Washington Contribution to the 2017 Meeting of the Technical Sub-Committee (TSC) of the Canada-U.S. Groundfish Committee: Reporting for the period from May 2016-April 2017

April 25th-26th, 2017

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April 2017

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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. The Unit is overseen by Theresa Tsou, who also oversees the Coastal Marine Fish Science Unit (see below) and supported by Phil Weyland (programming and data systems). On April 17th, 2017 Phill Dionne was hired to assume authority for state-wide marine forage fish research and management.

Staff of the Puget Sound Marine Fish Science (PSMFS) Unit during the reporting period included Dayv Lowry (lead), Robert Pacunski, Larry LeClair, Todd Sandell, Jen Blaine, Adam Lindquist, Lisa Hillier, Taylor Frierson, Patrick Biondo, Andrea Hennings, Mike Burger, Mark Millard, Chris Fanshier, Will Dezan, Amanda Philips, and Phil Campbell. In addition, Courtney Adkins and Peter Sergeeff work as PSMFS employees during the annual spring bottom trawl survey. Within the Fish Management Division of the Fish Program a second work unit also conducts considerable marine forage fish and groundfish research in Puget Sound, but focuses on the accumulation of toxic contaminants in these species. The Toxics-focused Biological Observation System for the Salish Sea (TBiOS) (formerly Puget Sound Ecosystem Monitoring Program or PSEMP) consists of Jim West (lead), Sandy O'Neill, Jennifer Lanksbury, Laurie Niewolny, Mariko Langness, and Rob Fisk.

PSMFS 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 Rockfish, Yelloweye Rockfish, and Bocaccio, in Puget Sound since 2010 (National marine Fisheries Service 2010). In 2017 Canary Rockfish were delisted, but Yelloweye Rockfish and Bocaccio still very much drive management of all groundfish species.

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Staff of the Coastal Marine Fish Science (CMFS) Unit during the reporting period included Lorna Wargo, Brad Speidel, Rob Davis, Donna Downs, Bob Le Goff, Kristen Hinton, Jamie Fuller, Hannah Grout, Michael Sinclair, Grace Thornton, and Tim Zepplin. 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 Phill Dionne.

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 SSC 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 the Ocean Policy Unit, which consists of Michele Culver, Corey Niles, Heather Reed, and Jessi Doerpinghaus.

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II. Surveys

Puget Sound Bottom Trawl – Since 1987, the 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, Georgia Basin, 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.

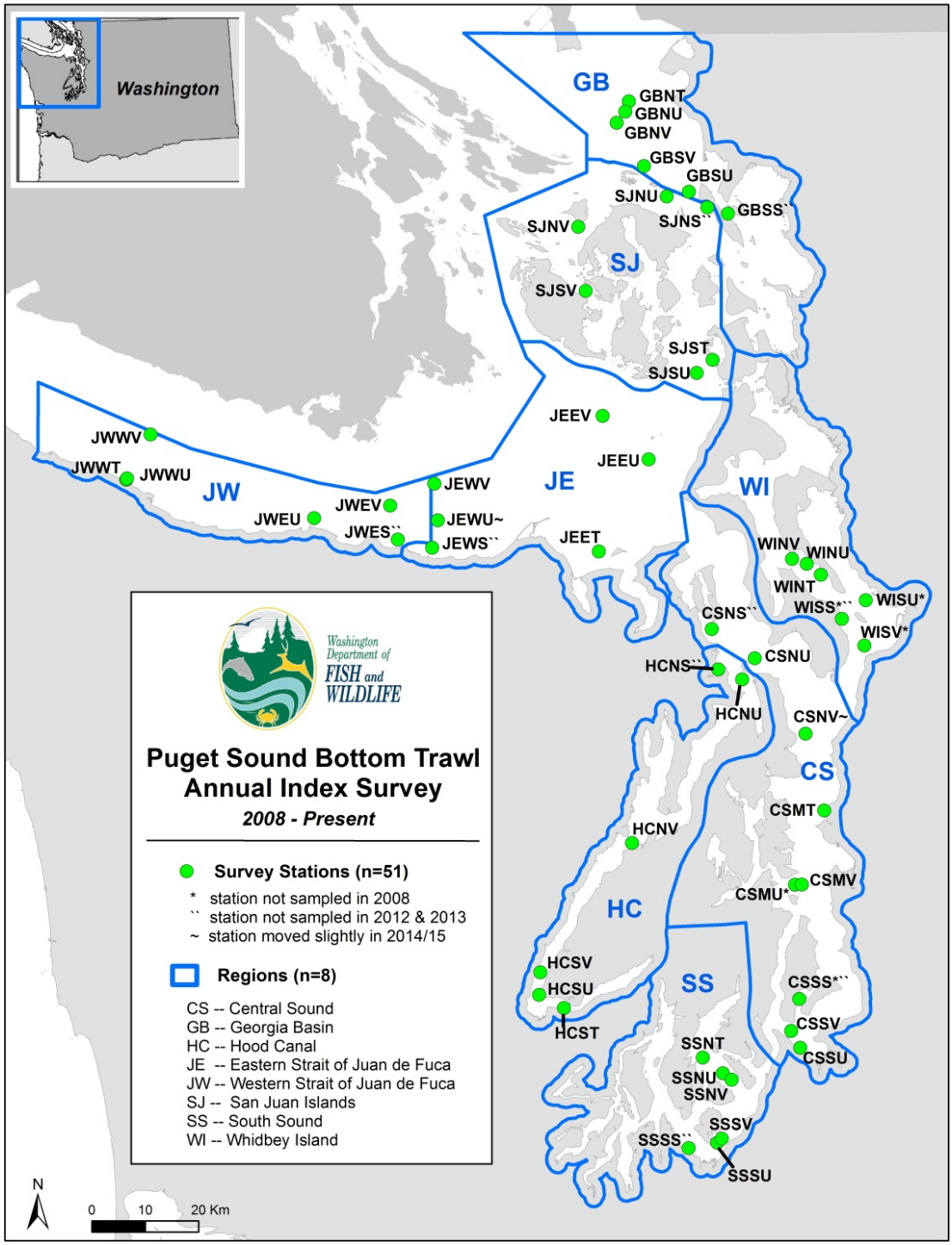

Figure 1. Trawl site locations for the Index survey design sampled in 2016

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.

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' confidence interval around the 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 both 2015 and 2016 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, North Pacific 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 2016, the WDFW conducted the 9th Index trawl survey of Puget Sound from May 2 through May 25. During our 15 survey days, we occupied all 51 stations and conducted 55 bottom trawls. An estimated 22,400 individual fish among 80 species weighing 7.9 mt were collected (2015: 20,300 fish; 77 species; 7.7 mt). Similar to 2014 and 2015, Spotted Ratfish constituted 56% of the total fish catch by weight and 30% of the total number of individual fish, followed by English Sole at 18% and 17%, respectively. The remaining fish species contributed 5% or less to the fish catch weight and 9% or less to the total number of individual fish. For invertebrates, an estimated 7,000 individuals from 73 different species/taxa weighing 1.5 mt were caught in 2016, compared to 9,500 individuals from 67 species/taxa weighing 1.8 mt caught in 2015. By weight, the most dominant species were Dungeness Crab and Metridium anemones, comprising a respective 41% and 30% of the total invertebrate catch weight. By number of individuals, Alaskan Pink Shrimp, Dungeness Crab, and Sidestriped Shrimp comprised 22%, 13%, and 13%, respectively, of the invertebrate catch. The remaining species contributed 10% or less to the total invertebrate catch by weight or by number.

Pacific Eulachon was the most abundant ESA-listed species encountered during the 2016 survey; 34 individuals were caught (up from 24 in 2015) in regions JE, JW, GB, and SJ (Figure 1). Additionally, two juvenile Coho Salmon were caught in HC. Genetic samples were collected for each of these in accordance with the Section 10 permit for the trawl survey. Bocaccio were also encountered for the second time in the history of the bottom trawl survey (first in 2012); however, all 11 individuals were found in the western portion of region JW, which is outside of

the species' Puget Sound DPS boundary. Fin clips were taken as genetic samples and a few individuals were sacrificed for otoliths.

Catches of two key Gadiformes species, Walleye Pollock and Pacific Whiting (Hake), increased in the 2016 survey compared to the 2015 survey. Walleye Pollock catch increased in abundance but not in weight, as an estimated 893 individuals weighing a total of 87 kg were caught in 2016, compared to 810 individuals/114 kg in 2015. Pacific Whiting (Hake), however, increased substantially in both metrics from an estimated 450 individuals weighing a total of 25 kg in 2015 to 2,100 individuals totaling 390 kg in 2016; increases occurred in every region except JW, in which Pacific Hake haven't been captured in the survey since 2011. While overall lengths of Hake ranged from 7 cm-59 cm, 85% of those measured were 15cm-20cm long. Catches of Pacific Cod, however, continued to decline. In 2016, only caught 26 individuals weighing a total of 48 kg were caught, down from 43 individuals/75 kg in 2015 and 88 individuals/86 kg in 2014. Similar to previous years, 88% of Pacific Cod were found in JW.

Despite the higher North Pacific Spiny Dogfish catch in 2015 of 246 individuals weighing a combined 387 kg, the catch rate in 2016 of 65 individuals/78 kg was more similar to values observed in 2014. Dogfish were most prevalent in GB and JE regions, with over 50% of both total individuals and total weight coming from these regions. Catches of Raja sp. skates (i.e., Big and Longnose Skates) increased in total individuals from 162 in 2015 to 270 in 2016; total weight of these skates, however, decreased slightly from 395 kg in 2015 to 389 kg in 2016. Encounter rates were highest in GB (31% of total individuals) and CS (22%), but while GB also contributed the highest catch weight (34% of total), CS only contributed 5% of the total.

The 2017 Index bottom trawl survey is scheduled to occur from April 24 – June 1, concurrently with the Toxics-focused Biological Observation System (TBiOS) trawl survey.

