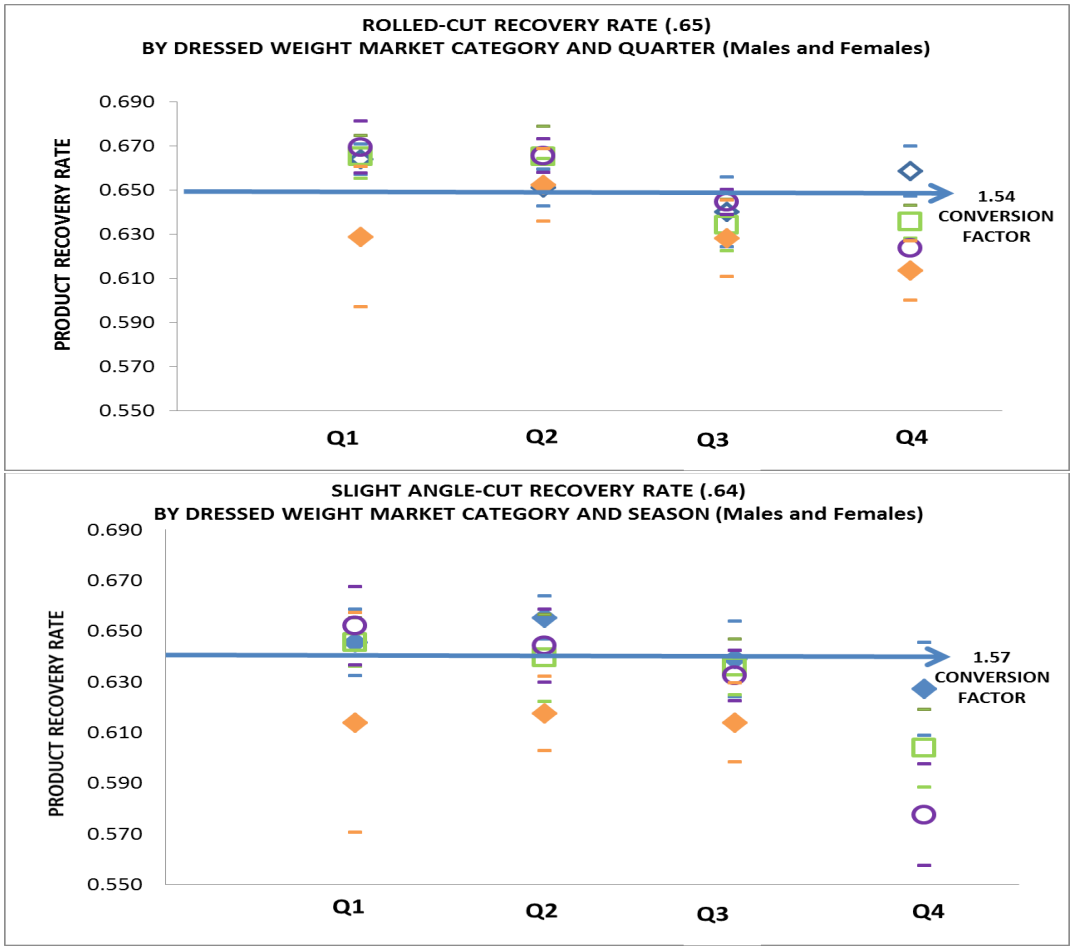

Figure 16. Recovery rate of the two J-cut styles, stratified by quarter, graph depicts the mean recovery rate at the 95 percent confidence interval (conversion factor for the rolled-cut and slight angle-cut types investigated, 1.54 and 1.57 respectively).

