COLVILLE RIVER FISH STUDY

1985 ANNUAL REPORT

FINAL REPORT
MAY 1986

Prepared by

Entrix, Inc.

for

ARCO Alaska, Inc.
North Slope Borough
and
City of Nuiqsut

E N T R I X

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PREFACE

The Lisburne Unit owners have proposed to construct a solid-fill causeway in Prudhoe Bay for the most efficient development of the Lisburne Field. Concern has arisen that the causeway may alter anadromous fish habitat and/or movements such that fish populations are affected. Because of these concerns over potential causeway effects, a variety of mitigative actions were considered, including various causeway and breach designs. The North Slope Borough recognized that breaches were not cost-effective mitigations and agreed that an offsite technical program would be an appropriate use of resources.

The offsite technical program was to be in the form of (1) assistance in training of personnel and (2) population monitoring and evaluation of harvestable fish stocks in the Colville River. The population monitoring will provide baseline data to help identify changes in the fish populations that may arise from various coastal developments. The fishery assessment will allow the resident fishermen to develop the most appropriate harvest strategies to optimize harvests of local stocks. A multi-year study financed by ARCO Alaska was begun in 1985. There are two main parts to the study: the Fishery Assessment and the Biological Study. This volume presents the results of the first year of study.

The successful completion of the first year of study involved the cooperation of a variety of people from many different organizations. The study could not have been accomplished without the support of the Nuiqsut City Council and Mayors Ms. Maggie Kovalsky and Mr. Sam Taalak. The Fish Advisory Committee, composed of Ms. Maggie Kovalsky, Mr. Nelson Ahvakana, and Mr. Abe Simmonds, provided valuable guidance through the field season. Administrative support was efficiently handled by Ms. Joy Oyagak. North Slope Borough coordination, which included active participation in the field effort, was provided by Mr. J.C. George. Nuiqsut residents were responsible for successful completion of the field and data entry tasks. Significant contributions were provided by:

Mr. Abraham Woods
Mr. Clarence Ahnupkana
Mr. Kenneth Harmon
Ms. Emma Ahvakana
Mr. Jeff Long
Ms. Hester Gerke
Mr. Sam Kunaknana

Dr. Robert Newell and Dr. Robert Griffeth of ARCO Alaska, Inc. provided substantial logistical and administrative support and were actively involved in the implementation of the study.

Mr. Jim Helmericks, Colville Delta resident, supplied logistical support, tag returns and catch data. Many fishermen in Nuiqsut returned tags throughout the fishing season and cooperated with the necessary questions and interviews regarding catch, gear, and effort.

Joseph M. Colonell
Project Manager

Lawrence L. Moulton
Principal Investigator

EXECUTIVE SUMMARY

1.0 Chapter 1. Literature Review

A literature review of the biology of nine species of fish in the Colville River was conducted. The nine species were selected for analysis because of known or potential harvest value. Species selected for analysis were: arctic cisco (qaaktaq), least cisco (iqalussaq), broad whitefish (anaakliq), humpback whitefish (pikutuuq), char (iqalugaaq), rainbow smelt (ilhaugniq), arctic grayling (sulukpaugaq), round whitefish (siguilaraq), and burbot (tittaaliq).

2.0 Chapter 2. Biological Report

In 1985 a biological study was conducted on the lower river to gather information on the life history, growth, age composition, and seasonal movements of fish in the Colville River. The study focused on arctic and least cisco, and broad and humpback whitefish. Five stations were occupied near the village of Nuiqsut, four on the main Colville channel and one in the Nigliq (or Nechelik) Channel. Three stations were occupied in the outer delta, two in the East Channel and one in the Kupigruak (or main) Channel. Sampling was primarily by fyke nets. Early in the season hoop nets were fished in the river stations but these proved ineffective.

All fish captured were at least identified, counted, and released. The four primary species were measured, samples were taken for length-weight and age analysis. Specimens between 120-250 mm fork length were marked with a blue dot and released, while fish larger than 250 mm were tagged with a Floy injection tag. Otoliths were collected from samples in the net or purchased from fishermen. Ages were determined from otoliths using the break-and-burn method.

Least cisco was the most abundant species in both the river and delta nets, comprising 27 percent and 50 percent of the total catch in the two areas. Humpback whitefish was second in abundance at the river stations (22 percent) and fifth in abundance at the delta stations (7 percent). Broad whitefish was fourth in abundance at the river stations (11 percent) and second in the delta (12 percent). Arctic cisco were rare in the river catches but were the third most abundant species in the delta (11 percent of the total catch).

All four species showed an early season outmigration and late season return migration. The arctic cisco left the river first and returned the latest. Least cisco left slightly later and returned earlier. In-migration began in the middle of August, which is when this species normally disappears from the coastal region. Many least cisco less than 120 mm remained in the delta region the entire summer. Broad whitefish showed a lesser tendency to leave the outer delta region with substantial catches of all size groups occurring through the summer. The pattern with humpback whitefish was less well-defined. This species was captured in the delta only in mid-summer and was probably upriver in early and late summer.

Age-length relationships were established for each of the four primary species. Growth was rapid for the first 6-8 years and then leveled off. The age associated with the onset of reduced growth rates appears to be the age of sexual maturity. This occurred at about age-7 to 8 for arctic and least cisco, age-11 for broad whitefish, and age-10 for humpback whitefish.

On August 26 a recruitment of age-0 arctic cisco began to enter the Colville delta. The numbers of age-0 arctic cisco continued to increase until sampling ceased on September 11. Catch data from other locations along the coast confirmed that the small fish moved westward from the Mackenzie Delta at a mean rate of approximately 7 miles per day. Movement from the Sagavanirktok region to the Colville was at a rate of 8-9 miles per day. Larger fish of this age group arrived first followed by smaller fish. Age-0 fish for the other primary species were routinely captured through the summer as they grew large enough to be caught in the fyke nets. Catch rates in the Colville delta were similar to catch rates at other locations along the coast.

3.0 Chapter 3. Fishery Assessment Report

In 1985 a fishery assessment was undertaken on the lower Colville River and delta to estimate the total effort and total catch for the open-water summer and under-ice fall fisheries. Information was collected on fishing methods, species composition, catch rate and fish length by mesh size, age distribution of the catch, seasonal variation in the catch, and tag recaptures from fish tagged in various tagging programs.

About 20 groups of fishermen participated in the summer fishery. Gill nets 60 ft in length with 5.0-inch stretched mesh comprised the main fishing gear. Approximately 1,300 net days of effort was expended in the summer fishery resulting in an estimated harvest of 4,500 broad whitefish. About 300 char and 300 humpback whitefish were also caught. Most of the effort for and catch of broad whitefish occurred in the Nigliq (Nechelik) Channel near the village of Nuiqsut. The size of broad whitefish in catch samples ranged from 365 to 650 mm in length and fish averaged 2.0 kg (4.4 lbs) in weight. The catch of broad whitefish was dominated by fish between age-11 and age-20.

An estimated 30 groups of fishermen were active in the fall fishery. Gill nets of 2.5 to 3.5-inch stretched mesh (primarily 3.0-inch mesh) were used. Arctic cisco was the target species in the fall fishery and comprised the major portion of the catch. Least cisco was considered a less desirable co-occurring species. Fishing was concentrated in three areas: the upper Nigliq Channel, the lower Nigliq Channel, and the outer Colville Delta. Almost 900 net-days of effort occurred on the upper Nigliq Channel, 350 net-days on the lower Nigliq Channel, and about 1,450 net-days on the outer Colville Delta. Based on catch and effort data, an estimated 18,000 arctic cisco were caught in the fall fishery on the upper Nigliq Channel, about 8,500 arctic cisco on the lower Nigliq Channel, and almost 44,000 on the outer Colville Delta. Over 33,400 least cisco were caught in the fall fishery, with 95 percent of the catch occurring in the outer Colville Delta.

The mean length of arctic cisco in 3.0-inch mesh nets was 330 mm, while the mean length of least cisco was 320 mm. Most arctic cisco caught in the fall fishery were ages 6 and 7, and most least cisco were estimated to be age-8 through age-13.

The larger, 3.5-inch mesh nets were more selective for arctic cisco than 3.0 inch mesh, substantially reducing the catch per unit effort (CPUE) of the less-desirable least cisco. However, the CPUE of arctic cisco in 3.5-inch mesh nets was also reduced. Gill nets with mesh of 3.125 inch or 3.25 inch would likely reduce the catch of least cisco, while maintaining acceptable catch rates of arctic cisco.

Catch rates declined in nets left unchecked for more than 24 hrs as compared to catch rates in nets checked on a daily basis. Catch rates were also reduced in areas of increased fishing effort (more nets fishing). As more fishermen enter the fishery in future years or if stocks decline in abundance catch rates will likely decline, which will likely cause user conflicts.

In the fall fishery 1,704 tagged fish were recaptured. About 60 percent of the recaptured fish were tagged and released by the 1985 Endicott Project. Based on tag/recapture data, the size of arctic and least cisco populations in the catchable pool (vulnerable to the fishing gear) was 1,139,000 arctic cisco and 333,000 least cisco. The estimated total catch of 70,400 arctic cisco and 33,400 least cisco indicates that the exploitation rate of the catchable arctic cisco population was about 6 percent, while the exploitation rate of the catchable least cisco population was about 10 percent. These are considered low rates of removal. Based on the studies by Healy (1980) on lake whitefish (Coregonus clupeaformis), an exploitation rate of 20 percent would be moderate, while a rate of removal of 30 percent or more would be heavy and could result in overfishing.

The catch of arctic cisco is based on the abundant 1978 and 1979 year-classes. In 1985, the 1978 year-class dominated the fishery. In 1986, it is likely that the fishery will be dependent on the 1979 year-class and remnants from the 1978 year-class. Recruitment has been weak between the 1979 and 1985 year-classes, thus catch rates will likely decline substantially in 1987 and remain low until the 1985 year-class enters the fishery in the early 1990's.

CHAPTER 1

COLVILLE RIVER FISHES:

A LITERATURE REVIEW

Prepared by:

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1.0 INTRODUCTION

Fish populations in the Colville River have received increasing attention as a result of increased resource use and industrial development in the area. A number of surveys have been conducted since 1970, primarily to describe fish use of the Colville drainage and surrounding waterbodies. Most of these surveys have been performed by the Sport Fish Division of the Alaska Department of Fish and Game, with the results published in the annual performance report series (Kogl 1971, Alt and Kogl 1973, Bendock 1979 to 1983, Bendock and Burr 1984a). A summary of freshwater fish distribution and habitat use between the Ikpikpuk and Colville rivers was also recently produced (Bendock and Burr 1984b). Research activities prompted by oil and gas leasing and development in the coastal region have provided substantial information on anadromous fish utilization of coastal habitats in the Colville River area (Craig and Haldorson 1981, Dew 1983, Schmidt et al. 1983, Moulton and Fawcett 1984) and nearby waters (Griffiths and Gallaway 1982, Griffiths et al. 1983, Critchlow 1983, Woodward-Clyde Consultants 1983, Moulton et al. 1985a,b).

The studies conducted to date indicate that the Colville River supports an abundance of fish, composed of at least twenty species, which are dominated by whitefishes and ciscos (Table 1). Char and arctic grayling are also abundant. Eight marine species have been documented in adjacent coastal waters. Twelve species found in the Colville River demonstrate some degree of anadromy, ranging from salmon and smelt, which return to the river only to spawn, to humpback and broad whitefish, which use the estuary for feeding during the summer and return to the river for spawning and overwintering.

Residents along the Colville River harvest a variety of fish for both subsistence and commercial use. Sport harvests are presently light. The commercial fishery targets primarily on arctic and least cisco, with some broad and humpback whitefish also taken. The subsistence harvest consists of a variety of species, including ciscos, whitefishes, char, lake trout, grayling and burbot. Broad whitefish is the primary species taken during the summer subsistence fishery, while arctic cisco is the target species in the fall and winter fishery.

Table 1. List of fish species, Inupiaq names, and relative abundance in the Colville River drainage system, delta, and nearshore coast outside of the delta. A = abundant, AS = seasonally abundant, M = moderate abundance, O = occasional.

	Upper River[1]		Lower River				
	Tributaries	Lakes	Mainstem	Tributaries	Delta[2]	Coastal Lakes & Streams	Coastal Area
Anadromous:							
Arctic cisco[3] (Qaaktaq)			O		A		A
Least cisco[3] (Iqalussaq)	M	M	M	M	A	A	A
Bering cisco (Qaaktaq)					O		O
Broad whitefish[3] (Anaakliq)	M	M	AS	M	A	A	M
Humpback whitefish[3] (Pikutuuq)			AS	M	AS	O	M
Char[3] (Iqalugaaq)	O	M	A	A	M		A
Rainbow smelt[3] (Ilhaugniq)				O	M		A
Pink salmon (Amaqtuq)			O	O	O		O
Chum salmon (Iqalugruaqpak)	O		O	O	O		O
Chinook salmon	O		O		O		O
Sockeye salmon			O		O		O
Threespine stickleback							O
Freshwater:							
Grayling[3] (Sulukpaugaq)	A	A	A	A	M	O	O
Round whitefish[3] (Siguilaraq)	A	M	M	M	O	M	O
Burbot[3] (Tittaaliq)	M	M	M	M	M	O	O
Ninespine stickleback	M	M	M	M	O	M	O
Slimy sculpin (Kanayuq)	M	M	M	M	O	O	
Lake trout (Iqalukpik)	O	A	O	O	O	M	
Longnose sucker (Milugiaq)	M		M	M	M		
Northern pike (Siulik)		O		O			
Marine:							
Fourhorn sculpin					M		A
Arctic flounder (Puyyagiaq)							M
Arctic cod (Uugaq)							A
Saffron cod					O		M
Capelin (Panmagriq)							O
Pacific herring (Uqsruqtuuq)							O
Snailfish							O
Pacific sandlance							O

[1] Upstream from Umiat
[2] Downstream of Itkillik River
[3] Species selected for analysis

The biological information on Colville River fishes is fragmentary and a complete description of the populations does not exist. The objective of this paper is to present a review of existing information on the dominant fish populations so that information needs can be identified. Nine species were selected for analysis because of known or potential harvest value (Table 1). Other species may be harvested on occasion but are generally not sufficiently abundant within the river to be a primary target species. The geographic area covered by the literature review is the area between the Ikpikpuk and Colville rivers (Figure 1). While the primary focus is on river, stream and delta habitat, some lakes are also included.

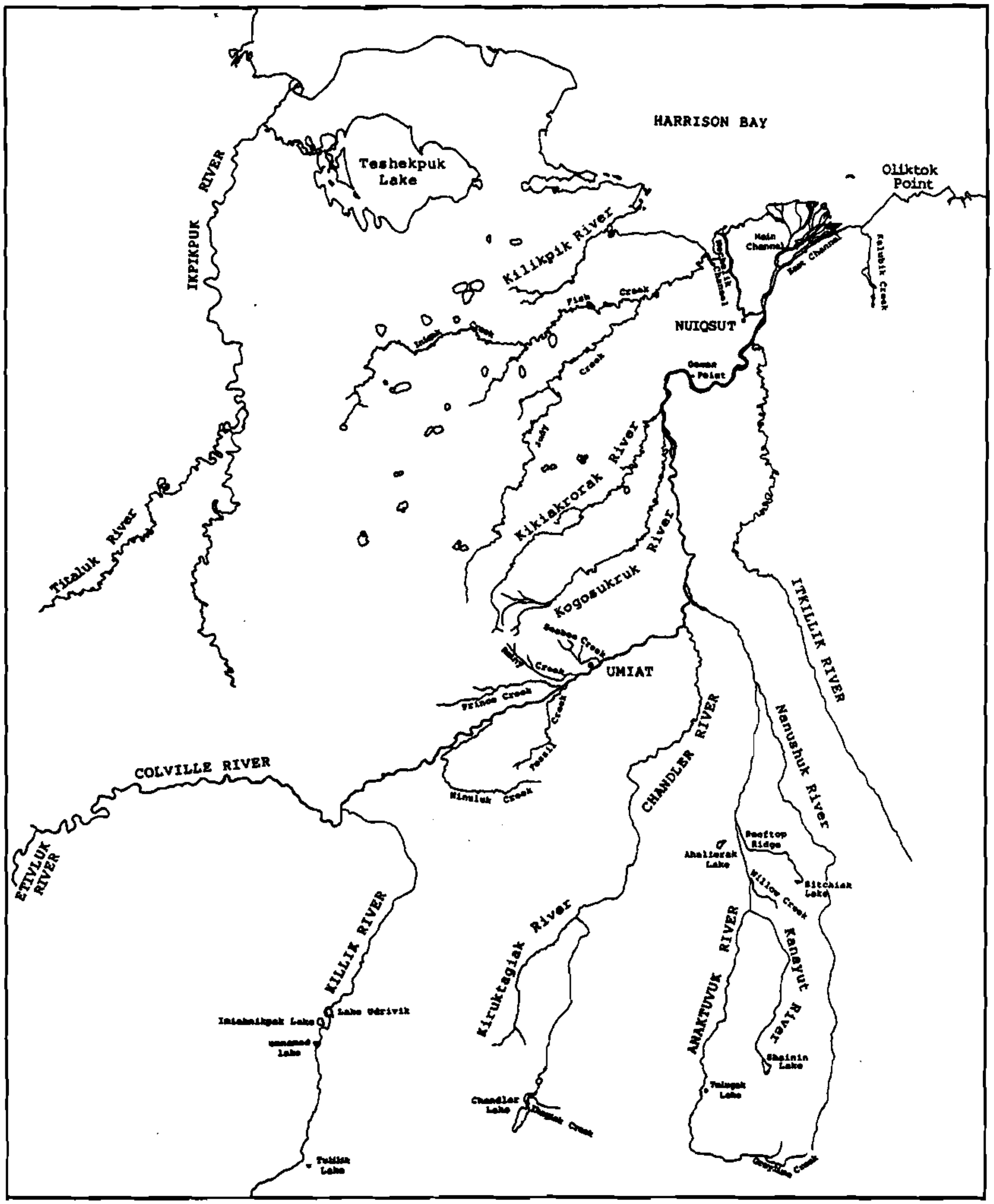


Figure 1. Colville River study area including surveyed lakes.

2.0 SPECIES DESCRIPTIONS

2.1 ARCTIC CISCO (*Coregonus autumnalis*)

Abundance and Distribution

In coastal areas of the Beaufort Sea near the Colville River, arctic cisco is one of the most abundant species present during the open water season, often representing 30 to 50 percent of the anadromous fish captured by gill or fyke nets (Bendock 1977, Craig and Haldorson 1981, Dew 1983, Moulton and Fawcett 1984, Moulton et al. 1985). It is abundant in river deltas as well, accounting for 29 percent of fyke net catches and 44 percent of gill net catches at the Sagavanirktok River delta (Griffiths et al. 1983). Arctic cisco is the dominant species in the commercial catch in the fall/winter fishery at the Colville River delta with a mean catch of about 31,000 fish/year over the last 20 years (Table 2 and Alt and Kogl 1973, Gallaway et al. 1983, Moulton et al. 1985). The abundance of arctic cisco rapidly declines further upstream in the Colville River. They were found in the Itkillik River (Kogl 1971), but Bendock (1979) and Gallaway et al. (1983) suggest that there are few arctic cisco upstream from the Itkillik River. No arctic cisco were caught at Umiat during summer gill netting studies in 1970 (Alt and Kogl 1973) while three were captured in 1977 (Bendock 1979). Except for Teshekpuk Lake, no arctic cisco were found in coastal plain lakes or streams during two summer surveys (Bendock 1982, Bendock and Burr 1984a). Based on studies to date, the distribution of arctic cisco in the Colville River appears to be confined to the delta area downstream of the Itkillik River. However, extensive surveys have not been conducted between Umiat and the Itkillik River.

Spawning

Until recently it was thought that the abundance of arctic cisco in the Colville River delta was related to a spawning migration as well as overwintering use. Alt and Kogl (1973) suggested that spawning occurred in the lower Colville River late in the summer (September or later), but examination of fish collected in the delta and river revealed few fish in

Table 2. Colville River commercial catches, 1964-1984.

	Broad Whitefish	Humpback Whitefish	Arctic Cisco	Least Cisco
1964	2,951 a/		16,000	9,000
1965	3,000 a/		50,000	
1966	2,500 a/		40,000	
1967	Data not available			
1968	3,130		42,055	18,180
1969	Data not available			
1970	2,080 a/		19,602	25,930
1971	3,815	132	38,016	22,713
1972	3,850	1,497	37,333	13,283
1973	2,161		71,569	25,188
1974	3,177	2,316	35,601	13,813
1975	2,201	1,946	28,921	20,778
1976	2,172	1,815	31,659	34,620
1977	443	1,431	31,796	14,961
1978 b/	20 c/	1,102	17,292	21,589
1979	c/	1,831	8,684	24,984
1980	c/	4,231	14,657	31,459
1981			38,176	15,504
1982			15,975	27,085
1983			18,162	37,909
1984			27,677	13,076

a/ Includes small numbers of humpback whitefish

b/ Also reported taken were one king salmon, two red salmon, nine chum salmon and 118 pink salmon.

c/ No fishing effort during June or July.

(Average weight: Broad Whitefish 5.1 pounds, Least cisco 0.91 pounds, arctic cisco 1.0 pounds)

SOURCES: F.M. Anderson, Division of Commercial Fisheries, Department of Fish and Game. February 1981.

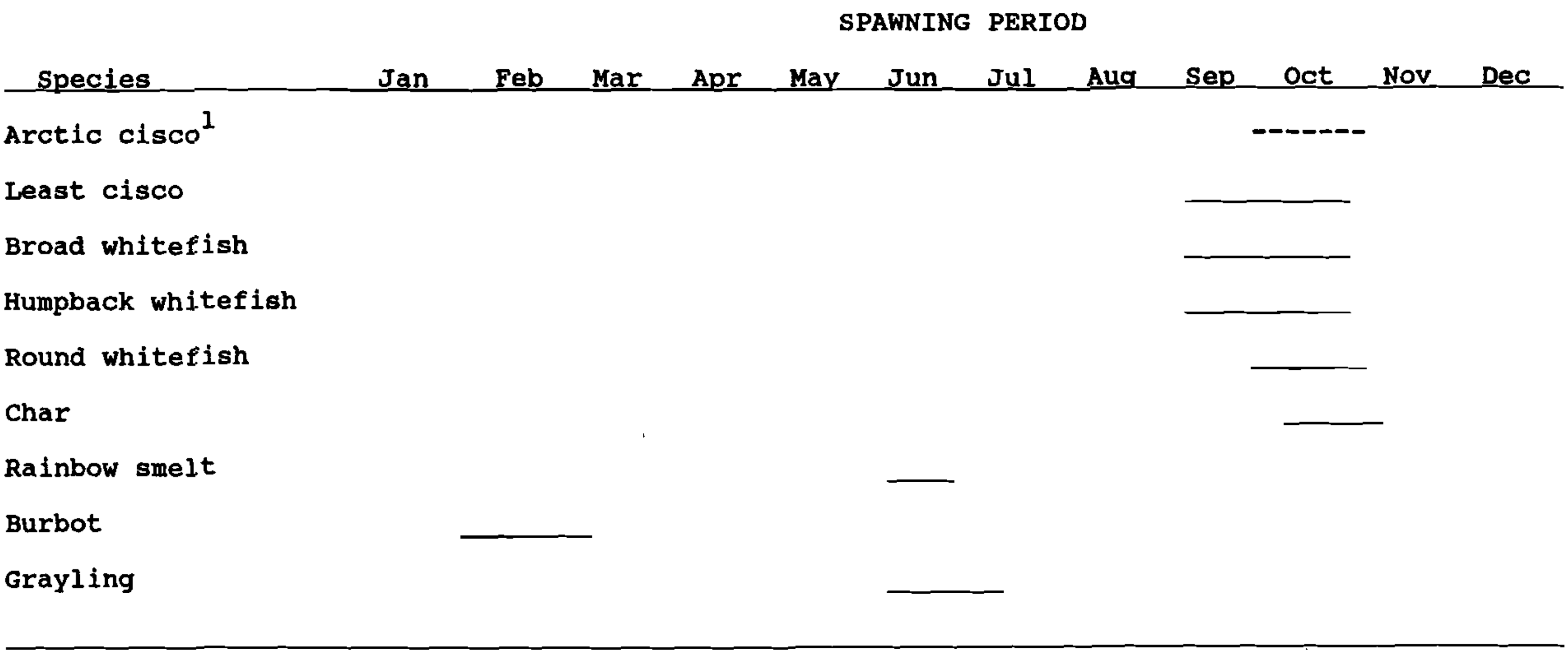
J. Helmericks, Colville Delta, pers. comm. 1985 spawning condition. Kogl and Schell (1975) found 12 mature female arctic cisco out of a sample of 70 taken in the fall, but only two showed evidence of spawning. Craig and Haldorson (1981) report one mature adult in pre-spawning condition out of 689 fish collected in the fall fishery, and two mature females that would not spawn that year out of 65 fish collected in April. The fall collections were composed of 12 to 57 percent mature fish that would not spawn that same year, the remainder were immature. Three mature males were the only arctic cisco collected at Umiat during a 1977 summer survey (Bendock 1979). However, their potential for spawning was not determined. Ripe arctic cisco have been reported in the upper Colville River by fishermen (Moulton et al. 1985), but have not been verified. These studies indicate that major spawning runs of arctic cisco do not occur in the Colville River. Surveys of the Colville River during the fall and winter have not located arctic cisco spawning sites (Bendock 1979, 1980, McElderry and Craig 1981). Thus, arctic cisco utilization of the Colville Delta appears to be primarily for overwintering. Spawning is thought to occur in the Mackenzie River drainage (see discussion below) and rearing occurs mainly in the Beaufort Sea.

Arctic cisco spawning migrations, locations, and timing are known in the Mackenzie River drainage (Wynne-Edwards 1952, Hatfield et al. 1972, Craig and Mann 1974). Migrations to upstream spawning sites in tributaries such as the Peel, Arctic Red and Laird Rivers occur from late June through October and are followed by post-spawning downstream migrations from October to December (Figure 2). All arctic cisco caught in the Mackenzie River drainage between June 23 and August 6 were mature green or spent fish (Craig and Mann 1974), in contrast to the few occurrences of mature arctic cisco in the Colville River drainage noted above.

Seasonal Movements

Arctic cisco move into coastal marine areas of Simpson Lagoon during early breakup (Craig and Haldorson 1981). The older fish (including mature adults) subsequently leave Simpson Lagoon for most of the summer, but young fish and non-spawning adults remain until early September (Alt and Kogl 1973, Craig and Haldorson 1981). Arctic cisco was the second most abundant anadromous species collected by fyke net (following least cisco) at Oliktok Point, with the catch

Figure 2. Spawning time of major fish species in the Colville River



[1] Probable spawning areas are in the Mackenzie River

primarily composed of young fish smaller than 250 mm (Dew 1983, Moulton and Fawcett 1984).

Returns of tagged fish indicate that most large arctic cisco return to the Colville River delta between October and December (Craig and Haldorson 1981), although this movement apparently does not include the segment of the population that will spawn the same year. Overwintering fish were found in the Colville River delta in salinities of 18 to 32 ppt within a few kilometers of the coast during April and May (Craig and Haldorson 1981). No arctic cisco were collected in coastal or marine habitats at this time.

Six arctic cisco tagged in Simpson Lagoon or Prudhoe Bay were recovered far to the east; one at Griffin Point (Craig and Haldorson 1981), four at Barter Island (Griffiths and Gallaway 1982), and one at the Mackenzie River delta (Gallaway et al. 1983). This information supports the current theory that arctic cisco in the Colville River delta and Prudhoe Bay are part of the population originating in the Mackenzie River. Gallaway et al. (1983) describe the evidence suggesting the single-stock theory: the lack of fish in spawning or post-spawning condition, absence of arctic cisco further upstream in the Colville River than Umiat, the Native people's lack of knowledge of arctic cisco spawning habits in the area, absence of age-0 fish in coastal rearing areas, and the low return rate of arctic cisco after the first year they are tagged. It is hypothesized that young arctic cisco from the Mackenzie River delta are carried westward by prevailing longshore currents during the summer and remain in the vicinity of major river deltas (Sagavanirktok, Colville) for the first few years of their lives, feeding in the coastal areas during the summer and overwintering under the ice in the deltas. Moulton et al. (1985) suggest that a cohort of young arctic cisco recruited into a river delta to the west of the Mackenzie River remain in the same delta area for several years. Members of the 1979 year-class were marked in the Sagavanirktok River delta and recaptured near the delta in 1982, 1983, and 1984. A similar pattern was shown by the 1982 year-class in 1984.

Recruitment of young fish from the Mackenzie River population, feeding in areas along the Beaufort Sea, overwintering for several years in the Colville Delta, and a return to the Mackenzie River for spawning as mature adults is a plausible explanation for movement and composition patterns of the Colville River arctic cisco population. Low return rates of tagged arctic cisco in the Colville Delta fishery, as discussed by Moulton et al. (1985), may be explained by migration of mature fish away from the Colville River and towards the Mackenzie River as they ripen for spawning. Although arctic cisco are abundant along the Beaufort Sea coastline, relative abundances are higher in the eastern Beaufort than the western Beaufort (Schmidt et al. 1983).

Growth and Maturity

Beaufort Sea arctic cisco grow slower and mature later than other populations. Bendock (1977) reports slower growth for fish along the Alaskan coastline as compared to Mackenzie River or Siberian fish. Moulton et al. (1985) provide evidence that in recent years small arctic cisco in the Prudhoe Bay region are growing slower than the equivalent cohort in the Colville River delta area.

Male arctic cisco from the Colville River mature at 7 to 9 years, while females mature later at 8 to 10 years (Table 3, Craig and Haldorson 1981). Arctic cisco in Kaktovik Lagoon mature slightly earlier at 6 to 9 years (Griffiths et al. 1977) and those in Nunaluk Lagoon at 7 to 9 years (Griffiths et al. 1975). In comparison, fish in Siberia are reported to reach maturity at 5 to 7 years or 9 to 10 years in different rivers in the U.S.S.R. (Nikolski 1961). Roguski and Komarek (1971) suggested that Beaufort Sea arctic cisco may be non-consecutive spawners as they are in the U.S.S.R. (Nikolski 1961). Evidence from the Mackenzie River delta also indicates that arctic cisco are non-consecutive spawners (Lawrence et al. 1984).

2.2 LEAST CISCO (*Coregonus sardinella*)

Abundance and Distribution

Least cisco are common throughout the Colville River drainage and coastal plain lakes and streams (Bendock 1979, 1982, Bendock and Burr 1984a, McElderry and Craig 1981). Two life history types exist in the area. Some least cisco populations are anadromous while others are lake dwellers and never leave fresh water. Fish in lakes of the Killik River drainage (e.g. Udrivik Lake)

Table 3. Summary of spawning and maturation information.

Species	Maturation Age	Spawning: Annual	Spawning: Non-consecutive	Spawning: Known/Suspected Locations & habitat	Time of Year
Arctic Cisco	males: 7-9 yr, females: 8-10 yr, Colville River (Craig and Haldorson 1981)		X(?)	Mackenzie River and tributaries	August-September
	6-9 yr, Kaktovik Lagoon (Griffiths et al. 1977)				
	7-9 yr, Nunaluk Lagoon (Griffiths et al. 1975)				
	5-7 yr, 9-10 yr, U.S.S.R. (Nikolski 1961)				
Least Cisco	Anadromous: 4-5 yr (Alt and Kogl 1973), males: 6-7 yr, females: 7-10 yr (Craig and Haldorson 1981), Colville River			Colville, Ikpikpuk, and Price rivers (Bendock and Burr 1984b)	September
	7-8 yr, Prudhoe Bay (Bendock 1977)		X(?)	Colville River delta and lower river, downstream from Ocean Point	September-October
	5-8 yr, Yukon (Mann 1974) males: 2-3 yr, females: 3-4 yr (Morrow 1980)				
	5-6 yr, Siberia (MacPhail and Lindsey 1970)				
	3-7 yr, U.S.S.R. (Nikolskii 1961)				

Table 3. (Continued)

Species	Maturation Age	Spawning: Annual	Spawning: Non-consecutive	Spawning: Known/Suspected Locations & habitat	Time of Year
Char	Anadromous: 7-8 yr 7-8 yr (Griffiths et al. 1975) Stream resident: males: 2-4 yr (Glova and McCart 1974, Morrow 1980)		X	Anaktuvuk and Nanushuk rivers	fall-early winter, with peak in September to October
Broad Whitefish	9 yr, Coastal Plain Streams and Lakes (Bendock and Burr 1984b)		X	Fish Creek, Ikpikpuk River, Teshekpuk Lake	September
	7-8 yr, Colville River (Alt and Kogl 1973)			upper and middle Colville River	July-September
	9-14 yr, Beaufort Sea (Craig and Haldorson 1981)		X		
	7 yr, Yenisei River, U.S.S.R. (Nikolski 1961)		X (females)	upper Colville River and delta	September-October
Humpback Whitefish	8-10 yr, Colville River (Alt and Kogl 1973)				
	8 yr, Northern Canada (McPhail and Lindsey 1970)				
	7 yr, Coastal Plain Streams and Lakes (Bendock and Burr 1984b)				

Table 3. (Continued)

Species	Maturation Age	Spawning: Annual	Spawning: Non-consecutive	Spawning: Known/Suspected Locations & habitat	Time of Year
Round Whitefish	6-8 yr, Colville River (Bendock 1979) 6-7 yr, Great Bear Lake, Canada (McPhail and Lindsey 1970)			Colville River and tributaries	late September to mid-Oct.
Grayling	4-6 yr, Coastal Plain Streams (Bendock and Burr 1984b) 7-8 yr, Umiat, Kiruktigiak Creek (Kogl 1971, Bendock 1979) 8-9 yr, Ikagiak Creek (Kogl 1979) 5 yr, Great Bear Lake, Canada (McPhail and Lindsey 1970)	X		Colville River drainage, Colville River upriver from Etivluk River; also Kikiakrorak, Kogosukruk, Killik, Chandler rivers and Seabee, Rainy, Prince, Fossil, Ninuluk creeks	late May-June
Burbot	7 yr (Bendock 1979, Morrow 1980)			near Umiat	late winter (February to mid-March)

and several lakes of the drainages above the Killik River (Tukuto, Akuliak, unnamed lakes) may represent non-migratory least cisco populations (McPhail and Lindsey 1970, Bendock 1979). Least cisco was the most abundant species found in surveys of coastal plain lakes and streams north and west of the Colville River (McElderry and Craig 1981, Bendock 1982, Bendock and Burr 1984a,b). Fish collected from coastal plain streams (Kalikpik, Kikiakrorak, and Kogosukruk rivers) may be anadromous, while least cisco in coastal plain lakes probably are not.

Anadromous least cisco is the second most abundant species taken (mean catch of about 22,000 fish/year) in the fall commercial gill net fishery at the Colville River delta (Table 1) (Alt and Kogl 1973). They are more common in the deeper Main Channel of the delta than in the shallower East Channel (Gallaway et al. 1983). During the open-water season least cisco occur upstream to the vicinity of the Anaktuvuk River (140 km) (Bendock, pers. comm. 1985) and approximately 45 km upstream in the Kogosukruk River (Bendock and Burr 1984b). However, they were not collected at Umiat (175 km) by September (Alt and Kogl 1973).

In the nearshore coastal areas and lagoons between the Colville River and Prudhoe Bay, least cisco is one of the three most abundant anadromous fish species present (along with arctic cisco and char) during the open-water season (Kogl 1971, Furniss 1975, Craig and Haldorson 1981, Dew 1983, Schmidt et al. 1983, Moulton and Fawcett 1984, Moulton et al. 1985). Least cisco in these coastal areas are assumed to originate in the Colville River since no rivers between the Colville and Mackenzie rivers are known to support spawning populations of least cisco (Schmidt et al. 1983).

Spawning

Least cisco spawn in freshwater in late September and early October (Morrow 1980). Spawning areas in the lower Colville River were located by McElderry and Craig (1981). As many as 75 to 86 percent of the least cisco collected between Ocean Point and the coast in summer and fall were ripe or spent (Alt and Kogl 1973, McElderry and Craig 1981). The lower Colville River and delta apparently contain the most important spawning areas for anadromous least cisco originating from the Colville River. The mouth of the Titaluk River in the Ikpikpuk drainage is also used for spawning in early to mid-September (Bendock and Burr 1984a).

Seasonal Movements

Some least cisco remain in the lower Colville River and delta after freezeup. Six fish were collected under the ice at the mouth of the Itkillik River in April (Kogl and Schell 1975) and 42 were caught in the delta (Anachlik Island) in salinities of 18 to 32 ppt in April and May (Craig and Haldorson 1981). The absence of least cisco at lagoon and marine sites suggests that they do not overwinter in the nearshore coastal area. Least cisco also were absent during winter surveys of the main river channel between Uluksrak Bluff and Prince Creek Bluff (156 to 200 km) (Bendock 1979).

Craig and Haldorson (1981) propose that following breakup, least cisco move from overwintering areas in the Colville River delta into the brackish shoreline waters of Simpson Lagoon and eastward into Prudhoe Bay. Eastward movement into and through Simpson Lagoon was documented during the summers of 1978 (Craig and Haldorson 1981), 1983 (Moulton and Fawcett 1984), and 1984 (Moulton et al. 1985). Highest abundance of least cisco in Prudhoe Bay and the Sagavanirktok River delta occurred in late July and August (Bendock 1977, Critchlow 1983, Griffiths et al. 1983, Moulton et al. 1985). Although westward movement of least cisco towards the Colville River delta later in the summer is not well defined (Critchlow 1983, Griffiths et al. 1983, Moulton and Fawcett 1984), many tag returns at the Colville River commercial fishery were from least cisco tagged in Prudhoe Bay (Bendock 1977, Doxey 1977, Griffiths and Gallaway 1982, Critchlow 1983, Moulton et al. 1985) or Simpson Lagoon (Craig and Haldorson 1981, Griffiths and Gallaway 1982, Moulton et al. 1985).

Growth and Maturity

Growth and maturity patterns for least cisco show many variations between different populations. Wohlschlag (1954) found that lake-resident (Ikroavik Lake) fish were fatter and heavier than anadromous fish of the same length from a brackish lagoon (Elson Lagoon) near Barrow. Lake-resident least cisco of the Killik and Etivluk rivers (tributaries of the Colville River) grow slower and reach a smaller maximum size than anadromous populations (Bendock 1979). Growth rates of anadromous fish in Prudhoe Bay were found to be lower than Mackenzie River fish (Bendock 1977).

Fish in the lakes of the Killik and Etivluk river drainages are reported to be sexually mature at four years (Kogl 1971, Bendock 1979), and those of interior Alaska at 2 to 3 years for males and 3 to 4 years for females (Morrow 1980). Anadromous least cisco in the coastal region of Yukon Territory mature at 5 to 8 years while lake-resident populations mature later (6 to 9 years) in this region (Mann 1974). Bendock and Burr (1984b) report two size modes of least cisco in coastal plain lakes, including Teshekpuk Lake, with both size modes containing mature fish. The small size group (dominant mode of 140 to 149 mm) matured at age-3 while the large size group (dominant mode of 280 to 289 mm) matured at age-6. In comparison, anadromous Colville River least cisco mature at 6 to 7 years for males, and 7 to 10 years for females (Craig and Haldorson 1981). Bendock (1977) reported maturation ages of 7 to 8 years for least cisco captured in Prudhoe Bay. Except for reported maturation ages of 4-5 years (Alt and Kogl 1973), ages of maturity for Colville River fish are later than least cisco in Siberia that mature at 5 to 6 years (McPhail and Lindsey 1970). Nikolski (1961) reports variations of 3 to 7 years for the age of maturity of least cisco in different river systems of the U.S.S.R. Mann (1974) and Bendock (1977) believe that mature least cisco do not spawn every year. Other authors have left this question unanswered (Craig and Haldorson 1981).

2.3 BROAD WHITEFISH (*Coregonus nasus*)

Abundance and Distribution

Broad whitefish are distributed throughout the Colville River drainage and coastal plain water bodies and are common in coastal waters in the vicinity of the Colville delta. During the summer open-water season broad whitefish are found in the delta (Kogl and Schell 1975), the main river channel, the main tributaries (Itkillik, Anaktuvuk, Chandler rivers), smaller tributaries and coastal streams (Kikiakrorak and Kalikpik rivers, Inigok and Judy creeks), and mountain (Imiaknikpak and unnamed lakes) and coastal lakes (Bendock 1979, 1982, Bendock and Burr 1984a). Broad whitefish was the most abundant species captured at Umiat during the summer (Alt and Kogl 1973). The commercial fishery at the Colville River delta takes about 2800 fish/year (Table 1). Highest abundances in coastal marine waters are near river deltas (Furniss 1975, Griffiths et al. 1983, Schmidt et al. 1983, Moulton and Fawcett 1984, Moulton et al. 1985). Small broad whitefish seldom travel far from the river deltas (Bendock 1977, Moulton et al. 1985), although tag returns show that large fish may move at least between the Colville River and Prudhoe Bay region (Furniss 1975, Craig and Haldorson 1981, Critchlow 1983, Moulton and Fawcett 1984). Broad whitefish show a strong preference for nearshore habitats when in coastal waters (Craig and Haldorson 1981), appearing only rarely in offshore or barrier island locations (Critchlow 1983, Craig 1984, Moulton et al. 1985). Correlation of CPUE with temperature and salinity (Griffiths et al. 1983) suggested that broad whitefish prefer warm brackish water that is more common in nearshore areas.

Spawning

Following a summer of foraging in coastal and delta areas, broad whitefish migrate upstream in the Colville River to spawn. Small groups of fish (86 percent mature adults) move upstream from July through September, with a peak in the run at Umiat in late July (Alt and Kogl 1973) or August (Bendock 1979). It is suspected that spawning occurs in the Colville River upstream to at least the Etivluk River during September (Alt and Kogl 1973, Bendock 1979). Broad whitefish were found in pre-spawning condition in the Chandler River in August (Bendock 1979), and spawning was observed in the Colville River upstream from Umiat by Hablett (1979) in September. Bendock and Burr (1984a) report broad whitefish in spawning condition in the Ikpikpuk River on September 10. A limited amount of spawning also occurs in the Nigliq (Nechelik) Channel of the Colville River delta in September and October (Kogl and Schell 1975). Rearing areas probably are located at the mouths of minor tributaries such as the Kikiakrorak and Kogosukruk rivers, and Seabee, Rainy, Prince, Fossil and Ninuluk creeks (Bendock 1979). Substantial rearing also occurs in isolated backwaters, oxbows, and other low-velocity areas throughout the middle and lower river (Bendock, pers. comm. 1985).

Seasonal Movements

Broad whitefish were abundant in the Nigliq (Nechelik) Channel of the Colville River delta in late September-early October (Kogl and Schell 1975). Broad whitefish also occur in the main and east channels of the delta in the fall (Gallaway et al. 1983).

During winter surveys broad whitefish were found under the ice in the main river between the Anaktuvuk River and Ninuluk Creek (Bendock 1979, 1980). Broad whitefish apparently do not use the Colville River Delta for overwintering as they were absent during winter surveys of the delta (Alt and Kogl 1973).

Growth and Maturity

Broad whitefish from the Colville River are reported to grow faster than the same species inhabiting Teshepuk Lake and the Seward Peninsula, but slower than Yukon River fish (Bendock 1979). The Colville River population also grows slower than fish in the U.S.S.R. and interior Alaska, reaching a mean length of 39 cm at 8 years as compared to the same length at 4 to 6 years in the U.S.S.R. population (McPhail and Lindsey 1970), and a mean length of 50 to 55 cm at 8 years in the Minto population (Alt and Kogl 1973). Sexual maturity occurs over a wide range of ages. Alt and Kogl (1973) report maturation ages of 7 to 8 years, Craig and Haldorson (1981) report ages of 9 to 14 years for Beaufort Sea fish, while Bendock and Burr (1984b) report age-9 as the age of first maturity for broad whitefish in streams. Broad whitefish in the Yenisei River (U.S.S.R.) mature at age-7 (Nikolski 1961). Spawning appears to be non-consecutive and irregular (Bendock, pers. comm. 1985).

2.4 HUMPBACK WHITEFISH (Coregonus pidschian)

Abundance and Distribution

The abundance of humpback whitefish in the Colville River drainage and in coastal lakes and streams west of the Colville River varies dramatically with the seasons. Pre-spawning migrations of anadromous humpback whitefish result in high abundance of fish in the Colville River in late summer. Pre-spawning fish migrate through the middle river during August and September as far upstream as Umiat where they were the second most abundant species collected (Kogl 1971). The peak of migration occurred in mid-August (Kogl 1971, Alt and Kogl 1973) or late August and into September (Bendock 1979). Humpback whitefish were found in the lower Itkillik and Chandler rivers, and at the mouth of the Anaktuvuk River (Kogl and Schell 1975, Bendock 1979). Humpback whitefish comprise about 10 percent of the summer catch (about 1800 fish/year) and 1 percent of the winter catch in the Colville River delta commercial fishery (Table 1, Alt and Kogl 1973). A few coastal plain lakes with large outlet streams and the coastal plain Kikiakrorak River contain a few humpback whitefish (Bendock 1982, Bendock and Burr 1984a). In coastal waters humpback whitefish are less common than other anadromous species. Studies in coastal areas show that catch rates are low in Simpson Lagoon (Craig and Haldorson 1981, Dew 1983, Moulton and Fawcett 1984) and Prudhoe Bay (Doxey 1977, Griffiths and Gallaway 1982, Moulton et al. 1985) during the open-water season.

Spawning

Alt and Kogl (1973), Bendock (1979), and Kogl and Schell (1975) suggest that humpback whitefish spawn in the upper Colville River (upstream from Umiat) during September and October. Spawning also occurs in the Colville River delta and throughout the middle reach up to and beyond Umiat in late September to early October (Kogl and Schell 1975, Bendock, pers. comm. 1985). Bendock and Burr (1984a) report humpback whitefish in spawning condition at the mouth of Titaluk River in the Ikpikpuk drainage on September 10. Humpback whitefish may be the most abundant species in some Colville delta channels during the spawning season, with higher abundance in the deeper main (Kupigruak) channel than in the East Channel (Kogl and Schell 1975, Gallaway et al. 1983). Spawning occurs in both channels. Spawning by humpback whitefish appears to be non-consecutive (Bendock and Burr 1984b).

Seasonal Movements

Kogl and Schell (1975) provide some evidence for a post-spawning migration down river in October, but such movements have not been verified. Humpback whitefish have not been collected in winter sampling surveys of the Colville River and delta, or in coastal areas (Kogl and Schell 1975, Bendock 1979, 1980, Craig and Haldorson 1981). Hence, overwintering areas for humpback whitefish remain unknown.

Humpback whitefish occasionally move into coastal waters during the summer, but do not usually move far from the mainland or the Colville River delta (Bendock 1977, Craig and Haldorson 1981, Craig 1984, Moulton and Fawcett 1984). Griffiths (1983) shows that the coastal distribution of humpback whitefish can be related to the stream type in the area (stream types as defined by Craig and McCart 1976). Humpback whitefish use the Colville River and other "coastal plain streams" to the west for spawning, but do not use "mountain streams" (such as Sagavanirktok, Canning, and Firth rivers) between the Colville and Mackenzie rivers. Thus, they are found near the Colville River (Craig and Haldorson 1981, Dew, 1983 Moulton and Fawcett 1984), and to the west (Schmidt et al. 1983), but seldom occur in the eastern Beaufort Sea (Griffiths et al. 1975, 1977, Griffiths 1983).

Growth and Maturity

Alt and Kogl (1973) report that humpback whitefish in the Colville River mature sexually at 8 to 10 years, which is similar to the maturation age (8 years) reported for fish in northern Canada (McPhail and Lindsey 1970). Humpback whitefish mature earlier in more southern regions (McPhail and Lindsey 1970).

2.5 CHAR (Salvelinus sp.)

The anadromous char of the Alaskan North Slope is considered by Morrow (1980) to be Dolly Varden (Salvelinus malma) while others consider this fish to be the western form of arctic char (Salvelinus alpinus) (McPhail and Lindsey 1970). Stream and lake resident populations are also found. The Colville

River drainage contains all these population types (Bendock 1979). All types will be considered together under the general term "char".

