Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Synthesis of Existing Fish Population Data

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
APA	Alaska Power Authority
cfs	cubic feet per second
Confluence	The junction of two or more rivers or streams.
Cross-section	A plane across a river or stream channel perpendicular to the direction of water flow.
DIDSON	Dual Frequency Identification Sonar. Sonar imaging instrumentation developed by Sound Metrics Corp. with applications for fish enumeration, behavior and habitat mapping.
Drainage area	The total land area draining to any point in a stream. Also called catchment area, watershed, and basin.
El.	elevation
FERC	Federal Energy Regulatory Commission
Fishwheel	A device for catching fish which operates much as a water-powered mill wheel. A wheel complete with baskets and paddles is attached to a floating dock. The wheel rotates due to the current of the stream it is placed into. The baskets on the wheel capture fish traveling upstream. The fish caught in the baskets fall into a holding tank.
Floodplain	1. The area along waterways that is subject to periodic inundation by out-of-bank flows. 2. The area adjoining a water body that becomes inundated during periods of over-bank flooding and that is given rigorous legal definition in regulatory programs. 3. Land beyond a stream channel that forms the perimeter for the maximum probability flood. 4. A relatively flat strip of land bordering a stream that is formed by sediment deposition. 5. A deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
fps	feet per second
Fyke net	Fyke/Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open.
Geomorphology	The scientific study of landforms and the processes that shape them.
Gradient	The rate of change of any characteristic, expressed per unit of length (see Slope). May also apply to longitudinal succession of biological communities.
Groundwater (GW)	In the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone.
Hydraulic model	A computer model of a segment of river used to evaluate stream flow characteristics over a range of flows.
Hyporheic	The hyporheic zone is the subsurface volume of sediment and porous space beneath and lateral to a river or streambed, where there is mixing of shallow groundwater and surface water.
Ice cover	A significant expanse of ice of any form on the surface of a body of water.
Ice-free	No floating ice present.
Inclined plane trap	This trap consists of a revolving screen suspended between two pontoons. Downstream migrant fish reaching the back of the trap are dropped into a live box where they can later be enumerated.
Intergravel	Intergravel refers to the subsurface environment within the riverbed.
Macroinvertebrate	An invertebrate animal without a backbone that can be seen without magnification.

Abbreviation	Definition
Mainstem	Mainstem refers to the primary river corridor, as contrasted to its tributaries. Mainstem habitats include the main channel, split main channels, side channels, tributary mouths, and off-channel habitats.
mg	milligram
mg/L	milligrams per liter
mi	mile(s)
mi^2; sq.mi.	square mile(s)
Minnow trap	Normally composed of small steel mesh with 2-piece torpedo shape design, this trap is disconnected in the middle for easy baiting and fish removal.
mph	miles per hour
NCI	Northern Cook Inlet
NMFS	NOAA National Marine Fisheries Service
NTU	nephelometric turbidity unit
ºC	degrees Celsius
ºF	degrees Fahrenheit
Open lead	Elongated opening in the ice cover caused by water current (velocity lead) or warm water (thermal lead).
Project	Susitna-Watana Hydroelectric Project
Riparian	Pertaining to anything connected with or adjacent to the bank of a stream or other body of water.
River mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.
RM	River Mile(s) referencing those of the 1980s APA Project and designated within R&M (1981).
Seine (beach)	A fishing net that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. Seine nets can be deployed from the shore as a beach seine, or from a boat.
Slope	The inclination or gradient from the horizontal of a line or surface.
Thalweg	A continuous line that defines the deepest channel of a watercourse.
Three Rivers Confluence	The confluence of the Susitna, Chulitna, and Talkeetna rivers at Susitna River Mile (RM) 98.5 represents the downstream end of the Middle River and the upstream end of the Upper River.
Tributary	A stream feeding, joining, or flowing into a larger stream (at any point along its course or into a lake). Synonyms: feeder stream, side stream.
Trotline	A heavy fishing line with baited hooks attached at intervals by means of branch lines called snoods. A snood is a short length of line which is attached to the main line using a clip or swivel, with the hook at the other end.
TWG	Technical Workgroup
Upwelling	The movement of groundwater into rivers, stream, sloughs and other surface water features. This is also called groundwater discharge and may be associated with a gaining reach of a river or stream.
USACE	U.S. Army Corps of Engineers
USFWS	DOI, Fish and Wildlife Service
USGS	DOI, Geological Survey
Wetted channel width (wetted Perimeter)	The length of the wetted contact between a stream of flowing water and the stream bottom in a plane at right angles to the direction of flow.

SUMMARY

The Alaska Energy Authority (AEA) is preparing a license application that will be submitted to the Federal Energy Regulatory Commission for the Susitna-Watana Hydroelectric Project (Project) located on the Susitna River, which drains into Cook Inlet located in Southcentral Alaska. The Susitna River drainage covers about 19,400 square mi. The Susitna River is approximately 300 miles long and joined by two major rivers, the Chulitna (river mile [RM] 98) and Talkeetna (RM 97), in the vicinity of the town of Talkeetna. A third major tributary, the Yentna River (RM 28), joins the Susitna River about 70 mi farther downstream. The Chulitna River is the largest of the tributaries joining the Susitna River.

The proposed Project dam is located at RM 184. As currently envisioned, the Project would include a large dam with a 20,000-acre, 39-mile long reservoir. Project construction and operation would have an effect on the flows downstream of the dam site, the degree of which will ultimately depend on final Project design and operating characteristics. Key flow changes will likely occur in the form of load following during the winter months of November through April each year. Seasonal variation in flows will occur with flows higher during the winter months and lower during reservoir refill, and drafting of the reservoir during the winter months. If operated in this fashion, Project operations would cause seasonal, daily, and hourly changes in Susitna River flows compared to existing conditions. The potential alteration in flows would influence downstream resources and processes, including fish and aquatic biota and their habitats, channel form and function including sediment transport, water quality, groundwater/surface water interactions, ice dynamics and riparian and wildlife communities (AEA 2011).

Development of hydroelectric facilities on the Susitna River has been considered since the early 1950s (USFWS 1952). The Alaska Power Authority (APA) prepared a formal proposal to the Federal Energy Regulatory Commission (FERC) in the early 1980s (FERC No. 7114). The FERC No. 7114 project was proposed as a two dam development with a storage dam and power plant located at RM 184, the location of the currently proposed Watana Dam site, and a re-regulating dam located at RM 152 near the downstream end of Devils Canyon. Because of falling energy prices, further development of FERC No. 7114 was halted in 1986 (AEA 2011).

The objective of this technical memorandum (TM) is to summarize the available contemporary and historical fish and aquatic studies to support the development and implementation of studies needed to understand the potential effects of the proposed Susitna-Watana Hydroelectric Project. The summary is focused on the studies conducted by the Alaska Department of Fish and Game and Trihey and Associates during the 1980s as part of the Susitna-Hydroelectric Aquatics Studies Program. The number of reports produced as part of the Su-Hydro Aquatic Studies Program included over 80 volumes and several thousand pages of text, maps, charts, and tabular summaries, and raw data tables. By intention, this TM is selective in the subjects covered and relatively coarse in the level of detail provided for any specific subject area. The reader is encouraged to pursue the source reports for a higher level of detail on the methods, results, and conclusions that can be drawn from the studies conducted as part of the Aquatic Studies Program.

The Aquatic Studies Program had three components: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH). In addition to work completed by ADF&G, the AH component included work conducted by Trihey and Associates. The objectives for each of the components were (Schmidt and Bingham 1983):

- AA – determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area;
- RJ – determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area; and
- AH – characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

Field studies were conducted monthly from November 1980 through October 1985, except for periods of freeze-up and ice-off, which were too risky and unsafe for equipment and staff. Fish surveys were a challenge because of high turbidity during most of late spring and summer seasons, except in tributaries mouths, and side channels and sloughs affected by groundwater or clearwater tributary inflow. In contrast, during fall and winter most of the river has complete ice cover, except in areas of small open leads that resulted from groundwater inflow and water velocity. In general, RJ and AH studies were broad-based during 1981 and 1982 with the widest geographic scale and sampling methods. As the Aquatic Studies Program progressed, studies became more focused on acquiring specific information needs for habitat modeling and acquisition of specific biological data. In addition, the results of 1981 and 1982 fish distribution and habitat utilization studies led to more intensive sampling at fewer sites with known fish use.

A major objective of the 1980s Aquatic Studies Program was to understand the seasonal fish use of six mainstem (macro-) habitat types. The six mainstem habitat types consisted of mainstem (main channel), side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). The major fish species studied as part of the Aquatic Studies Program included Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), rainbow trout (*O. mykiss*), burbot (*Lota lota*), eulachon (*Thaleichthys pacificus*), and Arctic grayling (*Thymallus arcticus*). Pink salmon (*O. gorbuscha*) are also present in the Susitna River in large numbers; however the species was relatively unimportant in the studies, because they spawned almost exclusively in tributary streams, and fry outmigration was nearly complete before open water sampling could occur. In addition, pink salmon have a relatively low commercial and sport fishing value compared to the other salmon species. Consequently, pink salmon were monitored as part of the AA component, but played a minor role in the RJ component, and no role in the AH component.

From 1981 to 1985, fishwheels and sonar were deployed at Flathorn Station (RM 18.2) or Susitna Station (RM 25.5), Sunshine Station (RM 80.0), Talkeetna Station (RM 103.0), Curry Station (RM 120.0), and the Yentna River Station (RM 30.1, tributary river mile [TRM] 4.0). The techniques provided a relatively good understanding of adult salmon run timing. The periodicity of adult salmon presence and spawning are summarized in Table S-1. Chinook salmon and sockeye salmon (first-run) were the first adult salmon to enter the Susitna River, and they were followed by pink salmon and sockeye salmon (second run), chum salmon, and coho salmon. First run sockeye salmon spawned in the Yentna River and other lower river tributaries, but did not spawn in the middle river.

Chinook salmon and sockeye salmon (first-run) were the first adult salmon to enter the Susitna River, and they were followed by pink salmon and sockeye salmon (second run), chum salmon, and coho salmon. First run sockeye salmon spawned in the Yentna River and other lower river tributaries, but did not spawn in the middle river.

An important discovery in 1982 was the observation of Chinook salmon spawning upstream of Devils Canyon (Barrett et al. (1983). Anecdotal observations of salmon upstream of Devils Canyon were reported in the late 1950s (USFWS 1957), but were not confirmed until the 1980s. Since that time, relatively small numbers of Chinook salmon have been documented spawning in tributary streams upstream of Devils Canyon to the Oshetna River (Buckwalter 2011). To date, no other salmon species has been observed to pass Devils Canyon. The hydrologic conditions under which passage through Devils Canyon is possible are uncertain but are thought to occur around a relatively narrow discharge level (AEA unpublished data).

One of the early conclusions from the surveys conducted during 1981 and 1982 was that little to no salmon spawning occurred in the main channel habitats because of high water velocities and unsuitable spawning substrate. Mainstem substrates generally consisted of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands (Estes and Schmidt 1983). In contrast, the more protected side channels and side sloughs often included smaller substrate that was occasionally disturbed during high flow events that breached berms at the head of the channel or slough. In addition, many side channels and sloughs had upwelling from hyporheic or groundwater sources that provided more stable and higher temperatures during egg incubation than mainstem water (ADF&G 1982b).

Spawning surveys conducted during the 1980s suggested the Lower Susitna River (i.e., downstream of the confluence of the Chulitna, Talkeetna, and Susitna Rivers near RM 98) was primarily a migration corridor for adult salmon accessing a number of substantial tributaries for spawning (e.g., Montana Creek, Birch Creek, Willow Creek, Deshka River, etc.). Six chum salmon spawning locations were identified in 1981 (ADF&G 1981); however, it was reported that chum salmon did not spawn in the 811 mainstem sites surveyed in the lower river during 1982 (Barrett et al. 1983). Similarly, Barrett et al. (1983) reported that sockeye salmon did not spawn at any of the sites checked. Mainstem spawning surveys were not conducted during 1983. During 1984, Barrett et al. (1985) identified 3,400 to 5,125 chum salmon spawning at thirteen mainstem sites, five sloughs, and five tributary mouths. A few coho salmon were also observed spawning at three sites. The unexpected use of these lower river mainstem sites and sloughs for spawning by a relatively large number of chum salmon resulted in additional instream flow modeling and egg incubation monitoring at six of the sites (Bigler and Levesque 1985).

Spawning surveys from 1981 through 1985 (ADF&G 1981, Barrett et al. 1983, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986) indicated that Chinook salmon and coho salmon spawn exclusively in tributary streams, while pink salmon spawn primarily in tributary streams, but may occasionally spawn in side channels or side sloughs (Figure S-1). Sockeye salmon in the middle Susitna River spawn exclusively in side sloughs; no lakes associated with tributary streams draining to the middle river support sockeye salmon spawning or rearing. Chum salmon in the middle Susitna River primarily spawn in side sloughs and tributaries, but occasionally spawn in side channels and mainstem channel edges. Based upon the preferred spawning habitat, ADF&G concluded that chum salmon and sockeye salmon spawning and incubation habitat were at higher risk of adverse effects from hydroelectric development on the Susitna River compared to Chinook salmon, coho salmon, and pink salmon spawning and incubation habitat (Jennings 1985).

Tributary surveys were also conducted in the upper Middle and Upper Susitna River (i.e., upstream of the proposed Devils Canyon Dam). These focused primarily on portions of 11 tributaries that would be inundated by the proposed dams (Delaney et al. 1981c, Sautner and Stratton 1983). These included Cheechako Creek, (RM 152.4), Chinook salmon Creek (RM 157.0), Devil Creek (RM 161.4), Fog Creek (RM 173.9), Tsusena Creek (RM 178.9), Deadman Creek (RM 183.4), Watana Creek (RM 190.4), Kosina Creek (RM 202.4), Jay Creek (RM 203.9), Goose Creek (RM 224.9), and Oshetna River (RM 226.9). Only the latter eight streams were surveyed during 1981. During 1982 seven sloughs in the mainstem were also sampled. The fish community in tributaries was much less diverse in the Upper Susitna River compared to the lower Middle and Lower Susitna River. The tributaries were dominated by Arctic grayling and relatively few Dolly Varden (*Salvelinus malma*). Burbot, longnose sucker (*Catostomus catostomus*), and round whitefish (*Prosopium cylindraceum*). A few humpback whitefish (*Coregonus pidschian*) were observed in the mainstem Susitna River at tributary confluences.

1. INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a license application that will be submitted to the FERC for the Susitna-Watana Hydroelectric Project (Project) using the Integrated Licensing Process. The Project dam is located at RM 184 on the Susitna River, an approximately 300-mile long river in the Southcentral region of Alaska. As currently envisioned, the Project would include a large dam with a 20,000-acre, 39-mile long reservoir. Project construction and operation would have an effect on the flows downstream of the dam site, the degree of which will ultimately depend on final Project design and operating characteristics. Key flow changes will likely occur in the form of load following during the critical winter months of November through April each year, seasonal variation with flows higher during the winter months and lower during reservoir refill, and drafting of the reservoir during the winter months. Project operations would cause seasonal, daily, and hourly changes in Susitna River flows compared to existing conditions. The potential alteration in flows would influence downstream resources and processes, including fish and aquatic biota and their habitats, channel form and function including sediment transport, water quality, groundwater/surface water interactions, ice dynamics and riparian and wildlife communities (AEA 2011).

Development of hydroelectric facilities on the Susitna River has been considered since the early 1950s (Friese 1975). The U.S. Army Corps of Engineers were authorized in 1972 by the U.S. Senate to investigate development near Devils Canyon and the National Marine Fisheries Service contracted with the Alaska Department of Fish and Game (ADFG) to assess salmon populations in the Susitna River (Friese 1975). The Alaska Power Authority (APA) prepared a formal proposal to the Federal Energy Regulatory Commission (FERC) in the early 1980s (FERC No. 7114). The FERC No. 7114 project was proposed as a two dam development with a storage dam and power plant located at river mile[1] (RM) 184, the location of the currently proposed Watana Dam site, and a re-regulating dam located at RM 152 near the downstream end of Devils Canyon. Because of falling energy prices, further development of FERC No. 7114 was halted in 1986 (AEA 2011).

In addition to fisheries studies conducted by ADFG in 1974 and 1975, APA contracted with ADFG to conduct a series of fish and aquatic studies from 1981 through 1985. More recent studies include on-going monitoring in support of sport and commercial fisheries in the Cook Inlet Region. Annual index reaches are surveyed for spawning salmon and sonar and fish wheel counts were made on an annual basis.

The objective of this technical memorandum (TM) is to summarize the available contemporary and historical fish and aquatic studies to support the development and implementation of studies needed to understand the potential effects of the proposed Susitna-Watana Hydroelectric Project. Because the number of studies is voluminous, the focus of this TM is on the ADFG studies conducted during the 1980s, but pertinent studies from the 1970s, late-1990s, and 2000s are also presented. Specific objectives include the synthesis of the information identified below.

[1] River miles are those used in the 1980s studies and designated within R&M (1981).

- Synthesize existing information on life history, spatial and temporal distribution, and relative abundance by species and life stage.
- Synthesize recent ADF&G run apportionment and timing data for sockeye salmon, coho salmon, and chum salmon.
- Prepare periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and outmigration).
- Summarize mainstem Susitna River habitat utilization for each species, by riverine habitat type (main channel, side channel, side slough, upland slough, tributary mouth, tributary).
- Summarize existing age, size, and genetics information.
- Summarize distribution of invasive species, such as northern pike (*Esox lucius*).
- Summarize seasonal distribution of macroinvertebrates by riverine habitat types.

2. SUSITNA RIVER BASIN DESCRIPTION

The Susitna River drainage area is about 19,400 mi^2 and located in the Southcentral portion of Alaska (Figure 2.1-1). The Susitna River is joined by two major rivers, the Chulitna (RM 98) and Talkeetna (RM 97), about 40 miles downstream of Gold Creek in the vicinity of the town of Talkeetna. A third major tributary, the Yentna River (RM 28), joins the Susitna River about 70 miles farther downstream.

The Susitna-Watana Hydroelectric Project area lies near the border of the Continental and Transitional climate zones of Alaska (AEA 2012). Continental Zone temperatures in the summer average around 60°F (15°C). Mean lows in the winter are near minus10°F (minus 23°C), with minus 45°F (minus 43°C) to minus 55°F (minus 48°C) on occasion. Annual precipitation is generally about 10 inches with the majority falling within the summer months. Where orographic lift occurs, annual precipitation totals may exceed 20 inches. In general, this zone is located south of the Brooks Range and inland. The sun does not set for more than a month during the summer and likewise does not rise for more than month during winter. Surface winds are lighter than those in the Arctic.

The Transitional Zone includes the region around the Cook Inlet and the lower Susitna River. The coolest month in Transitional Zone has temperature averages between 20°F (minus 3°C) and 64°F (18°C) while the warmest month is generally above 50°F (10°C). In addition, it is considered to only have one to three months with a high temperature above 50°F (10°C). Moderate moisture is present in all seasons. Winds are moderate, skies are usually cloudy, and the relative humidity is moderate to high. In addition, heavy fog is very frequent as a result of maritime influences. Both continental and maritime climate systems affect the Transitional Zone.

In general, the Susitna River was divided in the 1980s studies into three reaches:

1. Upper River – Representing that portion of the watershed above the proposed Devils Canyon Dam site at RM 152;
2. Middle River – Extending approximately 53.5 miles from RM 152 downstream through Devils Canyon to the confluence of the three rivers at RM 98.5; and
3. Lower River – Extending the entire 98.5 miles downstream from the three rivers confluence to Cook Inlet (RM 0).

In contrast to the 1980s reach designations, the contemporary Project has designated the Upper River segment as the reach extending upstream from the proposed Watana Dam site and the Middle River as the reach extending from the confluence of the three rivers to the proposed Watana Dam (AEA 2011). Under the current Project, the Middle River segment is further delineated into three subreaches including the lower Middle River from RM 98.5 to downstream end of Devils Canyon at RM 150, the middle Middle River from RM 150 to Devil Creek (RM 161) at the upper end of Devils Canyon, and the upper Middle River from RM 161 to the proposed Watana Dam site.

The following provides a general description of the three river segments as delineated for the current Project.

2.1. Upper River

The drainage area upstream of the proposed location of the Watana Dam (RM 184) is about 5,180 mi^2. The Upper Susitna River (i.e., area upstream of the proposed dam site) is fed by three glaciers in the Alaskan Range. The glaciers cover an area of 290 mi^2 (Acres 1983). The three glacially fed forks, including the Maclaren River, flow southward for about 18 miles before joining to form the mainstem of the Susitna River. The river flows an additional 55 miles southward through a broad valley, where much of the coarse sediment from the glaciers settles out. The river then flows west about 56 miles to the proposed Watana Dam site. Other tributaries that flow into the proposed reservoir include Deadman, Watana (RM 194), Kosina (RM 206.8), Goose (RM 231.3), and Jay creeks, along with the Oshetna River (RM 233.4).

2.2. Middle River

Downstream of the proposed dam site, the Susitna River continues west for about 40 mi through the Devils Canyon area; the river valley in this segment is narrow with violent rapids. Within the 96-mile westward section of the Susitna River, there are numerous small, steep gradient, clear water tributaries that flow into the Susitna River. Several of these tributaries traverse waterfalls as they enter the gorge. Tributaries located between the proposed dam site and Devils Canyon include Devil, Fog (RM 179.2), and Tsusena (RM 181.3) creeks. Portage Creek enters the Susitna River below Devils Canyon. As the Susitna River curves south past Gold Creek (RM 136.8), about 12 miles downstream from Devils Canyon, its gradient gradually decreases.

Within Devils Canyon there are three partial barriers to upstream migration by anadromous fish. Chinook salmon are known to pass the two lower barriers on a regular basis; however passage over the third barrier located downstream of Devil Creek appears to occur only under narrow hydraulic conditions. During 2012 radio-tagged Chinook salmon passed the third barrier during a short period when flows were approximately 16,000 cubic feet per second (cfs; AEA unpublished data). Other anadromous salmon in the Susitna drainage (chum salmon, sockeye salmon, pink salmon, and coho salmon) have not been observed to pass any of the three partial barriers.

The lower Middle River generally has a single main channel, with some segments containing one or two secondary side channels, complex islands, side sloughs, and upland sloughs. Mainstem habitat is typically characterized by high water velocities and well armored streambeds. Mainstem substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands while more protected side channels and side slough often include smaller substrate (Estes and Schmidt 1983).

2.3. Lower River

From the confluences with the Chulitna and Talkeetna rivers, the Susitna River flows south for about 97 miles until it empties into Cook Inlet near Anchorage, approximately 318 miles from its source. Channel morphology in the Lower River is influenced by the large volume of sediment delivered from the Chulitna River and lower gradient than the lower Middle River. The Yentna River, which accounts for about half of the sockeye salmon returns to the Susitna Basin, joins the Susitna River at RM 28 (Jennings 1985). Located within a wide gravel floodplain, the Lower River segment includes braided channel sections as well as areas with a main channel and multiple secondary channels. Downstream of RM 19.0, the river divides into two main channels with the majority of flow following the east channel (Ashton and Klinger-Kingsley 1985). During low flow periods large gravel bars are present in the Lower River.

3. OVERVIEW OF EXISTING STUDIES

Historically, fish studies in the Susitna River basin were initiated in the 1950s. During these studies, fish surveys were conducted in nine tributaries upstream and downstream of Devils Canyon. Tributaries surveyed included: Indian River, Jack Long Creek, Portage Creek, Deadman Creek, Watana Creek, Jay Creek, Kosina Creek, Goose Creek, and the Oshetna River (USFWS 1957, 1959a, 1959b). Fish observations included the following: adult Chinook salmon, chum salmon, pink salmon, coho salmon, Arctic grayling and rainbow trout in the Indian River; grayling and rainbow trout in Jack Long Creek; four pink salmon carcasses, but no salmon spawning grounds, in Jack Long Creek; Chinook salmon, chum salmon, pink salmon, coho salmon, and Arctic grayling in Portage Creek; Arctic grayling, burbot, slimy sculpin, round whitefish, humpback whitefish, and longnose sucker in Watana Creek and the mouths of Watana and Deadman creeks; no salmon observed in Jay Creek; and abundant Arctic grayling in Kosina Creek and the Oshetna River.

However, more intensive studies were conducted in the 1980s. An overview of these studies is provided herein. Detailed results specific to species and life stages are provided in Sections 5 through 8. In addition, results related to other study components, such as barriers, access corridors, and aquatic productivity, are provided in Sections 9 through 11.

3.1. 1980 Era Aquatic Studies Program

A five- year, two-phase program for assessing the feasibility of a two-dam hydroelectric project on the Susitna River was initiated by APA in 1979 with Acres American Inc. (Acres) as the prime contractor for implementing the program (Estes and Bingham 1982). Acres subcontracted to ADF&G to describe the fishery and aquatic habitat resources of the Susitna River. The ADF&G Aquatic Studies Program began in November 1980 and had three components: Adult Anadromous Fish Studies (AA), Resident and Juvenile Anadromous Fish Studies (RJ), and Aquatic Habitat and Instream Flow Studies (AH). In addition to work completed by ADF&G, the AH component was supported by work conducted by Trihey and Associates. The objectives for each of the components were (Schmidt and Bingham 1983):

- AA - determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area;
- RJ - determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area; and
- AH - characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

Field studies were conducted monthly from November 1980 through October 1985, except for periods of freeze-up and ice-off, and resulted in more than 80 volumes of annual reports (Table 3.1-1). A wide variety of fisheries field and habitat modeling studies occurred over the 5-year period when most studies were completed (Table 3.1-2). In general, RJ and AH studies were broad-based during 1981 and 1982 with the widest geographic scale and sampling methods. As the Aquatic Studies Program progressed, studies became more focused on acquiring specific information needs for habitat modeling and acquisition of specific biological data. In addition, the results of 1981 and 1982 sampling led to conclusions regarding fish distribution and hypotheses about habitat utilization that led to more intensive sampling at fewer sites with known fish use. Fewer crews limited their sampling techniques to those that had demonstrated effective fish capture success previously. These sampling techniques included fishwheels and incline plane traps to understand migratory timing, minnow traps, trotlines, beach seines, boat electrofishing, and backpack electrofishing to understand fish distribution and habitat utilization, and radio-tracking to understand adult fish behavior. Sampling sites for RJ studies and AH studies were frequently the same during the 1983 and 1984 field seasons.

A major objective of the 1980s Aquatic Studies Program was to understand the seasonal fish use of six mainstem (macro-) habitat types. The six mainstem habitat types consisted of mainstem (main channel), side channel, side slough, upland slough, tributaries, and tributary mouths (Figure 3.1-1; ADF&G 1984). The distribution and frequency of these habitats varied longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. The habitat types are depicted graphically and were described with respect to mainstem flow influence by ADF&G in the Susitna Hydroelectric Aquatic Studies Procedures Manual (1984) as follows, with additional clarification added herein where considered appropriate.

- **Main Channel Habitat** was defined as those portions of the Susitna River that normally convey streamflow throughout the year. Both single and multiple channel reaches were included in this habitat category. Groundwater and tributary inflow appeared to be inconsequential contributors to the overall characteristics of mainstem habitat. Mainstem habitat was typically characterized by high water velocities and well-armored streambeds. Substrates generally consisted of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands. Suspended sediment concentrations and turbidity were high during summer due to the influence of glacial melt-water. Streamflows receded in early fall and the mainstem cleared appreciably in October. An ice cover formed on the river in late November or December.
- **Side Channel Habitat** consisted of those portions of the Susitna River that normally convey streamflow during the open water season but became appreciably dewatered during periods of low flow. Side channel habitat existed either in well-defined overflow channels, or in poorly defined water courses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side channel streambed elevations were typically lower than the mean monthly water surface elevations of the mainstem Susitna River observed during June, July and August. Side channel habitats were characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river.
- **"Side" Slough Habitat** was located in spring fed overflow channels between the edge of the floodplain and the mainstem and side channels of the Susitna River and was usually separated from the mainstem and side channels by well vegetated bars. An exposed alluvial berm often separated the head of the slough from mainstem or side channel flows. The controlling streambed/streambank elevations at the upstream end of the side sloughs were slightly less than the water surface elevations of the mean monthly flows of the mainstem Susitna River observed for June, July, and August. At intermediate and low-flow periods, the side sloughs conveyed clear water from small tributaries and/or

upwelling groundwater (ADF&G 1981c. 1982b). These clear water inflows were essential contributors to the existence of this habitat type. The water surface elevation of the Susitna River generally caused a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982b). Even though this substantial backwater existed, the sloughs functioned hydraulically very much like small stream systems and several hundred feet of the slough channel often conveyed water independent of mainstem backwater effects. At high flows, the water surface elevation of the mainstem river was sufficient to overtop the upper end of the slough (ADF&G 1981, 1982b). Surface water temperatures in the side sloughs during summer months were principally a function of air temperature, solar radiation, and the temperature of the local runoff.

- **"Upland" Slough Habitat** differed from the side slough habitat in that the upstream end of the slough was not interconnected with the surface waters of the mainstem Susitna River or its side channels at less than bankfull flows. The upstream end might have been vegetated with mature trees, although a morphologic signature of a converging inlet and gravel levee closure was still discernible. These sloughs were characterized by the presence of beaver dams and an accumulation of silt substrate that resulted from the absence of mainstem scouring flows. They were not truly "upland" in the geomorphic sense, but the use of this nomenclature in the 1980s studies reflected the observation that the understanding of floodplain and channel forming processes was in the early stage in fisheries, where some variation in interpretation existed over what constituted a floodplain versus an upland terrace (e.g., see Williams 1978). Essentially, the main distinguishing characteristic between a "side" slough and an "upland" slough was the level of high flow at which each was engaged.
- **Tributary Habitat** consisted of the full complement of hydraulic and morphologic conditions that occurred in the tributaries. Their seasonal streamflow, sediment, and thermal regimes reflected the integration of the hydrology, geology, and climate of the tributary drainage. The physical attributes of tributary habitat were not dependent on mainstem conditions.
- **Tributary Mouth Habitat** extended from the uppermost point in the tributary influenced by mainstem Susitna River or slough backwater effects to the downstream extent of the tributary plume which often extended into the mainstem Susitna River or slough (ADF&G 1981c, 1982b).

Beginning in the 1983 open water studies, a fundamental change was made in how side sloughs and side channels were identified (Dugan et al. 1984). During 1981 and 1982, side sloughs and side channels were distinguished primarily on their morphology. Side sloughs included an unvegetated berm at the head of the slough and were rarely overtopped. In contrast, a side channel conveyed mainstream flow during most of the year. During 1983 and following years, if a berm was overtopped and a channel conveyed mainstem flows it was characterized as a side channel. If the berm was not overtopped it was characterized as a side slough. Consequently, during the latter years of the 1980s Aquatic Studies Program an area may be characterized as a side channel during periods of high flows and a side slough during periods of lower flows.

Another major objective of the 1980s Aquatic Studies Program was to gain an understanding of the escapement and distribution of adult salmon. These efforts were primarily based upon three sampling techniques:

- Fishwheels and sonar
- Spawning surveys
- Radio tracking

Sampling at the fishwheels included fish length measurements, attachment of floy tags, and removal of scales for aging fish. Floy spaghetti tags or Petersen disc tags were used to study fish movements and to estimate escapement using Peterson estimation techniques. Adult periodicity information is primarily available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 3.1-3). Stations were generally deployed in early- to mid-June and fished through early- to mid-August. Spawning surveys occurred annually by foot, raft, airplane, or helicopter. The surveys included index streams/reaches that were checked once or twice on an annual basis at the time of peak spawning. Additional surveys were also conducted specifically for the Aquatic Studies Program and varied in the level of intensity and location each year. In general, between 1981 and 1985, all side channels, sloughs and tributaries that are in the reach from Talkeetna to Devils Canyon and that were known to have spawning fish present were surveyed on a weekly basis during the salmon spawning season. In 1981 and 1982, radiotracking was used to identify spawning and holding locations and better understand migration rates (ADF&G 1981, ADFG 1982). However, the number of fish tracked within a species was 18 or fewer fish.

Information on the distribution and abundance of juvenile and resident fish was also important to the Aquatics Study Program. Sampling for juvenile and resident fishes from November 1980 through mid October1981 included a wide range of sites and sampling techniques (Figure 3.1-2Figure). By June of 1981, the Aquatic Studies Program had settled on 39 areas, which they termed "habitat locations," that were the focus of sampling during the open water period (Delaney et al. 1981). During the winter of 1980 to 1981, 29 of the habitat locations were sampled, plus an addition 48 "selected fish habitat sites" that were described as exploratory sampling. An understanding of habitat utilization by juvenile anadromous and resident fish was developed as part of more focused studies during 1982, 1983, and 1984. During 1982, 17 sites referred to as Designated Fish Habitat (DFH) sites were surveyed twice monthly from June through September during the open water season (Estes and Schmidt 1983). Twelve sites were located in the Middle River (Whiskers Creek and Slough to Portage Creek Mouth) and five were located in the Lower River (Goose Creek and Side Channel to Birch Creek and Slough; Table 3.1-4; Figure 3.1-3; Figure 3.1-4).

Habitat zones were delineated within each DFH site based upon the influence of mainstem flow, tributary flow, and water velocity (Table 3.1-5; Figure 3.1-5). Because the zones were based upon flow characteristics, the size of the zones may have varied from survey to survey. As part of the statistical analysis the nine zones were aggregated into Hydraulic and Water Source Zones (Table 3.1-6). In addition to statistical tests to determine associations between fish species catch per unit effort and aggregate hydraulic and water source zones, tests were also run to examine correlations between catch per unit effort and habitat variables including water temperature, turbidity, and velocity (Schmidt and Bingham (1983, Appendix E). A large number of sites (275 mainstem sites and 55 tributary and other slough sites) called Selected Fish Habitat (SFH) sites were also sampled in 1982, but these sites were usually sampled less frequently (1 to 3 times) and more opportunistically than DFH sites (Figure 3.1-6).

During 1983 and 1984, studies were focused on obtaining information needed for developing instream flow models under the AH component and sampling was coupled with obtaining additional distribution and abundance information desired for the AJ component (Schmidt et al. 1984, Suchanek et al. 1985). The instream flow models include Resident Juvenile Habitat (RJHAB) and Instream Flow Incremental Methology (IFIM) models The 1983 open water studies included 35 study sites (called Juvenile Anadromous Habitat Study or JAHS sites) in the lower Middle River while the 1984 studies included 20 sites in the Lower River (Table 3.1-7). Macro habitat types included in the study were tributary, upland slough, side slough, and mainstem side channel. Rationale for sites selected for study included (Dugan et al. 1984):

1. Sites where relatively large numbers of spawning adult salmon were recorded in 1982 (ADFG 1982),
2. Sites where concentrations of rearing juvenile salmon were observed or collected in 1981 and 1982, and
3. Sites representing macrohabitat types associated with the Susitna River that are affected by changes in mainstem flow.

In addition to the combined AH and AJ sampling efforts, studies were implemented to better understand juvenile salmon outmigration and growth (Roth et al. 1984, Roth and Stratton 1985), resident fish distributin and abundance (Sundet and Pechek 1985), river productivity (Wilson 1985, Nieuwenhuyse 1985), and invertebrate food sources for Chinook salmon (Hansen and Richards 1985).

The 1983 and 1984 JAHS sites were sampled in a systematic fashion within grids delineated at each site (Dugan et al. 1984, Suchanek et al. 1985). As described in Dugan et al. (1984) and depicted in Figure 3.1-7:

> *"Each of the study sites was divided into one or more grids. Grids were located to keep water quality (temperature, turbidity) within the site as uniform as possible and to encompass a variety of depth, velocity, cover, and substrate types. Each grid consisted of a series of transects which intersected the channels of the study sites at right angles. There were one to three cells (6 ft. in width by 30 ft. in length = 300 sq. ft.) at every transect within the grid. An attempt was made to confine uniform habitat within each cell. Fish were usually sampled from a minimum of seven cells within each grid at each site.*
>
> *The cells were selected to represent the complete range of habitat types available within the grid. Fish density was estimated by electrofishing or beach seining the entire cell, attempting to capture all fish. Catch per unit effort (CPUE) was defined as the catch (number of fish) per cell."*

The analysis utilized the percent distribution of each salmon species among the four macrohabitat types sampled as the evaluation metric. Analysis of variance (ANOVA) techniques were used to discern factors affecting habitat use by the differen juvenile salmon species. In addition to site and sampling period, the factors collected in each cell following fish sampling included mean water depth, mean water velocity, mean percent cover, water temperature, and turbidity. Depth, velocity, and cover measures were averaged over the entire site because the cells were not randomly distributed.

During winter of 1984-1985 JH studies included a Chinook salmon and coho salmon habitat study (Stratton 1986) and resident fish study (Sundet 1986). Stratton (1986) sampled four locations in the lower Middle River (Indian River, Slough 9A, Slough 10, and Slough 22) using minnow traps and backpack electrofishing at an interval of ten to fifteen days from October through April. Captured Chinook salmon and coho salmon were marked with a cold brand identifying the location and time period of capture. For the winter-time resident fish study (Sundet 1986), 23 rainbow trout, fourteen burbot, and five Arctic grayling were radio-tagged in the lower and middle Susitna River between early September and October. An additional 15 rainbow trout radio-tagged during the spring were also tracked. Tracking surveys occurred primarily by airplane or helicopter, but occassionally included snow machines. Burbot spawning was also studied by deployment of trotlines in areas near where radio-tagged fish were located.

The open water season of 1985 included a study of juvenile salmon migration and growth (Roth et al. 1986) and continued monitoring of adult salmon escapement and spawning habitat use (Thompson et al. 1986). Outmigration was studied by deployment of fixed incline plane traps near Flathorn Station (RMS 22.4 and 24.6) and at Talkeetna Station (RM 103) and deployment of a mobile trap that sampled along a cross sectional transect at RM 25.4. Coded wire tags were embedded into juvenile chum salmon and sockeye salmon collected at selected sites upstream of Talkeetna. Chinook salmon and coho salmon were cold branded at sites in the Indian Creek, Portage Creek, Sice Channel 10A, and Slough 15.

A number of instream flow modeling studies were conducted during 1984, 1985, and 1986 based upon the field studies conducted in 1983 and 1984. The details and results of these instream flow studies are described in an Instream Flow Technical Memorandum (R2 Resource Consultants 2013).

4. HABITAT DISTRIBUTION

Most of the habitat characterization in the Susitna River has occurred in the Middle and Lower River with limited data collection in the Upper River. Habitat characterization methods have varied within each of these river segments but were most similar in Middle and Lower River studies conducted in the 1980s. These studies provide the majority of the historic habitat data presented herein. In addition, tributary habitats upstream and downstream of Devils Canyon were characterized during fish studies in the 1950s, and in the early 2000s, some habitat data was also collected in Upper River tributaries as part of the Alaska Freshwater Fish Inventory (AFFI) program (Buckwalter 2011a, Buckwalter 2011b). However, the scale of these data collection efforts limits the utility of the data for evaluating fish-habitat relationships and potential changes in fish habitat use as a result of hydropower facility development and operation.

Habitat was characterized and mapped in a number of different ways during the 1980s in addition to the macrohabitat types described in Section 3.1. Steward and Trihey (1984) also defined unique categories of river habitat based on clear or turbid water conditions under specific flow levels in combination with the presence or absence of open water leads during winter and hydrologic zones within DFH sites were assigned as part of sampling during 1982 (Estes and Schmidt 1983, Schmidt et al. 1983). The macrohabitat categories used in the lower Middle Susitna River were focused on main channel, side-channel, and side-slough habitats in intensively studied areas in an attempt to scale the information up to the entire Middle Susitna River Reach for simulating the relationship between habitat and flow (Aaserude et al. 1985, Klinger-Kingsley et al. 1985). Ashton and Klinger-Kingsley (1985) examined how channel morphology and aquatic habitat in the lower river, as measured by surface area, were affected by changes in flow; however, aquatic habitat suitability to fish species was not considered.

4.1. Susitna River Upstream of Devils Canyon

During the 1950s fish studies, tributaries upstream of Devils Canyon that were surveyed included: Deadman, Watana, Jay, Kosina, and Goose creeks, as well as the Oshetna River (USFWS 1957, 1959a, 1959b). Deadman Creek was described as a clear stream 30 miles long with numerous pools and rock and boulder substrate (USFWS 1959a). Water temperatures were 53.5°F (11.9°C) and 54.0°F (12.2°C) on June 21 and June 30, 1957, respectively, and aquatic insects were observed to be abundant. Watana Creek was described as a green-tinged clearwater stream 20 miles long, 40 feet wide, and 1 to 2 feet deep. Discharge was measured as 150 to 160 cfs at the time of the survey. Substrate was considered suitable for salmon, and occasional deep pools were present. Mean water temperature measured during the early morning between June 20 and August 30 was 52°F (11.1°C) and ranged from 49 to 69°F (9.4 to 20.6°C). Jay Creek was described as a yellow and turbid low gradient stream for two miles, then substantially steeper (USFWS 1957). Kosina Creek was described as slightly yellow-tinged clearwater stream 35 miles in length with a steep gradient (USFWS 1959a). Habitat was primarily riffles with steep banks and substrate of rock and boulders. Water temperature was measured as 63°F (17.2°C). Goose Creek was described as a clearwater stream having riffle-pool habitat with substrate consisting of gravel, rubble, and boulders (USFWS 1959b). Water temperature was 52°F (11.1°C) at 1 pm, July 31. The creek had relatively high water (200 cfs) during the survey due to heavy precipitation with depths averaging two feet and width averaging 25 feet. The Oshetna River was described as a fast clearwater stream 100 feet wide and four feet deep with few pools.

Substrate was gravel, rubble, and boulders. Water temperature was 48°F (8.9°C) at 7:30 am, July 31, and an abundance of caddis flies were observed.

Sautner and Stratton (1983) surveyed eleven streams upstream of the proposed Devils Canyon Dam: Cheechako Creek, Chinook salmon Creek, Devils Creek, Fog Creek, Tsusena Creek, Deadman Creek, Watana Creek, Kosina Creek, Jay Creek, Goose Creek, and Oshetna River (Figure 4.1-1). Discharge measurements were taken during mid-August and mid-September at six of the streams (Figure 4.1-2). Habitat characteristics of these tributaries from Sautner and Stratton (1983) are summarized in Table 4.1-1. At the time, salmon spawning was thought to extend as far as Chinook salmon Creek and the best spawning habitat was considered to be the clearwater plume downstream of Cheechako Creek and very little of the creeks upstream of the mouths were considered suitable for salmon spawning because of high velocities (Sautner and Stratton (1983). Sautner and Stratton (1983) frequently observed sand as a component to the sediment load from tributaries draining from the north of the mainstem Susitna River. Cobble and rubble was observed to be highly embedded within sand in lower velocity habitat types (Figure 4.1-3).

4.2. Middle Susitna River Downstream of Devils Canyon

During the 1980s study efforts, habitat characterization and mapping in the mainstem of the lower Middle Susitna River segment was conducted at the macrohabitat scale (Klinger-Kinsley et al. 1985). The mapping effort by Klinger-Kinsley et al. (1985) was part of a process developed by Trihey and Associates (Steward and Trihey 1984, Aaserude et al. 1985) for extrapolating the results of instream modeling at selected representative locations to a larger unmodeled portion of the river. The mainstem macrohabitat types were representative of distinct functional hydrology and channel morphology were identified. Under this system, the lower Middle Susitna River was classified into seven mainstem macrohabitat types: mainstem channel, side channel, side slough, upland slough, tributary mouth, tributary, and lakes, defined by source water and hydrologic connectivity (Trihey 1982, Estes and Schmidt 1983). Detailed descriptions of these macrohabitat types are provided in Section 3.1. Areas delineated by Klinger-Kingsley et al. (1985) included mainstem, side channel, and side slough aquatic habitat plus gravel bars and vegetated bars.

Aaserude et al. (1985) reported that ten sets of aerial photography were available for habitat characterization (Table 4.2-1). For determination of the amount of surface area for the macrohabitat types, eight of the aerial photo sets were used: 23,000 cfs, 18,00 cfs, 16,000 cfs, 12,500 cfs, 10,600 cfs, 7,400 cfs, and 5,100 cfs (Klinger-Kinsley et al. 1985). Photos at lowest flow level and at 9,000 cfs were not used because of the presence of ice cover. No explanation was provided for not using photos at the 26,900 cfs flow level. The relative amount of the different habitat types delineated by Klinger-Kingsley et al. (1985) are depicted in Figure 4.2-1 and demonstrate the increase in mainstem and side channel habitat area as flows increase with a concurrent decline in the surface area of side slough habitat, gravel bars, and vegetated bars.

The characterization of tributary habitat downstream of Devils Canyon was available from data collected in 1956 and was limited to the Indian River, Jack Long Creek, and Portage Creek (USFWS 1957). Indian River was described as a clear and fast stream 25 feet wide and 3.5 feet deep. The lower 1.5 miles were considered too steep for salmon spawning, although suitable spawning habitats were observed further upstream. Jack Long Creek was described as steep with clear, but slightly yellow tinged water. Portage Creek was described as a blue-tinged clearwater stream larger than Indian River with a width of 40 to 60 feet and depth of 5 to 8 feet. Many deep pools were observed.

4.3. Lower Susitna River

Similar to the middle river for the macrohabitat types, Ashton and Klinger-Kingsley (1985) estimated wetted surface area from aerial photos over a range of mainstem river flows for channel types and macrohabitat types within selected representative areas of the lower river. Five sets of aerial photos taken at mainstem discharge levels of 13,900 to 75,000 cfs (Sunshine gage) were evaluated. Five river segments were delineated based upon river morphology and hydrology:

- Segment I – RM 98.5 to RM 78.0
- Segment II – RM 78.0 to RM 51.0
- Segment III – RM 51.0 to RM 42.5
- Segment IV – RM 42.5 to RM 28.5
- Segment V – RM 28.5 to RM 0.0

Channel classifications were delineated in Segment I to Segment IV. Segment V is influenced by tidal flow and the Yentna River discharge and was not delineated. Because of geomorphic differences in the river form, the lower river classification system was different than the middle river (Ashton and Klinger-Kingsley 1985). Two main channel classifications were delineated on aerial photos: Mainstem Channel and Side Channel Complexes. Each of these had two or three subclassifications:

- Mainstem Channel - That portion of the river floodplain between the vegetated boundaries, including the wide gravel floodplain and isolated vegetated islands in mid-channel
- Mainstem River – the thalweg channel and main subchannels
- Alluvial Island Complexes – Areas of broad gravel islands with numerous subchannels which dewater as flow decreases
- Side Channel Complexes – One or more channels flowing among a group of vegetated islands. These complexes are usually located along the edge of the mainstem river but, in areas such as the Delta Islands, may occur in the middle of the river.
- Major Side Channels are overtopped at mainstem flows of 13,900 cfs and lower. They tend to be, but are not limited to, the outside-most channel of a complex, closest to the edge of the floodplain. These channels may collect groundwater seepage and tributary flow.
- Intermediate Side Channels – These dewater at their upstream berm in the mainstem flow range of 13,900 cfs to 59,000 cfs. After their upstream berm dewaters, some intermediate channels maintain turbid water to mainstem flow of 21,100 cfs or less, while other contain clearwater from groundwater and/or surface water inflow. Other intermediate side channels dewater the complete length of the channel before the mainstem flow

decreases to 21,000 cfs. Intermediate side channels may be extensions of tributaries once their upper berms dewater.

- Minor Side Channels – These side channels dewater at their upstream berm at mainstem flows of 59,100 cfs and higher. These channels tend to be dewatered the complete length of the channel at mainstem flows of 36,600 cfs.

Ashton and Klinger Kingsley (1985) found the rate of change in the surface area of mainstem channels was relatively steady over the mainstem discharge levels evaluated (Figure 4.3-1). In contrast, the surface area of side channel complexes changed more rapidly at mainstem flows between 13,900 cfs and 21,000 cfs. Ashton and Klinger-Kingsley (1985) also selected eight representative areas for delineation of 8 macrohabitat types: mainstem, primary side channel, secondary side channel, turbid backwater, clearwater, side slough, tributary mouth, and tributary (Table 4.3-1). However, because of difficulty in seeing the water's edge in the aerial photos they did not delineate Birch Creek Slough. Definitions of macrohabitat types were slightly different than those used for the middle river:

- Mainstem – Habitats consist of the thalweg channel, major subchannels and alluvial island complexes.
- Primary Side Channel – Habitats are those channels which normally convey streamflow throughout the entire year. They are characterized by turbid glacial water, high velocities, and few mid-channel gravel bars.
- Secondary Side Channels – These habitats also have turbid water, but exhibit characteristics of middle river side channels. These habitats include mid-channel gravel bars and riffles or water surface features that indicate slower-moving, shallower water.
- Turbid Backwater – These habitats are nonbreached channels containing turbid water. They have non-vegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. They represent a transitional habitat type between breached secondary side channel habitats and nonbreached clearwater or side slough habitats.
- Clearwater – These habitats are nonbreached channels containing clear water that dewater completely at a mainstem discharge of 13,000 cfs or higher. They have non-vegetated upper thalwegs that are overtopped during periods of moderate to high mainstem discharge. Groundwater and local surface runoff appear to supply water these areas at mainstem flows above 13,900 cfs.
- Side Slough - These habitats contain clear water. Upwelling and local surface runoff appear to supply sufficient clear water to these areas to maintain wetted areas at a mainstem discharge of 13,000 cfs. Side sloughs also have non-vegetated upper thalwegs that are overtopped at moderate to high mainstem discharges.
- Tributary Mouth – These habitats are clear water habitats that exist between the downstream extent of a clear water plume and upstream into the tributary to the upper extent of the backwater influence. The surface area depends on the discharge of both the tributary and mainstem.
- Tributary – This habitat exists upstream of the tributary mouth habitat and was measured to the extent of the aerial photo. Tributary habitat may increase dramatically when the

tributary flows into a nonbreached side channel and the clear tributary flows through the side channel to join the Susitna River.

In addition to these aquatic habitat types, the area occupied by gravel bars was also estimated from the aerial photos (Ashton and Klinger-Kingsley 1985). The proportion (Figure 4.3-2) and area (Figure 4.3-3) of each of these habitats is graphically depicted for five of the seven sites delineated. At flows of 21,000 cfs and lower, gravel bars represent more than half of the surface area at the sites. Conversely, mainstem and secondary side channel habitat types account for increasing amounts of the surface area at the sites as flows increase. Side sloughs, tributary mouths, tributaries, and turbid backwaters represent relatively small amounts of area at each of the sites, both individually and in total.

5. ADULT SALMON

5.1. Chinook Salmon

5.1.1. Abundance/Escapement

Of the five salmon species returning to the Susitna River, Chinook salmon have had the fewest number of fish but have been the most important sport fish (Jennings 1985). Long term escapement trend data from 1974 to 2009 are available for a number of index streams in the Susitna River Basin monitored by ADF&G, but between stream comparisons are unreliable because of different survey methods (weirs, foot, or aerial; Fair et al. 2010). Most index streams are tributaries to the mainstem in the Lower River or tributaries in the Chulitna and Talkeetna subbasins and surveyed by aerial methods (Fair et al. 2010). The Deshka River (RM 40.6) has the highest escapement of all tributaries with a median of 35,548 fish (Figure 5.1-1). ADF&G installed a counting weir in the Deshka River prior to the 1995 season to improve the accuracy of salmon escapement counts (Fair et al. 2010). All other index streams generally have fewer than 5,000 fish spawning during peak surveys (Figure 5.1-2).

Total peak counts of Chinook salmon spawning in Middle River tributaries between 1981 and 1985 ranged from 1,121 to 7,180 fish with a median of 4,179 fish (Jennings 1985, Thompson et al. 1986). Generally over 90 percent of the Chinook salmon returns to the Middle Susitna River have spawned in Indian or Portage creeks. Peak spawner counts from 1976 to 1984 ranged from 114 to 1,456 fish (median 479.5 fish) in Indian Creek and 140 to 5,446 fish (median 680.5 fish) in Portage Creek (Jennings 1985).

ADF&G used mark recapture techniques to estimate escapement to fishwheel stations during the early 1980s (Figure 5.1-3). From 1982 to 1985, total escapement (point estimates) to Sunshine Station ranged from 52,900 to 185,700 fish with a median 103,614 (Barrett et al. 1983, Barrett et al. 1984, Barrett et al. 1985, Thompson et al. 1986). Escapement to Talkeetna Station ranged from 10,900 to 24,591 fish (median 14,400 fish), but was considered an overestimate because many Chinook salmon tagged at Talkeetna Station have been found to spawn in tributaries downstream of Talkeetna Station (Jennings 1985). The large difference between these two stations, especially considering the overestimate at Talkeetna, reflects the large number of fish that returned to tributaries downstream of the Three Rivers Confluence, as well as to the Chulitna and Talkeetna rivers.

Within the Susitna River drainage, ADF&G has established escapement goals on the Chulitna and Deshka rivers, and on Chunilna, Montana, Willow, and Little Willow creeks. Aside from the Deshka River weir, all of these goals are based on counts indexed with a single annual aerial survey. Chinook salmon escapements were also counted at a floating weir operated at Willow Creek from 2000 through 2002. Counts were used as part of a coded wire tag recovery project, and were not expanded to the entire Susitna River drainage (Yanusz 2013, pers. comm.).

Declines in returns of Chinook salmon have prompted the Alaska Board of Fisheries to list several Susitna River tributaries as a Stock of Concern. These include Alexander Creek as Management Concern listed in 2011 and Willow and Goose Creeks as Yield Concern in 2011. Low returns to the Deshka River in 2007 through 2009 have also prompted concern and in 2012 low returns resulted in an early closure to the sport fishery.

5.1.2. Distribution

Based upon observations of juveniles, Chinook salmon are distributed in the Susitna River up to the Oshetna River (RM 225; Table 5.1-1; Buckwalter 2011). Buckwalter also observed juvenile Chinook salmon in Fog Creek, Kosina Creek, and Oshetna River during 2003 and a Fog Creek tributary during 2011. During 1984, two spawning Chinook salmon were observed in Fog Creek (RM 176.7; Table 5.1-2; Barrett 1985). More recently, Buckwalter (2011) observed adult Chinook salmon in Fog Creek and Tsusena Creek (RM181.3) during 2003 and in Kosina Creek (RM 201) during 2011. In addition, 16 adult Chinook salmon were observed in Kosina Creek during 2012 (AEA unpublished data). During 2012, ADF&G began a mark-recapture study to identify the spawning distribution of Chinook salmon in the Susitna River drainage (Cleary et al. *in prep*).

A series of three partial velocity barriers are present in Devils Canyon that restricts access to upstream habitat. Chinook salmon are the only known anadromous salmon that can pass all three barriers (AEA unpublished data). The lower two barriers appear to be passable by Chinook salmon at a relatively broad range of flows. Data from 2012 indicated that the upper barrier, located downstream of Devil Creek, can be passed at flows of approximately 16,000 cfs as measured at the Gold Creek gage.

Chinook salmon spawn exclusively in tributary streams (Thompson et al. 1986, Barrett 1985, Barrett 1984, Barrett 1983). Consequently, the mainstem Susitna River primarily provides a migration corridor and holding habitat for adult Chinook salmon. Apportionment of Chinook salmon among the major Susitna River subbasins based on peak spawning surveys has been somewhat confounded by inconsistent surveys, in part because poor visibility and partly due to annual differences in surveying priorities. Nevertheless, major patterns in the distribution of Chinook salmon spawning during the late 1970s and early 1980s are discernible based upon data summarized in Jennings (1985). Tributaries to the Lower Susitna River tend to account for 50 percent or more of the Chinook salmon spawning (Figure 5.1-4). Important spawning tributaries in the Lower River are the Deshka River and Alexander Creek. The Yentna River and Talkeetna/Chulitna subbasins typically account for about 20 percent and 15 percent, respectively. The Middle River tributaries typically account for about 5 percent of the Chinook salmon spawning in the Susitna River. Considering only the Middle River, Portage Creek and Indian River account for nearly all Chinook salmon spawning (Figure 5.1-5). Fourth of July Creek and Whiskers Creek account for minor amounts of spawning, generally with no more than about 2.5 percent of the spawning in the Middle River.

5.1.3. Age of Return

On average, Chinook salmon return to the Susitna River at roughly similar proportions for Age 3 (21.0 percent), Age 4 (24.9 percent), Age 5 (23.7 percent), and Age 6 (27.4 percent; Figure 5.1-6; ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986). On average, about 2.7 percent of the returns are Age 7 fish. Variability in the age structure of Chinook salmon is influenced by sampling error due to the location and hydraulic conditions at a particular fishwheel's location (Thompson et al. 1986) as well as interannual differences in age class strength. Fishwheels located in areas with lower water velocities tend to catch fewer large fish, thus the age structures could be biased towards higher proportions of Age 3 and Age 4 fish. During 1985 the average length of Chinook salmon was 508 mm for fish captured at the Flathorn

Station, 778 mm at the Sunshine Station, and 730 mm at the Curry Station (Thompson et al. 1986).

5.1.4. Periodicity

Adult periodicity information was primarily available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 3.1-3). Adult Chinook salmon begin their upstream migration in late-May to early June (Jennings 1985, ADF&G 1984; Figure 5.1-7). Although a few Chinook salmon passed Susitna Station (RM 26.7) as late as mid-August, nearly all Chinook salmon (95 percent) passed the station by the first week of July (ADF&G 1981, Jennings 1985). Peak run timing was generally later at Talkeetna Station (RM 103) compared to Sunshine Station. However, peak run timing at Curry Station appeared to be similar to, or earlier than, Talkeetna Station. This indicates that upriver fish (i.e., Chinook salmon bound primarily for Indian and Portage creeks) enter and migrate during the early portion of the overall Susitna migration period. Based on 1980s surveys, Chinook salmon spawning begins in mid-July and is finished by the end of August (Barrett 1985, Jennings 1985). Peak spawning was during the last week of July and first week of August (Jennings 1985). Run timing (decreased fishwheel catch rates) may have been affected by high flow levels; however, this pattern was not consistent across all years (Jennings 1985).

5.1.5. Holding and Spawning Habitat Utilization

Little information was available describing holding habitat used by Chinook salmon. Tracking of a few radio-tagged Chinook salmon in 1981 (16 fish) and 1982 (16 fish) indicated that the Three Rivers Confluence and tributary mouths were frequently used for holding and milling (Schmidt and Bingham 1983). Chinook salmon radio-tagged at Talkeetna Station during 1981 frequently moved downstream to the Three Rivers area and remained in that area for up to two weeks (ADF&G 1981). In contrast, four of eight Chinook salmon radio-tagged at Curry station migrated upstream shortly after release. Similar behavior patterns were observed in 1982 (ADF&G 1982c). Based on the recapture of fish tagged at the Talkeetna Station fishwheels and the radio-tracking studies, some Chinook salmon were known to mill in the Susitna River upstream of Talkeetna, but then migrated downstream to spawn in tributaries to the Lower River (Jennings 1985). Chinook salmon spawned exclusively in tributary streams to the Susitna River (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett 1985, Thompson 1986).

Vincent-Lang et al. (1984) investigated spawning habitat characteristics used by Chinook salmon as part of the development of instream flow modeling habitat suitability curves. Measurements at 265 Chinook salmon redd locations indicated use of depths up to 2.7 feet, velocities up to 4.3 feet per second, and substrates primarily of rubble and cobble (Figure 5.1-8 and Figure 5.1-9; Vincent-Lang et al. 1984).

5.2. Sockeye Salmon

5.2.1. Abundance/Escapement

Susitna River sockeye salmon are the third most important contributor to the Upper Cook Inlet (UCI) Management Area behind sockeye salmon from the Kenai and Kasilof rivers (Fair et al. 2009). Sockeye salmon generated an average of nearly $16 million per year from 1999 to 2009

(Barclay et al. 2010). During 2005 to 2008, the Susitna and Yentna Rivers contributed an average of 2.2 percent (range 0.7 percent to 4.3 percent) to the UCI commercial harvest based upon genetic identification of harvested fish (Barclay et al. 2010). Sockeye salmon have accounted for the second largest salmon escapement to the Susitna River following behind chum salmon.

There are no estimates of sockeye salmon escapement to the entire Susitna River drainage. Instead, ADF&G has generated counts for counts to portions of the drainage using weirs at three lakes, and mark-recapture methods for inriver abundance in the Yentna River and in the Susitna River above Sunshine (RM 80). Escapement data from 1981 to 2008 were available for the Yentna River and were useful for understanding past trends in sockeye salmon returns (Figure 5.2-1). The data was based upon expanding sonar counts and apportioning them among the salmon species determined from fishwheel catch. Yentna River escapements were historically expanded by 1.95 to estimate escapement to the entire Susitna River, but this is no longer done (Yanusz et al. 2011). Beginning in 2001, the Yentna River had an escapement target of 90,000 to 160,000 sockeye salmon. Fair et al. (2010) cautioned there is substantial uncertainty regarding escapement estimates via apportionment of sonar counts and noted the Yentna River escapement targets were dropped in 2009 and replaced by separate escapement targets for Chelatna Lake (20,000-50,000) and Judd Lake (25,000 – 55,000) in the Yentna River drainage and a target was added for Larsen Lake (15,000 – 50,000) in the Talkeetna River drainage.

In 2007 and 2008, ADF&G used mark-recapture methods to estimate inriver abundance and distribution of sockeye salmon in the Yentna River, and in the mainstem Susitna River above Sunshine (river mile 80; Yanusz et al. 2011). Point estimates of abundance for the Susitna River above Sunshine were 88,000 fish in 2007 and 71,000 fish in 2008. No estimate was generated in 2006 (Yanusz et al 2011).

For the Susitna River, Jennings (1985) reported the minimum average sockeye salmon escapement between 1981 and 1984 was 248,400 fish. Sockeye salmon entered the river in two runs (Jennings 1985); the first run was the smaller of the two with a run size generally of less than 15,000 fish (Jennings 1985, Thompson et al. 1986). The second run was substantially larger with total escapement estimates ranging from approximately 340,000 to 606,000 fish (ADF&G 1981, Barrett et al.1983, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986; Figure 5.2-2). The 1981 estimates at Susitna Station were based upon apportioning sonar counts among the salmon species, while escapement estimates at other Susitna stations are from Peterson mark-recapture estimates.

Sockeye salmon escapement estimates at Talkeetna Station (RM 103), which ranged from 3,123 to 13,050 fish, were considered an overestimate, because sockeye salmon were observed milling in the lower reaches of the Susitna River above the Three Rivers Confluence then moved downstream to spawn (Jennings 1985). Escapement estimates at Curry Station (RM 120) ranged from 1,281 to 3,593 fish from 1981 to 1985 with a median escapement of 2,800 fish. Historically, sockeye salmon spawning in the Middle Susitna River represented around 1 or 2 percent of the total Susitna River escapement.

5.2.2. Distribution

Historically, sockeye salmon were present in the mainstem Susitna River up to Devils Canyon (Jennings 1985). Fried (1994, as cited in Fair 2009) used sonar and fishwheel counts data to estimate that between 41 and 59 percent of the sockeye salmon entering the Susitna River between 1981 and 1985 spawned in the Yentna River drainage. During the two years (i.e., 1984 and 1985) when Peterson estimates were available from both the Sunshine Station and Flathorn/Susitna Stations, data indicated that 21 to 30 percent of sockeye salmon spawned upstream of Sunshine Station (Barrett et al. 1985,Thompson 1986). While there was some uncertainty regarding the precise proportional distribution of sockeye salmon among the different Susitna River subwatersheds (Fair 2009), the tributaries associated with the Lower Susitna River were the major sockeye salmon production areas. In addition to the Yentna River, other Lower River spawning areas included lakes in the Fish Creek drainage (RM 7.0), Alexander Lake (Alexander Cree drainage, RM 10.1), Whitsol Lake (Kroto Slough drainage RM 35.2), Trapper and Neil Lakes (Deshka River drainage, RM 40), and Fish Lake (Birch Creek drainage, RM 89.3). Spawning surveys conducted in the Lower Susitna River indicated that sockeye salmon did not spawn in the main channel, tributary stream mouths or associated sloughs (ADF&G 1981, Barrett et al. 1983, Barrett et al. 1985).

Yanusz et al. (2007, 2011a, 2011b) radio-tagged 75 sockeye salmon captured by fishwheels at Sunshine during 2006, 311 during 2007, and 253 during 2008. Sockeye salmon were also radio-tagged at the Yentna Station. Tracking of tagged fish confirmed the historic data that indicated sockeye salmon spawn primarily in Susitna River tributaries (Figure 5.2-3). Within the Susitna River tributaries, spawning occurred in the main channel, sloughs, or in lake systems (inlets, outlets, and beaches). It is of interest that during 2007 and 2008, more than half of the fish radio-tagged at Sunshine were returning to the Larson Lake system in the Talkeetna River drainage (Yanusz et al. 2011b). Also during 2007 and 2008, approximately 2.6 percent and 1.8 percent, respectively, of the fish tagged at Sunshine spawned in habitats associated with the mainstem river (Figure 5.2-4). During 2007, 17 fish tagged at Sunshine were not assigned a spawning location (Yanusz et al. 2011). These included seven fish last recorded below the Talkeetna River mouth, one fish that moved downstream below the tagging location, one fish that was recorded in an off-channel area, four fish (possibly two others) that were captured in the sport fishery, two fish that moved downstream, and one fish that returned to Cook Inlet. Thus, the terminal locations depicted in Figure 5.2-3 do not necessarily indicate final spawning locations for tagged fish.

Historically, sockeye salmon spawning in the lower Middle Susitna River was a relatively small component to the total Susitna River run, but was important as these fish exhibit a life history pattern that is not dependent upon lakes for juvenile rearing. While juvenile lake rearing is the norm for most sockeye salmon populations, “river-type” and “ocean-type” life history patterns have also been identified, particularly in glacial rivers (Gustafson and Winans 1999). Unlike the Lower Susitna River, which has had substantial amounts of spawning habitat in tributaries that have adjacent lake rearing areas, spawning in the Middle Susitna River occurred primarily in sloughs and side channels with little use of tributaries or the mainstem. Sockeye salmon spawning was observed within 24 sloughs of the Middle Susitna River from 1981 to 1985 (Jennings 1985, Thompson et al. 1986).

Sockeye salmon primarily spawned in Sloughs 11, 8A, and 21 (Table 5.2-1; Figure 5.2-5). Some sloughs were used for spawning by sockeye salmon in all years while others were only intermittently used.

Although sockeye salmon spawning was rarely observed within tributaries of the Middle Susitna River, Roth and Stratton (1985) reported the capture of sockeye salmon fry in the Indian River during July and August 1984. No adult sockeye salmon were observed in tributaries to the Middle Susitna River during 1981 through 1983. Barrett et al. (1985) observed one sockeye salmon adult in Indian River and 12 in Portage Creek during 1984, but suspected most were milling; only one pair of sockeye salmon were spawning. During 1985, Thompson et al. (1986) observed two adult sockeye salmon in the Indian River, but no spawning activity. Few lake systems were accessible to sockeye salmon between Talkeetna and Devils Canyon and none were regularly monitored by ADF&G (Fair 2010).

5.2.3. Age of Return

On average, sockeye salmon predominately returned to the Susitna River at Age 5 (56.6 percent) and Age 4 (37.0 percent) with a few Age 3 and Age 6 (Figure 5.2-6; ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986).

5.2.4. Periodicity

The first sockeye salmon run entered the Susitna River in late May to early June and spawned in the Fish Lake Creek system in the Yenta River and the Papa Bear Lake system (Fish Creek drainage) of the Talkeetna River (Barrett et al. 1985). Some first run sockeye salmon may have temporarily held in the Middle Susitna River, but did not use it for spawning (Barrett et al. 1985). Spawning in the Papa Bear Lake system occurred in mid-July. During 1984 (Barrett et al. (1985) observed no carcasses, but 500 to 1,000 sockeye salmon were staging near the creek mouth and about 1,500 fish were in the early stages of spawning on July 14. By July 26th most fish were in post spawning condition.

The second run began in late June with the peak occurring in late July and early August for the Middle Susitna River (Figure 5.2-7). Spawning began in early August and ended in early October with peak spawning during the last week of August through the third week in September (Schmidt and Bingham 1983, Thompson et al. 1986).

5.2.5. Holding and Spawning Habitat Utilization

Very little information was available regarding sockeye salmon adult holding areas or habitat use. No sockeye salmon were radio-tagged during the 1980s studies; however, salmon with Floy or Peterson disc tags attached at the Talkeetna or Curry fishwheels were often relocated at downstream spawning locations. These data indicated that some fish would enter and mill in the Middle Susitna River prior to movement back downstream (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). During 1982 set nets were fished for 19.6 hours in lower Devils Canyon at RM 150.2 and 150.4 between August 10 and September 12 and electrofishing occurred four times between August 11 and September 23. No sockeye salmon were captured (ADF&G 1982c).

During 2006 to 2008 Yanusz et al. (Yanusz et al.2007, Yanusz et al.2011a, Yanusz et al. 2011b) radio-tagged over 1500 sockeye salmon in the Susitna River. However, the objectives of the studies were primarily to estimate escapement and determine the distribution and location of spawning. Mainstem macrohabitat types (e.g., main channel, side channel, side slough, tributary, tributary mouth) were not reported in detail and mesohabitat types (e.g., cascades, rapids, riffles, runs, or pools) were not reported at all.

Within the Middle Susitna River sockeye salmon spawned in side channel or side slough habitats that were associated with upwelling (Jennings et al. 1985). Schmidt and Bingham (1983) reported that sockeye salmon selected slower, deeper pools with rubble-cobble substrate for spawning. Measurements at 81 sockeye salmon redd locations indicated use of depths up to 3.0 feet, velocities up to 1.0 feet per second, and substrates primarily of large gravel and rubble (Figure 5.2-8 and Figure 5.2-9; Vincent-Lang et al. 1984).

5.3. Chum Salmon

5.3.1. Abundance/Escapement

Chum salmon have been the most abundant anadromous salmon returning to the Susitna River Basin with the exception of even-year pink salmon runs. Chum salmon have been an important component to the commercial salmon fishery with an average of 478,000 caught in the UCI Management Area during 1966 to 2006 (Merizon et al. 2010). Chum salmon also have contributed to the sport fishery with an average of 2,893 captured during 1998 to 2007 (Merizon et al. 2010). In 2009, Merizon et al (2010) began a four-year study to describe spawning distribution of chum salmon throughout the drainage. This study was expanded in 2010 to add escapement estimates, results of which are pending (Cleary al. *in prep*). ADF&G conducts aerial surveys for chum salmon on only one stream in all of Upper Cook Inlet, and there are no escapement goals for chum salmon in the Susitna River drainage (Fair et al. 2010).

Based upon sonar counts to the Yentna River plus the Peterson estimates to the Sunshine Station, minimum chum salmon returns to the Susitna River averaged 440,751 fish (range 276,577 to 791,466) from 1981 through 1985[2] (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. (1986). These counts were considered minimums because sonar counts at the Yentna River station underestimated the total returns (Jennings 1985). The average returns to the Talkeetna Station during a similar time period was 54,640 chum salmon, but this was probably an overestimate since chum salmon have been documented entering the Middle Susitna River and then migrating back downstream to spawn in Lower River habitats (Figure 5.3-1). The Talkeetna Station was not operated during 1985. Average returns to Curry Station were 21,993 fish (range 13,068 to 29,413) from 1981 to 1985. The returns to Curry Station were likely reasonable estimates of the returns to the Middle Susitna River because all of the known primary spawning areas are upstream of Curry Station.

5.3.2. Distribution

Historically, chum salmon were present in the Susitna River basin from the mouth to Devils Canyon (RM 151) and in most accessible tributaries (Jennings et al. 1985). Low capture rates early in the chum salmon run resulted in extremely wide error bands for the chum salmon estimate at Flathorn Station; the east bank fish wheel was relocated on July 29 to improve chum salmon capture efficiency (Thompson et al. 1986). Chum salmon counted at the Yentna Station represented 3 to 7 percent (average 5 percent) of the combined escapement estimated at the

[2] No estimate was available for the Yentna River during 1985 and the estimate at the downstream Flathorn Station was 56,800 fish lower than the Sunshine estimate. Consequently, the minimum chum run size for 1985 was estimated using the Sunshine estimate plus the four-year average at the Yentna Station from 1981 to 1984.

Yentna and Sunshine Stations (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). Merizon et al. (2010) radio-tagged 239 chum salmon at Flathorn during 2009 and assigned a spawning location to 210 of the tagged fish. Chum salmon were strongly oriented toward the east or west banks. Consequently, fish captured and tagged on the west side of the river primarily entered the Yentna River, while those captured on the east side tended to migrate up the Susitna River. Ten (4.8 percent) of the 210 chum salmon tagged at Flathorn and assigned a spawning location were assigned as spawning in the Middle Susitna River and none entered tributaries (Figure 5.3-2; Merizon et al. 2010). For the Lower Susitna River, 99 (47.1 percent of those assigned a spawning location) chum salmon spawned in the Yentna River drainage, 33 (15.7 percent) spawned in the Lower Susitna River mainstem, and 107 (50.9 percent) spawned in tributaries to the Lower River other than the Yentna River drainage (primarily the Talkeetna, Deshka, and Chulitna drainages).

Spawning surveys were conducted each year from 1981 to 1985, but the level of intensity varied from year to year. In 1982, spawning surveys conducted at 811 sites in the Lower Susitna River did not identify any chum salmon spawning locations in the main channel (Barrett et al. 1983). However, Barrett et al. (1984) and Thompson et al. (1986) conducted intensive surveys during 1984 and 1985 and identified chum salmon tributary and slough spawning locations in the Lower and Middle River (Figure 5.3-3). During 1984 Barrett et al. (1985) documented spawning in twelve non-slough and five slough habitats in the mainstem of the Lower River. Indian River and Portage Creek account for the majority tributary spawning in the Middle Susitna River while Sloughs 11, 8A, and 21 account for the majority of slough spawning. During 1984 Barrett et al. (1985) identified 36 non-slough spawning areas in the mainstem of the Middle Susitna River. Peak counts in these areas ranged from 1 to 131 (HRM 136.1) chum salmon. During 1985, with relatively poor viewing conditions, Thompson et al. (1986) identified three mainstem spawning areas with 13 to 17 peak chum salmon counts.

While there is some uncertainty regarding the precise proportional distribution of chum salmon among the different Susitna River spawning areas due to annual variations, the tributaries associated with the Lower Susitna River are the major chum salmon production areas with lower amounts of production from mainstem channels and sloughs. The Middle Susitna River mainstem channels, sloughs, and tributaries also account for a small, but significant portion of the total river chum salmon production.

5.3.3. Age of Return

Chum salmon have predominately returned to the Susitna River at Age 4 (80.0 percent) and Age 5 (12.8 percent) with a few Age 3 and Age 6 fish returning (Figure 5.3-4; ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986). The age structure during 1983 was anomalous with predominance of Age 5 rather than Age 4 fish.

5.3.4. Periodicity

Adult periodicity information was available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 3.1-3). Historically, adult chum salmon began their upstream migration in late May to early July (Jennings 1985, ADF&G 1984; Figure 5.3-5). Although a few chum salmon passed Sunshine Station (RM 80) as late as the last week of September, nearly all chum salmon (95 percent) passed the station by the first week of August (ADF&G 1981, Jennings 1985). Run timing (decreased fishwheel catch rates) may have been affected by high flow levels; however, this pattern was not consistent across all years (Jennings 1985). Chum salmon spawning generally began in mid-July and was finished by the end of August (Barrett 1985, Jennings 1985). Peak spawning in streams was during the last week of August while spawning in mainstem sloughs typically peaked during the first two weeks of September (Jennings 1985). However, during 1985 a secondary peak of chum salmon spawning occurred the last week of September at Slough 8B and to a lesser extent other sloughs (Thompson et al. 1986).

5.3.5. Holding and Spawning Habitat Utilization

Very little information was available regarding chum salmon adult holding areas or habitat use. During 1981 and 1982, radio tags were used to track 11 and 18 chum salmon, respectively (ADF&G 1981, ADF&G 1982c). The objectives of the studies were to determine migration timing, milling behavior, and the distribution and location of spawning. In addition to the radio-tracking studies chum salmon were also tagged with Floy or Peterson disc tags attached at the Flathorn/Susitna, Sunshine, Talkeetna, or Curry fishwheels.

During 1981, three chum salmon displayed holding behavior near the mouth of Fourth of July Creek (3 days and 11 days, 2 fish) or Lane Creek (6 days, 1 fish). During 1982, 6 of 10 chum salmon radio-tagged at Talkeetna Station eventually moved downstream and entered the Talkeetna River. Two of these fish moved as far upstream as Curry Station before returning downstream. Two fish tagged in lower Devils Canyon were observed to enter Portage Creek, but one later moved to Indian River for spawning while the other moved downstream and was last observed in the mainstem Susitna River below RM 97. The radio tagging studies in 1981 and 1982 suggested that some chum salmon make substantial upstream and downstream movements prior to spawning and that holding behavior may occur near the mouths or within tributary streams. A radio-tracking study in 2009 with 239 chum salmon tagged at Flathorn generally supported the behavior patterns observed during the 1980s. Merizon et al. (2010) reported that milling behavior was observed for 23.4 percent of the fish and 3.5 percent entered more than one tributary prior to spawning.

Recoveries of chum salmon tagged with Peterson disc or Floy tags also supported the notion that chum salmon mill or temporarily hold in the Middle Susitna River prior to moving downstream to spawn (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). During 1982 set nets were fished for 19.6 hours in lower Devils Canyon at RM 150.2 and 150.4 between August 10 and September 12 and electrofishing occurred four times between August 11 and September 23. The effort resulted in the capture of 25 chum salmon, indicating that lower Devils Canyon is used as a holding area by chum salmon (ADF&G 1982c).

Within the Middle Susitna River chum salmon spawned primarily in tributary streams; however, a substantial number of chum salmon also spawned in side channel or side slough habitat that was associated with upwelling (Jennings et al. 1985). Measurements at 333 chum salmon redd locations indicated use of depths up to 2.8 feet, velocities up to 4.5 feet per second, and substrates primarily of large gravel and rubble (Figure 5.3-6 and Figure 5.3-7; Vincent-Lang et al. 1984).

5.4. Coho Salmon

5.4.1. Abundance/Escapement

Historically, coho salmon have been the least abundant anadromous salmon returning to the Susitna River Basin. Coho salmon have been an important component to the commercial salmon fishery with an average of 313,000 caught in the UCI Management Area during 1966 to 2006 (Merizon et al. 2010). Next to Chinook salmon, coho salmon have been the second highest contributor to the sport fishery with an average of 40,767 captured during 1998 to 2007 (Merizon et al. 2010).

In 2002, Willette et al (2003) used radio tags applied in Upper Cook Inlet to generate an escapement estimate of 663,000 coho salmon for the Susitna River (95% CI of 435,000 – 892,000 fish) and to describe coho salmon distribution throughout the drainage. The estimate was split out separately for the Yentna River and the rest of the Susitna River drainage. In 2009, Merizon et al (2010) began a four-year study to describe spawning distribution of coho and salmon throughout the drainage. This study was expanded in 2010 to add escapement estimates, results of which are pending (Cleary al. *in prep*). Coho salmon are also recorded incidentally at the Yentna River sonar site, which is operated primarily for sockeye salmon and not considered to provide complete estimates of other species (Westerman and Willette 2011). There are no escapement goals for coho salmon in the Susitna River drainage (Fair et al. 2010).

Based upon sonar counts to the Yentna River plus the Peterson estimates to the Sunshine Station, minimum coho salmon returns to the Susitna River have averaged 61,986 fish (range 24,038 to 112,874) from 1981 through 1985 (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. (1986). These were considered minimums, because sonar counts at the Yentna River station underestimated the total returns to the Yentna River (Jennings 1985). The average returns to the Talkeetna Station from 1981 to 1984 was 5,666 coho salmon (Figure 5.4-1), but this was probably an overestimate, because radio-tracking studies and traditional tag recaptures have indicated that coho salmon enter the Middle Susitna River and then migrate back downstream to spawn. The Talkeetna Station was not operated during 1985. Average returns to Curry Station were 1,613 fish (range 761 to 2,438) from 1981 to 1985. The returns to Curry Station were likely underestimates of the returns to the Middle River based on milling behavior described previously and the fact that one of the known primary spawning areas, Whiskers Creek, is downstream of Curry Station.

5.4.2. Distribution

Coho salmon have been documented in the Susitna River basin from the mouth to Devils Canyon (RM 151) and most accessible tributaries (Jennings et al. 1985). Historically, coho salmon counted at the Yentna Station represented 16 to 46 percent (average 35 percent) of the combined Yentna and Sunshine Stations counts (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). Merizon et al. (2010) radio-tagged 300 coho salmon at Flathorn during 2009 and assigned a spawning location to 275 of the tagged fish. Coho salmon were strongly oriented toward the east or west banks. Consequently, fish captured and tagged on the west side of the river primarily entered the Yentna River, while those captured on the east side tended to migrate up the Susitna River. Four (1.5 percent) of the 275 coho salmon tagged at Flathorn and assigned a spawning location spawned in the Middle Susitna River, and none entered tributaries (Figure

5.4-2; Merizon et al. 2010). For the Lower River, 130 (47.3 percent of those assigned a spawning location) coho salmon spawned in the Yentna River drainage, 39 (14.2 percent) spawned in the Lower River mainstem, and 102 (37.1 percent) spawned in tributaries to the Lower Susitna River other than the Yentna River drainage (primarily the Talkeetna, Deshka, and Chulitna drainages).

Spawning surveys were conducted each year from 1981 to 1985, but the level of intensity varied from year to year. During 1982, spawning surveys conducted at 811 sites in the Lower Susitna River did not identify any coho salmon spawning in the main channel (Barrett et al. 1983). Barrett et al. (1985) and Thompson et al. (1986) documented coho salmon spawning in tributaries of the Middle Susitna River (Figure 5.4-3). However, in 1984, Barrett et al. (1985) identified two non-slough and one slough spawning areas in the mainstem of the Lower Susitna River. They also identified 11 tributary mouths that were used as holding habitat, but not for spawning. Whiskers Creek, Indian River and Chase Creek (RM 106.9) account for the majority of the tributary spawning in the Middle Susitna River. Thompson et al. (1986) observed coho salmon milling in five sloughs of the Middle Susitna River during 1985 and Barrett et al. (1985) observed milling three sloughs during 1984, but no spawning activity was observed in sloughs during either year. During 1984 Barrett et al. (1985) identified one non-slough spawning area with two coho salmon in the mainstem of the Middle Susitna River.

While there is some uncertainty regarding the precise proportional distribution of coho salmon among different Susitna River spawning areas, tributaries associated with the Lower River were the major coho salmon production areas, and mainstem channels and sloughs were occasionally used. The Middle Susitna River tributaries support spawning coho salmon but account for a small portion of the total river production. Middle River mainstem habitats have been used for holding and, albeit rarely, spawning by coho salmon (Jennings 1985).

5.4.3. Age of Return

On average, coho salmon have predominately returned to the Susitna River at Age 4 (58.0 percent) and Age 3 (40.4 percent) with a few Age 5 (Figure 5.4-4; ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986).

5.4.4. Periodicity

Adult periodicity information was available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 3.1-3). Adult coho salmon began their upstream migration in early to mid-July (Jennings 1985, ADF&G 1984; Figure 5.4-5). Although a few coho salmon passed Sunshine Station (RM 80) as late as the last week of September, most (95 percent) passed the station by the end of August (ADF&G 1981, Jennings 1985). Run timing (decreased fishwheel catch rates) may have been affected by high flow levels; however, this pattern was not consistent across all years (Jennings 1985). Coho salmon spawning generally began in early August and was finished by the first week of October (Barrett 1985, Jennings 1985). Peak spawning in streams occurred during the first two weeks of September (Jennings 1985). However, during 1985 a secondary peak of chum salmon spawning occurred the last week of September at Slough 8B and to a lesser extent other sloughs (Thompson et al. 1986).

5.4.5. Holding and Spawning Habitat Utilization

Very little information was available regarding coho salmon adult holding areas or habitat use. Radio tags were used to track 20 coho salmon during 1981 and 16 during 1982 (ADF&G 1981, ADF&G 1982c). The objectives of the studies were primarily to determine migration timing, milling behavior, and the distribution and location of spawning. In addition to the radio-tracking studies, some coho salmon were collected at the Flathorn/Susitna, Sunshine, Talkeetna, and Curry fishwheels and tagged with Floy or Peterson disc tags.

During 1981, five chum salmon displayed holding behavior near the mouths of Gash Creek, Fourth of July Creek, and Little Portage Creek for periods ranging from several days to several weeks. During 1982 six of ten chum salmon radio-tagged at Talkeetna Station eventually moved downstream and entered Whiskers Creek, Birch Creek, or the Talkeetna River. The radio tagging studies in 1981 and 1982 indicated that some coho salmon made substantial upstream and downstream movements prior to spawning and that holding behavior may occur near the mouths of tributary streams prior to entering the stream for spawning. A radio-tracking study in 2009 with 300 coho salmon tagged at Flathorn generally supported the behavior patterns observed during the 1980s. Merizon et al. (2010) reported that milling behavior was less frequently observed for coho salmon (15.5 percent of fish assigned with spawning location) compared to chum salmon (23.4 percent) and substantially more coho salmon (50.2 percent) compared to chum salmon (38.1 percent) made consistent upstream movements throughout the tracking period.

Recoveries of coho salmon tagged with Peterson disc or Floy tags supported the hypothesis that many chum salmon mill in the downstream reaches of the Middle Susitna River prior to spawning elsewhere (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). During 1982 set nets were fished for 19.6 hours in lower Devils Canyon at RM 150.2 and 150.4 between August 10 and September 12 and electrofishing occur four times between August 11 and September 23. These efforts resulted in the capture of three coho salmon indicating some coho salmon have used lower Devils Canyon for milling and/or holding (ADF&G 1982c). This is not surprising given the use of Portage Creek, located a few miles downstream, as an important coho salmon spawning tributary in the Middle Susitna River.

Coho salmon primarily spawn in tributary streams, with relatively little use of main channel, side channels, or sloughs. Unlike Chinook salmon, chum salmon, and sockeye salmon, micro-habitat measurements were not made at coho salmon redds during the 1980s. Consequently, there is no drainage-specific depths and velocity data for coho salmon spawning habitat.

5.5. Pink Salmon

5.5.1. Abundance/Escapement

Pink salmon have a strict two-year life history. Consequently, even and odd year populations are genetically distinct stocks. During even years pink salmon are often the most abundant anadromous salmon returning to the Susitna River Basin. Pink salmon account for a substantial portion of the commercial salmon fishery with an average of 88,000 fish caught during odd years and 34,000 fish caught during even years in the UCI Management Area during 1997 to 2009 (Shields and Dupuis 2012). However, pink salmon represent a small proportion of the total ex-vessel value of salmon in the UCI Management Area (<0.1 percent).

Based upon sonar counts to the Yentna River plus the Peterson estimates to the Sunshine Station, minimum pink salmon returns to the Susitna River averaged 546,888 fish (range 85,554 to 1,386,321) from 1981 through 1985 (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. (1986). These were considered minimums, because sonar counts at the Yentna River station underestimated the total returns to the Yentna River (Jennings 1985). The average returns to the Talkeetna Station from 1981 to 1984 was 65,684 pink salmon (Figure 5.5-1), but this was probably an overestimate because traditional tag recaptures have indicated pink salmon have entered the Middle Susitna River and then migrated back downstream to spawn. The Talkeetna Station was not operated during 1985. Average returns to Curry Station were 22,437 fish (range 1,041 to 58,835) from 1981 to 1985.

ADF&G has operated a counting weir at TRM 7.0 on the Deshka River (RM 40.6) since 1995. The weir was built and operated for counting Chinook salmon. In recent years, the counting operation ceased prior to the completion of the pink salmon run. Consequently, recent pink salmon escapement counts to the Deshka River were underestimates. Nevertheless, the available information suggests the Deshka River has been also an important spawning tributary in the lower river for pink salmon with escapement estimates of up to 1.2 million fish.

In 2012, ADF&G began a mark-recapture study to identify major spawning locations of pink salmon throughout the Susitna River drainage (Cleary al. *in prep*). Pink salmon are also recorded incidentally at the Yentna River sonar site, which is operated primarily for sockeye salmon and not considered to provide complete estimates of other species (Westerman and Willette 2011). There are no pink salmon escapement goals in the Susitna River drainage (Fair et al. 2010).

5.5.2. Distribution

Pink salmon have been documented in the Susitna River basin from the mouth to Devils Canyon (RM 151) and in most accessible tributaries (ADF&G 1982c, Jennings et al. 1985). Spawning primarily occurs in tributaries to the Susitna River. Counts at the Yentna Station have indicated that this tributary has been an important producer of pink salmon. These counts have represented 27 to 60 percent (average 45 percent) of the combined escapement estimated at the Yentna and Sunshine Stations (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985). Counts of pink salmon at the Deshka River weir indicated that this tributary was also an important pink salmon production area in the Lower Susitna River (Figure 5.5-2).

Spawning surveys were conducted each year from 1981 to 1985, but the level of intensity varied from year to year. Spawning surveys conducted at 811 sites in the Lower Susitna River during 1982 did not identify any pink salmon spawning locations in the main channel (Barrett et al. 1983). Barrett et al. (1985) and Thompson et al. (1986) conducted intensive surveys in 1984 and 1985 and found pink salmon spawning in tributaries of the Lower and Middle Susitna River. The reports concluded that pink salmon did not spawn in main channel habitat.

In the Lower Susitna River most pink salmon spawned in Birch Creek, Willow Creek, and Sunshine Creek. During 1984, Barrett et al. (1985) identified both Birch Creek (5 percent of peak survey counts) and Birch Creek Slough (59 percent of peak survey counts) as important spawning locations in the Lower River. Birch Creek Slough was the only slough habitat in the Lower River with significant pink salmon spawning during 1984. In contrast, during 1985, Thompson et al. (1986) identified Birch Creek as a spawning area that accounted for 55 percent of the peak survey counts in the Lower Susitna River. Most of the pink salmon counted in Birch Creek Slough were live, up to 9,917 fish, while 222 or fewer pink salmon were dead. Thus, it is possible that Birch Creek Slough provided holding habitat for fish spawning in Birch Creek, with little to no spawning in the slough.

Indian River (RM 138.6), Portage Creek (RM 148.9), 4th of July Creek (RM 131.1), and Lane Creek (RM 113.6) accounted for the majority of the pink salmon tributary spawning in the Middle Susitna River (Figure 5.5-3). Pink salmon holding or spawning occurred in a number of sloughs within the Middle Susitna River. Habitat use was not consistent from year to year. Barrett et al. (1984) identified 17 sloughs that pink salmon occupied, but only ten of the sloughs were used for spawning. Barrett et al. (1985) identified Sloughs 8A, 11, and 20 as the most important for pink salmon spawning. In contrast, during 1985 Thompson et al. (1986) observed pink salmon in seven sloughs and a peak dead fish count of 5 fish in Slough 16. During 1985, pink salmon were only observed in one (Slough 20) of the three sloughs considered important during 1984. Use of sloughs for spawning by pink salmon in the Middle Susitna River may in part depend upon run strength, which is typically larger during even years.

While there is some uncertainty regarding the precise proportional distribution of pink salmon among the different Susitna River spawning areas, the tributaries associated with the Lower Susitna River, primarily the Deshka, Talkeetna, and Yentna rivers, have been the major pink salmon production areas. The Middle Susitna River tributaries have accounted for a small portion of the total Susitna River pink salmon production.

5.5.3. Periodicity

Adult periodicity information was primarily available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 3.1-3). Adult pink salmon began their upstream migration in late June to early-July (Jennings 1985, ADF&G 1984; Figure 5.5-4). Although a few pink salmon passed Sunshine Station (RM 80) as late as the second week of September, nearly all pink salmon (95 percent) passed the station by the third week of August (ADF&G 1981, Jennings 1985). Run timing (decreased fishwheel catch rates) may have been affected by high flow levels; however, this pattern was not consistent across all years (Jennings 1985). Pink salmon spawning generally began in early August and was finished by the first week of October (Barrett 1985, Jennings 1985). Peak spawning in streams was during the first three weeks of August (Jennings 1985). Pink salmon spawning in sloughs occurred slightly later and more variable than tributary spawning. In 1981 peak spawning sloughs was the last week of August, but was during the first three weeks of August in 1982, occurred from mid-August to the first week of September in 1984, and the last week of August in 1985 (Jennings 1985, Barrett et al. 1985, Thompson et al. 1986). No pink salmon were observed to spawn in sloughs during 1983 (Jennings 1985).

5.5.4. Holding and Spawning Habitat Utilization

There was no information available specific to Susitna River pink salmon adult holding areas or habitat use from work conducted in the 1980s. No radio-tracking studies were conducted on pink salmon during the 1980s. Peterson or Floy tags were attached to pink salmon at fishwheel stations for use in mark-recapture abundance estimation and to estimate migration rates, but were not helpful in understanding habitat utilization. Unlike Chinook salmon, chum salmon, and sockeye salmon, micro-habitat measurements were not made at pink salmon redds during the 1980s. Consequently, there was no drainage-specific information regarding pink salmon spawning habitat for the Susitna River.

6. EGG INCUBATION

Egg incubation is an important life stage for salmon and trout because a substantial amount of the freshwater rearing period, more than six months for chum salmon, can be spent developing into free swimming fry within redds. During this stage, eggs and alevin are relatively immobile. Consequently, there is no way to avoid factors such as temperature, water quality, or fines that can adversely affect survival to emergence.

Because chum salmon and sockeye salmon are the principle salmon species using side channels and side sloughs for spawning in the Susitna River (Sautner et al. 1984), egg development and incubation studies were conducted on these two species and focused on chum salmon. Studies included monitoring of surface and intergravel water temperatures, egg development, spawning substrate composition, and trapping of emergent fry.

