STUDY 5.

LIFE-HISTORY OF OCEAN-TYPE SOCKEYE IN THE SITUK RIVER

Rationale

After Hubbard Glacier dams Russell Fiord, water overflowing into the Situk River drainage will flood most habitat used by the endemic ocean-type sockeye. Gaining a better understanding of the life history and habitat of these uncommon fish will allow better assessment of the effects of flooding and informed decisions on restoration.

Objectives

Objectives of this study were to describe migration timing, size at migration, habitat utilization, and salinity tolerance of ocean-type sockeye in the Situk River.

Summary of Results

Eleven sites located from the estuary to Forest Highway 10 were sampled for juvenile sockeye from March to September 1988. Two separate migrations of sockeye fry were apparent: an early migration of newly emerged fry into the estuary in March and April, and a later migration of larger sockeye through the lower river in May and June. Neither group remained long in the estuary or lower river; most early migrants disappeared from their primary habitat (tidal sloughs) by mid-May, and most later migrants spent less than 3 weeks in the lower river and estuary. Size was a determining factor in seaward migration. Fry apparently left rearing areas throughout the river and estuary and moved seaward as their size approached 50 mm, the threshold size for 100% survival in full-strength seawater.

METHODS

Heifetz et al. (1989) sampled the estuary and three upriver sites in Old Situk River in 1987; our 1988 study resampled some of the 1987 estuary sites and added sites in the lower and upper river to obtain a fuller picture of the migration of ocean-type sockeye (Fig. 5.1). Ocean-type sockeye abundance and distribution data from Heifetz et al. (1989) are also included in Study 8.

Sampling sites were established in the Situk estuary, lower Situk River, upper main-stem Situk River, and Old Situk River. In the estuary, five sites were established in two habitat types: two "tidal sloughs" in the intertidal *Carex* marshes and three "estuary beaches" in the estuary basin (Fig. 8.1). In the lower river, four sites were located between the boat landing and the upstream limit of tides; in the upper river, one site was in the main stem about 100 m upstream of Forest Highway 10, and one site was in Old Situk River 30 m upstream of Forest Highway 10 (Fig. H.4). All sites were sampled for juvenile sockeye about every 3 weeks from 13 March to 1 September 1988.

To show relative changes in sockeye abundance, we indexed fish numbers by catch per unit effort and report total numbers caught each sampling period. Sampling methods differed among habitat types. At each beach site in the estuary, three separate areas 20-50 m apart were sampled with a seine that was 28 m long and 3 m deep, with wings of 13-mm mesh and a central bag of 6-mm mesh. The seine was set parallel to and 40 m from shore with a skiff and retrieved with ropes from shore. In tidal sloughs and in riverine sites, a 30-m section was repeatedly seined (≥3 times) with a pole seine (Fig. 5.2). At sites in the lower river, minnow traps were also fished, but were ineffective on sockeye (Study 2). In all sampling periods, the same areas were seined the same number of times so that effort was approximately constant.

Salmonids caught were tranquilized with dilute MS-222, identified, and measured for FL. Scale samples were taken from a size range of sockeye to determine age. To assess residence time, juvenile salmonids in all sites in the lower river and in one tidal slough were marked externally with fluorescent pigment sprayed on with compressed air; pigment colors were changed each sampling period. All captured salmonids were examined for marks under an ultraviolet lamp inside a darkened box.

Salinity tolerance tests were used by Heifetz et al. (1989) to determine the ability of sockeye fry to survive in seawater. For convenience, we include their results in this report. In May and June 1987, Heifetz et al. (1989) collected sockeye from tidal sloughs and placed them in 60-L plastic containers filled with aerated water at 0, 26, 28, or 30‰ salinity at ambient temperature (mean 10.0°C in May and 9.1°C in June). Ocean water was mixed with either fresh water or Instant Ocean[1] salts to obtain desired salinity. To avoid crowding, no more than 15 fish were placed in each container. Mortalities were removed and measured every 12 h.