Abundance and Distribution

Char are distributed widely in the Colville River drainage, including major tributaries (Itkillik, Anaktuvuk, Chandler and Killik rivers) and smaller tributaries and lakes (Ikiakpupik and Willow creeks, Kiruktagiak River, Shainin, Chandler and Tolugak lakes) (Kogl 1971, Bendock 1979, Morrow 1980). Kogl (1971) reports that char are seldom found upriver from Umiat, but rearing young are found in the upper tributaries. These probably represent two different population types: anadromous fish returning to tributaries of the middle and lower river, and stream resident fish in the upper tributaries. Char are normally not found in coastal plain lakes nor in streams north and west of the Colville River (Bendock 1982, Bendock and Burr 1984a), although one population in a coastal plain lake in the lower Chipp River has been identified (Bendock and Burr 1985). Char move into coastal waters during the summer to rear. Char is the most abundant of the anadromous species collected offshore of the barrier islands where salinities tend to be higher (Bendock 1977, Craig and Haldorson 1981, Dew 1983, Moulton and Fawcett 1984, Craig 1984, Moulton et al. 1985).

Spawning and Overwintering

Several studies investigated the spawning and overwintering habitats of char in northern Alaskan and Canadian rivers, including the Colville, Sagavanirktok, Kavik, Canning and Mackenzie (Yoshihara 1972, 1973, Furniss 1975, Craig 1977a, 1977b, Bendock 1983, Bendock and Burr 1984a) (Figure 3). Char spawning and overwintering sites are generally located where spring fed channels remain ice-free through the winter. A major spawning area in the Anaktuvuk River near "Rooftop Ridge" is surveyed annually by ADF&G (Bendock 1980, 1981, 1982, 1983, Bendock and Burr 1984a). Sites on the Nanushuk and Kanayut rivers have concentrations of char in the fall (Bendock 1982). Spawning takes place during fall and early winter (peak spawning in September-October) (Griffiths et al. 1975). Char apparently remain near the spawning area through the winter. Bendock (1982) showed movements of 0.07 - 1.6 miles from September 21 to April 1 by char tagged in the Anaktuvuk River.

Seasonal Movements

Following breakup in June, char move out of tributary rivers to the river delta, then disperse into coastal areas (Bendock 1977, 1982, Griffiths et al. 1983). Char are more wide ranging than other anadromous fish species, as long distance movements have been documented (Bendock 1977, Griffiths and Gallaway 1982, Moulton et al. 1985). For example, fish from the Sagavanirktok River were captured in Simpson Lagoon and at Barrow (Furniss 1975) and a fish tagged at Milne Point was recaptured in the Canning River (Craig and Haldorson 1981). Small char marked at Heald Point were recaptured at Oliktok Point (Moulton and Fawcett 1984) and char from the Colville and Canning rivers moved to Prudhoe Bay during the summer (Critchlow 1983).

Growth and Maturity

Char populations have different growth rates and maturation ages due to the variety of life history patterns exhibited in various geographic regions. Lake-dwelling char are slow-growing fish, averaging 424 mm in length at 10+ years of age and 537 mm at 14+ years in Chandler Lake (Morrow 1980). Resident fish mature earlier than anadromous fish. Over 50 percent were mature at age-4 in a lake of the Babbage River system (Bain 1974). Kogl (1971) provides evidence that char in Ikagiak Creek grow slower than fish in the Anaktuvuk and Kiruktagiak rivers, thus indicating that two separate populations are represented. The resident fish lagged one year in growth behind the anadromous fish in the rivers.

Anadromous char grow rapidly, with fish in arctic Alaska growing faster than those in southeastern Alaska (Morrow 1980). An eight year old anadromous char in the arctic may reach 470 mm, while a ten year old fish typically is 517 mm. Glova and McCart (1974) report that anadromous char in the Firth River were at least twice the length of equivalent aged stream-resident fish. Lengths of anadromous char captured in Simpson Lagoon averaged 507 mm at eight years, 554 mm at 10 years, and 643 mm at 14 years (Craig and Haldorson 1981).

Char first move into sea between ages 2 and 5 and become sexually mature at 7 to 8 years (Griffiths et al. 1975). Age-3 fish are the youngest char usually found in Simpson Lagoon (Craig and Haldorson 1981). In some instances, male char do not migrate to salt water even though females of the same population are anadromous. These fish mature early (age 2 to 4), remain small, and spawn annually after reaching maturity (Glova and McCart 1974, Morrow 1980). In contrast, spawning probably occurs every second year in populations that contain anadromous males and females.

2.6 RAINBOW SMELT (*Osmerus mordax*)

Abundance and Distribution

Except for localized concentrations prior to spring spawning migrations, rainbow smelt occur in relatively low abundance in nearshore coastal waters and the Colville River delta. Catch rates are generally lower than other anadromous fish species (Kogl 1971, Doxey 1977, Bendock 1977, Craig and Haldorson 1981, Griffiths and Gallaway 1982, Moulton and Fawcett 1984, Moulton et al. 1985), but occasionally catches of rainbow smelt have ranked second to fourth in abundance in fyke nets at Oliktok Point and west of the Colville River (Dew 1983, Schmidt et al. 1983). Higher abundance near the Colville River is expected since rainbow smelt are believed to remain close to natal or other streams (Morrow 1980). During winter surveys in the Colville River delta and the nearshore region, rainbow smelt were abundant near Thetis Island while other anadromous fishes were absent (Craig and Haldorson 1981). These fish apparently were concentrated in preparation for a spawning migration into the Colville River immediately after breakup. Rainbow smelt are not known to occur upstream from the Colville River delta or in coastal plain lakes or streams (Bendock 1979, Bendock and Burr 1984a).

Spawning

In contrast to other anadromous fishes in the arctic, rainbow smelt spawn in the spring (Morrow 1980). Spawning fish move from marine waters into the Colville River Delta as soon as breakup occurs (Morrow 1980, Craig and Haldorson 1981), or while ice is still present (Nikolski 1961). Spawning areas must have gravel or stones for attachment of eggs (Nikolski 1961, McPhail and Lindsey 1970). Spawning areas for rainbow smelt in the Colville River delta are unknown.

Growth and Maturity

The population of rainbow smelt in the Colville River region is slow-growing and long-lived, reaching ages of 13 to 15 years (Craig and Haldorson 1981).

Rainbow smelt may spawn as young as 2 year olds (Morrow 1980), but generally mature at 3 to 4 years in U.S.S.R. waters (Nikolski 1961). Fish in the Colville River area mature at 5 years for males and 5 to 7 years for females (Craig and Haldorson 1981).

2.7 ARCTIC GRAYLING (*Thymallus arcticus*)

Abundance and Distribution

Grayling is one of the most abundant and widespread fish species in the Colville River drainage above the confluence of the Nigliq (Nechelik) and main river channels. Surveys by Bendock (1979) and Kogl (1971) located grayling in abundance in the main river channel at Umiat during the summer as well as in major tributaries (Itkillik, Anaktuvuk, Chandler and Killik rivers), smaller streams (e.g. Kiruktagiak River and Ikagiak Creek), and lakes (Shainin, Sitchiak, Ahaliorak, Chandler, and Tulilik lakes). Grayling were also found in coastal plain streams (Kalikpik and Inigok creeks) and lakes although they were less abundant in these areas (Bendock 1982, Bendock and Burr 1984a,b). Several authors report incidental catches of grayling in coastal waters (Roguski and Komarek 1971, Bendock 1977, Doxey 1977, Craig and Haldorson 1981, Dew 1983, Griffiths et al. 1983, Moulton and Fawcett 1984, Moulton et al. 1985). The presence of grayling in coastal areas generally is associated with periods of low salinity, as grayling prefer to inhabit freshwater areas.

Spawning and Overwintering

Grayling spawn throughout the Colville River drainage. The mainstem Colville River upstream from the Etivluk River is more heavily utilized than mainstem areas downstream from the Etivluk River (Bendock 1979). Tributaries provide the primary spawning habitat in the middle and lower reaches. Spawning and/or rearing sites identified in the middle and lower river include the Kikiakrorak, Kogosukruk, Killik, and Chandler rivers, and Seabee, Rainy, Prince, Fossil and Ninuluk creeks (Bendock 1979). Grayling spawn during June and July, beginning earlier in the middle river and later in the lower and upper portions of the drainage (Bendock 1979, pers. comm. 1985). Spawning commences in the second week of June and can extend to as late as the second week of July (Bendock pers. comm. 1985).

During winter surveys on the Colville River, grayling was the most abundant species present (Bendock 1979). Important overwintering areas occur between the Anaktuvuk River and Ninuluk Creek. Young grayling were also found near open water in the Chandler River in late winter (Kogl and Schell 1975).

Growth and Maturity

Young grayling in Kiruktagiak River and Ikagiak Creek are reported to grow slower than fish at Umiat, while fish from the Colville River grow slower and reach a smaller ultimate size than fish in lakes of the Colville River drainage (Bendock 1979).

Maturation ages of 7 to 8 years in Kiruktagiak River and at Umiat (Kogl 1971) are later than that (5 years) reported for fish in Great Bear Lake (McPhail and Lindsey 1970). Bendock and Burr (1984b) report ages 4 to 6 as the age of first maturity for grayling in coastal plain streams between the Ikpikpuk River and the Colville River. Grayling apparently spawn every year after reaching maturity (Wilson et al. 1977).

2.8 ROUND WHITEFISH (*Prosopium cylindraceum*)

Abundance and Distribution

Round whitefish is a freshwater species, common in the upper Colville River, tributaries and lakes, while only occasionally caught in coastal waters. McPhail and Lindsey (1970) state that it prefers shallow areas of lakes and clear streams. In the Colville River drainage, round whitefish were caught in the lower reaches of the Itkillik, Anaktuvuk, Chandler, Killik, Kogosukruk, and Kiruktagiak rivers, Ikagiak, Seabee, and Graylime creeks, and Shainin, Chandler, and Tulilik lakes (Kogl 1971, Bendock 1979, Bendock and Burr 1984a). Round whitefish also occur in lakes and streams of the upper Colville River (Alt and Kogl 1973, Bendock 1979). Round whitefish were present in 9 of 62 surveyed coastal plain lakes north of the Colville River and were also found in the Kalikpik and Kogosukruk rivers and Inigok and Judy creeks on the coastal plain (Bendock and Burr 1984b). They were not found in Teshekpuk Lake drainages or the Ikpikpuk River drainage (Bendock and Burr 1984b). Occasional catches of round whitefish in delta and coastal areas have been reported (Doxey 1977, Craig and Haldorson 1981, Griffiths and Gallaway 1982, Dew 1983, Griffiths et al. 1983, Moulton and Fawcett 1984, Moulton et al. 1985).

Spawning

An upstream spawning migration is reported for round whitefish in Canada (McPhail and Lindsey 1970). Similar movements in the Colville River drainage have not been documented, although round whitefish are known to spawn in the river and its tributaries from late September to mid-October (Alt and Kogl 1973, Bendock 1979). Stream and lake shorelines are typically used for spawning (McPhail and Lindsey 1970). In the Colville River, overwintering fish were located between the Anaktuvuk River and Ninuluk Creek (Bendock 1980).

Growth and Maturity

Little information is available concerning the growth and sexual maturity of round whitefish. Fish in lake populations of the Colville River drainage are heavier than stream populations at the same length, but both have a smaller maximum size than fish in the Kuskokwim River drainage (Bendock 1979). Sexual maturity is reached at 6 to 8 years (Bendock 1979), which is similar to the maturation age (6 to 7 years) reported for round whitefish in Great Bear Lake, Canada (McPhail and Lindsey 1970).

2.9 BURBOT (Lota lota)

Abundance

Burbot is a freshwater species that is abundant in the middle and lower Colville River (Bendock 1979). It occurs in the Anaktuvuk, Chandler, and lower Killik rivers and Seabee Creek as well as in the Colville River near the Itkillik River. It is found in the delta throughout the year (Furniss 1974, Kogl and Schell 1975, Bendock 1979). Both mountain (Tulilik and unnamed lakes in the Killik River drainage) and coastal plain lakes, and the coastal plain Kogosukruk River contain burbot (Bendock 1979, 1982, Bendock and Burr 1984a). Lakes and streams upstream from the Etivluk River are also known to contain burbot (Bendock 1979). Burbot are rarely reported in coastal waters (Griffiths and Gallaway 1982, Moulton et al. 1985) and apparently are intolerant of high salinities.

Spawning and Overwintering

Overwintering burbot were located in the Colville River between the Anaktuvuk River and Ninuluk Creek (Bendock 1980). Burbot are known to spawn in the Colville River near Umiat during late winter, prior to mid-March (Bendock 1979). Burbot rearing areas include the mouths of minor tributaries of the lower Colville River such as the Kikiakrorak and Kogosukruk rivers, and Seabee, Rainy, Prince, Fossil and Ninuluk creeks (Bendock 1979).

Growth and Maturity

Burbot are long-lived, the oldest fish being recorded at 24 years of age (Morrow 1980). The usual life span is probably 15 years with the age of sexual maturity at seven years (Bendock 1979, Morrow 1980).

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CHAPTER 2

COLVILLE RIVER FISHES:

1985 BIOLOGICAL REPORT

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1.0 INTRODUCTION

The Colville River is the largest river system on the Arctic Slope of Alaska and supports substantial populations of fish (Figure 1). These fish stocks are used by local residents, primarily from Nuiqsut and a homestead in the lower delta, for food and trade (Figure 2). Despite the importance of these fish populations to the region as a whole, the basic biology of the species found in the river is not well documented (see Moulton and Carpenter 1986). The overall objective of the 1985 biological study was, therefore, to obtain information on the four most abundant anadromous species: arctic and least cisco, broad and humpback whitefish. The information will serve a dual purpose - it will provide a baseline to guide future development decisions in the region and will be used to support information gained during the concurrent assessment of the fisheries operating on Colville River stocks. Specific objectives were to gain information on relative abundance, length frequency, age composition, seasonal movement patterns, growth rates, length-weight relationships, reproductive status and recruitment patterns for each of the four dominant species. Additional information on abundance was obtained for secondary species.

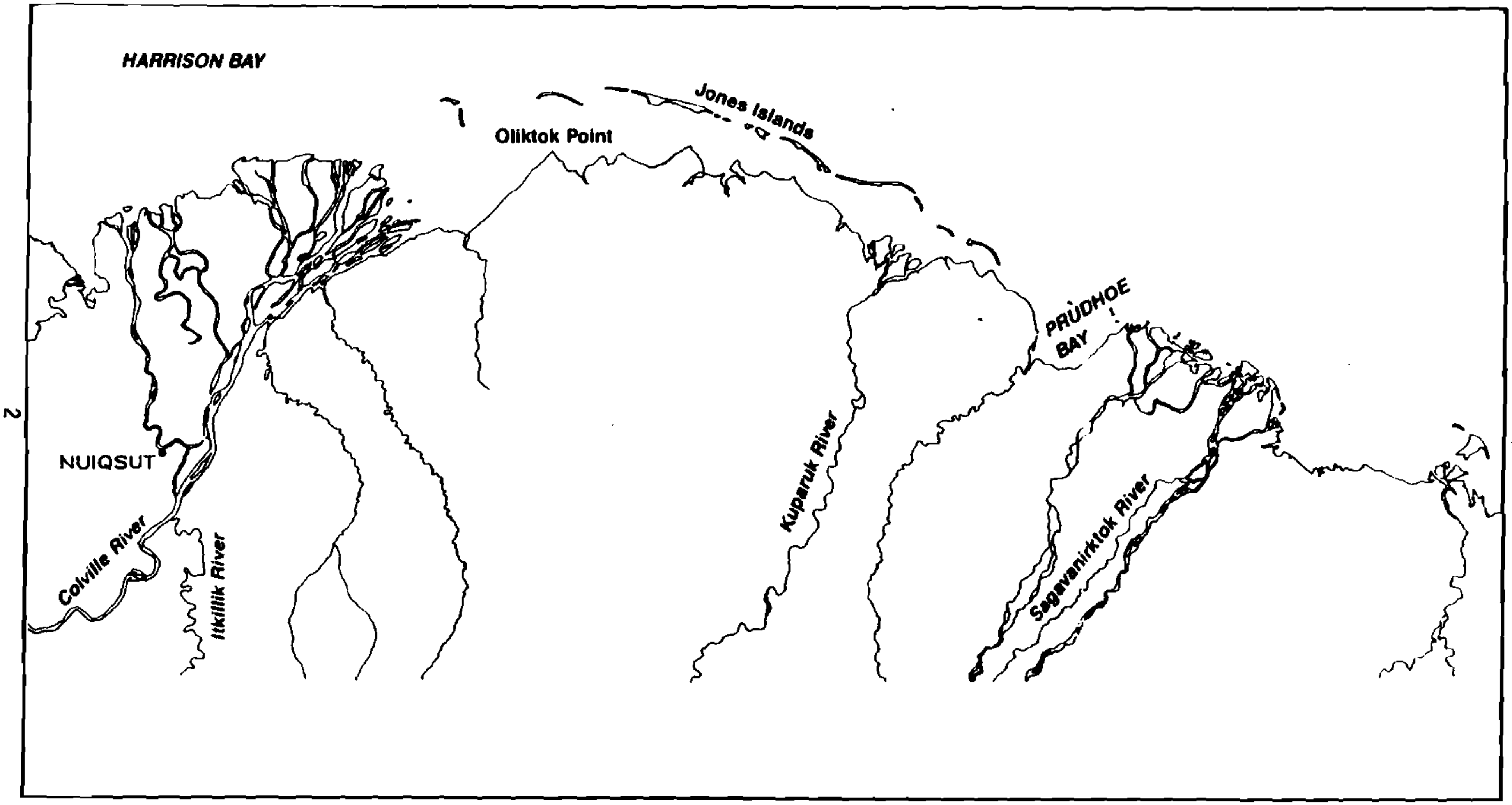

Figure 1. Beaufort Sea coastline from the Colville River to the Sagavanirktok River.

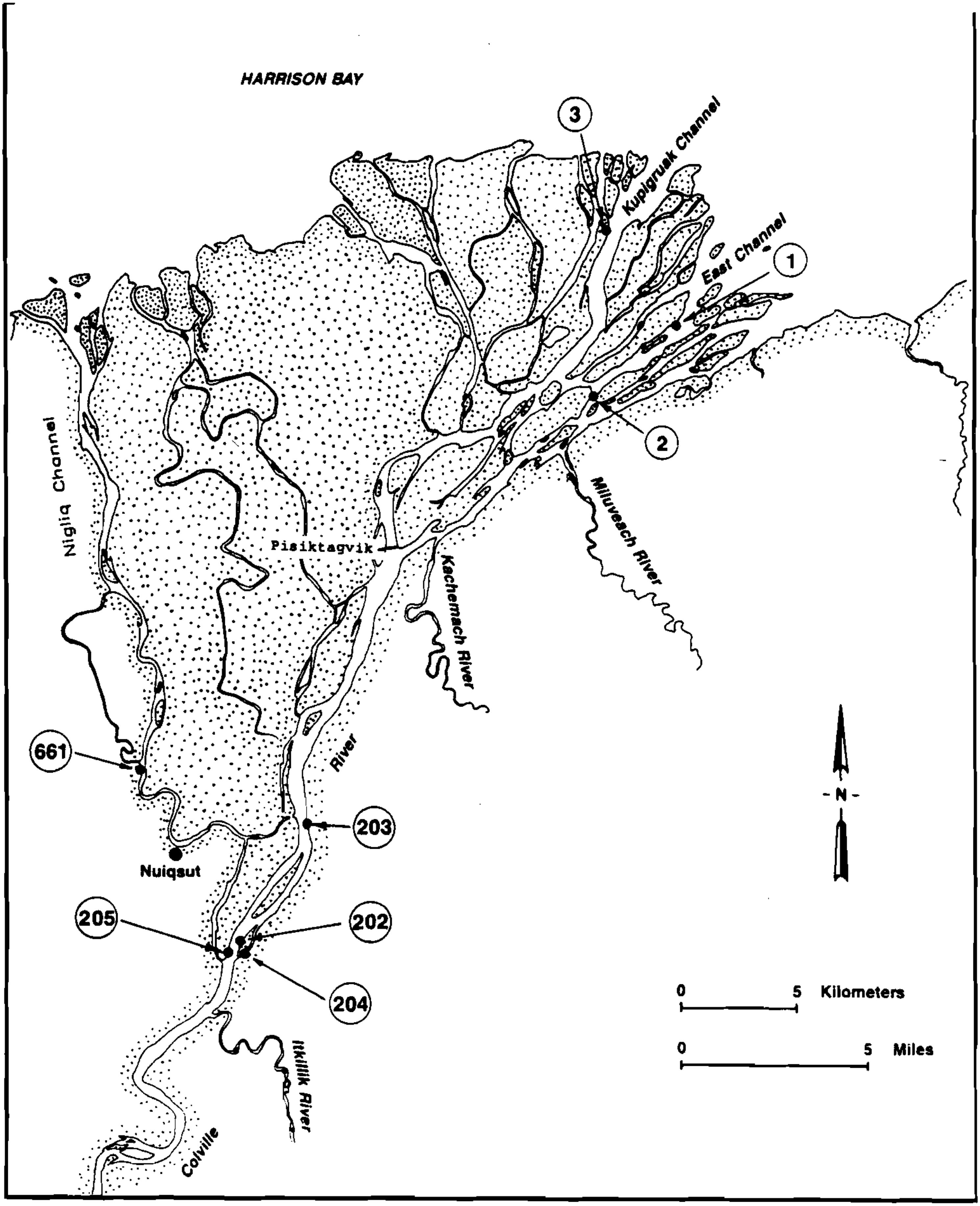

Figure 2. Location of fyke and hoop net sampling sites in the Colville River during summer 1985.

2.0 METHODS

2.1 GENERAL APPROACH

The combined study area for the Lower River Study and the Outer Delta Study is shown in Figure 2. For this report, the term Lower River refers to that area between Ocean Point and Pisiktagvik, including the Nigliq Channel. The Outer Delta is the area downstream from Pisiktagvik on the main channel. The primary study method was daily fish sampling by fyke nets or hoop nets arrayed as shown in Figure 2. Stations 1, 2, and 3 represent the Outer Delta Study, and Stations 202 through 205 and 661 represent the Lower River Study. The study focused on four anadromous fish species: arctic cisco, least cisco, broad whitefish, and humpback whitefish. Individuals of these species ≥120 mm in fork length were measured, then marked or tagged, and released. Smaller fish were measured and released. Sample specimens of the four target species were collected throughout the open-water season for analysis of life history features such as age-length-weight relationships, growth, and maturity. Fish of other species were identified, counted, and sometimes measured before release. All anadromous fish captured were examined for tags, freeze brands, dye dots, or fin clips.

Measurements of water level, wave height, and surface water temperature were taken daily at each station. In addition, salinity was measured daily at each of the outer delta stations. Meteorological data were obtained from meteorological stations at Umiat and Oliktok (National Climatic Data Center).

Detailed descriptions of field and laboratory methods, data management, and analytical procedures used are provided below.

2.2 FIELD METHODS

2.2.1 Outer Delta Study

2.2.1.1 Net Deployment

Fyke net sampling was conducted at three stations located in the eastern delta region, as shown in Figure 2. The sampling schedule at each station is shown in Table 1. Sampling effort for each day of the study is provided in Appendix Table A-1. Sampling was conducted daily from Monday through Friday of each week except when prevented by rough seas, high water, or other conditions. After completion of sampling on Fridays, the cod end traps of the nets were closed and the leads lifted from the bottom to allow fish passage. The nets were reset on Sunday afternoons.

The fyke nets consisted of double cod-end traps, two wings, and a lead stretched from the shore to the traps at a right angle to the shoreline, as shown in Figure 3. Each cod-end trap had a stainless steel frame mouth (1.7 m deep, 1.8 m wide) attached to a knotless nylon net bag (3.7 m long, tapered to 0.9 x 0.9 m on a side of 1.27 cm stretched mesh, with five internal steel frames and two throats (15 x 25 cm). Leads and wings were composed of 2.5 cm knotless nylon mesh. Wings were 1.5 m deep and 15.2 m long. Leads were 1.5 m deep and varied in length depending on water depth and bottom topography. Lead length was 30 m at Station 1 and 26 m at Station 2. At Station 3 the bottom profile had a shallow slope; consequently, the length of lead immersed in the water varied from 61 to 91 m, depending on fluctuations in water level caused by river runoff, tidal action, and storm surges. Nets were held in place by pieces of iron reinforcing rod pounded into the bottom.

2.2.1.2 Water Quality and Physical Measurements

Each time the nets were sampled measurements were made at each station of water temperature, salinity, water level, and wave height. Temperature and salinity of surface water near the cod end of the net were measured with a Beckman Model RS5-3 portable salinometer. Salinity was recorded to the

Table 1. Duration of fyke and hoop net sampling by station, summer 1985.

Study Area	Station Number	Date First Set	Date Last Fished
Outer Delta	1	7/9	9/11
	2	7/2	9/10
	3	7/15	9/10
Lower River	661	7/8	9/6
	202	7/8	9/6
	203	7/9	9/6
	204	7/11	9/6
	205	7/29	9/6

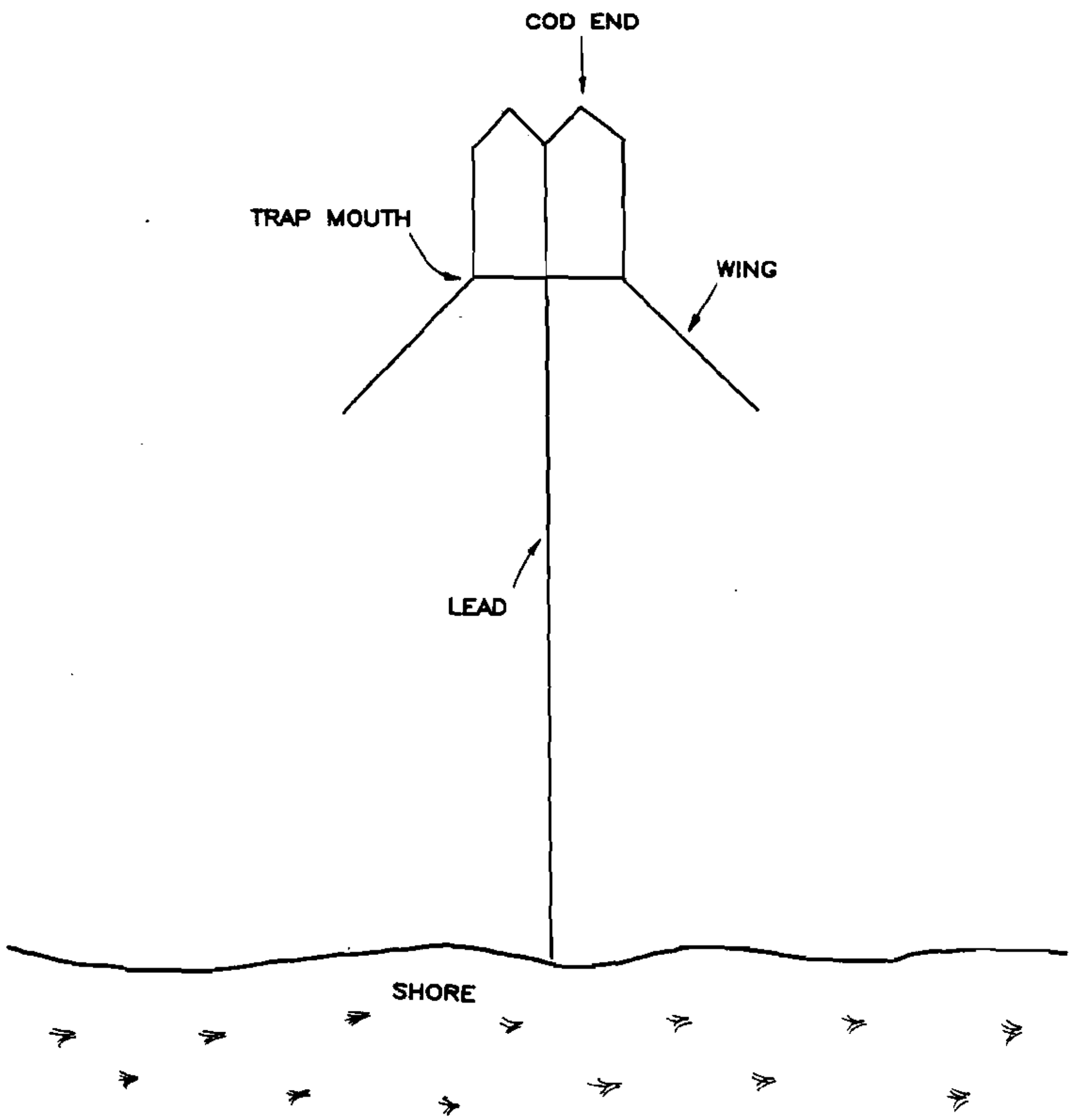

Figure 3. Schematic diagram of double fyke net used in outer delta study.

nearest 0.1 parts per thousand (ppt). Accuracy of the salinity measurements was checked periodically with standard solutions prepared by ARCO's Prudhoe Bay Central Laboratory. At the end of the field season the instrument was tested again by Chemical and Geological Laboratories of Alaska, Inc. (ChemLab), and found to be accurate within 0.2 ppt throughout the range of measured salinity (0-32 ppt).

Temperature was recorded to the nearest $0.1^{o}C$. Temperature measured by the instrument was compared periodically to measurements made with a hand-held Taylor thermometer that had previously been checked against a certified thermometer.

Water level and wave height were estimated by reference to a staff gage graduated in 0.1 m increments attached to the cod-end array of each net.

In addition to the daily measurements at each station, a weekly survey of surface and bottom temperatures and salinities in deeper parts of the two main channels was conducted. The purpose of these surveys was to detect intrusions of marine water, which have been shown to affect fish distribution and abundance (Moulton et al. 1980, Tarbox and Moulton 1980, Dew 1982, WCC 1983, 1984, Moulton and Fawcett 1984). If a layer of cold, high salinity water was detected beneath the warmer river water offshore of Stations 1 and 3, sampling proceeded upstream at approximately 1 km intervals until the layer of marine water disappeared. If no evidence of intruding marine water was found offshore to 1 km seaward of Stations 1 and 3, no further sampling was done.

2.2.1.3 Daily Fish Sampling

Fish in cod-end traps were emptied into floating live pens for processing. Fish of non-target species were identified, counted, and released. Fish of the four target species were measured (fork length) to the nearest millimeter. All large fish ($\geq$250 mm) of the target species were measured each time the nets were sampled. All target fish between 120 and 249 mm in length were measured except on one occasion when arctic cisco, least cisco, and broad whitefish were subsampled by measuring at least 100 individuals and counting the rest. The same method of subsampling was frequently applied in the case of arctic cisco, least cisco, and broad whitefish less than 120 mm in length. On a few occasions, least cisco less than 120 mm were measured and recorded in 5 mm size classes.

2.2.1.4 Fish Marking

Large individuals (≥250 mm) of the four target species were measured, tagged below the dorsal fin with numbered Floy FD 68 anchor tags, and then released. Many of these fish were anaesthetized prior to measurement and tagging in a bath of MS 222 (tricain methane sulfonate) mixed with seawater in a dish pan. Individuals too large for the dishpan were measured and tagged without anaesthesia.

Target fish between 120 and 249 mm were anaesthetized, measured, and injected beneath the skin with an aqueous suspension of Alcian Blue dye, using a dental inoculator (Mizzy, Inc., Clifton Forge, Virginia). This method produces a bright blue dot from 2-4 mm in diameter which persists for two years or more. Many fish marked by this method in the Sagavanirktok River delta in 1982 (Griffiths et al. 1983) were recaptured in 1983 and 1984 (WCC 1983, Moulton, Fawcett and Carpenter 1985, Moulton et al. 1985). A few continued to be captured in 1985 (Envirosphere 1986). The dots were applied at different sites on the right or left sides of the fish to indicate the station at which they were marked and released. Anaesthetized fish were allowed to recover in a floating live pen before being released.

2.2.2 Lower River Study

2.2.2.1 Net Deployment

Fyke and hoop net sampling was conducted at five stations shown in Figure 2. The sampling duration at each station is shown in Table 1. Hoop nets were initially installed at Stations 202, 203, 204, and 661. Each hoop net consisted of a series of five circular steel frames, each 1.2 m in diameter, supporting a knotless nylon bag of 1.27 cm stretched mesh.

At each station a single hoop net was installed near the shore with the mouth facing downstream. A wing varying from 15 to 23 m in length stretched from the hoop net to the shore. A second 15 m wing was set offshore, angled downstream from the hoop net, as shown in Figure 4. Wings were 0.9 m deep and were composed of 2.5 cm knotless nylon mesh. In an attempt to increase fish catches, an additional 15 m wing, 2.4 m deep was added to the offshore wing of each net on July 16.

On July 29 Station 205 was installed, using a fyke net instead of a hoop net, with an offshore wing 61 m long. It was found that fyke nets were much easier to service than hoop nets and fished more effectively during periods of low water, so all the hoop nets were replaced with fyke nets during August 6 to 8. At the same time the offshore wings were increased to total lengths of 45 to 61 m, depending on depths and currents. For most species, this modification had little immediate effect on catch rate because arctic cisco, least cisco, large broad whitefish and char were virtually absent from the lower river until later in August. The greatest immediate increase in catch was with round whitefish.

The downstream orientation of the river hoop nets and fyke nets was designed to deflect current to relieve stress on the nets during high water. All stations were in low velocity areas when water level was moderate to low. The stations were selected based on subjective judgement that the areas were where fish movement would be expected within or between feeding areas or to upstream spawning or wintering areas. During normal mid-summer flow the velocity in most of the lower river was low and fish probably showed little response to flow.

2.2.2.2 Water Quality Measurements

Surface water temperature, water level, and wave height were recorded at each station on each sampling day. Temperature was measured with a hand-held Taylor thermometer checked for accuracy by comparison to a certified thermometer. Water level and wave height were estimated from a staff gage identical to those used at the delta stations.

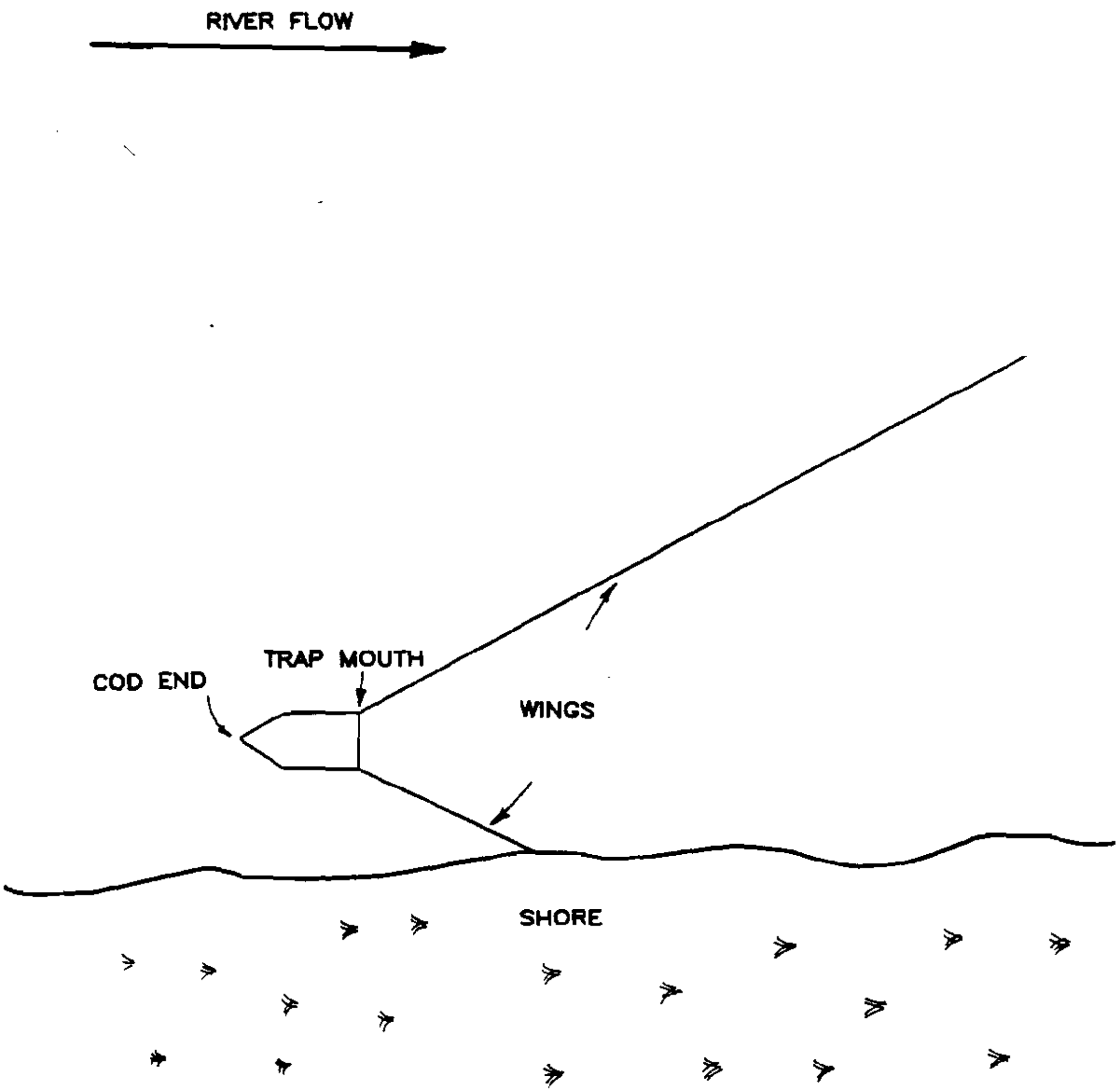

Figure 4. Schematic diagram of hoop or fyke net used in lower river study.

2.2.2.3 Daily Fish Sampling and Marking

Fish were handled and marked in the same manner as described above (Sections 2.2.1.3 and 2.2.1.4) for the outer delta stations.

2.3 LABORATORY METHODS

Samples of the four target species were retained from the net catches throughout the open water season for aging, length-weight analysis, and evaluation of maturity. Fish spanning the observed size range of each species were collected, with an attempt made to obtain 15 specimens of each species in each 50 mm size class.

2.3.1 Dissection

Fresh fish were kept cool or on ice until dissection could be performed (within 24 hours). Whole fish were weighed to the nearest gram on a triple-beam balance and fork length measured to the nearest millimeter. Otoliths were removed, cleaned, and placed in a labeled vial. The body cavity was then opened and the gonads located. Fish were identified as male or female based on the shape, size, color, and texture of the gonads. Young and immature fish were often difficult to separate into males and females due to the undeveloped state of the gonads.

The Nikolski classification of maturity (Lagler 1978) was used, with some modification. The classification scheme used was as follows:

1. Immature - little gonad development, difficult to distinguish males from females.

2. Immature/Resting stage - males and females distinguishable, but gonads small. Eggs very small, but distinguishable to the naked eye, testes transparent or pale pink. These fish would not have spawned in the present year.

3. Maturation - gonads developing for spawning in the present year, eggs larger than stage 2 eggs, testes pale pink and larger.

4. Maturity - gonads large and ripe, eggs fill body cavity, but sexual products not extruded when light pressure applied to the belly.

5. Reproduction - sexual products extruded when light pressure applied to the belly.

6. Spent - sexual products discharged, gonads deflated, residual eggs and sperm may be present, genital aperture inflamed.

2.3.2 Aging

Small otoliths (from young fish) were cleared by soaking in 50 percent glycerin for several days to two weeks. Cleared otoliths were examined in 50 percent glycerin under a dissection microscope at 15-25X magnification. The dark circuli distinguished by the clearing process were counted, beginning with the smallest one surrounding a light-colored center. The number of circuli was recorded, with a "+" if new, light-colored growth outside of the largest ring was observed. Otoliths were examined again several days later or by a second person and a second reading recorded. If the two ages were not the same the otoliths were examined a third time or circuli were counted by the cross-sectional burn technique (described below) to obtain the best possible age estimate. Otoliths were stored dry after the final reading.

Large otoliths, from fish older than about six years, generally cannot be aged by surface readings as the rings are crowded at the outer edge. Most of the large otoliths were not cleared in glycerin, but aged by the cross-sectional burn technique (Chilton and Beamish 1982). The otolith was first broken in two across the widest part. The exposed cross-sectional surface was then gently polished smooth on a whetstone. The polished edge was held briefly over a candle flame, just long enough to become light brown, after which it was once again lightly polished. The otolith was coated with 50 percent glycerin and the polished edge examined under the microscope. The heavy, dark circuli marking the first few years correspond to the circuli visible by surface readings. The rings become finer and more closely spaced after 5 to 7 years, but usually were visible in cross section. The age recorded was the number of heavy, dark circuli, plus the number of finer rings outside the heavier ones.

Otoliths of ages 1 to 17 years were examined by surface and cross-sectional methods to check the consistency between methods. Ages corresponded well between methods for ages up to 10 to 15 years, with some differences of 1 to 2 years noted. Otoliths from fish of about 15 years and older show few or none of the growth rings from the surface, thus could not be aged reliably except by a cross-sectional method. Westrheim (1973) had similar results for otolith readings with good consistency up to four years and decreasing consistency between readers for older fish. Because of the lack of consistency in reading older otoliths, Boehlert and Yoklavich (1984) suggest that cross-section ages are more accurate than surface readings. Ages determined by cross-sections tend to be higher than surface readings, as was the case in the Colville River samples.

2.4 DATA MANAGEMENT AND ANALYSIS

2.4.1 Management

All data were recorded onto waterproof paper in the boats at the time measurements were made. At the end of each day data sheets were reviewed for completeness, legibility, and out-of-range values. The data collected from the outer delta were brought to Nuiqsut at the end of the week.

Data were entered into an Entrix database management system in Nuiqsut utilizing customized data entry programs. All data were double-entered and verified. Following data entry, a number of programs were used to check for incomplete or unusual data values. Edited copies of the data were archived on magnetic tape and floppy disks.

2.4.2 Analyses

2.4.2.1 Fish Catches

Catch per unit effort was calculated as the number of fish caught per day (24 hours). At the outer delta stations, where double trap fyke nets were used, the same start and end times were used for both traps.

2.4.2.2 Growth

In order to determine growth rates of small fish during the summer, size frequency plots and otolith-based age data were used to follow the average length of different age groups throughout the sampling season. In most cases the separation of age groups by size mode was relatively clear. The size ranges used for calculating a mean size by week for each age group are listed in Appendix Table A-47. Annual growth, as mean length at age, was estimated from otolith readings of fish collected throughout the summer.

2.4.2.3 Length-weight Relationships

Regressions of the log transformed fork length and weight values for each species were used to determine the values of the constant (a) and the exponent (b) in the equation $W = aL^b$. The regression was performed for immature, male, and female fish combined for each species in order to make comparisons with previous studies. If adequate sample sizes were available the regression was also performed for separate sexes and immature fish.

The differences between regression lines for male, female, and immature fish were evaluated by analysis of covariance. For non-significant differences the groups were combined for further comparisons. Regression lines were calculated for tagged arctic and least cisco captured in the Colville Delta fishery in 1984 and 1985. Comparisons were made between tagged fish that were recaptured one or two years after tagging and those that had been tagged in the same year as recaptured. Comparisons between tagged and untagged fish were not possible because tagged fish recovered in the fall fishery freeze prior to measurements and there is significant shrinkage (paired t-test, $p \leq .01$) of the fish between lengths measured live and lengths measured frozen.

3.0 RESULTS

3.1 OUTER DELTA STUDY

The outer delta sampling effort extended from July 2 to September 11. A final attempt to set the nets on September 15 was abandoned when high winds, rough seas, and ice in the nets prevented the crew from processing the fish on September 16. Demobilization took place on September 17 and 18, and freezeup occurred on September 23. Three fyke nets (locations shown in Figure 2) were fished for a cumulative effort of 115.8 days. The duration of fishing for each net is shown in Table 2; a complete table of effort for each day of the study is provided in the Appendix (Table A-1).

3.1.1 Environmental Conditions

The 1985 open-water season for the Colville River lasted for 115 days, from breakup on May 31 to final freezeup on September 23 (J. Helmericks, pers. comm.). The weather pattern was dominated by northeasterly winds, particularly in June and July (for example July 16-24) (Figure 5). Wind direction was more variable in August and September, but the winds still were mainly from the east through mid-September. Easterly and southerly winds generally result in lowered water level along the Beaufort Sea coast (WCC 1983, 1984), but this effect was often masked on the Colville River by the effects of runoff from snowmelt and rainfall in the Brooks Range. Westerly and northerly winds were associated with higher water level in the delta and river at least as far upstream as Nuiqsut (Figures 6 and 10).

Westerly and northerly winds along the Beaufort Sea coast often result in shoreward movement of a subsurface layer of cold, high salinity marine water (WCC 1983, 1984). A deep layer of cold marine water was detected on two occasions in 1985 (July 26 and August 29) during mid-channel salinity surveys. However, the only corresponding effect observed at the shoreline fyke net

Table 2. Total catch and species composition from outer delta fyke nets, summer 1985.

Species	Total	Percent of Total Catch	Percent of Anadromous Catch
ANADROMOUS			
Least cisco	19,256	50.4	60.2
Broad whitefish	4,734	12.4	14.8
Arctic cisco	4,172	10.9	13.0
Humpback whitefish	2,801	7.3	8.8
Rainbow smelt	783	2.0	2.4
Char	251	0.7	0.8
Pink salmon	1	<0.1	<0.1
MARINE			
Fourhorn sculpin	4,078	10.7	
Arctic flounder	272	0.7	
Saffron cod	12	<0.1	
Arctic cod	8	<0.1	
FRESHWATER			
Round whitefish	1,499	3.9	
Arctic grayling	326	0.9	
Longnose sucker	29	0.1	
Ninespine stickleback	9	<0.1	
Burbot	5	<0.1	
TOTAL	38,236		

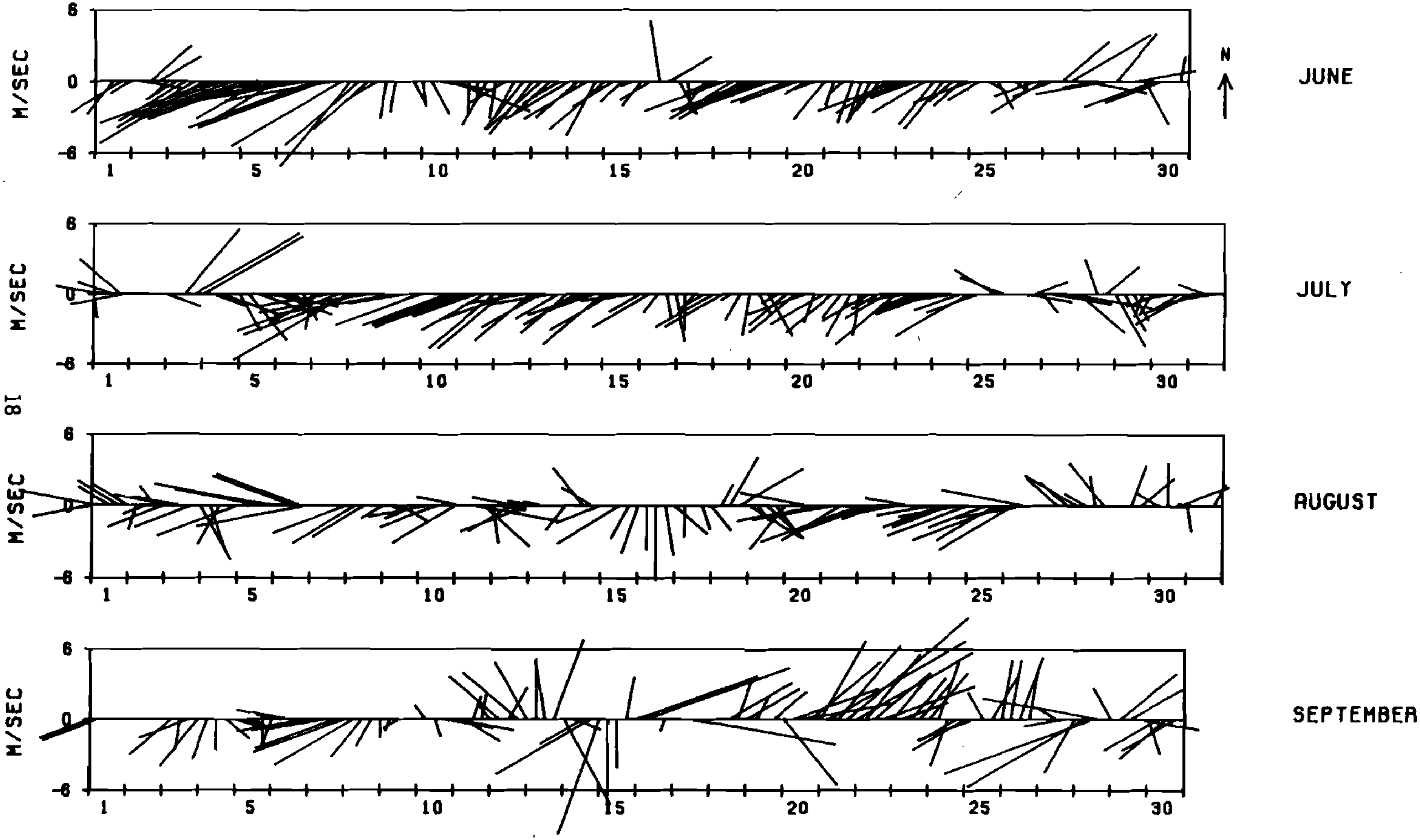

Figure 5. Wind speed and direction measured at Oliktok Point, summer 1985. Sticks point in the direction toward which the wind is blowing. Stick length is proportional to wind speed.