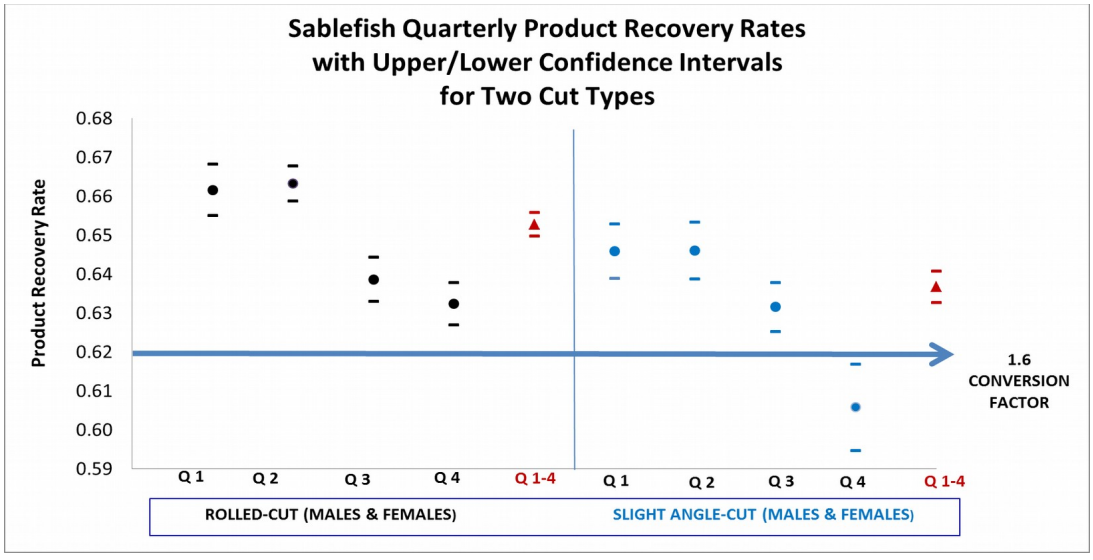

Figure 17. Seasonal differences for the product recovery rate of both J-cut types, rolled-cut and slight angle-cut, by quarter.

K. Lingcod

Comparison of ages determined from vertebrae, dorsal fin rays, and otoliths in Lingcod – An accurate and economical methodology for determining fish age is important to the successful management of any species. For Lingcod (*Ophiodon elongatus*), dorsal fin rays have been the primary structure used to determine age. However, this method is labor intensive and concerns have been raised regarding the precision of age determinations. The objective of a recent WDFW study was to evaluate the utility of otoliths and vertebrae as alternate ageing structures to dorsal fin rays while evaluating, cost, precision, bias, and uncertainty of determinations among structures. To address this objective we opportunistically sampled 124 lingcod from the recreational and commercial fishery off the coast of Washington, stratified by length (Large > 90 cm; Medium = 60-89 cm; Small < 59 cm TL). A set of 121 paired otoliths and fin rays, and 47 paired otoliths, fin rays, and vertebrae, were prepared using standard methodology, aged by two readers independently, and given a readability code. We evaluated each structure using average percent agreement (APE), age-bias plots, readability anomalies, and preparation and ageing time for each structure. Otoliths (surface aged) took just 3 minutes per sample to prepare and age but, had below average readability (readability anomaly = -0.8), the least precision between readers (APE = 14%), and the most bias between readers. Otoliths and vertebrae tended to produce younger age estimates relative to fin rays, and in particular for fish older than age-7. Vertebrae (surface aged) ages had intermediate precision between readers (APE = 8%), above average readability (readability anomaly = 0.13), and little bias between readers. Ages from fin rays and vertebrae had the highest concordance (APE = 8%), and vertebrae ages were on average 1 year younger than fin ray ages. Ages from dorsal fin rays were the most precise between readers (APE = 5%), had above average readability (readability anomaly = 0.17), and no bias between readers. We observed a negative relationship between the cumulative time it takes to prepare and age each sample and precision between readers. For example, ageing structures that were more intensive to prepare and age (fin rays and vertebrae > 30 minutes/sample), had the most repeatable age determinations. Our results suggest that despite some concordance between structures for younger fish, fin rays currently produce the most precise estimates across age classes, and are the only validated structure for ageing lingcod. Future work should focus on different preparation techniques for otoliths and vertebrae (e.g., sectioning, staining) and developing specific ageing criteria for those structures.

L. Atka mackerel

No specific, directed research or management to report.

M. Flatfish

Opening of localized flatfish fishery in long-term closure area – Hood Canal is a 110-km long fjord on the western side of Puget Sound that receives its water through a narrow (~2-km wide) connection with Admiralty Inlet. While much of the Canal is deep (approaching

175 m), a 65-m deep sill near the mouth of the canal, combined with seasonal stratification of the water column, significant freshwater input, and episodic upwelling in response to seasonal changes in wind patterns, leads to late fall and early winter fish kills in the southern portion of the Canal. As a consequence, the WDFW closed the entirety of Hood Canal to all bottom fishing in 2004. Though these fish kills typically only affect the southern third, or less, of the Canal, the northern portion was also closed under the assumption that individuals in this area would exploit vacant space in the southern portion of the Canal and redistribute themselves post-kill.

