Final Assessment of Threatened and Endangered Marine and Anadromous Fish Presence Adjacent to the NAS Whidbey Island Lake Hancock: 2015-16 Beach Seine Survey Results

Prepared for:

Naval Facilities Engineering Command Northwest (NAVFAC NW)

Submitted by:

The WDFW Marine Fish Science Unit

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FINAL REPORT

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Executive Summary

Puget Sound is home to a variety of marine and anadromous fish species that are afforded legal protection under the Endangered Species Act (ESA). The ESA-listed fish species within Puget Sound most relevant to this study include three species of rockfish (Yelloweye, Canary, and Bocaccio), four species of salmonid (Chinook, Hood Canal summer-run Chum, steelhead, and Bull Trout), and one species of forage fish (Eulachon). In an effort to determine whether occurrence of these ESA-listed species has the potential to affect operations in the waters adjacent to the Naval Air Station (NAS) Whidbey Island Lake Hancock, the Naval Facilities Engineering Command Northwest (NAVFAC NW) and the Washington Department of Fish and Wildlife (WDFW) entered into a cooperative agreement whereby the WDFW agreed to survey these waters to evaluate both the seasonal and resident presence of ESA-listed fish.

The NAS Whidbey Island Lake Hancock was surveyed by the WDFW in 2015 and 2016 with a beach seine, focusing on the shoreline areas adjacent to Admiralty Inlet. Beach seine surveys targeted forage fish and juvenile salmonids in the nearshore habitat, which occurred monthly from May to September 2015 and January to September 2016 in order to detect any temporal changes in fish abundance or distribution. See Appendix A for a comprehensive list of fish species recorded for beach seining in 2015-16.

There were three confirmed ESA-listed species captured with the beach seine at the NAS Whidbey Island Lake Hancock. These included Hood Canal summer-run Chum, Chinook Salmon, and steelhead. Summer-run Chum Salmon cannot be visually distinguished from fall-run Chum Salmon juveniles; therefore, tissue samples collected in 2016 facilitated run assignment through genetic analysis in a separate report. Sampling in 2016 began in January with the intention to capture Hood Canal summer-run Chum Salmon that were detected in nearshore areas earlier (January-February) than fall-run Chum Salmon (March-April). The peak catch rate for Chinook Salmon juveniles occurred in June of both survey years. The single adult steelhead was captured in July 2015. Based on results from the 2015-16 surveys, we preliminarily conclude the work window (July 15 to February 15) for the NAS Whidbey Island Lake Hancock properties' in-water maintenance, military construction (MILCON), mitigation projects, future Fleet training and testing should not include February through July, as consistent with the measures outlined in WAC 220-660-330.

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Background

The inland marine waters of Washington State, which include all waters east of Cape Flattery and south of the Canadian border (i.e., Puget Sound), are inhabited by a variety of species that have been afforded legal protection under the Endangered Species Act (ESA) due to a reduction in their range, average biomass, a combination of these population-level parameters, and/or their inherent "value" to humankind. This value may stem from fisheries or other exploitative uses, ecotourism, other non-exploitative uses, or recognition of the integral ecological role a species plays in the local or regional food web (NMFS online). Several fishes protected under the ESA within Puget Sound include Eulachon (*Thaleichthys pacificus*) (NMFS 2010a), Chinook Salmon (*Oncorhynchus tshawytscha*) (NMFS 1999a), Hood Canal summer-run Chum Salmon (*O. keta*) (NMFS 1999b), steelhead (*O. mykiss*) (NMFS 2007), and Bull Trout (*Salvelinus confluentus*) (USFWS 1999). Each of these species is listed as Threatened, being significantly reduced in abundance and experiencing ongoing pressure from several threats, but not under imminent threat of extirpation or extinction. In 2010, ESA protection was extended to three species of rockfish within a geographic area that includes the vast majority of Puget Sound (NMFS 2010b); Yelloweye Rockfish (*Sebastes ruberrimus*) and Canary Rockfish (*S. pinniger*) were afforded Threatened status, while Bocaccio (*S. paucispinis*) received an Endangered designation.

These ESA-listings have the capacity to influence nearshore construction activities and at-sea operations of private and government sector vessels. As a result, the United States Department of the Navy (DON) desired to understand the species composition, timing, and migration of ESA-listed Threatened and Endangered (T&E) fish, and additionally ensure compliance with the Fish and Wildlife Conservation Act, Magnuson-Stevens Fishery Conservation and Management Act, and the Sikes Act Improvement Act at the following nine Naval installations: Naval Air Station (NAS) Whidbey Island Crescent Harbor, NAS Whidbey Island Lake Hancock, Naval Magazine (NAVMAG) Indian Island, Naval Base (NAVBASE) Kitsap Keyport, NAVBASE Kitsap Bremerton, NAVBASE Kitsap Bangor, Naval Station (NAVSTA) Everett, Manchester Fuel Department (MFD), and Zelatched Point. A Cooperative Agreement (CA) was established between the DON and the Washington Department of Fish and Wildlife (WDFW) to design and implement studies to assess shoreline and adjacent marine water use by ESA-listed fish species. It was further agreed that the WDFW, based on known ESA-listed fish habitat preferences and trophic relationships, would also assess the suitability of the habitat and prey for supporting ESA-listed fish at each of the nine installations.

The four primary project tasks identified in the CA are: 1) a kick-off meeting to formalize the monitoring project planning and management; 2) develop survey protocols and a study plan; 3) conduct field surveys and collect field data; and 4) provide a final report documenting results of surveys at Navy installations. In accordance with Tasks 1 and 3, a kick-off meeting between principle participants from the WDFW and NAVFAC NW personnel was held in November 2015. The meeting included discussions on security, access, survey methods, scheduling, logistics, and installation-specific survey priorities. Monthly progress reports were prepared by the WDFW, and meetings were held periodically to discuss headway and to identify and resolve any impediments to the project. The WDFW coordinated and communicated extensively with installation security and other personnel to arrange for access at prescribed times and locations. Task 2 is detailed under headings below, and this report meets the deliverables requirement for the final task by detailing all research conducted as part of this cooperative agreement at the NAS Whidbey Island Lake Hancock property.

Methods

Study Area

The NAS Whidbey Island Lake Hancock is located along the western shore of Whidbey Island (Figure 1a) at the southern margin of Admiralty Bay (Figure 1b). The site is co-managed by the NAS Whidbey Island and the Nature Conservancy while remaining closed to civilian access. Lake Hancock is considered a barrier lagoon, supporting a saline ecosystem that is supplied with seawater from Admiralty Inlet by a shallow and narrow channel. The majority of bottom habitat is considered featureless mud and sand (NOAA nautical chart 18471), with vegetative habitat features including nearshore eelgrass (*Zostera* spp.) and macroalgal beds (e.g., Ulvales, Laminariales) occurring on pebble and cobble substrates (WA DOE Coastal Atlas Map).

Within the study area, survey sites were sampled with a beach seine along the marine shoreline and included sites to the north and south of the lagoon entrance (Figure 2). These sites were not restricted by security measures. The 1.3km property shoreline is classified as an accretion shoreform, buttressed between feeder bluffs to the north and south (WA DOE Coastal Atlas Map). Both sites are exposed to northerly wind-waves with increased wave action from ferry and shipping traffic in transit throughout Admiralty Inlet. Substrate composition at both sites consisted of coarse pebble and cobble with a sandy base.

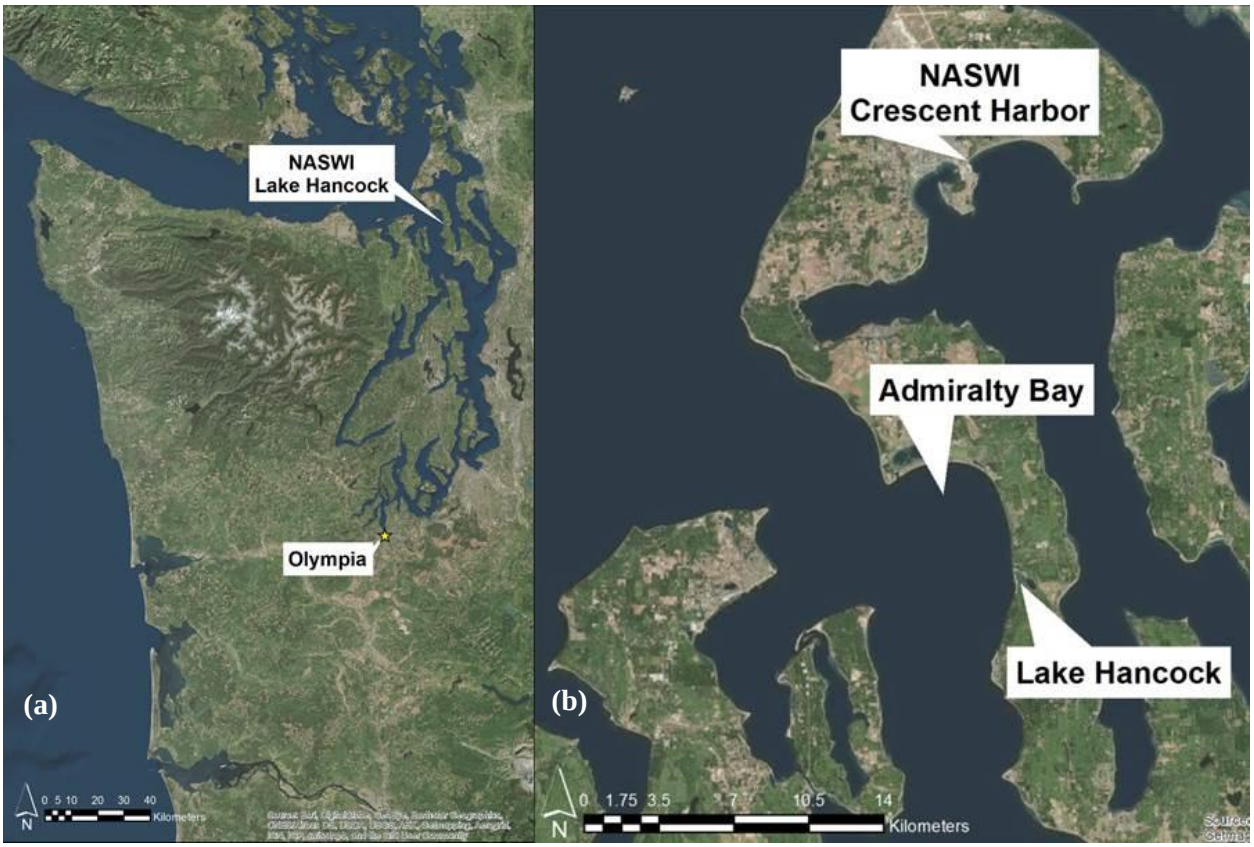

Figure 1. Orthophoto of the Naval Air Station Whidbey Island (NASWI) location in Puget Sound (a) showing, Crescent Harbor, Admiralty Bay, and Lake Hancock (b). Image from Esri DigitalGlobe.