Threatened and Endangered species surveys at Naval Installations – The U.S. Navy controls multiple restricted areas throughout Puget Sound that have been exempted from ESA-listed rockfish critical habitat designation by the NMFS. As a prerequisite, the Navy maintains an Integrated Natural Resource Management Plan (INRMP) to fulfill the requirements that authorize these exemptions. Following the submission of a report detailing the preliminary findings of the surveys at Naval Base (NAVBASE) Kitsap Bremerton and Keyport in 2013, the WDFW's PSMFS Unit entered into a Cooperative Agreement with the Navy to continue surveys for ESA-listed rockfish and their critical habitat at the following installations: Naval Air Station (NAS) Whidbey Island Crescent Harbor, Naval Magazine (NAVMAG) Indian Island, NAVBASE Kitsap Bangor, NAVBASE Kitsap Bremerton, NAVBASE Kitsap Keyport, Naval Station (NAVSTA) Everett. These surveys were conducted during 2014-15 and expanded on the 2013 pilot surveys. The combination of survey methods included ROV, scuba, hydroacoustics, and lighted fish traps 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 with conclusions 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. Due to the absence of deep-water critical habitat within the Naval restricted areas, deep-water surveys were discontinued after 2015. The nearshore critical habitats have been outlined in the reports along with recommendations to focus on juvenile rockfish surveys by scuba transect and fish trap methods, which began in January 2017.

Underwater visual strip transects by divers are being conducted monthly throughout 2017 at the NAVBASE Kitsap Bangor and NAVMAG Indian Island to monitor juvenile rockfish recruitment and settlement within nearshore vegetative zones. Several comparison areas in the vicinity of these Naval installations with optimal juvenile rockfish habitat (i.e., kelp forests), including a series of index stations near Edmonds, are also being surveyed with the same methods to assess the relative success of the 2017 recruitment cohort. As a supplement to the dive surveys, fish traps modified for juvenile rockfish are deployed at each of the dive sites and retrieved during each survey event (1-2 times a month). Preliminary results from January through April include the occasional capture of juvenile Copper/Quillback and Yellowtail Rockfish (from the 2016 cohort) when the dive surveys observe zero juvenile rockfish. Peak recruitment is expected to occur during summer and fall.

The WDFW's PSMFS Unit 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: NAS Whidbey Island Crescent Harbor and Lake Hancock, NAVMAG Indian Island, NAVBASE Kitsap Bangor and Zelatched Point, Manchester Fuel Department, NAVSTA Everett. Monthly sampling at each installation began in May 2015 and continued through September 2016 to assess the timing and abundance of migrating fish species adjacent to Navy facilities. Additionally, tissue samples (n=326) were collected from Chum Salmon captured in Hood Canal and Admiralty Inlet during 2016 sampling, and genetically analyzed to determine either summer-run or fall-run assignment. Analysis of the tissue samples revealed that ESA-listed Hood Canal summer-run fish comprised 95% of all Chum captured in both January and February, while 80% of all Chum captured from March through May were fall-run fish. Tissue samples (n=100) were also collected from Coastal Cutthroat Trout to detect possible hybridization with ESA-listed steelhead; a single F1 hybrid and two F3 hybrids were confirmed. As of April 2017, a final report for each installation was submitted, and confirmed that ESA-listed fish species captured in the beach seine included Chinook Salmon, Puget Sound Steelhead, Hood Canal summer-run Chum Salmon, and Bull Trout (varied by location). Regarding timing and abundance, juvenile salmonids and forage fish species generally followed the same trends previously documented in similar reports, which supports the work windows outlined in the WAC Hydraulic Code Rules.

Annual Pacific Herring Assessment in Puget Sound – Annual herring spawning biomass was estimated in Washington in 2016 using spawn deposition surveys. WDFW staff based in the Mill Creek, Olympia, and Port Townsend offices conduct these assessment surveys of all 21 known herring stocks in Puget Sound waters annually from early January to mid-June.
The herring spawning biomass estimate for all Puget Sound stocks combined in 2016 was 12,192 tons, a slight decrease from 2015 (13,2446 tons) (Table 1). The 2016 cumulative total is an increase from the 2013 low point of 7,332 tons and also higher than the mean cumulative total for the previous ten year (2007-2016) period of 11,101 tons. The general trend is driven mainly by increases in the Quilcene Bay stock (Hood Canal), estimated at 7,409 tons in 2016, the highest spawning biomass on record for this stock (a 59% increase from 2015). The other stock in this region, South Hood Canal, decreased slightly from 282 in 2015 to 249 tons in 2016, but is the third highest total in the past ten years.

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

STOCK	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Squaxin Pass	557	1,025	824	510	565	589	554	394	324	260
Purdy		496	125	500	711	135	260	83	32	0
Wollochet Bay	35	45	360	11	21	31	10	39	0	0
Quartermaster Harbor	441	491	843	143	96	108	157	44	55	0
Elliot Bay						290	214	29	135	109
Port Orchard-Port Madison	1,589	1,186	1,768	350	123	217	184	90	92	0
Port Gamble	826	208	1,064	433	1,464	404	273	170	345	179
Kilisut Harbor	24	0	0	0	0	0	0	5	0	0
Port Susan	643	345	252	152	138	61	29	68	70	61
Holmes Harbor	572	686	1,045	673	3,003	678	585	459	456	494
Totals for South and Central Puget Sound	**4,687**	**4,482**	**6,281**	**2,772**	**6,121**	**2,513**	**2,266**	**1,381**	**1,509**	**1,103**
Skagit Bay	1,236	1,342	1,036	402	469	443	454	294	285	48
Fidalgo Bay	159	156	15	103	119	89	100	221	80	5
Samish/Portage Bay	348	409	320	649	387	430	693	778	559	1,025
Int. San Juan Islands	33	60	0	24	0	5	0	5	38	
NW San Juan Islands	0	0	0	0	0	0				
Semiahmoo Bay	1,124	662	990	909	1,605	879	569	2,828	5,852	1,798
Cherry Point	2,169	1,352	1,341	774	1,301	1,120	908	1,003	524	516
Totals for North Puget Sound/SJI	**5,069**	**3,981**	**3,702**	**2,861**	**3,881**	**2,966**	**2,724**	**5,129**	**7,338**	**3,392**
South Hood Canal	70	223	156	214	156	264	199	112	282	249
Quilcene Bay	2,372	2,531	3,064	2,012	4,443	2,626	2,072	3,097	4,097	7,160
Totals for Hood Canal	**2,442**	**2,754**	**3,220**	**2,226**	**4,599**	**2,890**	**2,271**	**3,209**	**4,379**	**7,409**
Discovery Bay	42	248	205	26	0	105	0	5	12	244
Dungeness/Sequim Bay	34	69	46	75	104	43	71	72	8	44
Totals for Straight of Juan de Fuca	**76**	**317**	**251**	**101**	**104**	**148**	**71**	**77**	**20**	288
Annual Totals	**12,274**	**11,534**	**13,454**	**7,960**	**14,705**	**8,517**	**7,332**	**9,796**	**13,246**	**12,192**

The combined spawning biomass of South/Central Puget Sound herring stocks in 2016 was 1,103 tons, a slight decrease from the 2015 total of 1,509. A number of stocks in the region that were previously at relatively large abundances are now at low levels, particularly the Purdy, Wollochet Bay, Quartermaster Harbor, Port Orchard-Port Madison, Kilisut Harbor stocks, which had no spawn recorded in 2016. Two of these sites- Purdy and Wollochet Bay- have now recorded zeros for two years in a row, and are being closely monitored in 2017.

The cumulative biomass of North Puget Sound stocks declined dramatically from 2015 (7,338 tons) to 3,392 tons, which was also a decrease from 2014 (5,129 tons). This was primarily the result of a return to a more average year (1,798 in 2106) for the Semiahmoo Bay stock, which had a record year in 2015 (5,852 tons). However, the spawning biomass of the Cherry Point stock also decreased slightly in 2016 to 516 tons, falling from 2015 (524 tons) and almost half of the ten year average for this site (1,101 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 increased dramatically in 2016 to 288 tons, a ten-fold increase from 2015 (20 tons) that was driven by the Discovery Bay stock, which had the highest estimated spawn since 2008. The 2017 spawn surveys are now underway and will continue through mid-June.

Yelloweye Rockfish habitat exploration on the Washington outer coast – The WDFW has been conducting longline surveys off the northern Washington coast to better understand seasonal changes in catch rates for rockfish that inhabit rocky habitat. Results from these surveys will be used to improve future strategies to monitor and assess rockfish populations, evaluate the risk of localized depletion and survey effects, and to monitor the growth and movement of several important rockfish species. Recent research has focused on Yelloweye Rockfish (*Sebastes ruberrimus*). In 2002, the Pacific Fishery Management Council declared Yelloweye Rockfish overfished under provisions of the Magnuson Stevens Fishery Conservation and Management Act. To achieve rebuilt status, conservation measures including prohibiting catch and area closures have been implemented during ensuing years. Effects of these measures have been two-fold. Fishery catch, a customary source of biological and population trend data, is now severely limited or lacking altogether; and more than any other single groundfish species, Yelloweye Rockfish constrain both commercial and recreational groundfish fisheries.

Due to stringent catch restrictions on slope and shelf rockfish, fishery-dependent data is very limited for many of these species. A lack of data exists for rockfish species such as Yelloweye Rockfish, Rougheye Rockfish (*S. aleutianus*), Shortraker Rockfish (*S. borealis*), and Redbanded Rockfish (*S. babcocki*) as a result of a low number of encounters with these species.

Fishery-independent data sources have also had limitations. The International Pacific Halibut Commission (IPHC) has conducted longline surveys off the Oregon and Washington coasts since 1997 to monitor halibut abundance. These are standardized fixed-station surveys based on a 10 NM grid. Beginning in 2007, a number of rockfish stations were added to the IPHC survey to enhance knowledge of rockfish populations. The addition of rockfish stations to the survey improved the opportunity to collect biological data from these rockfish during summer halibut stock assessment surveys, however the survey fishing effort is not concentrated on specific habitat and halibut monitoring is the primary focus. The NMFS triennial trawl survey has also been an insufficient source of data for rockfish species that inhabit rocky habitat due to fish behavior and habitat inaccessible to trawl gear. Using the IPHC survey design and data, the WDFW is refining a survey more specific to rockfish that inhabit rocky habitat. Such a survey is needed to collect species specific data to inform population assessments and conservation efforts.

