Final Assessment of Threatened and Endangered Marine and Anadromous Fish Presence Adjacent to the NAS Whidbey Island Crescent Harbor: 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 Crescent Harbor, 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 Crescent Harbor was surveyed by the WDFW in 2014, 2015, and 2016 using various techniques and technologies. After reviewing the geographic scope, depth profile, water quality, and security restrictions associated with the survey area, it was determined that a combination of sampling methods including a remotely operated vehicle (ROV), split-beam echosounder (hydroacoustics), scuba diving, lighted fish traps, and beach seining would be used to survey the entire Crescent Harbor area. Beach seine surveys targeted forage fish and juvenile salmonids in the nearshore, while all other sampling techniques were appropriate to surveying rockfish and critical habitat for all species. Surveys for rockfish were conducted at six month intervals in 2014 and 2015, while surveys for forage fish and juvenile salmonids occurred monthly 2015 and 2016 in order to detect temporal changes in fish abundance or distribution. See Appendix A for a comprehensive list of fish species recorded for beach seining in 2015-16. For results on rockfish, their critical habitat, and a description of sampling methods other than beach seine see the 2014-15 final report.

There were three ESA-listed species captured with the beach seine at the NAS Whidbey Island Crescent Harbor; these included Chinook Salmon, Bull Trout, and steelhead. Based on results from the 2015-16 surveys, we preliminarily conclude that the work window (July 15 to February 15) for any of the NAS Whidbey Island Crescent Harbor facilities' in-water maintenance, military construction (MILCON), mitigation projects, and future Fleet training and testing should not include March through July, as is consistent with the measures outlined in WAC 220-660-330. We recommend that the aforementioned activities should also be avoided during the month of August and September due to potential late occurrence of Chinook Salmon in the nearshore, which is not 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 Crescent Harbor installation.

Methods

Study Area

The NAS Whidbey Island is located in the northern region of Whidbey Island (Figure 1a), which includes a marine facility at Crescent Harbor and property adjacent to Oak Harbor, and encompasses a marine area of approximately 17.5km^2. The study area was not restricted by security measures and included all of the Crescent Harbor area and adjacent properties (Figure 1b). The majority of bottom habitat is considered featureless mud and sand (NOAA nautical chart 18428), 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).

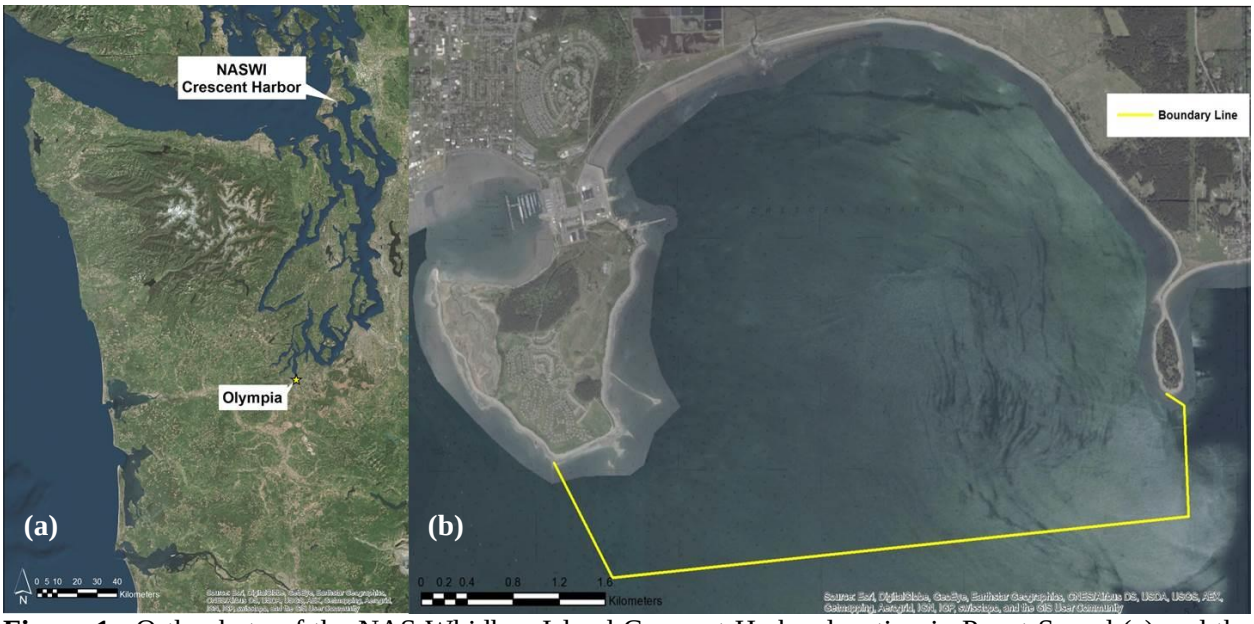

Figure 1. Orthophoto of the NAS Whidbey Island Crescent Harbor location in Puget Sound (a) and the Crescent Harbor Naval operating area boundary line in yellow (b). Image from Esri DigitalGlobe.

Within the study area, survey sites were sampled with a beach seine along beach areas adjacent to Oak Harbor Marina (Maylor Point trail), Forbes Point, west/east shorelines adjacent to a pocket estuary bridge, and west/east sides of the tombolo near Polnell Point (Figure 2). The two sites within Oak Harbor lie along the southern edge of the marina basin, east of the entrance to a slough; both are classified as no appreciable drift-artificial shoreforms. This area was supplemented with over 12,000m^3 of a gravel mix designed to match forage fish spawning substrate for beach nourishment as part of a 2012 restoration effort. The site at Forbes Point occurs along a feeder bluff with cobble and pebble substrates. The shorelines west and east of the pocket estuary bridge are classified as accretion shoreforms that border a pocket estuary entrance to Crescent Harbor Salt Marsh, substrates included gravel and sand. The tombolo sampling sites west and east of Polnell Point occurred at the base of a feeder bluff with substrates comprised of gravel, pebble, and cobble on a sandy base. The tombolo and pocket estuary bridge sites are historically documented as spawning locations for Surf Smelt (*Hypomesus pretiosus*) and Pacific Sand Lance (*Ammodytes personatus*) (WDFW online).

Figure 2. Orthophoto of the NAS Whidbey Island Crescent Harbor identifying the beach seining survey sites: Maylor Point trail, Forbes Point, west/east pocket estuary, west/east tombolo. 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, sampling sites were selected based on the priorities of Navy personnel to determine fish presence and occupancy timing adjacent to the NAS Whidbey Island Crescent Harbor facilities. Large boulders observed along most of the shoreline during low tide restricted many sites from beach seining methods due to the potential of snagging the net. These selected sites were sampled monthly from May 2015 to September 2016 at high-slack tides, which are known to be preferred by beach-spawning forage fish and migrating juvenile salmonids. A minimum of one or two beach seine "sets" were performed at each of the sites on a single date each month. Sampling typically began east of Polnell Point, and subsequent sets were deployed towards the west and ended at the Oak Harbor marina. 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.

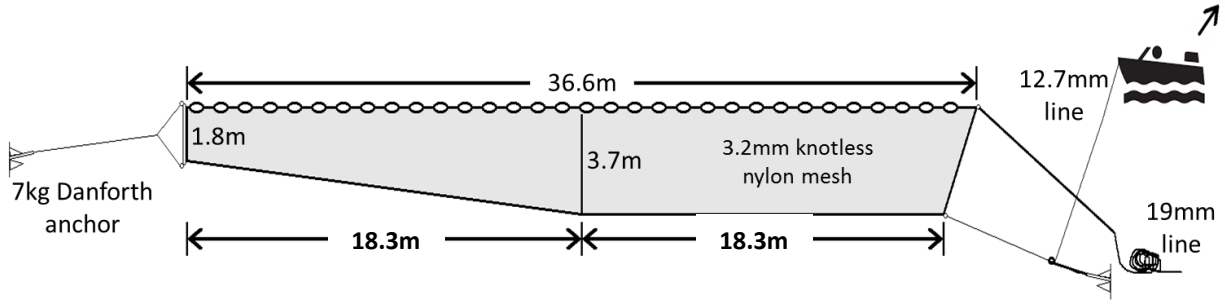

Figure 3. Diagram of the beach seine and dimensions used for sampling.

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 the net was secured to the bow with approximately 10m of line between the boat and end of the net. The net was towed in reverse by the boat 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.

