HISTORY AND DESCRIPTION OF STUDY AREA

HUBBARD GLACIER AND SITUK RIVER

The advancing Hubbard Glacier (Fig. H.1) dammed Russell Fiord near Yakutat, Alaska (Fig. H.2) in May 1986 and created the world's largest glacier-formed lake. Rising water in the newly formed "Russell Lake" (Fig. H.3) threatened to overflow and flood the Situk River, one of Alaska's most productive salmon and trout rivers. Before flooding could occur, however, the ice dam burst. Based on tidewater glacier cycles, the ice dam is expected to rebuild within the next decade and may persist for hundreds of years (Trabant et al. 1991). Eventually, overflow from "Russell Lake" will probably flood the Situk River and drastically disrupt fisheries. Historically, the Hubbard and other glaciers that originate in icefields of the St. Elias Mountains have repeatedly advanced and retreated over the past 7,000 years, alternately impounding and releasing an enormous lake in the Russell Fiord basin (Mayo 1988). Prior to 1986, the last damming of Russell Fiord and flooding of the Situk River ended in the mid-1800s (De Laguna et al. 1964).

Flooding would change the present Situk River from a small, clear, groundwater-fed river, to a large, unstable, glacial river. USFS hydrologists expect flood waters to follow the same route of previous floods—down the Old Situk River, into the main-stem Situk River, then into the Pacific Ocean via the Lost River (Fig. H.4). The (predicted) flood zone will encompass nearly 70% of the Lost and Situk Rivers. After flooding, average flow will increase by a factor of 37 and the river will be turbid with fine glacial silt and sediment from erosion (Mayo 1988). The

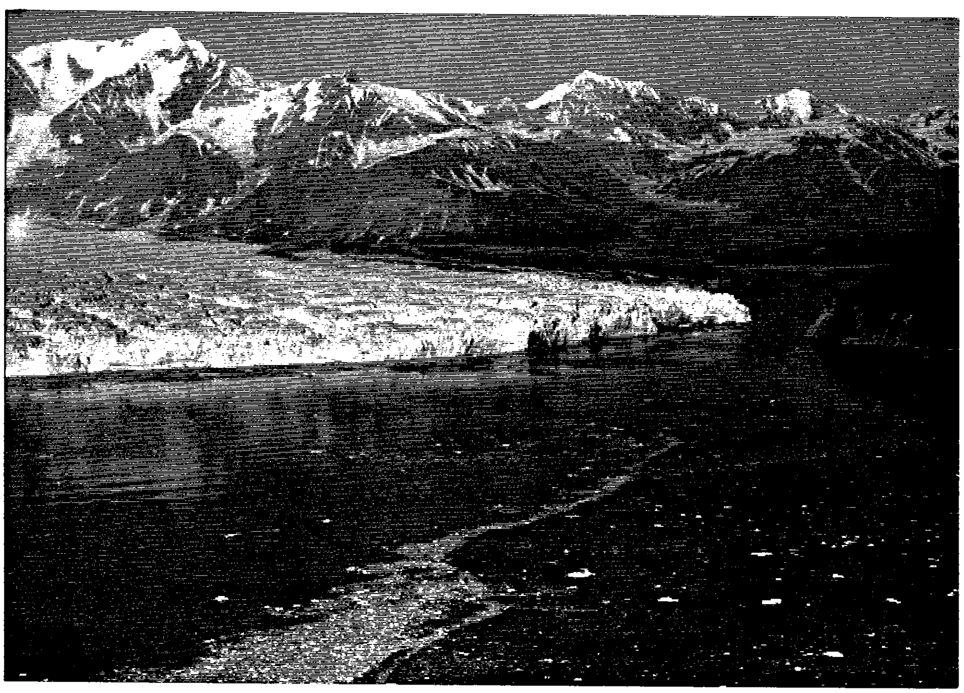

Figure H.1—Hubbard Glacier near Yakutat, Alaska.

