Taxonomic Composition of Fish Assemblages, and Density and Size of Juvenile Chinook Salmon in the Greater Skagit River Estuary
Field Sampling and Data Summary Report

September 2007

Prepared for

Department of the Army
Seattle District
Corps of Engineers
P.O. Box 3755
Seattle, WA 98124-2255

Prepared by

Eric Beamer[1], Casey Rice[2], Rich Henderson[1],
Kurt Fresh[2], Mindy Rowse[2]

[1]Skagit River System Cooperative; [2]Northwest Fisheries Science Center

Preface

This report summarizes over 4,500 individual fish catch records from beach seine, fyke trap, and surface trawl sets across habitat types and seasons over a three year period from 2001-2003. These collections were intended to document basic natural history information on estuarine fishes that could be used in a variety of management contexts, primarily salmon recovery planning, and monitoring and assessment. Funding for this study was primarily provided by the Northwest Indian Fisheries Commission (NWIFC) to the Skagit River System Cooperative (SRSC) as part of the Pacific Salmon Treaty Implementation and Pacific Salmon Coastal Recovery initiatives. NOAA Fisheries Northwest Fisheries Science Center provided offshore sampling capability (both staff and gear) for the years 2001-2003. Additional funding was provided by the Seattle District Army Corps of Engineers and Seattle City Light through a Planning Assistance to States (PAS) grant. The PAS funding enabled us to double our existing sampling efforts for the 2003 year, thus extending our spatial and temporal coverage of the greater Skagit River estuary. The data collected have been used in a number of analyses, including (Beamer et al. 2005, Rice 2007, Beamer et al. in prep, Beamer and Greene in prep.).

Acknowledgements

We gratefully acknowledge the following individuals and groups:

- Aundrea McBride for assistance with data management
- Karen Wolf for GIS and map making
- Bruce Brown, John Grossglass, Jason Boome, and Leonard Rodiguez for numerous hours of beach seining and fyke trapping.
- Northwest Fisheries Science Center (NWFSC), Watershed Program
- NWFSC vessels and staff
- Reg Reisenbichler and staff at USGS Western Fisheries Research Center
- Padilla Bay National Estuarine Research Reserve for permission to seine sites within Padilla Bay and help with seining
- Andy Culbertson for permission to seine sites within Turners Bay

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Introduction

Ecological restoration or flood control projects that change flow pathways of the Skagit River could significantly alter many attributes of estuarine environments, including hydrologic connectivity, sediment dynamics, and salinity regimes in the delta and its adjacent waters. Project planners must anticipate and evaluate the biotic responses of proposed restoration or flood control alternatives. This study provides empirical information on taxonomic composition of fish assemblages, and detailed information on juvenile salmon density, size, and origin, for differing physical habitat and salinity characteristics that may be useful in understanding changes in freshwater and sediment dynamics in the Skagit River delta.

Estuarine fish assemblages fluctuate based on seasonal shifts in habitat use and variations in habitat structure, connectivity, and spatial arrangement, as well as chemical and physical attributes such as temperature and salinity. This study stratified monthly estuarine fish use by physical habitat and salinity regimes using data collected by the Skagit River System Cooperative and NOAA Fisheries from 2001-2003. Direct area-to-area (Skagit Delta, Skagit Bay, Swinomish Channel, Padilla Bay) comparisons of taxonomic composition of fish assemblages, as well as densities, individual sizes, and origins of wild and hatchery juvenile Chinook salmon were made using data collected in 2003. Specifically, this study answers the following questions.

1. What is the taxonomic composition of greater Skagit estuary fish assemblages by habitat type, salinity regime, and season?
2. What are the differences in juvenile Chinook salmon abundance and size between Skagit Bay, Skagit Tidal Delta, Swinomish Channel Corridor, and Padilla Bay?
3. What is the origin of hatchery Chinook salmon found in Skagit Bay, Skagit Tidal Delta, Swinomish Channel Corridor, and Padilla?
4. Are fish assemblages within habitat types consistent across years?

Study Area

The greater Skagit estuary as defined here includes Skagit Bay, Swinomish Channel, and Padilla Bay, all part of the historic Skagit River estuary system (Figure 1). It includes part of the geomorphic delta and its adjacent nearshore marine waters.

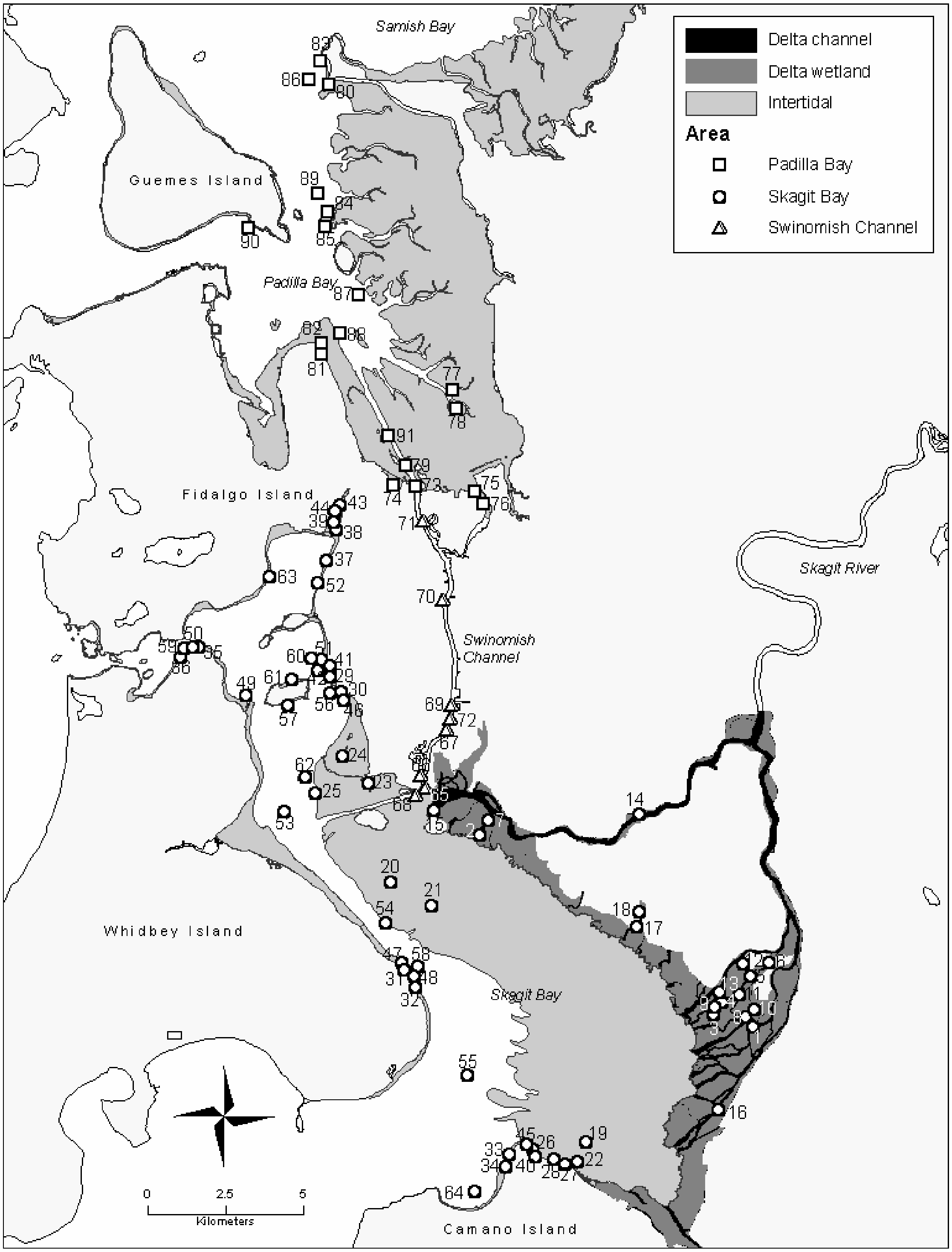

Figure 1. The greater Skagit River estuary. Sampling sites for fish assemblage were located in the Skagit delta, Skagit Bay, Swinomish Channel, and Padilla Bay. Each sampling site is numbered and the corresponding site names, habitat types, and gear used are shown in Table 1.

Fish Sampling Methods

The diversity of habitats within the greater Skagit River estuary requires use of multiple methods to sample fish assemblages. This section describes the environmental characteristics of the different areas, and the sampling methods used in each.

Site areas and habitat types

We divided the greater Skagit River estuary into three different areas: Skagit Bay, Swinomish Channel, and Padilla Bay based on their different levels of connectivity with the Skagit River (Figure 1).The Skagit Bay area is directly connected with the current Skagit River and contains tidal delta habitat as well as adjacent nearshore and offshore habitat within Skagit Bay proper. The Swinomish Channel area is less directly connected to the Skagit River under current conditions due to construction of dikes and a jetty that diverts direct Skagit river flow away from the channel. Historically, Swinomish Channel was part of the contiguous Skagit River tidal delta. The Padilla Bay area was also part of the historic contiguous Skagit River delta, but it is currently only connected to Skagit River flow through the Swinomish Channel. The Padilla Bay area has deltaic habitat as well as adjacent nearshore and offshore habitat within Padilla Bay proper.

Due to the differences geomorphology and connectivity with Skagit River flow each area has multiple habitat types and potentially different salinity regimes. We divided habitat types into two hierarchical categories: Habitat Type 1 and 2 (Table 1). Habitat Type 1 refers to larger scale areas within different parts of the geomorphic estuary whereas Habitat Type 2 relates to smaller habitat areas that specific methods can sample for fish. Habitat Type 2 differences relate primarily to depth of water and the type of channel (or non-channel).

Differences in salinity regime were empirically derived for each site using graphical analysis to bracket approximately the 10^{th} and 90^{th} percentiles around the median. Salinity regimes were defined as: 0-15 ppt, 5-25 ppt, and >20ppt. Our study sampled at 91 different sites within the greater Skagit estuary across a range of environmental conditions (Table 1, Figure 1). Specific site characteristics are summarized in Table 2.

Table 1. Number of sampling sites in the greater Skagit estuary by habitat type.

Habitat Type 1	Habitat Type 2						
	Blind Channel	Distributary Channel	Distributary Channel, shallow	Shallow intertidal	Subtidal Fringe	Surface Water	Total
Delta Flats (unvegetated)				8	3		11
Lagoon Pocket Estuary	2			3			5
Nearshore Beach				14	14		28
Offshore						18	18
Vegetated Delta	16	2	11				29
Total	18	2	11	25	17	18	91

Table 2. Sampling site characteristics and key to figures (location shown in Figure 1) and fish assemblage results (Figures 2-26).

Figure 1 Label	Site Name	Figure Number	Salinity Range	Area	Habitat Type 1	Habitat Type 2	Sampling Method
1	Boom Sl Area	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
2	Cattail Area	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
3	DW Reference Main Ch W 1-3	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
4	DW Reference Main Ch W 4-6	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
5	DW Treatment Inside Lower s1	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
6	DW Treatment Inside Upper s1	2	0-15 ppt	Skagit Bay	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
7	Cattail Saltmarsh	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
8	DW Reference E Blind	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
9	DW Reference W Blind	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
10	DW Treatment E Blind	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
11	DW Treatment W Blind	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
12	DW Treatment W Pond1	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	beach seine small net method
13	FWP New Site	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
14	Grain of Sand	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
15	Ika	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
16	Tom Moore	3	0-15 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
17	Browns Sl Barrow Ch	4	5-25 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
18	Browns Sl Diked Side	4	5-25 ppt	Skagit Bay	Vegetated Delta	Blind Channel	Fyke Trap
19	English Boom Bar N Area	5	0-15 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
20	N Fork Flats N Area	5	0-15 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
21	N Fork Flats S Area	5	0-15 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
22	English Boom Bar S Area	6	5-25 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
23	PBD Flats E Area	6	5-25 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
24	PBD Flats NW Area	7	>20 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
25	PBD Flats SW Area	7	>20 ppt	Skagit Bay	Delta Flats	Shallow intertidal	beach seine small net method
26	Brown Point (X)	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
27	English Boom Beach E	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
28	English Boom Beach W	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
29	SneeOosh N	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
30	SneeOosh S	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
31	Strawberry Pt N	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
32	Strawberry Pt S	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method

33	Utsalady N	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
34	Utsalady S	8	5-25 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
35	Hoypus Pt E	9	>20 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
36	Hoypus Pt W	9	>20 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
37	Similk Bay (N)	9	>20 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
38	Turners Spit S	9	>20 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
39	Turners Spit N	9	>20 ppt	Skagit Bay	Nearshore Beach	Shallow intertidal	beach seine small net method
40	Arrowhead	10	5-25 ppt	Skagit Bay	Lagoon Pocket Estuary	Blind Channel	Fyke Trap
41	Lone Tree Lagoon	10	5-25 ppt	Skagit Bay	Lagoon Pocket Estuary	Blind Channel	Fyke Trap
42	Lone Tree Lagoon s1	11	5-25 ppt	Skagit Bay	Lagoon Pocket Estuary	Shallow intertidal	beach seine small net method
43	Turners Bay Inside E	12	>20 ppt	Skagit Bay	Lagoon Pocket Estuary	Shallow intertidal	beach seine small net method
44	Turners Bay Inside W	12	>20 ppt	Skagit Bay	Lagoon Pocket Estuary	Shallow intertidal	beach seine small net method
45	Brown Point (X)	13	5-25 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
46	SneeOosh S	13	5-25 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
47	Strawberry Pt N	13	5-25 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
48	Strawberry Pt S	13	5-25 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
49	Ala Spit	14	>20 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
50	Hoypus Pt E	14	>20 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
51	Lone Tree Pt	14	>20 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
52	Similk Bay (N)	14	>20 ppt	Skagit Bay	Nearshore Beach	Subtidal Fringe	beach seine large net method
53	Dugualla	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
54	NFF	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
55	SFF	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
56	Snee-Oosh	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
57	South Hope	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
58	Strawberry Point	15	5-25 ppt	Skagit Bay	Offshore	Surface Water	Townet
59	Hoypus	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
60	Lone Tree	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
61	North Hope	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
62	PBD	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
63	Similk	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
64	Utsalady	16	>20 ppt	Skagit Bay	Offshore	Surface Water	Townet
65	Swin Ch Site 51	17	5-25 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
66	Swin Ch Site 52	17	5-25 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
67	Swin Ch Old Bridge Blind	18	5-25 ppt	Swinomish Channel	Vegetated Delta	Blind Channel	Fyke Trap

68	Swin Ch Site 52	19	5-25 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel	beach seine large net method
69	Swin Ch Site 55	20	>20 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
70	Swin Ch Site 60	20	>20 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
71	Swin Ch Site 70	20	>20 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel, shallow	beach seine small net method
72	Swin Ch Site 55	21	>20 ppt	Swinomish Channel	Vegetated Delta	Distributary Channel	beach seine large net method
73	Swin Ch Site 80	22	>20 ppt	Padilla Bay	Delta Flats	Shallow intertidal	beach seine small net method
74	SW Padilla Lagoon	23	>20 ppt	Padilla Bay	Vegetated Delta	Blind Channel	Fyke Trap
75	Telegraph Sl (A)	23	>20 ppt	Padilla Bay	Vegetated Delta	Blind Channel	Fyke Trap
76	Telegraph Sl (B)	23	>20 ppt	Padilla Bay	Vegetated Delta	Blind Channel	Fyke Trap
77	Bayview Ch N	24	>20 ppt	Padilla Bay	Delta Flats	Subtidal Fringe	beach seine PS protocol
78	Bayview Ch S	24	>20 ppt	Padilla Bay	Delta Flats	Subtidal Fringe	beach seine PS protocol
79	Swin Ch Site 80	24	>20 ppt	Padilla Bay	Delta Flats	Subtidal Fringe	beach seine large net method
80	Camp Kirby	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
81	March Pt E	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
82	March Pt W	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
83	Pt Williams	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
84	Saddlebag Is N	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
85	Saddlebag Is S	25	>20 ppt	Padilla Bay	Nearshore Beach	Subtidal Fringe	beach seine PS protocol
86	Camp Kirby	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet
87	Hat Island	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet
88	March Point	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet
89	Saddlebag	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet
90	South Guemes	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet
91	Swinomish Channel	26	>20 ppt	Padilla Bay	Offshore	Surface Water	Townet

Small Beach Seine

Small net beach seine methods were used for sampling shallow intertidal shoreline areas of Skagit and Padilla Bays, pocket estuaries with lagoon impoundments, or distributary channel habitat in the Skagit tidal delta and Swinomish Channel. The areas seined were typically less than 1.2 m deep, and have relatively homogeneous habitat features (water depth, velocity, substrate, and vegetation). A 24.4 m by 1.8 m by 0.3 cm mesh, knotless nylon net was set in "round haul" fashion by fixing one end of the net on the beach while the other end was deployed by wading "upstream" against the water current, hauling the net in a floating tote, and then returning to the shoreline in a half circle. Both ends of the net were then retrieved yielding a fish catch which was completely counted by species. We typically did three sets per site. Average set area was 96 m^2. Temperature and salinity measurements were taken in the area seined at the time of beach seining using an electronic meter (YSI model 30).

Large Beach Seine

Large net beach seine methods were used for sampling the intertidal-subtidal fringe of Skagit and Padilla Bays and deeper distributary channel habitat in Swinomish Channel. These areas were typically 1-4 m deeper than the areas seined by small net beach seine, requiring a longer and deeper net. A 36.6 m by 3.7 m by 0.3 cm mesh, knotless nylon net was deployed by fixing one end of the net on the beach while the other end was set by boat across the current a distance of approximately 60% of the net's length. After the set was held open against the tidal current for a period of 4 minutes, the boat end was brought to the shoreline edge and both ends retrieved yielding a catch in the net's bunt section. We usually did three sets per site. Set area varied because of varying tow times, set widths, and tidal current velocities moving past the site. Average set area was 486 m^2. The fish catch was completely counted by species. Temperature and salinity measurements were taken at the start and end of trapping using an electronic meter (YSI model 30).

Puget Sound Protocol Beach Seine

Puget Sound protocol beach seine methods are also used for sampling the intertidal-subtidal fringe of Padilla Bay. The beach seine used was 36 m long and ranged from a width of 2 m in the wings to 3.1 m at the bag. Mesh sizes ranged from 3 cm in the wings to 3.2 mm knotless nylon in the bag. Floats arrayed along the cork line kept the net from sinking. The net was set about 33 m from and parallel to shore. A line attached to each end of the net was used to pull the net to shore. The net was brought in at the same pace by crew hauling from each side and, when the net was about 10 m from shore, the two ends were pursed together to force fish into the bag. The average area sampled by the net was about 1,200 m^2 , with most sets occurring within $\pm$ 10% of this value. The fish catch was completely counted by species. Temperature and salinity measurements were taken at the start and end of trapping using an electronic meter (YSI model 30).

Fyke Trap

Fyke trap methods were used for sampling blind tidal channel habitat in the Skagit tidal delta, Swinomish Channel corridor, southern Padilla Bay, or pocket estuary sites dominated by tidal channels. Fyke trap methodology used nets constructed of 0.3 cm mesh, knotless nylon with a 0.6 m by 2.7 m diameter cone sewn into the net to collect fish draining out of the blind channel site. Overall net dimensions (length and depth) are variable depending on the site's cross-sectional channel dimensions. All nets were sized to completely block fish access at high tide. The net was set across the blind channel site at high tide and "fished" through the ebb tide yielding a catch. The fish catch was completely counted by species. Temperature and salinity measurements were taken at the start and end of trapping using an electronic meter (YSI model 30).

The juvenile Chinook catch was adjusted by a trap recovery efficiency (RE) estimate derived from mark-recapture experiments using a known number of marked fish released upstream of the trap at high tide. RE is usually related to hydraulic characteristics unique to the site (e.g., change in water surface elevation during trapping or water surface elevation at the end of trapping). Multiple RE tests (several times per season) at each site are used to develop a regression model to convert the "raw" juvenile Chinook catch to an estimated population within the habitat upstream of the fyke trap on any sampling day.

Surface Trawl

Surface trawling was used to sample the neritic environment (waters overlying the sublittoral zone) in Skagit and Padilla Bay. A 3.1 m high x 6.1 m wide Kodiak surface trawl, or "townet," was deployed between two boats, each with a 15.2 m tow line connected to a bridle on the net. The primary vessel (13.7 m long power by a 174 hp diesel engine) towed the left side of the net while trawling, and the secondary vessel (a 5.5 m long skiff powered by a 225 hp gasoline outboard engine) towed the right side. The net was towed at the surface for 10 minutes per tow unless shortened by gear problems or limited towing area, at a typical towing speed of 2-3 knots through the water. Distance through the water was recorded with a mechanical flowmeter (General Oceanics model 2030). Up to two tows were done per site. Start and end times, general towing direction, and weather, tide, and current conditions were recorded manually. The surface water area swept was estimated for each tow by multiplying the distance through the water by the net width. Typical area swept was approximately 0.4 hectares per tow. Temperature and salinity measurements were taken using an electronic meter (YSI model 30) on water drawn by the primary vessel's deck hose from a depth of approximately 1.2 m.

At the end of each tow the boats came together side by side and the net was hauled back onboard the primary vessel. The entire catch was then placed in tanks supplied with flowing water from the site, and identified, counted, and weighed by species.

Individual fish records

All captured juvenile salmon were removed from the catch as soon as possible. Individual Chinook and coho salmon were measured for length and weight, visually examined for clipped adipose fins, and checked for coded wire tags (CWT) using a handheld tag detecting wand manufactured by Northwest Marine Technologies. Juvenile pink and chum salmon were measured (up to 25 per haul) and released. All non-salmon were counted and released after lengths were measured on 20-25 individuals per haul (fork length if the species had a fork in its tail and total length for other species).

Juvenile Chinook and coho salmon into one of four categories based on fin clips and CWTs:

1. Unmarked (inferred as wild origin) = intact adipose fin, no CWT.
2. Marked (hatchery origin) = intact adipose fin, with CWT
3. Marked (hatchery origin) = no adipose fin, with CWT
4. Marked (hatchery origin) = no adipose fin, no CWT

Some of the unmarked fish were undoubtedly of hatchery origin but were not conclusively identified in this study. A sub-sample of Chinook salmon with CWTs were retained to determine their hatchery of origin.

While this report only presents results for juvenile Chinook abundance, size, and hatchery origin, a sub-sample of marked (adipose-clipped or CWT), and unmarked (wild) Chinook salmon were sacrificed for a variety of other purposes. Sample data included otoliths (for age, growth, and life history studies), stomach contents (for dietary analysis), kidneys (for analysis of bacterial kidney disease prevalence), and blood plasma (for growth studies). Heads containing otoliths were preserved in 90% ethanol, and viscera with gut contents were preserved in 10% neutral buffered formalin. Scales were collected from all sacrificed Chinook and archived. Carcasses of most of the sacrificed Chinook were frozen at –20°C for possible analysis of genetics and/or chemical contamination.

Analysis

Assemblage Composition

Graphical and statistical analysis focused on the influence of season, geographic location, physical habitat, and salinity class on counts and relative abundance of individual taxa, usually species. In addition, consistency of assemblage composition across years was examined. Area graphs were used to illustrate seasonal changes in catch composition for habitat types and selected species groups in the three areas (Skagit Bay, Swinomish Channel, and Padilla Bay). Multivariate statistical treatments were used to evaluate fish assemblage composition differences among, and similarities within, areas, habitats, and months, sub-basins, and estuaries; and across years in habitats where data were available for multiple years. All multivariate analyses were conducted following the approach of Clarke and Warwick (Clark 1993, Clark and Warwick 2001) using Primer statistical software version 6 (Clarke and Gorley 2006).

Counts of each fish species was averaged by site/month combination for 2003 data, and by site/month/year combinations for selected habitat types from 1996-2003. Relative abundances were calculated for each sample. The data matrices were then transformed to down-weight the effect of highly abundant taxa using a square-root transformation, and non-metric multidimensional scaling (MDS) ordinations were performed on Bray-Curtis dissimilarity matrices of the data. Graphs of the resulting MDS ordinations were used to evaluate relationships among years from the four habitat types where multiple years of data were available. A dimensionless "stress" value provides a non-parametric regression estimate of reliability of the ordination. Values < 0.2 are considered to give a useful and interpretable representation of the relationships among samples (Clark and Warwick 2001, McCune and Grace 2002).A two-way analysis of similarity procedure (ANOSIM) was applied to the resemblance matrices to evaluate *differences* in the assemblage composition based on area, habitat type, month, year, and salinity class. The ANOSIM procedure calculates an R statistic based upon the difference between average within group rank similarities and average among group rank similarities. Values of R range between 0 (rank similarities between and within areas, habitats, or months are the same, on average) and 1 (all replicates within areas, habitats, or months are more similar to each other than any replicates from different areas, habitats, or months), and significance level is computed using a permutation procedure. A two-way similarity percentages procedure (SIMPER) was applied to the same resemblance matrices to evaluate the contribution of various taxa to *similarities* in the assemblage composition by area, habitat, and month.

Juvenile Chinook Abundance

Density estimates were calculated only for juvenile Chinook salmon because mark and recapture test were conducted only with Chinook salmon at fyke trapped blind channel sites. Fish densities were calculated by dividing the raw catch by the area swept (distance traveled through the water multiplied by estimated width of the net opening).

Significance tests of differences in densities of marked, unmarked, and total Chinook between areas for each month were done by using analysis of variance (ANOVA). Because of an unbalanced design caused by zero and missing values, a generalized linear model (GLM) univariate ANOVA was used to perform individual tests on each month/habitat combination only in cases were data were available. Thus, only a subset of all the data collected were used in the statistical analysis. To reduce the effects of nonnormal data distribution and heteroscedasticity, fish density data were transformed using a log (x+1) transformation (Zar 1996). Graphical analysis of residuals from the ANOVA tests revealed no serious violations of ANOVA assumptions.

Results

We made 2,285 townet, fyke trap, or beach seine hauls during the 2003 sampling year. The effort yielded a catch of 877,042 fish representing at least 58 different species, and is summarized in Table 3.

Table 3. Total counts and percentage of samples containing selected species or groups of fishes captured in 2003.

Fish assemblage or species	Total Catch	Percent Occurrence
Salmon:		
Chinook (wild)	48,185	46.2%
Chinook (hatchery)	1,183	10.0%
Coho (wild)	2,804	8.8%
Coho (hatchery)	201	1.1%
Pink	756	3.5%
Chum	91,738	32.3%
Cutthroat	394	4.2%
Bull trout	306	6.2%
Other small pelagic fishes:		
Pacific herring (*Clupea pallasii*)	52,884	18.3%
Pacific sand lance (*Ammodytes hexapterus*)	30,031	13.7%
Surf smelt (*Hypomesus pretiosus*)	130,053	37.8%
Peamouth chub (*Mylocheilus caurinus*)	8,403	2.4%
Shiner perch (*Cymatogaster aggregata*)	111,754	30.5%
Sculpins:		
Pacific staghorn sculpin (*Letocottus armatus*)	22,304	53.0%
Prickly sculpin (*Cottus asper*)	472	3.5%
Other marine sculpins	445	4.8%
Common flatfish:		
Starry flounder (*Platichthys stellatus*)	5,194	40.5%
English sole	1,435	12.1%
Other abundant or frequently occurring fish species:		
Three-spine stickleback (*Gasterosteus aculeatus*)	181,988	38.4%
Pipefish	1,133	9.3%
Snake prickleback	2,584	6.6%
Gunnels (all species combined)	3,454	13.3%
All other fish:	3,646	16.2%

Fish Assemblage by area, habitat type, and salinity regime

Twenty-five different combinations of area, habitat type, and salinity regime exist for the 91 different sites within our study area (Figures 2-27). Multivariate statistical analysis revealed differences in assemblages relating to all factors tested, especially by habitat, area, and month, and sometimes by a priori salinity class (Tables 4, 5, and 33). Species contributing to taxonomic similarity within areas and habitats varied (Table 6), and the salmon signal was particularly strong in Skagit.

We examined potential differences in the fish assemblage by plotting catch results of frequently occurring fish species or indicator species within the study area (Figures 2A-26A).

We also plotted the salmon assemblage for each area, habitat type, and salinity regime combination. These results are shown in Figures 2B-26B.

Several species of sculpin and flatfish are indicative of certain salinity conditions, including prickly sculpin (freshwater), staghorn sculpin (wide range), other marine sculpins (high salinity) (Figures 2C-26C); starry flounder (wide and fresh), English sole (higher salinity required) (Figures 2D-26D).

A synthesis of these results shapes a picture of the monthly fish assemblage for different habitat types and salinity regimes. If management actions (e.g., flood control projects or restoration projects) change existing habitat, we can use these results to help predict the fish assemblage response if we can hypothesize the habitat type and salinity regime change.

Table 4. ANOSIM global R statistics by area for tests of fish assemblage differences related to habitat type, month, and salinity class in 2003.

Area	**Habitat Types 1 & 2** (across months)		**Month** (across habitats)		**Habitat Types 1 & 2, and Salinity Class** (across months)	
	R	**p**	**R**	**p**	**R**	**p**
Skagit	0.65	0.001	0.44	0.001	0.66	0.001
Swinomish	0.26	0.02	0.56	0.001	0.07	0.49
Padilla	0.56	0.001	0.25	0.001	0.56	0.001

Table 5. ANOSIM global R statistics by habitat type for tests of fish assemblage differences related to habitat type, month, and salinity class in 2003. Two-way tests, except one-way tests for season indicated by asterisk; dashes indicate instances of insufficient data.

Habitat Type	Area		Month		Salinity	
	R	p	R	p	R	p
Vegetated Delta; Blind Channel	0.61	0.001	0.31	0.001	0.50	0.001
Vegetated Delta; Shallow Distributary Channel	0.71	0.001	0.48	0.001	0.68	0.001
Vegetated Delta; Distributary Channel	–	–	0.59*	0.001	–	–
Delta Flats; Shallow intertidal	0.07	0.36	0.50	0.001	0.0	0.82
Delta Flats; Subtidal Fringe	–	–	0.55*	0.001	–	–
Lagoon Pocket Estuary; Blind Channel	–	–	0.59*	0.001	–	–
Lagoon Pocket Estuary; Shallow intertidal	–	–	0.49*	0.001	–	–
Nearshore Beach; Shallow intertidal	–	–	0.41*	0.001	–	–
Nearshore Beach; Subtidal Fringe	0.58	0.001	0.53	0.001	0.0	0.70
Offshore; Surface Water	0.46	0.001	0.31	0.001	0.0	0.95

Table 6. Percentage of individual taxa contributing to top 90% of taxonomic similarity by habitat type for entire study area and for each sub-area (salinity classes not included; dashes indicate where habitat-area combinations were not sampled; asterisks indicate insufficient data for analysis). SIMPER test of within group similarity (across all month groups).