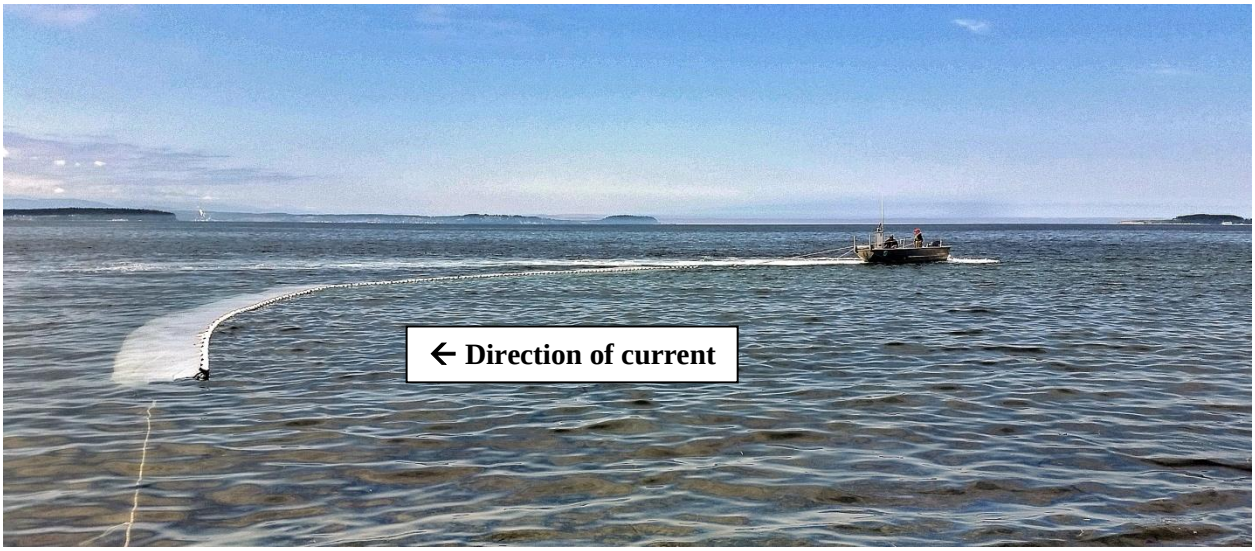

Figure 4. Photo taken while beach seining showing the "round haul" net deployment method into the current.

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 Oak and Crescent Harbors adjacent to the NAS Whidbey Island Crescent Harbor properties once a month from May to December 2015 (see Figure 2). A total of 54 sets were completed in 2015, with one or two sets occurring at each site on each day. Maximum nearshore water depth averaged 3.0m at Oak Harbor marina, 2.8m at Forbes Point, and 2.8m at the tombolo sites. The pocket estuary bridge sites were not sampled in 2015.

A total of 32 fish species (including unidentified taxa) were captured over the eight months of sampling at all six sites. Overall catch composition consisted primarily of Shiner Perch, Surf Smelt, Chum Salmon, Threespine Stickleback (*Gasterosteus aculeatus*), and Pacific Staghorn Sculpin (*Leptocottus armatus*) (Table 1). Species richness varied monthly from 6 to 21 species captured during each sampling event, with peak species richness observed in August (Figure 6). Fork lengths were recorded for a total of 211 forage fish and 178 salmonids during the eight 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	14-May	11-Jun	9-Jul	25-Aug	23-Sep	21-Oct	19-Nov	16-Dec	Total	% of Total
# of Sets Completed	7	6	7	7	7	7	7	6	54	-
American Shad				2					2	0.01%
Bay Goby			13						13	0.08%
Bay Pipefish	13	7	1	2					23	0.15%
Bluegill							1		1	0.01%
Buffalo Sculpin		1							1	0.01%
Bull Trout		1					1		2	0.01%
Chinook Salmon		1	23	39					63	0.40%
Chum Salmon	287	4	2					2	295	1.89%
Coho Salmon	27	2	8						37	0.24%
Crescent Gunnel		3		1					4	0.03%
Cutthroat Trout	1		3						4	0.03%
English Sole		2	1	2					5	0.03%
Flatfish (unidentified)		14		1					15	0.10%
Fluffy Sculpin			1	1					2	0.01%
Northern Anchovy				*200000					*	*
Pacific Herring		1		2	3	1	6		13	0.08%
Pacific Sand Lance				129	7			3	139	0.89%
Pacific Sanddab	4	1	1	9					15	0.10%
Pacific Staghorn Sculpin	8	89	79	23	1	1		2	203	1.30%
Padded Sculpin			6	5			2		13	0.08%
Pile Perch		47	26	43	10				126	0.81%
Pink Salmon	1								1	0.01%
Plainfin Midshipman			1	3					4	0.03%
Saddleback Gunnel		7	3						10	0.06%
Sculpin (unidentified)	1			2					3	0.02%
Sharpnose Sculpin					1			2	3	0.02%
Shiner Perch	515	3172	6373	1156	474	67	15		11772	75.45%
Snake Prickleback		8	22	48				2	80	0.51%
Starry Flounder	9	17	15	20	3	6	5	6	81	0.52%
Surf Smelt	9	3		702	1497	6	59	108	2384	15.28%
Threespine Stickleback	96	35	71	24	6	7	46	4	289	1.85%
Tubesnout					1		1		2	0.01%

*Total excludes an estimated 200,000 Northern Anchovy captured in two sets.

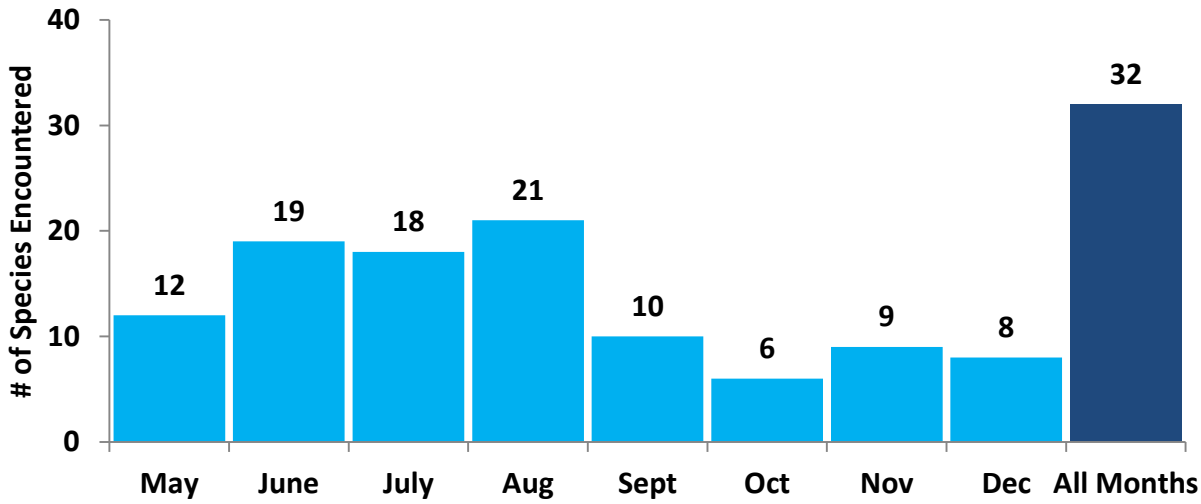

Figure 6. Species richness (including unidentified taxa) of all captured fish during beach seining, by month and all months combined in 2015.

Table 2. Fork length (mm) data summaries for salmonid (left) and forage fish (right) species sampled in 2015. *Chum and Pink Salmon fry captured only in December.

Species	Mean ±SD	CV	n
Chinook natural	127.59 ±19.32	0.15	27
Chinook hatchery	124.6 ±18.94	0.15	35
Coho natural	93.87 ±19.69	0.21	23
Coho hatchery	85.64 ±9.90	0.12	14
Chum Salmon	65.75 ±12.56	0.2	68
Chum Salmon fry*	36.5 ±3.54	0.1	2
Pink Salmon	49.00	-	1
Pink Salmon fry*	29.5 ±3.54	0.1	2
Cutthroat Trout	316.75 ±12.55	0.04	4
Bull Trout	421.50 ±34.65	0.08	2

Species	Mean ±SD	CV	n
Surf Smelt	94.08 ±53.05	0.56	151
Pacific Sand Lance	131.86 ±16.90	0.13	28
Pacific Herring	103.33 ±19.27	0.19	12
Northern Anchovy	41.20 ±4.24	0.10	20

Forage fish species captured in 2015 included Surf Smelt, Pacific Sand Lance, Pacific Herring (*Clupea pallasii*), and Northern Anchovy (*Engraulis mordax*), with peak catch rates occurring in August and September (Figure 7). The most commonly captured forage fish species over all eight months was Surf Smelt, with the highest catch rates encountered at the eastern most tombolo site. Surf Smelt catch rates were high in August (100.3 fish/set), with a peak rate in September (213.9 fish/set), and primarily consisted of adult fish. Surf Smelt fork length data for all months combined showed high variation (CV=0.56), and a multimodal distribution of age-0, age-1, and age-2+ fish (Figure 8) with variation in length between sexes (Penttila 1978). Pacific Sand Lance were primarily captured at the Forbes Point site with a peak catch rate in August (18.4 fish/set). Pacific Sand Lance fork length data for all months combined indicated adult fish age-3+ (Emmett et al. 1991, Greene at al. 2011) (Figure 9). Pacific Herring were only encountered at the tombolo and Oak Harbor sites at very low catch rates (<1 fish/set). Pacific Herring fork length data for all months combined resulted in high variation (CV=0.19), and a bimodal distribution of age-0 and age-1 fish (Buchanan 1985) (Figure 10). Northern Anchovy larvae were only captured at the Oak Harbor sites in August at very high densities (estimated 100,000 fish/set). Northern Anchovy mean fork length data indicated a single class of age-0 fish (Emmett et al. 1991). No ESA-listed Eulachon were captured during any beach seine sampling.