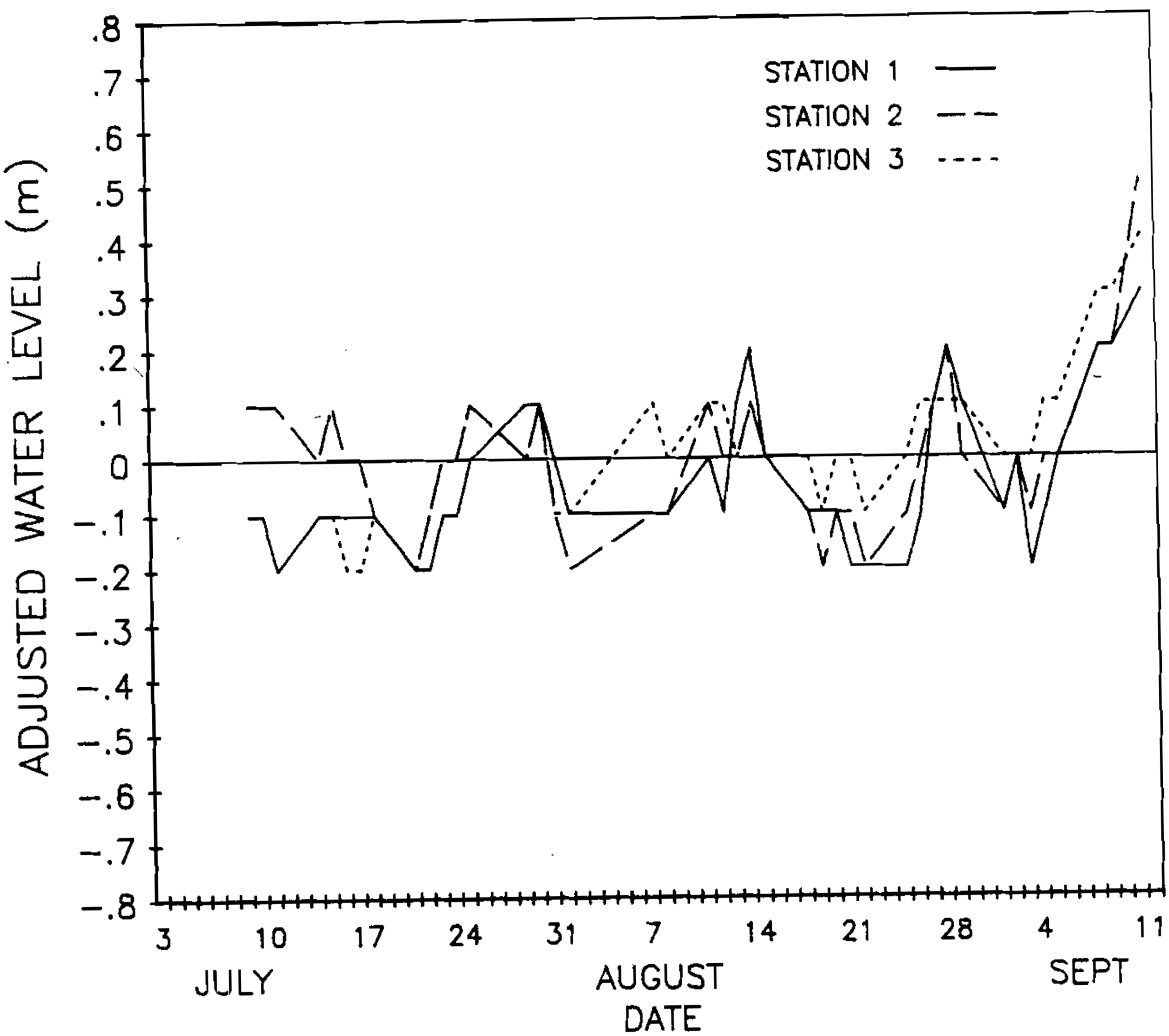

Figure 6. Water level at delta sampling sites, adjusted to the mean water level (mean = 0).

stations was an increase in salinity on August 29 and 30 at Stations 1 and 3 (Figure 7 and 8). The highest salinity observed at any of the fyke net stations was 12.8 ppt, which occurred on August 8 at Station 1. Each of the three observed intrusions of marine water was associated with a brief period of westerly winds (Figure 5).

In general, the salinities and temperatures recorded in 1985 at the outer delta fyke net stations indicate that there was slight mixing of river water and sea water at most times, and a gradual decline in water temperature from 10-12^{0}C early in the summer to 1-3^{0}C near freezeup.

Beginning in early September, air temperatures dropped below freezing and remained there. By September 11 ponds and small river channels were frozen, and a combination of high winds, strong currents, deep water, and spray icing of boats and fyke nets created difficult fishing conditions. By September 15, shallow areas along the banks of the river were frozen, and frazil (slush) ice and pans of solid ice were floating downriver. On the morning of September 18 the surface of the East Channel was frozen completely across the river in some places, but broke up again later in the day. Final freezeup occurred during the night of September 23.

3.1.2 Fish Distribution, Abundance, and Movements

A total of 38,236 fish were caught, representing 16 species. The total catch and percent contribution of each species is shown in Table 2. The four key anadromous species (arctic cisco, least cisco, broad whitefish, and humpback whitefish) comprised 81 percent of the catch. Tables of daily catch and catch per unit effort (CPUE) for all sizes, and catch for small (<120 mm), medium (120-249 mm), and large ($\geq$250 mm) fish of the four key species are provided in the Appendix (Tables A-6 through A-33). The use of 250 mm as the length for dividing fish into two size categories was continued for comparison with previous studies. In the 1984 Lisburne and Waterflood Fish Studies (Moulton, Fawcett and Carpenter 1985, Moulton et al. 1985) it was found that anadromous fish in those two size groups exhibited distinct differences in habitat preference, movements, and other aspects of behavior. The occurrence of large

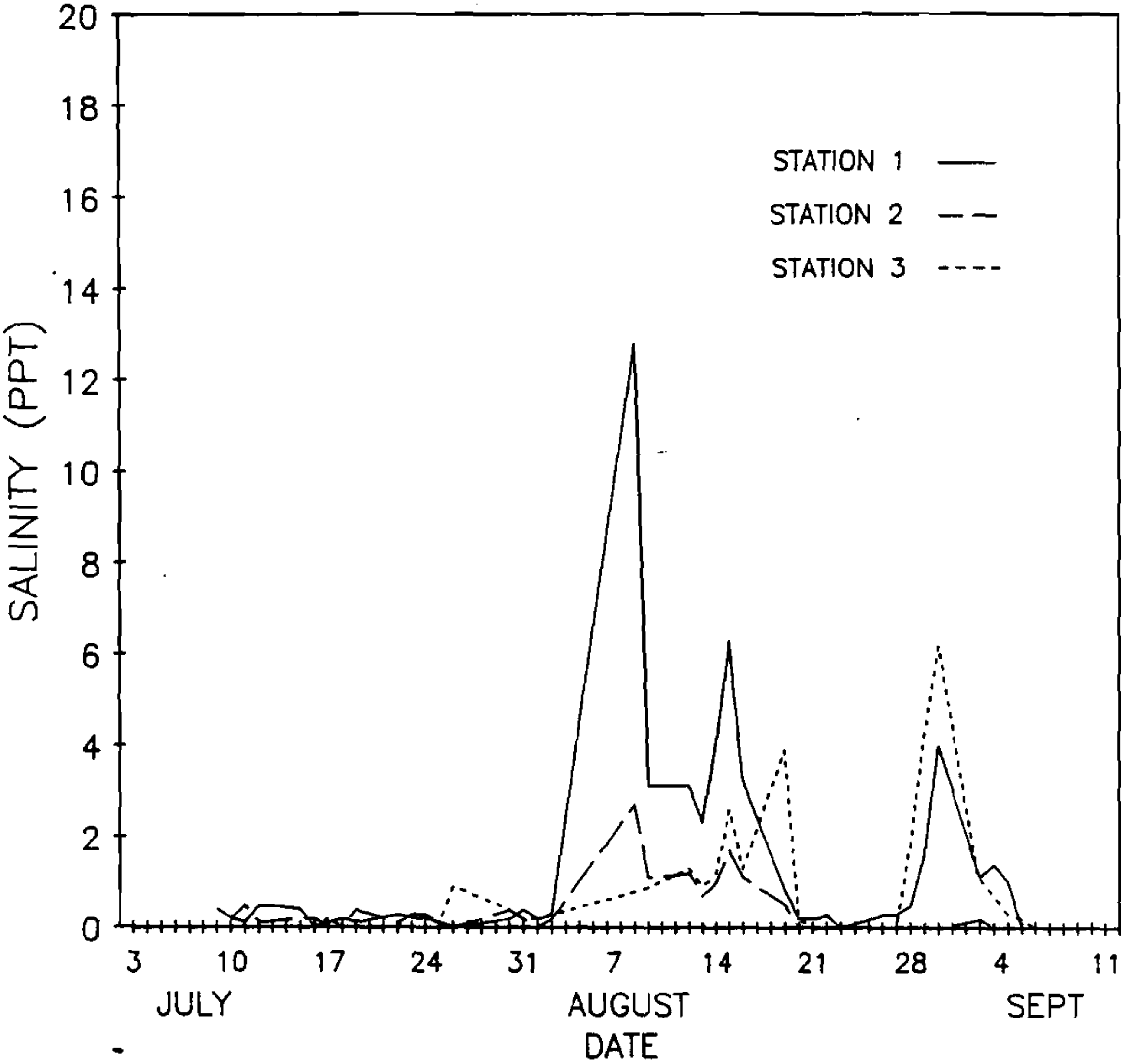

Figure 7. Surface water salinity measured at delta sampling sites, summer 1985.

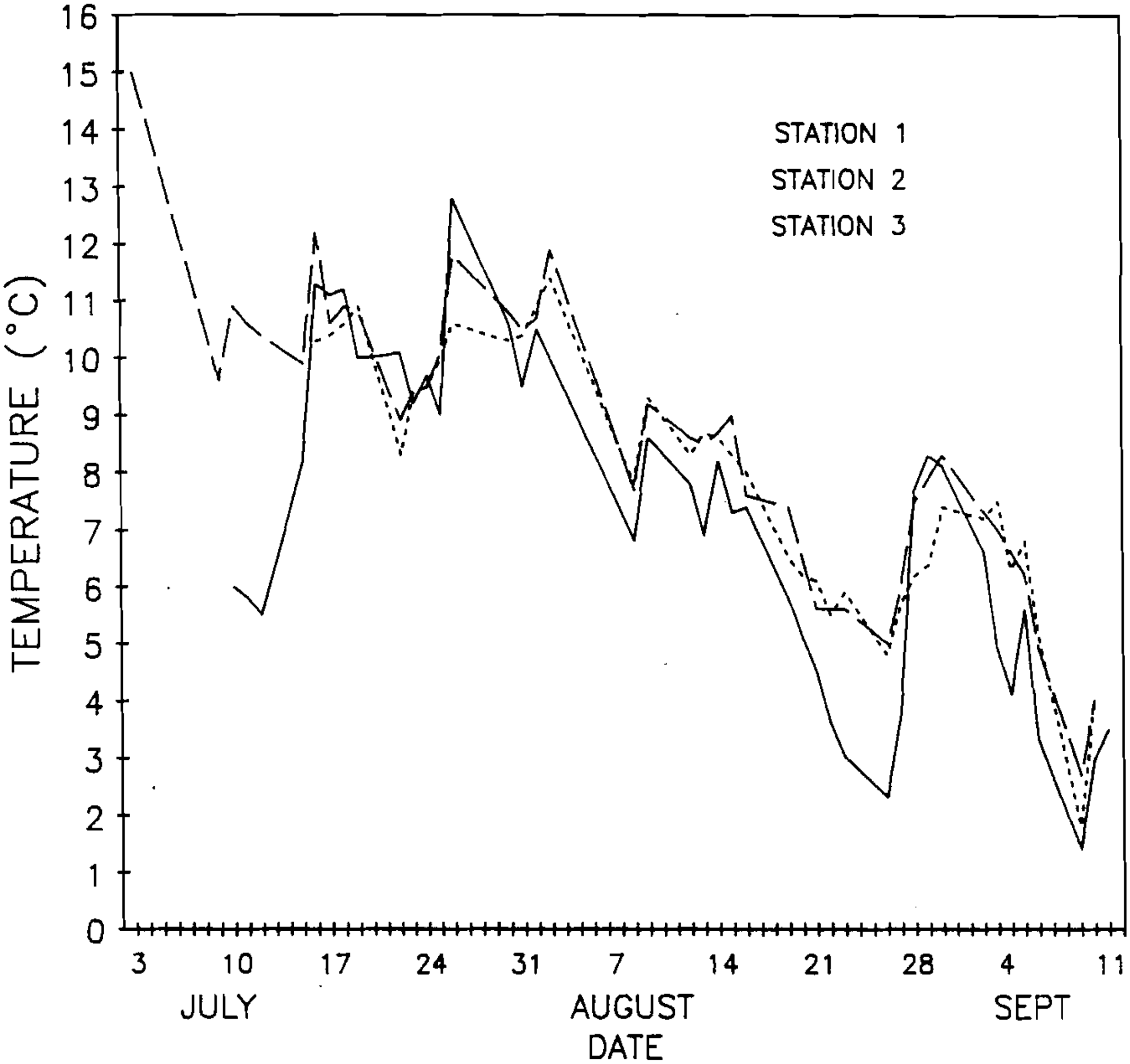

Figure 8. Surface water temperature measured at delta sampling sites, summer 1985.

numbers of small (<120 mm) fish of the four key species in this study suggested that a further division of fish into those less than 120 mm and those from 120 to 249 mm would be useful in enhancing our understanding of fish distribution, abundance, and behavior.

Total daily catch and CPUE for non-key species are provided in Appendix Tables A-34 through A-43.

Of the four key anadromous species, least cisco were by far the most abundant throughout the summer, followed by broad whitefish, arctic cisco, and humpback whitefish (Table 2). Arctic cisco were not abundant until the last three weeks of the study, whereas the other three species were caught consistently throughout the sampling period.

3.1.2.1 Arctic Cisco

Arctic cisco was the third-most abundant anadromous species captured in outer delta fyke nets (Table 2). The total number caught was 4,172, of which 92 percent (3,856) were captured during the last three weeks of sampling (Appendix Figure B-1). Some fish were in the area when sampling was begun in early July, but few were captured from then until the latter half of August.

Preferential use of the East channel of the Colville River is indicated by the much greater catches at Station 1 than at Station 3 in the Kupigruak Channel (Appendix Figure B-1). Preferential use of the East channel by arctic cisco has also been reported by J. Helmericks (pers. comm., 1985), based on many years of gill netting in the fall.

Approximately three-fourths of all arctic cisco captured at outer delta stations were classified as small (Appendix Table A-8). The subpopulation of small arctic cisco was apparently composed primarily of age-0 fish, i.e., the 1985 year class (see Section 3.3.1). This group of small fish appeared in the study area on August 26 and 27 (Appendix Figure B-2). The number of small fish increased during the following week (September 2 through 6) at Station 1 and appeared to be increasing further during the last week of sampling. A large catch of small arctic cisco occurred at Station 1 on September 11, the last day of sampling, but is not shown on Appendix Figure B-2. Bad weather on that day forced the crew to stop measuring fish of all sizes, so the actual numbers of small, medium, and large fish on that day are unknown. However, it was estimated that 90 percent of the 708 unmeasured arctic cisco (Appendix Table A-8) were small, which would make the CPUE over 750/24 hr.

Some large and medium-sized arctic cisco were present in the study area when sampling was begun in early July (Appendix Figures B-3 and B-4). Catches declined to low levels through the remainder of July and early August, as the fish presumably moved out into nearshore areas of the Beaufort Sea to feed. Arctic cisco began moving back into the delta in the second week of August and were consistently abundant from then until the end of sampling in September. Concentration in delta areas for overwintering as freezeup approaches is typical behavior for arctic cisco in the western Beaufort region (Griffiths et al. 1983, WCC 1983, Moulton, Fawcett and Carpenter 1985).

There were no consistent patterns of movement within the delta area revealed by the directional fyke net catches (Appendix Figure B-1, Appendix Tables A-10 through 12). Shifts in abundance from one side of a net to the other were not consistently related to any of the physical parameters measured. Similarly, the mark-tag recapture study did not provide sufficient information on movements to identify movement patterns. Relatively few arctic cisco were dye-dotted (534) or tagged (158) and most of the marking was done near the end of the sampling season. Four dye-dotted arctic cisco were recaptured during the open-water season, and of those four, only one was recaptured at a different station than where it was released. None of the tagged fish were recaptured during the open-water season. Five of the tagged arctic cisco were recaptured during the fall fishery. Four were recaptured in the lower delta near the point of release (Station 3 and Station 1) and the other moved from Station 3 into the Nigliq (Nechelik) Channel (Appendix Table A-46).

One arctic cisco freeze-branded by the Endicott Project was recaptured at Station 1. Release information was not provided. Four arctic cisco tagged by the Endicott Project in 1985 were recaptured at delta stations. Two of the tagged arctic cisco were tagged and released at West Beach in Prudhoe Bay (13 and 39 days earlier), the third was tagged and released at the Kuparuk Delta and the fourth at Oliktok Point (Appendix Table A-46).

3.1.2.2 Least Cisco

More least cisco were captured than any other species in outer delta fyke nets in 1985 (Table 2). There were 19,256 individuals caught, accounting for fifty percent of the total catch and sixty percent of the catch of anadromous fish. The highest catch rates occurred at Station 1, followed by Station 3 (Appendix Figure B-5).

About 73 percent of all the least cisco caught were less than 120 mm in length (Appendix Table A-15). Catches of small least cisco were initially high, declined in mid-summer, and rose again late in the summer (Appendix Figure B-6). Downstream movement in mid-July is suggested by the timing of high catches at Station 2 vs. Stations 1 and 3. In the second week of July high catches of small least cisco occurred at Station 2, while moderate numbers were caught at Station 1 (Station 3 was not in service yet). In the following week high catches occurred at Stations 1 and 3, and moderate catches at Station 2 further upstream. During the same two week period catches declined to low levels at the stations further upstream near Nuiqsut (see Section 3.2.2.2 below).

The catch pattern suggests that small least cisco moved down the river in July to outer delta and coastal areas to feed. A return migration in late summer is indicated by increased catches at delta and river stations in late August and early September (Appendix Figure B-7 and Section 3.2.2.2).

Medium-sized (120-249 mm) least cisco comprised about 22 percent of the total catch of least cisco at delta stations in 1985 (Appendix Table A-15). The pattern of abundance for medium least cisco (Appendix Figure B-7) is similar to that for small fish (Appendix Figure B-6). Initially high catches in early to mid-July declined to very low catches in late July to mid-August as the fish moved out into summer feeding grounds in coastal waters. The fish began returning to the delta in mid-August. The highest catches of the season occurred in the last week of August and first week of September. Catch rates were similar at Stations 1 and 3 throughout the sampling period; fewer fish were caught at Station 2.

Large ($\geq$250 mm) least cisco were scarce in the study area until mid-August (Appendix Figure B-8). Catches increased dramatically at Station 3 during the spawning run in late August. Samples taken for life history analysis during this time showed that many of the large least cisco were in spawning condition (Appendix Table A-49). Large fish comprised about four percent of the total catch of least cisco at delta stations.

As was the case with arctic cisco, little insight on movements of least cisco was gained from the directional fyke net catches. Changes in relative abundance from one side of a net to the other were not correlated with any of the physical parameters measured.

There were 3,765 medium least cisco dye-dotted at delta stations during the 1985 open-water season. Twenty-two (0.6 percent) of those fish were recaptured, but only eight were recaptured at a different station than where they were released. Five fish had moved from one delta station to another, and three were recaptured at river stations near Nuiqsut. Two additional least cisco with dye-dots were recaptured in the Endicott study area, one at Oliktok Point and the second on the west side of the West Dock causeway.

There were also too few tagged fish recaptured to provide detail on short-term movements in the river and delta. A total of 646 least cisco were tagged at delta stations. Two were recaptured one day after tagging and at the same station as released (such fish are not considered recaptures for purposes of analysis). Twenty-one tagged least cisco were recaptured during the fall under-ice fishery (Appendix Table A-46). Seven moved from the main channel stations 202, 204, and 205 to the delta near Station 3 or Station 1. The other fourteen were released from Stations 1, 2, and 3 and were recaptured in the outer delta. Eleven least cisco tagged in the concurrent 1985 Endicott Study were recaptured at Colville Delta stations (Appendix Table A-46). One least cisco freeze-branded by the Endicott Project in 1985 was recaptured at Station 3 (Appendix Table A-46). Release information was not provided. Twenty-four least cisco tagged near Prudhoe Bay in the 1984 Waterflood Monitoring Program Fish Study and one from 1982 were recaptured at delta and river stations in 1985 (Appendix Table A-46).

3.1.2.3 Broad Whitefish

Broad whitefish was the second-most abundant anadromous species captured in outer delta fyke nets in 1985 (Table 2). The 4,734 individuals caught represented twelve percent of the total catch and fifteen percent of the catch of anadromous fish. Appendix Figure B-9 shows how the catch of broad whitefish was distributed over the sampling period at each of the three delta stations. Catch rates at each station were relatively consistent throughout the sampling period, indicating that broad whitefish tended to remain within the delta area throughout the open-water period. This consistency was true for small, medium, and large fish (Appendix Figures B-10 to B-12). It was noted in previous studies in the western Beaufort Sea that broad whitefish tend to remain within the influence of their river of origin (WCC 1983, Moulton, Fawcett and Carpenter 1985, Moulton et al. 1985).

Small broad whitefish comprised about 51 percent of the catch of broad whitefish, medium-sized fish 41 percent, and large fish 6 percent (Appendix Table A-22).

There were 1,759 broad whitefish marked with dye dots at delta stations. Fifteen were recaptured at a different station than where released. Seven fish had moved from Station 2 to Station 1. Two fish moved from Station 3 to 1, and two from Station 3 to 2. The other moves by single fish were from Station 1 to 3, 1 to 2, 2 to 3, and 2 to 205. These results suggest free movement of broad whitefish between the two main river channels.

A total of 238 broad whitefish were tagged at delta stations. Two were recaptured during the open-water season, one at the same station eight days later, and the second one moved from Station 1 to Station 2 in 22 days

(Appendix Table A-46). One fish released at Station 3 was recaptured near Station 3 during fall subsistence fishing. Eight broad whitefish tagged in the Endicott study area in 1985 were recaptured at delta stations during the summer. Four of the tagged broad whitefish were released at the Kuparuk Delta, while another was released at Oliktok Point (Appendix Table A-46). One broad whitefish tagged and released in Foggy Island Bay on July 29 was recaptured 16 days later by a local fisherman in the Nigliq Channel, having traveled a distance of about 140 km (87 mi). Another fish moved from the west side of West Dock on July 29 to the Nigliq Channel (100 km) in 10 days. Two broad whitefish freeze-branded by the Endicott Project were captured at delta stations. Release information was not provided.

3.1.2.4 Humpback Whitefish

There were 2,801 humpback whitefish caught in outer delta fyke nets, representing seven percent of the total catch and nine percent of the catch of anadromous fish (Table 2). Daily CPUE for all humpback whitefish at each delta station is shown in Appendix Figure B-13. CPUE for small, medium and large fish is shown in Appendix Figures B-14 to B-16. Some humpback whitefish were present in the delta area throughout the open-water season, but catch rates for all three size groups tended to increase after the first week of August, then decline near the end of August.

Sixty-four percent of the humpback whitefish were small, 31 percent medium, and 4 percent large (Appendix Table A-29).

A total of 751 humpback whitefish were dye-dotted at outer delta stations. Three of these were recaptured at a different station than where released. Two moved from Station 2 to Station 1, and one from Station 1 moved upriver to Station 205.

There were 99 humpback whitefish tagged at delta stations. One was recaptured in the lower delta during the fall under-ice fishery. One humpback whitefish tagged in July 1984 in Gwydyr Bay was recaptured at Station 1 during the summer (Appendix Table A-46).

3.1.2.5 Char

There were 251 char captured at outer delta fyke nets, representing about one percent of the total catch of fish and one percent of the anadromous fish catch (Table 2). Char were caught in low but consistent numbers at Stations 2 and 3 in July and early to mid-August (Appendix Figure B-17). Few were caught at Station 1 until mid-August. Catch rates increased at all three stations in the third week of August, then declined to near zero by the end of the first week of September. The increased catches in late August indicate that char were leaving their summer feeding grounds in the Beaufort Sea at this time and moving up the river to spawning and overwintering grounds in spring-fed tributaries (see review in Moulton and Carpenter 1986). Increased catches of char at the lower river stations (Section 3.2.2.5) occurred about a week later than at the delta stations, which also suggests upstream movement.

One char tagged in the 1985 Endicott study was recaptured on September 10 at Station 2. It had been released at the Kuparuk Delta three days earlier (Appendix Table A-46).

3.1.2.6 Arctic Grayling

There were 326 arctic grayling captured in outer delta fyke nets, representing about one percent of the total catch (Table 2). Moderate numbers of grayling were caught at Stations 1 and 2 in July and early August, while few were caught in the Kupigruak Channel at Station 3 (Appendix Figure B-18). Catches declined to low levels after mid-August, indicating that most grayling had left the delta area and moved upstream. This is supported by continued catches of moderate numbers of grayling at river stations until early September (Section 3.2.2.6).

3.1.2.7 Round Whitefish

There were 1,499 round whitefish captured at outer delta stations, representing four percent of the total catch (Table 2). Daily CPUE at each station is shown in Appendix Figure B-19. Catch rates were highest in July and early August, declining from mid-August to the end of the sampling period.

3.1.2.8 Rainbow Smelt

Rainbow smelt was the fifth-most abundant anadromous species captured in the outer delta fyke nets, with 783 individuals representing about two percent of the total catch and two percent of the catch of anadromous species (Table 2). Daily CPUE at each station is shown in Appendix Figure B-20.

3.1.2.9 Fourhorn Sculpin

There were 4,078 fourhorn sculpin captured at outer delta stations, representing about eleven percent of the total catch (Table 2). Daily CPUE at each station is shown in Appendix Figure B-21. Fifty-seven percent of the fourhorn sculpin were caught at Station 1 (Appendix Table A-42). Appendix Figure B-22 shows that fourhorn sculpin were caught consistently throughout the sampling period.

3.2 LOWER RIVER STUDY

The lower river sampling effort extended from July 8 to September 6. Five nets were fished at the locations shown in Figure 2. The combined fishing effort for the five stations was 180.4 days. Table 1 shows the sampling schedule for each net. The sampling effort for each day of the study for each station is provided in the Appendix (Table A-1).

3.2.1 Environmental Conditions

Wind and weather patterns for the lower river study area were generally the same as described above (Section 3.1.1) for the outer delta area. Air and water temperatures (Figure 9) were higher in the lower river area than in the outer delta area, and fog occurred less frequently. Variations in water level were more extreme at the lower river stations than in the outer delta (Figure 10). On September 7 the water suddenly rose so high that the nets and staff

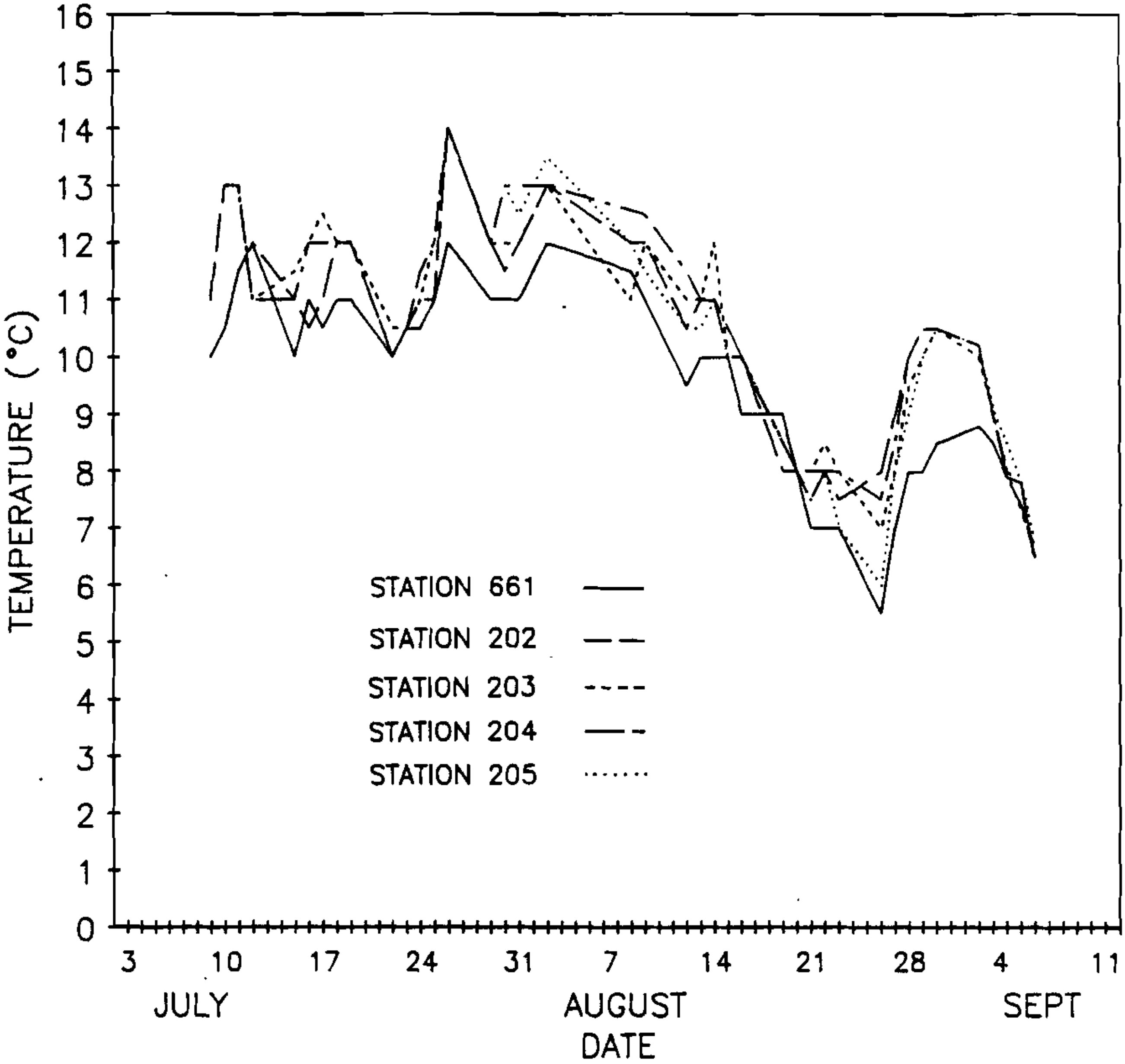

Figure 9. Surface water temperature measured at lower river sampling sites, summer 1985.

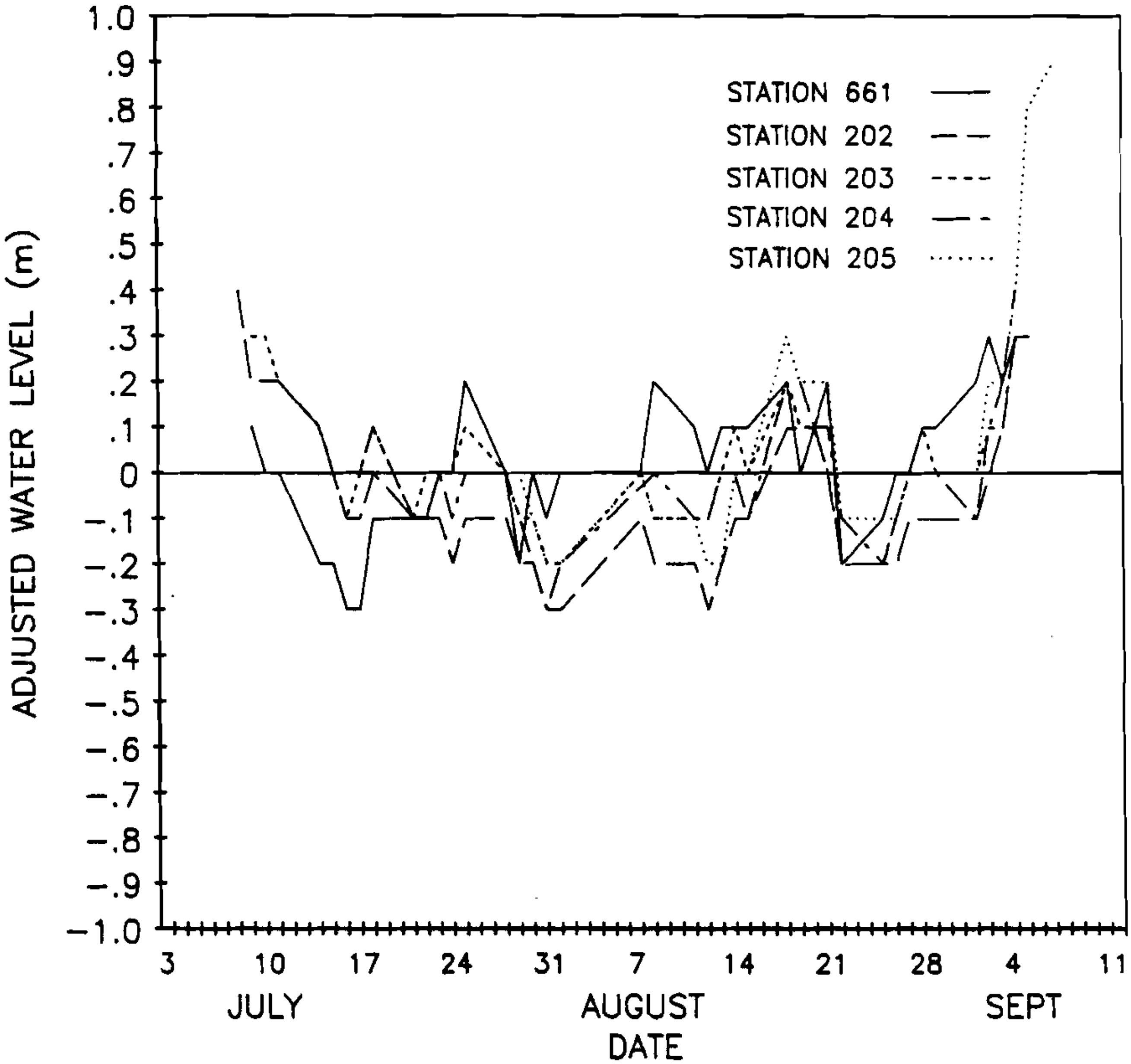

Figure 10. Water level at lower river sampling sites, adjusted to the mean water level (mean = 0).

gages were completely submerged or washed away. The water level remained high until freezeup, apparently due to rainfall in the Brooks Range.

3.2.2 Fish Distribution, Abundance, and Movements

A total of 11,205 fish were caught, representing 16 species. The total catch and percent contribution of each species is shown in Table 3. The four key anadromous species (arctic cisco, least cisco, broad whitefish, and humpback whitefish) comprised 61 percent of the catch. Tables of daily catch and CPUE for the four key species plus char, grayling, round whitefish, fourhorn sculpin and longnose sucker are provided in the Appendix (Tables A-6 to A-43).

Of the four key anadromous species, catches of least cisco were highest, followed by humpback whitefish, broad whitefish, and arctic cisco (Table 3). In general, catches of the key anadromous species were lower at lower river stations than at the outer delta stations (Table 2).

3.2.2.1 Arctic Cisco

Arctic cisco was the fifth-most abundant anadromous species captured in the lower river nets (Table 2). Only 52 individuals were caught. Daily CPUE for small, medium, and large fish is plotted in Appendix Figures B-22 to B-27. More than two thirds of the arctic cisco caught were medium-sized fish (Appendix Table A-9). Only three arctic cisco were captured at lower river stations prior to August 20 (Appendix Table A-6). The net at Station 205 caught the most arctic cisco (17), followed by Stations 661 and 202.

Thirty-one arctic cisco were dye-dotted and six tagged at lower river stations. None were recaptured. One freeze-branded arctic cisco from the Endicott Project was recaptured at Station 205. Release information was not provided.

Table 3. Total catch and species composition from lower river fyke and hoop nets, summer 1985.

Species	Total	Percent of Total Catch	Percent of Anadromous Catch
ANADROMOUS			
Least cisco	3,076	27.4	43.8
Humpback whitefish	2,472	22.1	35.2
Broad whitefish	1,253	11.2	17.8
Char	141	1.3	2.0
Arctic cisco	52	0.5	0.7
Rainbow smelt	25	0.2	0.4
Pink salmon	2	<0.1	<0.1
MARINE			
Fourhorn sculpin	705	6.3	
Saffron cod	1	<0.1	
FRESHWATER			
Round whitefish	2,018	18.0	
Longnose sucker	786	7.0	
Arctic grayling	510	4.6	
Burbot	134	1.2	
Ninespine stickleback	24	0.2	
Slimy sculpin	5	<0.1	
Arctic lamprey	1	<0.1	
TOTAL	11,205		

3.2.2.2 Least Cisco

There were 3,076 least cisco captured at the five lower river stations in 1985, representing 27 percent of the total catch and 44 percent of the catch of anadromous species (Table 3). Sixty-one percent of the least cisco were caught at Station 205 (Appendix Table A-13).

Small least cisco comprised 54 percent of the catch of least cisco at river stations (Appendix Table A-15). Daily CPUE for small least cisco is shown for each station in Appendix Figures B-28 to B-29. Small least cisco were present in moderate numbers in the study area during the second and third weeks of July, and then left the area, presumably moving downriver to coastal feeding grounds. The return migration began in late August, with peak numbers caught in the last week of August and first week of September at Station 205.

Medium and large least cisco showed essentially the same pattern and timing of abundance as described for small fish (Appendix Figures B-30 to B-33). A total of 1,072 (35 percent) medium and 350 (11 percent) large least cisco were captured at lower river stations.

There were 1,019 least cisco dye-dotted and 297 tagged at lower river stations. None were recaptured in the river during the open-water season. Four fish tagged at lower river Stations 202, 204, and 205 were recaptured in the outer delta during the under-ice fisheries (Appendix Table A-46).

Two least cisco tagged in the Endicott study area were recaptured at river stations 203 and 205. Both of the tagged fish were released from Kuparuk Delta stations (Appendix Table A-46).

3.2.2.3 Broad Whitefish

Broad whitefish were third in abundance at lower river stations in 1985, representing 11 percent of the total catch and 18 percent of the anadromous catch (Table 3). About twice as many broad whitefish were caught at Station

205 as at either of the two stations next highest in abundance (Stations 661 and 202, Appendix Table A-20).

Small broad whitefish comprised 64 percent of the catch of broad whitefish at river stations, medium 29 percent, and large 7 percent (Appendix Table A-22). Daily CPUE of small, medium, and large fish at each station is plotted in Appendix Figures B-34 to B-39. The figures show that broad whitefish were present in the lower river area throughout the open-water season.

There were 338 broad whitefish dye-dotted at lower river stations. Three were recaptured. One had moved from the Nigliq Channel to the Main Channel (Station 661 to 205), one from Station 204 across the river to Station 205, and one from Station 203 downriver to Station 3.

Sixty-seven broad whitefish were tagged at lower river stations; none were recaptured during the open-water season. Two fish tagged in the main channel (Stations 202 and 205) were recaptured by local fishermen from under the ice in the lower Nigliq Channel in October.

3.2.2.4 Humpback Whitefish

Humpback whitefish were second in abundance at lower river stations in 1985 (Table 3). There were 2,472 individuals caught, comprising 22 percent of the total catch and 35 percent of the anadromous catch. Over half of the humpback whitefish captured at river stations were caught at Station 205 (Appendix Table A-27).

The catch of humpback whitefish was composed of 71 percent small fish, 26 percent medium fish, and 3 percent large fish (Appendix Table A-30). Daily CPUE for small, medium, and large fish is shown in Appendix Figures B-40 to B-45. Catch rates for all size groups generally increased in mid-August at all stations. This increase occurred about a week later than at delta stations (Section 3.1.2.4 above), which suggests an upstream migration. The wings were lengthened at all the river stations except Station 205 during August 6-8, but catches did not increase substantially until the following week. Therefore, the observed increase in catch rates probably reflects a true increase in the density of fish in the area.

There were 631 humpback whitefish marked with dye dots at lower river stations in 1985. One fish marked at Station 205 was recaptured downriver at Station 2. Forty-two fish were tagged at river stations, and none were recaptured. One humpback whitefish tagged and released on the west side of Prudhoe Bay in 1984 was recaptured at Station 204.

3.2.2.5 Char

There were 141 char captured in lower river nets in 1985, representing about one percent of the total catch and two percent of the anadromous catch (Table 3). Eighty percent of the char were caught after August 25, mostly during the week of August 26-30 (Appendix Figures B-46 and B-47). Char at that time were probably on their way upstream to spawning and overwintering areas in spring-fed tributaries such as the Anaktuvuk River (Bendock 1980, 1981, 1982, 1983, Bendock and Burr 1984a).

One char tagged near the West Dock in 1982 was recaptured on August 16 at Station 661.

3.2.2.6 Arctic Grayling

There were 510 arctic grayling captured at lower river stations in 1985, representing about five percent of the total catch (Table 3). Daily CPUE at each station is shown in Appendix Figures B-48 and B-49. Catch rates did not vary greatly during the sampling season, suggesting that grayling in the lower river area are summer-long residents.

3.2.2.7 Round Whitefish

Round whitefish was the third-most abundant species captured in lower river nets (Table 3). The 2,018 individuals caught comprised 18 percent of the total catch at river stations. Round whitefish were consistently more abundant at Station 661 in the Nigliq Channel than at the other stations (Appendix Figures B-50 and B-51). Over fifty percent of all the round whitefish caught at river stations were caught at Station 661 (Appendix Table A-38).

3.2.2.8 Fourhorn Sculpin

There were 705 fourhorn sculpin caught at lower river stations in 1985 (Table 3). Daily CPUE at each station is shown in Appendix Figures B-52 and B-53, which shows that most (72 percent) of the fourhorn sculpin were caught at Station 661 in the Nigliq Channel. Few sculpin were caught before July 20, but catch rates were fairly consistent from then until the end of the sampling period.

3.2.2.9 Longnose Sucker

Longnose sucker comprised seven percent of the total catch at lower river stations (Table 3). Catch rates were highest in July and early August (Appendix Figures B-54 and B-55).

3.3 LIFE HISTORY ANALYSIS OF KEY SPECIES

3.3.1 Arctic Cisco

3.3.1.1 Size and Age Structure

The size frequency distribution of arctic cisco for each week of sampling is shown in Figure 11. Three length modes are apparent. The group showing a modal size of 60 to 70 mm represents age-0 fish (based on otolith readings) in their first summer of growth. The size frequency distribution of small (<120 mm) arctic cisco in 5 mm size groups for the last three weeks of sampling is shown in Figure 12. A large peak of age-0 fish shows a mode at 70 to 74 mm for August 26 to 30. The mode decreases to 65 to 69 mm the following two weeks, probably as a result of the later arrival of the smaller, slower swimming members of the age group. By otolith readings the known size range

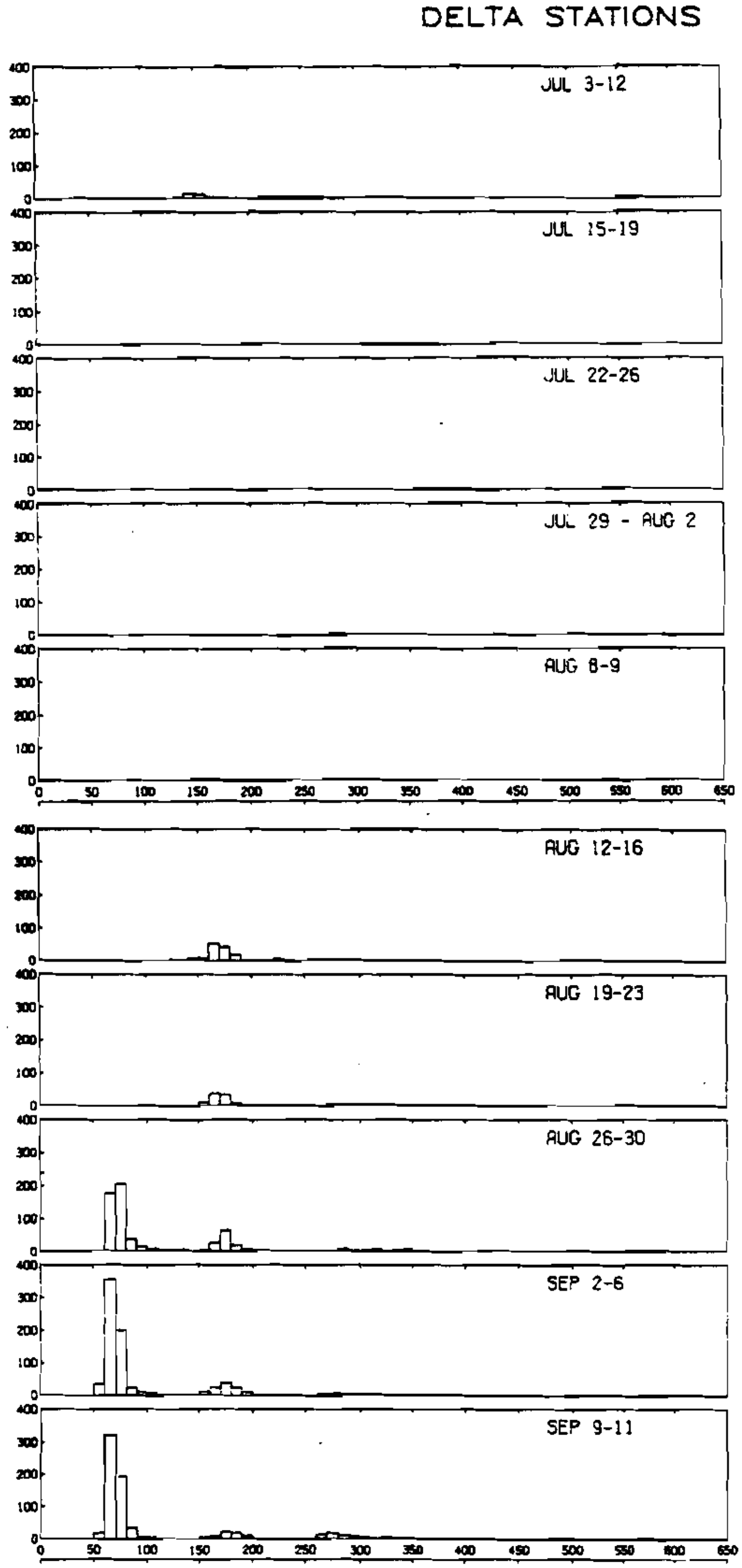

Figure 11. Size frequency of arctic cisco by week of sampling.

