Fishery Data Series No. 13-47

Salmonid Use of Nearshore Marine and Estuarine Habitats of the Taku River and Inlet, 2008 and 2009

by

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October 2013

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 13-47

SALMONID USE OF NEARSHORE MARINE AND ESTUARINE HABITATS OF THE TAKU RIVER AND INLET, 2008 AND 2009

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ABSTRACT

Estuaries and nearshore marine habitats provide critical ecological functions for many anadromous and marine fish species; however, only limited information exists on fish habitat use in these valuable areas in Southeast Alaska. In 2008 and 2009, the Alaska Department of Fish and Game, Division of Sport Fish conducted surveys to investigate spatial and temporal fish habitat use patterns in nearshore areas of Taku Inlet and the Taku River estuary in Southeast Alaska. Data collection occurred between May and October, 2008 and between May and September, 2009. A total of 90 unique locations were sampled throughout the study area; 2 locations were sampled more than once to address seasonal, annual, and tidal variation in catch results. Fish were captured primarily using a beach seine, pole seine, and minnow traps. Intertidal habitat transects and water quality data were also collected at each sampling location and the results were analyzed to determine which habitat variables had significant association with the presence of juvenile Pacific salmon. During the study a total of 2,525 salmon and an overall total of 3,873 fish were captured. Results showed that slightly more salmon were captured in 2009 than 2008, and catches were slightly higher during high tide than low tide. In both years, salmon catches were slightly higher during June sampling events. Habitat variables that showed significant influence on the presence of juvenile Pacific salmon include: temperature, salinity, turbidity, pH, dominant intertidal substrate, and slope of the intertidal beach being sampled.

Key words: estuary, nearshore marine, fish survey, habitat survey, Southeast Alaska, Taku Inlet, Taku River estuary, anadromous fish, marine fish, Pacific salmon, juvenile Pacific salmon

INTRODUCTION

In 2001, the Alaska Department of Fish and Game (ADF&G), Division of Habitat and Restoration conducted a 2-day workshop with approximately 40 participants representing 18 agencies and organizations. The purpose of the workshop was to identify existing resource knowledge and prioritize information needs (i.e., “gaps”) related to salmonids and their habitats. This strategy was considered necessary to the process of conducting habitat condition assessments. The group concluded that little was known about the nearshore marine habitats in Southeast Alaska (SEAK) that are important to Pacific salmon (*Oncorhynchus* spp.) and other marine species. Identification and mapping of these areas was considered a high priority for achieving a more comprehensive understanding of salmonid habitat. Anadromous migration corridors were also recognized as a component of critical nearshore marine habitats due to their connectivity with the freshwater environment. Ultimately, the working group identified a goal of increasing our knowledge of how fish and other organisms respond to and are dependent upon the full diversity of nearshore marine habitats. Two information needs or “gaps” in conventional wisdom where thus identified: 1) identification, classification, and mapping of habitats; and 2) species occurrence, distribution, and interactions with these habitats.

Similar to nearshore marine habitats, there is little information on fish habitat use in estuaries in SEAK, which also provide important habitat to salmon and other marine fish species. Ecological functions provided by estuaries and nearshore habitats include: refuge and rearing habitat for juvenile salmonids, forage fish and groundfish; food production for juvenile fish; areas suitable for the physiological transition from freshwater to marine habitat; migration corridor for juvenile fish from fresh water to a marine system; migration corridor for adult fish returning to natal spawning grounds; food production for adults; and spawning habitat for forage fish, ground fish and salmonids (Abookire et al. 2000; Brennan et al. 2004; Fresh 2006; Lorenz and Schroeder 2010; Macdonald et al. 1987; Simenstad et al. 1982; Williams and Thom 2001). Although limited information exists on fish habitat use in nearshore and estuarine waters of SEAK, it is clear that habitats utilized during early-ocean entry are critical to the survival of many juvenile anadromous and forage fish (Benaka 1999).

In 1996, the U.S. Congress reauthorized the Magnuson-Stevens Fishery Conservation and Management Act through the Sustainable Fisheries Act. Amendments to the Sustainable Fisheries Act included the Essential Fish Habitat (EFH) policy, which required all fishery management councils to identify and map EFH for all life stages of federally-managed fish species. In the policy, EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (Benaka 1999).

As a result of the EFH policy, the National Oceanic and Atmospheric Administration – National Marine Fisheries Service (NOAA-NMFS) has focused significant effort on fish sampling in nearshore marine habitats throughout Alaska. Assessing fish habitat utilization in these important habitats and identifying the characteristics of the habitat associated with fish use is extremely difficult and expensive to document (Simenstad et al. 1991). Despite all of their efforts to date, NOAA-NMFS still lacks the basic information needed to identify and describe EFH for many federally-managed species in Alaska (Alaska Fisheries Science Center 2008). This supports the need for continued research in these important habitats by all fisheries management entities.

In 2007, the Alaska Department of Fish and Game, Division of Sport Fish participated in a collaborative project (funding provided through the Pacific Salmon Commission-Northern Fund) with the NOAA-NMFS called, “Assessment of critical salmon habitat in a transboundary river estuary.” The purpose of the project was to investigate spatial and temporal patterns of salmon distribution in the Taku River estuary relative to the different habitats available. This project ended in 2007, but provided relevant information and momentum from which the current project was developed.

In 2008, Alaska Department of Fish and Game, Division of Sport Fish developed the project described in this report, which included a similar purpose to the collaborative project with NOAA-NMFS. However, a few modifications were made for the current project in order to comply with standards and requirements established by ADF&G and the project funding source. Implementation of this project is scheduled to occur over 5 years and will include 2 phases. The focus of the first phase of this project was to sample nearshore habitats throughout the study area. Sampling for the first phase of this project occurred in 2008 and 2009; results from this sampling are presented in this report. The second phase of the project will focus on offshore sampling and will also occur over 2 years (2010 and 2011). The fifth year will be available, if necessary, for any additional sampling that is required for accomplishing our overall project goal.

OBJECTIVES

The overall goal of this project is to identify, quantify, and characterize estuarine, nearshore, and offshore/neritic habitats in Taku Inlet and the Taku River estuary with respect to fish distribution patterns.

Specific objectives for 2008 and 2009 (phase 1 of the project) were to:

1. Identify and map the spatial distribution of all fish species that utilize the nearshore areas of the Taku River estuary and Taku Inlet.
2. Measure and map a selection of on-site habitat variables thought to be important for juvenile Pacific salmon. This will be done in the nearshore area of the Taku River estuary and Taku Inlet. The selection of habitat variables to be measured include: water quality

(temperature, specific conductivity, salinity, turbidity, dissolved oxygen, and pH), woody debris, substrate, slope, and intertidal biota.

3. Identify those on-site habitat characteristics (Objective 2) associated with the presence of juvenile Pacific salmon.

STUDY AREA

The Taku watershed is a large, glacial mainland river system originating in the Stikine Plateau of northwestern British Columbia, Canada, and empties into the head of Taku Inlet, approximately 20 km southeast of Juneau, Alaska (Figure 1). The watershed is host to 5 species of Pacific salmon, and is one of the largest producers of Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in the region (Der Hovanisian and Geiger 2005). The Taku watershed also produces significant numbers of sockeye (*O. nerka*) and chum salmon (*O. keta*) relative to other stream systems in SEAK, and has documented use by eulachon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), and Pacific sand lance (*Ammodytes hexapterus*) for spawning in the lower reaches near the estuary (Johnson and Daigneault 2008). Data collected under a separate project conducted in 2007 (Lorenz and Schroeder 2010) and results discussed in this report indicate that the estuarine environment at the mouth of the river may also provide habitats important to emigrating juvenile salmon.

The entire study area encompasses approximately 108 km^2 and includes Taku Inlet and the Taku River estuary (Figure 2). The boundary line used to separate Taku Inlet from the Taku River estuary is consistent with the northern boundary line established for the Taku Inlet commercial gillnet fishery (Figure 2). The northern boundary line, which was established by the Alaska Department of Fish and Game, Division of Commercial Fisheries, separates the shallow waters in the estuary from the deeper waters in the inlet.

TAKU INLET

Taku Inlet is a large, steep fiord which functions as a migratory corridor between the Taku River and marine waters that ultimately empty into the Gulf of Alaska. The inlet is 3–6 km wide and reaches depths of over 200 m. The lower extent of the study area is a line that identifies approximately where Taku Inlet empties into Stephens Passage (Figure 2).

TAKU RIVER ESTUARY

The Taku River estuary is considered to be large in comparison to others across SEAK. The upper extent of the study area (Figure 2) remains consistent with regard to the upper extent of the estuary work conducted in the previously mentioned 2007 collaborative project with NOAA-NMFS. For the purposes of the collaborative project and defining the study area in the present context, the Taku River estuary is defined as the area between the extreme high water mark and a depth of 20 m in areas where bottom sediments are derived predominately from fluvial sources. We used this definition to help determine the upper and lower extents of the estuary section of the study area.

The estuary is a dynamic area, with continually changing conditions due to tide levels, river discharge levels, sediment transport, etc. During low tide, extensive mud flats and sand bars become exposed throughout the estuary. Locations of the sand bars tend to change frequently due to the dynamic and converging influences of the fresh and marine waters in the estuary.

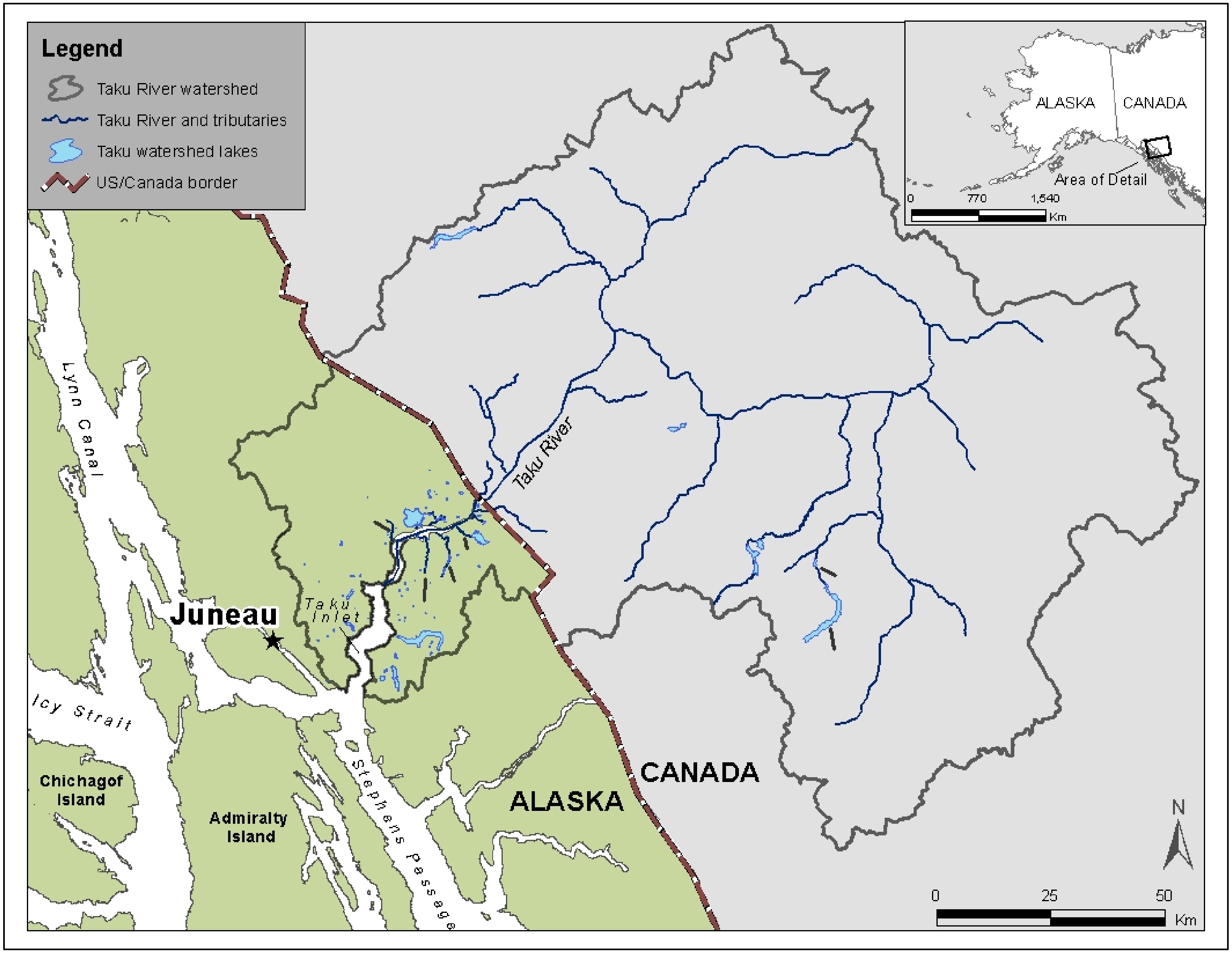


Figure 1.–Location of the Taku River watershed in Southeast Alaska.