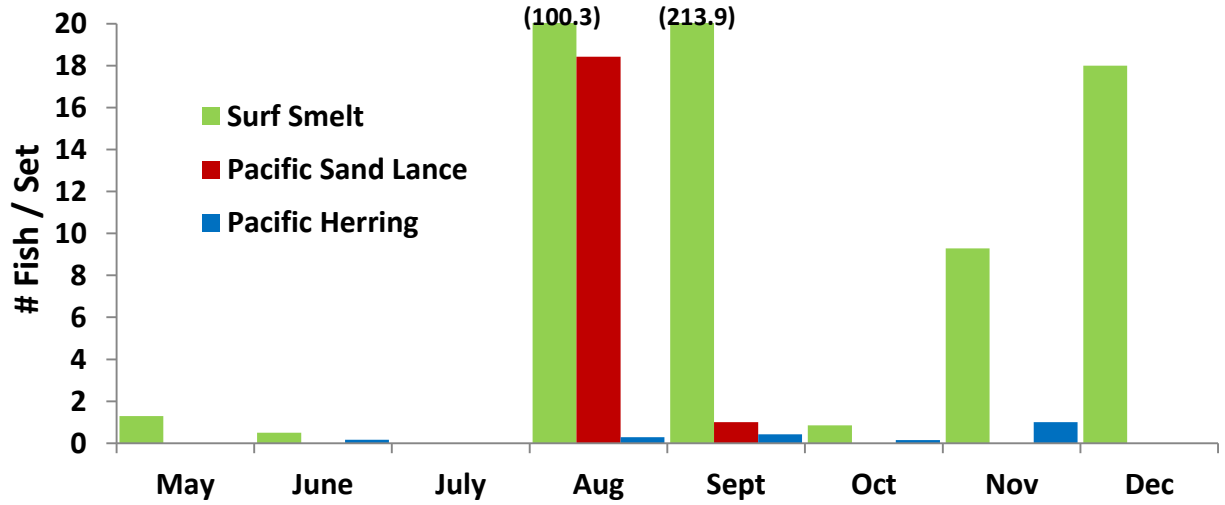

Figure 7. Catch rates for forage fish species captured during beach seining, by month for all sites combined in 2015. Northern Anchovy catch rate in August has been omitted from this figure.

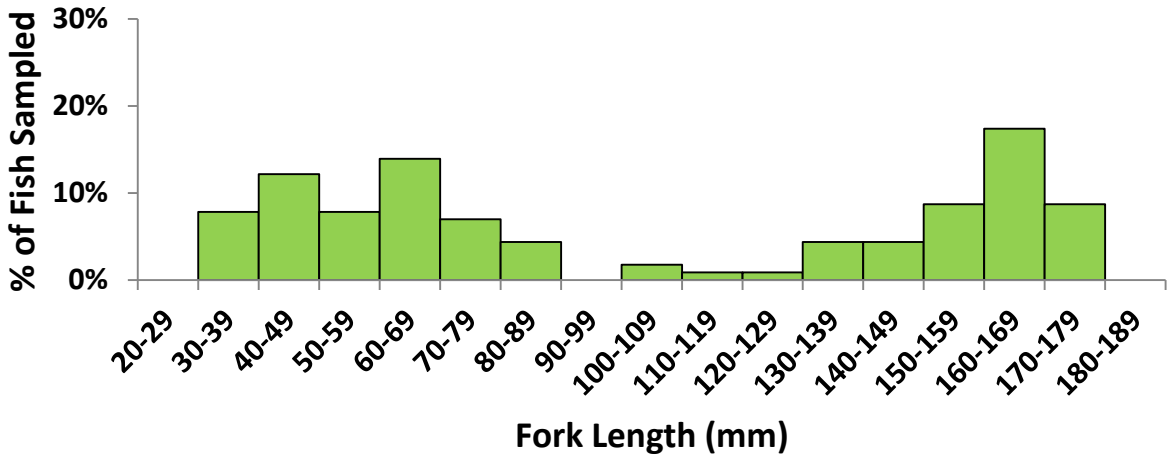

Figure 8. Surf Smelt fork length histogram for all months and sites combined in 2015.

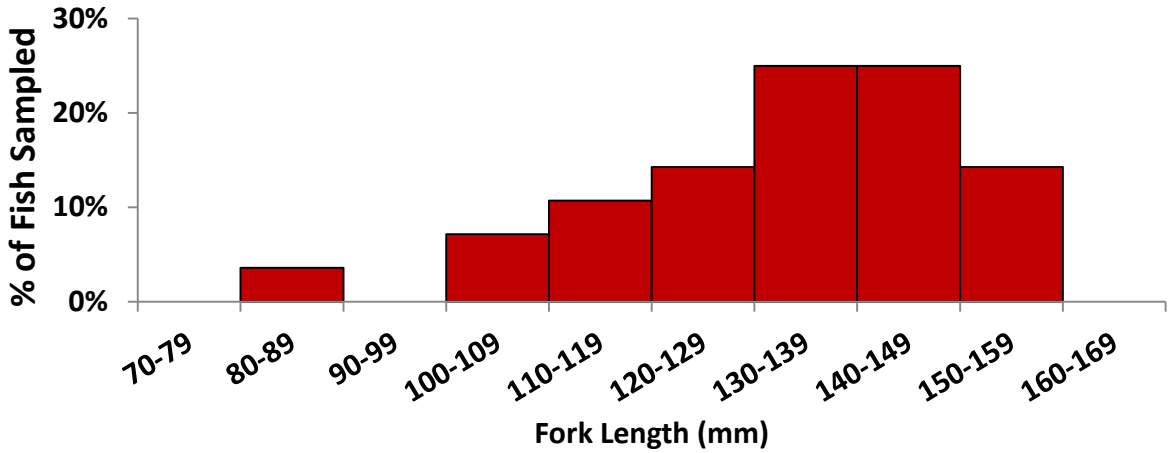

Figure 9. Pacific Sand Lance fork length histogram for all months and sites combined in 2015.

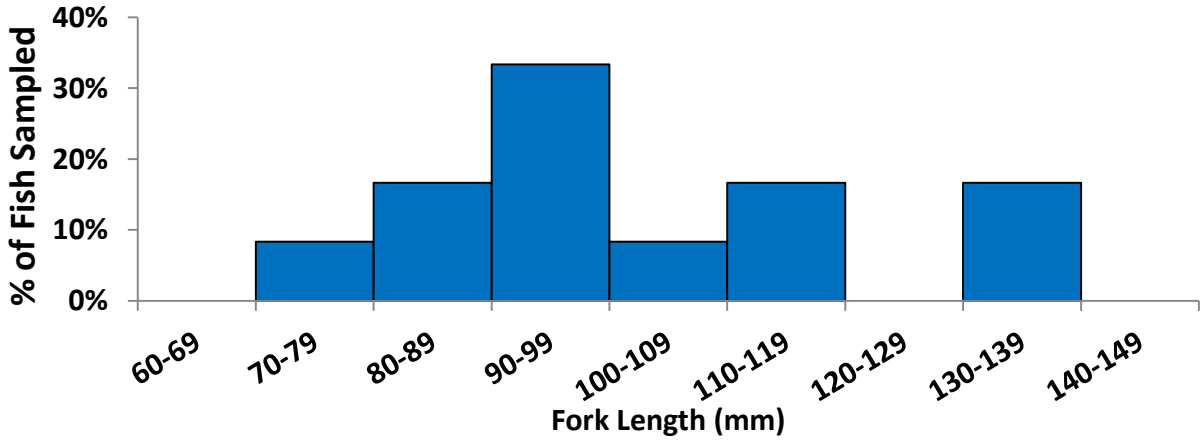

Figure 10. Pacific Herring fork length histogram for all months and sites combined in 2015.