Quilcene and Dabob Bays are northwestern offshoots from the main arm of Hood Canal. These bays are well removed from areas known to host fish kills and significant pressure has been put on the WDFW in recent years to allow a localized bottomfish fishery here. Through the Fish and Wildlife Commission rulemaking process, a petition was received in 2014 requesting a flatfish only fishery in these two bays. After considering all known observations of ESA-listed rockfish in the vicinity, opportunistically reviewing localized ROV footage and bottom trawl sampling data, conducting a two-day test fishery in the area, and conducting two public meetings, PSMFS Unit staff recommended that a fishery be opened in the portion of the bays north of the mouth of Turner Creek, and only in waters shallower than 120 ft deep. This latter provision mirrored an existing requirement effective in all other Marine Areas of Puget Sound in order to reduce barotrauma on bycaught rockfish (which are illegal to retain throughout most of Puget Sound). All species of flatfish, other than Pacific Halibut, are now legal to retain in this area. Anecdotal information collected from local fishers indicates that this was a well-received policy change and that they appreciate seeing this fishing opportunity made available to them. Formal catch monitoring from this area is not currently planned, but periodic test fisheries will occur on a semi-annual basis for the next few years.

N. Pacific halibut & IPHC activities

No specific, directed research or management to report.

O. Other groundfish species

No specific, directed research or management to report. Various species of groundfish are counted, and density and abundance estimates are derived for them, during ROV, scuba, and trawl surveys described above.

V. Ecosystem Studies

Puget Sound Ecosystem Monitoring Program update – The Washington Department of Fish and Wildlife is a key partner of the Puget Sound Ecosystem Monitoring Program Project (PSEMP), a multi-agency effort to assess the health of Puget Sound. The WDFW's "Toxics in Biota" group is staffed by Jim West, Jennifer Lanksbury, Laurie Niewolny, Stefanie Orlaineta, Andrea Carey, Mariko Langness, and Sandie O'Neill. This group conducts regular status and trends monitoring of toxic contaminants in a wide range of indicator species in Puget Sound, along with evaluations of biota health related to exposure to contaminants. This group has recently conducted additional focus studies on toxic contaminants in Dungeness crab (*Cancer magister*), spot prawn (*Pandalus platyceros*), blue mussels (*Mytilus* spp), as well as a field experiment testing the effects of chemicals leaching from creosote-treated wooden pilings on the health of developing Pacific herring (*Clupea pallasii*) embryos. (Contact: Jim West, james.west@dfw.wa.gov; 360-902-2842)

Groundfish, Forage Fish, and Salmonid Surveys at U.S. Navy Facilities – The U.S. Navy controls multiple restricted areas throughout Puget Sound which have been exempted from rockfish critical habitat designation by NMFS, however an Integrated Natural Resource Management Plan (INRMP) provided by the Navy is required to fulfill the obligations necessitated by these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at NBK-Bremerton and NUWC-Keyport in 2013, the WDFW entered a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and critical habitat at the following installations: NASWI-Crescent Harbor, NAVMAG-Indian Island, NBK-Bangor, NBK-Bremerton, NUWC-Keyport, NAVSTA-Everett. These surveys, which expanded on the 2013 surveys, were conducted during 2014-15 and included ROV, scuba, hydroacoustic, and lighted fish trap methods to establish baseline densities, distributions, and habitat classification for rockfish and other groundfish at each installation. As of February 2016, a final report for each installation was submitted which concluded: no ESA-listed rockfish were observed, no deep-water critical habitat (>30m) for adult rockfish was present, and some nearshore critical habitats (<30m) with hard substrates and vegetation for juvenile rockfish do occur. These nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect methods in 2016-17. The deep-water surveys have concluded and will not continue in 2016.

The WDFW has also entered a Cooperative Agreement with the Navy to conduct beach seining surveys for ESA-listed forage fish and salmonids at the following installations: NASWI-Crescent Harbor, NASWI-Lake Hancock, NAVMAG-Indian Island, NBK-Bangor, Manchester Fuel Depot, NAVSTA-Everett. Monthly sampling at each installation began in May 2015 and will continue through the summer of 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. A summary of the results from 2015 sampling was included with the rockfish final reports. The only ESA-listed fish captured in the beach seine in 2015 were Puget Sound Chinook Salmon, Puget Sound Steelhead, Hood Canal Summer Chum Salmon, and Bull Trout. Regarding timing and abundance, juvenile salmonids and forage fish species generally followed trends previously documented in similar reports, which supports the work windows outlined in the Washington Administrative Code.