Figure 2. Orthophoto of the NAS Whidbey Island Lake Hancock identifying the beach seine survey sites: north and south of the lagoon entrance. Image from Esri DigitalGlobe.

Survey Design

Beach seining allows fish to be collected in the intertidal and shallow subtidal zone (<5m deep) where few other techniques are capable of sampling. This is critically important for assessing forage fish and juvenile salmonids because they rely heavily on this nearshore zone for spawning, feeding, refuge, and/or migration. From the possible array of shorelines controlled by the DoN in need of assessment, beach seine sampling sites were selected based on the priorities of Navy personnel to determine fish presence and occupancy timing adjacent to the lagoon entrance. Shallow depths in the lagoon channel restricted the research vessel from entering and sampling the lagoon shoreline. The north and south sites were sampled once a month at high-slack tides from May to September in 2015 and January to September in 2016, which are known to be preferred by beach-spawning forage fish and migrating juvenile salmonids. A minimum of two to three beach seine "sets" were performed at each of the sites on a single date each month. Sampling typically began at the northern most site, and subsequent sets were always conducted to the south. All fish captured during sampling were identified, counted, and released.

Beach Seining Survey Protocols

Beach seine surveys were conducted during daylight hours, within two hours of high-slack tide using a 5.5m WDFW research vessel (aluminum hull, 115hp outboard motor) equipped with a bowpicker. The beach seine was 36.6m long x 3.7m deep with 3.2mm knotless nylon mesh (Cristensen Net Works - Everson, WA). The net was cut to taper from 1.8m to 3.7m deep in the leading 18.3m of net, followed by 18.3m of netting 3.7m deep (Figure 3). This "Skagit" net design is widely used by the WDFW, Wild Fish

Conservancy (WFC), Skagit River System Cooperative (SRSC), and many other organizations to assess nearshore fish assemblages throughout the Puget Sound region.

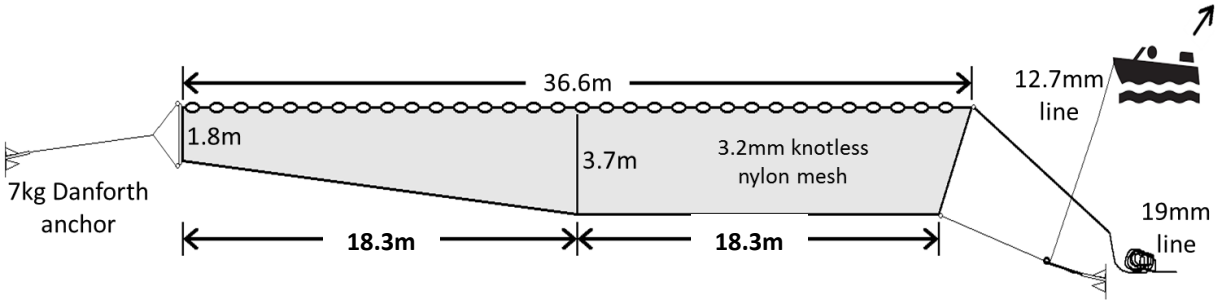

Figure 3. Diagram of the beach seine with dimensions used for sampling.

During sampling, the shallow end of the net was anchored to the beach with a 7kg Danforth anchor and deployed perpendicular to the beach. A haul line of 19mm braided nylon attached to the deep end of net was secured to the bow with approximately 10m of line between the boat and end of the net. The net was towed by the boat in reverse against the current in a "round haul" fashion and returned towards shore at a point approximately 75% of the net's length (Figure 4). As the boat approached shore, a second line of 12.7mm, three-strand nylon attached at the net's lead line was tossed to a crew member on shore, passed through a stainless steel snatch block attached to a second anchor, and returned to the boat where it was secured to a post on the bow. The boat then carefully reversed away from shore pulling the line through the anchored snatch block, and landing the net on the beach (Figure 5a). Set durations ranged from three to five minutes from net deployment to landing on the beach, and each sampling trip typically included six to eight total sets on a given date.

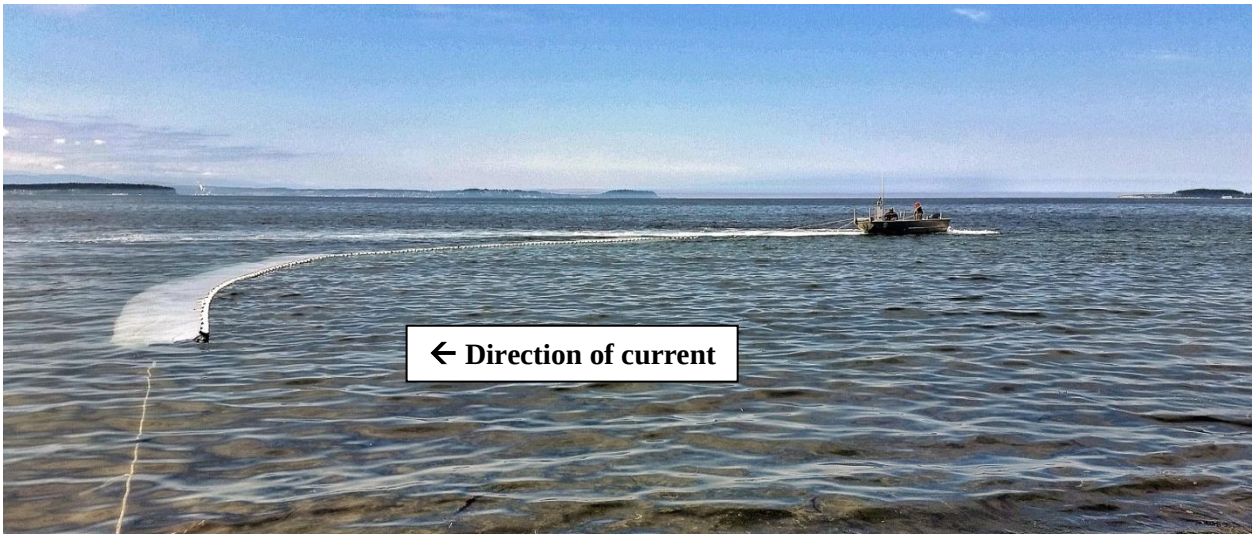

Figure 4. Photo taken while beach seining showing the "round haul" net deployment method into the current.

Figure 5. Photo taken during a beach seine set showing the use of a snatch block anchored to shore and research vessel to land the net (a). The WDFW beach seine staff sorting fish species in the landed net enclosure (b).

Upon landing the net, smaller catches were transferred to 113L containers that were aerated by bubblers and regularly irrigated with fresh seawater. Larger catches were retained in the net enclosure to minimize heat and oxygen stress during handling. Each set's catch was sorted and identified to the lowest possible taxonomic level and enumerated before release (Figure 5b). Holding time was often less than 5 minutes and not longer than 15 minutes. A subsample of each species of forage fish (n=40) and juvenile salmonid (n=20) was measured (fork length) to the nearest millimeter for each sampling trip. Salmonids were checked for adipose fin presence/absence to determine hatchery or natural-origin, if applicable. In addition to collecting biological data specific to catch, information describing weather, water surface conditions, depth, tide stage and elevation, primary and secondary substrate characteristics, and amount of algae in each set was recorded.

Results

Beach Seine Surveys in 2015

Beach seine sampling occurred at sites north and south of the lagoon entrance once a month from May to September 2015 (see Figure 2). A total of 25 sets were completed in 2015, with two to three sets completed at each site on each day. Maximum nearshore water depths recorded while sampling averaged 2.9m at the northern site, and 1.9m at the southern site.

A total of 38 fish species (including unidentified taxa) were captured over the five months of sampling at all sites. Overall catch composition consisted primarily of Shiner Perch (*Cymatogaster aggregata*), Surf Smelt (*Hypomesus pretiosus*), and Striped Seaperch (*Embiotoca lateralis*) (Table 1). Species richness varied monthly from 11 to 32 species captured during each sampling event, with peak species richness observed in June (Figure 6). Fork lengths were recorded for a total of 160 forage fish and 80 salmonids during the five months of sampling at all sites (Table 2).

Table 1. Total number of beach seine sets completed and counts of all marine fish captured by sampling month in 2015.