One issue that has been apparent in the longline surveys is the lack of occurrence of yelloweye rockfish that are less than 40 centimeters (cm) in length. To understand why only larger fish were coming up on the survey, gear and area experiments were conducted. Smaller hooks were used to see if smaller fish could be caught and gear was deployed in shallower areas where yelloweye were known to occur. It was determined that it is likely an area issue- the smaller, younger fish don’t seem to reside out at the survey zone which is located in the 80-100 fathom depth range. So, additional areas need to be surveyed in order to sample a representative portion of the population. Also, not all areas that contain yelloweye are well documented and this information would be valuable for future survey design.

In the fall of 2016, an effort to document some additional areas in shallower waters than 80 fathoms where Yelloweye Rockfish occur was undertaken. These areas were searched with a rod and reel gear vessel to document location and evaluate size distribution of Yelloweye and other rockfish. The F/V Hula Girl out of Westport, WA was chartered for this work. The skipper of the Hula Girl, Steve Westrick, had experience encountering Yelloweye Rockfish on past recreational

fishing trips as well as agency sponsored research. Several areas were identified in the northern part of Marine Area 1 and Marine Area 2 within a 30-80 fathom depth range for searching and a plan was developed to visit these areas starting in late September. Previous surveys have searched shallower areas in Marine Area 3 for Yelloweye Rockfish with some success but a shallower area in Marine Area 4 where Yelloweye Rockfish are concentrated is unknown. The timing for these trips was based on charter availability and weather. For each trip, 4-6 volunteers were enlisted to fish with typical recreational rod-reel gear.

For each day, information was collected for each fishing set and all species encountered. A fishing set was defined as a block of fishing time for which there was no significant change in effort, gear, or location. GPS location of the start of each set, disposition of vessel (anchored or drifting), number of anglers, amount of time fished, depth, and gear used was collected for each fishing set made. Gear used was uniform among all anglers for each set. Anglers were monitored to account for any significant breaks from fishing that were taken within a set and recorded as less than one angler based on the length of the break. All catch was identified to species, measured (FL, cm), scanned for previously implanted tags, recorded by fish identification number if either recaptured or receiving a tag. A caudal fin clipping was collected, preserved, and recorded by individual fish for yelloweye encountered. Yelloweye, Quillback, and Tiger Rockfish were also tagged with an internal PIT tag and an external spaghetti tag.

The weather only allowed three trips to be taken aboard the Hula Girl in September where three distinct areas were fished one per day. A total of 30 yelloweye were encountered and the catch was similar at each location (Table 2). Six other species of rockfish were encountered and the total catch of rockfish for the three days was 300 fish. Overall, yellowtail rockfish was the most prevalent species but was only encountered in large numbers at the areas fished on the 26th and 29th. The other predominant species encountered were Lingcod and North Pacific Spiny Dogfish. Depths fished ranged from 239-478 ft (39.8-79.7 fathoms). A total of 24 Yelloweye, 7 Quillback, and 3 Tiger rockfish were tagged and released at the fishing locations. Additional searching for Yelloweye Rockfish habitat is planned to take place on future cruises in order to provide information to aid design of a relative abundance survey for Yelloweye Rockfish and other rockfish that inhabit similar areas.

Table 2. Catch and CPUE (fish/rod hour) for each cruise and combined cruises.

	Cruise Date							
Species	**9/26/2016**		**9/29/2016**		**9/30/2016**		**All Cruises**	
Bocaccio rockfish		0.000	6	0.260		0.000	6	0.102113
Canary rockfish	6	0.330	26	1.128	11	0.628	43	0.731811
Spiny dogfish		0.000		0.000	39	2.226	39	0.663736
Lingcod	14	0.770	18	0.781	7	0.400	39	0.663736
Longnose skate		0.000	1	0.043		0.000	1	0.017019
Pacific sanddab		0.000		0.000	1	0.057	1	0.017019
Quillback rockfish		0.000		0.000	7	0.400	7	0.119132
Spotted ratfish	1	0.055	1	0.043		0.000	2	0.034038
Rosethorn rockfish	2	0.110		0.000		0.000	2	0.034038
Tiger rockfish	1	0.055	1	0.043	1	0.057	3	0.051057
Yelloweye rockfish	12	0.660	8	0.347	10	0.571	30	0.510566
Yellowtail rockfish	68	3.738	40	1.735	1	0.057	109	1.855056
Totals	**104**	**5.717**	**101**	**4.382**	**77**	**4.396**	**282**	**4.799319**

Nearshore rockfish longline surveys on the outer coast – The focus of the spring 2016 cruise season was to experiment with longline gear in nearshore waters (inside 30 fathoms or 55 meters) to target rockfish. The WDFW has been considering longline gear as a potential tool for future nearshore rockfish surveys due to its use in nearshore fisheries for demersal rockfish species. Previously, the existing rod-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 concern about gear standardization with rod and reel surveys prompted the effort to begin experimentation with longline gear in nearshore waters. Pilot use of this gear began in 2015; additional modifications to the gear were made in 2016 prior to this cruise.

In April of 2016 a seven day cruise deployed fixed longline gear to target nearshore groundfish species. The timing for this cruise was based on vessel availability for both the longline vessel and rod reel charters. It was desired to deploy effort of both of these gears within a short time period. Also, low catch rates have been the norm for spring rod and reel surveys when deploying effort too early in the spring (March) months. The second half of April was chose to complete this work to accommodate these needs. Seven general fishing areas were predetermined for operations: Westport, Pt. Grenville, Destruction Island, Giants Graveyard (south La Push), Cape Johnson, Ozette/Cape Alava, and Makah Bay/Pt. of Arches. These areas were identified as potential target species habitat by looking at species compositions from previous rod-reel survey data and the longline cruise from the previous fall. It was estimated that six sets could be deployed each charter day and that a charter day would be spent at each of the seven general areas. Specific set locations were chosen each day after reconnoitering substrate characteristics with the vessel's onboard sounding equipment. Gear was deployed in an orientation that would adhere to the shape of the reef and also to be contained in a grid cell.

It was intended to send a vessel using rod-reel gear to similar locations that the longline gear was deployed at to compare catch rates and composition. Each longline set was deployed within a grid cell with one to two sets deployed within each chosen cell. Each day, four to six cells were used. As soon as it was possible, the rod-reel vessel would follow (usually next day if possible) with effort based on the proportional effort deployed by the longline vessel. For instance if the longline vessel deployed one set in each of six cells, the rod-reel vessel would deploy the same amount of effort (time based) in each of those six cells for the day that they were fishing that area. The goal is to compare the catch rates and composition between the two methods based on the charter day and the area that could be covered in one day.

Gear for this cruise consisted of 5/16" sinking groundline with either 12/0 or 11/0 circle hooks affixed by a #48 nylon double braid gangion line 24-28 inches in length. The mainline is broken into "skates" 1800' long with gangions spaced at 1.5 fathom (9 feet) intervals to accommodate 200 hooks per skate. For storage and deployment purposes, skates are kept in ½ skate "tubs" (100 hooks) which are tied together to form the skate at the time of deployment. The 12/0 and 11/0 hooks were consistent throughout each tub. Each skate was deployed with one tub (1/2 skate) of 11/0 hooks and one tub with 12/0 hooks.

The seven planned fishing areas were covered over seven charter days with 41 individual locations (sets) fished at 5-6 sets per day. Individual sets ranged in depth from 6-37 fathoms. Cruise operations began out of Westport, WA to begin sampling directly off of Grays Harbor and incrementally moved northward, ending operations in Makah Bay. Before gear deployment each

day, time was spent getting familiarized with reef structures at specific locations identified from rod-reel survey data and the fall 2015 longline cruise to determine suitability for longline fishing operations. Specific locations and set orientations were chosen based on rugosity, previous rod-reel and longline 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.

A total of 430 hooks were recorded with catch at the vessel rail upon retrieval for a total hook occupancy rate of 5.3%. Hook occupancy rates ranged from 0.5% to 13.1% (0.0% sets listed were unsuccessful sets) for individual sets. The full range of catch rates were seen coast wide. Higher catch rates were observed on the far norther parts of the coast such as Makah Bay. Nineteen different species were encountered (excludes invertebrates) including eight different species of rockfish. All focus species except Tiger Rockfish were caught. Cabezon, Lingcod, and China Rockfish were the most frequently encountered catch (Tables 3-5). All locations were fished with one skate of gear (200 hooks) except for set 16 at Destruction Island where two skates were set on an area that had a long rocky structure. Soak times varied from 185 to 343 minutes with an average soak time of 251 minutes. Due to vessel mechanical issues, the CTD was not deployed during this cruise.

Table 3. Marine Area 2 Catch Summary

	Survey Area and Set Number												
	Westport						Pt. Grenville						
Species	1	2	3	4	5	6	7	8	9	10	11	12	**Totals**
Big Skate			3								1		**4**
Black Rockfish						1	2	7	3	1		3	**17**
Cabezon					2		1	4	1			1	**9**
Canary Rockfish				6	2	2							**10**
Copper Rockfish								1				1	**2**
Deacon Rockfish					3								**3**
Inanimate Object				1									**1**
Kelp Greenling												1	**1**
Lingcod					1	6	5	2	2	1		4	**21**
Pacific Halibut	1							2					**3**
Pacific Sanddab	5	1											**6**
Quillback Rockfish						1							**1**
Unidentified Invertebrate				1		2		2					**5**
Unidentified Sculpin							1	1			1		**3**
Unidentified Starfish							4	5	5	2	1	3	**20**
Yelloweye Rockfish						1							**1**
Totals	**6**	**1**	**3**	**8**	**8**	**13**	**13**	**24**	**11**	**4**	**3**	**13**	**107**