Salmonid species captured in 2015 included Chinook Salmon, Coho Salmon (*O. kisutch*), Chum Salmon, Pink Salmon (*O. gorbuscha*), Cutthroat Trout (*O. clarkii*), and Bull Trout with variable peak catch rates occurring from May through August (Figure 11). Salmonid catch rates were generally higher at the Forbes Point and Oak Harbor sampling sites. Salmonid fork lengths generally increased for each species' cohort, as a consequence of seasonal growth after outmigration from local watersheds, from May through August (Figure 12). Chinook Salmon and Bull Trout were the only confirmed ESA-listed species captured at the NAS Whidbey Island Crescent Harbor. Chinook Salmon catch rates were low in June (n=1), increased in July (3.3 fish/set), and the peak catch rate occurred in August (5.6 fish/set); overall they consisted of 35 hatchery and 28 natural-origin fish. A single adult Bull Trout was captured at the east tombolo site in both June and November. Chum Salmon were captured primarily at the Oak Harbor and Forbes Point sites with a peak catch rate in May (41 fish/set), then greatly declining during June and July sampling (<1 fish/set). Few Chum (n=2) and Pink Salmon (n=2) fry were captured during December sampling, primarily at the Oak Harbor sites. Coho Salmon were captured at every site, with a peak catch rate in May (3.9 fish/set), and declining in June and July (≤1 fish/set). Of the Coho Salmon captured, 14 were hatchery and 23 were natural-origin fish. Cutthroat Trout were only encountered at the tombolo sites in May (n=1) and July (n=3).

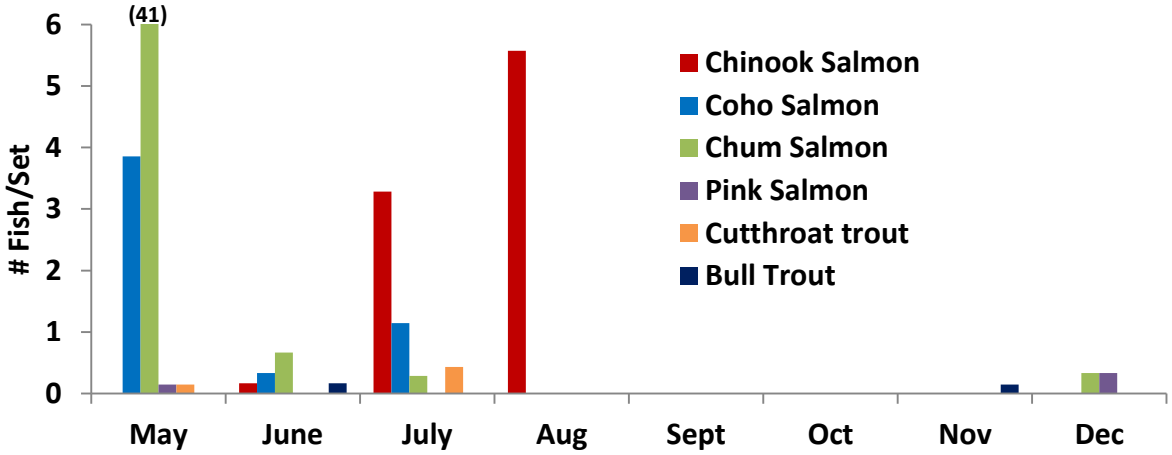

Figure 11. Catch rates for salmonid species captured during beach seining, by month for all sites combined in 2015. Values are labeled for catch rates exceeding the vertical axis.

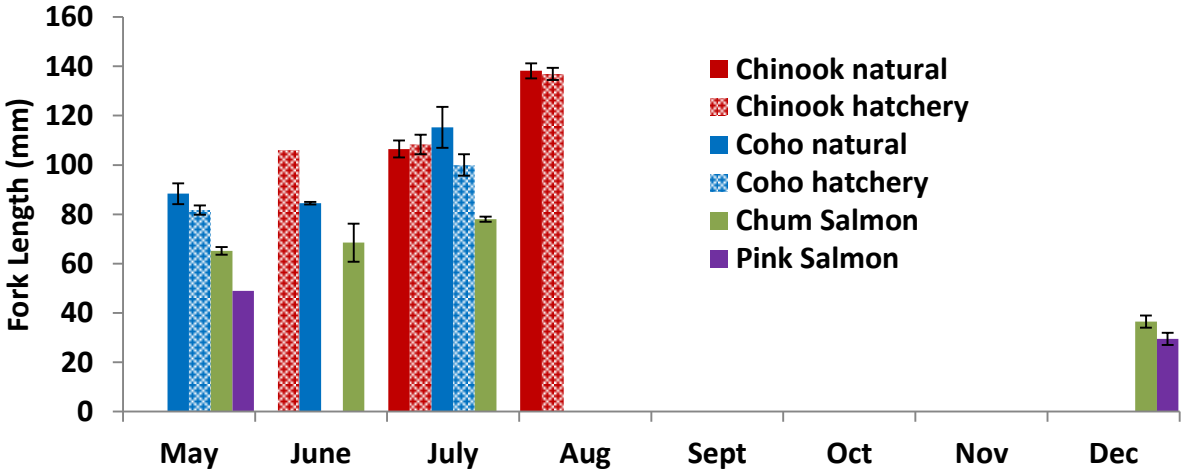

Figure 12. Mean fork length (± 1SE) for juvenile salmonid species by month for all sites in 2015.

Beach Seine Surveys in 2016

Beach seine sampling occurred at Oak and Crescent Harbors adjacent to the NAS Whidbey Island Crescent Harbor properties once a month from January to September 2016 (see Figure 2). A total of 69 sets were completed in 2016, with one set occurring at each site on each day. The pocket estuary bridge and Forbes Point sites were not sampled in January due to inclement weather. Maximum nearshore water depth averaged 2.7m at Oak Harbor marina; 2.8m at Forbes Point; 2.2m at the pocket estuary bridge sites; 2.5m at the tombolo sites.

A total of 24 fish species (including unidentified taxa) were captured over the nine months of sampling at all eight sites. Overall catch composition consisted primarily of Shiner Perch, Surf Smelt, Pacific Sand Lance, and Pink Salmon (Table 3). Species richness varied monthly from 7 to 17 species captured during each sampling event, with peak species richness observed in May (Figure 13). Fork lengths were recorded for a total of 526 forage fish and 339 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	20-Jan	4-Feb	16-Mar	15-Apr	17-May	15-Jun	14-Jul	10-Aug	9-Sep	Total	% of Total
# of Sets Completed	**5**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**69**	**-**
American Shad						1	1	4		6	0.03%
Bay Pipefish		1	2		2	1	2	1		9	0.04%
Bull Trout	1			3		2				6	0.03%
Chinook Salmon			29	6	48	19	26	17	10	155	0.75%
Chum Salmon		10	23	95	67	6				201	0.98%
Coho Salmon					26		1	1		28	0.14%
Cutthroat Trout				3	3	2		1		9	0.04%
English Sole					1					1	<0.01%
Northern Anchovy								3	3	6	0.03%
Pacific Herring				1	1		283			285	1.38%
Pacific Sand Lance	19			1037	1			1		1058	5.14%
Pacific Sanddab							1			1	<0.01%
Pacific Staghorn Sculpin		5	8	29	14	55	131	32	11	285	1.38%
Pile Perch					82	57	11	15	2	167	0.81%
Pink Salmon	12	59	177	268	4					520	2.53%
Sculpin (unidentified)			6	1						7	0.03%
Sharpnose Sculpin	5	1	1	1						8	0.04%
Shiner Perch					2397	3343	4254	931	1071	11996	58.28%
Snake Prickleback							26	4		30	0.15%
Speckled Sanddab					1	1				2	0.01%
Starry Flounder	3	10	20	25	15	9	31	21	24	158	0.77%
Steelhead					1					1	<0.01%
Surf Smelt	786	3268	556	39	307	127	38	78	128	5327	25.88%
Threespine Stickleback	5	3	4	2	30	94	114	45	20	317	1.54%

Table 4. Fork length (mm) data summaries for juvenile salmonids (left) and forage fish (right) species sampled in 2016. *Indicates adult salmonids (>300mm). Cutthroat Trout includes juvenile and adult fish.