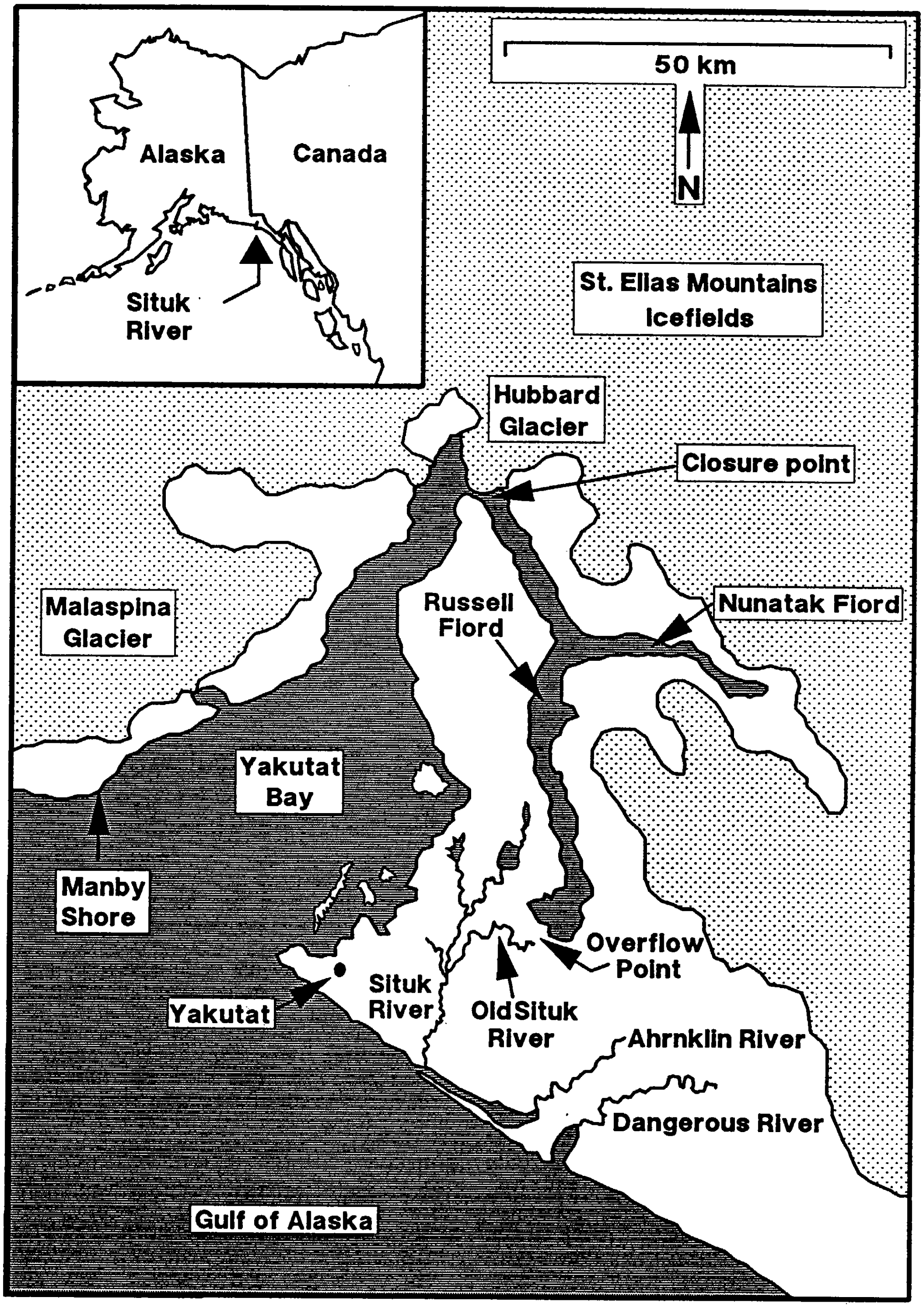

Figure H.2—Location of Hubbard Glacier, Russell Fiord, and Situk River near Yakutat, Alaska, and location of predicted closure of Russell Fiord by Hubbard Glacier and overflow point into the Situk River.

Figure H.3—Russell Lake near Yakutat, Alaska, after Russell Fiord was dammed by Hubbard Glacier in 1986.

first 3-5 years of flooding are expected to be the most destructive. Eventually, the river will stabilize as it regains its former channel.

Flooding could seriously jeopardize important commercial, subsistence, and recreational fisheries in the Yakutat area. Anadromous fish from the Situk River are primarily harvested in terminal gill-net fisheries near the mouth of the river (McPherson et. al 1987; Riffe 1987; Bethers and Ingledue 1989). The Situk River provides approximately 25% of the Yakutat area's commercial gill-net harvest (Pahlke 1989) and also contributes substantially to the off-shore troll fishery. Subsistence harvests of fish and wildlife in Yakutat are some of the highest in Southeast Alaska: an average 168 kg per capita in 1984 (Mills and Firman 1986). Each year, sport anglers from around the world spend a total of 25,000 hours fishing for salmon and steelhead in the Situk River (Bethers and Ingledue 1989). Commercial and recreational fisheries combined are worth approximately $3 million annually to the local economy.

Research began in 1987 to establish a database to help predict the effects of flooding on the production of salmonids and other fish species in the Situk River. From 1987 through 1990, adult and juvenile salmonids were studied in the Situk River and adjacent drainages, the Situk estuary, and Russell Fiord. Objectives were to 1) determine the location and use of spawning and rearing habitat of salmonids; 2) determine characteristics and habitat requirements of stocks with uncommon life histories; 3) predict effects of flooding on fish and habitat; and 4) identify strategies to restore fish and habitat that could be impacted by flooding.

STUDY AREA

Situk River

The Situk River is located 18 km east of Yakutat, Alaska (Fig. H.2), and flows through a glacial outwash plain and uplifted seabed called the Yakutat Forelands. The main stem is 35 km long, originating at Situk Lake (315 ha). The Situk River has an average summer flow of 6 m^3/s (Clark and Paustian 1989). In this report the "lower river" refers to the lowermost 3.5 km of the main-stem Situk River that is influenced by daily tides. At high tide, the lower river deepens, water velocity slows, and salinity increases but remains low (mean bottom salinity less than 5.0‰; Heifetz et al. 1989). The remainder of the main stem upstream of tidal influence is called the "upper river".

The Situk River averages 25 m wide, drains an area about 200 km^2 (USFS 1985), and has two major tributaries (Fig. H.4). Old Situk River is 20 km long and has an average summer flow of 1.5 m^3/s; it originates from a small pond and joins the main stem 17 km upstream of the estuary. The West Fork is 10 km long and has an average summer flow of 1 m^3/s; it flows from Redfield Lake (200 ha) and joins the main stem 21 km upstream of the estuary. Mountain Stream (6 km long) is a tributary to Situk Lake, connecting Situk Lake and Mountain Lake (87 ha). A more detailed description of the Situk River and Russell Fiord watersheds is provided in Riffe (1987).

Discharge in the Situk River is usually greatest in fall after heavy rains (Fig. H.5; Lamke et al. 1990, 1991). From October through December 1989 and 1990, peak monthly discharge ranged from about 10 to 75 m^3/s. From June through August, discharge was more stable, and usually ranged from 5 to 30 m^3/s. A more complete description of Situk River flow is in this section of the report under Reasons for Situk River Productivity.