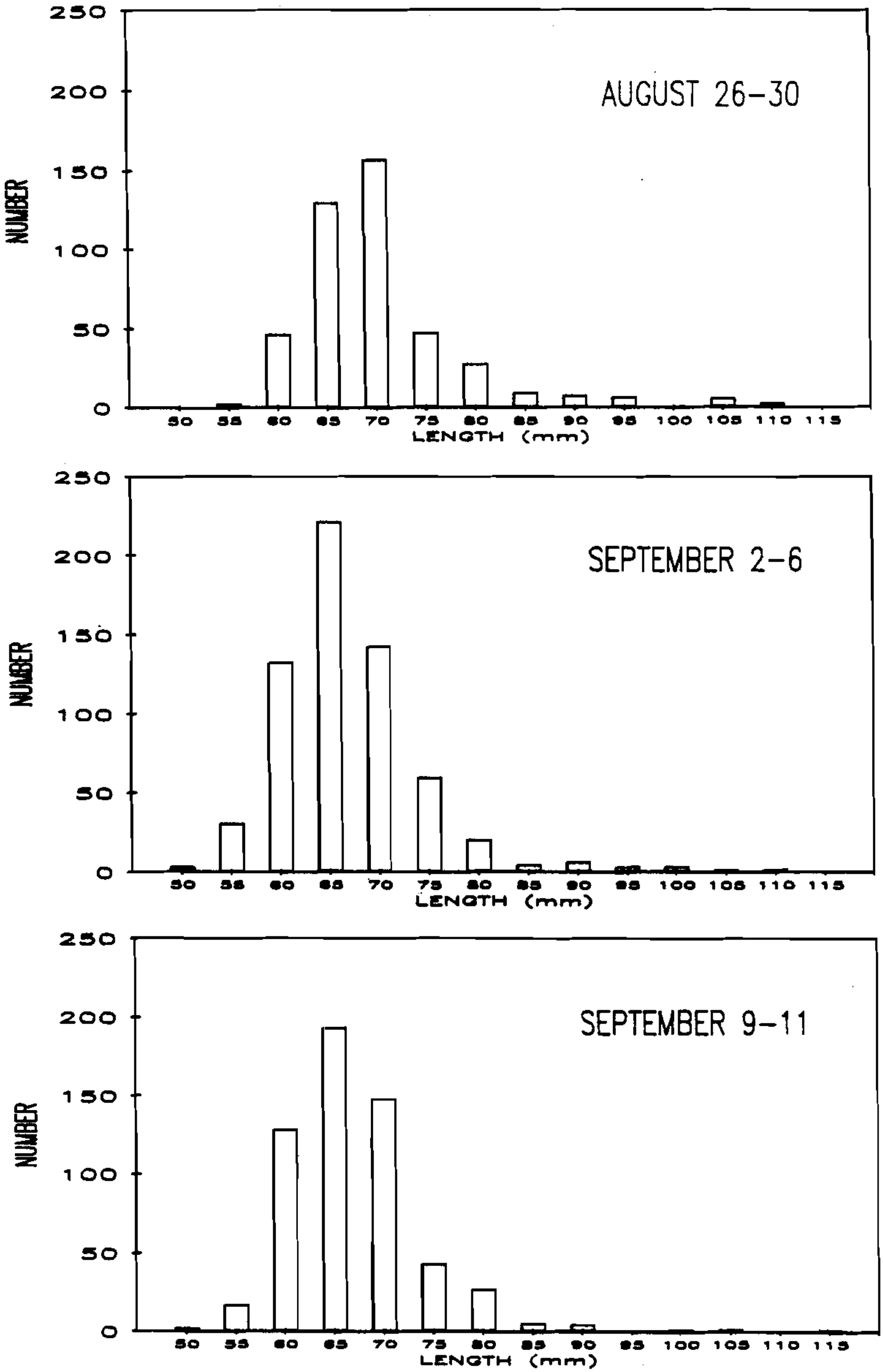

Figure 12. Size frequency of small (<120 mm) arctic cisco in 5 mm size groups for three weeks in late summer.

of age-0 fish was 62 to 80 mm and for age-1 fish was 82 to 98 mm. The age-1 group is weakly represented, showing a mode at 85 or 90 mm.

The group of arctic cisco with a late-summer mode of 160 to 170 mm (Figure 11) represents the 1982 year class. The weakly represented group from about 250 to 320 mm in length in the last week of sampling probably consists of fish of the 1979 year class. The fish from 320 to 360 mm may represent the 1978 year class. The 1980, 1981, 1983 and 1984 year classes are virtually absent from the population in the Colville delta.

3.3.1.2 Growth and Maturity

Growth rates were calculated from the mean length of the size groups pictured in the length-frequency histograms. The size ranges used for calculating weekly means are listed in Appendix Table A-47. Age-0 and age-1 arctic cisco appeared only during the last three weeks of sampling, thus growth rates could not be calculated for those age groups. Age-3 fish had a mean length of 151 mm when sampling began in early July (Figure 13). When they reappeared in mid-August the mean length of the sample was about 170 mm and eventually reached 177 mm by the end of sampling. The estimated growth rate was 0.45 mm/day through the end of August (Table 4). This growth rate is less than the estimated rate of 0.67 mm/day for the same group of fish (1982 year class) in the 1984 Prudhoe Bay study (Moulton, Fawcett and Carpenter 1985) or the estimated 0.52 mm/day for similar size fish in the 1982 Endicott study (Griffiths et al. 1983).

Mean length at age for arctic cisco collected in 1985 is shown in Figure 14. Growth appears to slow at about seven to eight years of age. Few fish older than age-7 were captured in the Colville or Prudhoe Bay areas. It is assumed that arctic cisco mature at age 7 to 8 and migrate to the Mackenzie River to spawn, thus are scarce in the western Beaufort Sea. Mean lengths at age for arctic cisco collected from Prudhoe Bay and the Colville River are compared in Figure 15. There is considerable variation between growth curves for age-5 and older 1984 Prudhoe Bay fish and the other sample groups. Age-1 to age-4 fish from the 1985 Colville River sample were relatively small as compared to the other samples. The mean sizes of older (ages 5 to 7) fish were smaller

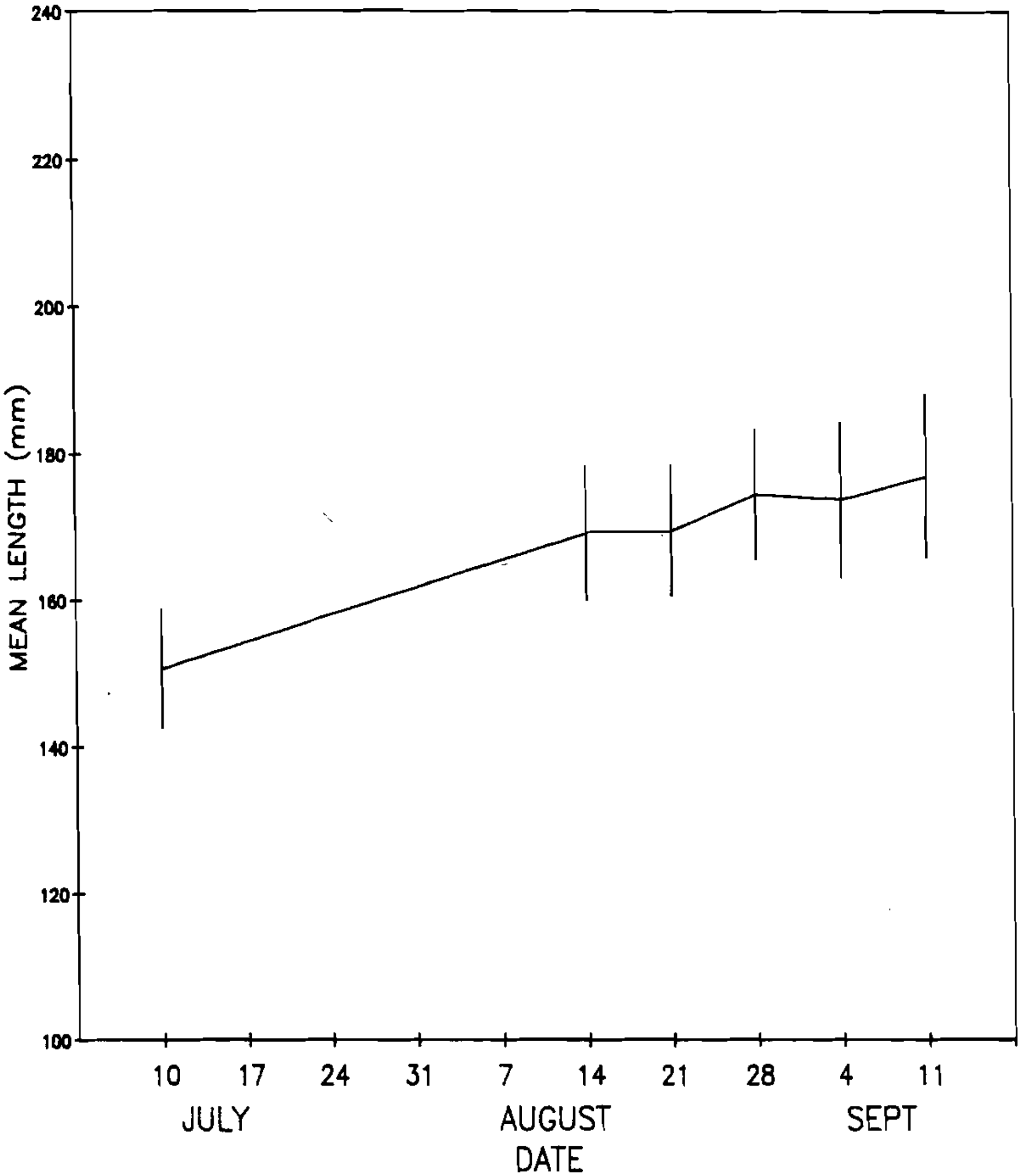

Figure 13. Mean length of age-3 arctic cisco by week of sampling.

Table 4. Summer growth and growth rates for 0 to 3 year old fish.

Age	Year Class	Date	Start Length (mm)	Std. Dev.	Date	End Length (mm)	Std. Dev.	Growth Rate (mm/day)	Source
Arctic cisco									
2	1982	6/22	90	15.0	8/31	130	10.0	0.67	2
3	1979	7/7	135		9/11	170		0.52	3
3	1982	7/8	151	8.0	8/30	174	8.8	0.45	1
Least cisco									
0	1985	8/12	56	13.9	8/30	61	8.8	---	1
1	1984	7/8	72	5.8	8/30	99	7.9	0.52	1
2	1983	7/8	109	7.1	8/30	134	7.1	0.48	1
Broad whitefish									
0	1985	7/22	47	4.7	8/30	62	6.7	0.42	1
0	1984	7/22	55		8/31	70		---	2
1	1984	7/8	80	13.1	8/30	116	12.8	0.68	1
1	1983	7/22	75		8/31	125		0.83	2
1	1981	7/7	73		9/11	128		0.83	3
2	1983	7/8	129	10.2	8/30	158	10.2	0.55	1
2	1982	6/22	130		8/31	180		0.83	2
2	1980	7/7	125		9/11	174		0.73	3
3	1981	6/22	180		8/31	220		0.67	2
3	1979	7/7	198		9/11	251		0.78	3
Humpback whitefish									
0	1985	7/30	48	4.2	8/30	59	6.9	0.38	1
1	1984	7/22	81	6.8	8/30	98	6.3	0.44	1
2	1983	7/22	123	8.7	8/30	138	8.5	0.39	1

Sources:

1 this study
2 Moulton, Fawcett and Carpenter 1985
3 Griffiths et al. 1983

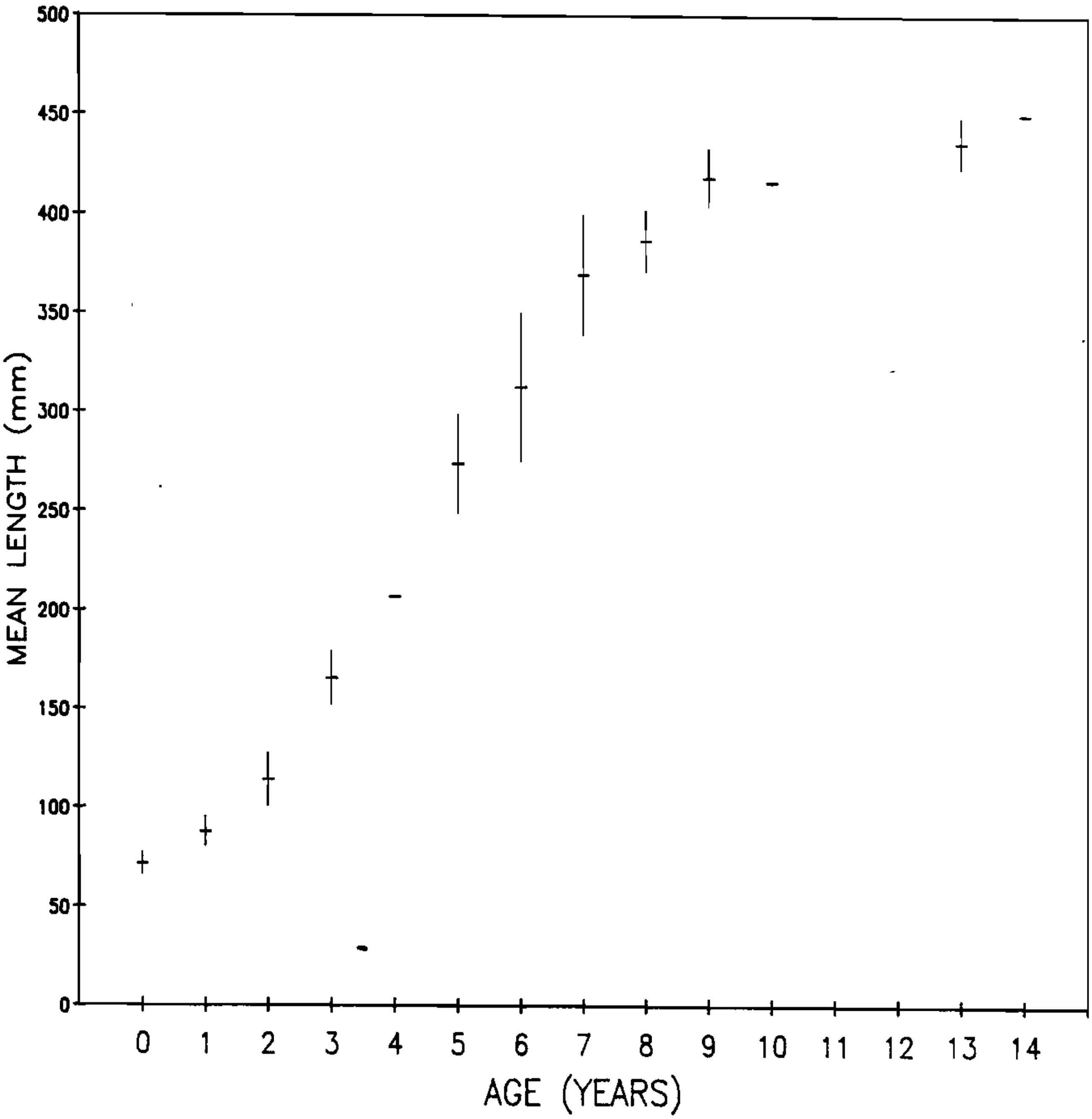

Figure 14. Mean length at age for arctic cisco.

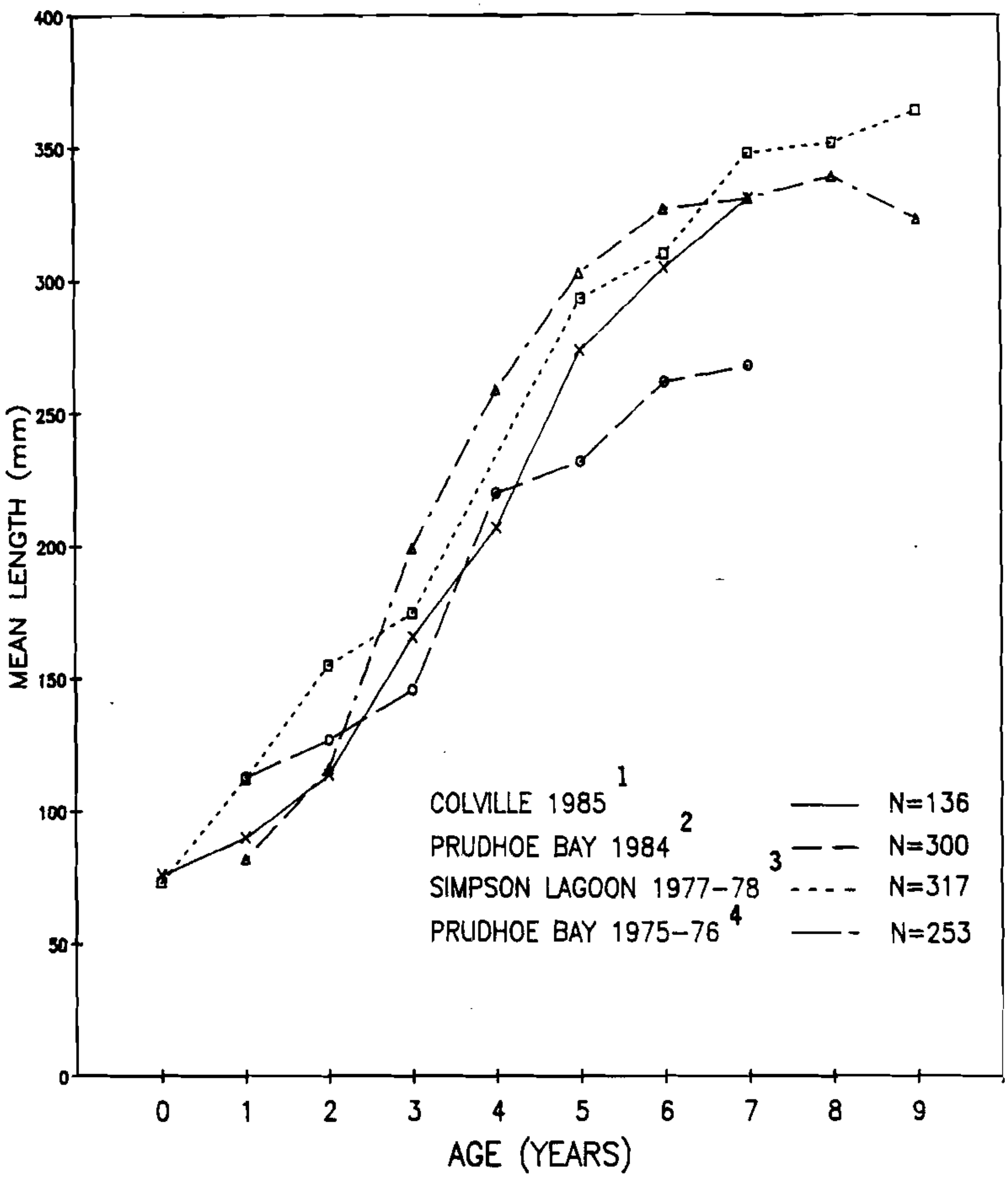

Figure 15. Mean length at age for arctic cisco collected in Prudhoe Bay and the Colville River region.

[1] this study

[2] Moulton, Fawcett and Carpenter 1985

[3] Craig and Haldorson 1981

[4] Bendock 1979

than those from previous studies (except 1984 Prudhoe Bay fish), but the differences become smaller with increasing age.

Growth of individual large fish tagged in 1984 and recaptured more than a year later is shown in Table 5. The increases in length were 30 to 53 mm with a mean growth rate of 0.338 mm/day over a 90 day summer growing season. These fish probably were sub-adults, ages 5 to 7. Their annual growth was similar to the mean annual growth for 300 to 350 mm arctic cisco shown in Figure 14. The growth rates were lower than those of younger fish shown in Table 4.

Analysis of covariance showed no significant difference between the regression lines for either mature or immature male and female arctic cisco (Appendix Table A-52). Thus, males and females were grouped and comparisons made between maturity classes. The length-weight relationship for the youngest immature fish (0-3 years) of unknown sex was significantly different from the relationship for immature female and male fish (ages 3-7), and the relationship for mature fish (ages 5-14) was significantly different from that for immature female and male fish. No significant differences were found between fish that had been tagged in two different years (1984 and 1985). There also was no difference between the fish that had carried a tag for over a year and those that were tagged recently.

A length-weight relationship for all sizes of arctic cisco captured in the Colville River delta was calculated from the data shown in Figure 16. The relationship is:

$$\log \text{weight (g)} = -5.6695 + 3.28 \log \text{length (mm)}$$
$$N = 122,\ r = 0.997$$

For comparison, previously reported length-weight relationships are:

$$\log \text{weight (g)} = -5.321 + 3.135 \log \text{length (mm)}$$
$N = 279,\ r = 0.991$ (Moulton, Fawcett and Carpenter 1985)

and

$\log \text{weight (g)} = -5.617 + 3.279 \log \text{length (mm)}$ (Craig & Haldorson 1981).

Table 5. Growth of arctic cisco tagged near Prudhoe Bay in 1984 and recaptured in the Colville Delta in 1985.

Release Date	Release Length (mm)	Recapture Date	Recapture Length (mm)	Length Increase (mm)	Estimated Growing Days[1]	ΔL/day (mm)
7-13-84	296	10-16-85	327	31	137	0.226
7-17-84	292	10-15-85	330	38	133	0.286
7-17-84	306	10-15-85	347	41	133	0.308
7-18-84	300	10-6-85	345	45	132	0.341
7-21-84	330	10-15-85	375	45	129	0.349
7-21-84	318	10-12-85	354	36	129	0.279
7-21-84	365	11-1-85	395	30	129	0.233
7-27-84	305	11-1-85	343	38	123	0.309
7-28-84	310	10-15-85	363	53	122	0.434
8-1-84	302	10-18-85	339	37	119	0.311
8-1-84	297	10-11-85	335	38	119	0.319
8-3-84	319	10-13-85	358	39	117	0.333
8-5-84	295	10-28-85	338	43	115	0.374
8-6-84	262	10-15-85	301	39	114	0.342
8-7-84	296	10-15-85	336	40	113	0.354
8-12-84	294	10-25-85	338	44	108	0.407
8-13-84	284	10-24-85	325	41	107	0.383
8-13-84	296	10-25-85	336	40	107	0.374
8-16-84	306	10-22-85	349	43	104	0.413
8-16-84	324	11-1-85	367	43	104	0.413
8-18-84	296	10-16-85	326	30	102	0.294
8-18-84	289	10-15-85	328	39	102	0.382
8-18-84	302	10-15-85	334	32	102	0.314
8-22-84	292	10-9-85	325	33	98	0.337

Mean ΔL/day = 0.338 mm/day
standard deviation = 0.054
N = 24

[1] assumes 90 day growing season beginning June 1 (see Moulton, Fawcett and Carpenter 1985)

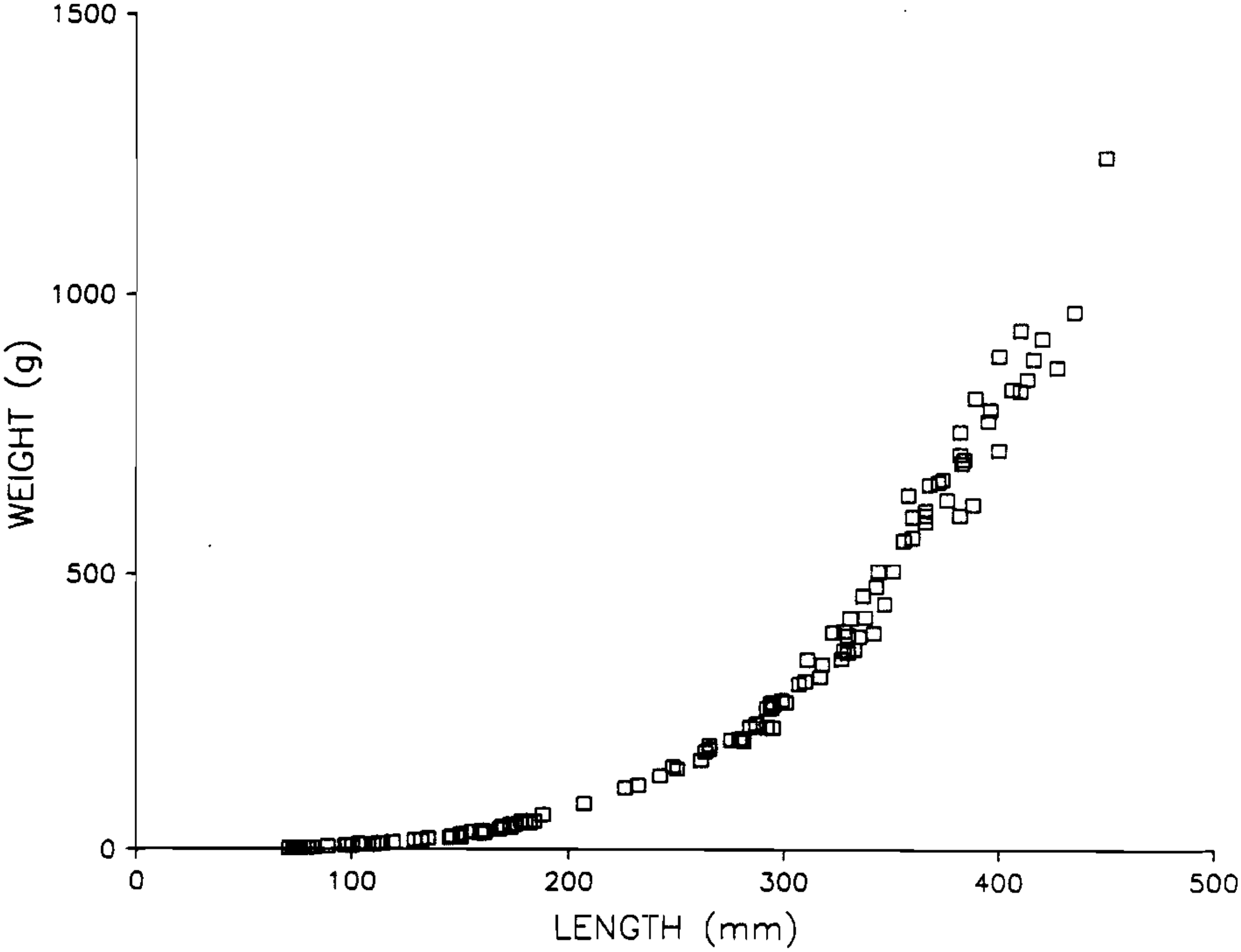

Figure 16. Scatter plot of length and weight data for arctic cisco collected in the Colville River, summer 1985.

For lengths up to 250 mm the relationship suggests that fish in the 1985 study were not as heavy as those from 1984 Prudhoe Bay studies, while for lengths greater than 250 mm the Colville River fish were heavier.

3.3.2 Least Cisco

3.3.2.1 Size and Age Structure

The size frequency distribution of least cisco shows three size modes during the first two weeks of sampling (Figure 17). Age-1 fish, with an initial size mode at 60 to 79 mm, were captured throughout the summer sampling at delta stations. By mid- to late August when age-1 fish again appeared in large numbers and at river stations the modal size was between 90 to 109 mm. Age-2 and age-3 least cisco appeared as size modes of 100 to 109 mm and 130 to 149 mm in early July. These size groups were rare or absent from all sampling sites for three to four weeks in mid-summer. By mid-August least cisco of all sizes were captured more often. The age-2 and age-3 groups appeared again and age-0 fish were first seen in the 40 to 69 mm range. In addition, fish greater than 200 mm in length were captured at both river and delta stations. The larger fish (greater than about 170 mm) showed little modal pattern. Ages as determined from otoliths show a great deal of overlap in the size ranges of four year old and older fish.

3.3.2.2 Growth and Maturity

Age-0 fish apparently grew from a mean of 56 mm to 61 mm over a two week period (Figure 18). This growth may be an artifact of choosing size groups from the size frequency distribution. For the first three weeks (August 12-30) the age-0 group included a relatively greater proportion of the larger size fish (60-79 mm) whereas during the last two weeks large numbers of age-0 fish were caught with a mode of 50 to 59 mm. The September means are based on a sample of over 500 fish and probably are a better estimate, thus no growth would be apparent from mid-August to early September. The mean size of age-1 fish increased from 72 mm in early July to 102 mm by the end of sampling in September. Age-2 least cisco had a mean length of 119 mm when sampling began,

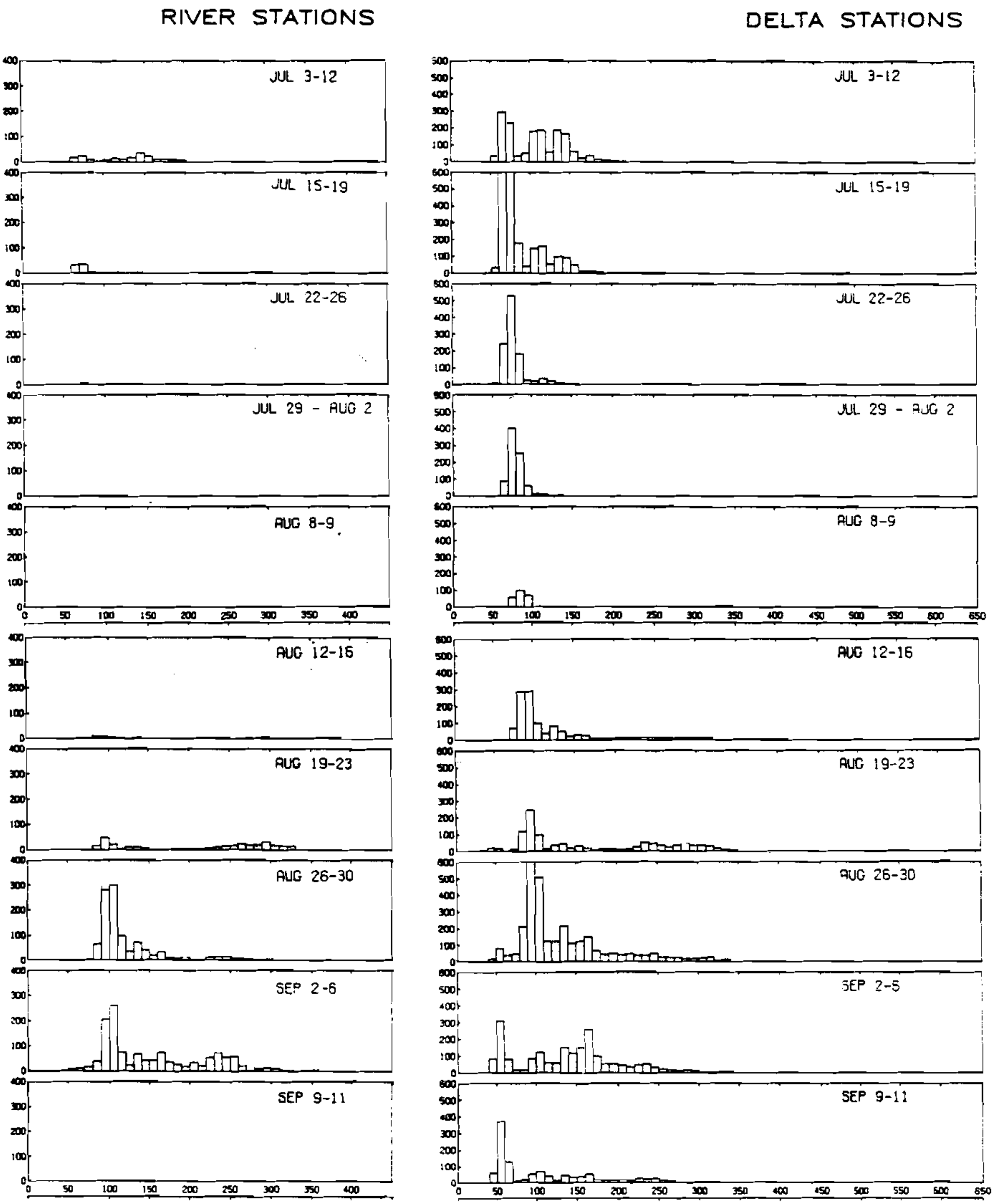

Figure 17. Size frequency of least cisco by week of sampling.

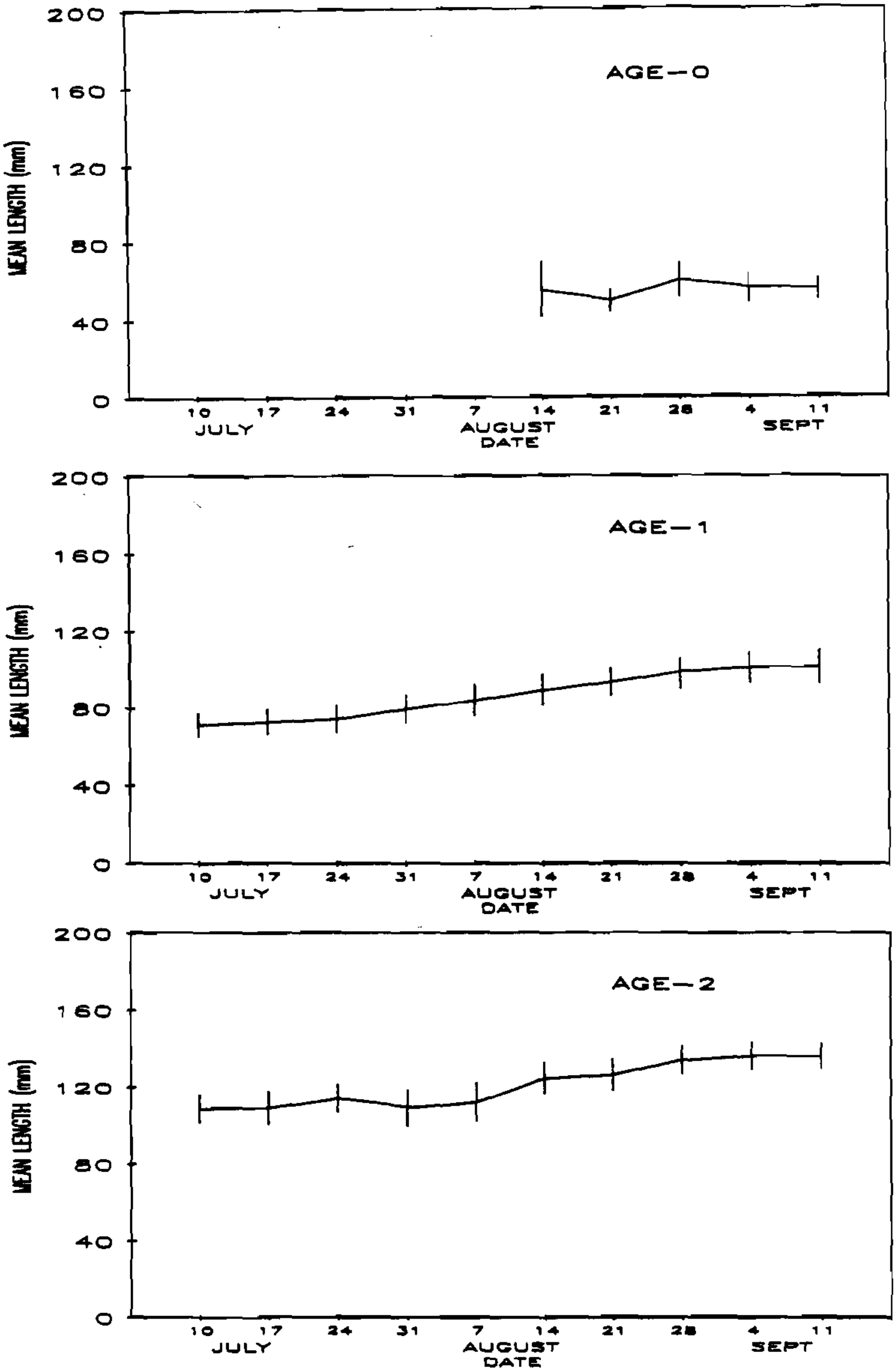

Figure 18. Mean lengths of age-0, age-1 and age-2 least cisco by week of sampling.

and grew to a mean of 136 mm in September. Estimated growth rates were 0.52 and 0.48 mm/day for age-1 and age-2 least cisco, respectively (Table 4). The differences between the last length estimate and the first estimate for the next older group suggest that the sampling period did not cover the entire growing season. An additional 26 days at the estimated growth rates approximates the difference.

Mean length at age for least cisco collected in the Colville River delta in 1985 are plotted separately in Figure 19 and plotted with data collected from the Colville area and Prudhoe Bay in previous years in Figure 20. The 1985 data show a slowing of growth rate after about age-7, or about 270 mm. Male and female least cisco apparently mature at six to nine years. Non-spawning mature fish were found at ages 7 to 16. Age-1 through age-3 fish were similar in size to the 1984 Prudhoe Bay sample, but smaller than other samples (Figure 20). Age-4 through age-8 fish were smaller than all the other samples.

Length-weight regression lines calculated separately for male and female, mature and immature least cisco showed only one significant difference by analysis of covariance (Appendix Table A-52). The relationship for immature female and male fish (3 to 6 years) was different than the immature fish of unknown sex (1 to 3 years).

A length-weight equation was calculated for the entire least cisco sample for comparison with previous studies. The length and weight data used is plotted in Figure 21. The equation is:

$$\log \text{weight (g)} = -5.633 + 3.256 \log \text{length (mm)}$$
$$N = 121,\ r = 0.997$$

Comparable relationships from previous studies in Prudhoe Bay and Simpson Lagoon are:

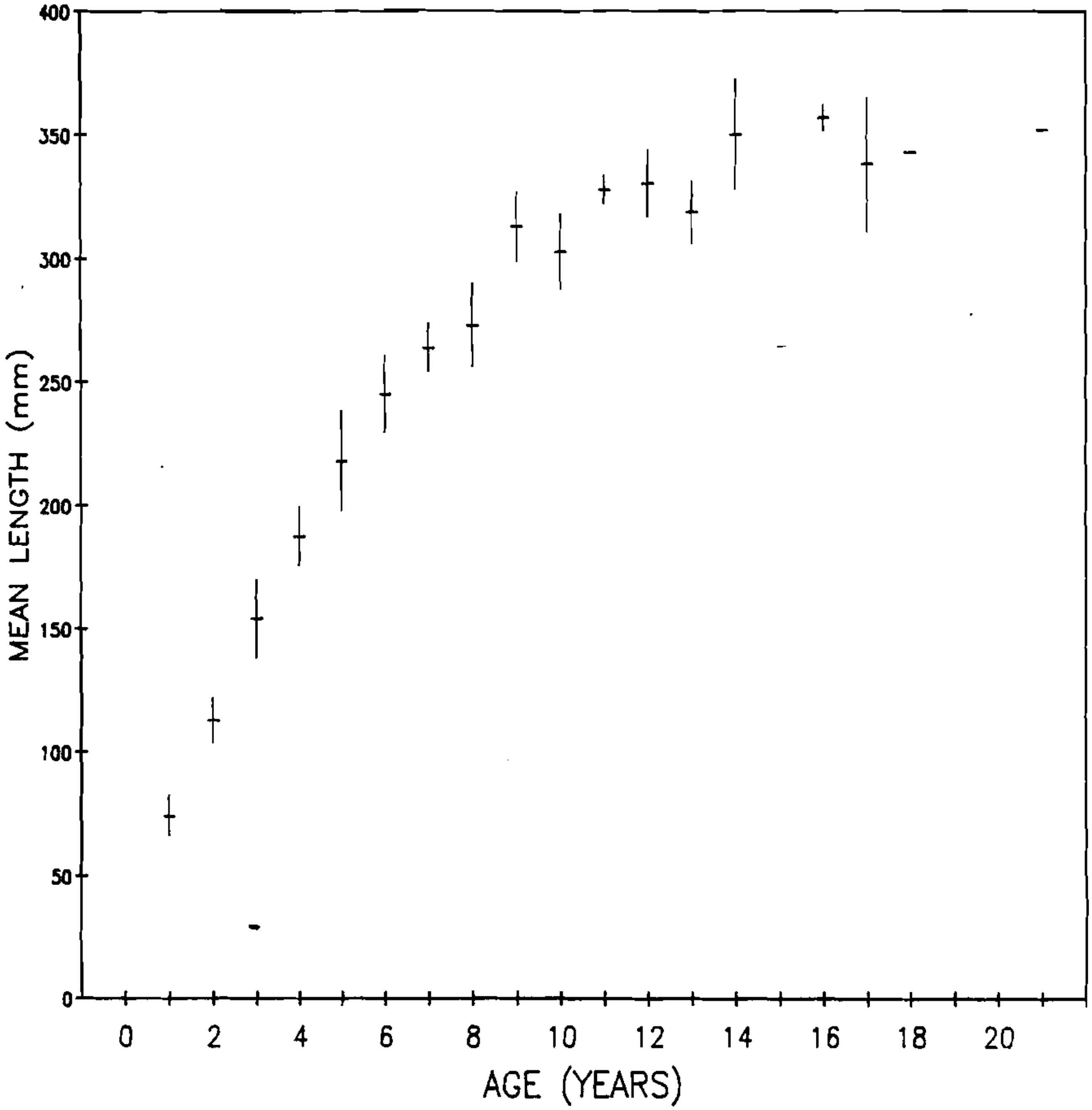

Figure 19. Mean length at age for least cisco.

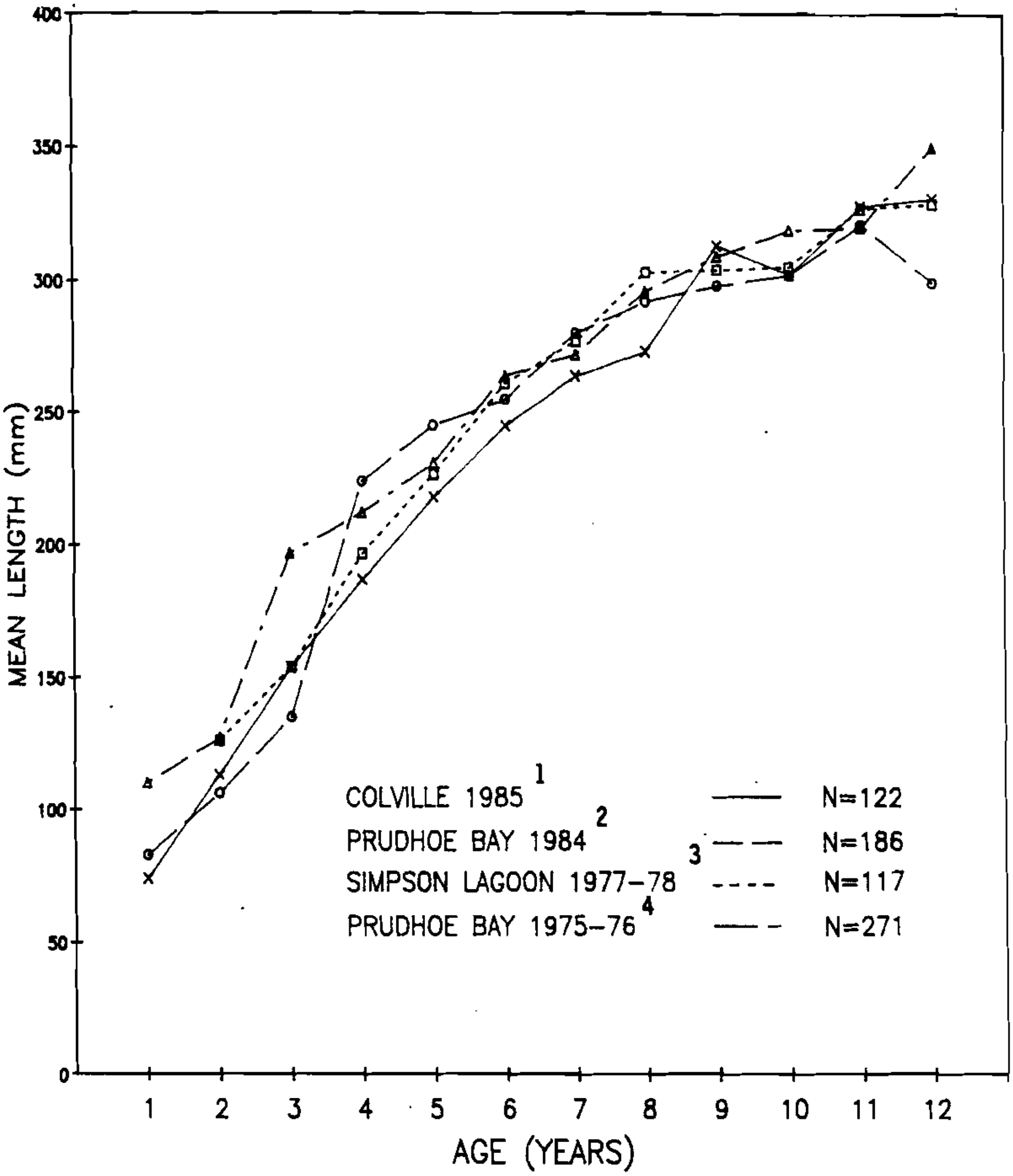

Figure 20. Mean length at age for least cisco collected in Prudhoe Bay and the Colville River area.

[1] this study

[2] Moulton, Fawcett and Carpenter 1985

[3] Craig and Haldorson 1981

[4] Bendock 1979

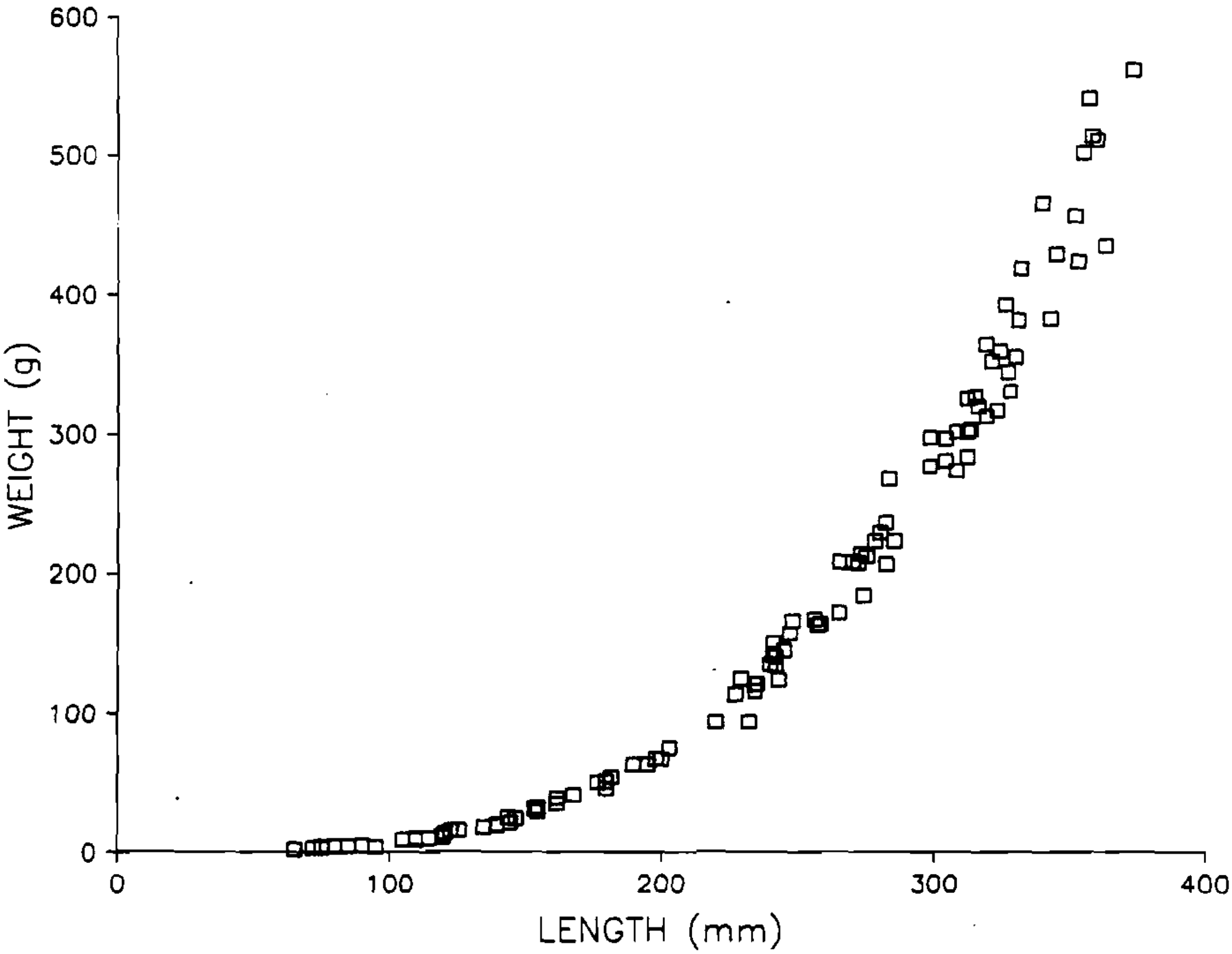

Figure 21. Scatter plot of length and weight data for least cisco collected in the Colville River, summer 1985.

log weight (g) = -5.333 + 3.148 log length (mm)
N = 187, r = 0.993 (Moulton, Fawcett and Carpenter 1985)

and

log weight (g) = -5.151 + 3.070 log length (mm)
N = 384, r = 0.97 (Craig and Haldorson 1981)

The equations suggest that the Colville River fish were not as heavy as similar sized fish in the other samples.