Puget Sound mid-water trawl study – Funding from the Washington State Legislature was appropriated through Substitute Senate Bill No. 5166 in May of 2015 to support an evaluation of forage fish abundance and distribution throughout Puget Sound using an acoustic/trawl survey design. The resulting survey design calls hydroacoustic data, mid-water trawl samples, and plankton samples to be collected for three weeks every other month from February of 2016 to February of 2017 at 18 reaches throughout the Sound (Figure 18). The initial field sampling phase of the Puget Sound Mid-water Acoustic/Trawl Survey was conducted February 2nd-23rd. To date, acoustic analysis has been limited to comparing historic methods, when data were collected using older equipment, to current methodologies employing state of the art hydroacoustic equipment (Biosonics DT-X; 38 kHz and 120 kHz transducers). Additional analyses will include species-specific estimation of abundance, density, and biomass by site and across sites.

A total of 32 mid-water trawls were completed in February, including three trawls that captured no fish. The empty trawls occurred during the first week of the survey when there was no real-time information on net performance or depth during the tows. Prior to the second week of the survey, a Marport Trawl sensor was placed on the head rope of the trawl. This system provides

the trawl vessel with real-time information on net depth and performance and greatly improves efficiency of the tows.

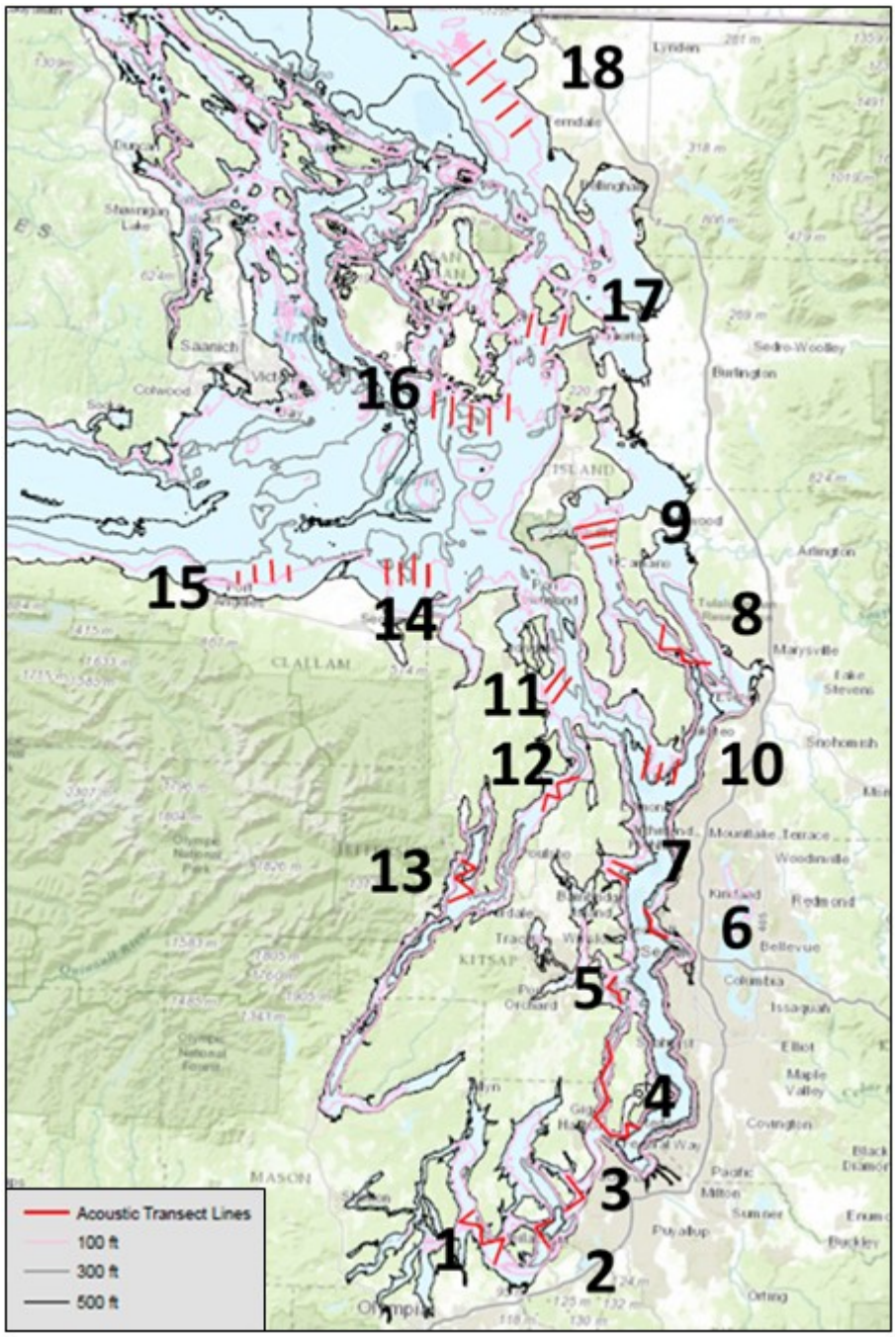

Figure 28. Map of station locations for the Puget Sound Mid-Water Acoustic Trawl Survey.