Table 4. Marine Area 3 Catch Summary

	Survey Area and Set Number																				
	Destruction Island					South LaPush - Giants Graveyard						North LaPush - Cape Johnson						Ozette Lake			
Species	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	**Totals**
Big Skate	2					4	1	2	2	2			1	1	1	1	2				**19**
Black Rockfish										2			1			1	1		6		**11**
Buffalo Sculpin				5	2	1			1	1				2							**12**
Cabezon	2	2	5	4	4		1		2	7		2	21	5	9	5	9	6	3	3	**90**
China Rockfish			2							1			1					4	2	9	**19**
Copper Rockfish			1																		**1**
Deacon Rockfish																1			4		**5**
Kelp Greenling		1	1	6	1		1			1		1	1		1			1		1	**16**
Lingcod			1	5	2			1		1					1			1		2	**14**
Spiny Dogfish						1	1														**2**
Starry Flounder				1																	**1**
Unidentified Flatfish							1														**1**
Unidentified Invertebrate													1							1	**2**
Unidentified Starfish				16									1		1					1	**19**
Totals	**4**	**3**	**10**	**37**	**9**	**6**	**5**	**3**	**5**	**15**	**0**	**3**	**27**	**8**	**13**	**8**	**12**	**12**	**15**	**17**	**212**

Table 5. Marine Area 4 Catch Summary

	Survey Area and Set Number									
	Cape Alava			Point of Arches - Makah Bay						
Species	33	34	35	36	37	38	39	40	41	**Totals**
Big Skate			3							**3**
Black Rockfish					2				1	**3**
Cabezon	1	3	3	3	7	8		13	8	**46**
Canary Rockfish				1				3	4	**8**
China Rockfish	1	6		2	1	2		3	3	**18**
Copper Rockfish									3	**3**
Deacon Rockfish	2									**2**
Kelp Greenling		1		1	2				1	**5**
Lingcod		3		1	4	4		1		**13**
Pacific Halibut								5		**5**
Quillback Rockfish	1			1					3	**5**
Unidentified Sculpin			1	1						**2**
Unidentified Starfish		1								**1**
Vermilion Rockfish								1	1	**2**
Totals	**5**	**14**	**7**	**10**	**16**	**14**	**0**	**26**	**24**	**116**

Biological information was collected from retained and released fish; released fish were measured and retained fish were measured, weighed, sexed, and dissected for otoliths. 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.

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. Estimating removals is really hard, though, especially for periods with limited record keeping. 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, and for which the level of reporting detail can vary widely. 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 and continued making necessary revisions. Washington's first attempt in reconstructing commercial landings for lingcod and rockfish market categories was completed to support 2017 PFMC groundfish stock assessments. Efforts will continue to reconstruct flatfish catch histories.

III. Reserves

Marine reserve monitoring and evaluation – Due to changes in program priorities and staffing limitations brought on by intensive ROV survey work over the last five years, very little directed monitoring of marine protected areas and reserves has occurred in Puget Sound since 2011 and no monitoring activities were conducted in 2016. A systematic evaluation of data from SCUBA-based surveys collected between 2000 and 2010 at six sites for which sufficient data are available has been performed to evaluate reserve efficacy.

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 clearly apparent at multiple sites, specifically for rockfishes during 2006. For most species and locations 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) and dives at select sites will occur in 2017.

Larry LeClair, Lisa Hillier, Bob Pacunski, Jen Blaine, and Dayv Lowry have generated 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. This report is under final review and should be available later this summer.

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 and is open access. Figure 2 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. Live hagfish vessels typically fish grounds closer to their home port, while at-sea freezing allows ovther vessels to fish further afield. 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 3); 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.

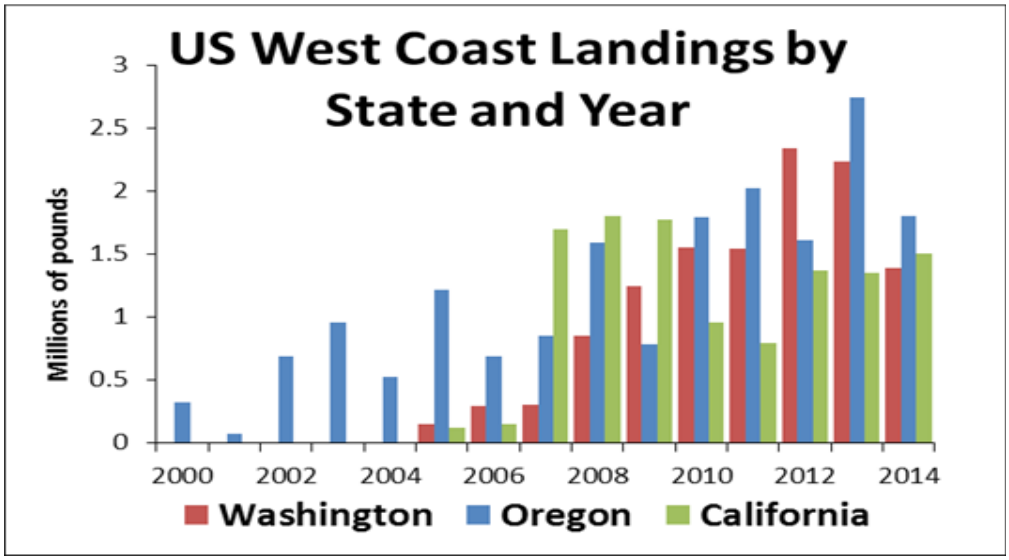

Figure 2. Hagfish Landings in pounds by Washington, Oregon, and California; 2000-2014.

Fishing occurs on soft, muddy habitat (Figure 4). 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. Median CPUE is about 4.5 pounds. Instances of high CPUE are evident; in these situations skippers reported "plugged" barrels.

Figure 3. 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 5). 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 6). An evaluation of maturity suggests year-round spawning (Figure 7). 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.

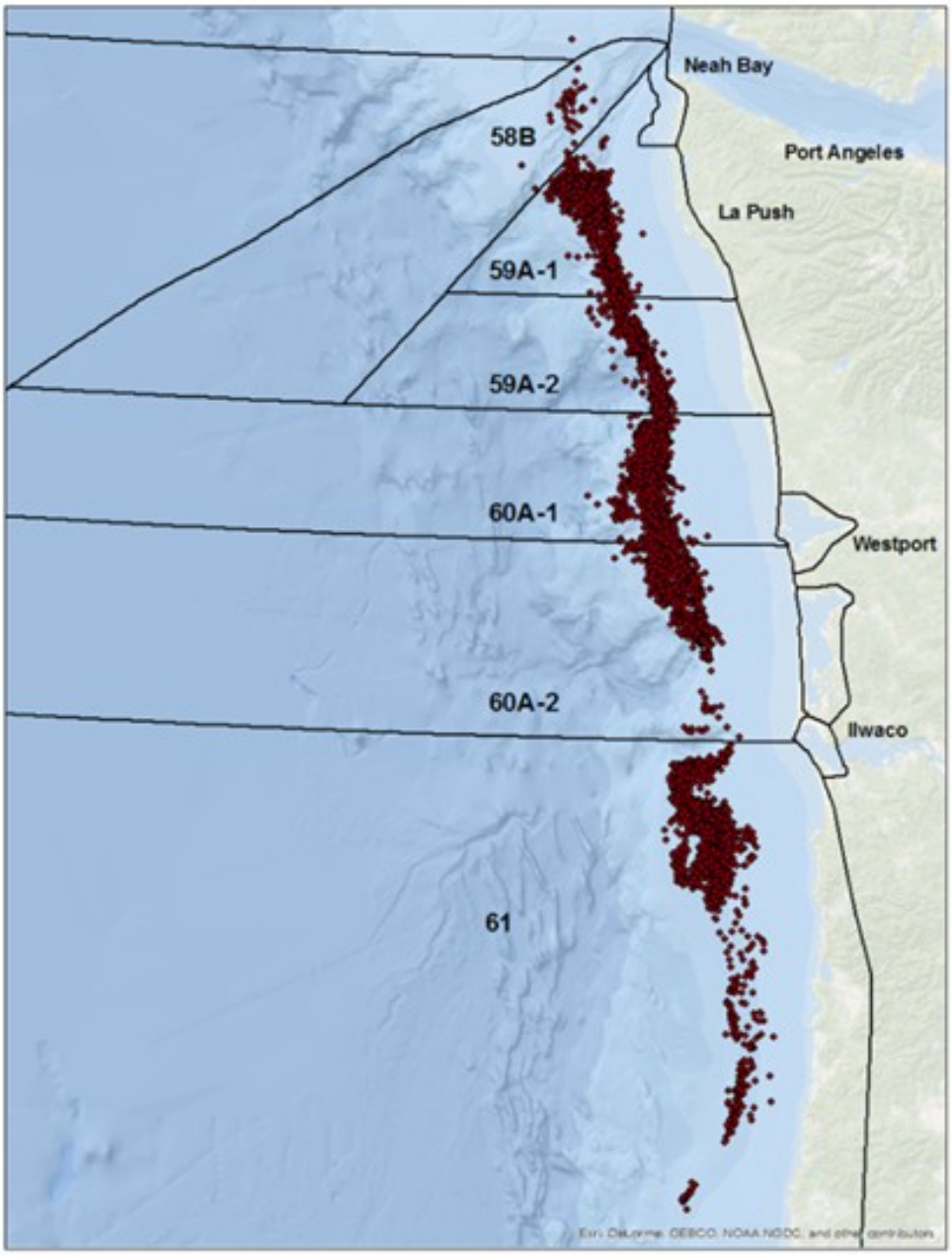

Figure 4. Hagfish fishing off WA and OR, from Washington logbooks, 2005-2014.

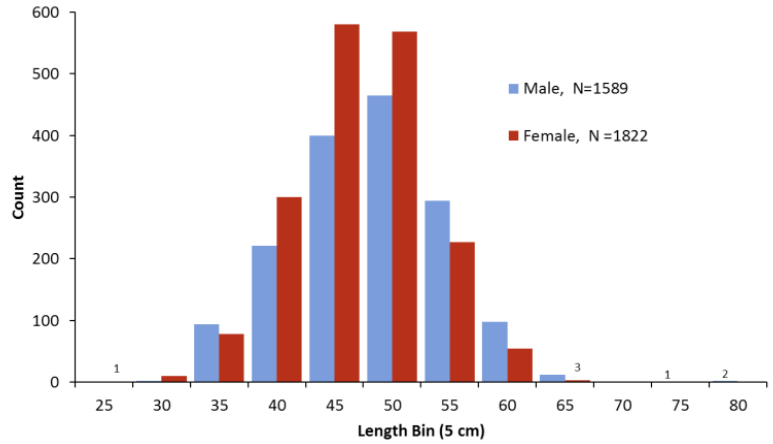

Figure 5. Length (cm), male and female Pacific Hagfish only.