3.3.3 Broad Whitefish

3.3.3.1 Size and Age Structure

The size frequency distribution of broad whitefish is shown in Figure 22. The most apparent size modes are the age-1 fish at 80 to 129 mm and age-0 at 40 to 69 mm. Age-1 broad whitefish showed a strong peak through most of the sampling at delta stations and during late summer at river stations. Age-0 fish of 40 to 69 mm appeared in river net samples during the week of July 22-26 and continued to make up a large portion of the broad whitefish catch throughout the sampling period. At delta stations a few age-0 fish appeared between July 29 and August 2, with numbers increasing each week into September. Age-2 and age-3 fish likely comprise the 120 to 200 mm segment of the population. This group is less abundant in the river samples than younger fish at delta stations throughout the summer and appears in small numbers in August and September at river stations. Larger broad whitefish (>200 mm) were present in small numbers throughout the summer.

3.3.3.2 Growth and Maturity

Growth rates were estimated from weekly mean lengths of age-0, age-1, and age-2 broad whitefish as plotted in Figure 23 (size ranges listed in Appendix Table A-47). Age-0 broad whitefish grew from a mean of 47 mm when first caught in late July to 62 mm five weeks later. Age-1 fish were about 80 mm in

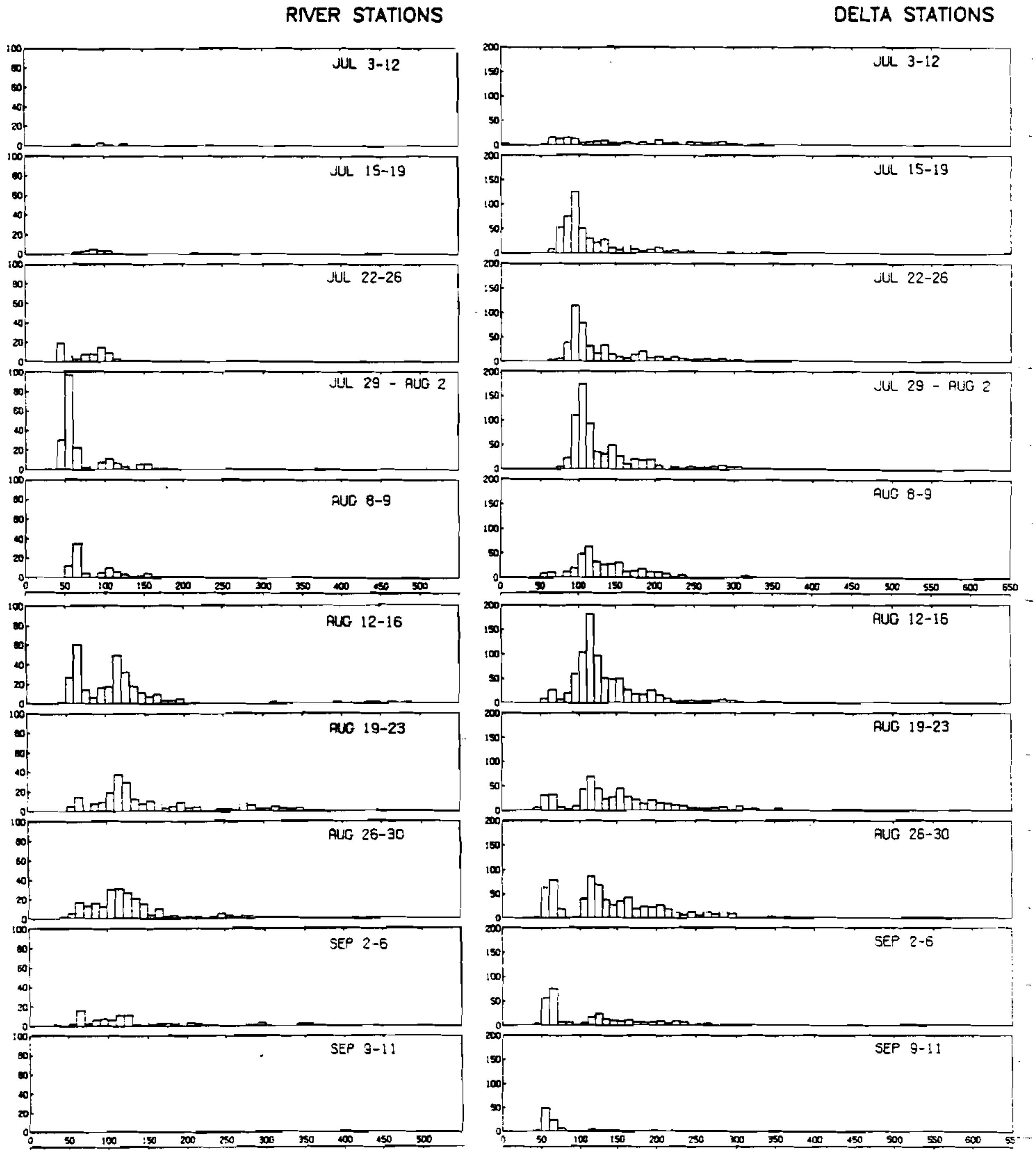

Figure 22. Size frequency of broad whitefish by week of sampling. Note the difference in scales.

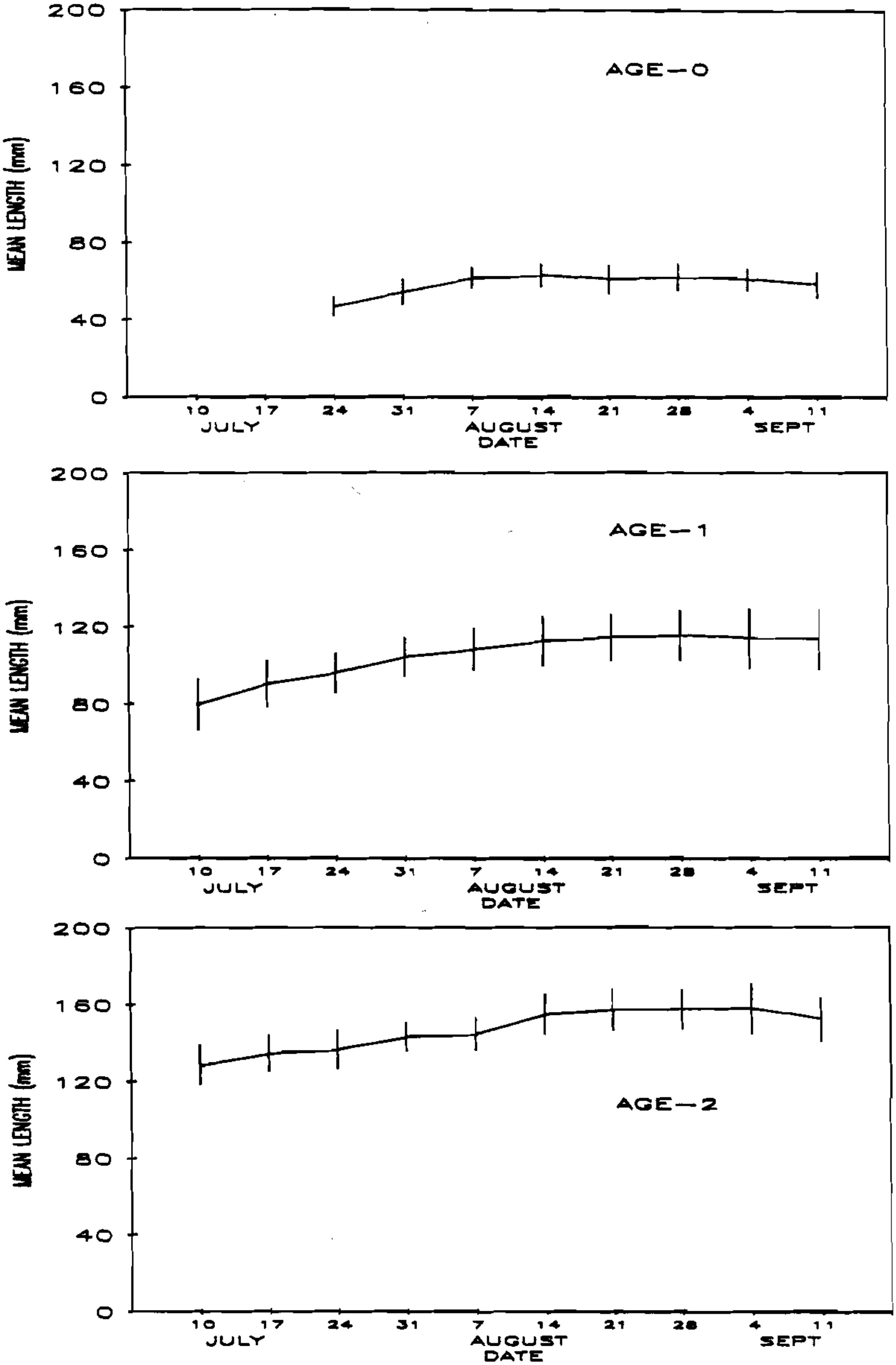

Figure 23. Mean lengths of age-0, age-1 and age-2 broad whitefish by week of sampling.

early July and 116 mm by the end of August. The age-2 group increased in size from 129 mm to 158 mm over the same period. The growth rates through the end of August were 0.42, 0.68 and 0.55 mm/day for age-0, age-1 and age-2 fish, respectively (Table 4). An additional 15 to 20 mm of growth during the winter or most likely during the earlier part of the summer is suggested by the size gaps between age groups.

Age groups 1 to 3 appeared to grow faster in the Prudhoe Bay area in previous years (Table 4). The estimated rate was 0.83, 0.73 and 0.78 mm/day for age-1, age-2, and age-3 fish, respectively, in the 1982 Endicott study (Griffiths et al. 1983), and was about the same for broad whitefish in the 1984 Lisburne study (Moulton, Fawcett and Carpenter 1985).

Annual growth of Colville River broad whitefish is shown in Figure 24. The break in the growth curve from rapid to slower growth occurs at about age-11 and 525 mm. The age of mature, non-spawning fish was age 7 to 9 for males and age 8 to 11 for females. These fish were 300 to 500 mm in length. Potential spawners were seen as young as ages 7 and 9 (male and female, respectively) but more commonly were at least ages 11 to 13 and 450 mm or larger. Mean lengths at age (Figure 25) for broad whitefish from the Colville River correspond closely with those reported from Prudhoe Bay in 1984 (Moulton, Fawcett and Carpenter 1985). Mean lengths are also plotted for fish from a 1978 survey near the Mackenzie River delta (Lawrence, Lacho and Davies 1984). The Mackenzie fish were much larger at all ages past age-1.

A length-weight relationship was calculated separately for all female, all male, and unknown immature broad whitefish as there were few mature fish in the sample (Figure 26). The equations and comparisons by analysis of covariance are listed in Appendix Table A-52. No significant difference was found between the female and male fish, but when these two groups were combined and compared with the smallest immature fish of unknown sex (1-2 years) a significant difference occurred.

For the entire sample collected the equation is:

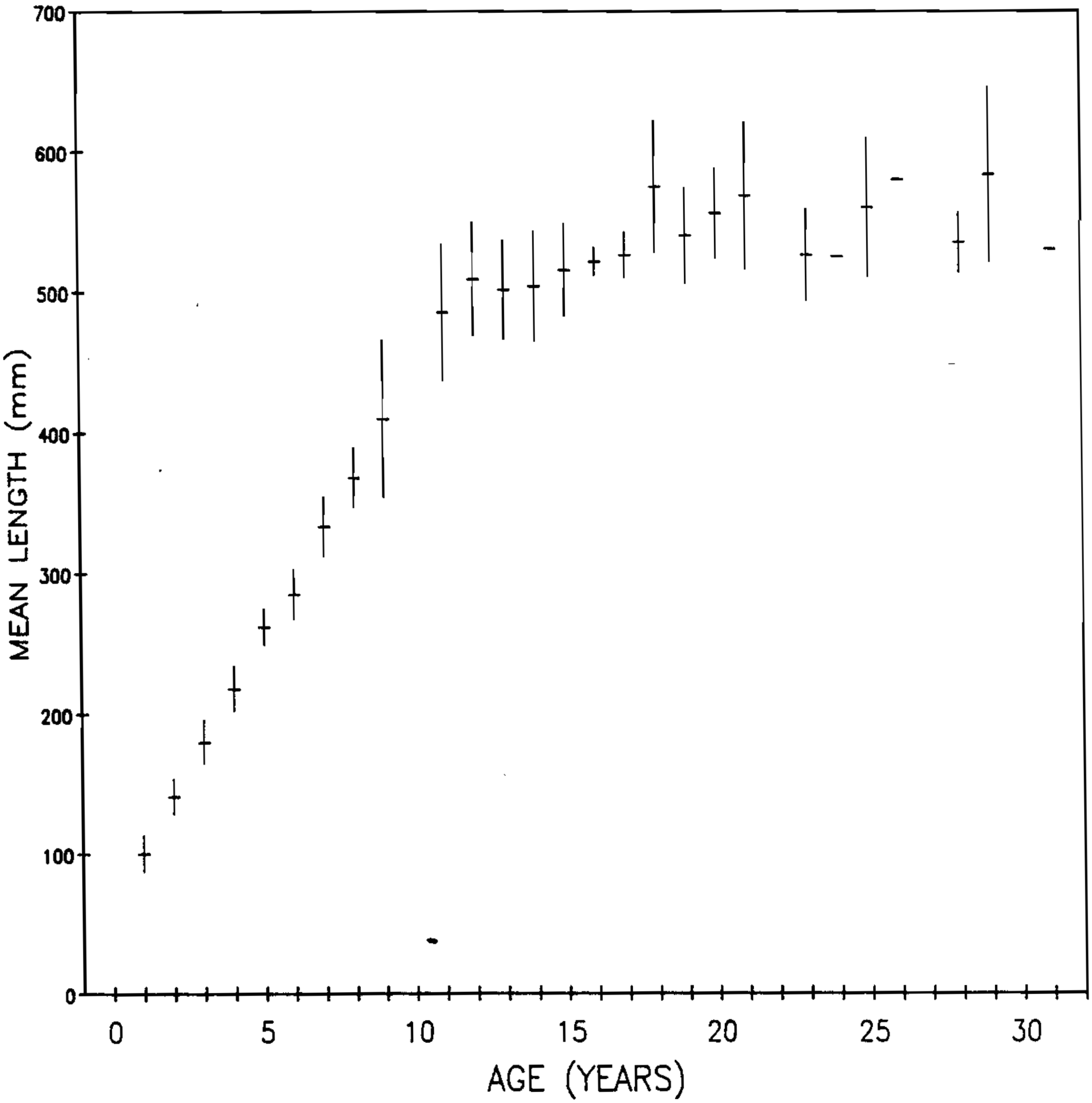

Figure 24. Mean length at age for broad whitefish.

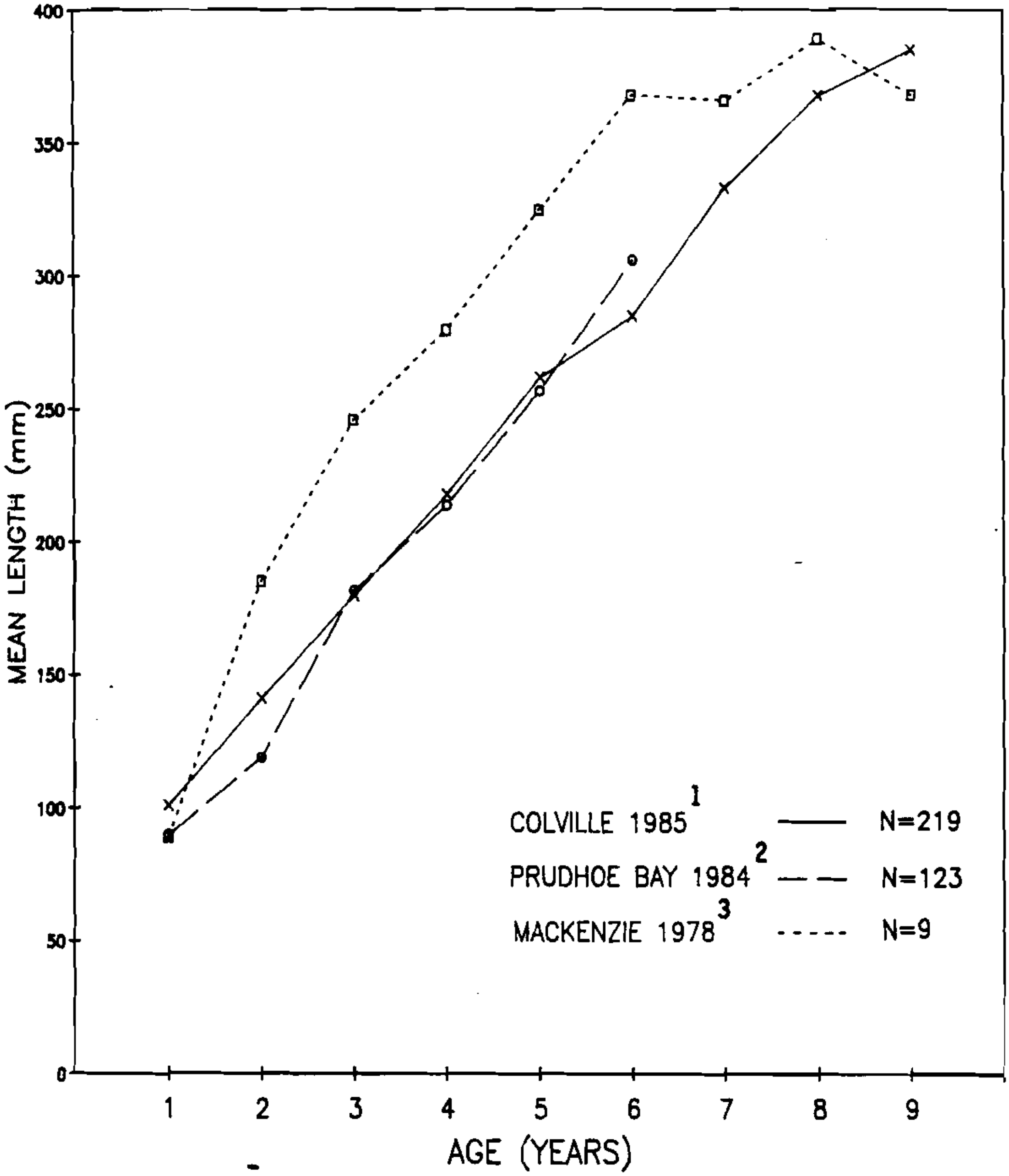

Figure 25. Mean length at age for broad whitefish collected in Prudhoe Bay and the Colville and Mackenzie rivers.

[1] this study

[2] Moulton, Fawcett and Carpenter 1985

[3] Lawrence, Lacho and Davies 1984

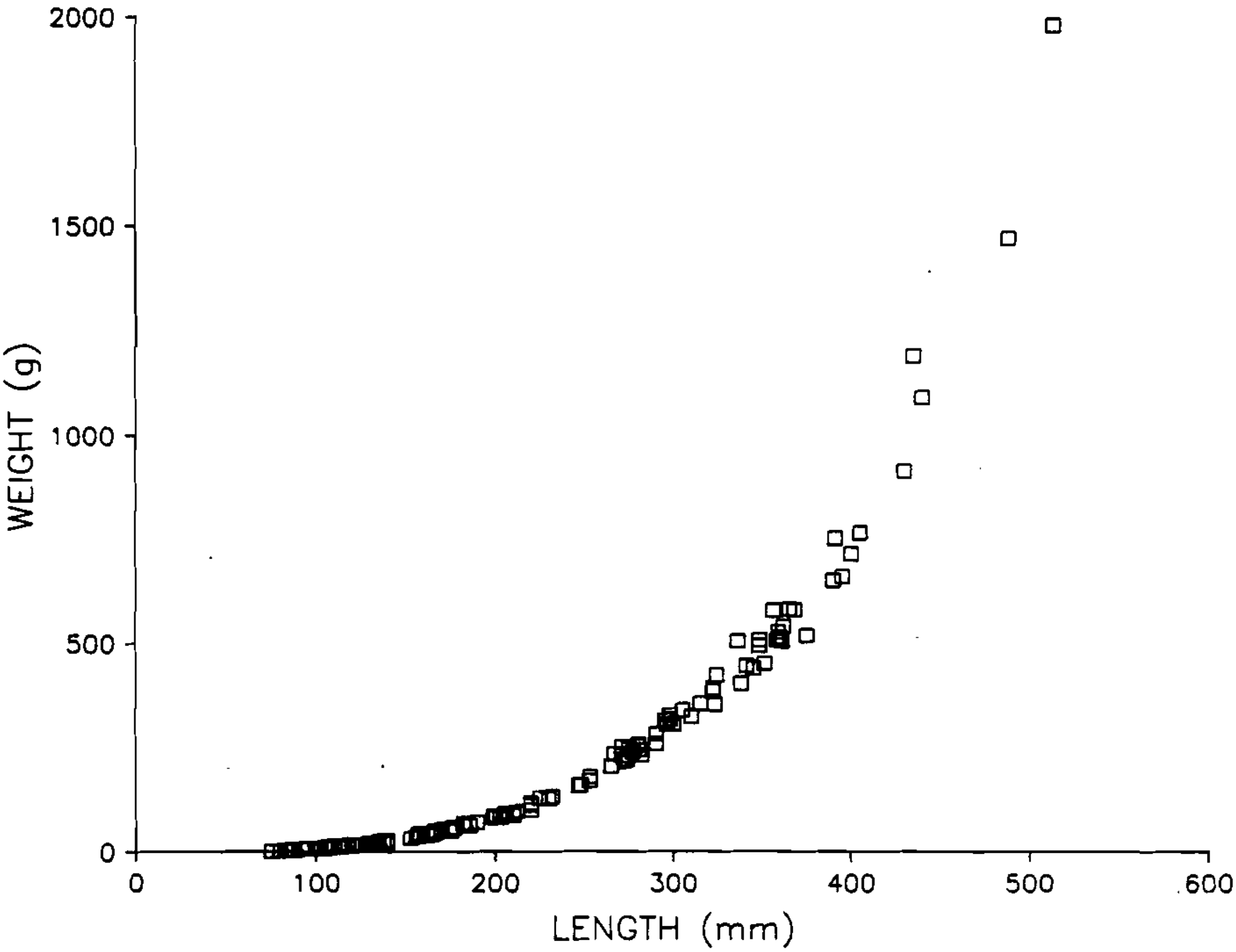

Figure 26. Scatter plot of length and weight data for broad whitefish collected in the Colville River, summer 1985.

$$\log \text{weight (g)} = -5.591 + 3.26 \log \text{length (mm)}$$
$$N = 138,\ r = 0.998$$

The relationship for the 1984 Prudhoe Bay sample (all fish <250 mm) was similar:

$$\log \text{weight (g)} = -5.708 + 3.325 \log \text{length (mm)}$$
$$N = 127,\ r = 0.981$$

The relationships suggest that at any size over 67 mm in length the Prudhoe Bay fish were heavier.

3.3.4 Humpback Whitefish

3.3.4.1 Size and Age Structure

Humpback whitefish size frequency distribution by week is shown in Figure 27. Age-1 fish, with a mode at 70 to 109 mm, were the largest part of the catch for all weeks at both river and delta stations. The age-1 group appeared in the delta between July 22 and 26 and remained through August 30. Age-1 fish appeared later at river stations, in small numbers from July 29 through August 9, and then in high numbers from August 12 through 16, but were present through September 6 when sampling ended. Age-2 humpback whitefish with a mode at 130 to 149 mm, and a small number of larger fish appeared at the same times as the more numerous age-1 group. Age-0 fish were first caught between August 12 and 16 and appear as a distinct mode at 50 to 69 mm by late August at river stations. Few age-0 fish were caught in the delta.

3.3.4.2 Growth and Maturity

Weekly mean lengths of the age-0, age-1 and age-2 groups are plotted in Figure 28. Since few or none were caught during the first two or three weeks of sampling growth rates were calculated for the late-July to August 30 period which probably does not represent maximum growth rates. Growth rates were approximately the same for the three age groups, 0.38, 0.44, and 0.39 mm/day

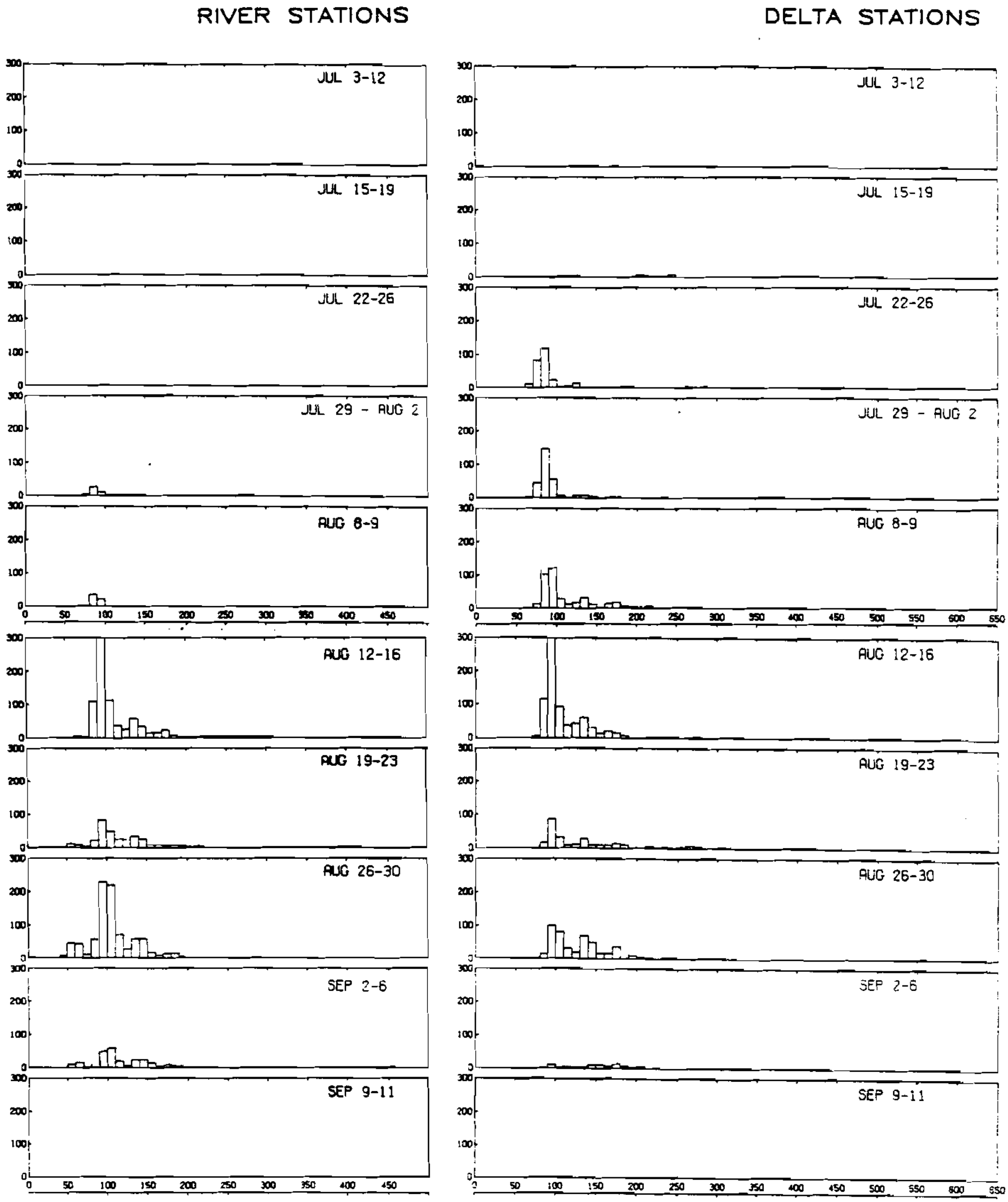

Figure 27. Size frequency of humpback whitefish by week of sampling.

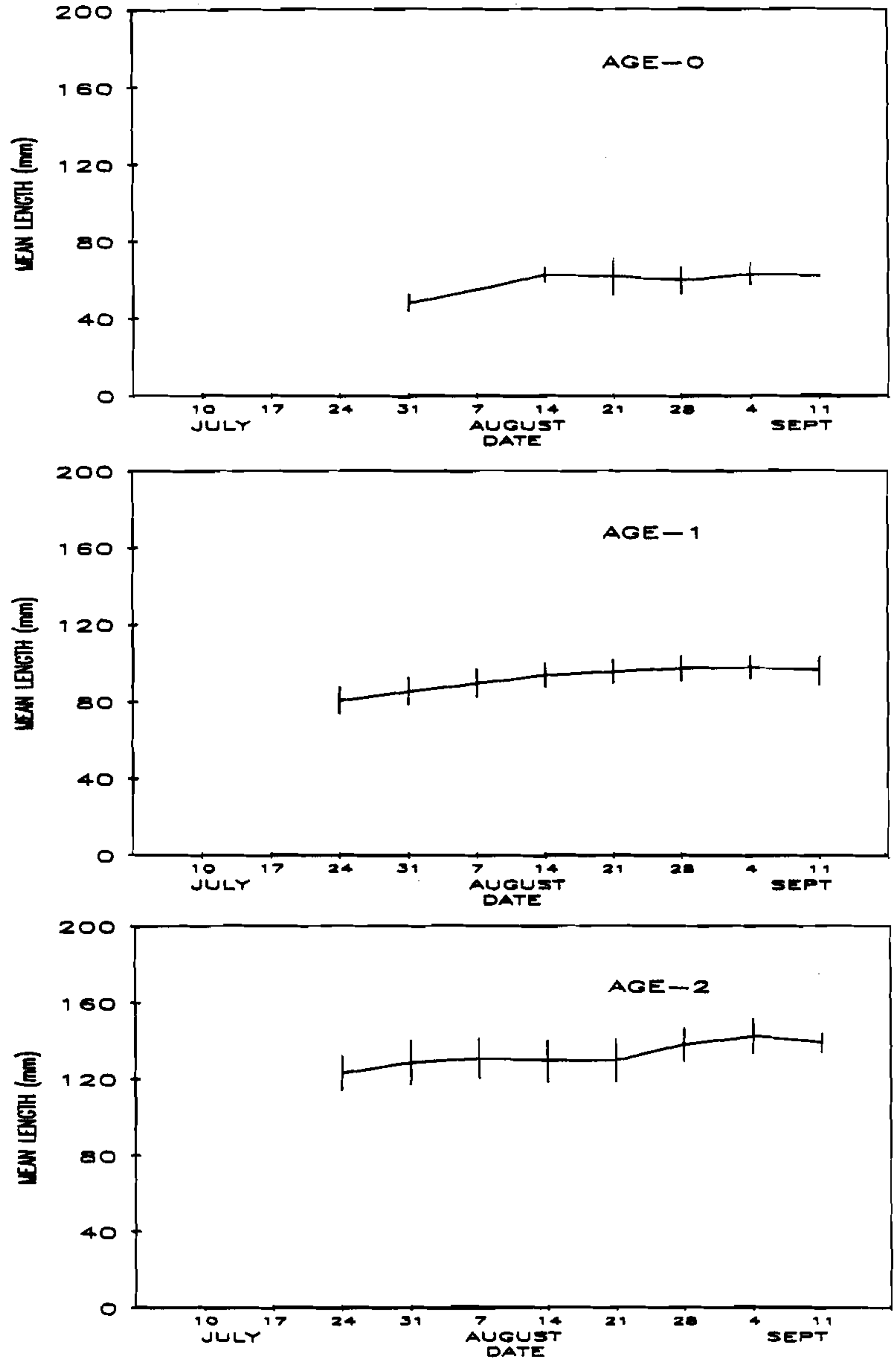

Figure 28. Mean lengths of age-0, age-1 and age-2 humpback whitefish by week of sampling.

for age-0, age-1 and age-2 fish, respectively (Table 4). Age-0 fish were first seen at the end of July at about 48 mm and grew to a mean of 63 mm by the end of sampling in early September. Age-1 fish were about 81 mm when first captured between July 22 and 26 and grew to about 98 mm. Age-2 fish grew from 123 mm to 143 mm by the first week of September. The difference of about 20 mm between the mean lengths in September and lengths initially measured for the next year older age group in late July suggests that at least half of the annual growth occurred outside of the sampling period.

Mean length at age for humpback whitefish is plotted in Figure 29. The curve shows rapid growth until about age-10 and 375 to 400 mm length. This corresponds with age at first maturity as suggested by dissection. Age 10 and older fish (male and female) were 360 mm or larger and were in pre-spawning or mature, non-spawning condition during July and August.

There were too few mature fish to calculate separate length-weight relationships for mature males and females. Equations for all females (2-25 years), all males (2-37 years), and all immature fish of unknown sex (1-4 years) were calculated and compared by analysis of covariance (Appendix Table A-52). There was no significant difference between male and female fish, but there was a significant difference between the combined female and male fish and the immature fish of unknown sex. The combined equation for all humpback whitefish calculated from the data shown in Figure 30 is:

$$\log \text{weight (g)} = -5.474 + 3.20 \log \text{length (mm)}$$

$$N = 105, \ r = 0.998$$

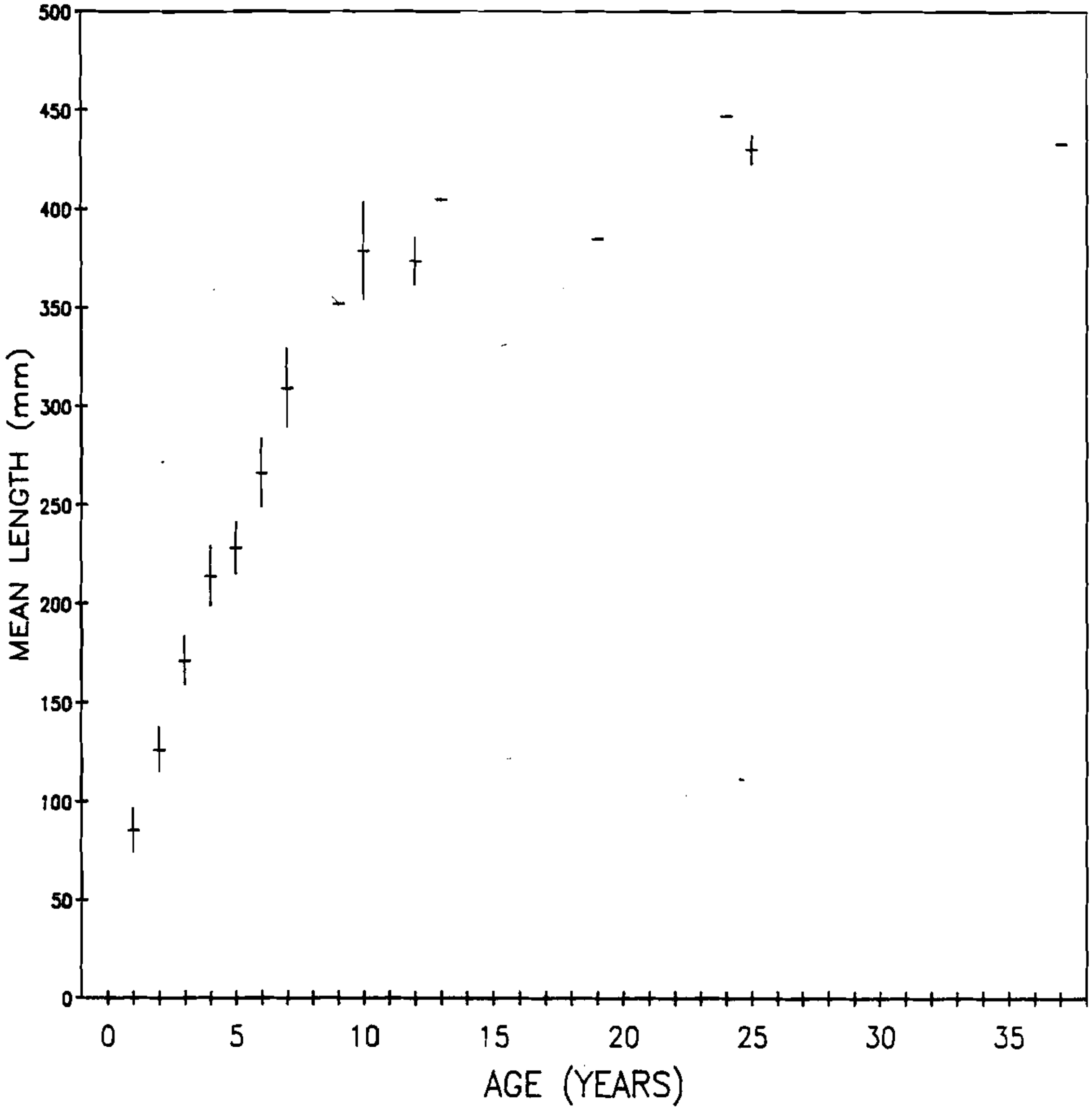

Figure 29. Mean length at age for humpback whitefish.

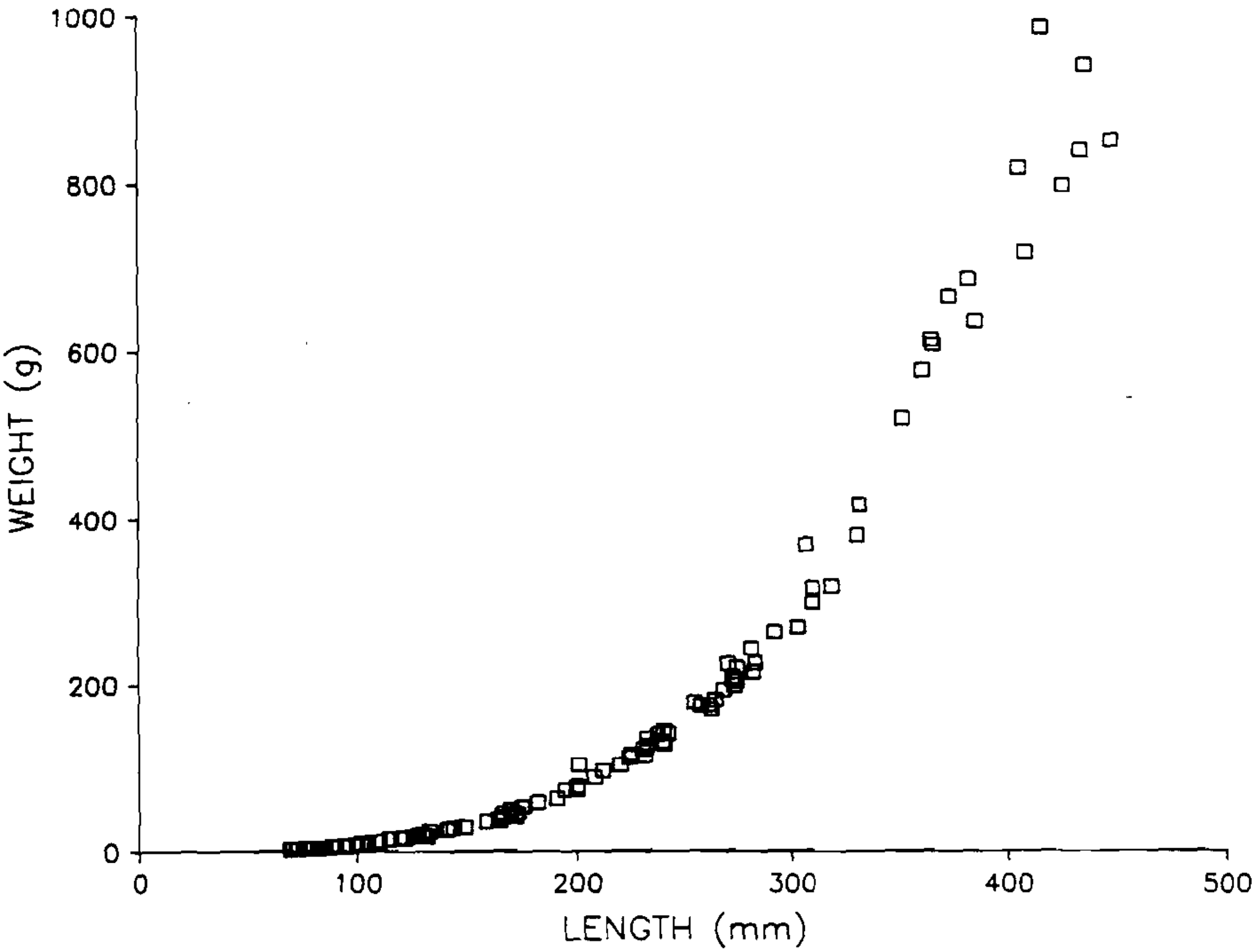

Figure 30. Scatter plot of length and weight data for humpback whitefish collected in the Colville River, summer 1985.

4.0 DISCUSSION

4.1 SEASONAL DISTRIBUTION AND MOVEMENTS OF ANADROMOUS FISH

4.1.1 Early Summer (July 3 - August 2)

A few arctic cisco, primarily medium-sized fish (120-249 mm), were caught at both river and delta stations during the first few days of sampling in early July (Figure 11). From July 15 until mid-August arctic cisco were essentially absent from both the lower river and outer delta study areas. It is presumed that the main outmigration of arctic cisco that overwintered in the Colville River and delta had occurred by the time sampling was initiated in early July, and that most of the population was feeding in the Beaufort Sea outside the Colville Delta during the early summer period. Data collected in two coastal areas confirmed that arctic cisco had entered Simpson Lagoon and Gwydyr Bay by the first week in July (Envirosphere 1986). This is consistent with the timing of arctic cisco movements identified at Oliktok Point by Moulton and Fawcett (1984).

Small and medium-sized least cisco were present at river and delta stations during the first two weeks of sampling, declining from then through the end of the early summer period. Larger size classes of fish disappeared first (Figure 17). Catches declined to nearly zero at the river stations by July 22. In the outer delta area, age-1 fish (60-100 mm) were almost the only least cisco left by the end of July and catches of this group were less than earlier in the summer.

Broad whitefish were scarce at river stations during the first three weeks of sampling, but moderate numbers spanning a wide range of sizes were caught at delta stations (Figure 22). Catch rates at the delta stations were consistent throughout the summer, indicating that many broad whitefish used the delta area throughout the open-water season. However, catch rates for the larger size classes decreased after the first week of sampling at delta stations, suggesting that the larger fish moved out into coastal waters to feed. Previous studies in the region have indicated that large broad whitefish range more widely than smaller ones (WCC 1983, Moulton and Fawcett 1984, Moulton et al. 1985). A similar pattern was indicated in 1985 (Envirosphere 1986, data appendices). Several tag returns in the Colville River from fish marked in the Endicott study area as far east as Foggy Island Bay also indicate long distance movement by large broad whitefish. Young-of-the-year (age-0, 40-79 mm) broad whitefish first appeared at river stations in the third week of July (Figure 22), and dominated catches there for several weeks. The same size group began appearing in substantial numbers at delta stations about two weeks later; these fish probably moved downriver from spawning areas upstream.

Few humpback whitefish were caught in the lower river study area during the early summer period. Low numbers of fish in all size classes were caught in the delta area during the first two weeks of sampling. Age-1 (60-109 mm) humpback whitefish suddenly appeared in substantial numbers at delta stations in the third week of July (Figure 27) and were a dominant part of the catch there for the remainder of the summer. The delta region is probably the main summer rearing area for small humpback whitefish of Colville River stock, as it appears to be for broad whitefish and least cisco.

In summary, the early summer period was characterized by general movement of arctic cisco, least cisco, humpback whitefish, and to a lesser extent, broad whitefish, out of the lower river area and into the delta and coastal waters for summer feeding. Substantial numbers of least cisco, broad whitefish, and humpback whitefish (especially smaller size classes) remained in the delta area, but nearly all of the arctic cisco left the delta area. The above pattern fits well with previous observations on summer movements of these species, i.e., arctic cisco range more widely from overwintering areas than the other whitefishes (Craig and Haldorson 1981, WCC 1983, Craig 1984, Moulton and Fawcett 1984, Moulton, Fawcett and Carpenter 1985, Moulton et al. 1985).

4.1.2 Mid-Summer (August 3-30)

Arctic cisco reappeared in the delta study area during the week of August 12 to 16. The catch was dominated by age-3 fish (1982 year class) until the last week of August, when newly recruited age-0 fish appeared in greater numbers than any other size group (Figure 11). Assuming a Mackenzie River origin for arctic cisco in the Central Beaufort region (Gallaway et al. 1983), the strong recruitment of the 1985 year class was likely facilitated by the persistent easterly winds in 1985 (Figure 5).

Low numbers of medium and large arctic cisco were caught at river stations in the third and fourth weeks of August.

Least cisco increased in number at both delta and river stations during the mid-summer period as fish returned for spawning and overwintering. Medium and large least cisco were essentially absent from both study areas prior to the week of August 12 to 16, when moderate numbers of fish began to appear at delta stations (Figure 17). The spawning run was well underway by the following week, when large, mature fish formed a significant part of the catch at both delta and river stations. Young-of-the-year least cisco (40 to 69 mm) appeared for the first time in the third week of August, primarily at delta stations.

Broad whitefish catches increased at river stations during the mid-summer period, but remained stable at delta stations. Young-of-the-year broad whitefish decreased in number at river stations while increasing at delta stations, indicating some downstream movement into delta rearing habitat (Figure 22).

Humpback whitefish increased in abundance in both the lower river and delta areas during the mid-summer period. The increase was most dramatic at the river stations during the week of August 12 to 16. Catches in both areas were dominated by age-1 fish (20-109 mm, Figure 27). Age-0 fish (40-79 mm) became a significant part of the catch at river stations after August 19, but few were caught in the delta.

The mid-summer period was characterized by generally increasing concentrations of fish of the four key species in river and delta areas. The spawning run of least cisco was noted. Young-of-the-year least cisco, broad whitefish, and humpback whitefish, which presumably originated in the Colville River system, became abundant during the mid-summer period.

4.1.3 Late Summer (August 31 - September 11)

Arctic and least cisco increased in abundance at delta and river stations during the late summer period. Arctic cisco were probably still arriving from coastal waters when sampling was discontinued on September 11. Broad and humpback whitefish left the delta area and presumably moved upriver to overwintering areas. Decreased catches of broad and humpback whitefish at river stations during this period may be partly due to rising water over-topping nets and traps, decreasing trap efficiency.