6.1. Egg Survival

Vining et al. (1985) reviewed the rationale and importance of studying redd stranding in the Susitna River. Declines in mainstem flow levels following spawning can result areas that were suitable for spawning becoming dewatered or having an increased risk of freezing. Chum salmon in the Susitna River frequently select areas of groundwater upwelling for spawning. Vining et al. (1985) noted that selection for upwelling areas is not unique to the river and has been observed in the Amur River of Russia regions, British Columbia, the Columbia River, and other areas of Alaska. Upwelling areas can have the dual effect of preventing redd freezing and providing a stable thermal regime for developing eggs.

Vining et al. (1985) had two objectives:

1) Monitor selected physical and chemical conditions at chum salmon incubation sites in selected slough, side channel, tributary, and mainstem habitats of the middle Susitna River; and,
2) Evaluate the influence of selected physical, chemical, and biological variables on the survival and development of chum salmon embryos placed in artificial redds in slough, side channel, tributary, and mainstem habitats of the middle Susitna River.

These researchers selected eight primary sites within slough, side channel, tributary, and mainstem habitats that included a range of conditions for: spawning density, upwelling, temperature, and substrate. Primary sites were sampled for water quality, substrate composition, continuous water temperature, embryo survival, and embryo development. The primary sites included:

- Fourth of July Creek (RM 131.1)
- Slough 10 (RM 133.8)
- Side Channel 10 (RM 133.8)
- Slough 11 (RM 135.3)
- Upper Side Channel 11 (RM 136.1)
- Mainstem (RM 136.1)
- Side Channel 21 (RM 141.0

- Slough 21 (RM 141.8)

They also selected eight secondary sites that were only monitored for water quality conditions. The selected sites were a subset of those used in instream flow spawning analyses conducted by Vincent-Lang et al. (1984). Standpipes were used collect intergravel water samples and measurements. Sediment samples were collected using a McNeil Sampler. Water quality measurements included dissolved oxygen, pH, conductivity, and turbidity. Depths and velocities were periodically collected at each site.

Chum salmon survival and development was studied by artificially spawning chum salmon and placing 50 fertilized eggs in Whitlock-Vibert Boxes (WVBs) containing appropriately sized gravel. To evaluate egg survival, WVBs were subsequently placed into artificial redds dug at randomly selected locations from a grid pattern. To evaluate egg development EVBs at two sites were placed in a single artificial redd. Artificial redds at most sites were created shortly after the fertilization process on August 26, 1983. However, some artificial redds at the Mainstem RM 136.1 were dug on October 1 because water depths were too high for digging prior to that date. For these sites, eggs were temporarily incubated in streamside incubators prior to burying in artificial redds.

During the 1984-1985 winter study, chum salmon egg survival in artificial redds ranged from 0.0 percent (Side Channel 21 subsite A) to 43.0 percent (Slough 21; Vining et al. 1985; Figure 6.1-1). They concluded that freezing was the major factor affecting egg survival in the artificial redds and that upwelling was the main moderating factor. Upwelling contributed two important functions: it maintained flow when surface flows declined; and it provided warmer water that reduced ice cover and deep freezing of substrate. Vining et al. (1985) stated:

> *"The areas which were observed as being the most susceptible to high embryo mortality due to surface dewatering and freezing in this study were those most directly influenced by mainstem stage at the time when fish were actively spawning (mid August - mid September) and which lacked an upwelling water source. These areas include the mouths of sloughs and tributaries, major portions of side channels, and peripheral areas in the mainstem river. In each of these areas, water levels were significantly higher during the spawning period when fertilized eggs were deposited. However, as the mainstem stage decreased with winter flows, these areas progressively became dewatered and were exposed to freezing ambient temperatures."*

Events at Side Channel 21 were particularly important to their conclusion (Vining et al. 1985). Egg boxes (40) were initially buried (subsite A) during a period when mainstem flows were high (27,000 cfs) and the berm at the head of the side channel was breached, which resulted in relatively high water elevations in the side channel. Two weeks later they returned when mainstem flows were 11,000 cfs and the berm was no longer breached. All redds in areas without upwelling were dewatered. At that time, they buried an additional 20 egg boxes in an area (subsite B) that was still wet. Mainstem flows continued to fall throughout the winter. All of the eggs that were buried at subsite A died from dewatering and freezing while 16 percent survival was observed at subsite B. Vining et al. (1985) concluded that effective spawning habitat that reflected flow and upwelling throughout the incubation period may be different than the amount of habitat available during spawning.

Vining et al. (1985) also concluded that sediment composition was also a factor contributing to egg survival. They observed that slough habitats had the highest level of fines, followed by side channel, tributary, and mainstem habitats (Figure 6.1-2). However, sediment composition sampled directly from redds were much lower (Figure 6.1-3). They suggested that egg survival approaches zero when fines (< 0.08 inches in diameter) in redds exceed 16 percent (Figure 6.2-4).

6.2. Emergence Timing

Water temperature is the most important determinant of egg development and the timing of emergence (Quinn 2005). Intragravel water temperature studies began in February 1982, which led to the development of the following three hypotheses (Trihey 1982).

1) Mid-winter water temperatures in the sloughs are independent of mainstem water temperatures.
2) River stage appears to be influencing groundwater upwelling in the sloughs.
3) Spawning success at upwelling areas in side channels appears to be limited by availability of suitable substrate (streambed materials).

In addition to the importance to incubating salmon eggs, groundwater inflows to sloughs were also considered potentially important to overwintering habitat. During 1982 intragravel temperature monitoring occurred at thirteen sites between RM 125 and 143 that were identified from ADF&G 1981 spawning surveys and were thought to have groundwater upwelling. Measurements of surface and intragravel water temperature at these sites revealed that intragravel temperatures were higher and more stable than surface water temperatures (e.g., Figure 6.2-1).

More intensive winter studies were implemented in March 1983 (Hoffman et al. (1983) and 1984-1985 (Vining et al. 1985; described in the previous section). Hoffman et al. (1983) reported on surface and intragravel water temperature monitoring at seven sites during the winter of 1982 to 1983 and also conducted incubation and emergences studies. In addition to water temperature, Hoffman et al. (1983) also monitored dissolved oxygen, pH, and specific conductance levels and noted the importance of dissolved oxygen exchange as a factor affecting egg incubation. Continuous surface and intragravel monitoring sites were established at six sloughs (Sloughs 21, 19, 16B, 11, 9, and 8A) and the mainstem at LRX 29 and Gold Creek. Measurements were collected from late August 1982 through early June 1983. Sites were chosen because they were known chum salmon and/or sockeye salmon spawning locations.

Incubation and emergence studies were conducted at seven sites (sloughs 21, 20, 11, 9 and 8A) and two side channels (A and B located at RM 136.2 and 137.3, respectively; Hoffman et al. 1983). Standpipes to measure intragravel water temperature and chemistry were located along each bank of the selected sloughs (10 per bank, 20 total per location). Sampling at these locations occurred during April 15 to18 and April 29 to May 2. Eggs were sampled once per month from September 1982 through May 1983 using high pressure water jet to dislodge eggs into a mesh sack.

The 1982-1983 winter study (Hoffman et al. 1983) and 1984-1985 winter study (Vining et al. 1985) confirmed patterns of surface- and ground-water temperature observed by Trihey (1982). Intragravel water temperatures in slough habitats tend to be relatively stable (Hoffman et al. 1983). Vining et al. (1985) observed similar patterns for sloughs and side channels with upwelling was present. At tributary and mainstem sites Vining et al. (1985 observed that intragravel temperatures were variable and approach 0°C in October, which indicated intragravel waters were originating from surface waters. The continuous monitoring stations demonstrated intragravel water temperatures in areas with upwelling were warmer than surface waters during the ice covered period. As the spring thaw begins (about mid-April in 1983), intragravel temperatures then become cooler than surface water temperatures.

Monitoring during three days in mid-April and four days in late-April,1983, at sites with standpipes placed along slough banks indicated substantial variability in upwelling water temperatures with no consistent relationship between right bank and left bank standpipes at a site (e.g., Figure 6.2-2; Hoffman et al. 1983). Average intragravel temperatures were cooler than surface waters, which was consistent to the patterns observed from continuous monitoring.

Mean intragravel dissolved oxygen measurements ranged from 4.6 mg/L at Slough 8A during both sampling periods to 8.5 mg/L at Slough 11 during the first sampling period of 1983 (Hoffman et al. 1983). Intragravel dissolved oxygen was substantially lower than surface water dissolved oxygen that ranged from a mean of 9.1 mg/L at Slough 21 during the first sampling period to 11.2 mg/L at Slough 8A during the second sampling period. Measurements of pH were found to be within suitable levels for both intragravel and surface water. Significant differences and a significant interaction was found for specific conductance between sites and between left and right banks within the sites. Hoffman et al. (1983) concluded that multiple water sources were the cause of these differences. Vining et al. (1985) observed similar patterns for dissolved oxygen and pH. For specific conductance, Vining et al. (1985) observed similar patterns in sloughs; however, specific conductance was lower in tributary sites, which were not studied by Hoffman et al. (1983), than slough and mainstem sites.

The sensitivity of the incubating eggs to mechanical shock (e.g., scour), temperature, and dissolved oxygen changes over the course of egg development (Quinn 2005, Myrick and Cech 2004). Understanding when incubating eggs are more sensitive to perturbations can be important to assessing potential effects of modified flow or temperature regimes. Sampling chum salmon and sockeye salmon redds for developing eggs by Hoffman et al. (1983) indicated that chum salmon eggs deposited during late August and early September of 1982 were eyed by mid-December, hatched in late February and March and emergence occurred between early April through May (Figure 6.2-3). The development of sockeye salmon eggs collected from field sites was not substantially different than chum salmon (Figure 6.2-4).

Egg development was also monitored by Vining et al. (1985). Hatching first occurred in Side Channel 11 during late to early January, followed by hatching in Slough 11 during January (Figure 6.2-5). Hatching at the mainstem site did not occur until April. Although interruptions in temperature monitoring prevented a quantitative comparison of temperature regimes, Vining et al. (1985) attributed the different development rates to temperature and the effects of upwelling. Upwelling was relatively strong at Slough 11, present, but relatively weak at Side Channel 21, and not present at the mainstem site. Vining et al. (1985) concluded that the presence of upwelling is an important factor contributing to emergence timing and that the beneficial effects of upwelling are more prominent in sloughs compared to mainstem, side channel, and tributary habitats because higher surface flows in the latter habitats dilute upwelling.

Wangaard and Burger (1983) incubated chum salmon and sockeye salmon eggs fertilized on three different dates (September 3rd, 9th, and 15th) under four different temperature regimes (Figure 6.2-6). Two of the regimes simulated natural temperatures measured in mainstem Susitna River at RM 136 near Gold Creek and at Slough 8A. The third regime tracked the temperature at Slough 8A, but was 1°C lower. The fourth regime was incubation at a constant 4°C.

Egg development was evaluated based upon accumulated temperature units (ATUs). One ATU is one day of temperature at 1°C, two ATUs could be two days at 1°C or one day at 2°C. Consequently, at a constant temperature of 4°C over a five-day period results in 20 ATUs. ATUs in Wangaard and Burger (1983) were based upon mean daily average temperature. An example of ATUs based upon fertilization at the time of the first egg collection (September 3rd) is provided in Figure 6.2-7.

Chum salmon eggs incubated under the mainstem temperature regime required substantially longer and fewer ATUs to reach the 50 percent hatch and yolk absorption stages compared to the Slough 8A and constant temperature regimes (Figure 6.2-8; Wangaard and Burger 1983). A similar pattern was observed for incubating sockeye salmon eggs. Following hatch, alevins required different amounts of ATUs to complete yolk absorption (Figure 6.2-9). Using data collected during the study and from the literature, Wangaard and Burger developed predictive regression equations for 50 percent hatch and complete yolk absorption for chum salmon and sockeye salmon eggs based upon average incubation temperature (Table 6.2-1).

Bigler and Levesque (1985) monitored surface and intergravel water temperature, egg development, outmigration, and substrate composition at three Lower River side channels where relatively high levels of chum salmon spawning was documented. The three sites included the Trapper Creek side channel (RM 91.6), Sunset Side Channel (RM 86.9), and Circular Side Channel (RM 75.3). Chum salmon surveys and instream flow modeling were also conducted at these sites. Egg development was also monitored at the Birch Creek Camp Mainstem (RM 88.6) site and a fyke net deployed for two days in early May 1984.

Similar to Hoffman et al. (1983), Bigler and Levesque (1985) observed that most of these chum salmon spawning areas had upwelling and intragravel temperatures were higher than surface water temperatures. In general, eggs developed thorough the alevin and emergence stage at all sites. The upper portion of the Sunset Side Channel did not have groundwater upwelling and eggs laid in this portion of the study site froze. Development of eggs ranged from the caudal bud free stage to pigmentation stage by late January. Fyke nets to capture emerging fry were deployed beginning April 15, 1985 and fished periodically. Sockeye salmon fry were captured on the first day of deployment at the Trapper Side Channel and chum salmon fry were present in the catch beginning April 30.

7. JUVENILE SALMON

7.1. Chinook Salmon

7.1.1. Life History Patterns

Susitna River Chinook salmon exhibited very little freshwater life history diversity. Scale samples from adult Chinook salmon collected at fishwheels indicated that nearly all Chinook salmon exhibit a stream-type life history pattern and outmigrate to the ocean as yearlings (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986). Plots of the year of life at ocean entry for adults returning in 1983 and 1984 were typical of other years sampled between 1981 and 1985 (Figure 7.1-1). A small percentage of returning adult Chinook salmon outmigrated as fry. Roth et al. (1986) explained that the patterns from the scales represent successful life history patterns. For example, he suggested that a higher proportion of fry may have left the river than indicated by scale analysis, but they may not have survived as well as other life stages and thus are not represented in the returning adults.

7.1.2. Periodicity

Historically, Chinook salmon spawning in Susitna River tributary streams peaked during the last week of July and first week of August (Jennings 1985; Section 5.1.4). Juvenile Chinook salmon periodicity is depicted in Table 7.1-1. The timing of Chinook salmon fry emergence and downstream migration in Susitna River tributaries is poorly understood because of the difficulty of sampling during the spring. High flows following ice-out prevented sampling in most years prior to mid-May or even early June. In 1981, Delaney et al. (1981) reported that Chinook salmon fry were collected in Indian River in April as part of winter sampling. In 1982, sampling did not begin until early June, and Chinook salmon fry were already present (Schmidt et al. 1983). During 1985, sampling in Portage and Indian creeks occurred beginning July 9 and Chinook salmon fry were being captured at relatively high rates with lengths ranging from 36 to 64 mm (Roth et al. 1986; Figure 7.1-2), indicating that emergence was primarily completed by that time. Schmidt and Bingham (1983) reported Chinook salmon fry emergence occurs during April and March while Stratton (1986) reported Chinook salmon fry emerge in April; however, neither of these authors provides any supporting field sampling data for these conclusions.

As discussed in Section 7.1.1, nearly all Chinook salmon juveniles outmigrated to the ocean as Age 1+ fish. Understanding the timing of this out-migration both from natal tributaries to the mainstem Susitna River and again from the Middle Susitna River to Lower Susitna River is important for assessing the potential effects of the proposed Susitna-Watana Project. During 1983 to 1985, incline plan traps at fixed stations were deployed (Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). The following focuses on the results from 1984 and 1985 because both catch rates and cumulative catch were reported. The general pattern of outmigration timing in 1983 was consistent with observations during 1984 and 1985.

During 1980s studies, the bulk of Chinook salmon fry outmigrated from Indian and Portage creeks by mid-August and redistributed into sloughs and side channels of the Middle Susitna River or migrated to the Lower River (Roth and Stratton 1985, Roth et al. 1986; Figure 7.1-3). Outmigrant trapping occurred at Talkeetna Station (RM 103) during open water periods from 1982 to 1985 and demonstrated Chinook salmon fry were captured migrating downstream to the

Lower Susitna River throughout the time traps were operating (Schmidt et al. 1983, Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). Peak catch often occurred during periods of high flows. Outmigrant traps were also fished at Flathorn Station (RHM 22.4) during 1984 and 1985 and demonstrated peak periods of Chinook salmon fry movement during early July; however, many of these fry may have originated from the Deshka River (Roth and Stratton 1985, Roth et al. 1986). Based on timing of movements, Roth and Stratton (1986) suggested that some Chinook salmon fry either overwinter in Lower Susitna River downstream of Flathorn Station or outmigrate to the ocean as fry. They also suggested that outmigration as fry is a relatively unsuccessful Chinook salmon life history pattern in the Susitna River because scale pattern analysis indicates that few adults return.

The capture of a small number of Age 1+ Chinook salmon juveniles in the Indian River during winter sampling (Stratton 1986) indicated that some Chinook salmon fry remain in natal tributaries throughout their first year of life. During 1984, sampling in the Indian River failed to capture any Chinook salmon Age 1+ fish during July, but were successful during May and June, indicating that Age 1+ Chinook salmon juveniles emigrated from tributary streams shortly after ice-out (Roth and Stratton 1985). The cumulative frequency of Age 1+ Chinook salmon juveniles catch at the Talkeetna Station reached 90 percent by early July in 1985 and by late-July at the Flathorn Station (Roth et al. 1986; Figure 7.1-4). Consequently, outmigrating Chinook salmon Age 1+ smolts are generally in estuarine or nearshore waters by mid-summer.

7.1.3. Growth

The smallest Chinook salmon fry captured at outmigrant traps were 35 mm during 1984 (Roth and Stratton 1985) and 32 mm during 1985 (Roth et al. (1986). Growth of Chinook salmon fry during 1984 and 1985 was similar (Figure 7.1-5). Average size of fry captured at the Flathorn Station were about 5 to 15 mm larger than fry captured at the Indian River and Talkeetna Station during the same time period. From early June to Late September, average fry length was larger at any given site. Differences in Chinook salmon Age 1+ size between Talkeetna and Flathorn stations appeared less dramatic than for fry during 1984 (Figure 7.1-6; no data available for 1985). Age 1+ Chinook salmon juveniles tended to be around 85 to 95 mm in length during the peak movement past Talkeetna and Flathorn in late June and early July 1984. Roth et al. (1986) indicated Age 1+ juveniles averaged 87 mm in length at Flathorn Station and 81 mm in length at Talkeetna Station during the open water season of 1985. Roth et al. (1986) explained that a number of factors likely contributed to spatial and temporal differences in mean length for fry including emergence timing, habitat quality, and water temperatures.

7.1.4. Habitat Utilization

7.1.4.1. Open Water Season

Analyses for habitat utilization were more robust for Age 0 fish because few Age 1+ fish were captured during the 1982 and 1983 field seasons. A 1982 analysis of Chinook salmon juvenile catch rates by Schmidt and Bingham (1983, Appendix F) indicated that Chinook salmon juveniles were more commonly found in tributary zones (Zones 1 and 2, Table 3.1-5) and backwaters downstream of a tributary mouth (Zone 7). When examined using aggregated hydraulic or water zones (Table 3.1-6), Chinook salmon juveniles were more abundant in the tributary water zone (W-I) over mainstem water (W-II) and mixed water (W-III) zones and a substantial avoidance for the mainstem mixing zone (H-III) compared to the not mainstem backwater (H-I) and mainstem backwater (H-II) zones. Little difference in abundance was demonstrated for fast (V-II) versus slow (V-I) velocity zones.

Schmidt and Bingham (1983, Appendix G) also compared the frequency that juvenile Chinook salmon were present in five major habitat types using Chi-square analyses. The five major habitat types were: tributary mouths, upland sloughs, side sloughs with large tributaries, side sloughs without large tributaries, and side channels with large tributaries. The analysis found no significant difference in the presence/absence of Chinook salmon juveniles in these five habitat types. However, a significant difference was found when all salmon juveniles were combined, with a relatively high frequency of salmon juveniles being present in side sloughs with large tributaries and a relatively low frequency of observations in tributary mouths. Schmidt and Bingham (1983) concluded that the habitat types had distinctive salmon juvenile communities.

The 1984 field work (Dugan et al. 1984) tended to contradict the findings from 1983 (Figure 7.1-7 and Figure 7.1-8). Chinook salmon juveniles had relative high density distribution (61 percent) in tributaries, followed by side channels (23 percent), side sloughs (9.3 percent), and upland sloughs (6.7 percent). ANOVA tests suggested that macrohabitat type, sampling period, mean velocity, and turbidity were significant factors affecting juvenile Chinook salmon CPUE. They concluded that Chinook salmon juveniles utilized turbid water as cover. They also concluded that tributaries had a high CPUE because they were the source of Chinook salmon juveniles prior to dispersing into side channels and sloughs. Outmigration of Age 0+ Chinook salmon juveniles from the tributaries peaked during early July with a lower peak in mid-August. They suggested that as temperature drops in September, Chinook salmon juveniles departed side channels and tributaries to seek side sloughs with upwelling that provided over-wintering habitat.

7.1.4.2. Overwintering

Little information was available regarding over winter habitat use by Susitna River Chinook salmon. Surveys during the winter of 1980 to 1981 (Delaney et al. 1981) and during 1985 to 1986 (Stratton 1986) provided information on the winter distribution and habitat characteristics. Delaney et al. (1981) conducted surveys at 87 sites between Alexander Creek (RM 10.1) to Portage Creek (RM 148.8) using minnow traps as a collection method. Approximately one third (29) of the sites were standard habitat locations used for open water sampling. The majority of the sites (53, 61 percent) were in sloughs or tributaries associated with the Middle Susitna River. Sampling effort was variable with events occurring once per month during one to seven months between November and May. Chinook salmon juveniles were captured at 59 percent of the sites. Most (77.4 percent) of the catch occurred from sites in the Middle Susitna River. Whiskers Creek accounted for over a quarter (27 percent) of the catch. Chinook salmon were consistently captured throughout the winter in three sloughs in the Middle Susitna River (Slough 8A, Slough 10, and Slough 20) and two sites in the Lower Susitna River (Sunshine Creek and Rustic Wilderness). Delaney et al. (1981) noted that juvenile Chinook salmon were frequently observed at tributary mouths during the summer (80 to 100 percent incidence) but less commonly during the winter (25 percent incidence). They observed that many sloughs were ice-free during winter and provided what appeared to be rearing habitat throughout the year even though they were not used by Chinook salmon for spawning. Sites surveyed in both the mainstem and sloughs were used by coho and Chinook salmon for overwintering habitat (Delaney et al. 1981).

Stratton (1986) studied overwinter habitat use by Chinook salmon and coho salmon at four locations (Indian River, Slough 9A, Slough 10, and Slough 22) from October 1985 to April 1986. Fish were captured using minnow traps, cold branded with a mark unique to the time period and location of sampling and released at the capture site. During the study 33.5 percent of 9,744 marked Chinook salmon were recaptured. Nearly all recaptured Chinook salmon were located in the same site as where they were marked. Only two were recaptured elsewhere than the marking site. Based upon declines in the catch of Chinook salmon in the Indian River and increases in two sloughs downstream, Stratton (1986) concluded that many juvenile Chinook salmon emigrated from the Indian River during the late-October to mid-January period. He speculated that the amount of ice cover in the Indian River may have been a factor. Relative to coho salmon, Chinook salmon juveniles preferred shallower and slightly higher velocity habitat with cover consisting of rocks and boulders.

Bigler and Lefesque (1985) captured Chinook salmon juveniles using fyke nets at Trapper Side Channel (RM 92.7; April 15 through May 28), Sunset Side Channel (RM 86.9; May 25 through May 27), Circular Side Channel (RM 75.3; April 30 through May 24) and Birch Creek Side Channel (RM 88.6; April 30 through May 2). These data indicated that Chinook salmon may also have used side channels during the ice-in period.

7.2. Sockeye Salmon

7.2.1. Life History Patterns

There appears to be a moderate amount of freshwater life history diversity for sockeye salmon. Scale samples from adult sockeye salmon collected at fishwheels indicated that most sockeye salmon had a stream-type life history pattern and outmigrated to the ocean after overwintering during their second year of life (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986). Plots of the year of life at ocean entry for adults returning in 1983 and 1984 were typical of other years sampled between 1981 and 1985 (Figure 7.2-1). Around ten percent of returning adult sockeye salmon outmigrated as fry or during their third year. Roth et al. (1986) explained that the patterns from the scales represented only successful life history patterns. A higher proportion of fry may have exited the system than indicated by the scale analysis, but they may not have survived as well as other life stages and thus were not represented in the samples of returning adults.

While there was relatively low life history diversity related to freshwater rearing, sockeye salmon life history diversity in the Susitna River was increased by the presence of juveniles that did not rear in a lake environment, which is an uncommon life history pattern for sockeye salmon in southern latitudes (Foerster 1968, Burgner 1991), but relatively common in northern latitude rivers with a predominance of glacial influence (Wood 1995, Gustafson and Winans 1999). Yanusz et al. (2011) observed that many (52 percent in 2008) sockeye salmon within the Yentna River did not enter a major lake, and substantial spawning occurred in sloughs associated with the main channel. Sockeye salmon in the Middle Susitna River spawned primarily in sloughs with upwelling, and occasionally in side channels (Section 5.2.2). The location of freshwater rearing for juveniles hatched out in sloughs has not been determined.

7.2.2. Periodicity

A second-run of slough-spawning sockeye salmon peaked during the first three weeks of August (Jennings 1985; Section 5.2.4). Sockeye salmon fry periodicity is depicted in Table 7.2-1. The timing of sockeye salmon fry emergence in the Middle Susitna River was fairly well understood based upon the work by Hoffman et al. (1983) and Wangaard and Burger (1983). Most sockeye salmon fry emergence occurred in March and is mostly complete by the end of April (Schmidt et al. 1983, Hoffman et al. 1983). However, based upon the smallest fry sizes reported from outmigrant traps, some sockeye salmon fry did not emerge until mid- to late-June. Delaney et al. (1981) sampled Slough 11 and Indian River during March and observed 2,000 pre-emergent pink salmon, chum salmon, and sockeye salmon alevins. Emerging fry were first captured on March 23, but it was not reported how many were sockeye salmon fry. Most sockeye salmon fry appeared to emerge at around 32 mm in size (Roth and Stratton 1985). The minimum fry size collected at the Talkeetna Station outmigration trap during June 16-30 1985 sampling period was 27 mm (Roth et al. 1986).

As discussed in Section 6.1.1, over 90 percent of sockeye salmon juveniles that successfully returned as adults outmigrated to the ocean as Age 1+ fish. During 1983 to 1985, incline plan traps at fixed stations were deployed to collect data on migration timing (Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). The following discussion focuses on the results form 1984 and 1985 because both catch rates and cumulative catch were reported. The general pattern of outmigration timing in 1983 was consistent with observations during 1984 and 1985.

Outmigrant trapping began May 14 during 1984 and May 27 during 1985. Outmigration timing was influenced by flow and turbidity conditions (Hale 1985). During 1984, some sockeye salmon fry were captured immediately after trap deployment, but peak capture rates did not occur at Talkeetna Station until mid-June when peak flows occurred (Figure 7.2-2; Roth and Stratton 1985). In contrast, peak fry capture rates occurred immediately at the time of trap deployment during late-May 1985 and was concurrent with the highest flow of the season (Figure 7.2-3; Roth et al. 1986). Roth and Stratton (1985) concluded that most sockeye salmon fry from the Middle Susitna River emigrated to the Lower Susitna River by mid-September for overwintering, because overwintering habitat in the middle river was limited. Nevertheless, some sockeye salmon fry overwintered in the Middle Susitna River, as evidenced by the capture of Age 1+ juveniles at the Talkeetna Station outmigrant trap (Figure 7.2-4).

The period of outmigration by Age 1+ sockeye salmon was substantially narrower than fry. The cumulative frequency of Age 1+ sockeye salmon juveniles catch at the Talkeetna Station reached 90 percent by the third week of June in 1985 and by the end of June at the Flathorn Station (Roth et al. 1986; Figure 7.2-4). Consequently, outmigrating sockeye salmon Age 1+ smolts were generally in estuarine or nearshore waters by early summer.

7.2.3. Growth

Most sockeye salmon fry emerged at approximately 32 mm in size (Roth and Stratton 1985). Growth of sockeye salmon fry during 1984 and 1985 was similar (Figure 7.2-5), and by the end of September sockeye salmon fry are about 55 to 60 mm in length. Information on the growth of Age 1+ sockeye salmon juveniles was more limited, because most outmigrate during the late spring prior to deployment of outmigrant traps. Roth and Stratton (1985) observed that Age 1+ juveniles captured in the spring were an average of 10 mm longer than fry captured at the end of the open-water season in the previous year. This indicated that some growth occurred during the winter and spring period. Roth et al. (1986) suggested that growth potential for fry that overwintered in the Middle and Lower Susitna River was low compared to fry that rear in lake systems. During 1985 they observed Age 1+ sockeye salmon juveniles captured at the Talkeetna Station were 11 mm in length shorter on average than Age 1+ sockeye salmon juveniles captured at the Flathorn Station (69 mm compared to 80 mm).

7.2.4. Habitat Utilization

7.2.4.1. Open Water Season

Analyses for habitat utilization were more robust for Age 0 fish than for Age 1+ fish due to greater catch of the younger fish. Schmidt and Bingham (1983) did not report on the relative abundance of sockeye salmon juveniles by individual habitat zone (Table 3.1-5). Analysis of sockeye salmon juvenile catch rates within aggregate zones during 1982 by Schmidt and Bingham (1983, Appendix F) indicated that sockeye salmon were more abundant in turbid mainstem water in low velocity backwaters. A major exception to this pattern was Slough 6A in 1983, which had relatively high numbers of sockeye salmon juveniles using clear water low velocity habitat with substantial cover (Dugan et al. 1984). The analysis by Schmidt and Bingham (1983) indicated sockeye salmon juveniles were more commonly found in aggregated mainstem backwater zones (Zones 2, 6, 7, and 8; Table 3.1-6) and low-velocity pools. Analysis of the aggregate hydraulic or water zones, suggested sockeye salmon juveniles demonstrated a strong preference for the mainstem water zone (W-I) over the mixed water (W-III) zone and a substantial preference for the mainstem backwater (H-II) and avoidance for the mainstem mixing zone (H-III) and not mainstem backwater (H-I) zones. Sockeye salmon juveniles were more abundant in slow (V-I) velocity zones as compared to fast (V-II) zones.

Schmidt and Bingham (1983, Appendix G) compared the frequency of juvenile sockeye salmon in five major habitat types using Chi-square analyses and found a significant difference. Sockeye salmon juveniles were frequently found in upland sloughs and side sloughs with large tributaries. A significant difference was found when all salmon juveniles were combined, with a relatively high frequency of salmon juveniles being present in side sloughs with large tributaries and a relatively low frequency of observations in tributary mouths. Schmidt and Bingham (1983) concluded the habitat types had distinctive salmon juvenile communities.

The 1984 field work (Dugan et al. 1984) tended to support the findings from 1983 (Figure 7.2-6 and Figure 7.2-7). Sockeye salmon juveniles had relative high density distribution (46.5 percent) in upland sloughs, followed by side sloughs (44.1 percent), side channels (8.6 percent), and tributaries (0.8 percent). The results of ANOVA tests indicated that macrohabitat type, sampling period, and mean velocity were significant factors affecting juvenile sockeye salmon CPUE. Analysis of microhabitat data indicated that sockeye salmon juveniles use deeper, slower water than the other salmon species; however the authors expressed concern that low sample sizes resulting from the limited distribution of sockeye salmon juveniles in the Middle Susitna River reduced the reliability of these results (Suchanek et al. 1984).

7.2.4.2. Overwintering

Roth and Stratton (1985) concluded that most sockeye salmon fry from the Middle Susitna River emigrated to the Lower Susitna River for overwintering, but a significant number remained and overwintered upstream of Talkeetna. Schmidt and Bingham (1983) concluded that Age 0+ sockeye salmon in the Middle Susitna River primarily used upland sloughs and side sloughs for overwintering and speculated that mainstem or side channel habitats were rarely used. Delaney et al. (1981) conducted surveys during the March and April 1981 that included several sites in the Lower Susitna River, but it was ineffective for sockeye salmon with only one juvenile captured by minnow trap in the mainstem at RM 97.5. Consequently, sockeye salmon overwintering habitat in the Lower Susitna River is yet undetermined.

7.3. Chum Salmon

7.3.1. Life History Patterns

Chum salmon exclusively outmigrated to marine waters as fry. Consequently, life history diversity for chum salmon was derived primarily from maturation and spawning at multiple age classes.

7.3.2. Periodicity

Chum salmon spawning in sloughs of the Middle Susitna River peaked during the last week of August through the third week of September (Jennings 1985; Section 5.3.4). Chum salmon fry periodicity was depicted in Table 7.3-1. The timing of chum salmon fry emergence in the Middle Susitna River is fairly well understood based upon the work by Hoffman et al. (1983) and Wangaard and Burger (1983). Most chum salmon fry emergence in the Middle Susitna River occurred in March and was mostly complete by the end of April (Schmidt et al. 1983, Hoffman et al. 1983), and this was consistent with the size of fry captured in outmigrant traps. Delaney et al. (1981) sampled Slough 11 and Indian River during March and observed 2,000 pre-emergent pink salmon, chum salmon, and sockeye salmon alevins. Additional observations on April 11 indicated nearly all the chum salmon alevins were at the button-up stage. Emerging fry were first captured on March 23, but it was not reported how many were chum salmon fry. Most chum salmon fry appeared to emerge at less than 35 mm in size (Roth and Stratton 1985). Fry were collected at the Talkeetna Station outmigration trap during May 1984 and were thought to have emerged in April (Roth and Stratton 1985). Sampling for outmigrating fish following ice-out seldom occurred prior to mid-May or even early June. Therefore, the early portion of the outmigration season was generally not sampled.

As discussed in Section 6.3.1, all chum salmon outmigrated to the ocean as fry. During 1983 to 1985, incline plan traps were deployed (Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). The following discussion focuses on the results from 1984 and 1985 because both catch rates and cumulative catch were reported. The general pattern of outmigration timing in 1983 was consistent with observations during 1984 and 1985.

Outmigrant trapping began May 14 during 1984 and May 27 during 1985. Outmigration timing of sockeye salmon fry was influenced by flow and turbidity conditions (Hale 1985). Roth et al. (1984) found that chum salmon fry catch rates were similarly affected by flow conditions. During 1984, patterns of outmigration catch rates for chum salmon fry were similar to sockeye salmon fry. Some chum salmon fry were captured immediately after trap deployment, but peak capture rates did not occur at Talkeetna Station until mid-June when peak flows occurred (Figure 7.3-1; Roth and Stratton 1985). Also similar to sockeye salmon fry, peak chum salmon fry capture rates occurred immediately at the time of trap deployment during late-May 1985 and was concurrent with the highest flow of the season (Figure 7.3-2; Roth et al. 1986). Roth et al. (1986) and Roth and Stratton (1985) concluded that about 95 percent of chum salmon fry from the Middle Susitna River emigrated to the Lower Susitna River by mid-July. The pattern of chum salmon fry outmigration was similar at the Flathorn Station, even though catch at this location includes chum salmon production from the Yentna, Deshka, and Talkeetna rivers; most chum salmon fry have emigrated by the end of June and outmigration is essentially complete by mid-July.

Moulton (1997) conducted early marine life history studies in northern Cook Inlet from early June through early September 1993. Chum salmon fry had the second highest catch rate (behind pink salmon) during the June 3-7 sampling period and increased steadily through June. The highest chum salmon catch rate occurred during the July 13-15 sampling period. Unlike Chinook salmon, coho salmon, and sockeye salmon, which passed through relatively quickly, chum salmon fry tended to have a more extended rearing period and were more widely distributed in the northern Cook Inlet area. The results of Moulton (1997) are consistent with the pattern of outmigration by chum salmon fry discerned by the outmigration traps at Flathorn and Talkeetna Stations reported by Roth and Stratton (1985) and Roth et al. (1984).

7.3.3. Growth

Chum salmon fry appeared to emerge at sizes of less than 35 mm (Roth and Stratton 1985). The minimum fry size collected at the Talkeetna Station outmigration trap during May 1984 was 32 mm, but the average size was 40.1 mm, indicating that the fry had emerged in April and experienced growth prior to reaching Talkeetna Station (Roth and Stratton 1985). During 1984, the average size of outmigrating chum salmon was approximately 40 to 45 mm (Figure 7.3-3; Roth and Stratton (1985). Roth et al. (1986) reported a similar average size of outmigrants during 1985. Even during the late May and early June sampling periods of 1984, maximum chum salmon fry sizes ranged as high as 62 mm in May at the Flathorn Station, and 68 mm in early June at the Talkeetna Station. Consequently, some chum salmon fry demonstrated substantial growth prior to or during the outmigration period. The average size of chum salmon fry that entered northern Cook Inlet during early June 1993 was about 43 mm and the size distribution widened over the summer sampling period (Moulton 1997). During the July 13-17 sampling period, the size of chum salmon fry in northern Cook Inlet averaged 57.7 mm with a range of 35 to 75 mm. The change in length frequency was likely due to both early marine growth of chum salmon fry that entered Cook Inlet as smaller fish and the outmigration of larger chum salmon fry that reared and grew for a period within their riverine production areas.

7.3.4. Habitat Utilization

7.3.4.1. Open Water Season

Estes and Schmidt (1983) cautioned that interpretation of habitat utilization data for chum salmon was difficult because it was generally unclear if fry were rearing and feeding in an area or quickly passing through during outmigration. Analyses of chum salmon fry catch rates within aggregate zones by Schmidt and Bingham (1983; Appendix F) and Estes et al. (1983) indicated that sockeye salmon prefer moderately turbid water in low velocity backwaters (aggregate zone H-II, zones 2, 6, and 7; see Table 3.1-5 and Table 3.1-6 for descriptions). Analysis of the aggregate hydraulic or water zones, suggested chum salmon juveniles demonstrated a strong preference for the mainstem backwater zone (H-II) and avoidance for the mainstem mixing zone (H-III) and not mainstem backwater (H-I) zones (Schmidt and Bingham 1983 Appendix F).

Schmidt and Bingham (1983, Appendix G) also compared the frequency of juvenile chum salmon in five major habitat types using Chi-square analyses. The analysis found no significant difference among tributary mouths, upland sloughs, side sloughs with large tributaries, side sloughs without large tributaries, and side channels with large tributaries.

Dugan et al. (1984) observed that chum salmon fry were less evenly distributed among the five major habitat types during 1983 compared to 1982 (Figure 7.3-4 and Figure 7.3-5). Chum salmon juveniles had relatively high density distribution (59.3 percent) in side sloughs, followed by tributary mouths (34.1 percent), mainstem side channels (4.1 percent), and upland sloughs tributaries (2.5 percent). The results of ANOVA tests indicated that macrohabitat type and sampling period were significant factors affecting juvenile chum salmon CPUE ($p<0.10$). Analysis of microhabitat data suggested chum salmon juveniles used relatively shallow, slower water with large substrate; however the authors expressed concern that low sample sizes reduced the reliability of the results for chum salmon fry (Suchanek et al. 1984).

7.4. Coho Salmon

7.4.1. Life History Patterns

In the 1980s, there was what appeared to be a high amount of freshwater life history diversity evident for coho salmon. Scale samples from adult coho salmon collected at fishwheels indicated that nearly all coho salmon exhibited a stream-type life history pattern and that about 50 to 60 percent outmigrated to the ocean after during their third year of life and 30 to 45 percent outmigrate during their second year of life (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986). Consequently, most coho salmon juveniles overwintered in the Susitna River for one or two winters. Plots of the year of life at ocean entry for adults returning in 1983 and 1984 were typical of other years sampled between 1981 and 1985 (Figure 7.4-1). A small and variable percentage of returning adult coho salmon outmigrated during their fourth year of life.

7.4.2. Periodicity

Nearly all coho salmon in the Middle Susitna River spawned in tributaries with peak activity during the last week of July and first week of August (Jennings 1985). Juvenile coho salmon periodicity is depicted in Table 7.4-1; however, there is some uncertainty for the initiation of fry emergence and downstream migration. The timing of coho salmon fry emergence in Susitna River tributaries is poorly understood because of the difficulty of sampling during the spring. Sampling for outmigrating fish following ice-out seldom occurred prior to mid-May and frequently could not begin until early June. Consequently there was little sampling occurring at the time when coho salmon began emerging from the gravel.

Delaney et al. (1981) were unsuccessful at capturing coho salmon fry in Indian River and Portage Creek during 1981 as part of winter sampling. Sampling did not begin until early June during 1982 and coho salmon fry were already present (Schmidt et al. 1983). Schmidt et al. (1983) concluded the surveys conducted during 1981and 1982 would not help in determining the time of coho salmon fry emergence, but suggested the wide range of fry sizes observed indicated emergence occurred over a broad period. Dugan et al. (1984) citing Delaney and Wadman (1979), indicated coho salmon fry in the Little Susitna River emerge from April through June based upon observations of fry near spawning areas.

During 1985, sampling in Portage Creek and Indian River began July 6 and coho salmon fry catch rates peaked in late August (Roth et al. 1986). While the mean length of coho salmon fry captured at the mouth of Indian River increased from 34.7 mm to 53.2 mm from early July to the end of September, the minimum size ranged from 30 mm to 38 mm. Fry captured during the early July period ranged from 30 to 47 mm. Furthermore, the relative small size of some coho salmon fry throughout the summer supported the hypothesis by Schmidt et al. (1983) that there was a protracted period of emergence by coho salmon fry.

As discussed in Section 6.4.1, coho salmon smolts outmigrated to the ocean as Age 1+ and Age 2+ fish. During 1983 to 1985, incline plan traps were deployed to provide information on the timing of smolt migration (Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). The following discussion focuses on the results form 1984 and 1985, because both catch rates and cumulative catch were reported. The general pattern of outmigration timing in 1983 was consistent with observations during 1984 and 1985.

In 1985, coho salmon fry outmigration from tributaries, such as Indian River and Portage Creek, both commenced and peaked in July (Figure 7.4-2; Roth et al. 1986). However, the emigration from the Middle River tributaries was protracted, with some fry emigrating through October. Roth and Stratton (1985) observed a similar pattern during 1984. Upon entering the mainstem Susitna River, coho salmon fry redistributed into sloughs and side channels of the Middle Susitna River or migrated to the Lower Susitna River (Roth and Stratton 1985, Roth et al. 1986; Figure 7.4-3). From 1982 to 1985, outmigrant trapping occurred at Talkeetna Station (RM 103) and Flathorn Station (RM 22.4) during open water periods and demonstrated coho salmon fry were migrating to the Lower Susitna River throughout the time traps were operating (Schmidt et al. 1983, Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). Roth and Stratton (1985) suggested that some coho salmon fry either overwintered in Lower Susitna River between the mouth and Flathorn Station or outmigrated to the ocean as fry. However, based upon the aging of adult coho salmon returns, very few, if any, coho salmon fry survive and return as adults to the river.

Based on the capture of a small number of Age 1+ Coho salmon juveniles in the Indian River during winter sampling (Stratton 1986), some coho salmon fry remain in natal tributaries throughout their first year of life and overwinter in any available suitable habitat. However, of the 472 juveniles captured during the winter of 1985 and 1986 in the Indian River, only 3.8 percent were Age 2+ juveniles (Stratton 1986). Consequently, nearly all coho salmon juveniles emigrate from natal tributaries by the end of their second summer.

Comparison of the pattern in catch rates for coho salmon Age 1+ and 2+ at the Talkeetna and Flathorn Stations showed a different pattern than fry (Figure 7.4-4 and Figure 7.4-5; Roth et al. 1986, Roth and Stratton 1985). During 1985 coho salmon Age 1+ and 2+ passed the Talkeetna Station throughout the summer. In contrast, there was large peak during June at the Flathorn Station and a smaller peak during August. Roth et al. (1986) reported that based upon scale analysis most of the coho salmon juveniles during the June peak were Age 2+ while those in August were Age 1+ fish. The pattern of outmigration appeared substantially different during

1985 with no peak in June. Roth and Stratton (1985) explained that only 44 Age 2+ fish were captured during 1984 so the pattern of catch represents the redistribution of Age 1+ fish only. Roth and Stratton (1985) and Roth et al. (1986) concluded that Age 2+ coho salmon smolts outmigrated during June while Age 1+ coho salmon juveniles redistributed throughout the summer.

7.4.3. Growth

Growth of coho salmon fry during 1984 and 1985 was similar (Figure 7.4-6). The average size of fry captured at the Flathorn Station was about 3 to 8 mm larger than fry captured at the Talkeetna Station and about 10 to 20 mm larger than fry captured at the Indian River during the same time period. From early June to Late September, average fry length increased at all sites. During 1984 and 1985, the differences in Age 1+ coho salmon size at Talkeetna and Flathorn stations appeared less dramatic than for fry. In 1984, mean size of Age 1+ coho salmon juveniles increased about 45 mm at Talkeetna Station and about 26 mm at Flathorn (Roth and Stratton (1985). In contrast, growth was somewhat lower and more variable in 1985 with an increase in average size of about 41 mm at the Talkeetna Station and 7 mm at the Flathorn Station (Roth et al. 1986). Roth et al. (1986) explained that a number of factors contribute to spatial and temporal differences in mean length for fry including emergence timing, habitat quality, and water temperatures. During 1985 Age 2+ coho salmon averaged 132 mm with a range of 109 to 174 mm (Roth et al. 1986).

7.4.4. Habitat Utilization

7.4.4.1. Open Water Season

Analyses for habitat utilization were more robust for Age 0 fish because few Age 1+ fish were captured during the 1982 and 1983 field seasons. Analysis of coho salmon juvenile catch rates during 1982 by Schmidt and Bingham (1983, Appendix F) indicated coho salmon juveniles were more commonly found in tributary zones (Zones 1 and 2, Table 3.1-5) and downstream of a tributary mouth (Zone 5). Coho salmon juveniles were more abundant in clear water areas. When examined using aggregate hydraulic or water zones (Table 3.1-6), coho salmon juveniles were more prevalent in the tributary water zone (W-I) over mainstem water (W-II) and mixed water (W-III) zones and a substantial avoidance for the mainstem mixing zone (H-III) compared to the not mainstem backwater (H-I) and mainstem backwater (H-II) zones. Little difference in fish abundance was seen in fast (V-II) versus slow (V-I) velocity zones.

Schmidt and Bingham (1983, Appendix G) also compared the frequency of juvenile coho salmon in five major habitat types using Chi-square analyses and found significant differences. Coho salmon juveniles were commonly found at side channels with large tributaries (87.5 percent of samples) and side sloughs with large tributaries (68 percent of samples). Coho salmon were captured in upland sloughs during about 48 percent of the sampling events. Coho salmon were rarely observed in tributary mouths or side sloughs without large tributaries (13 percent and 16 percent, respectively).

The 1983 field work (Dugan et al. 1984) partially supported the findings from 1983 (Figure 7.4-8 and Figure 7.4-9). Coho salmon juveniles had relative high density distribution (51 percent) in tributaries, followed by upland sloughs (35.3 percent). Side channels (4.0 percent) and side sloughs (9.8 percent) were infrequently used by coho salmon. The ANOVA tests indicated that macrohabitat type, sampling period, mean depth, and turbidity were significant factors affecting juvenile coho salmon CPUE. The major difference in the results from Dugan et al. (1984) and Schmidt and Bingham (1983) were those regarding the use of tributaries. The results from Dugan et al. (1984) suggested there was relatively high use while those of Schmidt and Bingham (1983) suggested there was relatively little. Although the Chi-square analysis in Schmidt and Bingham (1983, Appendix G) did not result in a statistical association between coho salmon juveniles and tributary mouths, they concluded in the main body of the report that coho salmon juveniles are most abundant in clear water tributaries. It is possible the discrepancy in the results is related to specific tributary habitats. In 1982, Schmidt and Bingham (1983) sampled at three tributary mouths (Indian River, Portage Creek, Fourth of July Creek), while the 1983 study included eleven tributaries and included areas upstream of the tributary mouths.

Dugan et al. (1984) and Schmidt and Bingham (1983) each concluded that Coho salmon juveniles have a preference for areas with clear tributary water sources. They also concluded that tributaries had a high CPUE because they were the source of coho salmon juveniles prior to dispersal into side channels and sloughs. Outmigration of Age 0+ coho salmon juveniles from the tributaries peaked during early July. They suggested that as temperature dropped in September, coho salmon juveniles depart side channels and tributaries to seek side sloughs and upland sloughs that provide over-wintering habitat with upwelling groundwater.

7.4.4.2. Overwintering

Little information was available for over winter habitat use by Susitna River coho salmon. Surveys during the winters of 1980 to 1981 (Delaney et al. 1981) and of 1985 to 1986 (Stratton 1986) provided some information on the winter distribution and habitat characteristics. Delaney et al. (1981) conducted surveys at 87 sites between Alexander Creek (RM 10.1) to Portage Creek (RM 148.8). Approximately one third (29) of the sites were standard habitat locations used for sampling during the open water period. The majority of the sites (53, 61 percent) were in sloughs or tributaries associated with the Middle Susitna River. Sampling effort was variable with monthly sampling events occurring from one to seven times between November and May.

During the study 337 coho salmon juveniles were captured, which is approximately half (48 percent) the number of Chinook salmon juveniles captured during the same period. Coho salmon juveniles were captured at 39 percent of the sites. About half (49 percent) of the catch occurred at sites in the Middle Susitna River. However, the catch was more evenly distributed in the Lower Susitna River with juvenile coho salmon captured at 21 of the 34 sites (62 percent). In contrast, coho salmon juveniles were captured at only 12 of 42 sites (29 percent) in the Middle Susitna River.

Within the Middle Susitna River, coho salmon juveniles were captured at multiple events, including winter sampling events, at Slough 8A, Slough 10, Slough 11, and Slough 20. Although it was only sampled once, Slough 6A had the highest catch rate of 8 Age 1+ fish per trap-day. Whiskers Creek was sampled twice; no coho salmon juveniles were captured there in February while a relatively high catch rate of 1.7 Age 1+ and 0.7 Age 2+ coho salmon fry per trap-day occurred in March. In the Lower Susitna River, coho salmon juveniles were captured during multiple sampling events at Rustic Wilderness, Sunshine Creek, Montana Creek, and the mouth of Birch Creek.

Stratton (1986) studied overwinter habitat use by coho salmon at four locations (Indian River, Slough 9A, Slough 10, and Slough 22) from October 1985 to April 1986. Fish were captured using minnow traps and a portion cold branded with a mark unique to the time period and location of sampling, then released at the capture site. Relatively few coho salmon (472 fish) were captured compared to Chinook salmon (11,543 fish). This led Stratton (1986) to conclude that most Age 2+ coho salmon overwintered in the Lower Susitna River. Marks were applied to 393 coho salmon and 7.6 percent were recaptured. All but one recaptured coho salmon were located in the same site as where they were marked. Relative to Chinook salmon, coho salmon juveniles more abundant in deeper and slower velocity habitat with cover consisting of debris, vegetation, and undercut banks. Stratton (1986) also noted that beaver complexes were excellent overwintering habitat for coho salmon juveniles.

Bigler and Lefesque (1985) captured coho salmon juveniles using fyke nets at Trapper Side Channel (RM 92.7; April 15 through May 28), Sunset Side Channel (RM 86.9; May 25 through May 27), Circular Side Channel (RM 75.3; April 30 through May 24) and Birch Creek Side Channel (RM 88.6; April 30 through May 2) and suggested that these side channels in the Lower Susitna River were being utilized as overwintering habitat.

7.5. Pink Salmon

7.5.1. Life History Patterns

Pink salmon outmigrate to marine waters as fry and mature as two year old fish. Consequently, life history diversity for pink salmon is low compared to the other salmon species.

7.5.2. Periodicity

Pink salmon spawning occurred primarily in tributaries to the Susitna River and occasionally in sloughs. Spawning generally occurred from the last week of July through the first week of September and peaked during the first two weeks of August (Jennings 1985; Section 5.5.3). Pink salmon fry periodicity is depicted in Table 7.5-1; however, there is some uncertainty for the initiation of fry emergence and downstream migration. The timing of pink salmon fry emergence in the Middle Susitna River is poorly understood. Delaney et al. (1981) sampled Slough 11 and Indian River during March and observed 2,000 pre-emergent pink salmon, chum salmon, and sockeye salmon alevins. Additional observations on April 11 indicated about 50 percent of the pink salmon alevins were at the button-up stage. Emerging fry were first captured on March 23 and most were pink salmon fry.

Based upon the observations by Delaney et al. (1981) and inference from outmigration traps, most pink salmon fry emergence in the Middle River occurred in March and was mostly complete by the end of April. Most pink salmon fry appeared to emerge at about 35 mm in size (Roth and Stratton 1985). The minimum pink salmon fry size collected at the Talkeetna Station outmigration trap during May 1984 was 29 mm, but the average size was 36 mm, suggesting that most of the fry had emerged in April (Roth and Stratton 1985). Sampling for outmigrating fish following ice-out seldom occurred prior to mid-May or even early June. Therefore, part of the outmigration season was not sampled.

As discussed in Section 6.5.1, all pink salmon outmigrate to the ocean as fry. During 1983 to 1985, incline plan traps were deployed to produce information on the timing of smolt migration

(Roth et al. 1984, Roth and Stratton 1985, Roth et al. 1986). The following discussion focuses on the results from 1984 and 1985, because both catch rates and cumulative catch were reported. The general pattern of outmigration timing in 1983 was consistent with observations during 1984 and 1985.

Outmigrant trapping began May 14 during 1984 and May 27 during 1985. Pink salmon were present in the catch immediately following deployment in both years. Peak capture rates did not occur at Talkeetna Station until mid-June when peak flows occurred (Figure 7.5-1; Roth and Stratton 1985). In 1985, peak pink salmon fry capture rates occurred in early June, which was concurrent with the highest flow of the season (Figure 7.5-2; Roth et al. 1986). Roth et al. (1986) and Roth and Stratton (1985) concluded that about 95 percent of pink salmon fry from the Middle Susitna River emigrated to the Lower Susitna River by mid-July. The pattern of pink salmon fry outmigration was similar at the Flathorn Station and included pink salmon production from the Yentna, Deshka, and Talkeetna rivers; most pink salmon fry had emigrated by the end of June, and outmigration was essentially complete by mid-July.

Moulton (1997) conducted early marine life history studies in northern Cook Inlet from early June through early September 1993. Pink salmon fry captures were greatest in mid-June and then declined. Similar to Chinook salmon, coho salmon, and sockeye salmon, pink salmon fry tended to move out of the area quickly during June. However, during July pink salmon fry demonstrated some growth, indicating that many were remaining in the area to rear. These results were consistent with the pattern of outmigration reported by Roth and Stratton (1985) and Roth et al. (1984).

7.5.3. Growth

Most pink salmon fry appeared to emerge at about 35 mm in size (Roth and Stratton 1985). The average size of pink salmon fry collected at the Talkeetna Station outmigration trap during 1984 was 36 mm with a range of 29 to 53 mm (Roth and Stratton 1985). This was similar to the size of pink salmon fry collected at the Flathorn Station, which had mean size of 34 mm and range of 25 to 46 mm. Sizes were similar during 1985, with an average pink salmon fry length of 37 mm and a maximum size of 48 mm (Roth et al. 1986). The average size of pink salmon fry entering northern Cook Inlet during early June 1993 was 35.9 mm (Moulton 1997), which indicates that pink salmon fry did not grow a substantial amount in the Susitna River prior to outmigration into nearshore marine waters.

7.5.4. Habitat Utilization

7.5.4.1. Open Water Season

Studies conducted during the 1980s provided no information on habitat use by pink salmon fry during the spring outmigration. Based upon the size of fry collected from outmigration traps (Roth ad Stratton 1985, Roth et al. 1986) and the size of fry collected in northern Cook Inlet (Moulton 1993), pink salmon outmigrated from the Susitna River shortly after emergence with little use of rearing habitat. Schmidt and Bingham (1983) suggested that turbidity may have been an important factor during the pink salmon outmigration, because it could provide protection from visual predators such as other fish and birds.

7.6. Juvenile Salmon Diet

Riis and Friese (1978) examined the stomach contents of 377 Chinook salmon, 53 sockeye salmon, and 62 coho salmon juveniles collected from 25 mainstem Susitna locations in the lower and middle river plus several tributary streams (Whiskers Creek, Fourth of July Creek, Chase Creek, McKenzie Creek. Adult aquatic insects accounted for the highest proportion by volume of food items for Chinook salmon and coho salmon juveniles during the summer and fall (Figure 7.6-1). In contrast, immature insects (primarily diptera larvae) were the highest proportion for sockeye salmon during the summer, but adult life stages represented the highest volume during the fall. Cladocera were also part of the sockeye salmon diet at three of the sloughs sampled. Stomach contents volumes or proportions were not reported by taxon; however, table notes suggested that adult diptera were the predominant adult life stage found within the adult insect category.

Schmidt et al. (1983) investigated the stomach contents of 313 Chinook salmon, 171 coho salmon, and 116 sockeye salmon juveniles collected from four sloughs (Sloughs 8A, 11, 20, and 21) and two tributary streams (Fourth of July Creek, and Indian River). Data was reported by prey item taxon and summarized for each salmon species, site, and date. Diptera larvae, pupae, and adults were the most frequently consumed food items, but emphemeroptera (mayflies) and plecoptera (stoneflies) were also represented in the diets. Terrestrial insects were also commonly found and represented up to 29 percent of the items consumed. Similar to Riis and Fiese (1978), sockeye salmon were found to consume copepods and cladocerans in some locations. Schmidt et al. (1983) calculated electivity indices that proportionally compared prey species in stomach contents to drift net collections and benthic samples. The results indicated Chinook salmon, coho salmon, and sockeye salmon juveniles had been selecting for chironomidae larvae.

Hansen and Richards (1985) examined 72 juvenile Chinook salmon stomachs for food content. Chinook salmon food items were derived from eleven insect orders and one non-insect order. On a numerical basis larval diptera were the most frequently consumed food item (46 percent) and burrowers were the frequently consumed guild (87 percent; Figure 7.6-2). Although dipteran flies were the most frequently consumed prey item, they are also relatively small. Hansen and Richards (1985) suggested that plecopterans and ephemeropterans were likely more important to the diet of juvenile Chinook salmon than dipteran flies because they are on the order of ten times larger than dipterans.

8. NON-SALMONIDS AND RESIDENT FISHES

During 1981 and 1982 Su-Hydro Aquatic Studies, surveys were conducted to better understand the distribution and relative abundance of resident fish and the anadromous non-salmonids in the Upper, Middle, and Lower Susitna River (Delaney et al. 1981, Delaney et al. 1981b, Sautner and Stratton 1983, Schmidt et al. 1983). During 1983 and 1984, ADF&G monitored changes in the fish community and movement of floy-tagged fish at thirteen index sites, estimated population sizes at five sites, and conducted radio-tracking on rainbow trout and burbot (Sundet and Wenger 1984, Sundet and Pechek 1985). A winter study was conducted during 1984 – 1985 that focused primarily on the radio-tracking of rainbow trout, burbot, and Artic grayling. During 1982 and 1983, the AA component to the Su-Hydro Aquatic studies conducted surveys for spawning eulachon and Bering cisco (*Coregonus laurettae*)in the Lower Susitna River and examined the characteristics of eulachon spawning habitat (ADF&G 1982c, ADF&G 1984, Vincent-Lang and Queral 1984).

8.1. Fish Assemblage

Historically, the Susitna River basin included at least 20 species of fish (Table 8.1-1). With the exception of northern pike, all fish are considered native to the basin. The diversity of the fish community was highest in the Lower Susitna River and declined in an upstream direction. A large decline in diversity occurred at Devils Canyon because of insurmountable rapids.

Data reported in Schmidt et al. (1983) provides a representative depiction of the resident fish community at 17 DFH locations (Table 3.1-4) within the Middle and Lower Susitna River segments. During 1982 sampling generally occurred twice per month (bi-weekly) at each DFH site during the open water season from June through September (Table 8.1-2). Sampling methods included beach seines, minnow traps, trot lines, backpack electrofishing, boat electrofishing, set gillnets, hook and line, unspecified fish traps, hoop nets, and dip nets. Sampling also occurred at some sites during late-May, early October, and during winter. Sampling for resident fish also occurred in 1981, 1983, 1984, and winter 1984/1985, but only summary data is available for 1983 to1985 surveys (Schmidt et al. 1984, Schmidt et al. 1985, Sundet 1986). Catch per unit effort data is available for 44 sites surveyed during 1981 (Delaney et al. 1982), but with the exception for minnow traps and trot lines, sampling was less systematic than conducted during 1982 at the DFH sites. Furthermore, actual catch and effort data were not reported for 1981 surveys only catch per unit effort for sites with catch greater than zero during one or more sampling periods. Despite the differences in survey site locations, level of effort among the gear types, and level of reporting detail, summary information from Delaney et al. (1984), Schmidt et al. (1984), and Schmidt et al. (1985) support the conclusion that 1982 surveys were representative of the general distribution and relative abundance of resident fish species in the Susitna River mainstem during the early 1980s.

8.2. Distribution, Abundance, and Habitat Utilization

8.2.1. Susitna River Downstream of Devils Canyon

Jennings (1985) provided a concise summarization of the distribution of resident fish in the Middle Susitna River. Portions of the text in Sections 7.2.1.1 through 7.2.1.15 are quotes taken from that report with minor corrections to some citations.

Eulachon are an important forage species for beluga whale. Distribution, life history characteristics, and habitat utilization information on eulachon are summarized in the beluga whale technical memorandum (HDR 2012A). Consequently, information on eulachon will only be briefly discussed below.

8.2.1.1. Rainbow Trout

Jennings (1985) provided the following summarization of rainbow trout distribution and abundance in the middle Susitna River segment.

> *"Rainbow trout occur throughout the Susitna Basin below Devil Canyon (Schmidt et al. 1983). Upstream from Talkeetna, they mainly use tributaries for spawning*

and rearing, while overwintering occurs primarily in the mainstem (Schmidt et al. 1984).

Upstream of the Chulitna River confluence (RM 98.6), rainbow trout move into tributaries to spawn in late May and early June (Schmidt et al. 1984). Whiskers Creek (RM 104.4), Lane Creek (RM 113.6) and Fourth of July Creek (RM 131.1) are the major spawning areas in this river reach, whereas the larger tributaries (Indian River and Portage Creek) are of lesser importance (Schmidt et al. 1984). Both sexes mature by Age 5+ (Schmidt et al. 1984).

There is a post-spawning movement from spawning areas to feeding areas (Schmidt et al. 1984). These feeding areas may be located in the same tributaries in which spawning occurred, or in other tributaries and at tributary mouths (Schmidt et al. 1983, Schmidt et al. 1984). During August and September rainbow trout can be found in sloughs and at tributary mouths that are occupied by adult salmon (Schmidt et al. 1983, Schmidt et al. 1984). It is suspected that rainbow trout feed on salmon eggs at these sites (Schmidt et al. 1984).

Juvenile rainbow trout rear mainly in tributaries (Schmidt et al. 1983, Schmidt et al. 1984). Some juveniles also rear in the mainstem and sloughs, but the use of these habitats appears to be limited (ADF&G 1983b, Schmidt et al. 1984). Fourth of July Creek (RM 131.1) is an important rearing area for juvenile rainbow trout (Schmidt et al. 1984).

In the fall, rainbow trout move out of tributaries into the mainstem to overwinter (Schmidt et al. 1983, Schmidt et al. 1984). By early December in 1983, most radio-tagged rainbow trout were located in mainstem areas that were not influenced by tributary inflow (Schmidt et al. 1984).

Based on recaptures from three years of tagging (1981-1983), the population size of rainbow trout in the Talkeetna-to-Devil Canyon reach was estimated to be about 4,000 fish (greater than 150 mm in length; Schmidt et al. 1984). This estimate should be viewed as an approximation because it does not account for annual recruitment, mortality or emigration (Schmidt et al.1984).”

During 1982, rainbow trout were widely distributed at the 17 DFH sites (Figure 8.2-1). Rainbow trout were captured at all DFH sites except Whitefish Slough. Rainbow trout catch was frequently higher and more consistent at DFH sites associated with tributary streams (Lane Creek and Slough 8, 4th of July Creek, Whiskers Creek and Slough) and clearwater sloughs (e.g., Slough 6A and Slough 8A). Boat electrofishing and trotlines were the most effective capture methods, accounting for 43.4 percent and 33.2 percent of the 205 rainbow trout captured, respectively. However, rainbow trout were captured by a wide variety of gear types.

8.2.1.2. Arctic Grayling

Jennings (1985) provided the following summarization of rainbow trout distribution and abundance in the middle Susitna River segment.

“Arctic grayling are found throughout the Susitna Basin (Schmidt et al. 1983). In the Ta1keetna-to-Devil Canyon reach, Arctic grayling primarily use mainstem habitats for overwintering and tributaries for spawning and rearing (Schmidt et

al. 1983, Schmidt et al. 1984).Upstream of Talkeetna, Arctic grayling move into tributaries to spawn in May and early June (Schmidt et al. 1983, Schmidt et al. 1984).High catches occurred in Whiskers Creek Slough (RM 101.2), Lane Creek (RM 113.6), Fourth of July Creek (RM 131.1), Indian River (RM 138.6), Jack Long Creek (RM 144.5) and Portage Creek (RM 148.8) in 1982 and 1983 (Schmidt et al. 1984). Although these tributaries have not been identified as spawning areas, they are likely candidates. Spawning may also occur in the mainstem. In 1983, it was suspected that spawning occurred at or near RM 150.1 (Schmidt et al. 1984). After spawning, most adults and juveniles remain in tributaries or move to tributary and slough mouths until early September (Schmidt et al. 1983, Schmidt et al. 1984). Some juvenile fish rear in mainstem areas (Schmidt et al. 1983, Schmidt et a1. 1984). These juveniles may be displaced from tributary habitat by the territorial behavior of older, larger fish (Schmidt et al. 1983, Schmidt et al. 1984). During September, Arctic qray1ing move into the mainstem from tributaries (Schmidt et al. 1983, Schmidt et al. 1984). It is suspected that this movement to the mainstem is for overwintering, however specific areas have not been identified (Schmidt et al.1984). Some fish may use the larger, deeper pools in Portage Creek for overwintering (Schmidt et al. 1984)."

During 1982, Arctic grayling were captured at 15 of the 17 DFH sites (Figure 8.2-2). Arctic grayling catch was highest at tributary mouths of Indian River, Portage Creek, 4th of July Creek, and Whiskers Creek and Slough. Boat electrofishing and backpack electrofishing were the most effective capture methods, accounting for 70.6 percent and 13.7 percent of the 520 Arctic grayling captured, respectively. Arctic grayling were captured by a wide variety of gear types.

8.2.1.3. Burbot

Jennings (1985) provided the following summarization of burbot distribution and abundance in the middle Susitna River segment.

"Burbot occur throughout the Susitna River basin (Delaney 1981a, Schmidt et al. 1983). Burbot appear to be more abundant downstream from the Chulitna River confluence (RM 98.6; Schmidt et at. 1984). Burbot are associated almost exclusively with the mainstem and mainstem-influenced areas.

Burbot apparently move to spawning areas in the winter and then disperse to feeding areas after spawning is completed (Schmidt et al. 1983, Schmidt et al. 1984). Other than these migrations, burbot are generally sedentary (Schmidt et al. 1983). Burbot spawning takes place from mid-January to early February in mainstem-influenced areas (Schmidt et al. 1983, Schmidt et al. 1984). Tributary and slough mouths are thought to be important areas of spawning, as are mainstem areas with groundwater upwelling (Schmidt et al. 1983, Schmidt et al. 1984). Spawning areas have not been located in the Talkeetna-to-Devil Canyon reach (Schmidt et al. 1984). Downstream of Talkeetna, the mouth of the Deshka River (RM 40.5) is a known spawning area (Schmidt et al. 1983).

> *Due to the limited catch data, juvenile rearing areas are unknown. It is suspected that juvenile burbot rear in the mainstem, tributary and slough mouths, and clearwater sloughs (Delaney 1981a, 1983b).*
>
> *In 1983, 15 burbot were estimated to occur between RM 138.9 and140.1 (Schmidt et al. 1984). This population estimate should be viewed as an approximation because few fish were caught during this study (Schmidt et al. 1984). However, it appears that the burbot population size in the middle Susitna River is low."*

During 1982 relatively low numbers of burbot were captured at all 17 DFH sites in the Lower and Middle Susitna River (Figure 8.2-3; Schmidt et al. 1983). Most burbot (69.3 percent of 155 fish) were captured by trotline. However, 18 burbot were captured from three hauls of a beach seine at Slough 9 during late June 1982, which was the maximum burbot catch at any site and period (Figure 8.2-3). CPUE for burbot captured by trotline at the DFH sites averaged 0.4 fish per trotline- day and the maximum for individual sites/periods was 2.7 fish per trotline-day (Figure 8.2-4).

8.2.1.4. Round Whitefish

Jennings (1985) provided the following summarization of round whitefish distribution and abundance in the middle Susitna River segment.

> *"Round whitefish occur throughout the Susitna River drainage (Delaney et al. 1981a). Downstream from Devil Canyon, they appear to be more abundant in the middle river reach (Schmidt et al. 1983). Within this reach, round whitefish are most numerous between RM 132.6 and 150.1 (Schmidt et al. 1984). Round whitefish were found in tributaries and sloughs more often than mainstem areas in 1982 and 1983 (Schmidt et al.1984). The mainstem is used for some spawning and juvenile rearing, and as a migrational corridor. During September, there is an upstream migration of round whitefish that is thought to be associated with spawning (Schmidt et al. 1983). This species spawns in the mainstem and at tributary mouths in October (Schmidt et al. 1983, Schmidt et al. 1984). During 1981 through 1983, nine spawning areas were identified upstream of Talkeetna. Mainstem sites were: RM 100.8, 102.0, 102.6, 114.0, 142.0 and 147.0 (Schmidt et al. 1984). Round white fish may also spawn in tributaries, such as Indian River and Portage Creek (Schmidt et al. 1984). Juvenile round whitefish rear mainly in the mainstem and sloughs (Schmidt et al. 1983, Schmidt et al. 1984). Slow velocities and turbid water are apparently preferred (Schmidt et al.1984). Overwintering areas of round whitefish have not been identified (Schmidt et al. 1983)."*

During the 1982 surveys, round whitefish were captured at all sites by a variety of gear types (Figure 8.2-5). Round whitefish catch was highest mouths of Portage Creek, Indian Creek, 4th of July Creek, and at Slough 9. Boat electrofishing and beach seines were the most effective capture methods and accounted for 59.7 percent and 27.8 percent of the 890 round whitefish captured, respectively.

8.2.1.5. Humpback Whitefish

Jennings (1985) provided the following summarization of round whitefish distribution and abundance in the middle Susitna River segment.

> *"Humpback whitefish are found downstream of Devil Canyon between RM 10.1 and 150.1 (Schmidt et al. 1984). They appear to be more abundant downstream from the Chulitna River confluence (RM 98.6; Schmidt et al. 1984). In the Talkeetna-to-Devil Canyon reach, tributary and slough mouths are used by adults most frequently, with the mainstem serving mainly as a migrational corridor (Schmidt et al. 1983, Schmidt et a1. 1984). Due to low catches of humpback whitefish, little is known of their overwintering, spawning and juvenile rearing areas (ADF&G 1983b, Schmidt et al. 1984). It is suspected that they spawn in tributaries during October (Schmidt et al. 1984)."*

During the 1982 surveys, humpback whitefish were captured at 12 of the 17 DFH sites in low numbers (Figure 8.2-6). Humpback whitefish catch was highest at the mouth of Portage Creek and at Sunshine Creek and Side Channel (12 fish each). Boat electrofishing was the most effective capture methods and accounted for 96.1 percent of the 52 humpback whitefish captured.

8.2.1.6. Longnose Sucker

Jennings (1985) provided the following summarization of longnose sucker distribution and abundance in the middle Susitna River segment.

> *"Longnose suckers occur throughout the Susitna Basin (Schmidt et al. 1984, Sautner and Stratton 1984). They appear to be more abundant downstream of the Chulitna River confluence (RM 98.6; Schmidt et al. 1984). In the Talkeetna-to-Devil Canyon reach (RM 98.6-152), longnose suckers are primarily associated with tributary and slough mouths, although the mainstem is also used throughout the open-water season (Schmidt et al. 1983, Schmidt et al.1984). The major overwintering and juvenile rearing areas of this species are unknown (Schmidt et al. 1983). The mouths of Trapper Creek (RM 91.5) and Sunshine Creek and side channel (RM 85.7) are known spawning areas (Schmidt et al. 1983)."*

During the 1982 surveys, longnose suckers were captured at all sites by a variety of gear types (Figure 8.2-7). Longnose sucker catch was highest at Rabideaux Creek and Slough (68 fish), Whiskers Creek and Slough (56 fish), Sunshine Creek and Side Channel (55 fish), and Slough 8A (51 fish). Boat electrofishing and beach seines were the most effective capture methods and accounted for 74.3 percent and 12.3 percent of the 447 longnose suckers captured, respectively.

8.2.1.7. Dolly Varden

Jennings (1985) provided the following summarization of Dolly Varden distribution and abundance in the middle Susitna River segment.

> *"Dolly Varden occur throughout the Susitna Basin (Schmidt et al.1984). In the Talkeetna-to-Devi1 Canyon reach, Dolly Varden are found primarily in the upper reaches of tributaries and at tributary mouths (Schmidt et al. 1983, Schmidt et al.*

> *1984). They apparently use the mainstem for overwintering (Schmidt et al.1984). Spawning and juvenile rearing areas are suspected to be in tributaries (Schmidt et al. 1983). The population size of Dolly Varden in the Talkeetna-to-Devil Canyon reach appears to be low and they are apparently more abundant downstream from the Chulitna River confluence (RM 98.6; Schmidt et al. 1984)."*

During the 1982 surveys, Dolly Varden were captured in low numbers at nine of the 17 DFH sites by a variety of gear types (Figure 8.2-8). Dolly Varden catch was highest at Lane Creek and Slough 8 (8 fish). Boat electrofishing and trotlines were the most effective capture methods and accounted for 40.0 percent and 36.0 percent of the 25 Dolly Varden captured, respectively.

8.2.1.8. Arctic Lamprey

Jennings (1985) provided the following summarization of Arctic lamprey distribution and abundance in the middle Susitna River segment.

> *"Arctic lamprey have been found in the: Susitna River as far upstream as Gash Creek (RM 111.5), however they are more abundant downstream of RM 50.5 (Schmidt 1983, Schmidt et al.1984). Most fish have been found in tributaries and tributary mouths (Schmidt et al. 1983, Schmidt et al. 1984)."*

Arctic lamprey were captured at three DFH sites during 1982: Birch Creek and Slough (31 fish), Sunshine Creek and Side Channel (1 fish), and Whiskers Creek and Slough (3 fish). Capture occurred by backpack electrofishing (30 fish) and minnow traps (5 fish).

8.2.1.9. Threespine Stickleback

Jennings (1985) provided the following summarization of threespine stickleback (*Gasterosteus aculeatus*) distribution and abundance in the middle Susitna River segment.

> *"Threespine stickleback have been caught: in the Susitna River as far upstream as RM 146.9, but they are more abundant downstream of the Chulitna River confluence (RM 98.6; Schmidt et al. 1983, Schmidt et al. 1984). Spawning and juvenile rearing apparently occur in tributary and slough mouths (Schmidt et al. 1983). Over-wintering areas of this species are unknown (Schmidt et al. 1983)."*

During 1982, threespine sticklebacks were captured at the six DFH sites from Goose Creek 2 and Side Channel to Whiskers Creek and Slough by a variety of methods (Figure 8.2-9). Beach seines and minnow traps were the most effective capture methods with each accounted for 41.9 percent of the 210 threespine sticklebacks captured, respectively. However, most of the beach seine catch, 52 of 88 fish, came from a single haul at Whitefish Slough during early August.

8.2.1.10. Bering Cisco

Jennings (1985) provided the following summarization of Bering cisco distribution and abundance in the middle Susitna River segment.

> *"Bering cisco occur mainly downstream of the Chulitna River confluence (RM 98.6) in the Susitna River (Barrett et al.1984). In 1981 and 1982, the major spawning areas for this species were in the mainstem between PM 75 and 85*

> *(Barrett et al. 1984). In 1982, most spawning fish were Age 5 that had gone to the ocean for rearing in their first summer (ADF&G 1982c)."*

Information gathered on Bering cisco during the 1980s was focused on identification of spawning areas and periodicity. Bering cisco were not captured at any of the DFH sites surveyed during 1982 (Schmidt et al. 1983). Barrett et al. (1983) reported the capture of Bering cisco at fishwheels located at Susitna Station (RM 26; 42 fish), Yentna Station (RM 30.1, TRM 4.0; 4 fish), and Sunshine Station (RM 80; 165 fish). Catch of Bering Cisco at Sunshine Station began in late-August and peak in late-September, just prior to demobilizing the fishwheels (Figure 8.2-10). During 1982 spawning ripe females were observed beginning October 2 and through the end of surveys on October 13. Spawning locations were identified at a shoal between RM 76.8 to 77.6 and near RM 81.2. Barrett et al. (1983) reported that no Bering cisco spawning was observed at any of the 397 main channel sites surveyed between RM 98.5 and RM 150. In addition, only one Bering cisco was captured upstream of the Three Rivers confluence at RM 101.9.

8.2.1.11. Eulachon

Jennings (1985) provided the following summarization of Bering cisco distribution and abundance in the middle Susitna River segment.

> *"Eulachon occur in the Susitna River as far upstream as RM 50.5, but are more abundant downstream of RM 29 (Barrett et al.1984). Because eulachon are not found in the middle reach of the Susitna River, they are not discussed in great detail. Information on preferred habitat and life history information can be found in reports by Barrett et al. (1984) and Vincent-Lang and Queral (1984). Eulachon enter the Susitna River in two runs (Barrett et al. 1984). The first run enters the river during the last two weeks of May, while the second run follows during the first two weeks of June (Barrett et al.1984). Fish from both runs spawn in the mainstem (Barrett et al. 1984). The first-run population size is likely several hundred thousand fish, while the second run is probably several million fish (Barrett et al. 1984). In 1982, most returning adults were Age 3 that had gone to the ocean for rearing in their first summer (ADF&G 1982c)."*

Similar to Bering cisco, information gathered on eulachon during the 1980s was focused on identification of spawning areas and periodicity. Eulachon were not captured at any of the DFH sites surveyed during 1982 (Schmidt et al. 1983). Barrett et al. (1983) captured eulachon in the estuary on May 16, 1982, which was the first ice-free day of the year. Based upon the gillnet catch rates, Barrett et al. (1983) concluded that eulachon enter the river in two runs. Surveys during 1983 confirmed this pattern of entry into the Susitna River (Figure 8.2-11). Barrett et al. (1984) concluded that eulachon migrate up to about 50 miles in the Susitna River, but spawning occurs within 29 miles. In addition, Barrett et al. (1984) concluded that spawning begins within about five days of entering the river.

Vincent-Lang and Queral (1984) investigated spawning habitat characteristics for eulachon, particularly for water depth, velocity, and substrate. They concluded that eulachon spawn in turbid water along shoreline margins over a broad range of these parameters (Figure 8.2-12). While gravel/rubble was the most commonly used spawning substrate, they also observed spawning in areas that were 100 percent silt and others that were a mix of silty sand mixed with gravel and rubble. Water temperatures during spawning ranged from 6.2°C to 11.2°C and averaged 8.5°C during 1982 and 8.3°C during 1983 (Vincent-Lang and Queral (1984).

Additional details on the distribution, life history characteristics, and habitat utilization of eulachon are summarized in the beluga whale technical memorandum (HDR 2012a).

8.2.1.12. Sculpin

Jennings (1985) provided the following summarization of sculpin distribution and abundance in the middle Susitna River segment.

> *"Slimy sculpin occur throughout the Susitna River drainage (Delaney et al. 1981c, Schmidt et al. 1983). They are most abundant in tributaries and tributary mouths, although the mainstem is also used (Schmidt et al. 1983). Sculpin in the Susitna River are sedentary with spawning, juvenile rearing and adult movements confined to a limited area (Schmidt et al. 1983). In addition to slimy sculpin, other species of sculpin may occur in the lower Susitna River (Delaney et al. 1981a)."*

During 1982, slimy sculpin were captured at all 17 DFH sites using a variety of gear (Figure 8.2-13). Catch was highest at Whiskers Creek and Slough (107 fish), Birch Creek and Slough (81 fish), Lane Creek and Slough (59 fish), and Sunshine Creek and Slough (56 fish). Backpack electrofishing and beach seines were the most successful capture methods that accounted for 43.3 percent and 29.1 percent of the 533 slimy sculpin captured, respectively.

8.2.1.13. Lake Trout

Jennings (1985) provided the following summarization of lake trout (*Salvelinus namaycush*) distribution and abundance in the middle Susitna River segment.

> *"Lake trout occur throughout the Susitna Basin primarily in larger, deeper lakes. Occasionally they can be found in the inlet or outlet streams of these lakes. Lake trout have not been captured in the mainstem-influenced areas of the Susitna River below Devil Canyon (Delaney et al. 1981c, Schmidt et al. 1983; Schmidt et al.1984)." Northern Pike*

Please see Section 8.4, Invasive Fish Species.

8.2.1.14. Ninespine stickleback

Jennings (1985) provided the following summarization of ninespine stickleback (*Pungitius pungitius*) distribution and abundance in the middle Susitna River segment.

> *"Ninespine stickleback are apparently rare in the Susitna River. This species has been captured in the vicinity of the Deshka River (RM 40.5; ADF&G Su Hydro, unpublished data)."*

8.2.2. Susitna River Upstream of Devils Canyon

Surveys were conducted in the Susitna River and tributaries upstream of Devils Canyon during 1981 and 1982 (Delaney et al. 1981c, Sautner and Stratton 1983). During 1981, eight tributary streams were selected for surveys: Fog Creek (173.9), Tsusena Creek (RM 178.9), Deadman Creek (RM 183.4), Watana Creek (RM 190.4), Kosina Creek (RM 202.4), Jay Creek (RM 203.9), Goose Creek (RM 224.9), and Oshetna River (RM 226.9; Delaney et al. 1981c). Each tributary was surveyed for fish in up to 5 segments (0 to 500, 1000 to 1500, 2000 to 2500, 2500 to 3000, 4000 to 4500). The lowermost sites included sampling immediately upstream and downstream of the tributary confluence in the mainstem river. In some tributaries additional sites were sampled up to the anticipated elevation of the impoundment. Sites were sampled monthly during the open water period using hook and line, minnow traps, trotlines, beach seines, backpack electrofishing, and variable mesh gillnets. Not all collection methods were used at each site. Detailed results were reported for Arctic grayling, burbot, round whitefish, longnose sucker, sculpin, and lake trout. In addition to these species one humpback whitefish (347 mm fork length) was captured at the mouth of Kosina Creek and one Dolly Varden (235 mm) was captured at the mouth of Fog Creek.

The 1982 study was focused on: 1) measuring tributary habitat and water quality characteristics within and upstream of the proposed inundation zone; and 2) collecting additional biological information on Arctic grayling, lake trout, and fish communities at seven mainstem slough areas. These areas included: Site No. 1 (RM 191.5), Site No. 2 (RM 191.5), Watana Creek Slough (RM 194.1), Site No. 3 (RM 197.8), Site No. 3A (RM 201.6), Site No, 4 (RM 201.2), and Site No. 5 (Lower Jay Creek Slough, RM 208.1; Sautner and Stratton 1983) and Sally Lake.

8.2.2.1. Arctic Grayling

Arctic grayling is one of the most abundant fish in Upper Susitna River tributaries. Delaney et al. (1981c) reported the capture of 3,313 Arctic grayling during 1981, and Sautner and Stratton (1983) reported the capture of 4,367 Arctic grayling during 1982. Hook and line was a very successful capture method in tributary streams during 1981 and 1982 with a median catch rate of 6.0 fish per hour and a maximum rate of 23.2 fish per hour.

During 1981, catch rates by anglers were highest for Kosina and Jay creeks (Figure 8.2-14). Angler catch rates increased from May (6.1 fish per hour) to July (8.1 fish per hour) and then declined in August (4.5 fish per hour) and September (4.0 fish per hour). A Chi-square analysis on the number of fish captured by angling indicated there were significant differences in catch between the tributaries.

For many sites and sampling periods, hook and line catch rates were somewhat higher in 1982 compared to 1981. During 1982, hook and line catch rates were highest for the Oshetna River (11.1 fish per hour) and Kosina Creek (10.4 fish per hour; Figure 8.2-14). Catch rates were highest in July (12.8 fish per hour) and August (13.4 fish per hour).

Observations of spent Arctic grayling with frayed fins during late May and early June suggested that most spawning had already been completed; however two ripe males were collected on May 22 (Delaney et al. 1981c). Based upon this information and experience from other areas, Delaney et al. (1981c) suggested that Arctic grayling spawning likely occurs during late-April to mid-May. Arctic grayling fry and Age 1+ were observed in the slough near Jay Creek. Fry were 20 to 22 mm in June, 24 to 45 mm in July, and 47 to 60 mm in September. Age 1 Arctic grayling were 54 mm in May, 75 to 95 mm in June, and 84 to 98 mm in July.

In 1981, floy tags were attached to 2,511 Arctic grayling and 268 tagged fish were recaptured (Delaney et al. 1981c). In 1982, 3,560 Arctic grayling were tagged and 350 tagged fish were recaptured (Stratton 1983). Population sizes were estimated using the Schnabel method from the mark-recapture data with a total Upper Susitna River estimate of 10,279 fish with a 95 percent confidence interval of 9,194 to 11,654 fish (Table 8.2-1). Total Arctic grayling population size during 1982 was 16,346 fish (Sautner and Stratton (1983). Arctic grayling abundance was highest in Kosina Creek and lowest in Fog Creek. Tagged Arctic grayling moved around considerably (Delaney et al. 1981c Sautner and Stratton 1983). In 1981, 243 fish were recaptured within the same tributary in which they were tagged. Of these fish, 50 moved up to 2 miles downstream and 69 fish moved up to 12 miles upstream. Approximately half (124 fish) of the recaptured tagged fish remained at the tagging location, and nine percent were recaptured in a tributary or tributary mouth different from the tagging location. The longest movement was 34.5 miles from Goose Creek to Watana Creek. During 1982, Arctic grayling tagged in tributaries made movements of up to 30.2 miles, and similar to 1981, a substantial proportion of the recaptured fish (12.0 percent) were recaptured in a different stream than tagged (Sautner and Stratton 1983).

In 1982, relatively few Arctic grayling were captured (Sautner and Stratton 1983). Among the seven mainstem slough sites that were sampled, only 21 arctic grayling and, and all were captured at the Watana Creek Slough. Sampling in Sally Lake resulted in the capture of 42 Arctic grayling.

8.2.2.2. Dolly Varden

Dolly Varden were also present in the Upper Susitna River (Delaney et al. 1981b, Sautner and Stratton 1983) but were relatively uncommon compared to Arctic grayling. Delaney et al. (1981) captured one Dolly Varden (235 mm length) at the mouth of Fog Creek. Sautner and Stratton (1983) captured 16 Dolly Varden at five of the tributaries sampled during 1982 (Cheechako, Devil, Watana, Jay, and upper Deadman creeks). All of the Dolly Varden captured during 1982 in the Upper Susitna River were small (120 to 205 mm) and considered stunted.

8.2.2.3. Burbot

Burbot were present throughout the mainstem Upper Susitna River to at least the Oshetna River (Delaney et al. 1981b, Sautner and Stratton 1983). Delaney et al. (1981) captured 88 burbot immediately upstream or downstream from the mouth of tributaries. During 1981, CPUE was not reported by each period and site. However, the overall monthly CPUE ranged from 0.5 burbot per trotline-day in June to 1.0 burbot per trotline-day in September. Most burbot were captured near the mouth of Jay Creek (32 fish) and Watana Creek (24 fish) during 1981 (Figure 8.2-15). Sautner and Stratton (1983) sampled at seven locations within the mainstem during 1982 and captured 135 burbot by trotline. Overall monthly CPUE ranged from 0.6 (July and September) to 0.8 (June) fish per trotline-day. For individual sites and periods, CPUE ranged from zero (Mainstem Site 2 in September) to 3.5 fish per trotline-day (Watana Creek mouth in May; Figure 8.2-15). Burbot appeared to move little within the Upper Susitna River, or they may have returned to feeding territories. Floy tags were attached to 23 and 69 burbot in 1981 and 1982, respectively. Four of the burbot tagged during 1981 and three of burbot tagged during 1982 were recaptured during 1982 at the location of tagging (Sautner and Stratton (1983). Based upon observation of spent burbot and observations by anglers in Paxson Lake, Delaney et al. (1981c) suggested that burbot probably spawned during March in the Upper Susitna River.

8.2.2.4. Round Whitefish

Round whitefish were present in the Upper Susitna River (Delaney et al. 1981b, Sautner and Stratton 1983). Delaney et al. (1981) captured a total of 80 round whitefish immediately upstream or downstream of tributary mouths. Gillnets were effective at capturing adult round whitefish (33 fish), and beach seining and electrofishing captured 47 juvenile round whitefish at the mouth of Jay Creek. Jay and Kosina creeks accounted for 39.4 and 27.3 percent of the adult round fish captured. None of the 17 floy-tagged round whitefish were recaptured. During the studies by Sautner and Stratton (1983), five adult round whitefish were captured at the Watana Creek Slough during July and August and in prespawning condition.

8.2.2.5. Humpback Whitefish

Humpback whitefish were present in the Upper Susitna River in low numbers. During 1981, one humpback whitefish (347 mm in length) was captured at the mouth of Kosina Creek (Delaney et al. 1981), and in 1982, a single humpback whitefish was captured at RM 208.1 (Sautner and Stratton (1983). Delaney et al. 1981 also reported that humpback whitefish were present in lakes Susitna and Louise. These lakes are headwater lakes to the Tyrone River, which enters the Susitna River near RM 246.5.

8.2.2.6. Longnose Sucker

Longnose suckers were present throughout the mainstem Upper Susitna River to at least the Oshetna River (Delaney et al. 1981b, Sautner and Stratton 1983). Delaney et al. (1981) captured 168 longnose suckers immediately upstream or downstream from the mouth of all surveyed tributaries except Fog and Tsusena creeks. Gillnets were effective at capturing adult round whitefish (144 fish). Beach seines, electrofishing, and minnow traps captured 24 juvenile longnose suckers. The Watana Creek and Jay Creek sites accounted for 52.1 and 19.4 percent of the adult longnose suckers captured. However, catch rates were highest in Watana Creek (12.5 fish per net-day) and the Oshetna River (4.0 fish per net-day).

During 1982, longnose suckers were captured by gillnets at four of the seven mainstem slough sites (Sautner and Stratton 1983). Similar to 1981, the highest catch occurred near Watana Creek (80.3 percent of all captured suckers). The highest catch observed was in July, when 21 longnose suckers were captured near the mouth of Watana Creek. Longnose suckers were in spawning condition in May and early-June, but all were spent in late-June.

Tags were attached to 97 and 50 longnose suckers in 1981 and 1982, respectively (Sautner and Stratton 1983). One of the fish tagged in 1981 was recaptured during 1981, and two were recaptured in 1982. Two fish tagged in 1982 were subsequently recaptured. All recaptures occurred at the tagging location.

8.2.2.7. Sculpin

In 1981, slimy sculpin were captured in minnow traps within all tributaries sampled in the Upper Susitna River except Jay Creek (Delaney et al. 1981c). Catch rates were highest in Fog Creek (8 per trap-day), Tsusena Creek (9 per trap-day), and the Oshetna River (10 per trap-day). Length of captured sculpins ranged from 37 to 95 mm.

8.2.2.8. Lake Trout

Sampling for lake trout occurred in Sally Lake in 1981 and 1982 and in Deadman Lake in 1981 (Delaney et al. 1981c, Sautner and Stratton 1983). Sally Lake is a 63 acre lake with a maximum depth of 27 feet and mean depth of 11.6 feet (Figure 8.2-16; Sautner and Stratton 1983). The southern end of the lake is shallow (average depth of about 4 feet) and has substantial aquatic vegetation.

In 1981, sampling in Sally Lake was primarily by gillnet with some angling, and only angling was attempted at Deadman Lake. Lake trout were captured in both Sally Lake (32 fish, 2 by angling) and Deadman Lake (3 fish, all by angling). Lake trout in Sally Lake were captured in less than 6 feet of water and within 100 feet of shore. The length of lake trout in Sally Lake ranged from 305 to 508 mm with a mean of 410 mm. Most scales removed from Lake Trout were unreadable. Consequently, no age information was obtained. In 1982, sampling in Sally Lake resulted in the capture of 32 lake trout (Sautner and Stratton 1983), and fish sizes ranged from 260 to 490 mm with an average length of 419 mm.

8.3. Age and Size of Selected Resident Fish Species

Age and size (length) information was collected from captured resident and non-salmonid anadromous fish during all of the surveys conducted as part of the RJ component of the Su-Hydro Aquatic Studies Program. Fish age was determined through analysis of scales or otoliths. The range of age and size structure of the collected species did not vary substantially from year to year (Figures 8.3-1 to 8.3-7). However, the mean size at age during some years was affected by low sample size. Age determination was not possible for Dolly Varden and Arctic lamprey. Representative length frequency histograms from surveys in 1981 are provided in Figure 8.3-8.

8.4. Invasive Fish Species

The only documented invasive species in the Susitna River basin is northern pike, which were illegally transplanted into several lakes of the Yentna River in the 1950s (Delaney et al. 1981a). During the 1980s Aquatic Studies Program five northern pike were captured: one in Kroto Slough (RM 36.2), one at the Yenta Station fishwheel, and three at the Flathorn Station fishwheel (RM 22.4). Since the 1980s, the range of northern pike in the Susitna River basin has expanded greatly, and they are currently present throughout the Lower Susitna River and its tributaries (Ivey et al. 2009), yet may also be present elsewhere within the basin. Rutz (1996 and 1999) conducted several years of radio-tracking, demographics, and diet studies on northern pike.