Species	27-May	24-Jun	24-Jul	24-Aug	24-Sep	Total	% of Total
# of Sets Completed	**4**	**6**	**6**	**4**	**5**	**25**	**-**
Bay Pipefish	1	3	4	1	1	10	0.09%
Buffalo Sculpin	1	9	2		1	13	0.12%
Cabezon (juvenile)		2				2	0.02%
Chinook Salmon		33	4		1	38	0.35%
Chum Salmon	7	4	1			12	0.11%
Coho Salmon	12	23	1			36	0.33%
Crescent Gunnel		8	1	2		11	0.10%
English Sole		1	2			3	0.03%
Flatfish (unidentified)	1	1				2	0.02%
Fluffy Sculpin		4	2		1	7	0.06%
Gadidae (unidentified)		1				1	0.01%
Greenling (unidentified)	6	3				9	0.08%
Gunnel (unidentified)		6	3		1	10	0.09%
Kelp Perch			3			3	0.03%
Northern Clingfish		1				1	0.01%
Pacific Herring	1	5	10		2	18	0.17%
Pacific Sand Lance	36	2	4		19	61	0.56%
Pacific Sanddab	1	2				3	0.03%
Pacific Staghorn Sculpin	1	11	18	12	13	55	0.51%
Padded Sculpin		1				1	0.01%
Penpoint Gunnel	4	6	1		4	15	0.14%
Pile Perch	5	24	50	64	20	163	1.51%
Pink Salmon			1			1	0.01%
Rockweed Gunnel		17				17	0.16%
Saddleback Gunnel	4	4	7	8		23	0.21%
Sculpin (unidentified)	3	1				4	0.04%
Shiner Perch	164	4645	1282	1853	620	8564	79.30%
Silverspot Sculpin	1	4	5		1	11	0.10%
Slender Cockscomb			1			1	0.01%
Sockeye Salmon			1			1	0.01%
Starry Flounder	2	2	3	1	3	11	0.10%
Steelhead			1			1	0.01%
Striped Seaperch		119	89	54	4	266	2.46%
Surf Smelt	60	5	1076	32	27	1200	11.11%
Threespine Stickleback	18	54	103	25	3	203	1.88%
Tidepool Sculpin	1	5				6	0.06%
Tubesnout	2	8	1	3	1	15	0.14%
Whitespotted Greenling	1					1	0.01%

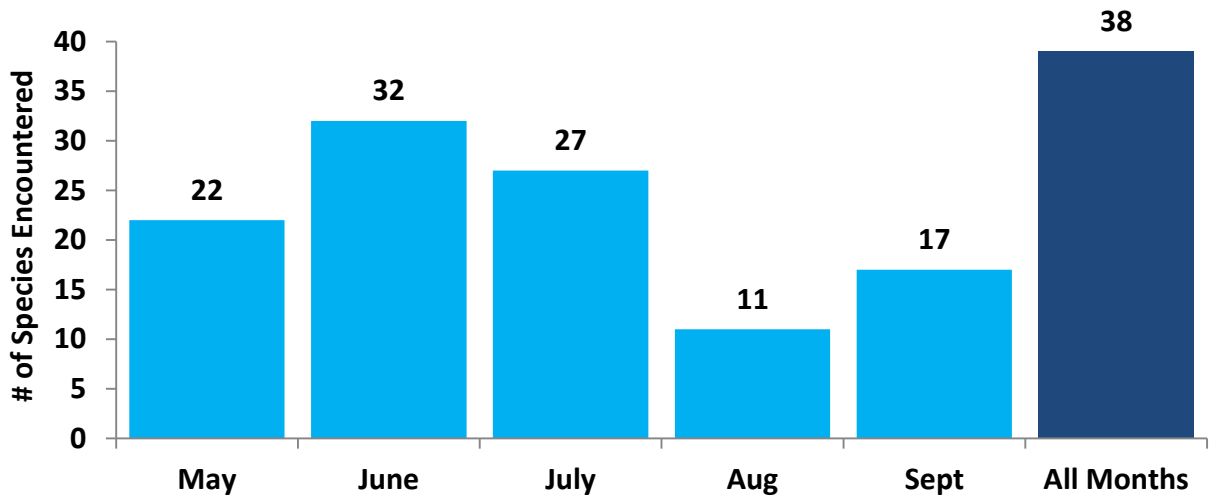

Figure 6. Species richness (including unidentified taxa) of all fish captured during beach seining surveys, by month and all months combined in 2015.

Table 2. Fork length (mm) data summaries for juvenile salmonid (left) and all forage fish (right) species sampled in 2015. *Indicates adult salmonids (>300mm).

Species	Mean ± SD	CV	n
Chinook natural	93.45 ± 11.07	0.12	11
Chinook hatchery	113.28 ± 22.59	0.20	18
Coho natural	111.06 ± 28.36	0.26	17
Coho hatchery	118.58 ± 33.43	0.28	19
Chum Salmon	70.33 ± 14.26	0.20	12
Pink Salmon*	439.00	-	1
Sockeye Salmon*	500.00	-	1
Steelhead*	700.00	-	1

Species	Mean ± SD	CV	n
Surf Smelt	69.68 ± 35.87	0.51	97
Pacific Sand Lance	93.87 ± 14.33	0.15	45
Pacific Herring	60.5 ± 12.14	0.20	18

Forage fish were primarily captured at the northern site, while salmonids were evenly dispersed between the northern and southern sites (Figure 7). Forage fish species captured in 2015 included Surf Smelt, Pacific Sand Lance (*Ammodytes personatus*), and Pacific Herring (*Clupea palasii*), with variable catch rates observed throughout the sampling months (Figure 8). The most commonly captured forage fish species over all five months was Surf Smelt, with the peak catch rate occurring at the northern site in July (179.3 fish/set). Surf Smelt fork length data for all months combined resulted in high variation (CV=0.51), and a multimodal distribution of age-0, age-1, and age-2+ fish (Figure 9) with variation in size between sexes (Penttila 1978). Pacific Sand Lance were only captured at the northern site with a peak catch rate in May (12 fish/set). Pacific Sand Lance fork length data indicates the presence of multiple classes of age-0 through age-3 fish (Emmett et al. 1991, Greene at al. 2011) (Figure 10). Pacific Herring were captured at both sites, with a peak catch rate in July (1.7 fish/set). Pacific Herring fork length data indicates a single class of age-0 fish (Buchanan 1985) (Figure 11). There were no ESA-listed species of forage fish (i.e., Eulachon) captured at the NAS Whidbey Island Lake Hancock during the 2015 sampling season.

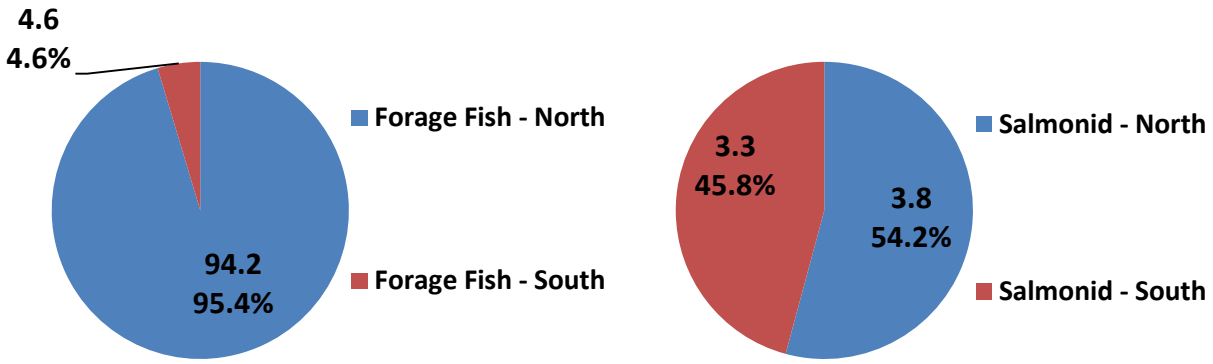

Figure 7. Catch rates (fish/set) and percentages within forage fish and salmonid species groups, separated by north and south sampling sites for all months combined in 2015.

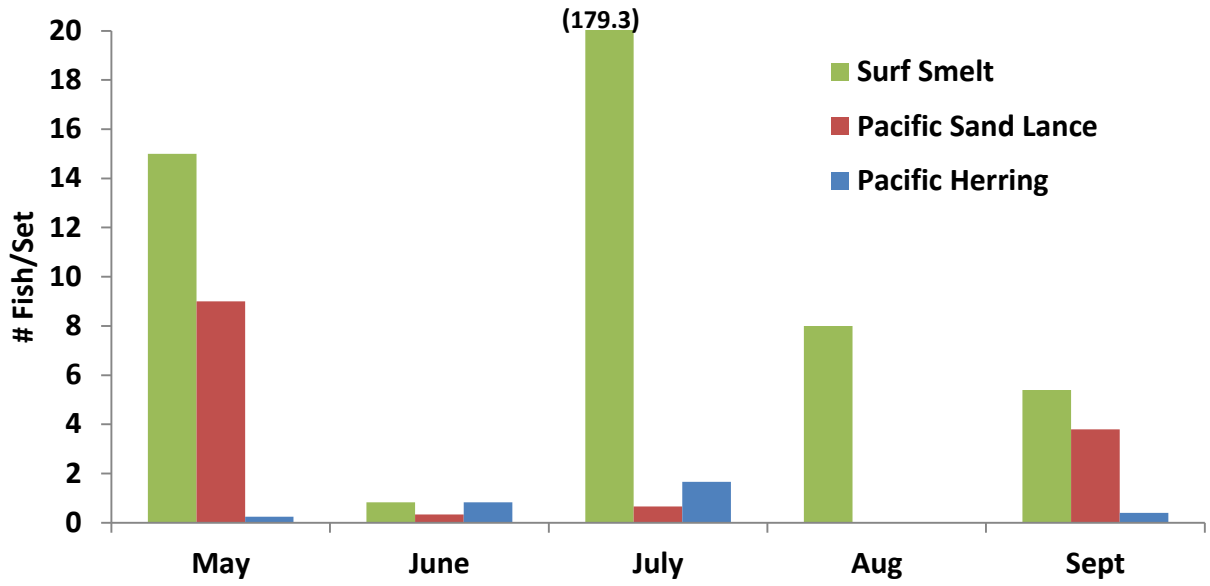

Figure 8. Catch rates for forage fish species captured during beach seining for all sites combined in 2015. Values are labeled for catch rates exceeding the vertical axis.

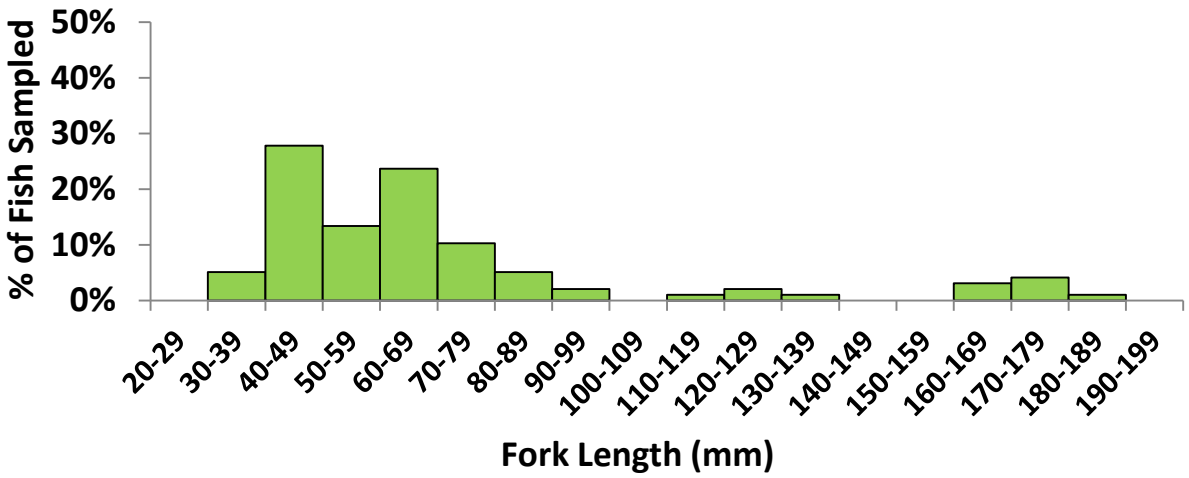

Figure 9. Histogram of Surf Smelt fork length data for all sites and months combined in 2015.