4.2 AGE STRUCTURE, GROWTH, AND LENGTH-WEIGHT RELATIONSHIPS OF KEY SPECIES

4.2.1 Arctic Cisco

a. Population Structure

Dominant age groups of arctic cisco in 1985 were the 1985, 1982, and 1979 year classes. The 1978 year class appeared to be weakly represented in the biological survey but were a major component of the arctic cisco caught in the gill net fishery (Moulton et al. 1986). This year class was represented in the Oliktok area in the 1982 and 1983 studies (Dew 1983, Moulton and Fawcett 1984), but was not represented in the Prudhoe Bay area in the 1981-84 Prudhoe Bay studies. It has been suggested (Moulton et al. 1985) that 1978 year class migrants from the Mackenzie River bypassed the Sagavanirktok Delta but re-cruited to the Colville Delta in 1978 or 1979. The 1979 year class dominated the catches in the Oliktok Point area in 1982 and 1983 studies. The 1979 year class also dominated arctic cisco catches in the Prudhoe Bay area in the years 1981 to 1983 (Griffiths and Gallaway 1982, Critchlow 1983, WCC 1983) and was a major component of the population sampled in 1984 (Moulton, Fawcett, and Carpenter 1985, Moulton et al. 1985). The 1982 year class first appeared as age-1 fish in the Prudhoe Bay area in late August/early September 1983 (WCC

1983). Fyke nets fished near Oliktok Point in 1983 (Moulton and Fawcett 1984) were removed at about the time this recruitment was observed in the Prudhoe Bay area, thus it is likely that recruitment to the Colville Delta occurred in that year after sampling was completed. Age-0 (1985 year class) fish arrived late in the summer thus their growth rates were not calculated. The growth rate for age-3 fish and the mean lengths at age for Colville River fish were similar to those reported for other areas of the North Slope of Alaska (Bendock 1979, Craig and Haldorson 1981, Moulton, Fawcett and Carpenter 1985). Differences between all growth curves for younger age groups from the different studies and areas may be due to the difficulty of identifying the first annulus and differences encountered when reading scales or otoliths by different methods.

The length-weight relationships suggest that age-1 to age-4 (<250 mm) Colville River arctic cisco in 1985 were not as heavy as the same age and size ranges in previous studies. A consistent pattern of slightly smaller, lighter fish in 1985 was shown by the different analyses, but these differences may be an artifact caused by the small range of lengths available in this group of fish - only one age group was present. Growth of tagged arctic cisco recaptured in the Colville River and delta (Table 5) was consistent with the age-length relationship for sub-adult fish of that size group.

Length-weight equations calculated for the different maturity stages of arctic cisco showed significant differences. Fish show different length-weight relationships as they pass through developmental stages and begin to mature (Bagenal and Tesch 1978). The small number of mature fish examined in the sample were in early maturity stages or were not spawners this year, and of those that may have spawned previously, most were females. Thus, the length-weight relationships calculated for mature females and mature males probably do not represent what would be found in an older, spawning population (e.g. at the Mackenzie River) where differences would be expected between the sexes.

The length-weight equations also suggested that there was no difference between fish that had carried a tag for over a year and those that were tagged recently. Thus, no effects of tagging were indicated. As discussed above and in Section 3.3.1.2 the tagged fish grew approximately 30 mm in a year, as expected for their size group.

b. Recruitment Patterns

A westward movement of age-0 arctic cisco along the Beaufort Sea coast was indicated by the catch of young-of-the-year arctic cisco at various sampling locations between the Mackenzie and Colville rivers (Table 6). Except for the Colville Delta stations of this study and Kay Point, all sampling locations along the Beaufort Sea coast were monitored as part of the Endicott Project (Envirosphere 1986). Data from Kay Point were obtained from Canadian studies (W. Bond, Canadian Fisheries and Oceans, pers. comm. 1985). The date of first capture of age-0 arctic cisco at the various sampling locations demonstrates a westward movement of fish from Kay Point (50 miles west of the Mackenzie River) on July 13 to the Colville River delta on August 26 (Figures 31 and 32). The criterion for date of first capture was a catch of two or more age-0 arctic cisco followed by increasing catches in subsequent days. At each of the sampling locations peak catches of age-0 fish generally occurred a few days after the date of first capture, with the eastern-oriented fyke nets usually recording the highest catches.

Larger fish were dominant in the first catches of age-0 arctic cisco in Colville delta fyke nets as indicated by a decrease in the size mode of fish from 70-74 mm for August 26-30 to 65-69 mm in the following two weeks (Figure 11). Thus, the date of first capture at sampling stations along the Beaufort Sea coast, timing and duration of peak catches, occurrence of higher catches in eastern-oriented fyke nets, and presence of larger age-0 fish in first catches (larger, stronger-swimming fish would be expected at the forefront of a migration) provide evidence for a westward movement of age-0 arctic cisco from the Mackenzie River to the Colville River in 1985.

Gallaway et al. (1983) suggested that under average summer wind and current conditions (5 m/sec and 15 cm/sec, respectively), passive drift of 70 to 110 mm arctic cisco from the Mackenzie River to the Colville River would require 35 days, or about 8 mi/day. This rate is similar to the rates

Table 6. Estimated rates of movement for age-0 arctic cisco between various locations along the Beaufort Sea coast and the Colville Delta.

Location	Date of Initial Capture[1]	Approximate distance to Colville Delta (mi)	Days between first catches of arctic cisco at location and Colville Delta	Rate of movement (mpd)[2]
Kay Point	Jul 13	300	44	6.8
Kaktovik	Aug 11	160	15	10.7
Foggy Island Bay	Aug 16	65	10	6.5
Eastern Sagavanirktok Delta	Aug 20	56	6	9.3
Niakuk Island	Aug 20	50	6	8.3
East Base of West Dock	Aug 21	40	5	8.0
Storkersen Point	Aug 23	30	3	10.0

[1]Day of first capture was defined as day when two or more fish were caught followed by increasing catches in subsequent days.

[2]mpd = miles per day.

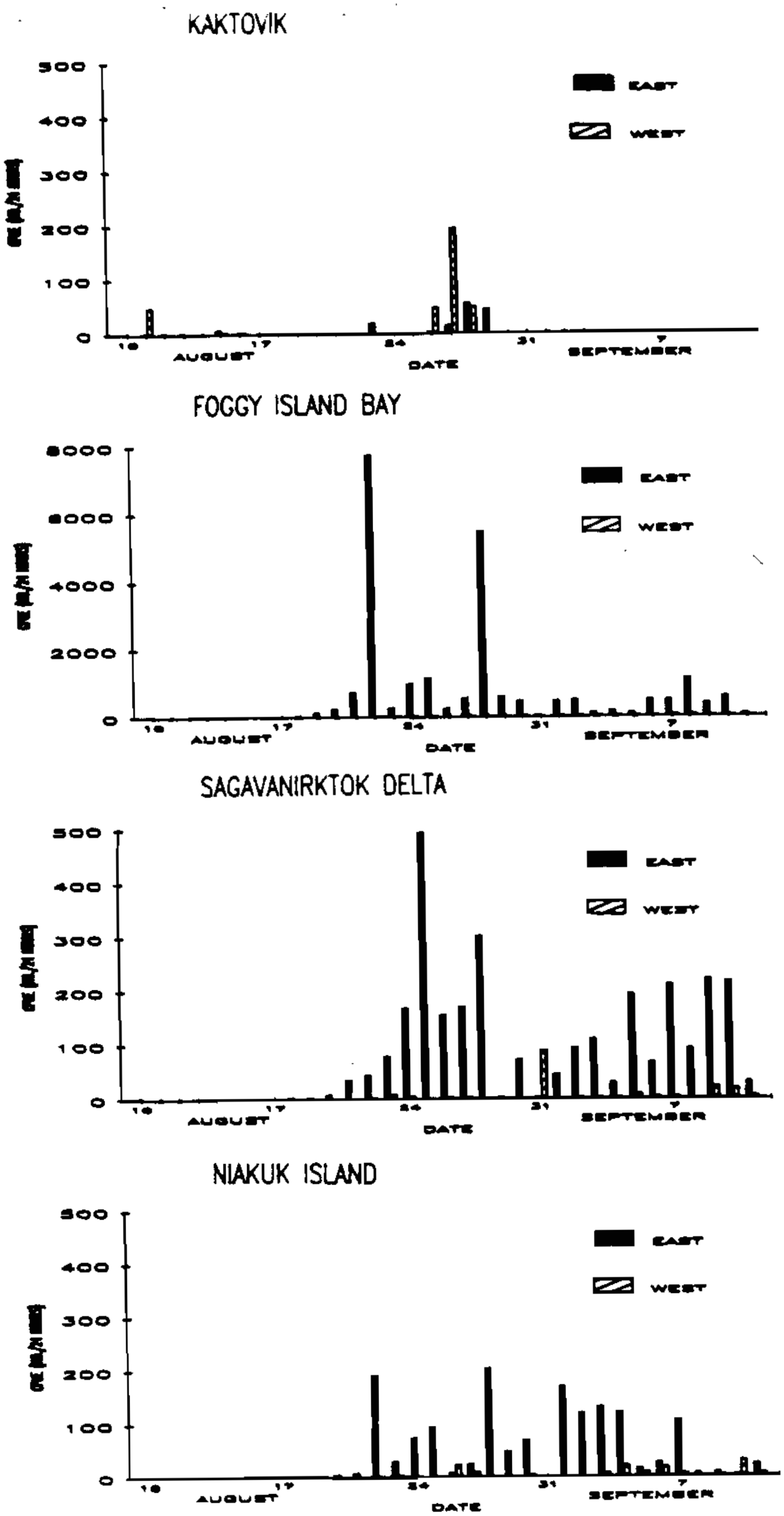

Figure 31. CPUE (No./24 hours) of small (<100 mm) arctic cisco at locations between the Mackenzie River and the Sagavanirktok River delta. Sampling at Kaktovik was not continuous from the first catch shown (data from Envirosphere 1986).

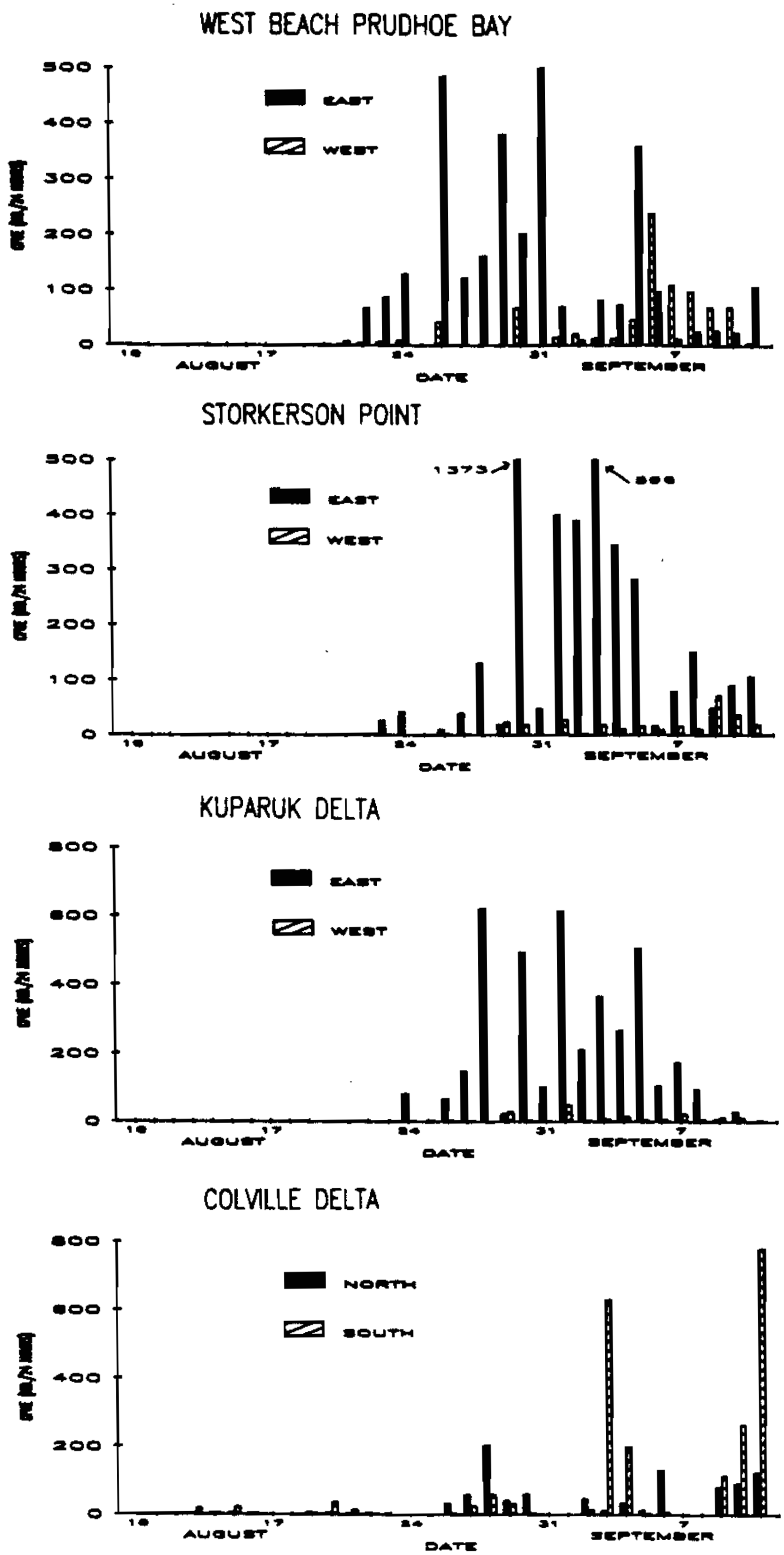

Figure 32. CPUE (no./24 hours) of small (<100 mm, or <120 mm at Colville) arctic cisco at locations between Prudhoe Bay and the Colville Delta (data from Envirosphere 1986 and this report).

calculated for the movement of fish in 1985 (Table 6). A comparison was made between the size distribution of age-0 arctic cisco in the Colville delta and the Sagavanirktok delta, using Sagavanirktok data from Envirosphere (1986) (Figure 33). Although all differences in mean size between the two areas were significant (t-test, x=0.05), the differences between age-0 fish were greatest in the first week with the difference decreasing in the following two weeks. The indication is that small fish continued to move into the Colville, thus reducing the apparent differences. It is apparent, however, that the smallest of the group, 45-55 mm, were still under-represented in the Colville delta when sampling ceased.

4.2.2 Least Cisco

Age-1 least cisco were captured all summer, age-2 and age-3 fish were captured during most of the summer, and age-0 fish were present only for the last few weeks. Growth rates calculated for these groups were less than the rates for other fish species, but there are no comparable data for least cisco in other studies (Table 4). Mean length at age was generally similar to, although slightly smaller than, fish in other western Beaufort Sea studies for ages four through eight.

Male and female least cisco showed no difference in length-weight relationships even for mature fish, although sample sizes of males were too small to place much confidence in the analysis of covariance. The difference between the one to three year old immature fish and the older immature females and males is a normal change in growth patterns as the fish develop.

The difference in length-weight relationships for tagged fish suggest that there was a significant effect of tagging or there was a significant difference in the length-weight relationships of fish greater than 250 mm in length in 1984 and 1985. The 1985 tagged fish were heavier at a given length for all sizes up to 330 mm.

The growth curve and age at first maturity as determined by dissection correspond well with maturation ages reported in the literature (see Moulton

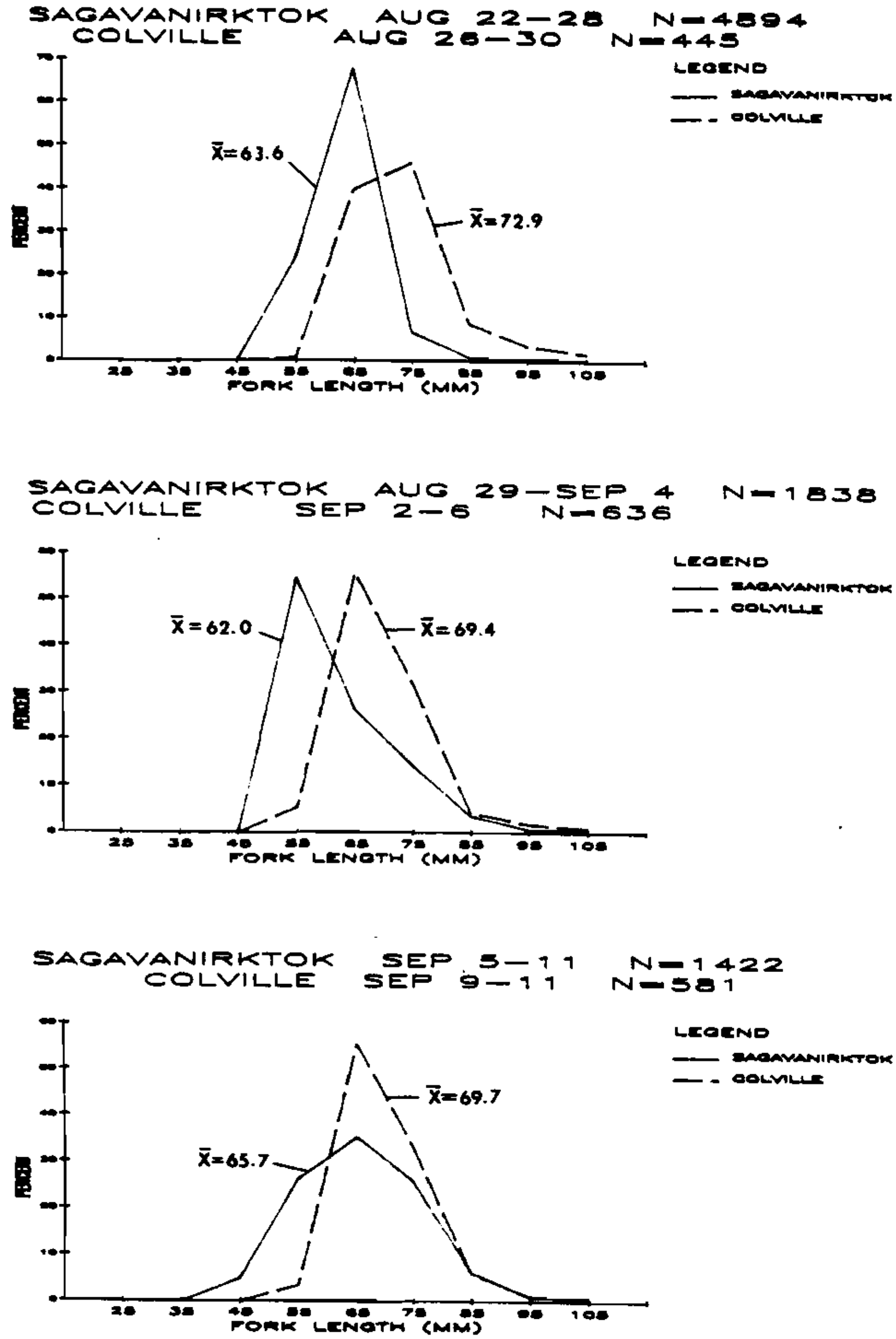

Figure 33. Comparison of size distribution of young arctic cisco in Colville and Sagavanirktok deltas, late summer, 1985. (Sagavanirktok data from Envirosphere 1986 data appendix).

and Carpenter 1986). Least cisco appeared to mature at six to nine years. Non-spawning, mature fish from seven to sixteen years were found, supporting the hypothesis that least cisco do not spawn every year.

4.2.3 Broad Whitefish

Age-0, age-1, and to a lesser extent, age-2 fish dominated the broad whitefish catch throughout the summer. Growth rates calculated for these groups were lower than those from previous studies (Griffiths et al. 1983, Moulton, Fawcett and Carpenter 1985), although the mean length at age curves for the 1984 and 1985 studies are almost the same. Mackenzie River fish are larger for most ages.

The length-weight equations estimated for Colville River broad whitefish in 1985 and Prudhoe Bay fish in 1984 suggest that the Colville fish were not as heavy. The Prudhoe Bay sample consisted of fish smaller than 250 mm, while about 30 percent of the Colville sample was larger than 250 mm. Length-weight relationships are expected to be different for different developmental stages, thus comparisons between samples of different length ranges may not be valid. The youngest (1-2 years) immature fish from the Colville sample had a significantly different length-weight relationship than the older fish as expected for the different developmental stages.

A wide range of ages at first maturity for broad whitefish are reported in the literature (see Moulton and Carpenter 1986). The ages of seven to nine years for males and eight to eleven years for females from the Colville Delta sample are within the reported ranges (Nikolski 1961, Alt and Kogl 1973, Craig and Haldorson 1981, Bendock and Burr 1984b). Few pre-spawning or mature, non-spawning broad whitefish were collected, thus no evidence in support of annual or non-consecutive spawning was provided.

4.2.4 Humpback Whitefish

The catch of humpback whitefish was largely composed of age-1 fish, with age-2 fish appearing in smaller numbers, and age-0 fish appearing in the later part of the sampling period. Growth rates for these groups were the lowest of all the species considered (Table 4). Humpback whitefish are more restricted to fresh water than the other species, thus may not be able to utilize the abundant marine and brackish-water food organisms found in low to moderate salinity water by the other anadromous species.

Length-weight relationships showed the expected difference between the youngest immature fish and the older fish. Significant differences between males and females were not found. Sample sizes were of marginal size for these analyses, thus additional data may clarify differences. Also, mature fish of either sex were not compared due to small sample sizes and the differences would probably be greatest between mature females and mature males.

Humpback whitefish in the Colville Delta sample appeared to mature at about ten years by the mean length at age curve and examination of gonads. This age corresponds with the ages of eight to ten years reported for fish from the same area by Alt and Kogl (1973). Non-spawning mature fish of 13, 19, and 37 years were found, suggesting that humpback whitefish are non-consecutive spawners.

5.0 SUMMARY AND CONCLUSIONS

A significant concern related to the hypothesized Mackenzie River origin of arctic cisco is the effect of causeways at Prudhoe Bay and Endicott on the movements of young-of-the-year arctic cisco. Assuming a Mackenzie River origin for arctic cisco in the Colville River, successful migration to the Colville River is a critical life history phase that insures continued arctic cisco utilization of the Colville River delta and availability to local fisheries. The 1985 data indicate that the larger individuals of the young-of-the-year arctic cisco successfully migrated past (or through the breaches of) the causeways and reached rearing and overwintering areas in the Colville River delta with no apparent delay. Catch rates were still increasing when sampling was discontinued because of ice formation. The difference in size between age-0 fish in the Colville and Sagavanirktok deltas was greatest during the first week of recruitment but decreased by the end of sampling. Environmental conditions (e.g. persistent easterly winds) and a strong year-class of age-0 arctic cisco likely facilitated the movement of young arctic cisco from the Mackenzie River to the Colville River in 1985.

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APPENDIX A

APPENDIX TABLES

TABLE A-1. Sampling effort (days) by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		0.80						
	4								
	5								
	6								
	7								
	8								
	9		0.96		0.93	0.84			
	10	0.75	0.97		1.02	1.00	0.88		
	11	1.00	0.96		1.00	1.00	1.01		
	12	1.00	0.95		1.19	0.93	0.91	0.90	
	13								
	14								
	15	0.79	0.79		0.67	0.62	0.70	0.65	
	16	1.00	1.20	0.96	0.99	1.00	1.02	1.10	
	17	1.03	0.88	1.01	1.00	1.02	0.99	0.93	
	18	0.97	0.96	0.99	0.98	0.99	1.03	1.07	
	19	0.95	0.94	1.01	1.00	1.00	1.00	0.98	
	20								
	21								
	22	0.93	0.83	0.76	0.83	0.88	0.90	0.91	
	23	0.95	1.02	0.98	1.00	0.99	1.00	1.01	
	24	0.96	1.00	1.01	1.00	0.98	1.00	0.99	
	25	0.96	0.96	0.97	0.99	1.00	1.00	1.00	
	26	1.07	1.05	1.02	1.01	1.03	1.00	1.01	
	27								
	28								
	29				0.61	0.63	0.65	0.71	
	30	0.91	0.79	0.73	1.01	1.04	1.05	1.03	0.93
	31	1.00	1.01	0.96	0.98	0.95	0.92	0.91	0.91
Aug	1	0.96	0.96	0.97	1.01	1.02	1.04	1.06	1.07
	2	0.93	0.96	1.00	0.99	1.00	0.97	0.95	0.94
	3								
	4								
	5								
	6								
	7								
	8	0.91	0.94	0.75	2.14	0.88	0.92		1.13
	9	0.92	0.91	1.00	0.74	0.85	0.92	0.98	0.82
	10								
	11								
	12	0.85	0.99	0.72	0.83	0.87	0.88	0.92	0.86
	13	0.82	0.85	1.15	1.04	1.05	1.07	1.06	1.04
	14	1.17	0.99	0.84	1.00	1.10	1.02	1.03	1.00
	15	1.07	1.04	1.00	1.00	1.02	1.00	1.00	1.00
	16	0.96	0.97	1.00	1.00	0.96	0.98	0.96	1.00
	17								
	18								
	19	0.84	0.84	0.75	0.79	0.96	0.99	1.04	0.90
	20	0.88	1.12	1.12	0.98	1.00	1.00	0.98	1.02
	21	1.00	0.88	1.01	1.00	1.00	1.00	1.02	1.00
	22	1.14	1.02	1.01	1.00	1.02	1.04	1.02	1.00
	23	0.98	0.99	0.99	0.99	0.96	0.94	1.00	0.97
	24								
	25								
	26	0.63	0.94	0.83	0.80	0.87	0.90	0.93	0.81
	27	0.99	0.87	1.05	1.02	1.02	1.01	1.03	1.03
	28	1.20	1.03	0.80	0.98	1.02	1.00	1.00	0.98
	29	1.02	1.01	1.00	1.03	1.01	1.00	1.00	1.02
	30	0.91	0.90	1.00	0.97	1.00	1.02	1.01	0.97
	31								
Sep	1								
	2	0.90	0.86	0.79	0.87	1.00	1.02	1.05	0.91
	3	1.00	1.04	1.00	1.00	0.95	0.96	0.96	0.98
	4	1.00	1.00	0.98	1.04	1.04	1.04	1.04	1.04
	5	0.94	0.93	0.99	0.98	0.92	0.93	0.95	0.98
	6	0.90	1.12	1.07	0.98	1.08	1.12	1.16	1.04
	7								
	8								
	9	0.76	0.76	0.71					
	10	0.39	0.99	0.97					
	11	0.93							
TOTAL EFFORT		39.87	40.98	34.90	40.39	39.50	38.83	36.35	25.35

TABLE A-2. Salinity (ppt) by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3								
	4								
	5								
	6								
	7								
	8								
	9		0.4						
	10	0.2	0.2						
	11	0.1	0.5						
	12	0.5	0.1						
	13								
	14								
	15	0.4	0.2						
	16	0.0	0.2	0.0					
	17	0.1	0.0	0.2					
	18	0.2	0.0	0.0					
	19	0.1	0.4	0.0					
	20								
	21								
	22	0.3	0.1	0.0					
	23	0.2	0.3	0.3					
	24	0.2	0.3	0.2					
	25	0.1	0.1	0.1					
	26	0.0	0.0	0.9					
	27								
	28								
	29								
	30	0.2	0.4	0.4					
	31	0.4	0.2	0.2					
Aug	1	0.2	0.0	0.2					
	2	0.3	0.2	0.3					
	3								
	4								
	5								
	6								
	7								
	8	12.8	2.7	0.8					
	9	3.1	1.1	0.9					
	10								
	11								
	12	3.1	1.2	1.3					
	13	2.3	0.7	0.9					
	14	4.0	1.0	1.2					
	15	6.3	1.7	2.6					
	16	3.2	1.1	1.3					
	17								
	18								
	19	0.8	0.5	3.9					
	20	0.2	0.0	0.2					
	21	0.2	0.0	0.0					
	22	0.3	0.0	0.0					
	23	0.0	0.0	0.0					
	24								
	25								
	26	0.3	0.0	0.0					
	27	0.3	0.0	0.0					
	28	0.5	0.0	1.9					
	29	1.6	0.0	4.2					
	30	4.0	0.0	6.2					
	31								
Sep	1								
	2	1.1	0.2	1.1					
	3	1.4	0.0	0.7					
	4	1.0	0.0	0.3					
	5	0.0	0.0	0.2					
	6	0.0	0.0	0.0					
	7								
	8								
	9		27.0						
	10	0.1	0.0	0.0					
	11	0.0							

TABLE A-3. Temperature (C) by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		15.0						
	4								
	5								
	6								
	7								
	8								
	9		9.6		10.0	11.0			
	10	6.0	10.9		10.5	13.0	13.0		
	11	5.8	10.6		11.5	13.0	13.0		
	12	5.5	10.4		12.0	11.0	11.0	12.0	
	13								
	14								
	15	8.2	9.9		10.0	11.0	11.5	11.0	
	16	11.3	12.2	10.3	11.0	10.5	12.0	12.0	
	17	11.1	10.6	10.4	10.5	11.0	12.5	12.0	
	18	11.2	10.9	10.6	11.0	12.0	12.0	12.0	
	19	10.0	10.8	10.9	11.0	12.0	12.0	12.0	
	20								
	21								
	22	10.1	8.9	8.3	10.0	10.0	10.5	10.0	
	23	9.2	9.4	9.4	10.5	10.5	10.5	10.5	
	24	9.7	9.5	9.5	10.5	11.0	11.0	11.5	
	25	9.0	10.1	10.0	11.0	11.0	12.0	12.0	
	26	12.8	11.8	10.6	12.0	14.0	14.0	14.0	
	27								
	28								
	29				11.0	12.0	12.0	12.0	
	30	10.6	10.8	10.3	11.0	11.5	12.0	13.0	13.0
	31	9.5	10.5	10.4	11.0	12.0	12.0	13.0	12.5
Aug	1	10.5	10.7	10.9	11.5	12.5	12.5	13.0	13.0
	2		11.9	11.4	12.0	13.0	13.0	13.0	13.5
	3								
	4								
	5								
	6								
	7								
	8	6.8	7.7	7.8	11.5	12.0	11.0		12.0
	9	8.6	9.2	9.3	11.0	12.0	12.0	12.5	11.5
	10								
	11								
	12	7.8	8.6	8.3	9.5	10.5	11.0	11.5	10.5
	13	6.9	8.5	8.7	10.0	11.0	11.0	11.0	10.5
	14	8.2	8.7	8.6	10.0	11.0	12.0	11.0	11.0
	15	7.3	9.0	8.3	10.0	10.5	10.0	10.0	10.0
	16	7.4	7.6	8.0	9.0	10.0	10.0	10.0	10.0
	17								
	18								
	19	5.8	7.4	6.5	9.0	8.0	8.5	8.5	8.5
	20	5.1	6.5	6.2	8.0	8.0	8.0	8.0	8.0
	21	4.5	5.6	6.1	7.0	7.5	8.0	8.0	7.5
	22	3.6	5.6	5.5	7.0	8.0	8.5	8.0	8.0
	23	3.0	5.6	5.9	7.0	7.5	8.0	8.0	7.0
	24								
	25								
	26	2.3	5.0	4.8	5.5	8.0	7.0	7.5	6.0
	27	3.8	6.0	5.7	7.0	9.0	8.0	8.5	8.0
	28	7.7	7.5	6.2	8.0	10.0	9.5	10.0	9.0
	29	8.3	7.9	6.4	8.0	10.5	10.0	10.5	10.0
	30	8.1	8.3	7.4	8.5	10.5	10.5	10.5	10.5
	31								
Sep	1								
	2	6.6	7.3	7.2	8.8	10.2	10.0	10.2	10.2
	3	4.9	7.0	7.5	8.5	9.0	9.0	9.0	9.1
	4	4.1		6.3	7.9	7.9	8.0	8.0	8.5
	5	5.6	6.2	6.8	7.8	7.4	7.3	7.8	7.8
	6	3.3	4.9	5.1	6.5	6.5	6.7	6.4	6.8
	7								
	8								
	9	1.4	2.7	1.8					
	10	3.0	4.0	4.0				4.0	
	11	3.5							
	12								
	13								
	14								
	15								
	16				0.5				

TABLE A-4. Relative water level (m) by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3								
	4								
	5								
	6								
	7								
	8								
	9					1.1			
	10	0.8	0.9		1.1	0.9	1.3		
	11	0.8	0.9		1.0	0.9	1.3		
	12	0.7	0.9		1.0	0.9	1.2	0.9	
	13								
	14								
	15	0.8	0.8		0.8	0.8	1.1	0.8	
	16	0.8	0.9	0.7	0.8	0.7	1.0	0.7	
	17	0.8	0.8	0.6	0.7	0.6	0.9	0.7	
	18	0.8	0.8	0.6	0.7	0.6	1.0	0.7	
	19	0.8	0.7	0.7	0.9	0.7	1.1	0.8	
	20								
	21								
	22	0.7	0.6	0.6	0.9	0.6	0.9	0.6	
	23	0.7	0.7	0.7	0.9	0.6	1.0	0.6	
	24	0.8	0.8	0.8	1.0	0.6	1.0	0.7	
	25	0.8	0.8	0.8	1.0	0.5	1.0	0.6	
	26	0.9	0.9	0.9	1.2	0.6	1.1	0.7	
	27								
	28								
	29				1.0	0.6	1.0	0.7	
	30	1.0	0.8	0.8	0.8	0.5	0.9	0.6	0.8
	31	1.0	0.9	0.9	1.0	0.5	0.9	0.5	0.7
Aug	1	0.9	0.7	0.7	0.9	0.4	0.8	0.4	0.6
	2	0.8	0.6	0.7	1.0	0.4	0.8	0.5	0.6
	3								
	4								
	5								
	6								
	7								
	8	0.8	0.7	0.9	1.0	0.6	1.0		0.8
	9	0.8	0.7	0.8	1.2	0.5	0.9	0.7	0.7
	10								
	11								
	12	0.9	0.9	0.9	1.1	0.5	0.9	0.6	0.7
	13	0.8	0.8	0.9	1.0	0.4	0.9	0.6	0.6
	14	1.0	0.8	0.8	1.1	0.5	1.0	0.7	0.6
	15	1.1	0.9	0.9	1.1	0.6	1.1	0.7	0.8
	16	0.9	0.8	0.8	1.1	0.6	1.0	0.6	0.8
	17								
	18								
	19	0.8	0.7	0.8	1.2	0.8	1.2	0.9	1.1
	20	0.8	0.6	0.7	1.0	0.8	1.1	0.9	1.0
	21	0.8	0.7	0.8	1.1	0.8	1.1	0.8	1.0
	22	0.7	0.7	0.8	1.2	0.7	1.0	0.8	1.0
	23	0.7	0.6	0.7	0.8	0.5	0.8	0.6	0.7
	24								
	25								
	26	0.7	0.7	0.8	0.9	0.5	0.8	0.5	0.7
	27	0.8	0.8	0.9	1.0	0.5	0.9	0.6	0.7
	28	1.0	0.9	0.9	1.0	0.6	1.0	0.7	0.8
	29	1.1	1.0	0.9	1.1	0.6	1.1	0.7	0.8
	30	1.0	0.8	0.9	1.1	0.6	1.0	0.7	0.8
	31								
Sep	1								
	2	0.8	0.7	0.8	1.2	0.6	1.0	0.6	0.8
	3	0.9	0.8	0.8	1.3	0.7	1.1	0.8	1.0
	4	0.7	0.7	0.8	1.2	0.8	1.1	0.9	1.0
	5	0.8	0.8	0.9	1.3	1.0	1.3	1.1	1.2
	6	0.9	0.8	0.9	1.2	1.4	1.6	1.5	1.6
	7								
	8								
	9	1.1	1.0	1.1					
	10	1.1	1.0	1.1		2.2		0.0	
	11	1.2							
	12								
	13					2.1		1.9	
	14								
	15								1.9
	16				2.1				

TABLE A-5. Wave height (m) by station and date.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		0.0						
	4								
	5								
	6								
	7								
	8								
	9		0.0		0.0	0.0			
	10	0.1	0.1		0.0	0.0	0.0		
	11	0.1	0.1		0.1	0.1	0.0		
	12	0.1	0.1		0.1	0.0	0.0	0.0	
	13								
	14								
	15	0.1	0.1		0.0	0.0	0.0	0.0	
	16	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
	17	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
	18	0.1	0.1	0.1	0.0	0.0	0.0	0.0	
	19	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
	20								
	21								
	22	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
	23	0.1	0.1	0.1	0.0	0.0	0.0	0.0	
	24	0.1	0.1	0.1	0.0	0.0	0.0	0.0	
	25	0.1	0.0	0.1	0.0	0.0	0.0	0.0	
	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	27								
	28								
	29				0.0	0.0	0.0	0.0	
	30	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	31	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Aug	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3								
	4								
	5								
	6								
	7								
	8	0.0	0.0	0.0	0.0	0.0	0.0		0.0
	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10								
	11								
	12	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.1
	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	15	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	16	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	17								
	18								
	19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	20	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	21	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	22	0.1	0.1		0.0	0.0	0.0	0.0	0.0
	23	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	24								
	25								
	26	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	31								
Sep	1								
	2	0.1	0.1	0.8	0.0	0.0	0.0	0.0	0.0
	3	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.1
	7								
	8								
	9	0.1	0.1	0.2					
	10	0.0	0.0	0.0					
	11	0.1							

Table A-6. Total catch of Arctic cisco by station and direction.

DATE		STATION										
		DELTA						RIVER				
		1		2		3		661	202	203	204	205
		N	S	E	W	N	S					
Jul	3			6	8							
	4											
	5											
	6											
	7											
	8											
	9			2	2			0	0			
	10	8	3	3	0			0	1	0		
	11	11	8	0	0			0	1	0		
	12	1	1	0	0			0	0	1	0	
	13											
	14											
	15	0	2	0	0			0	0	0	0	
	16	0	1	0	0	0	0	0	0	0	0	
	17	0	0	0	0	0	1	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	
	19	4	0	0	0	0	0	0	0	0	0	
	20											
	21											
	22	0	0	0	0	0	0	0	0	0	0	
	23	0	1	0	0	0	0	0	0	0	0	
	24	0	0	0	0	0	0	0	0	0	0	
	25	1	0	0	0	0	0	0	0	0	0	
	26	0	1	0	0	0	0	0	0	0	0	
	27											
	28											
	29							0	0	0	0	
	30	0	0	0	0	0	0	0	0	0	0	0
	31	0	1	0	0	1	0	0	0	0	0	0
Aug	1	0	0	1	0	0	0	0	0	0	0	0
	2	2	0	0	0	0	0	0	0	0	0	0
	3											
	4											
	5											
	6											
	7											
	8	3	1	1	0	0	0	0	0	0		0
	9	0	0	0	0	0	0	0	0	0	0	0
	10											
	11											
	12	1	0	0	0	3	5	0	0	0	0	0
	13	1	17	1	1	0	0	0	0	0	0	0
	14	4	2	1	0	2	2	0	0	0	0	0
	15	8	26	10	0	19	15	0	0	0	0	0
	16	1	1	4	0	5	13	0	0	0	0	1
	17											
	18											
	19	7	3	0	0	5	0	0	0	0	0	0
	20	6	34	22	0	0	0	2	0	0	0	1
	21	1	16	3	0	0	3	2	0	0	2	0
	22	7	1	0	0	10	3	0	0	0	1	0
	23	1	0	0	2	4	3	0	0	0	0	1
	24											
	25											
	26	22	1	3	5	14	17	0	0	0	0	3
	27	59	26	18	1	19	18	0	1	0	0	1
	28	246	72	4	1	65	2	0	0	0	1	3
	29	43	33	4	0	63	7	0	0	0	0	0
	30	56	4	2	0	11	0	0	0	0	0	0
	31											
Sep	1											
	2	43	15	71	1	0	2	4	0	0	0	5
	3	14	633	4	0	6	25	1	0	0	0	1
	4	35	202	11	7	2	1	0	1	0	0	1
	5	14	4	2	5	2	2	1	3	2	2	0
	6	119	8	23	78	76	8	3	4	2	0	0
	7											
	8											
	9	64	89	86	28	10	11					
	10	93	265	61	20	5	17					
	11	119	728									
TOTAL CATCH		994	2199	343	159	322	155	13	11	5	6	17

TABLE A-7. Catch per effort (no./24 hr) of Arctic cisco by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		17.50						
	4								
	5								
	6								
	7								
	8								
	9		4.17		0.00	0.00			
	10	14.67	3.09		0.00	1.00	0.00		
	11	19.00	0.00		0.00	1.00	0.00		
	12	2.00	0.00		0.00	0.00	1.10	0.00	
	13								
	14								
	15	2.53	0.00		0.00	0.00	0.00	0.00	
	16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	
	17	0.00	0.00	0.99	0.00	0.00	0.00	0.00	
	18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	19	4.21	0.00	0.00	0.00	0.00	0.00	0.00	
	20								
	21								
	22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	23	1.05	0.00	0.00	0.00	0.00	0.00	0.00	
	24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	25	1.04	0.00	0.00	0.00	0.00	0.00	0.00	
	26	0.93	0.00	0.00	0.00	0.00	0.00	0.00	
	27								
	28								
	29				0.00	0.00	0.00	0.00	
	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	1.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00
Aug	1	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
	2	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3								
	4								
	5								
	6								
	7								
	8	4.40	1.06	0.00	0.00	0.00	0.00		0.00
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10								
	11								
	12	1.18	0.00	11.11	0.00	0.00	0.00	0.00	0.00
	13	21.95	2.35	0.00	0.00	0.00	0.00	0.00	0.00
	14	5.13	1.01	4.76	0.00	0.00	0.00	0.00	0.00
	15	31.78	9.62	34.00	0.00	0.00	0.00	0.00	0.00
	16	2.08	4.12	18.00	0.00	0.00	0.00	0.00	1.00
	17								
	18								
	19	11.90	0.00	6.67	0.00	0.00	0.00	0.00	0.00
	20	45.45	19.64	0.00	2.04	0.00	0.00	0.00	0.98
	21	17.00	3.41	2.97	2.00	0.00	0.00	1.96	0.00
	22	7.02	0.00	12.87	0.00	0.00	0.00	0.98	0.00
	23	1.02	2.02	7.07	0.00	0.00	0.00	0.00	1.03
	24								
	25								
	26	36.51	8.51	37.35	0.00	0.00	0.00	0.00	3.70
	27	85.86	21.84	35.24	0.00	0.98	0.00	0.00	0.97
	28	265.00	4.85	83.75	0.00	0.00	0.00	1.00	3.06
	29	74.51	3.96	70.00	0.00	0.00	0.00	0.00	0.00
	30	65.93	2.22	11.00	0.00	0.00	0.00	0.00	0.00
	31								
Sep	1								
	2	64.44	83.72	2.53	4.60	0.00	0.00	0.00	5.49
	3	647.00	3.85	31.00	1.00	0.00	0.00	0.00	1.02
	4	237.00	18.00	3.06	0.00	0.96	0.00	0.00	0.96
	5	19.15	7.53	4.04	1.02	3.26	2.15	2.11	0.00
	6	141.11	90.18	78.50	3.06	3.70	1.79	0.00	0.00
	7								
	8								
	9	201.32	150.00	29.58					
	10	361.62	81.82	22.68					
	11	910.75							

Table A-8. Total catch of arctic cisco by size group at outer delta stations.

DATE		SIZE GROUP SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	3	0	11	3
	4			
	5			
	6			
	7			
	8			
	9	0	3	1
	10	0	12	2
	11	1	13	5
	12	0	1	1
	13			
	14			
	15	0	2	0
	16	0	1	0
	17	0	1	0
	18	0	0	0
	19	2	1	1
	20			
	21			
	22	0	0	0
	23	0	1	0
	24	0	0	0
	25	1	0	0
	26	0	0	1
	27			
	28			
	29			
	30	0	0	0
	31	0	2	0
Aug	1	0	1	0
	2	0	2	0
	3			
	4			
	5			
	6			
	7			
	8	0	3	2
	9	0	0	0
	10			
	11			
	12	0	5	4
	13	0	19	1
	14	0	11	0
	15	0	73	5
	16	0	22	2
	17			
	18			
	19	0	15	0
	20	1	59	2
	21	0	20	3
	22	0	3	18
	23	1	4	5
	24			
	25			
	26	7	27	28
	27	103	28	10
	28	344	44	2
	29	124	22	4
	30	65	8	0
	31			
Sep	1			
	2	122	9	1
	3	630	46	6
	4	217	40	1
	5	16	13	0
	6	275	19	18
	7			
	8			
	9	266	8	14
	10	401	19	41
	11*	69	45	25
TOTAL		2645	613	206

* Note: On September 11, 708 fish were not measured, but approximately 90% were in the small size group.

Table A-9. Total catch of arctic cisco by size group at river stations.

DATE		SIZE GROUP		
		SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	9	0	0	0
	10	0	1	0
	11	0	1	0
	12	1	0	0
	13			
	14			
	15	0	0	0
	16	0	0	0
	17	0	0	0
	18	0	0	0
	19	0	0	0
	20			
	21			
	22	0	0	0
	23	0	0	0
	24	0	0	0
	25	0	0	0
	26	0	0	0
	27			
	28			
	29	0	0	0
	30	0	0	0
	31	0	0	0
Aug	1	0	0	0
	2	0	0	0
	3			
	4			
	5			
	6			
	7			
	8	0	0	0
	9	0	0	0
	10			
	11			
	12	0	0	0
	13	0	0	0
	14	0	0	0
	15	0	0	0
	16	0	1	0
	17			
	18			
	19	0	0	0
	20	0	2	1
	21	0	4	0
	22	0	0	1
	23	0	1	0
	24			
	25			
	26	0	3	0
	27	0	2	0
	28	0	4	0
	29	0	0	0
	30	0	0	0
	31			
Sep	1			
	2	5	4	0
	3	0	2	0
	4	1	1	0
	5	0	5	3
	6	0	5	4
TOTAL		7	36	9

Table A-10. Total catch of large Arctic cisco by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			2	1							
4											
5											
6											
7											
8											
9			0	1			0	0			
10	0	2	0	0			0	0	0		
11	1	4	0	0			0	0	0		
12	1	0	0	0			0	0	0	0	
13											
14											
15	0	0	0	0			0	0	0	0	
16	0	0	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	0	0	
19	1	0	0	0	0	0	0	0	0	0	
20											
21											
22	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	
26	0	1	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0
Aug 1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3											
4											
5											
6											
7											
8	0	1	1	0	0	0	0	0	0		0
9	0	0	0	0	0	0	0	0	0	0	0
10											
11											
12	0	0	0	0	2	2	0	0	0	0	0
13	0	1	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	2	0	0	2	1	0	0	0	0	0
16	0	0	1	0	0	1	0	0	0	0	0
17											
18											
19	0	0	0	0	0	0	0	0	0	0	0
20	2	0	0	0	0	0	0	0	0	0	1
21	1	0	0	0	0	2	0	0	0	0	0
22	5	1	0	0	9	3	0	0	0	1	0
23	1	0	0	1	0	3	0	0	0	0	0
24											
25											
26	8	0	1	0	9	10	0	0	0	0	0
27	5	0	2	1	0	2	0	0	0	0	0
28	1	0	1	0	0	0	0	0	0	0	0
29	0	0	0	0	3	1	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0
31											
Sep 1											
2	1	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	5	0	0	0	0	0
4	0	0	0	0	0	1	0	0	0	0	0
5	0	0	0	0	0	0	0	2	0	1	0
6	0	0	0	18	0	0	0	2	2	0	0
7											
8											
9	6	2	3	0	0	3					
10	21	9	3	1	2	5					
11	0	25									
TOTAL	54	49	14	23	27	39	0	4	2	2	1

Table A-11. Total catch of medium Arctic cisco by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			4	7							
4											
5											
6											
7											
8											
9			2	1			0	0			
10	8	1	3	0			0	1	0		
11	10	3	0	0			0	1	0		
12	0	1	0	0			0	0	0	0	
13											
14											
15	0	2	0	0			0	0	0	0	
16	0	1	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	1	0	0	0	0	
18	0	0	0	0	0	0	0	0	0	0	
19	1	0	0	0	0	0	0	0	0	0	
20											
21											
22	0	0	0	0	0	0	0	0	0	0	
23	0	1	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0
31	0	1	0	0	1	0	0	0	0	0	0
Aug 1	0	0	1	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0	0	0
3											
4											
5											
6											
7											
8	3	0	0	0	0	0	0	0	0		0
9	0	0	0	0	0	0	0	0	0	0	0
10											
11											
12	1	0	0	0	1	3	0	0	0	0	0
13	1	16	1	1	0	0	0	0	0	0	0
14	4	2	1	0	2	2	0	0	0	0	0
15	8	24	10	0	17	14	0	0	0	0	0
16	1	1	3	0	5	12	0	0	0	0	1
17											
18											
19	7	3	0	0	5	0	0	0	0	0	0
20	4	33	22	0	0	0	2	0	0	0	0
21	0	16	3	0	0	1	2	0	0	2	0
22	2	0	0	0	1	0	0	0	0	0	0
23	0	0	0	1	3	0	0	0	0	0	1
24											
25											
26	10	0	1	4	5	7	0	0	0	0	3
27	11	2	11	0	0	4	0	1	0	0	1
28	20	13	1	1	9	0	0	0	0	1	3
29	2	3	1	0	14	2	0	0	0	0	0
30	2	2	2	0	2	0	0	0	0	0	0
31											
Sep 1											
2	5	2	1	0	0	1	4	0	0	0	0
3	3	34	1	0	1	7	1	0	0	0	1
4	5	31	2	0	2	0	0	0	0	0	1
5	8	3	0	0	0	2	1	1	2	1	0
6	5	0	1	6	7	0	3	2	0	0	0
7											
8											
9	2	3	2	0	0	1					
10	12	4	1	0	1	1					
11	0	45									
TOTAL	137	247	74	21	76	58	13	6	2	4	11

Table A-12. Total catch of small Arctic cisco by station and direction.