9. BARRIERS TO MIGRATION

9.1. Tributary Barriers

Using passage criteria based upon Thomson (1972), passage by adult salmon into tributary streams for spawning was evaluated for fifteen streams in the Lower and Middle Susitna River (Table 9.1-1; Trihey 1983, Ashton and Trihey 1985). Minimum depth for passage was 0.8 feet for Chinook salmon and 0.6 feet for coho, chum, pink, and sockeye salmon. Maximum velocity for passage was 8 feet per second for Chinook, coho, and chum salmon and 7 feet per second for pink and sockeye salmon. Under existing conditions, Ashton and Trihey (1985) concluded passage was not restricted at any of the tributary mouths in the Lower Susitna River. However, there were possible passage problems at Caswell Creek, Goose Creek, Montana Creek, and Trapper Creek. The types of potential problems were from low tributary flows, debris jams, or channel changes that could occur regardless of the proposed project. Under mainstem flows of 14,000 to 21,000 cfs at Gold Creek, Trihey (1983) concluded passage was not restricted at Indian River and Portage Creek, and under the flow regime considered for the proposed 1980s project configuration, the authors of both studies concluded that, passage into the tributaries would not be adversely affected by the proposed configuration.

9.2. Access to Sloughs

Sloughs provide important spawning habitat for chum and sockeye salmon, and side channels were occasionally used by chum and pink salmon. Sautner et al. (1984) evaluated passage into and within eight slough and four side channel sites. These included Whiskers Creek Slough, Sloughs 8A, 9, 9A, 11, 20, 21, and 22 and the following side channels: Mainstem 2 Side Channel, Side Channel 10, Upper Side Channel 11, and Side Channel 21. Most of sites were selected because of their use as spawning sites for chum salmon. Whiskers Creek Slough was selected, because it was used by pink salmon for spawning and served as a migration corridor into Whiskers Creek. Salmon spawning was not known to occur in Side Channel 10; however, it was selected for study because of its potential as a mitigation site. Chum salmon have been observed to spawn in Mainstem 2 Side Channel (RM 114.5), but the side channel was not consistently or heavily used (Sautner et al. 1984).

Sautner et al. (1983) reported that three types of flow (i.e., breaching, backwater, and local) were important for passage into sloughs and for accessing available spawning habitat within the slough. When mainstem discharge exceeded the breaching flow for a slough, passage was unrestricted. However, when mainstem discharge was less than the breaching flow, passage was a function of the mainstem backwater conditions at the mouth of the slough and of the amount of local flow present from groundwater and/or tributaries.

Slough morphology may also be an important physical constraint. Slough bathymetry is seldom regular. A slough may have shallow areas at the mouth and also at various locations within the slough. As an example, a plan view with spawning areas and a thalweg profile for Slough 9 is provided in Figure 9.2-1 and Figure 9.2-2. Sautner et al. (1983) identified five critical passage reaches. The head of Slough 9 began to breach at 16,000 cfs and was fully breached at 19,000 cfs. These flows were exceeded about 45 percent and 29 percent of the time, respectively, during the critical spawning period from August 20 to September 20 (Sautner et al. 1983).

Sautner et al. (1983) reported that most slough heads were fully breached at flows between 19,000 and 42,000 cfs. At lower discharges, mainstem flows that created backwaters controlled passage at the one or two downstream passage reaches within a slough. The authors concluded that backwater flows were the most important factor for successful passage into a slough. For Slough 9, the critical mainstem discharge level that provided successful passage at the mouth of the slough (Passage Reach I) was less than 12,000 cfs (70 percent exceedance value). For some sloughs, including Slough 9, stage rating curves were incomplete, and therefore, precise critical passage flows could not be determined.

If mainstem discharge provides a sufficient backwater flow for passage into a slough, local flows can be important for allowing passage across reaches within a slough and thus can determine the overall amount of habitat available for spawning. For Slough 9, it was determined that passage would be successful at Passage Reach I, II, and III with local flows of 2, 1, and 6 cfs, respectively. Sautner et al. (1983) concluded that local flows were generally adequate for passage at interior passage reaches as long as fish were able to successfully pass at the slough entrance.

Of the eight sloughs evaluated, Slough 9 and Slough 21 had the highest risk of unsuccessful passage conditions when flows were below the breaching level. Access to spawning areas upstream of Passage Reach III at Slough 9 would not be successful at flows lower than breaching, unless local flows were higher than 6 cfs; however, an analysis of local flows indicated that groundwater and tributary flows provided only approximately 5 cfs under base flow conditions. At Slough 21, chum salmon were observed to hold downstream of Passage Reach I and did not enter the slough until the head was breached.

10. ACCESS ALIGNMENT, CONSTRUCTION AREA, AND TRANSMISSION ALIGNMENT

Three transmission lines associated with the Project are proposed that will follow one or more routes (AEA 2011). One proposed transmission corridor, named the Chulitna Corridor, would extend west from the proposed Watana dam site on the north side of the Susitna River to the Anchorage-Fairbanks Intertie near the Chulitna River. A second proposed corridor, the Gold Creek Corridor, would run westward on the south side of the Susitna River and connect to the intertie at Gold Creek. A third option, the Denali Corridor, would extend north from the proposed dam site to the Denali Highway and then head west along the Denali Highway to an interconnection point at Cantwell. The two options being considered for the three transmission line are: 1) two circuits extending west and one circuit north, or 2) three circuits extending west (AEA 2011).

Access roads are intended to be co-located with transmission corridors and facilities to the extent possible. However, there are three specific sections of the proposed corridors that would not be co-located. For the Chulitna Corridor, the access road would be co-located with the transmission line with the exception of the eastern-most five miles of transmission line (AEA 2011). The Gold Creek Corridor will be most efficiently run by spanning the line over the rough terrain adjacent the Susitna River; consequently, the only co-located section of access road would be the western portion of the corridor (AEA 2011). The northern Denali Corridor will be co-located with the access road except for a 9-mile section near Deadman Lake; once at the Denali Highway, the corridor would follow the highway west to Cantwell. Transmission line sections without co-located roads in each proposed corridor would be accessed by helicopter (AEA 2011).

Construction will consist of right-of-ways for transmission lines, access roads, switchyards, and substations. Transmission right-of-ways will consist of linear strips of land 200, 300, or 400 feet in width depending on the number of lines (1, 2, or 3 lines; AEA 2011). The total area necessary for switchyards and substations is anticipated to be approximately 16 acres (AEA 2011). Construction access to all sites will be on planned permanent access roads. Stream crossings associated with the Chulitna Corridor access would occur at Tsusena Creek, Portage Creek, Devil Creek, Indian River, and two unnamed streams (AEA 2011). For the Gold Creek Corridor access, stream crossings would occur at Fog Creek, Prairie Creek, and five unnamed streams (AEA 2011). An alternative Gold Creek access route would not cross Prairie Creek but would cross an additional unnamed stream. The Denali Corridor access would require crossings of Deadman, Brushkana, Seattle, and Shale Creeks (AEA 2011).

10.1. Description of 1980s Alignments Pertinent to the Current Project

The transmission corridor route selected for the 1980s project extended to the west of the Watana dam to Gold Creek (Schmidt et al. 1984b). The proposed 1980s access corridors, which correspond to alternative transmission line corridors for the current project, extended north from the proposed Watana Dam site to the Denali Highway and west from the dam to Gold Creek. The proposed northern route followed a similar path as the Denali Corridor, while the west access route followed a route comparable to a portion of the Chulitna Corridor. During the 1983 open water season, studies were conducted to identify baseline fishery and stream habitat information at proposed stream crossings and selected lakes near the proposed transmission and access corridor routes. Stream crossings studied during 1983 that are pertinent to the current Project include: Deadman, Brushkana, and Seattle creeks in association with the Denali Corridor; and Tsusena and Devil creeks associated with the Chulitna Corridor (Schmidt et al. 1984b). Deadman, Tsusena and Devil creeks are tributaries to the Susitna River, while Brushkana and Seattle Creeks are located in the Tanana River basin.

10.2. Fish Assemblage

In 1983 species observed at the Denali Corridor stream crossings of interest (i.e., Deadman, Brushkana, and Seattle creeks) were Arctic grayling, slimy sculpin, and Dolly Varden (Schmidt et al. 1984b). Arctic grayling and slimy sculpin were found at all three proposed crossings. Dolly Varden were observed only at the Seattle Creek crossing, yet they were also observed in unnamed stream elsewhere in the Deadman and Brushkana basins (Schmidt et al. 1984b).

A greater number of species were observed at the stream crossings of interest along the proposed Chulitna Corridor than those along the proposed Denali Corridor. At the proposed Tsusena Creek crossing, which was located upstream of a large waterfall, small stream resident Dolly Varden and slimy sculpin were the only fish captured in 1983 (Schmidt et al. 1984b). Downstream of the Tsusena Creek falls, which is located approximately 3 miles upstream of the mouth, Arctic grayling were observed (Schmidt et al. 1984b). At the Devil Creek crossing, slimy sculpin were the only fish species captured in 1983, though Dolly Varden were observed at other sites in the Devil Creek basin (Schmidt et al. 1984b). The observed fish assemblage in Portage Creek included Chinook, chum, coho and pink salmon, and rainbow trout, Arctic grayling, and Dolly Varden (Jennings et al. 1984, Sundet and Pechek 1985).

10.3. Aquatic Habitat

Deadman Creek is a large clearwater tributary to the Susitna River. Deadman Lake is located approximately 19 miles upstream of the creek’s confluence with the Susitna River. The proposed access crossing was located about 15 miles upstream of Deadman Lake. The crossing site was in a steep, narrow, confined section of Deadman Creek with large substrates (cobble and boulder) and limited fish rearing habitat. Immediately downstream of the crossing site, the stream channel was less steep and better suited for fish holding and rearing (Schmidt et al. 1984b). Measured discharge at the crossing site in August 1983 was 37 cfs (Schmidt et al. 1984b).

Brushkana Creek is a large, low gradient tributary to the Nenana River and is approximately 26 miles long. The historic crossing site was located approximately 10 miles downstream of the headwaters in a broad valley (45-50 feet wide), with cobble and boulder substrate and pool-riffle channel morphology. Qualitative assessments of stream habitat conditions at the crossing site suggested high quality fish holding and rearing habitat (Schmidt et al. 1984b). Measured discharge at the crossing site in August 1983 was 83 cfs (Schmidt et al. 1984b).

Seattle Creek is a large clearwater tributary to the Nenana River approximately 12 miles in length. The historic crossing site was approximately 6 miles upstream of the confluence with the Nenana River. At the crossing site, the stream channel was approximately 25-30 feet wide with boulder, cobble and gravel substrate and pool-riffle channel morphology (Schmidt et al. 1984b). Measured discharge at the crossing site in August 1983 was 31 cfs (Schmidt et al. 1984b).

Tsusena Creek is a large clearwater tributary to the Susitna River, is approximately 30 miles in length, and has a large waterfall three miles upstream of the Susitna River. Tsusena Creek drains a large area of tundra downstream of the headwater area. The historic crossing site, located approximately 8 miles upstream of the confluence with the Susitna River, was situated in a wide section (150-200 feet wide) of the creek that consisted primarily of long riffles with small pools. Cobble and boulder substrates were highly embedded with sand, and gravel was found only in pools. In 1983, fish rearing and holding habitat appeared to be of high quality (Schmidt et al. 1984b).

Devil Creek, which is a large clearwater tributary to the Susitna River, originates in the Alaska Range and flows through a wide expanse of open tundra for much of its length. A steep cascade and waterfall, which blocked upstream fish access, was located approximately one mile upstream of the Susitna River confluence. The historic crossing site, located approximately seven miles upstream of the Susitna River confluence, was located in a wide and deep section of the river with moderate gradient and boulder and cobble substrate (Schmidt et al. 1984b).

10.4. Water Quality

In August 1983, instantaneous water quality measurements were recorded at stream crossing sites as part of the access and transmission corridor studies. Surface water temperatures in streams that are pertinent to the current proposed transmission and access corridors ranged from 6.6°C in Seattle Creek to 7.4°C in Deadman Creek (Schmidt et al. 1984b). Dissolved oxygen concentrations ranged from 9.1 mg/L in Devil Creek to 10.4 mg/L in Deadman Creek (Schmidt et al. 1984b). Conductivity ranged from 33 µmhos/cm in Deadman Creek to 67 µmhos/cm in Tsusena Creek (Schmidt et al. 1984b). Measurements of pH ranged from 6.6 in Deadman Creek to 7.2 in Brushkana Creek (Schmidt et al. 1984b).

11. AQUATIC PRODUCTIVITY

The production of freshwater fishes in a given habitat is constrained both by the suitability of the abiotic environment and by the availability of food resources (Wipfli and Baxter 2010). Algae is responsible for the majority of photosynthesis in a river or stream and serves as an important food source to many benthic macroinvertebrates. As such it is an important base component in the lotic food web. In turn, benthic macroinvertebrates are an essential component in the processes of an aquatic ecosystem, due to their position as consumers at the intermediate trophic level of lotic food webs (Hynes 1970; Wallace and Webster 1996; Hershey and Lamberti 2001). Macroinvertebrates are involved in the recycling of nutrients and the decomposition of terrestrial organic materials in the aquatic environment and thus serves as a conduit for the energy flow from organic matter resources to vertebrate populations, namely fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). Aquatic insects are generally considered the primary food source for juvenile anadromous salmon and other resident fishes (Wipfli and Baxter 2010). Aquatic insect larvae, pupae, and nymphs can live within the interstitial spaces in the substrate, on the substrate surface, or be found in the water column. Other likely important forage items are fish eggs, terrestrial insects, fish tissue from carcasses, and whole fish. In turn, nutrients and energy provided by spawning salmon have the potential to increase freshwater and terrestrial ecosystem productivity (Wipfli et al. 1998; Cederholm et al. 1999; Chaloner and Wipfli 2002; Bilby et al. 2003; Hicks et al. 2005) and may subsidize otherwise nutrient-poor ecosystems (Cederholm et al. 1999).

The significant functional roles that macroinvertebrates and algae play in food webs and energy flow in the freshwater ecosystem make these communities important elements in the study of a stream’s ecology. Studies during the 1970s and 1980s included evaluations of the benthic macroinvertebrate community, primary productivity, and dissolved nutrients. (Friese 1975; Riis 1975, Riis 1977, Estes et al. 1981, ADF&G 1983, Hansen and Richards 1985, Trihey and Associates 1986, Van Niuwenhuyse 1985).

11.1. Benthic Macroinvertebrates

A number of evaluations of the benthic macroinvertebrate community were conducted on the Susitna River in the 1970s and in the 1980s for the original APA Susitna Hydroelectric Project (Friese 1975; Riis 1975, 1977; ADF&G 1983; Hansen and Richards 1985, Van Nieuwenhuyse 1985, Trihey and Associates 1986). ADF&G studies in the 1970s included sampling of macroinvertebrates using artificial substrates (rock baskets) deployed for a set period of time to allow for colonization. Friese (1975) and Riis (1975) set a total of eight rock baskets in Waterfall Creek, Indian River, and the mainstem middle Susitna River for 30 days during the summer (July – September). Riis (1977) also deployed rock baskets in the Susitna River near the mouth of Gold Creek for a colonization period of 75 days; however, only two of seven baskets were retrieved. Results were limited to low numbers of invertebrates per basket, identified to taxonomic family.

Studies conducted in the 1980s for the original APA Susitna Hydroelectric Project focused on benthic macroinvertebrate communities in the sloughs, side channels, and tributaries of the middle reach of the Susitna River (RM 125 to 142) during the period from May through October. Efforts included direct benthic sampling with a Hess bottom sampler and drift sampling. ADF&G efforts in 1982 and 1984 also involved collection of juvenile salmon in these side channels and sloughs, and an analysis was conducted to compare gut contents with the drift and benthic sampling results (ADF&G 1983; Hansen and Richards 1985). In addition, Hansen and Richards (1985) collected water velocity, depth, and substrate-type data to develop habitat suitability criteria (HSC), which were used to estimate weighted usable areas for different invertebrate community guilds, based on their behavioral type (swimmers, burrowers, clingers, and sprawlers) in slough and side channel habitats. Efforts in 1985 (Trihey and Associates 1986) expanded to include sampling at nine sites in the middle reach of the Susitna River: three side channels, two sloughs, two tributaries, and two mainstem sites.

Schmidt et al. (1983) collected invertebrates from kick net and drift net sampling. The results were reported as part of electivity index analyses, but not otherwise summarized in the report. Proportions of the drift and kick samples from each date and site reported in tables were lumped differently depending upon the salmon species diet of interest; consequently, quantitative conclusions are difficult to make without a re-analysis of the data. Nevertheless, a qualitative review of the tabular data suggests that chironomid larvae, pupae, and adults were the predominate items collected, often in combination representing well over 50 percent of the items, but the relative proportions varied considerably among the collections. Some exceptions were noted. For example at Slough 11 on September 5, 1982, capniid stonefly nymphs represented 90 percent of the invertebrates collected.

Hansen and Richards (1985) concluded the composition of invertebrates within drift samples was affected by hydraulic conditions at the head of the side slough or side channel. When mainstem discharge was sufficiently high to breach slide slough channel heads, the amount of drift was higher than under unbreached conditions. The authors suggested that mainstem discharge slightly above the critical breaching flow was more important than higher flow levels because mainstem waters would provide greater amounts of drift, but turbidity would not be too high to substantially reduce visibility.

The invertebrate community in drift and benthic samples collected during 1984 were relatively diverse with 14 aquatic or semi-aquatic orders represented as well as eleven non-insect or non-aquatic orders (Hansen and Richards 1985). Chironomids (dipteran flies) were common throughout the sampling period and were numerically dominant in both drift and benthic collections. Ephemeropterans (mayflies) and plecopterans (stoneflies) were the second- and third-most prominent taxa in drift samples. Ephemeropterans were common in benthic samples early in the summer, and plecopeterans were more common later in the summer.

Hansen and Richards (1985) developed depth, velocity, and substrate habitat suitability indices for benthic invertebrate guilds and used instream flow hydraulic models developed for fish species to develop Weighted Useable Area (WUA) versus flow relationships for the guilds. Depth was not limiting to any of the guilds. Velocities from 0 to 3.0 feet per second (fps) were considered optimal for sprawlers, low velocities were optimal for burrowers, and relatively high velocities (up to 2.2 fps) were considered optimal for swimmers and clingers (Figure 11.1-1). Burrowers were more commonly found in sand and silt substrate, sprawlers and swimmers were commonly found in small gravel to rubble-sized substrate, and rubble substrate was optimal for clingers (Figure 11.1-2).

WUA versus flow relationships were developed for each of the guilds at four sites: Slough 9, Side Channel 10, Upper Side Channel 11 and Upper Side Channel 21 (Hansen and Richards 1985). In general, WUA increased with increasing flows (e.g., Slough 9; Figure 11.1-3).

Hansen and Richards (1985) concluded that WUA increases rapidly above the critical breaching flow level, which is the point where mainstem discharge becomes the main controlling factor.

Baseline field data for benthic primary and secondary production was collected in 1985 as part of the Primary Production Monitoring Effort (Van Nieuwenhuyse 1985). Chlorophyll-a (*chl-a*) and macroinvertebrates were collected from early April to late October in a variety of off-channel and mainstem habitat sites. Early April sampling took place in an open-water lead in Slough 8A and revealed high macroinvertebrate densities (average 17,600 individuals/m^2) comprised almost entirely of chironomid larvae. Chlorophyll-a densities averaged 34.4 mg/m^2. Macroinvertebrate densities in Slough 8A averaged 2,950 individuals/m^2 in early April (mostly chironomids) and ranged from 393 to 8,820 individuals/m^2 in May 1985, but with considerably more diversity. During May, chironomids accounted for an average of 53 percent of the density and only 8 percent of the macroinvertebrate biomass. No sampling results were given for summer macroinvertebrate sampling (June and July). August and September sampling results showed low average densities at mainstem sites (44 – 164 individuals/m^2), yet large increases were observed in October (1,729 – 7,109 individuals/m^2). Average densities in Slough 8A in August remained similar to spring levels at 2,851 individuals/m^2 and surged in September to 13,964 individuals/m^2; again, chironomids represented over 80 percent of the density.

11.2. Periphyton

Algal communities were periodically sampled and analyzed for chlorophyll-*a* at Susitna Station from 1978 to 1980. In the 1980s, algae samples were collected as part of the APA Project water quality studies, with sampling conducted at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna stations on the Susitna River, as well as on the Chulitna and Talkeetna rivers (Harza-Ebasco 1985 as cited in AEA 2011a). Analysis showed low productivity (less than 1.25 mg/m^3 chlorophyll-*a*) and indicated algal abundance was most likely limited by high concentrations of turbidity (AEA 2011a).

In 1985, chlorophyll-a and macroinvertebrates were collected from early April to late October in a variety of off-channel and mainstem habitat sites as part of the Primary Production Monitoring Effort (Van Nieuwenhuyse 1985). Early April sampling took place in an open-water lead in Slough 8A. Chlorophyll-a densities averaged 34.4 mg/m^2 during early April and 37 mg/m^2 during early May. Algae samples beyond May 1985 were not analyzed; therefore, no data were available for summer or fall.

11.3. Water Quality and Chemical Constituents

Water quality metrics and chemical constituents were monitored by the USGS and R&M Consultants at seven stations along the Susitna River and its tributaries: Denali (RM 290.8), Vee Canyon (RM 223.1), Gold Creek (RM 136.6), Chulitna (RM 98.0), Talkeetna (RM 97.0), Sunshine (RM 83.9), and Susitna (RM 25.8) stations. The Chulitna and Talkeetna stations samples were collected from the tributary rivers and not the mainstem Susitna River. During June, July, and September of 1981, the USGS also collected water quality samples once per month from five sloughs: 8A, 9, 16B, 19, and 21 (Estes et al. 1981).

Harza-Ebasco (1985) summarized information on two nutrients: nitrogen, and phosphorus. They also summarized water temperature and turbidity information, which are important factors affecting primary productivity. Harza-Ebasco (1985) suggested that orthophosphate levels were a better indicator of biologically available phosphorus, because other components tend to be bound with inorganic particulates. Orthophosphate levels were considered to be relatively low at 0.1 mg/L or less throughout the basin (Figure 11.3-1). Nitrogen levels in the form of nitrate were reported to be at low to moderate levels of less than 0.9 mg/L. Orthophosphate levels measured at five sloughs during 1981 averaged 0.37 mg/L and ranged from less than 0.03 mg/L (Sloughs 9, 16B, 19, and 21 during June) to 1.5 mg/L (Slough 9 during July; Estes et al. 1981). Nitrate levels averaged 5.36 mg/L and ranged from 2.9 mg/L (Slough 21 during July and Slough 16B during September) to 10. 0 mg/L (Slough 19 during June),

Turbidity, as measured in nephelometric turbidity units (NTUs), is a metric of light penetration which is an important factor affecting primary productivity. Turbidity in the Susitna River was primarily determined by levels of inorganic glacial flour suspended in the water (Harza-Ebasco 1985). Turbidity levels in the mainstem Susitna River can be quite high (Harza-Ebasco 1985). Glacial water from the Chulitna River, with turbidity measured as high as 1,920 NTU, is a major contributor of turbidity to the mainstem Susitna River. The maximum turbidity level measured in the Talkeetna River during 1982 was 272 NTU. Turbidity is affected by the amount of glacial melt and precipitation in the form of rain. Consequently, turbidity tends to be high in the summer and low in the winter (Harza-Ebasco 1985; Figure 11.3-2. Turbidity levels tended to decline in a downstream direction below the Three Rivers Confluence. Maximum turbidity measurements at Sunshine and Susitna stations were of 1,056 and 790 NTU, respectively.

Turbidity in side channels and side sloughs was affected by inflows from clear water tributaries and groundwater (Harza-Ebasco 1985). In addition, breaching at the heads of side sloughs or side channels allowed turbid mainstem water to flow through. When flows were below breaching levels, turbidity was substantially lower and less variable (Figure 11.3-3).

Water temperature influences the metabolic rates of fauna critical to nutrient cycling and production at secondary and higher trophic levels (Allan 1995). Water temperature can also influence primary production through via photosynthesis and respiratory rates (Russell-Hunter 1970). Morin et al. (1999) conducted a meta-analysis of published primary production and chlorophyll-a data and found that water temperature had a relatively high influence on periphyton productivity compared to lake and ocean phytoplankton productivity.

Water temperature was measured along with other physiochemical parameters at the seven stations described above. Surface and intragravel water temperatures were also measured as part of studies investigating chum and sockeye salmon egg incubation and winter rearing habitat. Water temperatures generally began to warm in May and then declined in late August and September, with maximum temperatures occurring between mid-June and early August and winter time temperatures just above 0°C (Harza-Ebasco 1985; Figure 11.3-4). Maximum temperatures throughout the river seldom exceeded 14°C (Figure 11.3-5), although a high of 16.5°C was recorded at Susitna Station on July 9, 1976. Typical of most rivers, water temperatures in the Susitna River increased in a downstream direction during the open water period (Figure 11.3-5). The temperature gradient was steeper above Vee Canyon (RM 223.1) due to the proximity of glaciers providing source water. The moderating influence of groundwater in side channels and side sloughs during the winter is discussed in Section 6 (Egg Incubation).

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13. TABLES

Table S-1. Periodicity of adult Pacific salmon presence in the Susitna River. Light gray indicates total duration of residence and dark gray represents periods of peak use.

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon	Adult Migration												
	Spawning												
Chum Salmon	Adult Migration												
	Spawning												
Coho Salmon	Adult Migration												
	Spawning												
Sockeye Salmon[1]	Adult Migration						A A A B				B		
	Spawning						A		A B		B		
Pink Salmon	Adult Migration												
	Spawning												

Notes:

1 First-run (A) and second-run (B) sockeye salmon exhibit distinct timing of adult migration and spawning, and utilize separate areas for spawning. Early-run sockeye do not spawn in the middle Susitna River.

Peak Use Off-Peak Use

Table 3.1-1. List of documents related to fish and aquatics studies on the Susitna River from the 1970s and 1980s.

Year	Title	APA Doc ID(s)	Type	No of APA Docs	Citation
1974	An Assessment of the Anadromous Fish Populations in the Upper Susitna River Watershed between Devil Canyon and Chulitna River	1612	Study	1	Barrett 1974
1975	December, January, and February Investigations on the Upper Susitna River Watershed Between Devil Canyon And Chulitna River	1609	Study	1	Barrett 1975
1975	Preauthorization Assessment of Anadromous Fish Population Upper Susitna River Watershed in the Vicinity of Proposed Devil Canyon Hydroelectric Project	549	Study	1	Friese 1975
1977	Pre-authorization Assessment of the Proposed Susitna River Hydroelectric Projects: Preliminary Investigations of Water Quality and Aquatic Species Composition	1610	Study	1	Riis 1977
1978	Preliminary Environmental Assessment of Hydroelectric Development on the Susitna River	1613	Summary	1	Riis and Friese 1978
1981	Attachment D to Hydrographic Surveys: Susitna River Mile Index	SUS131	Other	1	R&M 1981
1981	Resident Fish Investigation on the Lower Susitna River	318	Study	1	Delaney et al. 1981a
1981	Juvenile Anadromous Fish Study on the Lower Susitna River	1310	Study	1	Delaney et al. 1981b
1981	Resident Fish Investigation on the Upper Susitna River	316	Study	1	Delaney et al. 1981c
1981	Aquatic Habitat and Instream Flow Project	311, 312, 1307	Study	3	Estes et al. 1981
1981	Adult Anadromous Fisheries Project	324	Study	1	ADF&G 1981
1982	Aquatic Studies Procedures Manual	3554, 3555	SOP	2	ADF&G 1982a
1982	Aquatic Studies Program 1982	517	Synthesis	1	Estes and Bingham 1983
1982	Stock Separation Feasibility	320	Study	1	ADF&G 1982b
1982	Adult Anadromous Fish Studies, 1982	588, 589	Study	2	ADF&G 1982c
1982	1982 Winter Temperature Study Open File Report	526	Study	1	Trihey 1982a
1982	Preliminary Assessment of Access by Spawning Salmon to Side Slough Habitat above Talkeetna	510	Study	1	Trihey 1982b
1983	Resident and Juvenile Anadromous Fish Studies on Susitna, Below Devil Canyon	486, 487	Study	2	Schmidt et al. 1983
1983	Winter Aquatic Studies (October 1982 - May 1983)	397	Study	1	Hoffman et al. 1983
1983	Aquatic Habitat and Instream Flow Studies 1982	585, 586, 587	Study	3	Estes and Schmidt 1983
1983	Upper Susitna River Impoundment Studies 1982	590	Study	1	Sautner and Stratton 1983
1983	Report Synopsis of the 1982 Aquatic Studies and Analysis of Fish and Habitat Relationships and Appendices	40	Synthesis	1	Schmidt and Bingham 1983
1983	Summarization of Volumes 2, 3, 4; Parts I and II, and 5	96	Synthesis	1	ADF&G 1983
1983	Aquatic Studies Procedures Manual	938	SOP	1	ADF&G 1983
1983	Upper Susitna River Salmon Enhancement Study	Final of 522 (draft)	Study	1	Barrick et al. 1983
1983	Effects of Various Water Temperature Regimes on the Egg and Alevin Incubation of Susitna River Chum and Sockeye Salmon	317	Study	1	Wangaard and Burger 1983

Year	Title	APA Doc ID(s)	Type	No of APA Docs	Citation
1983	Preliminary Assessment of Access by Spawning Salmon into Portage Creek and Indian River	508	Study	1	Trihey 1983
1983	Slough Hydrogeology Report	519	Study	1	Burgess 1983
1984	Adult Anadromous Fish Investigations (May -October 1983)	1450	Study	1	ADF&G 1984
1984	Resident and Juvenile Anadromous Fish Investigations (May -October 1983)	1784	Study	1	Schmidt et al. 1984; Dugan et al. 1984; Suchanek et al. 1984
1984	Aquatic Habitat and Instream Flow Investigations (May - October 1983)	1930, 1931, 1934, 1935, 1936, 1937, 1938	Study	7	Vincent-Lang and Queral 1984; Quane et al. 1984; Sandone et al. 1984; Sautner et al. 1984; Vincent-Lang et al. 1984a; Vincent-Lang et al. 1984b
1984	Access and Transmission Corridor Aquatic Investigations (May - October 1983)	2049	Study	1	Schmidt et al. 1984
1984	Effects of Project-related Changes in Temperature, Turbidity and Stream Discharge on Upper Susitna Salmon Resources During June - Sept	454	Study	1	Wilson et al. 1984
1984	Assessment of the Effects of the Proposed SHP on Instream Temperature and Fishery Resources in the Watana to Talkeetna Reach	2330	Study	1	Meyer et al. 1984
1984	Interim Mitigation Plan for Chum Spawning Habitat in Side Sloughs of the Middle Susitna River	2332	Study	1	Woodward-Clyde Consultants 1984
1984	Slough Geohydrology Studies	1718	Study	1	Harza-Ebasco and R&M 1984
1984	ADF&G Su Hydro Aquatic Studies (May 1983 - June 1984) Procedures Manual	885, 886	SOP	2	ADF&G 1984
1984	Response of Aquatic Habitat Surface Areas to Mainstem Discharge in the Talkeetna to Devil Canyon Reach of the Susitna River, Alaska.	1693	Study	1	Klinger and Trihey 1984
1985	Winter Aquatic Studies (October 1983 - May1984)	2658, 2659	Study	2	Vining et al. 1985
1985	Adult Anadromous Fish Investigations (May - October 1984)	2748	Study	1	Barrett et al. 1985
1985	Resident and Juvenile Anadromous Fish Investigations (May -October 1984)	2836, 2837	Study	2	Roth and Stratton 1985; Suchanek et al. 1985; Sundet and Pechek 1985
1985	Availability of Invertebrate Food Sources for Rearing Juvenile Chinook Salmon In Turbid Susitna River Habitats	2846	Study	1	Hansen and Richards 1985
1985	Summary Of Salmon Fishery Data For Selected Middle Susitna River Sites	2749	Study	1	Hoffman 1985
1985	Preliminary Evaluations of Potential Fish Mitigation Sites in the Middle Susitna River	2908	Study	1	Seagren and Wilkey 1985a
1985	Lower Susitna River Preliminary Chum Salmon Spawning Habitat Assessment	3504	Study	1	Bigler and Levesque 1985

Year	Title	APA Doc ID(s)	Type	No of APA Docs	Citation
1985	Summary of Water Temperature and Substrate Data from Selected Salmon Spawning and Groundwater Upwelling Sites in the Middle Susitna River	2913	Study	1	Seagren and Wilkey 1985b
1985	Hydrological Investigations at Selected Lower Susitna River Study Sites	2736	Study	1	Quane et al. 1985
1985	Fish Resources and Habitats in the Middle Susitna River	2744	Synthesis	1	Jennings 1985
1985	Assessment of Access by Spawning Salmon into Tributaries of the Lower Susitna River	2775	Study	1	Ashton and Trihey 1985
1985	Access Corridor, Construction Zone And Transmission Corridor Fish Impact Assessment and Mitigation Plan	2921	Study	1	Entrix 1985a
1985	Impoundment Area Fish Impact Assessment and Mitigation Plan	2922	Study	1	Entrix 1985b
1985	Characterization of Aquatic Habitats in the Talkeetna to Devil Canyon Segment of the Susitna River Alaska	2919	Study	1	Aaserude et al. 1985
1985	Instream Flow Relationships	3060, 3061	Study	2	Trihey and Entrix 1985
1985	Hydraulic Relationships and Model Calibration Procedures at 1984 Study Sites in the Talkeetna-to-Devil Canyon Segment of the Susitna River, Alaska	2898, 2899	Study	1	Hilliard et al. 1985
1985	Response of Juvenile Chinook Salmon Habitat to Mainstem Discharge in the Talkeetna to Devil Canyon Segment of the Susitna River, Alaska	2909	Study	1	Steward et al. 1985
1985	Response of Aquatic Habitat Surface Areas to Discharge in the Yentna to Talkeetna Reach of the Susitna River.	2774	Study	1	Ashton and Klinger-Kingsley 1985
1985	Salmon Passage Validation Studies	2854	Study	1	Blakely et al. 1985
1985	Response of Aquatic Habitat Surface Areas to Discharge in the Talkeetna to Devil Canyon Segment of the Susitna River Alaska.	2945	Study	1	Klinger-Kingsley et al. 1985
1985	Susitna Hydroelectric Project License Application Exhibit E	3430, 3431, 3432, 3433, 3435, 3438	Synthesis	6	Harza-Ebasco 1985
1985	Resident and Juvenile Anadromous Studies Procedures Manual	3014	SOP	1	ADF&G 1985
1985	Task 31 Primary Production Monitoring Report	4018	Study	1	Wilson 1985
1986	Winter Studies of Resident and Juvenile Anadromous Fish (October 1984 - May 1985)	3062, 3063	Study	2	Sundet 1986; Stratton 1986
1986	Adult Salmon Investigations (May-October 1985)	3412	Study	1	Thompson et al. 1986
1986	The Migration and Growth of the Juvenile Salmon in the Susitna River, 1985	3413	Study	1	Roth et al. 1986
1986	Susitna River Aquatic Studies Review: Findings And Recommendations	3501	Synthesis	1	Cannon 1986
1986	Response of Chum Salmon Spawning Habitat to Discharge in the Talkeetna to Devil Canyon Segment of the Susitna River, Alaska	3423	Study	1	Trihey and Hilliard 1986
	Total Number of Volumes			89	

Table 3.1-2. Types of studies conducted as part of the Fish and Aquatics Study Program during 1981 to 1986.

Year	Adult Anadromous Studies	Resident and Juvenile Studies	Aquatic Habitat Studies
1981	Mainstem escapement monitoring (gillnet, electrofishing, fishwheel, and sonar sampling); radio-tracking, run timing, age and length, sex ratios, aerial and foot spawning surveys between Cook Inlet and Devils Canyon plus the Yentna River and selected tributaries (ADF&G 1981).	Resident fish distribution, abundance, age, length, sex composition, and floy tagging from Cook Inlet to Devils Canyon (Delaney et al. 1981a) and upstream of Devils Canyon (Delaney et al. 1981b); Juvenile anadromous winter and summer distribution, abundance, age, and length (Delaney et al. 1981c).	Measurement of physical parameters including hydrology (flow), hydraulics (water stage and velocity), water quality, and morphologic mapping at selected sites (Estes et al. 1981).
1982	Mainstem escapement monitoring (fishwheels, sonar) downstream of Devils Canyon, tagging, radio-tracking, run timing, age composition, fecundity, aerial and foot spawning surveys, eulachon and Bering cisco spawning surveys (ADF&G 1982C).	Chum and sockeye egg incubation and intragravel water monitoring in the Middle River (Hoffman et al. 1983); Distribution and abundance of resident fish and juvenile salmon downstream of Devils Canyon, radio-tracking of resident fish, emergence and outmigration of juvenile salmon, food habitats of juvenile salmon (Schmidt et al. (1983); Distribution and abundance of resident fish upstream of Devils Canyon, tributary habitat, passage barriers, and fish distribution/abundance, lake habitat and fish distribution (Sautner and Stratton 1983).	Characterization of spawning and rearing habitat for anadromous and resident fish (Estes and Schmidt 1983); Slough hydrogeology (Burgess 1983); Side slough access by spawning salmon (Trihey 1982);
1983	Mainstem escapement monitoring (fishwheels, sonar) downstream of Devils Canyon, tagging, run timing, age composition, fecundity, aerial and foot spawning surveys, eulachon and Bering cisco spawning surveys (Barrett et l. 1984).	Outmigration of juvenile salmon upstream of Talkeetna, distribution and abundance of juvenile salmon upstream of Talkeetna (Schmidt et al. 1984a); Temperature effects on chum and sockeye salmon egg development (Wangaard and Burger 1983); Access and transmission corridor aquatic study (Schmidt et al. 1984b)	Collection of hydrologic and water quality information and information needed for modeling adult salmon spawning habitat and access into selected sloughs used for spawning (Sautner et al. 1984); Juvenile salmon and resident fish rearing suitability criteria and habitat modeling (Schmidt et al. 1984a); Assessment of access into Indian and Portage creeks by spawning salmon (Trihey 1983).

Year	Adult Anadromous Studies	Resident and Juvenile Studies	Aquatic Habitat Studies
1984	Mainstem escapement monitoring (fishwheels, sonar) downstream of Devils Canyon, tagging, run timing, age composition, aerial and foot spawning surveys (Barrett et al. 1985).	Migration and growth of juvenile salmon (Roth and Stratton 1985); Abundance and distribution of juvenile salmon (Suchanek et al. 1985); Abundance, distribution, and radio-tracking of resident fish in the lower Middle River (Sundet and Pechek 1985); Invertebrate food sources for Chinook salmon juveniles (Hansen and Richards 1985). Water quality monitoring and chum egg incubation study in the lower Middle River (Vining et al. 1985); Intragravel water temperature, substrate composition, chum spawning habitat, and egg incubation in the Lower River (Bigler and Levesque 1985)	Collection of hydrologic and water quality information and information needed for modeling spawning and rearing flow:habitat relationships (Quane et al. 1985); Instream flow relationships for juvenile salmon (Suchanek et al. 1985); Access of spawning salmon into tributaries downstream of Talkeetna (Ashton and Trihey 1985); Chum spawning habitat in the Lower River instream flow model development (Bigler and Levesque 1985).
1985	Mainstem escapement monitoring (fishwheels) downstream of Devils Canyon, tagging, run timing, age composition, aerial and foot spawning surveys (Thompson et al. 1986); Summary of fishery data (Hoffman 1985).	Winter distribution of burbot and rainbow trout (Sundet 1986); Winter distribution, abundance, movement, and length of juvenile Chinook and coho salmon (Stratton 1986); Migration and growth of juvenile salmon (Roth et al. 1986). Preliminary results of primary productivity and macroinvertebrate monitoring in the Susitna and Kasilof rivers (Wilson 1985),	Characterization of aquatic habitats in the lower Middle River (Aaserude et al. 1985); Juvenile Chinook salmon instream flow modeling (Steward et al. 1985); Response of water surface area to discharge in the Yentna to Talkeetna Reach (Ashton and Klinger-Kingsley 1985) and Talkeetna to Devils Canyon Reach (Klinger Kingsley et al. 1985).
1986	No field, laboratory, or desktop studies.	No field, laboratory, or desktop studies.	Chum salmon spawning instream flow modeling (Trihey and Hilliard 1986).

Table 3.1-3. Deployment of fishwheel (F) and sonar stations (S) from 1981 to 1985. Sources: ADF&G 1982a,ADF&G 1982c, Barrett 1984, Barrett 1985, Thompson et al. 1986.

Station	River Mile	1981		1982		1983		1984		1985	
		Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation
Flathorn Station	22							4F	6/29 to 9/3	4F - 6F	5/26 to 9/3
Susitna Station	26.7	2F, 2S	6/27 to 9/2	2F, 2S	7/1 to 9/5						
Yentna Station	28, TRM 04	2F, 2S	6/29 to 9/7	2F, 2S	6/27 to 9/5	2F, 2S	6/30 to 9/5	2F, 2S	7/1 to 9/5		
Sunshine Station	80	4F, 2S	6/23 to 9/15	4F, 2S	6/4 to10/1	4F	6/3 to 9/11	4F	6/4 to 9/10	4F	6/3 to 9/10
Talkeetna Station	103	4F, 2S	6/22 to 9/15	4F, 2S	6/5 to 9/14	4F	6/7 to 9/12	4F	6/3 to 9/11		
Curry Station	120	2F	6/15 to 9/21	2F	6/9 to 9/18	2F	6/9 to 9/14	2F	6/9 to 9/14	2F	6/10 to 9/12

Table 3.1-4. Designated Fish Habitat Sites surveyed June through September 1982. Source: Estes and Schmidt (1983).

Reach	Site	River Mile
Lower River	GOOSE CREEK 2 AND SIDE CHANNEL	73.1
	WHITEFISH SLOUGH	78.7
	RABIDEUX CREEK AND SLOUGH	83.1
	SUNSHINE CREEK AND SIDE CHANNEL	85.7
	BIRCH CREEK AND SLOUGH	88.4
Middle River	WHISKERS CREEK AND SLOUGH	101.2
	SLOUGH 6A	112.3
	LANE CREEK AND SLOUGH 8	113.6
	SLOUGH 8A	125.3
	SLOUGH 9	129.2
	4th OF JULY CREEK-MOUTH	131.1
	SLOUGH 11	135.3
	INDIAN RIVER—MOUTH	138.6
	SLOUGH 19	140.0
	SLOUGH 20	140.1
	SLOUGH 21	142.0
	PORTAGE CREEK-MOUTH	148.8

Table 3.1-5. Description of habitat zones sampled at Designated Fish Habitat Sites: June through September 1982 (From Estes and Schmidt 1983).

Zone Code	Description
1	Areas with a tributary or ground water source which are not influenced by mainstem stage and which usually have a significant[1] surface water velocity.
2	Areas with a tributary or ground water source which have no appreciable[1] surface water velocity as a result of a hydraulic barrier created at the mouth of a tributary or slough by mainstem stage.
3	Areas of significant surface water velocities, primarily influenced by the mainstem, where tributary or slough water mixes with the mainstem water.
4	Areas of significant water surface velocities which are located in a slough or side channel above a tributary confluence (or in a slough where no tributary is present) when the slough head is open.
5	Areas of significant water surface velocities which are located in at slough or side channel below a tributary confluence when the slough head is open.
6	Backwater areas with no appreciable surface water velocities which result from a hydraulic barrier created by mainstem stage which occur in a slough or side channel above a tributary confluence (or in a slough or side channel where no tributary is present), when the head of the slough is open.
7	Backwater areas with no appreciable surface water velocities which result from a hydraulic barrier created by mainstem stage which occur in a slough or side channel below a tributary confluence, when the head of the slough is open.
8	Backwater areas consisting of mainstem eddies.
9	A pool with no appreciable surface water surface velocities which is created by a geomorphological feature of a free-flowing zone or from a hydraulic barrier created by a tributary; not created as a result of mainstem stage.

Notes:

1 "Significant" and "appreciable" surface water velocities mean a velocity of at least 0.5 ft/sec. However, there are site-specific exceptions to this, based on local morphology.

Table 3.1-6. Aggregate Hydraulic (H), Water Source (W) and Velocity (V) zones. Source: Estes and Schmidt (1983), Schmidt et al. (1983).

Aggregate Zone	Habitat Zone Included	Definition
H-I	1, 4, 5, 9	not backed up by mainstem
H-II	2, 6, 7, 8	backed up by mainstem
H-III	3	mainstem
W-I	1, 2	tributary water and/or ground water only
W-II	4, 6, 8, sometimes 3	mainstem water only
W-III	5, 7, sometimes 3	mixed water sources
V-I[1]	1, 3, 4, 5	Fast water
V-II[1]	2, 6, 7, 8, 9	Slow water

Notes:

1 The habitat zones included in aggregate zones V-I and V-II were not provided in the source documents. Zone descriptions were used to classify which zones were fast and slow water.

Table 3.1-7. JAHS sample sites for the AJ and AH components of the Aquatic Studies Program during 1983 and 1984.

Site	River Mile	Macro-habitat Type[2]	1983/1984 Sampling[1]			1982 DFH Site	1982 SFH Site	1981 Sample Site
			Fish Distri-bution Site	RJHAB Modeling Site	IFIM Modeling Site			
Eagles Nest Side Channel[3]	36.2	SC	X	X				
Hooligan Side Channel[3]	36.2	SC	X	X				
Kroto Slough Head	36.3	SS	X	X				
Rolly Creek Mouth	39.0	T	X	X			X	
Bear Bait Side Channel	42.9	SC	X	X				
Last Chance Side Channel	44.4	SC	X	X				
Rustic Wilderness Side Channel	59.5	SC	X	X				
Caswell Creek Mouth[3]	63.0	T	X	X			X	X
Island Side Channel	63.2	SC	X	X	X			
Mainstem West Bank	74.4	SC	X		X			
Goose 2 Side Channel	74.8	SC	X	X		X		
Circular Side Channel	75.3	SC	X		X			
Sauna Side Channel	79.8	SC	X		X			
Sucker Side Channel[3]	84.8	SC	X	X				
Beaver Dam Slough[3]	86.3	T	X	X				
Beaver Dam Side Channel[3]	86.3	SC	X	X				
Sunset Side Channel[3]	86.9	SC	X		X			
Sunrise Side Channel[3]	87.0	SC	X	X				
Birch Slough[3]	89.4	T	X	X		X		X
Trapper Creek Side Channel	91.6	SC	X	X	X			
Whiskers Creek Slough	101.2	SS/SC	X	X		X		X
Whiskers Creek[4]	101.2	T	X			X		X
Slough 3B	101.4	SS	X					
Mainstem at head of Whiskers Creek Slough[4]	101.4	SC	X					
Chase Creek	106.9	T	X				X	
Slough 5	107.6	US	X	X				
Oxbow I	110.0	SC/SS	X					
Slough 6A	112.3	US	X	X		X		X
Mainstem above Slough 6A[4]	112.4	SC	X					
Lane Creek[4]	113.6	T	X			X		X
Slough 8	113.6	SS	X	X		X		
Mainstem II	114.4	SC/SS	X					X
Lower McKenzie Creek[4]	116.2	T	X				X	
Upper McKenzie Creek[4]	116.7	T	X				X	
Side Channel below Curry[4]	117.8	SC	X					
Oxbow II[4]	119.3	SC/SS	X					
Slough 8A	125.3	SS	X		X	X		
Side Channel 10A	127.1	SC	X	X				
Slough 9	129.2	SS/SC	X		X	X		
Slough/Side Channel 10	133.8	SC/SS	X		X		X	X
Lower Side Channel 11[4]	134.6	SC	X		X			
Slough 11	135.3	SS	X			X		X
Upper Side Channel 11[4]	136.2	SC	X		X			
Indian River - Mouth	138.6	T	X			X		X
Indian River-TRM 10.1	138.6	T	X					
Slough 19[4]	140.0	US	X			X		

Site	River Mile	Macro-habitat Type[2]	1983/1984 Sampling[1] Fish Distri-bution Site	RJHAB Modeling Site	IFIM Modeling Site	1982 DFH Site	1982 SFH Site	1981 Sample Site
Slough 20[4]	140.1	SS/SC	X			X		X
Side Channel 21	140.6	SC			X			
Slough 21	142.0	SS/SC			X	X		
Slough 22	144.3	SS/SC	X	X				
Jack Long Creek[4]	144.5	T	X				X	
Portage Creek Mouth	148.8	T	X			X		X
Portage Creek TRM 4.2	148.8	T	X					
Portage Creek TRM 8.0	148.8	T	X					

Notes:

1 Sites from RM 36.2 to RM 91.6 were sampled in 1984 (Suchanek et al. 1985). Sites from RM 101.2 to 148.8 were sampled in 1983 (Dugan et al. 1984).

2 T – Tributary
US - Upland Slough
SS - Side Slough
SC - Side Channel

3 Located within representative side channel or slough complexes mapped by Ashton & Klinger (1985).

4 Sites sampled less than 3 times in 1983.

Table 4.1-1. Characteristics of tributaries upstream of the proposed Devils Canyon Dam as configured in the 1980s project. Source: Sautner and Stratton (1983).

Stream	RM	Elev. at Mouth	Inundated Reach[1] Len (mi)	Inundated Reach[1] Grad (%)	Ave Width (ft)	Ave Depth (ft)	Channel types	Substrate	Barriers
Cheechako	152.4	920	1.7	6.1%	20 to 30	2 to 4	rapids and waterfalls with few pools	large boulder and cobble	
Chinook	157.0	1065	1.3	5.8%	20 to 30	2 to 4	rapids and waterfalls with few pools	large boulder and small cobble	
Devil	161.4	1200	1.5	3.3%	30 to 40	2 to 4	rapids and large deep pools	large boulder and cobble with smaller rubble and gravel in pools	TRM 2.1
Fog	176.7	1375	1.3	1.4%	50 to 75	2 to 3	riffles with few pools, some braiding near mouth	rubble and cobble	Potential at TRM 2.7
Tsusena	181.3	1435	0.4	1.6%	75 to 100	2 to 3	shallow riffles with few small pools	large cobble and boulder embedded in sand, small gravel in pools	TRM 3.1
Deadman	186.7	1515	2.7	4.8%	75 to 100	3 to 5	rapids with few pools	Large boulder and cobble	TRM 0.6
Watana	194.1	1550	8.5	1.1%	40 to 60	2 to 4	pool-riffle	Gravel and rubble embedded in sand in moderate to slow water, cobble and boulder in faster water	
EF Watana		2060	1.2	2.1%	30 to 50	2 to 3	riffle with some small waterfalls and pools		potential at TRM 9.4
WF Watana		2060	2.1	1.3%	30 to 50	2 to 3	riffle with few pools		
Kosina	206.8	1670	4.5	2.2%	200+	3 to 5	riffle-pool, braided in sections	cobble and boulder in riffles; cobble, rubble and boulder embedded in sand in pools	
Jay	208.5	1695	3.5	2.7%	40 to 60	2 to 3	riffle-pool	gravel, cobble, and rubble often embedded in sand	potential at TRM 3.8
Goose	231.3	2060	1.2	2.2%	30 to 50	2 to 3	riffle-pool with some braiding in upper reaches	rubble, cobble, and boulder in riffles, gravel and rubble in slower water	
Oshetna	233.4	2110	2.2	0.8%	100 to 125	3 to 5	meandering riffles	cobble and boulder in riffles, and rubble and gravel in slower water	

Notes:

1 The inundation elevation as proposed during the 1980s was 2200.5 feet mean sea level for Watana Reservoir and 1466 feet msl for the Devils Canyon Reservoir.

Table 4.2-1. Black and white aerial photography available for the characterization of aquatic habitat during the 1980s. Discharge as measured at the USGS Gold Creek gage. Source: Aaserude et al. (1985).

Mainstem Discharge (cfs)	Date	Scale	Comments
1500 – 2000	March 1983	1 inch = 1,000 ft	Ice cover
5,100	October 14, 1984	1 inch = 250 ft	Open water
7,400	October 4, 1984	1 inch = 250 ft	Open water
9,000	October 8, 1983	1 inch = 1,000 ft	Some ice present
10,600	September 9, 1984	1 inch = 250 ft	Open water
12,500	September 11, 1983	1 inch = 1,000 ft	Open water
16,000	September 6, 1983	1 inch = 1,000 ft	Open water
18,000	August 20, 1980	1 inch = 1,000 ft	Open water
23,000	June 1, 1982	1 inch = 1,000 ft	Open water
26,900	August 27, 1984	1 inch = 1,000 ft	Open water

Table 4.3-1. Representative areas delineated by habitat type. Source: Ashton and Klinger-Kingsley (1985).

Representative Area Name	River Miles Included
Side Channel IV	32.5 - 36.0
Willow Creek (Side Channel III-1)	49.0 - 52.0
Caswell Creek	64.0
Sheep Creek	66.1
Goose Creek (Side Channel II-4)	68.5 - 72.5
Montana Creek (Side Channel II-1)	77.0 - 78.0
Sunshine Slough (Side Channel I-5)	84.0 - 86.5
Birch Creek Slough	88.5 - 93.0

Table 5.1-1. Information from Buckwalter (2011) Synopsis of ADF&G's Upper Susitna Drainage Fish Inventory, August 2011.

Stream	River Mile	Date	Lifestage	Number of Fish	Method	Reference
Above Devils Canyon (RM 152)						
Fog Creek	176.7	8/1/2003	adults	2	helicopter/foot	Buckwalter 2011, AWC Survey ID: FSS03USU01
Tsusena Creek	181.3	8/1/2003	adults	1	helicopter/foot	Buckwalter 2011, AWC Survey ID: FSS03USU02
Fog Creek	176.7	8/13/2003	juveniles	5	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0305A01
Fog Creek Trib	176.7	8/6/2011	juveniles	8	electrofishing	Buckwalter 2011, AWC Survey ID: FSS1104c01
Fog Creek	176.7	8/6/2011	redds			Survey ID: FSS1104B01
Above Watana Dam Site (RM 184)						
Kosina Creek	201	8/14/2003	juveniles	1	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0306A01
Oshetna River	225	8/14/2003	juveniles	3	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0306A05
Kosina Creek	201	8/15/2003	juveniles	2	electrofishing	Buckwalter 2011, AWC Survey ID: FSS0307A06
Kosina Creek	201	7/27/2011	adults	1	helicopter/foot	Buckwalter 2011, Survey ID: FSS1101G04

Table 5.1-2. Chinook salmon escapement survey results from 1982 to 1985 upstream of RM 152. Surveys conducted by helicopter.

Stream	1982				1983				1984				1985			
	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page	# Flights	Date of Peak Count	Peak Count	APA Source/PDF Page
Cheechako Cr	9	6-Aug	16	589/314	2	1-Aug	25	1450/111	7	1-Aug	29	2748/60, 506	11	24-Jul	18	3412/127
Chinook Cr	5	6-Aug	5	589/314	2	1-Aug	8	1450/111	7	1-Aug	15	2748/60, 506	11	23-Aug	1	3412/128
Devil Cr	5		0	589/314	1	1-Aug	1	1450/111	6		0	2748/60, 506	11		0	3412/128
Fog Cr	0			2748/60	0			2748/60	4	21-Jul	2	2748/60, 506	3		0	3412/128
Bear Cr	0				0			2748/151	4		0	2748/506	3		0	3412/128
Tsusena Cr	0				0			2748/151	4		0	2748/507	3		0	3412/128
Deadman Cr	0				0				3		0	2748/507	0			
Watana Cr	0				0				2		0	2748/507	0			

Table 5.2-1. Peak sockeye spawner counts (live plus dead) at sloughs located in the Middle Susitna River during 1981 to 1985. Source Jennings (1985), Thompson et al. (1986).

Slough	RM	Peak Counts						Average Percent Contribution
		1981	1982	1983	1984	1985	Average	
Slough 1	99.6	0	0	0	10	0	2	0.2%
Slough 2	100.2	0	0	0	7	0	1.4	0.2%
Slough 3B	101.4	1	0	5	20	0	5.2	0.6%
Slough 3A	101.9	7	0	0	11	0	3.6	0.4%
Slough 5	107.6	0	0	0	1	0	0.2	0.0%
Slough 6A	112.3	1	0	0	0	1	0.4	0.0%
Slough 8	113.7	0	0	0	2	0	0.4	0.0%
Bushrod	117.8	0	0	0	0	1	0.2	0.0%
Slough 8C	121.9	0	2	0	0	1	0.6	0.1%
Slough 8B	122.2	0	5	0	1	2	1.6	0.2%
Moose	123.5	0	8	22	8	0	7.6	0.9%
Slough 8A	125.1	177	68	66	128	165	120.8	14.2%
Slough B	126.3	0	8	2	9	5	4.8	0.6%
Slough 9	128.3	10	5	2	6	0	4.6	0.5%
Slough 9B	129.2	81	1	0	7	0	17.8	2.1%
Slough 9A	133.8	2	1	1	0	0	0.8	0.1%
Slough 10	133.8	0	0	1	0	0	0.2	0.0%
Slough 11	135.3	893	456	248	564	694	571	67.1%
Slough 15	137.2	0	0	0	1	0	0.2	0.0%
Slough 17	138.9	6	0	6	16	0	5.6	0.7%
Slough 19	139.7	23	0	5	11	1	8	0.9%
Slough 20	140.1	2	0	0	0	0	0.4	0.0%
Slough 21	141.1	38	53	197	122	53	92.6	10.9%
Slough 22	144.5	0	0	0	2	0	0.4	0.0%
Total		1241	607	555	926	923	850.4	100%

Table 6.2-1. Linear regression statistics for predicting the development of chum and sockeye eggs based upon average incubation temperature. All equations were significant at p<0.001 and r-0.99. Source: Wagaard and Burger (1983).

Species	Life Stage	Slope	Intercept
Chum	50% Hatch	1.40	3.23
	100% Yolk Absorption	0.59	2.25
Sockeye	50% Hatch	0.15	3.71
	100% Yolk Absorption	0.14	2.61

Table 7.1-1. Periodicity of juvenile Chinook salmon presence in the Susitna River. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use. Source: Schmidt and Bingham (1983), ADF&G (1983), Schmidt et al. (1984), Jennings (1985), Trihey and Associates and Entrix (1985), Roth et al. (1986), Stratton (1986).

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon	Incubation												
	Fry Emergence												
	Rearing (0+)												
	Rearing (1+)												
	Juvenile Migration (0+)												
	Juvenile Migration (1+)												

Peak Use Off-Peak Use

Table 7.2-1. Periodicity of second run sockeye salmon presence in the middle Susitna River, between the Chulitna River confluence (RM 98.5) and Devils Canyon (RM 152), by life history stage. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sockeye Salmon[1,2]	Incubation												
	Fry Emergence												
	Rearing (0+)												
	Rearing (1+)												
	Juvenile Migration (0+)												
	Juvenile Migration (1+)												

Peak Use Off-Peak Use

Table 7.3-1. Periodicity of juvenile chum salmon presence in the Susitna River. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chum Salmon	Incubation												
	Fry Emergence												
	Rearing (0+)												
	Juvenile Migration (0+)												

Peak Use Off-Peak Use

Table 7.4-1. Periodicity of juvenile coho salmon in the Susitna River by life history stage. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coho Salmon	Incubation												
	Fry Emergence												
	Rearing (0+)												
	Rearing (1+)												
	Rearing (2+)												
	Juvenile Migration (0+)												
	Juvenile Migration (1+)												
	Juvenile Migration (2+)												

Peak Use Off-Peak Use

Table 7.5-1. Periodicity of juvenile pink salmon presence in the Susitna River by life history stage. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pink Salmon[3]	Incubation												
	Fry Emergence												
	Juvenile Migration (0+)												

Peak Use Off-Peak Use

Table 8.1-1. Fish community in the Susitna River drainage. Source: Jennings (1985), Delaney et al. (1981).

Common Name	Scientific Name	Susitna River Segment				Tributaries	Lakes
		Lower	Middle River[1]		Upper		
			Lower	Upper			
Arctic grayling	*Thymallus arcticus*	X	X	X	X	X	
Dolly Varden	*Salvelinus malma*	X	X	X	X	X	
Humpback whitefish	*Coregonus pidschian*	X	X		X		
Round whitefish	*Prosopium cylindraceum*	X	X	X	X	X	
Burbot	*Lota lota*	X	X	X	X		
Longnose sucker	*Catostomus catostomus*	X	X	X	X	X	
Sculpin[2]	*Cottid*	X	X	X	X	X	
Eulachon	*Thaleichthys pacificus*	X					
Bering cisco	*Coregonus laurettae*	X					
Threespine stickleback	*Gasterosteus aculeatus*	X	X			X	
Ninespine stickleback	*Pungitius pungitius*	X					
Arctic lamprey	*Lethenteron japonicum*	X	X			X	
Chinook salmon	*Oncorhynchus tshawytscha*	X	X	X	X	X	
Coho salmon	*Oncorhynchus kisutch*	X	X			X	
Chum salmon	*Oncorhynchus keta*	X	X			X	
Pink salmon	*Oncorhynchus gorbuscha*	X	X			X	
Sockeye salmon	*Oncorhynchus nerka*	X	X			X	
Rainbow trout	*Oncorhynchus mykiss*	X	X			X	
Northern pike	*Esox lucius*	X	?			X	X
Lake trout	*Salvelinus namaycush*					X	X

Notes:

1 The Lower Middle River is from the confluence of the Chulitna River to Devils Canyon. Upper Middle River is from Devils Creek to the proposed Watana Dam Site.

2 Sculpin primarily include slimy sculpin (C. cognatus), but may also include coastrange sculpin (C. aleuticus), sharpnose sculpin (C. acuticeps), Pacific staghorn sculpin (Leptocottus armatus) and possibly others.

Table 8.1-2. Level of fishing effort at 17 DFH sites in the Lower and Middle Susitna River segments from June to September 1982. Data Source: Schmidt et al. (1983).

DFH Location	Boat Electrofishing		BP Electrofishing		Beach Seine		Minnow Trap		Trotline	
	Mean Eff (mins)	Sampling Events	Mean Eff (mins)	Sampling Events	Mean Eff (hauls)	Sampling Events	Mean Eff (traps)	Sampling Events	Mean Eff (lines)	Sampling Events
4th of July Creek-Mouth	18.1	6	23.3	3	1.0	4	16.0	8	2.0	7
Birch Creek and Slough	24.0	5	23.0	3	2.3	6	23.5	8	2.9	8
Goose Creek 2 and Side Channel	12.7	5	10.6	3	2.3	8	21.0	8	3.0	8
Indian River-Mouth	28.8	6	2.9	2	1.0	3	15.0	8	2.1	8
Lane Creek and Slough 8	17.3	8	8.1	5	1.1	7	20.3	8	2.9	8
Portage Creek	23.3	6		0		0	13.7	6	2.0	6
Rabideaux Creek and Slough	37.2	4	2.3	1	1.5	4	22.2	6	2.7	6
Slough 11	14.1	3	2.2	3	2.3	4	21.8	8	2.8	8
Slough 19	13.0	1	2.5	4	1.2	5	14.1	8	2.0	8
Slough 20	9.6	5	2.7	4	1.8	4	17.0	8	2.3	8
Slough 21	15.5	2	8.2	4	1.8	4	18.6	8	2.5	8
Slough 6a	17.1	3	11.4	1	1.4	7	14.0	8	2.0	8
Slough 8a	13.0	6	28.8	3	1.7	7	21.0	8	3.0	8
Slough 9	13.0	1	6.4	4	1.4	7	16.4	8	2.3	8
Sunshine Creek and Side Channel	17.9	5	8.2	2	1.8	4	16.5	8	2.5	8
Whiskers Creek and Slough	24.8	6	14.8	2	2.3	6	25.3	8	3.4	8
Whitefish Slough	13.2	5		0	1.0	5	9.6	7	2.0	5

Table 8.1-2. Continued.

DFH Location	Dip Net		Fish Trap		Hoop Net		Set Gillnet		Hook and Line	
	Mean Eff (nets)	Sampling Events	Mean Eff (traps)	Sampling Events	Mean Eff (nets)	Sampling Events	Mean Eff (nets)	Sampling Events	Mean Eff (hrs)	Sampling Events
4th of July Creek-Mouth		0		0		0		0	3.2	5
Birch Creek and Slough	1.7	3		0	1.0	2		0		0
Goose Creek 2 and Side Channel		0		0		0		0		0
Indian River-Mouth	1.0	1		0		0		0	2.0	1
Lane Creek and Slough 8	1.0	2	3.0	1		0		0	1.0	1
Portage Creek		0		0		0		0	1.7	3
Rabideaux Creek and Slough	1.0	4		0		0		0		0
Slough 11		0	3.0	1		0	2.0	1		0
Slough 19	1.0	4		0		0		0		0
Slough 20		0		0		0		0		0
Slough 21	1.0	1		0		0		0		0
Slough 6a	1.0	1	2.0	1	1.0	1		0		0
Slough 8a	1.3	3		0		0	2.0	2		0
Slough 9		0		0		0		0		0
Sunshine Creek and Side Channel		0		0		0		0	0.4	1
Whiskers Creek and Slough	1.0	2		0		0		0	2.0	1
Whitefish Slough	1.0	2		0	1.0	1	1.0	1		0

Table 8.2-1. Estimated Arctic grayling population sizes in tributaries to the upper Susitna River during 1981 and 1982. Source: Delaney et al. (1981b), Sautner and Stratton (1983).

Stream	1981[1]		1982[1]	
	Point Estimate (fish)	95% Confidence Interval (fish)	Point Estimate (fish)	Point Estimate (fish/mile)
Oshetna River	2,017	1,525 - 2,976	2,426	1,103
Goose Creek	1,327	1,016 - 1,913	949	791
Jay Creek	1,089	868 - 1,462	1,592	455
Kosina Creek	2,787	2,228 - 3,720	5,544	1,232
Deadman Creek	979	604 - 2,575	734	1,835
Tsusena Creek	1,000	743 - 1,530		
Fog Creek	176	115 - 369		440
Watana Creek			3,925	324
Upper Susitna River	10,279	9,194 - 11,654	16,346[2]	

Notes:

1 Fish densities were not reported for 1981. Confidence intervals were not reported for 1982.

2 Total of point estimates from 1982 plus 1981 point estimates for Tsusena and Fog creeks.

Table 9.1-1. Tributaries evaluated for passage by adult salmon. Source: Trihey (1983), Ashton and Trihey (1985).

Tributary	River Mile	Gradient
Alexander Creek	9.1	Low
Deshka River	40.6	Low
Willow Creek	49.1	Steep
Little Willow Creek	50.5	Steep
Kashwitna River	61.0	Steep
Caswell Creek	64.0	Low
Sheep Creek	66.1	Low
Goose Creek	72.0	Steep
Montana Creek	77.0	Steep
Rabideaux Creek	83.1	Low
Sunshine Creek	85.1	Low
Birch Creek	89.2	Low
Trapper Creek	91.5	Low
Indian River	138.7	-
Portage Creek	148.9	-

14. FIGURES

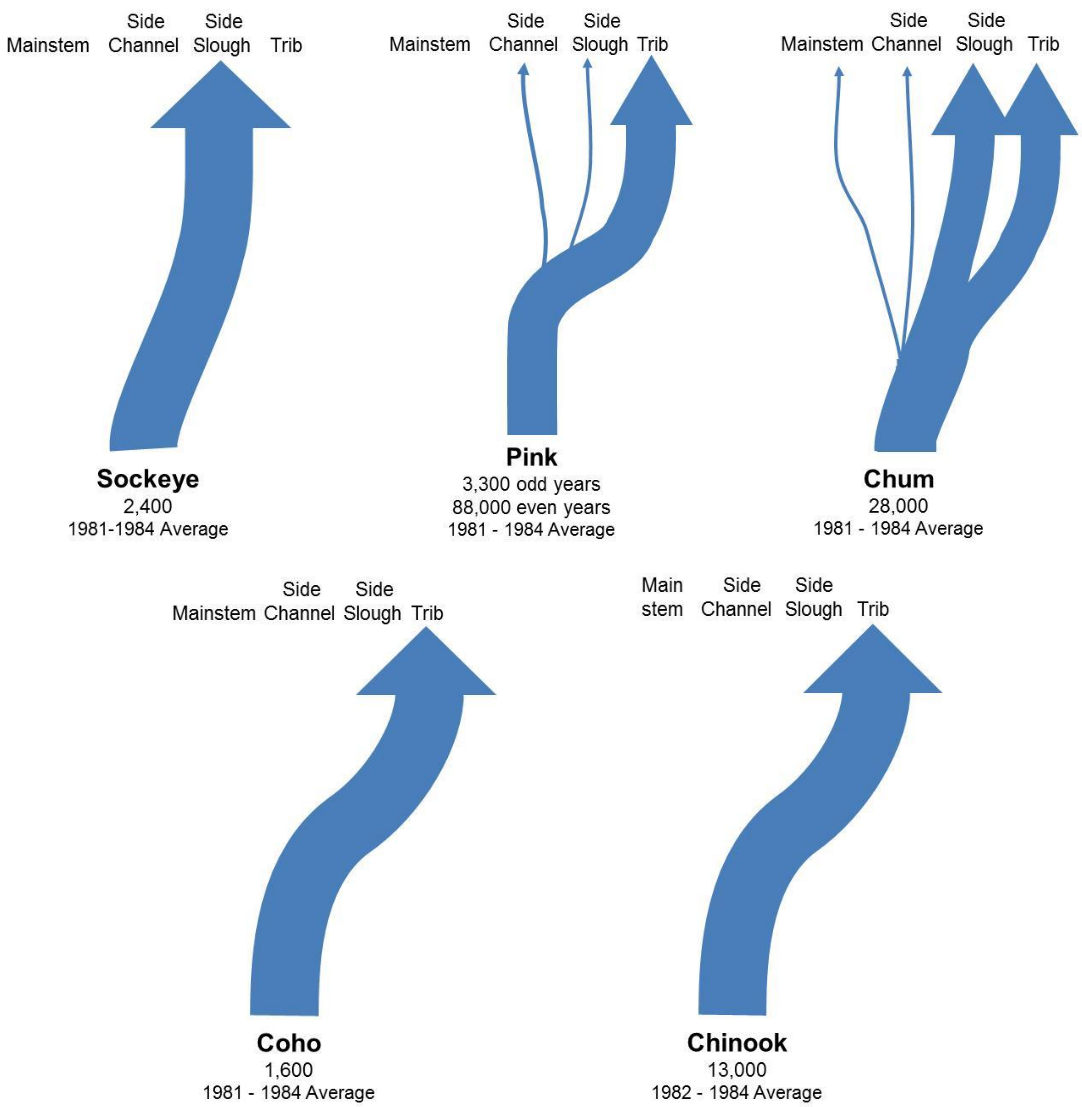


Figure. S-1. Spawning habitat utilization by anadromous salmon species and average run size in the middle Susitna River. Large arrows indicate primary spawning habitat and thin arrows indicate secondary spawning habitat. Source: Trihey and Entrix (1985) as modified from Sautner et al. (1984). Run size information from Barrett et al. (1985).

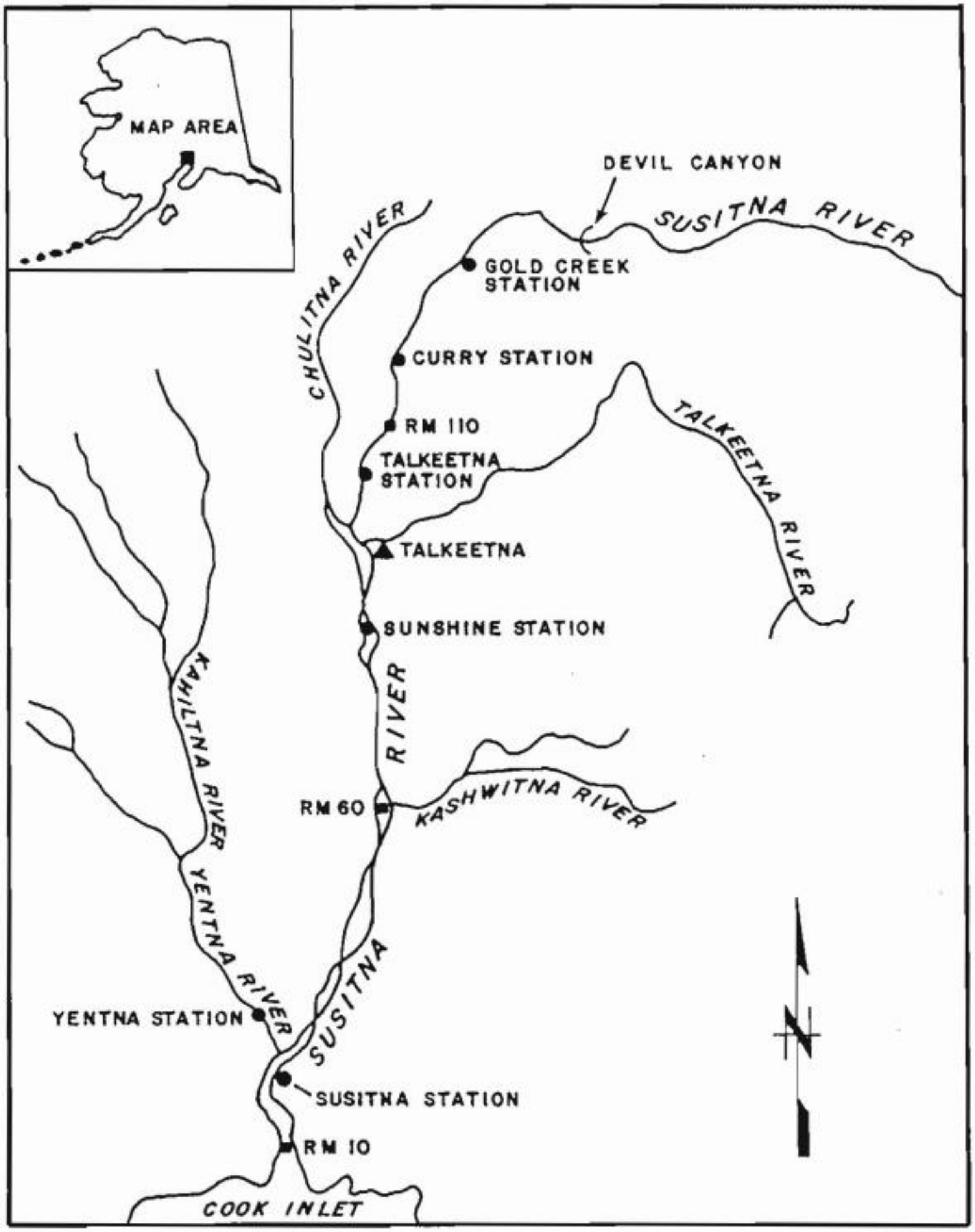


Figure 2.1-1. Susitna River basin map showing field stations and major glacial streams. Source: ADF&G (1983).

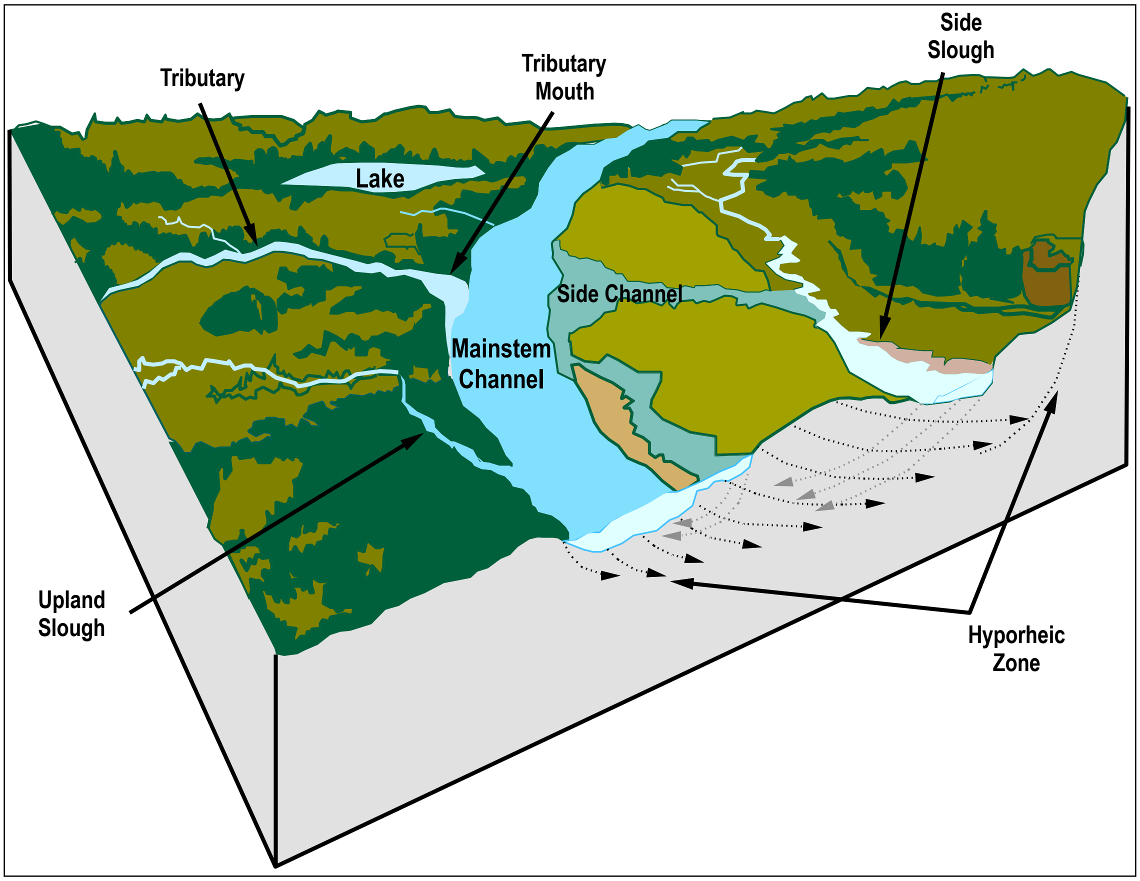


Figure 3.1-1. Habitat types identified in the middle reach of the Susitna River during the 1980s studies (adapted from ADF&G 1983; Trihey 1982).

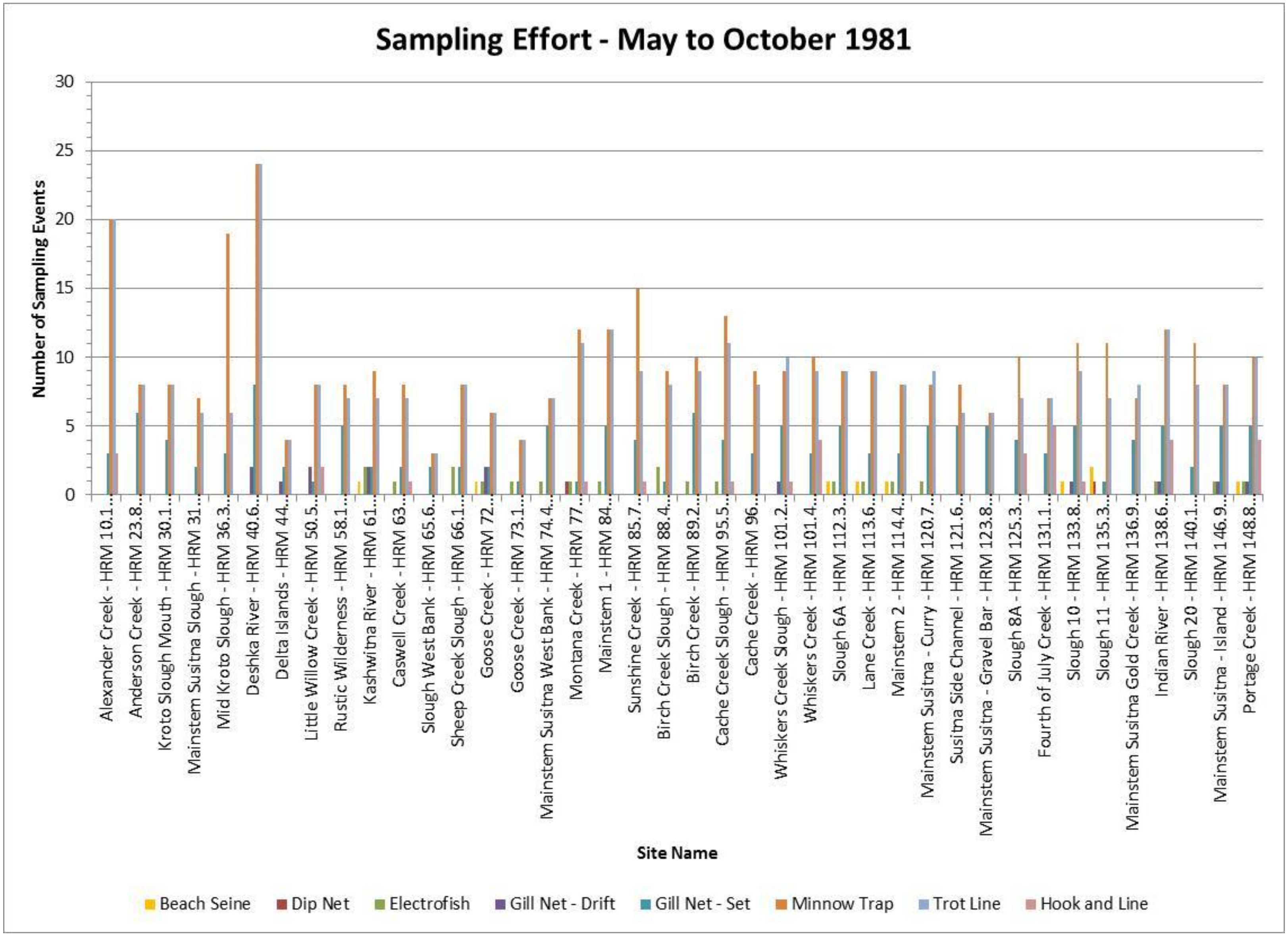


Figure 3.1-2. Sampling effort at 39 habitat locations sites from May to mid-October 1981. Source: Delaney et al. (1981).

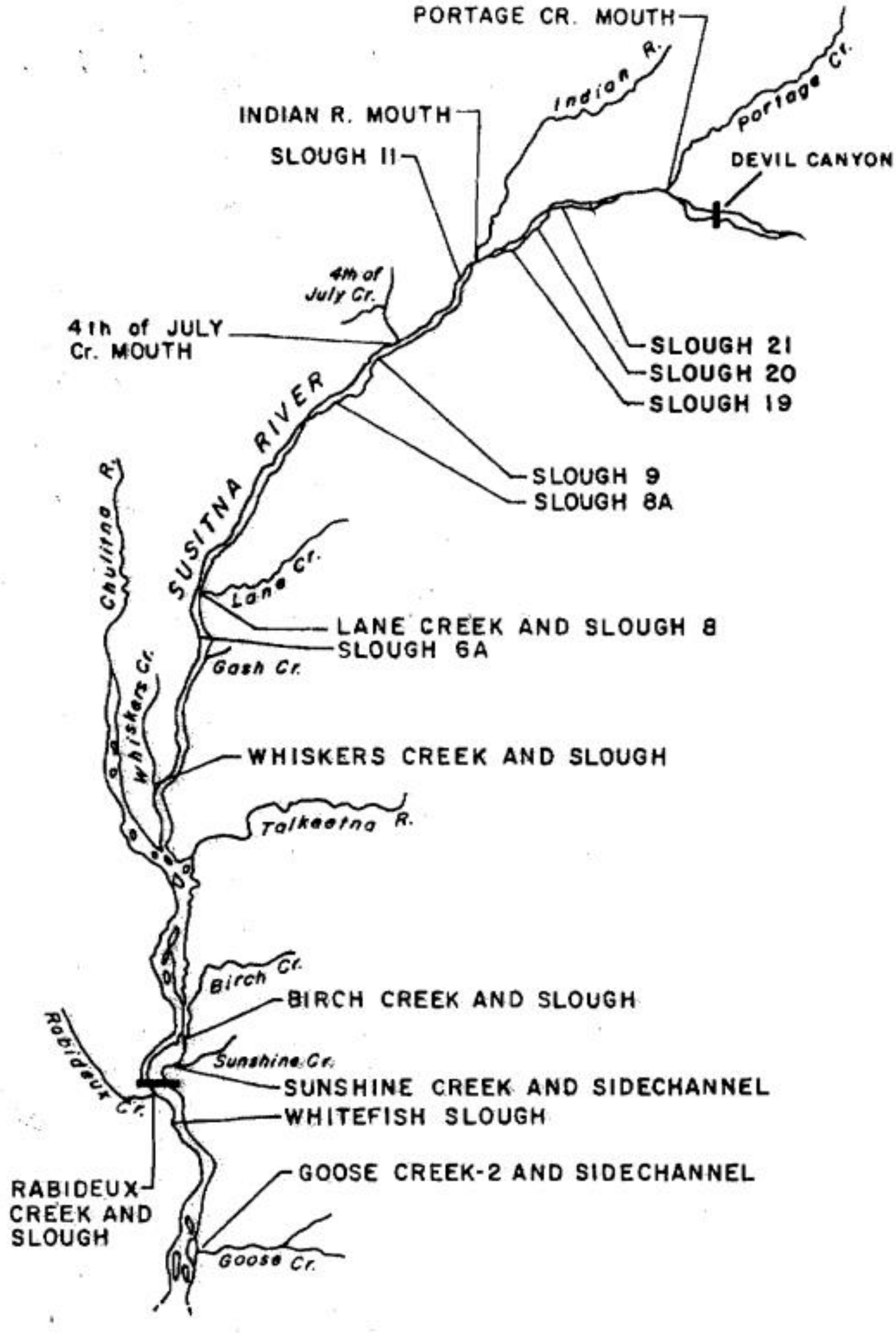


Figure 3.1-3. Map of Designated Fish Habitat (DFH) sites sampled on the Susitna River, June through September 1982. Source: Schmidt et al. (1983).

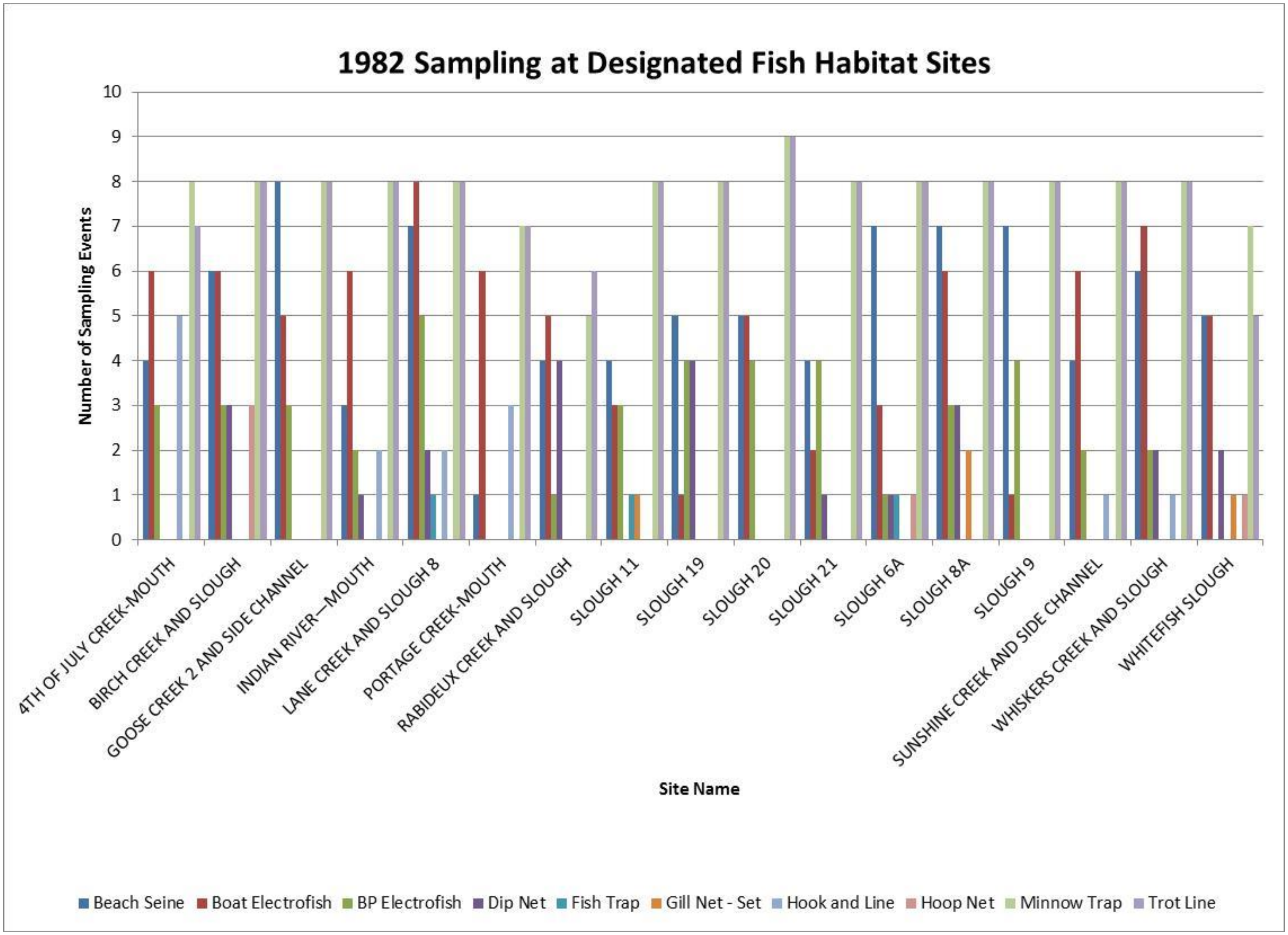


Figure 3.1-4. Sampling effort at 17 DFH sites during the 1982 open water season. Source: Schmidt et al. (1983).

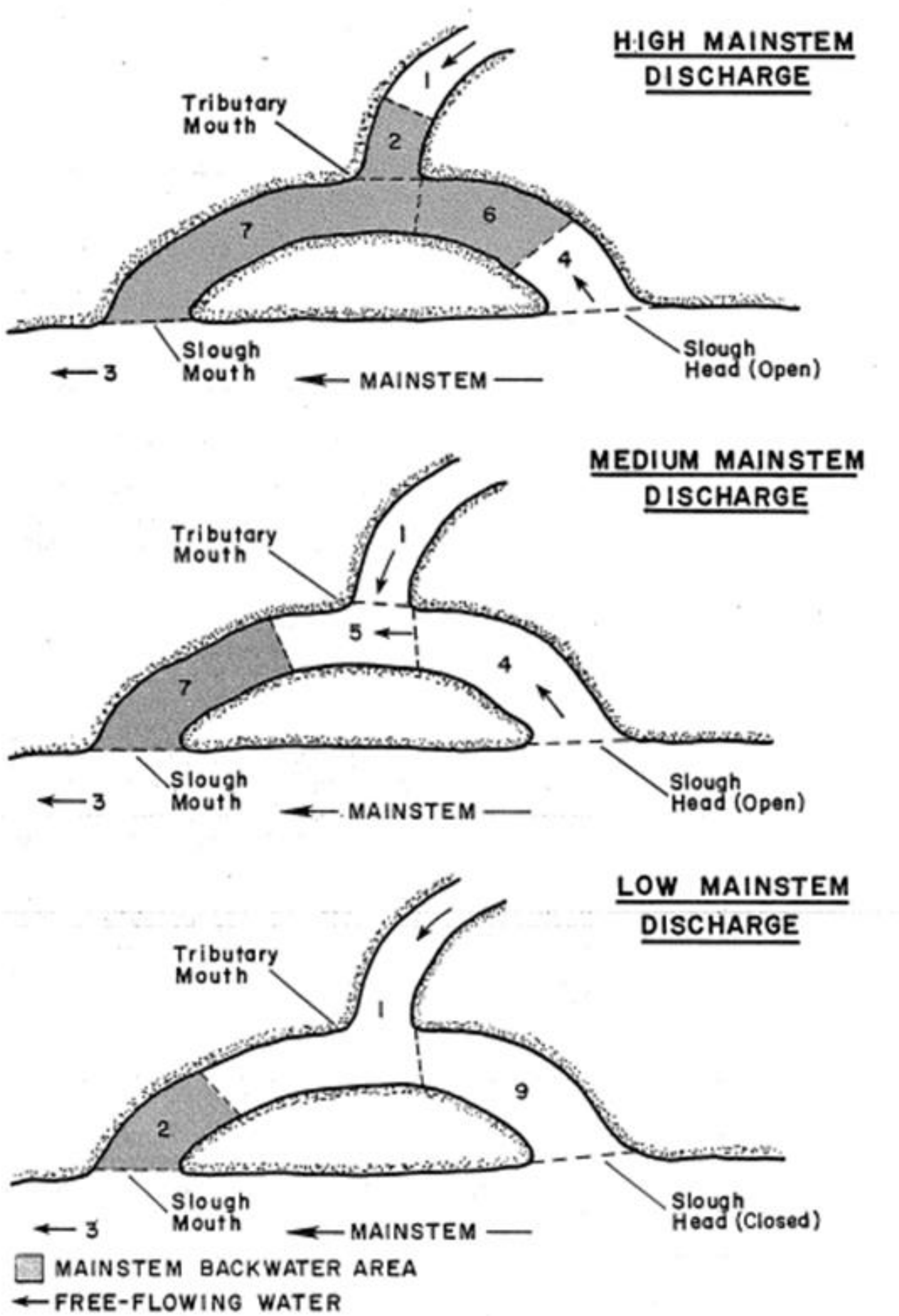


Figure 3.1-5. Hypothetical slough with delineated habitat zones. Source: Estes and Schmidt (1983).