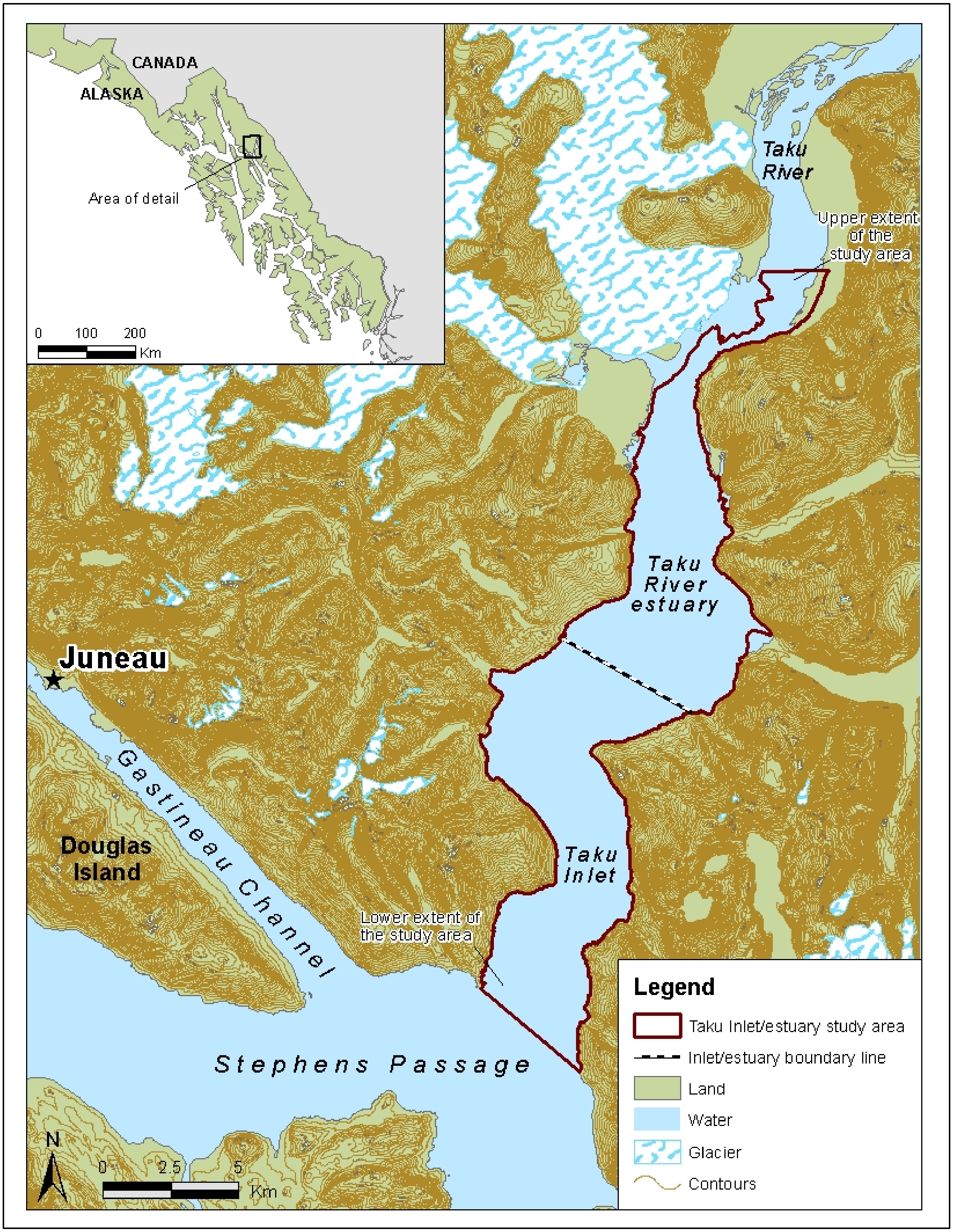


Figure 2.–Map showing the extent of the study area in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

METHODS

DATA COLLECTION

A systematic cluster sampling design was used to identify specific sampling locations throughout the study area. The study area included approximately 85 km of shoreline that was divided into equal and contiguous 250 m segments or “locations.” Each location was identified by a unique number (i.e., 339 uniquely-numbered locations). Several (47 in 2008, and 82 more in 2009) locations were removed from the sample selection process due to safety concerns. Each year sample locations were systematically selected and systematically assigned to a sampling month and tide (Table 1; Figure 3).

Table 1.–Planned number of unique locations sampled by year, month, and tide, Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

	2008			2009		
	Tide		Monthly	Tide		Monthly
Month	Low	High	total	Low	High	total
May	6	6	12	5	5	10
June	5	5	10	5	5	10
July	5	5	10	5	5	10
August	5	5	10	5	5	10
September	5	5	10	5	5	10
October	5	2	7	ND	ND	ND
Yearly totals	31	28	59	25	25	50

Each 250 m location included five 50 m “sublocations”; 3 sublocations were sampled at each location. The 1st, 3rd, and 5th sublocations were sampled, each of which were separated by 50 m of shoreline that did not get sampled (Figure 4).

Data collection for this project occurred between May and October, 2008, and between May and September, 2009 (Table 2). There was one sampling trip each month, for a total of 11 sampling events. The timing of each trip coincided with tide cycles that were representative of average annual high and low water levels (±0.6 m from mean lower low water) so that tidal conditions at each site were as similar as possible during each sampling period.

In addition to the sampling of unique locations described above, 2 locations that were sampled in May 2008 (one high tide and one low tide) were randomly chosen to be sampled multiple times throughout the project. These two locations were sampled each month at their original tide level in 2008. In 2009, these same two sites were sampled 3 times each, at their original tide level. Multiple sampling of these locations allowed evaluation of within- and between-year trends. Of the 50 locations selected for sampling in 2009, 4 were randomly chosen to be sampled at both high and low tide.

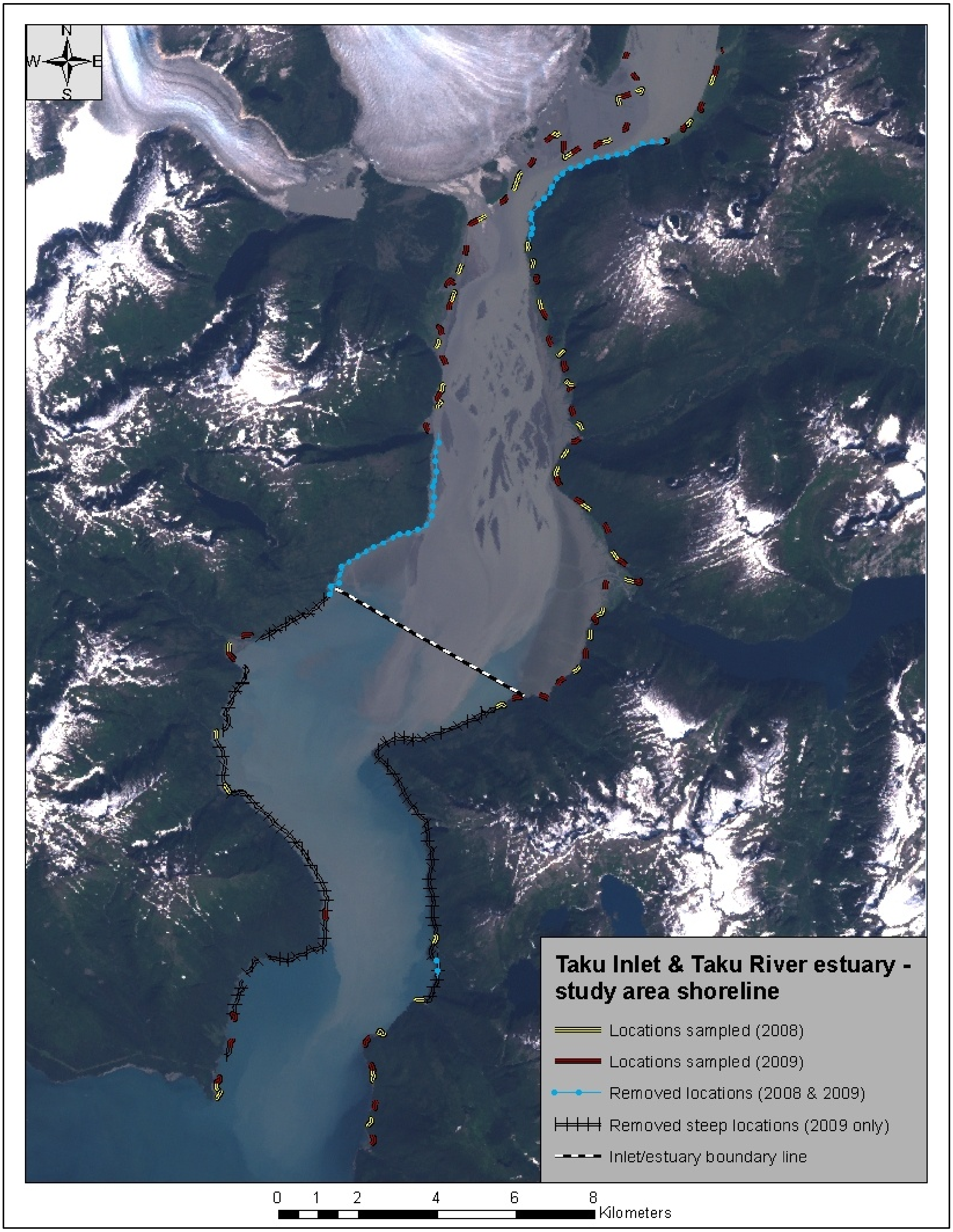
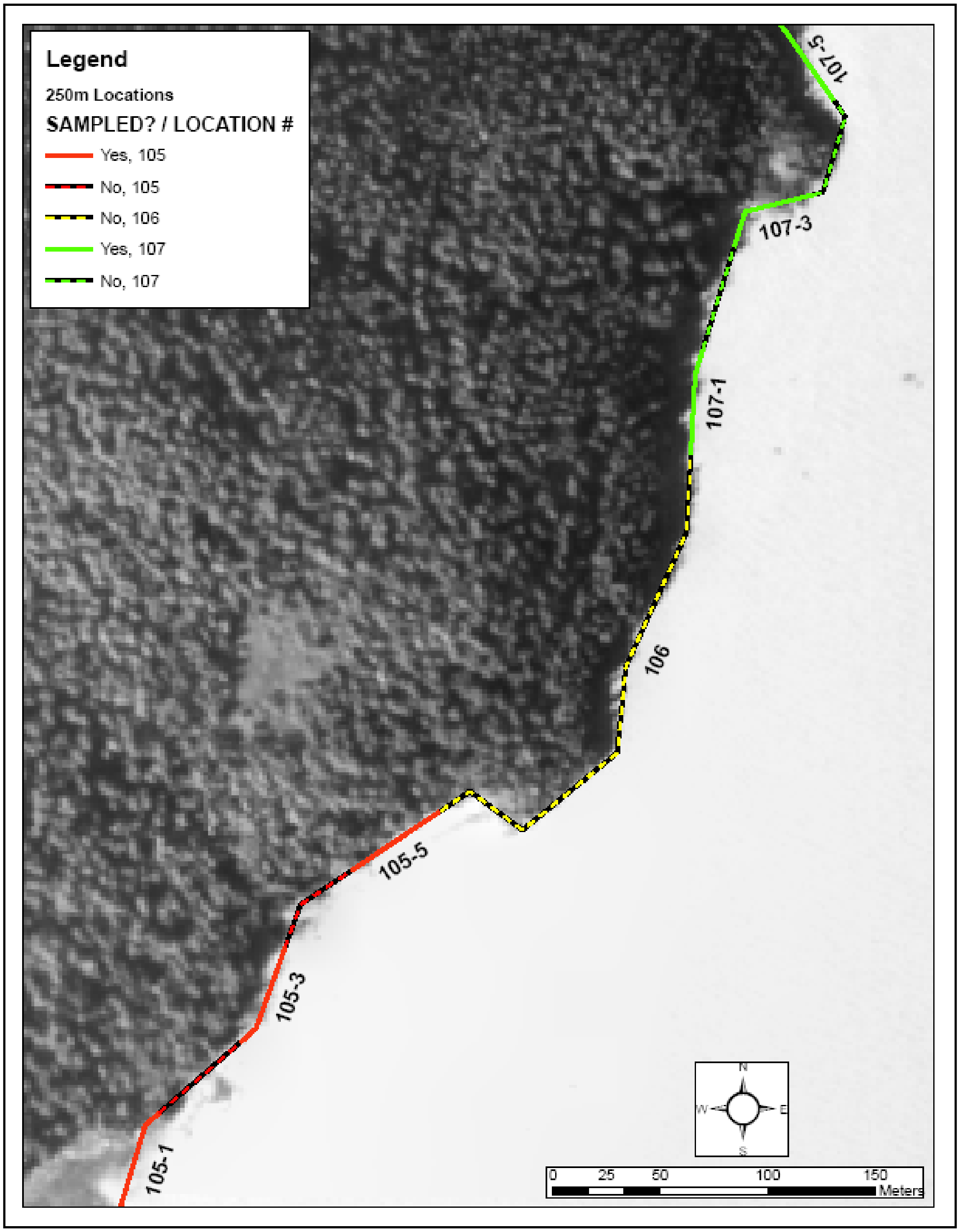


Figure 3.–Map identifying the locations sampled and locations removed in 2008 and 2009, Taku Inlet and the Taku River estuary, Southeast Alaska.