Habitat Type	Skagit		Swinomish		Padilla	
	Taxon	**%**	**Taxon**	**%**	**Taxon**	**%**
Vegetated Delta; Blind Channel	stickle	57	–	–	stickle	50
	Chin(W)	26	–	–	stag	27
	chum	10	–	–	shiner	15
			–	–		
Vegetated Delta; Shallow Distributary Channel	Chin(W)	42	stag	35	–	–
	stickle	28	starry	28	–	–
	starry	13	Chin(W)	13	–	–
	chum	13	Chum	10	–	–
			shiner	9	–	–
Vegetated Delta; Distributary Channel	–	–	smelt	31	–	–
	–	–	shiner	15	–	–
	–	–	starry	14	–	–
	–	–	stag	14	–	–
	–	–	Chin(W)	7	–	–
	–	–	chum	6	–	–
	–	–	stickle	3	–	–
	–	–	sand	2	–	–

Table 6 continued.

Habitat Type	Skagit		Swinomish		Padilla	
	Taxon	%	Taxon	%	Taxon	%
Delta Flats; Shallow intertidal	shiner	24	–	–	*	*
	starry	18	–	–	*	*
	stag	16	–	–	*	*
	smelt	12	–	–	*	*
	Chin(W)	9	–	–	*	*
	gl/pr	6	–	–	*	*
	stickle	5	–	–	*	*
			–	–	*	*
Delta Flats; Subtidal Fringe	–	–	–	–	smelt	28
	–	–	–	–	stickle	14
	–	–	–	–	starry	13
	–	–	–	–	shiner	11
	–	–	–	–	sand	10
	–	–	–	–	stag	7
	–	–	–	–	eng	7
	–	–	–	–	pipe	4

Table 6 continued.

Habitat Type	Skagit		Swinomish		Padilla	
	Taxon	%	Taxon	%	Taxon	%
Lagoon Pocket Estuary; Blind Channel	shiner	34	–	–	–	–
	stag	25	–	–	–	–
	chum	19	–	–	–	–
	Chin(W)	8	–	–	–	–
	smelt	8	–	–	–	–
Lagoon Pocket Estuary; Shallow intertidal	stag	47	–	–	–	–
	shiner	17	–	–	–	–
	chum	13	–	–	–	–
	Chin(W)	12	–	–	–	–
	stickle	4	–	–	–	–
Nearshore Beach; Shallow intertidal	chum	27	–	–	–	–
	stag	27	–	–	–	–
	shiner	14	–	–	–	–
	smelt	12	–	–	–	–
	Chin(W)	8	–	–	–	–
	sharp	4	–	–	–	–

Table 6 continued.

Habitat Type	Skagit		Swinomish		Padilla	
	Taxon	%	Taxon	%	Taxon	%
Nearshore Beach; Subtidal Fringe	smelt	32	–	–	shiner	47
	chum	17	–	–	stickle	17
	shiner	13	–	–	gu/pr	10
	Chin(W)	6	–	–	pipe	9
	herring	5	–	–	stag	7
	stag	4	–	–	smelt	4
	sand	3	–	–		
	stickle	3	–	–		
	gl/pr	2	–	–		
	starry	2	–	–		
Offshore; Surface Water	smelt	41	–	–	stickle	49
	herring	37	–	–	herring	18
	Chin(W)	6	–	–	smelt	12
	stickle	5	–	–	Chin(W)	6
	lamp	2	–	–	sand	6

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Shallow Distributary Channel Habitat in the Skagit Vegetated Delta, Salinity Regime 0-15ppt

Table 7. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
Chin(W)	45.99
stickle	27.82
starry	16.34
Chum	7.50
stag	0.74
prickly	0.51
pea	0.44
coho(W)	0.30
cut/bull 1	0.15
cut 1	0.07
Chin(H)	0.06
english	0.04
DVBT	0.02
sucker	0.01
wf	0.01

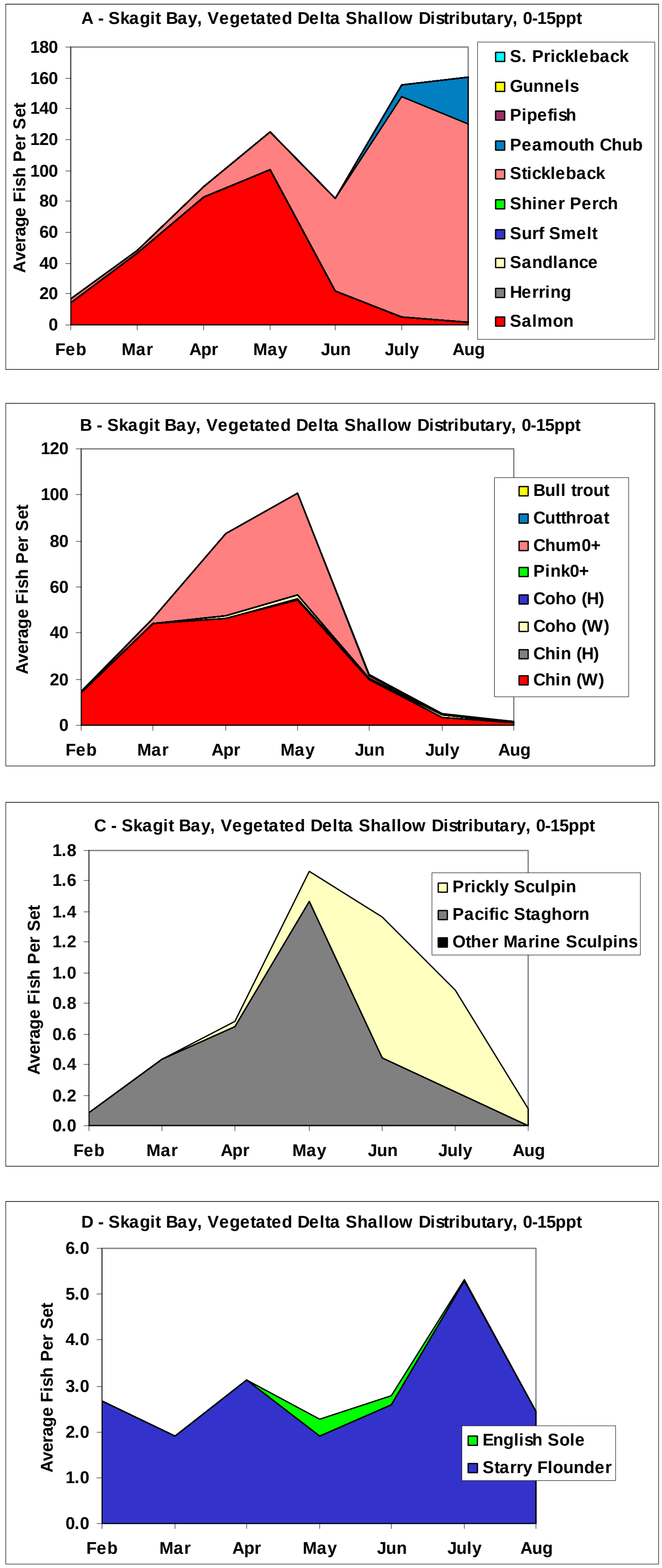

Figure 2. *Skagit Bay Fish Assemblages for the Shallow Delta Distributary With Salinity 0 to 15 ppt.*

Blind Channel Habitat in the Skagit Vegetated Delta, Salinity Regime 0-15ppt

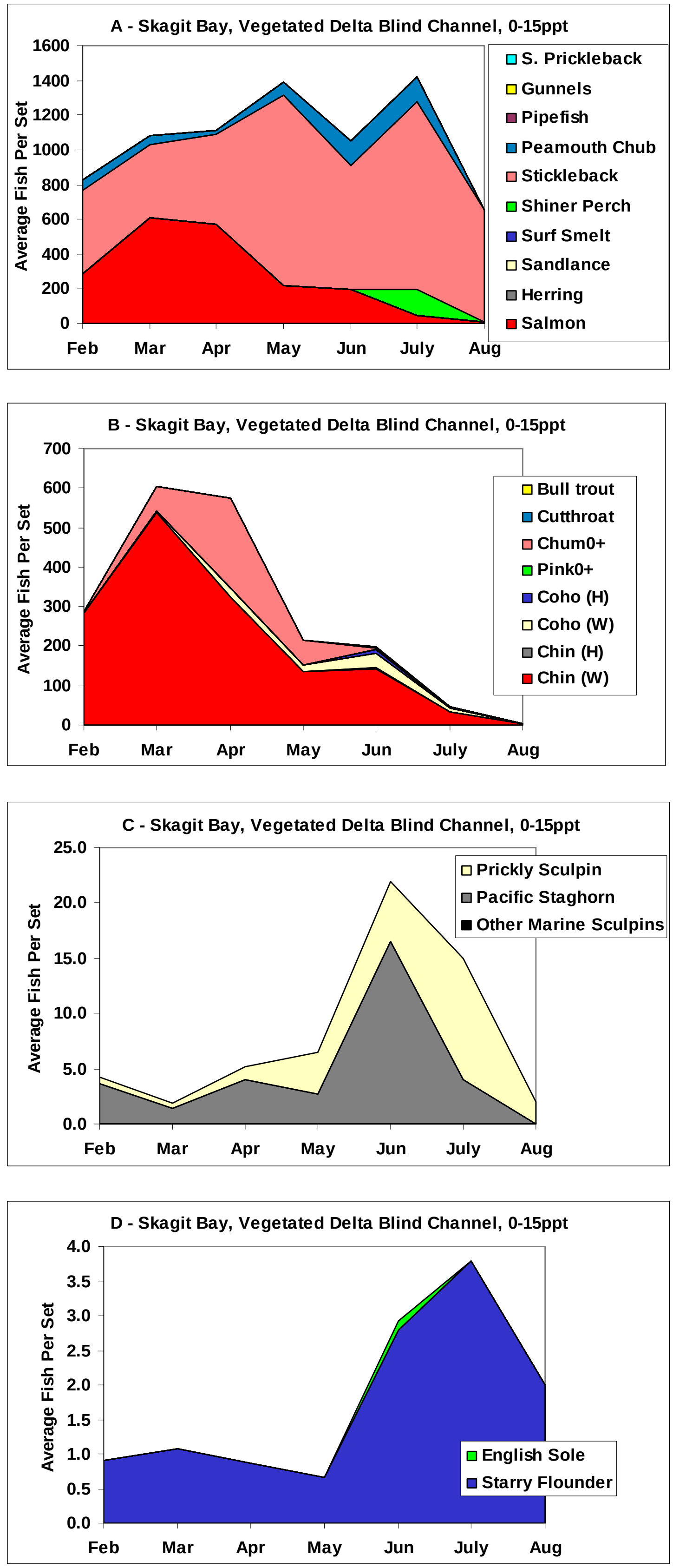

Figure 3. *Skagit Bay Fish Assemblages for Vegetated Delta Blind Channels With Salinity 0 to 15 ppt.*

Table 8. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stickle	60.40
Chin(W)	24.82
Chum	6.61
coho(W)	2.37
prickly	1.77
pea	1.33
stag	1.06
starry	1.05
cut/bull 1	0.14
sucker	0.08
shiner	0.08
cut 1	0.06
wf	0.06
pumpkin	0.05
Chin(H)	0.04
DVBT	0.03
smelt	0.03
U sculp	0.01
bluegill	0.01
coho(H)	0.01

Blind Channel Habitat in the Skagit Vegetated Delta, Salinity Regime 5-25ppt

Table 9. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stickle	76.67
Chin(W)	9.75
stag	4.90
shiner	4.09
Chum	2.54
smelt	1.43
starry	0.32
prickly	0.25
coho(W)	0.06

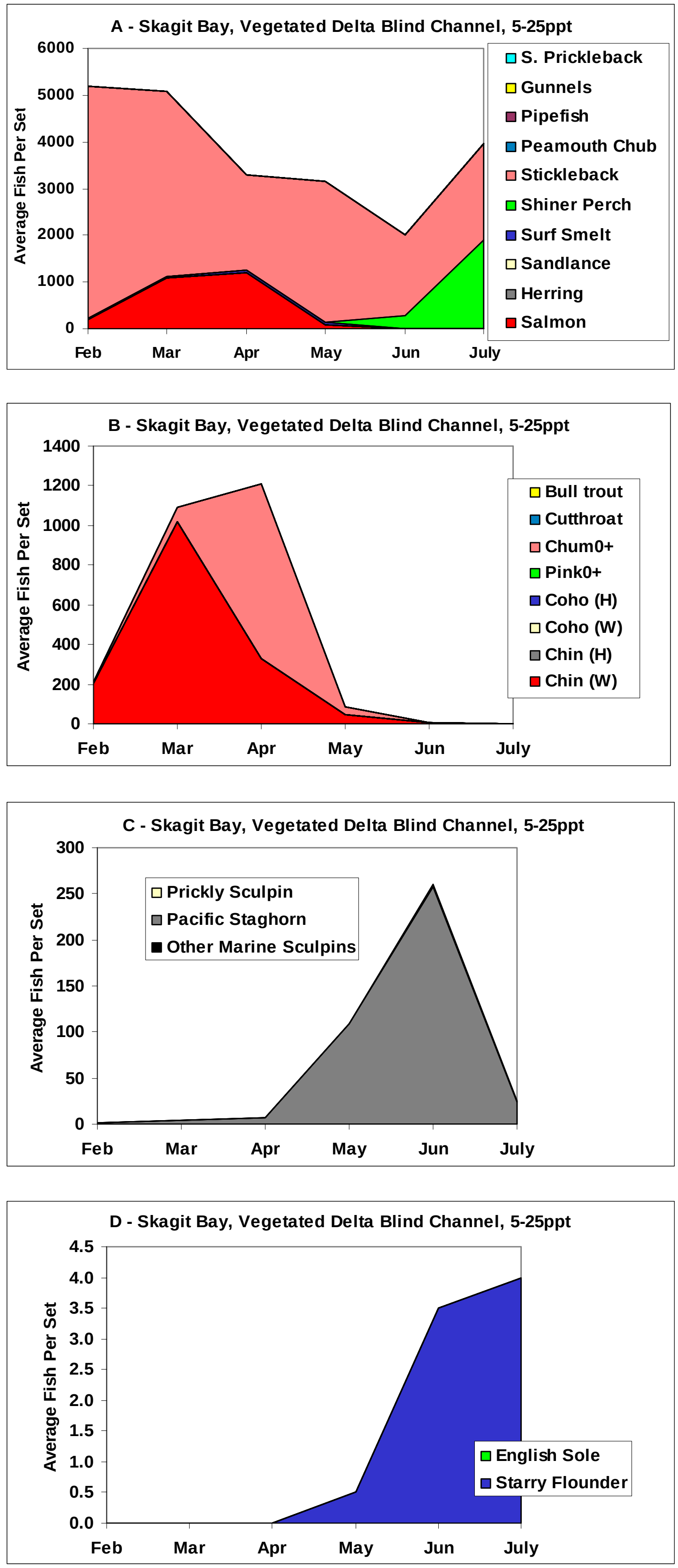

Figure 4. *Skagit Bay Fish Assemblages for Vegetated Delta Blind Channels With Salinity 5 to 25 ppt.*

Shallow Intertidal Habitat Along Skagit Bay Delta Flats, Salinity Regime 0-15ppt

Table 10. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
starry	33.69
stag	17.90
shiner	15.29
Chin(W)	11.45
smelt	9.89
sand	5.27
english	2.70
Chum	1.30
gl/pr	1.18
stickle	1.11
Chin(H)	0.14
pipe	0.07

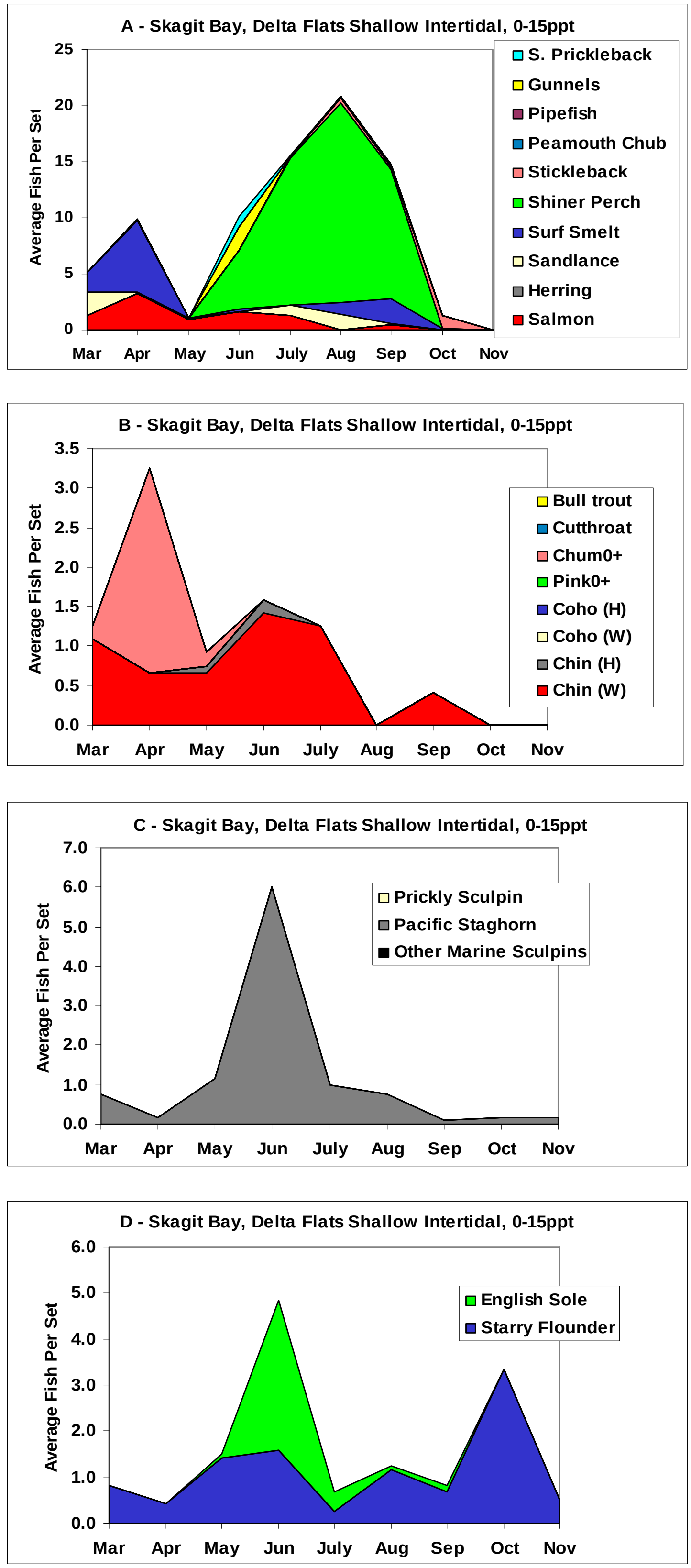

Figure 5. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of the Delta Flats With Salinity 0 to 15 ppt.*

Shallow Intertidal Habitat Along Skagit Bay Delta Flats, Salinity Regime 5-25ppt

Table 11. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	49.01
starry	25.91
Chin(W)	9.00
smelt	8.89
shiner	3.74
stickle	1.67
Chum	0.68
gl/pr	0.62
coho(W)	0.48

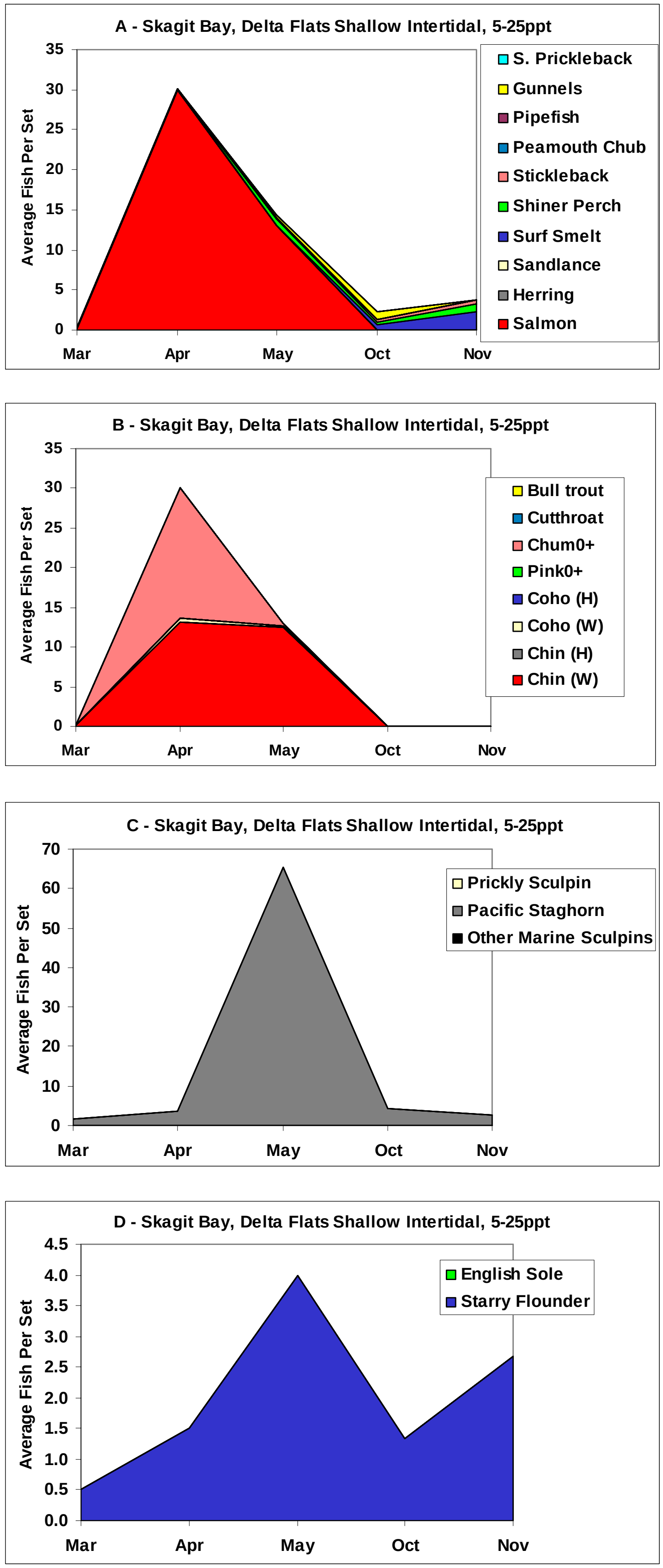

Figure 6. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of the Delta Flats With Salinity 5 to 25 ppt.*

Shallow Intertidal Habitat Along Skagit Bay Delta Flats, Salinity Greater Than 20ppt

Table 12. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
shiner	27.91
stag	13.77
gl/pr	13.57
smelt	13.40
stickle	12.14
starry	10.78
english	4.02
pipe	1.72
Chin(W)	0.67
sand	0.53
striped	0.52
sharp	0.40
herring	0.22
Chum	0.20
midship	0.06
sturg p	0.05
padded	0.04

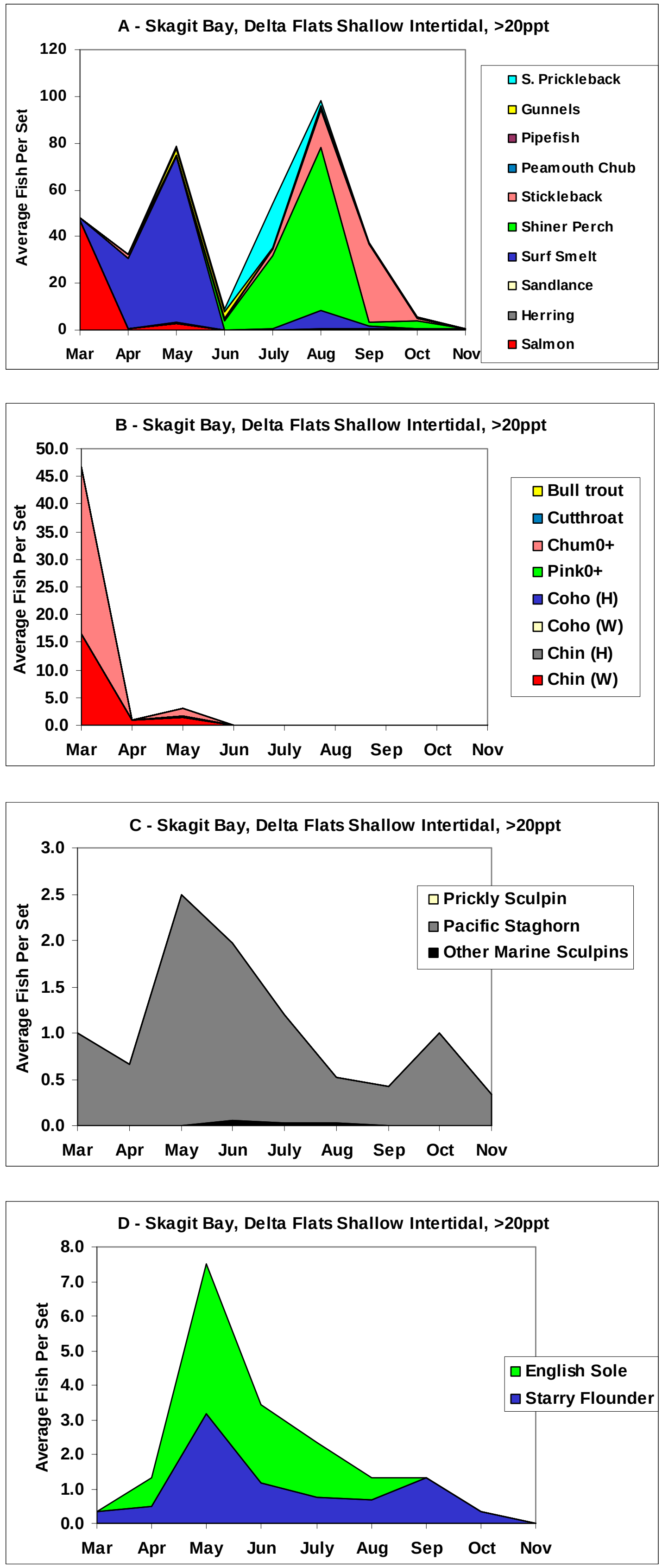

Figure 7. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of the Delta Flats With Salinity Greater Than 20ppt.*

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Shallow Intertidal Habitat Along Skagit Bay Beaches, Salinity Regime 5-25ppt

Table 13. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	26.47
Chum	19.88
stag	15.16
sharp	11.96
shiner	10.39
Chin(W)	6.67
starry	4.70
stickle	2.20
gl/pr	0.78
padded	0.60
buffalo	0.41
english	0.25
pipe	0.14
Chin(H)	0.13
coho(W)	0.09
pink	0.07
sand	0.06
herring	0.01
cut/bull 1	0.01

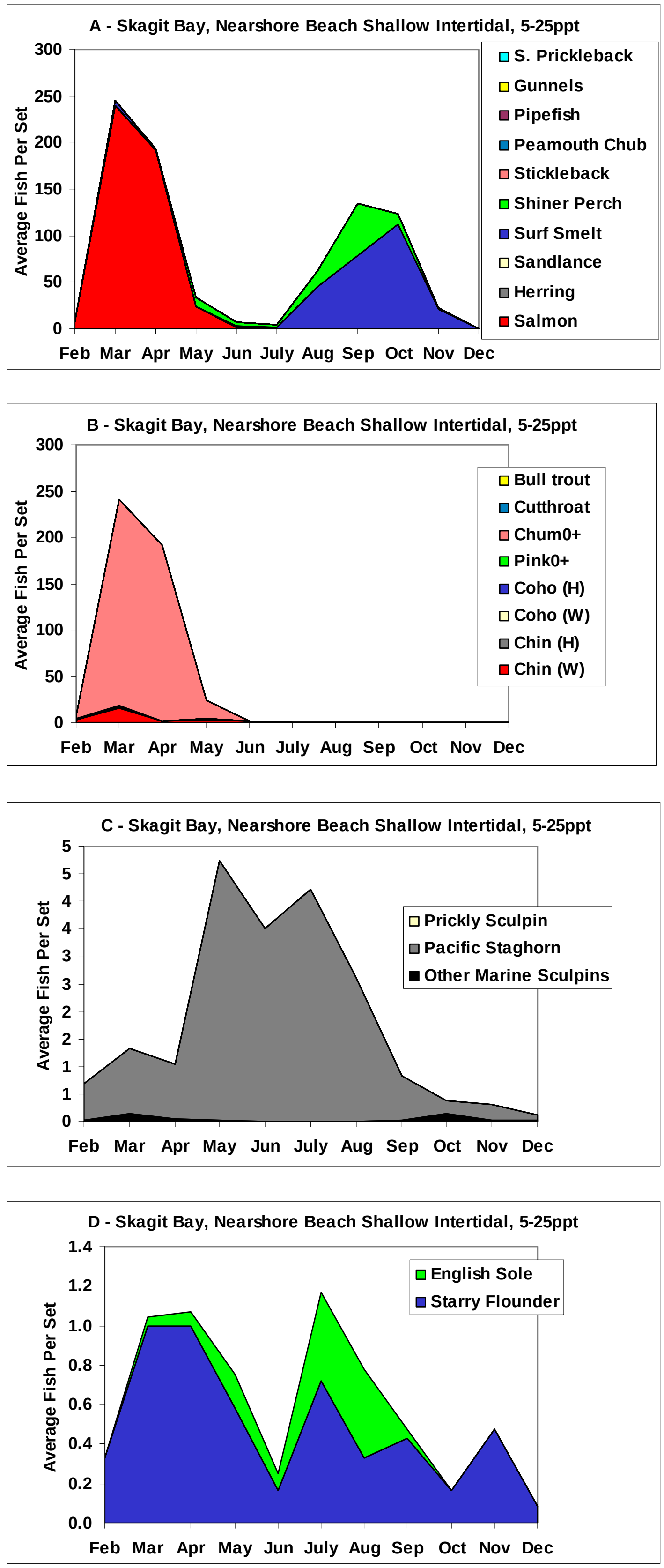

Figure 8. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of Nearshore Beaches With Salinity 5 to 25ppt.*

Shallow Intertidal Habitat Along Skagit Bay Beaches, Salinity Greater Than 20ppt

Table 14. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	67.01
shiner	9.67
Chum	7.07
smelt	4.18
Chin(W)	3.89
starry	2.64
stickle	2.37
sharp	1.00
arrow g	0.72
gl/pr	0.52
pink	0.35
sand	0.21
buffalo	0.15
pipe	0.07
great	0.06
padded	0.04
english	0.02
soft	0.01
tomcod	0.01