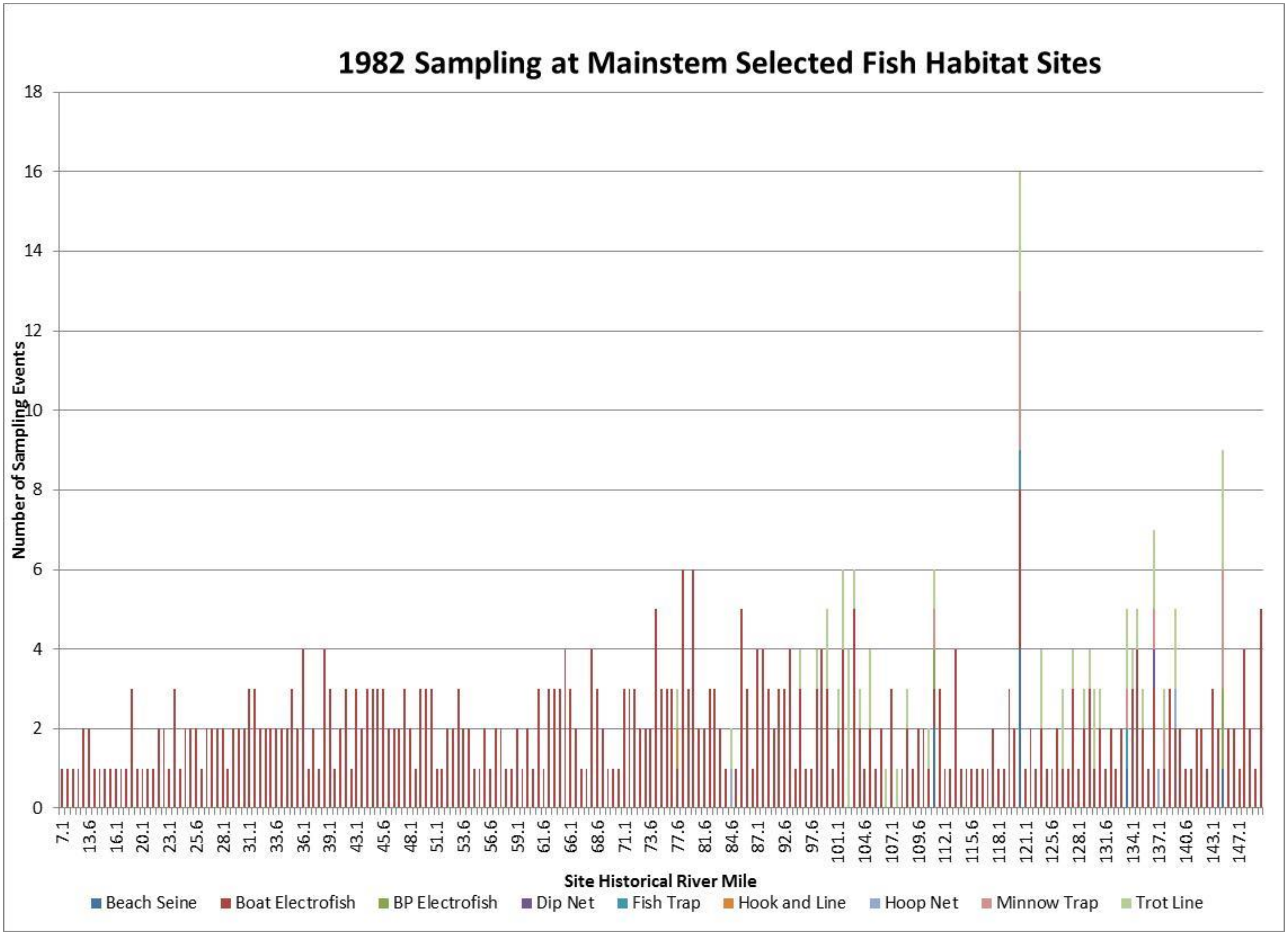


Figure 3.1-6. Sampling effort at 225 mainstem Selected Fish Habitat sites during 1982. Data Source: Schmidt et al. (1983).

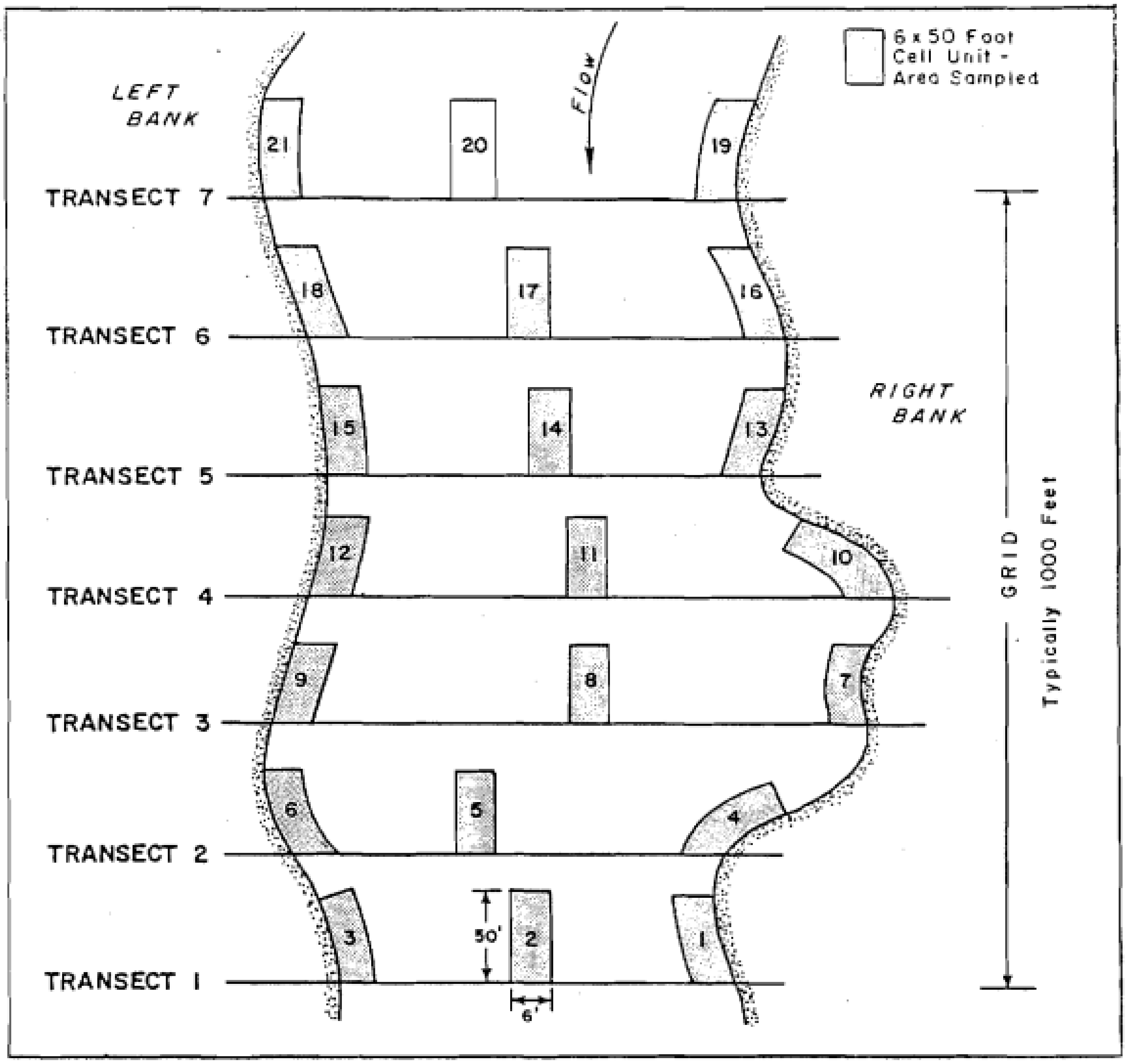


Figure 3.1-7. Typical arrangement of transects, grids, and cells at a JAHS site. Source: Dugan et al. (1984).

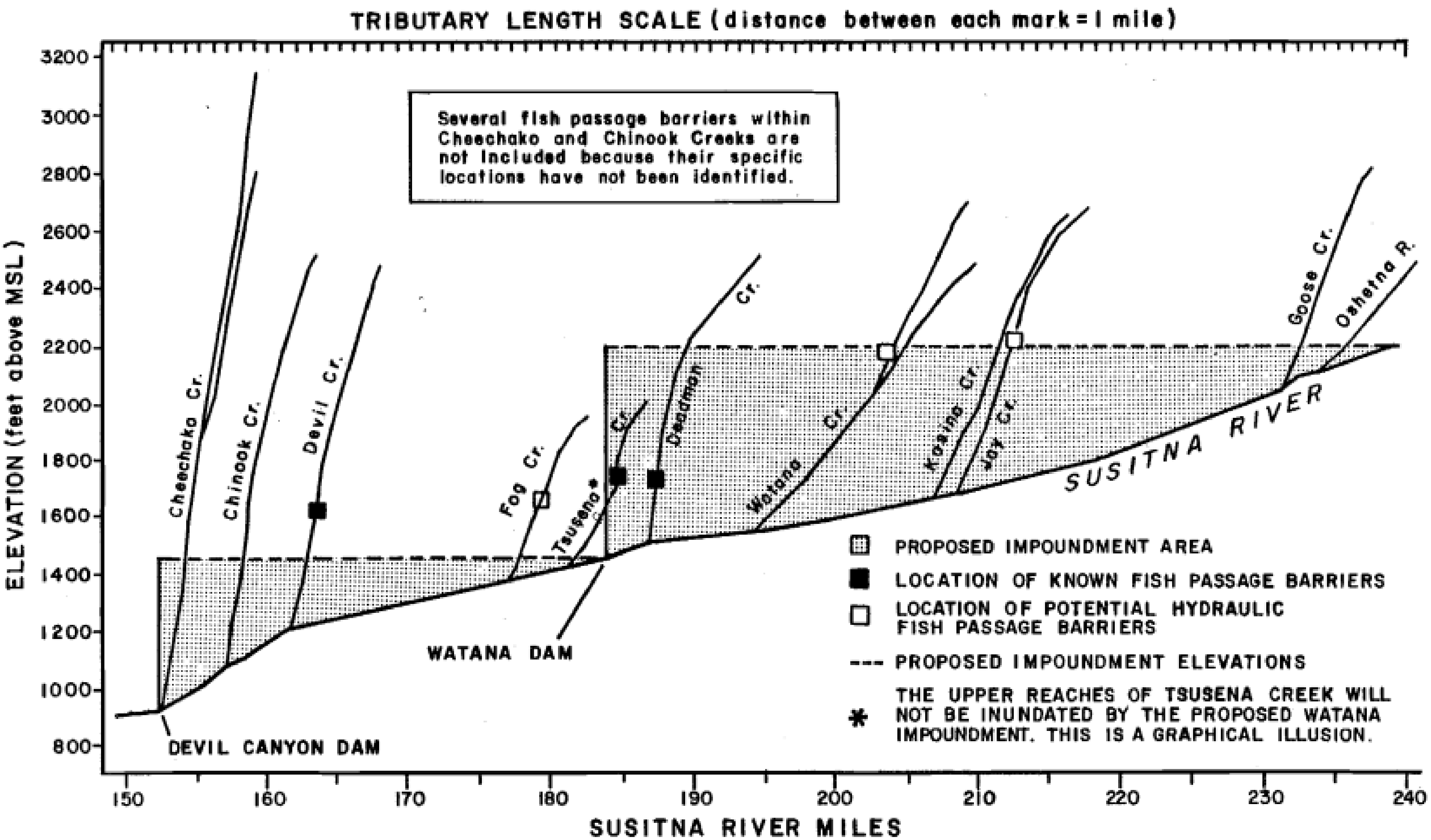


Figure 4.1-1. Gradient profile of the Susitna River and the major tributaries within the impoundment areas of the proposed 1980 project. Profile includes the five mile reach of each tributary immediately above the proposed impoundment elevation and identifies known. Source: Sautner and Stratton (1983).

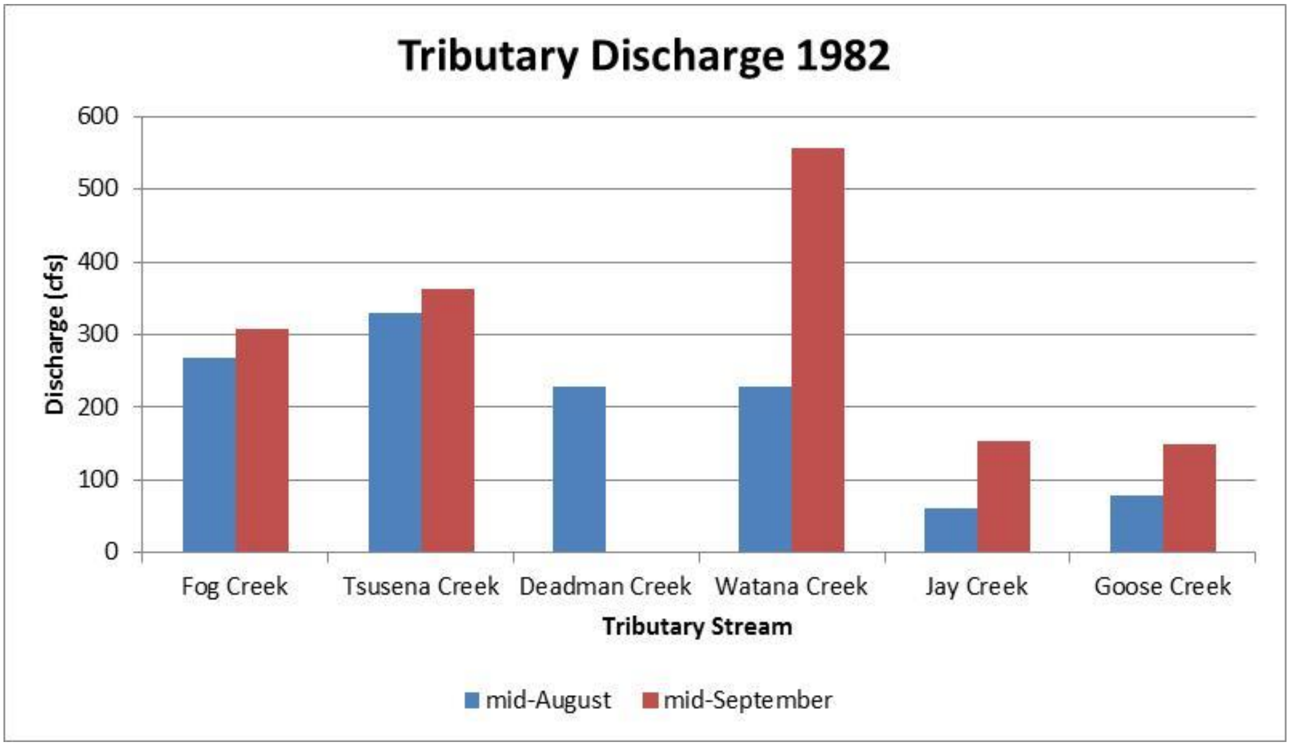


Figure 4.1-2. Discharge measured at six tributary streams in the Upper Susitna River during 1982. All discharges were taken in proximity of the mouth with the exception of Deadman Creek where it was taken approximately three miles upstream from the mouth. Discharge not measured at Deadman Creek during mid-September. Source: Sautner and Stratton (1983).

Figure 4.1-3. Typical substrate observed in Tsusena and Kosina Creeks during 1982. Ruler is 12 inches long. Source: Sautner and Stratton (1983).

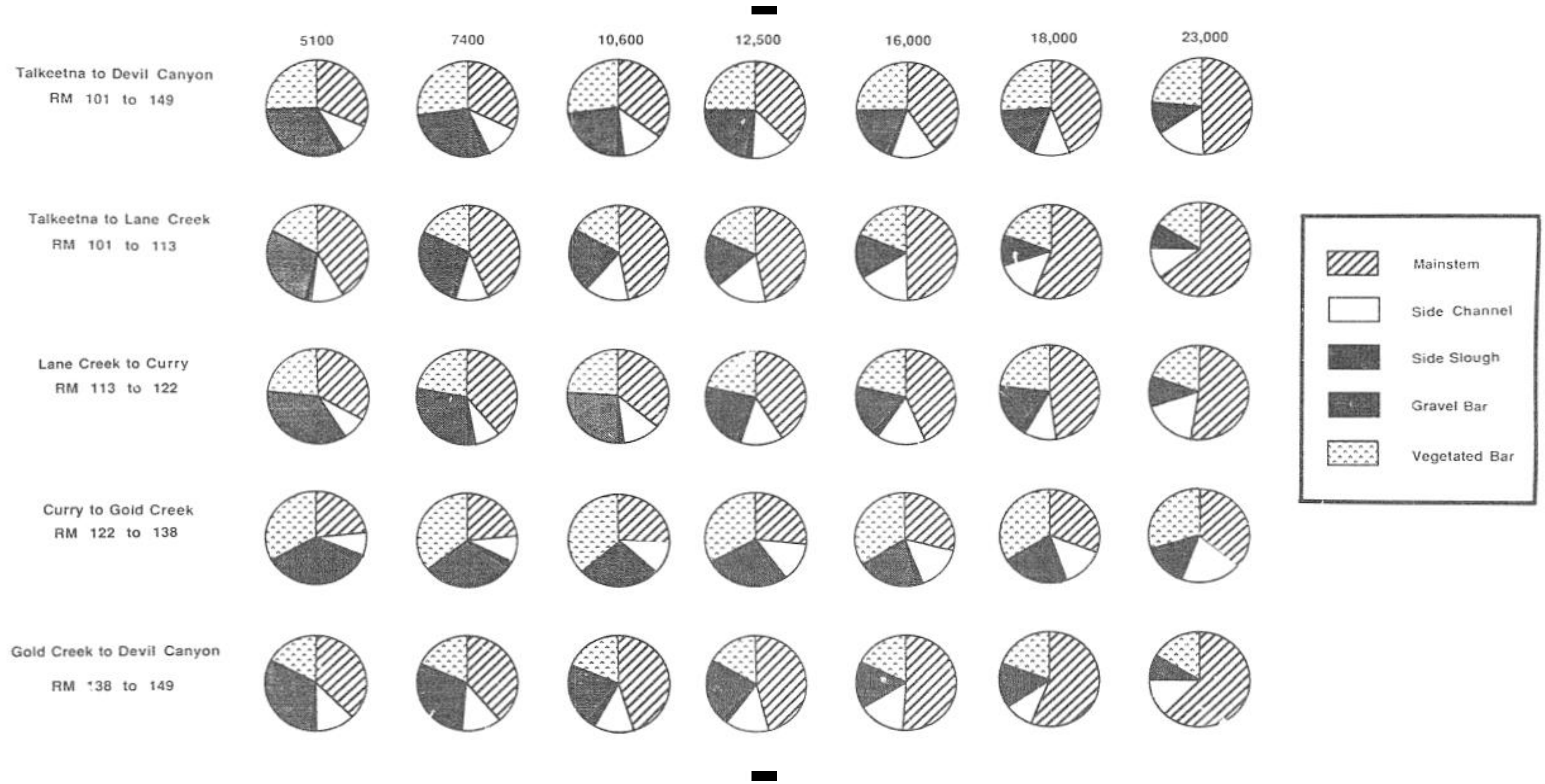
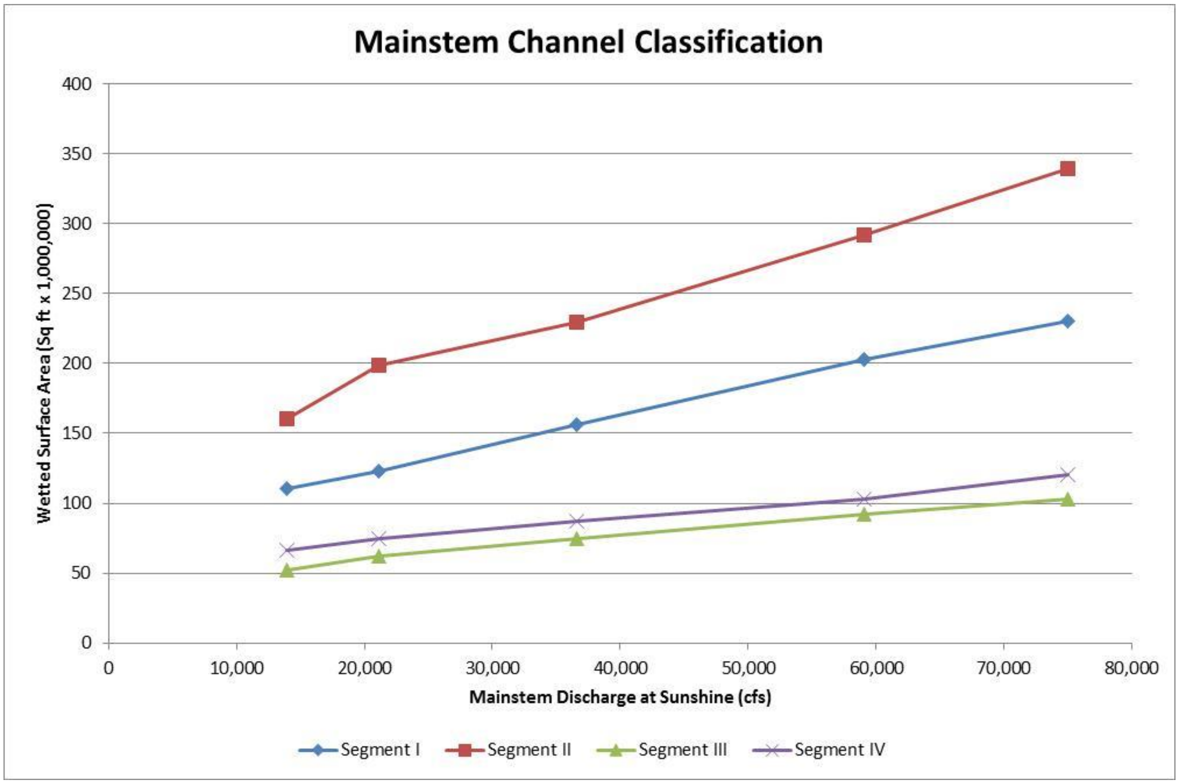


Figure 4.2-1. Relative amounts of habitat types in different areas of the Susitna River at seven mainstem discharges. Source: Klinger-Kingsley et al. (1985).



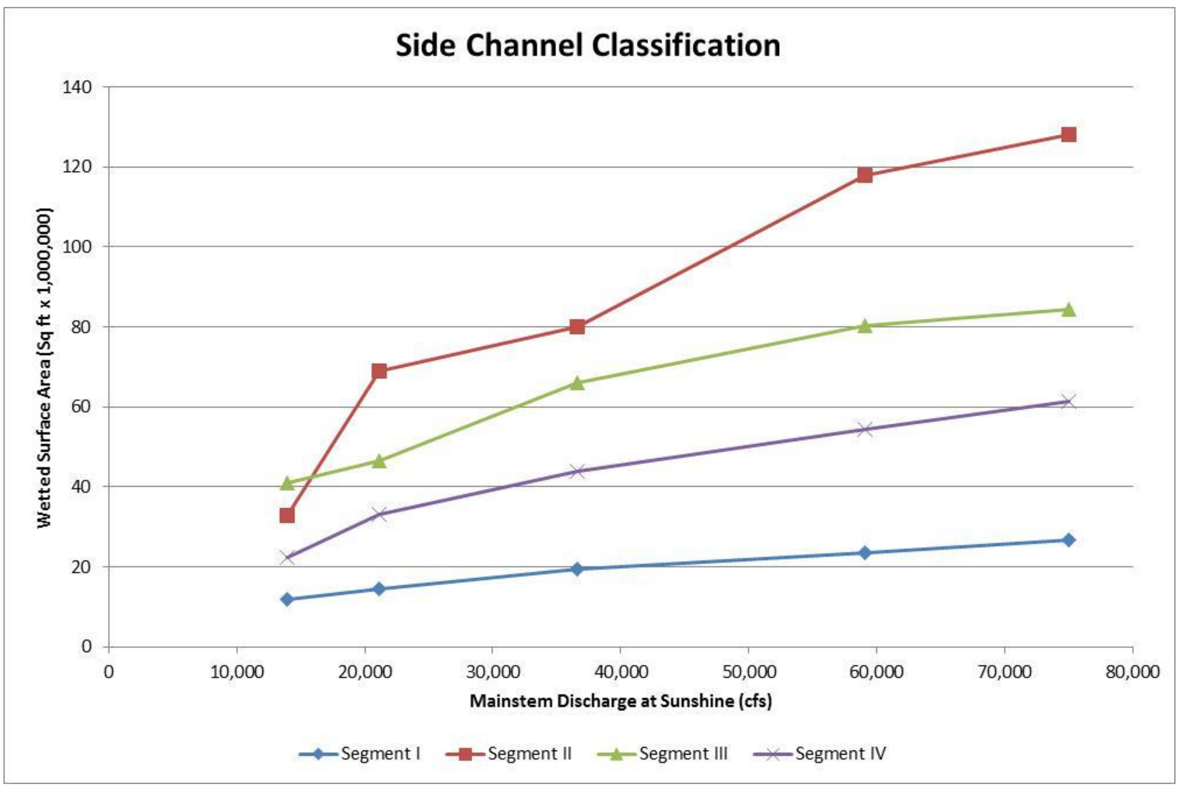


Figure 4.3-1. Amount of wetted surface area within mainstem channel (top) and side channel complexes (bottom) at five mainstem discharge levels for four lower river segments. Source: Ashton and Klinger-Kingsley (1985).

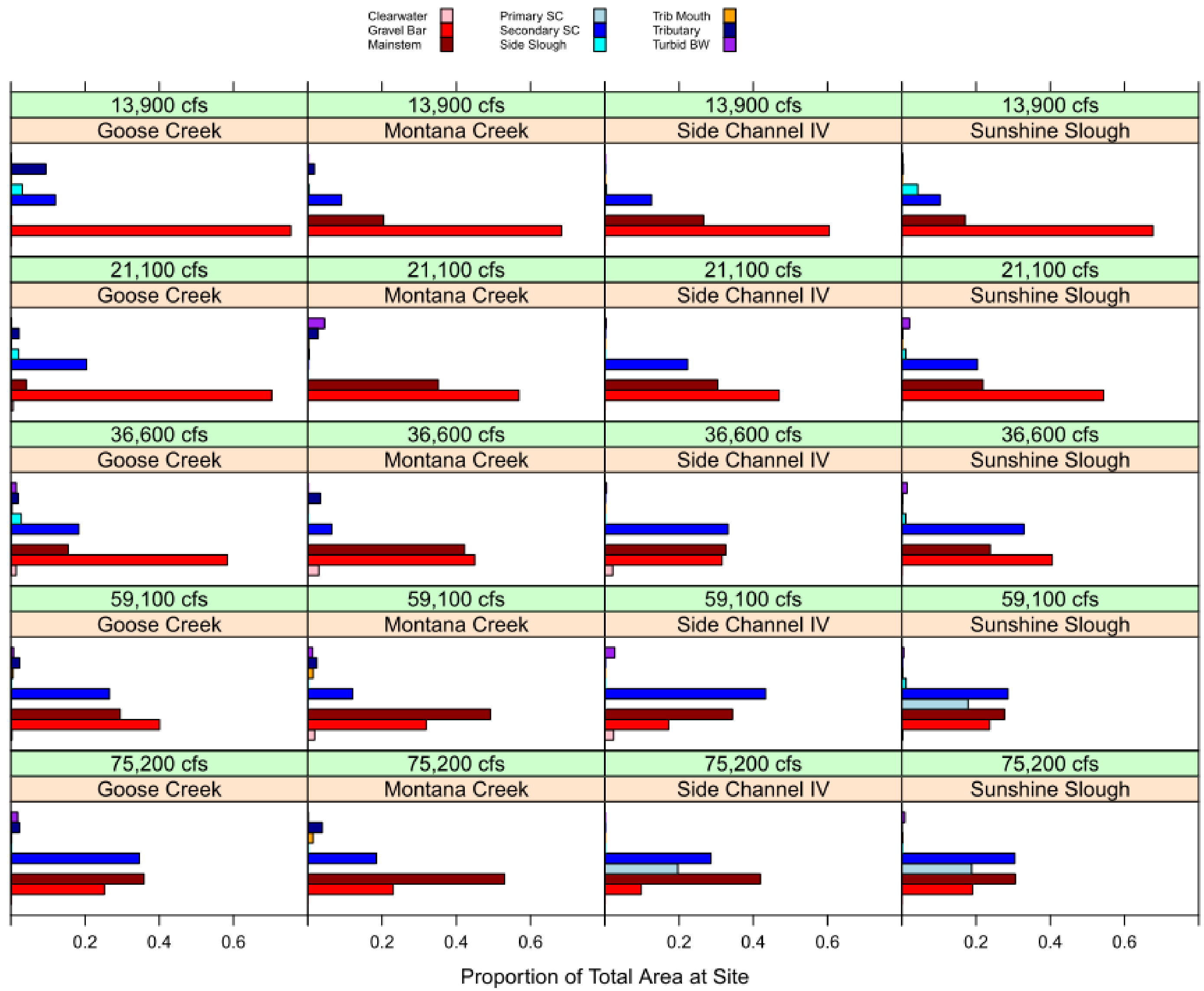


Figure 4.3-2. Proportion of area accounted for by nine habitat types delineated at five mainstem discharge levels for five sites in the lower Susitna River. Data Source: Ashton and Klinger-Kingsley (1985).

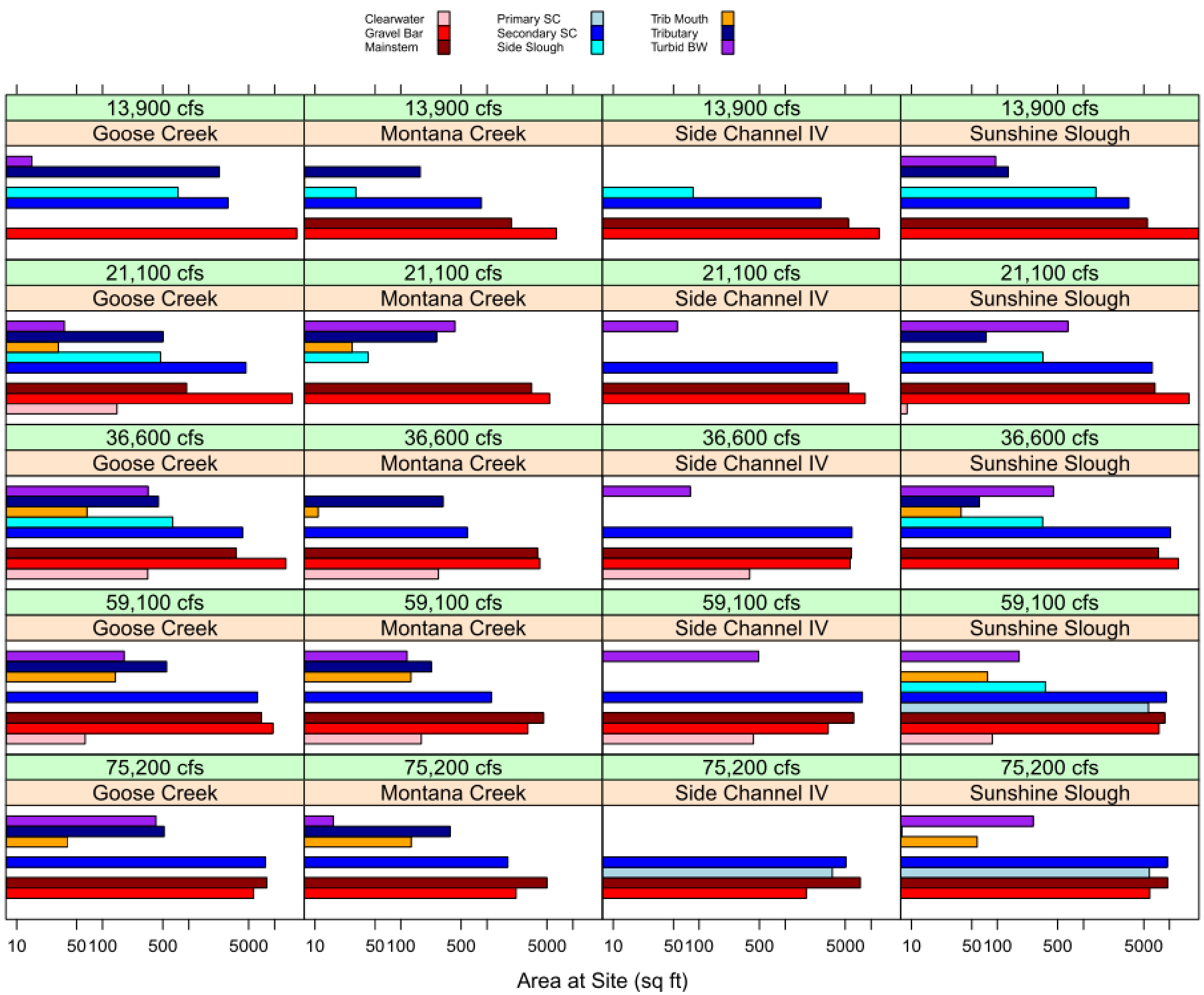


Figure 4.3-3. Area (ft^2 on log scale) accounted for by nine habitat types delineated at five mainstem discharge levels for five sites in the lower Susitna River. Data Source: Ashton and Klinger-Kingsley (1985).

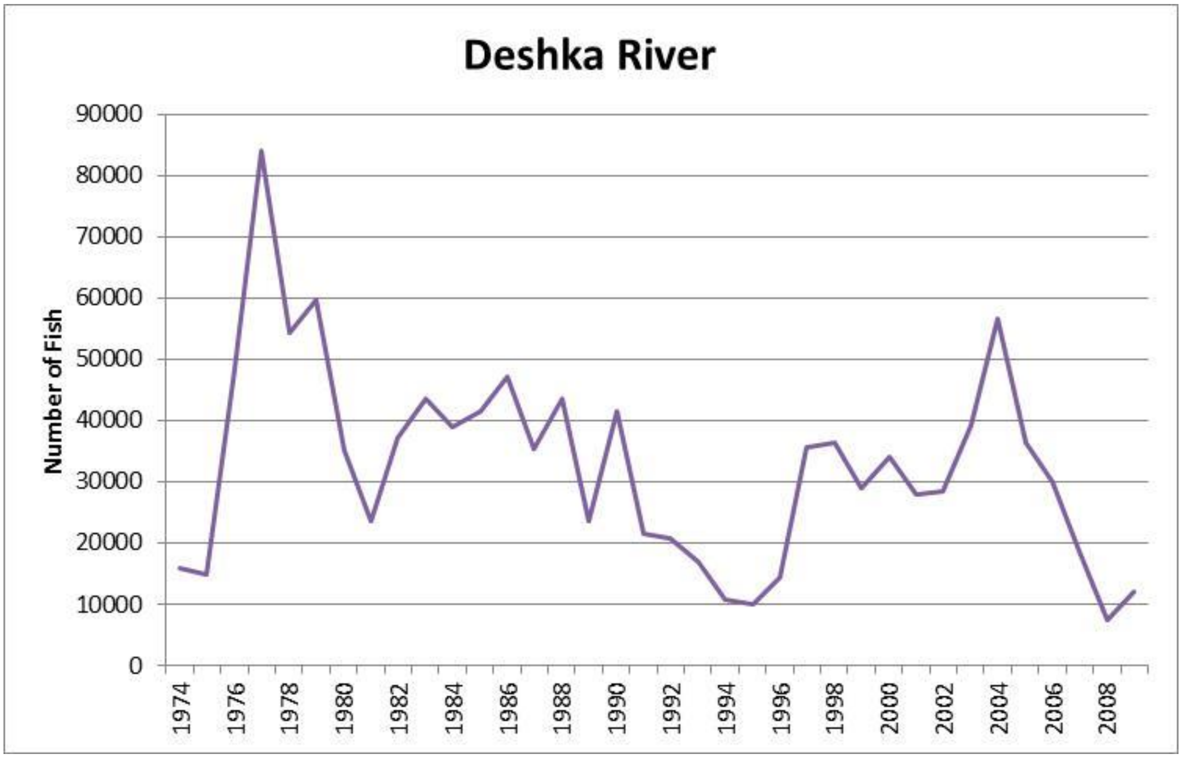


Figure 5.1-1. Deshka River Chinook salmon escapement. Source: Fair et al. (2010).

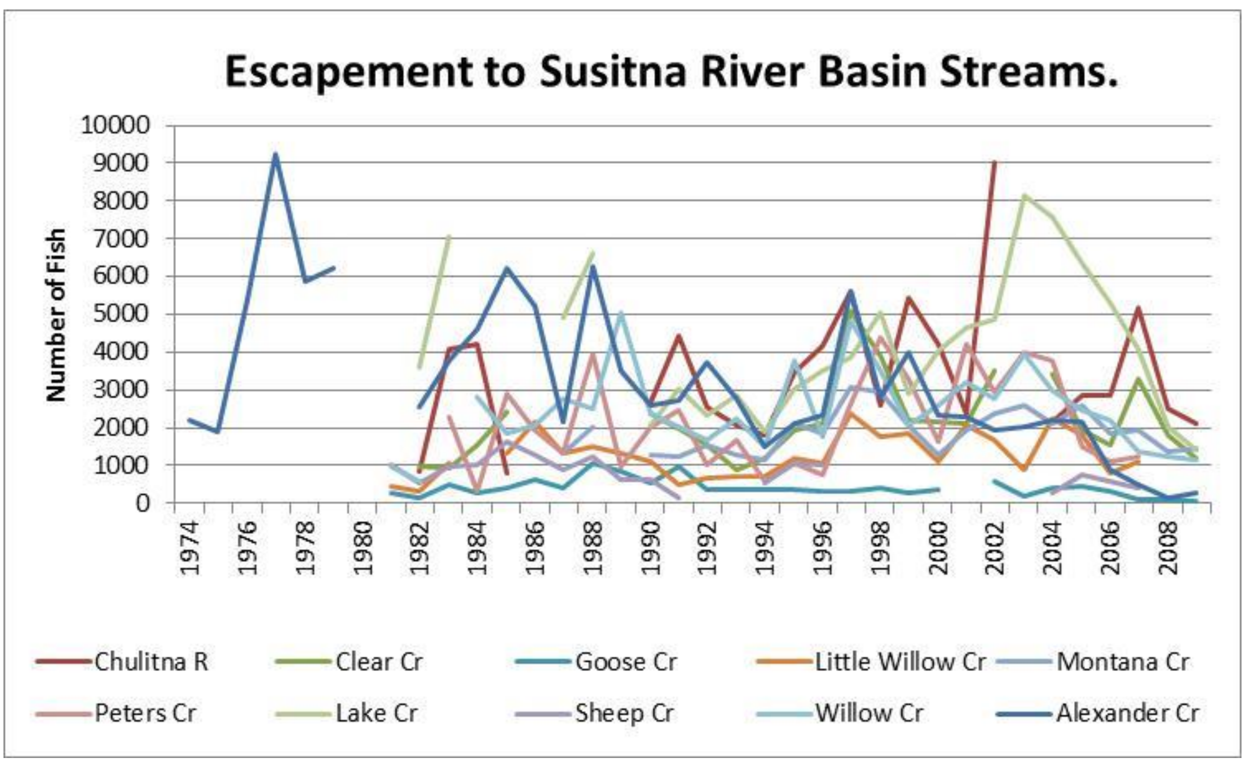


Figure 5.1-2. Escapement of Chinook salmon to Susitna River index streams other than the Deshka River. Source: Fair et al. (2010).

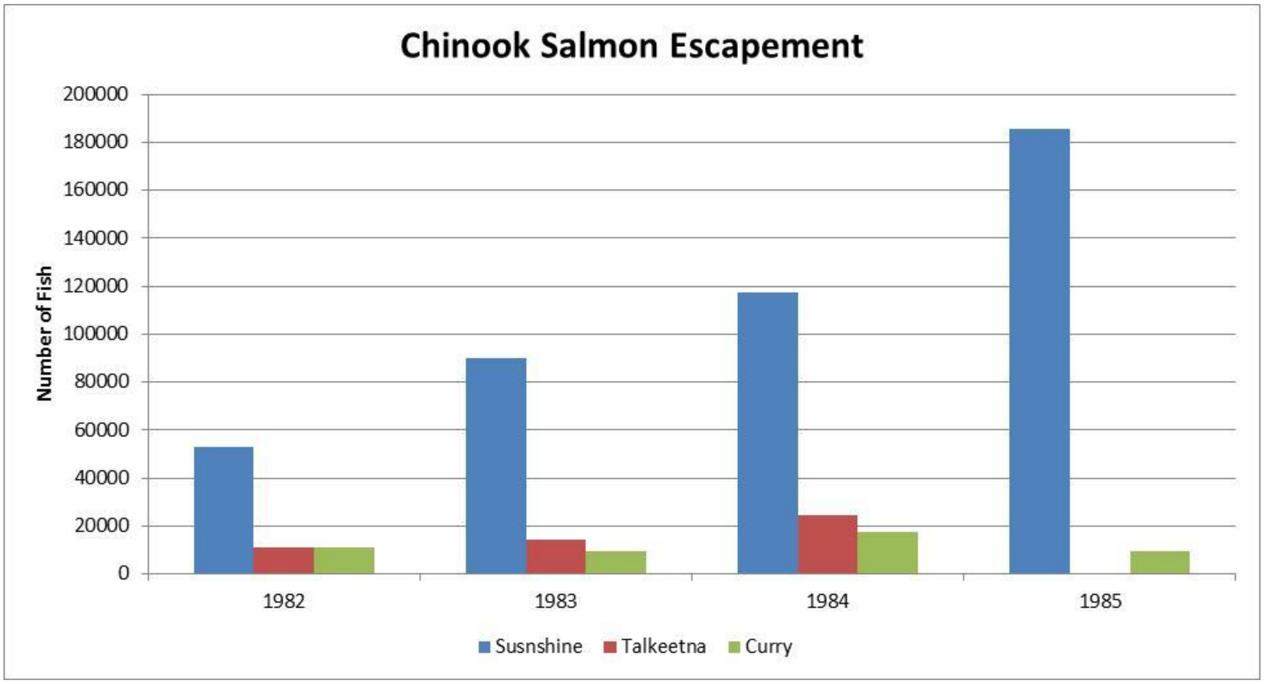


Figure 5.1-3. Escapement to Sunshine, Talkeetna, and Curry stations based upon mark-recapture techniques. No escapement estimates were made for Talkeetna Station during 1985. Source: Barrett et al. (1983), Barrett et al. (1984), Barrett et al. (1985), Thompson et al. (1986).

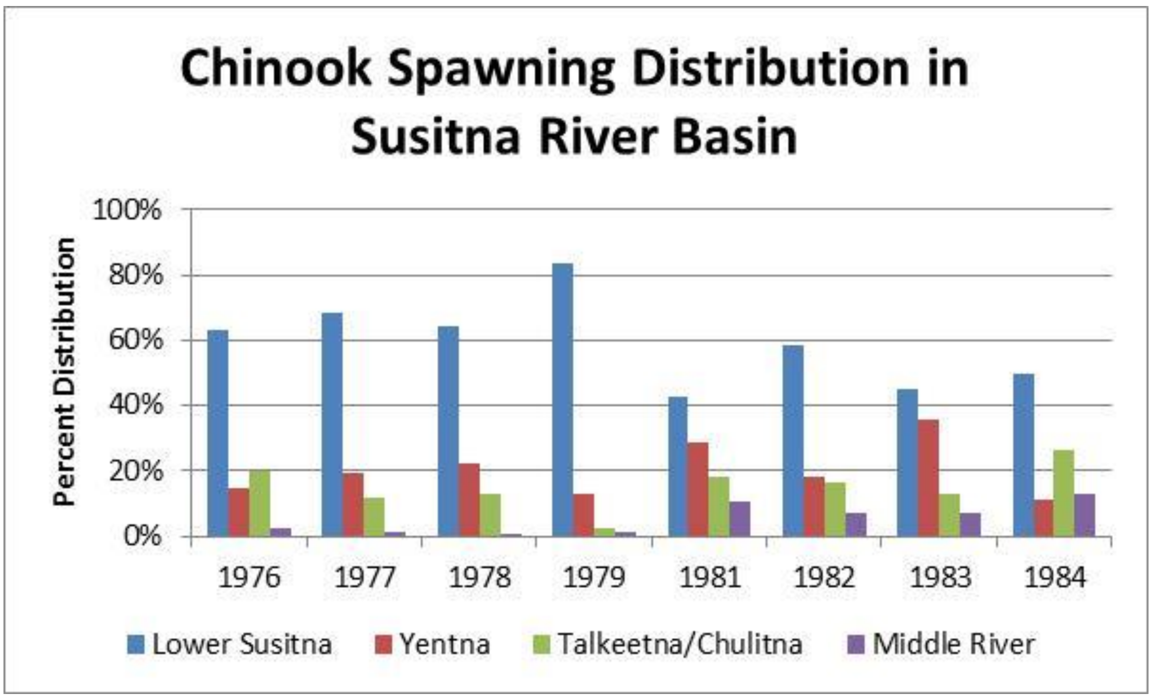


Figure 5.1-4. Distribution of Chinook Salmon spawning in the Susitna River 1976 to 1984. Source: Jennings (1985).

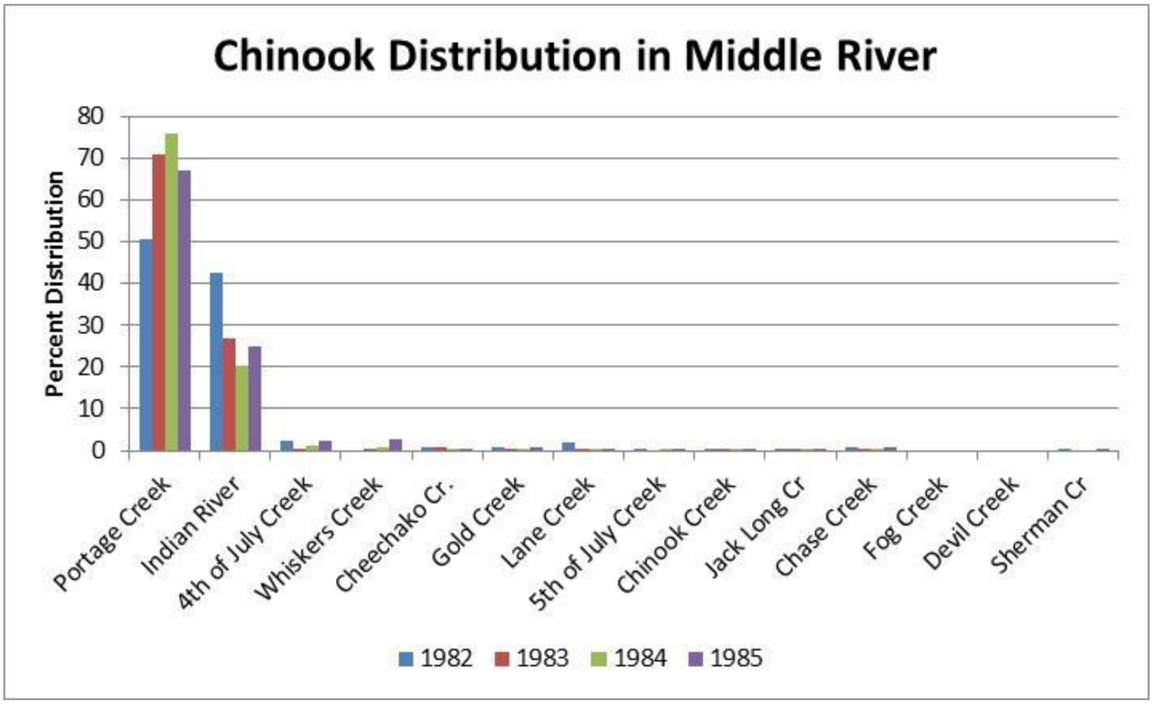


Figure 5.1-5. Distribution of Chinook salmon spawning in the Middle River 1982 to 1985. Sources: Thompson et al. (1986); Barrett (1985, 1984, 1983). Age of Return.

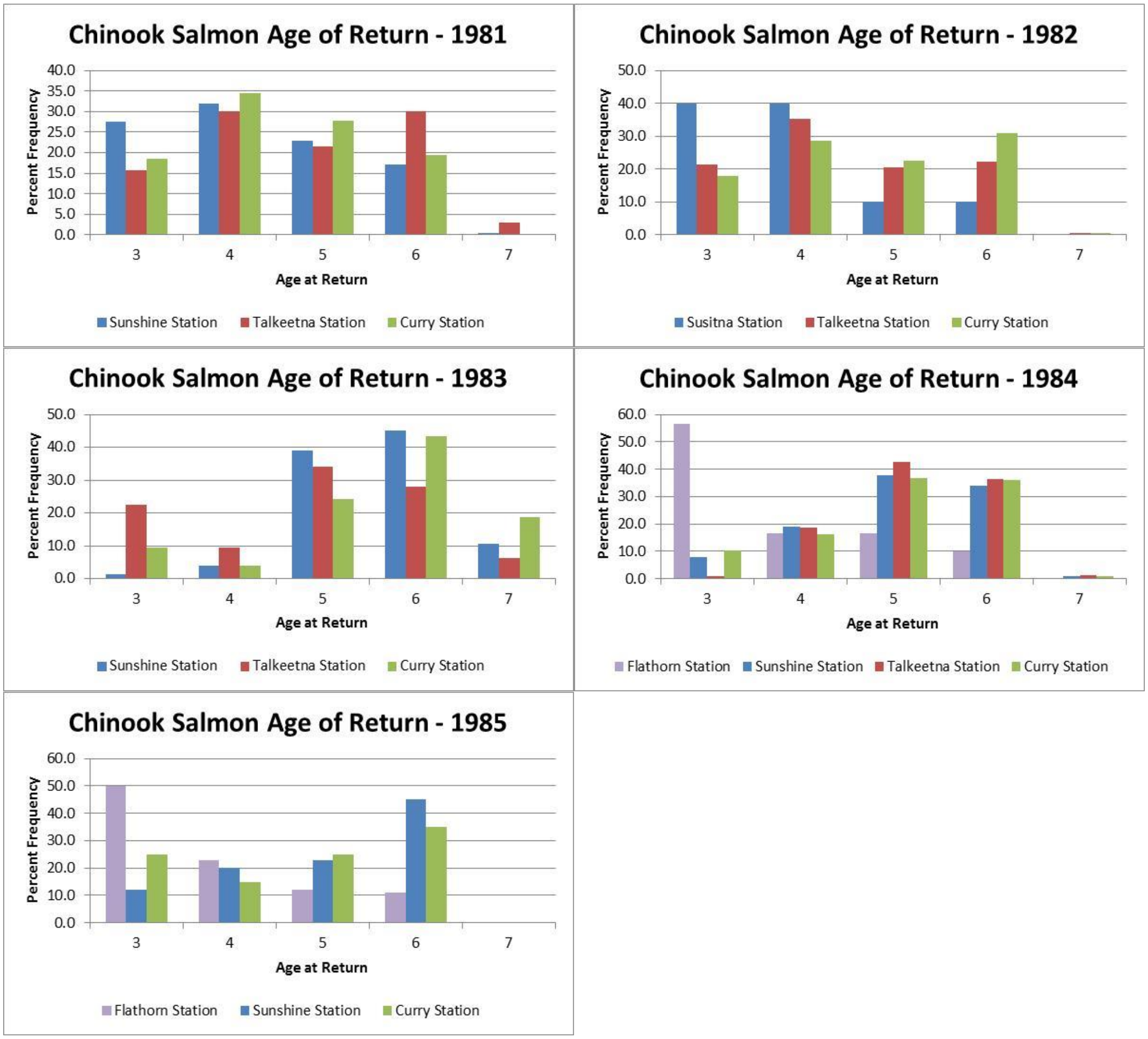


Figure 5.1-6. Age of return for Chinook salmon collected at the Sunshine, Talkeetna, and Curry Stations during 1981 to 1985. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

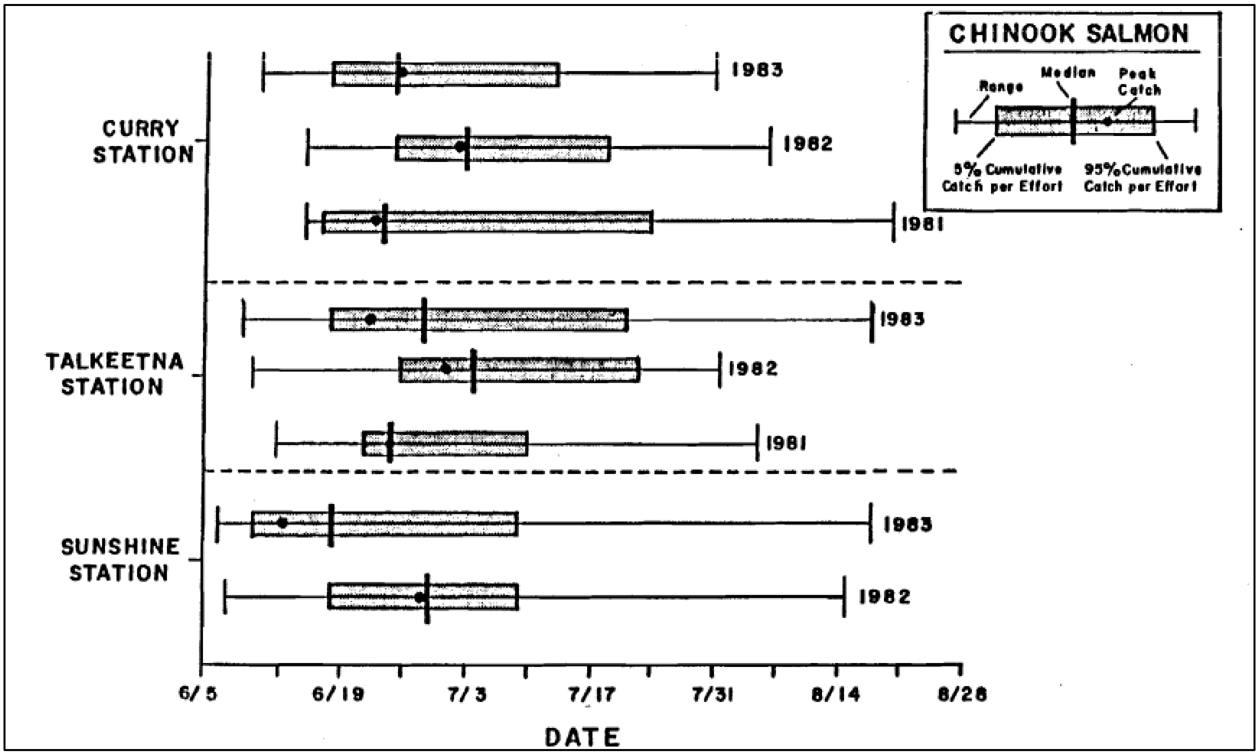


Figure 5.1-7. Upstream migration timing of adult Chinook salmon in the Susitna River based upon fishwheel catch per unit effort. Source: ADF&G (1984).

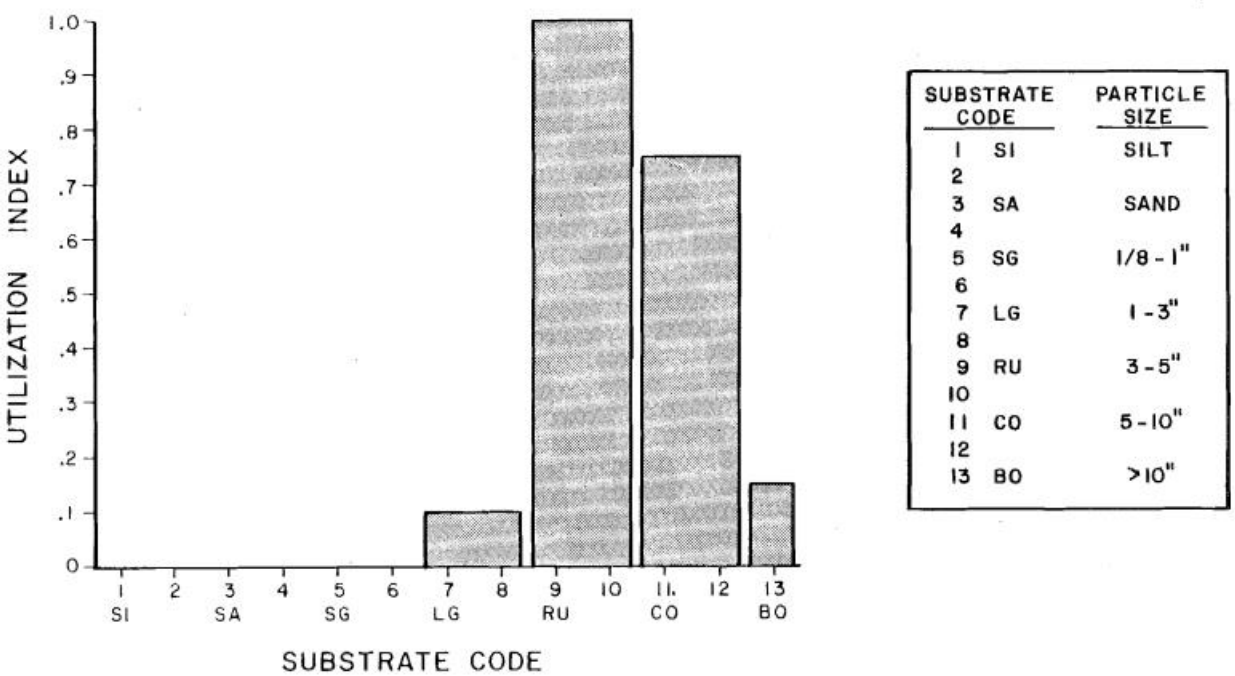


Figure 5.1-8. Substrate utilization curve for Chinook salmon based upon measurements at 265 redds. Source: Vincent-Lang et al. (1984).

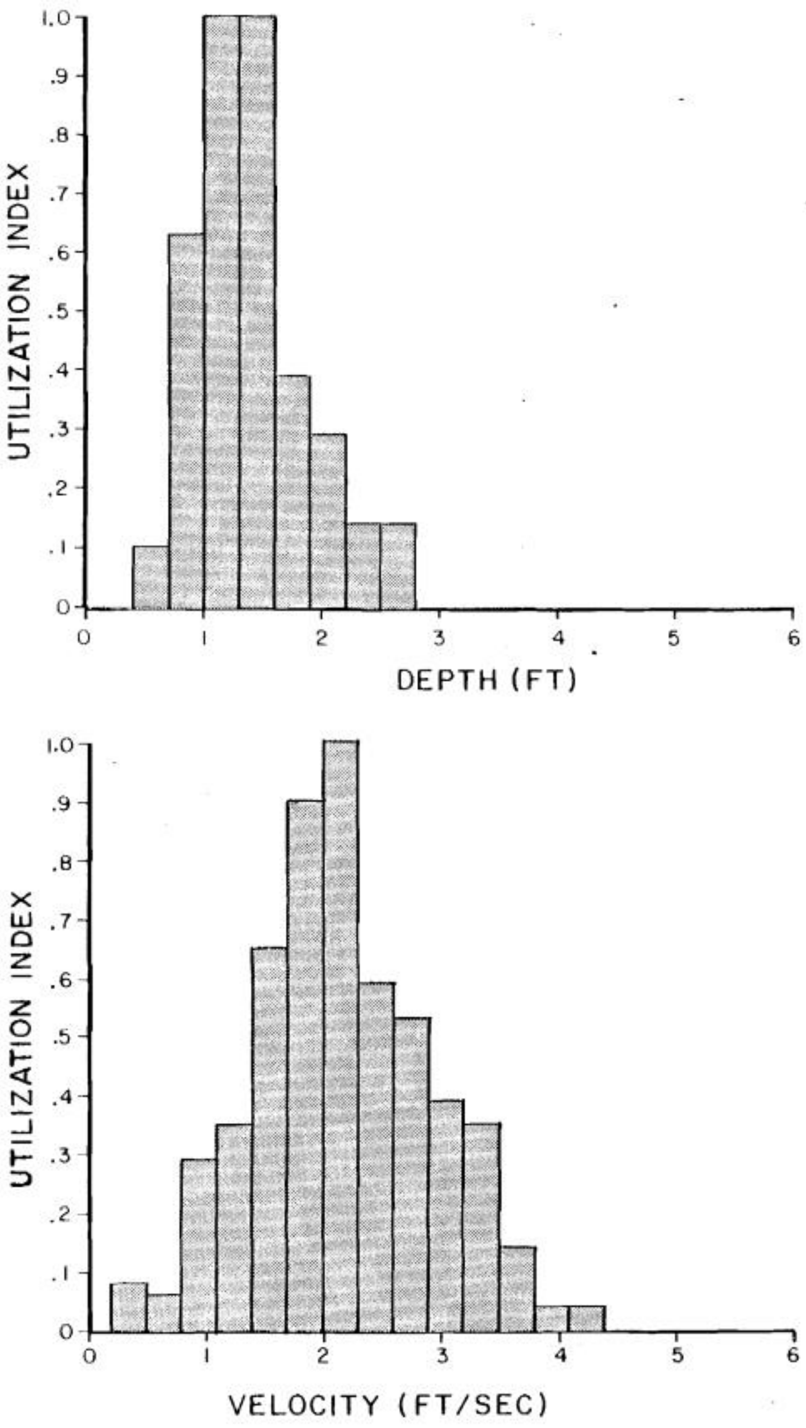


Figure 5.1-9. Best depth (top) and velocity (bottom) Chinook salmon utilization curves based upon measurements at 265 redds. Source: Vincent-Lang et al. (1984b).

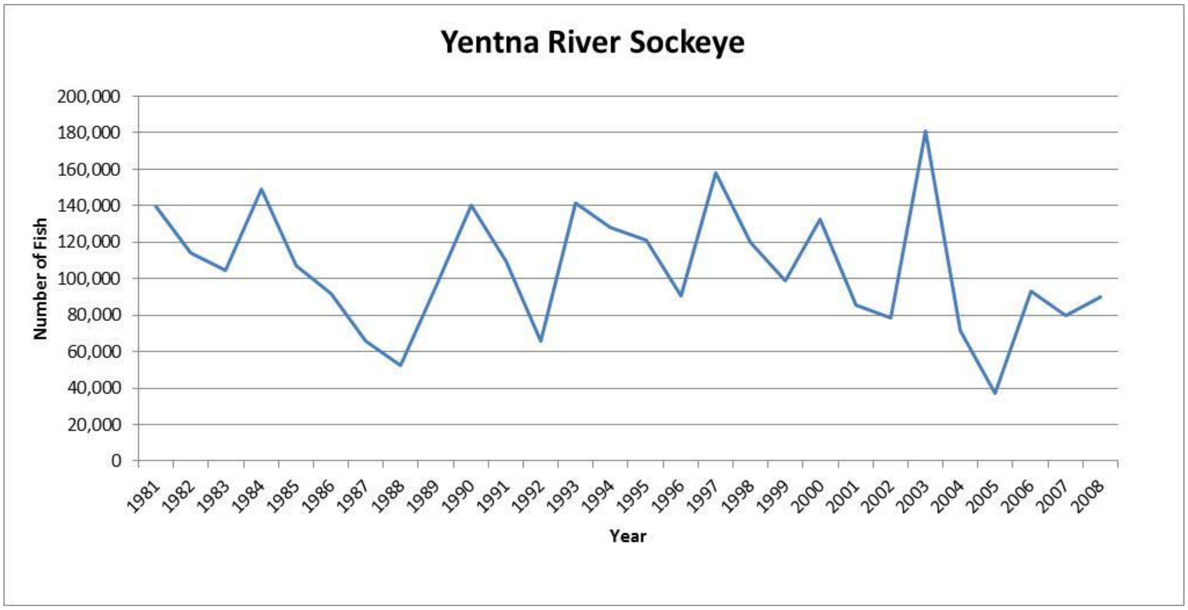


Figure 5.2-1. Escapement of sockeye salmon to the Yentna River 1981 to 2008 based upon expansion and apportionment of sonar counts. Source: http://www.adfg.alaska.gov/sf/FishCounts/

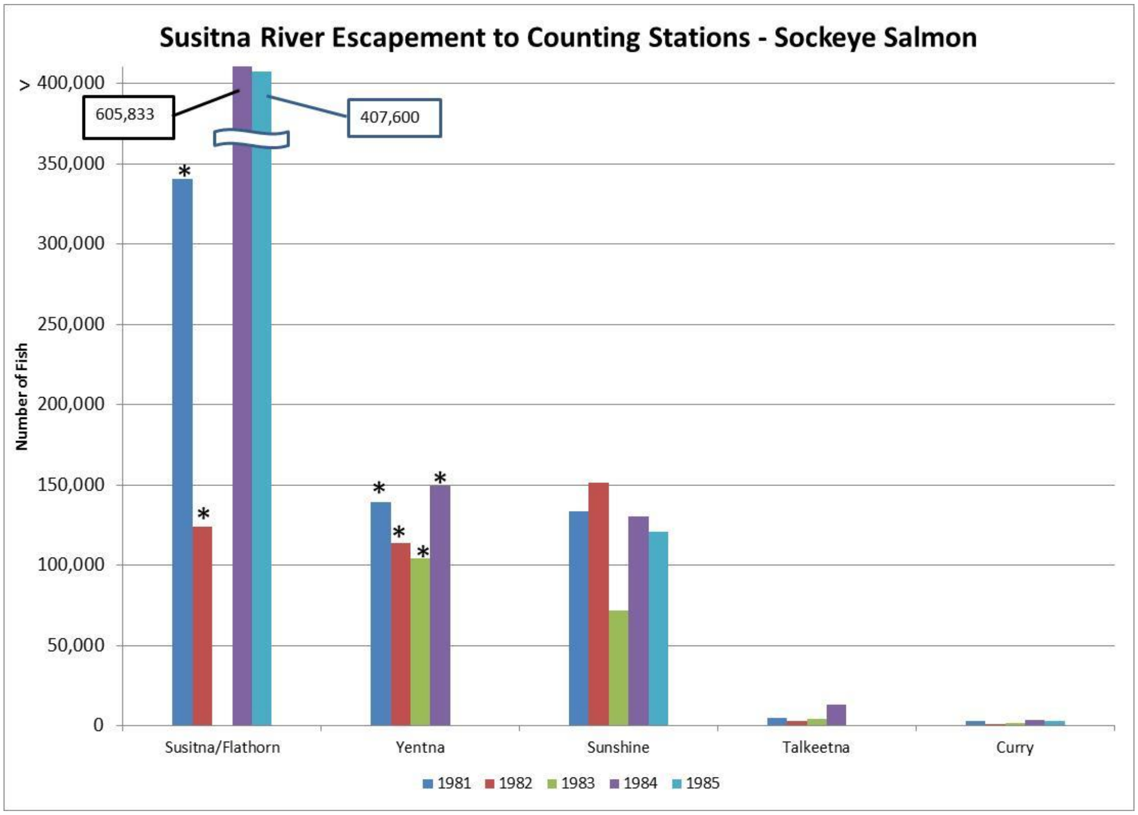


Figure 5.2-2. Second run sockeye salmon escapement estimates to the Susitna River 1981 to 1985. No estimates for the following stations and years Susitna/Flathorn (1982, 1983), Yentna (1982, 1985), and Talkeetna (1985). *: Estimate based upon apportionment of sonar counts. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

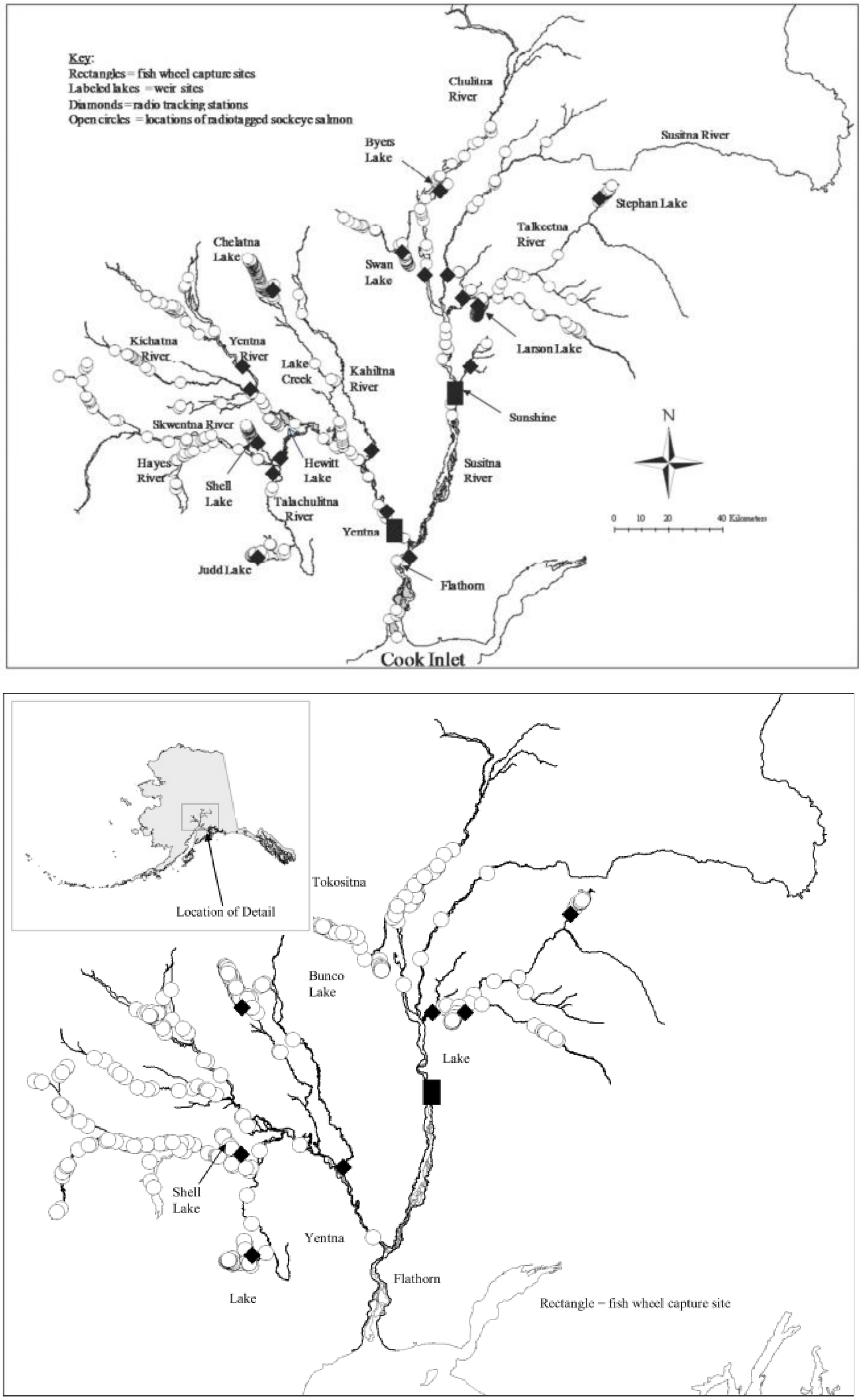
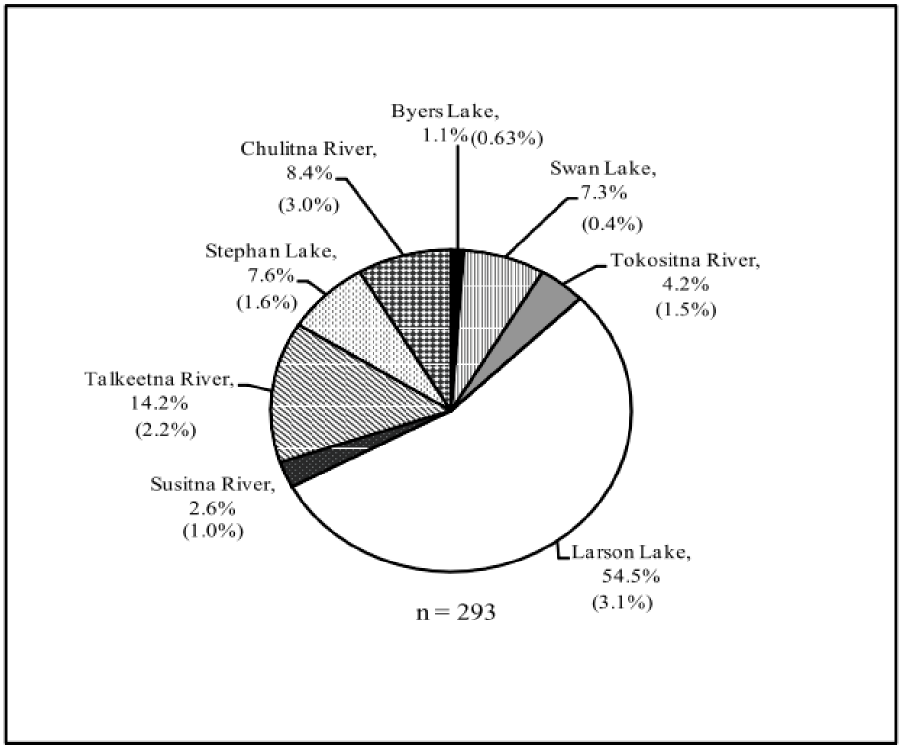
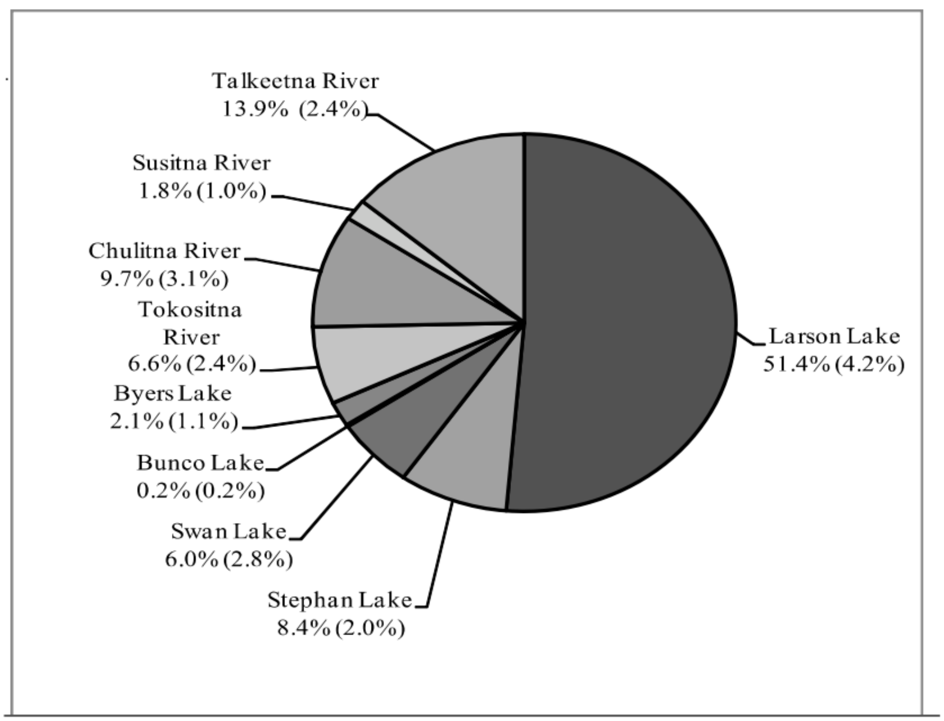


Figure 5.2-3. Location of fish wheel capture sites, weirs, and radio-tracking stations in the Susitna River drainage, and the terminal distribution of radio-tagged sockeye salmon based on aerial surveys, 2007 (top) and 2008 (bottom). Terminal location does not necessarily mean a spawning location Source: Yanusz et al. (2011a, 2011b).



Note: SE in parentheses.



Note: SE in parenthesis.

Figure 5.2-4. Weighted terminal distribution of sockeye salmon in the Susitna River system above Sunshine during 2007 (top) and 2008 (bottom). Source: Yanusz et al. (2011a, 2011b).

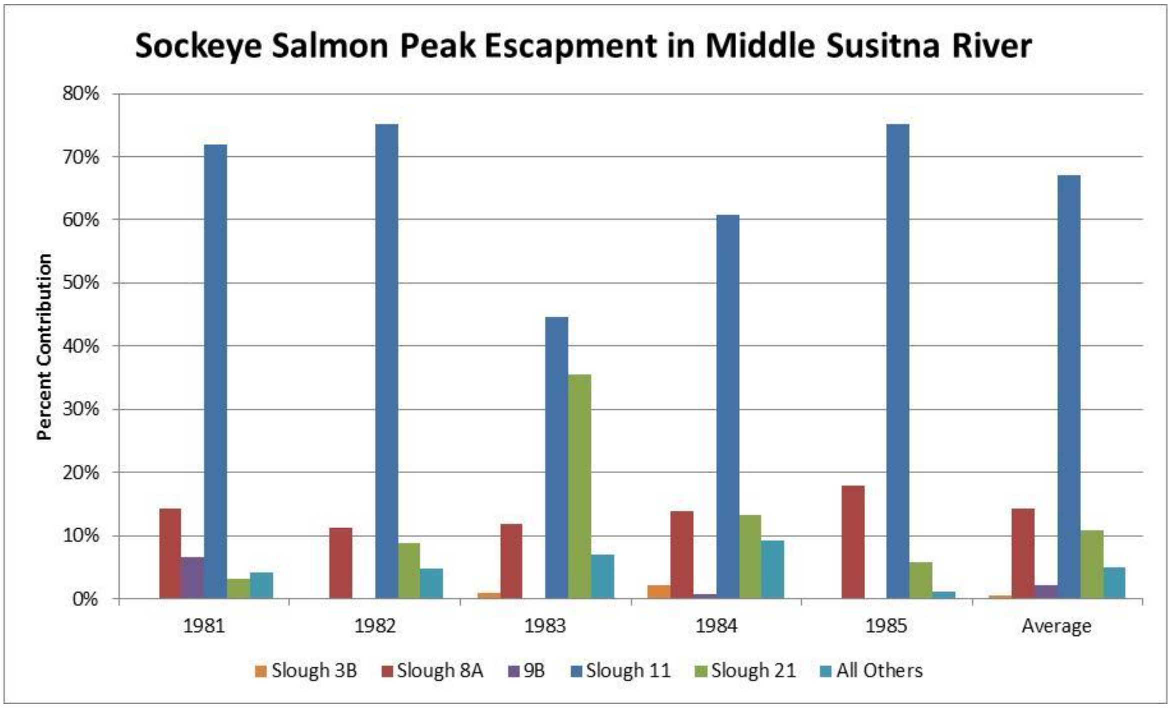


Figure 5.2-5. Distribution of sockeye spawning in Middle Susitna River sloughs. Source: Jennings (1985), Thompson et al. (1986).

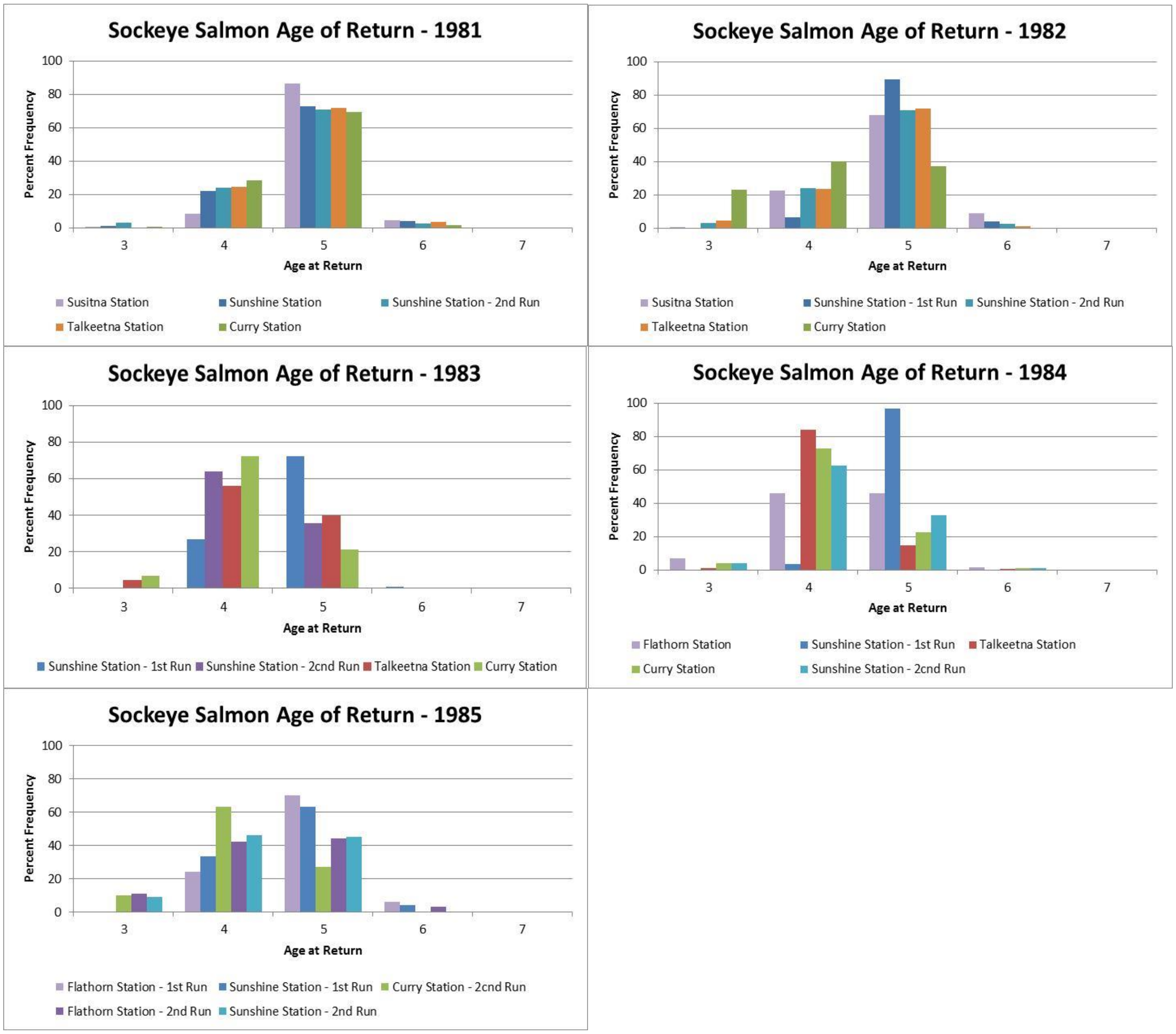


Figure 5.2-6. Age of return for sockeye salmon collected at the Sunshine, Talkeetna, and Curry Stations during 1981 to 1985. First run and second run fish were not distinguished at all stations during all years. First run fish are not known to spawn in the Middle Susitna River. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

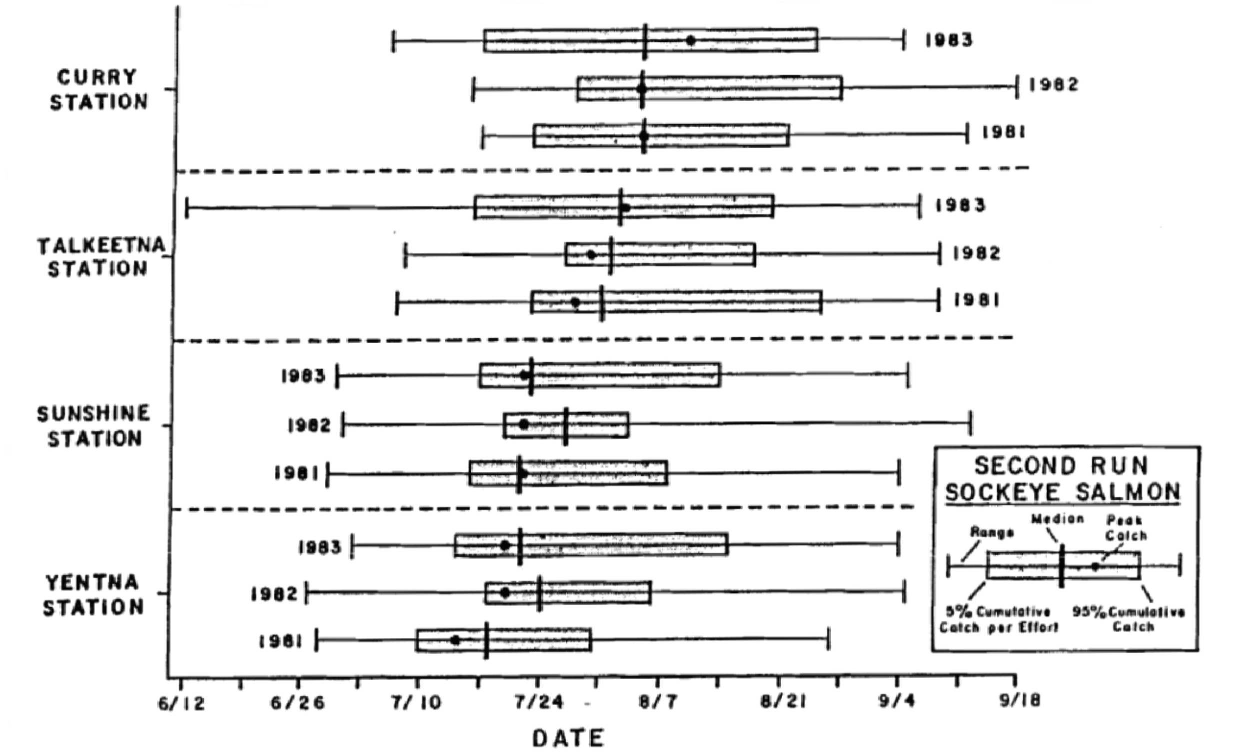


Figure 5.2-7. Upstream migration timing of second run adult sockeye salmon in the Susitna River based upon fishwheel catch per unit effort. Source: Jennings (1985).

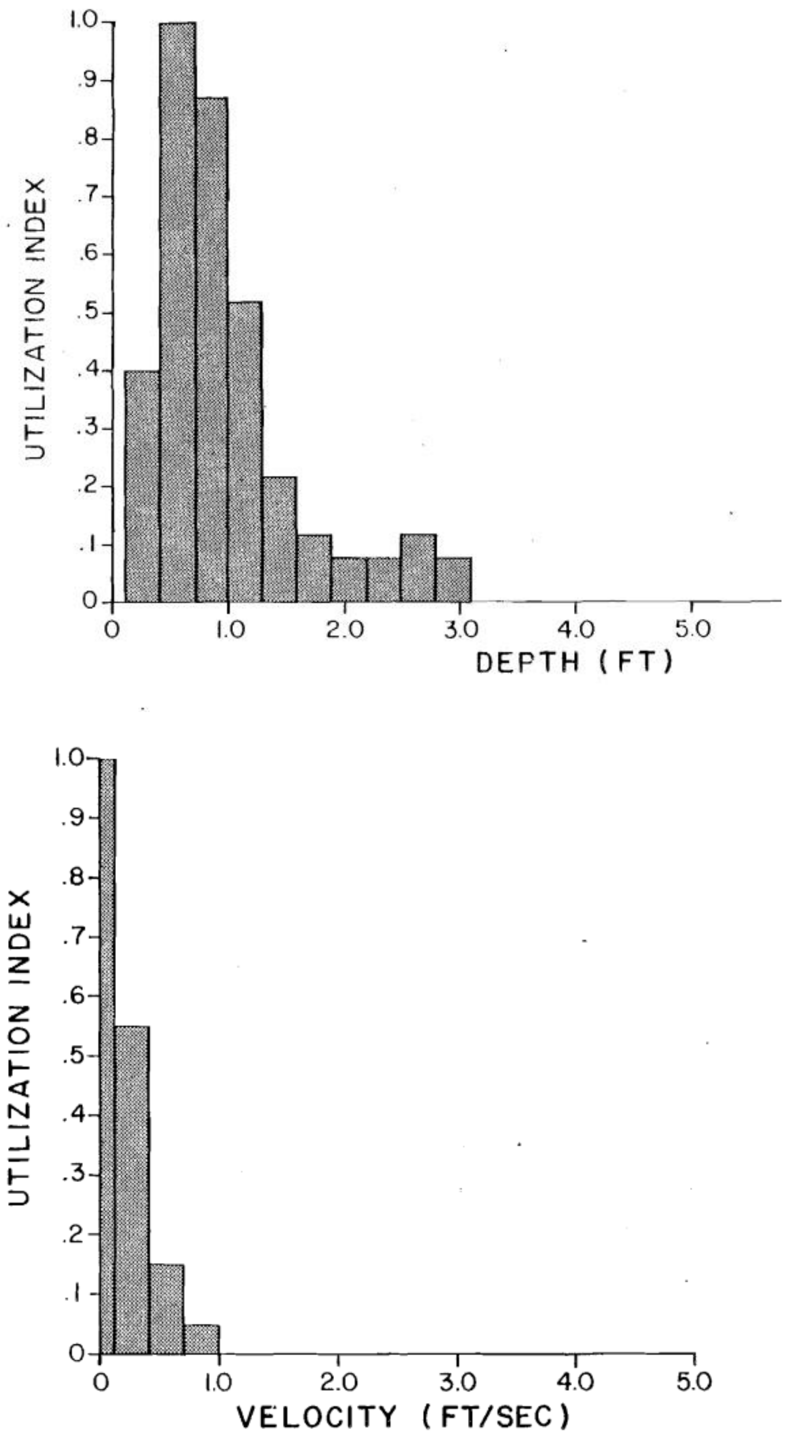


Figure 5.2-8. Best depth (top) and velocity (bottom) sockeye salmon utilization curves based upon measurements at 81 redds. Source: Vincent-Lang et al. (1984a).

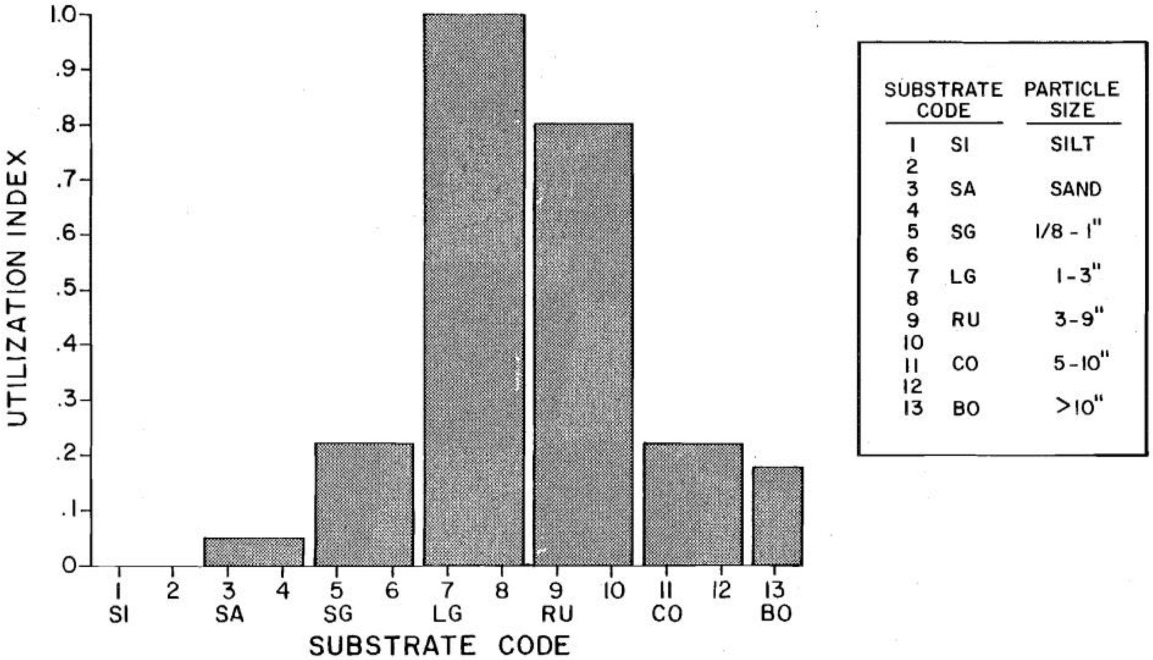


Figure 5.2-9. Substrate utilization curve for sockeye salmon based upon measurements at 81 redds. Source: Vincent-Lang et al. (1984).