Species	Mean ±SD	CV	n
Chinook natural	78.55 ±32.68	0.42	73
Chinook hatchery	117.06 ±30.58	0.26	49
Coho natural	102.79 ±18.53	0.18	19
Coho hatchery	123.75 ±12.58	0.10	4
Coho hatchery*	379.00	-	1
Chum Salmon	50.31 ±24.31	0.48	93
Pink Salmon	39.05 ±20.70	0.53	84
Steelhead	242	-	1
Cutthroat Trout	294.56 ±76.62	0.26	9
Bull Trout*	467.67 ±52.29	0.11	6

Species	Mean ± SD	CV	n
Surf Smelt	98.32 ±50.32	0.51	417
Pacific Sand Lance	134.54 ±12.30	0.09	61
Pacific Herring	71.19 ±13.68	0.19	43
Northern Anchovy	37.80 ±5.10	0.13	5

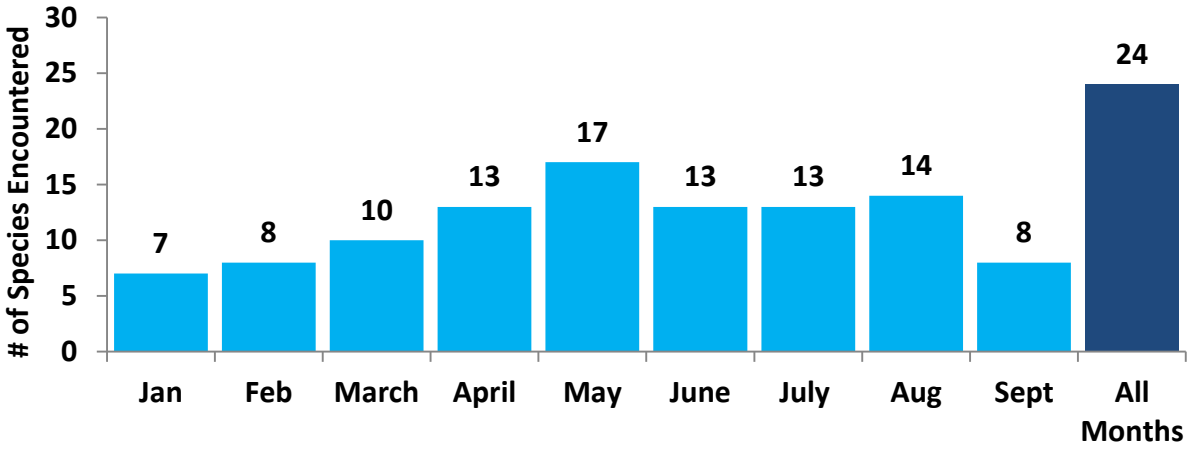

Figure 13. Species richness (including unidentified taxa) of all fish captured during beach seining, by month and all months combined in 2016.

Forage fish species captured in 2016 included Surf Smelt, Pacific Sand Lance, Pacific Herring, and Northern Anchovy, with variable catch rates occurring throughout the sampling period (Figure 14). Surf Smelt were the most commonly captured forage fish with the highest densities encountered at the Oak Harbor marina sites in January (157.2 fish/set), February (408.5 fish/set), and March (69.5 fish/set); which consisted primarily of post-larval fish. Surf Smelt fork length data for all months combined showed high variation (CV=0.51), and a multimodal distribution of age-0, age-1, and age-2+ fish (Figure 15) with variation in length between sexes (Penttila 1978). Pacific Sand Lance were primarily captured at the tombolo sites with a peak catch rate in April (129.6 fish/set). Pacific Sand Lance fork length data for all months combined indicated adult fish of age-3+ (Emmett et al. 1991, Greene at al. 2011) (Figure 16). Pacific Herring were encountered almost exclusively at the eastern tombolo site in July (35.4 fish/set), which consisted of all juvenile fish. Pacific Herring fork length data for all months combined indicated primarily age-0 fish and several age-1 fish. (Buchanan 1985) (Figure 17). Very few post-larval Northern Anchovy (n=6) were captured in August and September, primarily at the Oak Harbor sites. Northern Anchovy mean fork length data indicated a single class of age-0 fish (Emmett et al. 1991). No ESA-listed Eulachon were captured during any beach seine sampling.

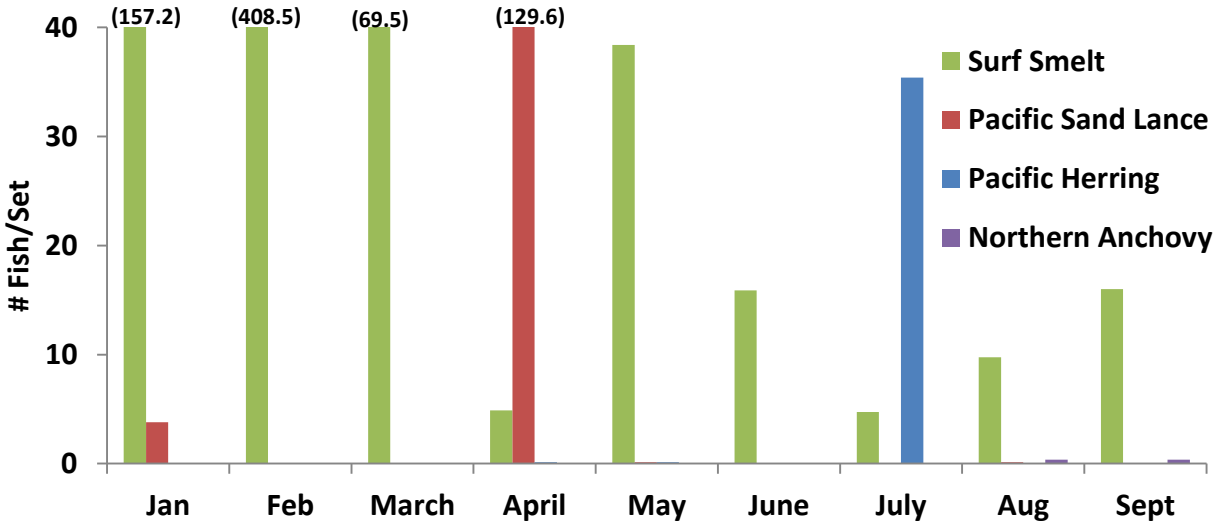

Figure 14. Catch rates for forage fish species captured during beach seining for all sites combined in 2016. Values are labeled for catch rates exceeding the vertical axis.

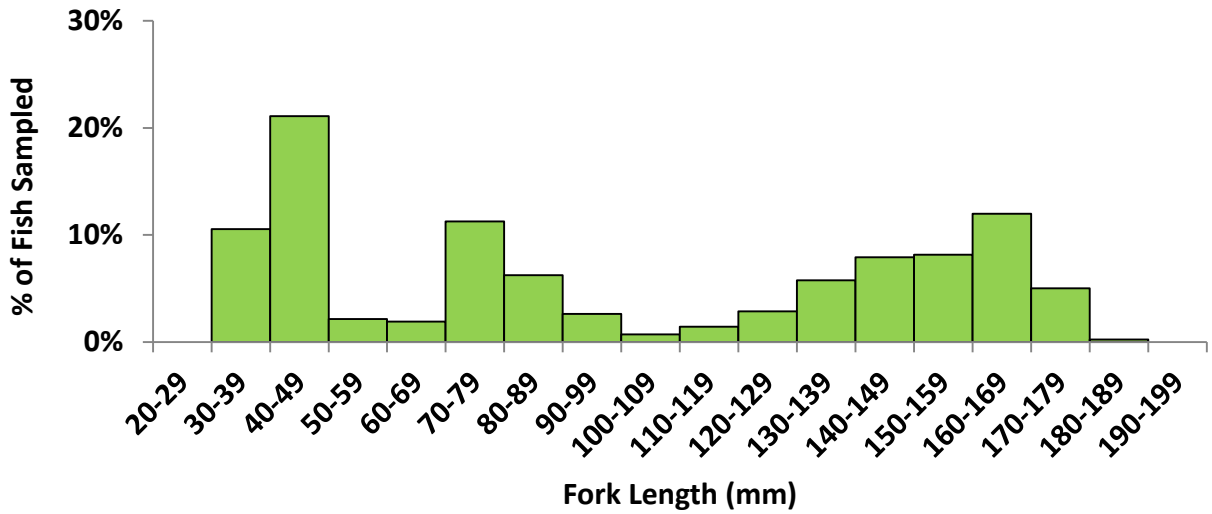

Figure 15. Surf Smelt fork length histogram for all months and sites combined in 2016.