From 1989 through 1991, water temperature was measured hourly with ENDECO[1] thermographs at seven locations and with a DATAPOD thermograph by the U.S. Geological Survey (USGS) at one location in the Situk River watershed (Fig. H.4). Water temperature varied greatly by location but was similar between years (Fig. H.6). Temperature was usually greatest in July, ranging from 4°C in Situk Meander to 19°C at the Situk Lake outlet. Temperature was usually lowest in January, ranging from 0 to 5°C. The most stable temperature was in Situk Meander, with an annual range from only 3 to 6°C, probably because of groundwater influence.

Neighboring watersheds include Kunayosh Creek (1 km east of Situk River), Seal Creek (8 km east), Ahrnklin River (11 km east), and Lost River (2 km west) (Figs. H.2, H.4). The largest of these watersheds, the Ahrnklin River, is larger than the Situk River.

Situk Estuary

Several rivers, Kunayosh Creek, Seal Creek, and the glacial Ahrnklin River empty into the estuary (Figs. H.2, H.4). The estuary basin is 6 km^2 in area and has mean surface salinity of 17‰, mean bottom salinity of 21‰, and mean depth at low tide of 4.1 m (Heifetz et al. 1989). The estuary also has other important habitat: mudflats, gravel or sand beaches, and numerous small (1-6 m wide) tidal sloughs bordered by *Carex* sp.

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

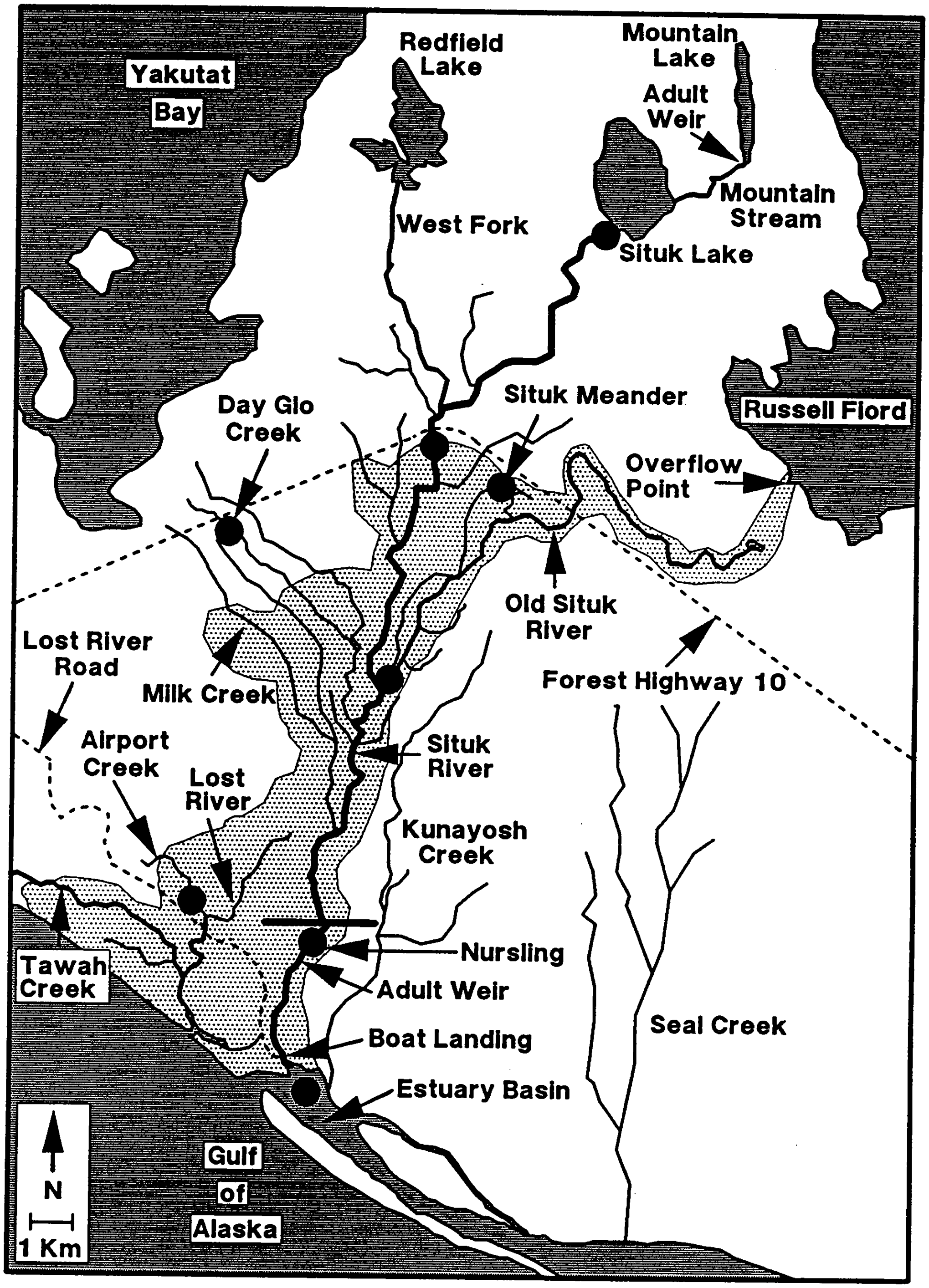

Figure H.4—Map of Situk River and adjacent watersheds. Stippled area is the predicted flood zone. Thermograph sites are designated by circles. Solid line across Situk River represents upper limit of tidal influence and boundary between upper and lower sections of river.

Russell Fiord

Russell Fiord, including Nunatak Fiord, has a watershed area of 1,873 km^2 (Fig. H.2). Russell Fiord is about 60 km long, 3 km wide, and 196 km^2 in area. The landscape is dominated by sparsely vegetated mountains and numerous large glaciers. Elevations range from sea level to over 2,700 m in the St. Elias Mountains. Rainfall and glacial melt account for about 80% of the runoff entering Russell Fiord in more than 100 inlet streams.