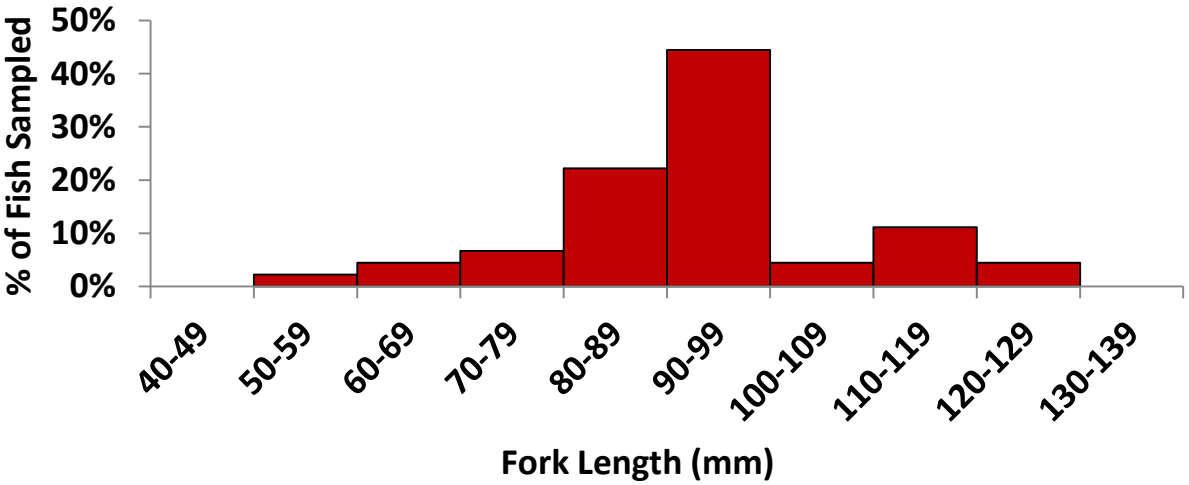

Figure 10. Histogram of Pacific Sand Lance fork length data for all sites and months combined in 2015.

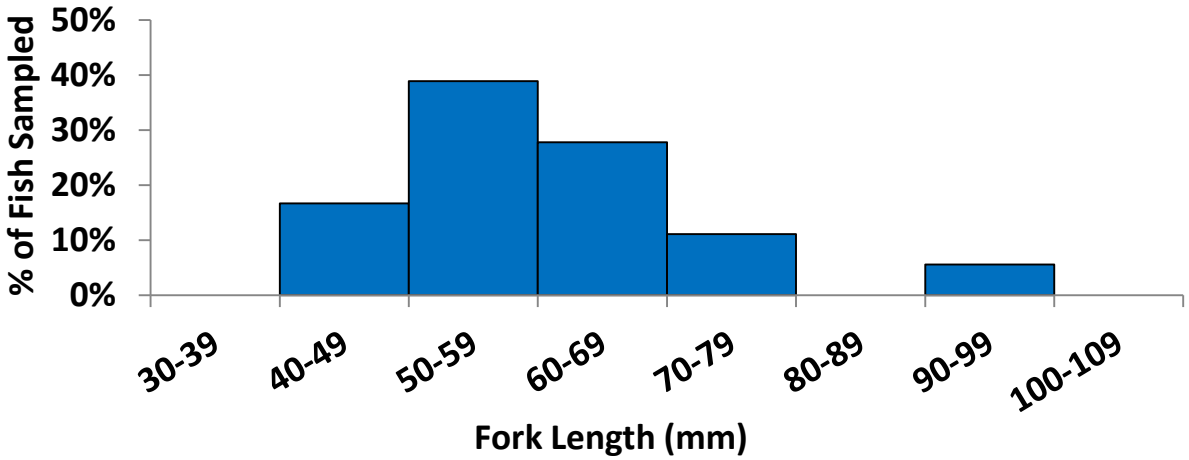

Figure 11. Histogram of Pacific Herring fork length data for all sites and months combined in 2015.

Salmonid species captured in 2015 included Chinook Salmon, Chum Salmon, Coho Salmon (*O. kisutch*), Pink Salmon (*O. gorbuscha*), Sockeye Salmon (*O. nerka*), and steelhead; with variable catch rates occurring in May, June, and July (Figure 12). Juvenile salmonid fork lengths increased for each species' cohort, as a consequence of seasonal growth after outmigration from local watersheds, from May through July (Figure 13). Chinook Salmon were captured from both sites with the peak catch rate observed in June (5.5 fish/set), and quickly declined in July and September (<1 fish/set). Chinook Salmon were classified as 13 natural and 25 hatchery-origin fish. A single adult hatchery-origin steelhead was captured in July while sampling the northern site. Coho Salmon were captured from both sites with a peak catch rate in June (3.8 fish/set), and declined in July (<1 fish/set). Coho Salmon were classified as 17 natural and 19 hatchery-origin fish. Chum Salmon were captured at both sites with a peak catch rate in May (1.8 fish/set), and also declined in June and July (<1 fish/set). A single adult Pink and Sockeye Salmon were captured from the northern site during July sampling.

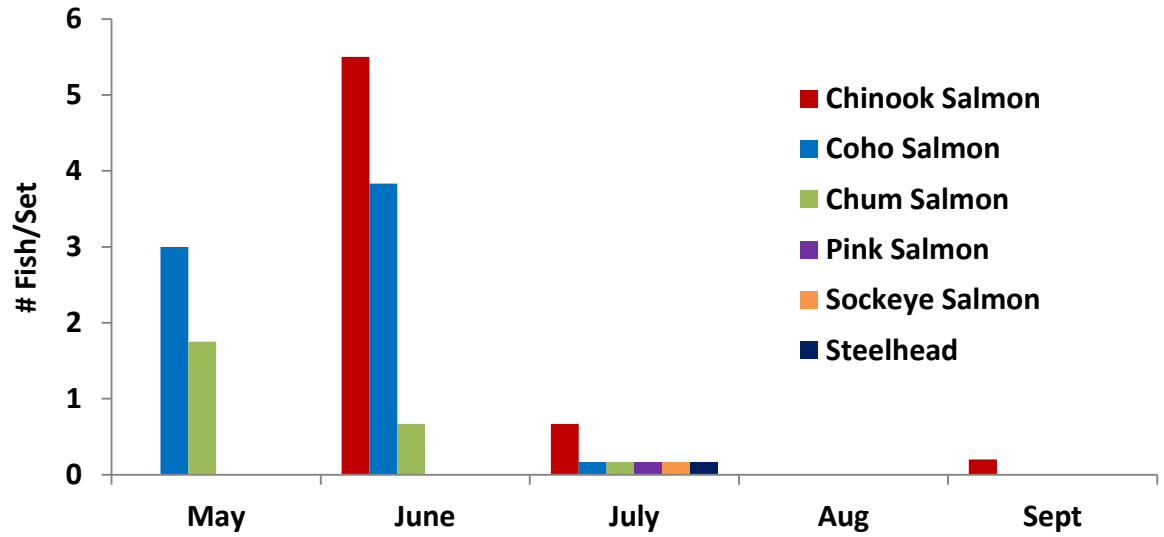

Figure 12. Catch rates for salmonid species captured during beach seining, by month for all sites combined in 2015.

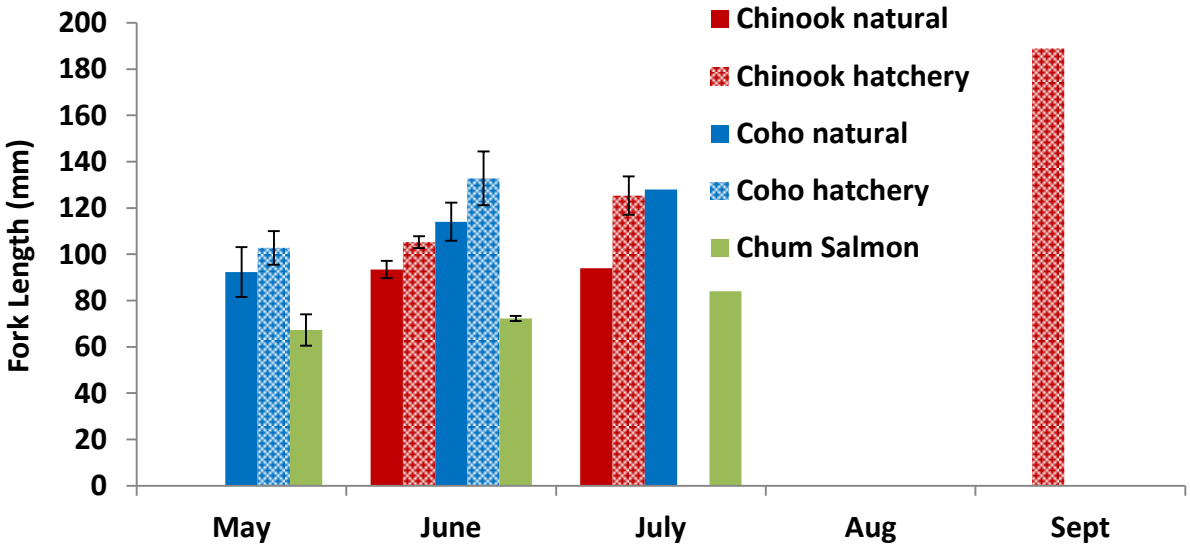

Figure 13. Mean fork length (± 1SE) for juvenile salmonid species by month for all sites in 2015.