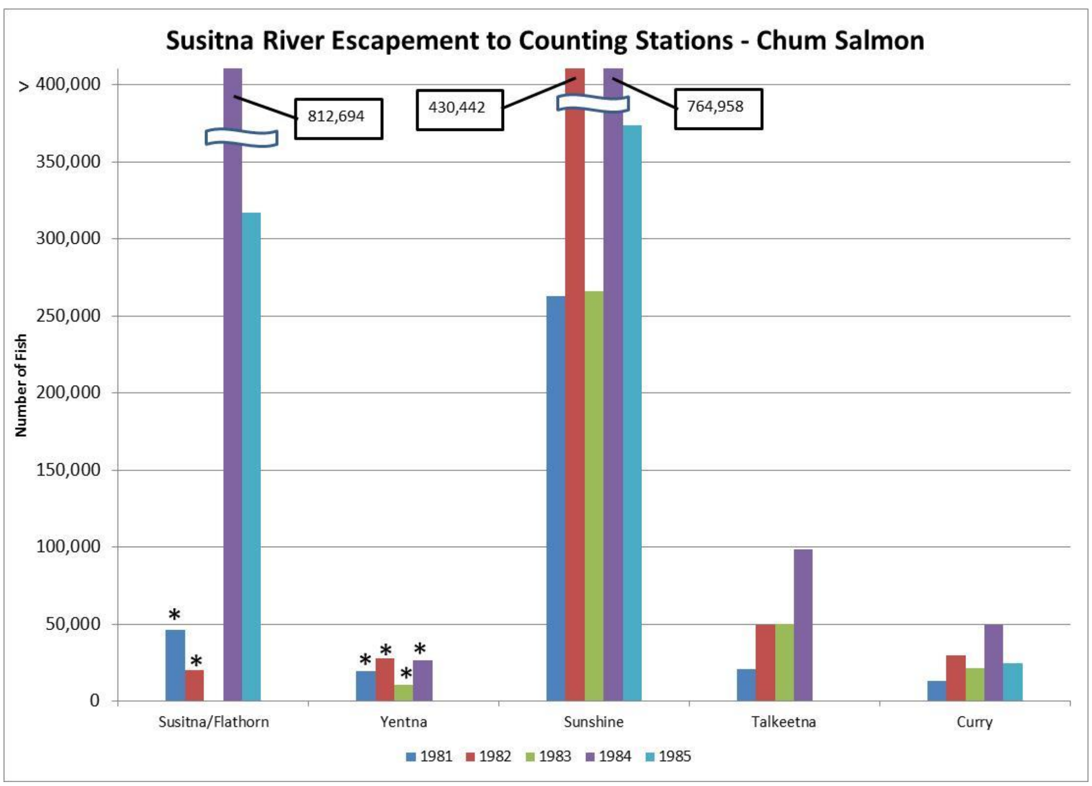


Figure 5.3-1. Chum salmon escapement estimates to the Susitna River 1981 to 1985. No estimates for the following stations and years Susitna/Flathorn (1982, 1983), Yentna (1982, 1985), and Talkeetna (1985). *: Estimate based upon apportionment of sonar counts. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

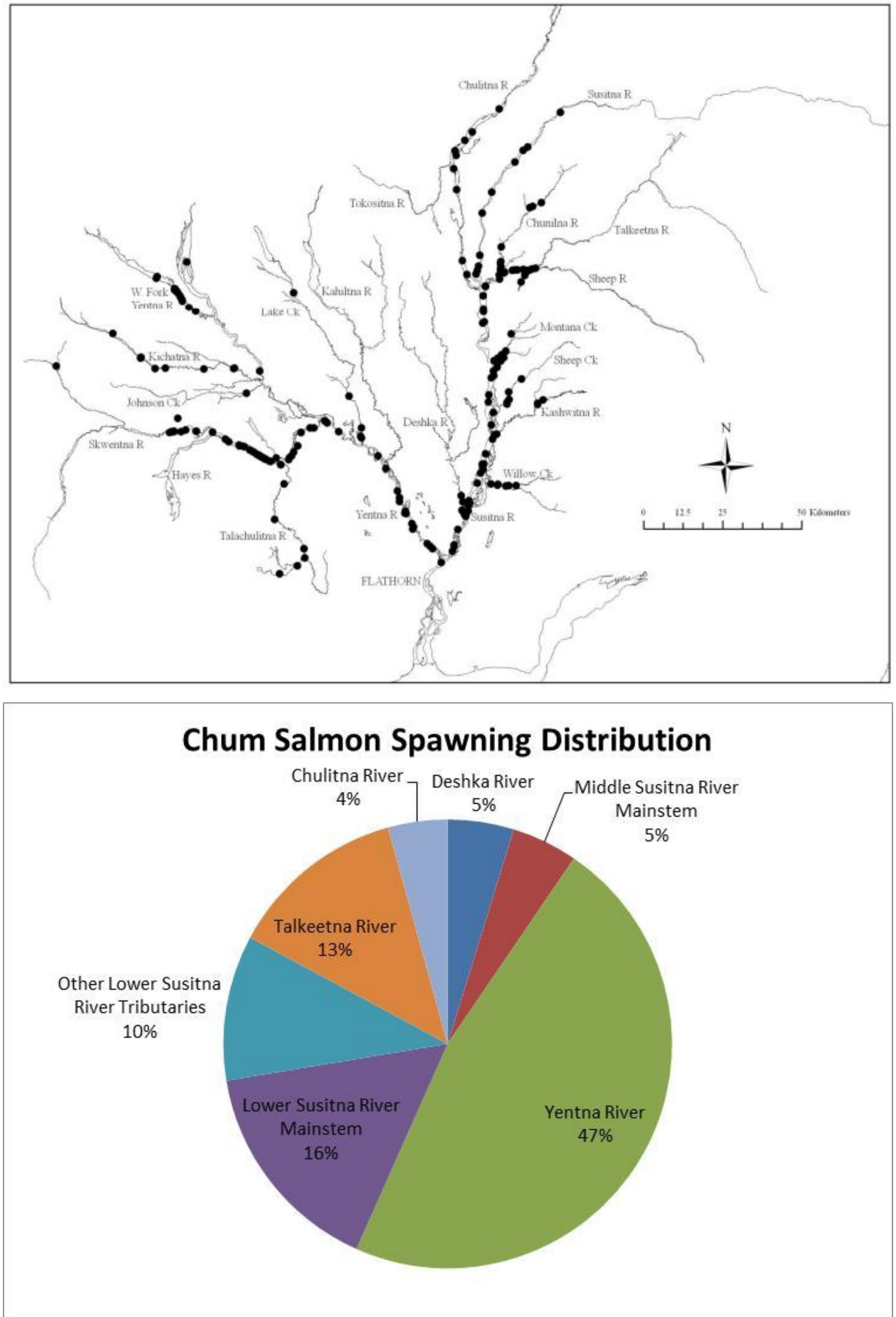


Figure 5.3-2. Spawning distribution of 210 chum salmon radio-tagged at Flathorn during 2009. Source: Merizon et al. (2010).

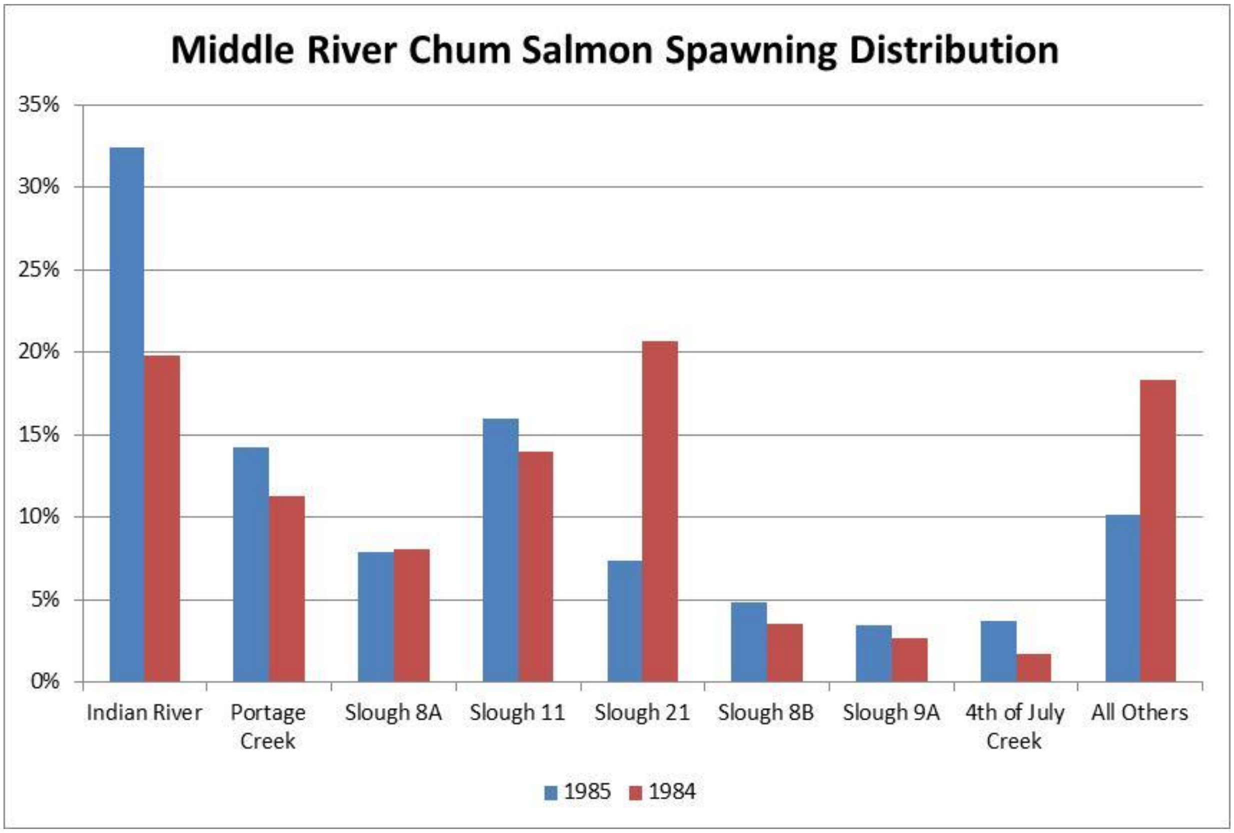


Figure 5.3-3. Chum salmon spawning distribution among tributaries and sloughs in the Middle Susitna River based upon peak counts. Source: Barrett et al. (1985), Thompson et al. (1986).

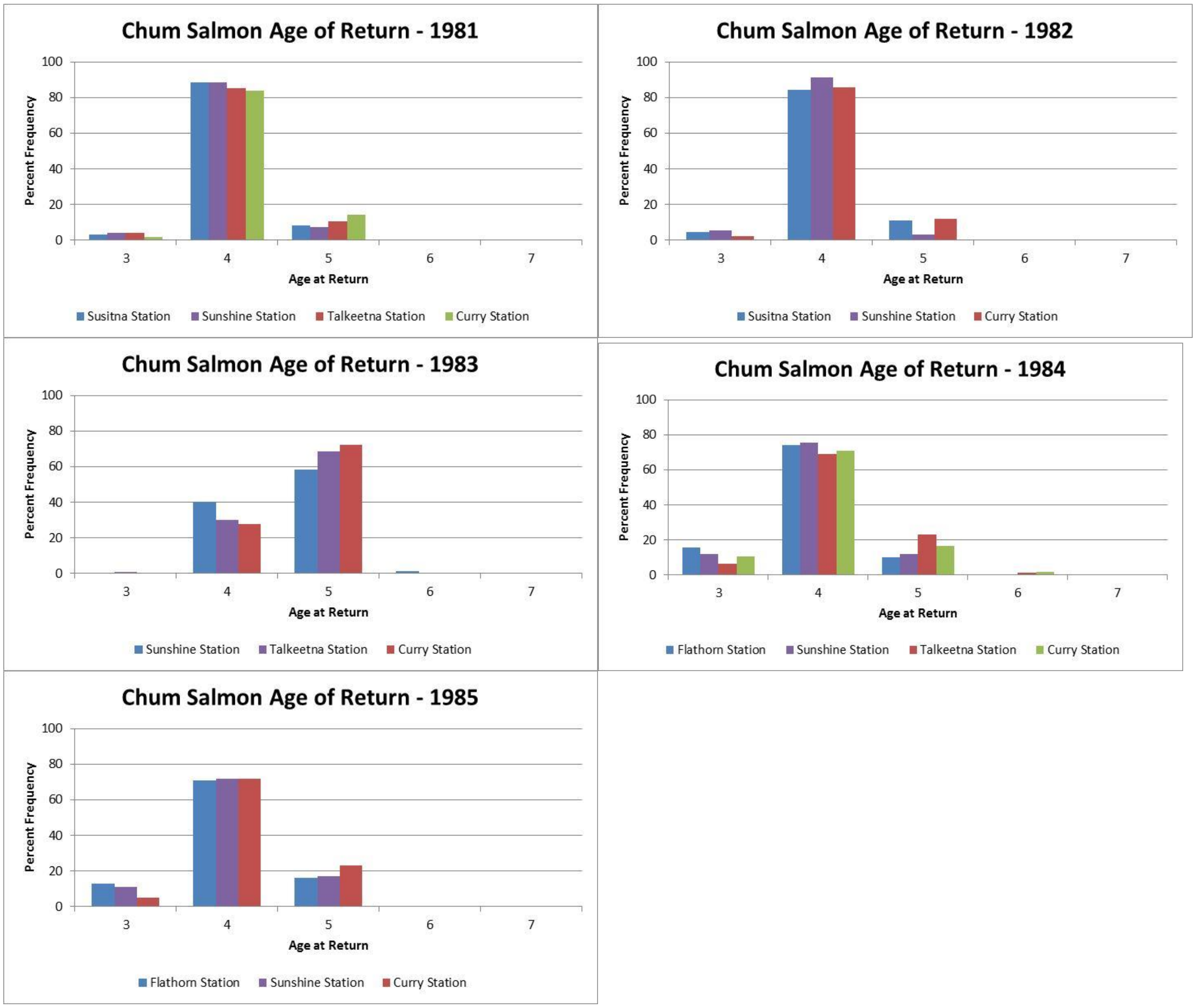


Figure 5.3-4. Age of return for chum salmon collected at the Sunshine, Talkeetna, and Curry Stations during 1981 to 1985. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

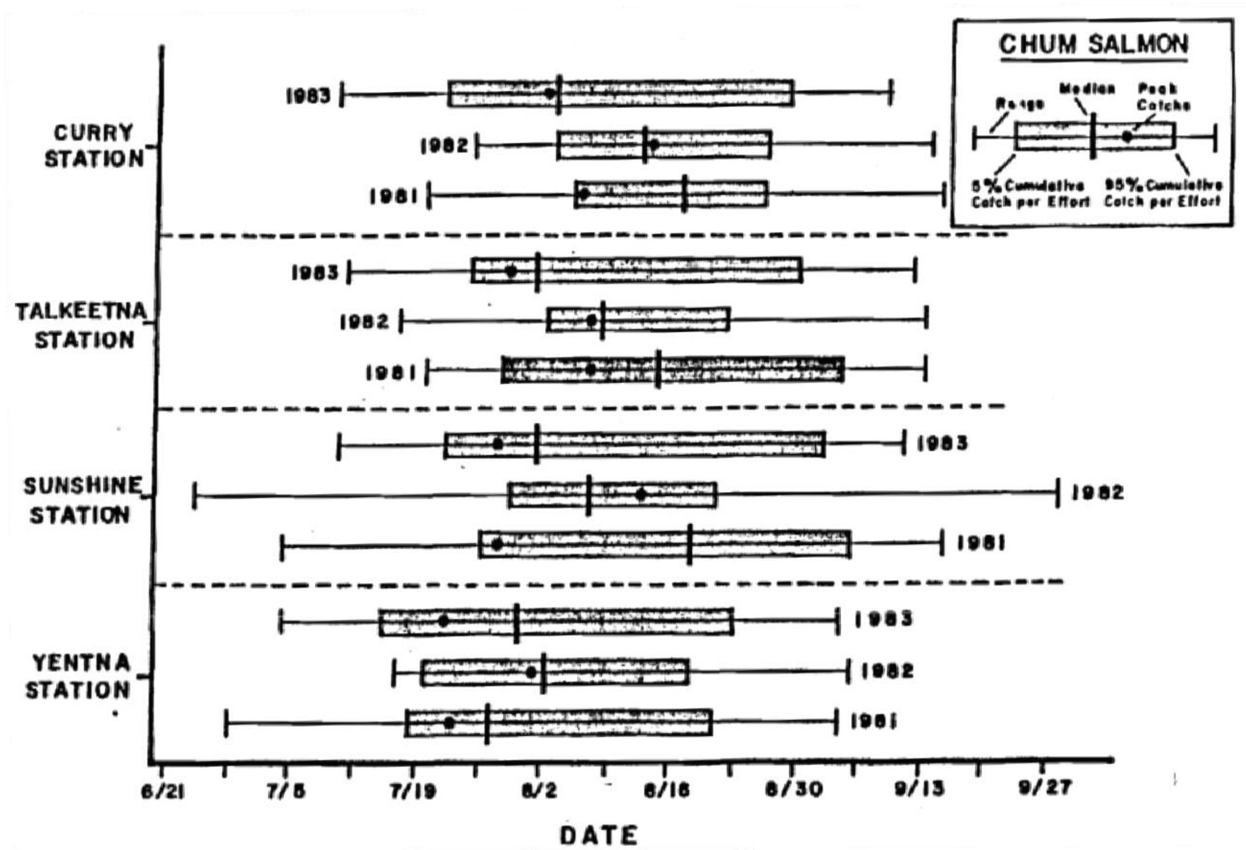


Figure 5.3-5. Upstream migration timing of adult chum salmon in the Susitna River based upon fishwheel catch per unit effort. Source: Jennings (1985).

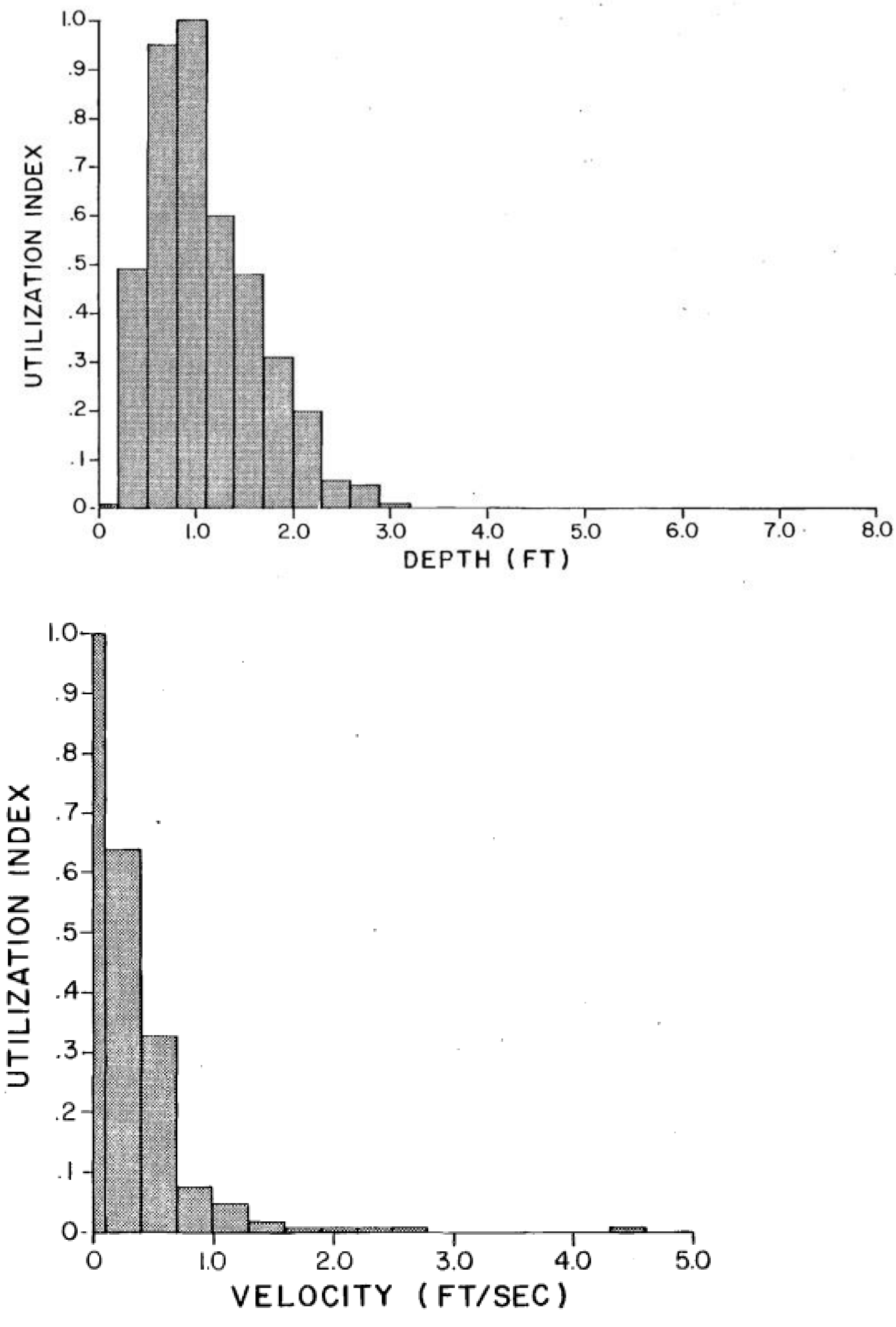


Figure 5.3-6. Best depth (top) and velocity (bottom) chum salmon utilization curves based upon measurements at 333 redds. Source: Vincent-Lang et al. (1984a).

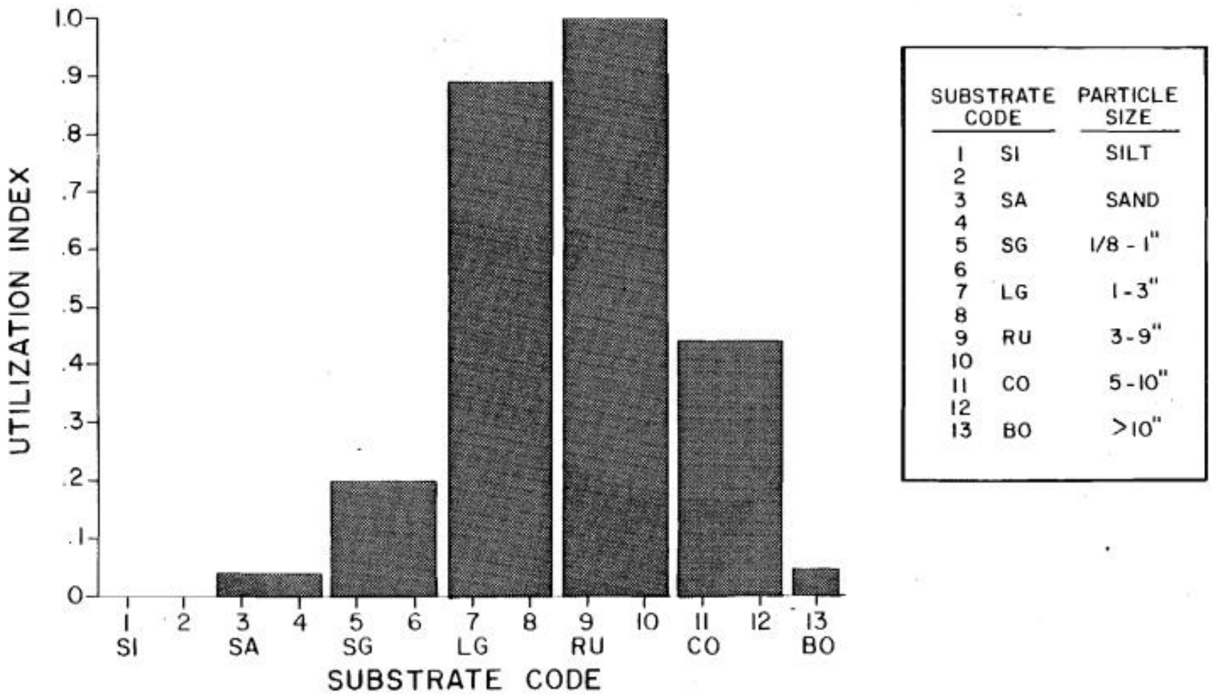


Figure 5.3-7. Substrate utilization curve for chum salmon based upon measurements at 33 redds. Source: Vincent-Lang et al. (1984a).

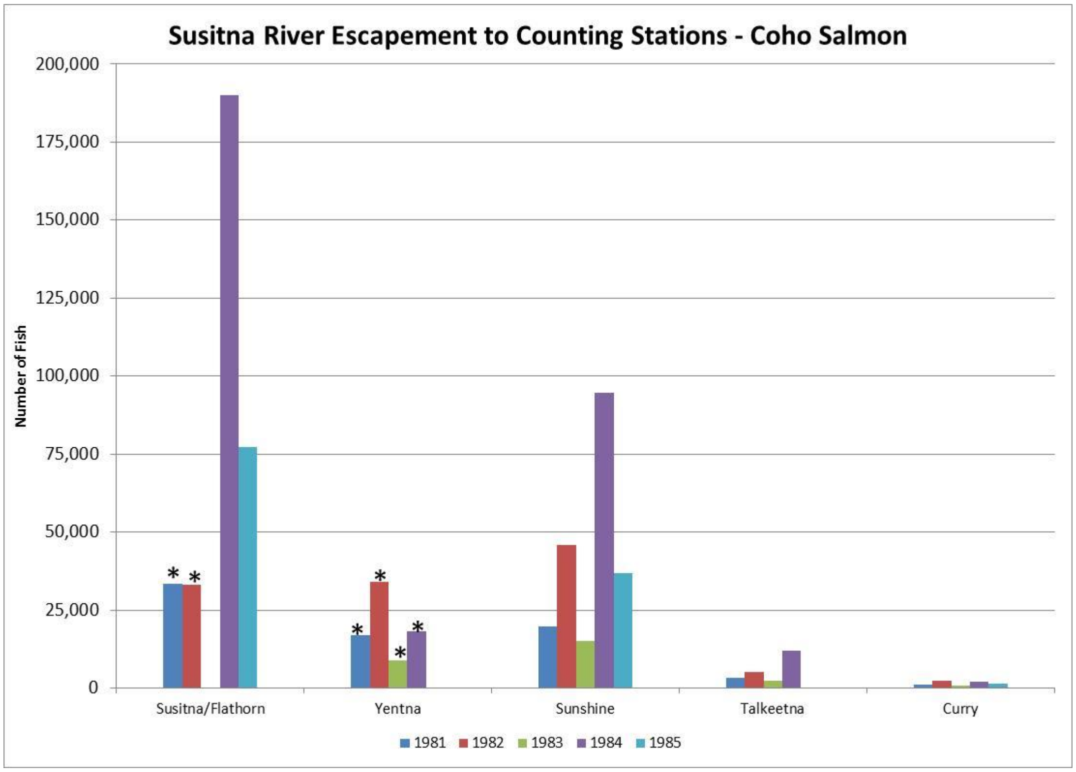


Figure 5.4-1. Coho salmon escapement estimates to the Susitna River 1981 to 1985. No estimates for the following stations and years Susitna/Flathorn (1982, 1983), Yentna (1982, 1985), and Talkeetna (1985). *: Estimate based upon apportionment of sonar counts. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986)

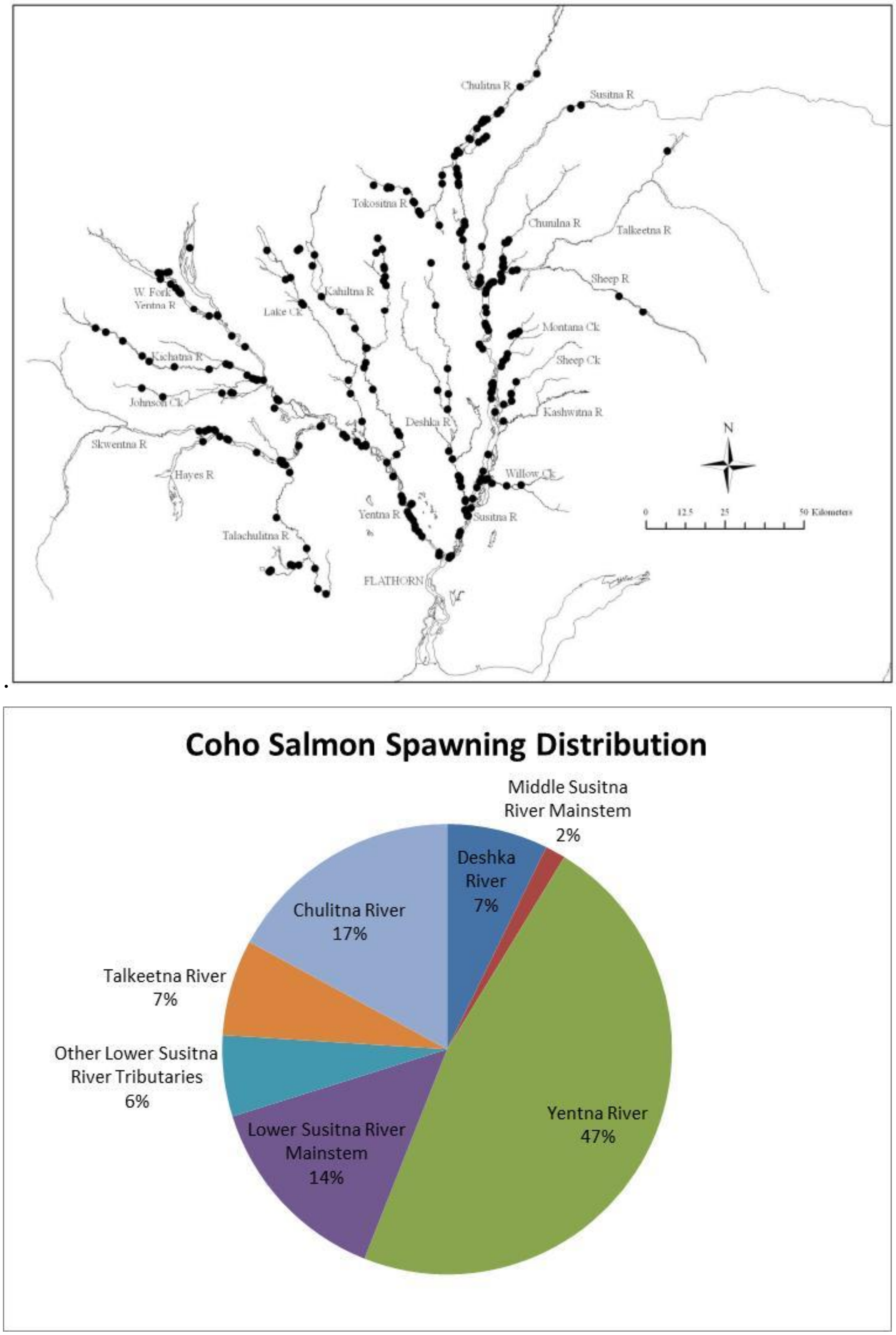


Figure 5.4-2. Spawning distribution of 275 coho salmon radio-tagged at Flathorn during 2009. Source: Merizon et al. (2010).

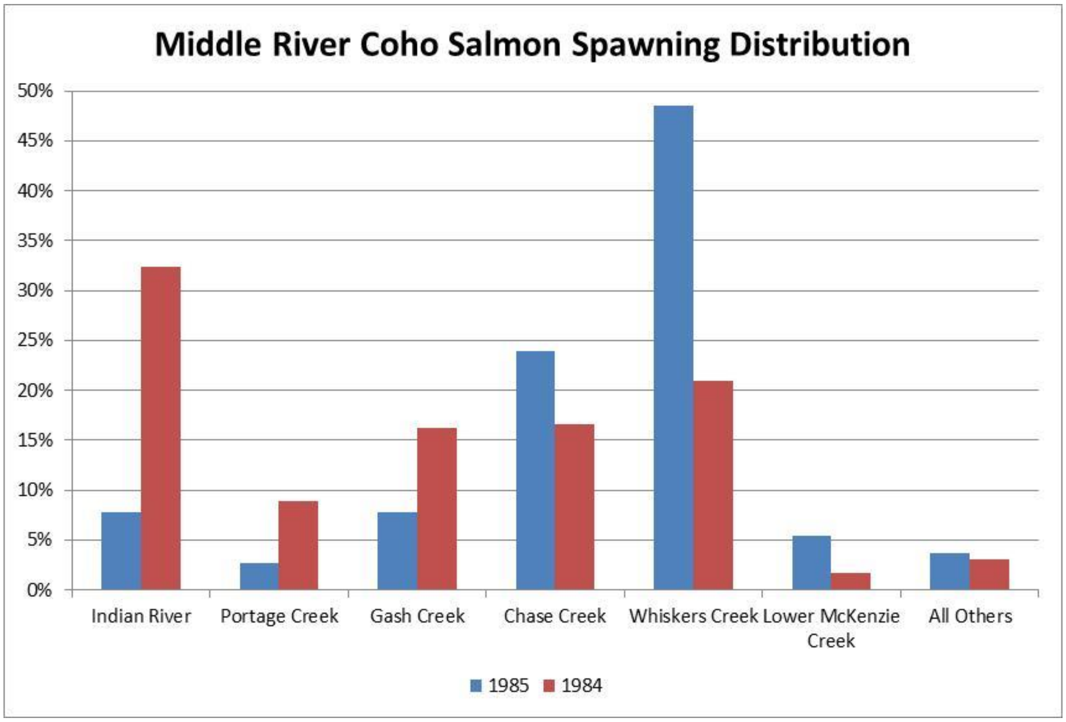


Figure 5.4-3. Coho salmon spawning distribution among tributaries in the Middle Susitna River based upon peak counts. Source: Barrett et al. (1985), Thompson et al. (1986).

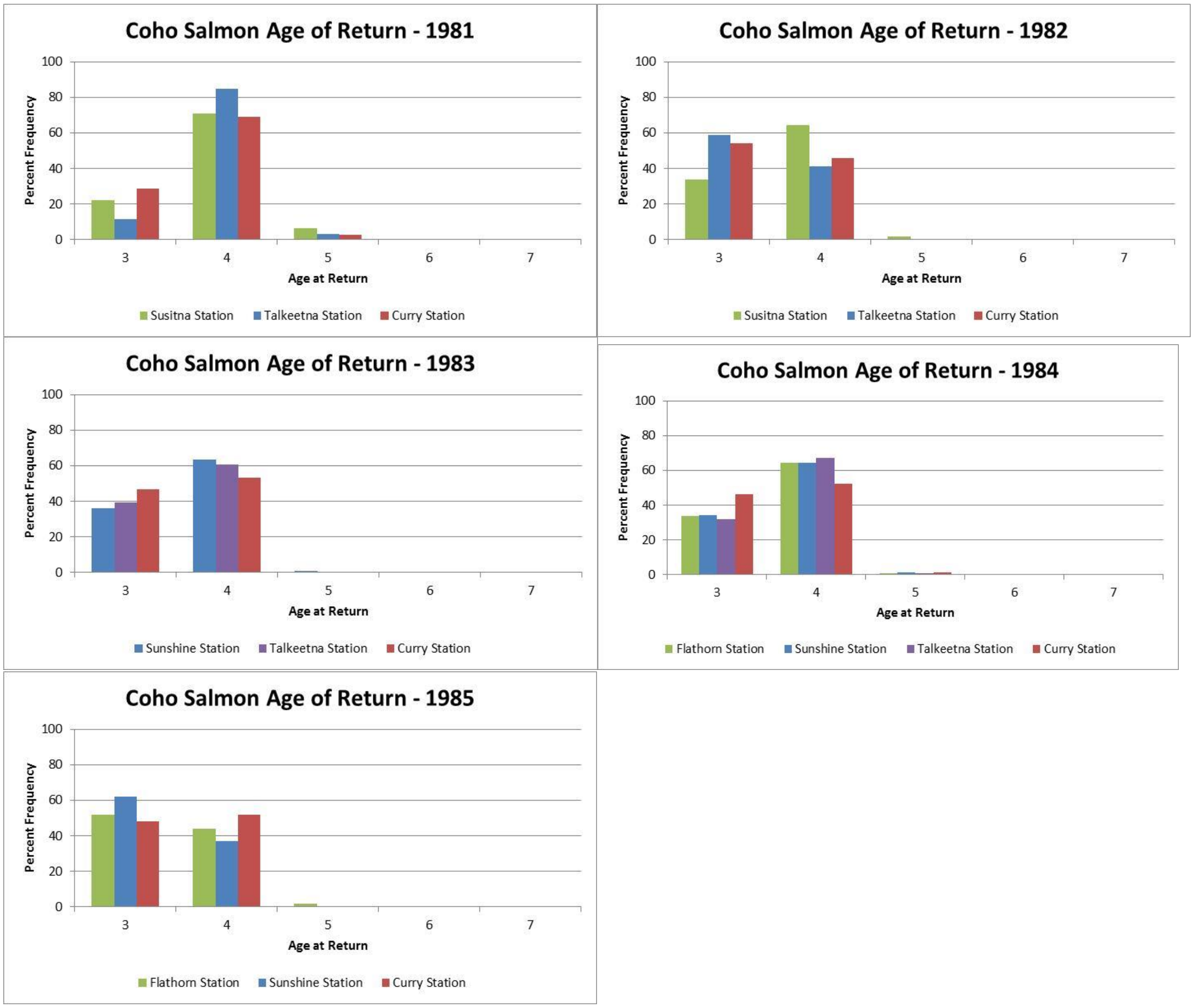


Figure 5.4-4. Age of return for coho salmon collected at the Sunshine, Talkeetna, and Curry Stations during 1981 to 1985. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

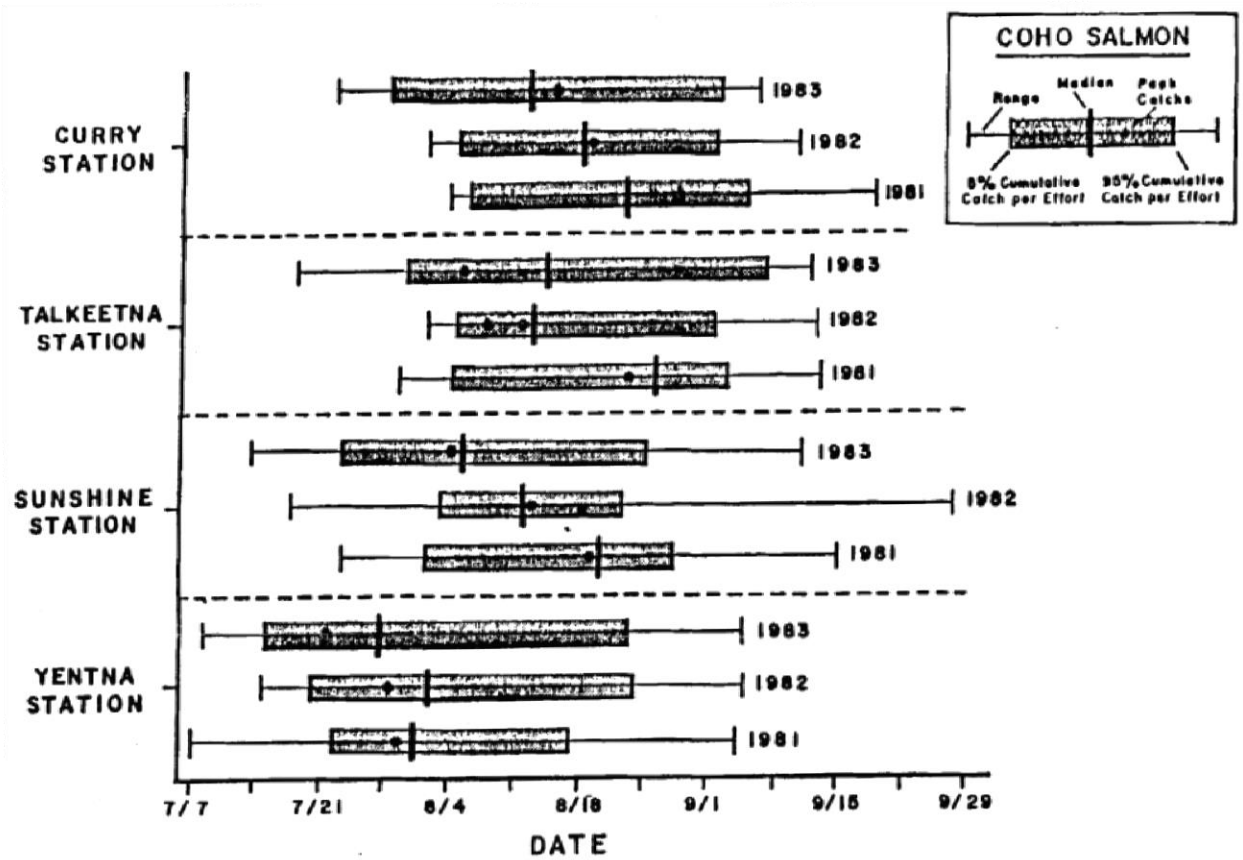


Figure 5.4-5. Upstream migration timing of adult coho salmon in the Susitna River based upon fishwheel catch per unit effort. Source: Jennings (1985).

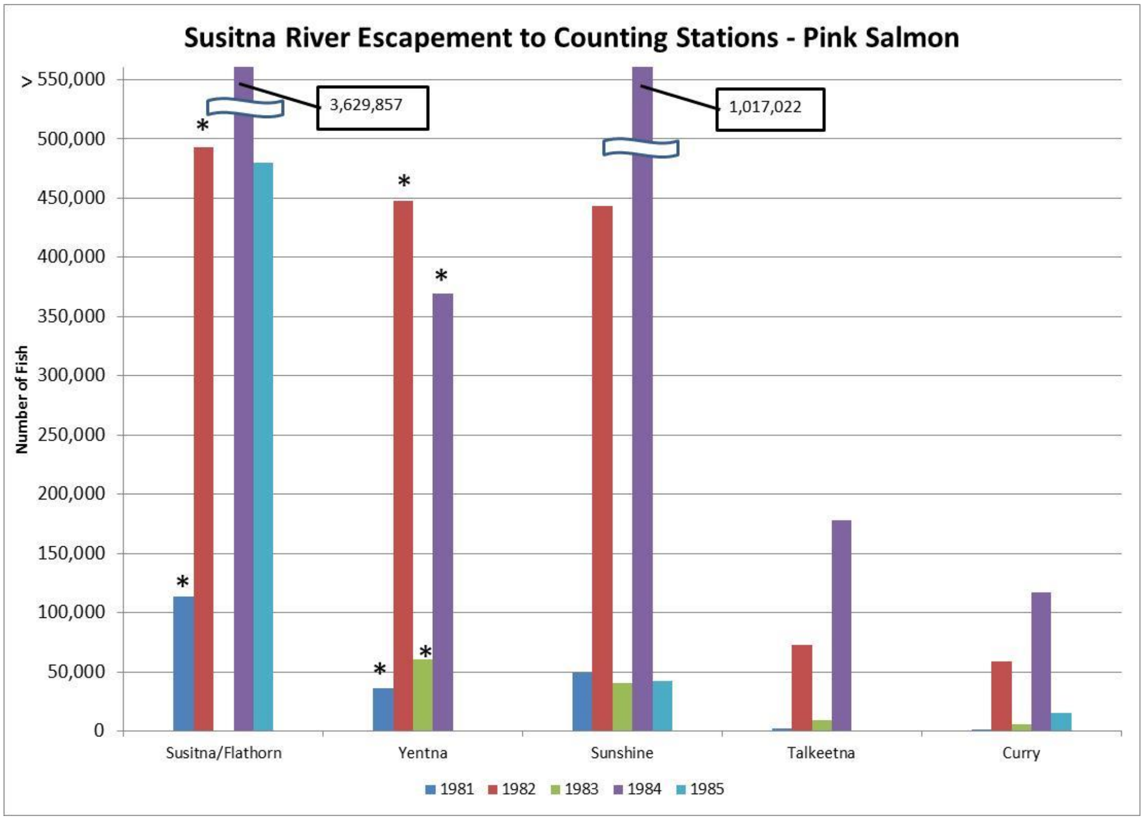


Figure 5.5-1. Pink salmon escapement estimates to the Susitna River 1981 to 1985. No estimates for the following stations and years Susitna/Flathorn (1982, 1983), Yentna (1982, 1985), and Talkeetna (1985). *: Estimate based upon apportionment of sonar counts. Source: ADF&G (1981), Barrett et al. (1983), ADF&G (1984), Barrett et al. (1985), Thompson et al. (1986).

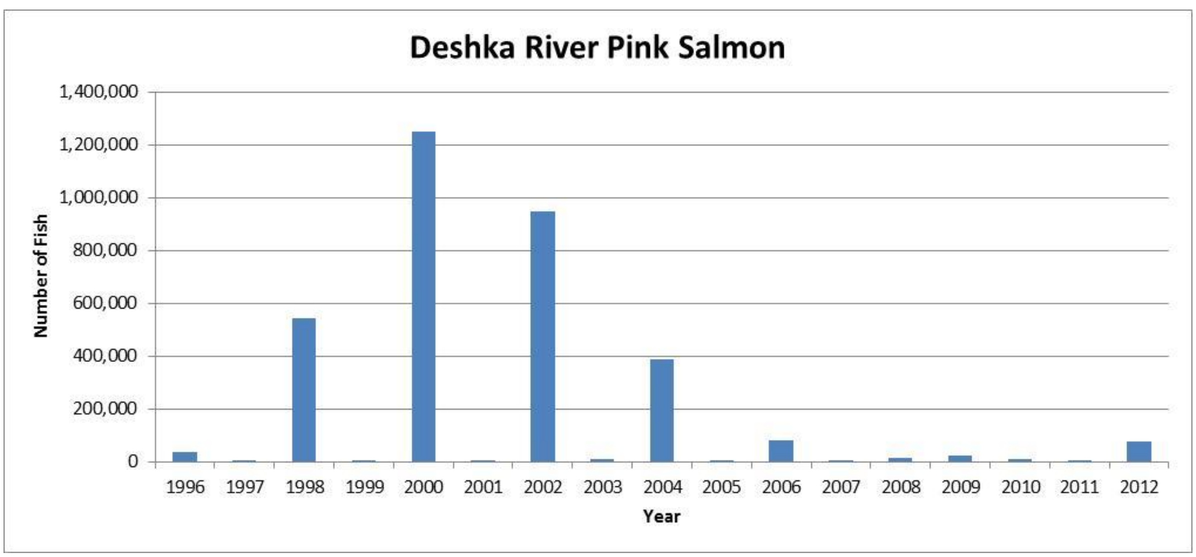


Figure 5.5-2. Pink salmon escapement estimates to the Deshka River 1996 to 2012. Source: http://www.adfg.alaska.gov/sf/FishCounts/

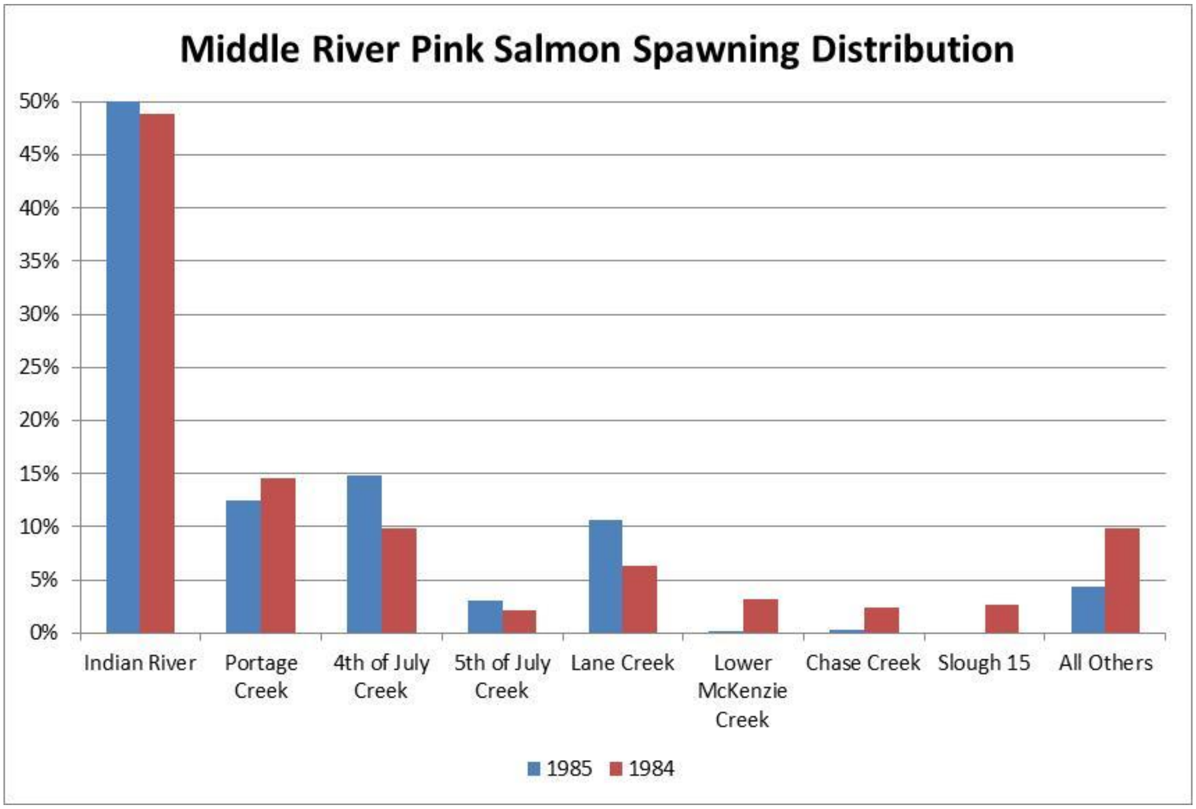


Figure 5.5-3. Pink salmon spawning distribution among tributaries in the Middle Susitna River based upon peak counts.Source: Barrett et al. (1985), Thompson et al. (1986).

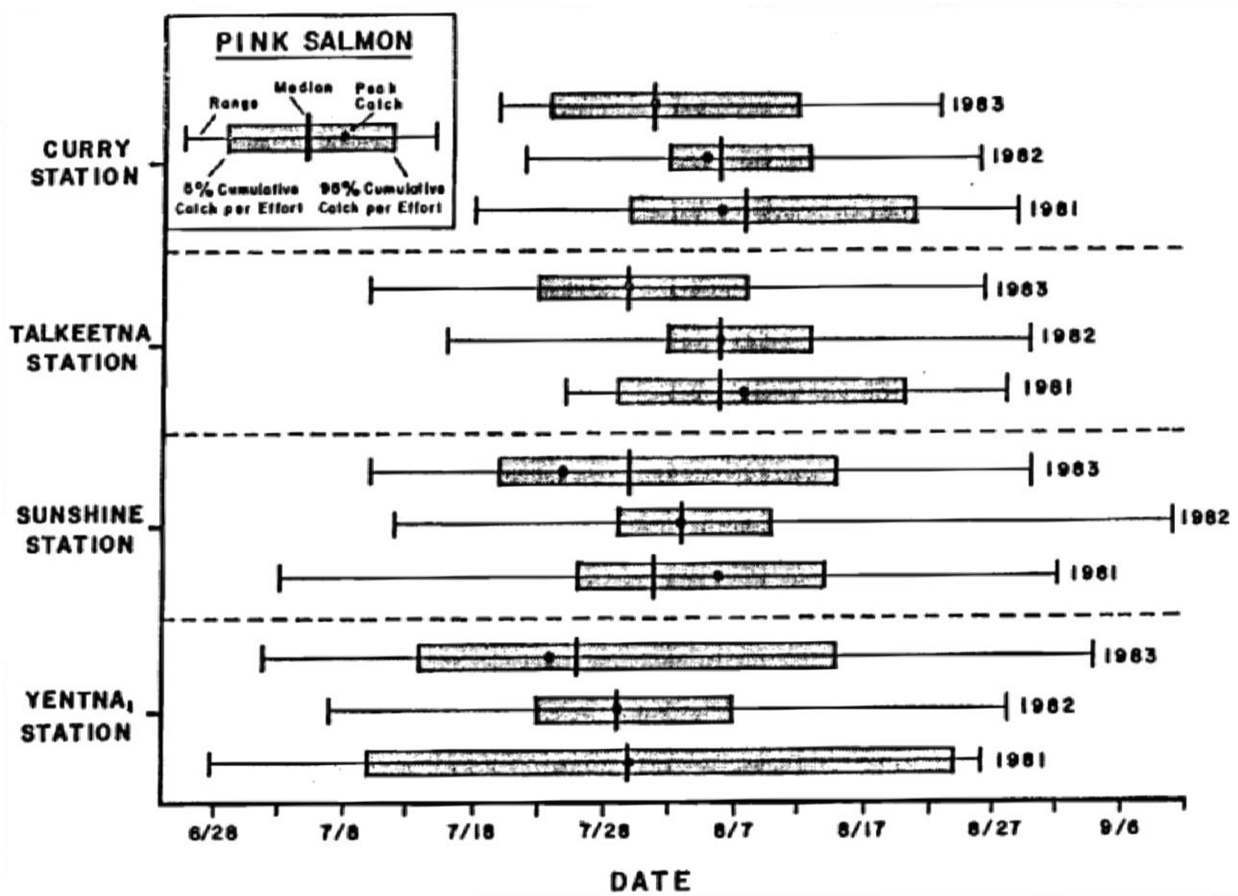


Figure 5.5-4. Upstream migration timing of adult pink salmon in the Susitna River based upon fishwheel catch per unit effort. Source: Jennings (1985).

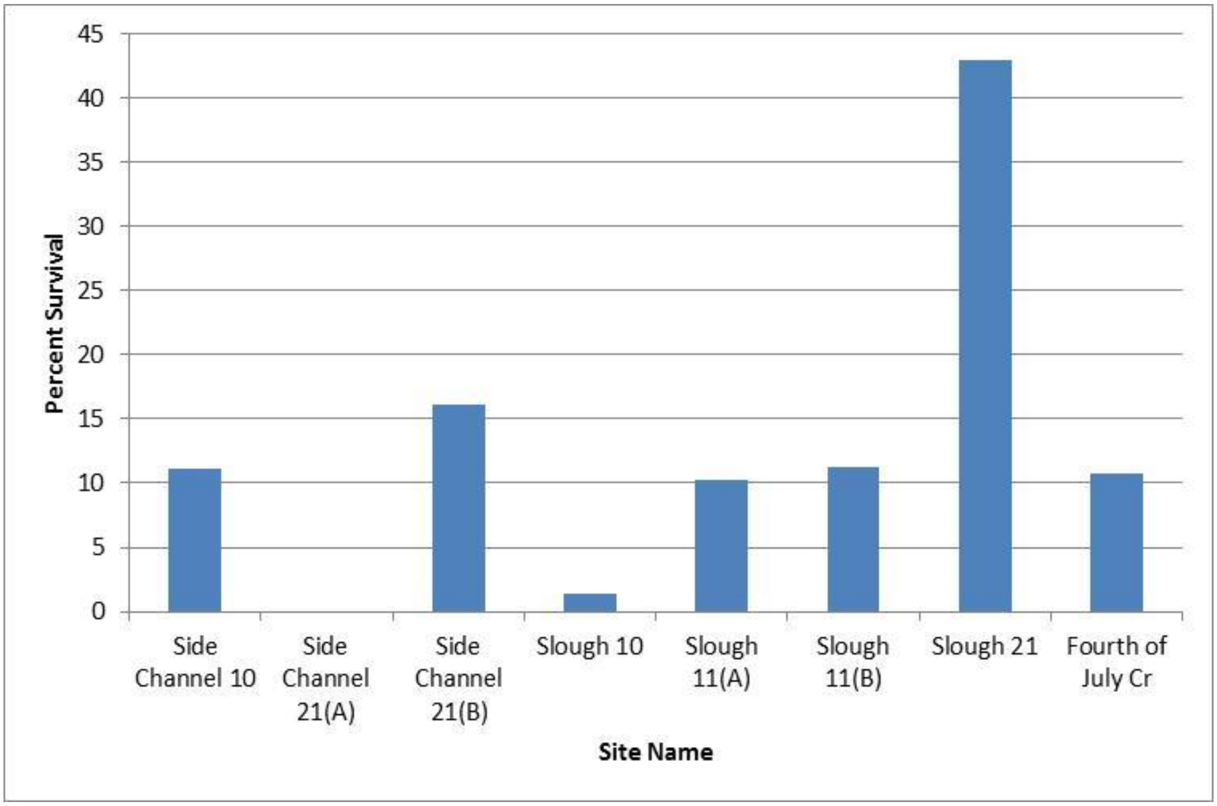


Figure 6.1-1. Percent survival of chum salmon eggs in artificial redds at eight sites during the winter of 1984-1985. Source: Vining et al. (1985).

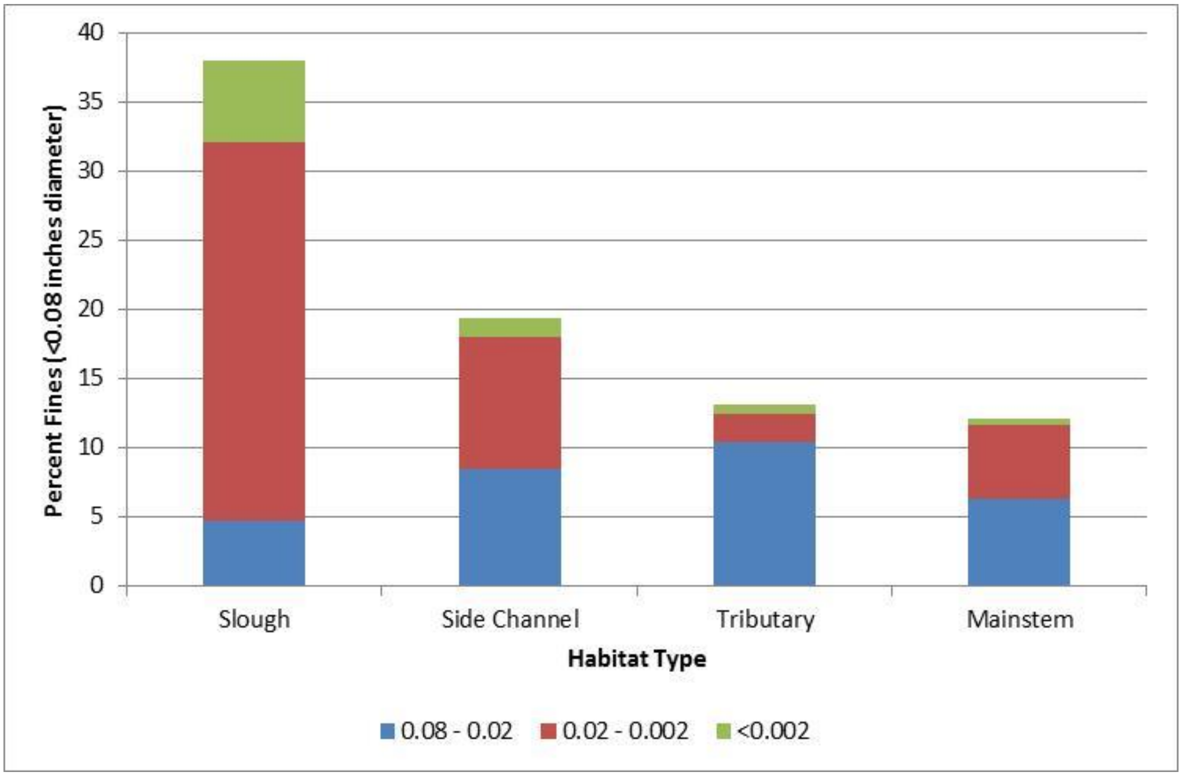


Figure 6.1-2. Percent size composition of fine substrate (<0.08 in. diameter) of McNeil samples collected in various habitat types in the middle Susitna River, Alaska. Source: Vining et al. (1985).

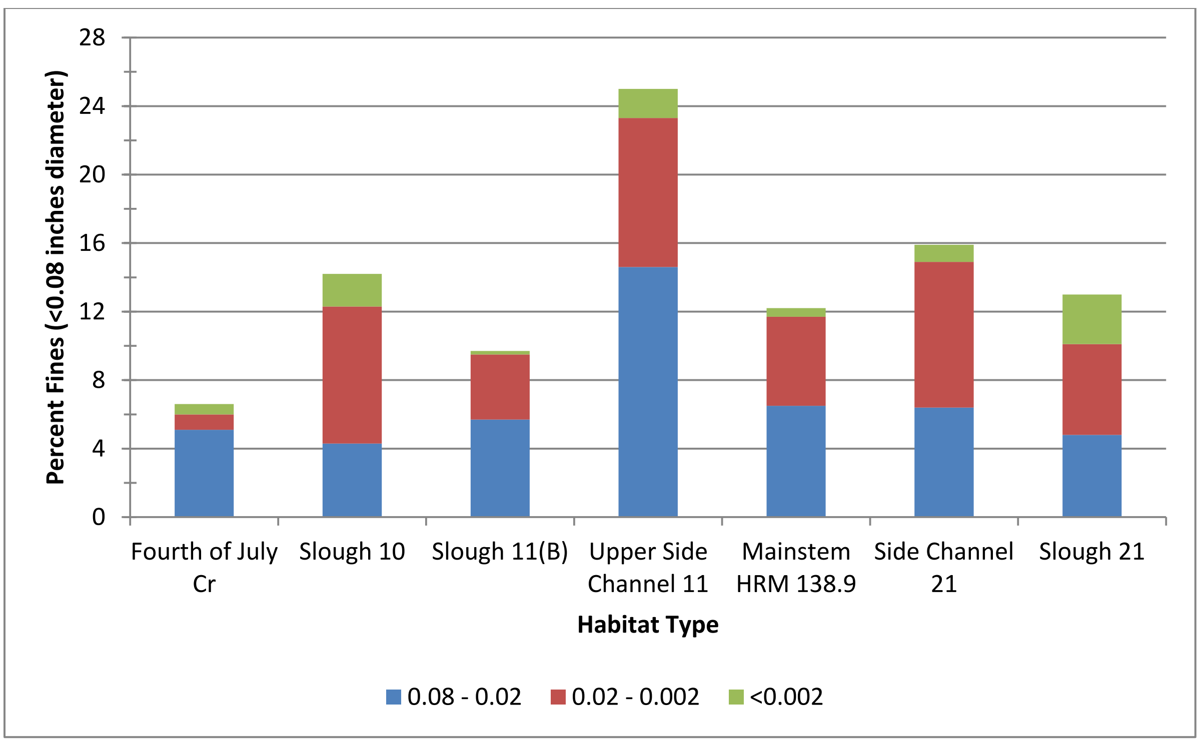


Figure 6.1-3. Percent size composition of fine substrate (<0.08 in. diameter) in McNeil samples collected at chum salmon redds during May 1984 in study sites of middle Susitna River, Alaska. Source Vining et al. (1985).

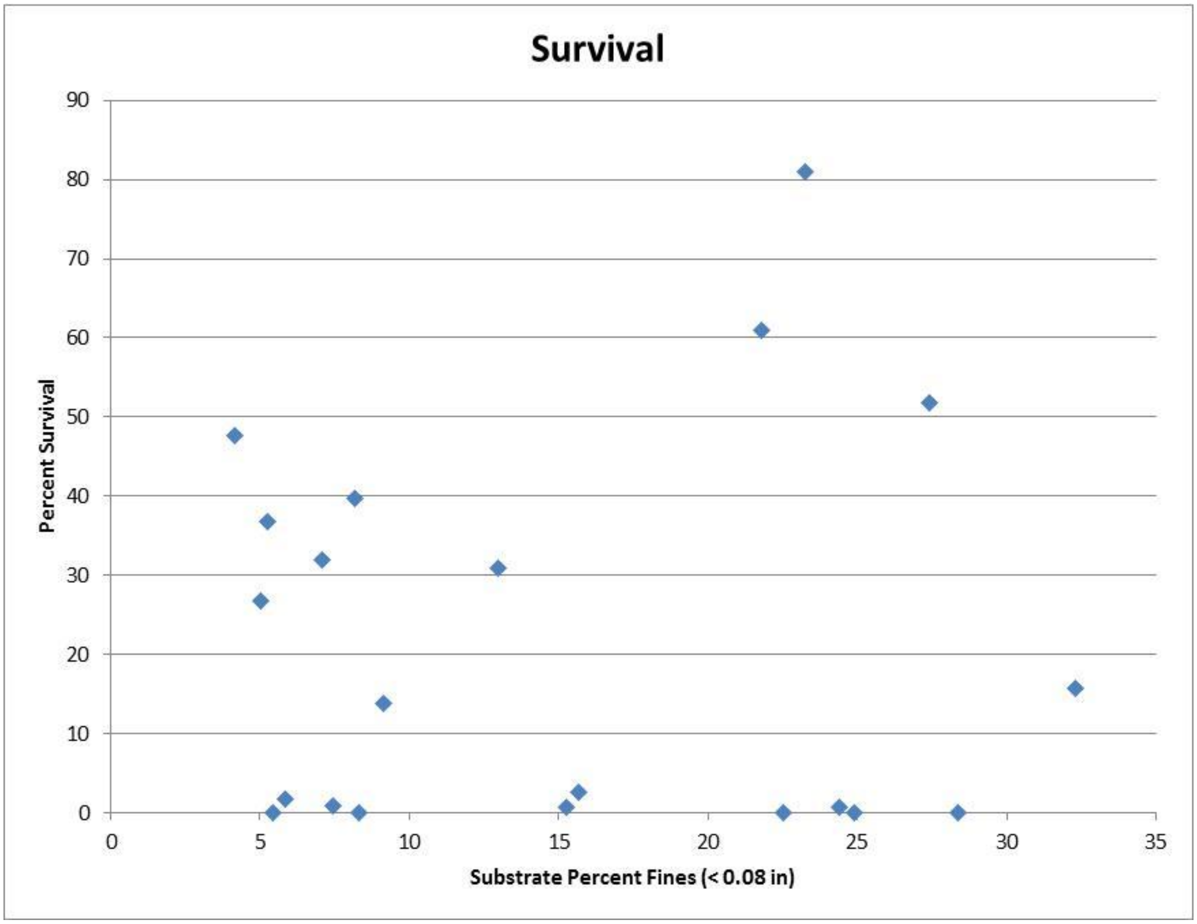


Figure 6.1-4. Relationship between percent survival of salmon embryos and the percent of fine substrate (<0.08 in. diameter) within Whitlock-Vibert Boxes removed from artificial redds within selected habitats of the middle Susitna River, Alaska. Source: Vining et al. (1985).

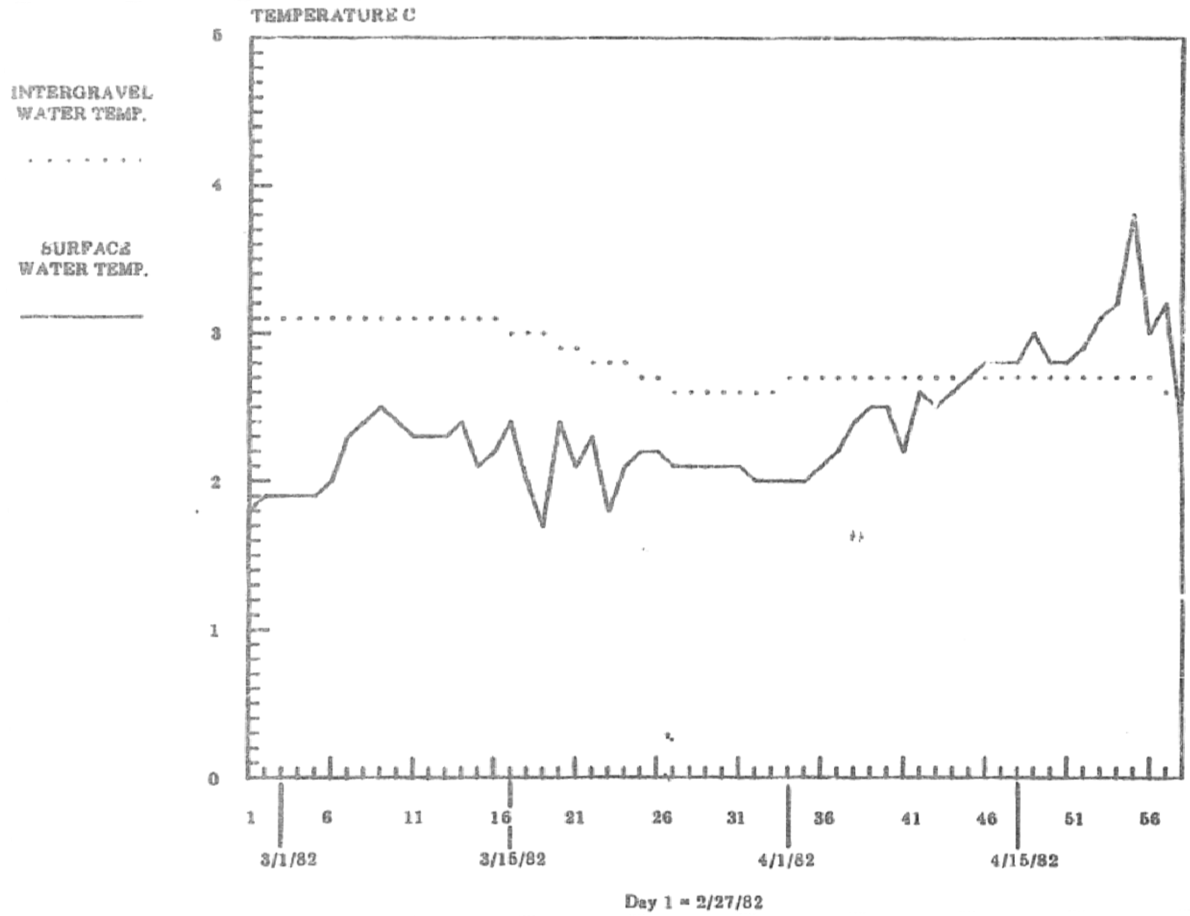


Figure 6.2-1. Mean daily intergravel and surface water temperature data from a spawning site in Slough 8A. Source: Trihey (1982).

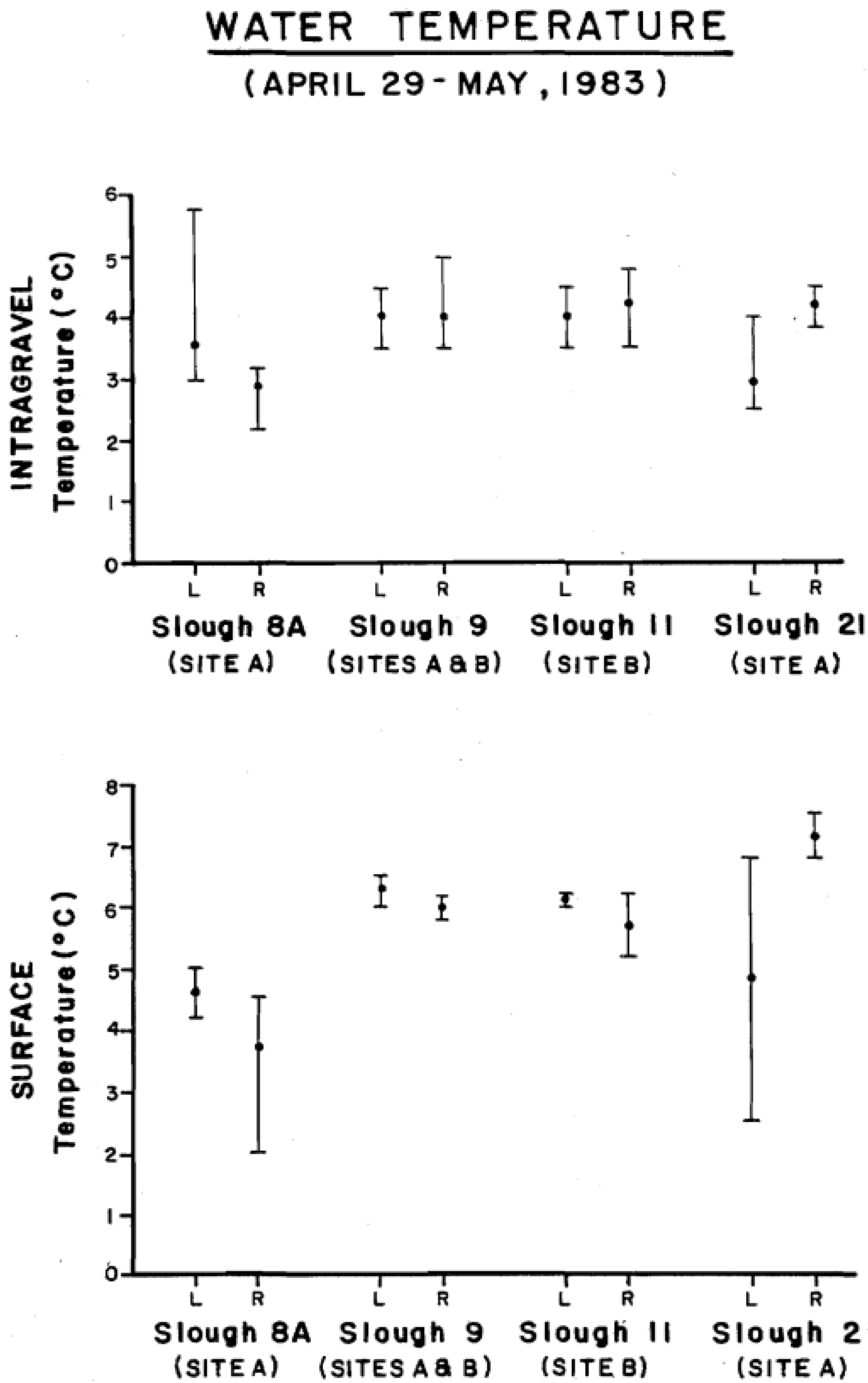


Figure 6.2-2. Summary (mean and range) of intragravel and corresponding surface water temperature data collected along left (L) and right (R) banks (looking upstream). Source: Hoffman et al. (1983).

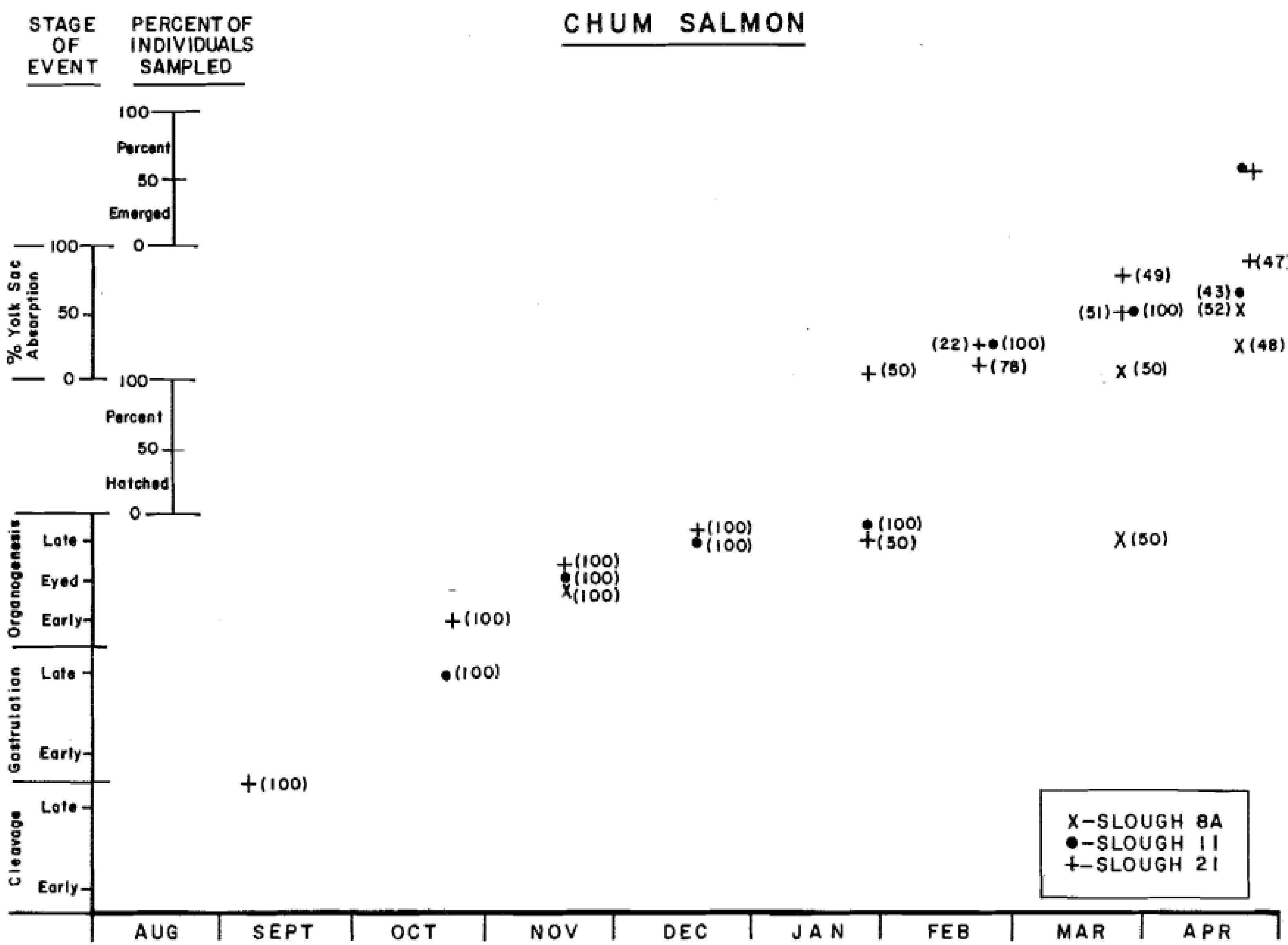


Figure 6.2-3. Embryonic development, hatching, yolk sac absorption, and emergence data for chum salmon at three sloughs, winter, 1982-1983. Numbers in parentheses are the percentages of individuals sampled which were at the indicated stage. Source: Hoffman et al. (1983).

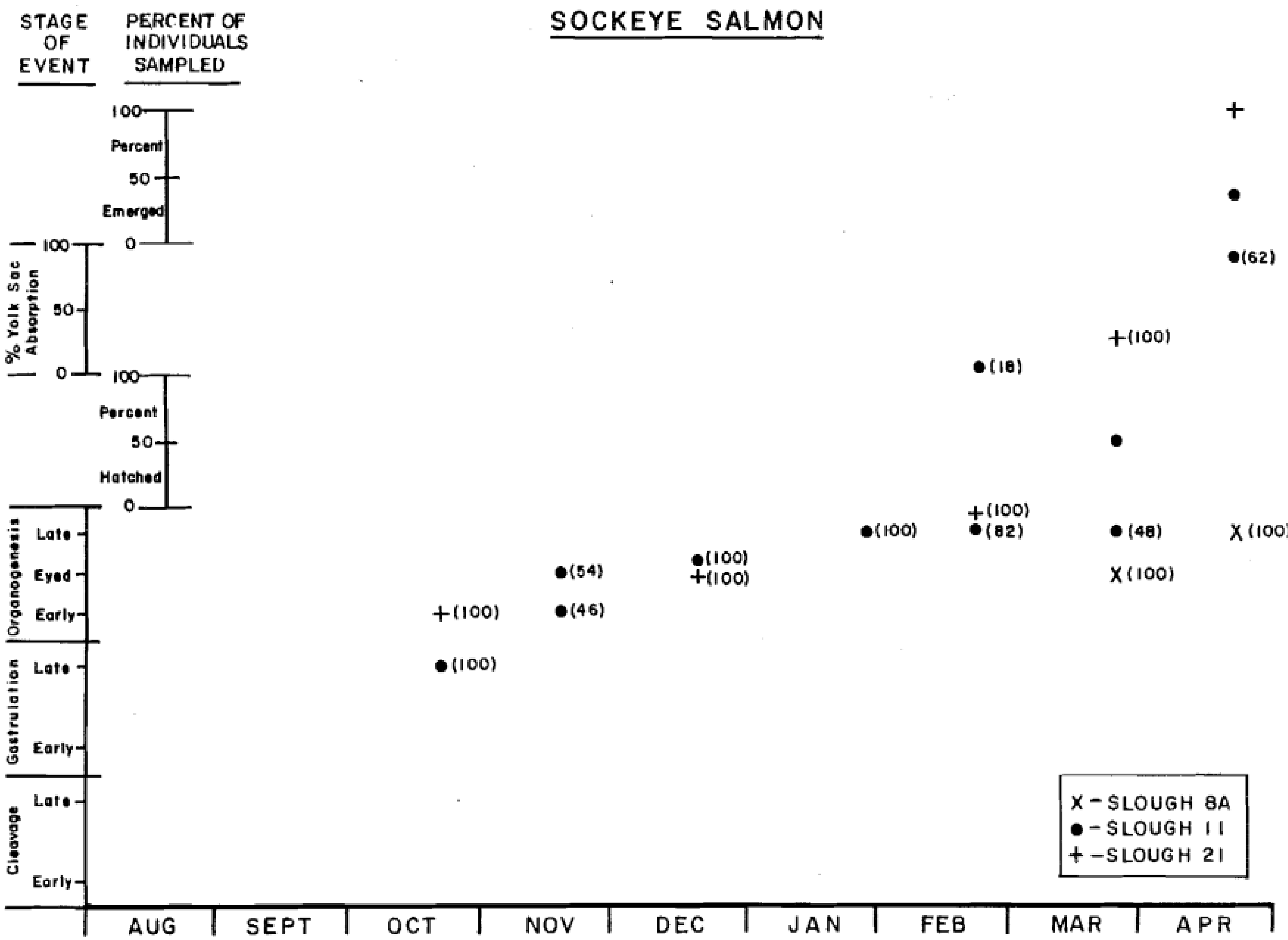


Figure 6.2-4. Embryonic development, hatching, yolk sac absorption, and emergence data for sockeye salmon at three sloughs, winter, 1982-1983. Numbers in parentheses are the percentages of individuals sampled which were at the indicated stage. Source: Hoffman et al. (1983).

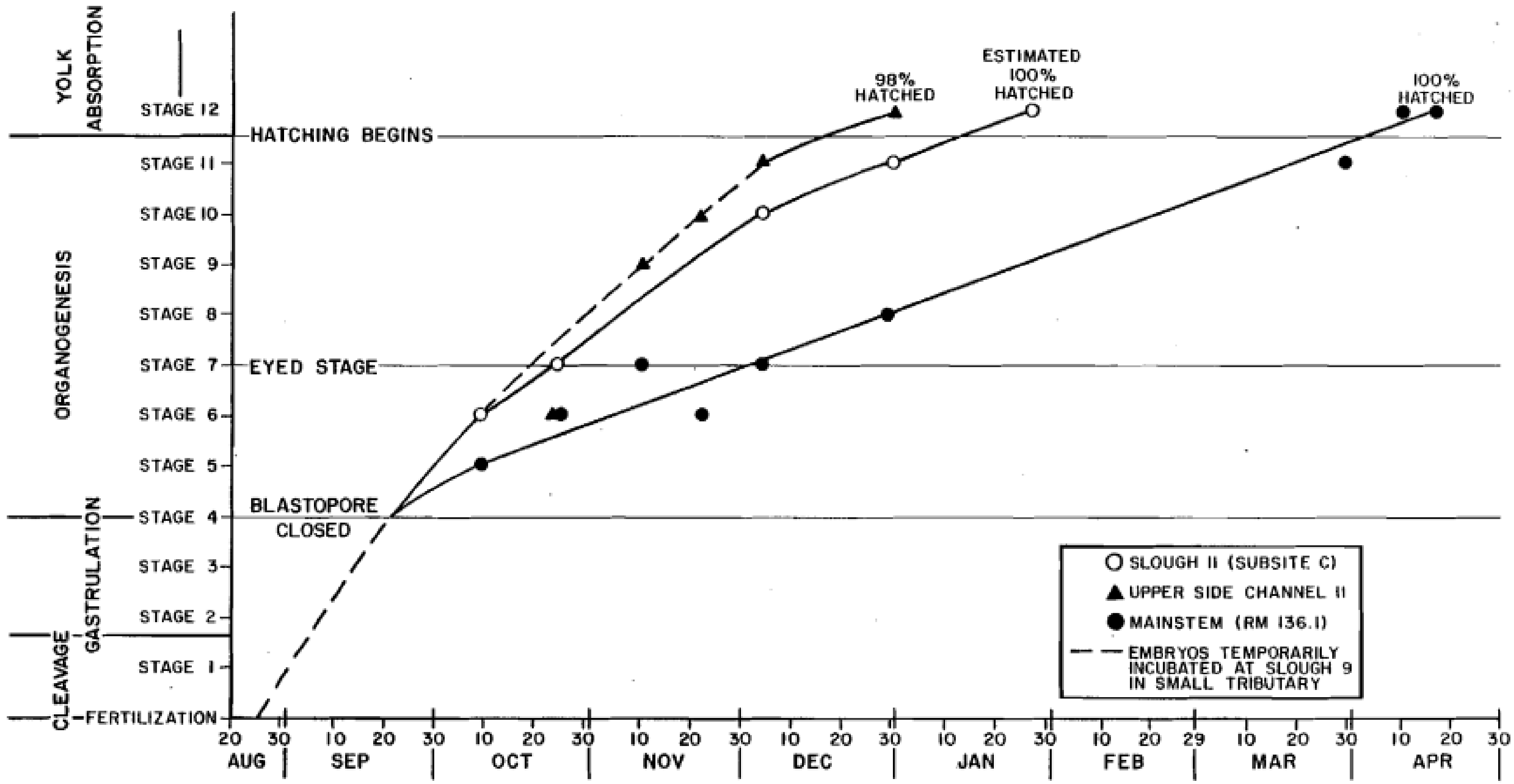


Figure 6.2-5. Comparison of the timing of development of chum salmon embryos placed within slough, side channel and mainstem habitats during the winter of 1984-1985. Source: Vining et al. (1985).

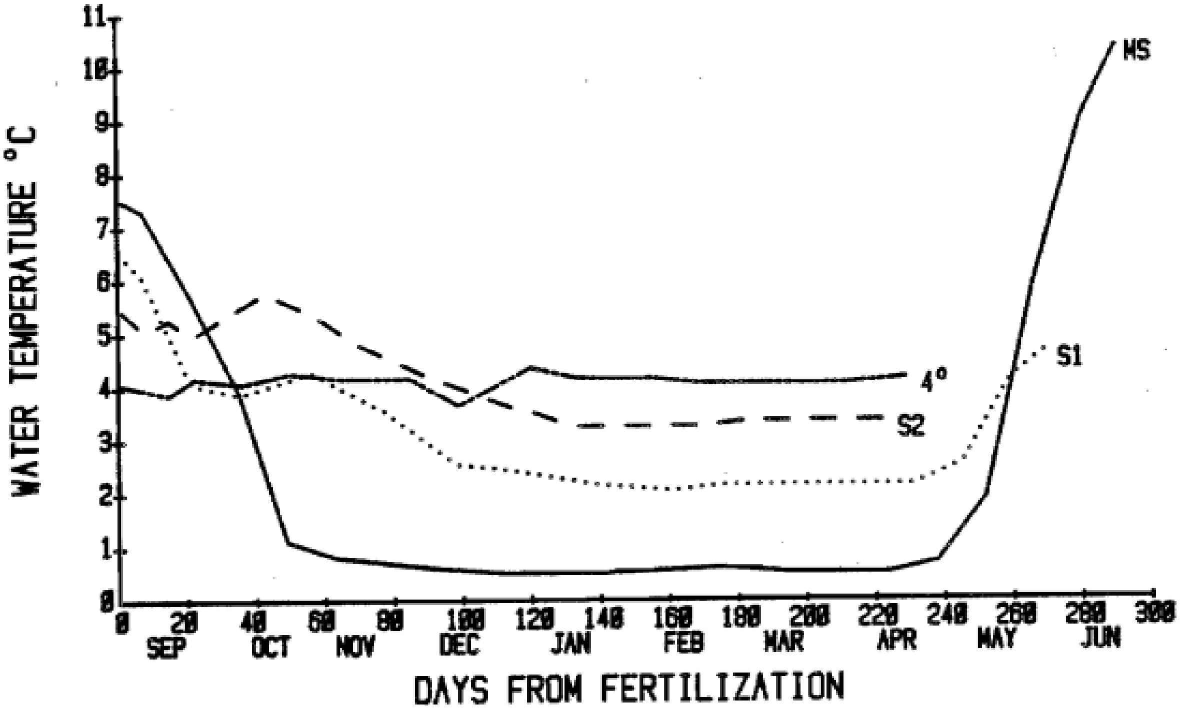


Figure 6.2-6. Temperature regimes for the Susitna River egg-incubation study which simulated the main-stem river RM 136 (MS), Slough 8A (S2), an intermediate regime (S1), and a constant 4°C regime (4°). Source: Wangaard and Burger (1983).

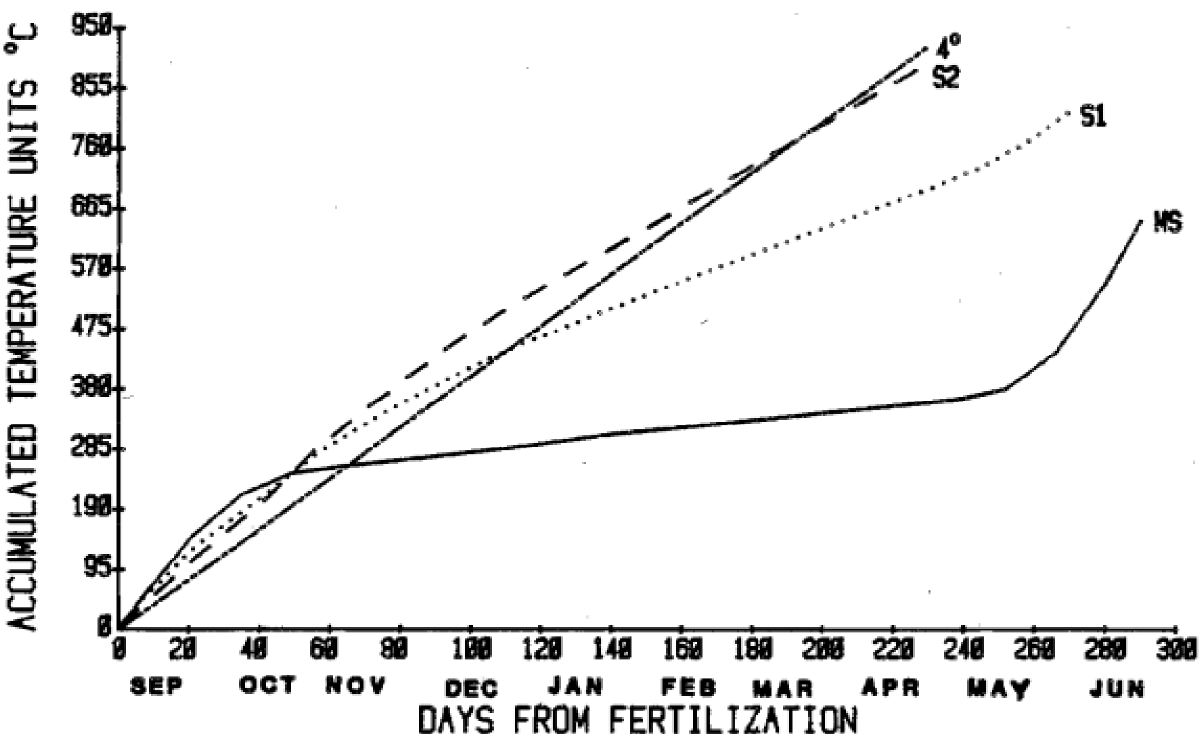


Figure 6.2-7. Accumulated temperature units beginning September 3 at four different temperature regimes for the Susitna River egg-incubation study. The four regimes simulated the Susitna main stem (MS), Slough 8A (S2), an intermediate regime (S1), and 4°C Constant (4°). Source: Wangaard and Burger (1983).

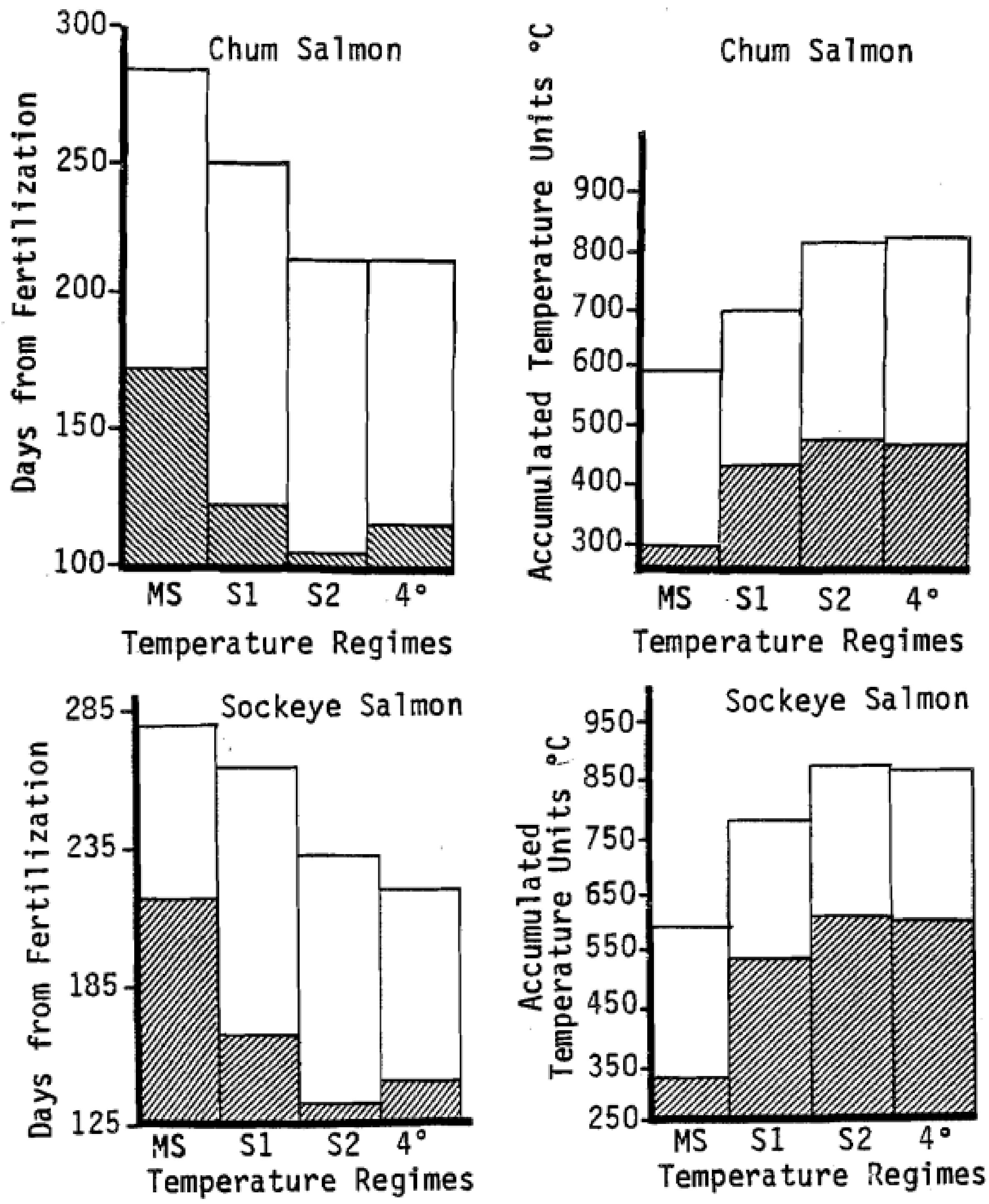


Figure 6.2-8. Left: days from fertilization to 50 percent hatch (cross- hatched bars) and complete yolk absorption (open bars). Right: Accumulated temperature units to reach 50 percent hatch (cross-hatched bars) and complete yolk absorption (open bars). Incubation occurred at four different temperature regimes which simulated the Susitna main stem (MS), Slough 8A (S2), an intermediary (Sl), and constant 4°C regime (4°). Data were pooled from three fertilization dates in September and from study replicates. Source: Wangaard and Burger (1983).