DATE	STATION										
	DELTA								RIVER		
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			0	0							
4											
5											
6											
7											
8											
9			0	0			0	0			
10	0	0	0	0			0	0	0		
11	0	1	0	0			0	0	0		
12	0	0	0	0			0	0	1	0	
13											
14											
15	0	0	0	0			0	0	0	0	
16	0	0	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	0	0	
19	2	0	0	0	0	0	0	0	0	0	
20											
21											
22	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	
25	1	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0
Aug 1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3											
4											
5											
6											
7											
8	0	0	0	0	0	0	0	0	0		0
9	0	0	0	0	0	0	0	0	0	0	0
10											
11											
12	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
17											
18											
19	0	0	0	0	0	0	0	0	0	0	0
20	0	1	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	1	0	0	0	0	0	0
24											
25											
26	4	1	1	1	0	0	0	0	0	0	0
27	43	24	5	0	19	12	0	0	0	0	0
28	225	59	2	0	56	2	0	0	0	0	0
29	41	30	3	0	46	4	0	0	0	0	0
30	54	2	0	0	9	0	0	0	0	0	0
31											
Sep 1											
2	37	13	70	1	0	1	0	0	0	0	5
3	11	598	3	0	5	13	0	0	0	0	0
4	30	171	9	7	0	0	0	1	0	0	0
5	6	1	2	5	2	0	0	0	0	0	0
6	114	8	22	54	69	8	0	0	0	0	0
7											
8											
9	56	84	81	28	10	7					
10	60	252	57	19	2	11					
11	0	69									
TOTAL	684	1314	255	115	219	58	0	1	1	0	5

Table A-13. Total catch of least cisco by station and direction.

DATE		STATION											
		DELTA						RIVER					
		1		2		3		661	202	203	204	205
		N	S	E	W	N	S					
Jul	3			131	68							
	4											
	5											
	6											
	7											
	8											
	9			261	219			2	10			
	10	116	46	97	312			3	10	10		
	11	267	92	16	113			9	11	8		
	12	122	30	24	56			3	68	58	9	
	13											
	14											
	15	96	42	41	18			2	2	8	2	
	16	273	205	77	41	106	22	0	20	2	14	
	17	406	402	50	19	254	13	1	11	0	2	
	18	718	135	21	27	366	80	2	1	0	7	
	19	377	65	90	0	35	2	1	6	0	3	
	20											
	21											
	22	172	180	1	0	0	27	0	2	0	2	
	23	73	36	17	7	95	74	4	1	0	0	
	24	29	52	4	0	29	51	0	0	0	0	
	25	36	0	39	0	11	60	1	0	0	0	
	26	3	146	21	1	0	78	4	0	0	0	
	27											
	28											
	29							0	0	0	0	
	30	204	102	49	0	11	10	0	0	1	0	4
	31	241	127	0	1	145	88	0	0	0	0	2
Aug	1	24	24	9	0	44	78	1	0	0	0	0
	2	65	12	0	0	24	33	0	0	0	0	0
	3											
	4											
	5											
	6											
	7											
	8	83	19	14	40	67	32	2	0	1		0
	9	4	11	10	3	7	6	1	0	0	0	0
	10											
	11											
	12	8	5	2	0	40	29	0	0	1	0	3
	13	39	47	1	0	30	18	0	1	1	1	1
	14	95	119	12	4	50	13	0	0	2	4	4
	15	69	72	182	2	78	72	1	1	3	2	2
	16	23	9	23	1	73	50	2	2	4	1	12
	17											
	18											
	19	41	27	13	3	94	3	0	7	14	5	15
	20	64	124	10	33	70	42	5	9	1	5	32
	21	48	52	9	8	72	119	4	14	5	10	28
	22	26	10	1	18	71	5	6	20	4	16	60
	23	20	0	1	29	108	5	2	1	0	1	68
	24											
	25											
	26	145	44	81	42	135	46	11	4	1	6	76
	27	149	86	41	21	319	114	14	0	2	11	53
	28	166	116	25	9	559	27	6	10	5	5	120
	29	93	26	24	7	388	10	3	14	1	4	293
	30	234	72	74	0	142	5	9	62	2	7	339
	31											
Sep	1											
	2	90	53	100	1	20	28	38	2	6	0	337
	3	67	334	47	0	68	106	20	4	8	3	200
	4	117	207	25	11	86	47	20	97	29	19	182
	5	68	5	2	44	19	9	8	49	47	19	34
	6	150	4	4	226	363	14	14	79	53	34	25
	7											
	8											
	9	117	43	68	152	54	16					
	10	145	70	64	31	135	27					
	11	161	959									
TOTAL CATCH		5444	4210	1781	1567	4168	1459	199	518	277	192	1890

TABLE A-14. Catch per effort (no./24 hr) of least cisco by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		248.75						
	4								
	5								
	6								
	7								
	8								
	9		500.00		2.15	11.90			
	10	216.00	421.65		2.94	10.00	11.36		
	11	359.00	134.38		9.00	11.00	7.92		
	12	152.00	84.21		2.52	73.12	63.74	10.00	
	13								
	14								
	15	174.68	74.68		2.99	3.23	11.43	3.08	
	16	478.00	98.33	789.58	0.00	20.00	1.96	12.73	
	17	784.47	78.41	264.36	1.00	10.78	0.00	2.15	
	18	879.38	50.00	450.51	2.04	1.01	0.00	6.54	
	19	465.26	95.74	36.63	1.00	6.00	0.00	3.06	
	20								
	21								
	22	378.49	1.20	35.53	0.00	2.27	0.00	2.20	
	23	114.74	23.53	172.45	4.00	1.01	0.00	0.00	
	24	84.38	4.00	79.21	0.00	0.00	0.00	0.00	
	25	37.50	40.62	73.20	1.01	0.00	0.00	0.00	
	26	139.25	20.95	76.47	3.96	0.00	0.00	0.00	
	27								
	28								
	29				0.00	0.00	0.00	0.00	
	30	336.26	62.03	28.77	0.00	0.00	0.95	0.00	4.30
	31	368.00	0.99	242.71	0.00	0.00	0.00	0.00	2.20
Aug	1	50.00	9.38	125.77	0.99	0.00	0.00	0.00	0.00
	2	82.80	0.00	57.00	0.00	0.00	0.00	0.00	0.00
	3								
	4								
	5								
	6								
	7								
	8	112.09	57.45	132.00	0.93	0.00	1.09		0.00
	9	16.30	14.29	13.00	1.35	0.00	0.00	0.00	0.00
	10								
	11								
	12	15.29	2.02	95.83	0.00	0.00	1.14	0.00	3.49
	13	104.88	1.18	41.74	0.00	0.95	0.93	0.94	0.96
	14	182.91	16.16	75.00	0.00	0.00	1.96	3.88	4.00
	15	131.78	176.92	150.00	1.00	0.98	3.00	2.00	2.00
	16	33.33	24.74	123.00	2.00	2.08	4.08	1.04	12.00
	17								
	18								
	19	80.95	19.05	129.33	0.00	7.29	14.14	4.81	16.67
	20	213.64	38.39	100.00	5.10	9.00	1.00	5.10	31.37
	21	100.00	19.32	189.11	4.00	14.00	5.00	9.80	28.00
	22	31.58	18.63	75.25	6.00	19.61	3.85	15.69	60.00
	23	20.41	30.30	114.14	2.02	1.04	0.00	1.00	70.10
	24								
	25								
	26	300.00	130.85	218.07	13.75	4.60	1.11	6.45	93.83
	27	237.37	71.26	412.38	13.73	0.00	1.98	10.68	51.46
	28	235.00	33.01	732.50	6.12	9.80	5.00	5.00	122.45
	29	116.67	30.69	398.00	2.91	13.86	1.00	4.00	287.25
	30	336.26	82.22	147.00	9.28	62.00	1.96	6.93	349.48
	31								
Sep	1								
	2	158.89	117.44	60.76	43.68	2.00	5.88	0.00	370.33
	3	401.00	45.19	174.00	20.00	4.21	8.33	3.12	204.08
	4	324.00	36.00	135.71	19.23	93.27	27.88	18.27	175.00
	5	77.66	49.46	28.28	8.16	53.26	50.54	20.00	34.69
	6	171.11	205.36	352.34	14.29	73.15	47.32	29.31	24.04
	7								
	8								
	9	210.53	289.47	98.59					
	10	217.17	95.96	167.01					
	11	1204.30							

Table A-15. Total catch of least cisco by size group at outer delta stations.

DATE		SIZE GROUP		
		SMALL (120 mm	MEDIUM 120-249 mm	LARGE) 249 mm
Jul	3	102	97	0
	4			
	5			
	6			
	7			
	8			
	9	460	19	0
	10	437	132	0
	11	267	220	0
	12	132	99	0
	13			
	14			
	15	156	41	0
	16	1147	207	0
	17	1117	27	0
	18	1285	61	1
	19	552	17	0
	20			
	21			
	22	369	11	0
	23	287	15	0
	24	153	11	1
	25	142	4	0
	26	246	3	0
	27			
	28			
	29			
	30	371	4	1
	31	601	1	0
Aug	1	175	4	0
	2	127	6	1
	3			
	4			
	5			
	6			
	7			
	8	208	22	25
	9	37	2	2
	10			
	11			
	12	63	14	7
	13	91	24	20
	14	230	56	7
	15	283	155	37
	16	117	52	10
	17			
	18			
	19	140	36	5
	20	176	97	70
	21	84	85	139
	22	38	45	48
	23	87	65	11
	24			
	25			
	26	284	128	81
	27	487	200	43
	28	540	336	26
	29	293	236	19
	30	299	200	28
	31			
Sep	1			
	2	140	134	18
	3	169	408	45
	4	116	352	25
	5	50	79	18
	6	582	168	11
	7			
	8			
	9	403	41	6
	10	282	159	31
	11*	55	137	11
TOTAL		13380	4210	747

* Note: On September 11, 917 fish were not measured, but approximately 90% were in the small size group.

Table A-16. Total catch of least cisco by size group at river stations.

DATE		SIZE GROUP		
		SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	9	5	7	0
	10	6	17	0
	11	18	10	0
	12	43	95	0
	13			
	14			
	15	13	1	0
	16	32	4	0
	17	13	1	0
	18	9	1	0
	19	10	0	0
	20			
	21			
	22	4	0	0
	23	5	0	0
	24	0	0	0
	25	1	0	0
	26	4	0	0
	27			
	28			
	29	0	0	0
	30	5	0	0
	31	1	1	0
Aug	1	1	0	0
	2	0	0	0
	3			
	4			
	5			
	6			
	7			
	8	2	0	1
	9	1	0	0
	10			
	11			
	12	2	0	2
	13	3	0	1
	14	3	1	6
	15	1	4	4
	16	12	3	6
	17			
	18			
	19	18	14	9
	20	10	18	24
	21	7	10	44
	22	18	24	64
	23	37	16	19
	24			
	25			
	26	76	17	5
	27	40	37	3
	28	99	41	6
	29	203	101	11
	30	332	81	6
	31			
Sep	1			
	2	245	133	4
	3	104	107	24
	4	197	129	21
	5	51	86	20
	6	22	113	70
TOTAL		1653	1072	350

Table A-17. Total catch of large least cisco by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			0	0							
4											
5											
6											
7											
8											
9			0	0			0	0			
10	0	0	0	0			0	0	0		
11	0	0	0	0			0	0	0		
12	0	0	0	0			0	0	0	0	
13											
14											
15	0	0	0	0			0	0	0	0	
16	0	0	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	0	0	
18	1	0	0	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	0	0	0	
20											
21											
22	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	1	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	0	1	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0
Aug 1	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0	0	0
3											
4											
5											
6											
7											
8	18	7	0	0	0	0	0	0	1		0
9	0	0	1	0	1	0	0	0	0	0	0
10											
11											
12	0	0	0	0	1	6	0	0	1	0	1
13	2	3	1	0	8	6	0	0	0	1	0
14	0	0	4	0	3	0	0	0	2	2	2
15	7	6	4	1	8	11	0	0	3	1	0
16	2	0	4	0	1	3	0	2	1	0	3
17											
18											
19	0	0	1	0	4	0	0	3	2	2	2
20	6	6	1	3	29	25	1	2	0	3	18
21	19	3	0	2	26	89	1	9	4	8	22
22	3	0	0	5	36	4	0	10	4	6	44
23	0	0	0	1	10	0	0	0	0	0	19
24											
25											
26	9	3	10	6	47	6	0	1	0	0	4
27	11	5	4	3	8	12	0	0	0	0	3
28	4	2	2	0	16	2	0	1	0	1	4
29	1	2	2	1	12	1	0	0	0	1	10
30	6	4	9	0	7	2	0	0	0	0	6
31											
Sep 1											
2	9	3	0	1	0	5	0	1	1	0	2
3	2	16	3	0	0	24	0	1	1	1	21
4	1	9	1	1	4	9	2	4	1	1	13
5	13	1	0	0	1	3	0	5	8	4	3
6	2	0	0	6	1	2	0	34	25	5	6
7											
8											
9	1	0	2	0	2	1					
10	14	6	0	0	11	0					
11	0	11									
TOTAL	132	88	49	30	237	211	4	73	54	36	183

Table A-18. Total catch of medium least cisco by station and direction.

DATE	STATION: DELTA 1 N	1 S	2 E	2 W	3 N	3 S	RIVER 661	202	203	204	205
Jul 3			63	34							
4											
5											
6											
7											
8											
9			19	0			0	7			
10	65	29	8	30			0	8	9		
11	153	47	4	16			1	6	3		
12	69	14	10	6			0	57	36	2	
13											
14											
15	24	7	6	4			0	0	0	1	
16	58	22	1	2	103	21	0	4	0	0	
17	4	6	0	2	13	2	0	1	0	0	
18	17	12	0	1	8	23	1	0	0	0	
19	14	0	1	0	1	1	0	0	0	0	
20											
21											
22	1	7	0	0	0	3	0	0	0	0	
23	0	5	0	0	5	5	0	0	0	0	
24	3	4	1	0	1	2	0	0	0	0	
25	0	0	1	0	1	2	0	0	0	0	
26	1	2	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	1	1	2	0	0	0	0	0	0	0	0
31	0	0	0	0	1	0	0	0	0	0	1
Aug 1	0	1	1	0	0	2	0	0	0	0	0
2	3	1	0	0	1	1	0	0	0	0	0
3											
4											
5											
6											
7											
8	5	5	0	4	8	0	0	0	0		0
9	0	0	0	0	0	2	0	0	0	0	0
10											
11											
12	0	1	0	0	10	3	0	0	0	0	0
13	5	8	0	0	9	2	0	0	0	0	0
14	13	15	6	1	18	3	0	0	0	0	1
15	17	38	32	0	32	36	1	1	0	1	1
16	3	2	1	0	22	24	0	0	0	1	2
17											
18											
19	9	9	7	0	11	0	0	3	4	2	5
20	13	39	5	2	28	10	3	6	0	2	7
21	9	7	2	3	35	29	3	4	1	0	2
22	8	3	0	5	29	0	2	8	0	6	8
23	6	0	1	9	45	4	1	0	0	0	15
24											
25											
26	32	8	12	8	51	17	2	0	0	1	14
27	51	24	11	6	62	46	7	0	1	7	22
28	80	44	10	2	187	13	4	2	2	0	33
29	27	11	10	2	180	6	3	2	1	2	93
30	56	40	37	0	65	2	5	9	2	2	63
31											
Sep 1											
2	62	36	5	0	10	21	26	0	3	0	104
3	35	226	36	0	39	72	7	2	5	2	91
4	85	159	23	5	48	32	16	13	19	10	71
5	42	3	2	18	9	5	8	28	28	4	18
6	12	0	1	54	100	1	10	44	24	17	18
7											
8											
9	16	3	5	1	14	2					
10	53	27	3	1	70	5					
11	0	137									
TOTAL	1052	1003	326	216	1216	397	100	205	138	60	569

Table A-19. Total catch of small least cisco by station and direction.

DATE	DELTA 1 N	DELTA 1 S	DELTA 2 E	DELTA 2 W	DELTA 3 N	DELTA 3 S	RIVER 661	RIVER 202	RIVER 203	RIVER 204	RIVER 205
Jul 3			68	34							
4											
5											
6											
7											
8											
9			241	219			2	3			
10	51	17	87	282			3	2	1		
11	113	45	12	97			8	5	5		
12	52	16	14	50			3	11	22	7	
13											
14											
15	72	35	35	14			2	2	8	1	
16	215	183	76	39	418	1	0	16	2	14	
17	402	396	50	17	241	11	1	10	0	2	
18	700	123	21	26	358	57	1	1	0	7	
19	363	65	89	0	34	1	1	6	0	3	
20											
21											
22	171	173	1	0	0	24	0	2	0	2	
23	73	31	17	7	90	69	4	1	0	0	
24	26	48	3	0	27	49	0	0	0	0	
25	36	0	38	0	10	58	1	0	0	0	
26	2	144	21	1	0	78	4	0	0	0	
27											
28											
29							0	0	0	0	
30	203	100	47	0	11	10	0	0	1	0	4
31	241	127	0	1	144	88	0	0	0	0	1
Aug 1	24	23	8	0	44	76	1	0	0	0	0
2	61	11	0	0	23	32	0	0	0	0	0
3											
4											
5											
6											
7											
8	60	7	14	36	59	32	2	0	0		0
9	4	11	9	3	6	4	1	0	0	0	0
10											
11											
12	8	4	2	0	29	20	0	0	0	0	2
13	32	36	0	0	13	10	0	1	1	0	1
14	82	104	2	3	29	10	0	0	0	2	1
15	45	28	146	1	38	25	0	0	0	0	1
16	18	7	18	1	50	23	2	0	3	0	7
17											
18											
19	32	18	5	3	79	3	0	1	8	1	8
20	45	79	4	28	13	7	1	1	1	0	7
21	20	42	7	3	11	1	0	1	0	2	4
22	15	7	1	8	6	1	4	2	0	4	8
23	14	0	0	19	53	1	1	1	0	1	34
24											
25											
26	104	33	59	28	37	23	9	3	1	5	58
27	87	57	26	12	249	56	7	0	1	4	28
28	82	70	13	7	356	12	2	7	3	4	83
29	65	13	12	4	196	3	0	12	0	1	190
30	172	28	28	0	70	1	4	53	0	5	270
31											
Sep 1											
2	19	14	95	0	10	2	12	1	2	0	230
3	30	92	8	0	29	10	13	1	2	0	88
4	31	39	1	5	34	6	2	80	9	8	98
5	13	1	0	26	9	1	0	16	11	11	13
6	136	4	3	166	262	11	4	1	4	12	1
7											
8											
9	100	40	61	151	38	13					
10	78	37	61	30	54	22					
11	0	55									
TOTAL	4097	2363	1403	1321	3130	851	95	240	85	96	1137

Table A-20. Total catch of broad whitefish by station and direction.

DATE		STATION										
		DELTA						RIVER				
		1		2		3		661	202	203	204	205
		N	S	E	W	N	S					
Jul	3			10	21							
	4											
	5											
	6											
	7											
	8											
	9			22	26			0	2			
	10	17	11	7	17			0	1	1		
	11	18	5	0	5			0	2	1		
	12	7	0	0	4			0	1	0	0	
	13											
	14											
	15	20	23	4	0			0	2	0	1	
	16	26	31	3	1	23	19	1	5	0	2	
	17	41	8	1	0	30	13	1	0	0	1	
	18	54	16	0	0	51	37	0	1	0	0	
	19	62	0	4	2	10	5	3	4	0	0	
	20											
	21											
	22	65	43	6	1	0	8	0	3	0	1	
	23	26	63	12	18	37	10	6	11	2	1	
	24	17	20	5	2	9	5	14	1	0	2	
	25	11	0	16	2	4	7	32	0	1	1	
	26	9	59	3	1	3	2	3	3	1	0	
	27											
	28											
	29							0	0	0	1	
	30	59	41	19	0	19	18	6	3	0	7	16
	31	116	132	5	2	27	45	4	3	0	0	16
Aug	1	25	36	24	0	0	36	103	8	1	0	9
	2	40	41	10	0	33	25	4	5	2	2	10
	3											
	4											
	5											
	6											
	7											
	8	79	23	21	31	95	63	8	4	6		30
	9	28	11	19	1	10	6	2	9	3	5	23
	10											
	11											
	12	25	9	2	0	53	29	1	15	7	10	16
	13	66	37	29	10	58	17	3	6	9	9	59
	14	77	53	115	12	33	9	5	9	5	9	18
	15	23	12	60	2	32	5	8	7	7	5	38
	16	4	0	10	0	8	12	8	3	6	2	20
	17											
	18											
	19	20	33	58	6	27	1	1	33	14	5	21
	20	30	36	72	7	16	7	3	20	7	3	29
	21	31	28	31	4	7	14	9	22	1	4	4
	22	15	22	16	17	3	2	21	5	0	1	7
	23	4	5	11	5	6	1	6	1	0	1	10
	24											
	25											
	26	98	22	80	16	40	29	2	7	4	2	19
	27	77	38	27	20	34	45	5	2	3	5	19
	28	26	89	5	2	19	2	4	9	6	3	44
	29	2	10	7	0	17	0	1	10	7	5	27
	30	2	6	5	0	2	0	3	14	5	6	28
	31											
Sep	1											
	2	27	9	31	1	4	8	6	0	2	0	17
	3	14	40	3	0	4	10	1	0	3	0	7
	4	10	21	5	2	6	3	1	5	10	2	7
	5	5	8	0	1	3	1	3	12	6	1	1
	6	22	4	5	27	16	2	2	2	1	5	5
	7											
	8											
	9	5	7	7	8	2	0					
	10	2	16	4	4	10	1					
	11	11	50									
TOTAL CATCH		1316	1118	774	278	751	497	280	250	121	102	500

TABLE A-21. Catch per effort (no./24 hr) of broad whitefish by station.

DATE		STATION							
			DELTA				RIVER		
		1	2	3	661	202	203	204	205
Jul	3		38.75						
	4								
	5								
	6								
	7								
	8								
	9		50.00		0.00	2.38			
	10	37.33	24.74		0.00	1.00	1.14		
	11	23.00	5.21		0.00	2.00	0.99		
	12	7.00	4.21		0.00	1.08	0.00	0.00	
	13								
	14								
	15	54.43	5.06		0.00	3.23	0.00	1.54	
	16	57.00	3.33	43.75	1.01	5.00	0.00	1.82	
	17	47.57	1.14	42.57	1.00	0.00	0.00	1.08	
	18	72.16	0.00	88.89	0.00	1.01	0.00	0.00	
	19	65.26	6.38	14.85	3.00	4.00	0.00	0.00	
	20								
	21								
	22	116.13	8.43	10.53	0.00	3.41	0.00	1.10	
	23	93.68	29.41	47.96	6.00	11.11	2.00	0.99	
	24	38.54	7.00	13.86	14.00	1.02	0.00	2.02	
	25	11.46	18.75	11.34	32.32	0.00	1.00	1.00	
	26	63.55	3.81	4.90	2.97	2.91	1.00	0.00	
	27								
	28								
	29				0.00	0.00	0.00	1.41	
	30	109.89	24.05	50.68	5.94	2.88	0.00	6.80	17.20
	31	248.00	6.93	75.00	4.08	3.16	0.00	0.00	17.58
Aug	1	63.54	25.00	37.11	101.98	7.84	0.96	0.00	8.41
	2	87.10	10.42	58.00	4.04	5.00	2.06	2.11	10.64
	3								
	4								
	5								
	6								
	7								
	8	112.09	55.32	210.67	3.74	4.55	6.52		26.55
	9	42.39	21.98	16.00	2.70	10.59	3.26	5.10	28.05
	10								
	11								
	12	40.00	2.02	113.89	1.20	17.24	7.95	10.87	18.60
	13	125.61	45.88	65.22	2.88	5.71	8.41	8.49	56.73
	14	111.11	128.28	50.00	5.00	8.18	4.90	8.74	18.00
	15	32.71	59.62	37.00	8.00	6.86	7.00	5.00	38.00
	16	4.17	10.31	20.00	8.00	3.12	6.12	2.08	20.00
	17								
	18								
	19	63.10	76.19	37.33	1.27	34.38	14.14	4.81	23.33
	20	75.00	70.54	20.54	3.06	20.00	7.00	3.06	28.43
	21	59.00	39.77	20.79	9.00	22.00	1.00	3.92	4.00
	22	32.46	32.35	4.95	21.00	4.90	0.00	0.98	7.00
	23	9.18	16.16	7.07	6.06	1.04	0.00	1.00	10.31
	24								
	25								
	26	190.48	102.13	83.13	2.50	8.05	4.44	2.15	23.46
	27	116.16	54.02	75.24	4.90	1.96	2.97	4.85	18.45
	28	95.83	6.80	26.25	4.08	8.82	6.00	3.00	44.90
	29	11.76	6.93	17.00	0.97	9.90	7.00	5.00	26.47
	30	8.79	5.56	2.00	3.09	14.00	4.90	5.94	28.87
	31								
Sep	1								
	2	40.00	37.21	15.19	6.90	0.00	1.96	0.00	18.68
	3	54.00	2.88	14.00	1.00	0.00	3.12	0.00	7.14
	4	31.00	7.00	9.18	0.96	4.81	9.62	1.92	6.73
	5	13.83	1.08	4.04	3.06	13.04	6.45	1.05	1.02
	6	28.89	28.57	16.82	2.04	1.85	0.89	4.31	4.81
	7								
	8								
	9	15.79	19.74	2.82					
	10	18.18	8.08	11.34					
	11	65.59							

Table A-22. Total catch of broad whitefish by size group at outer delta stations.

DATE		SIZE GROUP		
		SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	3	23	3	5
	4			
	5			
	6			
	7			
	8			
	9	21	20	7
	10	21	17	12
	11	5	18	5
	12	6	3	1
	13			
	14			
	15	23	22	2
	16	67	34	2
	17	75	16	2
	18	110	46	2
	19	68	13	2
	20			
	21			
	22	77	45	1
	23	90	62	14
	24	29	20	9
	25	24	8	8
	26	51	21	5
	27			
	28			
	29			
	30	97	48	11
	31	226	90	11
Aug	1	68	42	11
	2	83	56	10
	3			
	4			
	5			
	6			
	7			
	8	121	176	15
	9	44	28	3
	10			
	11			
	12	62	52	4
	13	120	94	3
	14	168	122	9
	15	40	83	11
	16	16	17	1
	17			
	18			
	19	99	45	1
	20	42	112	14
	21	29	65	21
	22	18	49	8
	23	17	13	2
	24			
	25			
	26	83	157	45
	27	101	130	10
	28	101	38	4
	29	15	18	3
	30	3	12	0
	31			
Sep	1			
	2	44	31	5
	3	33	37	1
	4	16	28	3
	5	8	10	0
	6	69	7	0
	7			
	8			
	9	24	2	3
	10	24	8	5
	11	43	6	1
TOTAL		2504	1924	292

Table A-23. Total catch of broad whitefish by size group at river stations.

DATE		SIZE GROUP	
	SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul 9	1	1	0
10	1	1	0
11	3	0	0
12	0	1	0
13			
14			
15	2	0	1
16	7	1	0
17	2	0	0
18	1	0	0
19	5	2	0
20			
21			
22	4	0	0
23	14	6	0
24	13	4	0
25	33	1	0
26	6	0	1
27			
28			
29	1	0	0
30	27	5	0
31	18	4	1
Aug 1	114	6	1
2	19	4	0
3			
4			
5			
6			
7			
8	36	9	3
9	36	4	2
10			
11			
12	39	9	1
13	63	22	1
14	34	9	3
15	34	29	1
16	20	19	0
17			
18			
19	36	35	3
20	16	27	19
21	14	17	9
22	20	9	5
23	13	4	1
24			
25			
26	21	12	1
27	25	7	2
28	34	28	4
29	23	23	4
30	22	24	10
31			
Sep 1			
2	13	10	2
3	6	3	2
4	10	9	6
5	13	8	2
6	9	6	0
TOTAL	808	359	85

Table A-24. Total catch of large broad whitefish by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			1	4							
4											
5											
6											
7											
8											
9			3	4			0	0			
10	8	4	0	0			0	0	0		
11	4	1	0	0			0	0	0		
12	1	0	0	0			0	0	0	0	
13											
14											
15	2	0	0	0			0	1	0	0	
16	0	0	0	0	1	1	0	0	0	0	
17	1	0	0	0	1	0	0	0	0	0	
18	0	0	0	0	0	2	0	0	0	0	
19	1	0	0	1	0	0	0	0	0	0	
20											
21											
22	1	0	0	0	0	0	0	0	0	0	
23	3	4	2	1	2	2	0	0	0	0	
24	5	1	2	0	1	0	0	0	0	0	
25	3	0	3	2	0	0	0	0	0	0	
26	0	2	0	1	2	0	0	0	1	0	
27											
28											
29							0	0	0	0	
30	2	5	3	0	1	0	0	0	0	0	0
31	2	4	3	1	0	1	0	0	0	0	1
Aug 1	3	1	5	0	0	2	0	0	0	0	1
2	0	2	4	0	2	2	0	0	0	0	0
3											
4											
5											
6											
7											
8	14	1	0	0	0	0	1	0	0		2
9	2	0	0	0	0	1	0	0	0	0	2
10											
11											
12	0	1	1	0	1	1	0	0	1	0	0
13	1	1	1	0	0	0	1	0	0	0	0
14	4	0	5	0	0	0	2	0	1	0	0
15	1	3	3	1	1	2	0	0	1	0	0
16	0	0	1	0	0	0	0	0	0	0	0
17											
18											
19	1	0	0	0	0	0	0	1	1	1	0
20	2	4	5	2	0	1	0	5	5	1	8
21	5	2	4	0	2	8	0	8	1	0	0
22	2	2	0	2	2	0	0	3	0	0	2
23	1	0	0	1	0	0	0	0	0	0	1
24											
25											
26	10	1	1	8	18	7	0	0	1	0	0
27	3	1	1	1	2	2	0	0	0	0	2
28	0	0	2	1	0	1	0	2	1	1	0
29	0	0	0	0	3	0	0	2	0	0	2
30	0	0	0	0	0	0	0	4	1	0	5
31											
Sep 1											
2	3	1	0	0	1	0	1	0	0	0	1
3	0	0	0	0	0	1	0	0	2	0	0
4	0	1	1	0	0	1	0	0	5	0	1
5	0	0	0	0	0	0	0	1	1	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7											
8											
9	1	1	1	0	0	0					
10	0	1	0	0	3	1					
11	0	1									
TOTAL	86	45	52	30	43	36	5	27	22	3	28

Table A-25. Total catch of medium broad whitefish by station and direction.

DATE	STATION										
	DELTA							RIVER			
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			3	0							
4											
5											
6											
7											
8											
9			10	10			0	1			
10	8	7	1	1			0	0	1		
11	12	4	0	2			0	0	0		
12	3	0	0	0			0	1	0	0	
13											
14											
15	5	17	0	0			0	0	0	0	
16	11	9	3	0	7	4	0	1	0	0	
17	9	1	0	0	3	3	0	0	0	0	
18	12	5	0	0	15	14	0	0	0	0	
19	8	0	1	0	1	3	1	1	0	0	
20											
21											
22	23	16	3	1	0	2	0	0	0	0	
23	13	31	1	4	8	5	3	1	2	0	
24	4	9	1	2	3	1	3	1	0	0	
25	3	0	2	0	1	2	1	0	0	0	
26	9	12	0	0	0	0	0	0	0	0	
27											
28											
29							0	0	0	0	
30	13	15	8	0	3	9	0	1	0	0	4
31	28	50	0	1	0	11	2	1	0	0	1
Aug 1	11	11	7	0	0	13	4	1	0	0	1
2	6	24	2	0	12	12	2	0	1	0	1
3											
4											
5											
6											
7											
8	32	14	6	13	71	40	3	0	2		4
9	11	4	6	0	6	1	0	2	0	0	2
10											
11											
12	4	5	1	0	25	17	0	3	0	4	2
13	25	25	16	5	16	7	2	3	0	0	17
14	33	11	50	6	18	4	1	1	0	1	6
15	15	3	38	0	24	3	5	1	1	0	22
16	0	0	6	0	3	8	7	0	1	0	11
17											
18											
19	10	3	17	3	12	0	0	17	3	3	12
20	21	20	54	4	9	4	1	10	1	1	14
21	22	14	19	3	3	4	5	9	0	0	3
22	11	13	11	11	1	2	5	1	0	0	3
23	2	2	5	1	2	1	0	0	0	0	4
24											
25											
26	63	15	39	2	18	20	1	1	2	0	8
27	31	21	16	10	19	33	0	0	0	1	6
28	11	21	2	1	2	1	2	3	2	1	20
29	1	5	2	0	10	0	0	4	4	1	14
30	2	6	4	0	0	0	1	5	0	1	17
31											
Sep 1											
2	19	6	1	1	2	2	4	0	0	0	6
3	12	15	1	0	3	6	1	0	0	0	2
4	5	11	4	1	5	2	0	2	3	0	4
5	4	6	0	0	0	0	1	3	3	0	1
6	0	1	2	3	1	0	0	1	0	1	4
7											
8											
9	0	1	0	0	1	0					
10	1	2	2	0	3	0					
11	0	6									
TOTAL	513	441	344	85	307	234	55	75	26	14	189

Table A-26. Total catch of small broad whitefish by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			6	17							
4											
5											
6											
7											
8											
9			9	12			0	1			
10	1	0	4	16			0	1	0		
11	2	0	0	3			0	2	1		
12	2	0	0	4			0	0	0	0	
13											
14											
15	13	6	4	0			0	1	0	1	
16	15	22	0	1	15	14	1	4	0	2	
17	31	7	1	0	26	10	1	0	0	1	
18	42	11	0	0	36	21	0	1	0	0	
19	53	0	3	1	9	2	2	3	0	0	
20											
21											
22	41	27	3	0	0	6	0	3	0	1	
23	10	28	9	13	27	3	3	10	0	1	
24	8	10	2	0	5	4	11	0	0	2	
25	5	0	11	0	3	5	31	0	1	1	
26	0	45	3	0	1	2	3	3	0	0	
27											
28											
29							0	0	0	1	
30	44	21	8	0	15	9	6	2	0	7	12
31	86	78	2	0	27	33	2	2	0	0	14
Aug 1	11	24	12	0	0	21	99	7	1	0	7
2	34	15	4	0	19	11	2	5	1	2	9
3											
4											
5											
6											
7											
8	33	8	15	18	24	23	4	4	4		24
9	15	7	13	1	4	4	2	7	3	5	19
10											
11											
12	21	3	0	0	27	11	1	12	6	6	14
13	40	11	12	5	42	10	0	3	9	9	42
14	40	42	60	6	15	5	2	8	4	8	12
15	7	6	19	1	7	0	3	6	5	5	15
16	4	0	3	0	5	4	1	3	5	2	9
17											
18											
19	9	30	41	3	15	1	1	15	10	1	9
20	7	12	13	1	7	2	2	5	1	1	7
21	4	12	8	1	2	2	4	5	0	4	1
22	2	7	5	4	0	0	16	1	0	1	2
23	1	3	6	3	4	0	6	1	0	1	5
24											
25											
26	25	6	40	6	4	2	1	6	1	2	11
27	43	16	10	9	13	10	5	2	3	4	11
28	15	68	1	0	17	0	2	4	3	1	24
29	1	5	5	0	4	0	1	4	3	4	11
30	0	0	1	0	2	0	2	5	4	5	6
31											
Sep 1											
2	5	2	30	0	1	6	1	0	2	0	10
3	2	25	2	0	1	3	0	0	1	0	5
4	5	9	0	1	1	0	1	3	2	2	2
5	1	2	0	1	3	1	2	8	2	1	0
6	22	3	3	24	15	2	2	1	1	4	1
7											
8											
9	4	5	6	8	1	0					
10	1	13	2	4	4	0					
11	0	43									
TOTAL	705	632	376	163	401	227	220	148	73	85	282

Table A-27. Total catch of humpback whitefish by station and direction.

DATE		STATION										
		DELTA						RIVER				
		1		2		3		661	202	203	204	205
		N	S	E	W	N	S					
Jul	3			2	0							
	4											
	5											
	6											
	7											
	8											
	9			3	3			0	0			
	10	2	1	1	0			0	0	0		
	11	9	1	1	0			0	0	0		
	12	0	0	0	0			0	0	0	0	
	13											
	14											
	15	0	2	1	0			0	0	0	0	
	16	5	1	0	0	2	3	0	0	0	0	
	17	4	0	0	0	2	1	0	0	0	0	
	18	2	2	1	0	3	2	0	0	0	0	
	19	6	0	0	0	0	0	0	0	0	0	
	20											
	21											
	22	16	11	1	0	0	3	0	0	0	0	
	23	26	9	7	12	20	7	0	0	0	0	
	24	14	3	0	1	12	15	1	0	0	0	
	25	17	0	10	0	8	15	5	0	0	0	
	26	4	75	6	3	2	5	2	1	1	1	
	27											
	28											
	29							0	1	1	2	
	30	27	3	8	2	5	8	2	0	0	0	13
	31	65	18	0	1	22	50	3	1	0	0	6
Aug	1	5	7	4	0	0	53	23	0	0	1	4
	2	35	7	1	0	15	4	0	0	0	0	8
	3											
	4											
	5											
	6											
	7											
	8	138	37	24	29	75	38	44	0	2		16
	9	9	16	35	9	4	7	4	0	1	2	5
	10											
	11											
	12	10	1	0	0	98	23	7	0	0	42	9
	13	30	27	8	0	23	16	11	2	0	22	54
	14	192	76	28	21	31	9	9	2	6	76	126
	15	23	8	40	6	45	10	26	18	3	25	224
	16	12	3	20	0	10	12	48	6	4	11	76
	17											
	18											
	19	12	7	30	3	41	5	14	10	19	22	53
	20	18	21	12	3	16	16	39	6	0	8	3
	21	11	14	3	0	12	26	53	4	0	12	5
	22	4	4	3	4	6	3	59	4	0	1	5
	23	2	0	3	7	3	0	11	1	0	4	21
	24											
	25											
	26	6	0	28	4	10	17	28	14	1	20	74
	27	8	8	33	4	8	34	16	13	2	26	133
	28	34	94	2	2	21	0	21	25	2	57	156
	29	19	33	8	1	42	1	2	11	2	20	98
	30	46	24	12	0	9	0	16	5	5	16	137
	31											
Sep	1											
	2	9	3	0	0	0	3	15	1	6	3	127
	3	2	9	2	1	9	6	4	1	1	1	44
	4	10	11	4	1	2	5	0	4	6	6	23
	5	0	0	1	0	0	0	3	0	1	2	2
	6	0	0	0	3	0	0	2	1	2	1	5
	7											
	8											
	9	0	0	0	1	0	0					
	10	2	1	0	2	0	0					
	11	1	11									
TOTAL CATCH		835	548	342	123	556	397	468	131	65	381	1427

TABLE A-28. Catch per effort (no./24 hr) of humpback whitefish by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		2.50						
	4								
	5								
	6								
	7								
	8								
	9		6.25		0.00	0.00			
	10	4.00	1.03		0.00	0.00	0.00		
	11	10.00	1.04		0.00	0.00	0.00		
	12	0.00	0.00		0.00	0.00	0.00	0.00	
	13								
	14								
	15	2.53	1.27		0.00	0.00	0.00	0.00	
	16	6.00	0.00	5.21	0.00	0.00	0.00	0.00	
	17	3.88	0.00	2.97	0.00	0.00	0.00	0.00	
	18	4.12	1.04	5.05	0.00	0.00	0.00	0.00	
	19	6.32	0.00	0.00	0.00	0.00	0.00	0.00	
	20								
	21								
	22	29.03	1.20	3.95	0.00	0.00	0.00	0.00	
	23	36.84	18.63	27.55	0.00	0.00	0.00	0.00	
	24	17.71	1.00	26.73	1.00	0.00	0.00	0.00	
	25	17.71	10.42	23.71	5.05	0.00	0.00	0.00	
	26	73.83	8.57	6.86	1.98	0.97	1.00	0.99	
	27								
	28								
	29				0.00	1.59	1.54	2.82	
	30	32.97	12.66	17.81	1.98	0.00	0.00	0.00	13.98
	31	83.00	0.99	75.00	3.06	1.05	0.00	0.00	6.59
Aug	1	12.50	4.17	54.64	22.77	0.00	0.00	0.94	3.74
	2	45.16	1.04	19.00	0.00	0.00	0.00	0.00	8.51
	3								
	4								
	5								
	6								
	7								
	8	192.31	56.38	150.67	20.56	0.00	2.17		14.16
	9	27.17	48.35	11.00	5.41	0.00	1.09	2.04	6.10
	10								
	11								
	12	12.94	0.00	168.06	8.43	0.00	0.00	45.65	10.47
	13	69.51	9.41	33.91	10.58	1.90	0.00	20.75	51.92
	14	229.06	49.49	47.62	9.00	1.82	5.88	73.79	126.00
	15	28.97	44.23	55.00	26.00	17.65	3.00	25.00	224.00
	16	15.62	20.62	22.00	48.00	6.25	4.08	11.46	76.00
	17								
	18								
	19	22.62	39.29	61.33	17.72	10.42	19.19	21.15	58.89
	20	44.32	13.39	28.57	39.80	6.00	0.00	8.16	2.94
	21	25.00	3.41	37.62	53.00	4.00	0.00	11.76	5.00
	22	7.02	6.86	8.91	59.00	3.92	0.00	0.98	5.00
	23	2.04	10.10	3.03	11.11	1.04	0.00	4.00	21.65
	24								
	25								
	26	9.52	34.04	32.53	35.00	16.09	1.11	21.51	91.36
	27	16.16	42.53	40.00	15.69	12.75	1.98	25.24	129.13
	28	106.67	3.88	26.25	21.43	24.51	2.00	57.00	159.18
	29	50.98	8.91	43.00	1.94	10.89	2.00	20.00	96.08
	30	76.92	13.33	9.00	16.49	5.00	4.90	15.84	141.24
	31								
Sep	1								
	2	13.33	0.00	3.80	17.24	1.00	5.88	2.86	139.56
	3	11.00	2.88	15.00	4.00	1.05	1.04	1.04	44.90
	4	21.00	5.00	7.14	0.00	3.85	5.77	5.77	22.12
	5	0.00	1.08	0.00	3.06	0.00	1.08	2.11	2.04
	6	0.00	2.68	0.00	2.04	0.93	1.79	0.86	4.81
	7								
	8								
	9	0.00	1.32	0.00					
	10	3.03	2.02	0.00					
	11	12.90							

Table A-29. Total catch of humpback whitefish by size group at outer delta stations.

DATE		SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	3	0	2	0
	4			
	5			
	6			
	7			
	8			
	9	1	3	1
	10	1	1	2
	11	0	6	5
	12	0	0	0
	13			
	14			
	15	0	2	1
	16	0	8	3
	17	0	6	1
	18	1	8	1
	19	1	5	0
	20			
	21			
	22	22	4	5
	23	65	12	4
	24	33	8	4
	25	42	5	3
	26	80	7	8
	27			
	28			
	29			
	30	45	6	2
	31	134	17	5
Aug	1	62	5	2
	2	57	2	3
	3			
	4			
	5			
	6			
	7			
	8	219	111	11
	9	60	19	1
	10			
	11			
	12	104	25	3
	13	62	41	1
	14	260	90	7
	15	99	31	2
	16	37	19	1
	17			
	18			
	19	75	22	1
	20	22	47	17
	21	20	34	12
	22	20	2	2
	23	13	0	2
	24			
	25			
	26	30	33	2
	27	37	56	2
	28	96	55	2
	29	48	55	1
	30	36	55	0
	31			
Sep	1			
	2	2	13	0
	3	10	18	1
	4	3	29	1
	5	0	1	0
	6	2	1	0
	7			
	8			
	9	0	1	0
	10	1	4	0
	11	6	5	1
TOTAL		1806	874	120

Table A-30. Total catch of humpback whitefish by size group at river stations.

DATE		SIZE GROUP SMALL < 120 mm	MEDIUM 120-249 mm	LARGE > 249 mm
Jul	9	0	0	0
	10	0	0	0
	11	0	0	0
	12	0	0	0
	13			
	14			
	15	0	0	0
	16	0	0	0
	17	0	0	0
	18	0	0	0
	19	0	0	0
	20			
	21			
	22	0	0	0
	23	0	0	0
	24	0	1	0
	25	5	0	0
	26	2	2	1
	27			
	28			
	29	1	2	1
	30	11	3	1
	31	8	2	0
Aug	1	24	3	1
	2	7	0	1
	3			
	4			
	5			
	6			
	7			
	8	56	1	5
	9	7	2	3
	10			
	11			
	12	44	14	0
	13	70	18	1
	14	176	37	6
	15	212	67	17
	16	78	63	4
	17			
	18			
	19	71	40	7
	20	17	35	4
	21	51	21	2
	22	36	33	0
	23	29	6	2
	24			
	25			
	26	112	24	1
	27	160	29	0
	28	195	64	2
	29	97	34	2
	30	120	55	4
	31			
Sep	1			
	2	105	45	2
	3	30	21	0
	4	26	13	0
	5	1	7	0
	6	5	6	0
TOTAL		1756	648	67

Table A-31. Total catch of large humpback whitefish by station and direction.