Note. Each 250 m location was given a unique number (e.g., 105, 106, 107). Each location includes five 50 m "sublocations." At locations selected for sampling, the 1st, 3rd, and 5th sublocation (e.g., 105-1, 105-3, 105-5) were sampled.

Figure 4.–Map identifying three 250 m "locations" along the shoreline in the study area in Taku Inlet and the Taku River estuary, Southeast Alaska.

Table 2.–Sampling dates for 2008 and 2009 field trips, Taku Inlet and the Taku River estuary, Southeast Alaska.

Month	2008 sampling dates	2009 sampling dates
May	5/20–5/25	5/6–5/10
June	6/16–6/21	6/4–6/9
July	7/14–7/18	7/7–7/10
August	8/15–8/19	8/4–8/7
September	9/12–9/17	9/1–9/4
October	10/12–10/17	ND

Spatial Distribution of Fish (Objective 1)

Minnow traps and 2 different types of nets were used to catch fish at sampling locations throughout the study area. Sampling was conducted out of an open skiff and required a crew of 4 people. Methods used to capture fish were as follows:

- Sloping beaches and deeper backwater areas were sampled with a beach seine (25 m long x 3 m deep) consisting of 25 mm stretch mesh. In most cases, 2 people were on land to hold one end of the seine while the other two people remained in the boat to set the seine. The seine was deployed parallel to shore and once the net was set, it was hauled to the beach by lines attached to each end of the seine.
- Shallow, wadeable areas along the shoreline were sampled with a pole seine. The seine (7.5 m long x 2 m deep) consisted of 13 mm stretch mesh and had a pole attached to each end of the net. The net was fished by pulling it into the current, parallel to the bank, for entire length of the 50 m sublocation.
- Minnow traps were set in salt marsh channels that were too small to sample with a beach seine and too wide or deep to sample with a pole seine. Each trap soaked for at least 1 hour and was baited with sterilized (i.e., borax and Betadine®[1] treated) salmon eggs.

At each sublocation, captured fish were retained in an aerated tank on the boat. All fish were counted and identified to species (or lowest taxon possible). In addition to identifying and counting all fish captured, length measurements were recorded for a subsample of salmonids. At the first sublocation sampled at a location, all salmonids were measured to the nearest mm fork length. Fish were released after processing. Fish that could not be identified to the species level while processing the catch were identified to the lowest taxon possible; comments were recorded describing physical characteristics of the fish, and photos were taken to assist with identification upon return to field camp when observers were able to reference detailed field guides.

Habitat Characterization (Objective 2)

Physical and chemical habitat parameters that were measured were selected from important estuarine and marine habitat characteristics identified in the EFH description for Pacific salmon (Benaka 1999). Important habitat features identified included: water quality; temperature; cover

[1] Product names are included for a complete description of the process and do not constitute product endorsement.

and aquatic vegetation. Habitat information was recorded at each scheduled sampling location; some of those habitat parameters were collected at the time of sampling and others were collected only during low tide.

Water Quality

At each location sampled, surface water physicochemical conditions were assessed at the third sublocation, at the time of sampling. A Quanta Hydrolab multi-sensor was used to collect water quality information for: temperature, specific conductivity, salinity, dissolved oxygen, pH, and turbidity.

Beach Transect

During daytime negative tides, observers sampled beach transects to record habitat information associated with the exposed intertidal zone. One transect was sampled in the third sublocation of each 250 m long fish sampling location. Transects were established perpendicular to the shoreline, and extended from the water line to the upper extent of the intertidal zone, which was commonly identified by a line of debris, or the area immediately below the "splash zone," which was identified by a black lichen (*Verrucaria*) band (Harney et al. 2007). Transects did not exceed 100 m in length at locations with very low slope, and exhibiting homogeneous substrate and biota (e.g., mud flats and salt marshes). In this situation, the transect began at the water's edge and was established perpendicular to the shoreline, similar to every other transect, but the transect ended 100 m from the water's edge instead of at the upper extent of the intertidal zone.

To establish a transect, observers first located the midpoint of the location (the middle of the third sublocation) using a Global Positioning System that had these locations uploaded as points. One observer held the tape measure at the water's edge, while another observer took the zero-end of the tape measure and walked straight up the beach until they reached the upper edge of the intertidal zone (or 100 m was reached, whichever came first). The transect line was established perpendicular to the shoreline using the tape measure.

Observers recorded information on the presence of woody debris, beach slope, dominant substrate(s), and biota present in the intertidal zone, intersecting the transect, as they worked their way down the transect (from the zero-end of the tape down to the waterline). Observers also identified the dominant general shoretype of each 250 m location sampled at the time when transects were conducted.

Large Woody Debris

Observers recorded whether individual large woody debris was present in the intertidal zone, intersecting the transect. For this project, large woody debris was defined as all pieces of wood, including rootwads, that were longer than 1 m in length and had greater than 10 cm diameter. The definition used was consistent with the ADF&G Stream Habitat Survey User Guide (Nichols et al. 2013).

Slope

Gradient-slope measurements within the intertidal zone were obtained by using an Abney hand-level. This measurement was taken using an Abney hand-level that had been retrofitted to attach to the top of a 1.5 m long piece of PVC pipe, and a second piece of PVC of equal length. One observer stood at the water line with one piece of PVC pipe, while the other observer stood at the top end of the transect with the Abney hand-level and the other piece of PVC pipe. The observer with the Abney level would "shoot" to the top of the other PVC that was being held by the other observer and record the slope in percent (%). The method used for obtaining gradient-slope measurements was consistent with the ADF&G Stream Habitat Survey User Guide.

Substrate

Geologic substrate was described and measured along the transect line using methods similar to those described in the operational plan[2] used for previous ADF&G nearshore marine surveys.

Starting at the zero-end of the transect, observers would walk down the line (towards the water) looking at the bands of substrate, and noting where the changes in substrate composition occurred along the transect line while recording the dominant and secondary substrate observed and their respective percentages. At times, no secondary substrate was observed; in those cases, the dominant substrate percentage was recorded as 100%.

The following is a list of substrate options used:

1. mud/organic/sand (<0.06 mm – 2 mm)
2. gravel (2 mm – 64 mm)
3. cobble (64 mm – 256 mm)
4. boulder (>256 mm)
5. bedrock (continuous rock)

Observers also recorded the beginning and ending distance along the transect line of each substrate band (e.g., 5 m – 10 m). This measurement was recorded to the nearest 0.5 m.

General Shoretype

In addition to collecting substrate information along the transect line, observers also identified the dominant intertidal substrate composition throughout the 250 m sampled location. The general shoretypes used were:

1. sediment (<0.06 mm – 256 mm)
2. mixed (shoreline composed of sediment and rock)
3. rock (continuous bedrock)

Biota

Species composition of flora and fauna in the intertidal zone were described and measured along the transect line using methods similar to those described in the operational plan[3] used for previous ADF&G nearshore marine surveys.

Starting at the zero-end of the transect line (nearest the tree line), observers would walk down the transect line (towards the water) observing the intertidal biota. Changes in biological bands (biobands) were recorded as observers moved down the transect line identifying dominant species present. Color changes along the transect often indicated a change in bioband.

One of the following codes was assigned to each bioband encountered:

0. bare (no living substrate)
1. marsh grasses, sedges and herbs
2. lichen

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[2] Frenette, B. *Unpublished*. Operational plan: nearshore marine habitat project. Alaska Department of Fish and Game, Douglas, AK.

3. *Fucus* sp.
4. barnacle
5. mussel
6. filamentous algae
7. leafy algae
8. algae conglomerate (filamentous (#6) and leafy algae (#7) are equally dominant)
9. eelgrass
10. canopy kelp (*Nereocystis* sp. and *Macrocystis* sp.)
11. leafy kelp

Observers also recorded the distance along the transect line at which each bioband started and ended (e.g., 5 m – 10 m) and also identified other biota present in each bioband. This measurement was recorded to the nearest 0.5 m.

Habitat Characteristics Associated with Juvenile Salmon (Objective 3)

No additional data were collected for this objective.

DATA ANALYSIS

For each location, the mean number of juvenile salmon captured was classified into 1 of 3 ordinal categories (catch scores; Table 3).

Table 3.–Ordinal categories (catch scores) used to analyze the catch data for surveys, Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Number of juvenile salmon caught	Catch score
0	1
1–5	2
>5	3

To determine if the same ordinal categories could be used for all gear types (beach seine, pole seine, and minnow traps), or if each gear type needed to have a different ordinal scale, the catch scores among gear types were compared at 4 locations. Four locations that met the following criteria were chosen:

1. all gear types could be fished effectively at the location; and
2. the habitat was homogenous within each location.

At the chosen four locations, sublocations 1, 3, and 5 were sampled as described above. For this comparison, sublocations 2 and 4 were also sampled using the remaining gear types (i.e., sub-locations 2, 3, and 4 were all fished with a different gear type). Sampling at sublocations 2 and 4 only involved counting juvenile salmon. The catch for each gear type and location was classified into the ordinal categories identified in Table 3.

The differences in catch scores among gear types were then examined by visually analyzing the graphs to determine whether a certain gear type consistently resulted in higher or lower catch scores than the other gear types.

Water Quality

An analysis of variance (ANOVA) was used to determine which water quality variables (temperature, specific conductivity, salinity, turbidity, dissolved oxygen, and pH) had a significant effect on the presence of juvenile salmon. The ANOVA was done for each water quality metric separately. The dependent variable was the individual habitat metric (e.g., temperature, specific conductivity, salinity, turbidity, dissolved oxygen, and pH) and the independent variable was the catch score of the mean number of juvenile salmon caught. If the water quality variable was not normally distributed, then a rank transformation was used.

For all water quality variables the assumption was made that area (inlet and estuary) had no significant effect on the catch scores of juvenile salmon. This assumption was tested by including area in the ANOVAs described.

Beach Transect

Mantel-Haenszel tests were used to determine which habitat variables (woody debris, intertidal substrate, and intertidal biota) had a significant association with the presence of juvenile salmon. The catch score for the number of juvenile salmon comprised the columns of the contingency table, and the nominal categories of the habitat variables comprised the rows.

An ANOVA was used to determine if the slope of the beach had a significant effect on the catch score of juvenile salmon. The dependent variable was percent gradient calculated for each location and the independent variable was the ordinal catch score.

RESULTS

DATA COLLECTION

A total of 40 unique locations were sampled in 2008, and 50 unique locations were sampled in 2009, for a total of 90 unique locations sampled. Catches of 1–5 juvenile salmon were most common (43% of the sampled locations; Table 4).

Table 4.–Total number of unique locations sampled and the associated catch scores, Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Catch score	Number of juvenile salmon caught	Number of sampled locations	Percent of sampled locations
1	0	27	30
2	1–5	38	43
3	>5	25	27
		90	100

In 2008, a total of 1,469 salmon and an overall total of 2,138 fish were captured between May and October. In 2009, a total of 1,056 salmon and an overall total of 1,735 fish were captured between May and September (Table 5; Figures 5 and 6). Sockeye salmon were the most abundant species captured during both 2008 and 2009 surveys.

Table 5.–Fish catch composition by taxa, year, and sampling period for Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

	2008							2009					
Species[a]	May	June	July	August	September	October	2008 total	May	June	July	August	September	2009 total
Penpoint gunnel	0	0	1	0	0	0	1	0	1	0	0	0	1
Pacific spiny lumpsucker	0	0	0	0	1	0	1	0	0	0	0	0	0
Threespine stickleback	22	18	86	4	0	3	133	14	11	15	21	2	63
Surf smelt	0	0	0	0	0	0	0	0	0	108	0	2	110
Northern sculpin	2	0	0	0	0	0	2	6	4	0	0	0	10
American river lamprey	0	1	0	0	0	0	1	0	0	0	0	0	0
Southern rock sole	0	0	0	0	0	0	0	0	2	0	0	0	2
Pacific staghorn sculpin	1	4	6	4	1	2	18	4	5	4	2	3	18
Snake prickleback	0	0	0	0	2	14	16	0	2	0	0	0	2
Shortfin eelpout	0	0	0	0	1	0	1	0	0	0	0	0	0
Capelin	0	0	1	0	0	3	4	0	0	0	0	0	0
Crescent gunnel	1	2	0	0	0	0	3	1	2	0	1	0	4
Starry flounder	10	28	59	100	19	5	221	26	90	26	24	10	176
Round whitefish	0	0	0	0	0	0	0	0	0	3	0	0	3
Cutthroat trout	0	0	0	0	0	0	0	0	0	0	1	0	1
Pink salmon	1	0	1	0	0	0	2	3	0	0	1	0	4
Chum salmon	0	25	3	4	0	2	34	52	90	25	2	0	169
Coho salmon	157	86	17	12	7	7	286	122	8	56	17	33	236
Rainbow trout	0	0	0	0	0	0	0	0	0	0	1	0	1
Sockeye salmon	104	358	133	21	47	15	678	27	132	135	32	106	432
Chinook salmon	237	199	13	16	2	2	469	44	42	50	8	71	215
Northern ronquil	0	0	0	0	0	0	0	0	0	0	0	1	1
Dolly Varden	47	75	28	30	11	1	192	53	21	28	31	31	164
Eulachon	0	12	22	0	1	0	35	31	0	1	0	0	32
Pacific sandfish	0	0	0	0	0	1	1	0	0	0	0	0	0
Family Cottidae	3	10	0	15	9	1	38	47	7	16	4	14	88
Family Osmeridae	0	0	0	0	2	0	2	3	0	0	0	0	3
Total	585	818	370	206	103	56	2,138	433	417	467	145	273	1,735

[a] Latin names (*genus species*) for all individual species identified above are provided in Appendix A.