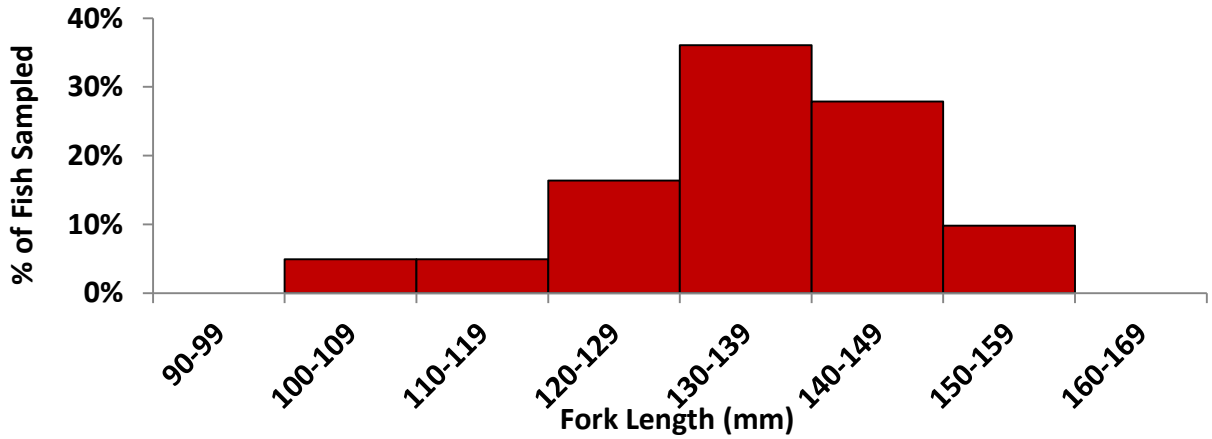

Figure 16. Pacific Sand Lance fork length histogram for all months and sites combined in 2016.

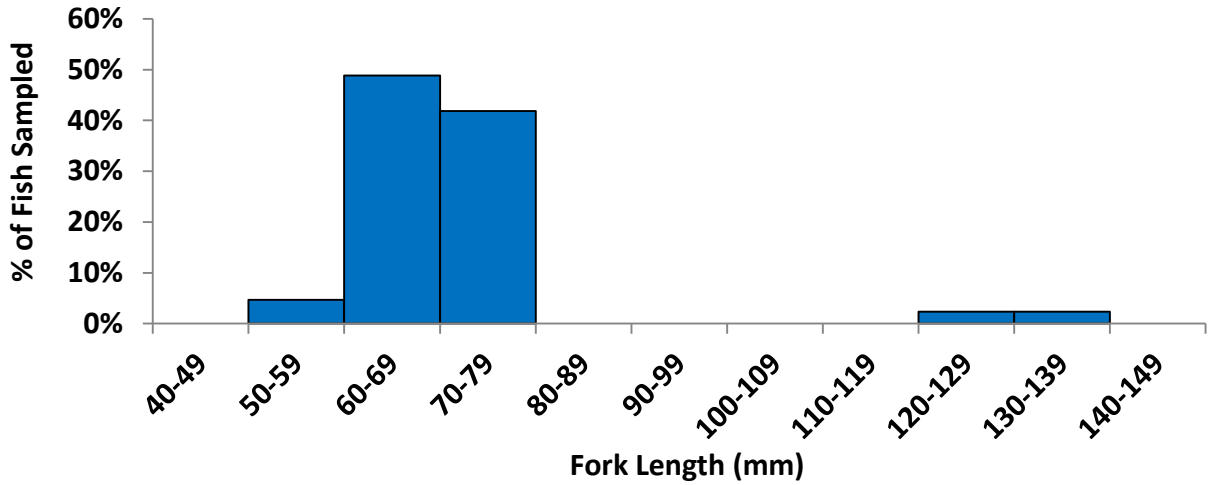

Figure 17. Pacific Herring fork length histogram for all months and sites combined in 2016.

Salmonid species captured in 2016 included Chinook Salmon, Coho Salmon, Chum Salmon, Pink Salmon, Cutthroat Trout, and Bull Trout with variable catch rates occurring throughout the entire sampling period (Figure 18). Salmonid fork lengths generally increased for each species' cohort, as a consequence of seasonal growth after outmigration from local watersheds, from December 2015 through September 2016 (Figure 19). Chinook Salmon, Bull Trout, and steelhead were the only confirmed ESA-listed species captured at the NAS Whidbey Island Crescent Harbor. Chinook Salmon were primarily captured at the Oak Harbor sites as early as March, with the peak catch rate occurring in May (6 fish/set) and steadily declining through September (1.2 fish/set); overall they consisted of 65 hatchery and 90 natural-origin fish. Adult Bull Trout were captured in January at the Oak Harbor site (n=1); April at the pocket estuary bridge (n=1) and east tombolo site (n=2); June at the pocket estuary bridge (n=1) and Oak Harbor site (n=1). A single juvenile steelhead was captured at the Oak Harbor site in May. Coho Salmon were captured at every site, with a peak catch rate in May (3.9 fish/set), and declined in June and July (≤1 fish/set). Of the Coho Salmon captured, 7 were hatchery and 21 were natural-origin fish. Chum Salmon were captured primarily at the tombolo sites with a peak catch rate in April (11.9 fish/set), then greatly declining during June sampling (<1 fish/set). Cutthroat Trout catch rates were highest during May through June sampling, and primarily encountered at the tombolo sites.

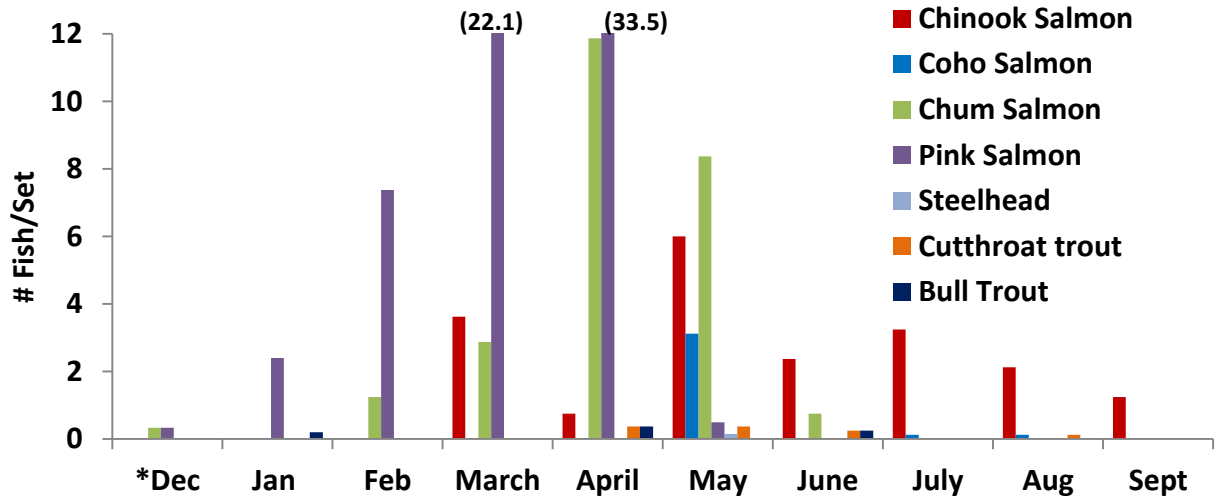

Figure 18. Catch rates for salmonid species from all sites combined in 2016. Values are labeled for catch rates exceeding the vertical axis. *December 2015.

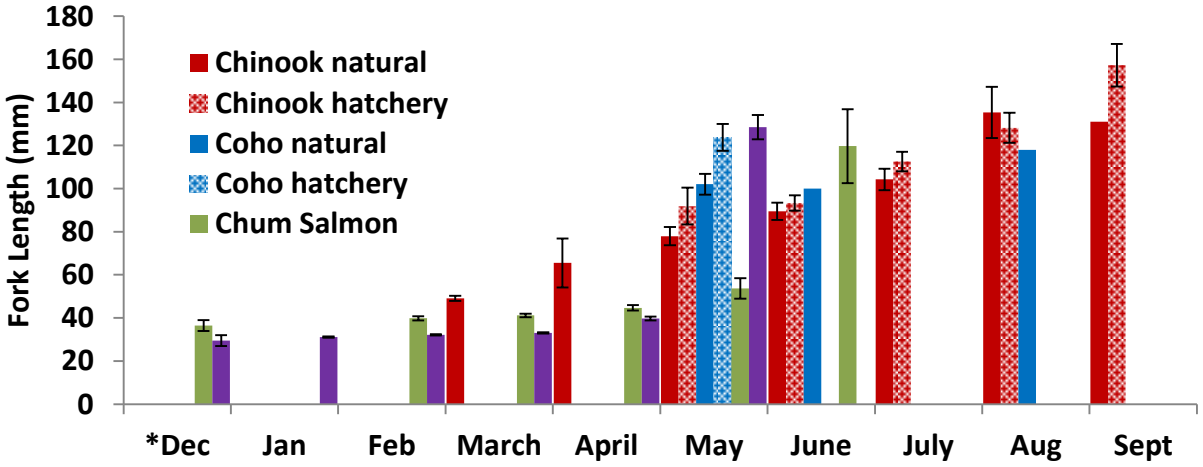

Figure 19. Mean fork length (± 1SE) for juvenile salmonid species by month for all sites in 2016. *December 2015.