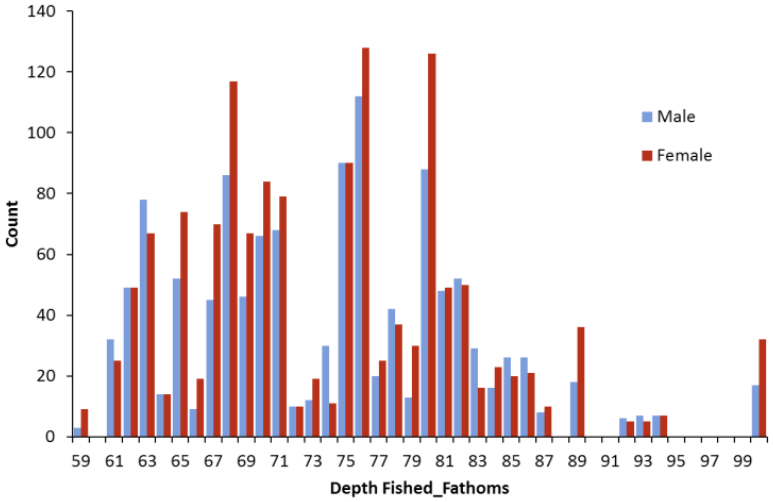

Figure 6. Distribution, by depth (fa), of male and female Pacific Hagfish.

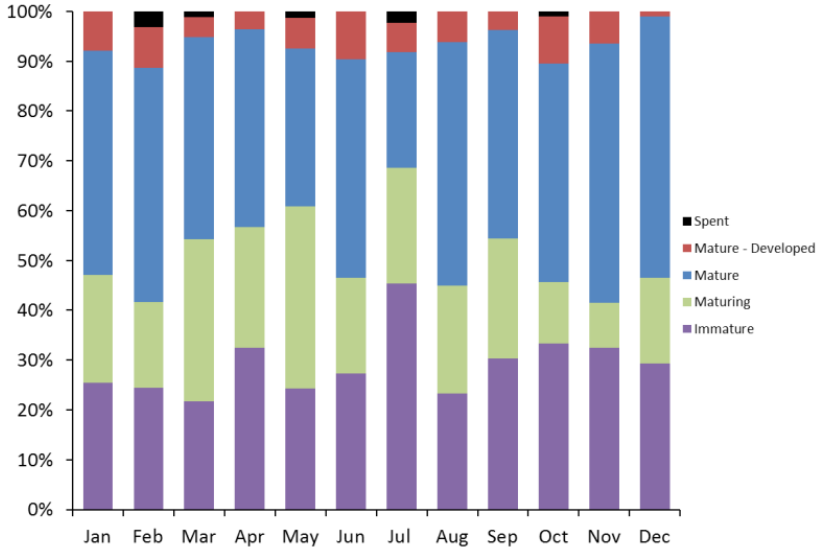

Figure 7. Female Pacific Hagfish maturity, proportion by month.

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 217k of which was taken in 2015. In 2016 harvest was 262k lbs. 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 and 2016 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 the 100 sharks sampled both years was female, and their average size was 88.8 cm. Many contained full-term embryos. Lummi biologist Breena Apgar-Kurtz confirmed this was a representative sub-sample both years and that the "vast majority" of the harvest consisted of relatively large female sharks.

Shark book -- Together with Dr. Shawn Larson of The Seattle Aquarium, Dayv Lowry is 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 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. Final versions of chapters are due May 30th and 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, and assessing implications of genetic selection of aquaculture – 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. In 2015 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 report detailing these results was produced (Hauser et al., 2016) and Co-PI Kristen Gruenthal presented a talk at the World Aquaculture Society's annual meeting in Las Vegas, NV detailing the potential value of genetic variation at these SNP sites for aquaculture of Pacific Cod. Specifically, she proposed that active selection in this population, which experiences a considerably warmer thermal regime than populations of the species that reside north of Washington waters, may predispose this stock to being more suitable for hatchery cultivation in coming years as global warming continues and sea surface temperatures further elevate.

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

i. Research

Genetic study on ESA-listed rockfish – In April of 2014 the WDFW partnered with NOAA's Northwest Fishery Science Center to conduct a two-year fishing study aimed at collecting genetic samples from ESA-listed rockfish (Dayv Lowry and Bob Pacunski are co-PIs, along with Kelly Andrews and Dan Tonnes). The fishing portion of the study was completed in early 2016 and utilized several local charter operators and recreational fishing club members with experience fishing for these species prior to the closure of rockfish fisheries in Puget Sound. The study collected samples from various locations along the west coast and Canada for comparison to samples collected in Puget Sound (Table 6). The study obtained samples from 67 Yelloweye Rockfish, 69 Canary Rockfish, and 3 Bocaccio in the Puget Sound DPS, with collections occurring throughout the Sound (Figure 8). Many of these fish were visibly tagged to aid in identification during future diving and remotely-operated vehicle surveys (one fish sighted by each method in 2015, and one additional fish sighted by each method in 2016). Based on the results of this study, Canary Rockfish were removed from the Endangered Species List on March 24th, 2017 after thorough evaluation of the results by a Biological Review Team. This represents the first time that a marine fish has ever been delisted under the ESA. Samples collected from Canadian waters north of the current DPS boundary line resulted in an expansion of the Yelloweye Rockfish DPS further north to include more of Johnstone Strait and interior waters to the northern end of Vancouver Island (Figure 9). No changes were made to the listing status of Bocaccio due to low sample size. A manuscript of the study was developed and has been submitted for publication in Biological Conservation (Andrews et al, in review).

Table 6 (from Andrews et al., in review)**.** Number of fin clip samples successfully sequenced from each region and used in subsequent analyses for each species.

Region of collection	Yelloweye	Canary	Bocaccio
Southeast Alaska	1[f]	0	0
Inland British Columbia, Can	18[b]	0	0
Coastal British Columbia, Can	10[b]	0	2[d]
U.S. West Coast	55[c]	19[c]	15[cd]
Strait of Juan de Fuca	19[a]	22[a]	1[e]
San Juan Islands	28[a]	24[a]	0
Hood Canal	16[a]	0	0
Central Puget Sound	4[a]	23[a]	3[a]
South Puget Sound	0	0	0
Total samples	**151**	**88**	**21**

[a]Cooperative fishing, this study; [b]Department of Fisheries & Oceans Canada (Yamanaka et al. 2006); [c]Northwest Fisheries Science Center (Bradburn et al. 2011); [d]Southwest Fisheries Science Center; [e]Washington Department of Fish & Wildlife; [f]Nichols opportunistic sampling.

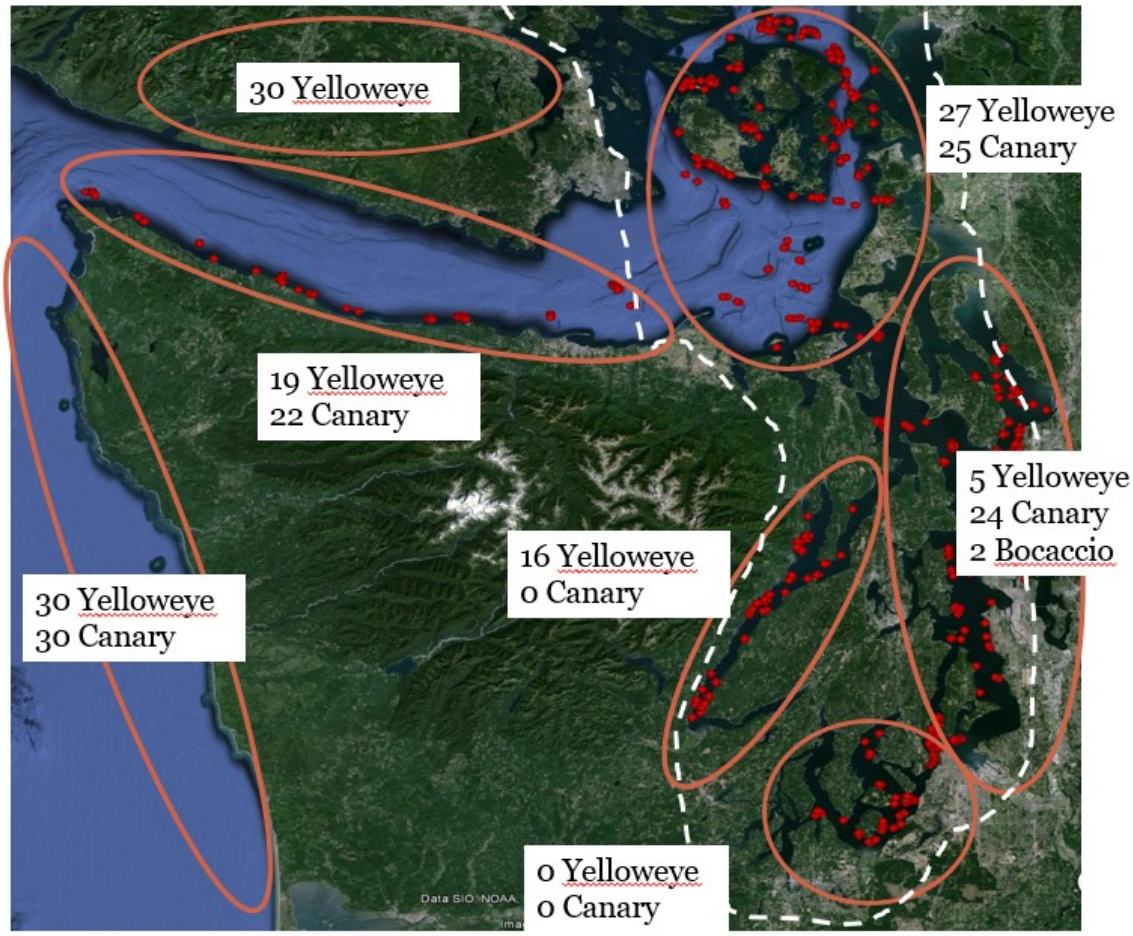

Figure 8. Total sample numbers for ESA-listed rockfish by region as of December 2016 for the Sound-wide genetic study. The 30 Yelloweye Rockfish samples

shown on Vancouver Island were provided by DFO from fish collected throughout the inside waters