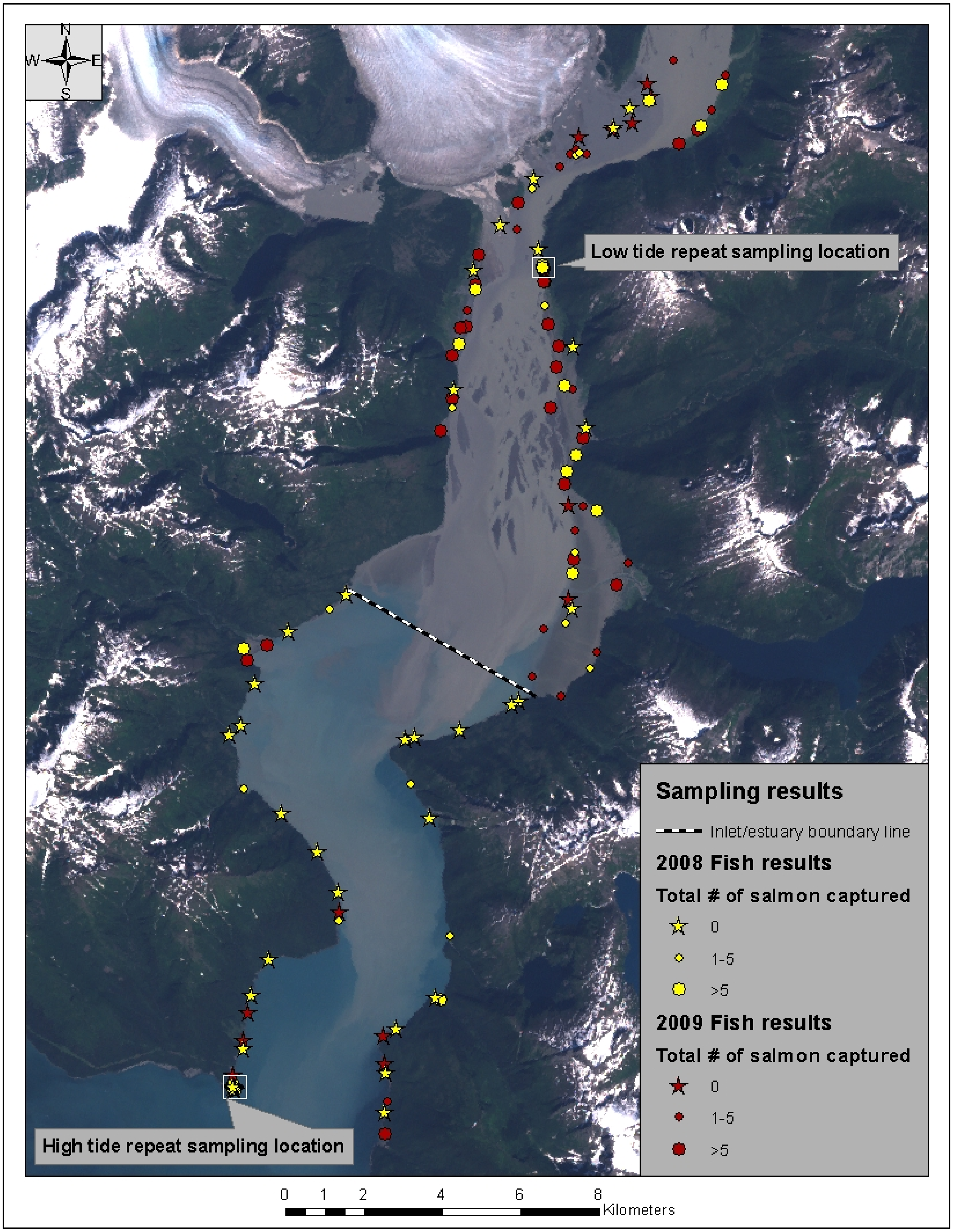


Figure 5.–Map showing general salmon catch results at all locations sampled throughout the study area, in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

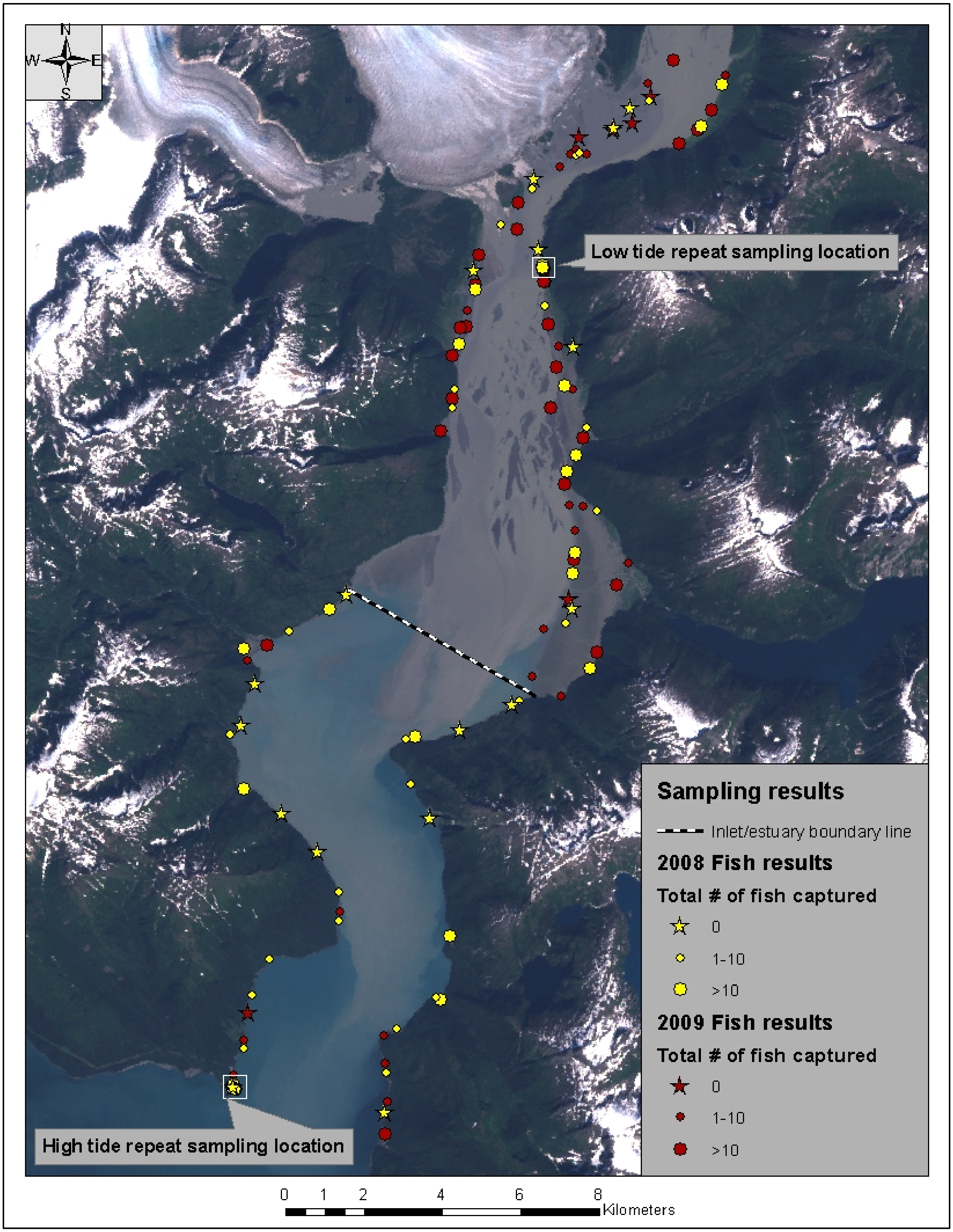


Figure 6.–Map showing general fish catch results at all locations sampled throughout the study area, in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Two sites were sampled multiple times in both 2008 and 2009; one of the repeat locations was always sampled at low tide, and the other was always sampled at high tide. Mean catch scores for repeat locations sampled at low and high tide, and at all locations are plotted in Figure 7. At the low tide repeat location there was no annual or monthly variation in the catch scores. The high tide repeat location did have both monthly and annual variation, but showed no defined pattern. Comparing the mean catch scores by year and month for all sites sampled showed the 2009 catch scores were slightly higher than the 2008 catch scores, and June had slightly higher catch scores in both years.

In 2009, 4 sites were sampled during both high and low tides in the same month. Catch scores for 2 of the 4 sites were exactly the same between tides. For the other two sites, the catch scores differed but there was no pattern to the differences (Figure 8). Comparing the mean catch scores by month and tide for all sites sampled showed the catch scores were slightly higher during high tides (Figure 9).

Annual and seasonal ranges of observed water quality conditions are identified in Table 6. In 2008, turbidity data was not collected because the sensor did not include a turbidity probe; a turbidity probe was installed prior to the 2009 field season.

DATA ANALYSIS

The average catch score was highest for pole seines followed by beach seines and minnow traps (Table 7; Figure 10). Because no gear type consistently had higher or lower catch scores than the other gear types, the ordinal categories described in Table 3 were used for all gear types.

Water Quality

Water quality parameters included water temperature, specific conductivity, salinity, turbidity, dissolved oxygen, and pH. All water quality variables were individually analyzed with respect to catch scores.

There was a significant difference in the water temperature between areas and among sites with different catch scores. Water temperatures were higher in the inlet than the estuary ($F = 7.46$, $P < 0.01$) and catch scores were higher in locations with higher temperatures ($F = 6.21$, $P < 0.01$; Figure 11).

The water quality sensor used in this project derives salinity values from the conductivity measurements; therefore, conductivity and salinity measurements are correlated and not independent. There was a significant difference in salinity between areas and among sites with different catch scores. Salinity was higher in the inlet than the estuary (rank transformed data, $F = 20.84$, $P < 0.01$) and catch scores were higher in locations with higher salinity (rank transformed data, $F = 5.51$, $P < 0.01$; Figure 11).

There was a significant difference in turbidity between areas and there was a marginally significant difference in turbidity among sites with different catch scores. Turbidity was higher in the estuary than the inlet (rank transformed data, $F = 22.09$, $P < 0.01$) and catch scores were higher in locations with lower turbidity (rank transformed data, $F = 3.07$, $P = 0.06$; Figure 11).

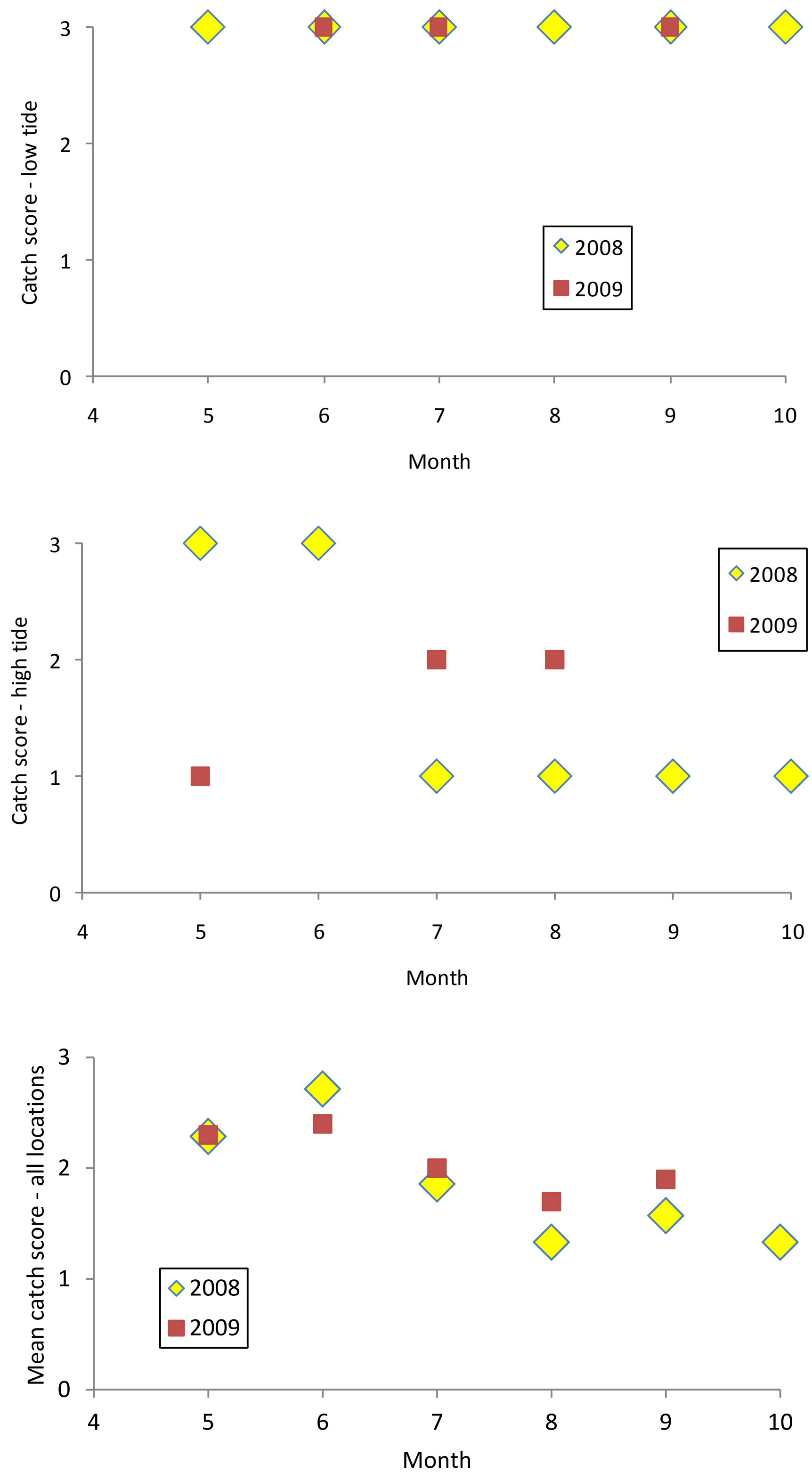


Figure 7.–Comparison of mean catch scores by month (April – October) and year for low tide (top graph) and high tide (middle graph) repeat sampling locations, and for all locations sampled (bottom graph) in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