A total of 52 different species of fish and invertebrates were captured in the trawls (Figure 19). Pacific Herring were the numerically most abundant species in the trawl catch and were the dominate species in the North (Whidbey) Basin and Hood Canal. Pacific Whiting (Hake) catch dominated the Central Puget Sound, and northern anchovy and shiner perch dominated in South

Sound. A total of 11 Chinook Salmon were captured (200-374 mm FL) and all were released alive. No other ESA listed species were encountered.

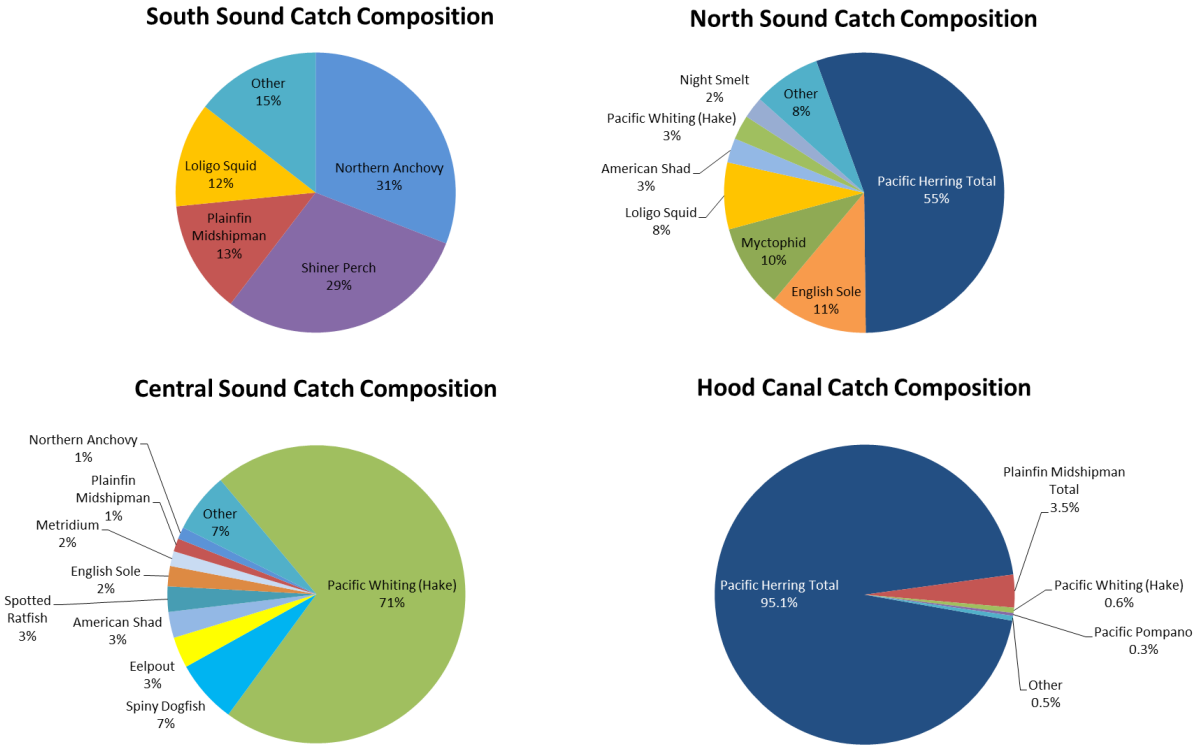

Figure 19. Trawl catch composition by region for samples taken during February of the Puget Sound Mid-Water Acoustic Trawl Survey.

A total of 24 vertical plankton tows were taken during February. Samples were preserved in buffered formalin and are currently stored at the WDFW waiting processing.

In a broad effort to reach out to collaborators the trawl survey has provided research specimens for Paul Hershberger, USGS (Pacific Herring, *Ichthyphonus* research), Sandie O'Neill and Jim West, WDFW (American Shad, ecology and toxicology), Virginia Butler (archaeology, University of Portland), Gary Winans (forage fish genetics, NOAA), Lorenz Hauser (Pacific Herring genetics, UW), and Katherine Maslenikov (fish collections) at the UW Burke Museum. A number of samples were also retained by the WDFW for use in evaluating age, sex ratio, and maturation stage of the sampled portion of each population.

The next sampling phase of the Puget Sound Mid-water Acoustic/Trawl survey began April 4th. Subsequent sampling events will occur every other month through February of 2017 with a final completion report delivered to the State Legislature in June.