Climate

The Yakutat area has a maritime climate; surrounding mountains cool moisture-laden air from the Pacific Ocean, resulting in annual rainfall of 330 cm (Riffe 1987). The heaviest rain falls between September and December, when monthly rainfall ranges from 38 to 51 cm (Riffe 1987). Mean monthly air temperature varies from -2.4°C in January to 11.9°C in July (Riffe 1987).

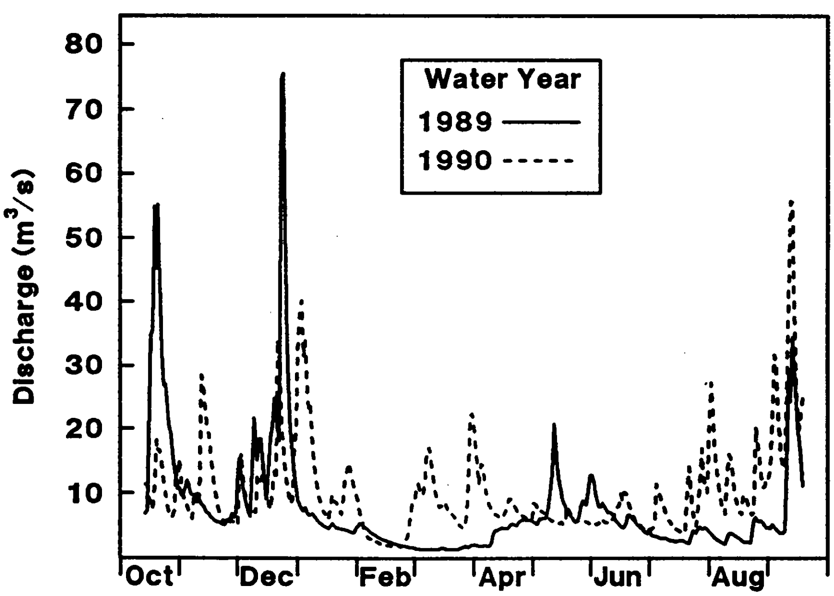

Figure H.5—Mean daily discharge of the Situk River, Alaska, in water years 1989 and 1990. Data are from Lamke et al. 1990, 1991.

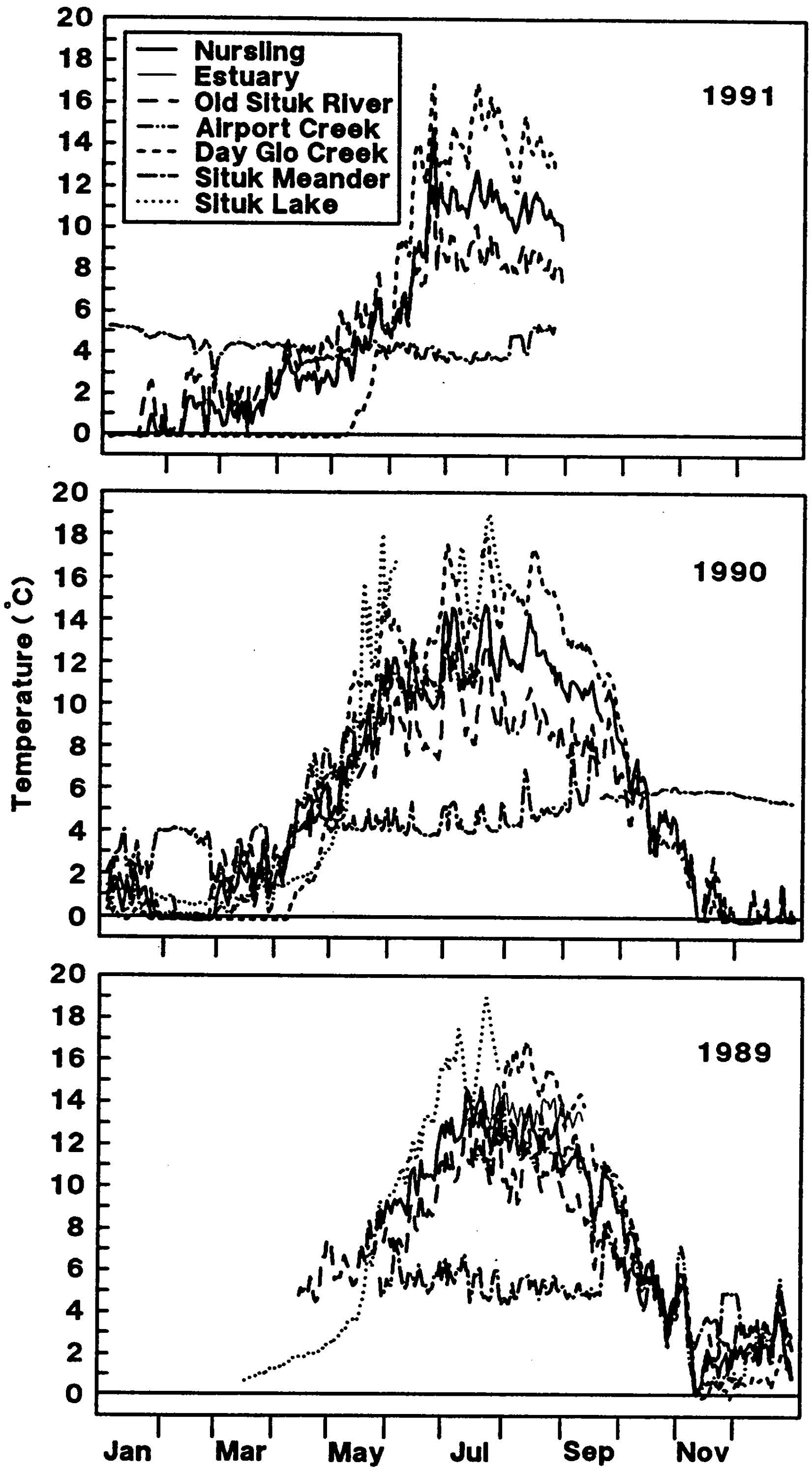

Figure H.6—Mean daily water temperature at seven locations, in the Situk and Lost River watersheds and the Situk estuary, 1989-1991 (USGS DATAPOD data not included).