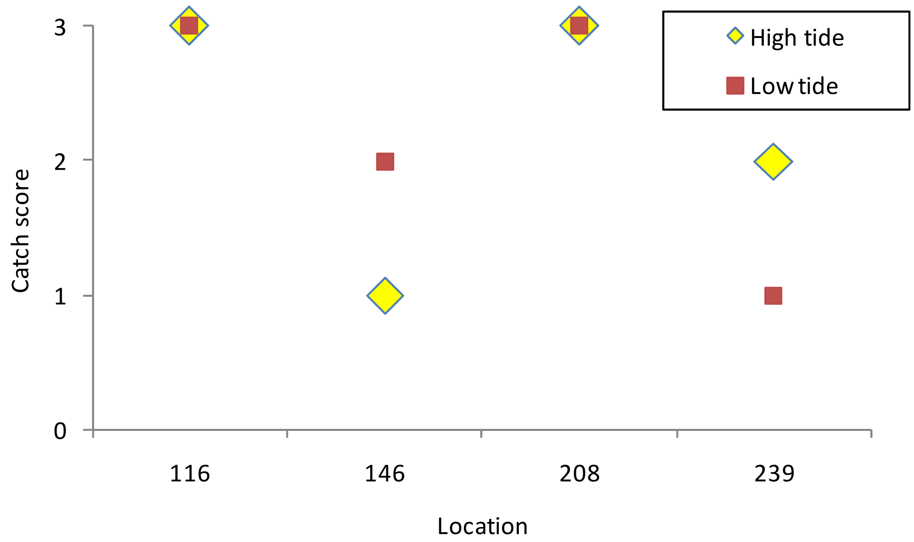


Figure 8.–Comparison of catch scores at the four locations sampled during both high and low tide, in the same month, in Taku Inlet and the Taku River estuary, Southeast Alaska, 2009.

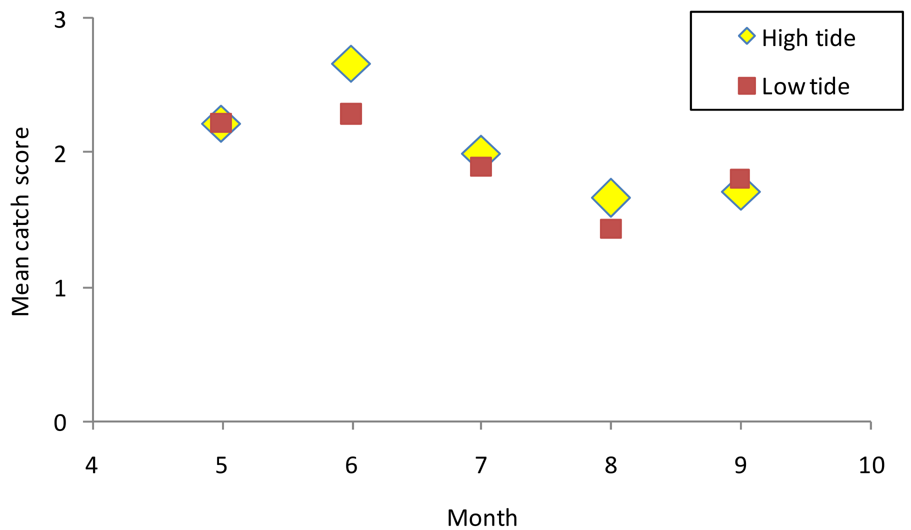


Figure 9.–Comparison of mean catch scores, by month (April–October) and tide, for all locations sampled in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Table 6.–Seasonal and annual ranges of collected water quality parameters in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

	2008						2009				
Surface water parameter	May	June	July	August	Sept	Oct	May	June	July	August	Sept
Temperature (°C; min.)	4.30	0.27	5.78	0.00	0.17	1.83	0.60	3.14	1.77	0.25	0.84
Temperature (°C; max.)	11.65	11.55	9.46	8.17	8.12	6.00	9.00	14.85	13.18	12.11	11.47
Specific conductivity (mS/cm; min.)	0.12	0.09	0.02	0.03	0.03	0.08	0.14	0.03	0.05	0.03	0.03
Specific conductivity (mS/cm; max.)	22.20	26.40	19.00	19.30	24.10	22.30	30.80	31.10	15.50	26.10	22.90
Salinity (PSS; min.)	0.06	0.04	0.01	0.01	0.01	0.03	0.06	0.01	0.02	0.01	0.01
Salinity (PSS; max.)	13.10	17.30	11.15	10.95	14.58	13.38	18.59	18.68	8.82	15.65	13.49
Turbidity (NTU; min.)	NA	NA	NA	NA	NA	NA	10.30	5.00	18.10	12.80	17.40
Turbidity (NTU; max.)	NA	NA	NA	NA	NA	NA	>1000	>1000	>1000	>1000	>1000
Dissolved oxygen (mg/L; min.)	9.87	9.96	11.67	8.59	8.11	9.78	12.64	12.88	12.92	11.32	12.88
Dissolved oxygen (mg/L; max.)	16.72	22.11	41.40	12.66	11.92	17.00	22.75	17.03	19.09	18.46	19.60
pH (min.)	7.79	7.58	7.70	7.54	8.00	7.52	7.71	7.52	7.13	7.83	7.86
pH (max.)	8.99	9.51	9.29	9.77	9.78	9.45	9.05	9.40	10.27	10.54	9.82

Table 7.–Average catch scores for each of the gear types used to capture fish during surveys, Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Gear	Average catch score
Beach seine	2.0
Minnow traps	1.5
Pole seine	2.5

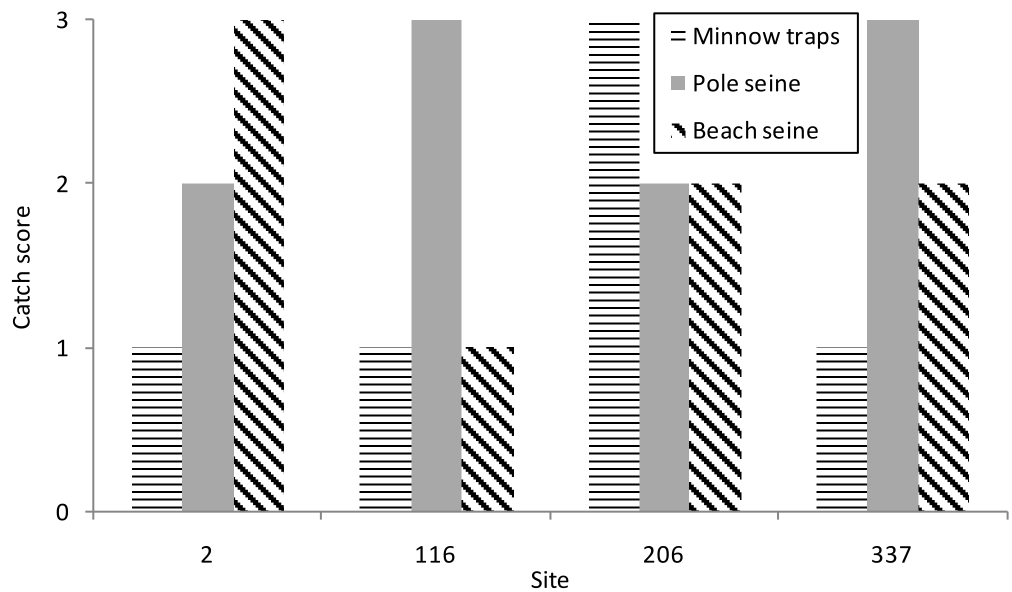
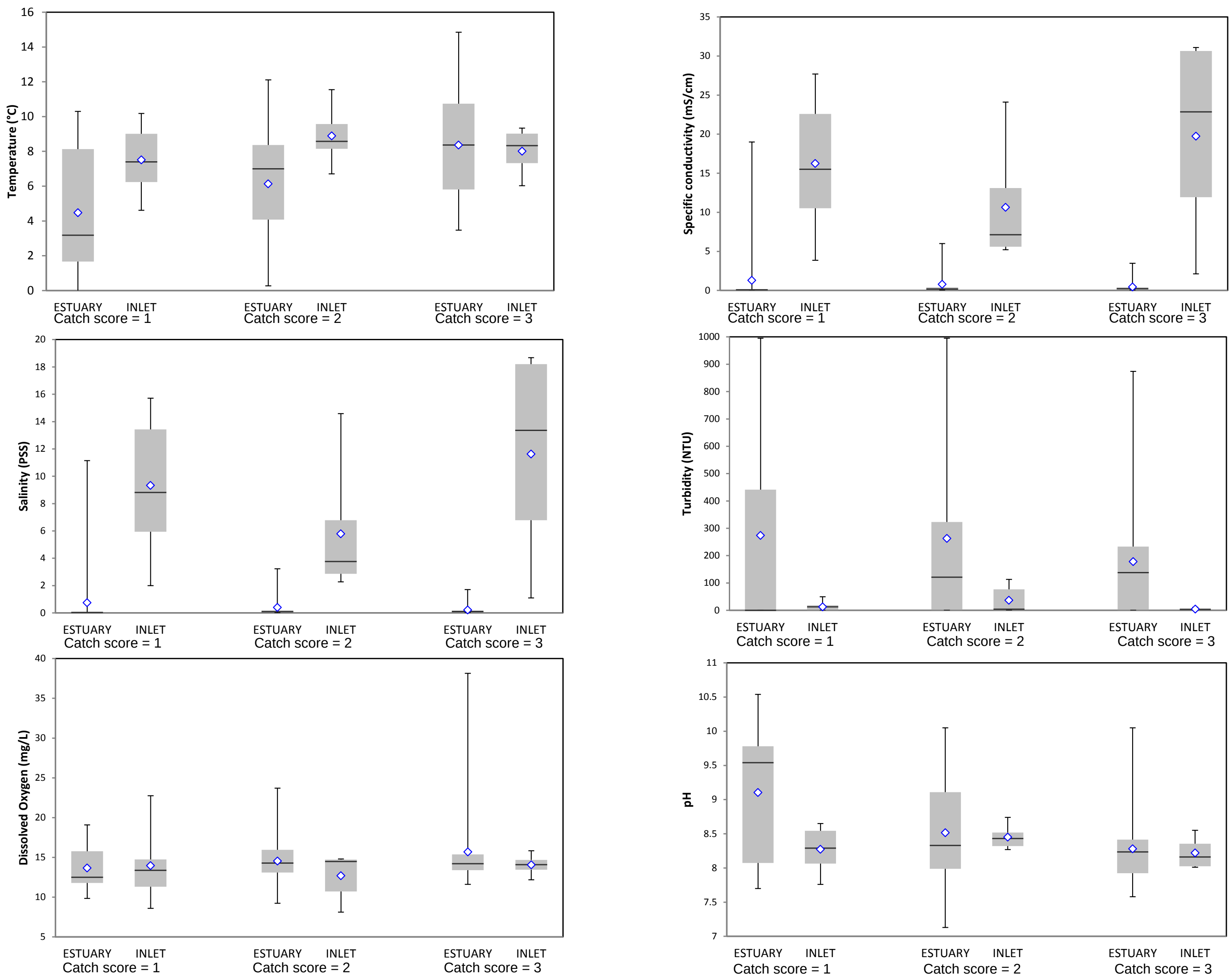


Figure 10.–Catch scores by gear type used at each of the four locations sampled for the gear comparison in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

There was no significant difference in the dissolved oxygen levels between areas ($F = 0.71$, $P = 0.40$) or among sites with different catch scores ($F = 0.96$, $P = 0.39$; Figure 11).

There was a significant difference in the pH between areas and among sites with different catch scores. The pH levels were higher in the estuary than the inlet ($F = 5.11$, $P = 0.04$) and catch scores were higher in locations with lower pH ($F = 4.67$, $P = 0.01$; Figure 11).



Note: Mean and median catch score values are identified by diamonds and solid horizontal lines, respectively, within box plots.

Figure 11.–Box plots displaying catch scores of juvenile Pacific salmon, relative to different water quality parameters at sampled locations in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Beach Transect

Physical habitat variables associated with beach transects were analyzed across the entire study area rather than separately for the inlet and estuary. This was because the variables were categorical and consistently defined throughout the study area.