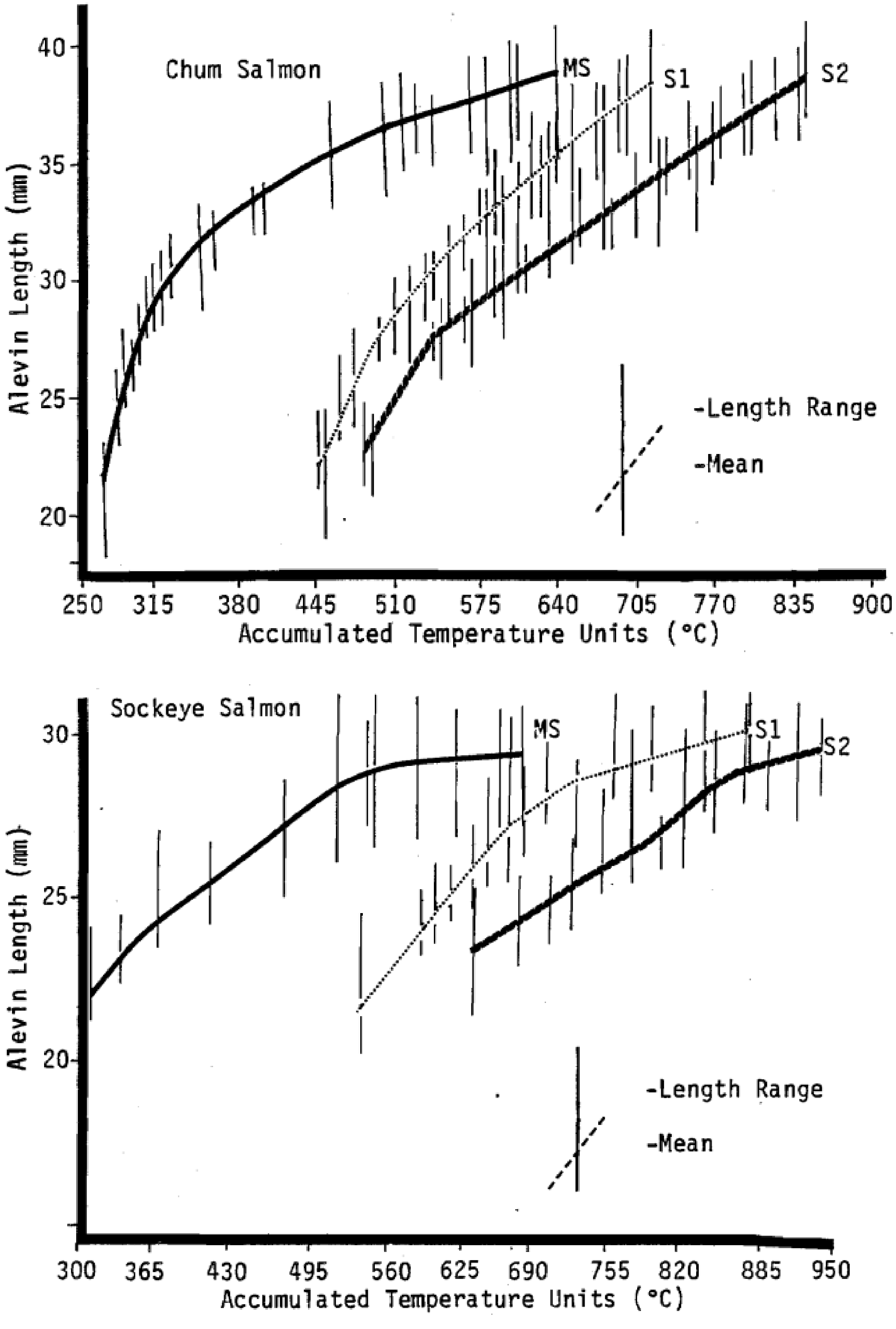
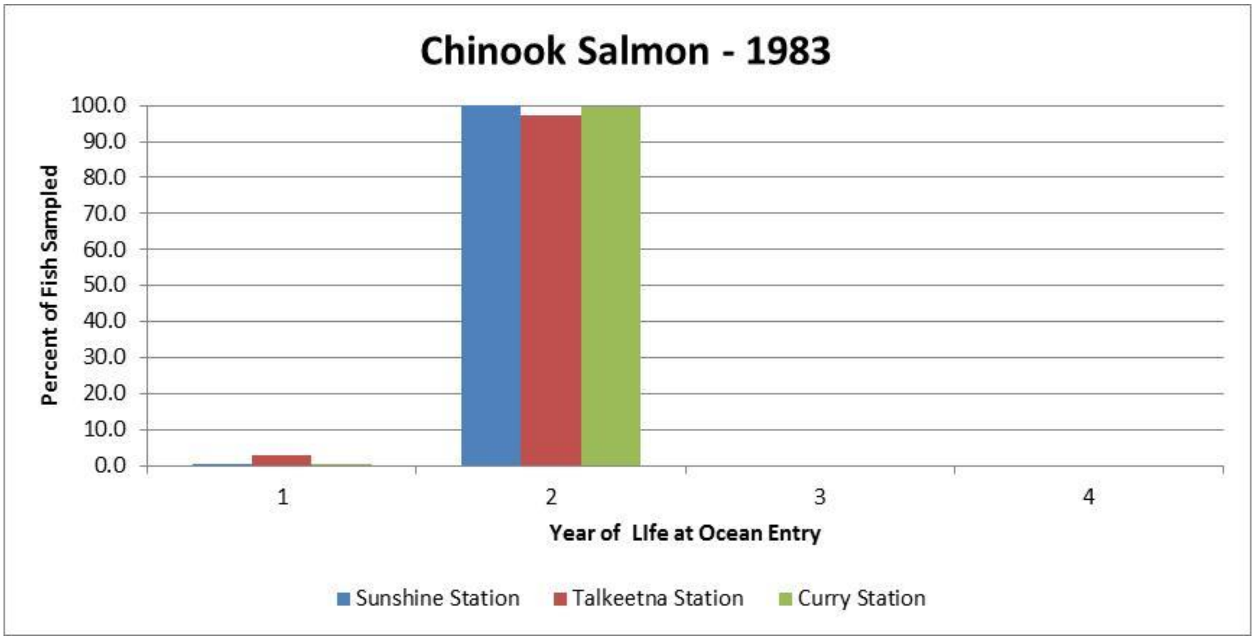


Figure 6.2-9. Alevin growth (total length) from 50 percent hatch to complete yolk absorption for chum and sockeye salmon incubated at three different temperature regimes. The regimes simulated the Susitna main stem (MS), Slough 8A (S2), and an intermediary (S1). (Data are based on a fertilization date of September 15. Data from replicates were pooled.). Source: Wagaard and Burger (1983).



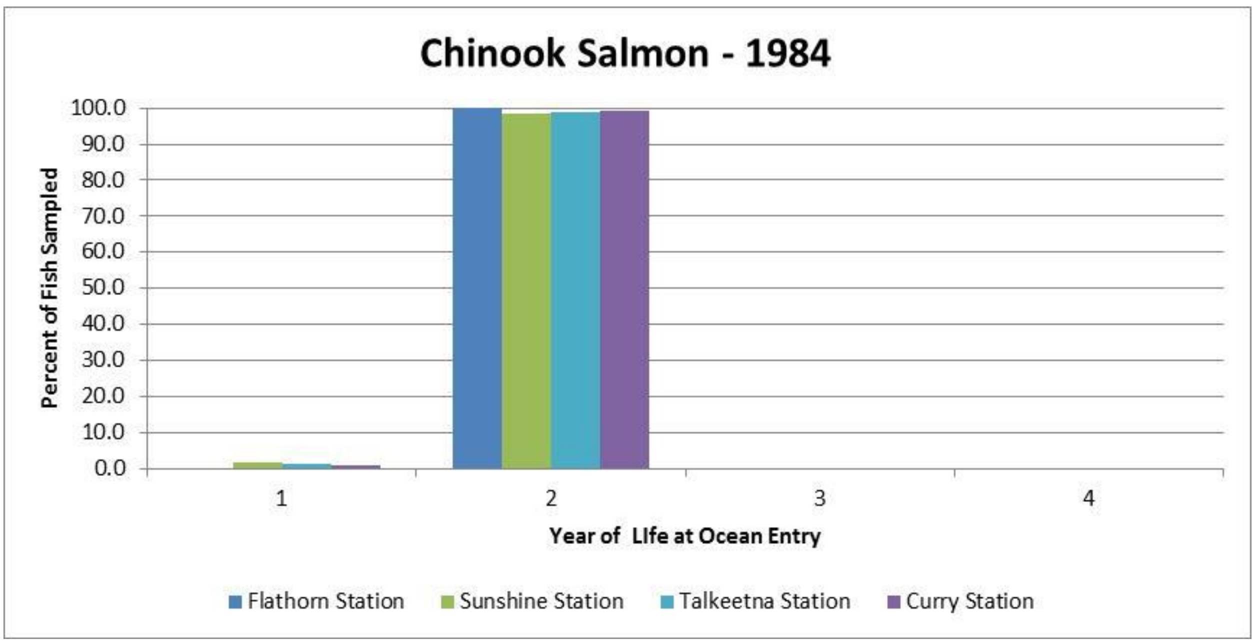


Figure 7.1-1. Year of ocean entry by Chinook salmon based upon scale analysis of adults returning in 1983 and 1984. Source: ADF&G (1984), Barrett et al. (1985).

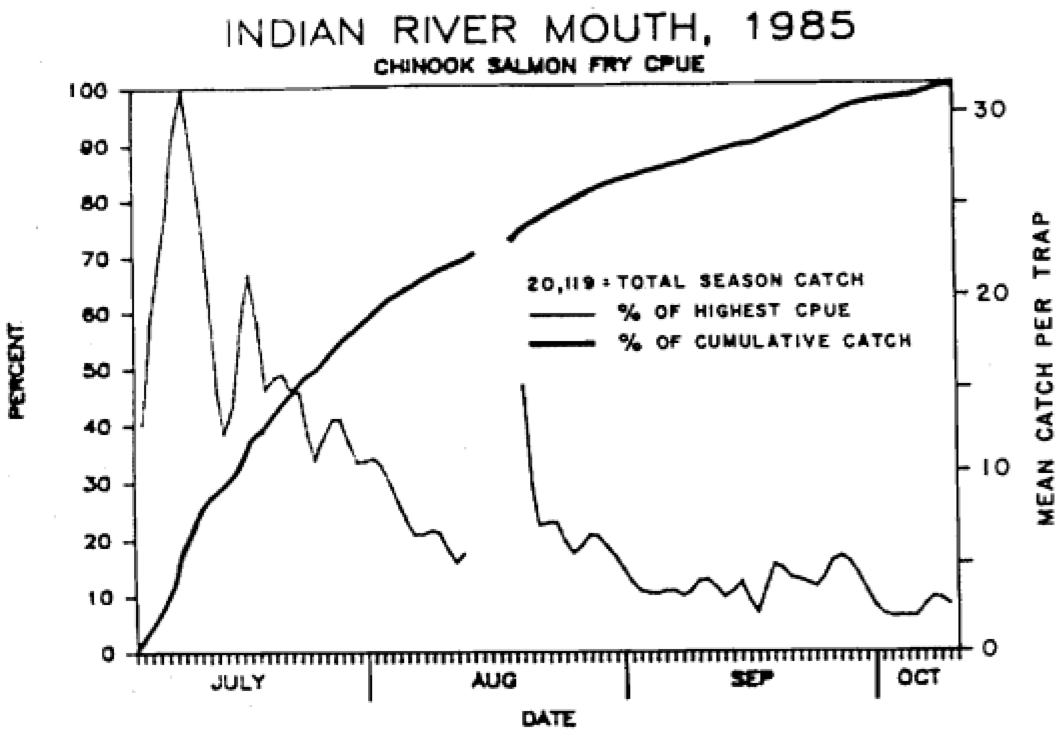


Figure 7.1-2. Chinook salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the mouth of Indian River. Source: Roth et al. (1986).

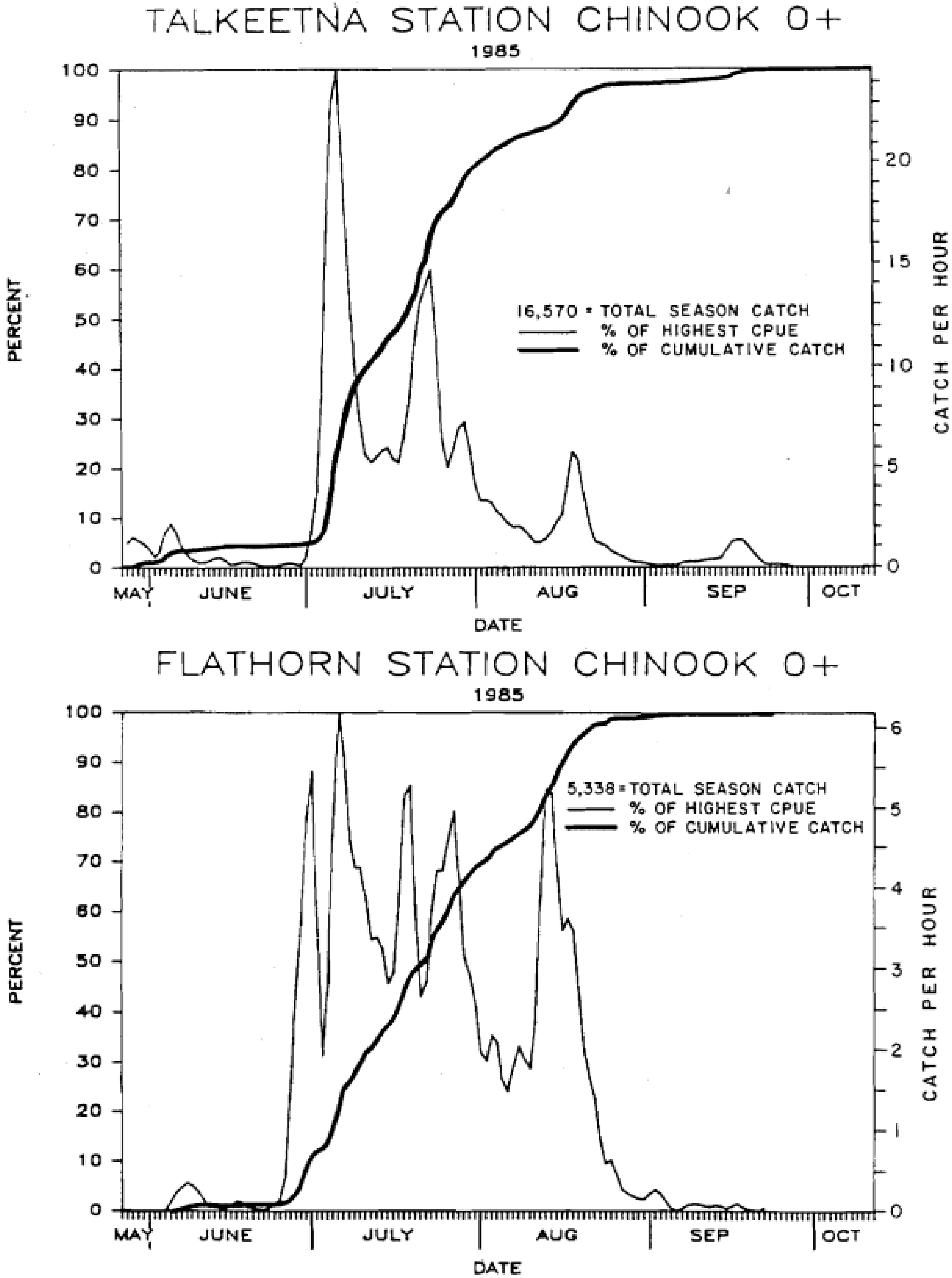


Figure 7.1-3. Chinook salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).

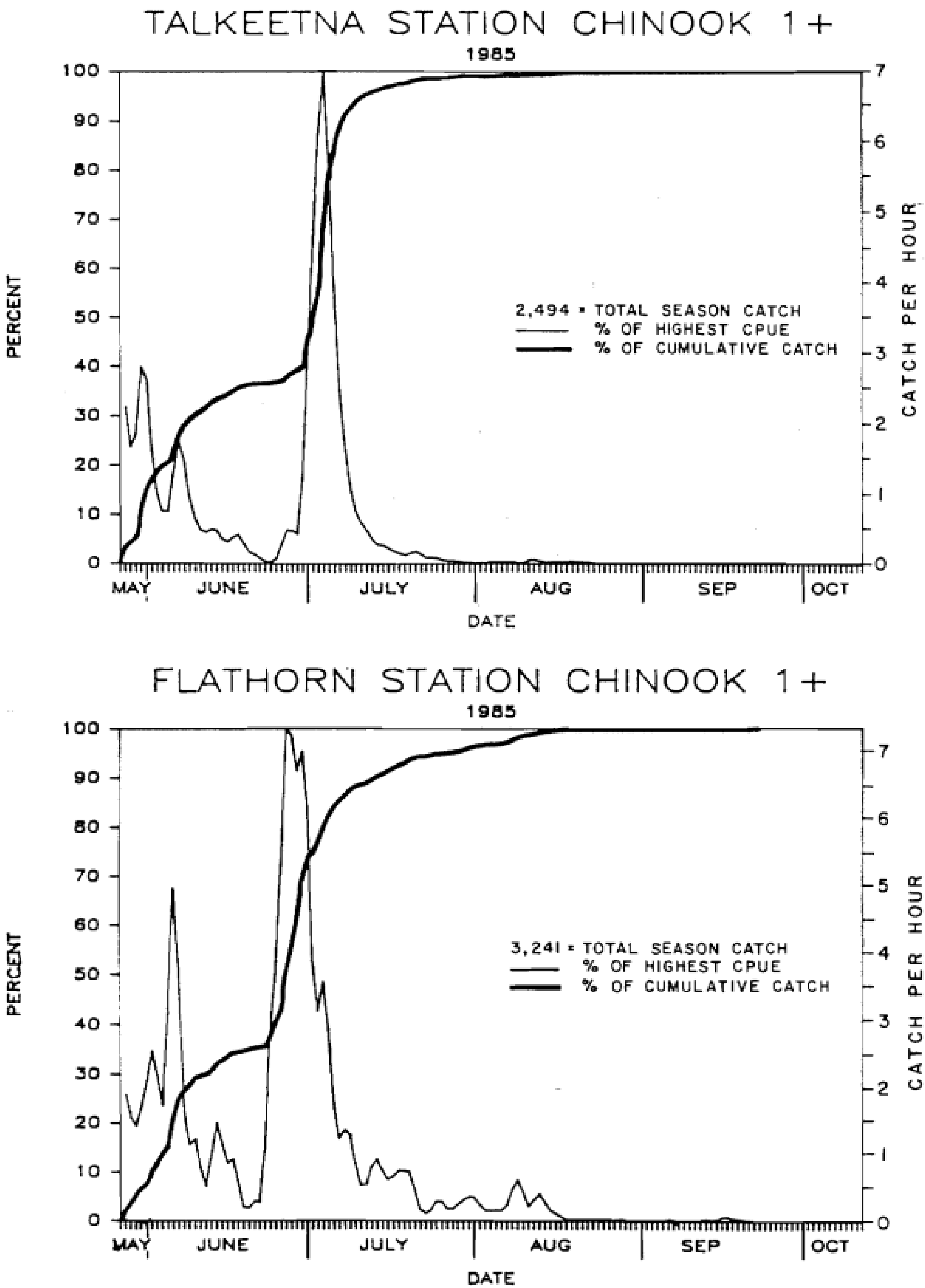
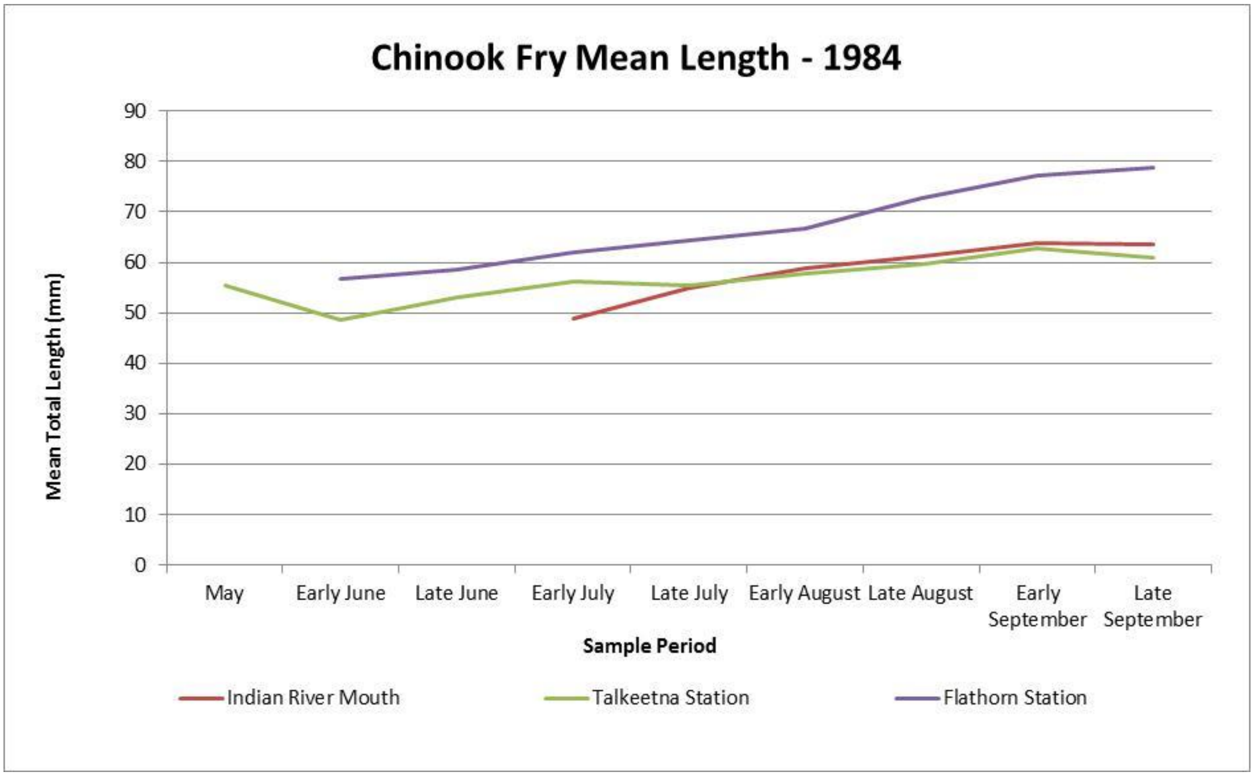


Figure 7.1-4. Chinook salmon (age 1+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).



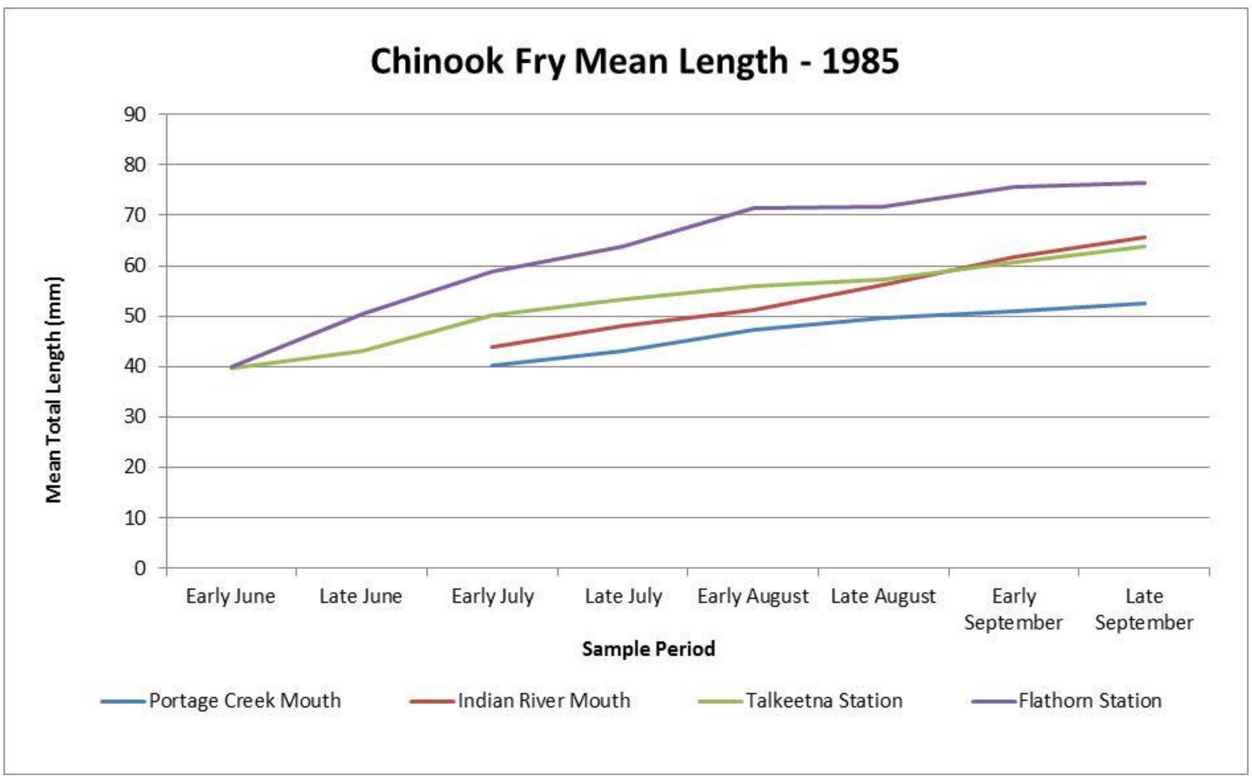


Figure 7.1-5. Mean length of Chinook fry captured at outmigrant traps during 1984 and 1985. Source: Roth and Stratton 1985, Roth et al. (1986).

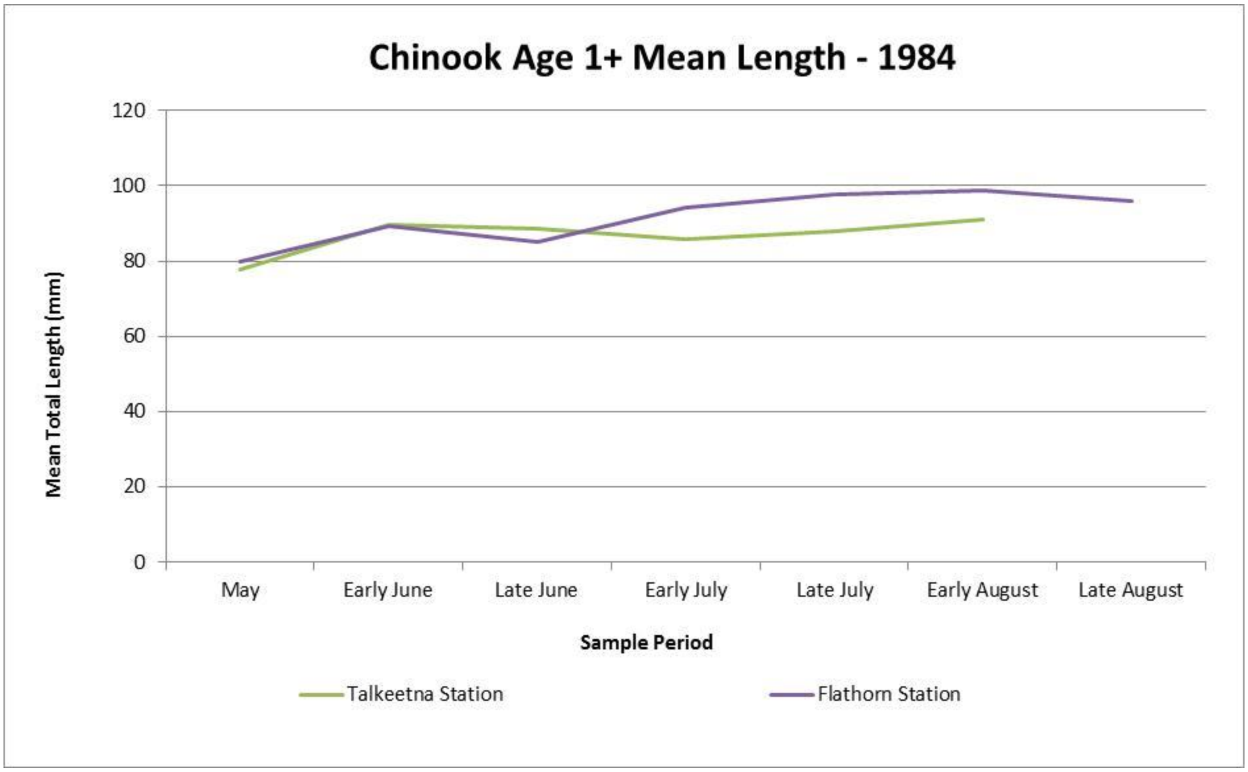


Figure 7.1-6. Mean length of Chinook Age 1+ captured at outmigrant traps during 1984. Source: Roth and Stratton 1985.

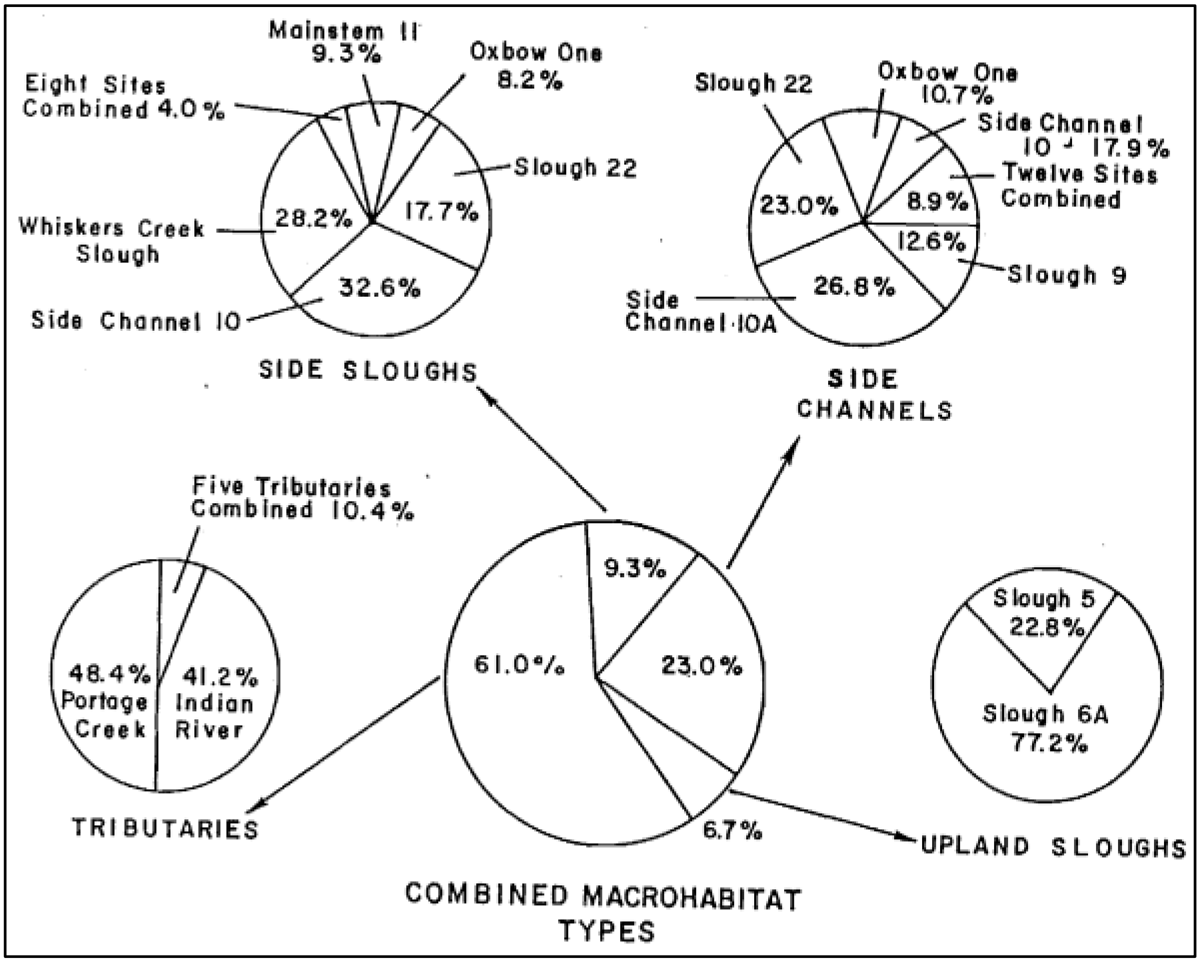


Figure 7.1-7. Density distribution and juvenile Chinook salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

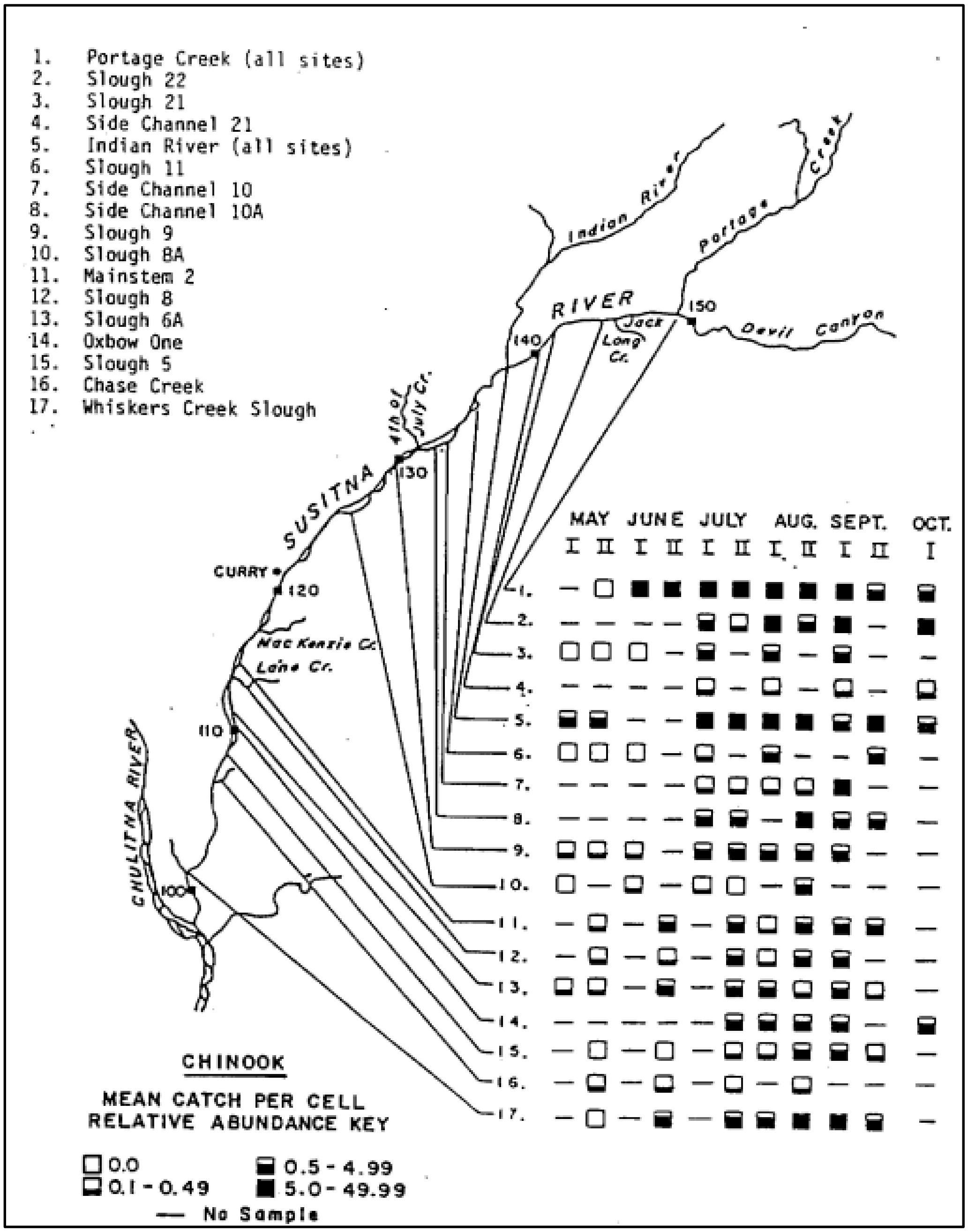
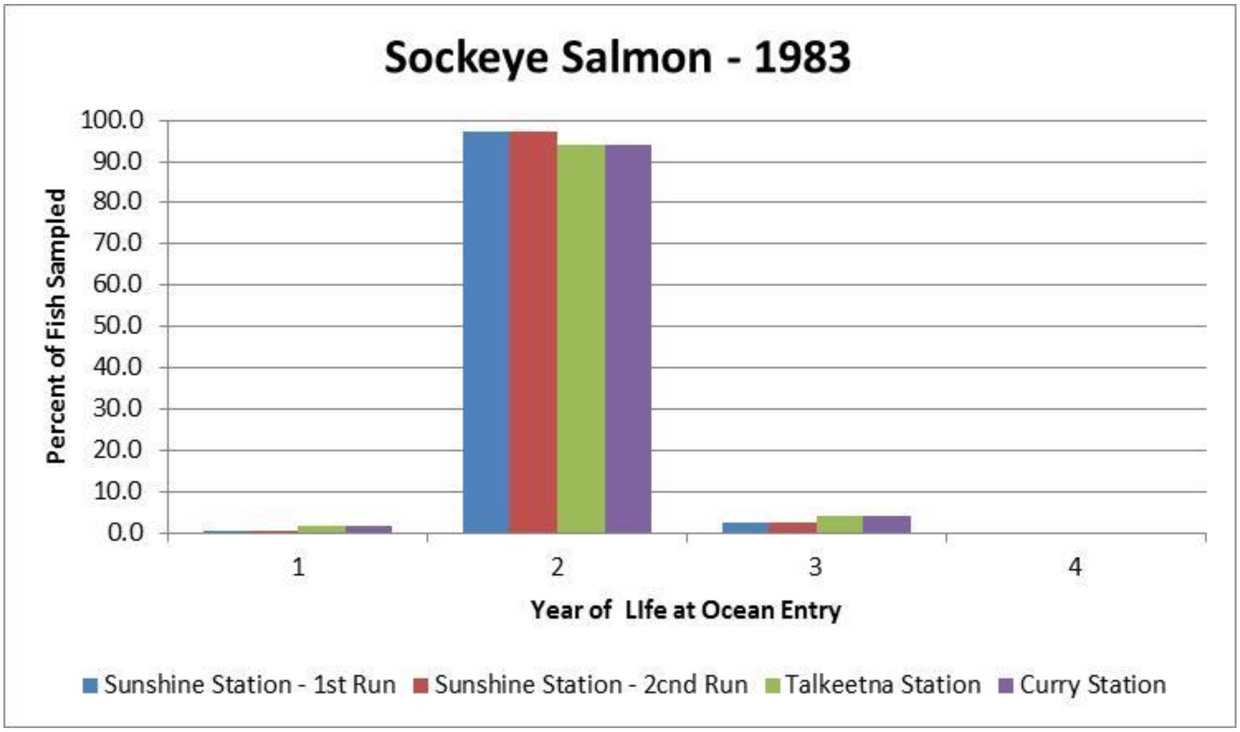


Figure 7.1-8. Seasonal distribution and relative abundance of juvenile Chinook salmon on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Source: Dugan et al. (1984).



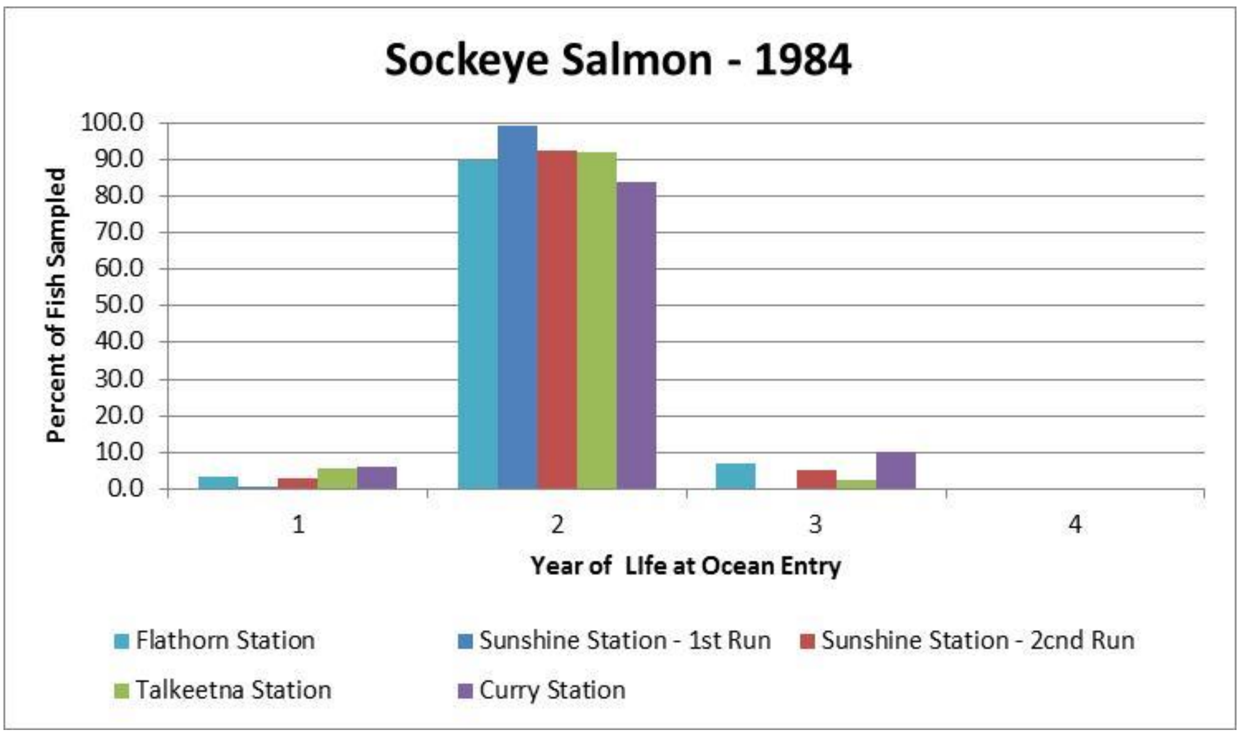


Figure 7.2-1. Year of ocean entry by sockeye salmon based upon scale analysis of adults returning in 1983 and 1984. Source: ADF&G (1984), Barrett et al. (1985).

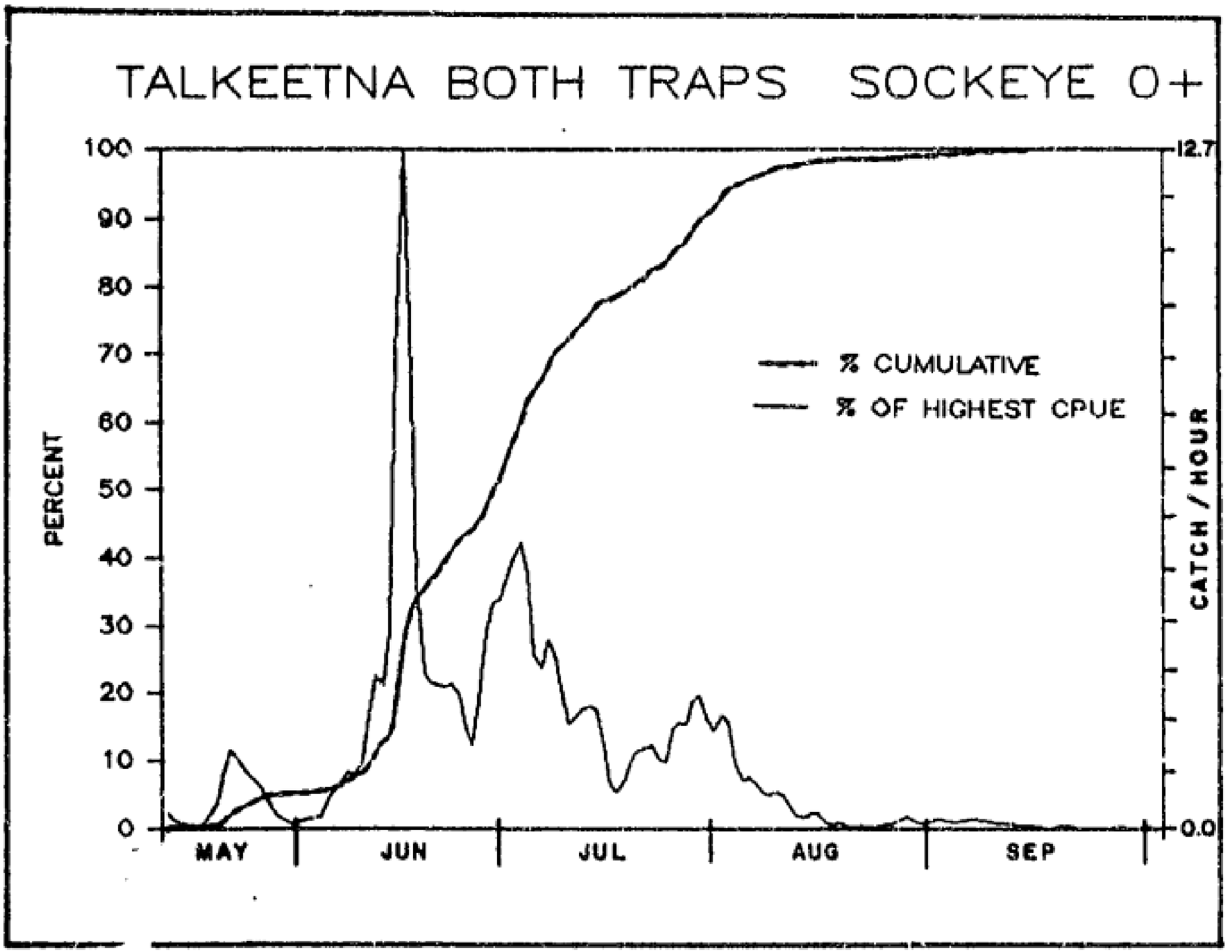


Figure 7.2-2. Sockeye salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna Station outmigrant traps, 1984. Source: Roth and Stratton (1985).

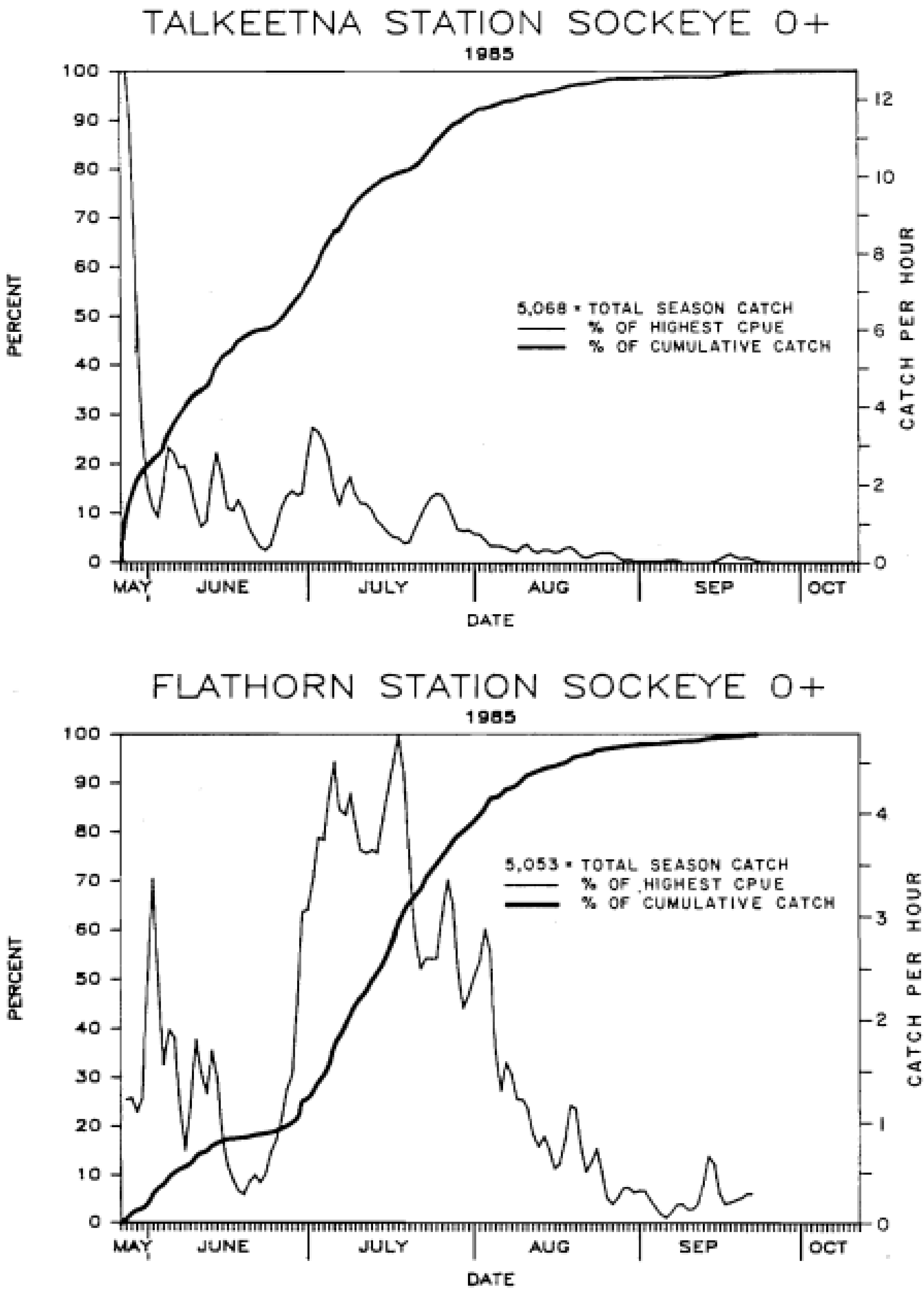


Figure 7.2-3. Sockeye salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).

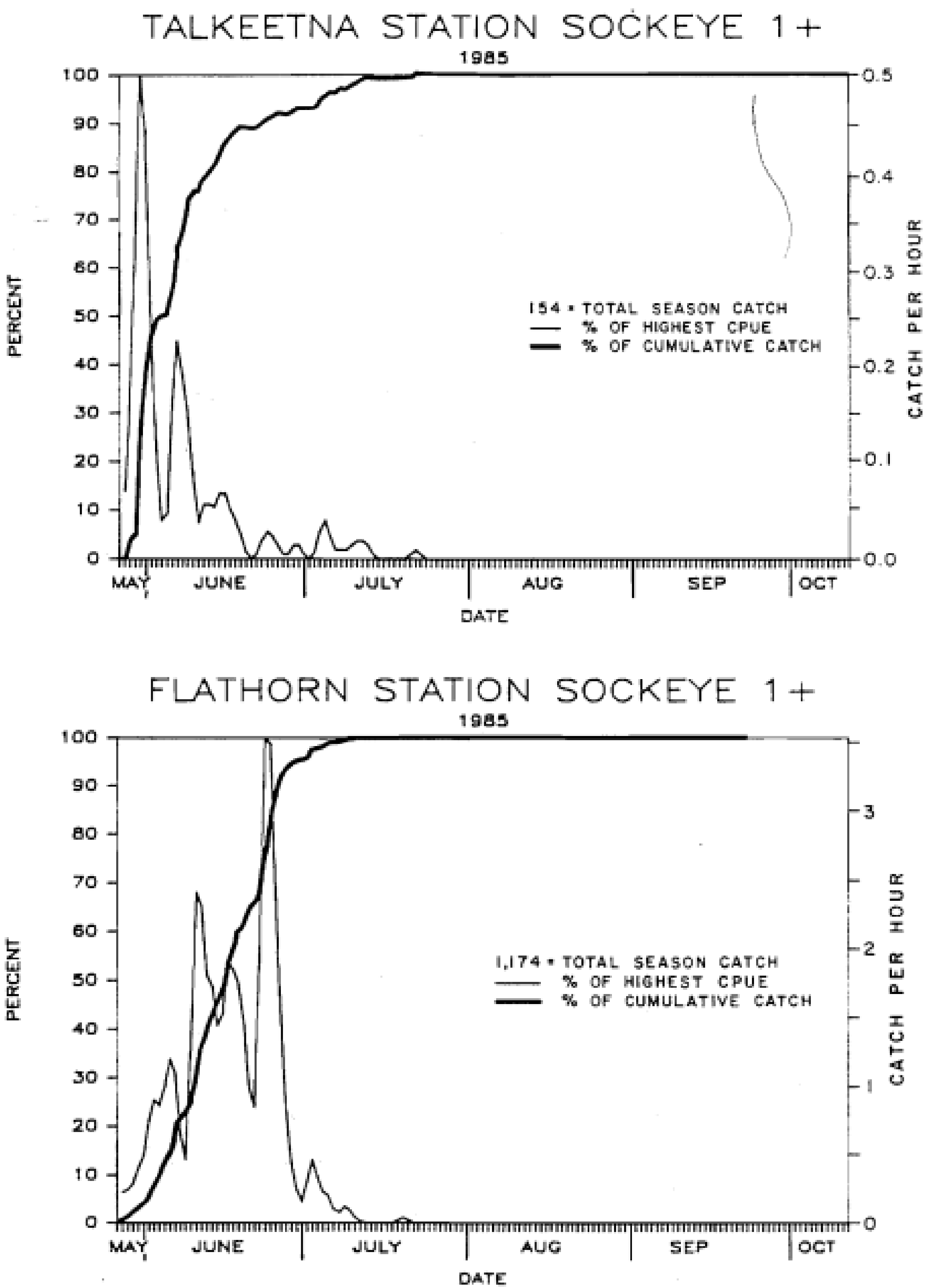
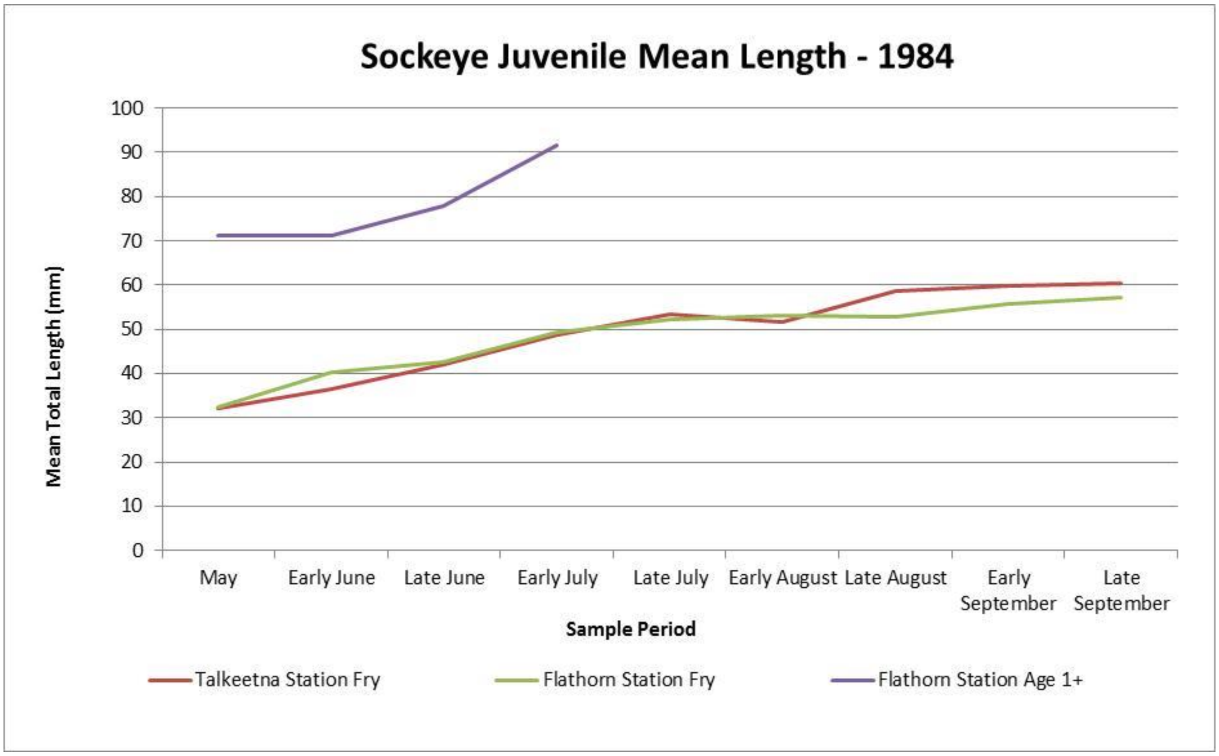


Figure 7.2-4. Sockeye salmon (age 1+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).



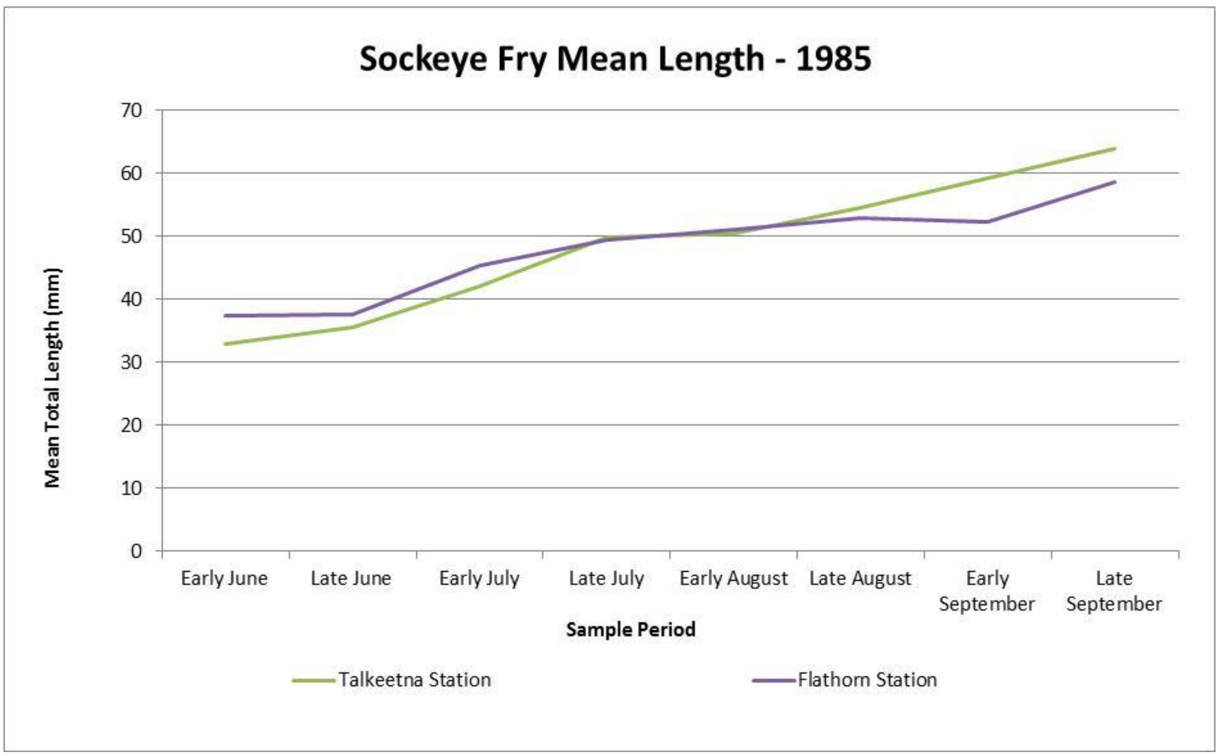


Figure 7.2-5. Mean length of sockeye salmon fry and Age 1+ captured at outmigrant traps during 1984 and 1985. Source: Roth and Stratton 1985, Roth et al. (1986).

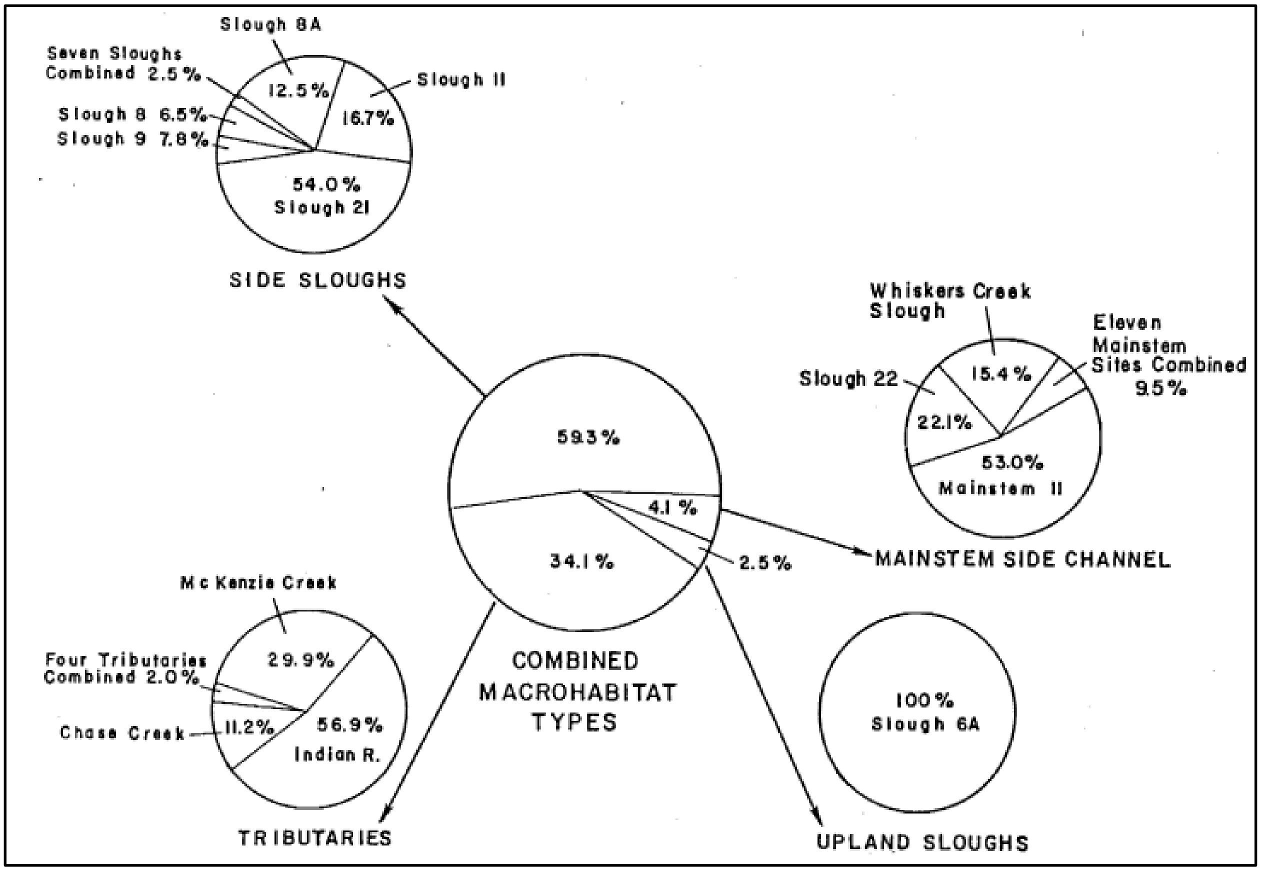


Figure 7.2-6. Density distribution and juvenile sockeye salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

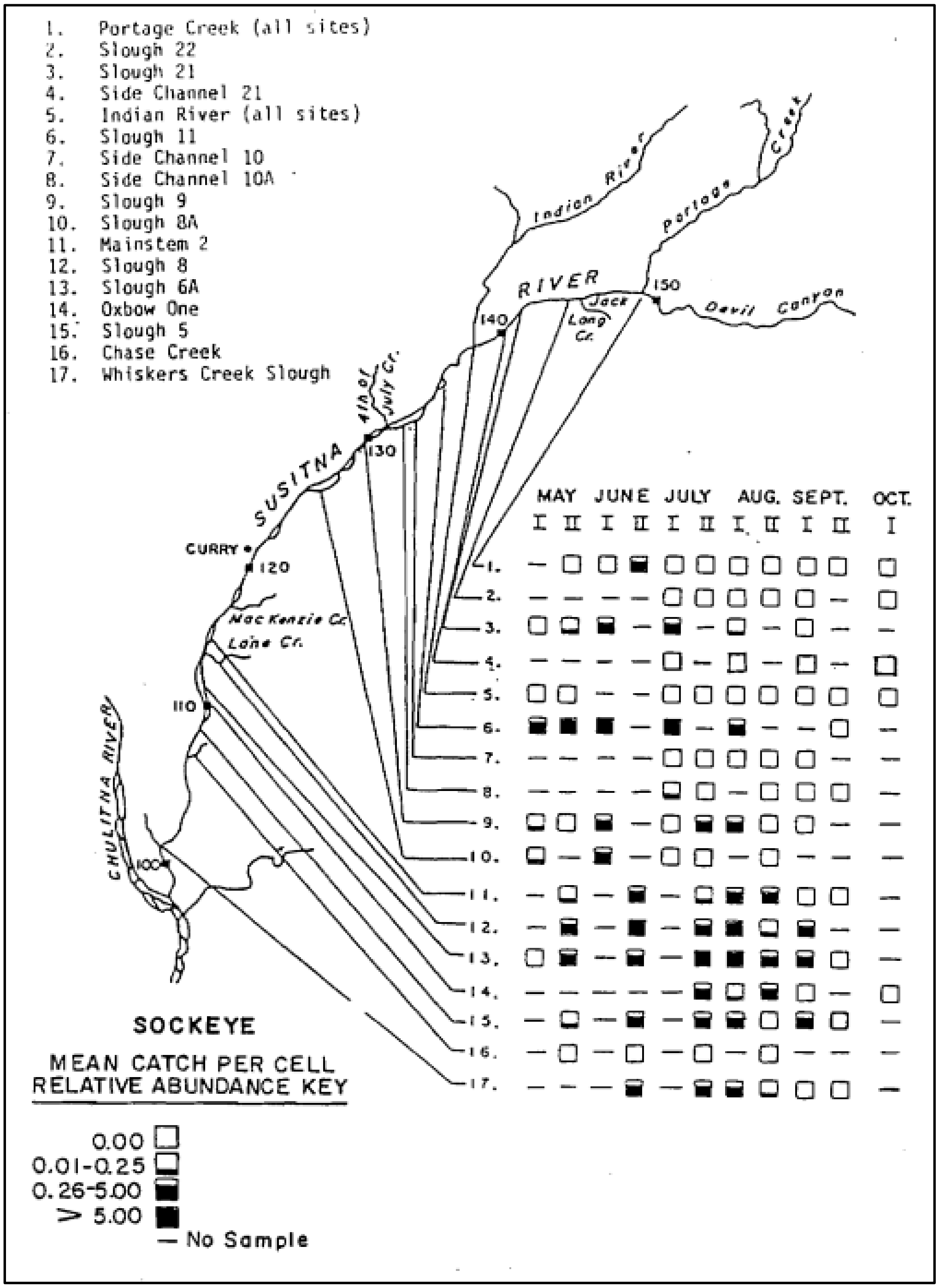


Figure 7.2-7. Seasonal distribution and relative abundance of juvenile sockeye salmon on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Source: Dugan et al. (1984).

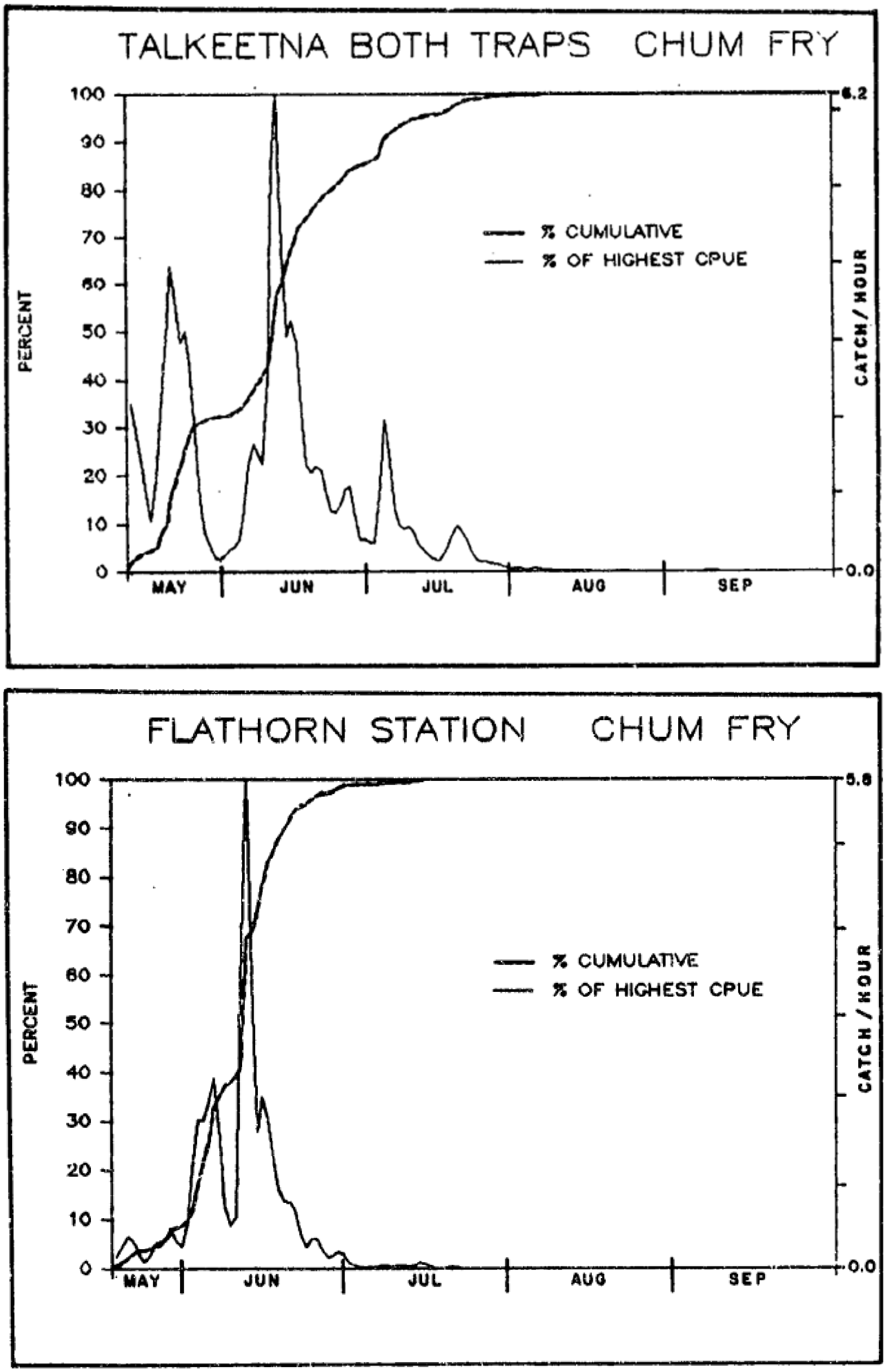
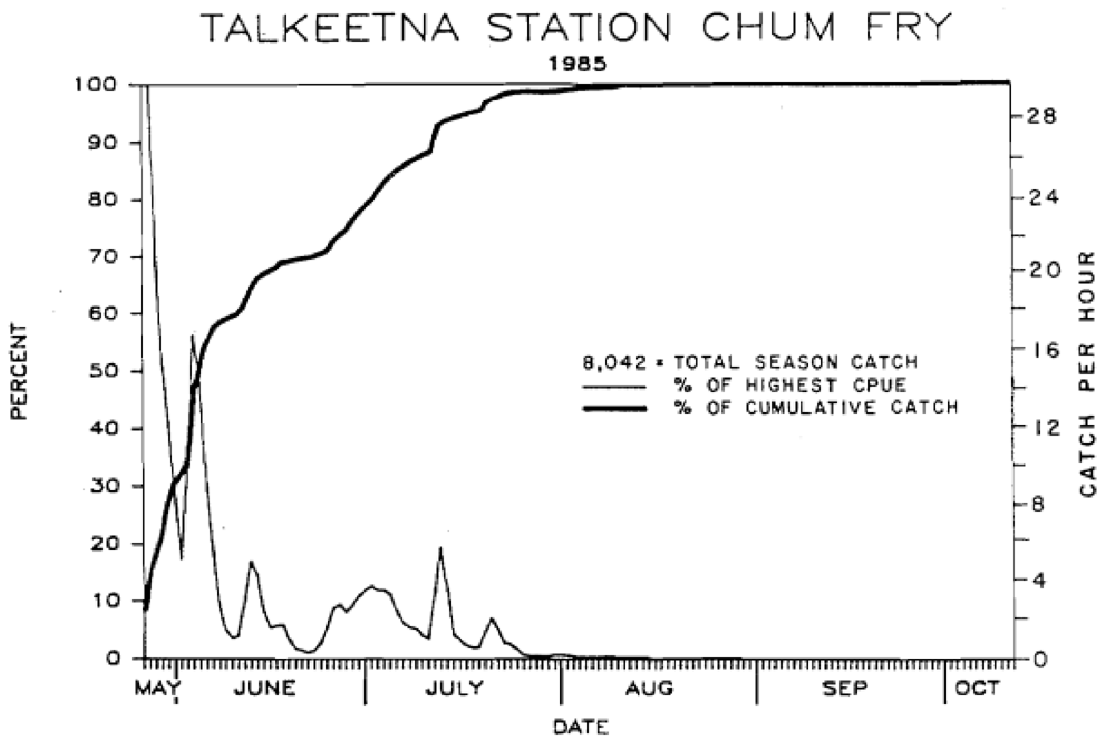


Figure 7.3-1. Chum salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper) and Flathorn (lower) station outmigrant traps, 1984. Source: Roth and Stratton (1985).



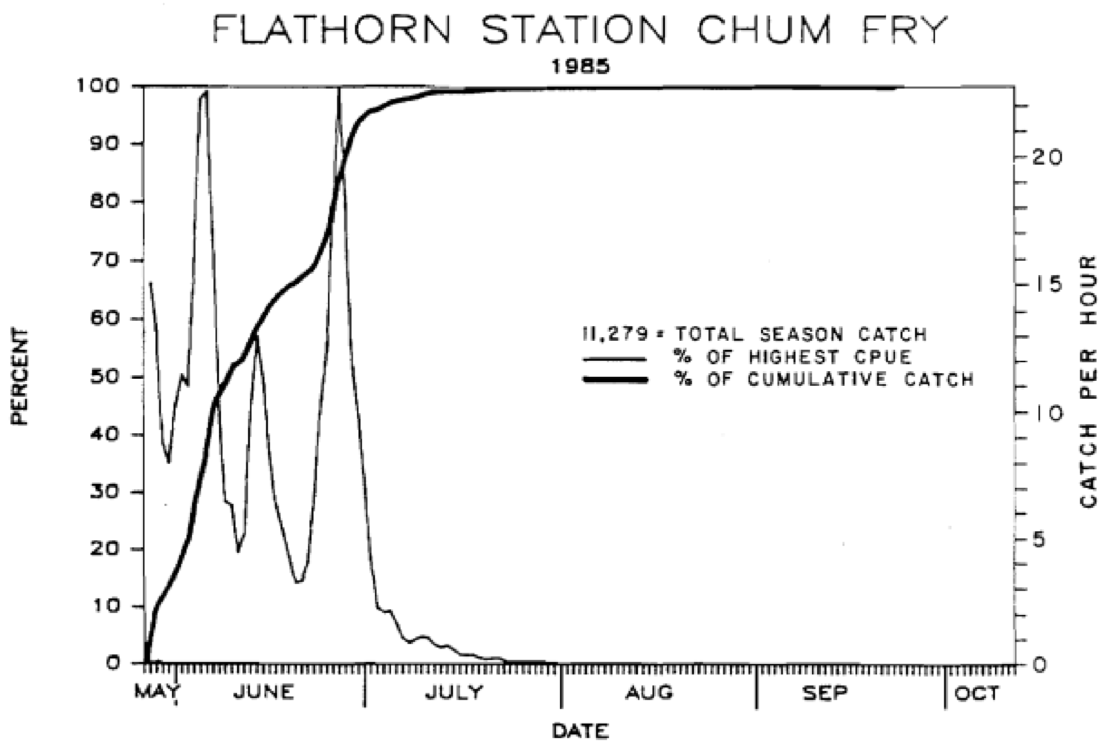


Figure 7.3-2. Chum salmon (Age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).

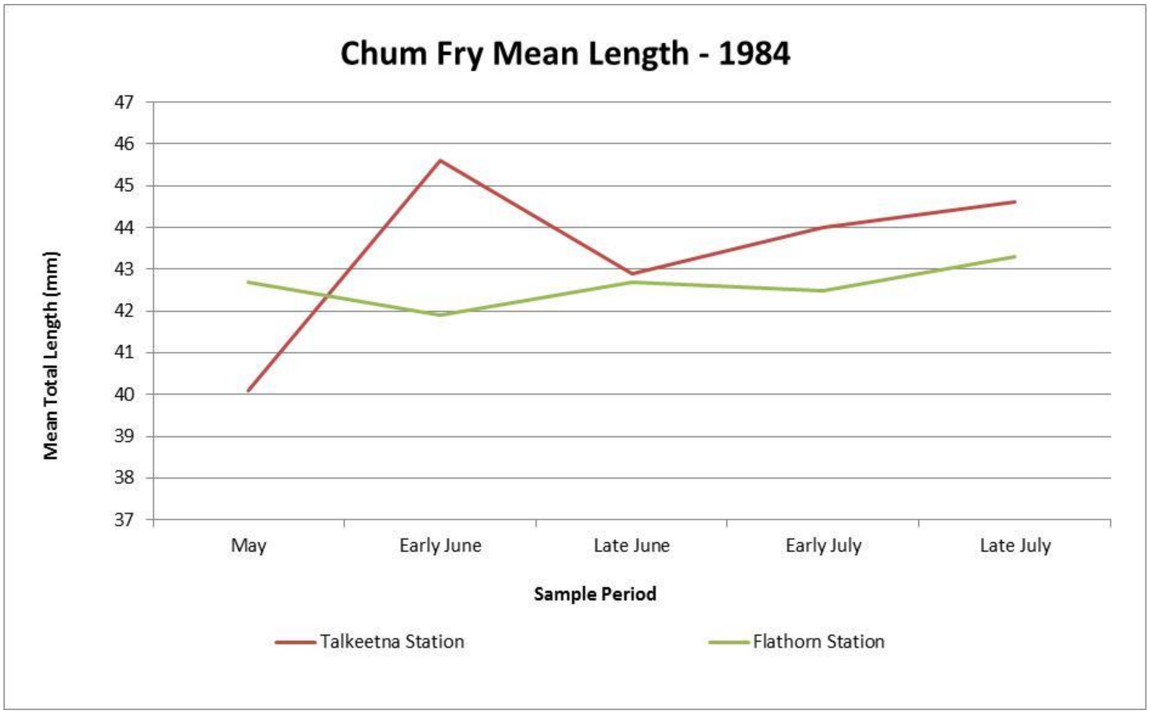


Figure 7.3-3. Mean length of sockeye salmon fry captured at outmigrant traps during 1984. Source: Roth and Stratton (1985).

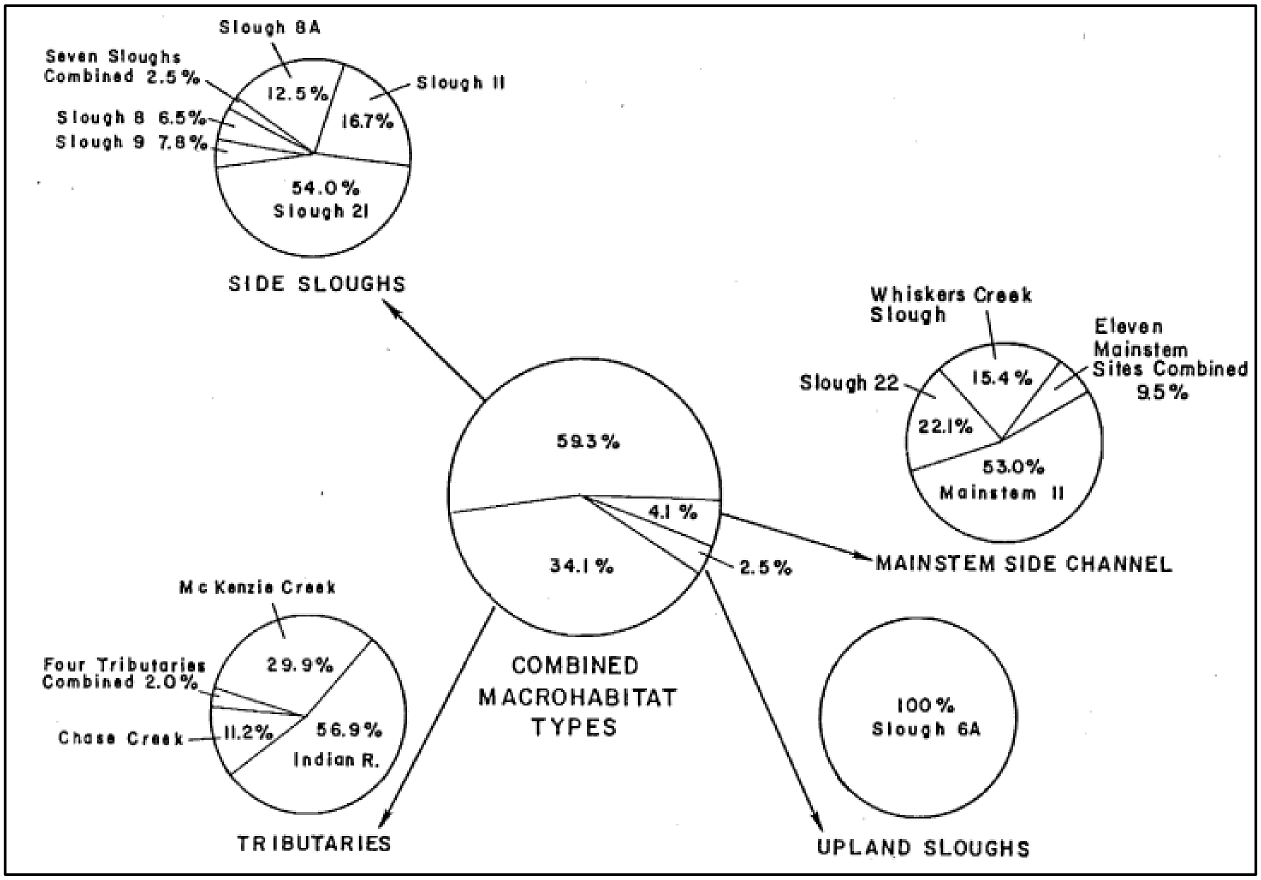


Figure 7.3-4. Density distribution and juvenile chum salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

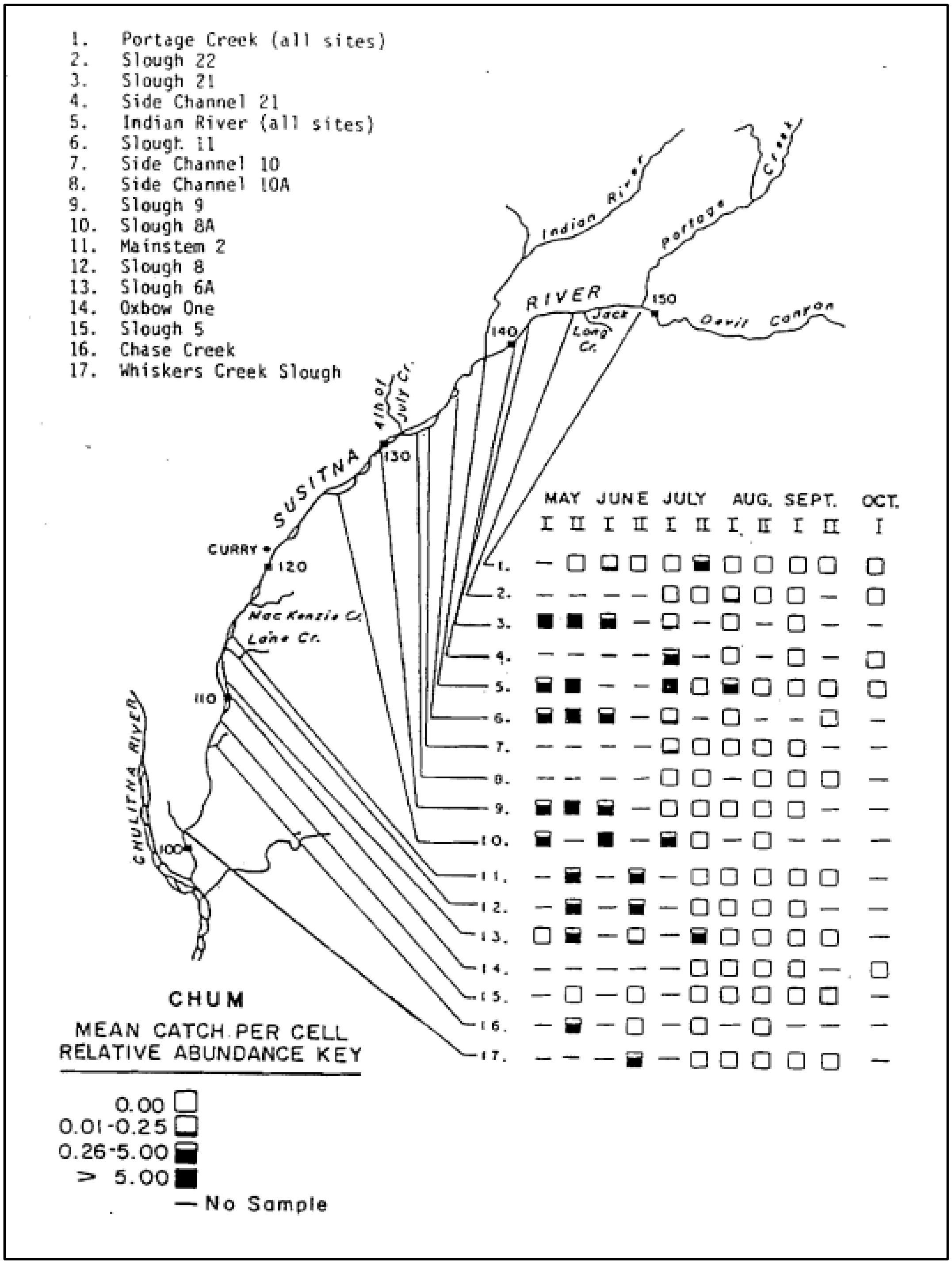


Figure 7.3-5. Seasonal distribution and relative abundance of juvenile chum salmon on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Source: Dugan et al. (1984).

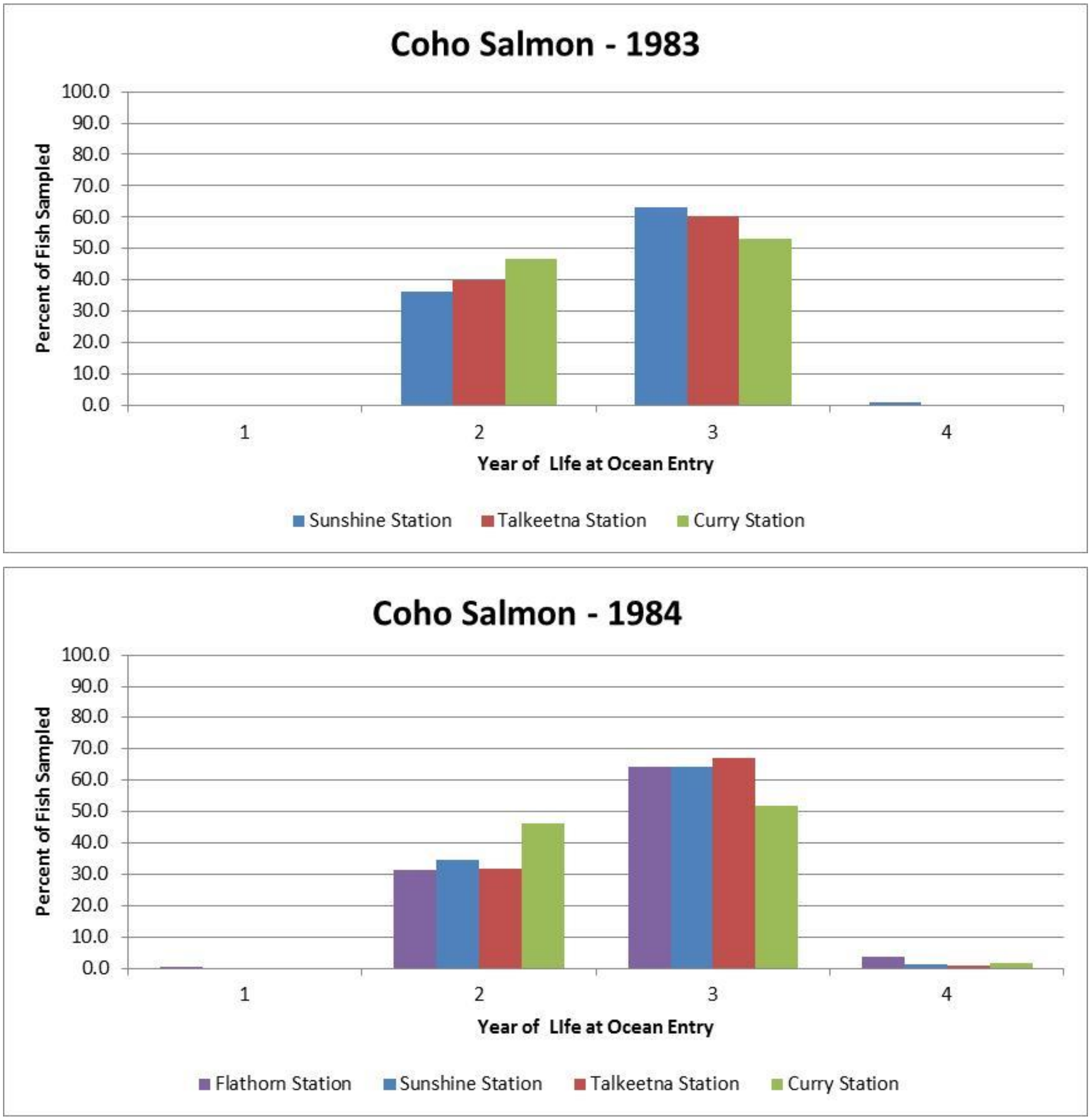


Figure 7.4-1. Year of ocean entry by coho salmon based upon scale analysis of adults returning in 1983 and 1984. Source: ADF&G (1984), Barrett et al. (1985).

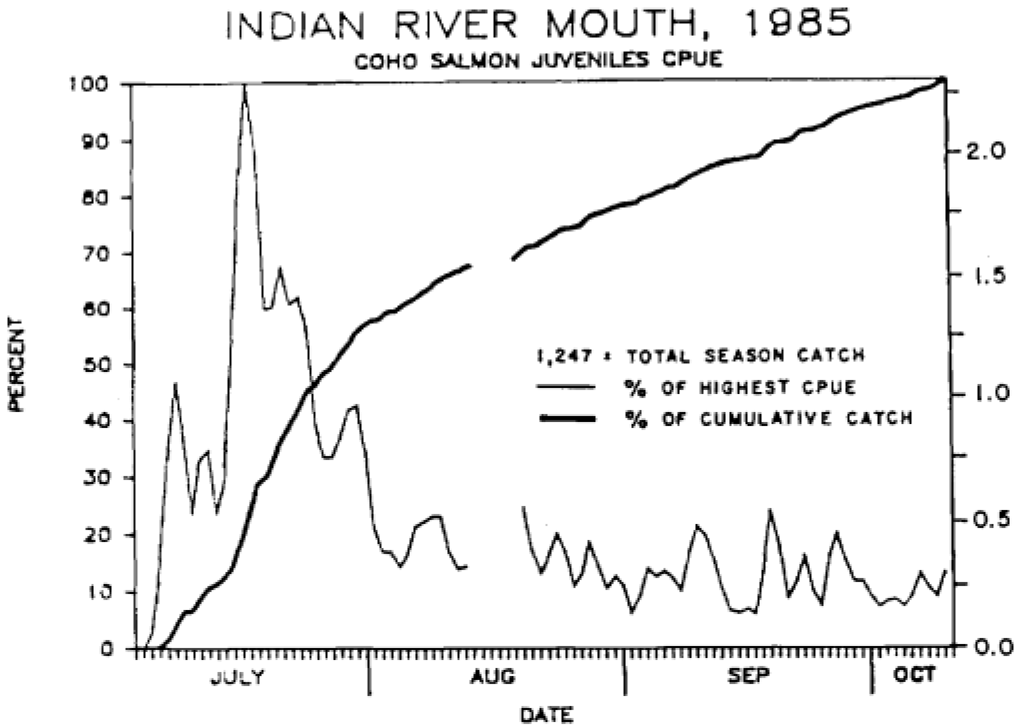


Figure 7.4-2. Coho salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the mouth of Indian River. Source: Roth et al. (1986).