RESULTS

Sockeye fry migrated in two phases (Table 5.1; Fig. 5.3). The first phase was an early migration of newly emerged fry into the estuary in March and April. Newly emerged fry (31-32 mm mean FL) were already present in large numbers in tidal sloughs when sampling began in March. These fish reached peak abundance in tidal sloughs in mid-April and most were gone by mid-May. Only small numbers were caught in estuary beaches. The second phase was a later migration of larger sockeye fry (40-50 mm mean FL) that moved through the lower river in large numbers in May and June. Their movement into the lower river roughly coincided with a decline in fry numbers in upper river areas (Table 5.1). In Old Situk River, fry numbers peaked in mid-June and declined sharply thereafter; in the upper main-stem, only small numbers of sockeye fry were caught after mid-May. Few sockeye fry were caught in the estuary from mid-June to September, indicating that during the second phase of the migration, sockeye were distributed in open water and migrated through the estuary without extended rearing.

Size of sockeye differed between the estuary, lower river, and upper river areas (Table 5.2; Fig. 5.4). In tidal sloughs, mean FL increased sharply between mid-April and late May, then remained at 47-49 mm thereafter. Mean FL also increased sharply in the lower river between mid-May and late June, but it remained at 50-56 mm thereafter. Thus, the asymptotic size was about 5 mm smaller in tidal sloughs than in the lower river. In upper river areas, sockeye FL averaged between 32 and 39 mm all sampling periods, and never exceeded 50 mm, indicating continuous emergence of fry throughout the study and emigration when fry reached about 50 mm.

Recaptures of spray-marked sockeye fry indicated they remained less than 3 weeks in the lower river, which was similar to chinook and age-1 sockeye smolts but shorter than coho fry (Table 5.3). A total of 5,634 sockeye fry were marked in the lower river; only 0.3% were recaptured. Similarly, only 0.2% of nearly 1,200 marked chinook and age-1 sockeye smolts were recaptured. In contrast, 3% of coho fry were recaptured, significantly ($P < 0.001$; Chi-square test) more than the other species. No marked fish was recaptured in an area different from its marking site. Too few fish were marked and recaptured in tidal sloughs to estimate residence time. Of 141 sockeye fry marked in the tidal slough, 2 were recaptured.

In the salinity tolerance tests conducted by Heifetz (1989), survival of sockeye fry was directly related to fish size (Fig. 5.5). Survival in 30‰ salinity was 30% for 30-39 mm FL, 67% for 40-49 mm FL, and 100% for 50-59 mm FL. About two-thirds of the mortalities occurred within 24 h, and all fish in fresh water survived. Thus, a threshold size of at least 50 mm was required for 100% survival in seawater.

DISCUSSION

Two life-history patterns of ocean-type sockeye were evident in the Situk River and estuary. One pattern was characterized by an early migration to the estuary of newly emerged fry where they reared in tidal sloughs to the threshold size of about 50 mm before migrating to sea by mid-May. The second pattern involved a later migration of larger fry (>50 mm mean FL) that had apparently reared in upper river areas before migrating downstream in May and June. These larger fry reared less than 3 weeks in the lower river and migrated directly through the estuary without using tidal sloughs.

In other studies (Study 6 and 7), two modes were also evident in the migration of sockeye fry. Large numbers of sockeye fry migrated from Old Situk River during two periods, with modes in April and June (Study 6). Smaller numbers of sockeye fry also migrated downstream from the lower main-stem Situk River during these same two periods (Study 7).

The asymptotic size of about 45-55 mm for sockeye fry in tidal sloughs and the lower river indicates that fish went to sea when they could survive in seawater. The slightly smaller asymptotic size in tidal sloughs compared to the lower river may indicate that rearing in brackish water allowed fry to acclimate to seawater at a smaller size.

The two life-history patterns may indicate the presence of more than one ocean-type stock of sockeye in the Situk River: one migrating seaward early and using estuarine wetlands for rearing, the other migrating later and using fresh water, upriver habitat for rearing. The early migrating fry could also originate from stocks in other streams that share the Situk estuary, such as the Ahrnklin River, or from a combination of stocks from the Situk and other rivers. Based on trapping of downstream migrants (Study 6), the larger sockeye fry in the lower river in mid-summer were mainly from the Situk and Old Situk Rivers.