Large woody debris was only found at 6 (7%) of the sampled locations. Eelgrass was not observed at any of the sampled locations. Kelp was only found at one (1%) location. Statistical testing for these 3 variables was not possible because the number of occurrences was too small for a valid test.

Sixty-six (73%) of the sampled locations had a general shoretype defined as sediment, followed by mixed (19 locations, 21%), and rock (5 locations, 6%; Figures 12 and 13). There was no significant difference in the mean catch scores between locations where the general shoretype was defined as sediment or mixed ($Q_s = 2.65$, $P < 0.10$). Locations where the general shoretype was defined as rock were not included in the analysis due to small sample sizes.

Seventy (78%) of the sampled locations had a dominant intertidal substrate defined as mud/sand/organic, followed by bedrock, cobble, gravel, and boulder (Figures 14 and 15). Statistical testing was only used to compare the catch scores between mud/sand/organic and bedrock due to the small sample size of some of the intertidal substrate categories. The catch scores were significantly greater in the locations with an intertidal substrate of mud/sand/organic than in locations with a bedrock substrate ($Q_s = 10.2164$, $P < 0.01$).

It was necessary to combine several biota classifications to perform valid statistical tests. All algae types were combined, both kelp types were combined, and mussels and barnacles were combined. Catch scores were not significantly different among locations with different dominant intertidal species ($Q_s = 4.07$, $P = 0.13$; Figures 16 and 17). There was no difference in catch scores between locations where the dominant species present was algae and where most of the transect was classified as bare. Locations where the dominant species present was barnacle/mussel were not included in the analysis due to small sample sizes.

There was a significant difference in the percent slope among sites with different catch scores ($F = 19.16$, $P < 0.01$; Figures 18 and 19). Salmon abundance was lowest in locations with a steeper slope.

DISCUSSION

The timing and capacity of salmon outmigration is thought to be influenced by a number of biotic and abiotic factors, including changes in physiology, behavior, size and condition of individual fish, stream discharge, temperature, turbidity, photoperiod, preference for increased salinity, etc. (Groot and Margolis 1991; McKeown 1984; Quinn 2005; Simenstad et al. 1982). It is therefore important to identify differences in sampling strategies in multi-year projects as well as recognizing normal variation in biotic and abiotic factors. There were a few differences between the 2008 and 2009 field seasons that might have affected the monthly catch totals or habitat use between years.

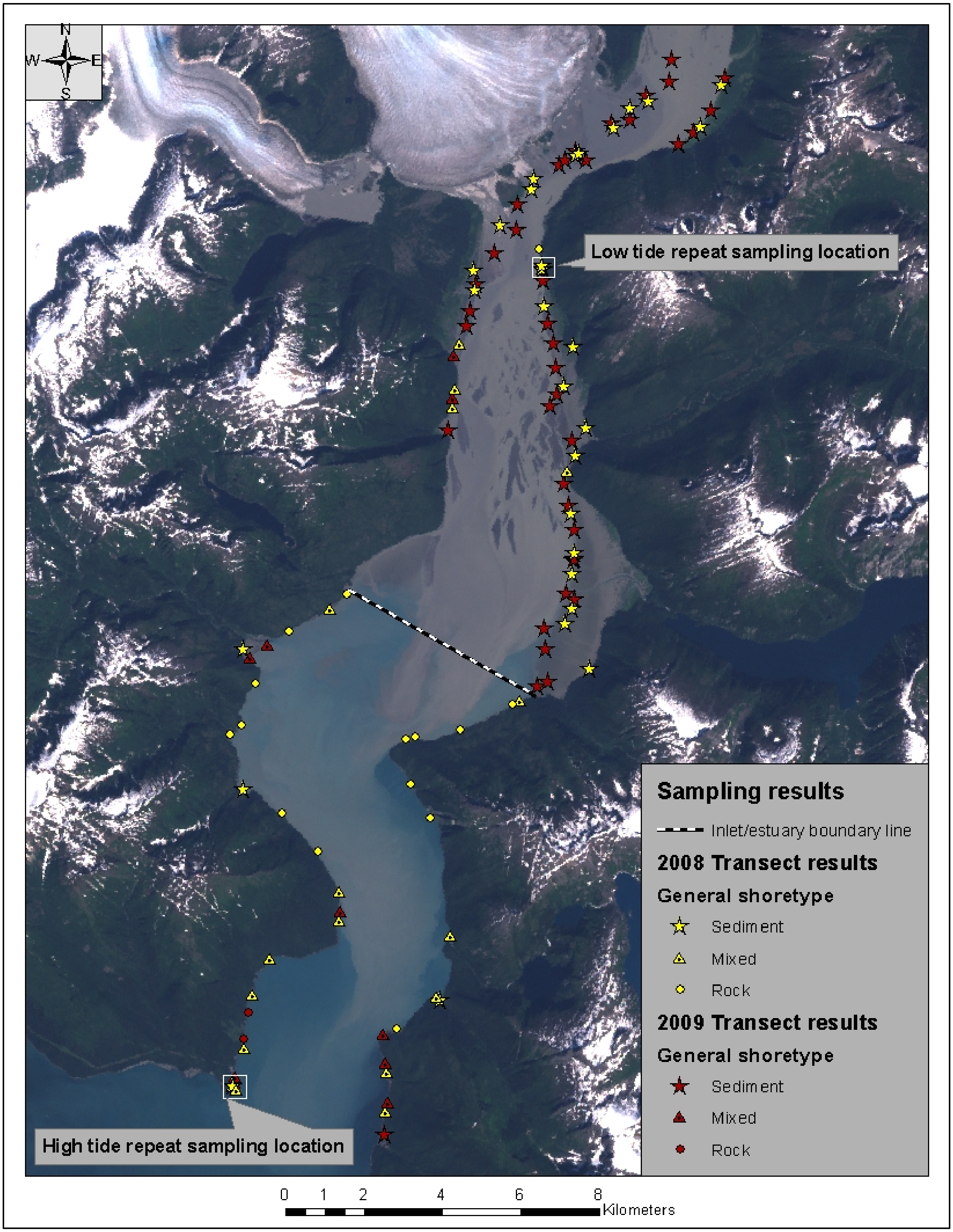


Figure 12.–Map showing general shoretype designations made during the intertidal beach transects in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

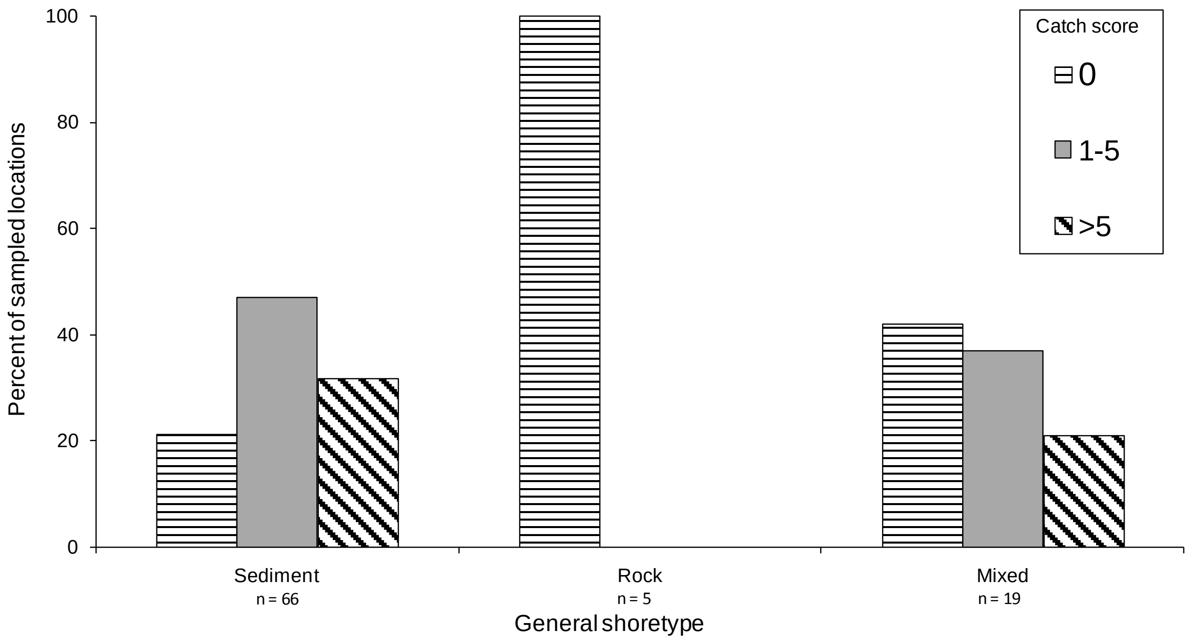


Figure 13.–Comparison of catch score compositions at sampled locations in Taku Inlet and the Taku River estuary, Southeast Alaska with respect to general shoretype, 2008 and 2009.

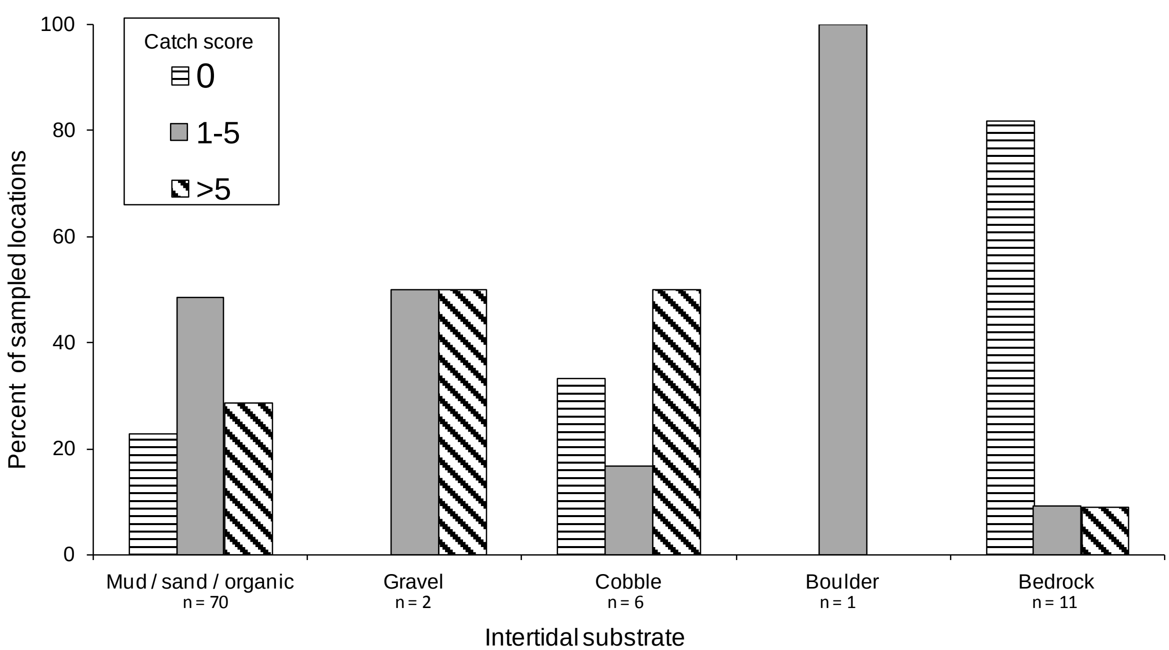


Figure 14.–Comparison of catch score composition at sampled locations in Taku Inlet and the Taku River estuary, Southeast Alaska, with respect to dominant intertidal substrate, 2008 and 2009.