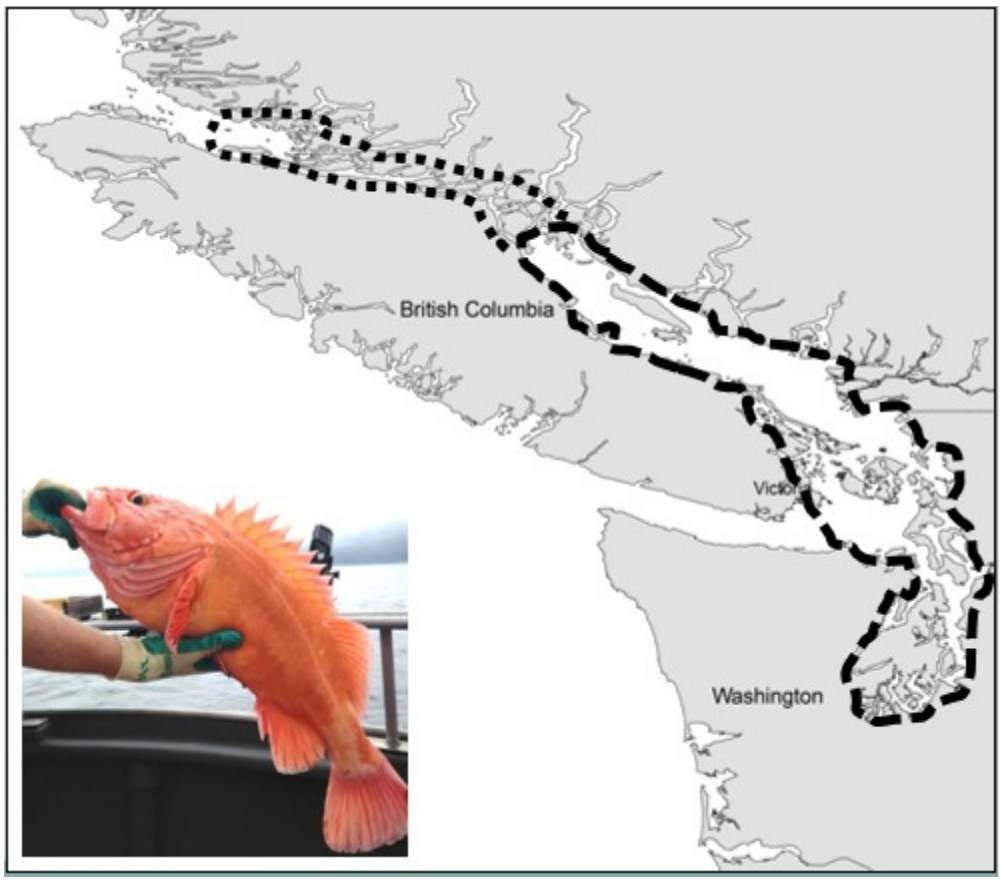

Figure 9. Depiction of the initial (long dashes) and revised (short dashes) DPS boundaries for Yelloweye Rockfish. The revised boundary was proposed based on the results of a collaborative genetic study.

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 continued in 2016

as noted above in the Surveys section (due to captures of more than just Yelloweye Rockfish).

ROV survey for ESA-listed rockfish, and their habitats, in Puget Sound – Dan Tonnes at NOAA's NWFSC was able to secure supplemental funding that allowed the WDFW to conduct a 2-year remotely-operated vehicle survey of large portions of Puget Sound. Year 1 of the survey was completed in January 2016 and Year 2 was completed in January 2017. This study was limited to Central Puget Sound, the Whidbey Basin, Hood Canal, and South Puget Sound (in total, referred to as Puget Sound proper) due to the availability of population estimates from recent ROV surveys in the San Juan Archipelago. A stereology-based ROV survey covering the same area 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. The goal of this new study was to develop valid population estimates for ESA-listed rockfish species in this undersampled portion of the U.S. DPSs. The survey design and methodology was consistent across both years, which will allow for independent population estimates to be made for all encountered species in each year. 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, which is represented as a probability surface. 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 Year 1 of the survey, the WDFW Marine Fish Science group conducted 68 days of sampling between February and December of 2015 and completed 387 transects; 249 high, 82 medium, and 56 low, representing 86% of the planned survey stations and over 90% of the High and Medium stations (Figure 10). Technical issues with the ROV and poor weather conditions prevented completion of the remaining stations, most of which were in the Low stratum. All three species of ESA-listed rockfish were encountered in Year 1; 35 Yelloweye Rockfish at 19 stations, 7 Canary Rockfish at 4 stations, and 1 Bocaccio, with all encounters occurring on High probability habitats.

In Year 2 we conducted 66 days of sampling from February 2016 to January 2017 and completed 418 transects; 266 High, 70 Medium stratum, and 73 Low. Sampling rates were higher than Year 1, with 96%, 76%, and 79% of the planned High, Medium, and Low stations sampled, respectively. In total, fewer ESA-listed rockfish were encountered in Year 2, although more Canary Rockfish were seen than in Year 1. Twenty-two Yelloweye Rockfish were observed at 15 High stations and 22 Canary Rockfish were seen at 7 High stations. No Bocaccio were encountered in Year 2.

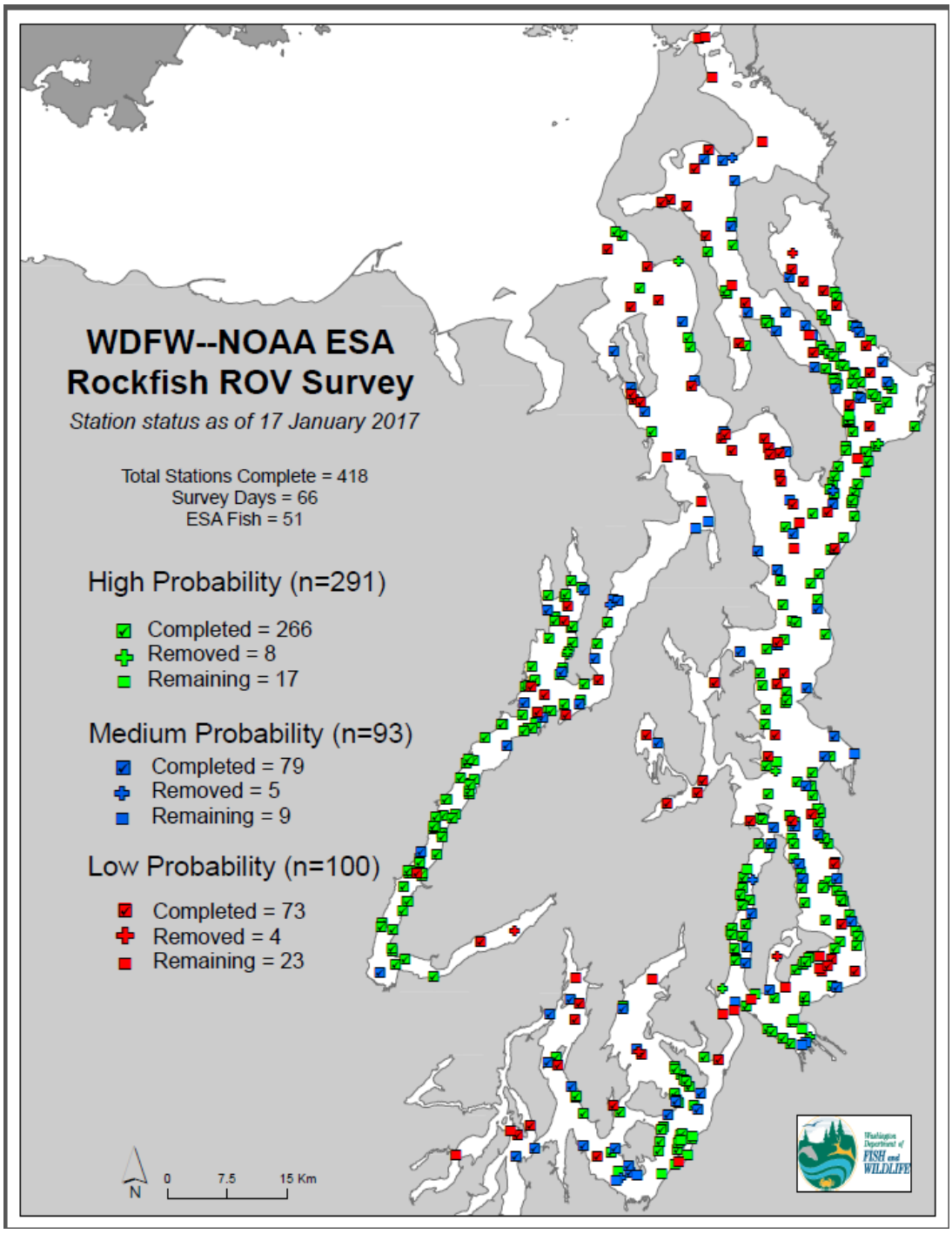

Figure 10. Stations sampled for ESA-listed rockfish and habitat in Year 2 of the Puget Sound ROV Survey. Stations are symbolized by their end-of-survey status.

Yelloweye Rockfish life history project – A collaborative, ongoing project involving the NWFSC, SWFSC, ODFW, and WDFW has been collecting and analyzing data for a Yelloweye Rockfish life history project for the last two years. Port samplers and survey teams have collected 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 2002-2016. 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 2004-2016 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 (previously WDFW), Robert Le Goff (WDFW), and Sheryl Flores (ODFW)

ii. Management

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 (Canary Rockfish, Yelloweye Rockfish, and Bocaccio) in Puget Sound and the Strait of Georgia. The team met in person twice during the reporting period and held several conference calls focused on revising the delisting and down-listing criteria and finalizing the plan for public consideration. The team held its last official meeting on February 27th, 2017 and is now dedicated solely to finalization of a draft recovery plan.