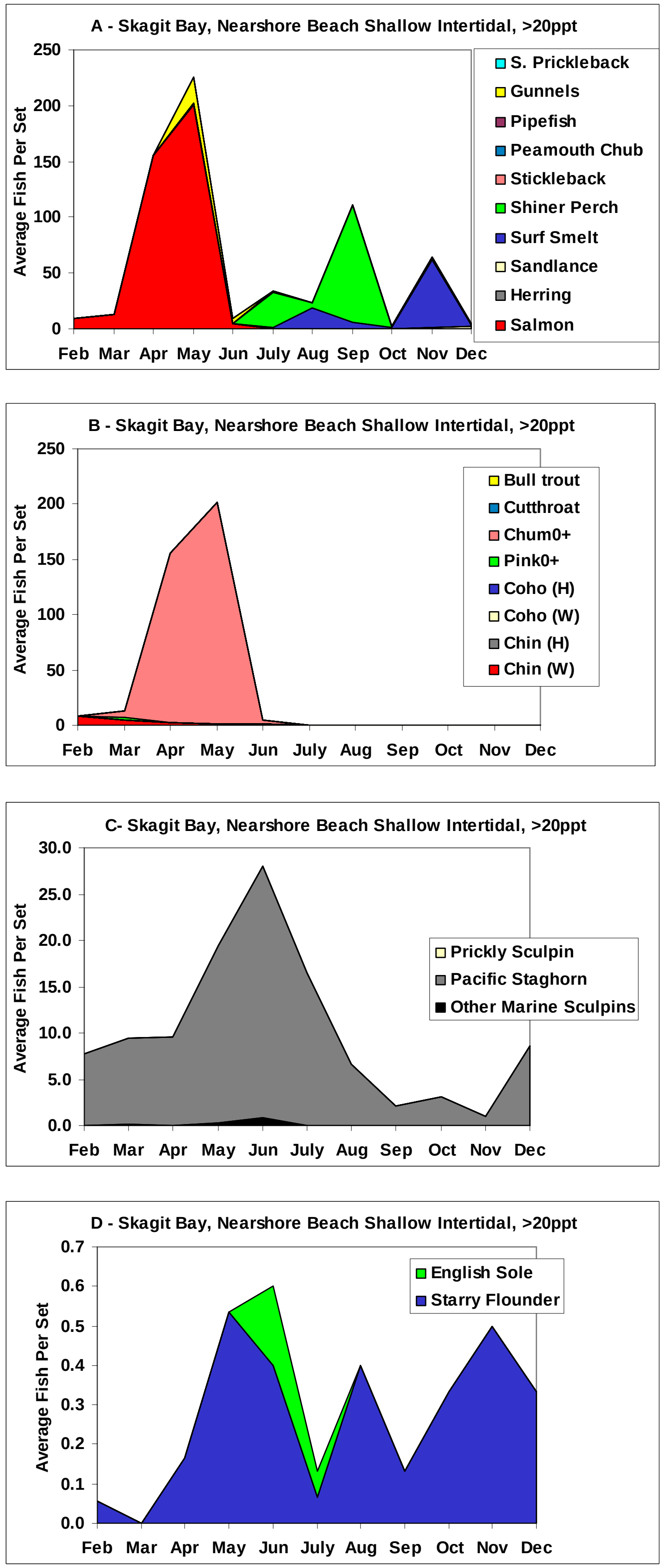

Figure 9. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of Nearshore Beaches With Salinity Greater Than 20ppt.*

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Blind Channel Habitat in Lagoon-type Pocket Estuaries in Skagit Bay, Salinity Regime 5-25ppt

Table 15. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
shiner	33.01
stag	31.92
stickle	10.50
smelt	10.39
Chum	6.57
Chin(W)	3.55
sharp	2.87
starry	0.88
arrow g	0.29
pink	0.02

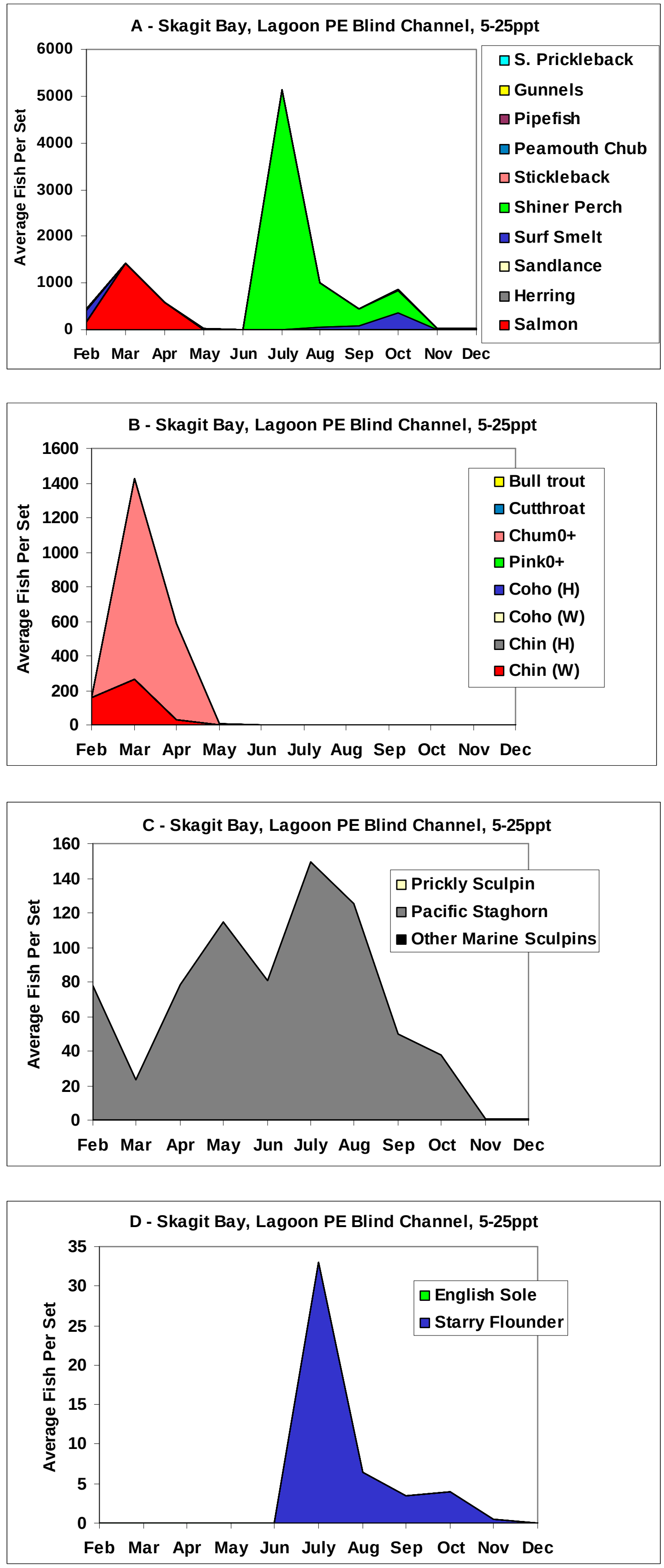

Figure 10. *Skagit Bay Fish Assemblages for Blind Channels in Lagoon-type Pocket Estuaries With Salinity 5 to 25 ppt.*

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Shallow Intertidal Habitat in Lagoon-type Pocket Estuaries in Skagit Bay, Salinity Regime 5-25ppt

Table 16. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	73.16
shiner	10.17
starry	4.41
Chin(W)	3.81
Chum	3.34
stickle	2.60
arrow g	0.91
smelt	0.59
sharp	0.51
gl/pr	0.43
english	0.04
pink	0.01
coho(W)	0.01

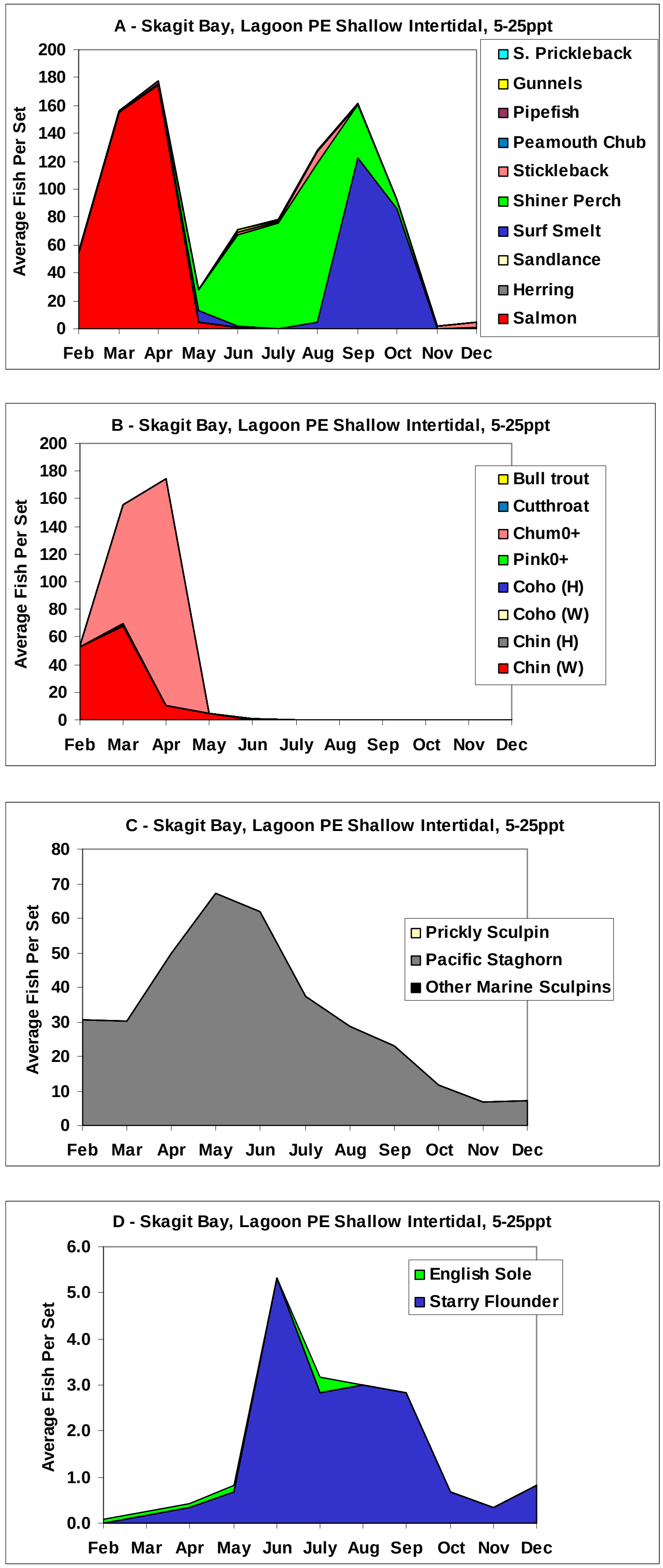

Figure 11. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of Lagoon-type Pocket Estuaries With Salinity 5 to 25 ppt.*

Shallow Intertidal Habitat in Lagoon-type Pocket Estuaries in Skagit Bay, Salinity Greater Than 20ppt

Table 17. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	32.93
smelt	29.64
shiner	15.58
Chin(W)	9.08
Chum	6.69
stickle	5.48
starry	0.27
arrow g	0.21
pink	0.08
U sculp	0.05

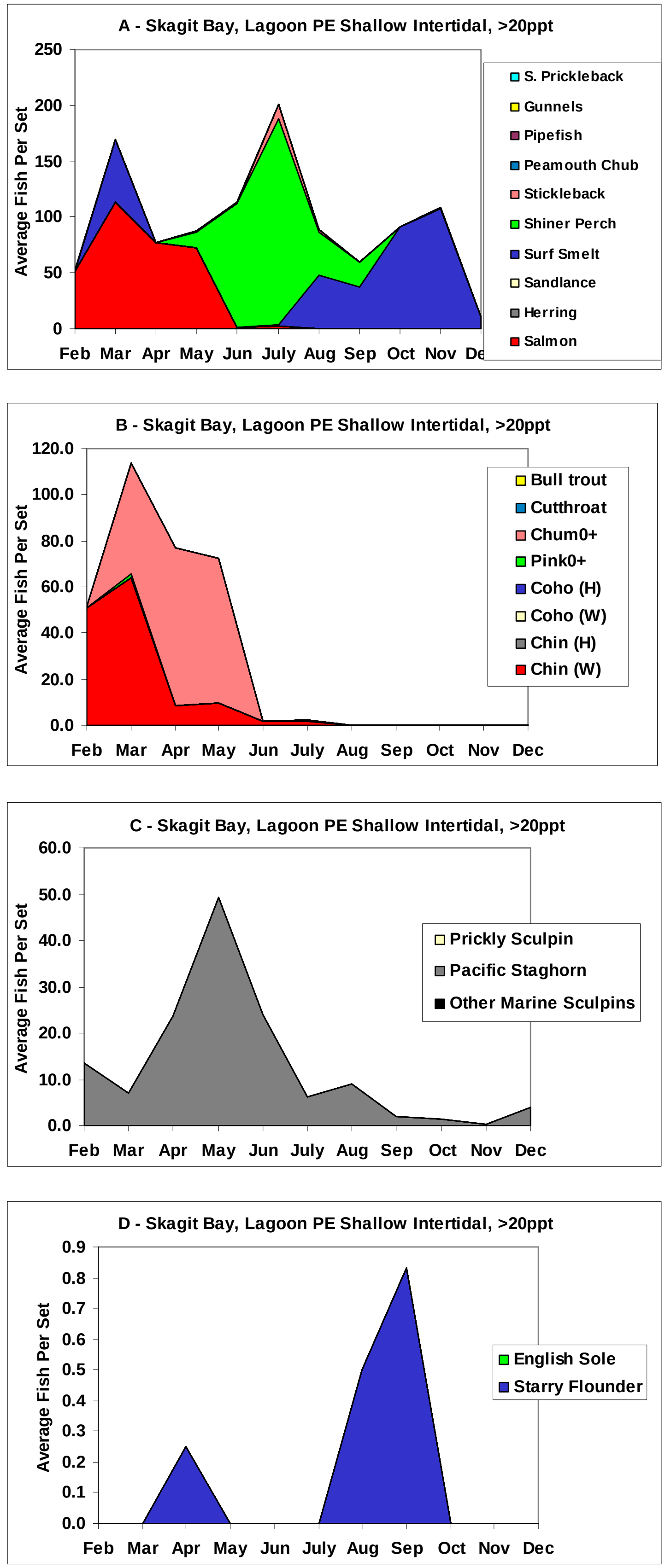

Figure 12. *Skagit Bay Fish Assemblages for the Shallow Intertidal Zone of Lagoon-type Pocket Estuaries With Salinity Greater Than 20ppt.*

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Subtidal Fringe of Skagit Beaches, Salinity Regime 5-25ppt

Table 18. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	40.04
shiner	11.53
Chum	7.98
Chin(W)	6.25
starry	5.24
stag	4.67
stickle	4.42
herring	4.33
sand	2.96
cut/bull 1	2.32
pipe	1.82
sharp	1.82
DVBT	1.62
gl/pr	1.33
english	0.68
Chin(H)	0.59
cut 1	0.50
pink	0.41
coho(W)	0.38
buffalo	0.37
padded	0.29
pile	0.14
coho(H)	0.09
striped	0.09
anchovy	0.08
great	0.04
u larval fish	0.01
U flat	0.01

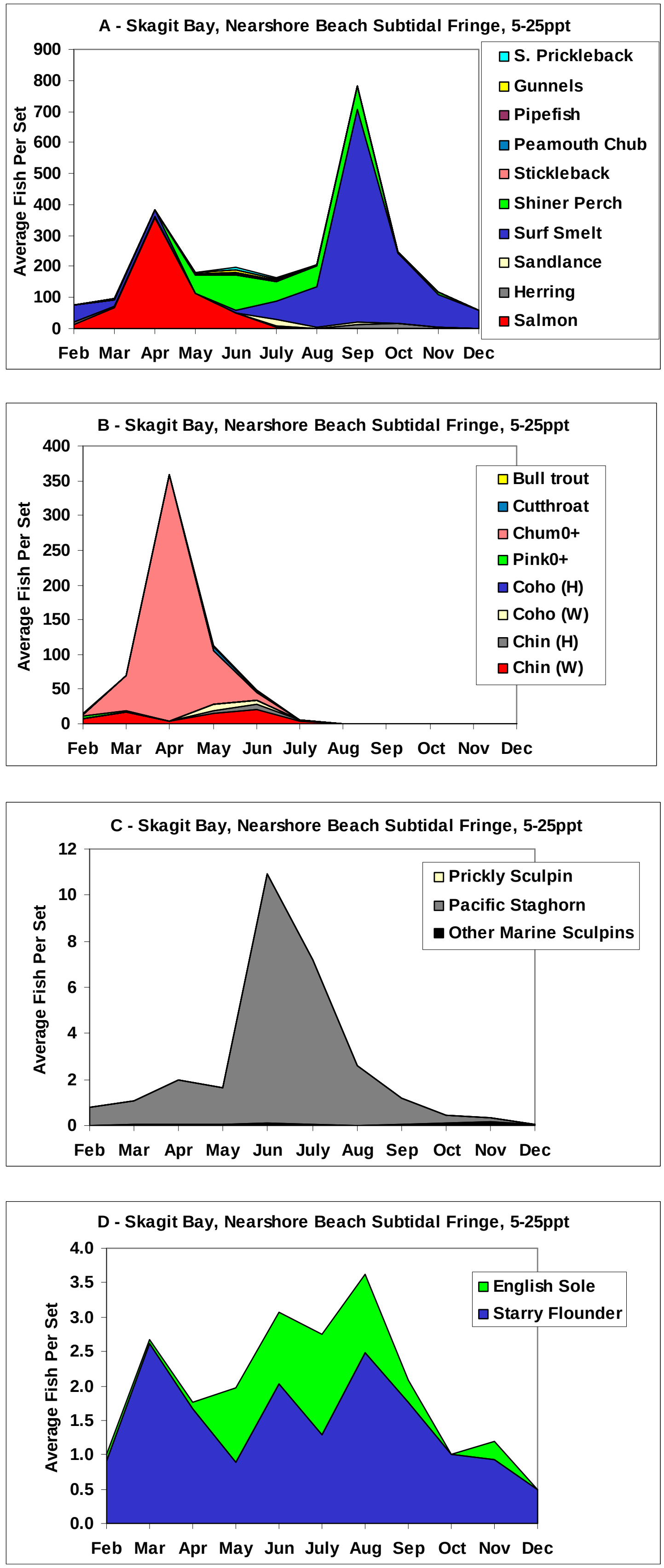

Figure 13. *Skagit Bay Fish Assemblages for the Subtidal Fringe of Nearshore Beaches With Salinity 5 to 25 ppt.*

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Subtidal Fringe of Skagit Beaches, Salinity Greater Than 20ppt

Table 19. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	33.54
shiner	10.73
Chum	10.06
stag	8.90
herring	7.79
sand	7.28
Chin(W)	4.04
stickle	3.01
gl/pr	2.34
starry	2.14
great	1.89
padded	1.53
buffalo	0.96
pipe	0.87
cut/bull 1	0.80
sharp	0.80
pink	0.58
Chin(H)	0.48
DVBT	0.46
english	0.36
coho(W)	0.29
pile	0.28
striped	0.25
cut 1	0.22
arrow g	0.12
tomcod	0.09
soft	0.09
anchovy	0.07
mask	0.01
coho(H)	0.01
lump	0.01
kelp g	0.01

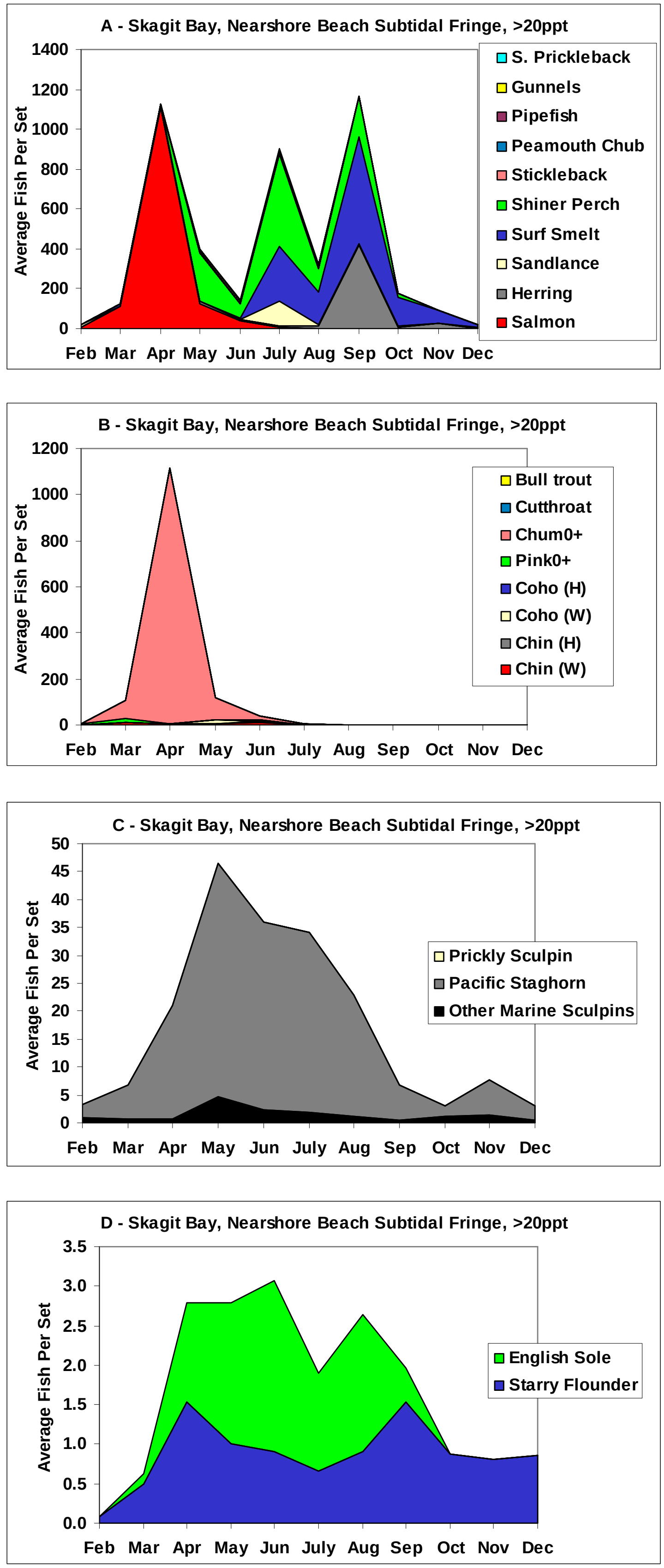

Figure 14. *Skagit Bay Fish Assemblages for the Subtidal Fringe of Nearshore Beaches With Salinity Greater Than 20ppt.*

Offshore Surface Water in Skagit Bay, Salinity Regime 5 to 25ppt

Table 20. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	51.67
herring	31.7
Chin(W)	5.69
stickle	5.24
sand	1.43
Chin(H)	1.28
lamp	1.06
sandfish	0.57
Chum	0.37
pipe	0.21
coho(W)	0.20
soft	0.19
u larval fish	0.13
starry	0.12
stag	0.05
U sculp	0.04
cut 1	0.02
cut/bull 1	0.02
shiner	0.01
sock1UM	0.01
gl/pr	0.01
anchovy	0.01
lump	0.01
striped	0.01

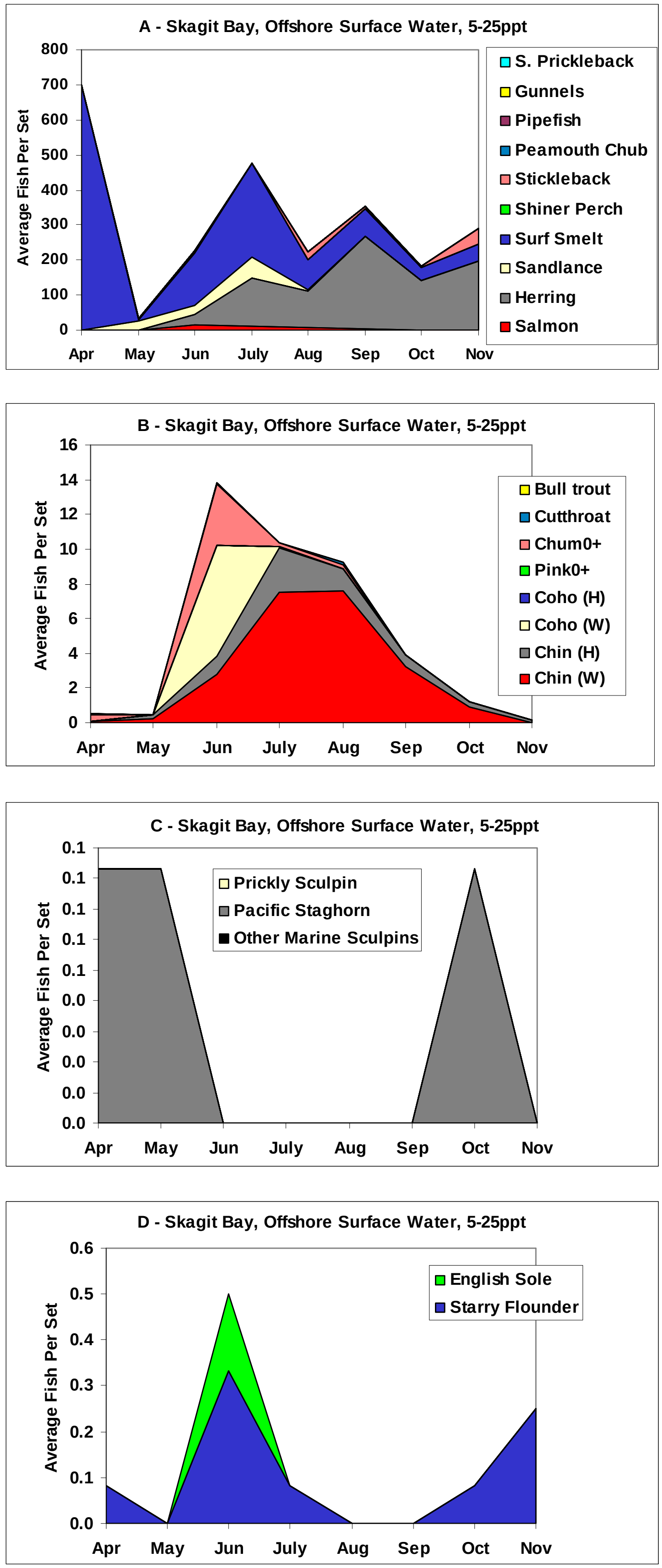

Figure 15. *Skagit Bay Fish Assemblages for Offshore Surface Water With Salinity 5 to 25 ppt.*

Offshore Surface Water in Skagit Bay, Salinity Greater Than 20ppt

Table 21. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	42.77
herring	37.66
stickle	6.65
Chin(W)	4.88
Chum	2.55
sand	1.51
Chin(H)	1.15
lamp	1.08
sandfish	0.37
u larval fish	0.30
soft	0.24
coho(W)	0.19
pipe	0.17
starry	0.15
U sculp	0.12
pink	0.09
shiner	0.06
gl/pr	0.02
anchovy	0.01
tubes	0.01
U greenling	0.01
lump	0.01
RB1UM	0.01
pile	0.01

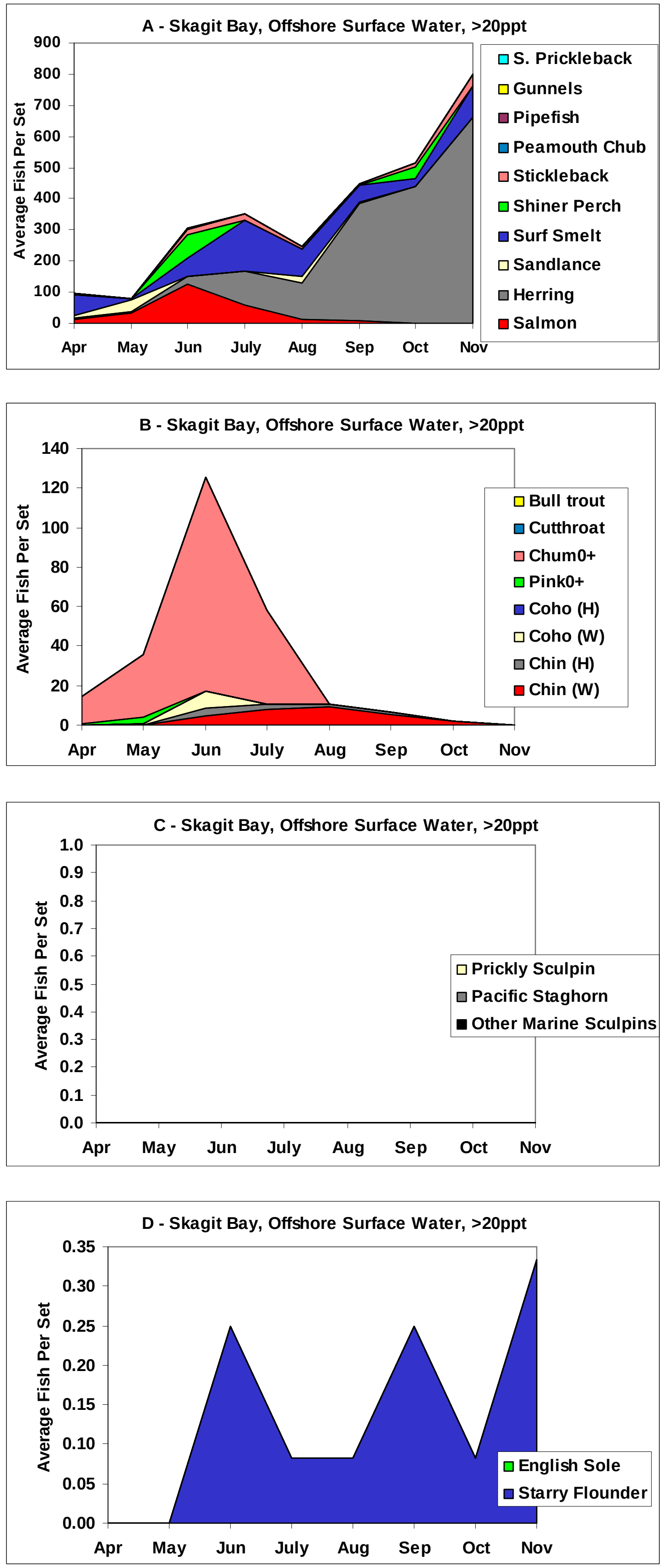

Figure 16. *Skagit Bay Fish Assemblages for Offshore Surface Water With Salinity Greater Than 20ppt.*

Shallow River Distributary Channels in Vegetated Delta Habitat Along Swinomish Channel, Salinity Regime 5-25ppt

Table 22. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	42.88
starry	33.99
shiner	7.63
Chin(W)	5.17
Chum	4.96
english	1.94
gl/pr	1.61
smelt	1.36
stickle	0.33
U sculp	0.13