Beach Seine Surveys in 2016

Beach seine sampling occurred at sites north and south of the lagoon entrance once a month from January to September 2016 (see Figure 2). A total of 52 sets were completed in 2016, with two to three sets completed at each site on each day. Maximum nearshore water depths recorded while sampling averaged 1.9m at the northern site, and 1.7m at the southern site.

A total of 30 fish species (including unidentified taxa) were captured over the nine months of sampling at all sites. Overall catch composition consisted primarily of Shiner Perch, Surf Smelt, Pink Salmon, and Chum Salmon (Table 3). Species richness varied monthly from 7 to 20 species captured during each sampling event, with peak species richness observed in June (Figure 14). Fork lengths were recorded for a total of 224 forage fish and 175 salmonids during the nine months of sampling at all sites (Table 4).

Table 3. Total number of beach seine sets completed and counts of all marine fish captured by sampling month in 2016.

Species	4-Jan	1-Feb	17-Mar	14-Apr	18-May	28-Jun	26-Jul	25-Aug	22-Sep	Total	% of Total
# of Sets Completed	**4**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**52**	**-**
Arrow Goby			1							1	0.01%
Bay Pipefish					1	2			1	4	0.03%
Buffalo Sculpin	2	2	2			5	2	1		14	0.11%
Chinook Salmon					4	5		1		10	0.08%
Chum Salmon	1	17	122	157	4	1				302	2.30%
Coho Salmon					2	1	1			4	0.03%
Crescent Gunnel						6				6	0.05%
English Sole					1	29	2		1	33	0.25%
Flatfish (unidentified)			1			21				22	0.17%
Greenling (unidentified)	3	1	6	2	12					24	0.18%
Northern Anchovy									1	1	0.01%
Pacific Herring						6		5		11	0.08%
Pacific Sand Lance			2	4	1					7	0.05%
Pacific Staghorn Sculpin	3	1	15	14	12	20	24	16	12	117	0.89%
Padded Sculpin					1	1			1	3	0.02%
Penpoint Gunnel					3	5			2	10	0.08%
Pile Perch				1	9	21	32	63	120	246	1.87%
Pink Salmon		45	80	183	117					425	3.23%
Saddleback Gunnel					13	56	9	6	8	92	0.70%
Sculpin (unidentified)				1						1	0.01%
Sharpnose Sculpin						2	3		2	7	0.05%
Shiner Perch					358	7882	987	563	923	10713	81.50%
Silverspot Sculpin					1					1	0.01%
Slender Cockscomb							1			1	0.01%
Starry Flounder	1	5	28	9		9	2	4	7	65	0.49%
Striped Seaperch						42	37	39	59	177	1.35%
Surf Smelt	3	10	1	20	88	204	21	342	2	691	5.26%
Threespine Stickleback	6	1	6	1	50	44	24	21		153	1.16%
Tidepool Sculpin			1				1	1		3	0.02%
Tubesnout							1			1	0.01%

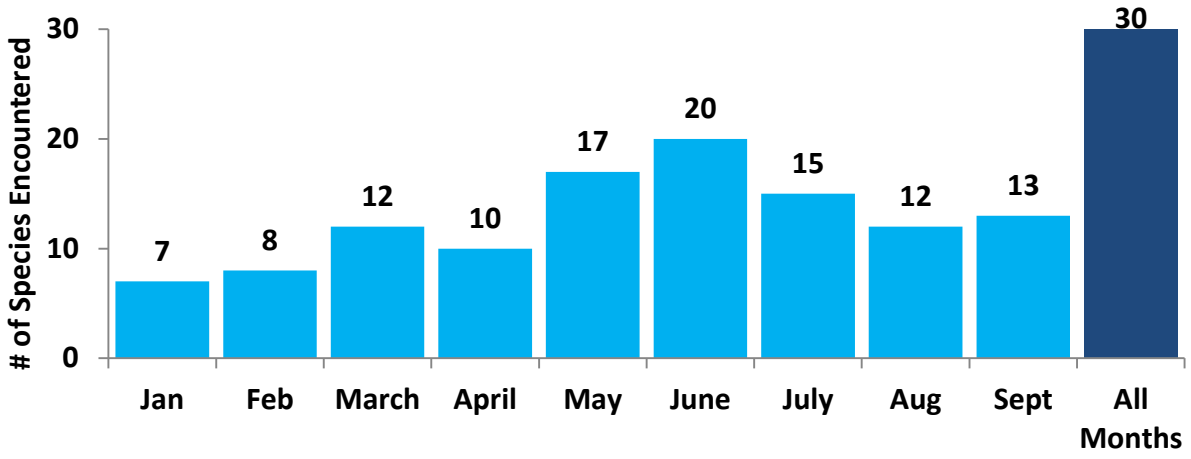

Figure 14. Species richness (including unidentified taxa) of all fish captured during beach seining surveys, by month and all months combined in 2016.

Table 4. Fork length (mm) data summaries for juvenile salmonid (left) and forage fish (right) species sampled in 2016.

Species	Mean ±SD	CV	n
Chinook natural	103.67 ±20.40	0.20	3
Chinook hatchery	103.71 ±13.72	0.13	7
Coho natural	132.00 ±12.77	0.10	3
Chum Salmon	53.81 ±18.69	0.35	67
Pink Salmon	43.32 ±13.51	0.31	95

Species	Mean ±SD	CV	n
Surf Smelt	66.00 ±30.54	0.46	205
Pacific Herring	59.36 ±5.52	0.09	11
Pacific Sand Lance	63.86 ±22.75	0.36	7
Northern Anchovy	65.00	-	1

Forage fish were primarily captured at the southern site, while salmonids were primarily captured at the northern site in 2016 (Figure 15). Forage fish species captured in 2016 included Surf Smelt, Pacific Sand Lance, and Pacific Herring, and Northern Anchovy (*Engraulis mordax*) with variable catch rates observed throughout each month (Figure 16). The most commonly captured forage fish species over all nine months was Surf Smelt, with the peak catch rate at the southern site in August (57 fish/set). Surf Smelt fork length data for all months combined resulted in high variation (CV=0.46), and a multimodal distribution of age-0, age-1, and age-2+ fish (Figure 17) with variation in length between sexes (Penttila 1978). Pacific Herring were only encountered during June (1 fish/set) and August (<1 fish/set) sampling. Pacific Herring fork length data indicates a single class of age-0 fish (Buchanan 1985) (Figure 18). Very few Pacific Sand Lance were captured, and only during March through May sampling with a peak catch rate in April (<1 fish/set). Pacific Sand Lance fork length data indicates the presence of multiple classes of age-0 through age-3 fish (Emmett et al. 1991, Greene at al. 2011) (Figure 19). A single juvenile Northern Anchovy was captured at the north site in September. There were no ESA-listed species of forage fish (i.e., Eulachon) captured at the NAS Whidbey Island Lake Hancock during the 2016 sampling season.

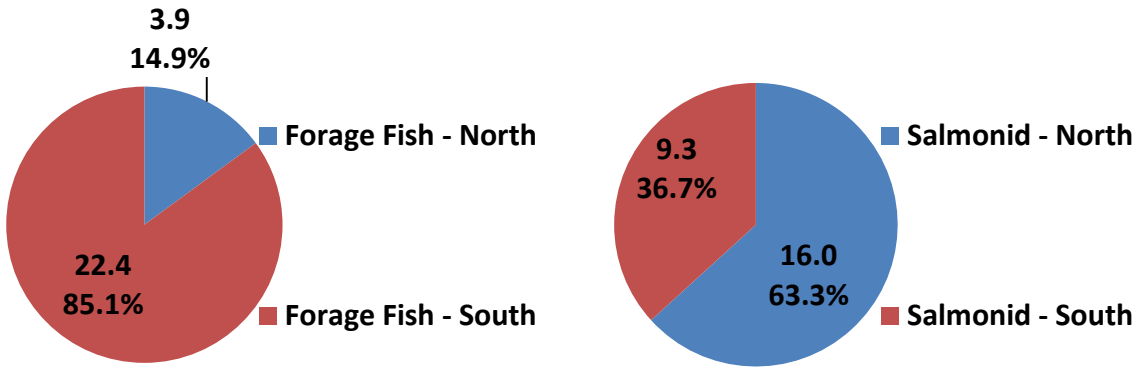

Figure 15. Catch rates (fish/set) and percentages within forage fish and salmonid species groups, separated by north and south sampling sites for all months combined in 2016.

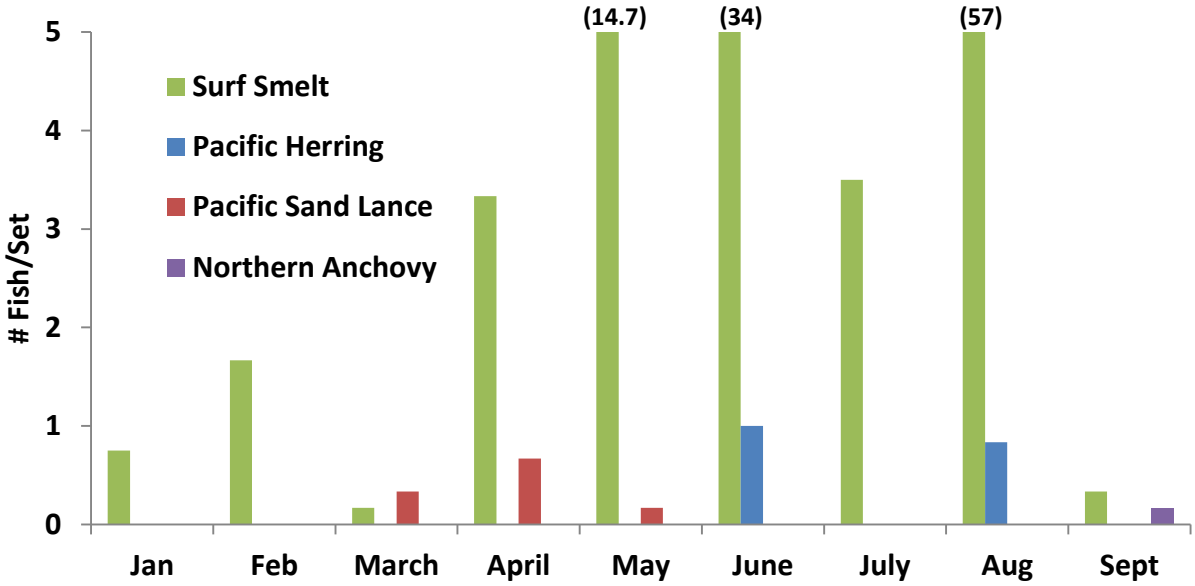

Figure 16. Catch rates for forage fish species captured during beach seining for all sites combined in 2016. Values are labeled for catch rates exceeding the vertical axis.