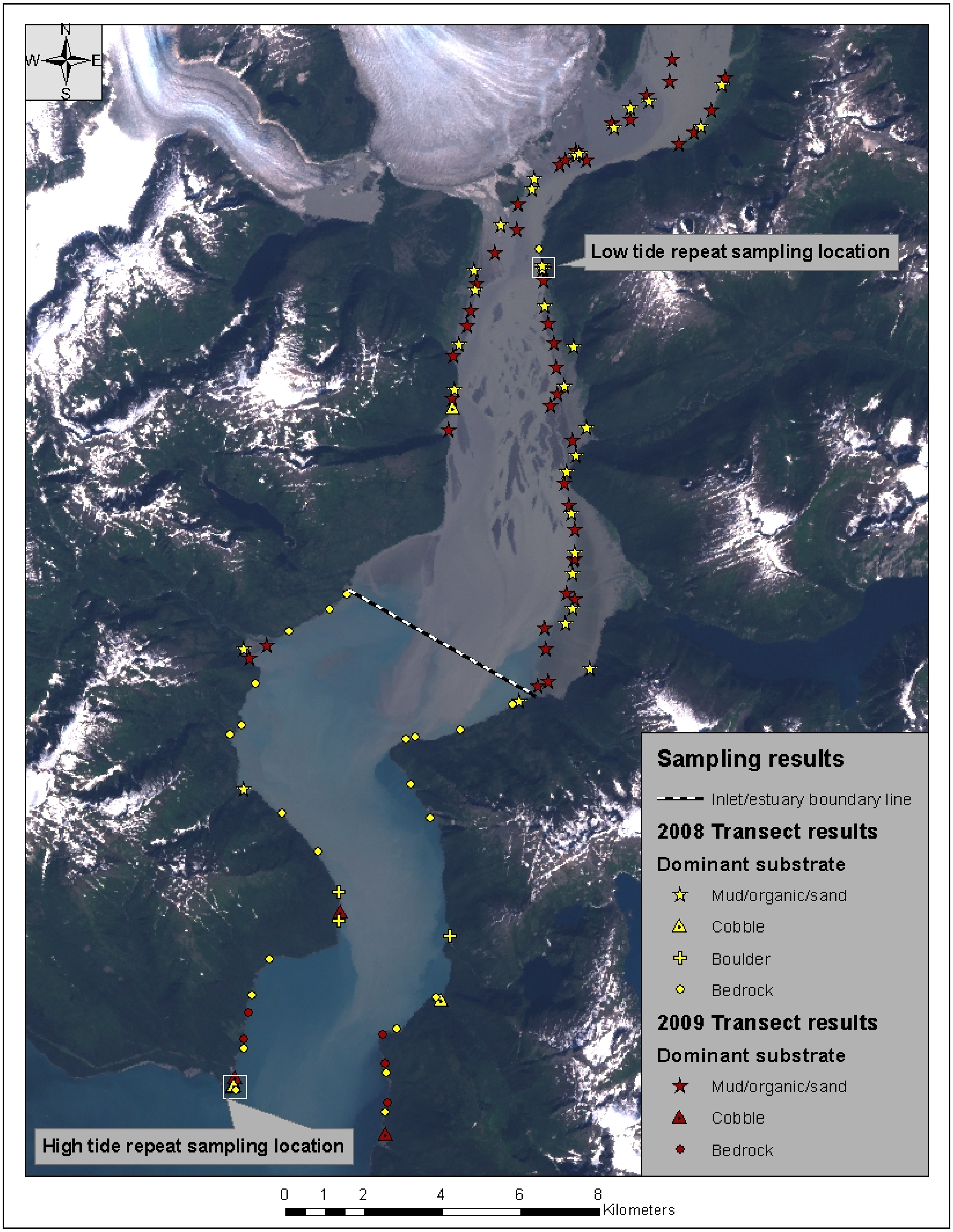


Figure 15.–Map showing dominant substrate designations made during the intertidal beach transects conducted in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

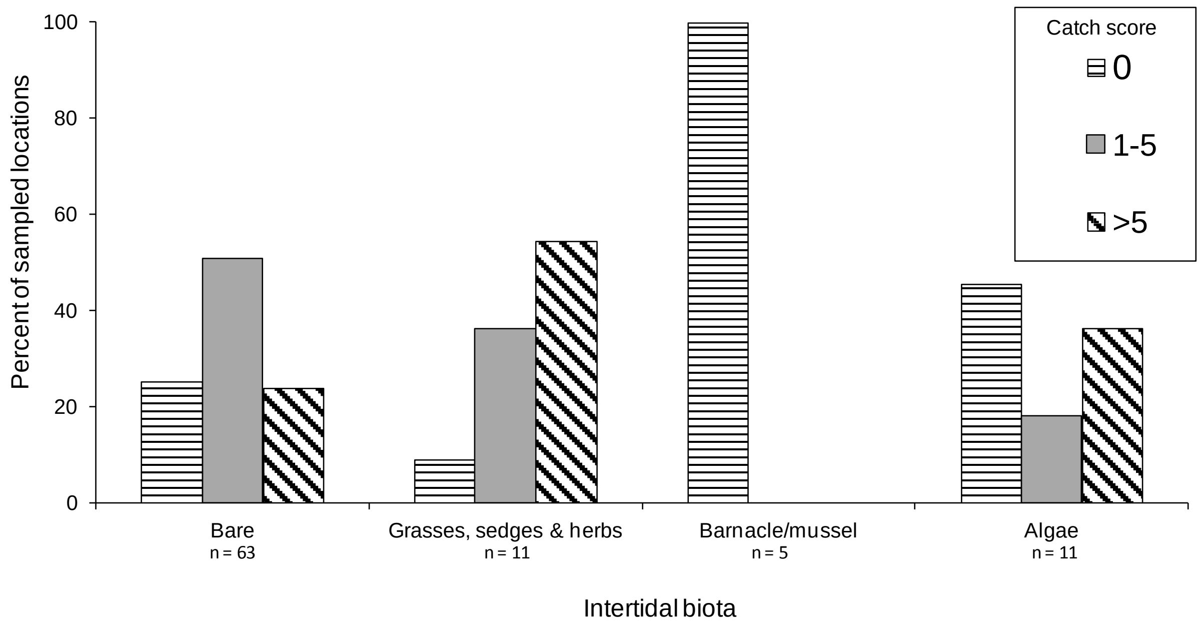


Figure 16.–Comparison of catch score compositions at sampled locations in Taku Inlet and the Taku River estuary, Southeast Alaska, with respect to intertidal biota, 2008 and 2009.

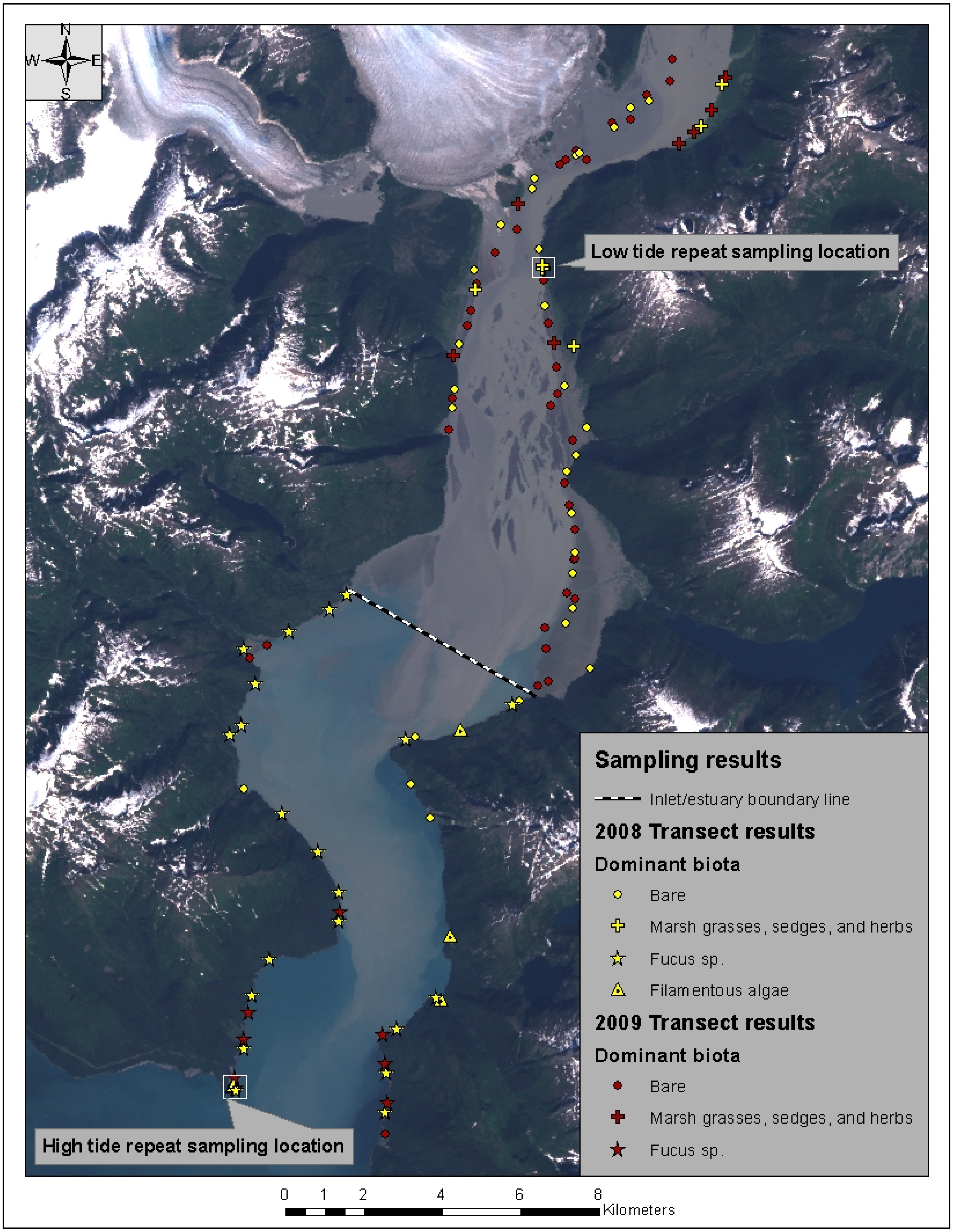
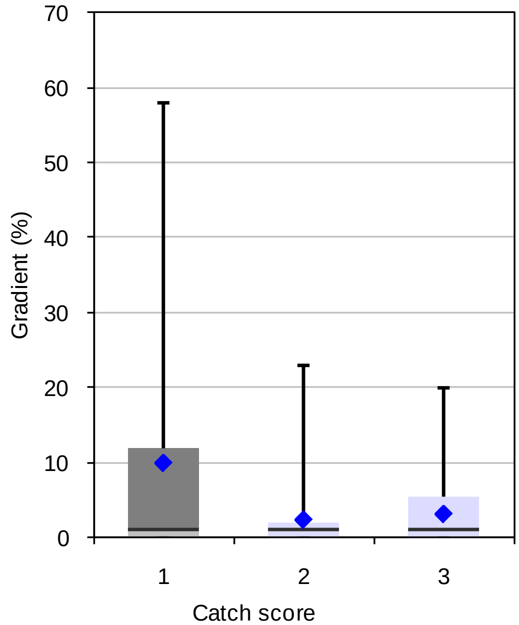


Figure 17.–Map showing dominant biota designations made during the intertidal beach transects conducted in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.



Note: Significant differences in catch scores for intertidal slope--% gradient are identified by off-colored boxes; mean and median catch score values are identified by diamonds and solid horizontal lines, respectively, within box plots.

Figure 18.–Catch scores for juvenile Pacific salmon relative to intertidal slope (measured as % gradient) at sampled locations in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

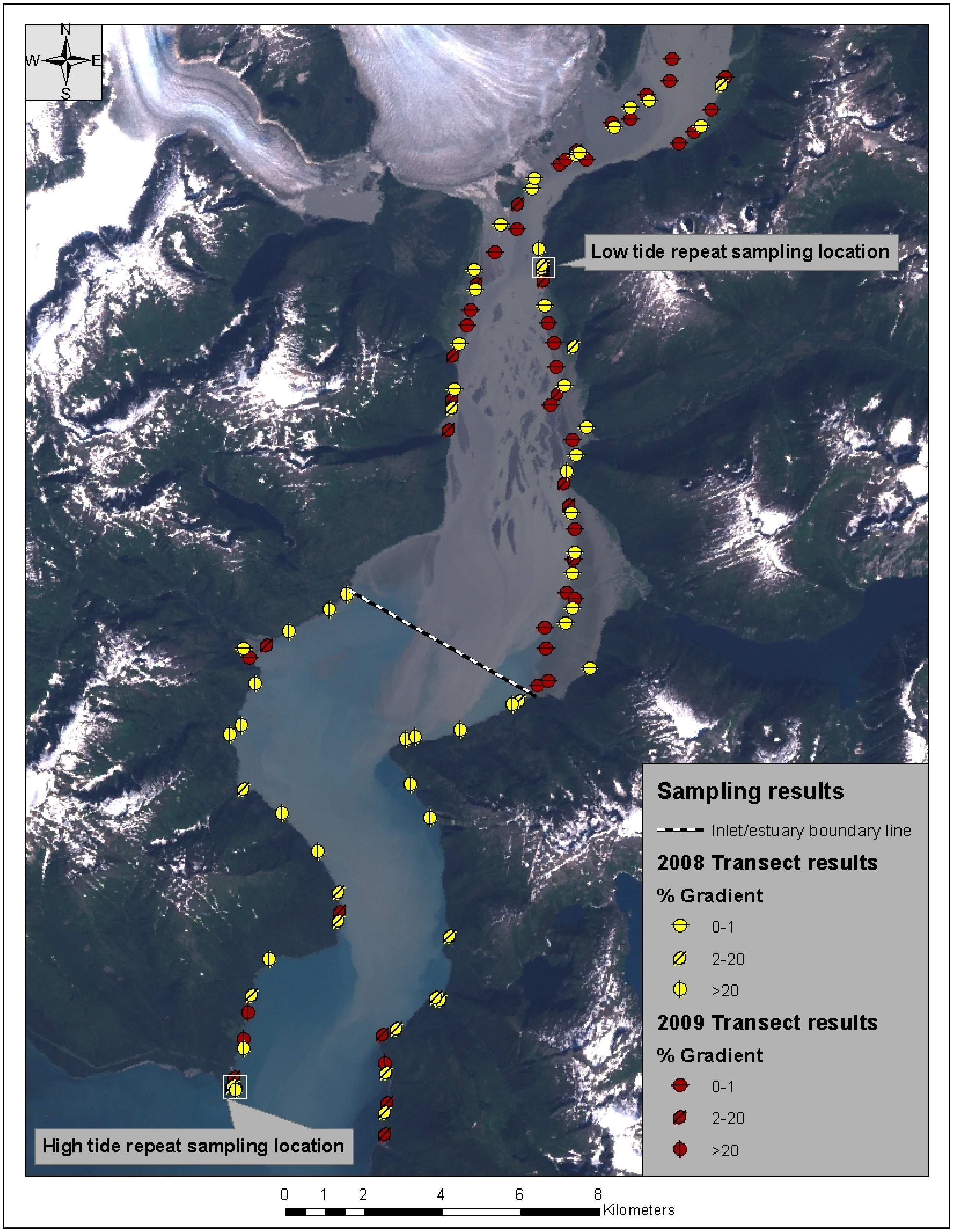


Figure 19.–Map showing slope measurements of the intertidal beach transects conducted in Taku Inlet and the Taku River estuary, Southeast Alaska, 2008 and 2009.