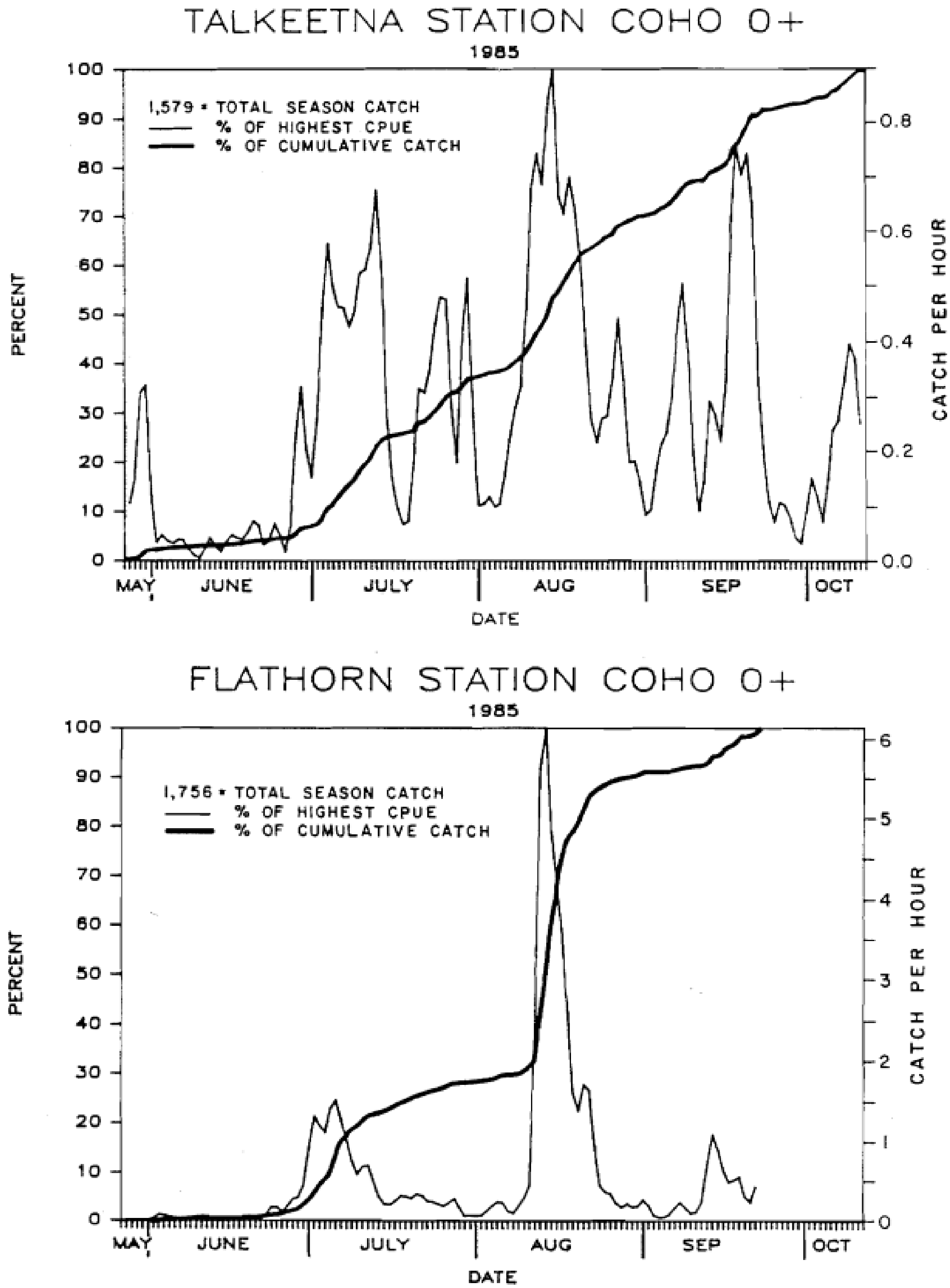


Figure 7.4-3. Coho salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).

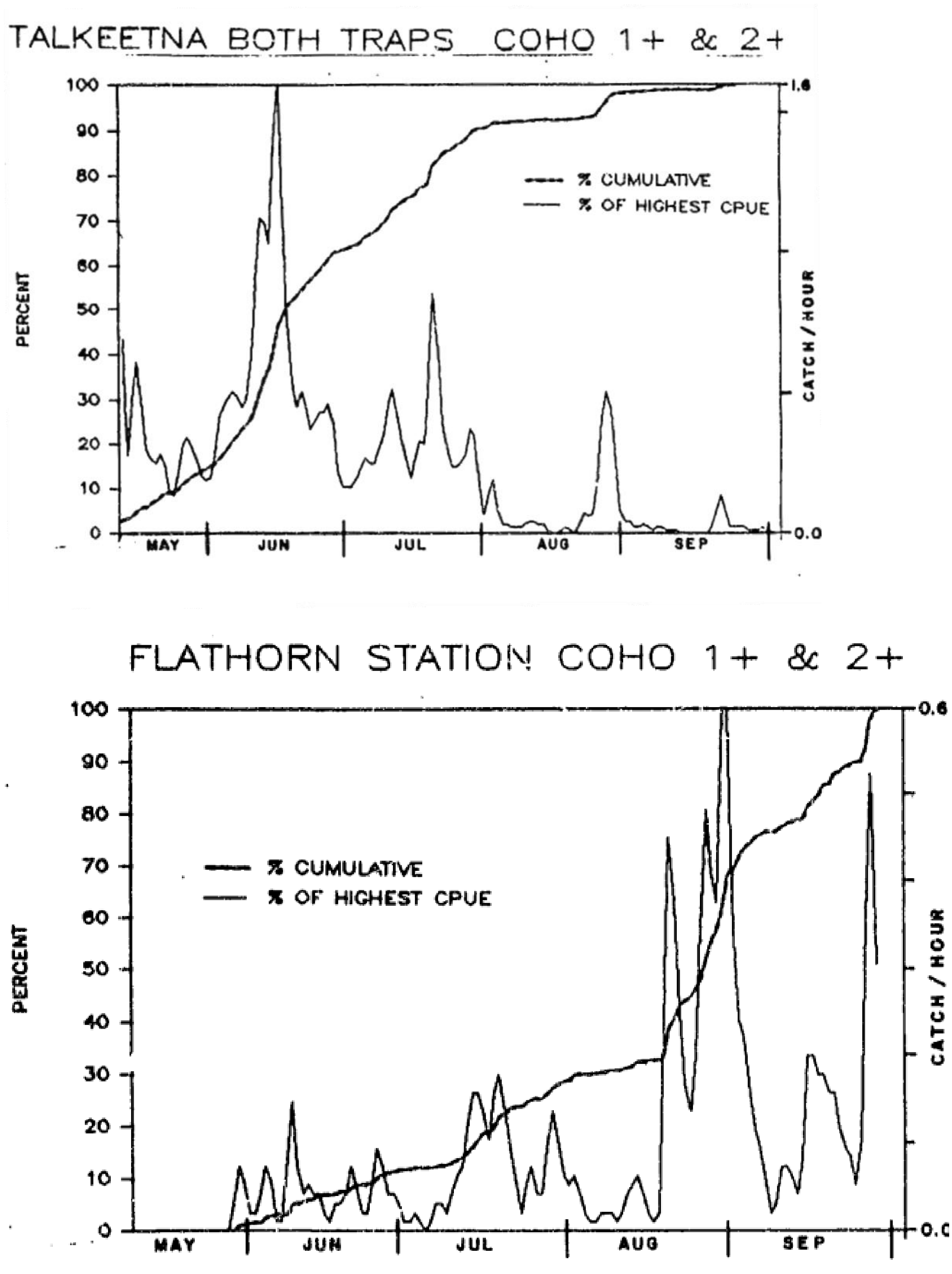
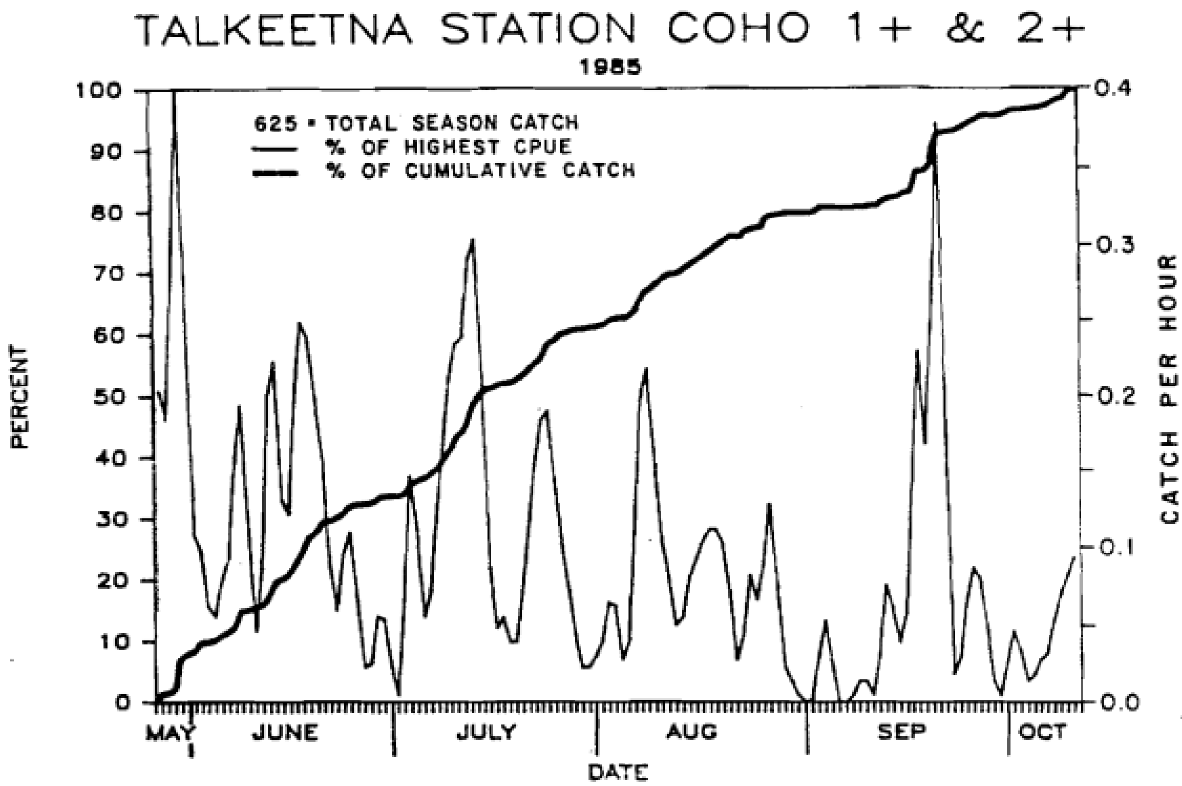


Figure 7.4-4. Coho salmon (age 0+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1984. Source: Roth and Stratton (1985).



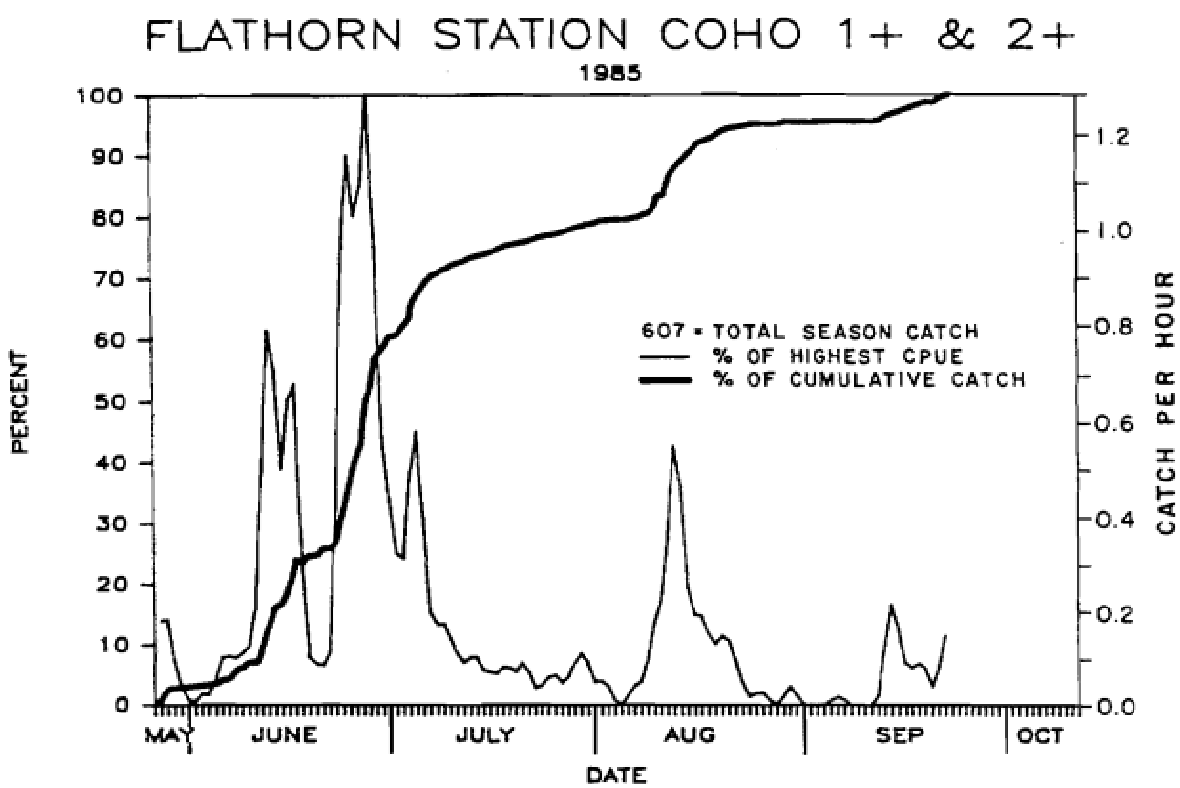
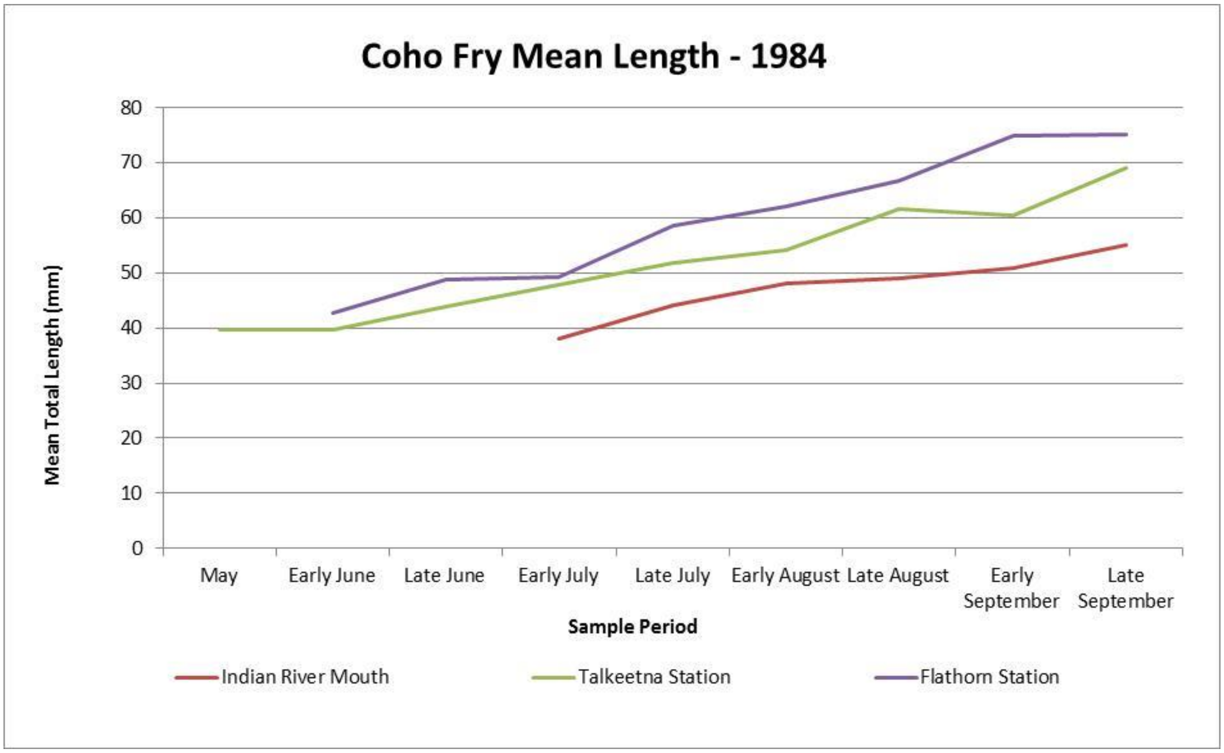


Figure 7.4-5. Coho salmon (Age 1+) daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).



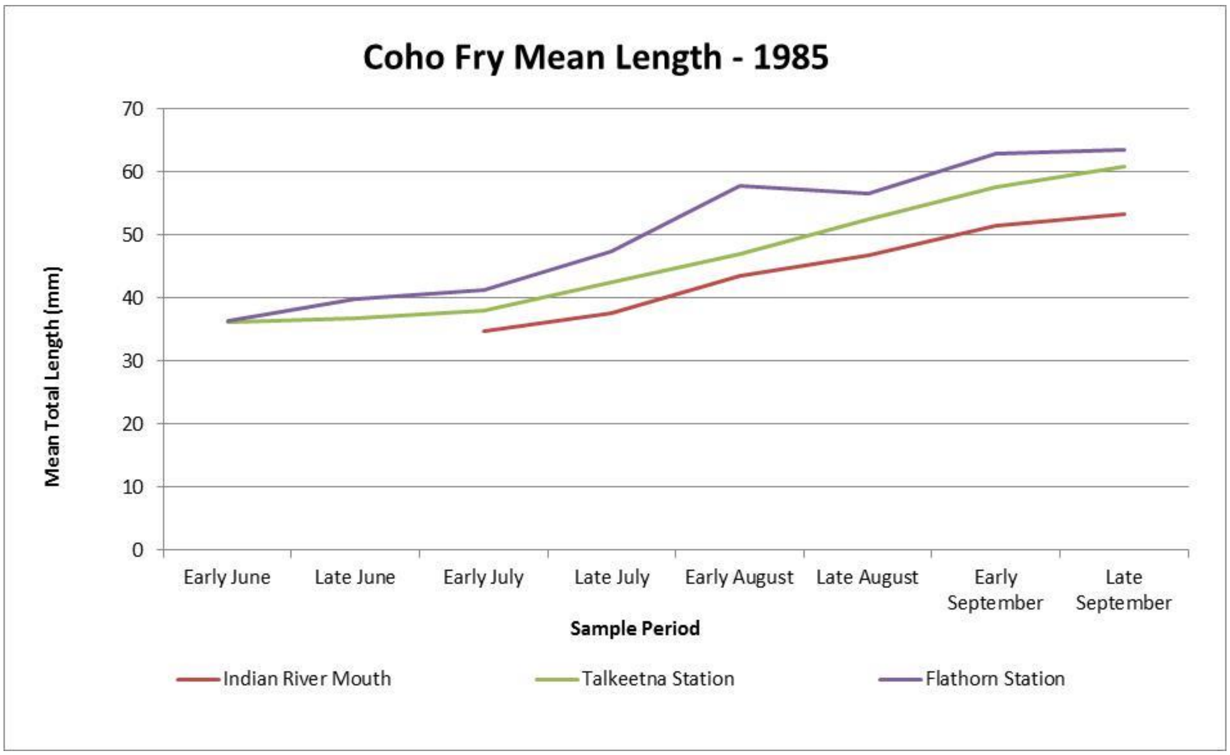
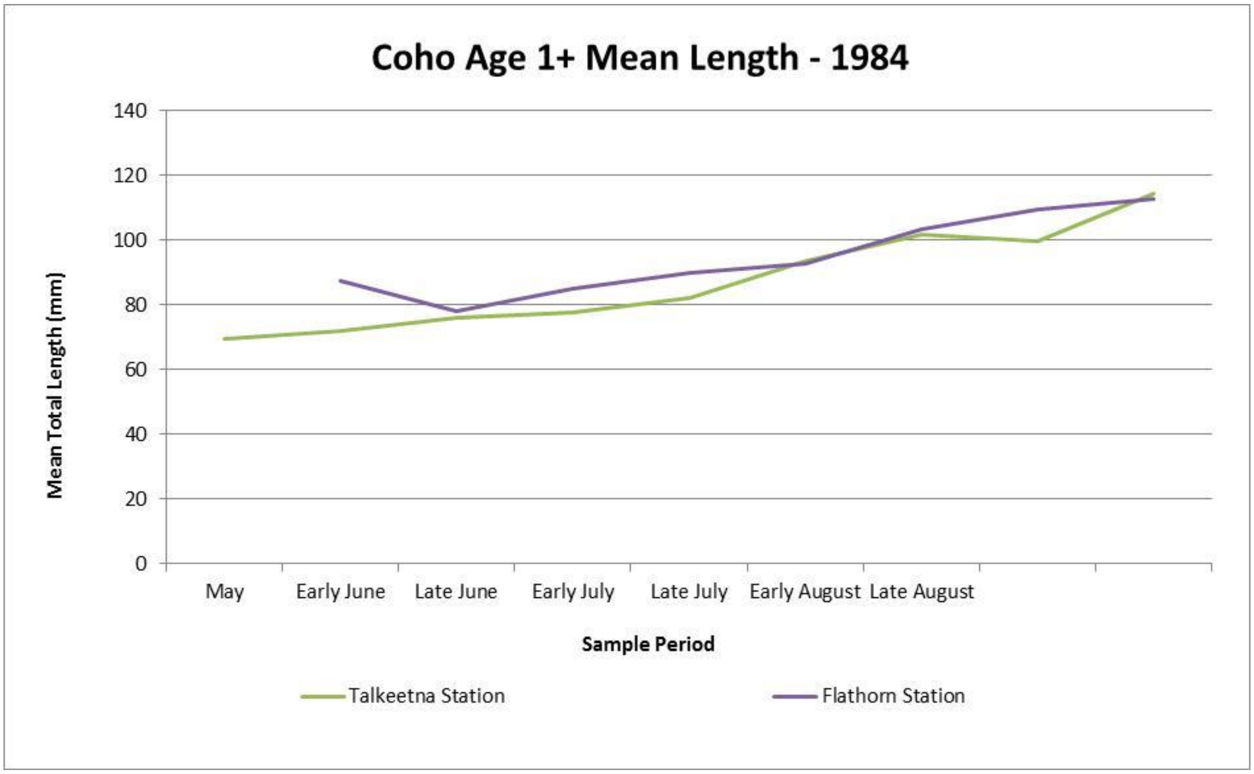


Figure 7.4-6. Mean length of coho fry captured at outmigrant traps during 1984 and 1985. Source: Roth and Stratton (1985), Roth et al. (1986).



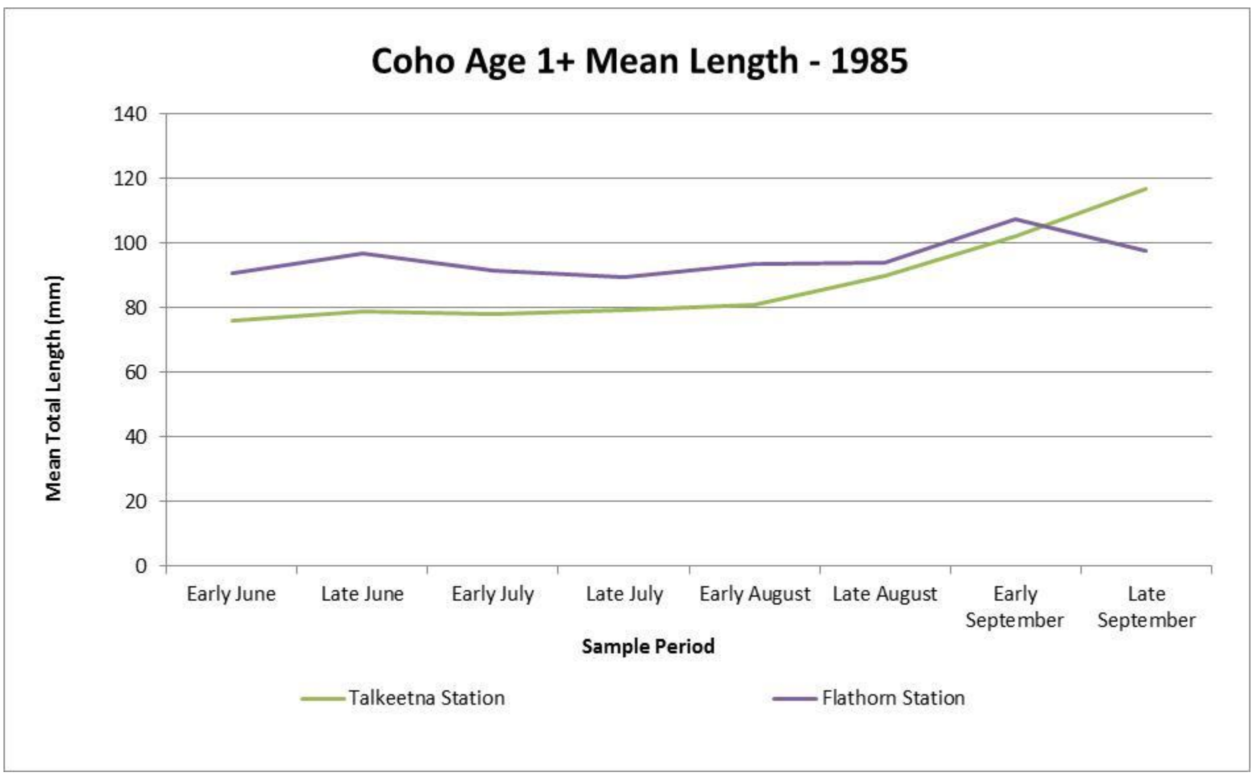


Figure 7.4-7. Mean length of coho salmon Age 1+ captured at outmigrant traps during 1984 and 1985. Source: Roth and Stratton (1985), Roth et al. (1986).

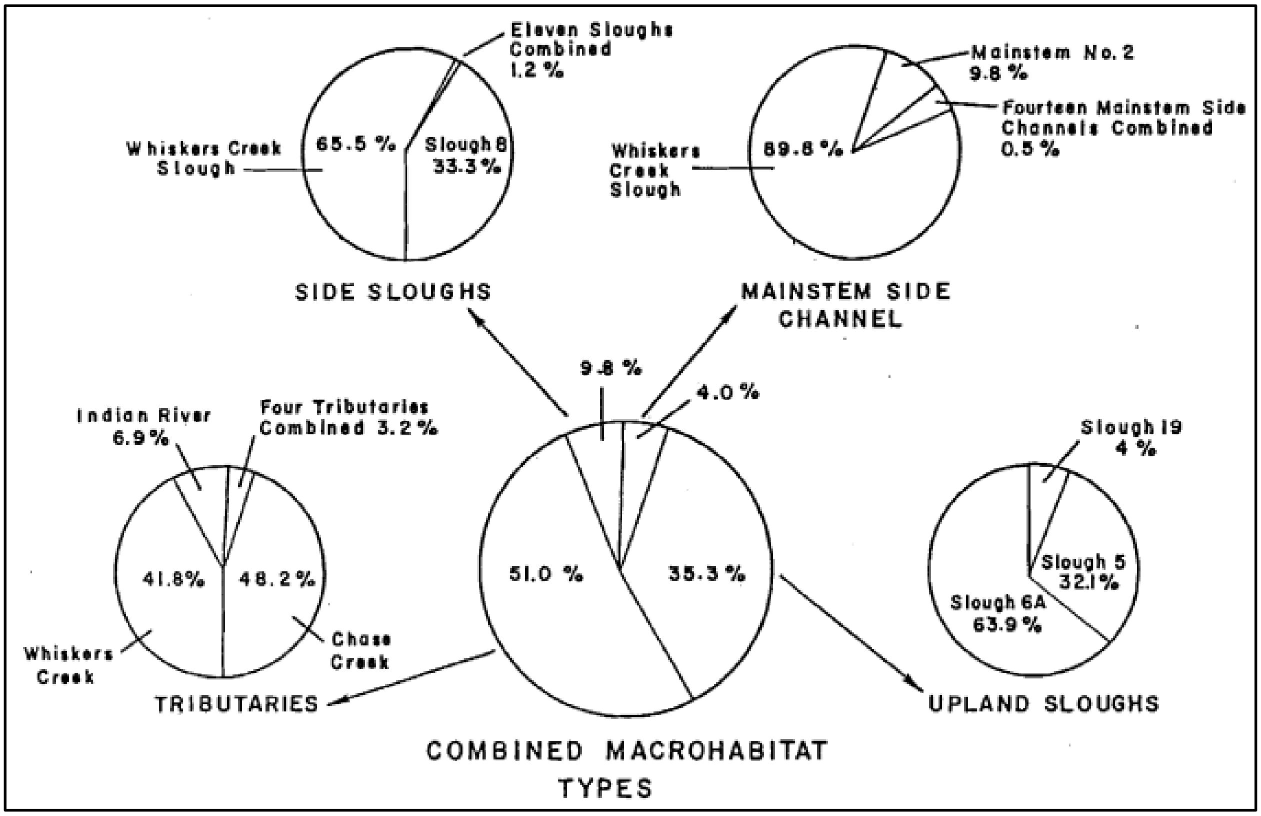


Figure 7.4-8. Density distribution and juvenile coho salmon by macrohabitat type on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Percentages are based on mean catch per cell. Source: Dugan et al. (1984).

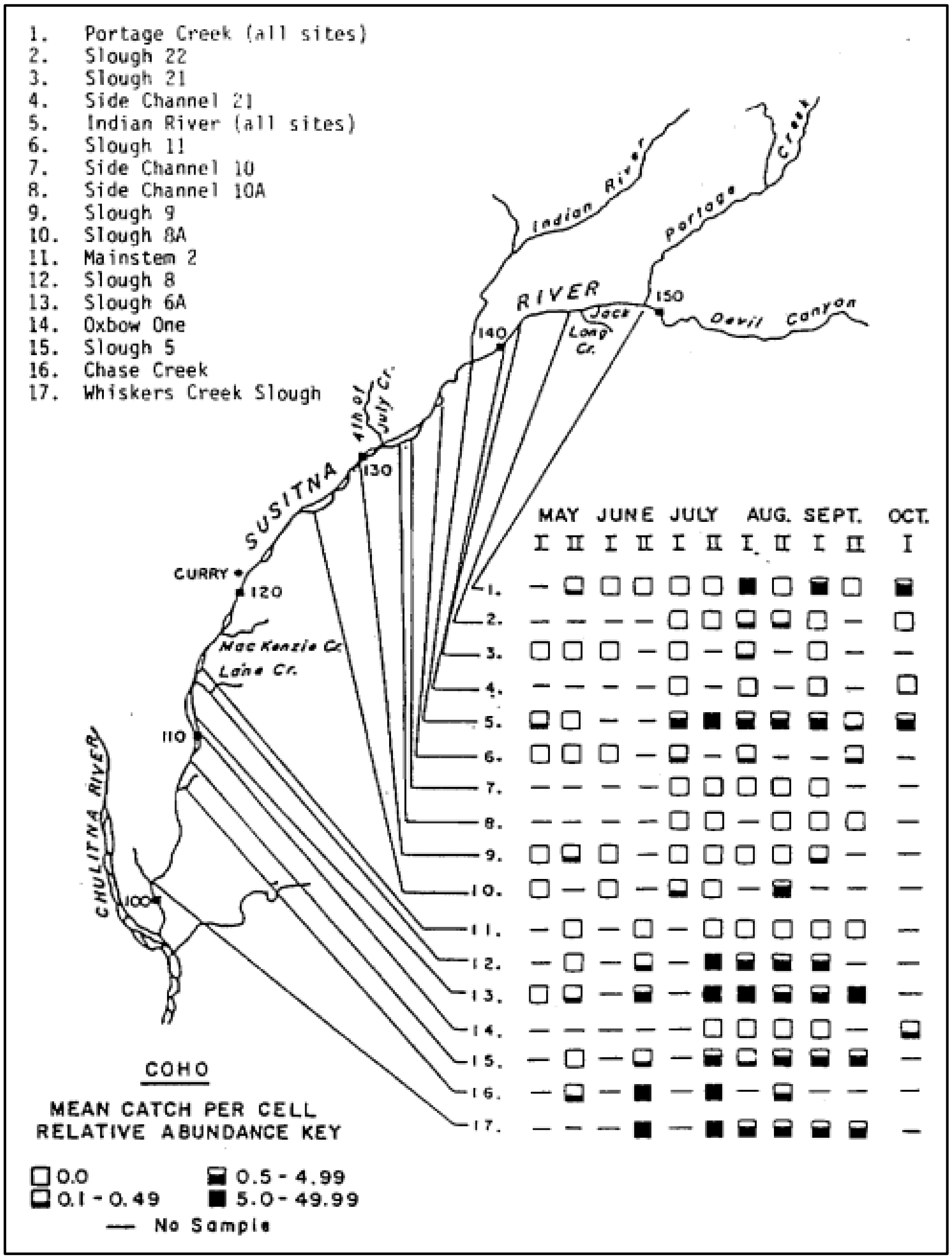


Figure 7.4-9. Seasonal distribution and relative abundance of juvenile coho salmon on the Susitna River between the Chulitna River confluence and Devils Canyon, May through November 1983. Source: Dugan et al. (1984).

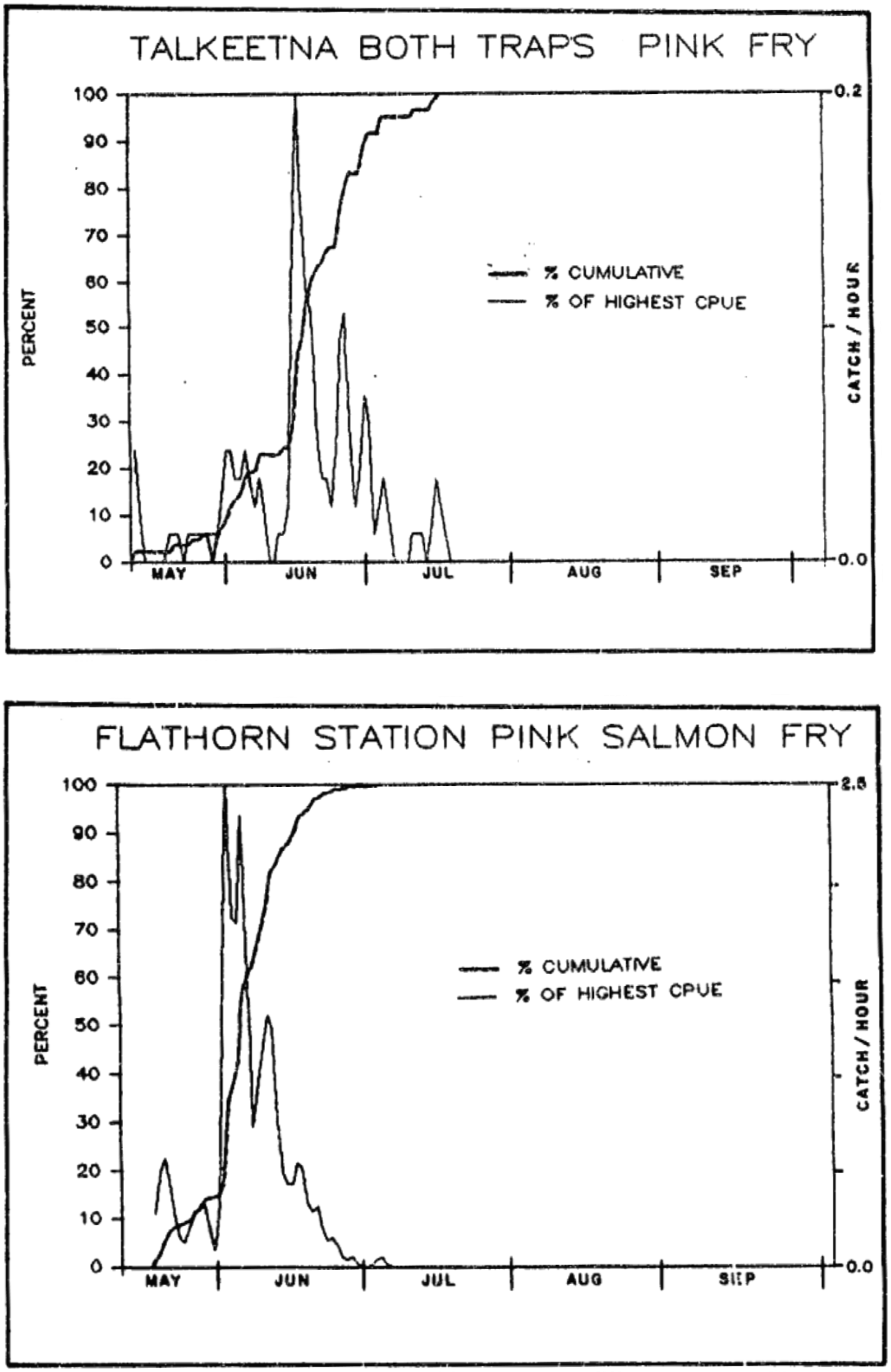
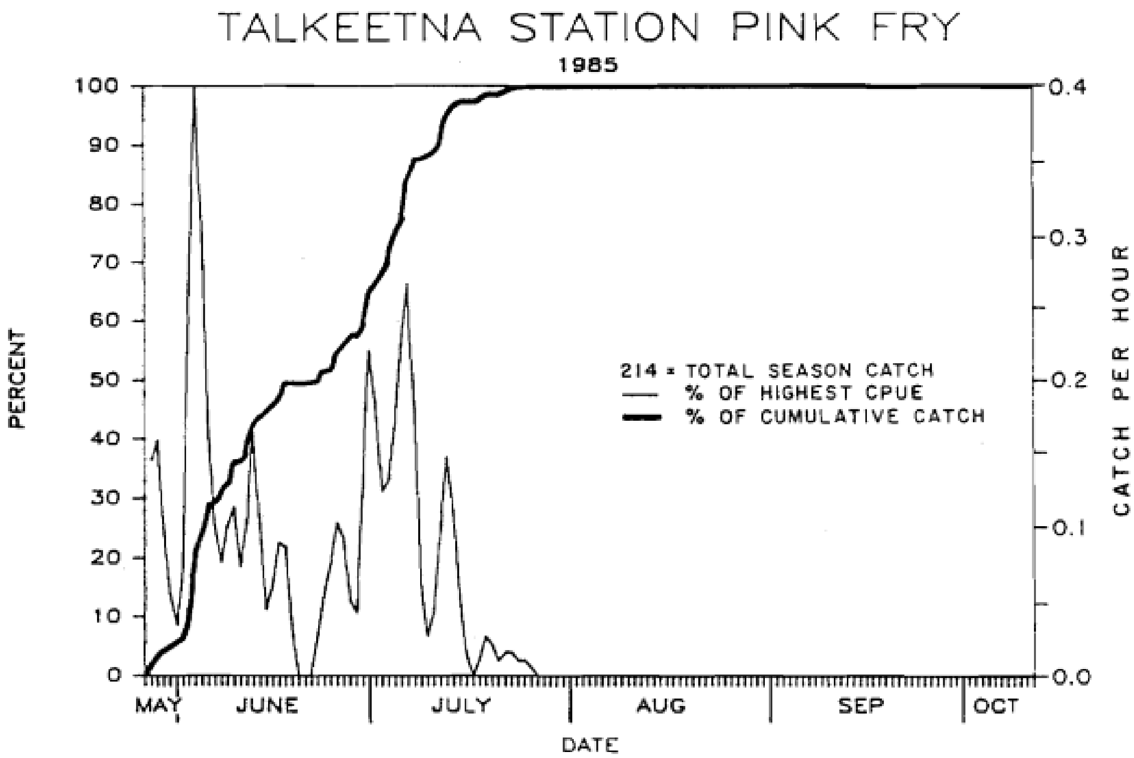


Figure 7.5-1. Pink salmon fry daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper) and Flathorn (lower) station outmigrant traps, 1984. Source: Roth and Stratton (1985).



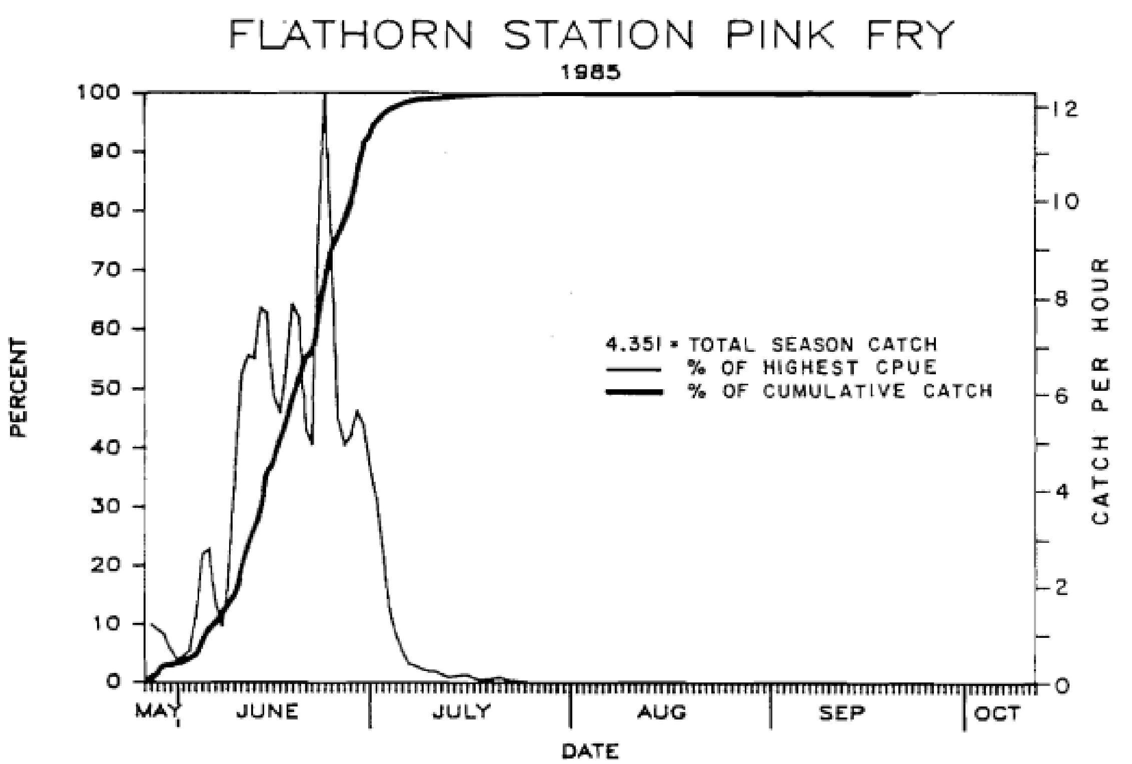


Figure 7.5-2. Pink salmon fry daily catch per unit effort and cumulative catch recorded at the Talkeetna (upper figure) and Flathorn (lower figure) stationary outmigrant traps, 1985. Source: Roth et al. (1986).

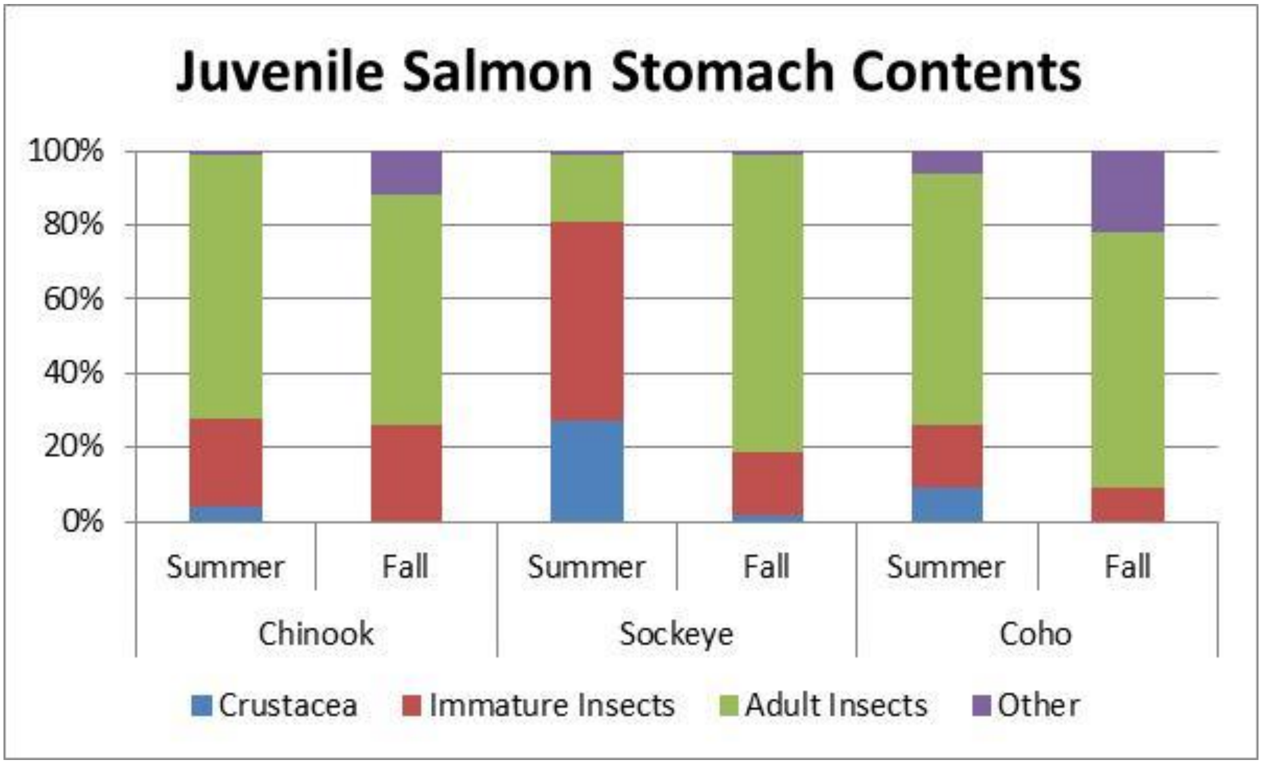


Figure 7.6-1. Stomach contents of Chinook, sockeye, and coho salmon juveniles during summer and fall 1977. Source: Riis and Friese (1977).

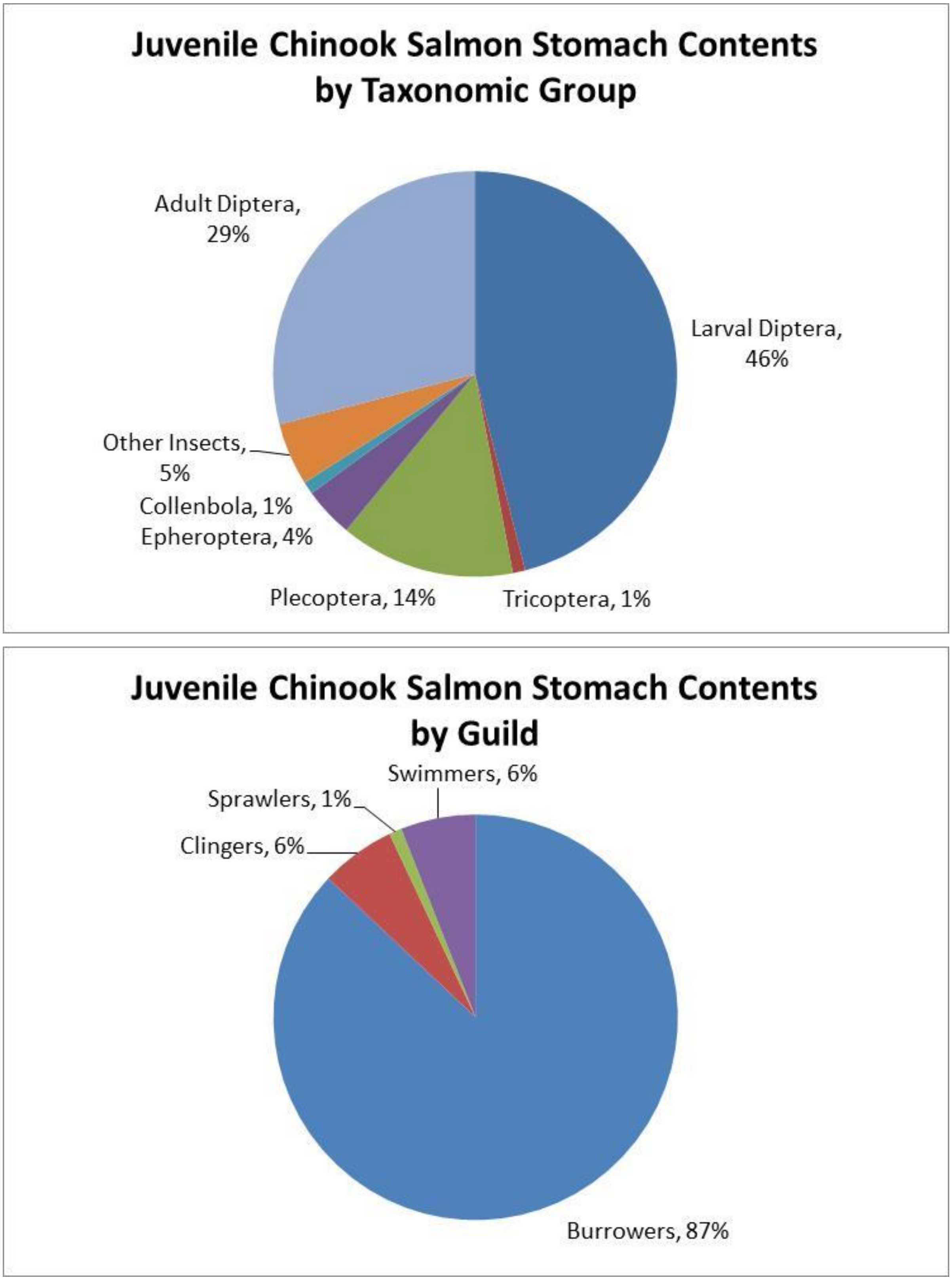


Figure 7.6-2. Frequency of food items by taxonomic group and guild within stomach contents of 72 juvenile Chinook salmon collected during 1984. Source: Hansen and Richards (1985).

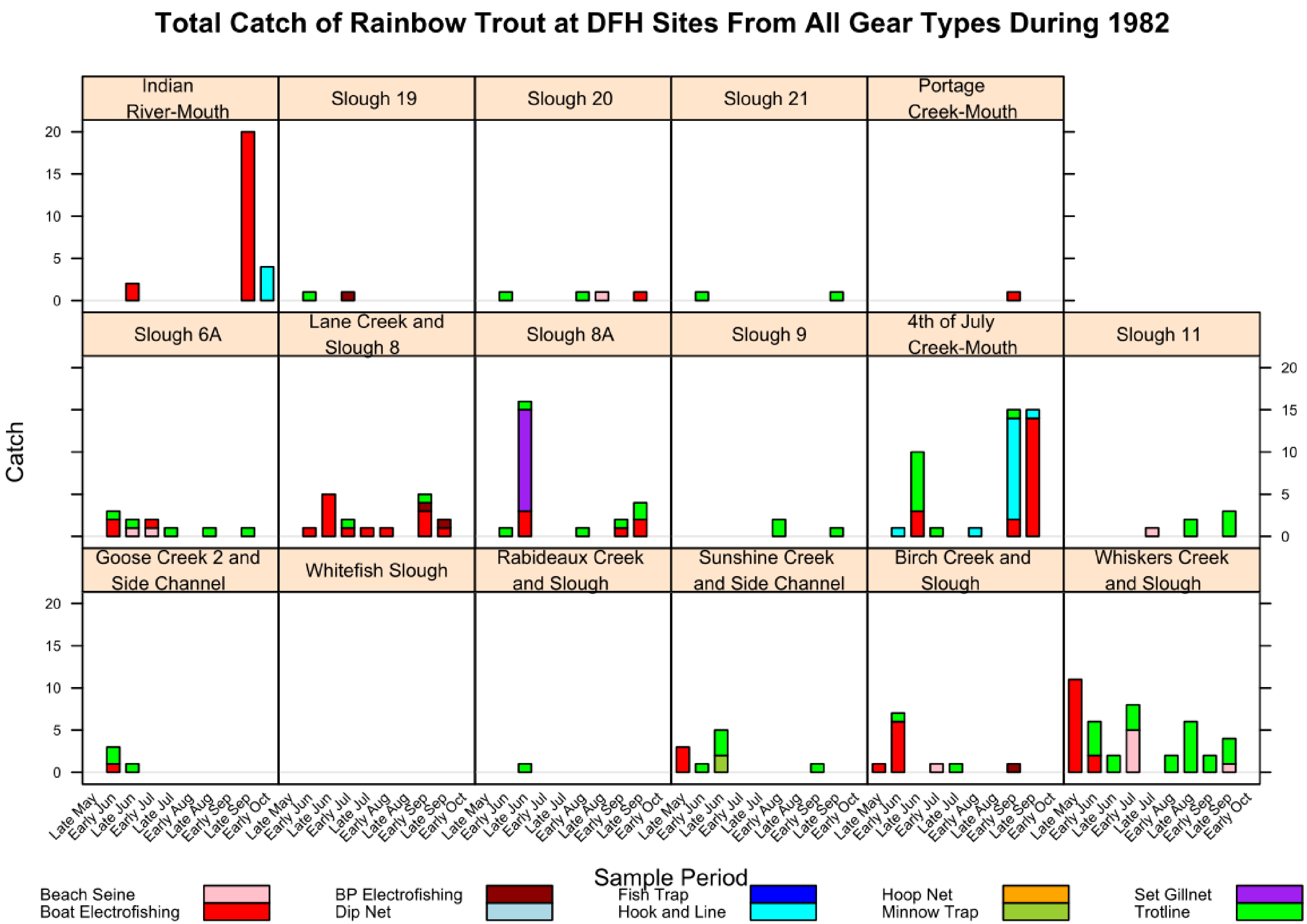


Figure 8.2-1. Total catch of rainbow trout at DFH sites within the middle and lower Susitna River segments during 1982. Data from Schmidt et al. (1983).

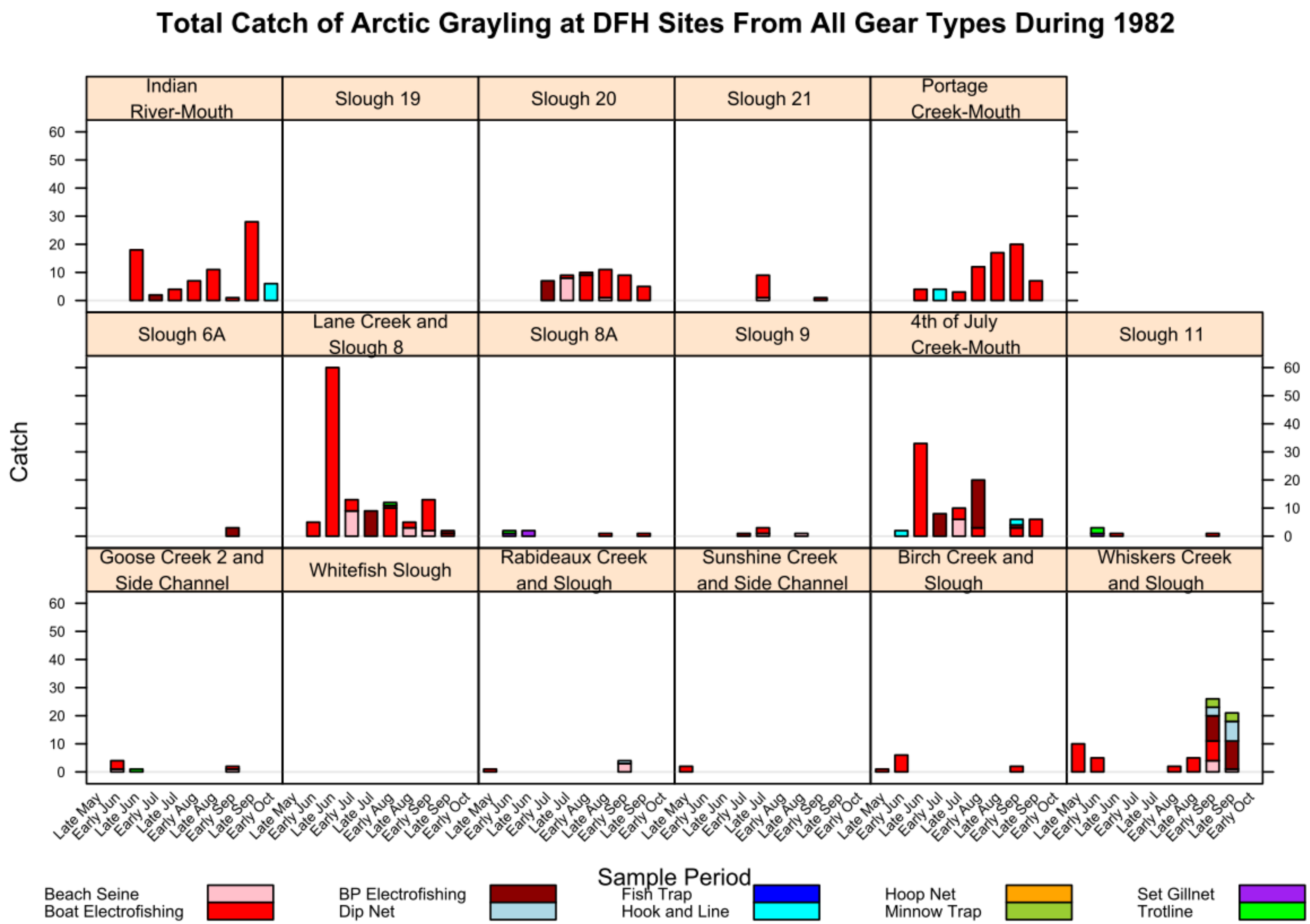


Figure 8.2-2. Total catch of Artic grayling at DFH sites in the Lower and Middle Susitna River during 1982. Data Source: Schmidt et al. (1983).

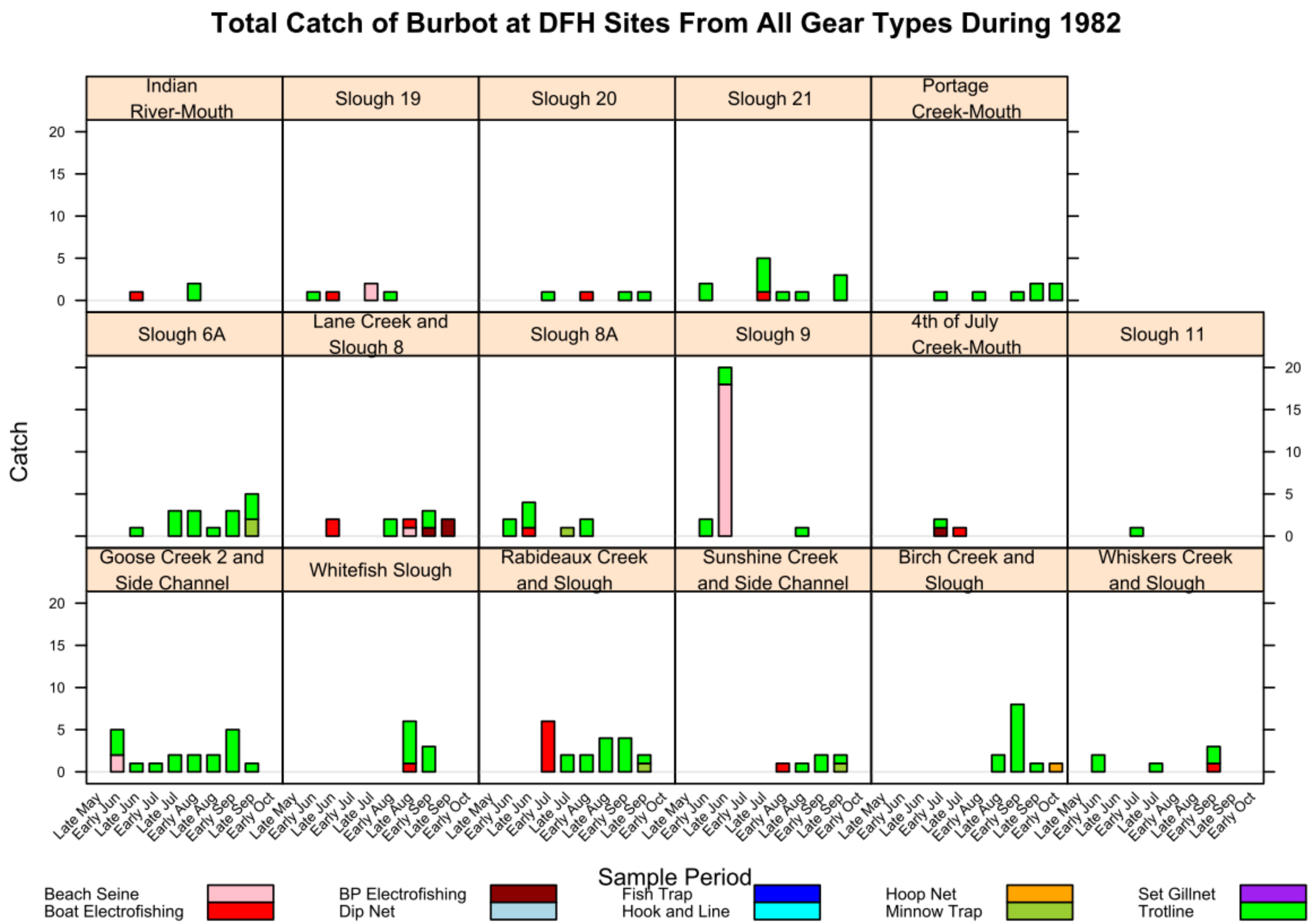


Figure 8.2-3. Total catch of burbot at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

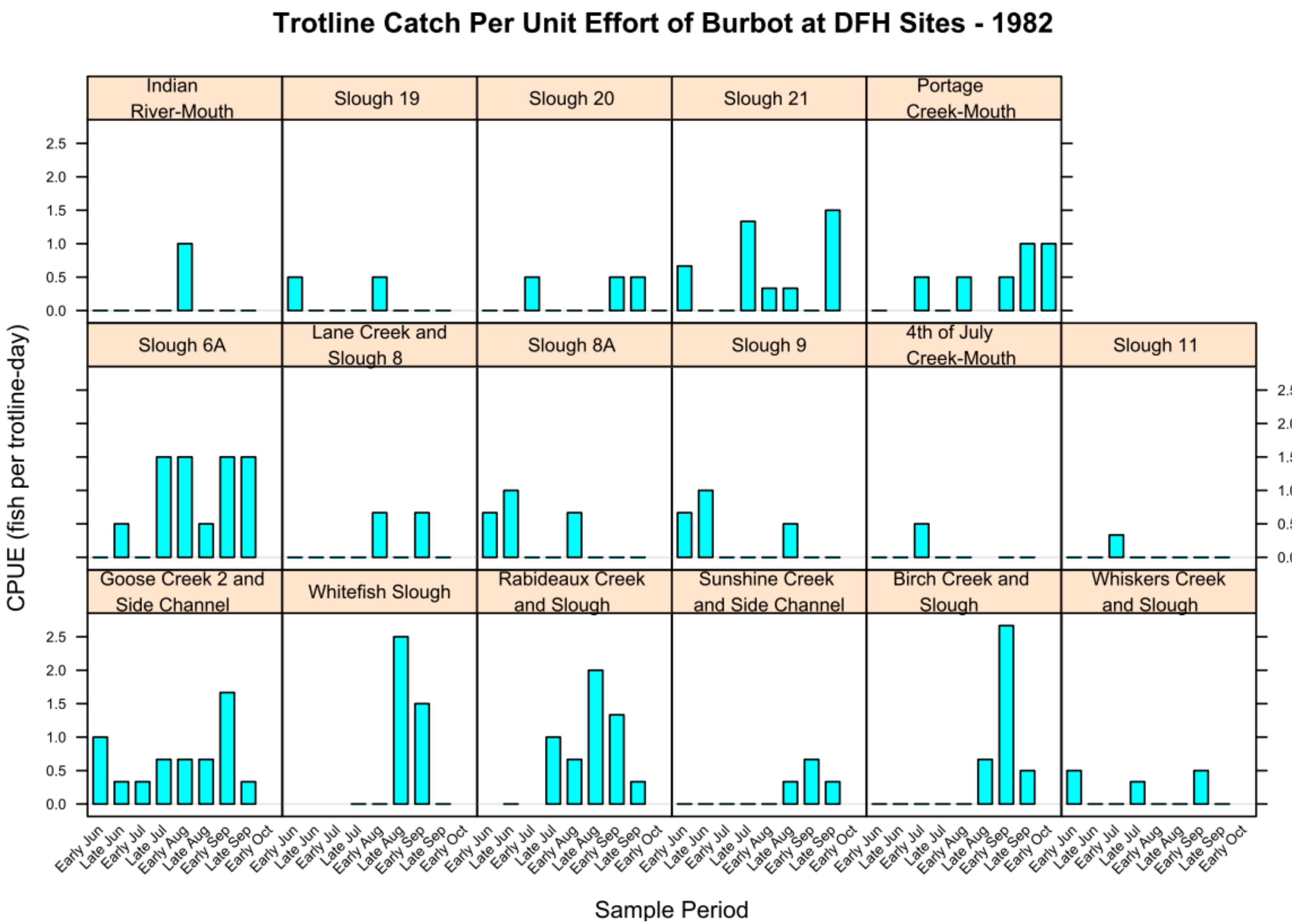


Figure 8.2-4. CPUE of burbot at DFH sites during 1982. Data Source: Schmidt et al. (1983).

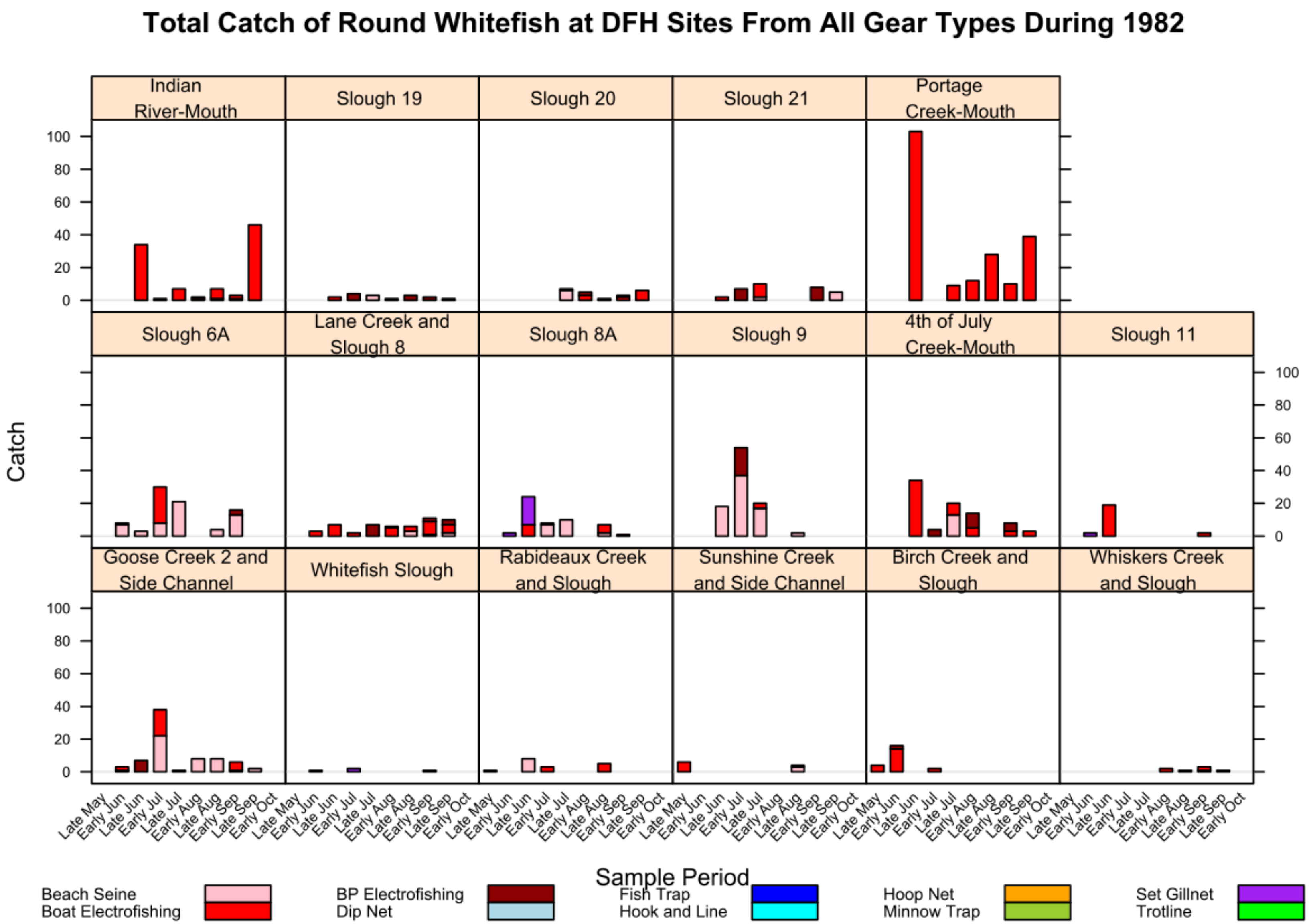


Figure 8.2-5. Total catch of round whitefish at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

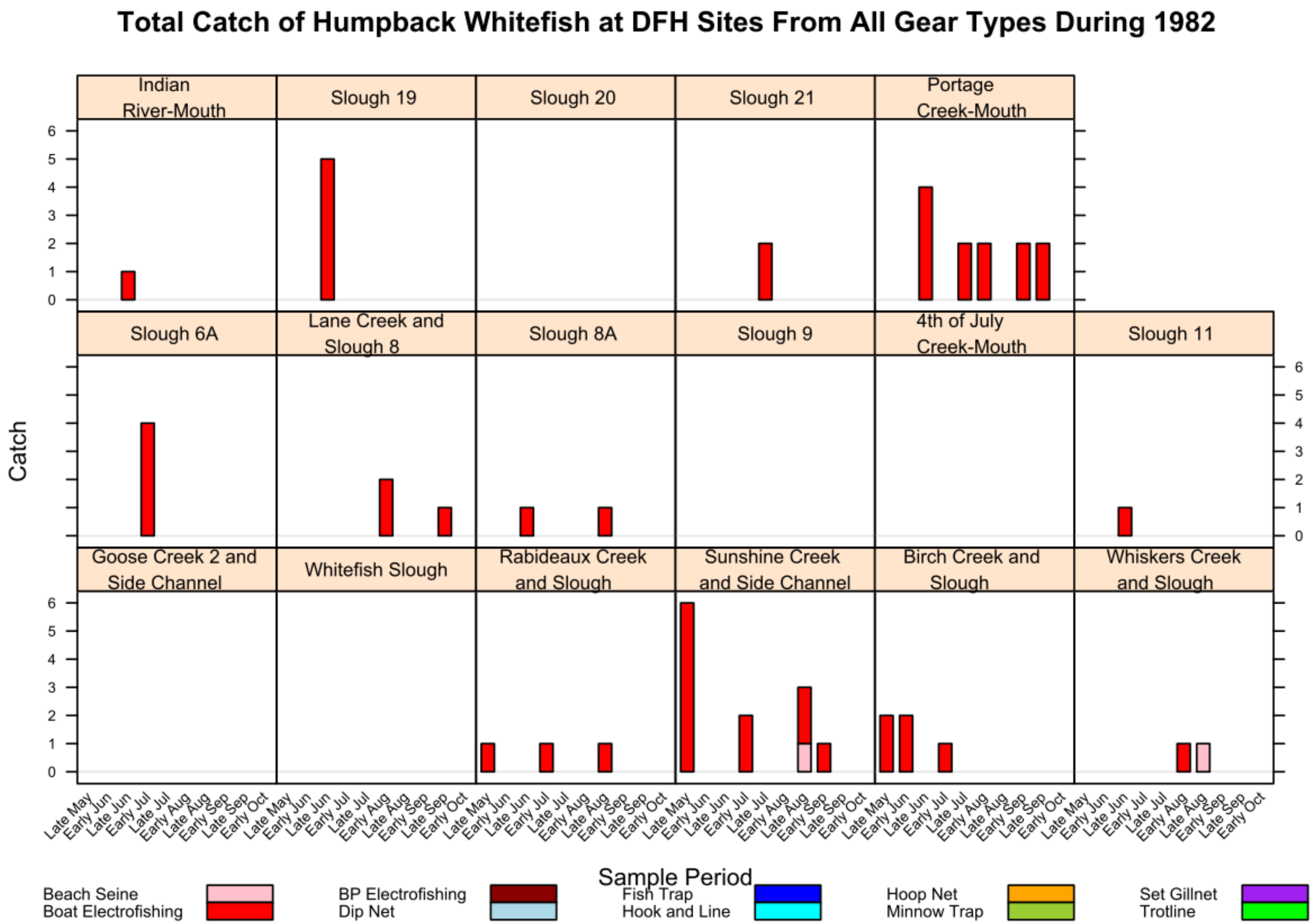


Figure 8.2-6. Total catch of humpback whitefish at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

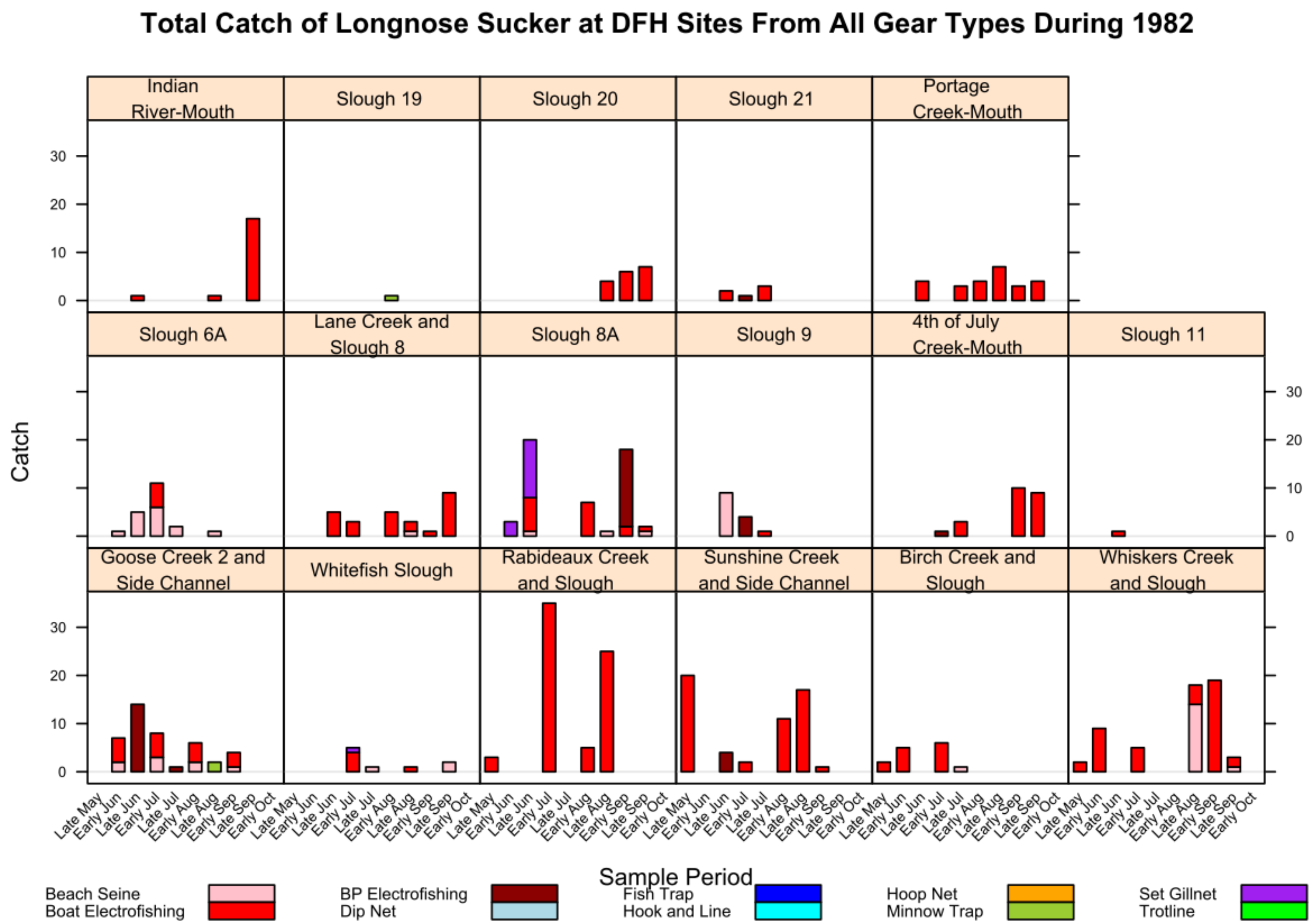


Figure 8.2-7. Total catch of longnose sucker at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

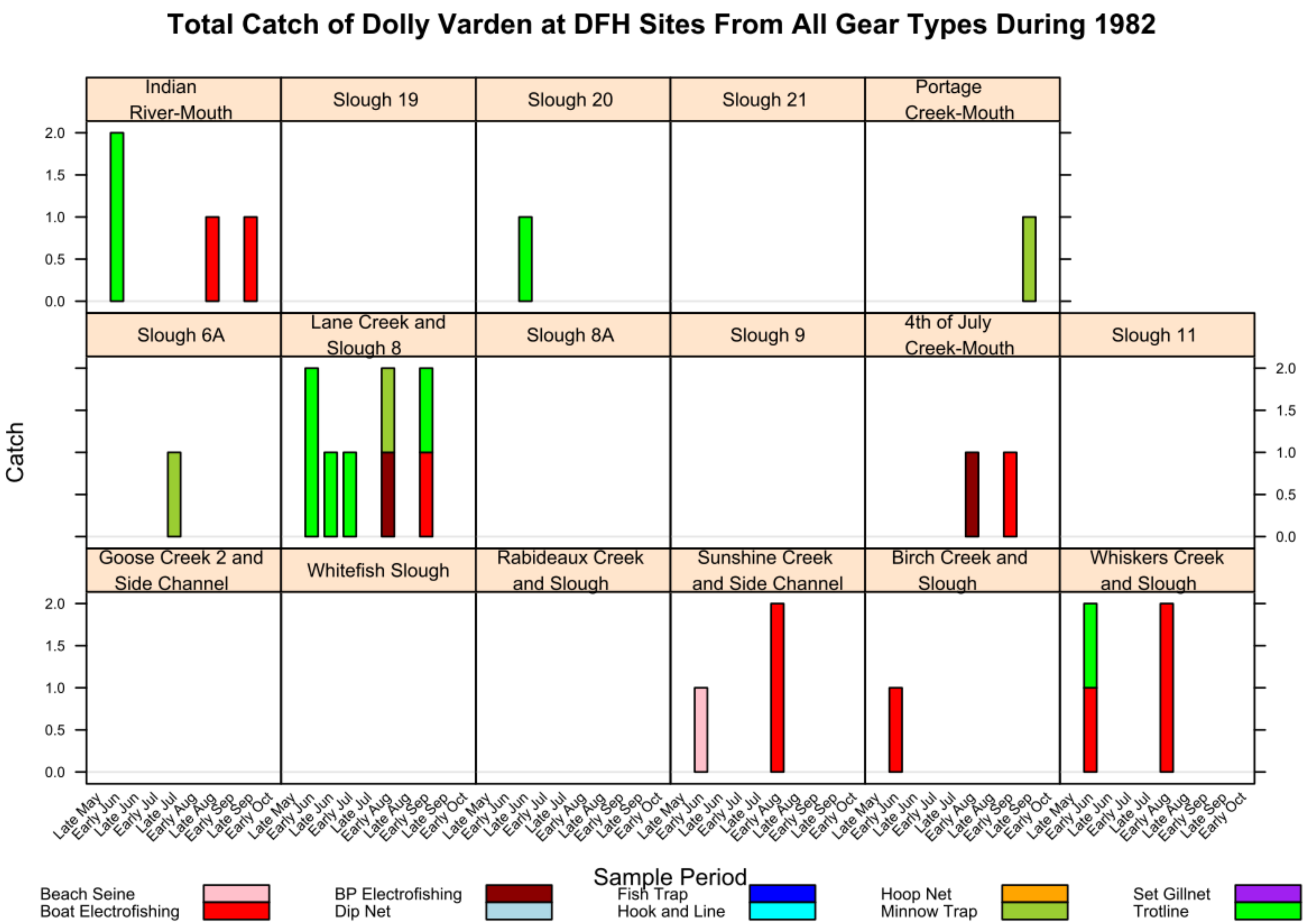


Figure 8.2-8. Total catch of Dolly Varden at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

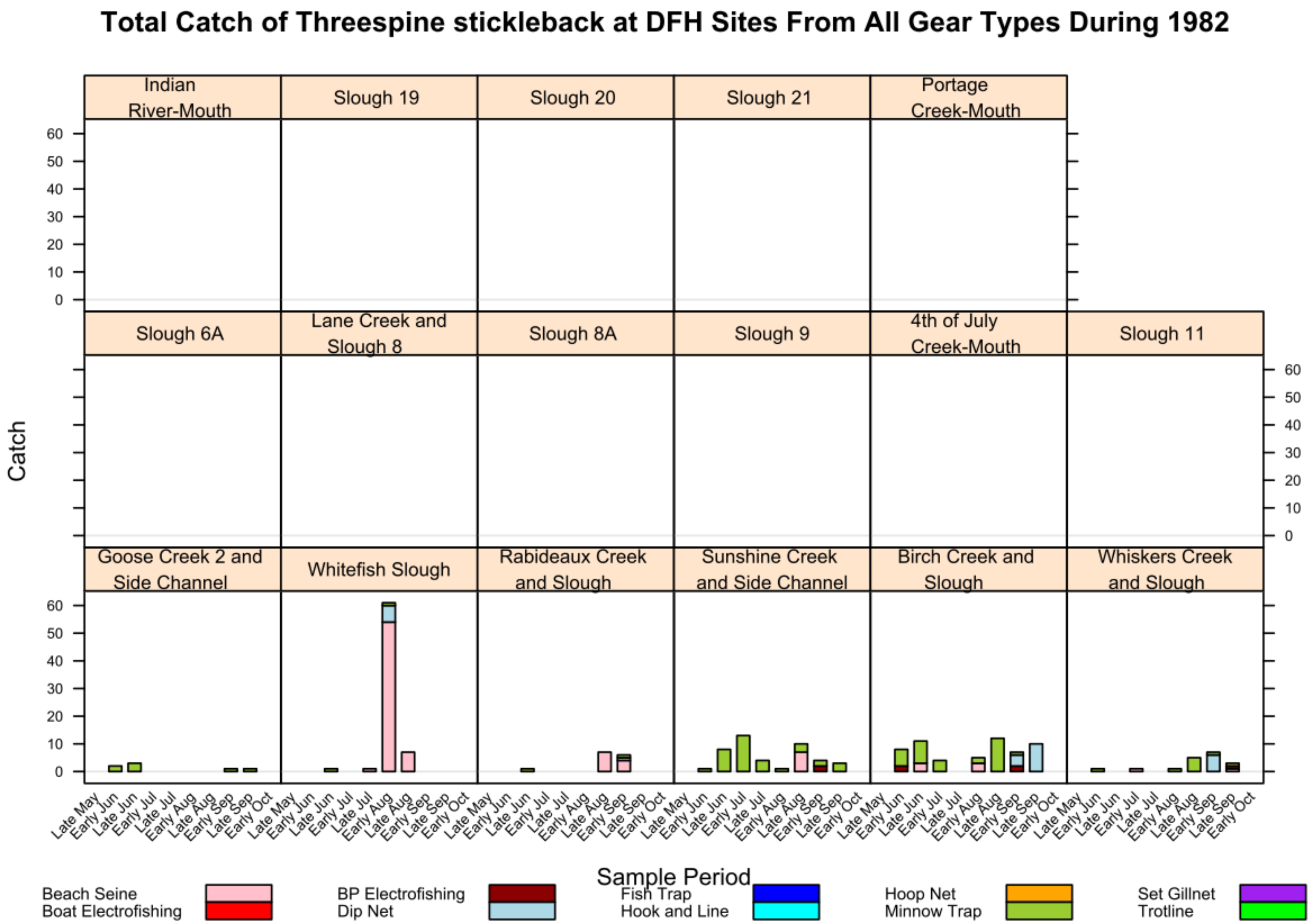


Figure 8.2-9. Total catch of threespine stickleback at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

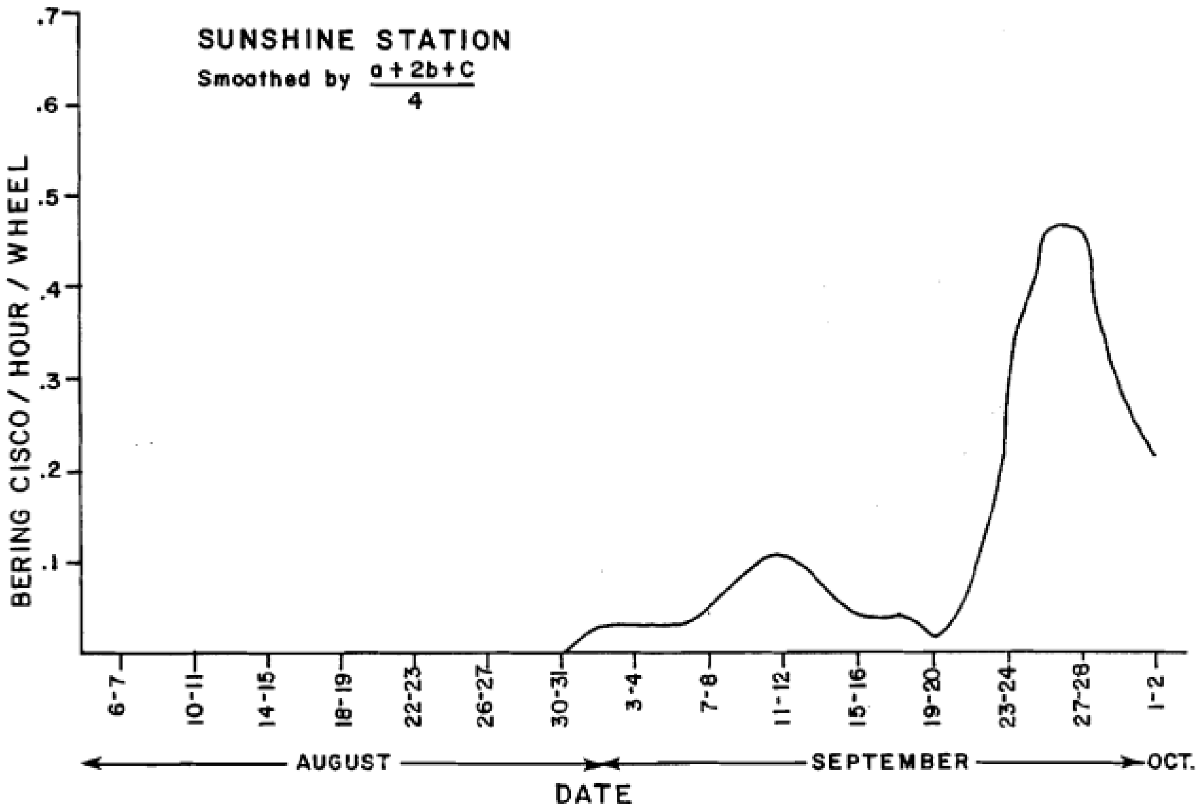


Figure 8.2-10. Mean hourly fishwheel catch of Bering cisco by two day periods at Sunshine Station. Source: Barrett et al. (1983).

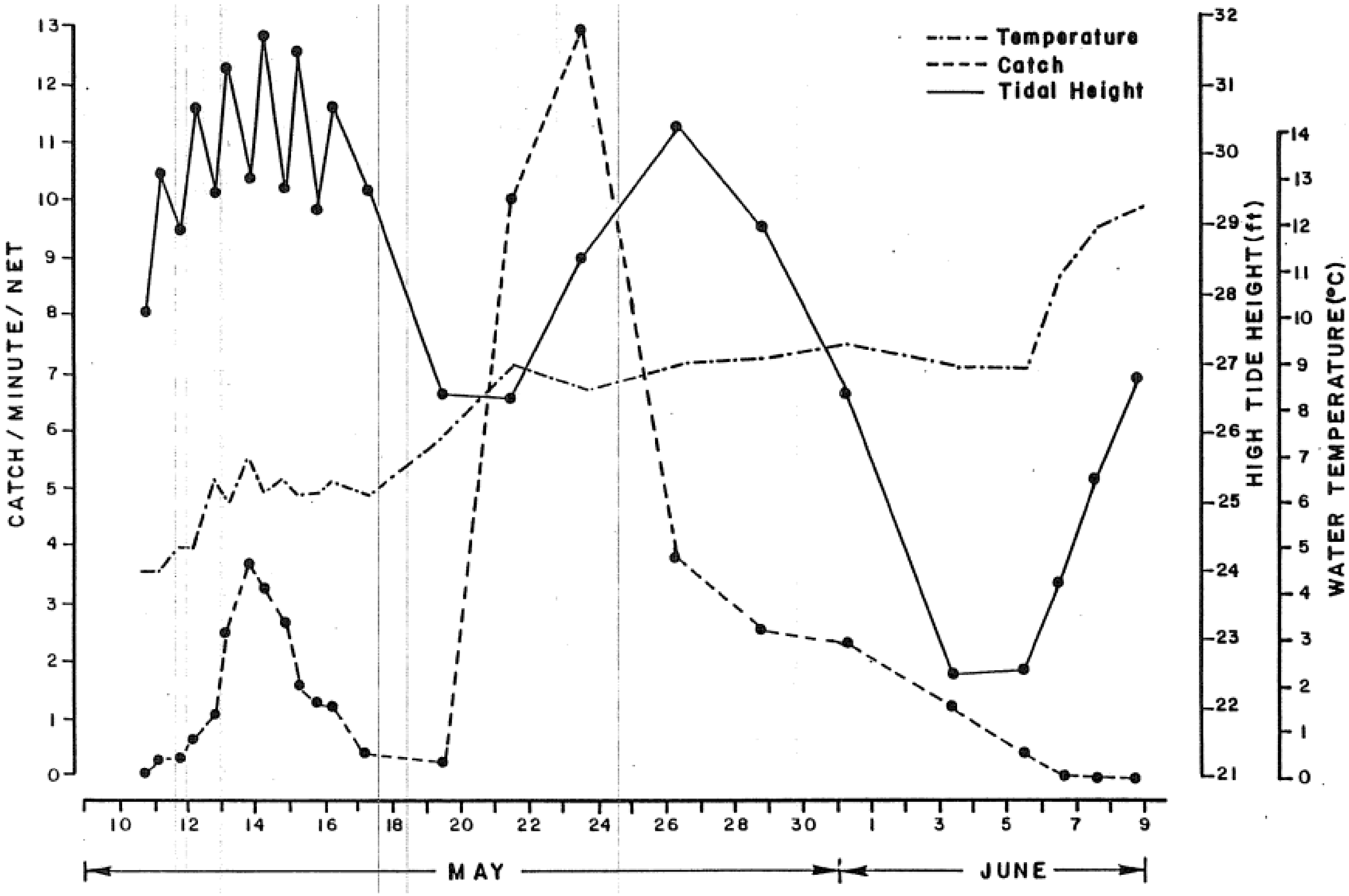


Figure 8.2-11. Mean CPUE of prespawning eulachon, tidal ranges, and temperature at the Susitna River estuary, 1982. Source: Barrett et al. (1984).

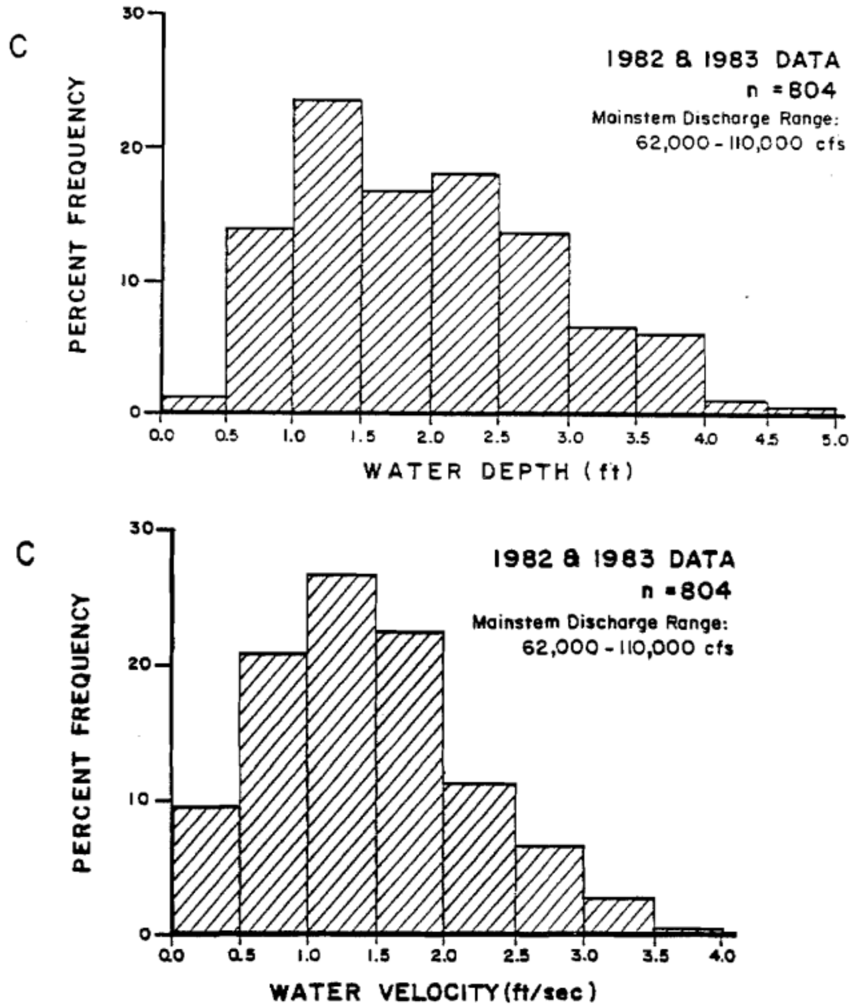


Figure 8.2-12. Frequency distributions of instantaneous water depths (top) and velocities (bottom) measured at sites at which eulachon spawning habitat surveys were conducted during1982 and 1983. Source: Vincent-Lang and Queral (1984).