STATUS OF STOCKS AND FISHERIES

Five species of Pacific salmon (*Oncorhynchus* spp.), steelhead trout (*O. mykiss*), Dolly Varden char (*Salvelinus malma*), eulachon (*Thaleichthys pacificus*), and Pacific lamprey (*Lampetra tridentata*) are indigenous to the Situk River. For the past 60 years, the annual return (harvest and escapement) of anadromous fish to the Situk River has been about 450,000 fish; over one-third is harvested in commercial, subsistence, and sport fisheries[2]. Sport anglers also catch and release several thousand fish annually (Johnson and Marshall 1991).

The annual total return of sockeye (*O. nerka*) to the Situk River is recovering from depressed levels. From 1934 to 1955, the total sockeye return averaged about 240,000 fish (110,000 harvest and 130,000 escapement), whereas the return from 1980 to 1989 averaged about 111,000 fish (36,000 harvest, 75,000 escapement)[2]. After the sockeye escapement goal was lowered in 1987 (from 80,000-100,000 fish to 40,000-55,000 fish; McPherson et al. 1987), harvest more than doubled (1987-89 mean, 71,858 fish; Didier and Marshall 1991) and the escapement goal has been reached or exceeded[2]. Thus, recent harvests of sockeye are similar to before 1955. Sockeye account for over one-half of the annual commercial salmon harvest in terminal Situk River gill-net fisheries (Bethers and Ingledue 1989) and about one-half of the dollar value[3]. Each year, subsistence fisheries harvest up to 3,000 sockeye (Didier and Marshall 1991), and sport fisheries harvest about 700 in the Situk River (Bethers and Ingledue 1989).

In the past decade, the annual total return of coho salmon (*O. kisutch*) to the Situk River averaged about 60,000 fish, of which about 30,000 fish were harvested: 20,000 in terminal gill-net fisheries and about 10,000 in commercial troll fisheries. The escapement goal for coho is 10,000-20,000 fish[4]. Coho account for about one-third to one-half of the commercial salmon harvest in terminal Situk River fisheries (Bethers and Ingledue 1989) and about one-half of the dollar value[5]. Annually, up to 1,600 coho are also harvested in subsistence fisheries (Didier and Marshall 1991), and about 1,800 fish in sport fisheries (Bethers and Ingledue 1989).

From 1980 to 1989, the total annual return of pink salmon (*O. gorbuscha*) to the Situk River averaged about 142,000 fish in even years and 265,000 fish in odd years[2]. These returns have been four times larger than between 1934 and 1955[2]. Low prices limit the commercial harvest of pinks, and harvest is mostly incidental to the gill-net sockeye fishery. Since 1934, an average of only 15,000 pinks have been harvested annually[2]. About 1,500 pinks are caught yearly in sport fisheries (Bethers and Ingledue 1989).

The annual total return of chinook salmon (*O. tshawytscha*) to the Situk River has declined in recent years. From 1980 to 1988, the return averaged about 2,000 fish (Bethers and Ingledue 1989) compared to 2,800 fish from 1933 to 1970 (Riffe 1987). Attempts to increase the return by curtailing harvest have been successful; escapement in 1992 was about 1,500 chinook[4, 5]. About 500 chinook are harvested annually in terminal fisheries (Bethers and Ingledue 1989), and about 5% of the annual return is probably taken in off-shore troll fisheries[6]. About 100 chinook

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[2]Unpubl. data. Alaska Dep. Fish and Game, Commercial Fisheries Div., P.O. Box 49, Yakutat, AK 99689.

[3]Unpubl. data. U.S. Forest Service, Yakutat Ranger District, Yakutat, AK 99869.

[4]Leon Shaul, Alaska Dep. Fish and Game, Commercial Fisheries Div., 802 Third St., Douglas, AK 99824. Pers. commun., Nov. 1991.

[5]Keith Weiland, Alaska Dep. Fish and Game, Commercial Fisheries Div., P.O. Box 49, Yakutat, AK 99689. Pers. commun., Oct. 1992.

[6]Sam Bertoni, Alaska Dep. Fish and Game, Fisheries Rehabilitation and Enhancement Div., Coded-wire Tag Processing Lab., P.O. Box 3-2000, Juneau, AK 99802-2000.

are harvested annually in subsistence fisheries, and another 135 fish are taken in sport fisheries (Bethers and Ingledue 1989; Didier and Marshall 1991).

Few chum salmon (*O. keta*) return to the Situk River, and few are harvested in terminal fisheries (Pahlke and Riffe 1988). Only about 500 chums return annually, and about 240 are harvested[2].

Recent returns of steelhead to the Situk River have averaged about 5,000-6,000 fish, considerably fewer than in the past: in 1952, over 20,000 steelhead returned (Knapp 1952). Both spring and fall races are present. The annual escapement of spring steelhead has averaged about 4,000 fish (Jones 1983; Johnson 1990, 1991); escapement of fall steelhead is probably less than 1,500 fish (Jones 1983; Johnson 1990). Annually, about 200 steelhead are harvested in terminal fisheries (Didier and Marshall 1991; Johnson and Marshall 1991), but harvests in other fisheries are unknown. From 1985 to 1990, the annual sport catch (harvest and catch-and-release) of steelhead averaged 3,500 fish (Johnson and Marshall 1991).