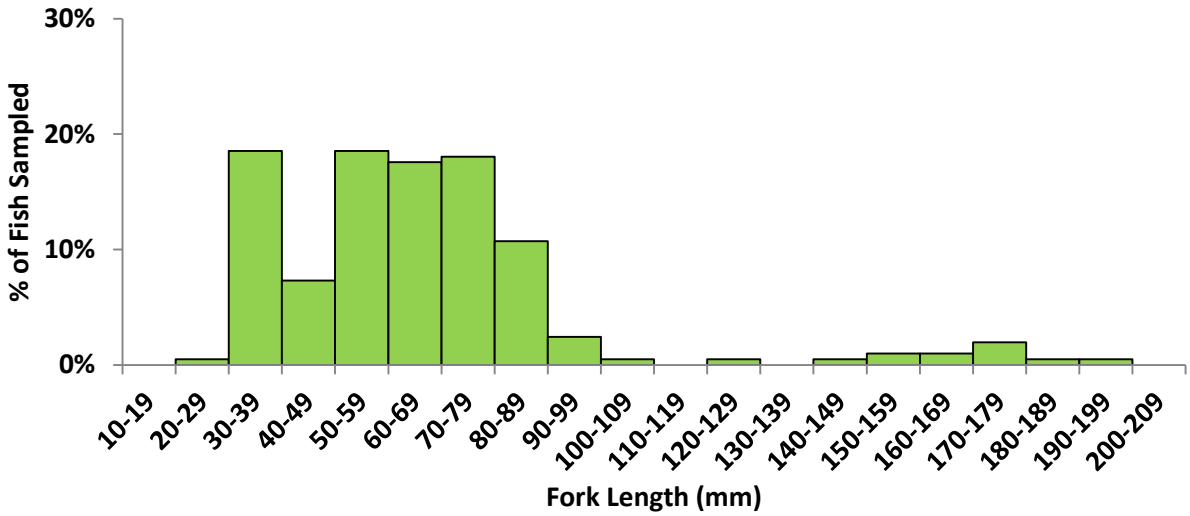

Figure 17. Surf Smelt fork length histogram for all months and sites combined in 2016.

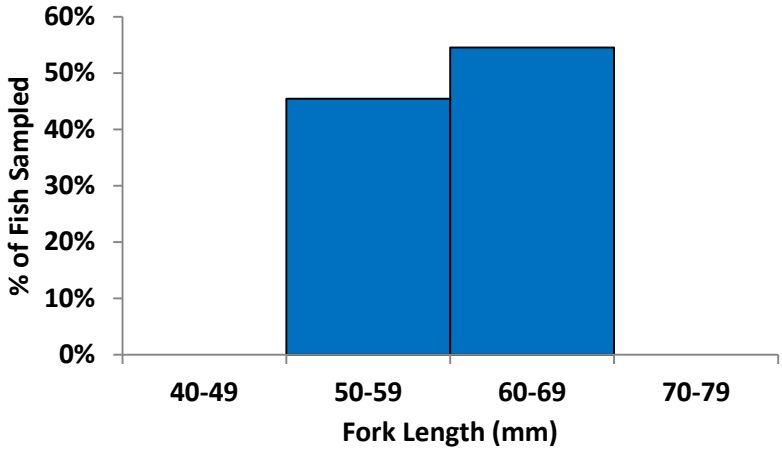

Figure 18. Pacific Herring fork length histogram for all months and sites combined in 2016.

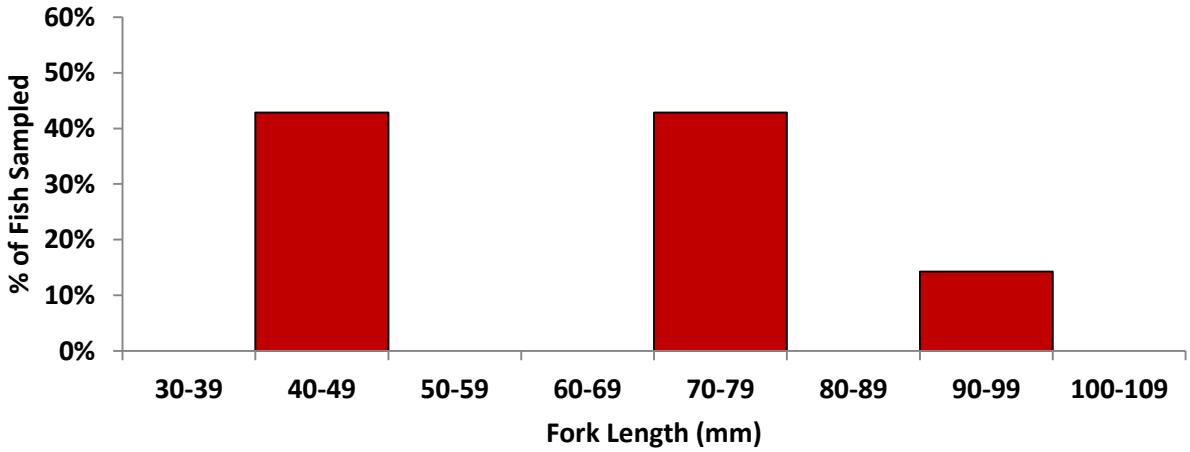

Figure 19. Pacific Sand Lance fork length histogram for all months and sites combined in 2016.

Salmonid species captured in 2016 included Chinook Salmon, Coho Salmon, Chum Salmon, and Pink Salmon; with variable catch rates occurring from January through August (Figure 20). Salmonid fork lengths generally increased for each species' cohort, as a consequence of seasonal growth after outmigration from local watersheds, from January through August (Figure 21). Chinook Salmon were captured from both sites with low peak catch rates observed in May and June (<1 fish/set), and a single fish captured in August. Chinook Salmon were classified as 3 natural and 7 hatchery-origin fish. Coho Salmon were captured at low catch rates from May through July (<1 fish/set), totaling 4 natural-origin fish. Chum Salmon were captured at both sites with peak catch rates occurring in March (20.3 fish/set) and April (26.2 fish/set), and quickly declined in May and June (<1 fish/set). Genetic analysis of Chum tissue samples revealed that ESA-listed Hood Canal summer-run fish comprised 78% of all Chum captured in both January and February, while 78% of all Chum captured from March through May were fall-run fish (Figure 22). Pink Salmon were encountered from February through May, with the peak catch rate occurring in April (30.5 fish/set).

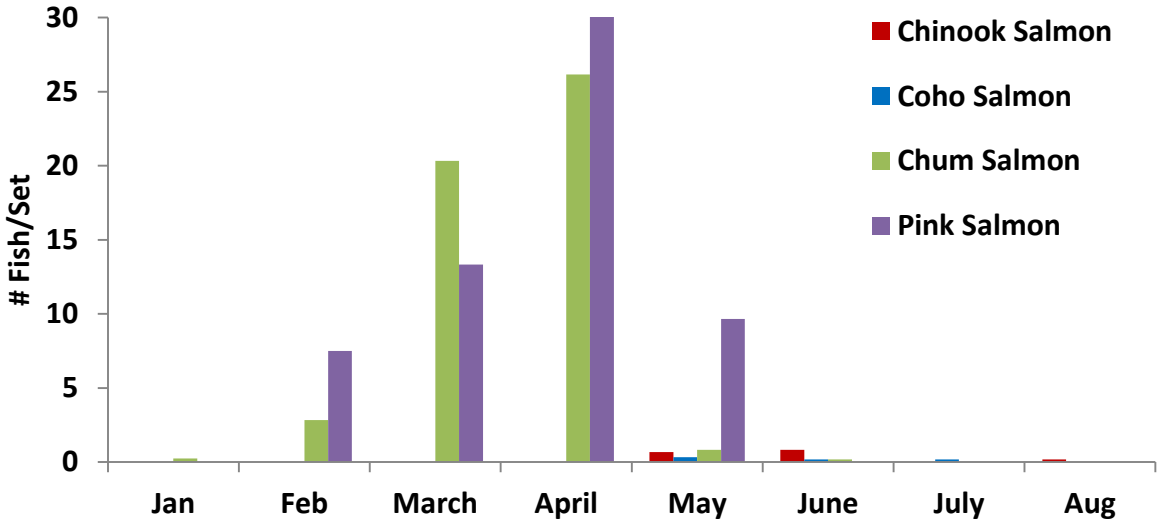

Figure 20. Catch rates for salmonid species captured during beach seining, by month for all sites combined in 2016.

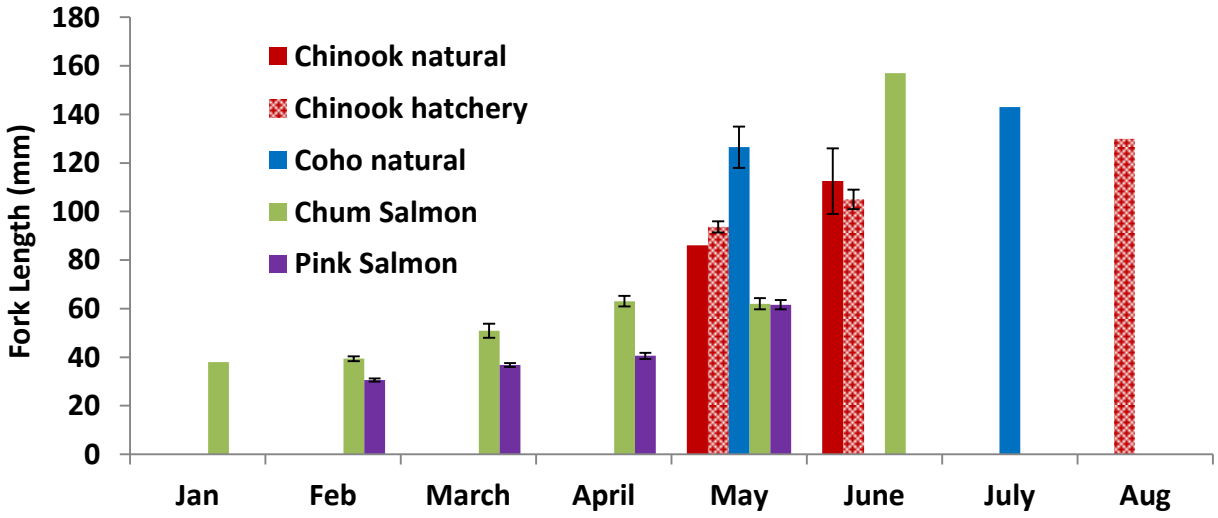

Figure 21. Mean fork length with standard error bars for juvenile salmonid species, by month for all sites in 2016.