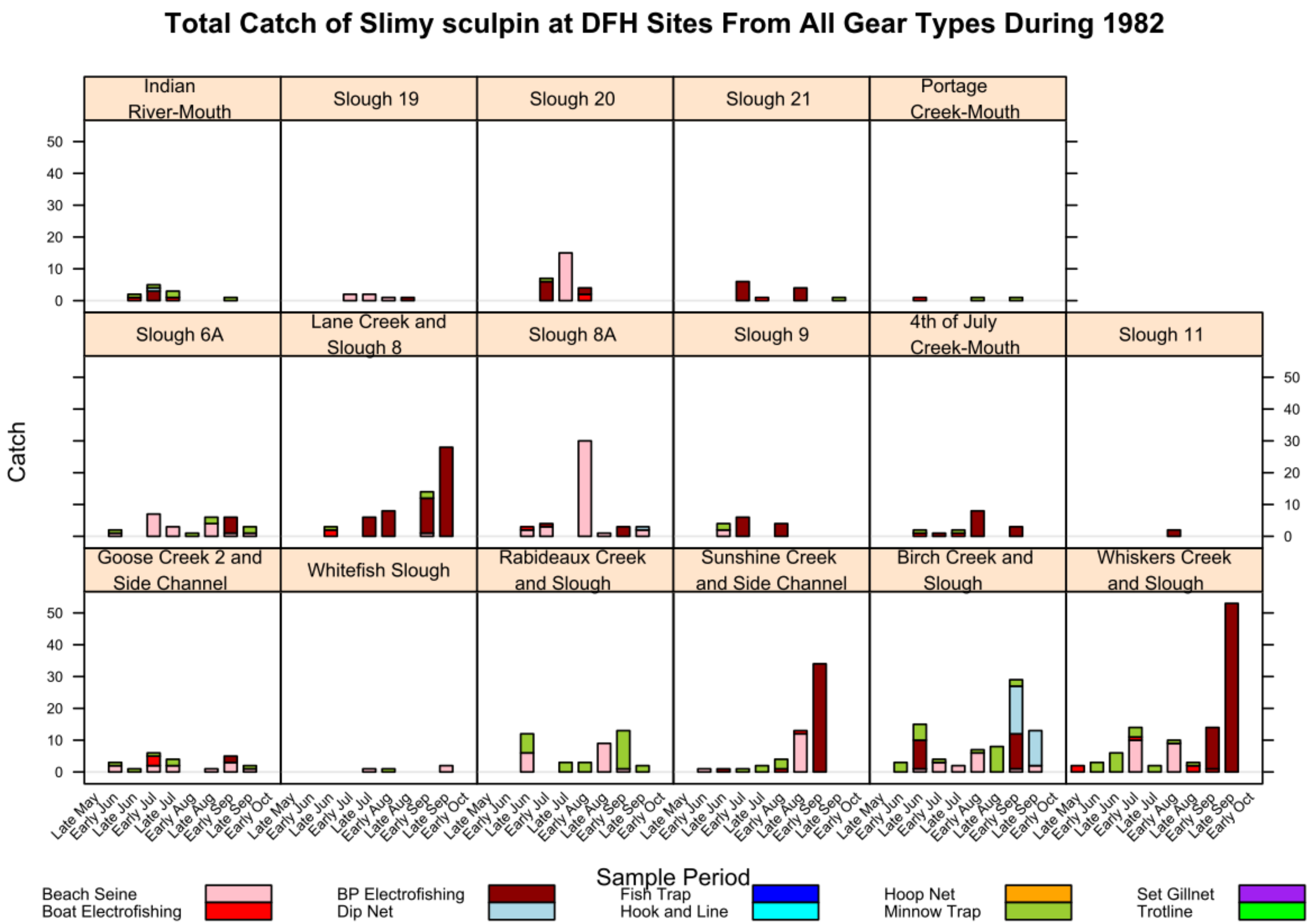


Figure 8.2-13. Total catch of slimy sculpin at DFH sites during 1982 by gear type. Data Source: Schmidt et al. (1983).

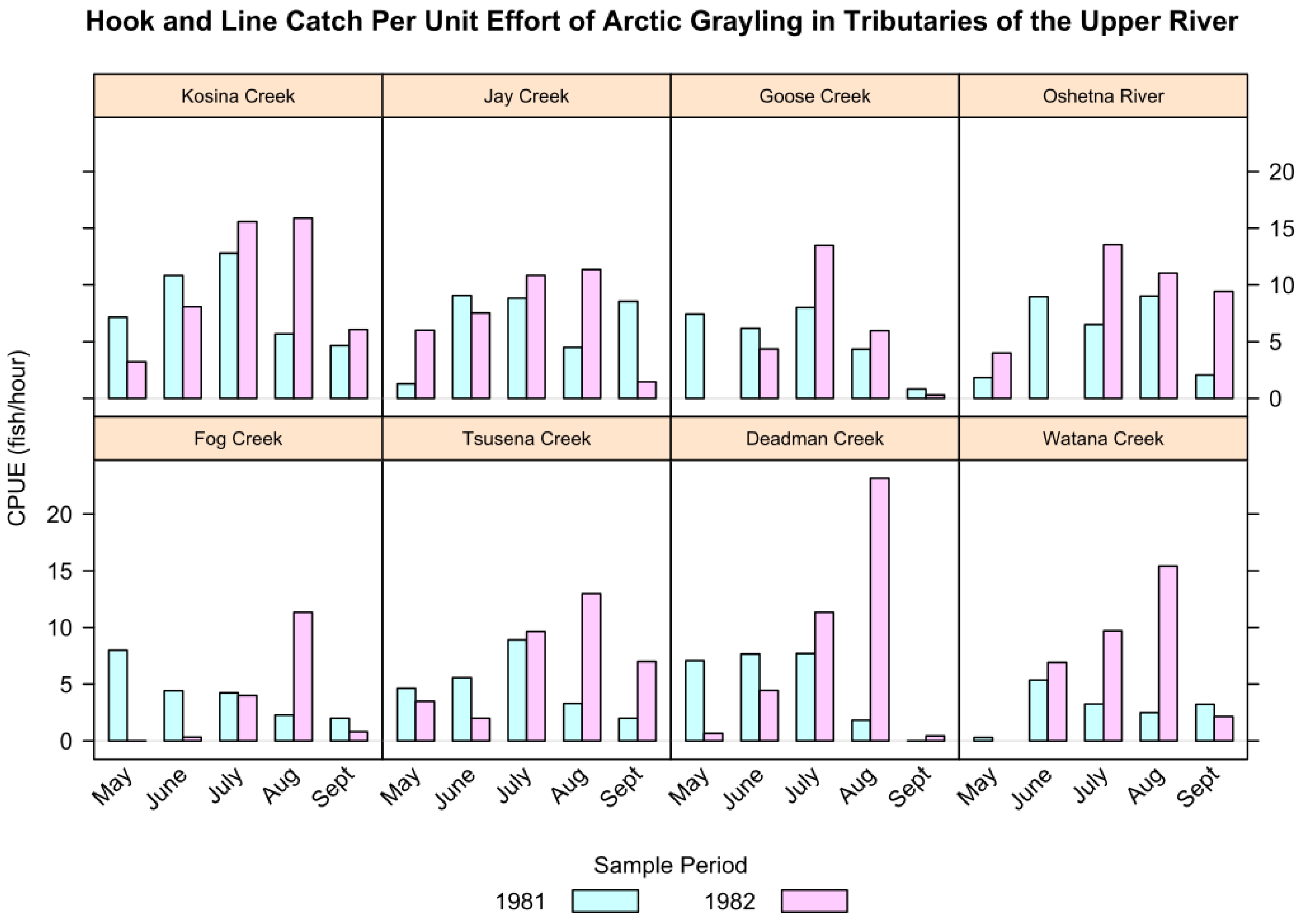
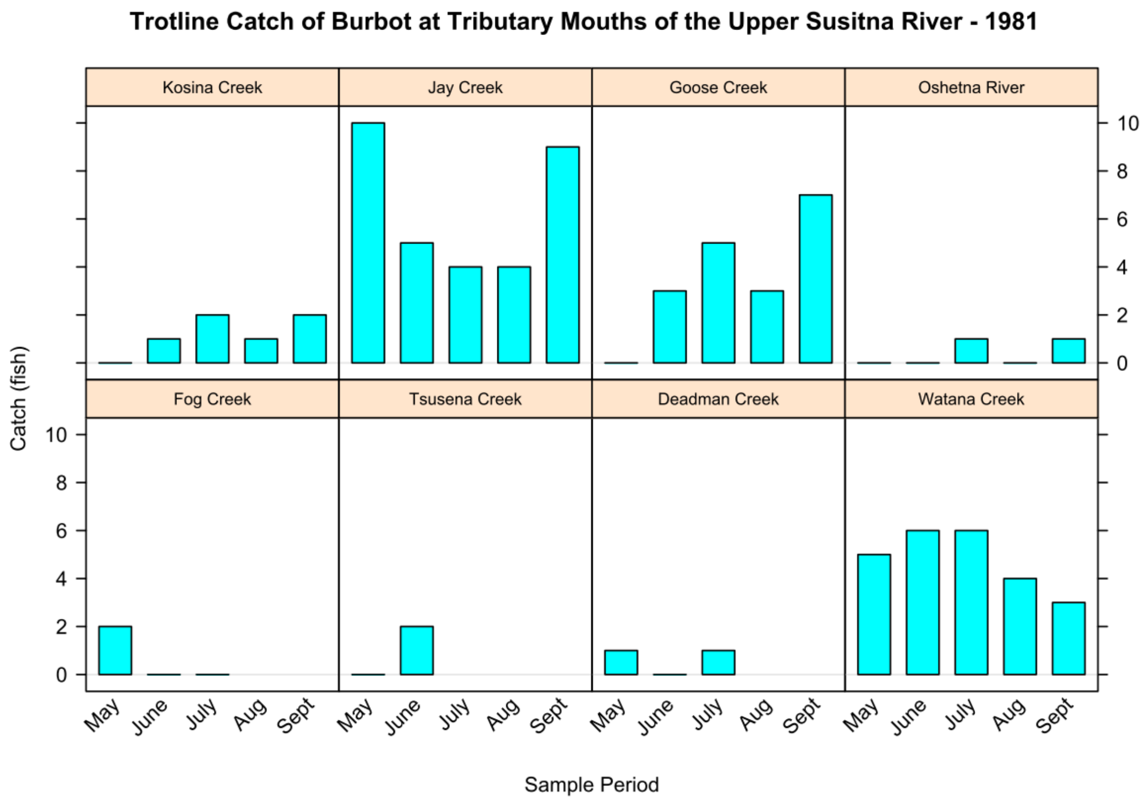


Figure 8.2-14. Catch per unit effort of Artic grayling by hook and line in tributaries to the Upper Susitna River during 1981 and 1982.The absence of a line at zero indicates no sampling occurred at that site and period. Data Source: Delaney et al. (1981), Sautner and Stratton (1983).



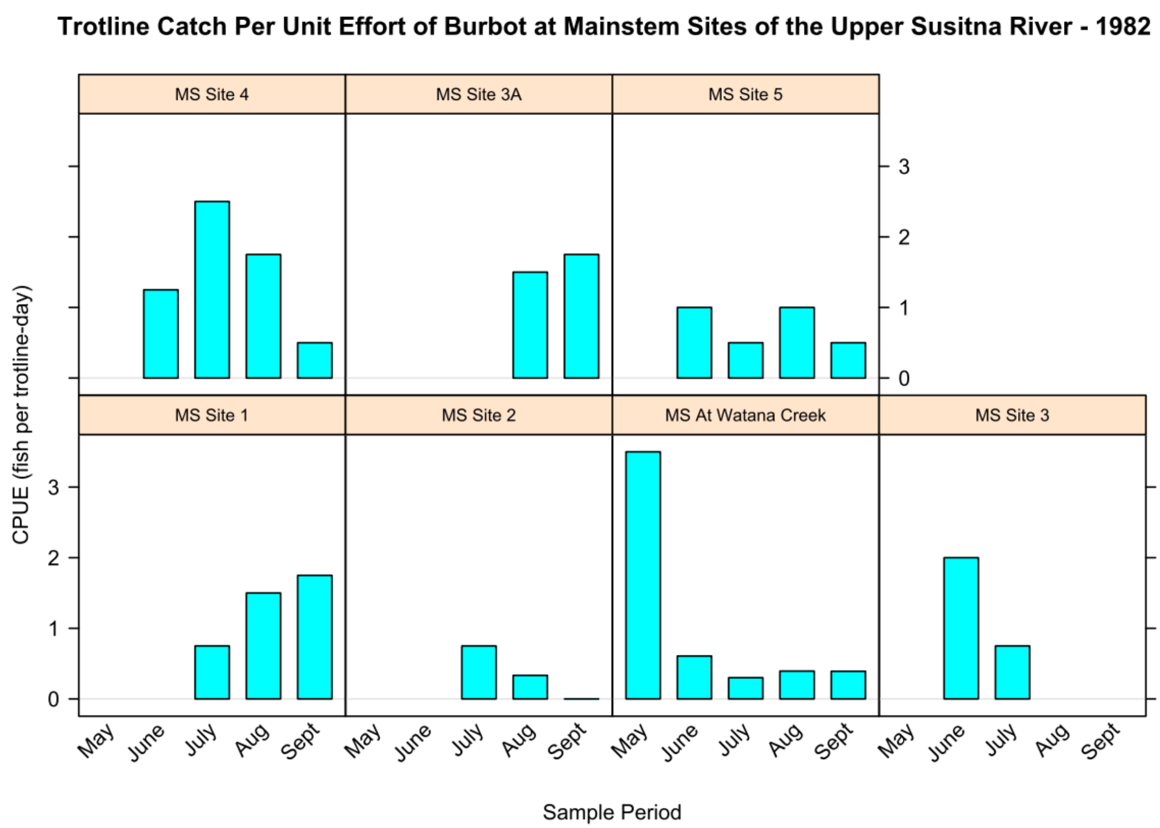


Figure 8.2-15. Total catch of burbot by trotlines during 1981 (top) at tributary mouths and CPUE of burbot at mainstem sites in the Upper Susitna River during 1982 (bottom). Data Sources: Delaney et al. (1981), Sautner and Stratton (1983).

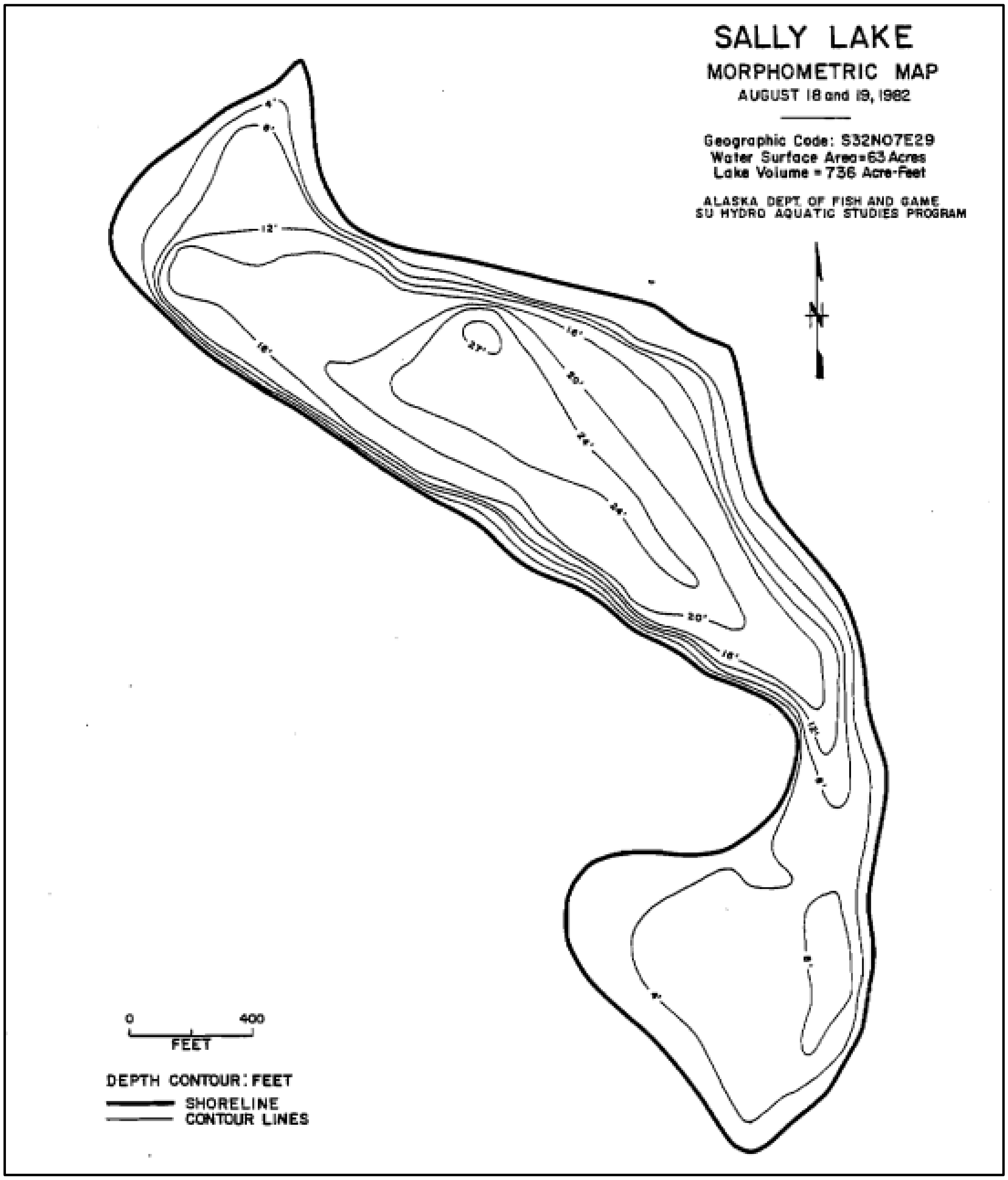


Figure 8.2-16. Bathymetric map of Sally Lake. Source: Sautner and Stratton (1983).

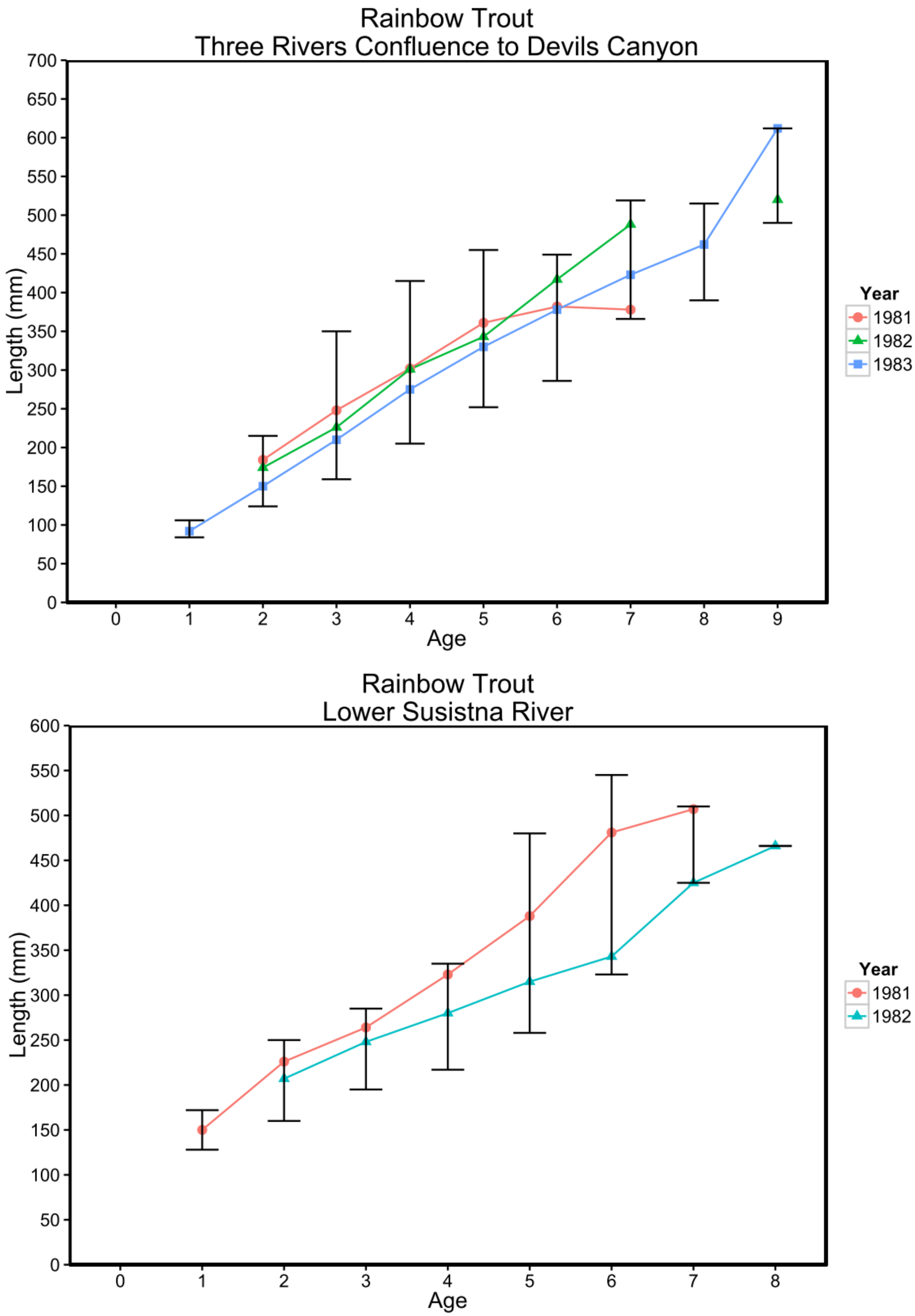


Figure 8.3-1. Age and length of rainbow trout collected in the Lower and Middle Susitna River during the open water seasons of 1981, 1982, and 1983. Data Source: Delaney et al. (1981a), Schmidt et al. (1983, 1984).

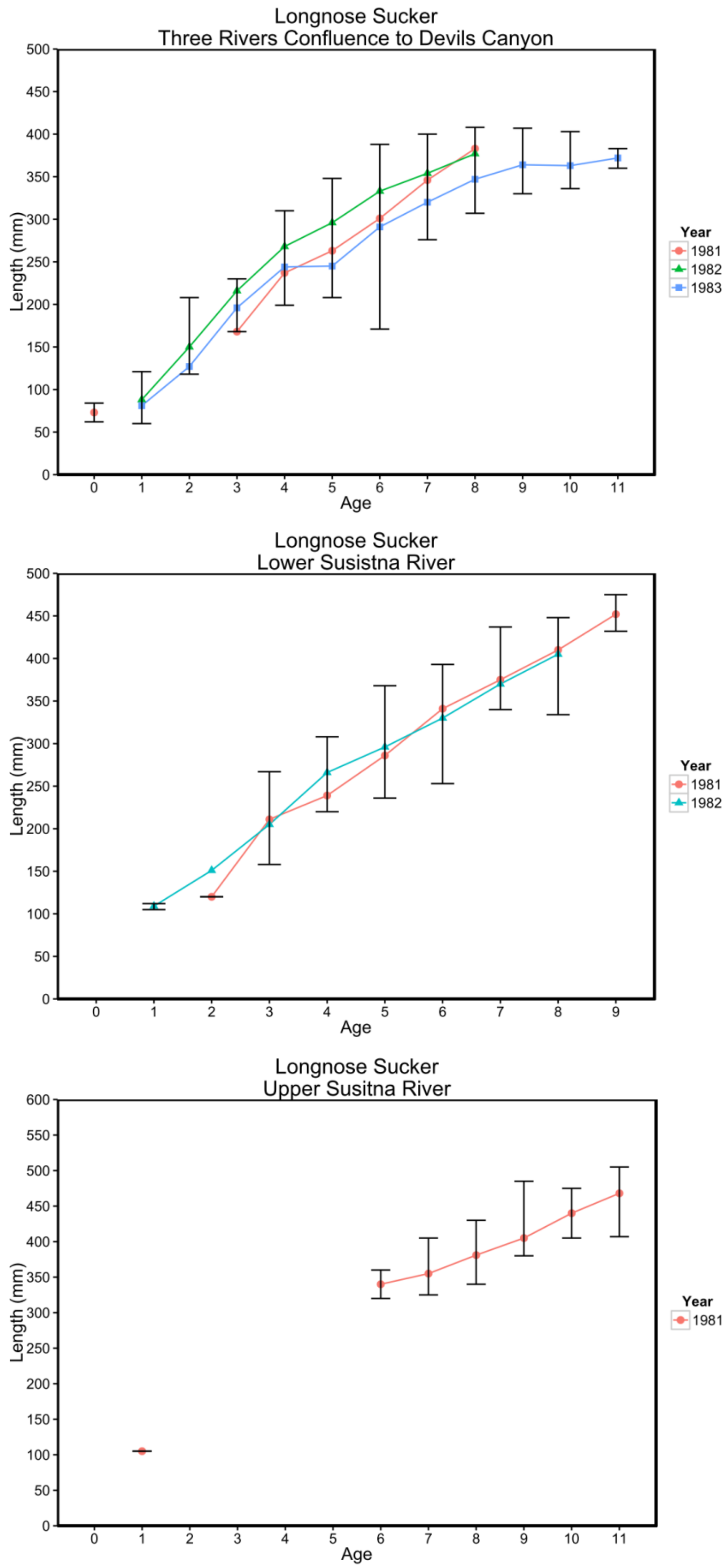


Figure 8.3-2. Age and length of longnose sucker collected in the lower, middle, and upper Susitna River during the open water seasons of 1981, 1982, and 1983. Data Source: Delaney et al. (1981a, 1981c), Schmidt et al. (1983, 1984), Sautner and Stratton (1983).

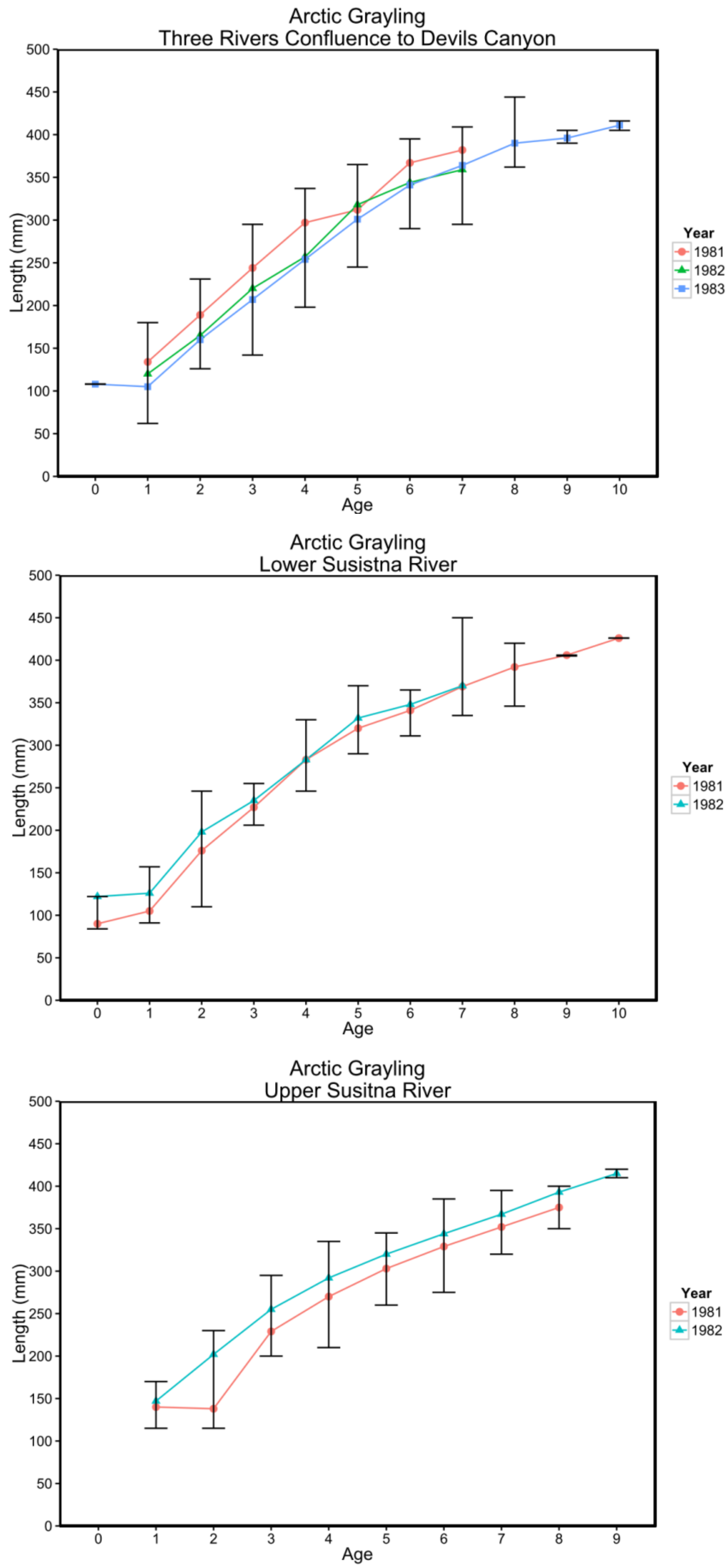


Figure 8.3-3. Age and length of longnose sucker collected in the lower, middle, and upper Susitna River during the open water seasons of 1981, 1982, and 1983. Data Source: Delaney et al. (1981a, 1981c), Schmidt et al. (1983, 1984), Sautner and Stratton (1983).

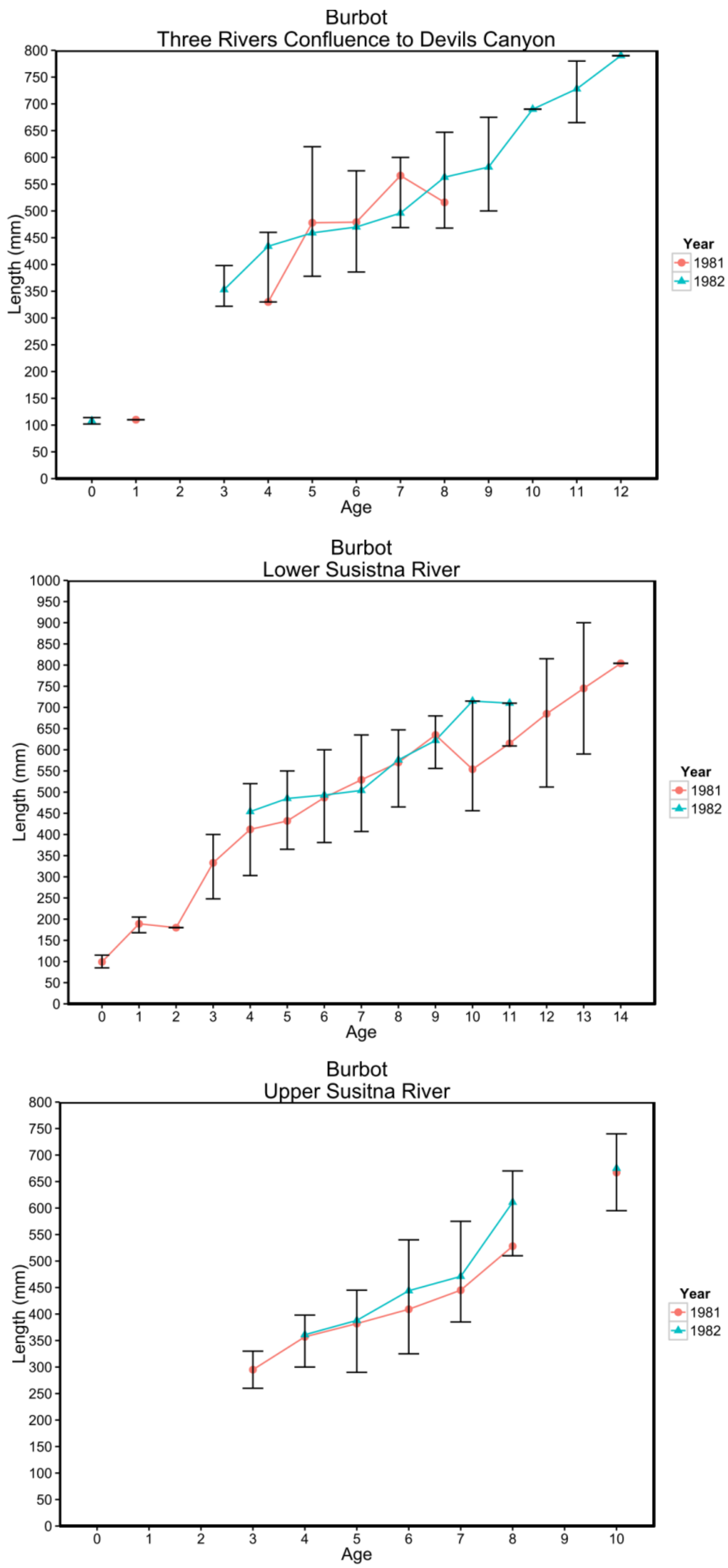


Figure 8.3-4. Age and length of longnose sucker collected in the lower, middle, and upper Susitna River during the open water seasons of 1981 and 1982. Data Source: Delaney et al. (1981a, 1981c), Schmidt et al. (1983), Sautner and Stratton (1983).

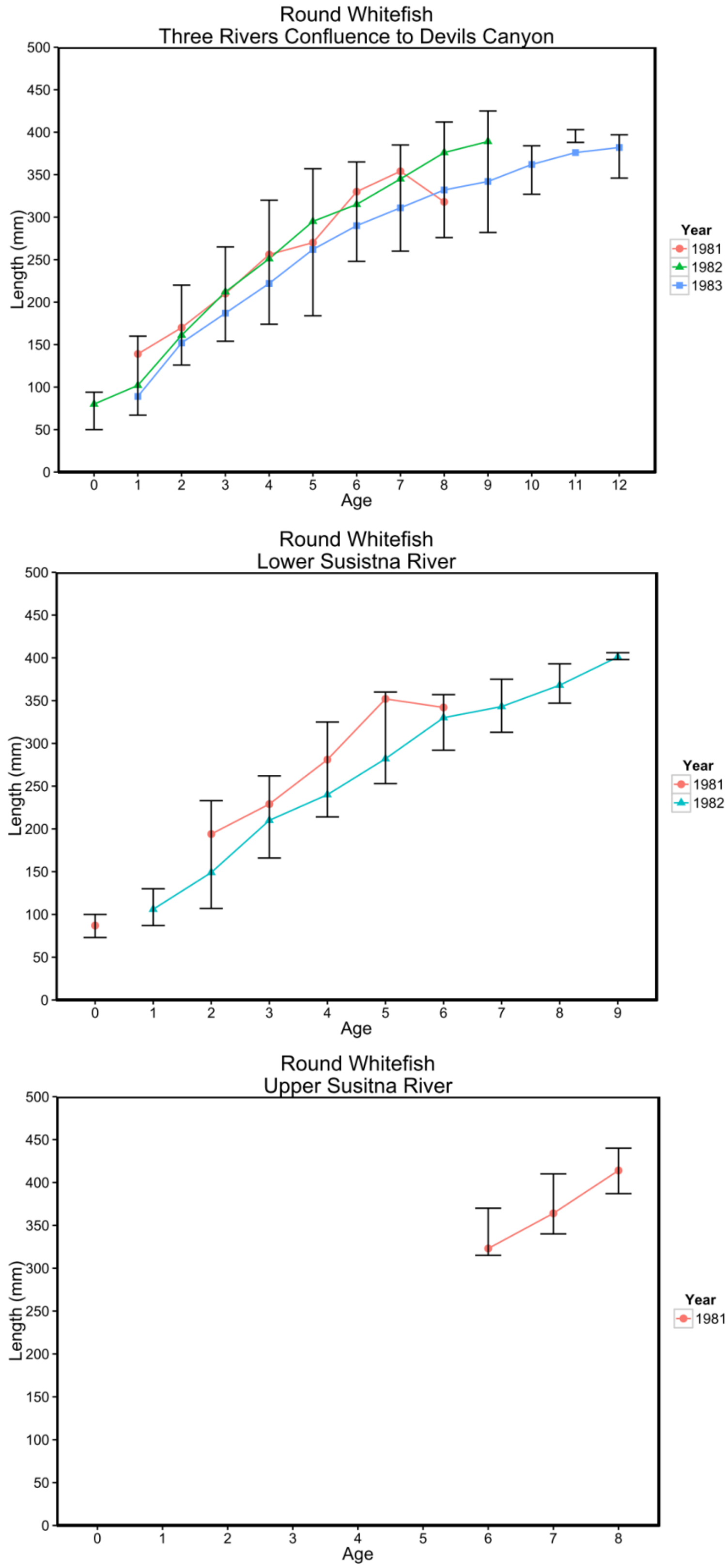


Figure 8.3-5. Age and length of round whitefish collected in the lower, middle, and upper Susitna River during the open water seasons of 1981, 1982, and 1983. Data Source: Delaney et al. (1981a, 1981c), Schmidt et al. (1983, 1984).

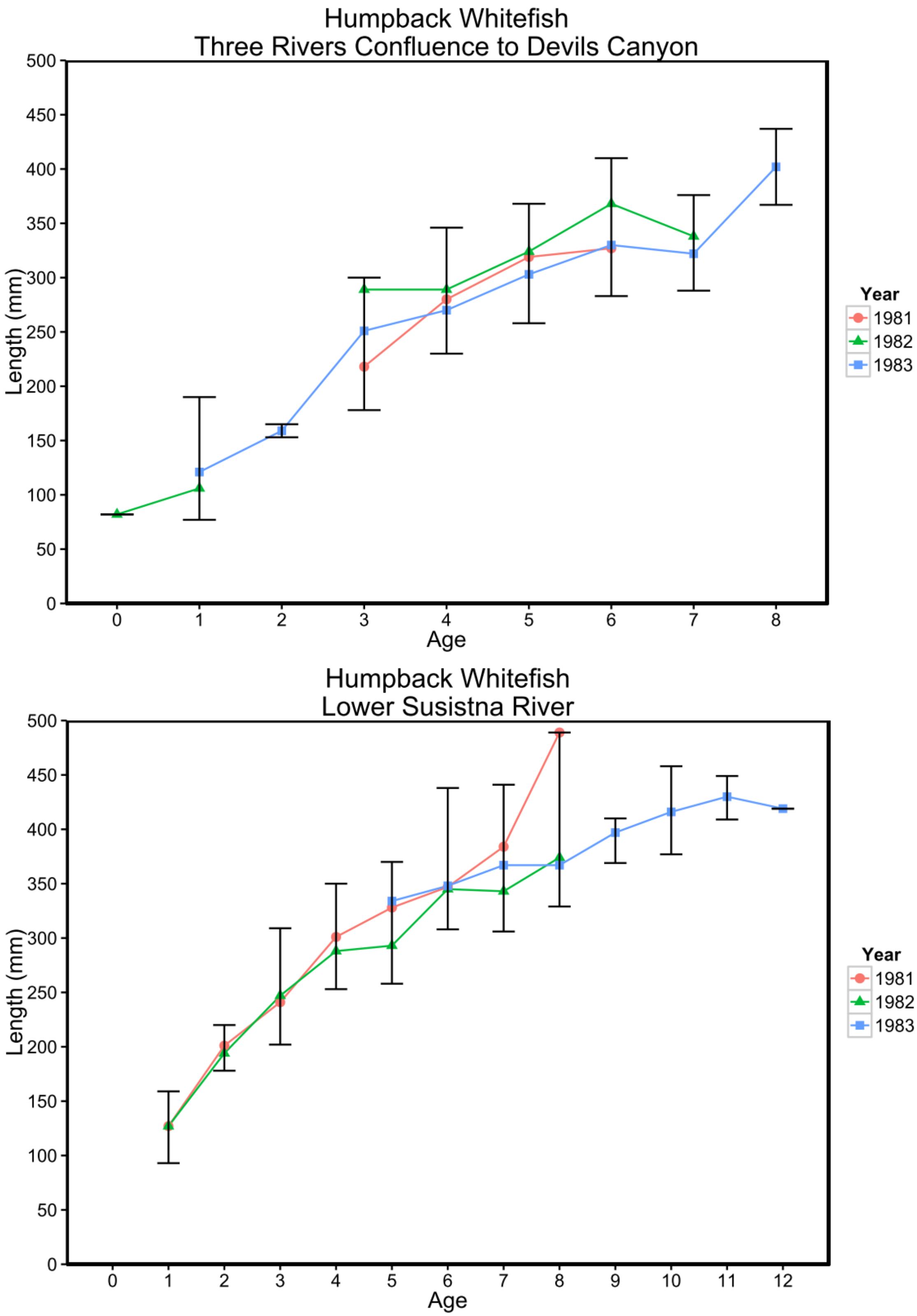


Figure 8.3-6. Age and length of humpback whitefish collected in the Lower and Middle Susitna River during the open water seasons of 1981, 1982, and 1983. Data Source: Delaney et al. (1981a, 1981c), Schmidt et al. (1983, 1984).

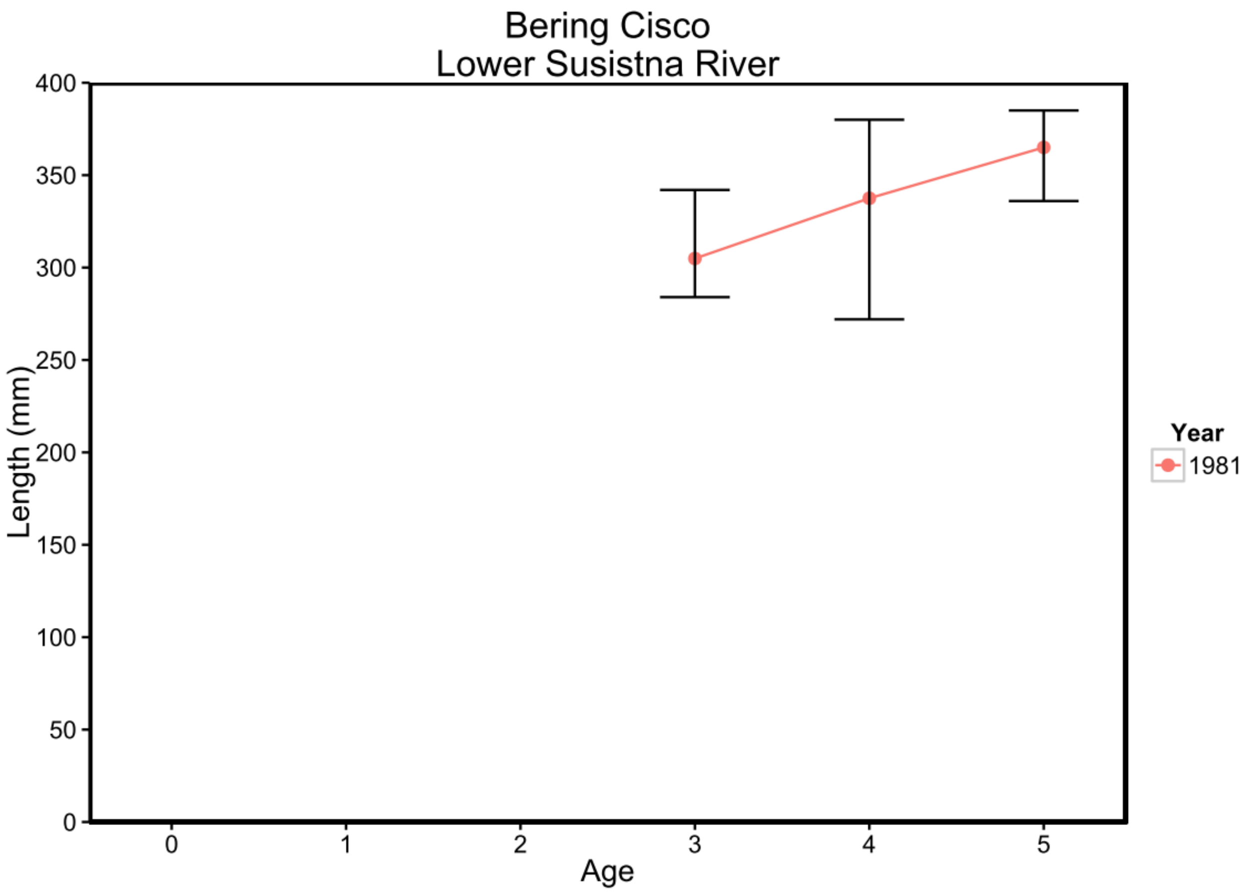


Figure 8.3-7. Age and length of Bering cisco collected in the Lower Susitna River during the open water seasons of 1981. Data Source: Delaney et al. (1981a).

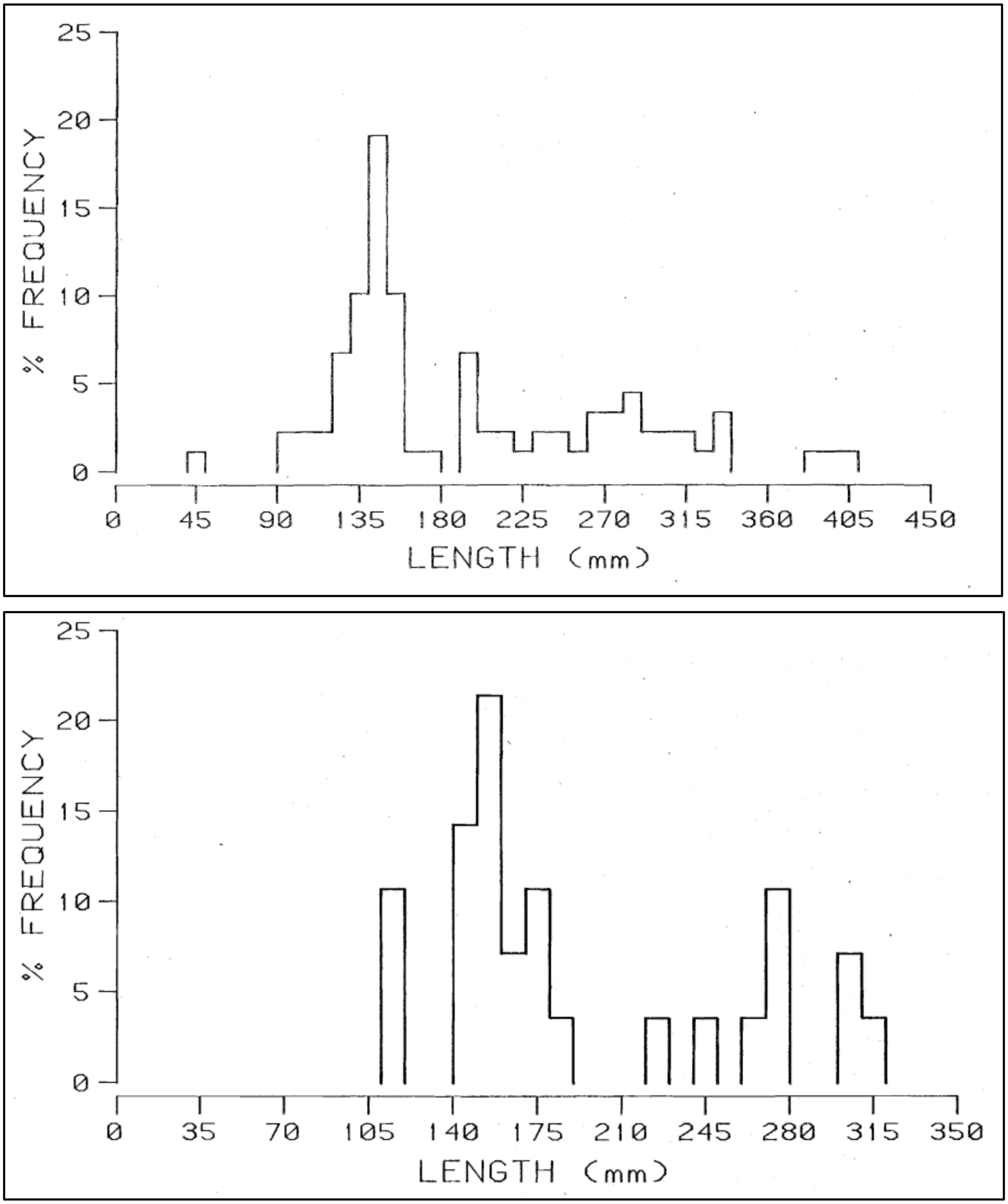


Figure 8.3-8. Length frequency of Dolly Varden (top) and Arctic lamprey (bottom) collected in the Susitna River downstream of Devils Canyon during the open water season of 1981. Source: Delaney et al. (1981a).

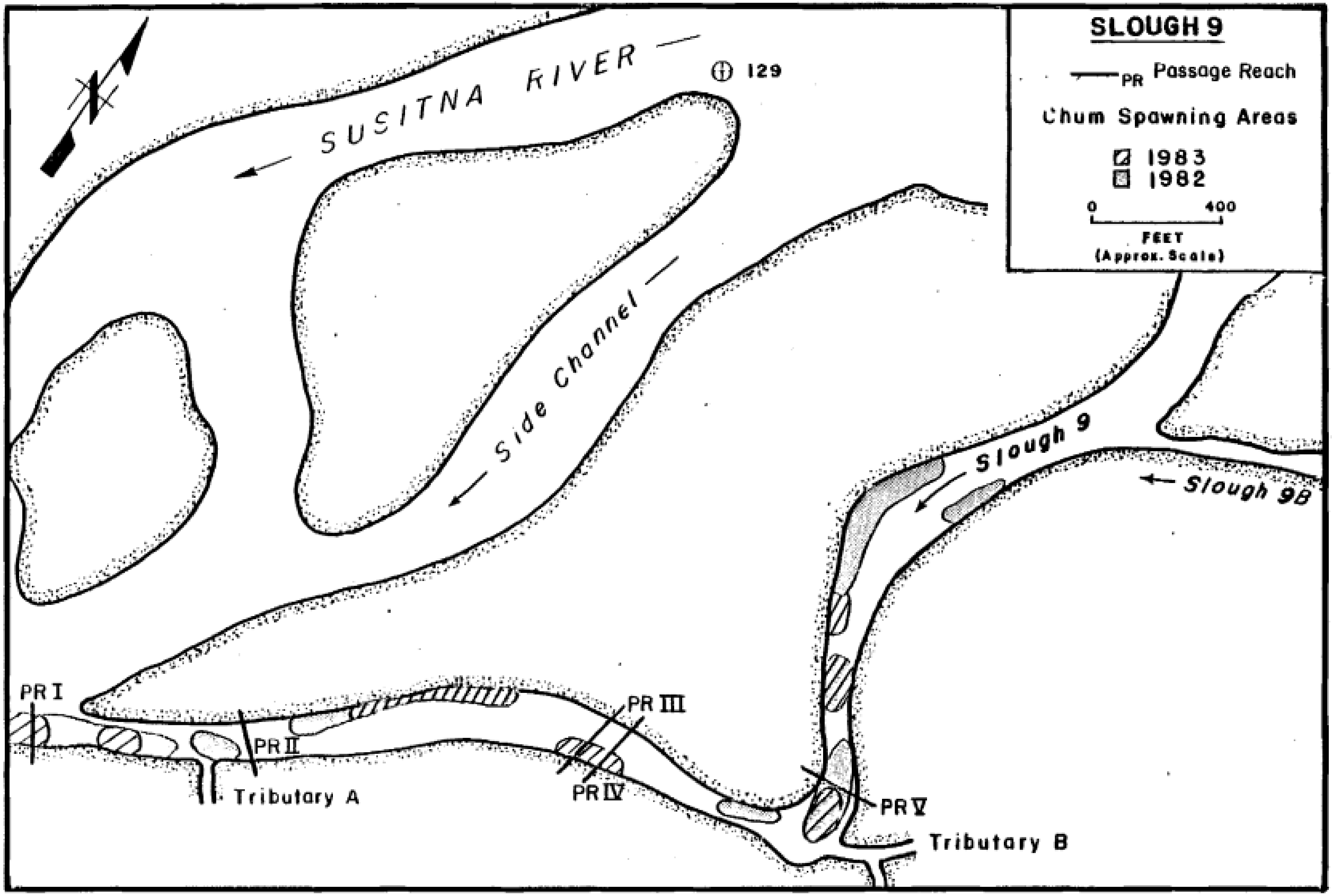


Figure 9.2-1. Chum spawning areas in Slough 9 during 1982. PR indicates downstream end of critical passage reaches. Source: Sautner et al. (1984).

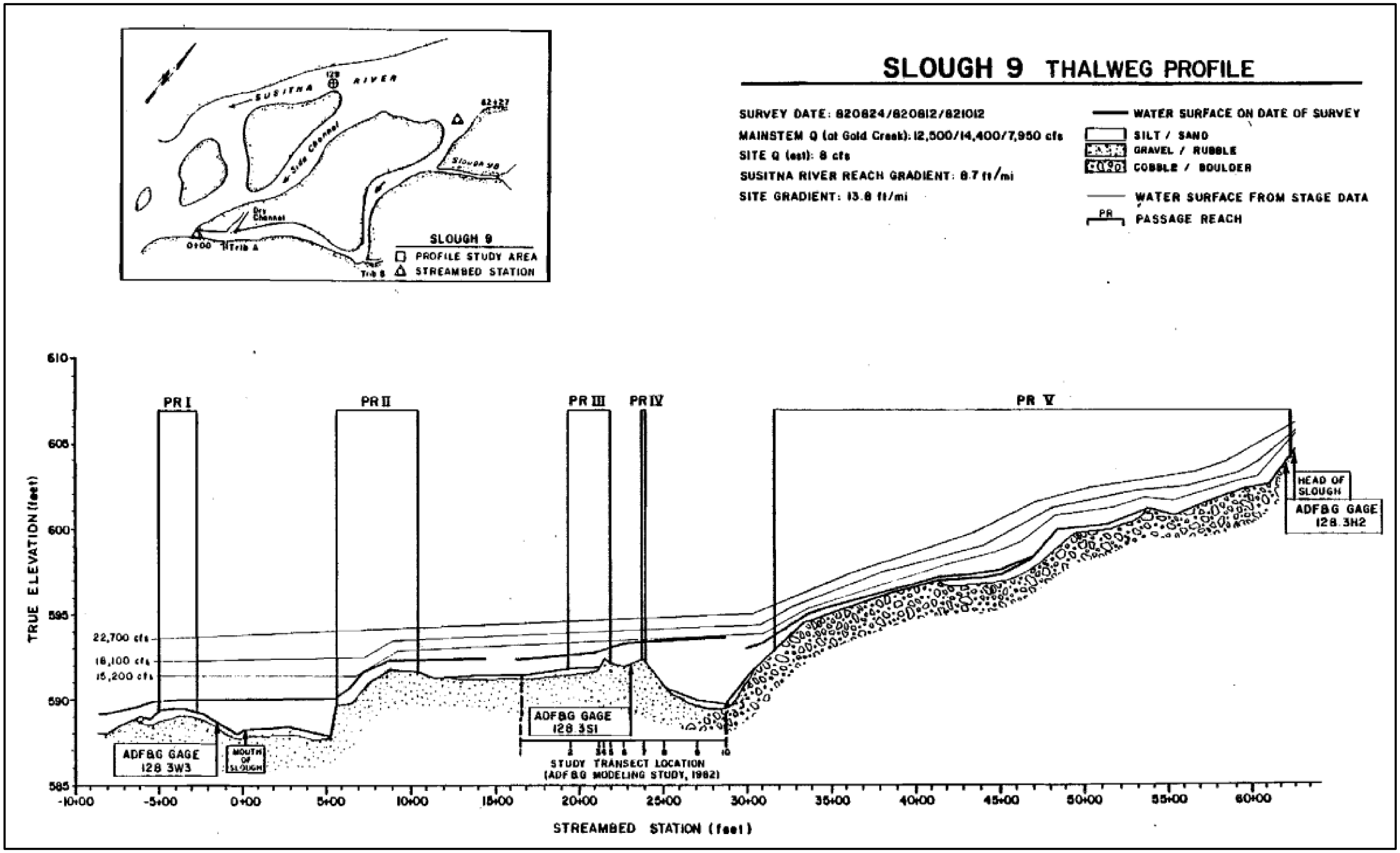


Figure 9.2-2. Thalweg profile of Slough 9. Source: Sautner et al. (1984).

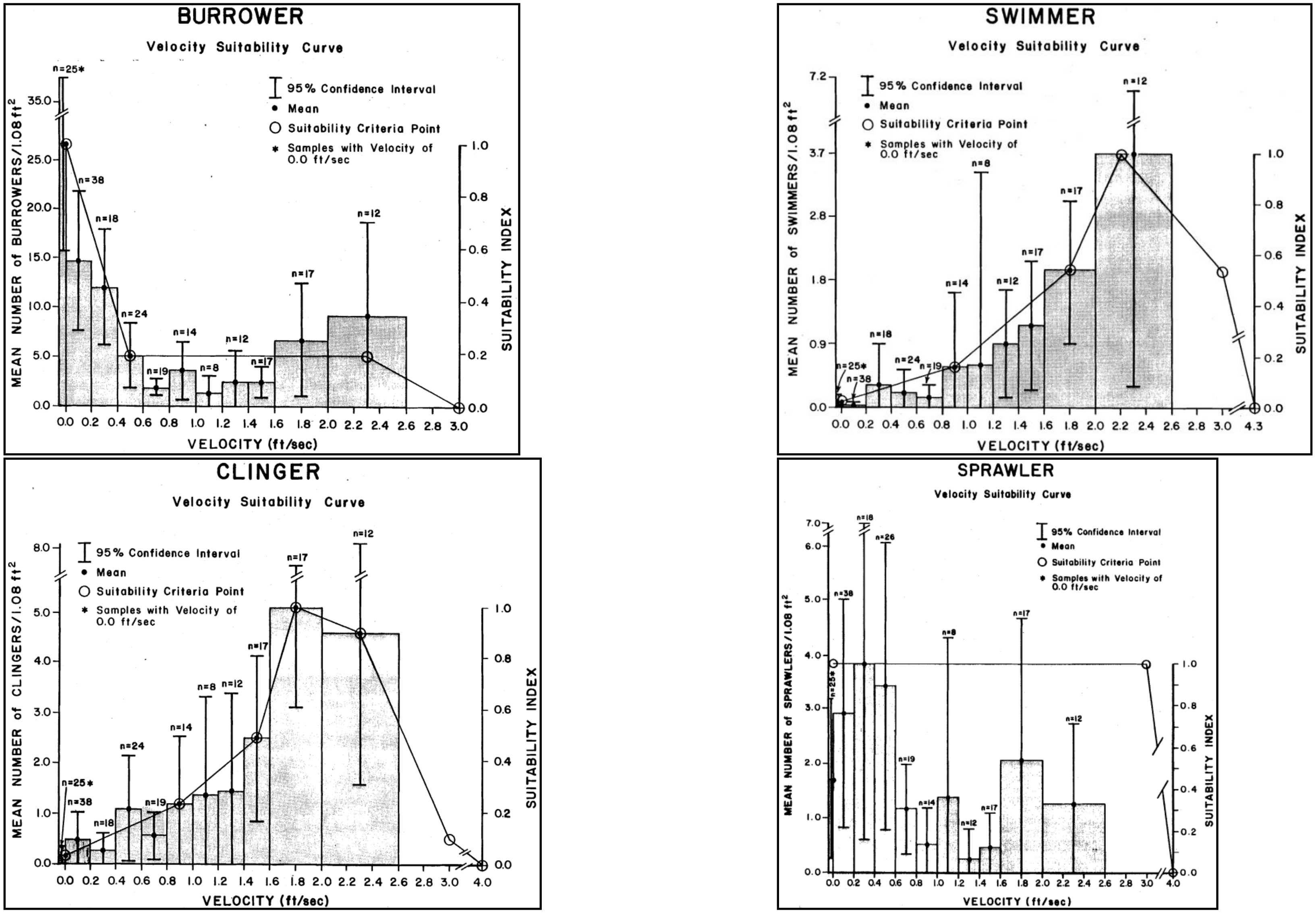


Figure 11.1-1. Velocity habitat suitability indices for benthic invertebrate guilds based upon sampling in the Middle Susitna River during 1984. Source: Hansen and Richards (1985).

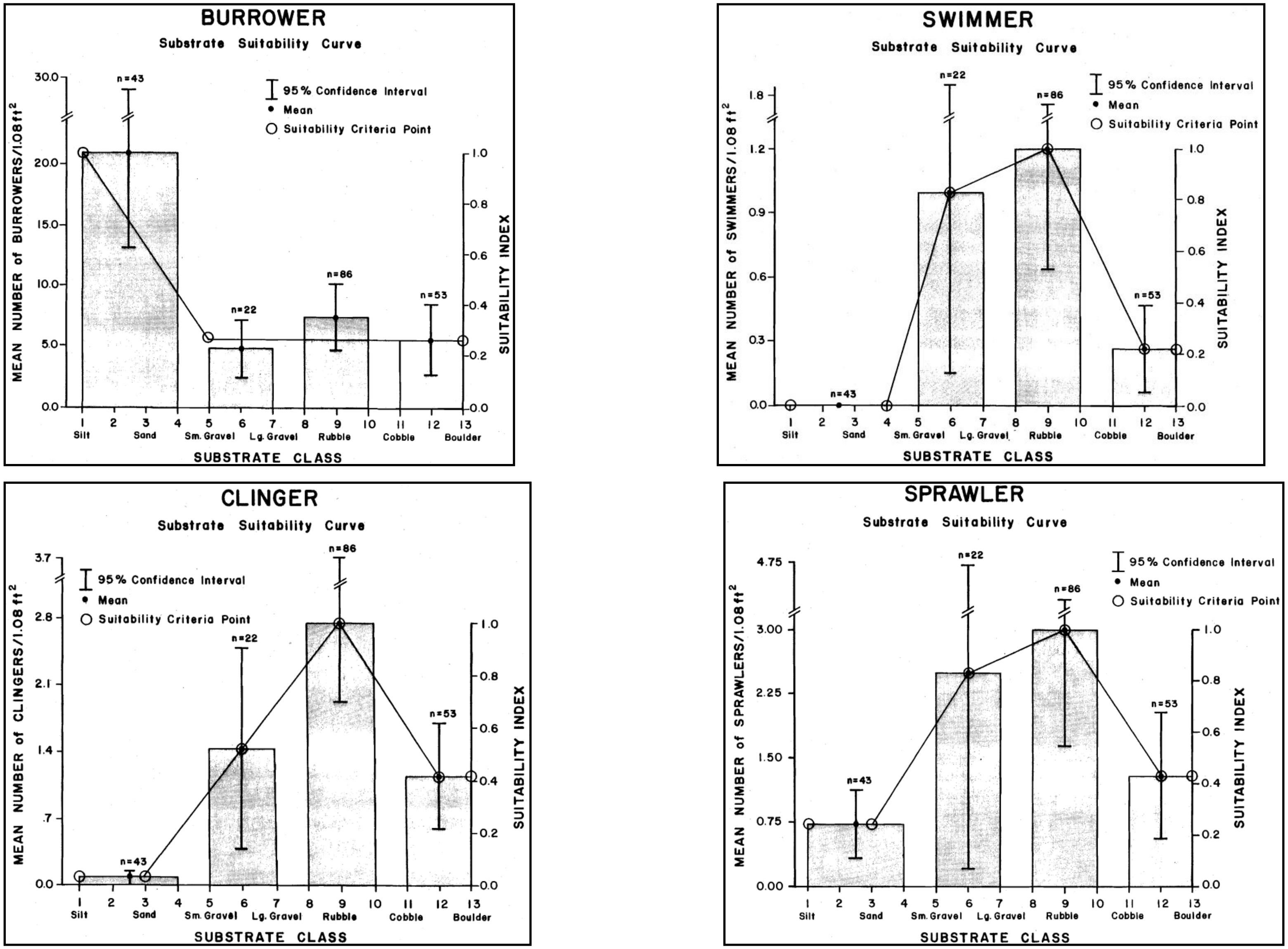


Figure 11.1-2. Substrate habitat suitability indices for benthic invertebrate guilds based upon sampling in the Middle Susitna River during 1984. Source: Hansen and Richards (1985).

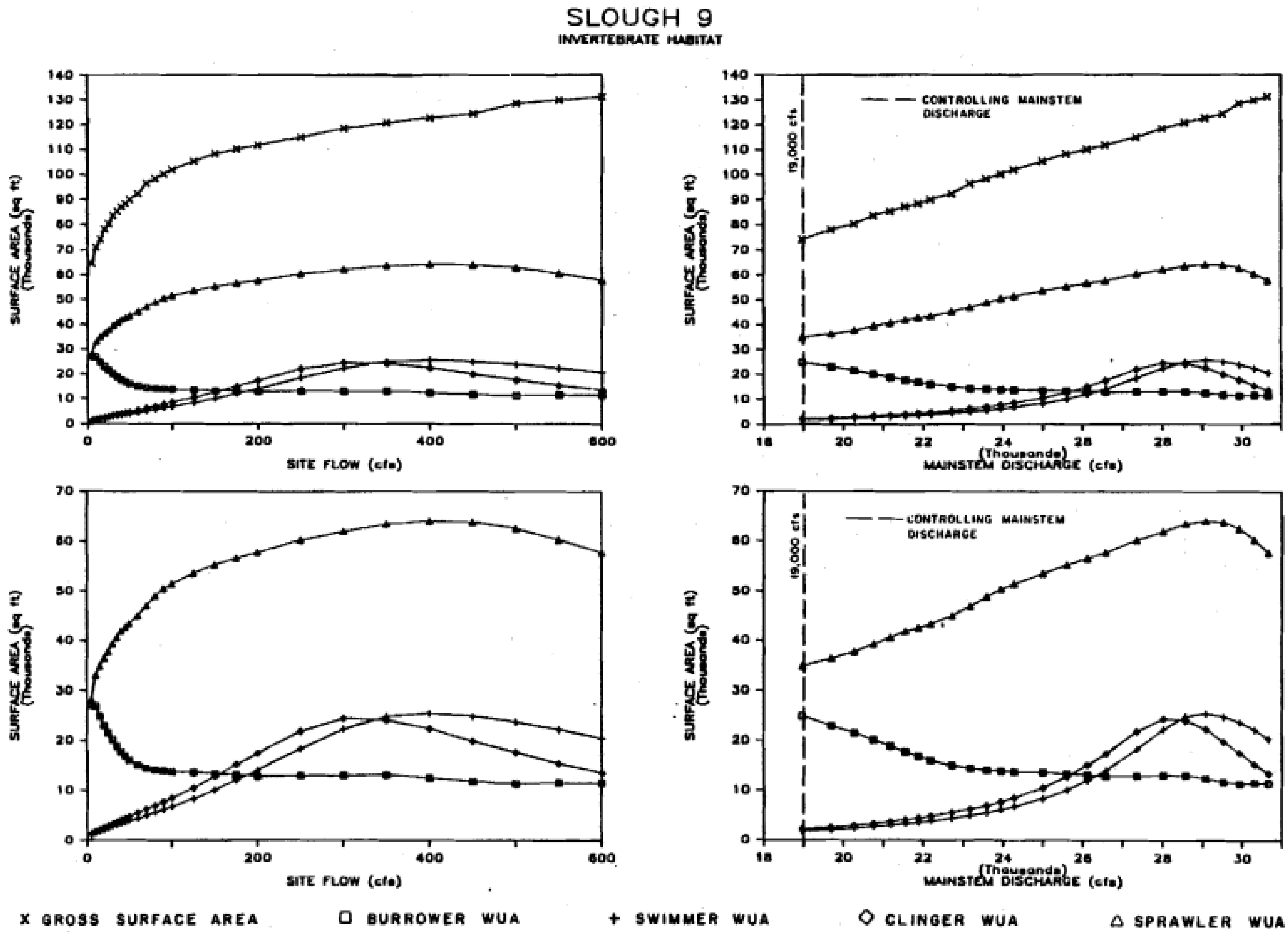


Figure 11.1-3. Projections of gross surface area and WUA of burrower, swimmer, clinger, and sprawler invertebrate habitat as a function of site flow and mainstem discharge for the Slough 9 modeling site. Source (Hansen and Richards 1985).

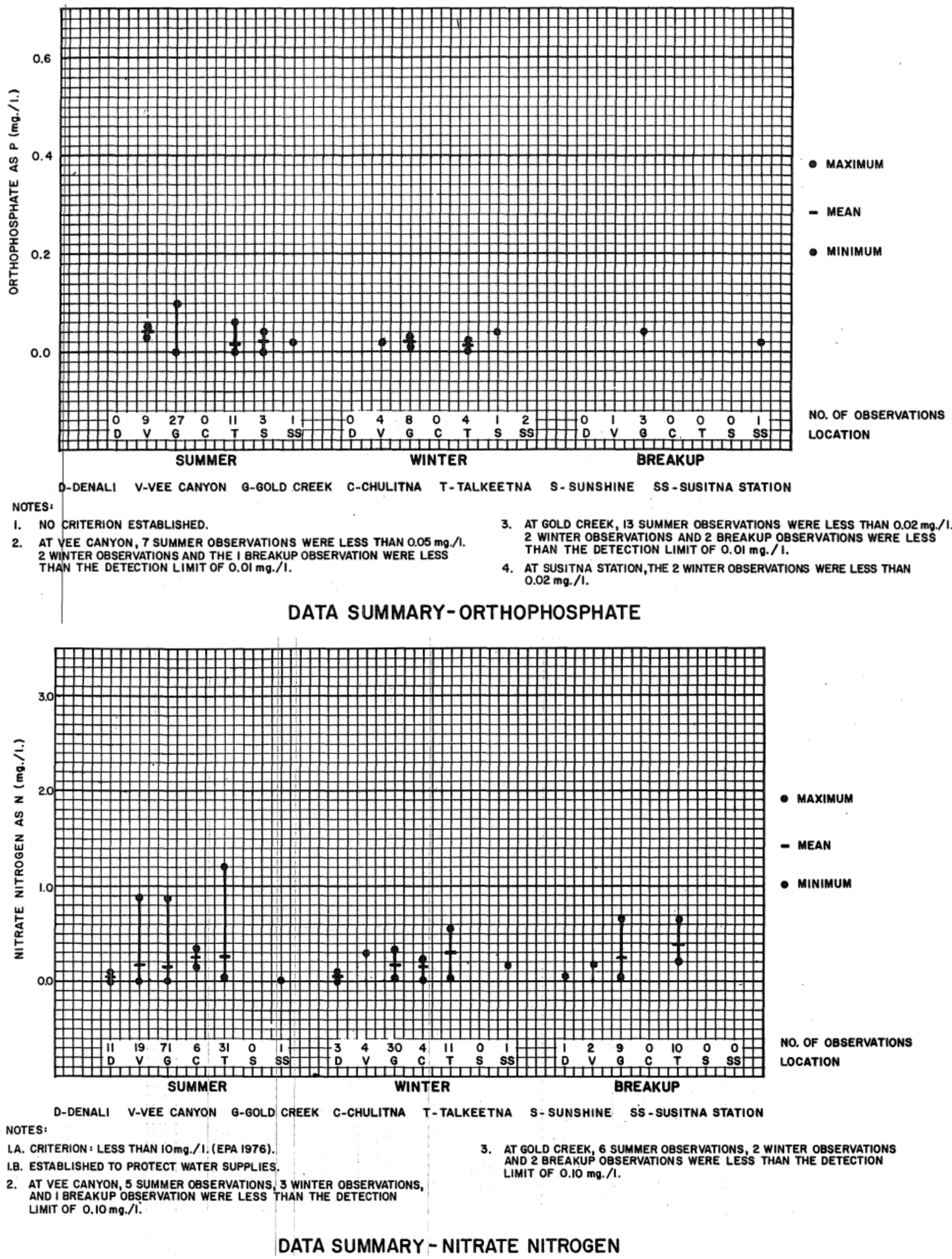


Figure 11.3-1. Levels of orthophosphate (top) and nitrate (bottom) measured at seven stations. Source: Harza-Ebasco (1985).

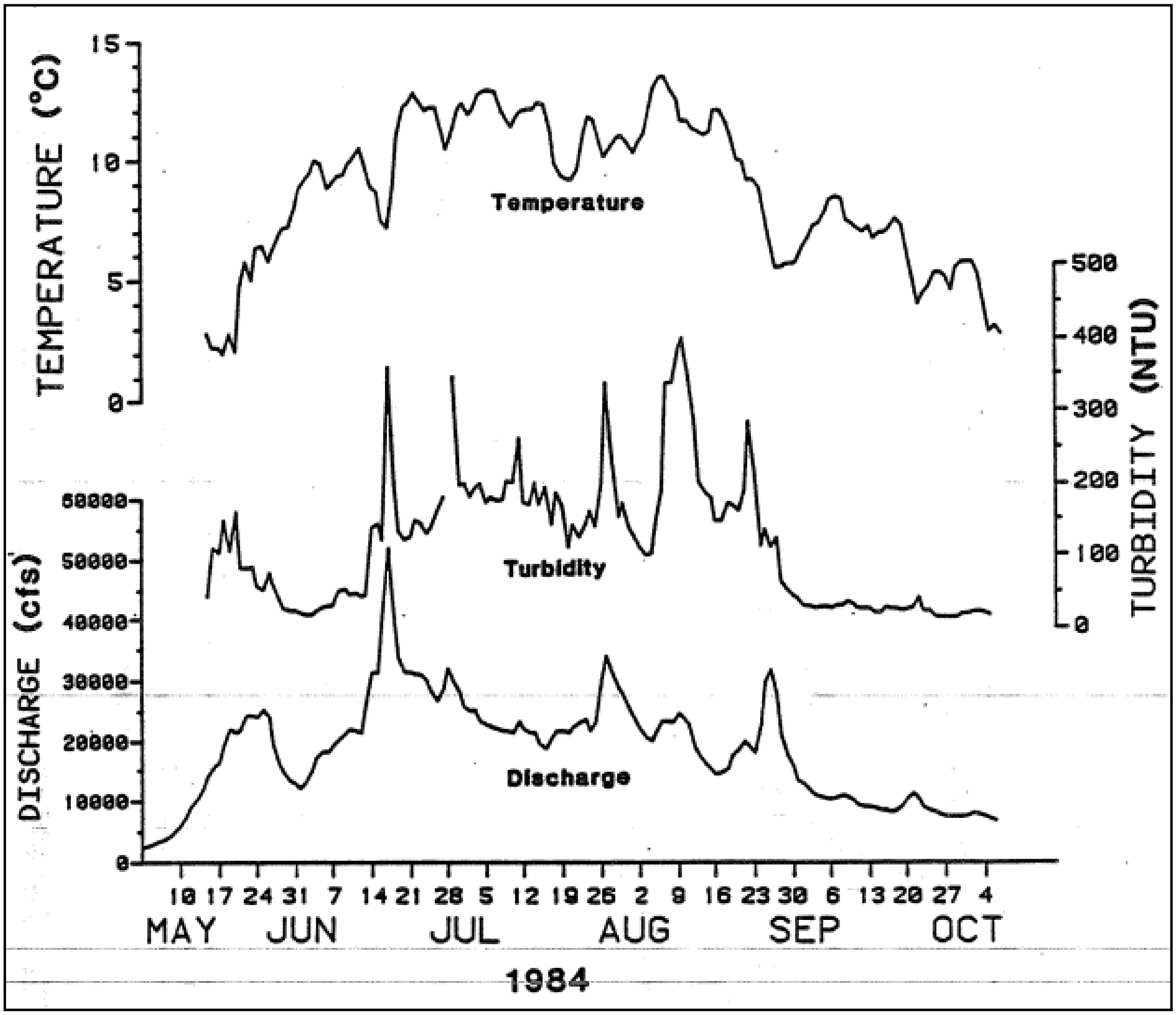


Figure 11.3-2. Turbidity and temperature measured at the Gold Creek Station and discharge measured at the Talkeetna Station during 1984. Source: Harza-Ebasco (1985).

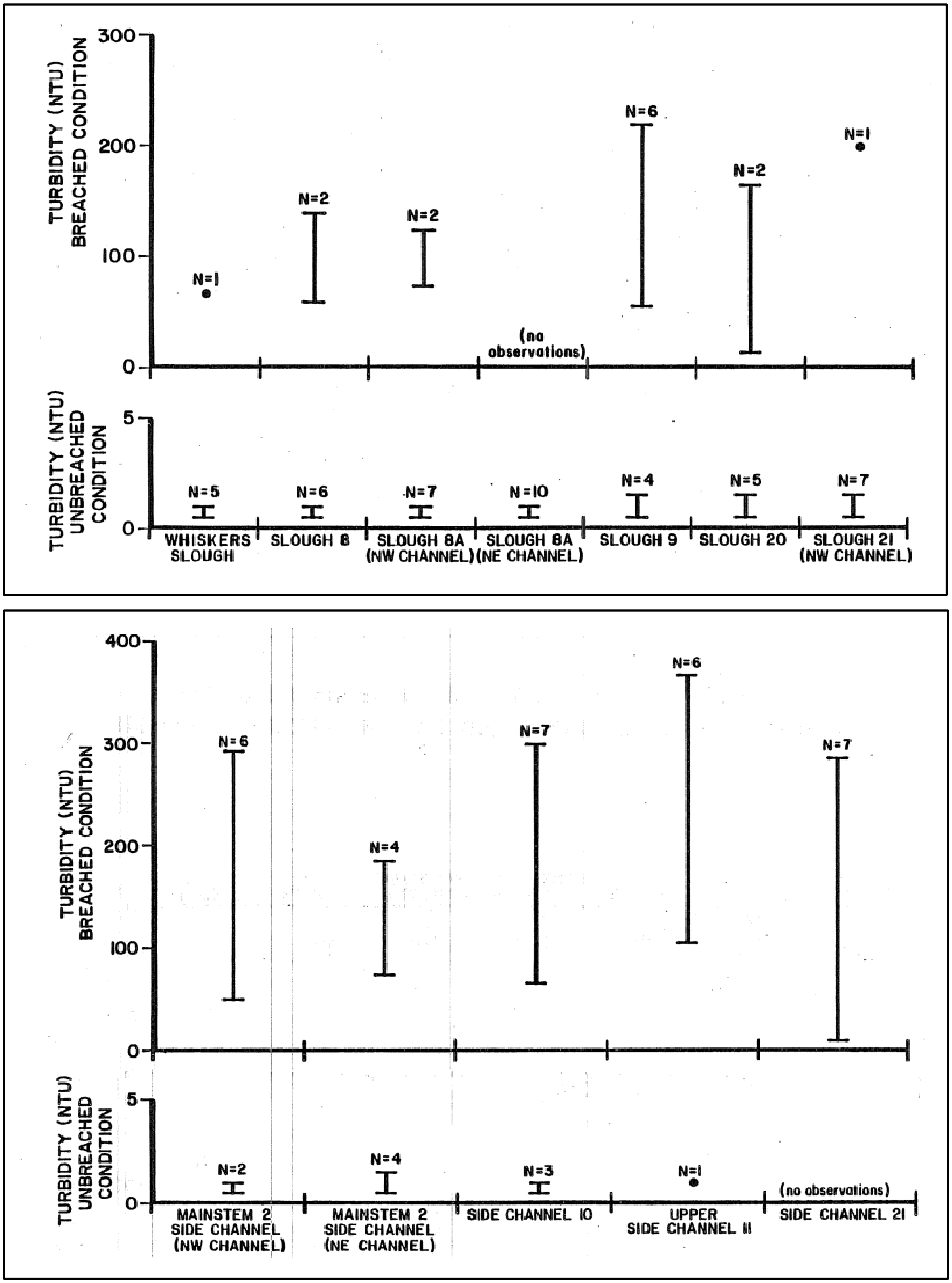


Figure 11.3-3. Range of turbidity during breached and unbreached conditions at twelve side sloughs and side channels. Source: Harza-Ebasco (1985).

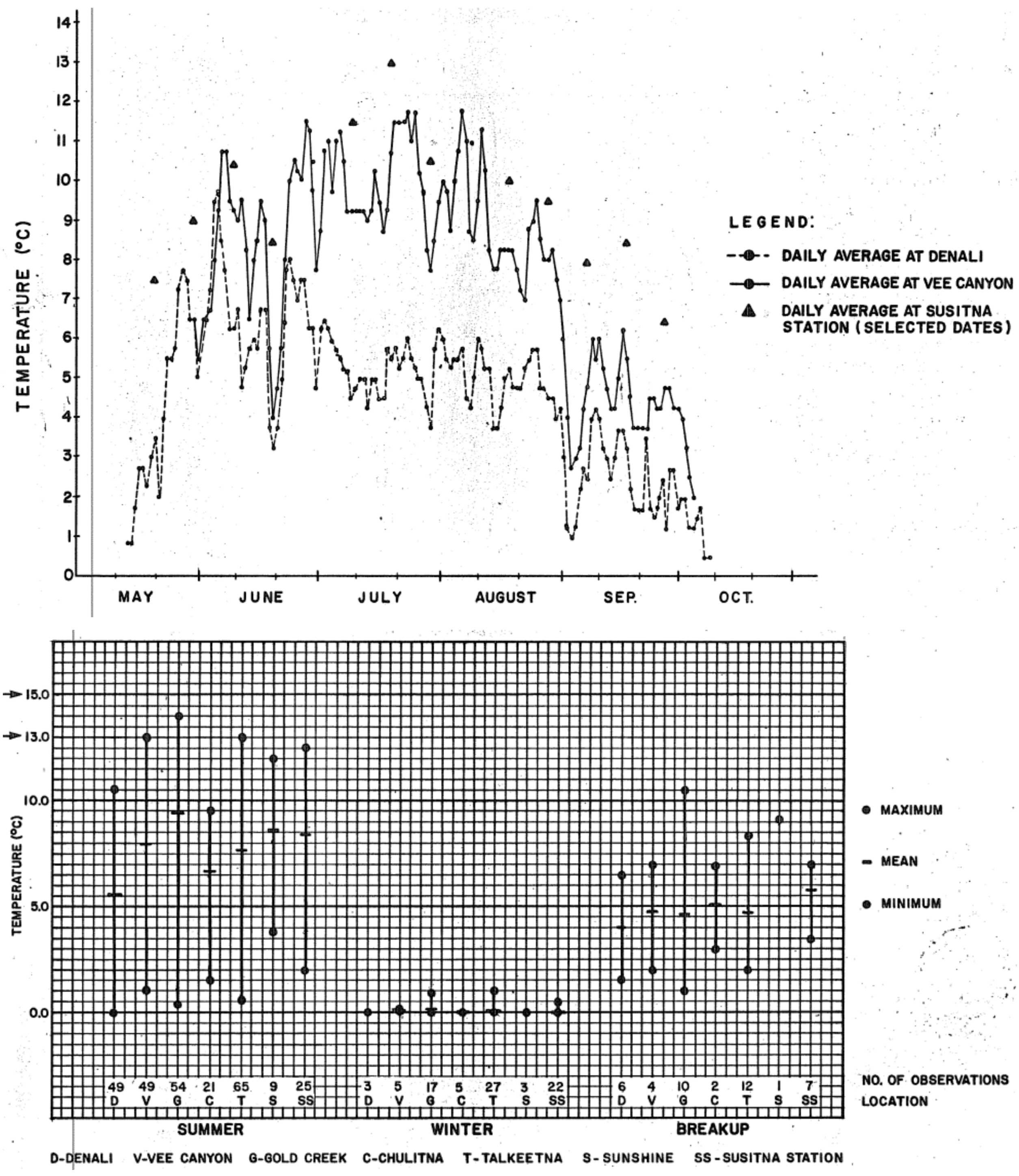


Figure 11.3-4. Seasonal water temperature in the Upper Susitna River during 1980 (top) and summary of discrete water temperature measurements at seven stations along the Susitna River (bottom). Source: Harza-Ebasco (1985).

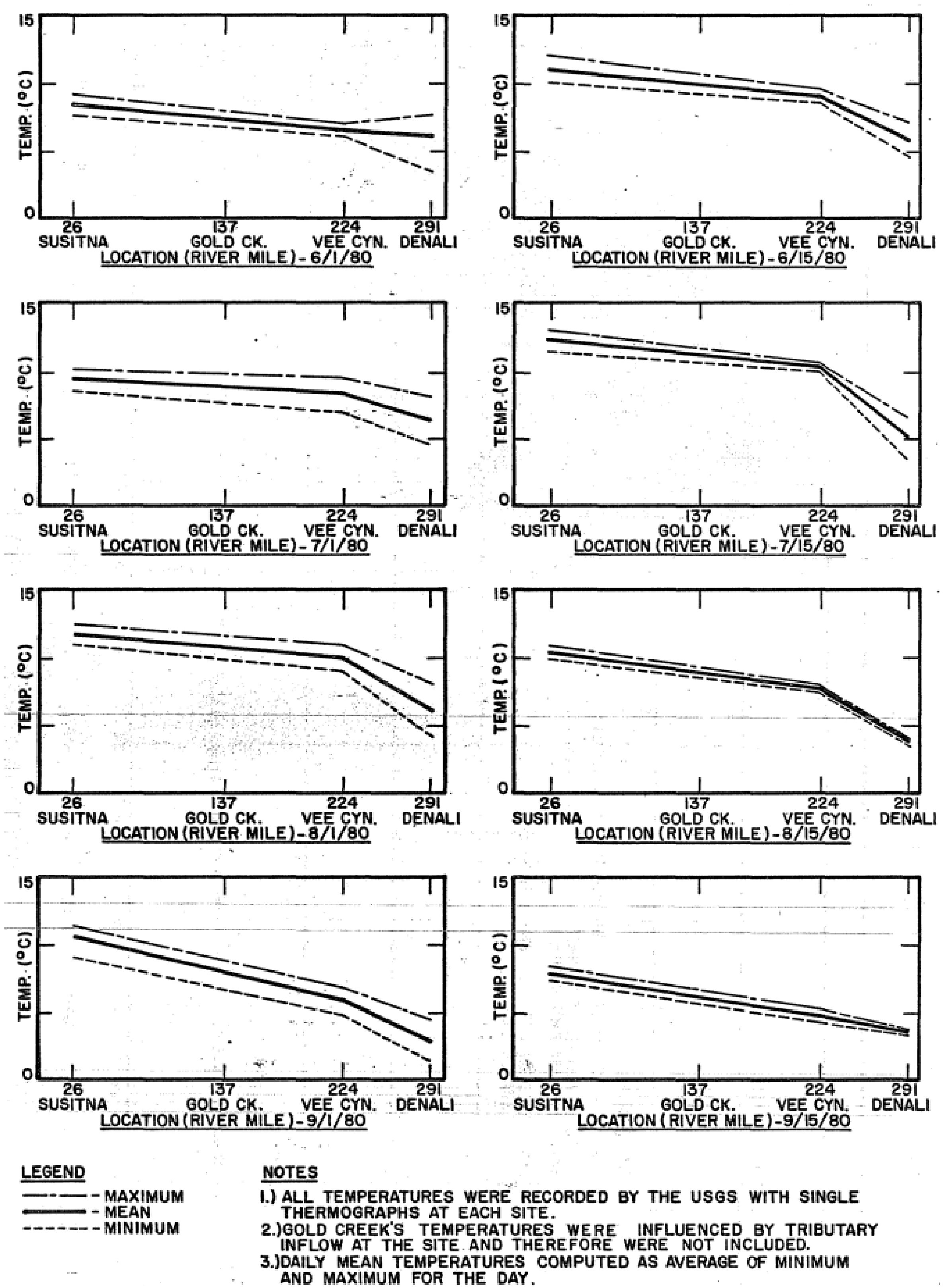


Figure 11.3-5. Temperature gradient in the Susitna River from RM 26 to 291. Source: Harza-Ebasco (1985).

APPENDIX 1. INDEX OF LOCATION NAMES AND RIVER MILE

Sorted By River Mile			Sorted By Location Name	
Location Name	River Mile		Location Name	River Mile
Alexander Creek	10.1		Alexander Creek	10.1
Flathorn Station	18.2		Anderson Creek	23.8
Anderson Creek	23.8		Answer Creek	84.0
Susitna Station	25.5		Birch Creek	88.4
Kroto Slough Mouth	30.1		Birch Creek Slough	88.4
Yentna River	30.1		Byers Creek (Chulitna R)	98.6
Mainstem Susitna Slough	31.0		Cache Creek	96.0
Mid Kroto Slough	36.3		Cache Creek Slough	95.5
Deshka River	40.6		Caswell Creek	63.0
Delta Islands	44.0		Chase Creek	106.4
Little Willow Creek	50.5		Cheechako Creek	152.4
Rustic Wilderness	58.1		Chinook Creek	157.0
Kashwitna River	61.0		Chulitna River	98.6
Caswell Creek	63.0		Curry Station	120.0
Slough West Bank	65.6		Dead Horse Creek	120.9
Sheep Creek Slough	66.1		Deadman Creek	186.7
Goose Creek	72.0		Delta Islands	44.0
Montana Creek	77.0		Deshka River	40.6
Sunshine Station	80.0		Devil Creek	161.0
Rabideaux Creek Slough	83.1		Devils Canyon Back Eddy	150.0
Parks Highway Bridge	83.9		Fat Canoe Island	147.0
Answer Creek	84.0		Fifth of July Creek	123.7
Question Creek	84.1		Fish Creek (Talkeetna R)	97.2
Sunshine Creek	85.7		Flathorn Station	18.2
Birch Creek Slough	88.4		Fog Creek	176.7
Birch Creek	88.4		Fourth of July Creek	131.1
Cache Creek Slough	95.5		Gash Creek	111.6
Cache Creek	96.0		Gold Creek	136.7
Fish Creek (Talkeetna R)	97.2		Gold Creek Bridge	136.7
Talkeetna River	97.2		Goose Creek	72.0
Byers Creek (Chulitna R)	98.6		Goose Creek	231.3
Troublesome Creek (Chulitna R)	98.6		Indian River	138.6
Swan Lake (Chulitna R)	98.6		Jack Long Creek	144.5
Chulitna River	98.6		Jay Creek	208.5
Slough 1	99.6		Kashwitna River	61.0
Slough 2	100.2		Kosina Creek	206.8
Whiskers Creek Slough	101.2		Kroto Slough Mouth	30.1
Whiskers Creek	101.4		Lane Creek	113.6
Slough 3B	101.4		Little Portage Creek	117.7
Slough 3A	101.9		Little Willow Creek	50.5
Talkeetna Station	103.0		Lower McKenzie Creek	116.2
Slough 4	105.2		Mainstem Susitna Slough	31.0
Chase Creek	106.4		Mid Kroto Slough	36.3
Slough 5	107.6		Montana Creek	77.0
Slough 6	108.2		Moose Slough	123.5

Sorted By River Mile			Sorted By Location Name	
Location Name	River Mile		Location Name	River Mile
Oxbow I	110.2		Oshetna River	233.4
Slash Creek	111.5		Oxbow I	110.2
Gash Creek	111.6		Parks Highway Bridge	83.9
Slough 6A	112.3		Portage Creek	148.9
Slough 7	113.2		Question Creek	84.1
Lane Creek	113.6		Rabideaux Creek Slough	83.1
Slough 8	113.7		Rustic Wilderness	58.1
Lower McKenzie Creek	116.2		Sheep Creek Slough	66.1
Upper McKenzie Creek	116.7		Sherman Creek	130.8
Little Portage Creek	117.7		Side Channel 10A	132.1
Curry Station	120.0		Skull Creek	124.7
Dead Horse Creek	120.9		Slash Creek	111.5
Susitna Side Channel	121.6		Slough 1	99.6
Slough 8D	121.8		Slough 10	133.8
Slough 8C	121.9		Slough 10	133.8
Slough 8B	122.2		Slough 10 Side Channel	133.7
Moose Slough	123.5		Slough 11	135.3
Fifth of July Creek	123.7		Slough 12	135.4
Slough A prime	124.6		Slough 13	135.9
Slough A	124.7		Slough 14	135.9
Skull Creek	124.7		Slough 15	137.2
Slough 8A	125.1		Slough 16B	137.3
Slough B	126.3		Slough 17	138.9
Slough 9	128.3		Slough 18	139.1
Slough 9B	129.2		Slough 19	139.7
Sherman Creek	130.8		Slough 2	100.2
Fourth of July Creek	131.1		Slough 20	140.0
Side Channel 10A	132.1		Slough 21	141.1
Slough 10 Side Channel	133.7		Slough 21 Side Channel	140.5
Slough 10	133.8		Slough 21A	144.3
Slough 9A	133.8		Slough 22	144.3
Slough 10	133.8		Slough 3A	101.9
Slough 11	135.3		Slough 3B	101.4
Slough 12	135.4		Slough 4	105.2
Slough 13	135.9		Slough 5	107.6
Slough 14	135.9		Slough 6	108.2
Gold Creek	136.7		Slough 6A	112.3
Gold Creek Bridge	136.7		Slough 7	113.2
Slough 15	137.2		Slough 8	113.7
Slough 16B	137.3		Slough 8A	125.1
Indian River	138.6		Slough 8B	122.2
Slough 17	138.9		Slough 8C	121.9
Slough 18	139.1		Slough 8D	121.8
Slough 19	139.7		Slough 9	128.3
Slough 20	140.0		Slough 9A	133.8

Sorted By River Mile			Sorted By Location Name	
Location Name	River Mile		Location Name	River Mile
Slough 21 Side Channel	140.5		Slough 9B	129.2
Slough 21	141.1		Slough A	124.7
Slough 21A	144.3		Slough A prime	124.6
Slough 22	144.3		Slough B	126.3
Jack Long Creek	144.5		Slough West Bank	65.6
Fat Canoe Island	147.0		Sunshine Creek	85.7
Portage Creek	148.9		Sunshine Station	80.0
Devils Canyon Back Eddy	150.0		Susitna Side Channel	121.6
Cheechako Creek	152.4		Susitna Station	25.5
Chinook Creek	157.0		Swan Lake (Chulitna R)	98.6
Devil Creek	161.0		Talkeetna River	97.2
Fog Creek	176.7		Talkeetna Station	103.0
Tsusena Creek	181.3		Troublesome Creek (Chulitna R)	98.6
Deadman Creek	186.7		Tsusena Creek	181.3
Watana Creek	194.1		Upper McKenzie Creek	116.7
Kosina Creek	206.8		Watana Creek	194.1
Jay Creek	208.5		Whiskers Creek	101.4
Goose Creek	231.3		Whiskers Creek Slough	101.2
Oshetna River	233.4		Yentna River	30.1