Water temperature appears to be an important environmental variable related to the activity level of juvenile salmonids and the timing of salmon outmigration (Chapman and Bjornn 1969; Groot and Margolis 1991; McKeown 1984; McMahon and Hartman 1989; Quinn 2005; Simenstad et al. 1982; Swales et al. 1986; Taylor 1988). Temperatures below 4°C have been suggested to be a threshold temperature, below which salmonids display cover-seeking behavior (Hillman and Griffith 1987; Taylor 1988), which was also observed in 2 studies in SEAK where little to no movement of salmonids was observed when water temperatures were below 4°C (Bryant et al. 2009; Crupi and Nichols 2012). During this project, all temperatures observed below 4°C occurred in the estuary, with the exception of one location that was close to the boundary line between the estuary and inlet. Catches of Pacific salmon in the study area were lower in 2009 than they were in 2008 (Table 5). Results from this project support the understanding that water temperature influences the timing of outmigration, considering that fewer salmon were captured in early spring (May and June) 2009 compared to 2008. In 2008, the minimum water temperature observed in this study was 4.3°C (in late May), compared to a minimum of 0.6°C in early May 2009. The lower water temperature observed while sampling in early spring 2009 might have caused fish to remain in sheltered, off-channel, overwintering habitats, and thereby delaying outmigration until water temperatures increased (Bramblett et al. 2002; Dolloff 1987; McMahon and Hartman 1989; Quinn and Peterson 1996; Swales et al. 1986; Taylor 1988).

Thedinga et al. (1988) observed an average turbidity of 246 nephelometric units (NTU) along main channel edges in a study conducted in the lower portion of the Taku River. Lorenz et al. (1991) reported an average of approximately 200 NTU during a different study conducted in the lower Taku River. As was previously mentioned in this report, turbidity measurements were only recorded for this project during the 2009 field season. In 2009, the average turdidity in the estuary was >378 NTU; the exact average is unknown because 9 measurements taken during the project exceeded the upper range (1,000 NTU) for the sensor. All measurements exceeding the 1,000 NTU range occurred on the side of the river (river right) where glacial melt-water from the nearby (≤4.5 km) Taku Glacier and Norris Glacier flow into the main channel. The high turbidity levels that occur in the lower Taku River and estuary are not believed to affect salmon migration, but can restrict spawning and rearing patterns at fine scales of some salmon species (Lorenz and Schroeder 2010). Highly turbid waters might provide young fish with refuge from visual predators (Hillgruber et al. 2007; Thorpe 1994); however, increased levels of turbidity reduce light penetration, which decreases primary and secondary production (Lloyd et al. 1987). As a result, less prey is available and it is more difficult for sight-feeders, like salmonids, to locate prey in turbid water (Bisson and Bilby 1982; Lloyd et al. 1987), which could help explain why, in the estuary, catch scores were higher in locations with lower turbidity.

Salinity conditions in estuaries are dynamic and are influenced by a variety of factors, including tidal fluctuations, wind, current, and changes in river discharge (McInerney 1964). The resulting salinity gradients that exist in estuaries help make the transition between living in freshwater and marine habitats more gradual for salmonids (St. John et al. 1992). In estuaries, prey for juvenile salmonids come from both riverine and marine sources. In British Columbia, St. John et al. (1992) examined the distribution of marine zooplankton with respect to salinity gradients in riverine, estuarine, and marine habitats, and confirmed that marine zooplankton were significantly more abundant in areas of higher salinity. Similarly, Hillgruber et al. (2007) reported that in Kuskokwim Bay, western Alaska, significantly more prey items were consumed in areas of higher salinity than in predominantly freshwater areas. In the current study, results in the estuary indicate that catch scores were higher at locations with higher salinity; however, prey availability and consumption were not investigated. Future research in the Taku River estuary should include an assessment of prey availability to determine if more prey is available in areas of higher salinity, which, as a result, could influence the distribution of juvenile salmon.

Another variable that potentially affected catch results between years was the Taku River stream flow level. Glacial rivers, including the Taku, often have discharge levels that fluctuate due to large seasonal changes in water yield from melting snow and glacial ice. Flow rates vary between years as well, due to different temperature and precipitation levels experienced from one year to the next. For example, the amount of snow accumulation during winter months, in combination with temperature and precipitation conditions the following spring, will result in different stream discharge levels between years. On the Taku River, flow levels are typically low in early spring and flood flows generally occur during the summer, which are almost always associated with outburst floods generated from the breaching of glacier-dammed lakes in the Tulsequah River basin (Neal 2007). In general, high flow events make it difficult to capture fish due to higher water velocity and an increase in debris flowing down river. High flows can also affect water quality conditions, such as temperature, salinity, and turbidity. As a result, water conditions during high flows could temporarily influence behavior of juvenile salmonids as they seek habitats with preferable water conditions. Murphy et al. (1989) observed that juvenile salmon in the lower Taku River utilized all types of habitat except where water velocity exceeded 30 cm/s.

Smaller fish tend to forage in shallow littoral areas at first, and move into deeper water as they grow (Celewycz 1989; Fresh 2006; Thorpe 1994). Swimming ability is proportional to fish size, and therefore, larger fish are able to occupy deeper habitats farther from shore where there is little protection from water currents (Chapman and Bjornn 1969; Hillman and Griffith 1987; Macdonald et al. 1987), but where more food is present per unit time (Macdonald et al. 1987). For salmonids, however, there exists an upper stream flow rate above which the energy used to remain in the current exceeds the energy gain from food that can be found in areas with faster current (Macdonald et al. 1987). As stream discharge increases, small fish (<150 mm) commonly seek shelter in areas of low velocity off the main channel (e.g., tidal sloughs; Bryant et al. 2009; Macdonald et al. 1987) to conserve energy.

In 2008, stream flows were primarily at, or below, the 20-year daily mean during the May, June, and July sampling events. In August, a Tulsequah flood event occurred toward the end of the trip, which likely affected the ability to capture fish in the estuary. In 2009, stream flows were generally above the 20-year daily mean for all trips, with the exception of September when flows were slightly below the 20-year daily mean (Appendix B). Levels were especially high during the June sampling event, which was likely due to significant snowmelt as a result of warm, sunny weather. It is possible that lower catch numbers during June 2009 were related to the very high stream flow levels observed, causing fish to seek more sheltered off-channel habitats.

Despite limited spawning habitat, the lower reaches of large river systems often have abundant low gradient habitats suitable for rearing, such as found in braided channels of the floodplain, and in broad tidal flats, both of which exist in the Taku River estuary. Glacial rivers transport large sediment loads, which strongly affect habitat formation as sediment gradually settles out of the water column in the low velocity, low gradient habitats that are common in estuaries (Murphy et al. 1997). In general, the intertidal beach slope was low to moderate in the northern portion of the study area, and was moderate to steep in the southern portion of the study area (Figure 19). Juvenile salmonid catch rates were significantly lower at locations with steep intertidal beach gradients compared to those with low to moderate beach gradients. Higher catch totals observed at locations in the northern portion of the study area (Figures 5 and 6), also correspond with locations that had a general shoretype defined as sediment, and a dominant intertidal substrate defined as mud/sand/organic (Figures 12 and 15). These findings are similar to results from previous studies that examined habitat use by juvenile salmon as they migrate through estuarine and nearshore marine environments, where juvenile salmon were found to prefer shallow water areas with low gradient, fine sediment beaches (Celewycz 1989; Fresh 2006).

This study was conducted over 2 consecutive years and sampling only occurred once a month during each field season. Sampling over a longer period of time (in years) and on a weekly basis during the field season would result in a more detailed account of spatial and temporal fish habitat use for the Taku River estuary and Taku Inlet. However, focusing future efforts on projects with similar objectives and study designs in other estuaries throughout SEAK would provide fisheries managers with baseline data for more than one important fish producing watershed and would result in a regional perspective on habitat use by juvenile salmonids.

The nearshore component (phase 1; presented in this report) of this project, in combination with the subsequent offshore component (phase 2), will seek to elucidate fish distribution patterns with respect to habitats, seasons, and spatial arrangement in one of the most significant fish producing systems in SEAK. Results from this project will ultimately provide information on how fish populations are distributed seasonally in the Taku River estuary and marine waters of Taku Inlet, and which habitats are most important. These baseline data may assist managers in making informed resource management decisions for these important habitats.

ACKNOWLEDGEMENTS

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APPENDIX A: FISH SPECIES

Appendix A1.–Taxonomic identification of all fish captured during this project (2008–2009) in Taku Inlet and the Taku River estuary, Southeast Alaska.

Species
Penpoint gunnel *(Apodichthys flavidus)*
Pacific spiny lumpsucker *(Eumicrotremus orbis)*
Threespine stickleback *(Gasterosteus aculeatus)*
Surf smelt *(Hypomesus pretiosus)*
Northern sculpin *(Icelinus borealis)*
American river lamprey *(Lampetra ayresii)*
Southern rock sole *(Lepidopsetta bilineata)*
Pacific staghorn sculpin *(Leptocottus armatus)*
Snake prickleback *(Lumpenus sagitta)*
Shortfin eelpout *(Lycodes brevipes)*
Capelin *(Mallotus villosus)*
Crescent gunnel *(Pholis laeta)*
Starry flounder *(Platichthys stellatus)*
Round whitefish *(Prosopium cylindraceum)*
Cutthroat trout *(Oncorhynchus clarkii)*
Pink salmon *(Oncorhynchus gorbuscha)*
Chum salmon *(Oncorhynchus keta)*
Coho salmon *(Oncorhynchus kisutch)*
Rainbow trout *(Oncorhynchus mykiss)*
Sockeye salmon *(Oncorhynchus nerka)*
Chinook salmon *(Oncorhynchus tshawytscha)*
Northern ronquil *(Ronquilus jordani)*
Dolly Varden *(Salvelinus malma)*
Eulachon *(Thaleichthys pacificus)*
Pacific sandfish *(Trichodon trichodon)*
Family Cottidae (not identified to species level)
Family Osmeridae (not identified to species level)

APPENDIX B: TAKU RIVER USGS STREAM FLOW DATA

Appendix B1.–Taku River stream flow data, including the 20-year daily mean, for sampling dates in 2008.

Sampling date	Stream discharge (cfs)	20-year daily mean discharge (cfs)
5/20	19,600	22,300
5/21	21,700	23,600
5/22	24,400	24,400
5/23	26,200	25,400
5/24	29,500	26,500
6/17	22,100	37,800
6/18	23,300	37,000
6/19	23,400	36,800
6/20	23,200	37,000
7/15	23,300	31,100
7/16	23,200	30,500
7/17	24,300	30,900
7/18	25,700	31,200
8/15	33,400	28,800
8/16	28,400	30,400
8/17	28,200	32,500
8/18	39,600	29,300
8/19	75,400	29.400
9/12	18,100	18,500
9/13	15,900	17,500
9/14	17,000	17,600
9/15	21,900	17,600
9/16	23,100	16,800
10/12	12,100	11,400
10/13	12,600	11,100
10/14	12,000	11,400
10/15	13,700	10,800
10/16	15,100	10,200
10/17	14,000	10,300

Appendix B2.–Taku River stream flow data, including the 20-year daily mean, for sampling dates in 2009.

Sampling date	Stream discharge (cfs)	20-year daily mean discharge (cfs)
5/7	19,400	12,800
5/8	20,700	13,200
5/9	20,200	13,700
5/10	19,500	14,400
6/5	50,900	35,500
6/6	55,300	36,900
6/7	58,800	37,200
6/8	62,700	36,800
7/8	35,700	32,300
7/9	35,500	30,600
7/10	38,400	30,400
8/5	27,400	26,500
8/6	28,000	25,900
8/7	28,100	25,900
9/2	22,500	23,400
9/3	19,200	21,300
9/4	17,700	19,900

APPENDIX C: DATA FILES

Appendix C1.–Electronic computer files submitted with this report.

File name	Description
Taku_2008.xls	Excel file containing all fish, water, and transect data collected during the 2008 field season.
Taku_2009.xls	Excel file containing all fish, water, and transect data collected during the 2009 field season.
Graphs_2008-2009_FDS_final.xls	Excel file containing all graphs and associated data produced by project biometrician.
TakuIneltEstuary_Nearshore_2008-2009_FDS.mxd	ArcMap project that includes shapefiles containing fish, water, and transect data collected during the 2008 and 2009 field seasons.
TakuFishMidLoc2008.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2008 fish data.
TakuFishMidLoc2009.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2009 fish data.
TakuTransects2008.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2008 transect data.
TakuTransects2009.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2009 transect data.
TakuWater2008.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2008 water data.
TakuWater2009.shp	GIS shapefile (State Plane, NAD83, FIPS 5001 projection) containing the 2009 water data.