High-resolution modeling of fish habitat associations, and predictive models -- In collaboration with the SeaDoc Society and Tombolo Laboratories, PSMFS Unit staff worked to integrate high-resolution multibeam bathymetry data from the San Juan Islands with fish occurrence data obtained from ROV and drop camera surveys over five years. H. Gary Greene, a geologist, has spent several years mapping and typing benthic habitats in the San Juans. Leveraging visual survey work conducted by WDFW that overlaps these focal areas, a unique opportunity has arisen to groundtruth Dr. Greene's bottom typing and to use benthic terrain modeler in ArcGIS to evaluate the occurrence of fish species over particular bottom types. A

cooperative agreement was established between WDFW and the SeaDoc Society in 2014 to conduct a pilot analysis in a small area of the San Juan Islands. The pilot study was completed in early 2015, with strong correlations established between rockfish occurrence and habitat variables such as slope, depth, and benthic position index. The next step is to expand this study to areas of Puget Sound with high-resolution bathymetry data to cross-validate the model in areas lacking a true habitat map (see below). This second phase of investigation recently received funding from NOAA and will help to pave the way for a Puget Sound-wide model that can be used to evaluate rockfish critical habitat designations made by NOAA in 2015.

ROV survey for ESA-listed rockfish, and their habitats, in Puget Sound – Dan Tonnes at NOAA's NWFSC was able to secure supplemental funding to allow a 2-year remotely-operated vehicle survey of large portions of Puget Sound beginning in 2015. Because past efforts had focused on the San Juan Archipelago, this new study was limited to Central Puget Sound, the Whidbey Basin, Hood Canal, and South Puget Sound (in total, referred to as Puget Sound proper). The goal of this study was to develop valid population estimates for ESA-listed rockfish species in this undersampled portion of the U.S. DPSs. The stereological survey of Puget Sound conducted in 2012 did not encounter ESA-listed rockfish in significant numbers, thus this supplemental survey was needed to provide baseline population estimates necessary to evaluate recovery of these species, per the conditions of the ESA. A secondary goal of this survey was to catalog and quantify high-relief, rocky habitat in Puget Sound proper in an effort to better define attributes of Critical Habitat for these ESA-listed rockfish species.

WDFW staff worked with Chris Rooper at NOAA's Alaska Fisheries Science Center to design a survey using a Maximum Entropy model to predict the potential distribution of listed rockfish habitat. The model inputs included all verified locations of Yelloweye and Canary Rockfish, a 30m x 30m bathymetry grid of Puget Sound, and bottom current velocities (resampled to 30m x 30m). From the bathymetry grid we extracted bottom depth, and measures of slope and bottom roughness (rugosity). Based on these attributes, combined with the bottom current velocities at the locations of ESA rockfish, the MaxEnt model predicts a probability surface representing the potential species distribution within the study area. The probability surface was parsed into high, medium, and low probability bins, which were used to stratify the study area. We used the encounter rates for ESA rockfish from previous ROV surveys in the San Juan Islands to model expected coefficients of variation and partitioned sampling effort among the three strata as follows: 60% high, 20% medium, 20% low. High probability habitats composed 7% of the study area, whereas medium and low probability strata composed 12% and 81% of the study area, respectively. We planned to conduct 900, half-hour ROV transects, 450 in each year. Using a random point generator in ArcGIS sampling locations were generated proportionally to each of the three strata, with additional buffer stations to accommodate potential need to drop stations in response to various field conditions (e.g., map inaccuracies, hazards to navigation)..

In 68 total survey days between February and December of 2015 we sampled 387 stations; 249 high, 82 medium, and 56 low, representing 86% of the planned survey stations and over 90% of the high and medium stations (Figure 20). Technical issues with the ROV and poor weather conditions prevented completion of the remaining stations. All three species of ESA rockfish were encountered during the 2015 survey year, with all encounters occurring on high probability habitats. In total we encountered 35 yelloweye rockfish at 19 stations, 7 canary rockfish at 4 stations, and 1 bocaccio.

The 2016 phase of this survey began February 29th and will continue until all stations have been sampled or until funding is no longer available.