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 Crescent Harbor properties. 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 the Crescent Harbor shoreline and other areas of Saratoga Passage. 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 (see Beamer et al. 2005, 2016).

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. Overwater structures (e.g., docks, piers, floats, breakwaters) have potential negative impacts on these spawning habitats, but they vary depending on the species and the size and configuration of the structure (Nightingale and Simenstad 2001, Penttila 2007). The extent of which the many overwater structures at the NAS Whidbey Island Crescent Harbor that may impact forage fish spawning grounds remains uncertain. The Crescent Harbor shoreline consists of several areas historically documented as Pacific Sand Lance spawning beaches in late fall and winter, as well as Surf Smelt spawning beaches in the summer and fall (WDFW online). Some of these spawning beaches are located in proximity to the breakwater and fuel pier structures. Some of the most prolific Surf Smelt spawning beaches in Puget Sound are well documented along the northern shoreline of Camano Island (Quinn at al. 2012), immediately across from Crescent Harbor.

Forage fish were captured with the beach seine in almost every month of sampling (except July 2015), with variable catch rates among corresponding months of both survey years. The disparities between both survey years 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. The high catch rates of adult Surf Smelt in August and September 2015 coincided with the summer spawning events observed annually at Camano Island (Penttila 1978; Quinn at al. 2012). The extremely high densities of post-larval Surf Smelt captured from January through March 2016 may represent the brood from these summer spawning adults detected in 2015. Pacific Sand Lance adults were only encountered in high densities during August 2015 and April 2016, but relatively absent for other months. The spawn timing for Pacific Sand Lance has been documented to occur during winter months on Camano Island (Quinn et al. 2009), and did not coincide with the timing of peak catch rates observed during this study. Pacific Herring were captured at low rates during both survey years, except for a single set in July 2016 that netted many juvenile fish. Post-larval Northern Anchovy were only encountered in high densities during August 2015 at the Oak Harbor sites, otherwise relatively absent during both survey years. Oak Harbor may serve as a suitable nursery habitat for post-larval Northern Anchovy in August. Northern Anchovy are pelagic broadcast spawners (Emmett et al. 1991) and do not rely on intertidal substrates during their early life history. Fork length data recorded for all species of forage fish indicate presence of primarily age-0 to age-3 classes utilizing nearshore habitat within the survey areas throughout the duration of 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 Saratoga Passage, including the Crescent Harbor shoreline, serves as an essential migration route for many of the juvenile salmonids (natural and hatchery) produced in the northern Puget Sound and Skagit regions. 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). Overwater structures have been well documented to impact fish migration behavior and increase mortality by creating sharp underwater light contrasts in ambient daylight conditions as well as artificial lights cast during nighttime conditions (Nightingale and Simenstad 2001). Salo et al. (1980) studied the effects of construction of Naval facilities on the outmigration of juvenile salmonids from Hood Canal; they concluded that the long-term effects of construction and operation upon the prey communities of outmigrating Chum and Pink Salmon fry were expected to be minimal as long as extensive areas of shallow eelgrass habitat were not destroyed. They also speculated that the illumination of the nearshore environment during nighttime was likely to alter the composition and standing stock of prey communities available to the salmon fry during their normal crepuscular feeding periods.

Past studies have documented the presence and timing of outmigrating juvenile salmonids along the Crescent Harbor shoreline to begin in January and continue through the summer (Beamer et al. 2005, 2016). Each of these studies reported primarily on Chinook sampling. However, they indicated that juvenile Chum and Pink Salmon were the predominant salmonid species captured with a beach seine, followed by Chinook and Coho, while relatively few Bull Trout and Cutthroat Trout were encountered. They also reported that juvenile steelhead were never captured. 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 the northern Puget Sound and Skagit regions 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 all the northern Puget Sound and Skagit hatchery releases were composed of unmarked fish, meaning they could not be visually distinguished from naturally produced fish (see Appendix B and C).

Chinook Salmon, Bull Trout, and steelhead were the only ESA-listed species captured at NAS Whidbey Island Crescent Harbor. Timing for outmigrating juvenile salmonids among the same sampling months in 2015 and 2016 showed little interannual variation, with the exception of Chinook Salmon. Chinook juveniles from the Skagit River are known to exhibit a variety of life histories and migration timings (Beamer et al. 2005). Catch rates for Chinook Salmon were low in June 2015, and quickly increased to their peak rate in August before disappearing for the remainder of the year. In 2016, Chinook Salmon were captured as early as March with the peak rate observed in May, and steadily declined through September. Timing of Chinook catches closely corresponded to the hatchery release of over 5 million fish in the northern Puget Sound and Skagit regions from April through June of both survey years, consisting of 89% adipose clipped fish. During both survey years, only 46% of captured Chinook were hatchery produced (adipose clipped) rather than naturally produced (non-clipped) fish, which is inconsistent with the hatchery release marked fish rate. Hatchery produced Chinook have been reported to show a narrower temporal distribution in Skagit estuaries as compared to naturally produced Chinook (Beamer et al. 2005), which may explain the lower catch rate of marked fish observed in the 2015-16 surveys. This 2015-16 data for Chinook is consistent with the timing and moderate catch rates reported from past studies along the Whidbey shoreline (Beamer et al. 2005, 2016).

A total of eight adult Bull Trout were captured in both survey years, half of which came from the east tombolo sites in April and June. This timing for Bull Trout corresponded to a study reporting peak abundance in Skagit Bay during May and June, but also occurring year round (Beamer and Henderson 2004).

The only juvenile steelhead was captured in May 2016, along with a few Cutthroat Trout. Hybridization between Cutthroat Trout and steelhead has been documented in several streams along the North American west coast, and confirmed specifically from Puget Sound (Campton and Utter 1985, Moore et al. 2010). Tissue samples collected from captured Cutthroat Trout during 2016 sampling detected second generation hybridization with steelhead in one sampled fish at Oak Harbor in May. The genetic analysis results are detailed in a separate report funded by another cooperative agreement (Small et al. 2017). These data can provide some evidence to confirm our visual identification of Cutthroat Trout versus steelhead based on occasionally equivocal phenotypic traits observed in juveniles. Further recommendations for these data may include a contribution to the WDFW fishery managers to better understand their stock status and genetic stock structure.

Coho Salmon showed similar trends for the same sampling months of both survey years, with a peak catch rate in May that quickly declined through July. However, the peak catch rate for Coho in April 2016 was only 29% of the peak rate recorded in May 2016. This timing corresponded with the hatchery releases of over 1.6 million total Coho in May of 2015-16, and consisted of approximately 90% adipose clipped fish. However, only 31% of captured Coho in 2015-16 were hatchery produced (adipose clipped). Surveys at other Navy installations in 2015-16 also observed this disproportionately low catch rate of hatchery produced Coho. This 2015-16 data for Coho is consistent with the low to moderate catch rates reported from past studies along the Crescent Harbor shoreline (Beamer et al. 2016).

Chum and Pink Salmon dominated the catch during March and April in 2016, which was missed in 2015 due to the later sampling start date in May. Chum Salmon were encountered at high densities in May 2015 and April 2016, which corresponded with the hatchery releases in April of both years. The high densities of Pink Salmon juveniles encountered in 2016 sampling corresponded with the species' biennial spawning in Puget Sound rivers, and likely from hatchery releases throughout other Puget Sound regions. Timing of juvenile Chum and Pink Salmon captured during this survey corresponded with results from other beach seining studies conducted along the Crescent Harbor shoreline (Beamer et al. 2016).

Conclusions

Overall, the relative timing and abundance of forage fish and salmonids sampled with a beach seine in 2015 and 2016 were consistent with past surveys conducted along the Crescent Harbor shoreline. Collectively, these studies indicate that whatever impacts to the nearshore habitat, as used by juvenile salmonids and forage fish, due to the NAS Whidbey Island Crescent Harbor facilities have remained consistent over time. Since the several overwater structures along the Crescent Harbor shoreline occur over 'saltwater habitats of special concern' (WAC 220-660-320), mitigation including periodic monitoring of fish and habitat is recommended to ensure optimal health.

Rockfish surveys conducted by the WDFW in 2014 and 2015 found very few rockfish associated with the rocky nearshore areas within the Crescent Harbor area. None of the rockfish species recorded in the 2014-15 surveys were ESA-listed. The rocky nearshore areas found at Polnell Point overlap with essential features for juvenile rockfish. Based on the results from the 2014-15 surveys, we concluded that the NAS Whidbey Island Crescent Harbor has the potential to support juvenile ESA-listed rockfish species and their preferred habitats (see Frierson et al. 2016). Ongoing monitoring of these essential features is recommended to further assess rockfish recovery in Puget Sound.