The Situk River supports a substantial run of anadromous Dolly Varden, although no estimates of total return are available. The annual sport catch of Dolly Varden averages about 1,000 fish, many caught incidentally by anglers targeting salmon and steelhead (Schwan 1984).

Tens of thousands of eulachon ascend the Situk River each year to spawn, and some are harvested for recreation and subsistence. Recreational harvest of eulachon in 1979 was about 1,500 fish (Schwan 1984), and the present annual combined recreation and subsistence harvest is estimated to be about 4,000 fish.

The Situk estuary is utilized by a wide variety of fish species, including the anadromous species described above and marine species, such as Pacific staghorn sculpin (*Leptocottus armatus*), starry flounder (*Platichthys stellatus*), threespine stickleback (*Gasterosteus aculeatus*), Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea pallasi*), arrowtooth flounder (*Atheresthes stomias*), Pacific prickleback (*Lumpenus sagitta*), sand sole (*Psettichthys melanostictus*), greenling (*Hexagrammos superciliosus*), and surf smelt (*Hypomesus pretiosus*). Crustaceans include Dungeness crab (*Cancer magister*). Other than the anadromous species and Dungeness crab, these species have little commercial or sport value. A more complete description of the fauna present in the estuary is provided in Study 8.

Anadromous fish that utilize Russell Fiord streams include primarily Dolly Varden, coho salmon, and pink salmon. Other fishes present in the streams include threespine stickleback and sculpins (*Cottus* sp.). Commercially important marine fish, crustaceans, and mollusks that occur in Russell Fiord include Pacific halibut (*Hippoglossus stenolepis*), Tanner crab (*Chionoecetes bairdi*), red king crab (*Paralithodes camtschaticus*), blue king crab (*P. platypus*), spot shrimp (*Pandalus platyceros*), and weathervane scallops (*Pecten caurinus*)[7].

LIFE HISTORIES

Life Stage and Stock Designations of Anadromous Fish

The life stages of juvenile salmonids are termed smolt, presmolt, parr, or fry throughout this report. Smolts are juveniles that are physiologically capable of adapting to seawater and have distinct morphological characteristics (e.g. silvered body, darkened fin tips) (Trautman 1973). We

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[7]Keith Weiland, Alaska Dep. Fish and Game, Commercial Fisheries Div., P.O. Box 49, Yakutat, AK 99689. Pers. commun., April 1992.

define parr as fish that have reared one or more years in fresh water (one or more annuli) and do not have smolt morphological characteristics. Presmolts have characteristics intermediate between smolts and parr. We define fry as fish that have reared less than a year in fresh water (emergence to first annulus).

Some sockeye and most chinook in the Situk River migrate to sea as fry (Studies 4 and 5). Fish with this uncommon life history are sometimes referred to as sea-type (Wood et al. 1987), ocean-type (Meehan and Bjornn 1991), age-0, or zero-check (McPherson et al. 1988) sockeye and fall or ocean-type chinook (Healy 1983). In this report, sockeye and chinook that migrate to sea as fry are called ocean type.

Sockeye

Life history of Situk River sockeye varies depending on location. Freshwater residence of juveniles ranges from a few days to 4 years. In Old Situk River, about 70% of juveniles are ocean type (Study 6); in Situk Lake, juveniles rear 1-2 years in fresh water before migrating to sea (60% stay 1 year, 40% stay 2 years; Rowse 1990); sockeye that rear 1 or more years in a lake are called "lake-type" (Wood et al. 1987). In Mountain Lake, 95% of juveniles rear 2-3 years in fresh water before migrating to sea (Rowse 1990). Most (95%) sockeye from the Situk River spend 2-3 years at sea.

Chinook

Chinook in the Situk River have a unique life history for Alaska—most juveniles are "age 0". In most other Alaska streams, chinook rear in fresh water at least 1 year before migrating to sea (Kissner 1986; Healey 1983). Chinook usually spend 3-4 years at sea.

Coho

Coho life history in the Situk River is similar to that in other Alaska streams. Coho typically spend 1-2 years in fresh water and about 18 months at sea. Most (95%) coho smolts in Old Situk River are age 1 (Study 6), whereas most (56%) coho smolts from the remainder of the watershed are age 2 and 3 (Study 7).

Pink and Chum

Pink and chum salmon in the Situk River exhibit life histories common to Alaska. Freshwater rearing is unimportant because juveniles of both species migrate to sea soon after emergence. Pinks return to spawn after one winter at sea, whereas chum spend 3-4 years at sea.

Steelhead

Juveniles of both spring and fall steelhead spend 2-4 years in fresh water. Juvenile fall steelhead rear in fresh water longer than spring steelhead; nearly 50% of fall fish spend at least 3 years in fresh water, whereas less than 25% of spring fish rear for that long (Jones 1983). Both races spend 2-5 years at sea, and about 25% of the total run are repeat spawners (Jones 1983).

Dolly Varden

Information is scarce on Dolly Varden in the Situk River. Adult Dolly Varden probably enter the Situk River in spring and summer to feed on salmon eggs and fry, as they do in other Alaska streams (Armstrong 1965a). Adult Dolly Varden ascend the river in fall to spawn and winter in lakes, as in other rivers in Southeast Alaska (Armstrong 1965a). Dolly Varden typically spend 3-4 years in fresh water before migrating to sea as smolts (Blackett 1968).

Eulachon

Little is known about the life history of Situk River eulachon. Elsewhere, eulachon typically spend little time in fresh water; adults spawn over a 4-week period in spring, and eggs incubate in streams for about 3 weeks (Hart and McHugh 1944). Larvae enter the ocean soon after hatching, and juveniles spend at least 3 years at sea before maturing and returning to spawn (Clemens and Wilby 1961).

A more detailed description on the migration timing of adults and juveniles, spawning, and incubation requirements of all species is provided in Studies 1, 4, 5, 6, and 7.