Conversely, the two life-history patterns could be exhibited by a single stock that spawns in a variety of habitat conditions, or produces fry that emerge over an extended period. The early migration to the estuary by newly emerged fry could be involuntary; fry could be swept downstream from certain spawning areas where suitable pool habitat is not available for rearing. Fry emerging during spring freshets may also be swept downstream, whereas fry emerging between freshets may be able to maintain position. More research is needed to determine whether the two life-history patterns observed in this study represent two genetically different ocean-type stocks in the Situk River.

Tidal sloughs appear to be critical habitats for sockeye fry that migrate into the Situk estuary in March and April. The south-facing aspect and exposure to sunlight of tidal sloughs in the estuary cause them to warm up earlier in spring than freshwater habitats in the river (Study 8). The brackish water in tidal sloughs also may allow sockeye fry to acclimate to seawater at a smaller size than sockeye rearing in fresh water. Although we did not measure food abundance, prey are probably abundant during flood tides. The combined effects of warm, brackish water and abundant prey allow sockeye fry in tidal sloughs to grow large enough to migrate to sea by mid-May.

Marine survival of the two different life-history patterns of ocean-type sockeye may differ because they enter the ocean at different seasons. The estuary-rearing sockeye enter the ocean about 1 month before both the river-rearing ocean-type sockeye and the lake-rearing age-1 sockeye. The estuary-rearing sockeye have a timing of ocean entry more like pink and chum salmon than other sockeye. Research is needed to determine marine survival of both life-history patterns of ocean-type sockeye and whether earlier entry into the ocean is advantageous.

Table 5.1—Total catch of sockeye fry in different areas of the Situk River, Old Situk River, and estuary, March-September 1988. A dash indicates the area was not sampled.

Date	Tidal slough	Estuary beach	Lower river	Upper Situk	Old Situk
March 13-15	1,101	40	—	—	—
April 11-15	2,015	33	674	—	—
May 11-15	70	—	1,836	82	—
June 1-3	112	0	2,836	3	230
June 20-24	23	4	892	3	561
July 12-15	5	3	71	6	65
August 2-5	0	0	35	3	7
August 30-September 1	0	—	6	—	6

Table 5.2—Mean fork length (mm) of sockeye fry in different areas of the Situk River, Old Situk River, and estuary, March-September 1988. Range is in parentheses. A dash indicates that no sockeye were captured or the area was not sampled.

Date	Tidal slough	Estuary beach	Lower Situk	Upper Situk	Old Situk
March 13-15	32 (29-57)	31 (29-32)	—	—	—
April 11-15	32 (25-46	31 (28-33)	31 (29-55)	—	—
May 11-15	39 (31-52)	—	33 (28-66)	33 (29-50)	—
June 1-3	48 (31-69)	—	40 (29-55)	32 (28-34)	35 (29-49)
June 20-24	49 (31-58)	57 (48-65)	50 (34-63)	33 (32-34)	34 (27-45)
July 12-15	47 (43-55)	61 (60-63)	53 (40-70)	39 (37-42)	34 (27-47)
August 2-5	—	—	51 (38-63)	39 (37-43)	38 (32-49)
Aug. 30-Sept. 1	—	—	56 (50-66)	—	40 (32-48)

Table 5.3—Number of fish marked with fluorescent pigment in a tidal slough in the Situk estuary and in the lower Situk River, 13 May to 5 August 1988. The number of marked fish recaptured in subsequent sampling periods is in parentheses.

	Sockeye		Coho		
Location	Fry	Smolt	Fry	Smolt	Chinook smolt
Lower Situk	5,634 (16)	596 (1)	4,415 (130)	111 (0)	595 (0)
Tidal slough	141 (2)	5 (0)	164 (2)	4 (1)	0