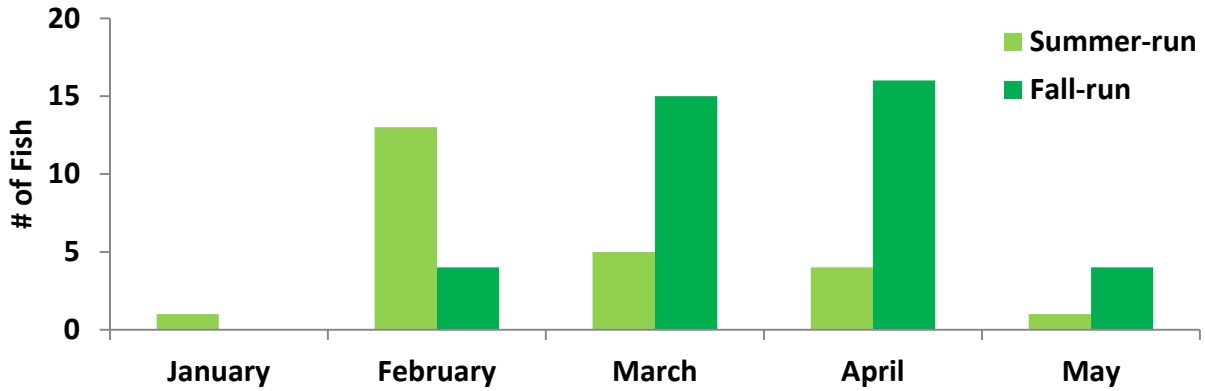

Figure 22. Run assignment of Chum Salmon captured at the NAS Whidbey Island Lake Hancock, by month in 2016.

Discussion

Forage Fish and Salmonids in 2015-16

Beach seine surveys were completed to assess ESA-listed forage fish and salmonid species' use of marine nearshore habitats, specifically with regard to their timing, distribution, and relative abundance adjacent to the NAS Whidbey Island Lake Hancock property. This report combines both 2015 and 2016 survey years with the intent to update and compare past surveys of forage fish and salmonids, conducted with a similar design, using a beach seine along Western Whidbey shoreline. Past studies have also focused their sampling efforts from January through early and late summer to assess the different outmigration patterns of each salmonid species, but did not report on forage fish catches (see Wait et al. 2007).

In Puget Sound, forage fish species occupy every marine and estuarine nearshore habitat, and their spawning habitats all commonly occur within the nearshore zone of Pacific Northwest beaches (Penttila 2007). However, little is known about any forage fish species away from their spawning grounds (Penttila 2007). Due to their critical role as prey species for salmon and marine mammals, conservation efforts regarding their abundance trends and spawning habitats have been considerably emphasized.

Forage fish were primarily captured from May through August during both 2015 and 2016 sampling, with greater overall densities of all forage fish species encountered in 2015. Forage fish were captured in each month of sampling during both survey years, despite the absence of historically documented spawning locations for Surf Smelt, Pacific Sand Lance, or Pacific Herring along the Admiralty Bay shoreline (WDFW online). Suitable substrate and habitat exists within the bay, and recently expanded survey efforts for beach-spawning forage fish may reveal their utilization of intertidal habitat in the vicinity of Lake Hancock. Regarding abundance, catches of forage fish in 2015-16 showed high variation and inconsistency, which was relatively similar to other DoN locations sampled by the WDFW throughout Puget Sound. The disparities among these different survey locations could be indicative of natural interannual variation driven by sea surface temperature, prey abundance, or other factors affecting both broad-scale population demographics and localized habitat usage. Surf Smelt peak catch rates for both survey years occurred in summer, however the peak rate during August 2016 sampling was only 53% of the rate recorded in July 2015. The overall mean catch rate for Pacific Sand Lance in 2016 was only 1% of the rate observed in 2015. Pacific Herring were never captured at rates >1 fish/set during any month of the 2015-16 sampling. Fork length data taken for all species of forage fish indicate the presence of

primarily age-0 and age-1+ classes utilizing nearshore habitat within the sampling areas. No ESA-listed species of forage fish (i.e., Eulachon) were captured during the 2015-16 sampling.

Pacific Salmon (*Oncorhynchus* spp.) depend upon a wide range of habitats throughout their life cycle (Groot and Margolis 1991, Nightingale and Simenstad 2001). The nearshore zone along the northern reaches of Admiralty Inlet, including the WPNRA shoreline, serves as an essential migration route for nearly all juvenile salmonids (natural and hatchery) produced in Puget Sound. When these juveniles enter the marine environment from their natal streams, they depend upon nearshore vegetated habitats for prey resources and shelter from predation. In this way, shallow nearshore habitats are critical to the survival of such species (Naiman and Seibert 1979; Simenstad 1979, 1980, 1982; Healey 1982; Johnson et al. 1997, Nightingale and Simenstad 2001).

A past study has documented the presence and timing of outmigrating juvenile salmonids along the western Whidbey shoreline, including Lake Hancock, to begin in January and continue through the summer (Wait et al. 2007). They reported that juvenile Chum and Pink (in even years) Salmon were the predominant salmonid species captured with a beach seine, followed by Coho and Chinook. Overall, the relative abundance and timing of each juvenile salmonid species reported in these past studies appears to have remained stable, coinciding with the 2015-16 survey results. Hatchery releases also corresponded to abundance and timing of salmonids captured in past studies and the 2015-16 surveys. Millions of hatchery produced juvenile salmonids are released throughout Puget Sound every year to provide increased recreational and commercial harvest opportunities, as well as supplement the recovery and conservation of naturally-spawning salmon populations. In 2015 and 2016, approximately 60% of the entire regional Puget Sound hatchery releases were composed of unmarked fish, meaning they could not be distinguished from naturally produced fish (see Appendix B and C). The 2005-06 survey along the western Whidbey shoreline reported that over 85% of the recovered Chinook with a coded wire tag (CWT) came from the Snohomish, Stillaguamish, Skagit, and Samish Rivers (Wait et al. 2007). They also recovered hatchery origin tagged Chinook and Coho released in Hood Canal and central Puget Sound. In 1977, Hood Canal hatcheries released 890,000 Chum Salmon 'spray-marked' with fluorescent pigment, of which five were recaptured with a beach seine at Walan Point (Moore et al. 1977). These mark-recapture data recapitulate the importance of nearshore outmigration pathways for juvenile salmonids throughout Admiralty Inlet, including Lake Hancock.

Chum Salmon dominated the catch from January through May 2016 sampling, and were encountered at low frequencies in May and June 2015. Unmarked Chum Salmon fry comprised over 40% of all regional Puget Sound hatchery released fish in both survey years, with the vast majority (30-40 million) being released in April. Hood Canal summer-run Chum Salmon are an ESA-listed species stock, but they are indistinguishable from fall-run Chum Salmon stocks by visual identification methods. We did not conduct the genetic analyses necessary to differentiate the two stocks potentially encountered during 2015 sampling. However, tissue samples were collected during January through May 2016 sampling in Hood Canal and Admiralty Inlet. Hood Canal summer-run Chum Salmon are typically expected to emerge into the marine environment earlier (January to March) than fall Chum Salmon stocks (March to June) which are greatly supplemented with hatchery fall Chum Salmon releases in April (Ames et al. 2000, Cook-Tabor 1995, Fletcher et al. 2013). A five year study at a WDFW screw trap in the Duckabush River showed that peak outmigration of summer-run Chum occurred between the last week of February and the middle of March, while fall-run Chum migrated over a more protracted time period (Weinheimer 2016). The presence of Hood Canal summer-run Chum Salmon at the NAS Whidbey Island Lake Hancock was confirmed by genetic analysis of the 2016 samples, and is detailed in a separate report funded by another cooperative agreement (Small et al. 2017). These 2015-16 data are consistent with recent genetic assignment studies for Chum in the Hood Canal region, as the majority (78%) of Chum sampled in January and February were summer-run fish.

High densities of Pink Salmon juveniles were captured during April 2016 sampling, which corresponds with the species' dominant biennial spawning (during odd years) in Puget Sound rivers and hatchery release of nearly half a million unmarked fish in March 2016. The timing and abundance for Pinks observed in 2016 closely aligns with the recent survey in 2006 (Wait et al. 2007).

Coho Salmon were first encountered in May of both survey years at their respective peak catch rates, and quickly declined in June. The mean catch rate for Coho in 2016 was only 10% of the 2015 mean catch rate. This timing corresponds with the hatchery releases of over 8 million total Coho in both April and May of 2015-16, consisting of approximately 92% adipose clipped fish. However, only 53% of captured Coho in 2015-16 were hatchery produced (adipose clipped), which is inconsistent with the hatchery release mark rates. This 2015-16 data for Coho is consistent with the timing and moderate catch rates reported from past studies conducted along the western Whidbey Island shoreline (Wait et al. 2007).

Catch rates for Chinook Salmon were highest in June of both survey years, but the peak rate in 2016 was only 15% of the rate recorded in 2015. Hatchery releases of approximately 30 million Chinook from April through June 2015-16 correspond to the peak catch rates observed, consisting of 70% (2015) and 75% (2016) adipose clipped fish. This mark rate was consistent with the 65% of all captured Chinook in 2015-16 that were hatchery produced (adipose clipped) rather than naturally produced (non-clipped) fish. This 2015-16 data for Chinook is consistent with the timing and moderate catch rates reported from past studies conducted along the western Whidbey Island shoreline (Wait et al. 2007).