REASONS FOR SITUK RIVER PRODUCTIVITY

The Situk River is one of the most productive rivers in Southeast Alaska. One aspect of this productivity is high species diversity: five species of Pacific salmon, two races of steelhead, Dolly Varden, and ocean-type stocks of chinook and sockeye. Another aspect is the high density of juvenile salmonids in many stream reaches. In this section, we examine possible reasons for the Situk River's high productivity.

The Situk River's high productivity is displayed primarily by stream-rearing salmonids. Summer densities of juvenile coho in flood-plain areas (FP channel type; Paustian 1992), for example, are 6-22 times greater than the average density in such areas in other Southeast Alaska streams (Table H.1). Summer density of Dolly Varden in the FP4 channel type (in Old Situk River) was 6 times greater than average for Southeast Alaska, but Dolly Varden density in the FP3 and FP5 channel types was less than average. Steelhead are abundant in many stream reaches, particularly the West Fork, whereas steelhead are absent from many Southeast Alaska streams (Johnson et al. 1986).

Unlike the riverine habitats, Situk and Mountain Lakes are not unusually productive. Although chemical analysis indicates high conductivity of water in these lakes (Schmidt 1981), plankton and fish populations are not exceptional. Production of sockeye smolts from Situk, Mountain, and Redfield Lakes totaled about 700,000 fish in 1990 (Study 7), which is less than the estimated production capacity of 960,000 smolts, based on the euphotic-volume model of Koenings and Burkett (1987) (Table H.2). Zooplankton biomass in the lakes, furthermore, was near the low end of the spectrum of selected lakes in Alaska[8]. Mountain Lake ranked 18 and Situk Lake ranked 23 out of 25 lakes surveyed (Table H.3). The low zooplankton biomass may have been the result of high escapements of adult sockeye in previous years, producing too many fry for the available food base[7,8].

The extraordinary productivity of Situk riverine habitats could stem from a combination of favorable hydrologic, topographic, and geologic factors, including 1) stable hydrologic regime and high baseflow, which result from the river's substantial groundwater inflow and attenuating effects of headwater lakes; 2) flat topography and low-gradient stream channels, which facilitate formation of pool habitat; 3) warm summer temperature, which may result from the presence of headwater lakes and the watershed's southern aspect; and 4) high food production, which may result from high levels of available nutrients and good exposure to sunlight.

Probably the most important factor in the Situk River's high productivity is the river's stable hydrologic regime. Compared to other streams and rivers in Southeast Alaska, the Situk

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[8]Dave Barto, Alaska Dep. Fish and Game, Div. Fisheries Rehabilitation, Enhancement, and Development, Southeast Region (1), 802 Third St., Douglas, AK 99824. Pers. commun., Feb. 1992.

River's discharge is quite stable. The ratio of the river's maximum and minimum flows was the smallest of 15 streams and rivers monitored by the USGS in 1990 (Table H.4). Maximum flow in the Situk River in 1990 was only 34 times the minimum flow; the ratio in the other streams ranged from 43 to 6,400. Attenuation of extremes in discharge probably reduces mortality of juvenile salmonids in fall and winter (Murphy et al. 1984).

Table H.1—Comparison of summer densities (no./100 m^2) of juvenile coho and Dolly Varden by channel type in the Situk River (Study 2) and the mean density in other streams in Southeast Alaska*.

Channel Type	Coho		Dolly Varden	
	Situk	Other	Situk	Other
FP3	203	35	17	34
FP4	278	30	170	29
FP5	176	8	1	19

*Steve Paustian, USDA Forest Service, Region 10, 204 Siginaka Way, Sitka, AK 99835. Pers. commun., Oct. 1991.

Table H.2—Area, euphotic depth, and predicted production capacity for sockeye salmon fry, smolts, and adults for some Southeast Alaska lakes, based on the euphotic-volume model of Koenings and Burkett (1987) and fry survival rates in winter observed by Kyle (1990)[7, 8].

Lake	Area (km^2)	Euphotic Depth (m)	Predicted Smolts (millions)	Predicted Adults (thousands)
Situk	**4.1**	**10.2**	**0.96**	**104**
Mountain	**0.8**	**12.0**	**0.28**	**30**
Crescent	3.3	9.1	0.99	75
Chilkoot	7.0	6.5	1.05	114
Chilkat	9.8	17.5	3.95	429

Table H.3—Comparison of mean (May-October) zooplankton density and biomass in some Alaska lakes[7, 8].

Lake	Density (thousands/m^2)	Biomass (mg/m^2)
Chenik	727	2,027
Hidden	570	1,939
Chelatna	633	1,902
Chilkat	696	1,349
Karluk	518	915
Eshamy	288	691
Packers[a]	194	625
Skilak	208	564
Hugh Smith	177	380
McDonald[a]	100	336
Leisure[a]	215	335
Bakewell	178	246
Chilkoot	139	191
Redoubt[a]	144	156
Afognak	153	154
Crescent	88	153
Coghill	64	127
Mountain	**112**	**117**
Frazer	88	114
Virginia	88	111
Tustumena	37	99
Redoubt[b]	94	85
Situk	**117**	**77**
Leisure[b]	49	53
English Bay	48	23

[a]Fertilized.

[b]Pre-fertilization.

Table H.4—Minimum and maximum daily discharge (m^3/s) of Southeast Alaska streams monitored by the USGS in 1990 (Lamke et al. 1991). Streams are listed in order of increasing minimum baseflow. The month of minimum flow is in parentheses.