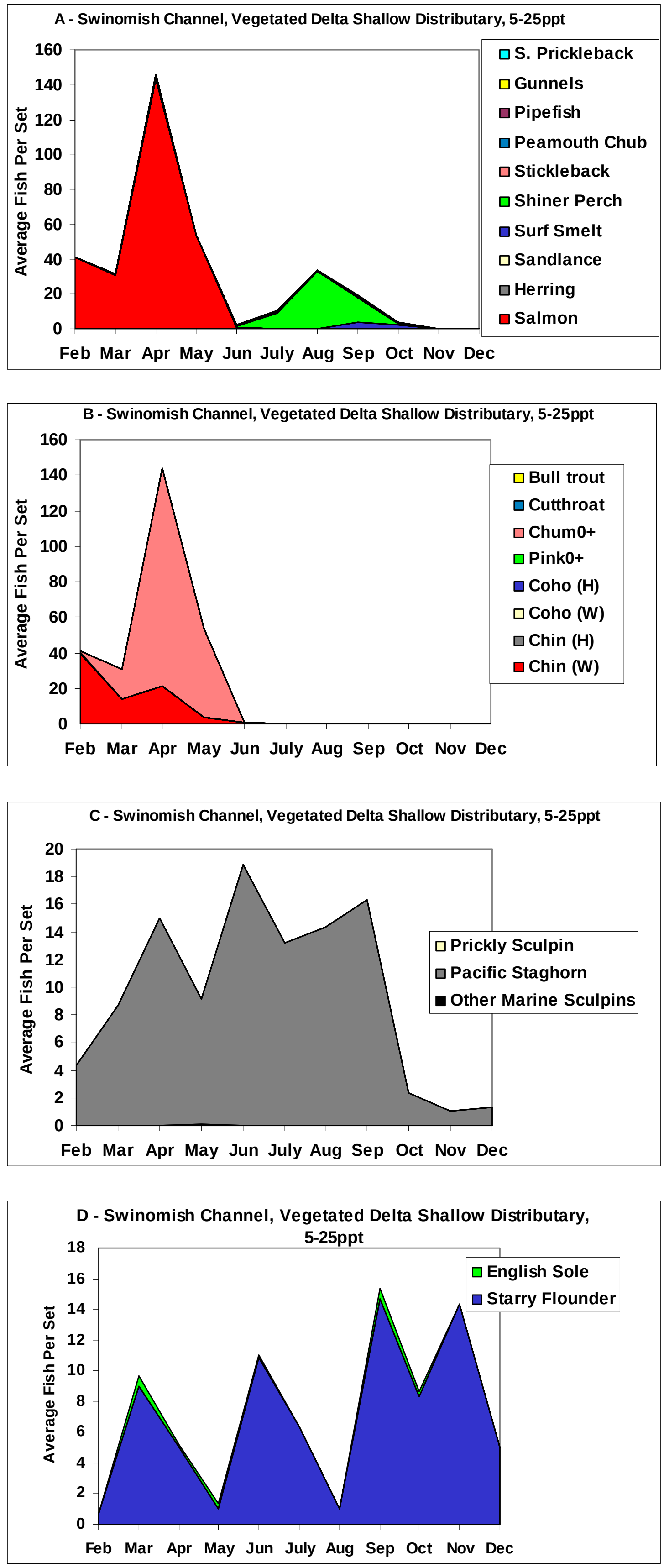

Figure 17. *Swinomish Channel Fish Assemblages for Vegetated Delta Shallow Distributaries With Salinity 5 to 25 ppt.*

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Shallow River Distributary Channels in Vegetated Delta Blind Channel Habitat Along Swinomish Channel, Salinity Regime 5-25ppt

Table 23. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
shiner	47.16
stag	32.98
Chin(W)	5.5
smelt	4.03
starry	3.26
stickle	2.19
gl/pr	1.92
Chum	1.8
sand	0.83
herring	0.2
coho(W)	0.13

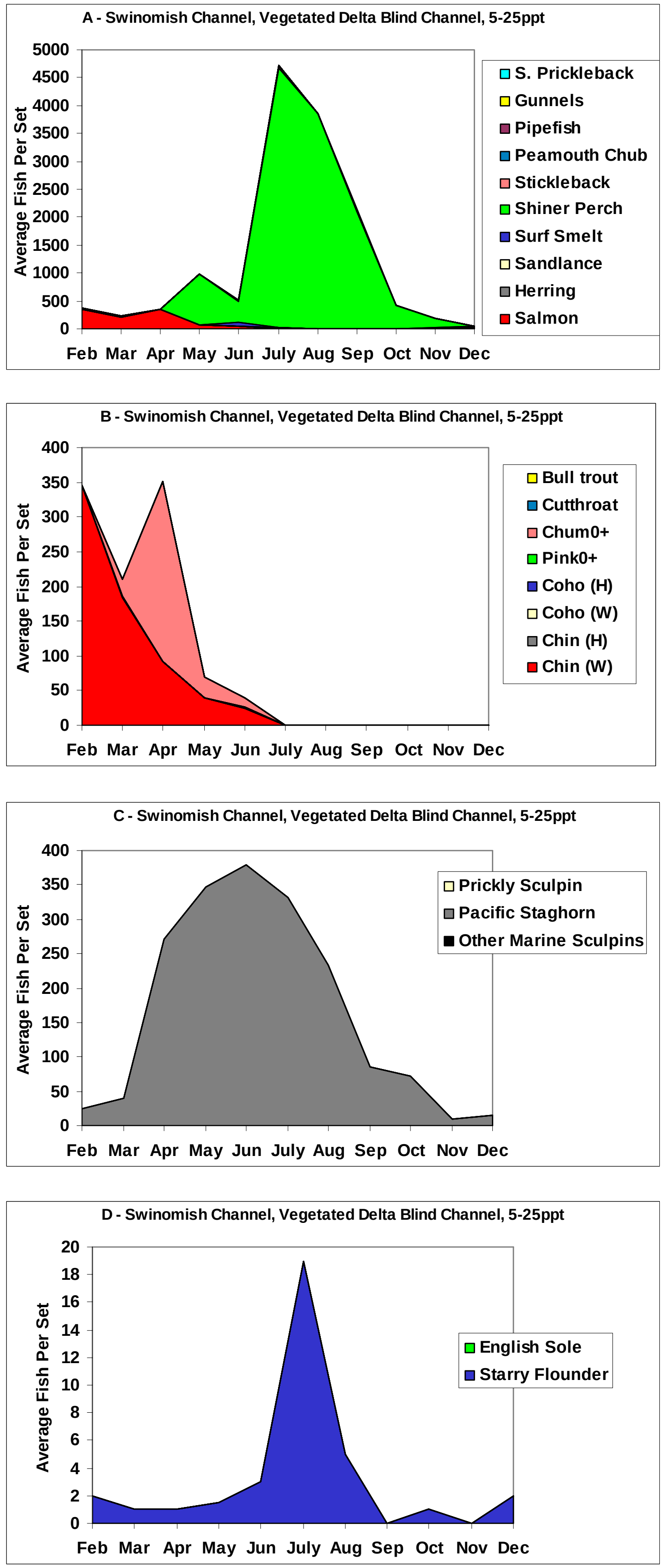

Figure 18. *Swinomish Channel Fish Assemblages for Vegetated Delta Blind Channels With Salinity 5 to 25 ppt.*

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River Distributary Channels in Vegetated Delta Habitat Along Swinomish Channel, Salinity Regime 5-25ppt

Table 24. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
shiner	47.16
stag	32.98
Chin(W)	5.50
smelt	4.03
starry	3.26
stickle	2.19
gl/pr	1.92
Chum	1.80
sand	0.83
herring	0.20
coho(W)	0.13

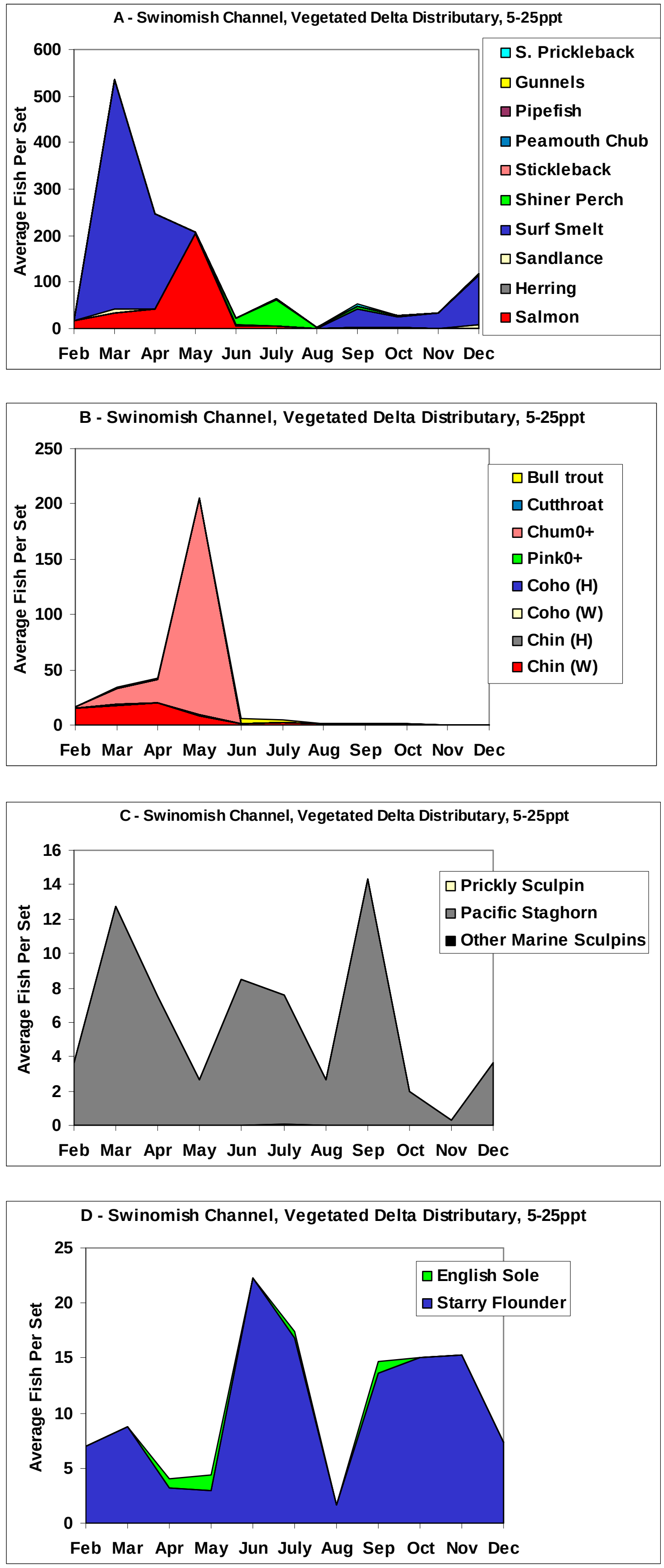

Figure 19. *Swinomish Channel Fish Assemblages for Vegetated Delta Distributaries With Salinity 5 to 25 ppt.*

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Shallow River Distributary Channels in Vegetated Delta Habitat Along Swinomish Channel, Salinity Greater Than 20ppt

Table 25. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	42.23
starry	34.52
smelt	5.98
Chin(W)	5.26
Chum	4.27
shiner	4.14
stickle	2.13
english	1.27
gl/pr	0.2

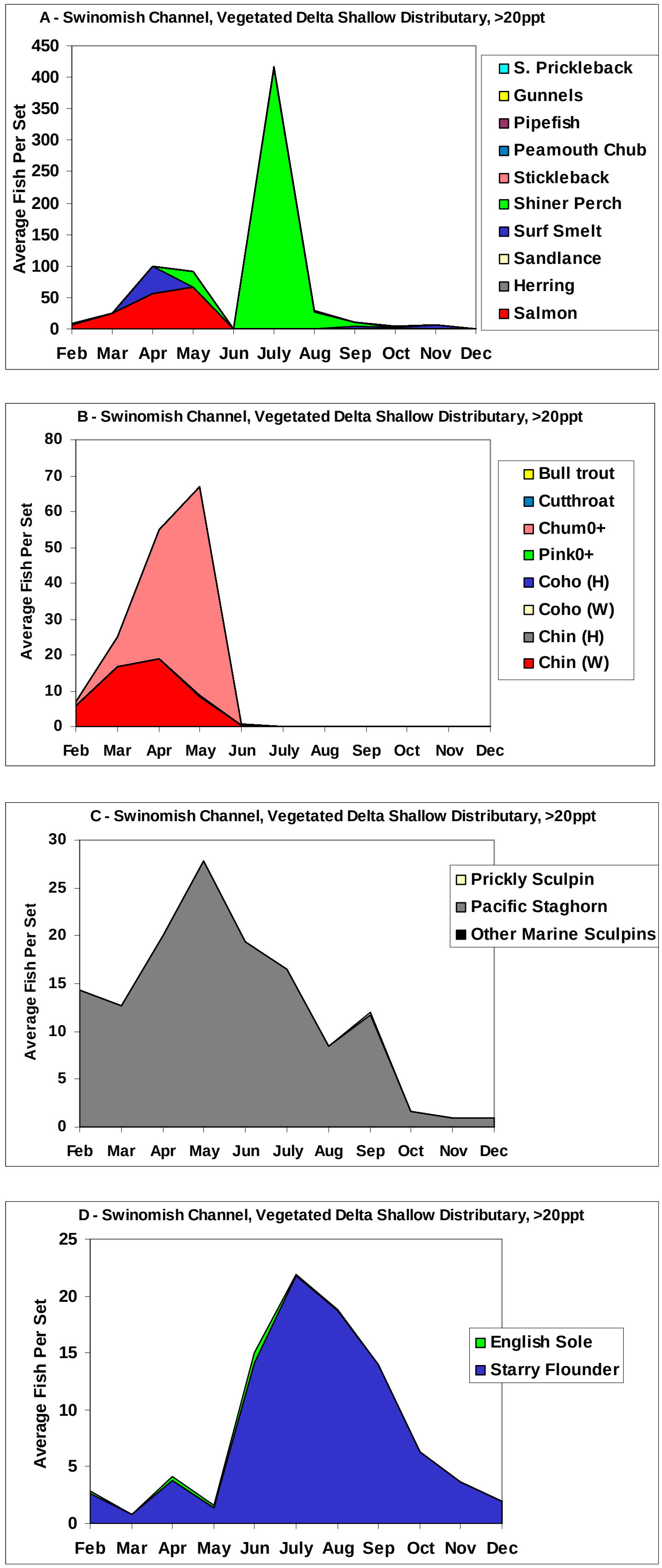

Figure 20. *Swinomish Channel Fish Assemblages for Vegetated Delta Shallow Distributaries With Salinity Greater Than 20ppt.*

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River Distributary Channels in Vegetated Delta Habitat Along Swinomish Channel, Salinity Greater Than 20ppt

Table 26. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stag	42.23
starry	34.52
smelt	5.98
Chin(W)	5.26
Chum	4.27
shiner	4.14
stickle	2.13
english	1.27
gl/pr	0.20

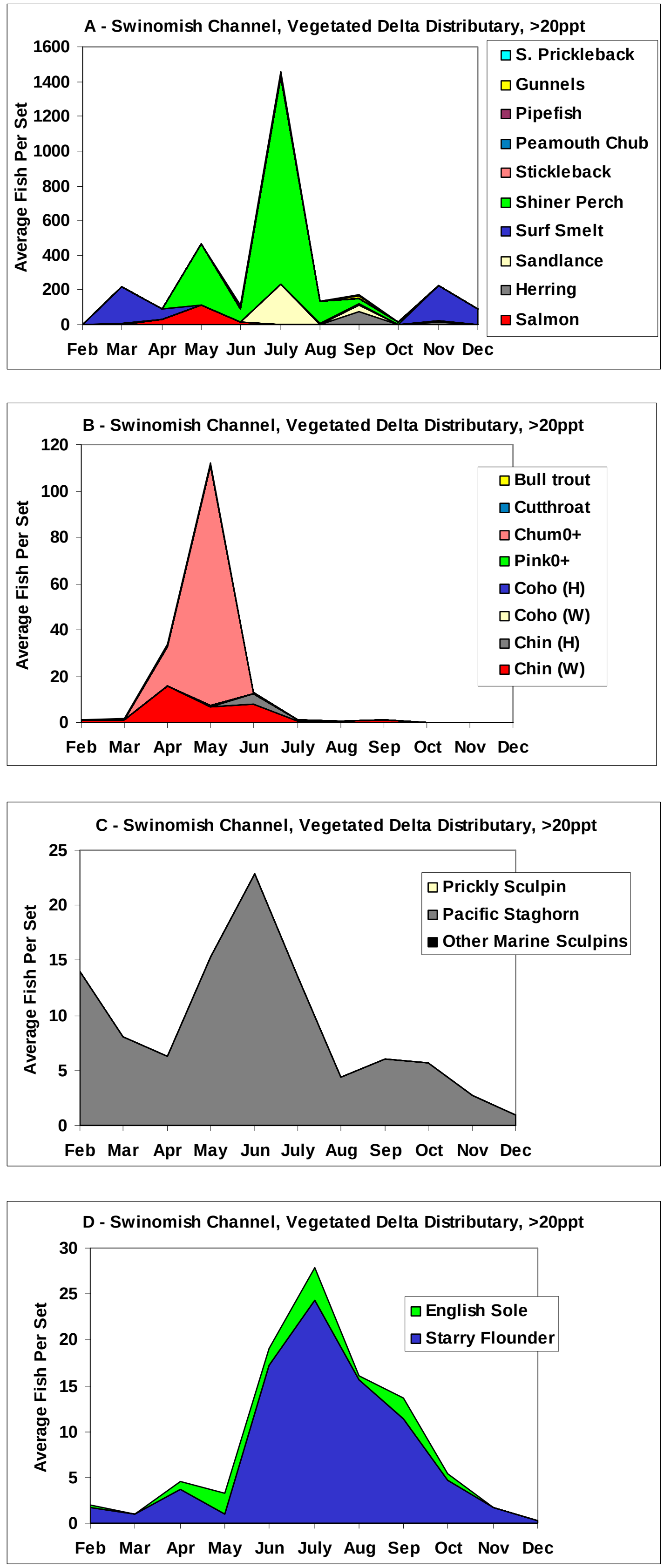

Figure 21. *Swinomish Channel Fish Assemblages for Vegetated Delta Distributaries With Salinity Greater Than 20ppt*

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Shallow Intertidal of Delta Flats in Padilla Bay, Salinity Greater Than 20ppt

Table 27. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
starry	44.04
stag	24.54
smelt	15.40
english	6.03
stickle	4.45
Chin(W)	2.55
shiner	2.16
chum	0.73
pipe	0.11

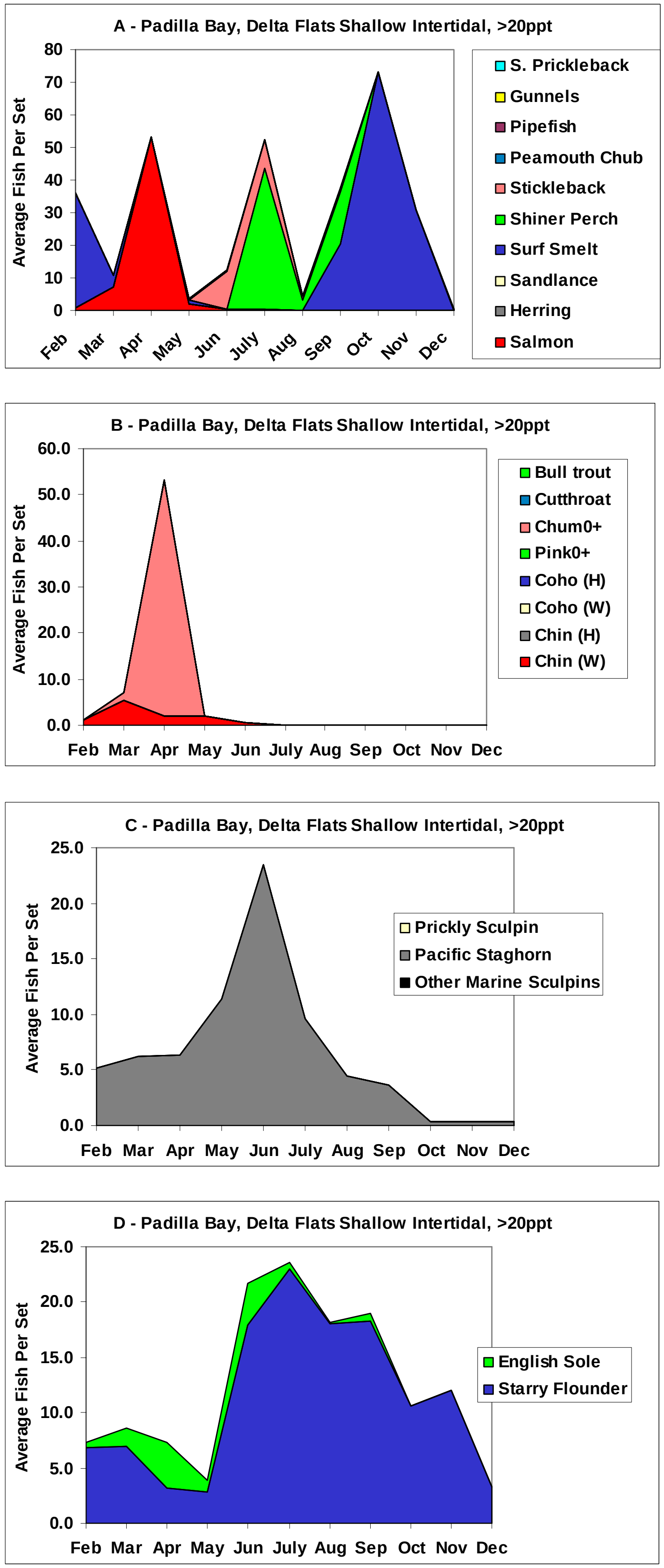

Figure 22. *Padilla Bay Fish Assemblages for the Shallow Intertidal Zone of the Delta Flats With Salinity Greater Than 20ppt.*

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Tidal Blind Channels in Vegetated Delta Habitat in Padilla Bay, Salinity Greater Than 20ppt

Table 28. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stickle	61.12
stag	23.69
shiner	10.16
arrow g	2.76
smelt	1.06
gl/pr	0.98
Chin(W)	0.23

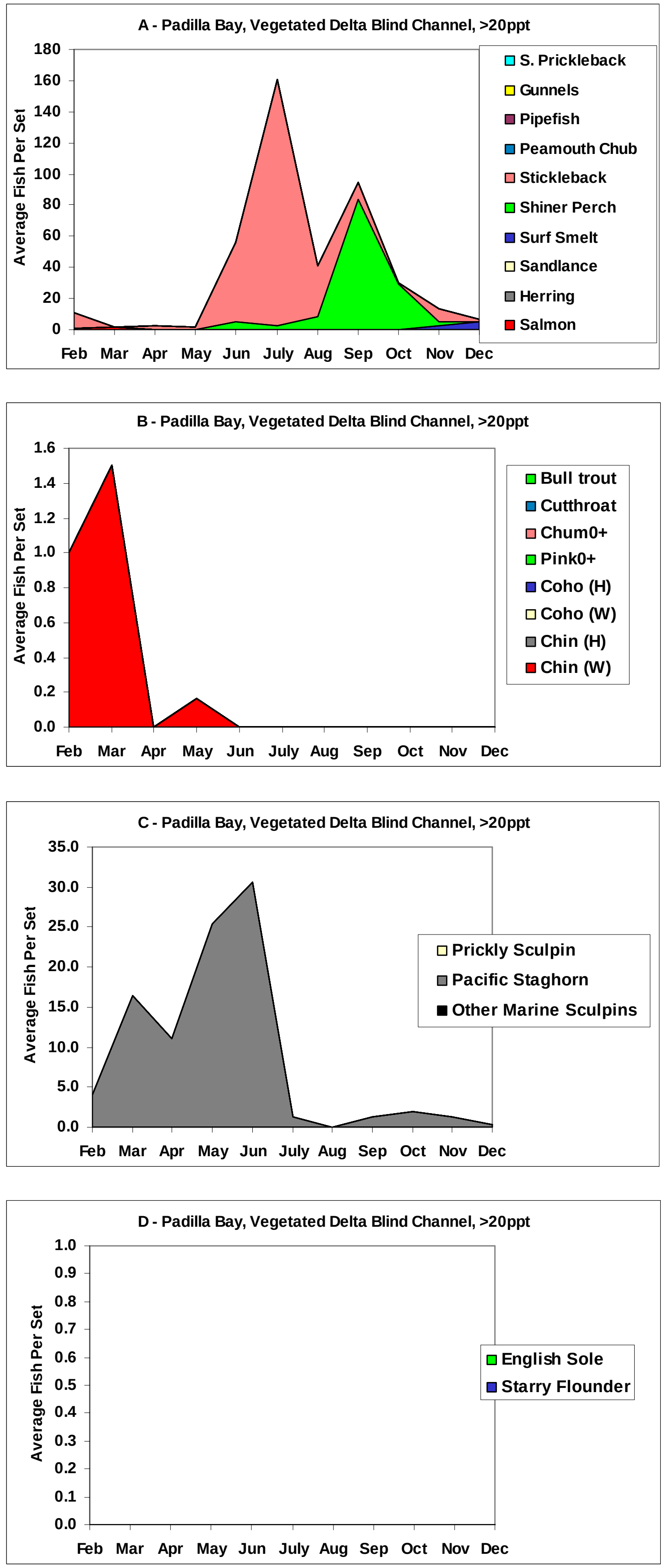

Figure 23. *Padilla Bay Fish Assemblages for Vegetated Delta Blind Channels With Salinity Greater Than 20ppt.*

Subtidal Fringe of Delta Flats in Padilla Bay, Salinity Greater Than 20ppt

Table 29. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
smelt	24.22
starry	16.67
stag	12.88
stickle	11.00
sand	7.71
shiner	6.98
english	6.23
Chin(W)	4.76
pipe	4.22
herring	1.73
gl/pr	1.17
chum	0.99
Chin(H)	0.68
DVBT	0.19
cut/bull 1	0.19
U sculp	0.10
shad	0.08
buffalo	0.07
U flat	0.06
kelp g	0.02
dab	0.02

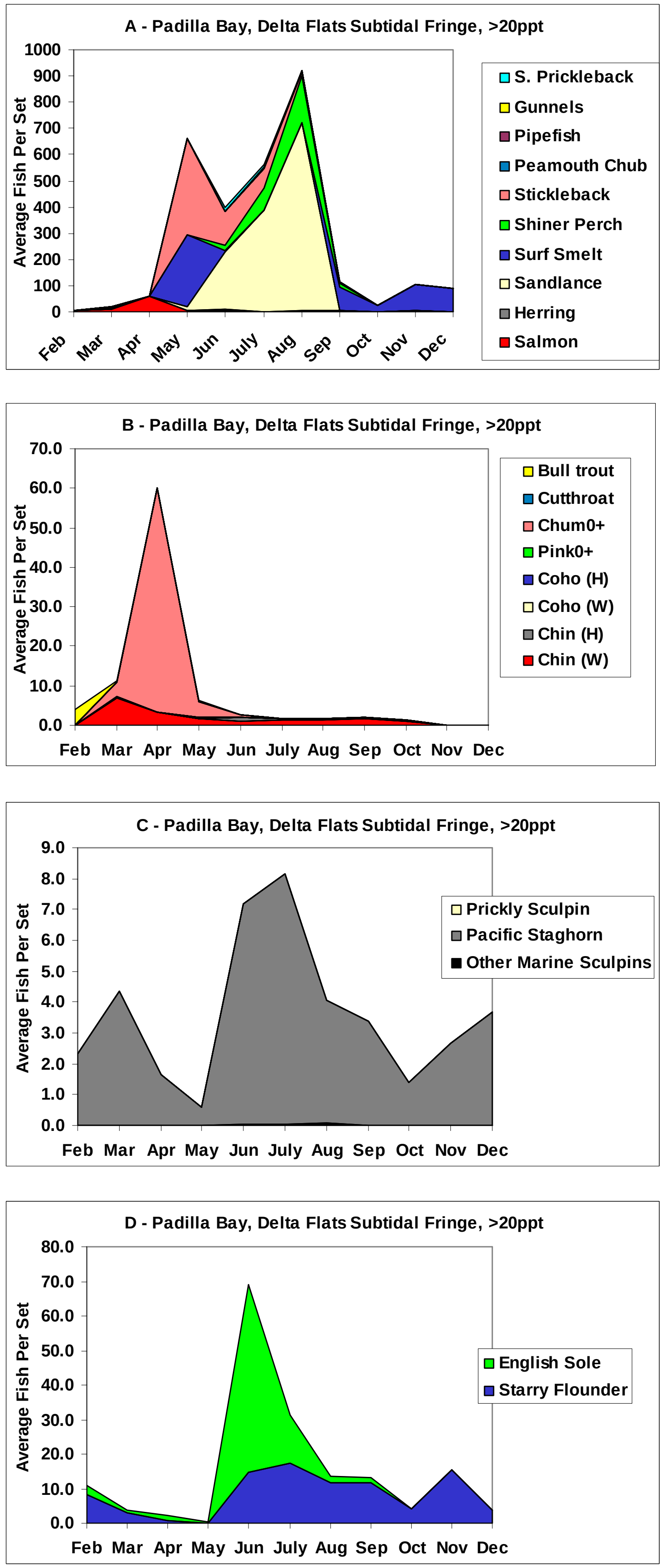

Figure 24. *Padilla Bay Fish Assemblages for Delta Flats Subtidal Fringe With Salinity Greater Than 20ppt.*

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Subtidal Fringe of Padilla Bay Beaches, Salinity Greater Than 20ppt

Table 30. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
shiner	47.93
stickle	14.71
gl/pr	12.15
stag	7.91
pipe	6.62
smelt	4.72
herring	0.99
Chin(W)	0.99
english	0.90
tubes	0.46
U sculp	0.45
chum	0.40
Chin(H)	0.38
kelp g	0.35
U flat	0.31
starry	0.23
sand	0.22
buffalo	0.20
U greenling	0.03
great	0.03
midship	0.01
coho(W)	0.01

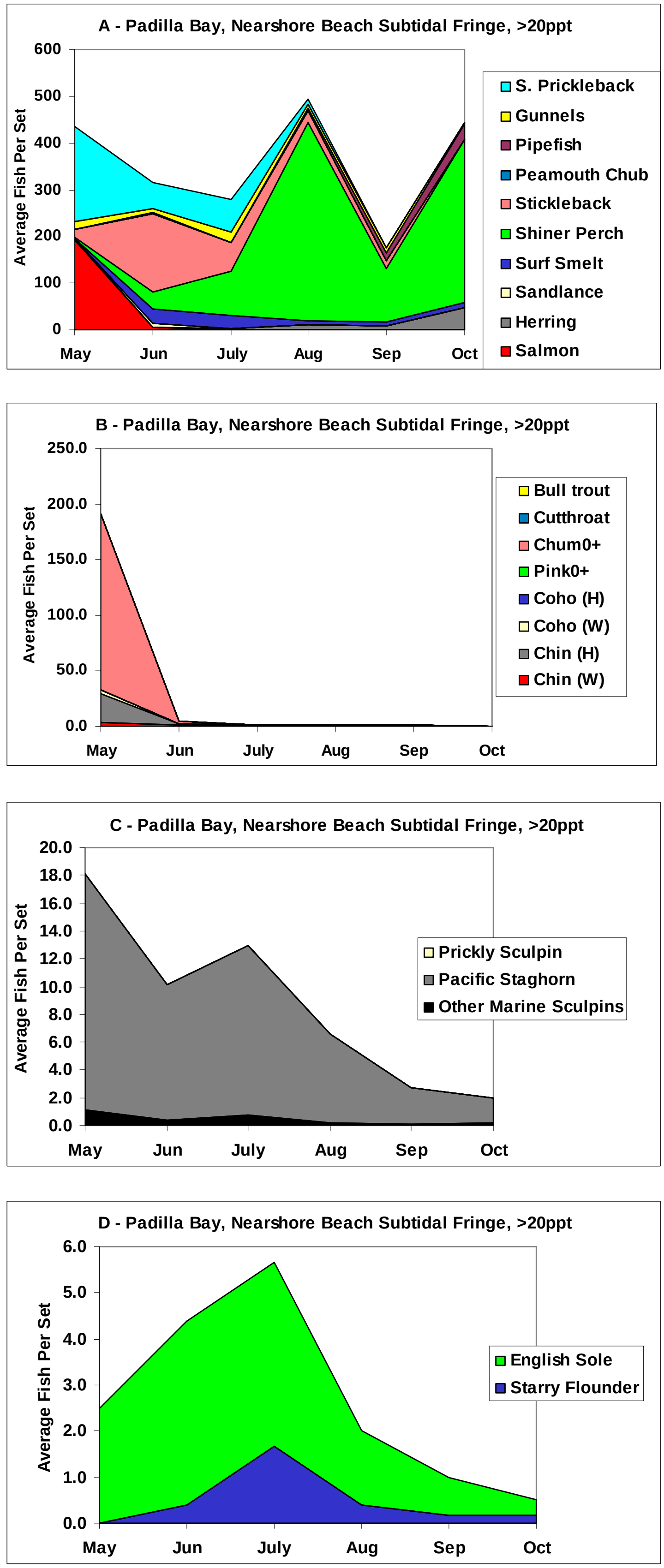

Figure 25. *Padilla Bay Fish Assemblages for the Subtidal Fringe of Nearshore Beaches With Salinity Greater Than 20ppt.*

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Offshore Surface Waters of Padilla Bay, Salinity Greater Than 20ppt

Table 31. Percent contribution of taxa to overall fish assemblage similarity. SIMPER test based on relative abundance, all months combined.