The draft recovery plan developed by the team underwent pre-public review by the WDFW and other state agencies at large, tribal co-managers, and representatives at the Department of Fisheries and Oceans Canada in mid-2016, and was released for public comment in August. Three public meetings to solicit feedback on the plan were held in western Washington in October of 2016. A 5-year review of the listed species was completed in April of 2016 and released to the public on May 5th, 2016. In July of 2016, NOAA Fisheries proposed the removal of Canary Rockfish from the Federal List of Threatened and Endangered Species, the removal of its critical habitat designation, and the update and amendment of the listing descriptions for Bocaccio and Yelloweye Rockfish based on the results of a genetic study of listed rockfish (see above). This rule became final on March 24th, 2017 (82 FR 7711) and the draft plan is now being revised to recognize these significant changes. The results of population change rate modelling in a MARSS framework conducted for the 5-year review were recently published in Ecology and Evolution (Tolimieri et al. 2017). Dayv Lowry and Bob Pacunski are co-authors on this paper. A talk will also be given on this topic at the national American Fisheries Society meeting in 2017.

I. Thornyheads

No specific, directed research or management to report.

J. Sablefish

No specific, directed research or management to report.

K. Lingcod

Comparison of ages determined from various skeletal elements, and support of a coast-wide stock assessment – 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 for use in stock assessments. However, this method is labor intensive and concerns have been raised regarding the precision of age determinations. In 2015 the WDFW conducted a study 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. We opportunistically sampled 124 lingcod from recreational and commercial fisheries 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 only 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 than fin rays, particularly for fish older than age 7. 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. These results indicated 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.

Having confirmed that fin rays are the most appropriate structure to use for aging studies, the WDFW is now moving forward with substantial collection of these samples from recreational fisheries, commercial fisheries, and scientific surveys throughout Washington waters in support of a coast-wide evaluation of regional differences in age and growth rate of Lingcod. Staff are coordinating these efforts with Jameal Samhouri and Kelly Andrews of NOAA's NWFSC and may enlist the services of recreational/charter fishers who also participated in the ESA-listed rockfish genetic survey detailed above. Cultivating these relationships has led to benefits for all parties, and has advanced research and management efforts.

L. Atka mackerel

No specific, directed research or management to report.

M. Flatfishes

No specific, directed research or management to report.

N. Pacific halibut & IPHC activities

No specific, directed research or management to report.

O. Other groundfish species

Ratfish toxin research – The PSMFS Unit has been providing specimens of Spotted Ratfish to Dr. Dominique Didier of Millersville University in Pennsylvania, and her students, for the past several years. Their goal is to use mass spectrometry to evaluate the chemical composition of the venom associated with the dorsal fin in an effort to identify chemicals that might be of medical value for the treatment of neurological, or other, diseases. Specimens come from the annual trawl survey and initially consisted of whole frozen fish. The past two years, however, students have traveled from Pennsylvania to participate in the collection of specimens and to excise venom glands aboard the survey vessel. This has provided a rare opportunity for undergraduate students from the east coast to gain valuable field experience in a novel ecosystem. One of these students have since moved on to pursue a graduate degrees in marine biology.

No addition 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 and below.

V. Ecosystem Studies

Puget Sound Ecosystem Monitoring Program update – WDFW's PSEMP Unit has changed its name! As noted above, the PSEMP Unit has now been rebranded as The Toxics-focused Biological Observation System for the Salish Sea, or TBiOS. This renaming recognizes that, while the WDFW is a key partner of a multi-agency effort to assess the health of Puget Sound known as PSEMP, there are also Unit goals that expand on and diverge from the needs of PSEMP. The TBiOS 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. For additional details and several recent reports on toxic contaminants in Puget Sound biota contact Jim West at james.west@dfw.wa.gov or 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 the abundance and distribution of forage fish and other mid-water species throughout Puget Sound using an acoustic/trawl survey design. The resulting survey, running every other month from February 2016 – February 2017, obtained hydroacoustic data (Biosonics DT-X; 38 kHz and 120 kHz transducers), mid-water biota samples via a Polish rope trawl, and plankton samples from 18 reaches throughout Puget Sound, the San Juan Islands, and the southern Strait of Georgia (Figure 11).

The acoustic analyses from the mid-water trawl are nearing completion and we will have species-specific estimates of abundance, density, and total biomass by site and across sites by the end of April, 2017. The catch data from 225 individual mid-water trawls showed that herring were the most common forage fish in Puget Sound in 2016-17, making up 61% of the total catch (Figure 12). Herring were the most abundant species in each of the four basins (Figure 13), although they exhibited wide fluctuations seasonally and were a minor component of the catch in June, August, and December (Figure 14). The last finding was surprising given that herring catches were quite large in October. We suspect that during December herring had largely moved to their shallow, pre-spawn holding locations and thus were not sampled effectively in the offshore, mid-water trawl.

As expected, other components of the catch also varied both between basins and seasonally. Pacific Whiting (hake) comprised 15% of the overall catch but were really only abundant in the Central basin (Figures 12, 13), particularly in Saratoga Passage where they were the dominant species caught during several months. Northern anchovy were infrequently captured but sometimes accounted for a large percentage of any given trawl, particularly in the North and South basins (Figure 13) in the late summer and early fall (Figure 14). During the summer (June-August), invertebrates (predominately a suite of jellyfish species) accounted for roughly

60% of the catch (data not shown) and fish catches declined (Figure 14), due in part to the emigration of Pacific herring to the ocean

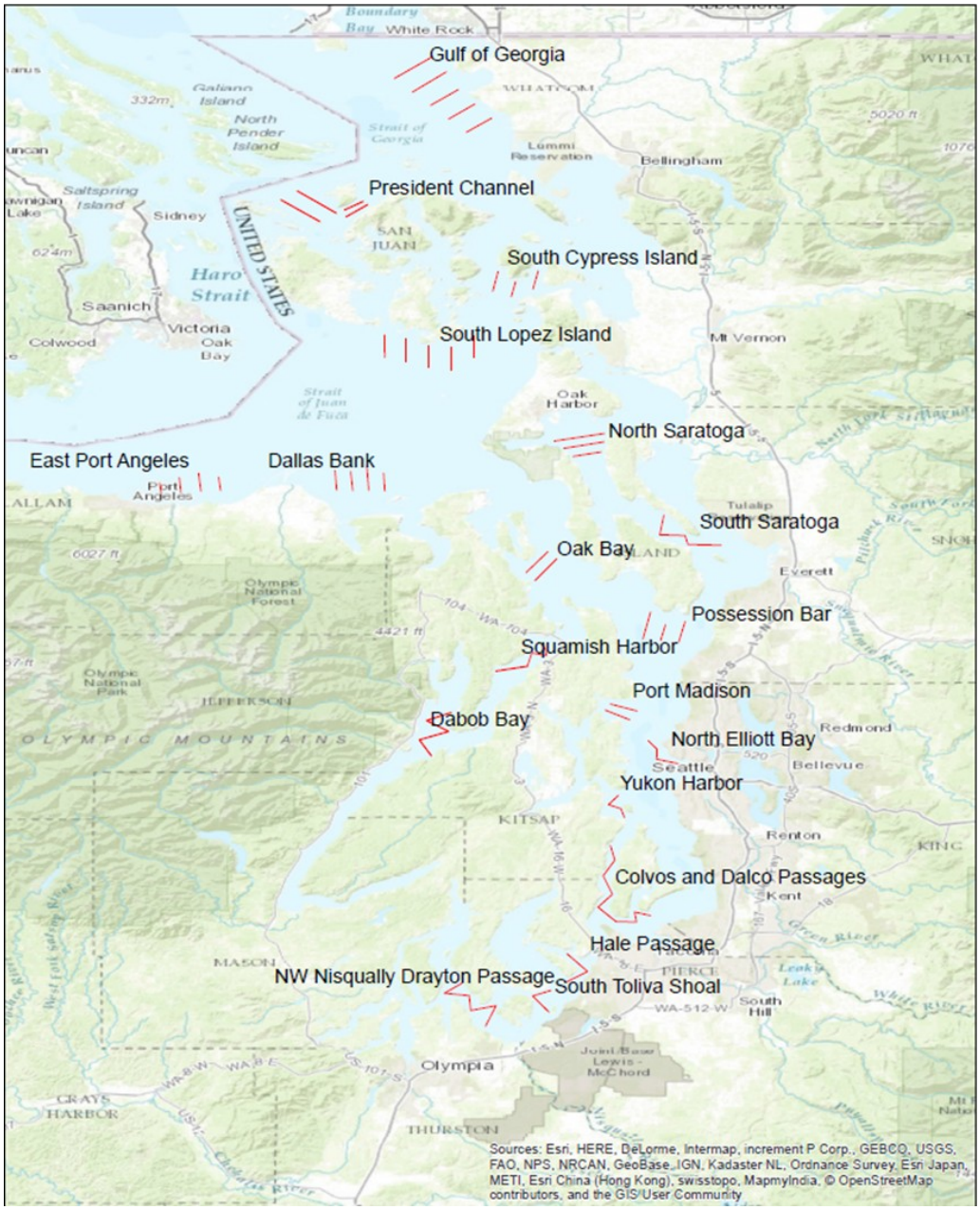

Figure 11. Map of station locations for the Puget Sound Mid-water acoustic trawl survey, Southern Salish Sea, WA.

Overall, a total of 52 different species of fish and invertebrates were captured in the trawls, although only nine made up 96% of the overall catch (Figure 12). Throughout the year a total of 183 juvenile and sub-adult Chinook salmon (163 were frozen for collaborators and the rest released), 69 chum salmon (13 released), 16 coho salmon (all retained), and 33 pink salmon (all retained) were captured. Besides the listed Puget Sound population of Chinook salmon, other ESA listed species captures were limited to 30 Eulachon (frozen for further analysis) and one Canary rockfish, which was descended according to protocol after the removal of a fin clip for genetic analysis.