Conclusions

Overall, the relative timing and abundance of forage fish and salmonids sampled with a beach seine in 2015 and 2016 were consistent with historical surveys conducted along the NAS Whidbey Island Lake Hancock shoreline. Collectively, these studies indicate that whatever impacts to the nearshore habitat, as used by juvenile salmonids and forage fish, have remained consistent over time.

The three ESA-listed species captured with the beach seine at the NAS Whidbey Island Lake Hancock were Hood Canal summer-run Chum Salmon, Chinook Salmon, and steelhead. Hood Canal summer-run Chum Salmon were detected in nearshore areas earlier (January-February) than fall-run Chum Salmon (March-April). The peak catch rate for juvenile Chinook Salmon occurred in June of both survey years. The single adult steelhead was captured in July. Based on results from the 2015-2016 surveys, we preliminarily conclude that the work window (July 15 to February 15) for the NAS Whidbey Island Lake Hancock properties' in-water maintenance, military construction (MILCON), mitigation projects, future Fleet training and testing should not include February through July, as is consistent with the measures outlined in WAC 220-660-330.

Acknowledgements

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Appendix A: Comprehensive list of all fish species recorded at the NAS Whidbey Island Lake Hancock in 2015 with the beach seine. Taxanomic nomenclature and phylogenetic organization follows arrangement from Pietsch and Orr (2015).

TAXON	COMMON NAME
CLUPEIFORMES	**HERRINGS**
Clupeidae	**Herrings and Sardines**
Clupea pallasii	Pacific Herring
OSMERIFORMES	**FRESHWATER SMELTS**
Osmeridae	**Smelts**
Hypomesus pretiosus	Surf Smelt
SALMONIFORMES	**TROUTS**
Salmonidae	**Trouts and salmon**
Oncorhynchus gorbuscha	Pink Salmon
Oncorhynchus keta	Chum Salmon
Oncorhynchus kisutch	Coho Salmon
Oncorhynchus mykiss	Steelhead
Oncorhynchus nerka	Sockeye Salmon
Oncorhynchus tshawytscha	Chinook Salmon
GADIFORMES	**CODS**
Gadidae	Gadidae unidentified
GASTEROSTEIFORMES	**STICKLEBACKS**
Aulorhynchidae	**Tubesnouts**
Aulorhynchus flavidus	Tubesnout
Gasterosteidae	**Sticklebacks**
Gasterosteus aculeatus	Threespine Stickleback
Syngnathidae	**Pipefishes**
Syngnathus leptorynchus	Bay Pipefish
SCORPAENIFORMES	**MAIL-CHEEKED FISHES**
Hexagrammidae	**Greenlings**
Hexagrammos stelleri	Whitespotted Greenling
	Greenling unidentified
Cottidae	**Sculpins**
Artedius fenestralis	Padded Sculpin
Enophrys bison	Buffalo Sculpin
Leptocottus armatus	Pacific staghorn Sculpin
Oligocottus maculosus	Tidepool Sculpin
Oligocottus snyderi	Fluffy Sculpin
Scorpaenichthys marmoratus	Cabezon
	Sculpin unidentified
Hemitripteridae	**Spiny Sculpins**
Blepsias cirrhosus	Silverspot Sculpin
PERCIFORMES	**PERCHES**
Embiotocidae	**Surfperches**
Brachyistius frenatus	Kelp Perch
Cymatogaster aggregata	Shiner Perch
Embiotoca lateralis	Striped Seaperch
Rhacochilus vacca	Pile Perch

Stichaeidae	**Pricklebacks**
Anoplarchus insignis	Slender Cockscomb
Pholidae	**Gunnels**
Apodichthys flavidus	Penpoint Gunnel
Apodichthys fucorum	Rockweed Gunnel
Pholis laeta	Crescent Gunnel
Pholis ornata	Saddleback Gunnel
	Gunnels unidentified
Ammodytidae	**Sand Lances**
Ammodytes personatus	Pacific Sand Lance
Gobiesocidae	**Clingfishes**
Gobiesox maeandricus	Northern Clingfish
PLEURONECTIFORMES	**FLATFISHES**
Paralichthyidae	**Sand Flounders**
Citharichthys sordidus	Pacific Sanddab
Pleuronectidae	**Righteye Flounders**
Parophrys vetulus	English Sole
Platichthys stellatus	Starry Flounder
	Flatfish unidentified

Appendix B: Hatchery releases in Puget Sound regions during 2015. Regions include Northern Washington (NOWA), Skagit (SKAG), North Puget Sound (NPS), Mid Puget Sound (MPS), Hood Canal (HOOD), and Strait of Juan de Fuca (JUAN). Data summarized from the Regional Mark Information System (RMIS).

Species	Release Year	Release Month	CWT only	CWT + Ad Clip	Unmarked	Ad Clip only	Mean Length (mm)
Chinook	2015	February			317		
Chinook	2015	March	32,705		1,597		
Chinook	2015	April	483,083	921,254	218,123	2,425,435	143
Chinook	2015	May	1,714,148	1,107,358	3,587,550	11,782,432	79
Chinook	2015	June	518,764	1,292,888	2,896,832	3,600,297	86
Chinook	2015	July		100,694	1,883	830,183	98
Chinook	2015	September			119	34,881	95
Chinook	2015	November				353,641	80
TOTAL			**2,748,700**	**3,422,194**	**6,706,421**	**19,026,869**	
Chum	2015	February			1,349,388		
Chum	2015	March			4,429,592		51
Chum	2015	April			40,885,937		51
Chum	2015	May			84,323		50
Chum	2015	October			863,000		
Chum	2015	December			210,400		
TOTAL					**47,822,640**		
Coho	2015	January			50,235	120,000	152
Coho	2015	February	1,456	106,062	35,515	1,248	123
Coho	2015	March	75,654	126,276	164,887	652,982	114
Coho	2015	April	219,723	351,538	116,018	4,043,496	126
Coho	2015	May	96,228	425,629	140,576	3,561,361	133
Coho	2015	June			159,315		
Coho	2015	July				250	
Coho	2015	September			12	120	
Coho	2015	December			72,000		
TOTAL			**393,061**	**1,009,505**	**738,558**	**8,379,457**	
Cutthroat	2015	January			1,124		
Cutthroat	2015	February			75		
Cutthroat	2015	May			29,695		
Cutthroat	2015	June			88,604		
Cutthroat	2015	July			2,130		
Cutthroat	2015	August			775		
Cutthroat	2015	September			7,140		
Cutthroat	2015	October			54,064		
Cutthroat	2015	November			18,040		
TOTAL					**201,647**		

Sockeye	2015	January	186	4,456	139
Sockeye	2015	February	2,041,563		32
Sockeye	2015	March	3,847,964	5,119	86
Sockeye	2015	April	4,484,080		32
Sockeye	2015	May	470,511		
Sockeye	2015	November	6,473	325,243	109
Sockeye	2015	December	26	838	109
TOTAL			**10,850,803**	**335,656**	
Steelhead	2015	February	120	6,047	498
Steelhead	2015	March	2,559	192,703	535
Steelhead	2015	April	45,687	605,156	184
Steelhead	2015	May	57,244	8,786	182
Steelhead	2015	June	17	16,807	192
Steelhead	2015	October	137	15,863	
Steelhead	2015	November	59	6,861	
TOTAL			**105,823**	**852,223**	

Appendix C: Hatchery releases in Puget Sound regions during 2016. Regions include Northern Washington (NOWA), Skagit (SKAG), North Puget Sound (NPS), Mid Puget Sound (MPS), Hood Canal (HOOD), and Strait of Juan de Fuca (JUAN). Data summarized from the Regional Mark Information System (RMIS).

Species	Release Year	Release Month	CWT only	CWT + Ad Clip	Unmarked	Ad Clip only	Mean Length (mm)
Chinook	2016	January	204,701	307,557	206,834	2,121,448	75
Chinook	2016	February				1,300	78
Chinook	2016	March	157,985		2,214		161
Chinook	2016	April	171,063	260,892	24,498	1,140,918	143
Chinook	2016	May	1,649,912	1,339,391	951,300	13,773,264	81
Chinook	2016	June	609,066	1,162,526	3,628,657	3,067,264	88
Chinook	2016	July				485,000	74
Chinook	2016	August	277,780		2,236		
Chinook	2016	October				294,318	74
Chinook	2016	November				213,000	78
Chinook	2016	December		208,863		1,261	81
TOTAL			**3,070,507**	**3,279,229**	**4,815,739**	**21,097,773**	
Chum	2016	January			80,000		
Chum	2016	February			245,024		
Chum	2016	March			4,314,344		49
Chum	2016	April			32,645,171		52
Chum	2016	May			571,908		55
Chum	2016	June			200		
TOTAL					**37,856,647**		
Coho	2016	February			123,579		
Coho	2016	March	1,092	50,318	139,437	71,641	
Coho	2016	April	220,109	561,452	189,202	3,290,731	122
Coho	2016	May	93,134	436,857	123,317	2,953,699	136
Coho	2016	June			38,415		
TOTAL			**314,335**	**1,048,627**	**613,950**	**6,316,071**	
Cutthroat	2016	January			750		
Cutthroat	2016	February			18,900		
Cutthroat	2016	April			26,400		
Cutthroat	2016	May			52,689		
Cutthroat	2016	June			74,510		
Cutthroat	2016	July			585		
Cutthroat	2016	August			1,140		
Cutthroat	2016	September			335		
Cutthroat	2016	October			37,609		
Cutthroat	2016	November			19,891		

Cutthroat	2016	December	10,000		
TOTAL			**242,809**		
Pink	2016	March	491,572		51
Pink	2016	May	67,087		
TOTAL			**558,659**		
Sockeye	2016	February	839,153		34
Sockeye	2016	March	4,429,846	3,035	85
Sockeye	2016	April	4,963,025		
Sockeye	2016	May	150,590		
Sockeye	2016	November	2,868	283,938	93
Sockeye	2016	December	18	1,782	101
TOTAL			**10,385,500**	**288,755**	
Steelhead	2016	January	40,000		
Steelhead	2016	March	11,610	92,723	148
Steelhead	2016	April	110,138	682,951	187
Steelhead	2016	May	48,166	51,465	181
Steelhead	2016	June	9	3,088	184
Steelhead	2016	November	82,000		
TOTAL			**291,923**	**830,227**	