Taxon	Similarity % Contribution
stickle	53.31
herring	19.04
smelt	11.74
sand	7.18
Chin(W)	4.52
chum	1.64
Chin(H)	1.35
pipe	0.38
u larval fish	0.33
shiner	0.14
anchovy	0.09
striped	0.07
starry	0.06
sandfish	0.05
U flat	0.03
coho(W)	0.02
gl/pr	0.02
lamp	0.01

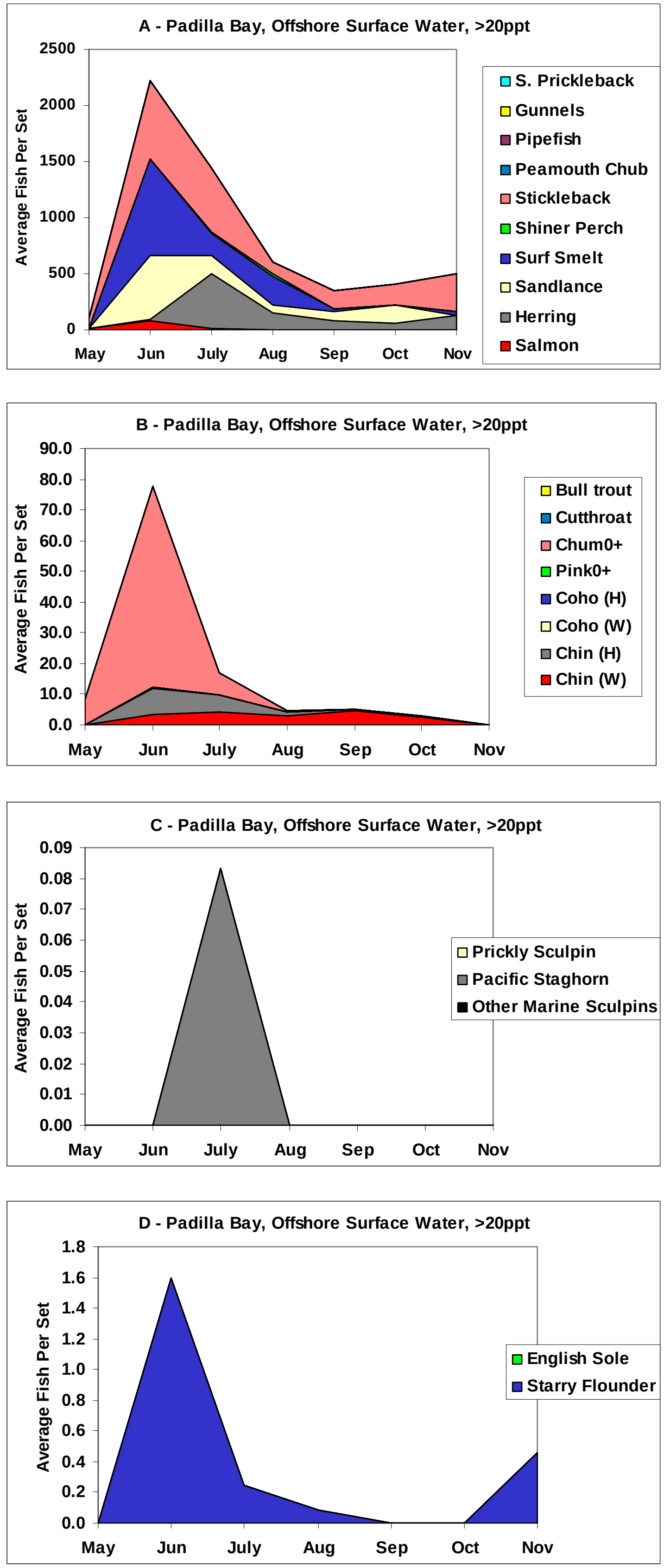

Figure 26. *Padilla Bay Fish Assemblages for Offshore Surface Waters With Salinity Greater Than 20ppt.*

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Juvenile Chinook salmon abundance

Juvenile Chinook salmon originating from the Skagit River must traverse distributary channels and unvegetated delta flats before entering Skagit Bay proper. We know some of these fish take up residence within the vegetated part of the delta often entering blind tidal channels when flooded (Beamer et al., 2005; Beamer and Larsen 2004). Juvenile Chinook salmon after moving through the unvegetated delta flats end up somewhere within Skagit Bay. The general pattern for early migrating fish shows them to be strongly shoreline oriented and accumulate within pocket estuaries (Beamer et al., 2003). Later in the year (starting in June), juvenile Chinook salmon move progressively more offshore to deeper habitats.

Many of the same habitats occurring within Skagit Bay also occur within Swinomish Channel and Padilla Bay. We compared juvenile Chinook salmon abundance to determine whether differences exist within Skagit Bay, Swinomish Channel, and Padilla Bay where we have data from the same habitat types. Results for unmarked (wild) and marked (hatchery) juvenile Chinook salmon are shown in Figures 28 and 29, respectively.

The overall seasonal pattern of juvenile Chinook abundance across habitat types is similar to what has been observed in previous years in the Skagit River estuary (Beamer et al. in prep): a general downstream and offshore transition over time with declining densities, presumably as a result of mortality, migration, and increased area of habitat. One exception to this is the pattern observed in pocket estuaries, where early fry migrants begin to appear in winter, often in relatively high densities. Differences between marked and unmarked fish are also generally similar to previous observations in the Skagit system, with increasing relative abundance of marked fish with distance downstream and offshore, and more protracted temporal distributions in unmarked fish (Beamer et al. in prep., Rice 2007). The shape of seasonal abundance curves in Skagit and Padilla Bays are generally similar but the Skagit system tends to have higher densities. The main differences in temporal patterns (e.g., early appearance of wild fish in the Skagit, and the presence of marked fish in delta habitats in the Skagit but not in Padilla Bay) are likely explained by the presence of the river (a source of fish) in one system but not the other.

Results of statistical significance tests on between-area differences in densities of unmarked, marked, and total Chinook by habitat (Table 31) are consistent with the graphical analysis. It is important to note that these test results are incomplete and conservative because of limited availability of matching samples from the different habitats and sampling dates, and low statistical power resulting from small sample sizes and high variability.

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Unmarked Chinook Salmon

Vegetated delta blind channel (Fig 28A): Strong area to area differences over the entire season. Other than a fry migrant signal (February) in Swinomish Channel that is comparable to the Skagit, there are many fewer fish. The order of abundance is Skagit>Swinomish>Padilla.

Vegetated delta shallow distributary (Fig 28B): Strong area to area differences over the entire season. Other than February, juvenile Chinook density in the Skagit is always greater than Swinomish Channel. We have no data for Padilla Bay shallow distributary channel because none are currently connected to the Skagit River (or any other Chinook bearing river).

Delta Flats shallow intertidal (Fig 28C): There did not appear to be a strong difference between Skagit and Padilla Bays for this habitat type. No delta flats habitat are associated with Swinomish Channel which is a historic delta distributary complex.

Nearshore beach (Fig 28D): Strong area to area differences over the entire season. We have no nearshore beach data for Swinomish Channel which is a historic delta distributary complex.

Offshore Surface Water (Fig 28E): Not strong area to area differences over the entire season. There may be more fish in the Skagit during August and September, and more fish in Padilla during June. Swinomish Channel does not have offshore surface water habitat.

Marked Chinook Salmon

Our results show very few hatchery Chinook go into blind channels anywhere in the study area compared to wild Chinook (Figs 28A and 29A). However, Skagit vegetated delta blind channel habitat had higher densities of hatchery Chinook than blind channels in the other areas (Fig 29A), logically because hatchery Chinook are released into the Skagit, and not directly into Swinomish Channel or Padilla Bay.

There are more hatchery Chinook in Skagit shallow distributary channel than in Swinomish Channel shallow distributary channel habitat (Fig 29B). We have no data for Padilla Bay shallow distributary channel because none are currently connected to the Skagit River (or any other Chinook bearing river).

Hatchery Chinook were only encountered in shallow intertidal habitat of delta flats within Skagit Bay (Fig 29C), abruptly appearing in May and June. Similar timing of hatchery Chinook was apparent for nearshore habitat in Skagit Bay and to a lesser degree in Padilla Bay (Fig 29D).

High catches of marked Chinook were found in offshore habitat of Padilla Bay (Fig 29E), peaking in June and rapidly declining through the summer. Lower densities of hatchery Chinook were found in Skagit Bay compared to Padilla Bay, but they peaked in August and generally had a more protracted timing curve.

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Table 32. Summary of statistically significant ($p \leq 0.05$, ANOVA) differences between Skagit Bay, Padilla Bay, and Swinomish Channel habitats in densities (fish/hectare) unmarked (UM), marked (M), and total (T) juvenile Chinook.

Habitat	Month	Area Comparisons
Vegetated Delta Blind Channel		Skagit vs. Padilla Differerences
	March	U, T
	April	U, T
	May	U, T
		Skagit vs. Swin. Differerences
	March	
	April	
	May	
		Padilla vs. Swin Differences
	March	U, T
	April	U, T
	May	U, T
Vegetated Delta Distributary Channel		Skagit vs. Swin Differerences
	February	
	March	
	April	U, T
	May	U, T
	June	U, T
	July	U, T
	August	U, T
Delta Flats Shallow Intertidal		Skagit vs. Padilla Differences
	March	U, T
	April	U, T
	May	U, T
	June	
	July	
	August	
	September	
	October	
	November	
Nearshore Beach Subtidal Fringe		
	May	M
	June	U
	July	U
	August	
	September	
	October	
Offshore Surface Water		
	May	
	June	M, T
	July	
	August	U, T
	September	
	October	
	November	

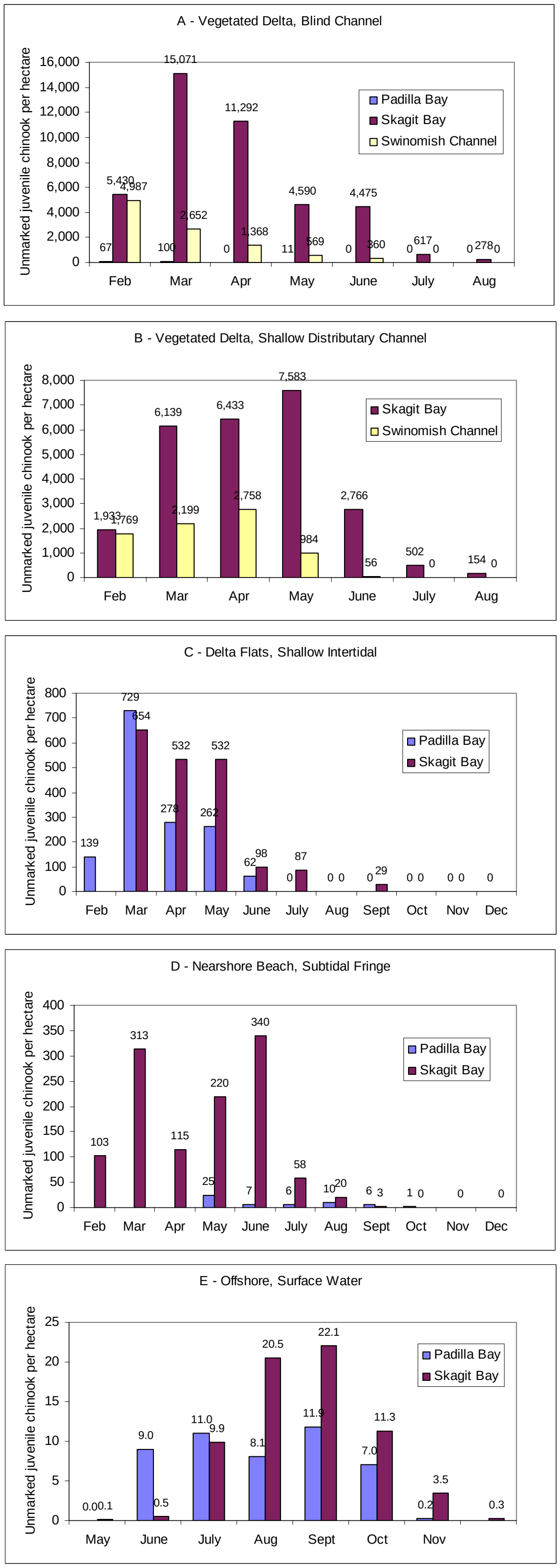

Figure 28. Comparison of unmarked (wild) juvenile Chinook salmon by area. Average values shown above bars.

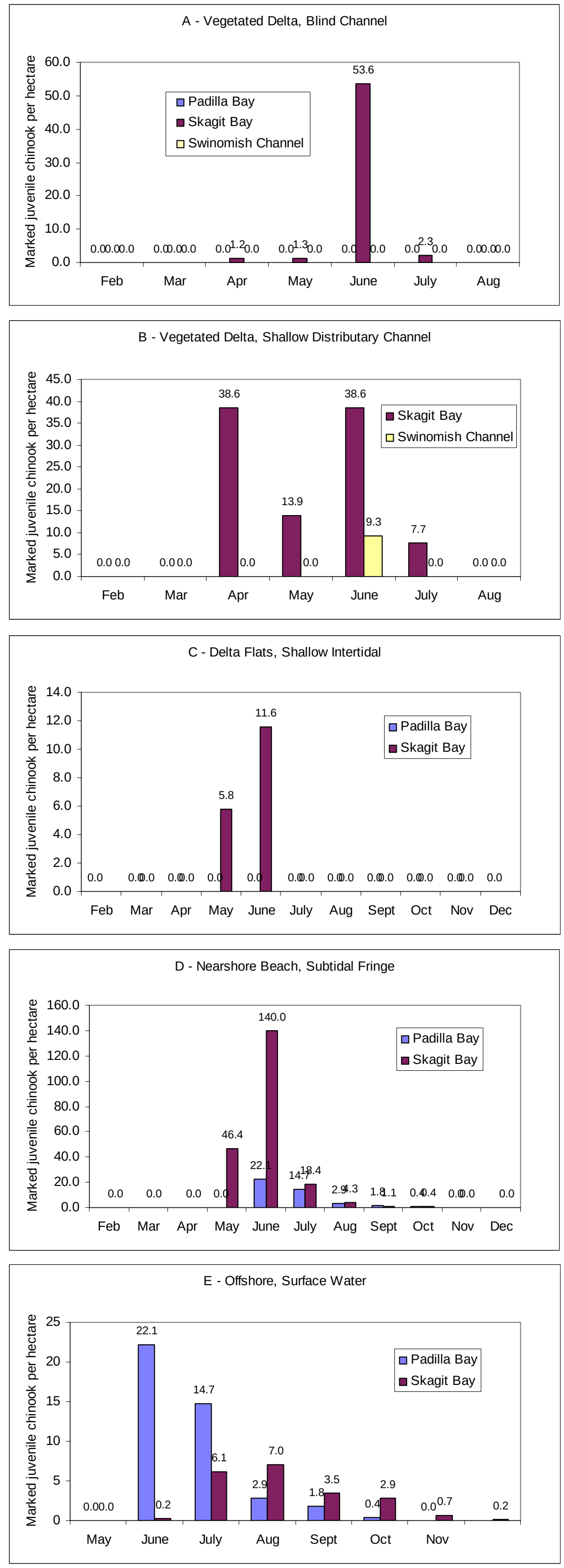

Figure 29. Comparison of marked (hatchery) juvenile Chinook salmon by area. Average values are shown above bars.

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Size of juvenile Chinook salmon

Lengths of juvenile Chinook over time and by habitat type were generally similar to those observed in previous work in the Skagit River estuary and elsewhere (Duffy et al. 2005, Fresh et al. 2006, Rice 2007, Beamer et al. in prep). Small (approximately 45 mm) subyearlings begin to appear in winter and little mean increase in size is observed until April and May, when a steady increase occurs as fish have benefited from several months of rearing (Figures 31). Marked (hatchery) fish are not typically present at smaller sizes (e.g. < 70mm) because of hatchery practices, and on average are larger than the unmarked fish in all habitats when the two co-occur (Figures 35-43). Area (e.g., Skagit vs. Padilla Bay) appears to have little or no effect on size as the habitats show similar sizes regardless of area.

Overall, mean length increases with downstream, seaward transition through habitats (Figure 30), and time (Figures 31-43). One exception to this is the abrupt increase in mean length that occurs in some estuarine habitats (especially offshore surface waters) in spring (e.g., Figures 31 and 39) caused by the migration of yearlings. Yearling migrants generally show up in April or May as much larger fish (>100 mm). Another exception is the relatively small size of fish in pocket estuaries (Figures 30, 31, and 37), habitats that are typically farther "downstream" of the delta habitats. Pocket estuaries are only occupied by subyearling Chinook early in the estuarine rearing period (February through May). For the 2003 outmigration, delta rearing significantly diminished by May (Figure 28A).The size of Chinook salmon within pocket estuary habitat tracks the size of fish rearing in blind channels within the vegetated delta over that same period (February – May). After May, fish in the delta were larger probably because of downstream migrating parr which had reared in freshwater habitats for several months, whereas the few remaining fish using pocket estuaries were smaller compared to fish from all other areas after May.

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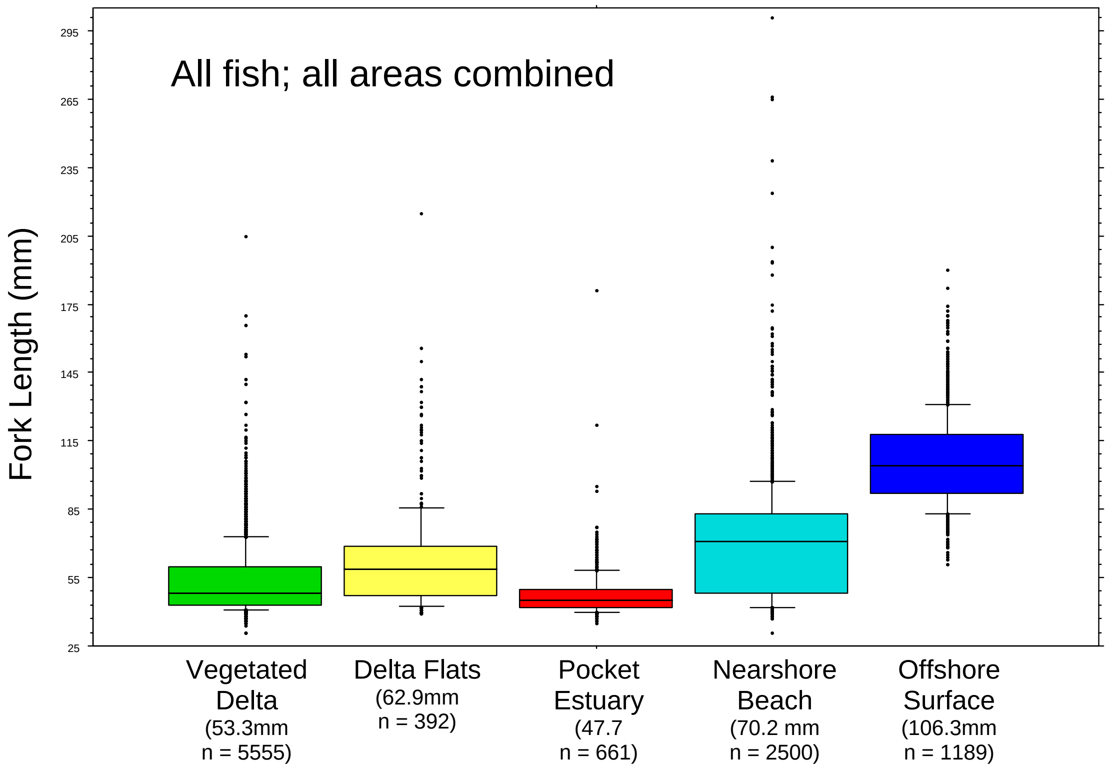

Figure 30. Lengths of all Chinook measured in Skagit Bay, Padilla Bay, and Swinomish Channel sites in 2003. All gear types within each habitat type combined. Boxplots show 5^{th}, 25^{th}, 50^{th}, 75th, and 95th percentiles. Mean lengths and sample sizes in parentheses.

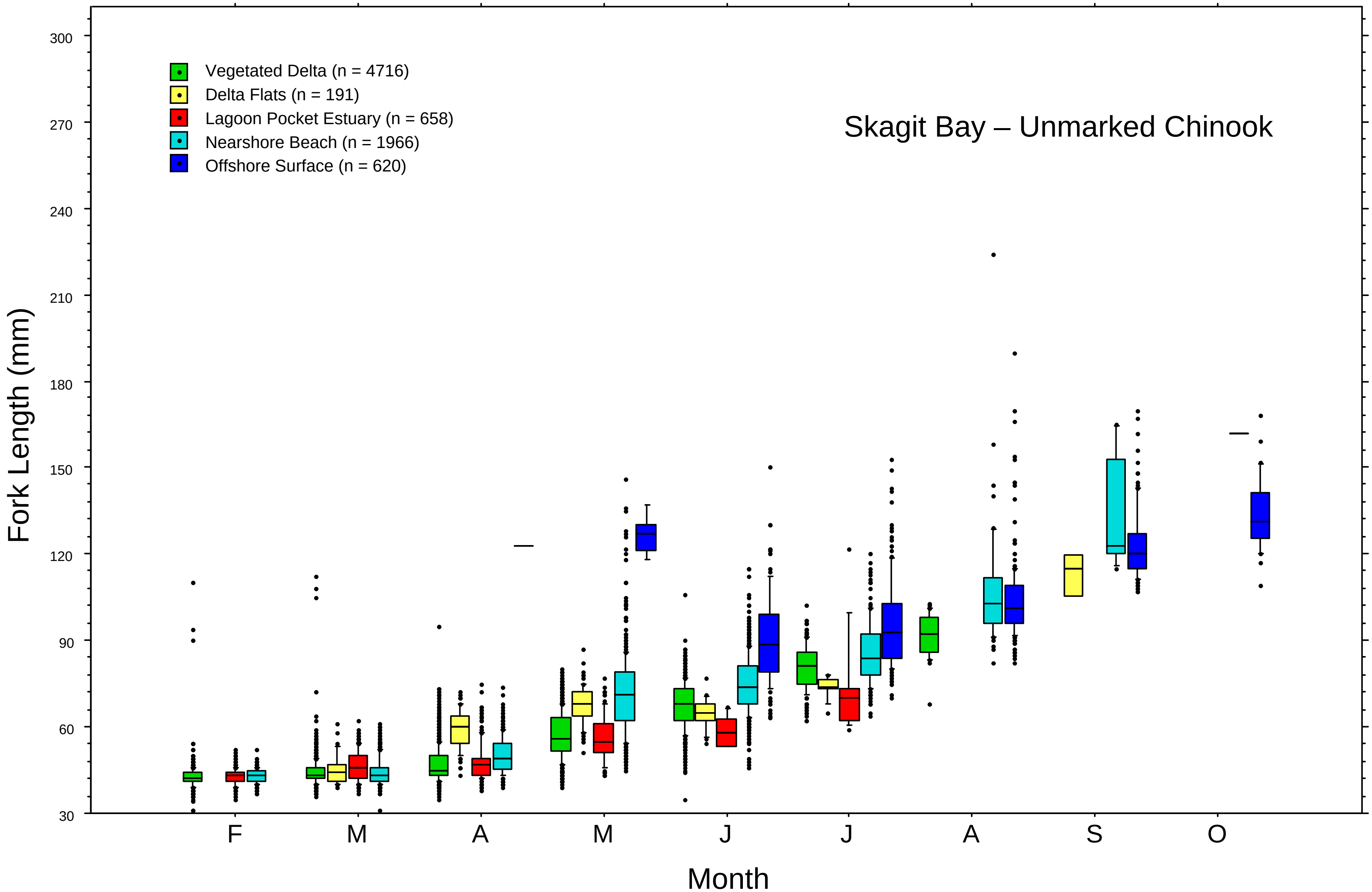

Figure 31. Lengths of all unmarked Chinook in measured in Skagit Bay in 2003. All gear types within each habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

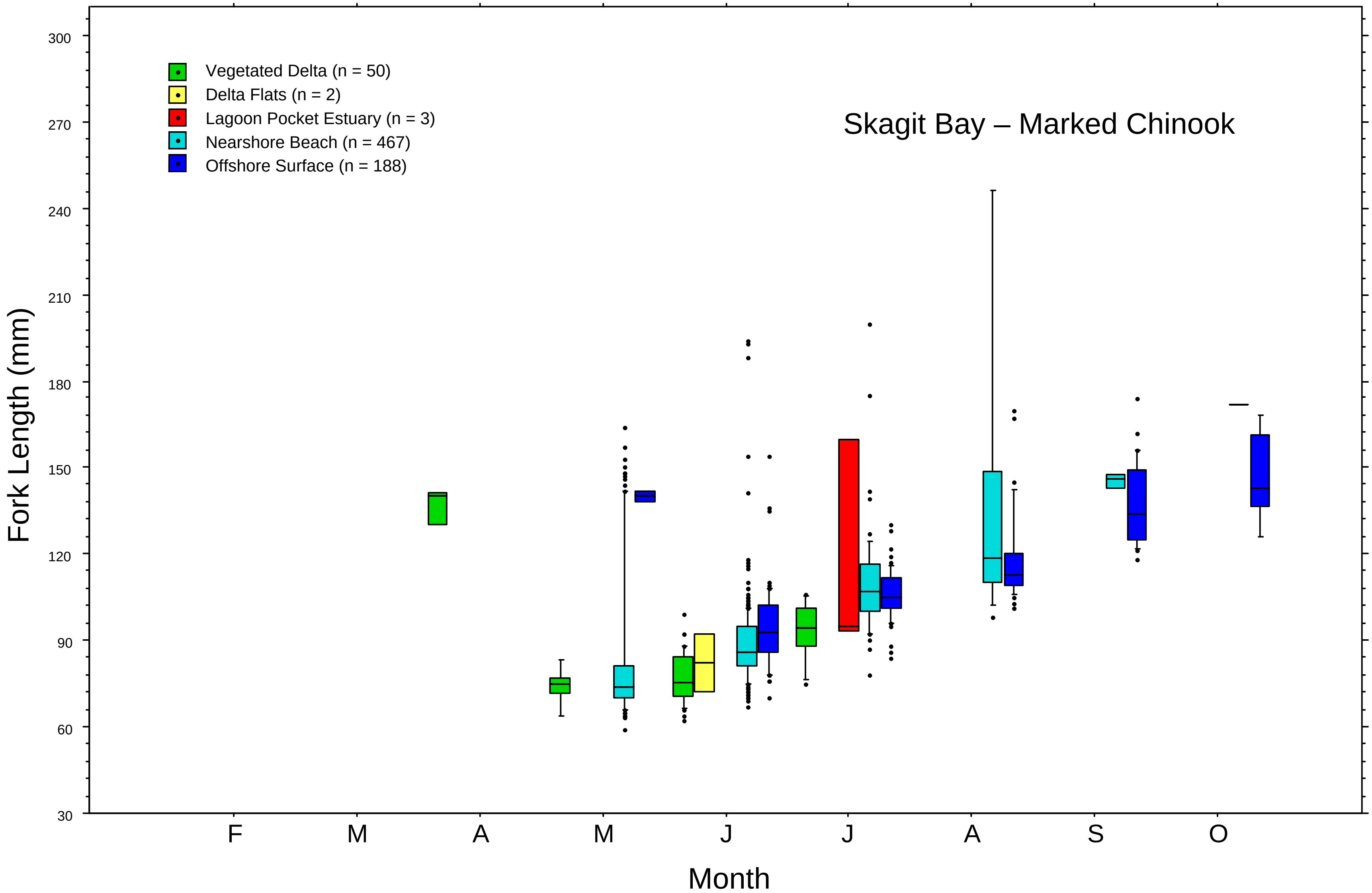

Figure 32. Lengths of all marked Chinook in measured in Skagit Bay in 2003. All gear types within each habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