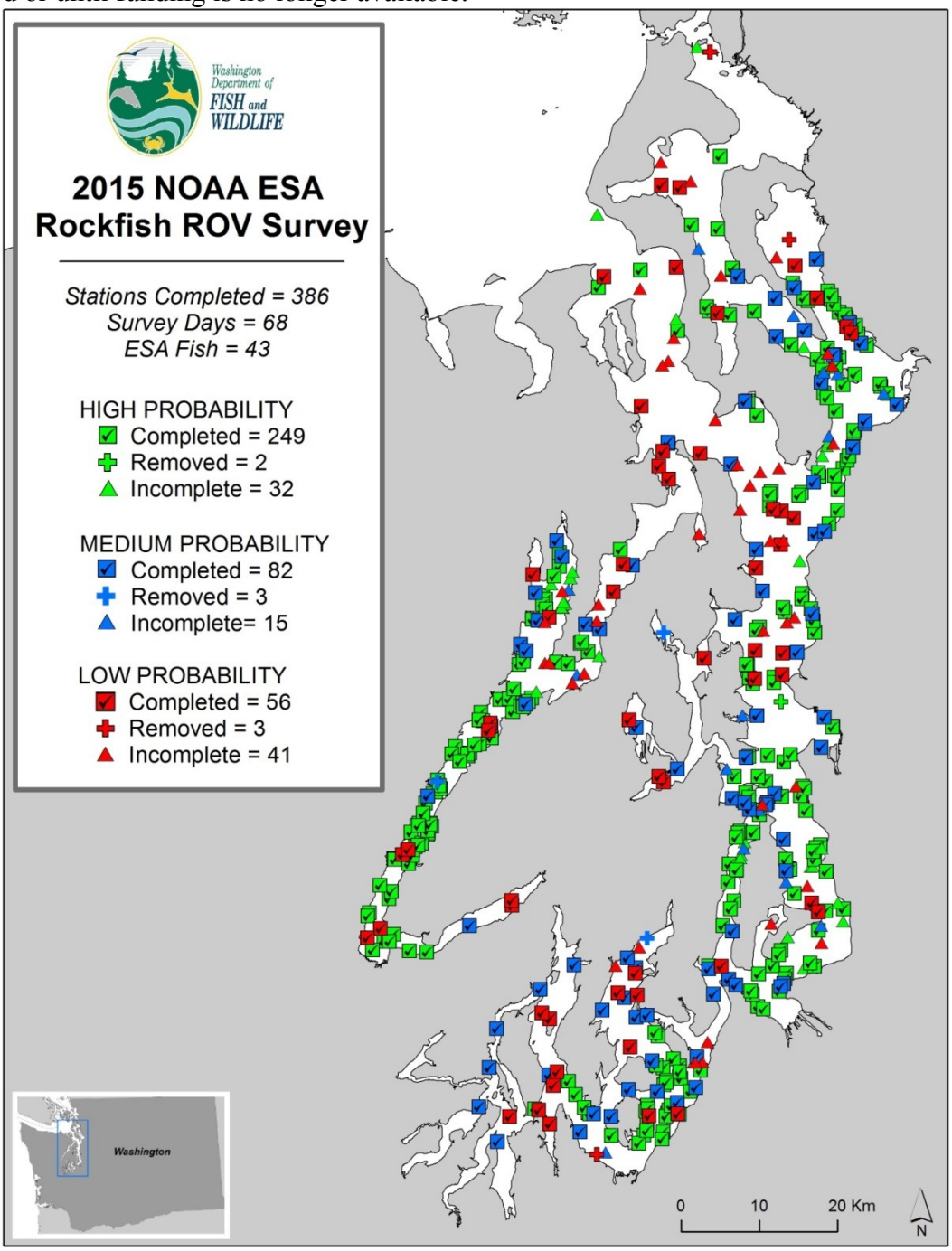

Figure 20. Planned survey stations for the ESA-listed rockfish, and habitat, survey in Puget Sound. Stations are symbolized by their end-of-survey status.

Derelict gear reporting, response, and removal grant funding – Marine fish mortality associated with derelict fishing gear has been identified as a threat to diverse species around the world. In Puget Sound, removal of derelict fishing nets has been the focus of a concerted effort by the Northwest Straits Foundations since 2002. In late 2013 the Washington State Legislature granted $3.5 million to the Foundation to "complete" removal of all known legacy fishing nets in waters shallower than 105 ft. A portion of this money was set aside for WDFW to assist with

planning of removal efforts and evaluation of the final results. In August of 2015 a celebration ceremony was held to commemorate completion of these net removal efforts, which resulting in 5,660 fishing nets being removed from the Sound and 813 acres of benthic habitat restored. The Northwest Straits Foundation and the PSMFS Unit have now moved on to pursue funding for removal of deep-water nets (>105 ft deep) in coming years after a successful pilot attempt to remove several such nets using an ROV instead of scuba divers.