Stream	Minimum	Maximum	Ratio Max/Min
Gold Creek (Jan)	0.01	64.0	6,400
Perkins Creek (Jul)	0.02	24.7	1,235
Old Tom Creek (Jul)	0.03	24.2	807
Greens Creek (Feb)	0.2	40.5	202
Salmon Creek (Feb)	0.2	16.4	82
Hamilton River (Jul)	0.2	264.6	1,323
Kadashan River (Jul)	0.2	27.9	140
Indian River (Feb)	0.4	161.8	404
Staney Creek (Aug)	0.4	317.4	793
Situk River (Feb)	**1.8**	**60.3**	**34**
Harding River (Feb)	2.0	161.5	81
Farragut River (Feb)	2.8	447.7	160
Klehini River (Feb)	3.6	255.0	170
Taku River (Feb)	34.0	2,244	66
Stikine River (Feb)	156.8	6,772	43

Another beneficial feature of the Situk River's hydrologic regime is a high baseflow in summer and winter. As with most mainland streams in Southeast Alaska, the Situk River's minimum flow is in February; most island streams' minimum is in July (Lamke et al. 1990). The Situk River's minimum flow of 1.8 m^3/s in February 1990 was higher than the minimum discharge of nine other streams monitored by the USGS in 1990 (Table H.4). The Situk River's summer minimum, furthermore, was 4.0 m^3/s in 1990, which was much higher than the summer baseflow of any of the monitored island streams. The streams with higher minimum baseflow than the Situk River were mainland rivers with glacial influence and much larger watersheds. Thus, the Situk River's baseflow is unusually high for a watershed of its size. Heavy rainfall, abundant groundwater, and attenuating effects of headwater lakes help maintain the river's high baseflow. Minimum streamflows are often critical for rearing juveniles (Bjornn and Reiser 1991), and the Situk River's high baseflow could help explain the river's high productivity.

Flat topography probably also contributes to the great abundance of stream-rearing salmonids in the Situk River because of the preponderance of flood-plain and palustrian stream channels. The Situk River's average gradient is 0.6%, which is low compared to many other streams in Southeast Alaska (Paustian 1992). Almost all segments of the Situk River and its tributaries are either flood-plain (61% by length) or palustrian (39%) channel types. Other Southeast Alaska watersheds typically have large components of erosional and transportational channels that have lower habitat capability for salmonids (Paustian 1992).

Stream temperature does not appear to be a principal cause of the unusual productivity of the Situk River. Comparison of temperature regimes with five other Southeast Alaska streams monitored by the USGS (Lamke et al. 1990, 1991) showed that the Situk River is about average (Table H.5). Maximum temperature in July 1990 was 18.0°C, in the middle of the range for Southeast Alaska streams; minimum July temperature was 10.5°C, on the low end of the range measured by the USGS. Maximum in January 1990 was 2.5°C, lower than four of the other five gauged streams; minimum was 0.0°C, the same as the other streams.

Water quality is another possible factor in the river's high productivity. Compared to some other Southeast Alaska streams, the Situk River has higher pH, conductivity, and alkalinity (Table H.6). Because alkalinity commonly results from dissolution of sedimentary carbonate rocks, the comparatively high alkalinity in the Situk River indicates an abundance of sedimentary rock, probably derived from uplifted marine deposits. Alkalinity is an index of aquatic productivity, being directly related to aquatic primary production (Cole 1979). Thus, relatively high alkalinity and primary productivity could contribute to the Situk River's high fisheries productivity by increasing the available food base.

Concentrations of the important inorganic nutrients (phosphate and nitrate) were not any greater than in other Southeast Alaska streams (Table H.6). Water samples, however, often do not indicate actual amounts of available phosphate because aquatic bacteria and algae rapidly withdraw it from the water (Cole 1979). Based on the Situk River's high alkalinity, phosphate is probably abundant because it is, like alkalinity, commonly derived from sedimentary carbonate rocks (Golterman 1975).

In conclusion, the Situk River's unusually high salmonid productivity is most evident in stream-rearing populations; lake-rearing populations are average. The productivity of the stream habitat probably derives primarily from the river's stable hydrologic regime, high baseflow, and low gradient. High levels of dissolved nutrients also may contribute to the productivity.

Table H.5—Comparison of maximum and minimum water temperature (°C) in January and July in Southeast Alaska streams monitored by the USGS in 1989 or 1990 (Lamke et al. 1990, 1991).

		January		July	
Stream	Year	Max	Min	Max	Min
Situk	**1990**	**2.5**	**0.0**	**18.0**	**10.5**
Kadashan	1989	1.0	0.0	15.0	10.5
Hamilton	1990	3.0	0.0	22.5	12.5
Old Tom	1990	5.0	1.0	17.0	11.0
Perkins	1989	3.5	0.0	18.0	12.0
Staney	1990*	3.0	0.0	25.5	15.0

*Partial data.

Table H.6—Comparison of water quality characteristics of the Situk River and some other Southeast Alaska streams.

Stream	pH	Conductivity[a]	Alkalinity[b]	Phosphate[c]	Nitrate[d]
Situk[e]	**7.4**	**123**	**59**	**<0.010**	**<0.100**
Kadashan[e]	7.0	64	20	—	—
Hamilton[e]	6.7	24	10	—	—
Old Tom[e]	6.2	44	14	0.010	<0.100
Perkins[e]	6.0	27	4	<0.010	<0.100
Sunny[f]	—	—	44	<0.005	0.080
Black Bear[f]	—	—	30	0.006	<0.050
Wheeler[f]	—	—	40	0.017	0.080
King Salmon[f]	—	—	14	0.025	<0.050
Freshwater[f]	—	—	53	0.018	0.103
Castle[f]	—	—	10	0.010	0.060
Wasta[f]	—	—	6	0.011	0.080

[a] µmho/cm.

[b] mg $CaCO_3$/L.

[c] mg P/L.

[d] mg N/L.

[e] Lamke et al. (1991).

[f] Murphy et al. (1987); means of 3-6 different channel types per stream.