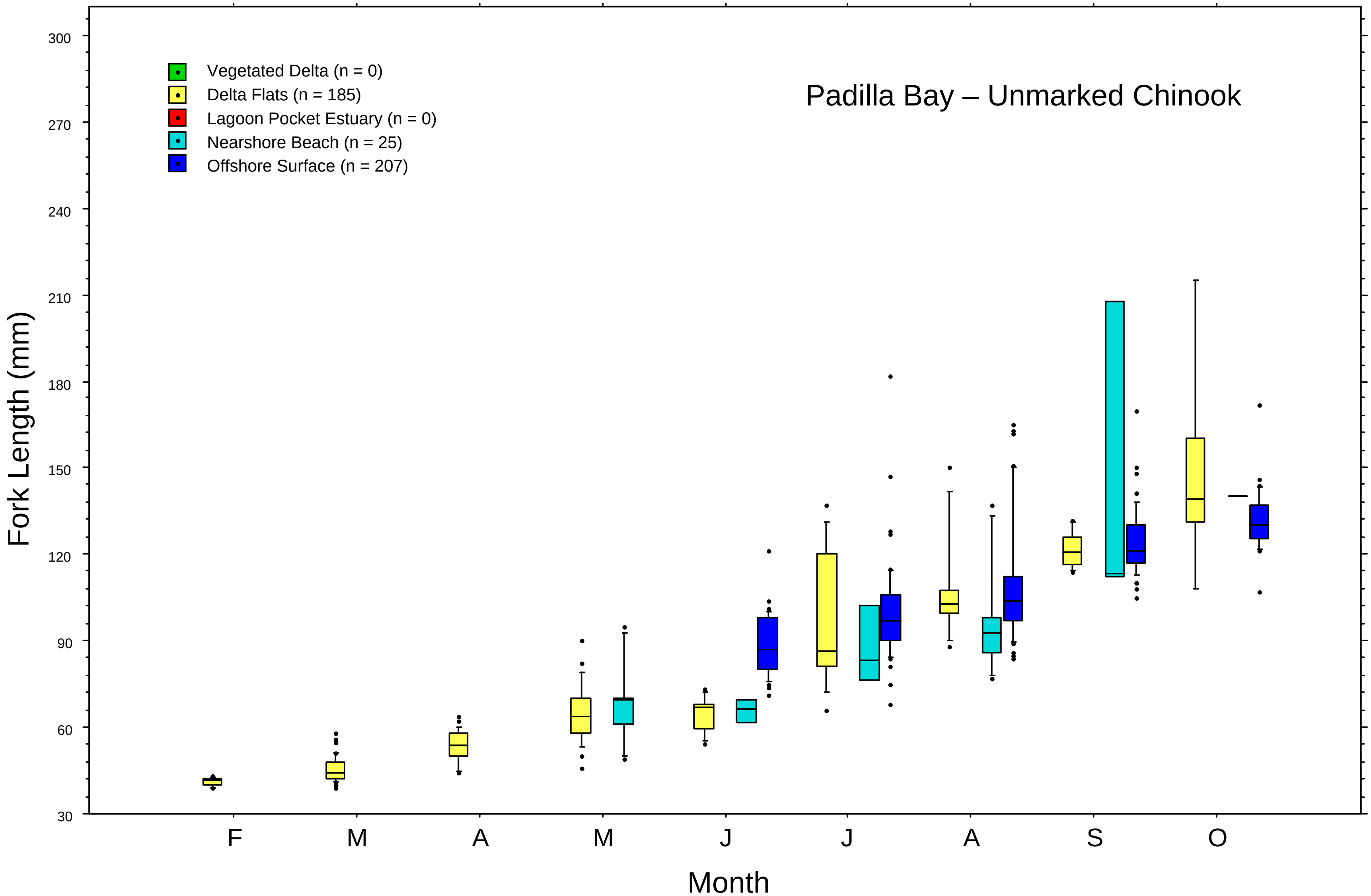

Figure 33. Lengths of all unmarked Chinook in measured in Padilla Bay in 2003. All gear types within each habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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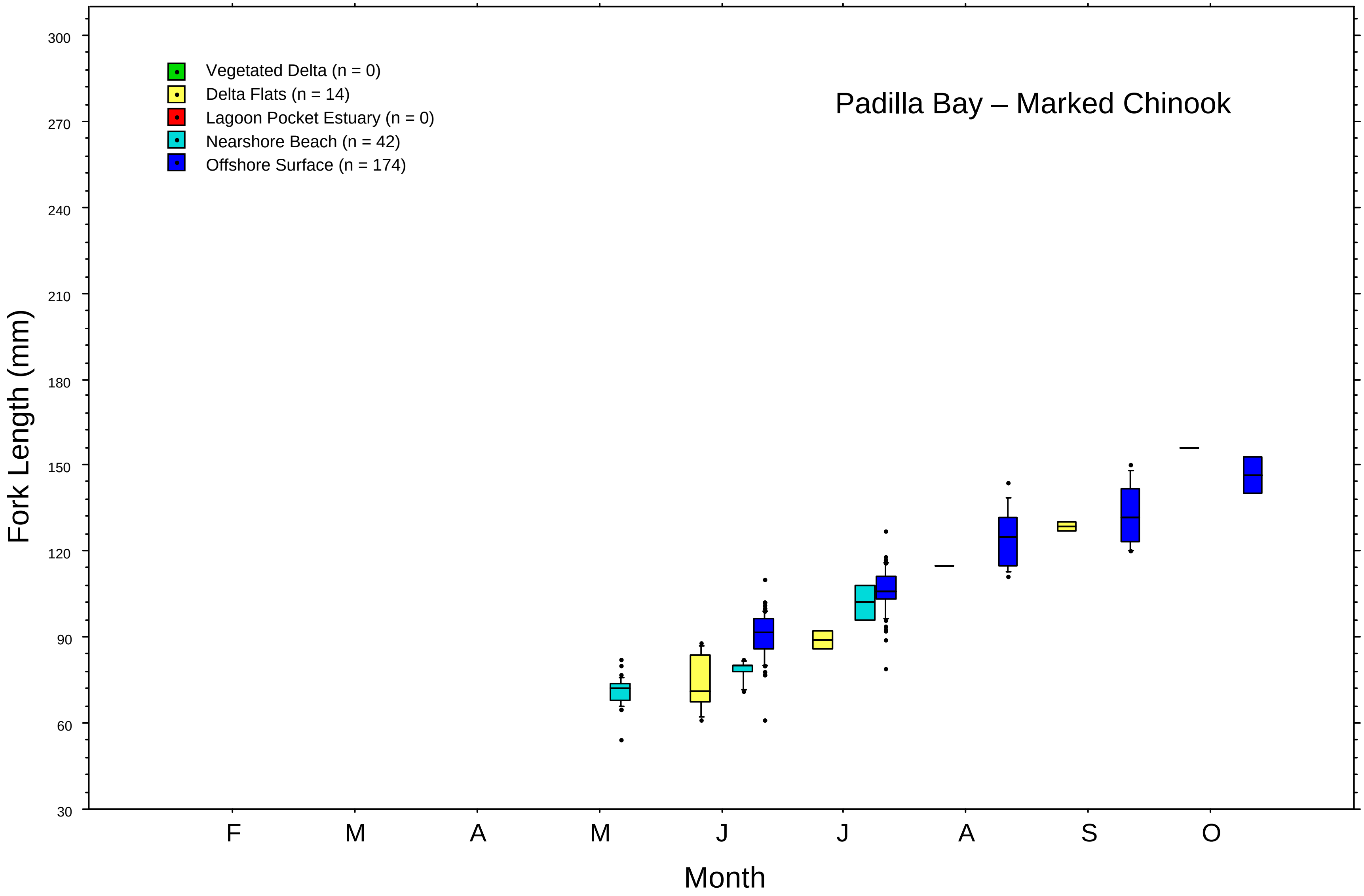

Figure 34. Lengths of all marked Chinook in measured in Padilla Bay in 2003. All gear types within each habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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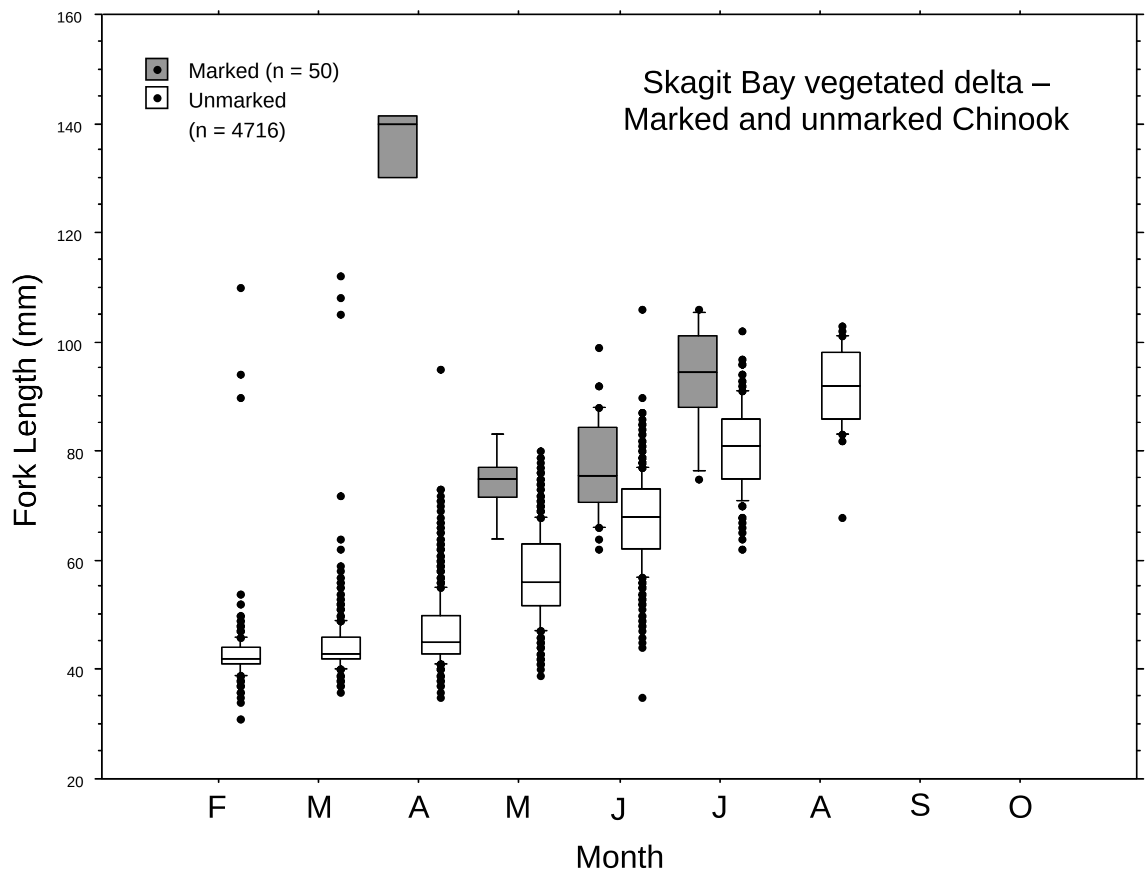

Figure 35. Lengths of all marked and unmarked Chinook captured in vegetated delta habitats in Skagit Bay in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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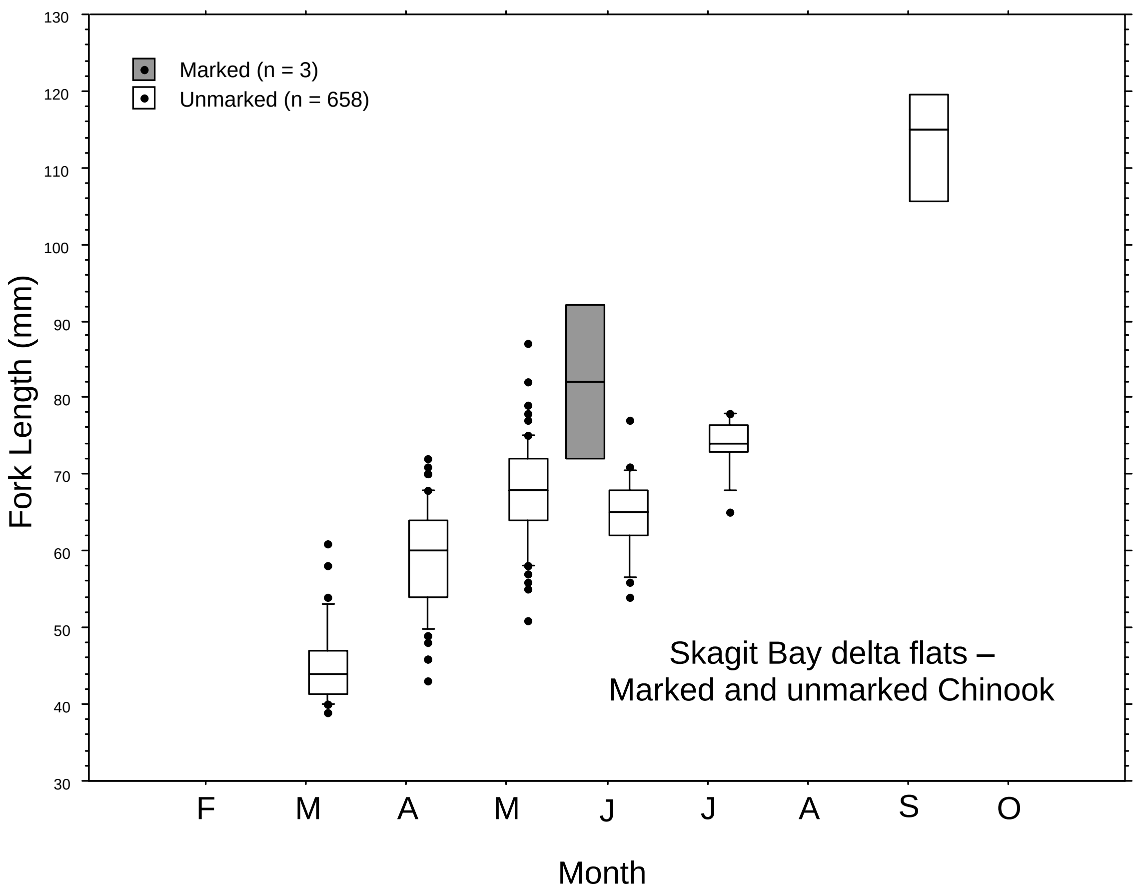

Figure 36. Lengths of all marked and unmarked Chinook captured in Skagit Bay delta flat habitats in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

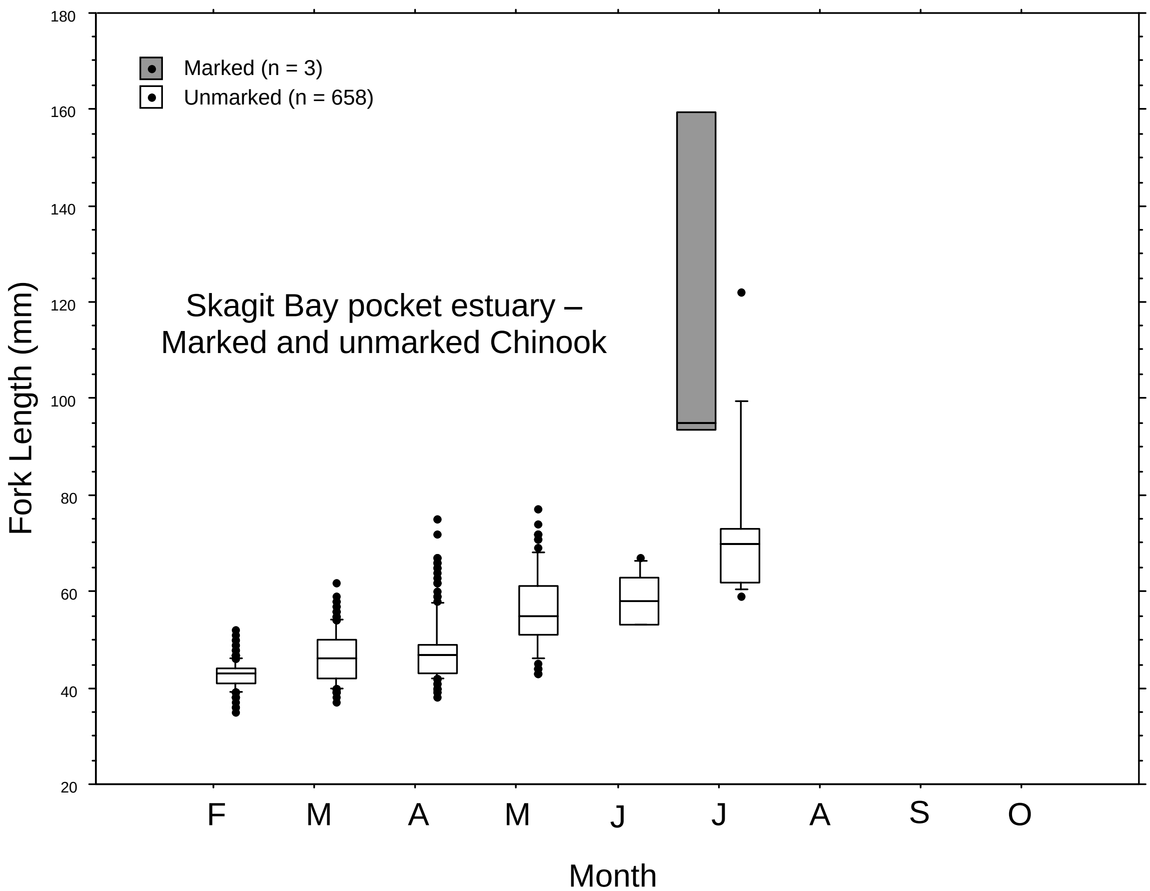

Figure 37. Lengths of all marked and unmarked Chinook captured in Skagit Bay pocket estuary habitats in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

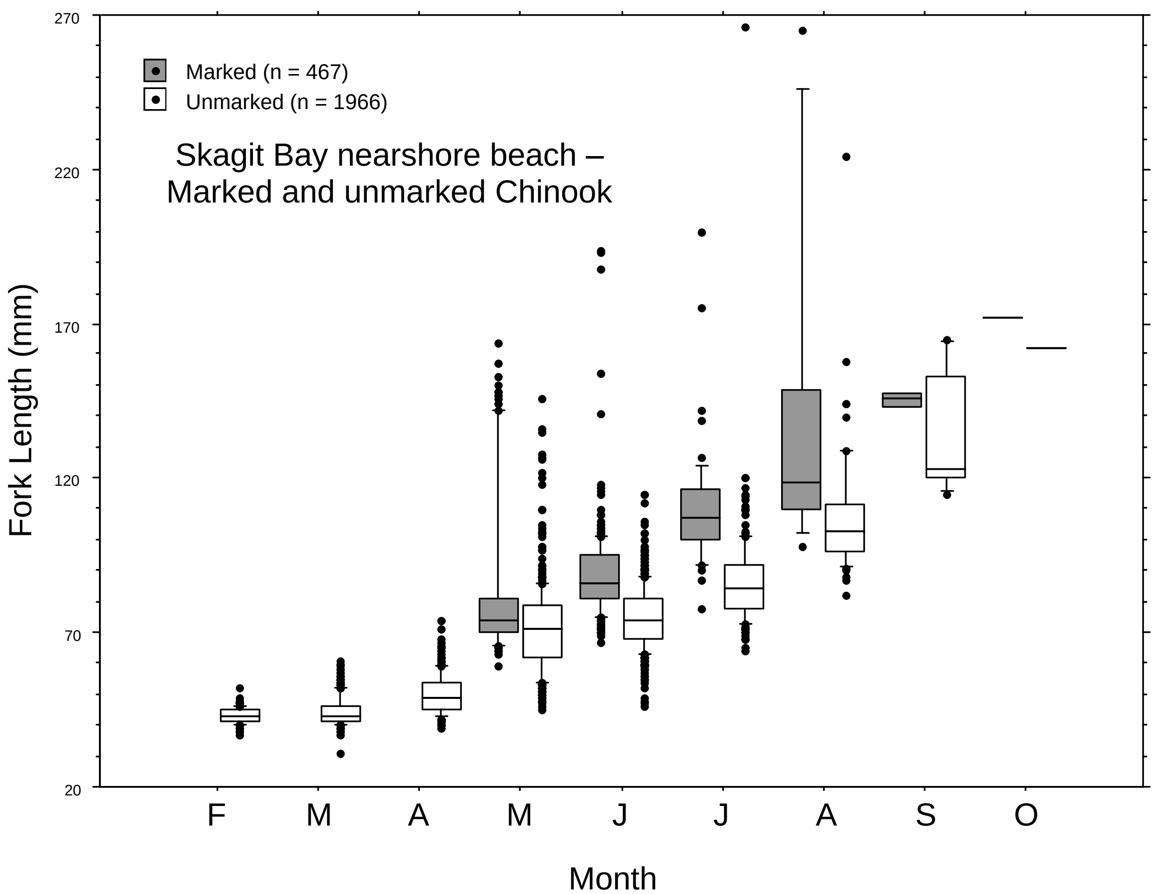

Figure 38. Lengths of all marked and unmarked Chinook captured in nearshore beach habitats in Skagit Bay in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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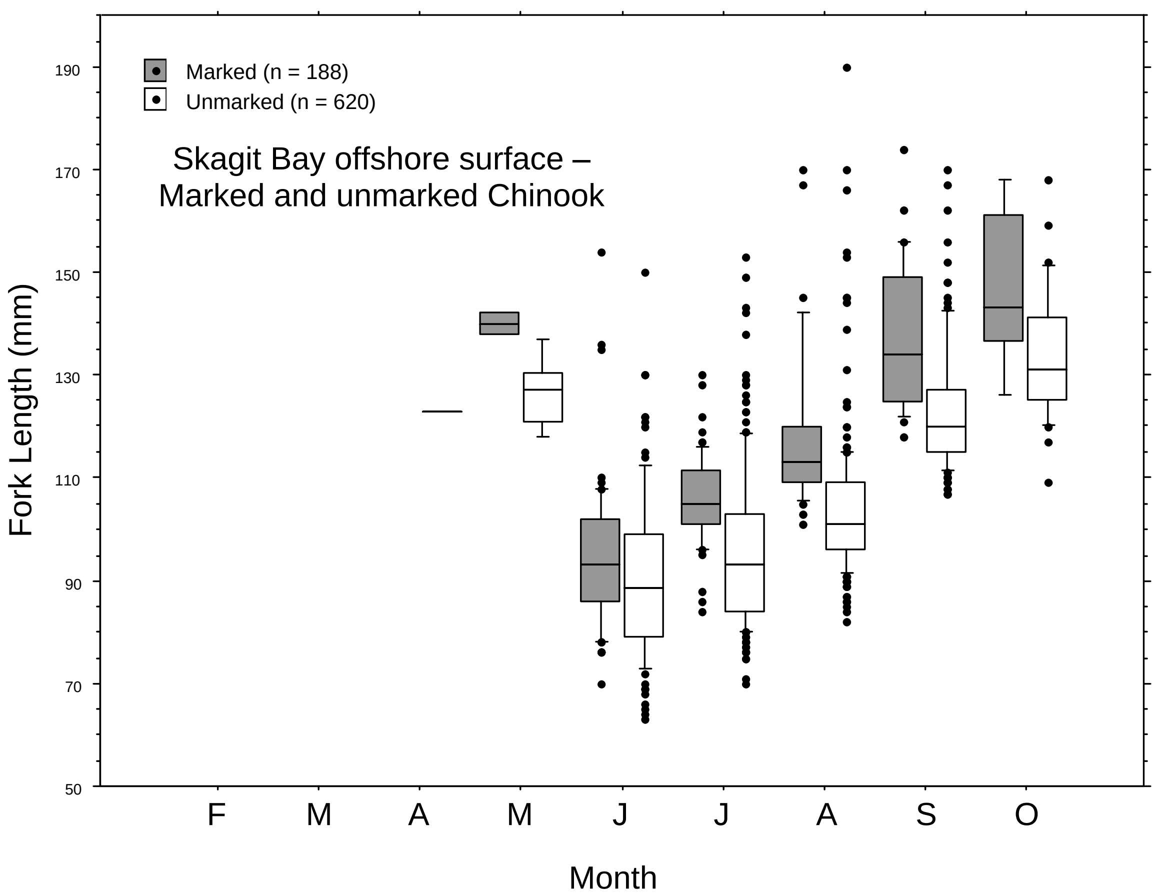

Figure 39. Lengths of all marked and unmarked Chinook captured in offshore surface habitats in Skagit Bay in 2003. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

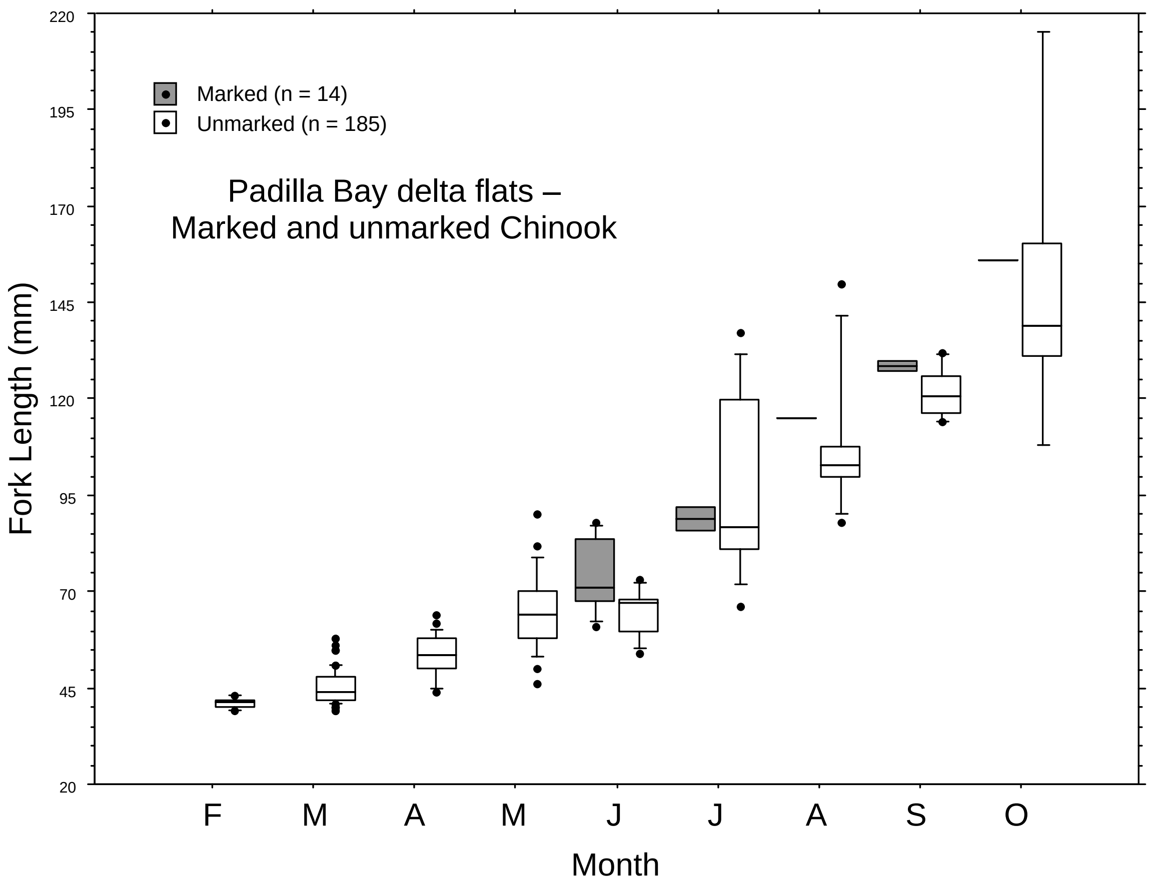

Figure 40. Lengths of all marked and unmarked Chinook captured in delta flat habitats in Padilla Bay in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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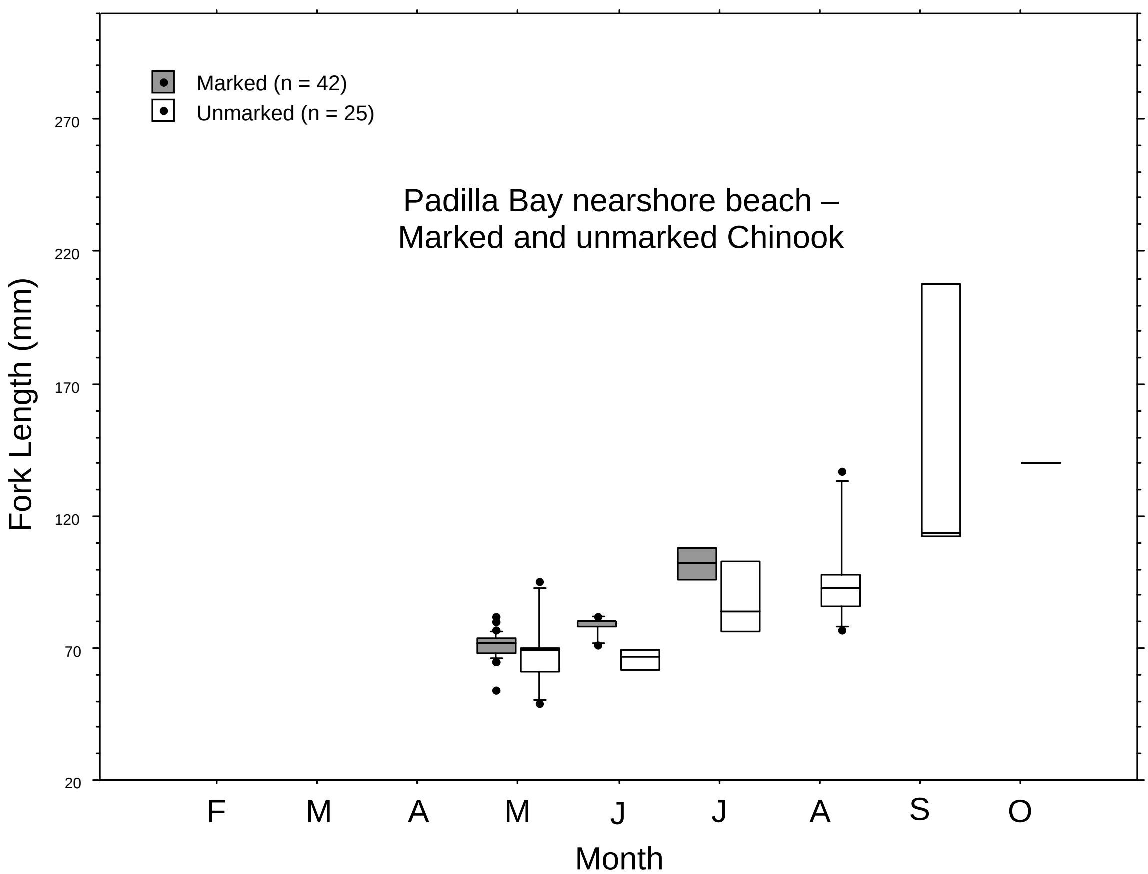

Figure 41. Lengths of all marked and unmarked Chinook captured in nearshore beach habitats in Padilla Bay in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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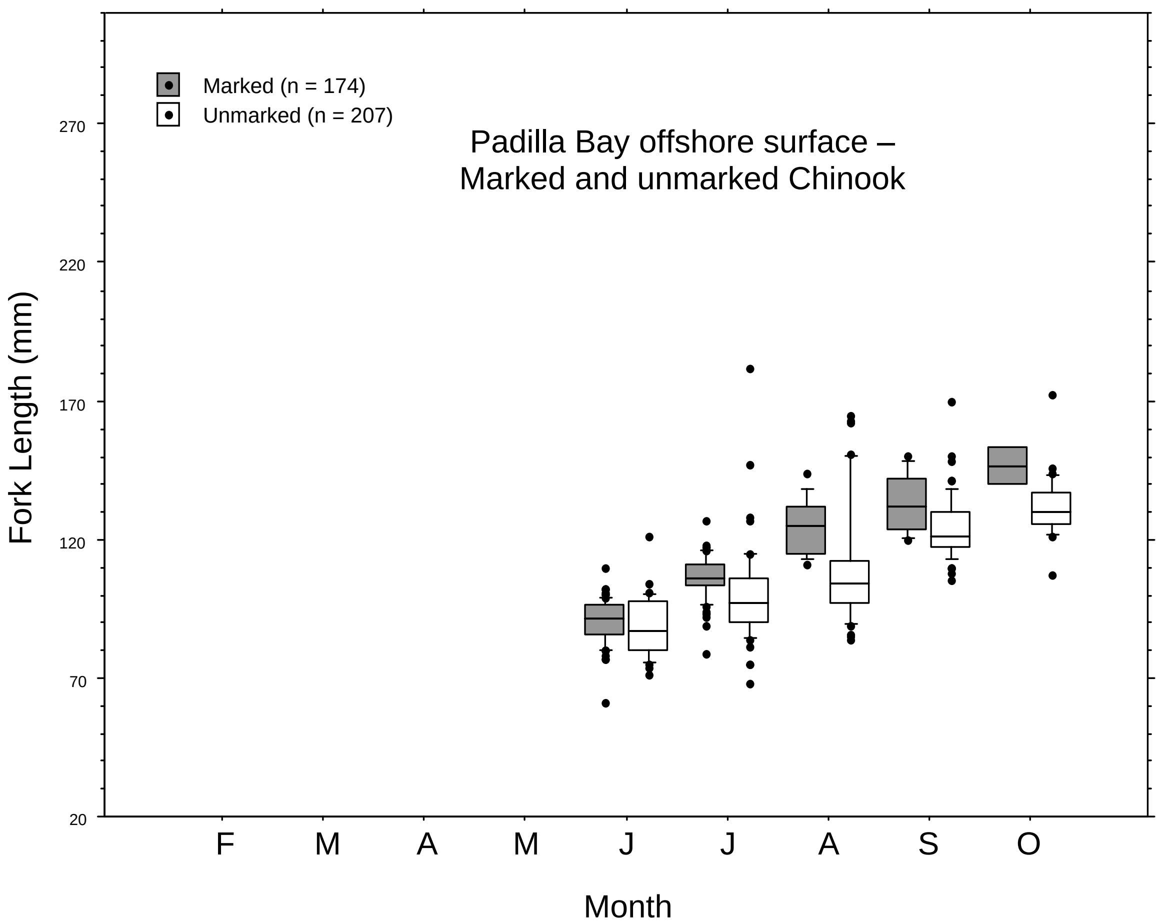