In 2012 a reporting hotline was developed, and a rapid response and removal team was formed, to prevent the accumulation of additional fishing nets. Because these nets are a direct threat to ESA-listed rockfish, in 2014 WDFW and the Foundation were able to obtain Section 6 funding to continue hotline service and ensure support for the response team through 2016. Combined with the legislative grant money mentioned above, this funding source allows the WDFW and Foundation to remove old nets, stay informed about newly lost nets, and remove new nets to minimize/eliminate this threat to rockfish, and the ecosystem at large. To date reports for several dozen nets have been responded to, resulting in the removal of numerous free-floating nets, a handful of sunken/entangled nets, and ample opportunity for public outreach regarding when nets are derelict and when they are legal fishing.

VI. Publications

Lowry, D, Pacunski, RE, Blaine, J, Tsou, T, Hillier, L, Beam, J, Wright, E, Cheng, YW, and A Hennings. (In prep). 2010 Assessment of San Juan Island bottomfish populations utilizing a remotely operated vehicle and a stereological survey protocol. Washington Department of Fish and Wildlife Technical Report. Expected completion July 2016.

Lowry, D, Pacunski, RE, Blaine, J, Tsou, T, Hillier, L, Beam, J, Wright, E, and A Hennings. (In prep). Assessing groundfish occurrence, abundance, and habitat associations in Puget Sound via a small remotely operated vehicle: results of the 2012-13 stereological survey. Washington Department of Fish and Wildlife Technical Report. Expected completion September 2016.

Pacunski, RE, Lowry, D, Hillier, L, and J Blaine. (2016). A comparison of groundfish species composition, abundance, and density estimates derived from a scientific bottom-trawl and a small remotely operated vehicle for trawlable habitats. Washington Department of Fish and Wildlife Technical Report. FPT 16-03. 36 pp.

Carson, HS, Ulrich, M, Lowry, D, Pacunski RE, and R Sizemore. (2016). Status of the California sea cucumber (*Parastichopus californicus*) and red sea urchin (*Mesocentrotus franciscanus*) commercial dive fisheries in the San Juan Islands, Washington State, USA. *Fish Res*. 179: 179-190.

McNeil, B, Griffing, D, Larson, S, and D Lowry. (In press). Feeding behavior of subadult sixgill sharks (*Hexanchus griseus*) at a bait station. *Mar Biol.* Online.

The IUCN Red List of Threatened Species. (2015). www.iucnredlist.org.
Cortes, E, Lowry, D, Bethea, D, and CG Lowe. *Sphyrna tiburo* – bonnethead shark.
Larson, S, Lowry, D, and D Ebert. *Hexanchus griseus* – bluntnose sixgill shark.
Lowry, D, Larson, S, and D Ebert. *Notorynchus cepedianus* – broadnose sevengill shark.
Lowry, D, and K Goldman. *Carcharhinus limbatus* – blacktip shark.

Larson, S, Farrer, D, Lowry, D, and DA Ebert. (2015). Preliminary observations of population genetics and relatedness of the Broadnose Sevengill Shark, *Notorynchus cepedianus*, in two Northeast Pacific estuaries. *PLoS One*. 10(6): e0129278.

Langness, M, Dionne, P, Masello, D, and D Lowry. (2015). Summary of Coastal Intertidal Forage Fish Spawning Surveys: October 2013- October 2014. Report to the Washington

Department of Natural Resources Marine Spatial Planning Funding Board. Washington Department of Fish and Wildlife Technical Reports. Report Number FPA 15-01. January 2015. 50 pp. + appendices.

Lowry, D, Stick, K, Lindquist, A, and YW Cheng. (2015). Evaluation of creel survey methods to estimate recreational harvest of Surf Smelt in Puget Sound, Washington. *N Amer J Fish Man*. 35 (3): 403-417. DOI 10.1080/02755947.2015.1009658.

VII. Conferences and Workshops

In 2015-16 staff of the PSMFS Unit presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events as indicated below.

2015 Annual Meeting of the American Fisheries Society, Aug. 16-20. Presenters: Dayv Lowry, Jen Blaine, Andrea Hennings, Lisa Hillier, Taylor Frierson. Symposia co-organizers: Dayv Lowry, Robert Pacunski, Jen Blaine.

19th Western Groundfish Conference, Feb. 8-11. Presenters: Dayv Lowry, Bob, Pacunski, Phil Weyland, Jen Blaine, Donna Downs, Theresa Tsou, and Jamie Fuller.

Seattle Aquarium Discover Science Days, Nov. 15-15, 2015. Presenters: Dayv Lowry, Robert Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Taylor Frierson, Adam Lindquist, Phil Campbell, Erin Wright, and Amanda Phillips.