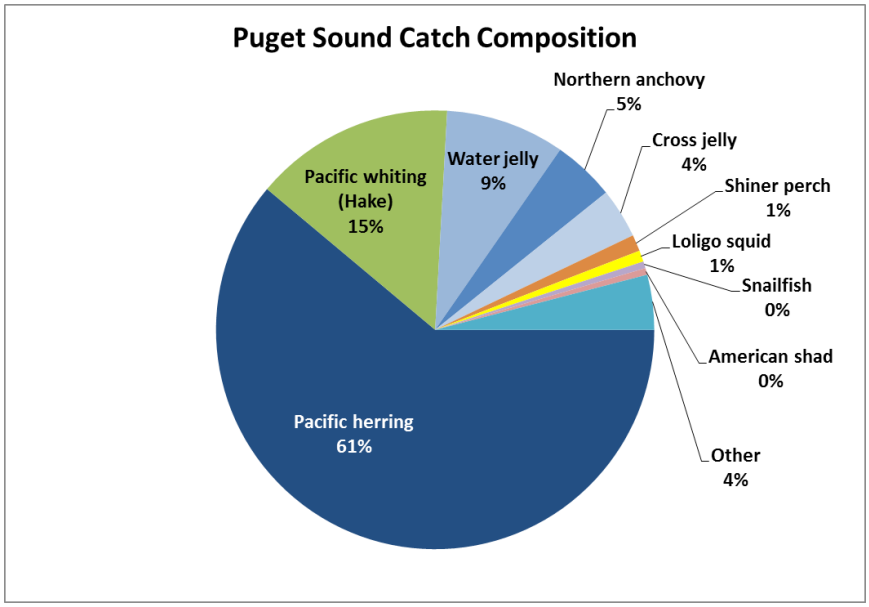

Figure 12. Overall catch composition during the Puget Sound Mid-Water Acoustic Trawl Survey. Species listed at "0%" made up <1% of the total catch.

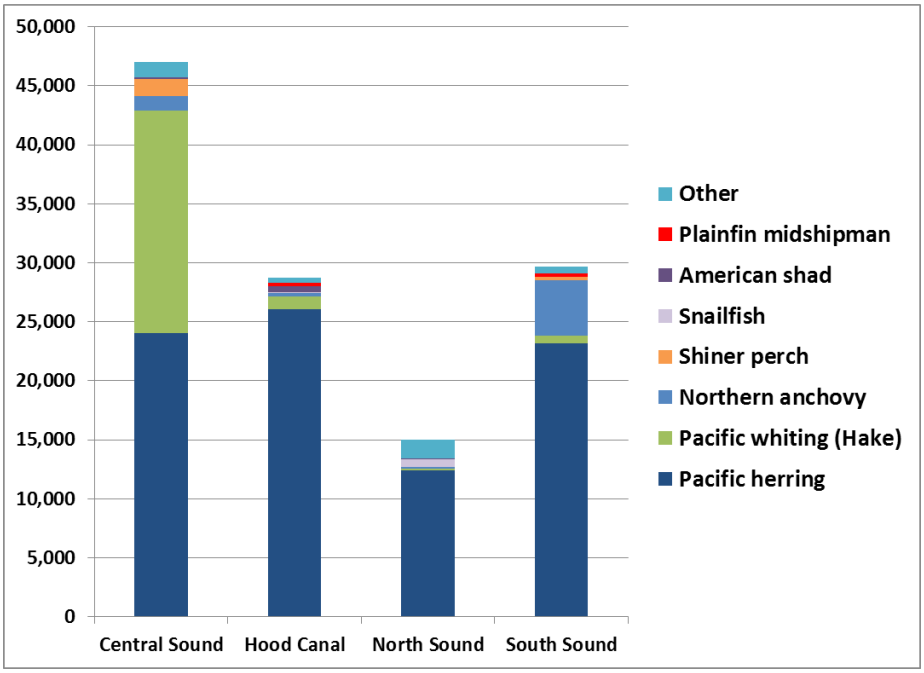

Figure 13. Mid-water trawl fish catch composition, all months by basin.

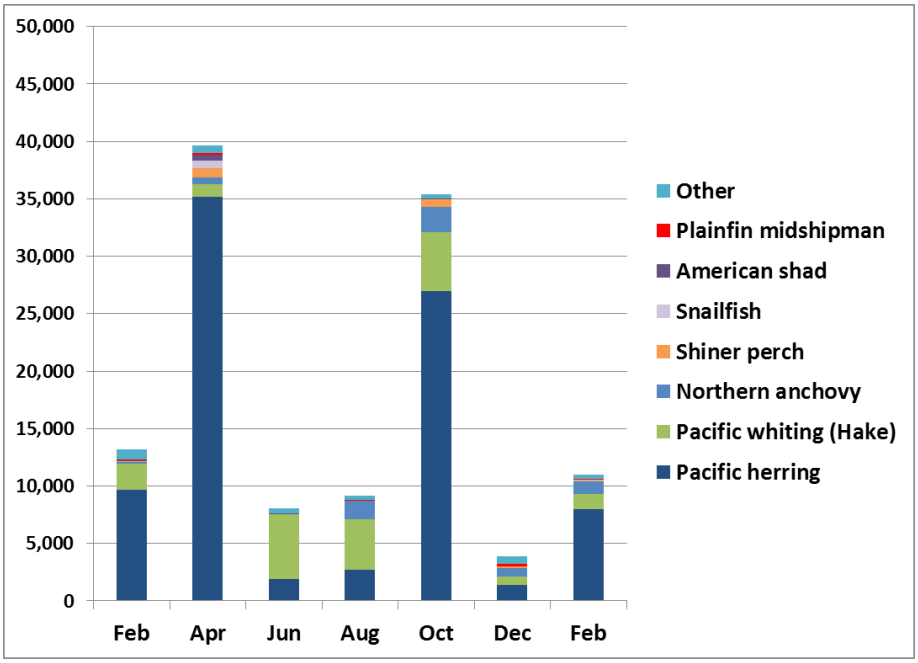

Figure 14. Mid-water trawl fish catch composition, all basins by month

A total of 127 vertical plankton tows (half meter nets) were conducted during the trawl surveys. The contents were preserved in buffered formalin and are currently stored at the WDFW waiting sorting and speciation. In addition, roughly 123 CTD (conductivity-temperature-depth sensor) casts were made to profile the water column and inform both the acoustic analyses and the catch interpretation.

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 (herring and American shad, ecology and toxicology), Virginia Butler (fish archaeology, University of Portland), Lorenz Hauser (Pacific herring genetics, UW), Julie Keister (zooplankton ecology, UW), Katherine Maslenikov (fish collections, UW Burke Museum) and numerous researchers at NOAA's Northwest Fisheries Science Center (juvenile and sub-adult salmon ecology). Thousands of samples were also retained frozen by the WDFW for use in evaluating age structure, maturation stage, and sex ratios of the sampled portion of each population; this "post-trawl" effort will continue throughout 2017. The next phase of the Puget Sound Mid-water Acoustic/Trawl will be a final report delivered to the State Legislature at the end of June, 2017.

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. A second contract established in 2016 has moved this project to the next phase, which is focused on expanding the 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). Data collected during a 2-year ROV survey of Puget Sound (see next section) is being used in this study and the results are expected to 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.

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 and this effort was finalized in 2015. In August of 2015 a celebration ceremony was held to recognize these extensive efforts to remove 5,660 fishing nets from the Sound and restore 813 acres of benthic habitat. The Northwest Straits Foundation and the PSMFS Unit then moved on to pilot methods to remove several deep-water nets using an ROV instead of scuba divers. A manual was developed detailing the pros and cons of various approaches to retrieve these nets and funding is now being sought to aggressively go after these remaining nets.

In 2012 a reporting hotline was developed, and a rapid response and removal team was formed, to prevent the accumulation of additional fishing nets due to loss during ongoing and future fisheries. 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 2017. 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. Funding has now been secured through the Puget Sound Marine and Nearshore Grant Program administered by the WDFW to continue this work through at least 2018. Funding beyond that date is uncertain.

VI. Publications

Andrews, K., K. Nichols, A. Elz, N. Tolimieri, C.J. Harvey, R. Pacunski, D. Lowry, K.L, Yamanaka, and D.M. Tonnes. (In Review). Cooperative research sheds light on population structure and listing status of threatened and endangered rockfish species. *Biol Cons.*

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.

Hauser, L, Gruenthal, K, Canino, M, and D Lowry. (2016). Local adaptation in Puget Sound Pacific Cod (*Gadus microcephalus*) phenotypic and genomic differentiation and the conservation of a depleted population in a warming environment. Washington Sea Grant Final Report for OMB Project Number 0648-0362. 12 pp.

LeClair, L, Pacunski, RE, Blaine, J, Hillier, L, and D Lowry. (In Final Review). A summary of findings from periodic scuba surveys of bottomfish conducted over a sixteen year period at six nearshore sites in central Puget Sound. Washington Department of Fish and Wildlife Technical Report. Expected completion June 2017.

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 2017.

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 2017.

McNeil, B, Lowry, D, Larson, S, and D Griffing. (2016). Feeding behavior of subadult sixgill sharks (*Hexanchus griseus*) at a bait station. *PLoS One*. **11(5)**: e0156730.

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.

Siple, MC, Shelton, AO, Francis, TB, Lowry D, Lindquist, A, and TE Essington. (In Review). Contributions of adult mortality to declines of Puget Sound Pacific herring. *ICES J Mar Sci*.

Tolimieri, N, Holmes EE, Williams GD, Pacunski R, Lowry D. (2017). Population assessment using multivariate time-series analysis: A case study of rockfishes in Puget Sound. *Ecol Evol*. 2017;00:1–15. https://doi.org/10.1002/ece3.2901

VII. Conferences and Workshops

In 2016-17 staff of the PSMFS Unit presented at, participated in research presented at, and/or arranged symposia at, several regional scientific meetings, and education/outreach events as indicated below.

ICES/PICES Symposium on Drivers of Dynamics of Small Pelagic Fish Resources, Mar. 6-11, 2017. Co-authors on presentations included Dayv Lowry and Todd Sandell.

Washington State Shellfish Growers Association annual meeting, Feb. 27, 2017. Dayv Lowry was invited speaker on forage fish survey requirements.

Seattle Aquarium Discover Science Days, Nov. 12-13, 2016. Presenters: Robert Pacunski, Jen Blaine, Lisa Hillier, Andrea Hennings, Taylor Frierson, Phil Campbell, and Amanda Phillips.

South Sound Science Symposium, Sept. 20, 2016. Phill Dionne and Dayv Lowry were invited speakers, and Dayv Lowry served on the organizing committee.

Salish Sea Ecosystem Conference, Apr. 13-15, 2016. Dayv Lowry, Bob Pacunski, and Phill Dionne were coauthors on a total of three talks.