Figure 42. Lengths of all marked and unmarked Chinook captured in offshore surface habitats in Padilla Bay in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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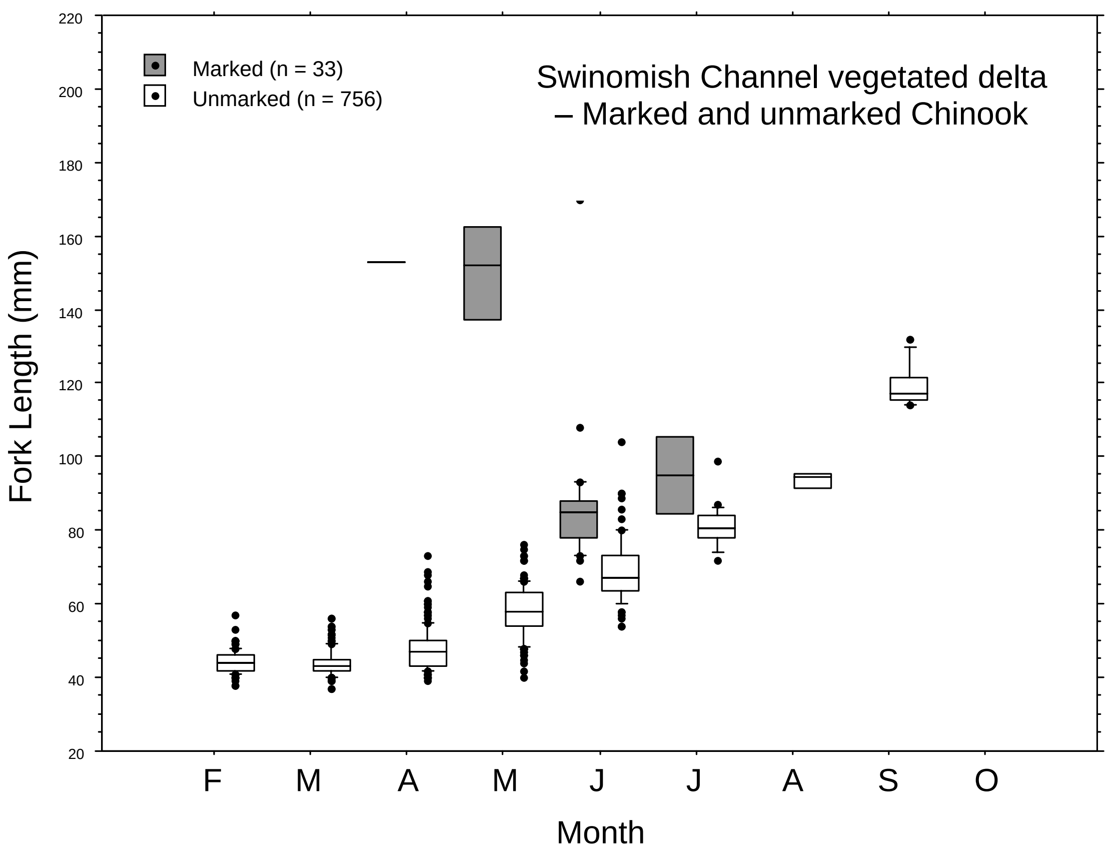

Figure 43. Lengths of all marked and unmarked Chinook captured in Swinomish Channel in 2003. All gear types used within habitat type combined. Boxplots show 5th, 25th, 50th, 75th, and 95th percentiles.

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Origin of juvenile hatchery Chinook salmon

A portion of many hatchery Chinook populations are coded wire tagged. We collected and read the tags of 253 marked hatchery fish caught during the 2003 sampling effort in order to understand the composition of hatchery Chinook salmon using the habitats within Skagit Bay, Swinomish Channel, and Padilla Bay. Figure 44 shows five habitat/area strata that had more than a few fish where we could potentially observe a monthly trend in composition of hatchery Chinook salmon. Hatchery Chinook salmon from eight different areas were observed. The Skagit is the most common river of origin represented and the Chilliwack (a lower Fraser River tributary) being the most distant river of origin represented.

The 23 fish collected in Skagit delta blind and distributary channels were all Skagit origin (Figure 44A). This pattern is different from all other habitat/area shown in Figure 44. All other combinations of habitat type and area had at least some non-Skagit fish present. This result suggests that juvenile hatchery Chinook salmon from other river systems are not extensively using the habitat of the Skagit vegetated delta.

The 10 fish collected in Padilla Bay nearshore beaches/delta flats were mostly a mix of Samish and Skagit origin fish (Figure 44B). However, one Nooksack origin fish was observed in September. No fish originating from rivers south of the Skagit were observed in Padilla Bay nearshore beaches/delta flats habitat.

Skagit Bay nearshore beach habitat was dominated by Skagit origin fish both early in the season (May) and late in the season (Figure 44C). However, there was an influx of hatchery fish from other river systems that peaked in July. The most common river basins represented were either within the Whidbey Basin (Stillaguamish, Snohomish) or immediately to the north (Samish). We did observe one fish from the Chilliwack River.

The 30 fish collected in Padilla Bay offshore surface water habitat were mostly a mix of Samish and Skagit origin fish with an increasing trend of Skagit fish later in the season (Figure 44D). However, Lummi Bay Seapen and Nooksack River origin fish were also present in three of the four months. No fish originating from rivers south of the Skagit were observed in Padilla Bay offshore habitat.

Skagit Bay offshore surface water habitat was dominated by Skagit origin fish both early in the season (May) and late in the season (Figure 44E). Similar to Skagit bay nearshore habitat, there was an influx of hatchery fish from other river systems in offshore habitat during the summer – peaking in September. The most common river basins represented were within the Whidbey Basin (Stillaguamish, Snohomish). Nooksack and Lummi Seapens origin fish were slightly more common than Samish fish. We also observed one fish from the Chilliwack River.

In addition to results shown in Figure 44, two coded wire tagged hatchery Chinook were captured in Skagit Bay lagoon pocket estuaries, two in Swinomish Channel, and three were captured in Skagit Bay delta flats. One fish caught in Skagit Bay lagoon pocket estuary was Skagit origin while the other was Stillaguamish. One fish caught in

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Swinomish Channel was Skagit origin while the other was Samish. All three fish caught in Skagit Bay delta flats were Skagit origin.

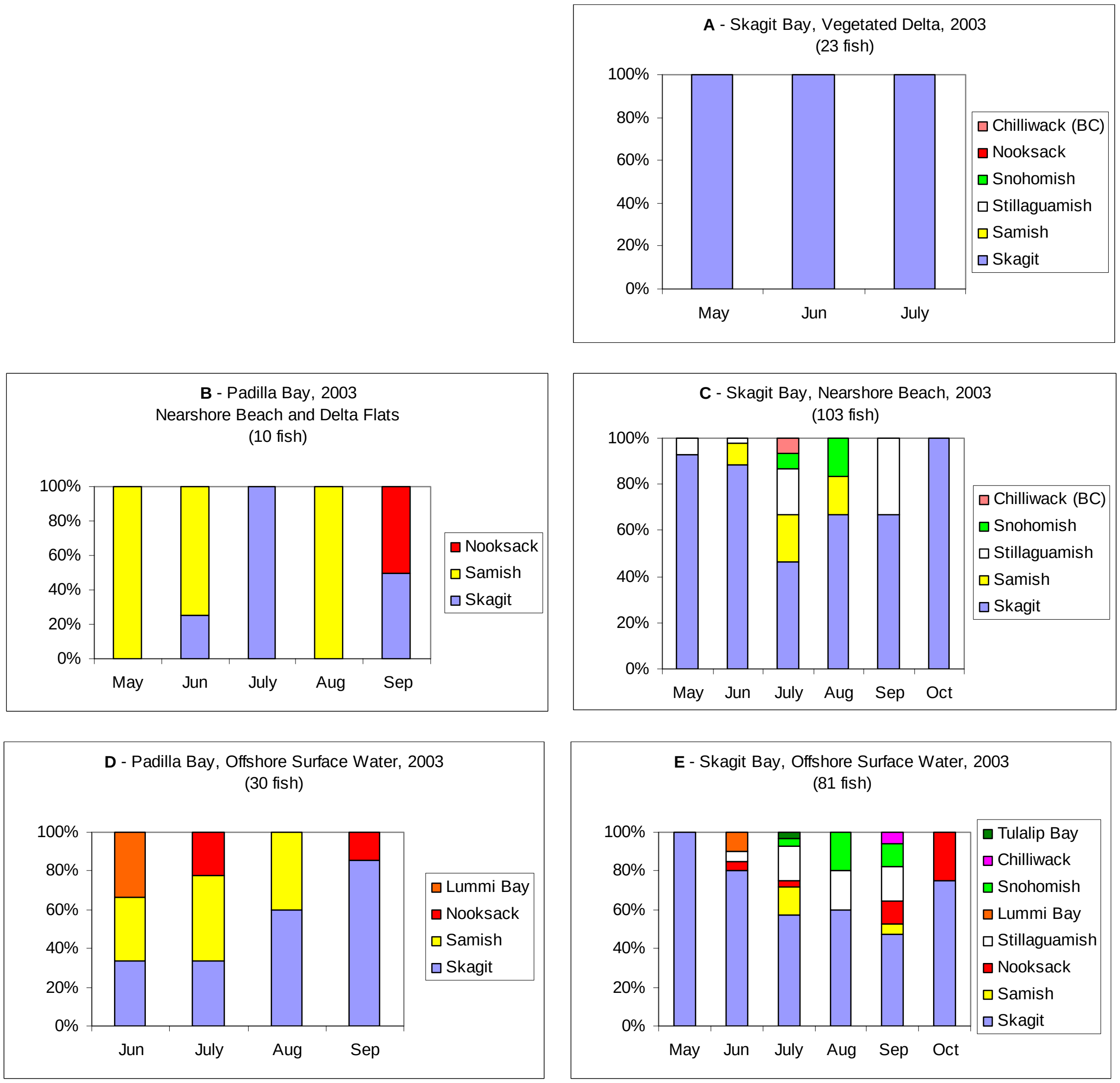

Figure 44. Percentage of coded wire tagged Chinook salmon by basin of origin for (A) Skagit delta channels, (B) Padilla Bay nearshore beach and delta flats combined, (C) Skagit Bay nearshore beach, (D) Padilla Bay offshore surface water, and (E) Skagit Bay offshore surface water. Results from 2003.

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Fish Assemblage composition across years.

Although some variation in fish assemblage composition among years was apparent (Figures 45-52), basic patterns were quite consistent within habitats across years (Figure 53). ANOSIM tests of effects of habitat type, salinity class, and year showed that basic habitat type had the strongest relationship with assemblage composition, but that in some months (e.g., June) habitat classification that included salinity class had the strongest effect, and the year effect was relatively minor (Table 33). The strongest year effect is the result of the alternating pattern of pink salmon abundance and is apparent in the area graphs (Figures 47, 48) and MDS plot for April (Figure 53). This pattern is in the nearshore beach habitats only, since few pinks were found in vegetated delta habitats.

Species contributions to statistical similarity of the various habitats across years are listed in Table 34.

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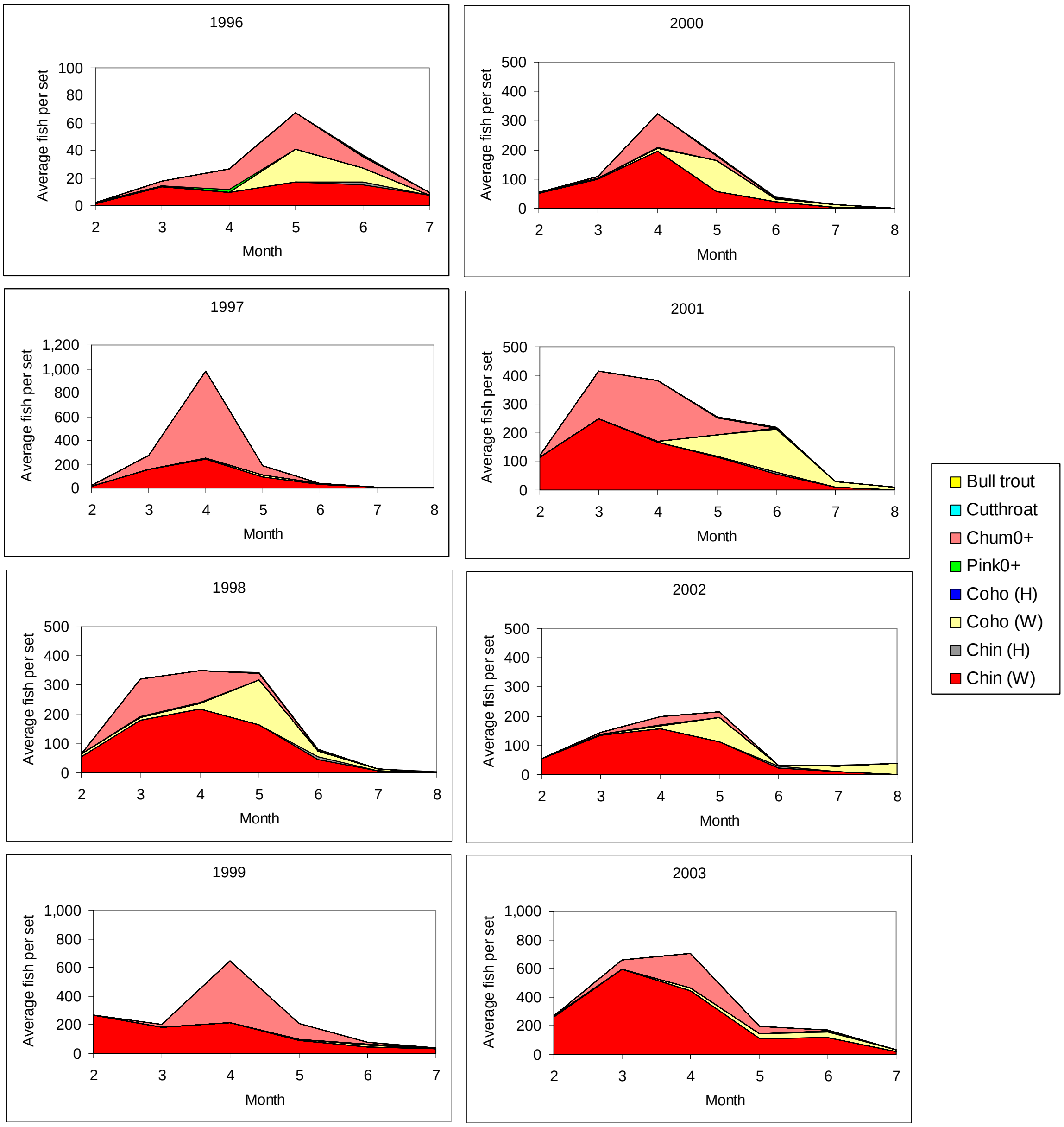

Figure 45. ***Salmon assemblage by year for Vegetated blind channel habitat with a salinity range 0 – 15 ppt in Skagit Bay***. Note differing scales on some graphs.

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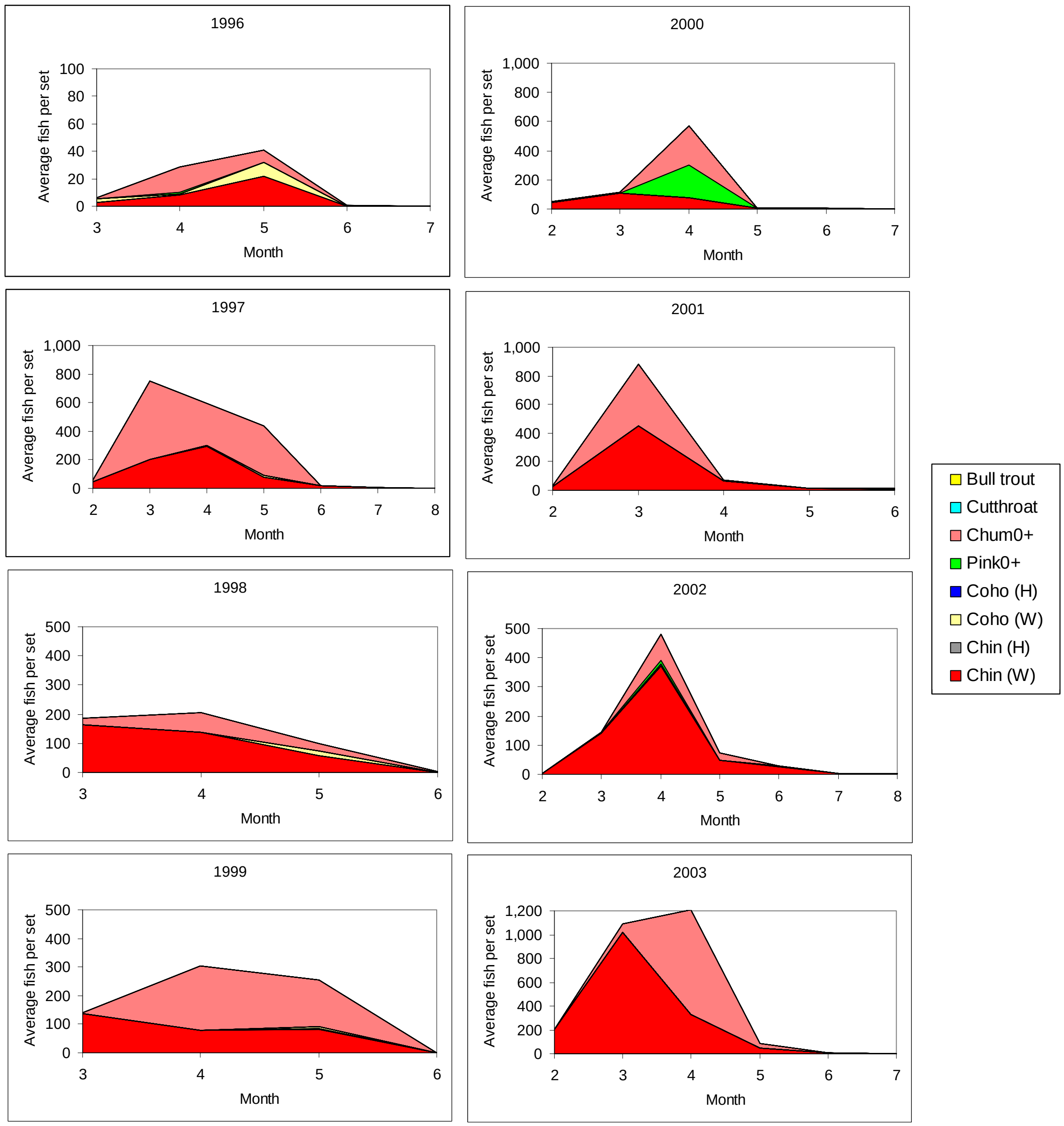

Figure 46. ***Salmon assemblage by year for Vegetated blind channel habitat with a salinity range 5 – 25 ppt in Skagit Bay.*** Note differing scales on some graphs.

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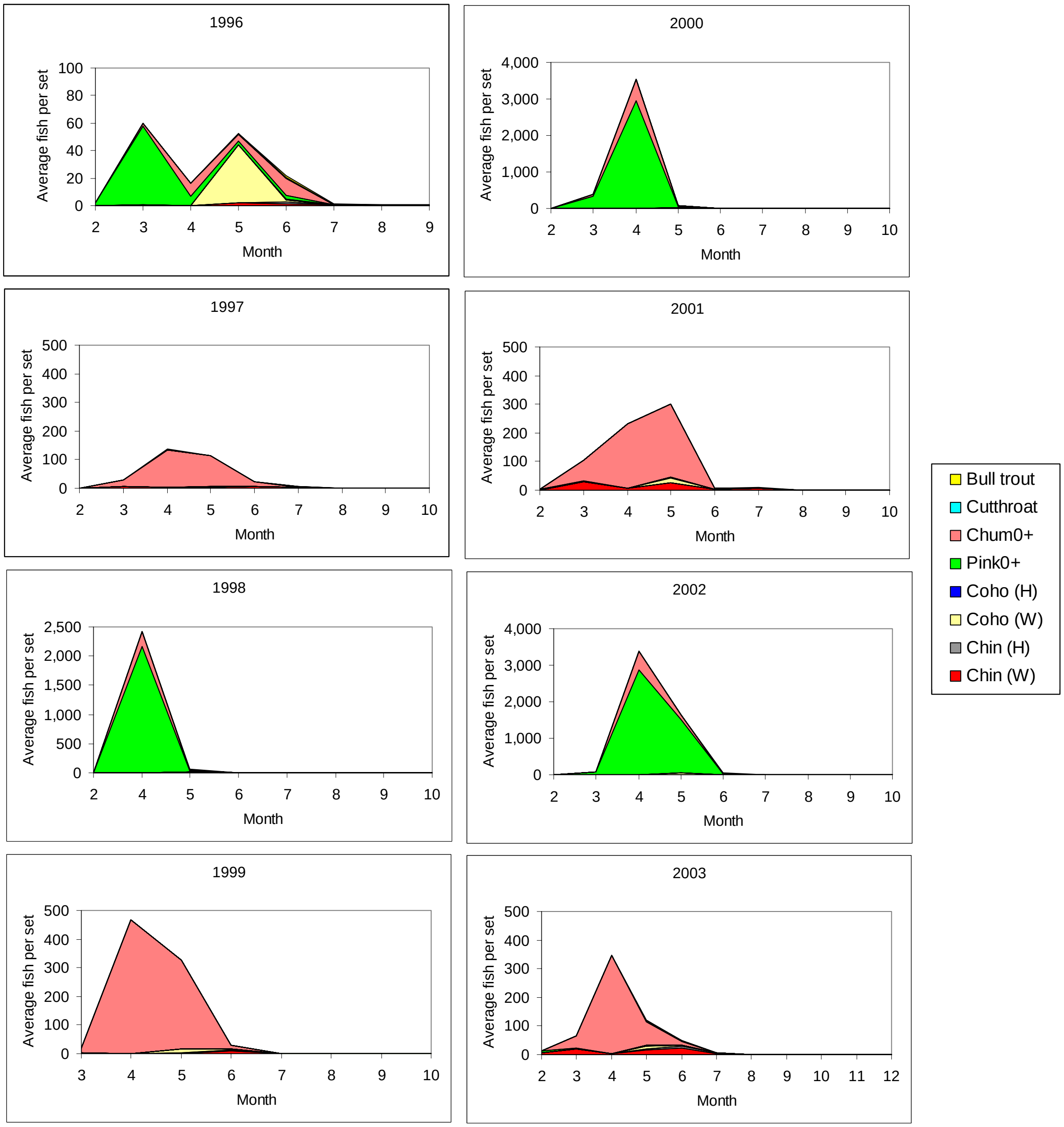

Figure 47. ***Salmon assemblage by year for Nearshore beach sub-tidal fringe habitat with a salinity range 5 – 25 ppt in Skagit Bay.*** Note differing scales on some graphs.

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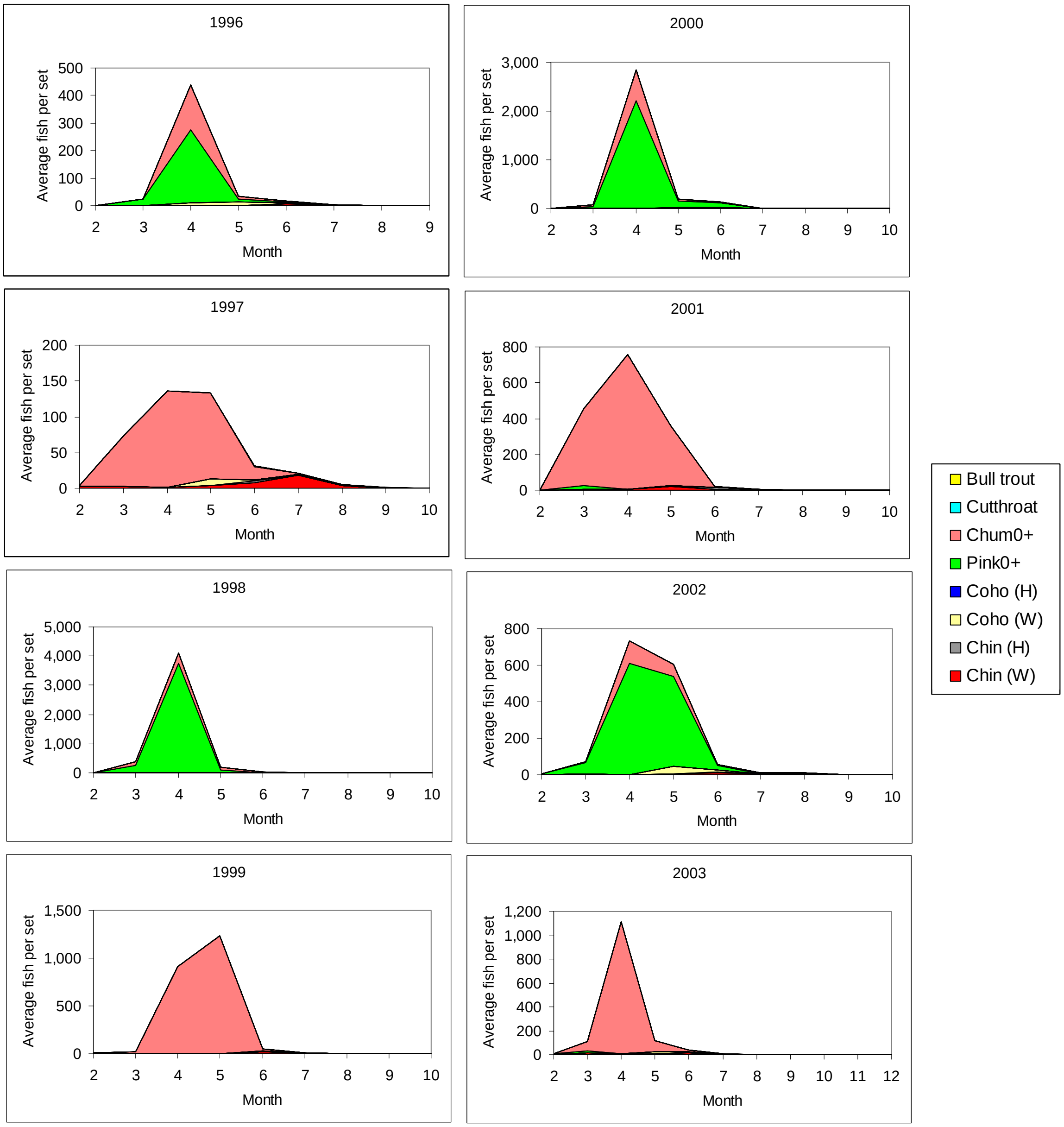

Figure 48. ***Salmon assemblage by year for Nearshore beach sub-tidal fringe habitat with a salinity > 20 ppt in Skagit Bay.*** Note differing scales on some graphs.

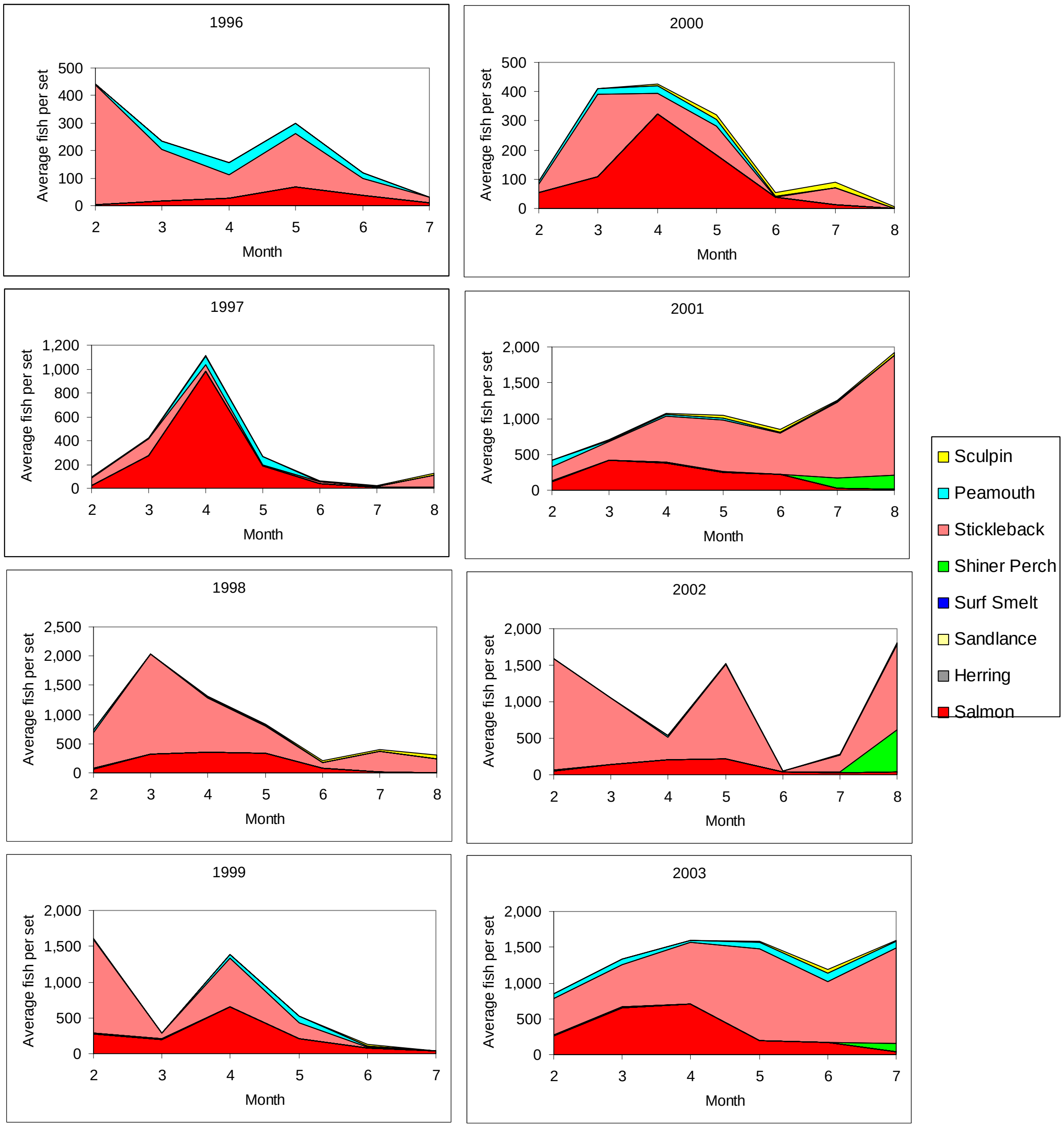

Figure 49. ***Fish assemblage by year for Vegetated blind channel habitat with a salinity range 0 – 15 ppt in Skagit Bay.*** Note differing scales on some graphs.