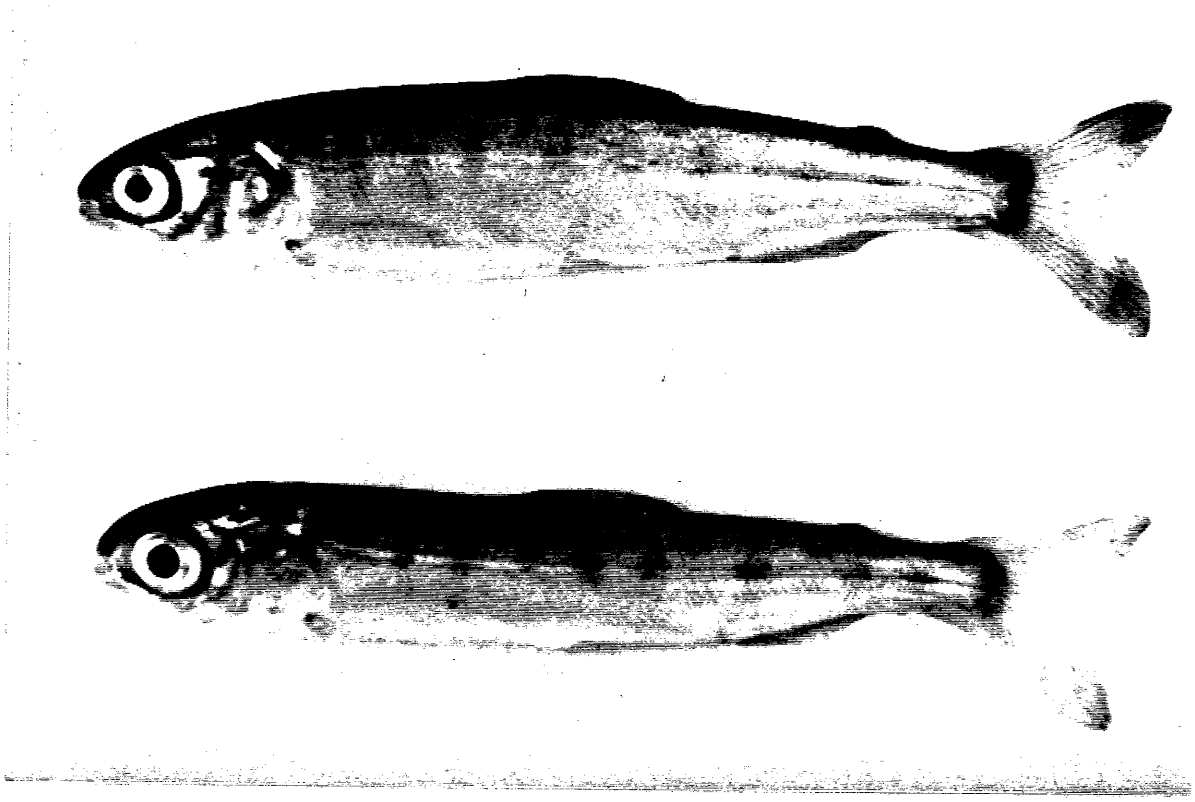

Figure 5.1—Ocean-type sockeye (top) and a 1-year-old lake-type sockeye smolt (bottom).

Figure 5.2—Sampling with a pole seine in a tidal slough, Situk estuary, May 1988.

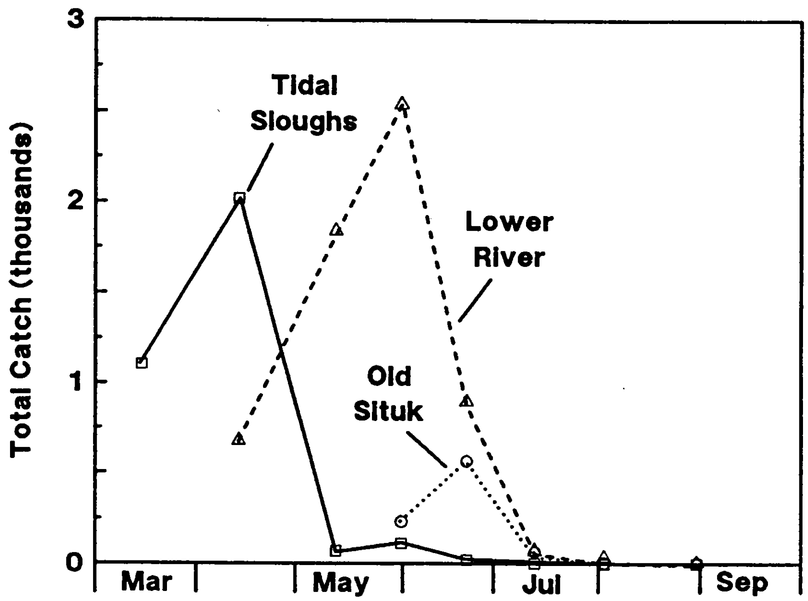

Figure 5.3—Catch of sockeye fry in the lower Situk River, tidal sloughs in the Situk estuary, and pools in Old Situk River, March-September 1988.