The three confirmed ESA-listed species captured with the beach seine at the NAS Whidbey Island Crescent Harbor were juvenile Chinook Salmon, adult Bull Trout, and juvenile steelhead. Chinook Salmon peak catch rates occurred in August 2015 and May 2016, while Bull Trout were primarily captured in April 2016 and June 2015-16. The single steelhead was captured in May 2016. Based on these results from the 2015-16 surveys, we preliminarily conclude that in order to reduce impact on juvenile salmon, the work window (July 15 to February 15) for the NAS Whidbey Island Crescent Harbor facilities' in-water maintenance, military construction (MILCON), mitigation projects, future Fleet training and testing should not include March through July, as is consistent with the measures outlined in WAC 220-660-330. We recommend the months of August and September should also be avoided for these aforementioned activities due to potential late occurrence of Chinook Salmon in the nearshore, which is not consistent with measures outlined in WAC 220-660-330.

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Appendix A: Comprehensive list of all fish species recorded at the NAS Whidbey Island Crescent Harbor in 2015 and 2016 with the beach seine. Taxonomic nomenclature and phylogenetic organization follows arrangement from Pietsch and Orr (2015) unless otherwise noted.

TAXON	COMMON NAME
CLUPEIFORMES	**HERRINGS**
Engraulidae	**Anchovies**
Engraulis mordax	Northern Anchovy
Clupeidae	**Herrings and Sardines**
Alosa sapidissima	American Shad
Clupea pallasii	Pacific Herring
OSMERIFORMES	**FRESHWATER SMELTS**
Osmeridae	**Smelts**
Hypomesus pretiosus	Surf Smelt
SALMONIFORMES	**TROUTS**
Salmonidae	**Trouts and Salmon**
Oncorhynchus clarkii	Cutthroat Trout (coastal)
Oncorhynchus gorbuscha	Pink Salmon
Oncorhynchus keta	Chum Salmon
Oncorhynchus kisutch	Coho Salmon
Oncorhynchus tshawytscha	Chinook Salmon
Salvelinus confluentus	Bull Trout
BATRACHOIDIFORMES	**TOADFISHES**
Batrachoididae	**Toadfishes**
Porichthys notatus	Plainfin Midshipman
GASTEROSTEIFORMES	**STICKLEBACKS**
Aulorhynchidae	**Tubesnouts**
Aulorhynchus flavidus	Tubesnout
Gasterosteidae	**Sticklebacks**
Gasterosteus aculeatus	Threespine Stickleback
Syngnathidae	**Pipefishes**
Syngnathus leptorynchus	Bay Pipefish
SCORPAENIFORMES	**MAIL-CHEEKED FISHES**
Cottidae	**Sculpins**
Artedius fenestralis	Padded Sculpin
Clinocottus acuticeps	Sharpnose Sculpin
Enophrys bison	Buffalo Sculpin
Leptocottus armatus	Pacific staghorn Sculpin
Oligocottus snyderi	Fluffy Sculpin
	Sculpin unidentified

PERCIFORMES	**PERCHES**
Centrarchidae	**Sunfishes**
Lepomis macrochirus	Bluegill
Embiotocidae	**Surfperches**
Cymatogaster aggregata	Shiner Perch
Rhacochilus vacca	Pile Perch
Stichaeidae	**Pricklebacks**
Lumpenus sagitta	Snake Prickleback
Pholidae	**Gunnels**
Pholis laeta	Crescent Gunnel
Pholis ornata	Saddleback Gunnel
Ammodytidae	**Sand Lances**
Ammodytes personatus	Pacific Sand Lance
Gobiidae	**Gobies**
Lepidogobius lepidus	Bay Goby
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 the North Puget Sound (NPS) and Skagit (SKAG) regions during 2015. Data summarized from the Regional Mark Information System (RMIS).

Species	Release Region	Release Year	Release Month	CWT only	CWT + Ad Clip	Unmarked	Ad Clip only	Mean Length (mm)
Chinook	NPS	2015	April	932	305,625	5,341	350,567	166
Chinook	NPS	2015	May	109,178	148,083		2,260,993	
Chinook	NPS	2015	June	200,277	198,443	8,832	658,763	90
Chinook	SKAG	2015	June	199,496	495,314	1,412	195,099	86
TOTAL				**509,883**	**1,147,465**	**15,585**	**3,465,422**	
Chum	NPS	2015	April			6,800,000		
Chum	SKAG	2015	March			2,500		
Chum	SKAG	2015	April			323,655		
TOTAL						**7,126,155**		
Coho	NPS	2015	February			300		
Coho	NPS	2015	March				60,000	
Coho	NPS	2015	April			5,106		
Coho	NPS	2015	May	44,835	106,570	17,171	1,453,717	128
Coho	NPS	2015	July				250	
Coho	NPS	2015	September			12	120	
Coho	SKAG	2015	March			371	3,149	114
Coho	SKAG	2015	April	20,792		402	2,098	113
Coho	SKAG	2015	May	47,766	47,575	3,097	214,099	132
Coho	SKAG	2015	June			144,235		
TOTAL				**113,393**	**154,145**	**170,694**	**1,733,433**	
Cutthroat	NPS	2015	June			72,594		
Cutthroat	NPS	2015	July			955		
Cutthroat	NPS	2015	August			85		
Cutthroat	NPS	2015	September			230		
Cutthroat	NPS	2015	October			8,162		
Cutthroat	NPS	2015	November			18,040		
Cutthroat	SKAG	2015	July			500		
Cutthroat	SKAG	2015	August			690		
Cutthroat	SKAG	2015	October			19,562		
TOTAL						**120,818**		
Sockeye	SKAG	2015	January			186	4,456	139
Sockeye	SKAG	2015	February			9,529		
Sockeye	SKAG	2015	March			671,407	5,119	139
Sockeye	SKAG	2015	April			4,398,188		
Sockeye	SKAG	2015	May			470,511		
Sockeye	SKAG	2015	November			6,473	325,243	109
Sockeye	SKAG	2015	December			26	838	109
TOTAL						**5,556,320**	**335,656**	

Steelhead	NPS	2015	February	103	3,986	
Steelhead	NPS	2015	April	7,752	438,080	195
Steelhead	NPS	2015	October	34	3,966	
Steelhead	SKAG	2015	June		5,304	208
TOTAL				**7,889**	**451,336**	

Appendix C: Hatchery releases in the North Puget Sound (NPS) and Skagit (SKAG) regions during 2016. Data summarized from the Regional Mark Information System (RMIS).

Species	Release Region	Release Year	Release Month	CWT only	CWT + Ad Clip	Unmarked	Ad Clip only	Mean Length (mm)
Chinook	NPS	2016	April	3,564	260,892	8,435	379,896	151
Chinook	NPS	2016	May	110,303	137,437	18,628	2,151,327	
Chinook	NPS	2016	June	205,864	203,964	3,422	687,157	84
Chinook	SKAG	2016	June	204,810	508,835	2,045	161,600	81
TOTAL				**524,541**	**1,111,128**	**32,530**	**3,379,980**	
Chum	NPS	2016	March			947,968		
Chum	NPS	2016	April			107,000		
TOTAL						**1,054,968**		
Coho	NPS	2016	February			249		
Coho	NPS	2016	March			327	60,000	
Coho	NPS	2016	April	525	33,715	14,375	2,094	
Coho	NPS	2016	May	45,213	108,988	9,268	1,191,699	132
Coho	NPS	2016	June			250		
Coho	SKAG	2016	March			250		
Coho	SKAG	2016	April			1,145	54,680	120
Coho	SKAG	2016	May	43,868	43,867	335	166,973	135
Coho	SKAG	2016	June			26,023		
TOTAL				**89,606**	**186,570**	**52,222**	**1,475,446**	
Cutthroat	NPS	2016	May			5,000		
Cutthroat	NPS	2016	June			63,708		
Cutthroat	NPS	2016	July			510		
Cutthroat	NPS	2016	August			700		
Cutthroat	NPS	2016	September			260		
Cutthroat	NPS	2016	October			5,672		
Cutthroat	NPS	2016	November			19,241		
Cutthroat	SKAG	2016	April			4,000		
Cutthroat	SKAG	2016	June			600		
TOTAL						**99,691**		
Sockeye	SKAG	2016	February			516,800		
Sockeye	SKAG	2016	March			1,767,976	3,035	138
Sockeye	SKAG	2016	April			4,963,025		
Sockeye	SKAG	2016	May			150,590		
Sockeye	SKAG	2016	November			2,868	283,938	93
Sockeye	SKAG	2016	December			18	1,782	101
TOTAL						**7,401,277**	**288,755**	

Steelhead	NPS	2016	April	2,982	541,706	200
Steelhead	NPS	2016	May	68	37,668	192
Steelhead	SKAG	2016	March	10,375		148
Steelhead	SKAG	2016	June	9	3,088	184
TOTAL				**13,434**	**582,462**	