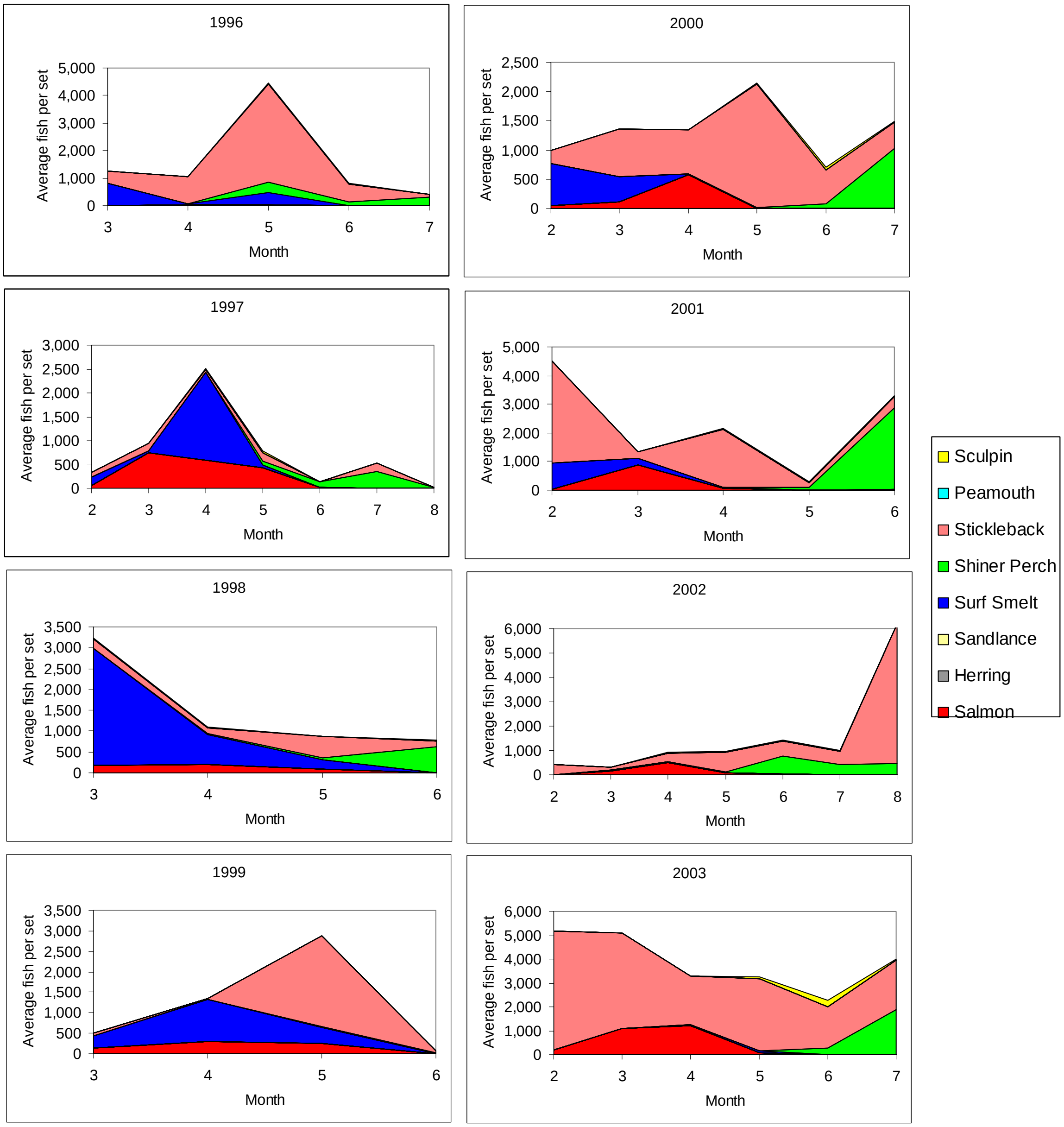

Figure 50. ***Fish assemblage by year for Vegetated blind channel habitat with a salinity range 5 – 25 ppt in Skagit Bay***. Note differing scales on some graphs.

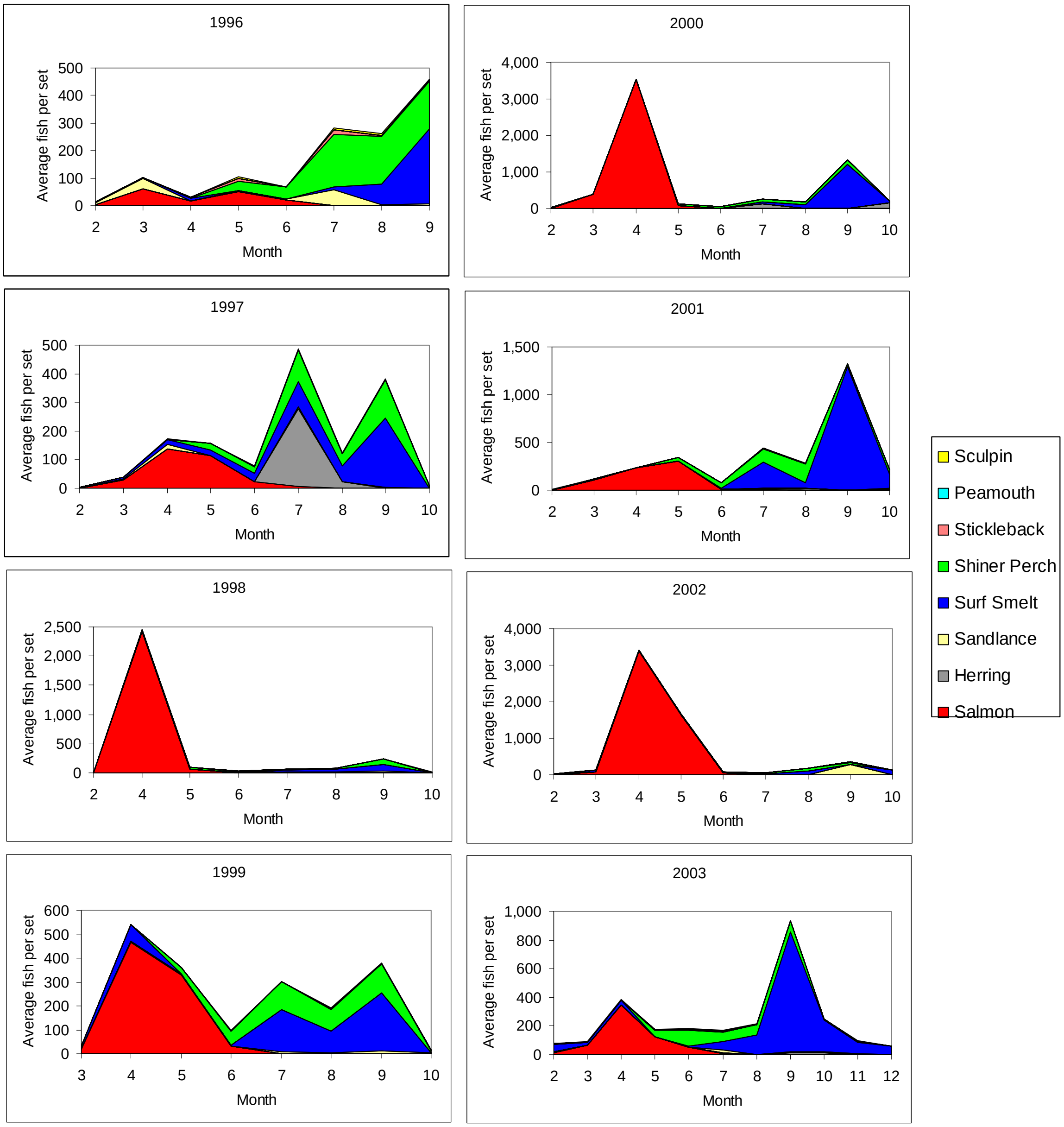

Figure 51. ***Fish assemblage by year for Nearshore beach sub-tidal fringe habitat with a salinity range 5 – 25 ppt in Skagit Bay***. Note differing scales on some graphs.

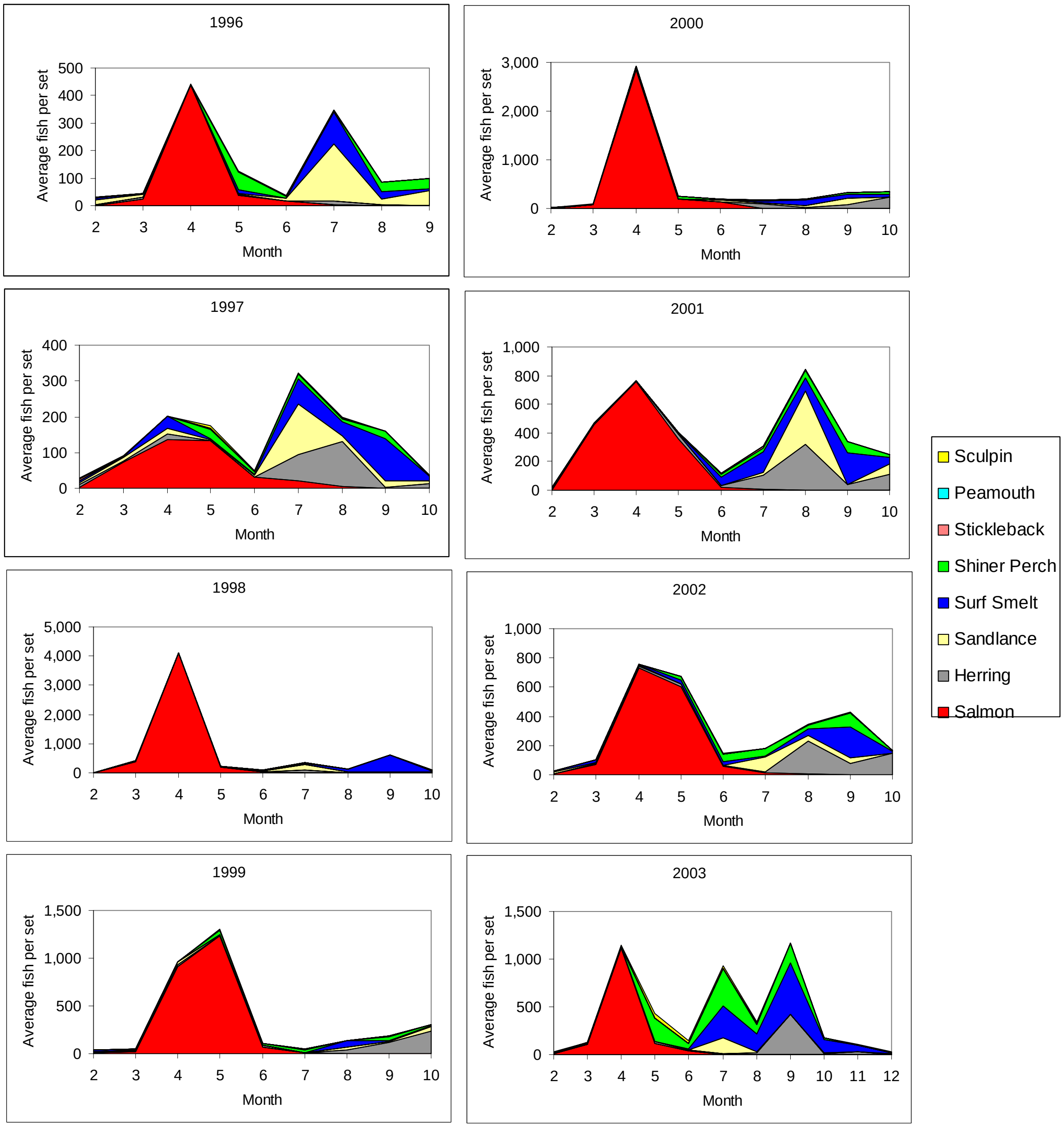

Figure 52. ***Fish assemblage by year for Nearshore beach sub-tidal fringe habitat with a salinity > 20 ppt in Skagit Bay***. Note differing scales on some graphs.

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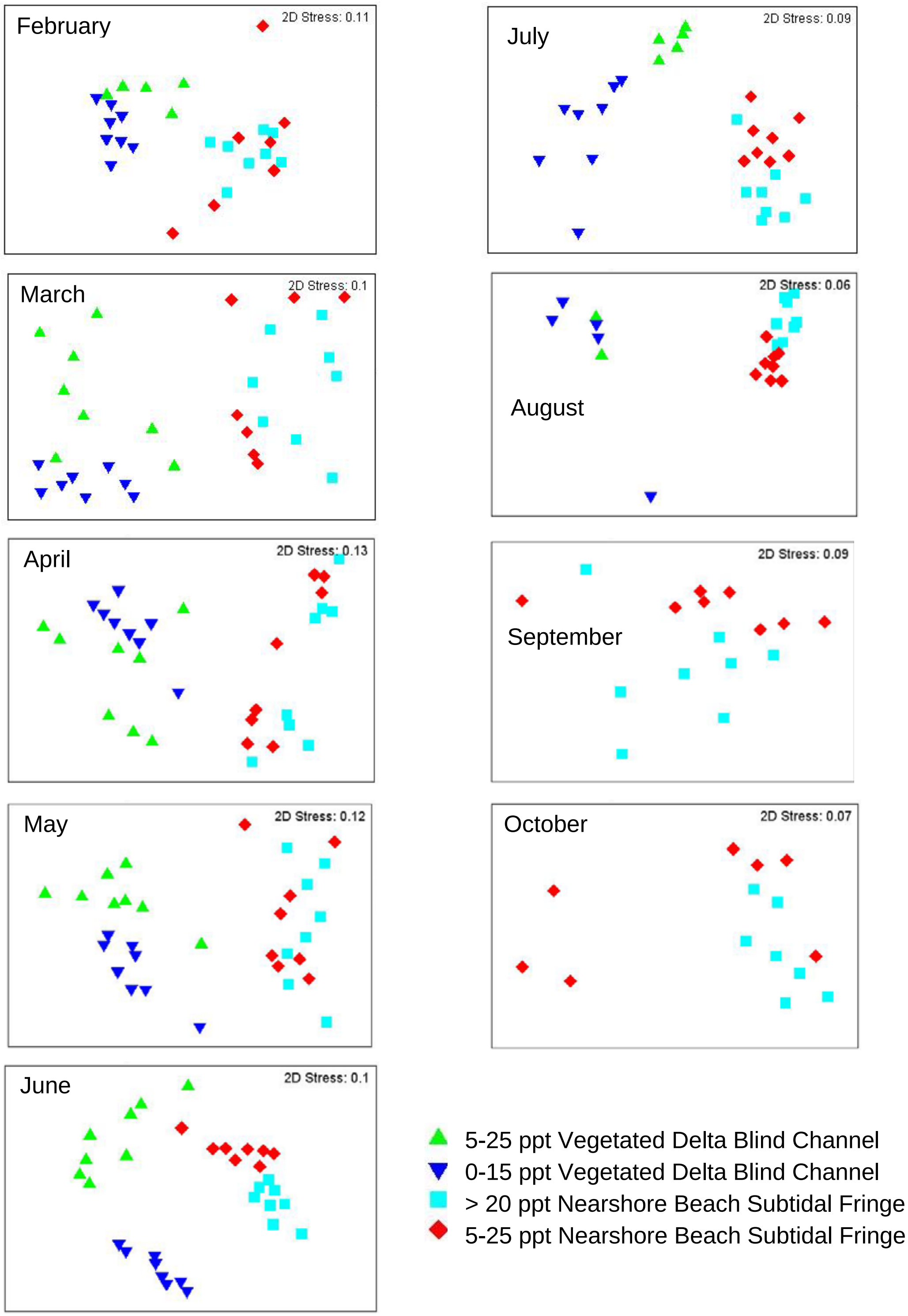

Figure 53. ***MDS plots by month and habitat from 1996-2003***. Each point represents a year/habitat combination.

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Table 33. ***ANOSIM global R statistics (two-way tests) by month for tests of fish assemblage differences related to habitat type and year from 1996 to 2003***. Based relative abundance from averages of site/month/year combinations.

Month	Habitat Type 1		Habitat Type 1 & Salinity Class		Year	
	R	p	R	p	R	p
February	0.63	0.001	0.60	0.001	0.10	0.04
March	0.82	0.001	0.65	0.001	0.19	0.001
April	0.76	0.001	0.58	0.001	0.26	0.001
May	0.76	0.001	0.65	0.001	0.17	0.002
June	0.55	0.001	0.71	0.001	0.10	0.02
July	0.74	0.001	0.59	0.001	0.10	0.03
August	0.78	0.001	0.49	0.001	0.04	0.23
September	*	*	0.27	0.01	0.17	0.02
October	*	*	0.27	0.03	0.20	0.02

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Table 34. ***Percent contribution (based on relative abundance) of various species to taxonomic similarity for fish assemblages in four habitat types by month, 1996-2003.***

February							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Stickleback	46.96	Stickleback	63.70	Surf Smelt	26.07	Surf Smelt	23.18
Chinook (W)	45.85	Surf Smelt	24.61	Chinook (W)	16.51	Sandlance	19.99
Chum	1.58	Chinook (W)	9.34	Pink	14.94	Other Marine Sculpins	13.03
Pacific Staghorn	1.23	Chum	1.77	Starry Flounder	11.13	Herring	12.55
Peamouth Chub	0.99	Pacific Staghorn	0.58	Other Marine Sculpins	8.66	Pink	9.10
Surf Smelt	0.99			Stickleback	8.28	Chinook (W)	8.48
Starry Flounder	0.80			Pacific Staghorn	4.56	Stickleback	6.73
Coho (W)	0.59			Sandlance	3.98	Chum	4.06
Prickly Sculpin	0.51			Herring	2.89	Pacific Staghorn	1.57
Pink	0.50			Chum	2.05	Starry Flounder	1.09
						Pipefish	0.22
March							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Chinook (W)	49.83	Stickleback	33.25	Chum	28.05	Chum	28.26
Stickleback	29.50	Chinook (W)	27.23	Pink	24.31	Pink	21.12
Chum	16.05	Surf Smelt	27.01	Chinook (W)	15.43	Surf Smelt	10.34
Starry Flounder	1.34	Chum	10.23	Surf Smelt	13.71	Herring	10.25
Peamouth Chub	0.86	Pacific Staghorn	1.19	Sandlance	7.24	Sandlance	10.14
Pink	0.70	Pink	0.55	Starry Flounder	6.74	Chinook (W)	8.64
Pacific Staghorn	0.62	Coho (W)	0.41	Herring	1.56	Other Marine Sculpins	5.14
Coho (W)	0.52	Starry Flounder	0.13	Pacific Staghorn	1.18	Starry Flounder	2.78
Prickly Sculpin	0.48			Other Marine Sculpins	0.97	Stickleback	1.89
Surf Smelt	0.07			Pipefish	0.30	Pacific Staghorn	1.09
Cutthroat	0.04			Stickleback	0.25	Pipefish	0.14
				Coho (H)	0.14	Coho (W)	0.11
				Chinook (H)	0.12	Coho (H)	0.11

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Table 34 continued.

April							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Chinook (W)0-1	36.81	Stickleback	46.49	Chum	53.02	Chum	52.02
Chum	30.75	Chinook (W)	16.36	Pink	26.89	Pink	31.62
Stickleback	23.15	Surf Smelt	15.16	Surf Smelt	5.56	Herring	5.10
Peamouth Chub	2.44	Chum	14.90	Chinook (W)	4.84	Sandlance	3.01
Prickly Sculpin	2.07	Pacific Staghorn	3.90	Starry Flounder	2.27	Chinook (W)	2.31
Coho (W)	1.95	Pink	1.34	Sandlance	2.06	Other Marine Sculpins	1.35
Pacific Staghorn	1.23	Coho (W)	0.98	Other Marine Sculpins	1.95	Surf Smelt	1.28
Pink	0.88	Starry Flounder	0.49	Pipefish	0.65	Coho (W)	0.83
Starry Flounder	0.61	Shiner Perch	0.37	Shiner Perch	0.64	Starry Flounder	0.77
Bull trout	0.06	Species	Contrib%	Herring	0.62	Pacific Staghorn	0.73
Surf Smelt	0.03	Stickleback April	46.49	Bull trout	0.49	Gunnels / S. Prickleback	0.31
Other Salmon	0.02	Chinook (W)	16.36	Pacific Staghorn	0.47	Stickleback	0.23
				Stickleback	0.28	Pipefish	0.21
				Cutthroat	0.16	Bull trout	0.10
				Coho (W)	0.12	Shiner Perch	0.08
						Cutthroat	0.04

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Table 34 continued.

May							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Stickleback	28.12	Stickleback	53.75	Chum	38.89	Chum	34.23
Chinook (W)	27.31	Chinook (W)	13.51	Shiner Perch	13.11	Coho (W)	12.22
Chum	19.32	Pacific Staghorn	10.50	Coho (W)	10.84	Pink	10.24
Coho (W)	15.03	Chum	7.95	Pink	8.25	Shiner Perch	8.94
Peamouth Chub	4.09	Shiner Perch	7.20	Chinook (W)	6.41	Herring	6.08
Prickly Sculpin	3.45	Surf Smelt	4.38	Gunnels / S. Prickleback	2.77	Chinook (W)	5.28
Starry Flounder	1.02	Coho (W)	2.08	Starry Flounder	2.75	Gunnels / S. Prickleback	4.84
Pacific Staghorn	0.77	Starry Flounder	0.63	Pipefish	2.30	Other Marine Sculpins	4.18
Cutthroat	0.66			Bull trout	2.24	Surf Smelt	3.42
Other Salmon	0.14			Cutthroat	2.09	Chinook (H)	1.78
Coho (H)	0.06			Pacific Staghorn	2.02	Pacific Staghorn	1.70
Chinook (H)	0.02			Other Salmon	1.92	Cutthroat	1.38
Bull trout	0.02			Other Marine Sculpins	1.53	Sandlance	1.25
				Chinook (H)	1.21	Other Salmon	1.21
				Surf Smelt	1.11	Stickleback	0.92
				Coho (H)	0.92	Pipefish	0.76
				Stickleback	0.72	Bull trout	0.70
				Herring	0.43	Starry Flounder	0.45
				Sandlance	0.39	Coho (H)	0.43
				English Sole	0.10		

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Table 34 continued.

June							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Chinook (W)	31.30	Stickleback	47.32	Shiner Perch	36.90	Chinook (W)	15.02
Stickleback	23.80	Shiner Perch	35.02	Chinook (W)	11.53	Chum	11.95
Coho (W)	13.62	Chinook (W)	7.21	Chum	8.71	Shiner Perch	11.44
Prickly Sculpin	13.26	Pacific Staghorn	7.04	Gunnels/S. Prickleback	7.28	Chinook (H)	8.64
Chum	7.14	Starry Flounder	1.96	Pacific Staghorn	6.35	Surf Smelt	7.10
Chinook (H)	3.59	Peamouth Chub	0.87	Coho (W)	4.59	Coho (W)	6.67
Peamouth Chub	3.47	Prickly Sculpin	0.46	Stickleback	4.47	Sandlance	6.42
Cutthroat	1.49	Chum	0.13	Chinook (H)	3.22	Other Marine Sculpins	5.37
Starry Flounder	1.02			Bull trout	3.06	Herring	5.13
Bull trout	0.55			Starry Flounder	2.90	Pacific Staghorn	4.59
Pacific Staghorn	0.39			Surf Smelt	2.27	Pink	3.50
Other Salmon	0.33			Cutthroat	1.84	Cutthroat	3.32
Coho (H)	0.03			Pipefish	1.83	Stickleback	2.97
Shiner Perch	0.03			Other Marine Sculpins	1.72	Gunnels / S. Prickleback	2.94
				English Sole	1.08	Coho (H)	1.15
				Pink	0.95	Bull trout	0.96
				Sandlance	0.76	Pipefish	0.86
				Herring	0.26	Other Flatfish	0.68
				Other Flatfish	0.16	Starry Flounder	0.66
				Coho (H)	0.13	Other Salmon	0.45
						English Sole	0.18

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Table 34 continued.

July							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Stickleback	47.51	Shiner Perch	52.86	Shiner Perch	33.05	Sandlance	26.67
Chinook (W)	16.09	Stickleback	42.32	Surf Smelt	15.36	Surf Smelt	22.06
Prickly Sculpin	15.58	Pacific Staghorn	2.98	Herring	13.44	Herring	11.84
Coho (W)	9.65	Starry Flounder	1.23	Gunnels/S. Prickleback	9.27	Shiner Perch	9.89
Peamouth Chub	2.87	Chinook (W)	0.62	Stickleback	5.48	Chinook (W)	7.14
Starry Flounder	2.21			Chinook (W)	5.27	Pacific Staghorn	4.59
Shiner Perch	2.11			Pacific Staghorn	5.02	Stickleback	4.29
Cutthroat	1.39			Sandlance	3.41	Chinook (H)	3.23
Chum	0.92			Starry Flounder	2.59	Other Marine Sculpins	2.94
Pacific Staghorn	0.92			Bull trout	1.71	Cutthroat	1.71
Chinook (H)	0.52			Other Marine Sculpins	1.49	Chum	1.57
Bull trout	0.23			Chinook (H)	1.11	Starry Flounder	1.29
				Pipefish	0.86	Gunnels/S. Prickleback	1.03
				Cutthroat	0.81	Coho (W)	0.62
				English Sole	0.44	Other Salmon	0.31
				Chum	0.35	Pipefish	0.30
				Coho (W)	0.32	Coho (H)	0.24
						Bull trout	0.19
						Pink	0.08

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Table 34 continued.

August							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
Stickleback	49.46	Stickleback	81.81	Shiner Perch	47.82	Surf Smelt	28.85
Prickly Sculpin	16.89	Shiner Perch	9.39	Surf Smelt	31.46	Sandlance	19.85
Coho (W)	12.02	Starry Flounder	2.90	Herring	4.11	Shiner Perch	16.90
Shiner Perch	7.48	Pacific Staghorn	2.69	Stickleback	4.01	Herring	16.40
Peamouth Chub	6.30	Coho (W)	1.76	Gunnels/S. Prickleback	3.89	Pacific Staghorn	4.15
Starry Flounder	4.23	Peamouth Chub	1.44	Pacific Staghorn	2.98	Chinook (W)	3.91
Pacific Staghorn	3.00			Starry Flounder	1.80	Stickleback	2.93
Cutthroat	0.33			Sandlance	1.50	Other Marine Sculpins	2.15
Bull trout	0.30			Chinook (W)	0.92	Chinook (H)	1.86
				Other Marine Sculpins	0.78	Cutthroat	1.37
				Cutthroat	0.29	Gunnels/S. Prickleback	1.08
				Chinook (H)	0.17	Starry Flounder	0.45
				Pipefish	0.16	Pink	0.10
				Other Flatfish	0.11		

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Table 34 continued.

September							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
				Surf Smelt	58.15	Surf Smelt	35.31
				Shiner Perch	27.30	Shiner Perch	27.45
				Sandlance	6.06	Sandlance	19.40
				Pacific Staghorn	3.39	Herring	10.93
				Starry Flounder	1.22	Pacific Staghorn	2.36
				Herring	1.07	Chinook (W)	1.52
				Other Marine Sculpins	1.05	Other Marine Sculpins	1.27
				English Sole	0.82	Starry Flounder	0.66
				Stickleback	0.50	Stickleback	0.36
				Pipefish	0.23	Gunnels/S. Prickleback	0.25
				Cutthroat	0.15	Cutthroat	0.25
				Gunnels/S. Prickleback	0.06	Chinook (H)	0.14
						Coho (W)	0.08
October							
Vegetated Delta 0-15 ppt		**Vegetated Delta 5-25 ppt**		**Nearshore Beach 5-25ppt**		**Nearshore Beach >20 ppt**	
Species	Contrib%	Species	Contrib%	Species	Contrib%	Species	Contrib%
				Surf Smelt	64.59	Surf Smelt	34.49
				Herring	12.62	Herring	24.30
				Shiner Perch	7.47	Sandlance	15.68
				Starry Flounder	6.08	Shiner Perch	14.97
				Pacific Staghorn	2.91	Other Marine Sculpins	4.78
				Stickleback	2.90	Starry Flounder	2.37
				Sandlance	1.78	Stickleback	1.93
				Gunnels/S. Prickleback	0.75	Pacific Staghorn	1.47
				Other Marine Sculpins	0.46		
				Pipefish	0.23		
				Coho (W)	0.21		

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Conclusions

Multivariate statistical analysis revealed differences in fish assemblages relating to all factors tested, especially by habitat, area, and month, and sometimes by salinity class. Fish species contributing to taxonomic similarity within areas and habitats varied, and the salmon signal was particularly strong in Skagit. Our synthesis of these results shapes a picture of the monthly fish assemblage for different habitat types and salinity regimes. These are illustrated by the twenty-five different combinations of area, habitat type, and salinity regime (Figures 2-27) from the 91 different sites within our study area. If management actions (e.g., flood control projects or restoration projects) change existing habitat type or salinity regime, we can use these pictures to predict the fish assemblage response to hypothesized habitat type and salinity regime change.

Our *a priori* assignment of habitat types is meaningful for understanding and predicting fish assemblages in the greater Skagit estuary. Our multi-dimensional scaling (MDS) analysis of four habitat types over eight years in Skagit Bay finds consistent annual monthly patterns in fish assemblages. Therefore, collecting monthly fish assemblage data over a period of just one year is adequate for understanding monthly fish assemblages by habitat type. This analysis also supports the idea we can predict, through inference, that changes to habitats types (e.g., restoration or flood control projects) from one type to another will have a corresponding to change in the fish assemblage.

Our analysis also shows there are significant differences in the abundance of species within any given fish assemblage that occurs annually. Therefore, while the fish assemblage appears robust year after year in any given habitat, the population size of individual fish species in the assemblage might vary dramatically. For example, the wild Chinook smolt population size entering the greater Skagit estuary varied from around ½ to 7 million outmigrants over our study period (Beamer et al 2005). Similar variability does exist with the other salmon species and likely exists for many other nearshore fish species. Therefore, if study goals are fish population size related (not fish assemblage related) then one year of data will not be adequate to understand fish abundance and habitat type relationships.

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