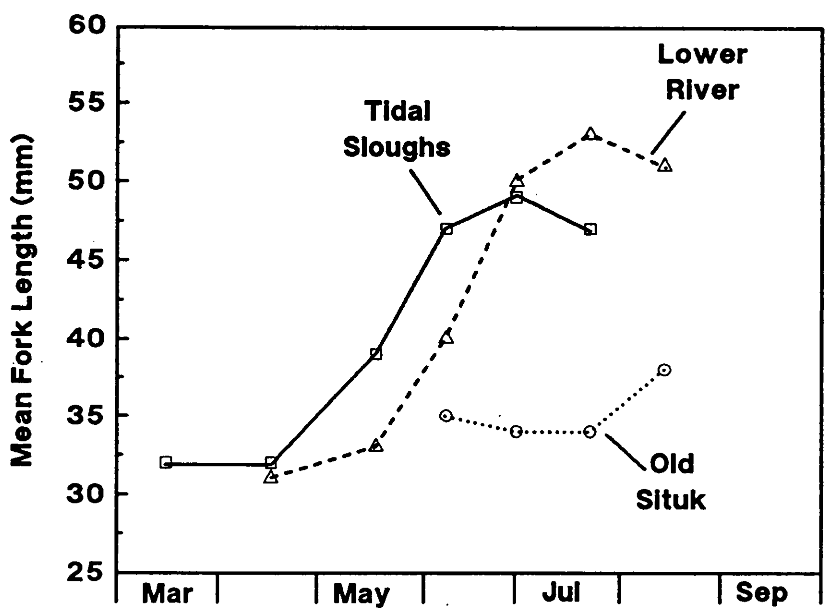

Figure 5.4—Mean fork length of sockeye fry in the lower Situk River, tidal sloughs in the Situk estuary, and pools in Old Situk River, March-September 1988.

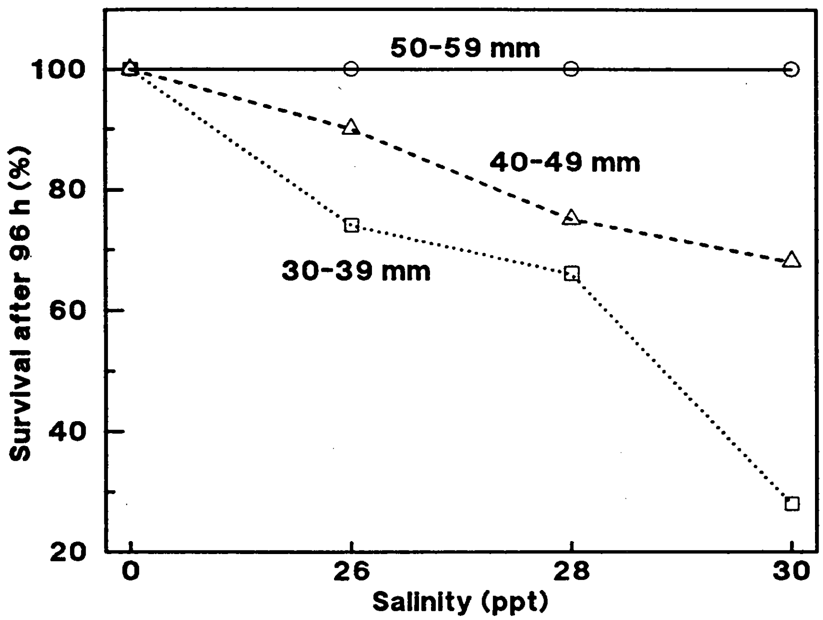

Figure 5.5—Percent survival of three size groups of sockeye fry from the Situk estuary after 96 h in 0, 26, 28, and 30‰ salinity. Data are from Heifetz et al. (1989).