DATE	STATION DELTA 1 N	1 S	2 E	2 W	3 N	3 S	RIVER 661	202	203	204	205
Jul 3			0	0							
4											
5											
6											
7											
8											
9			0	1			0	0			
10	2	0	0	0			0	0	0		
11	4	0	1	0			0	0	0		
12	0	0	0	0			0	0	0	0	
13											
14											
15	0	1	0	0			0	0	0	0	
16	2	0	0	0	0	1	0	0	0	0	
17	0	0	0	0	1	0	0	0	0	0	
18	0	0	1	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	0	0	0	
20											
21											
22	1	1	1	0	0	2	0	0	0	0	
23	0	0	0	1	2	1	0	0	0	0	
24	1	0	0	1	1	1	0	0	0	0	
25	0	0	1	0	2	0	0	0	0	0	
26	1	4	3	0	0	0	0	0	0	1	
27											
28											
29							0	0	0	1	
30	0	0	0	2	0	0	0	0	0	0	1
31	3	0	0	1	0	1	0	0	0	0	0
Aug 1	1	0	0	0	0	1	0	0	0	1	0
2	0	0	1	0	0	2	0	0	0	0	1
3											
4											
5											
6											
7											
8	3	1	1	0	4	2	2	0	2		1
9	0	0	1	0	0	0	1	0	0	1	1
10											
11											
12	0	0	0	0	1	2	0	0	0	0	0
13	0	0	0	0	1	0	0	0	0	1	0
14	1	0	4	0	2	0	0	0	0	0	6
15	0	0	1	0	1	0	4	0	2	7	4
16	0	0	1	0	0	0	1	1	1	0	1
17											
18											
19	0	0	0	0	1	0	0	4	1	1	1
20	4	1	0	0	6	6	2	1	0	1	0
21	1	0	0	0	2	9	1	0	0	0	1
22	1	0	0	0	1	0	0	0	0	0	0
23	0	0	0	1	1	0	0	0	0	2	0
24											
25											
26	0	0	1	0	1	0	0	0	0	0	1
27	0	0	0	0	0	2	0	0	0	0	0
28	0	1	0	0	1	0	0	0	0	1	1
29	0	0	0	0	1	0	0	0	1	0	1
30	0	0	0	0	0	0	0	0	0	2	2
31											
Sep 1											
2	0	0	0	0	0	0	0	0	1	1	0
3	0	0	0	0	1	0	0	0	0	0	0
4	0	0	0	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7											
8											
9	0	0	0	0	0	0					
10	0	0	0	0	0	0					
11	0	1									
TOTAL	25	10	17	8	30	30	11	6	8	20	22

Table A-32. Total catch of medium humpback whitefish by station and direction.

DATE	STATION										
	DELTA								RIVER		
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			2	0							
4											
5											
6											
7											
8											
9			1	2			0	0			
10	0	1	0	0			0	0	0		
11	5	1	0	0			0	0	0		
12	0	0	0	0			0	0	0	0	
13											
14											
15	0	1	1	0			0	0	0	0	
16	3	1	0	0	2	2	0	0	0	0	
17	4	0	0	0	1	1	0	0	0	0	
18	1	2	0	0	3	2	0	0	0	0	
19	5	0	0	0	0	0	0	0	0	0	
20											
21											
22	4	0	0	0	0	0	0	0	0	0	
23	4	2	0	1	1	4	0	0	0	0	
24	1	0	0	0	1	6	1	0	0	0	
25	0	0	1	0	0	4	0	0	0	0	
26	2	4	0	0	0	1	2	0	0	0	
27											
28											
29							0	1	0	1	
30	0	0	3	0	0	3	1	0	0	0	2
31	5	2	0	0	0	10	0	0	0	0	2
Aug 1	0	0	0	0	0	5	2	0	0	0	1
2	1	0	0	0	1	0	0	0	0	0	0
3											
4											
5											
6											
7											
8	60	11	5	2	20	13	1	0	0		0
9	5	3	8	0	2	1	1	0	0	0	1
10											
11											
12	2	1	0	0	17	5	3	0	0	8	3
13	8	8	8	0	7	10	2	0	0	5	11
14	46	12	12	6	11	3	1	1	0	9	26
15	2	2	14	1	7	5	5	3	0	10	49
16	3	0	5	0	3	8	32	0	2	4	25
17											
18											
19	3	2	7	1	9	0	5	3	7	7	18
20	8	11	9	3	9	7	27	4	0	4	0
21	4	5	0	0	8	17	15	1	0	4	1
22	1	0	0	1	0	0	27	1	0	1	4
23	0	0	0	0	0	0	1	1	0	0	4
24											
25											
26	3	0	14	2	4	10	1	0	0	6	17
27	5	2	19	3	3	24	2	1	0	9	17
28	16	29	1	1	8	0	1	5	1	8	49
29	12	11	6	0	26	0	0	1	0	5	28
30	24	14	10	0	7	0	9	0	0	0	46
31											
Sep 1											
2	8	3	0	0	0	2	7	0	1	2	35
3	1	8	2	0	3	4	3	1	1	1	15
4	10	10	4	0	1	4	0	3	1	5	4
5	0	0	1	0	0	0	3	0	1	1	2
6	0	0	0	1	0	0	1	0	2	1	2
7											
8											
9	0	0	0	1	0	0					
10	2	1	0	1	0	0					
11	0	5									
TOTAL	258	152	133	26	154	151	153	26	16	91	362

Table A-33. Total catch of small humpback whitefish by station and direction.

DATE	STATION										
	DELTA						RIVER				
	1		2		3		661	202	203	204	205
	N	S	E	W	N	S					
Jul 3			0	0							
4											
5											
6											
7											
8											
9			1	0			0	0			
10	0	0	1	0			0	0	0		
11	0	0	0	0			0	0	0		
12	0	0	0	0			0	0	0	0	
13											
14											
15	0	0	0	0			0	0	0	0	
16	0	0	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	0	0	
18	1	0	0	0	0	0	0	0	0	0	
19	1	0	0	0	0	0	0	0	0	0	
20											
21											
22	11	10	0	0	0	1	0	0	0	0	
23	22	7	7	10	17	2	0	0	0	0	
24	12	3	0	0	10	8	0	0	0	0	
25	17	0	8	0	6	11	5	0	0	0	
26	1	67	3	3	2	4	0	1	1	0	
27											
28											
29							0	0	1	0	
30	27	3	5	0	5	5	1	0	0	0	10
31	57	16	0	0	22	39	3	1	0	0	4
Aug 1	4	7	4	0	0	47	21	0	0	0	3
2	34	7	0	0	14	2	0	0	0	0	7
3											
4											
5											
6											
7											
8	75	25	18	27	51	23	41	0	0		15
9	4	13	26	9	2	6	2	0	1	1	3
10											
11											
12	8	0	0	0	80	16	4	0	0	34	6
13	22	19	0	0	15	6	9	2	0	16	43
14	145	64	12	15	18	6	8	1	6	67	94
15	21	6	25	5	37	5	17	15	1	8	171
16	9	3	14	0	7	4	15	5	1	7	50
17											
18											
19	9	5	23	2	31	5	9	3	11	14	34
20	6	9	3	0	1	3	10	1	0	3	3
21	6	9	3	0	2	0	37	3	0	8	3
22	2	4	3	3	5	3	32	3	0	0	1
23	2	0	3	6	2	0	10	0	0	2	17
24											
25											
26	3	0	13	2	5	7	27	14	1	14	56
27	3	6	14	1	5	8	14	12	2	17	115
28	18	64	1	1	12	0	20	20	1	48	106
29	7	22	2	1	15	1	2	10	1	15	69
30	22	10	2	0	2	0	7	5	5	14	89
31											
Sep 1											
2	1	0	0	0	0	1	8	1	4	0	92
3	1	1	0	1	5	2	1	0	0	0	29
4	0	1	0	0	1	1	0	1	5	1	19
5	0	0	0	0	0	0	0	0	0	1	0
6	0	0	0	2	0	0	1	1	0	0	3
7											
8											
9	0	0	0	0	0	0					
10	0	0	0	1	0	0					
11	1	5									
TOTAL	552	386	191	89	372	216	304	99	41	270	1042

TABLE A-34. Total catch of char by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		0						
	4								
	5								
	6								
	7								
	8								
	9		1		0	0			
	10	0	0		0	0	0		
	11	1	1		0	0	0		
	12	0	2		0	0	0	0	
	13								
	14								
	15	0	1		0	0	0	0	
	16	0	0	0	0	0	0	0	
	17	0	2	0	0	0	0	1	
	18	0	2	0	0	0	0	0	
	19	0	1	1	0	0	0	0	
	20								
	21								
	22	0	0	2	0	0	0	0	
	23	1	0	3	0	0	0	0	
	24	0	3	0	0	0	0	0	
	25	0	3	1	0	0	0	0	
	26	1	1	3	0	0	1	0	
	27								
	28								
	29				0	0	0	0	
	30	1	4	1	0	0	0	0	0
	31	0	5	1	0	0	0	0	3
Aug	1	0	2	1	0	0	0	0	0
	2	0	3	7	0	0	0	0	2
	3								
	4								
	5								
	6								
	7								
	8	0	0	4	0	0	0		1
	9	0	0	0	0	0	0	0	0
	10								
	11								
	12	2	0	6	0	0	0	0	0
	13	2	1	3	0	0	0	0	0
	14	1	4	1	0	0	2	0	0
	15	2	0	4	1	0	2	0	0
	16	2	0	0	1	0	0	0	0
	17								
	18								
	19	1	1	3	0	0	1	1	0
	20	8	5	16	1	0	1	0	0
	21	7	2	6	0	0	5	0	1
	22	6	5	3	0	0	0	1	0
	23	0	3	3	0	1	0	1	1
	24								
	25								
	26	7	12	12	0	3	10	6	2
	27	3	10	7	0	13	10	2	3
	28	3	5	5	0	5	11	1	2
	29	3	6	6	1	1	9	1	1
	30	2	0	2	0	0	6	2	4
	31								
Sep	1								
	2	1	0	1	2	2	1	1	2
	3	2	0	1	0	1	1	0	0
	4	0	3	3	0	1	1	0	0
	5	0	0	0	0	2	1	0	1
	6	0	0	0	0	2	1	0	1
	7								
	8								
	9	0	0	0					
	10	0	1	0					
	11	0							
TOTAL CATCH		56	89	106	6	31	63	17	24

TABLE A-35. Catch per effort (no./24 hr) of char by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		0.00						
	4								
	5								
	6								
	7								
	8								
	9		1.04		0.00	0.00			
	10	0.00	0.00		0.00	0.00	0.00		
	11	1.00	1.04		0.00	0.00	0.00		
	12	0.00	2.11		0.00	0.00	0.00	0.00	
	13								
	14								
	15	0.00	1.27		0.00	0.00	0.00	0.00	
	16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	17	0.00	2.27	0.00	0.00	0.00	0.00	1.08	
	18	0.00	2.08	0.00	0.00	0.00	0.00	0.00	
	19	0.00	1.06	0.99	0.00	0.00	0.00	0.00	
	20								
	21								
	22	0.00	0.00	2.63	0.00	0.00	0.00	0.00	
	23	1.05	0.00	3.06	0.00	0.00	0.00	0.00	
	24	0.00	3.00	0.00	0.00	0.00	0.00	0.00	
	25	0.00	3.12	1.03	0.00	0.00	0.00	0.00	
	26	0.93	0.95	2.94	0.00	0.00	1.00	0.00	
	27								
	28								
	29				0.00	0.00	0.00	0.00	
	30	1.10	5.06	1.37	0.00	0.00	0.00	0.00	0.00
	31	0.00	4.95	1.04	0.00	0.00	0.00	0.00	3.30
Aug	1	0.00	2.08	1.03	0.00	0.00	0.00	0.00	0.00
	2	0.00	3.12	7.00	0.00	0.00	0.00	0.00	2.13
	3								
	4								
	5								
	6								
	7								
	8	0.00	0.00	5.33	0.00	0.00	0.00		0.88
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10								
	11								
	12	2.35	0.00	8.33	0.00	0.00	0.00	0.00	0.00
	13	2.44	1.18	2.61	0.00	0.00	0.00	0.00	0.00
	14	0.85	4.04	1.19	0.00	0.00	1.96	0.00	0.00
	15	1.87	0.00	4.00	1.00	0.00	2.00	0.00	0.00
	16	2.08	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	17								
	18								
	19	1.19	1.19	4.00	0.00	0.00	1.01	0.96	0.00
	20	9.09	4.46	14.29	1.02	0.00	1.00	0.00	0.00
	21	7.00	2.27	5.94	0.00	0.00	5.00	0.00	1.00
	22	5.26	4.90	2.97	0.00	0.00	0.00	0.98	0.00
	23	0.00	3.03	3.03	0.00	1.04	0.00	1.00	1.03
	24								
	25								
	26	11.11	12.77	14.46	0.00	3.45	11.11	6.45	2.47
	27	3.03	11.49	6.67	0.00	12.75	9.90	1.94	2.91
	28	2.50	4.85	6.25	0.00	4.90	11.00	1.00	2.04
	29	2.94	5.94	6.00	0.97	0.99	9.00	1.00	0.98
	30	2.20	0.00	2.00	0.00	0.00	5.88	1.98	4.12
	31								
Sep	1								
	2	1.11	0.00	1.27	2.30	2.00	0.98	0.95	2.20
	3	2.00	0.00	1.00	0.00	1.05	1.04	0.00	0.00
	4	0.00	3.00	3.06	0.00	0.96	0.96	0.00	0.00
	5	0.00	0.00	0.00	0.00	2.17	1.08	0.00	1.02
	6	0.00	0.00	0.00	0.00	1.85	0.89	0.00	0.96
	7								
	8								
	9	0.00	0.00	0.00					
	10	0.00	1.01	0.00					
	11	0.00							

TABLE A-36. Total catch of Arctic grayling by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		2						
	4								
	5								
	6								
	7								
	8								
	9		1		0	0			
	10	3	7		0	0	3		
	11	0	13		0	0	0		
	12	3	14		0	1	1	1	
	13								
	14								
	15	2	9		0	2	5	2	
	16	3	16	1	0	2	4	2	
	17	3	7	3	0	2	0	3	
	18	0	11	0	0	5	3	3	
	19	1	4	0	0	3	0	4	
	20								
	21								
	22	1	5	0	3	0	12	3	
	23	4	9	0	1	3	5	2	
	24	7	20	1	6	0	0	5	
	25	13	12	0	0	0	0	1	
	26	15	12	1	2	0	1	2	
	27								
	28								
	29				2	2	1	2	
	30	8	7	1	3	8	0	4	8
	31	8	9	2	2	2	8	0	4
Aug	1	2	10	0	0	0	3	4	13
	2	5	15	0	0	2	1	1	2
	3								
	4								
	5								
	6								
	7								
	8	1	3	0	5	1	20		9
	9	1	4	0	7	11	9	5	6
	10								
	11								
	12	0	1	2	4	1	6	6	2
	13	3	1	0	5	5	3	9	15
	14	2	4	0	6	5	5	8	6
	15	4	2	0	1	5	7	4	1
	16	0	0	0	1	0	2	6	0
	17								
	18								
	19	4	0	0	0	1	5	1	1
	20	1	2	0	2	0	0	2	1
	21	0	1	0	1	2	0	5	0
	22	0	1	0	0	2	1	2	0
	23	0	4	0	0	4	2	5	1
	24								
	25								
	26	1	2	0	0	1	7	8	1
	27	0	2	0	0	6	1	5	6
	28	0	1	0	1	6	18	11	0
	29	0	1	0	1	3	1	9	0
	30	0	1	0	1	2	3	1	0
	31								
Sep	1								
	2	1	0	0	0	2	3	1	1
	3	1	1	0	2	1	2	1	0
	4	0	0	0	1	0	1	2	1
	5	2	0	0	2	0	2	1	0
	6	0	1	0	0	0	5	1	1
	7								
	8								
	9	0	0	0					
	10	0	1	0					
	11	0							
TOTAL CATCH		99	216	11	59	90	150	132	79

TABLE A-37. Catch per effort (no./24 hr) of Arctic grayling by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		2.50						
	4								
	5								
	6								
	7								
	8								
	9		1.04		0.00	0.00			
	10	4.00	7.22		0.00	0.00	3.41		
	11	0.00	13.54		0.00	0.00	0.00		
	12	3.00	14.74		0.00	1.08	1.10	1.11	
	13								
	14								
	15	2.53	11.39		0.00	3.23	7.14	3.08	
	16	3.00	13.33	1.04	0.00	2.00	3.92	1.82	
	17	2.91	7.95	2.97	0.00	1.96	0.00	3.23	
	18	0.00	11.46	0.00	0.00	5.05	2.91	2.80	
	19	1.05	4.26	0.00	0.00	3.00	0.00	4.08	
	20								
	21								
	22	1.08	6.02	0.00	3.61	0.00	13.33	3.30	
	23	4.21	8.82	0.00	1.00	3.03	5.00	1.98	
	24	7.29	20.00	0.99	6.00	0.00	0.00	5.05	
	25	13.54	12.50	0.00	0.00	0.00	0.00	1.00	
	26	14.02	11.43	0.98	1.98	0.00	1.00	1.98	
	27								
	28								
	29				3.28	3.17	1.54	2.82	
	30	8.79	8.86	1.37	2.97	7.69	0.00	3.88	8.60
	31	8.00	8.91	2.08	2.04	2.11	8.70	0.00	4.40
Aug	1	2.08	10.42	0.00	0.00	0.00	2.88	3.77	12.15
	2	5.38	15.62	0.00	0.00	2.00	1.03	1.05	2.13
	3								
	4								
	5								
	6								
	7								
	8	1.10	3.19	0.00	2.34	1.14	21.74		7.96
	9	1.09	4.40	0.00	9.46	12.94	9.78	5.10	7.32
	10								
	11								
	12	0.00	1.01	2.78	4.82	1.15	6.82	6.52	2.33
	13	3.66	1.18	0.00	4.81	4.76	2.80	8.49	14.42
	14	1.71	4.04	0.00	6.00	4.55	4.90	7.77	6.00
	15	3.74	1.92	0.00	1.00	4.90	7.00	4.00	1.00
	16	0.00	0.00	0.00	1.00	0.00	2.04	6.25	0.00
	17								
	18								
	19	4.76	0.00	0.00	0.00	1.04	5.05	0.96	1.11
	20	1.14	1.79	0.00	2.04	0.00	0.00	2.04	0.98
	21	0.00	1.14	0.00	1.00	2.00	0.00	4.90	0.00
	22	0.00	0.98	0.00	0.00	1.96	0.96	1.96	0.00
	23	0.00	4.04	0.00	0.00	4.17	2.13	5.00	1.03
	24								
	25								
	26	1.59	2.13	0.00	0.00	1.15	7.78	8.60	1.23
	27	0.00	2.30	0.00	0.00	5.88	0.99	4.85	5.83
	28	0.00	0.97	0.00	1.02	5.88	18.00	11.00	0.00
	29	0.00	0.99	0.00	0.97	2.97	1.00	9.00	0.00
	30	0.00	1.11	0.00	1.03	2.00	2.94	0.99	0.00
	31								
Sep	1								
	2	1.11	0.00	0.00	0.00	2.00	2.94	0.95	1.10
	3	1.00	0.96	0.00	2.00	1.05	2.08	1.04	0.00
	4	0.00	0.00	0.00	0.96	0.00	0.96	1.92	0.96
	5	2.13	0.00	0.00	2.04	0.00	2.15	1.05	0.00
	6	0.00	0.89	0.00	0.00	0.00	4.46	0.86	0.96
	7								
	8								
	9	0.00	0.00	0.00					
	10	0.00	1.01	0.00					
	11	0.00							

TABLE A-38. Total catch of round whitefish by station.

DATE		STATION							
			DELTA				RIVER		
		1	2	3	661	202	203	204	205
Jul	3		11						
	4								
	5								
	6								
	7								
	8								
	9		47		0	1			
	10	56	20		0	2	1		
	11	39	8		0	0	0		
	12	1	1		1	4	1	1	
	13								
	14								
	15	3	4		0	2	0	1	
	16	7	8	10	0	3	0	0	
	17	7	1	12	3	0	0	2	
	18	4	1	9	2	0	0	1	
	19	11	9	8	14	3	0	0	
	20								
	21								
	22	22	20	1	3	2	0	0	
	23	16	6	17	8	7	4	0	
	24	19	9	4	4	4	1	14	
	25	7	6	11	9	1	1	0	
	26	14	8	16	4	0	0	1	
	27								
	28								
	29				1	0	0	3	
	30	10	14	8	12	1	0	3	1
	31	27	10	23	6	2	0	3	0
Aug	1	10	6	32	7	1	0	3	5
	2	15	13	18	5	0	0	3	8
	3								
	4								
	5								
	6								
	7								
	8	307	23	167	202	1	23		27
	9	30	8	32	6	6	1	50	6
	10								
	11								
	12	27	0	27	73	6	1	23	1
	13	6	18	31	163	11	0	70	18
	14	13	22	26	74	62	5	97	27
	15	5	9	15	112	48	0	19	61
	16	2	2	1	22	4	0	14	6
	17								
	18								
	19	1	13	8	2	13	4	33	8
	20	1	3	0	72	4	3	1	2
	21	2	1	1	91	3	0	4	0
	22	0	1	0	72	0	0	0	1
	23	0	2	0	14	0	3	2	0
	24								
	25								
	26	1	7	1	23	11	9	13	3
	27	1	5	3	21	11	1	7	27
	28	8	4	5	12	18	0	15	10
	29	3	2	2	2	0	1	2	12
	30	2	0	1	8	6	1	6	1
	31								
Sep	1								
	2	0	1	1	2	0	2	2	5
	3	0	0	0	6	6	2	0	2
	4	0	0	0	1	3	0	5	1
	5	0	0	1	0	0	0	5	2
	6	0	1	0	1	0	3	7	3
	7								
	8								
	9	0	2	0					
	10	0	1	0					
	11	4							
TOTAL CATCH		681	327	491	1058	246	67	410	237

TABLE A-39. Catch per effort (no./24 hr) of round whitefish by station.

DATE		STATION							
			DELTA				RIVER		
		1	2	3	661	202	203	204	205
Jul	3		13.75						
	4								
	5								
	6								
	7								
	8								
	9		48.96		0.00	1.19			
	10	74.67	20.62		0.00	2.00	1.14		
	11	39.00	8.33		0.00	0.00	0.00		
	12	1.00	1.05		0.84	4.30	1.10	1.11	
	13								
	14								
	15	3.80	5.06		0.00	3.23	0.00	1.54	
	16	7.00	6.67	10.42	0.00	3.00	0.00	0.00	
	17	6.80	1.14	11.88	3.00	0.00	0.00	2.15	
	18	4.12	1.04	9.09	2.04	0.00	0.00	0.93	
	19	11.58	9.57	7.92	14.00	3.00	0.00	0.00	
	20								
	21								
	22	23.66	24.10	1.32	3.61	2.27	0.00	0.00	
	23	16.84	5.88	17.35	8.00	7.07	4.00	0.00	
	24	19.79	9.00	3.96	4.00	4.08	1.00	14.14	
	25	7.29	6.25	11.34	9.09	1.00	1.00	0.00	
	26	13.08	7.62	15.69	3.96	0.00	0.00	0.99	
	27								
	28								
	29				1.64	0.00	0.00	4.23	
	30	10.99	17.72	10.96	11.88	0.96	0.00	2.91	1.08
	31	27.00	9.90	23.96	6.12	2.11	0.00	3.30	0.00
Aug	1	10.42	6.25	32.99	6.93	0.98	0.00	2.83	4.67
	2	16.13	13.54	18.00	5.05	0.00	0.00	3.16	8.51
	3								
	4								
	5								
	6								
	7								
	8	337.36	24.47	222.67	94.39	1.14	25.00		23.89
	9	32.61	8.79	32.00	8.11	7.06	1.09	51.02	7.32
	10								
	11								
	12	31.76	0.00	37.50	87.95	6.90	1.14	25.00	1.16
	13	7.32	21.18	26.96	156.73	10.48	0.00	66.04	17.31
	14	11.11	22.22	30.95	74.00	56.36	4.90	94.17	27.00
	15	4.67	8.65	15.00	112.00	47.06	0.00	19.00	61.00
	16	2.08	2.06	1.00	22.00	4.17	0.00	14.58	6.00
	17								
	18								
	19	1.19	15.48	10.67	2.53	13.54	4.04	31.73	8.89
	20	1.14	2.68	0.00	73.47	4.00	3.00	1.02	1.96
	21	2.00	1.14	0.99	91.00	3.00	0.00	3.92	0.00
	22	0.00	0.98	0.00	72.00	0.00	0.00	0.00	1.00
	23	0.00	2.02	0.00	14.14	0.00	3.19	2.00	0.00
	24								
	25								
	26	1.59	7.45	1.20	28.75	12.64	10.00	13.98	3.70
	27	1.01	5.75	2.86	20.59	10.78	0.99	6.80	26.21
	28	6.67	3.88	6.25	12.24	17.65	0.00	15.00	10.20
	29	2.94	1.98	2.00	1.94	0.00	1.00	2.00	11.76
	30	2.20	0.00	1.00	8.25	6.00	0.98	5.94	1.03
	31								
Sep	1								
	2	0.00	1.16	1.27	2.30	0.00	1.96	1.90	5.49
	3	0.00	0.00	0.00	6.00	6.32	2.08	0.00	2.04
	4	0.00	0.00	0.00	0.96	2.88	0.00	4.81	0.96
	5	0.00	0.00	1.01	0.00	0.00	0.00	5.26	2.04
	6	0.00	0.89	0.00	1.02	0.00	2.68	6.03	2.88
	7								
	8								
	9	0.00	2.63	0.00					
	10	0.00	1.01	0.00					
	11	4.30							

TABLE A-40. Total catch of boreal smelt by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	561	202	203	204	205
Jul	3		13						
	4								
	5								
	6								
	7								
	8								
	9		17		0	0			
	10	27	12		0	0	1		
	11	108	10		1	0	0		
	12	13	13		0	0	0	0	
	13								
	14								
	15	18	0		0	0	0	0	
	16	22	7	55	0	0	0	0	
	17	10	0	4	0	0	0	0	
	18	32	3	24	0	0	0	0	
	19	8	1	2	0	0	0	0	
	20								
	21								
	22	2	0	2	0	0	1	0	
	23	7	8	4	0	0	0	0	
	24	4	0	11	0	0	0	0	
	25	0	0	6	0	0	0	0	
	26	1	0	0	0	0	0	0	
	27								
	28								
	29				0	0	0	0	
	30	0	0	0	0	0	0	0	0
	31	2	0	9	0	0	0	0	0
Aug	1	1	0	9	0	0	0	0	0
	2	5	0	1	0	0	0	0	0
	3								
	4								
	5								
	6								
	7								
	8	21	0	5	0	0	0		0
	9	0	2	1	0	0	0	0	0
	10								
	11								
	12	0	0	2	2	0	0	0	0
	13	4	1	5	0	0	0	0	2
	14	3	0	4	0	0	0	0	0
	15	35	1	29	0	0	0	0	0
	16	0	3	3	0	0	1	0	0
	17								
	18								
	19	0	2	1	2	0	1	0	4
	20	1	1	3	1	0	0	0	0
	21	1	15	4	0	0	0	0	0
	22	4	2	3	0	0	0	0	0
	23	0	2	3	0	0	0	0	0
	24								
	25								
	26	2	0	2	0	0	0	0	0
	27	3	1	3	0	0	0	0	0
	28	17	0	25	0	0	0	0	0
	29	14	4	0	0	0	0	0	0
	30	16	0	2	0	0	0	0	0
	31								
Sep	1								
	2	1	0	0	3	0	0	0	0
	3	11	0	2	0	1	0	0	0
	4	6	0	0	2	0	0	0	0
	5	2	0	0	1	0	1	1	0
	6	0	0	8	0	0	0	0	0
	7								
	8								
	9	0	1	6					
	10	1	0	4					
	11	20							
TOTAL CATCH		422	119	242	12	1	5	1	6

TABLE A-41. Catch per effort (no./24 hr) of boreal smelt by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		16.25						
	4								
	5								
	6								
	7								
	8								
	9		17.71		0.00	0.00			
	10	36.00	12.37		0.00	0.00	1.14		
	11	108.00	10.42		1.00	0.00	0.00		
	12	13.00	13.68		0.00	0.00	0.00	0.00	
	13								
	14								
	15	22.78	0.00		0.00	0.00	0.00	0.00	
	16	22.00	5.83	57.29	0.00	0.00	0.00	0.00	
	17	9.71	0.00	3.96	0.00	0.00	0.00	0.00	
	18	32.99	3.12	24.24	0.00	0.00	0.00	0.00	
	19	8.42	1.06	1.98	0.00	0.00	0.00	0.00	
	20								
	21								
	22	2.15	0.00	2.63	0.00	0.00	1.11	0.00	
	23	7.37	7.84	4.08	0.00	0.00	0.00	0.00	
	24	4.17	0.00	10.89	0.00	0.00	0.00	0.00	
	25	0.00	0.00	6.19	0.00	0.00	0.00	0.00	
	26	0.93	0.00	0.00	0.00	0.00	0.00	0.00	
	27								
	28								
	29				0.00	0.00	0.00	0.00	
	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	31	2.00	0.00	9.38	0.00	0.00	0.00	0.00	0.00
Aug	1	1.04	0.00	9.28	0.00	0.00	0.00	0.00	0.00
	2	5.38	0.00	1.00	0.00	0.00	0.00	0.00	0.00
	3								
	4								
	5								
	6								
	7								
	8	23.08	0.00	6.67	0.00	0.00	0.00		0.00
	9	0.00	2.20	1.00	0.00	0.00	0.00	0.00	0.00
	10								
	11								
	12	0.00	0.00	2.78	2.41	0.00	0.00	0.00	0.00
	13	4.88	1.18	4.35	0.00	0.00	0.00	0.00	1.92
	14	2.56	0.00	4.76	0.00	0.00	0.00	0.00	0.00
	15	32.71	0.96	29.00	0.00	0.00	0.00	0.00	0.00
	16	0.00	3.09	3.00	0.00	0.00	1.02	0.00	0.00
	17								
	18								
	19	0.00	2.38	1.33	2.53	0.00	1.01	0.00	4.44
	20	1.14	0.89	2.68	1.02	0.00	0.00	0.00	0.00
	21	1.00	17.05	3.96	0.00	0.00	0.00	0.00	0.00
	22	3.51	1.96	2.97	0.00	0.00	0.00	0.00	0.00
	23	0.00	2.02	3.03	0.00	0.00	0.00	0.00	0.00
	24								
	25								
	26	3.17	0.00	2.41	0.00	0.00	0.00	0.00	0.00
	27	3.03	1.15	2.86	0.00	0.00	0.00	0.00	0.00
	28	14.17	0.00	31.25	0.00	0.00	0.00	0.00	0.00
	29	13.73	3.96	0.00	0.00	0.00	0.00	0.00	0.00
	30	17.58	0.00	2.00	0.00	0.00	0.00	0.00	0.00
	31								
Sep	1								
	2	1.11	0.00	0.00	3.45	0.00	0.00	0.00	0.00
	3	11.00	0.00	2.00	0.00	1.05	0.00	0.00	0.00
	4	6.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00
	5	2.13	0.00	0.00	1.02	0.00	1.08	1.05	0.00
	6	0.00	0.00	7.48	0.00	0.00	0.00	0.00	0.00
	7								
	8								
	9	0.00	1.32	8.45					
	10	1.01	0.00	4.12					
	11	21.51							

TABLE A-42. Total catch of fourhorn sculpin by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		3						
	4								
	5								
	6								
	7								
	8								
	9		5		0	0			
	10	23	8		0	0	0		
	11	41	2		1	0	0		
	12	16	8		1	0	0	0	
	13								
	14								
	15	150	5		0	0	0	0	
	16	98	23	31	0	0	0	0	
	17	48	12	26	1	0	0	0	
	18	107	9	19	1	1	0	0	
	19	72	21	26	2	1	0	0	
	20								
	21								
	22	42	14	14	16	1	2	0	
	23	72	18	10	26	2	1	0	
	24	51	21	24	10	4	0	2	
	25	14	8	23	34	1	0	3	
	26	33	5	11	17	3	7	2	
	27								
	28								
	29				11	5	5	3	
	30	15	6	15	9	6	2	4	8
	31	38	7	20	13	6	1	9	6
Aug	1	33	8	48	14	5	4	2	5
	2	26	9	31	17	0	2	1	2
	3								
	4								
	5								
	6								
	7								
	8	55	13	13	68	1	2		3
	9	45	11	28	8	0	1	5	1
	10								
	11								
	12	14	1	15	19	1	3	0	4
	13	23	18	34	9	2	1	0	1
	14	32	11	23	50	1	1	2	2
	15	35	26	16	18	4	0	0	5
	16	20	13	22	19	2	1	1	1
	17								
	18								
	19	11	11	9	5	0	2	2	0
	20	78	29	26	5	1	0	1	0
	21	81	1	20	4	0	1	1	0
	22	97	15	7	12	0	1	1	1
	23	66	20	11	10	1	1	1	1
	24								
	25								
	26	38	27	14	9	4	0	0	0
	27	76	44	26	16	1	0	0	2
	28	41	30	20	13	0	1	0	0
	29	27	19	16	8	0	3	1	0
	30	25	41	22	13	1	0	4	0
	31								
Sep	1								
	2	237	44	123	5	2	0	1	0
	3	168	64	123	7	1	2	1	1
	4	99	47	111	13	2	2	0	0
	5	57	21	32	8	0	0	0	1
	6	34	17	21	17	0	0	0	0
	7								
	8								
	9	20	5	8					
	10	11	0	4					
	11	47							
TOTAL CATCH		2316	720	1042	509	59	46	47	44

TABLE A-43. Catch per effort (no./24 hr) of fourhorn sculpin by station.

DATE		STATION							
			DELTA				RIVER		
		1	2	3	661	202	203	204	205
Jul	3		3.75						
	4								
	5								
	6								
	7								
	8								
	9		5.21		0.00	0.00			
	10	30.67	8.25		0.00	0.00	0.00		
	11	41.00	2.08		1.00	0.00	0.00		
	12	16.00	8.42		0.84	0.00	0.00	0.00	
	13								
	14								
	15	189.87	6.33		0.00	0.00	0.00	0.00	
	16	98.00	19.17	32.29	0.00	0.00	0.00	0.00	
	17	46.60	13.64	25.74	1.00	0.00	0.00	0.00	
	18	110.31	9.38	19.19	1.02	1.01	0.00	0.00	
	19	75.79	22.34	25.74	2.00	1.00	0.00	0.00	
	20								
	21								
	22	45.16	16.87	18.42	19.28	1.14	2.22	0.00	
	23	75.79	17.65	10.20	26.00	2.02	1.00	0.00	
	24	53.12	21.00	23.76	10.00	4.08	0.00	2.02	
	25	14.58	8.33	23.71	34.34	1.00	0.00	3.00	
	26	30.84	4.76	10.78	16.83	2.91	7.00	1.98	
	27								
	28								
	29				18.03	7.94	7.69	4.23	
	30	16.48	7.59	20.55	8.91	5.77	1.90	3.88	8.60
	31	38.00	6.93	20.83	13.27	6.32	1.09	9.89	6.59
Aug	1	34.38	8.33	49.48	13.86	4.90	3.85	1.89	4.67
	2	27.96	9.38	31.00	17.17	0.00	2.06	1.05	2.13
	3								
	4								
	5								
	6								
	7								
	8	60.44	13.83	17.33	31.78	1.14	2.17		2.65
	9	48.91	12.09	28.00	10.81	0.00	1.09	5.10	1.22
	10								
	11								
	12	16.47	1.01	20.83	22.89	1.15	3.41	0.00	4.65
	13	28.05	21.18	29.57	8.65	1.90	0.93	0.00	0.96
	14	27.35	11.11	27.38	50.00	0.91	0.98	1.94	2.00
	15	32.71	25.00	16.00	18.00	3.92	0.00	0.00	5.00
	16	20.83	13.40	22.00	19.00	2.08	1.02	1.04	1.00
	17								
	18								
	19	13.10	13.10	12.00	6.33	0.00	2.02	1.92	0.00
	20	88.64	25.89	23.21	5.10	1.00	0.00	1.02	0.00
	21	81.00	1.14	19.80	4.00	0.00	1.00	0.98	0.00
	22	85.09	14.71	6.93	12.00	0.00	0.96	0.98	1.00
	23	67.35	20.20	11.11	10.10	1.04	1.06	1.00	1.03
	24								
	25								
	26	60.32	28.72	16.87	11.25	4.60	0.00	0.00	0.00
	27	76.77	50.57	24.76	15.69	0.98	0.00	0.00	1.94
	28	34.17	29.13	25.00	13.27	0.00	1.00	0.00	0.00
	29	26.47	18.81	16.00	7.77	0.00	3.00	1.00	0.00
	30	27.47	45.56	22.00	13.40	1.00	0.00	3.96	0.00
	31								
Sep	1								
	2	263.33	51.16	155.70	5.75	2.00	0.00	0.95	0.00
	3	168.00	61.54	123.00	7.00	1.05	2.08	1.04	1.02
	4	99.00	47.00	113.27	12.50	1.92	1.92	0.00	0.00
	5	60.64	22.58	32.32	8.16	0.00	0.00	0.00	1.02
	6	37.78	15.18	19.63	17.35	0.00	0.00	0.00	0.00
	7								
	8								
	9	26.32	6.58	11.27					
	10	11.11	0.00	4.12					
	11	50.54							

TABLE A-44. Total catch of longnose sucker by station.

DATE		STATION							
			DELTA				RIVER		
		1	2	3	661	202	203	204	205
Jul	3		0						
	4								
	5								
	6								
	7								
	8								
	9		10		3	0			
	10	0	1		13	0	4		
	11	2	0		3	0	2		
	12	0	0		64	2	1	0	
	13								
	14								
	15	2	0		2	0	3	0	
	16	0	0	0	36	0	4	1	
	17	0	0	2	7	2	6	3	
	18	0	1	0	30	1	2	2	
	19	0	1	0	28	1	19	2	
	20								
	21								
	22	0	0	0	6	1	2	1	
	23	0	0	0	0	2	16	4	
	24	1	0	0	3	3	10	5	
	25	0	0	0	2	4	10	17	
	26	1	0	0	3	4	18	15	
	27								
	28								
	29				4	0	16	2	
	30	0	0	0	4	0	9	2	3
	31	0	0	0	1	1	12	1	6
Aug	1	1	0	0	1	0	91	2	12
	2	0	0	0	0	0	16	0	4
	3								
	4								
	5								
	6								
	7								
	8	0	1	0	13	0	4		5
	9	0	0	0	5	1	3	4	1
	10								
	11								
	12	0	0	0	0	0	2	0	0
	13	0	1	1	0	0	1	0	0
	14	0	0	0	0	1	4	0	0
	15	0	0	1	1	0	1	1	0
	16	0	0	0	1	0	0	0	0
	17								
	18								
	19	0	0	0	0	1	6	4	1
	20	0	0	0	3	0	14	2	0
	21	0	0	1	2	1	2	1	1
	22	0	0	0	1	0	5	3	2
	23	0	0	0	0	1	4	1	1
	24								
	25								
	26	0	0	0	1	0	4	0	0
	27	0	0	0	1	0	1	1	1
	28	0	0	0	0	1	2	2	0
	29	0	0	0	0	0	3	2	0
	30	0	0	0	4	1	16	0	0
	31								
Sep	1								
	2	0	0	0	4	2	17	5	0
	3	0	1	0	0	1	6	22	0
	4	0	0	0	0	0	6	8	1
	5	0	1	0	1	0	5	4	1
	6	0	0	0	1	1	0	3	0
	7								
	8								
	9	0	0	0					
	10	0	0	0					
	11	0							
TOTAL CATCH		7	17	5	248	32	347	120	39

TABLE A-45. Catch per effort (no./24 hr) of longnose sucker by station.

DATE		STATION							
		DELTA			RIVER				
		1	2	3	661	202	203	204	205
Jul	3		0.00						
	4								
	5								
	6								
	7								
	8								
	9		10.42		3.23	0.00			
	10	0.00	1.03		12.75	0.00	4.55		
	11	2.00	0.00		3.00	0.00	1.98		
	12	0.00	0.00		53.78	2.15	1.10	0.00	
	13								
	14								
	15	2.53	0.00		2.99	0.00	4.29	0.00	
	16	0.00	0.00	0.00	36.36	0.00	3.92	0.91	
	17	0.00	0.00	1.98	7.00	1.96	6.06	3.23	
	18	0.00	1.04	0.00	30.61	1.01	1.94	1.87	
	19	0.00	1.06	0.00	28.00	1.00	19.00	2.04	
	20								
	21								
	22	0.00	0.00	0.00	7.23	1.14	2.22	1.10	
	23	0.00	0.00	0.00	0.00	2.02	16.00	3.96	
	24	1.04	0.00	0.00	3.00	3.06	10.00	5.05	
	25	0.00	0.00	0.00	2.02	4.00	10.00	17.00	
	26	0.93	0.00	0.00	2.97	3.88	18.00	14.85	
	27								
	28								
	29				6.56	0.00	24.62	2.82	
	30	0.00	0.00	0.00	3.96	0.00	8.57	1.94	3.23
	31	0.00	0.00	0.00	1.02	1.05	13.04	1.10	6.59
Aug	1	1.04	0.00	0.00	0.99	0.00	87.50	1.89	11.21
	2	0.00	0.00	0.00	0.00	0.00	16.49	0.00	4.26
	3								
	4								
	5								
	6								
	7								
	8	0.00	1.06	0.00	6.07	0.00	4.35		4.42
	9	0.00	0.00	0.00	6.76	1.18	3.26	4.08	1.22
	10								
	11								
	12	0.00	0.00	0.00	0.00	0.00	2.27	0.00	0.00
	13	0.00	1.18	0.87	0.00	0.00	0.93	0.00	0.00
	14	0.00	0.00	0.00	0.00	0.91	3.92	0.00	0.00
	15	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00
	16	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	17								
	18								
	19	0.00	0.00	0.00	0.00	1.04	6.06	3.85	1.11
	20	0.00	0.00	0.00	3.06	0.00	14.00	2.04	0.00
	21	0.00	0.00	0.99	2.00	1.00	2.00	0.98	1.00
	22	0.00	0.00	0.00	1.00	0.00	4.81	2.94	2.00
	23	0.00	0.00	0.00	0.00	1.04	4.26	1.00	1.03
	24								
	25								
	26	0.00	0.00	0.00	1.25	0.00	4.44	0.00	0.00
	27	0.00	0.00	0.00	0.98	0.00	0.99	0.97	0.97
	28	0.00	0.00	0.00	0.00	0.98	2.00	2.00	0.00
	29	0.00	0.00	0.00	0.00	0.00	3.00	2.00	0.00
	30	0.00	0.00	0.00	4.12	1.00	15.69	0.00	0.00
	31								
Sep	1								
	2	0.00	0.00	0.00	4.60	2.00	16.67	4.76	0.00
	3	0.00	0.96	0.00	0.00	1.05	6.25	22.92	0.00
	4	0.00	0.00	0.00	0.00	0.00	5.77	7.69	0.96
	5	0.00	1.08	0.00	1.02	0.00	5.38	4.21	1.02
	6	0.00	0.00	0.00	1.02	0.93	0.00	2.59	0.00
	7								
	8								
	9	0.00	0.00	0.00					
	10	0.00	0.00	0.00					
	11	0.00							

Table A-46. Release and recapture data for tags recaptured during summer sampling.

Species	Fork Length (mm)	Release Date	Release Location	Recapture Date	Recapture Location
Arctic	297	7/13/85	F29	7/26/85	1
Cisco	302	7/7/85	F23	8/8/85	2
	336	8/15/85	F18	8/28/85	1
	283	7/29/85	F18	9/6/85	2
Least	331	8/22/84	PB 5	8/8/85	1
Cisco	309	8/14/84	PB 13	8/8/85	1
	317	7/16/84	GB 12	8/14/85	205
*	365	7/6/84	GB 21	8/15/85	2
	258	8/3/84	PB 27	8/15/85	1
	313	8/12/84	GB 17	8/20/85	1
	277	7/21/84	GB 19	8/20/85	3
	305	7/31/84	PB 11	8/20/85	2
	326	7/30/84	PB 5	8/21/85	2
+	300	8/7/84	PB 1	8/21/85	205
	306	7/30/84	PB 5	8/21/85	204
	328	1982	PB	8/22/85	205
	323	8/16/84	GB 23	8/22/85	205
	320	7/12/84	PB 27	8/23/85	205
	305	7/26/84	GB 21	8/23/85	205
	272	7/22/84	GB 16	8/26/85	3
	274	8/13/84	PB 5	8/26/85	3
	313	8/20/84	PB 5	8/30/85	1
	315	7/19/84	GB 25	8/30/85	2
	296	7/21/84	GB 19	8/29/85	205
	311	7/22/84	GB 19	9/2/85	1
	386	8/16/84	GB 25	9/5/85	1
	306	7/21/84	PB 4	9/5/85	1
	322	7/10/84	GB 25	9/6/85	1
	310	8/10/84	GB 25	9/3/85	205
	231	7/12/85	F30	7/16/85	1
	251	7/30/85	F25	8/8/85	1
	319	7/28/85	F18	8/8/85	1
	274	7/14/85	F19	8/15/85	1
	330	7/22/85	F15	8/21/85	1
	297	7/22/85	F15	8/22/85	3
	286	7/10/85	F23	8/22/85	205
	265	7/30/85	F25	8/26/85	3
	293	7/30/85	F18	9/2/85	1
	325	7/30/85	F19	9/3/85	1
	389	8/27/85	F15	9/3/85	1
	251	7/19/85	F25	9/6/85	203
	310	7/12/85	F30	9/10/85	3

Table A-46 (Continued)

Species	Fork Length (mm)	Release Date	Release Location	Recapture Date	Recapture Location
Broad	281	7/23/85	1	7/31/85	1
Whitefish	276	7/30/85	1	8/21/85	2
	308	8/11/85	F25	8/15/85	1
Humpback	460	7/27/84	PB 6	7/26/85	204
Whitefish	317	7/20/84	GB 25	7/31/85	1
Char	228	9/7/85	F25	9/10/85	2

F = Endicott 1985 stations
PB = Prudhoe Bay, GB = Gwydyr Bay; 1984 Lisburne/Waterflood stations
() = approximate station locations
* this fish was also recaptured 3 miles downstream from Ocean Point on 8/21/85 by T. Bendock
+ fish was identified as arctic cisco when tagged
++fish was identified as arctic cisco when recaptured

Table A-47. Release and recapture data for 1985 Colville tags recaptured in the fall fishery.

Species	Fork Length (mm)	Release Date	Release Location	Recapture Date	Recapture Location
Arctic Cisco	329	9/9/85	3	10/18/85	Nigliq
	310	8/26/85	3	10/22/85	(3)
	312	8/26/85	3	10/8/85	(1,3)
	330	8/26/85	3	10/20/85	(1,3)
	298	8/22/85	3	11/5/85	(1,3)
Least Cisco	306	8/22/85	3	10/12/85	(3)
	263	8/21/85	204	10/17/85	(3)
	304	8/26/85	2	10/85	(1)
	304	9/6/85	202	10/85	(1)
	295	8/21/85	3	10/22/85	(3)
	336	8/27/85	2	10/24/85	(3)
	321	8/13/85	3	10/14/85	(3)
	348	8/22/85	2	10/9/85	(3)
	305	8/22/85	3	10/9/85	(3)
	318	8/29/85	1	10/22/85	(3)
	310	8/21/85	204	10/14/85	(3)
	319	8/22/85	205	10/22/85	(3)
	332	8/20/85	1	10/28/85	(1,3)
	334	8/20/85	3	10/19/85	(1,3)
	327	8/20/85	205	10/29/85	(1,3)
	326	8/22/85	205	10/17/85	(1,3)
	305	8/23/85	205	10/19/85	(1,3)
	305	8/30/85	3	10/11/85	(1,3)
	325	9/5/85	1	10/16/85	(1,3)
	323	9/6/85	2	10/24/85	(1,3)
	288	9/6/85	2	10/29/85	(1,3)
Broad Whitefish	500	8/1/85	205	10/16/85	Nigliq
	315	8/20/85	202	10/16/85	Nigliq
	595	7/24/85	3	10/31/85	(3)
Humpback Whitefish	287	7/10/85	1	10/25/85	(1,3)

Table A-48. Size groups used for calculating weekly mean lengths of 0 to 3 year old fish.

Species	Dates	Length range (mm) Age-0	Age-1	Age-2	Age-3
Arctic cisco	7/3-7/12			100-139	140-179
	8/12-8/16				140-199
	8/19-8/23				150-199
	8/26-8/30	50-84	85-109	110-149	150-199
	9/2-9/6	50-84	85-109	110-149	150-199
	9/9-9/11	50-84	85-109	110-149	150-199
Least cisco	7/3-7/12		50-89	90-124	
	7/15-7/19		50-89	90-124	
	7/22-7/26		50-99	100-129	
	7/29-8/2		50-99	100-129	
	8/8-8/9		50-99	100-129	
	8/12-8/16	30-69	70-109	110-139	
	8/19-8/23	30-69	70-109	110-139	
	8/26-8/30	30-79	80-119	120-149	
	9/2-9/6	30-79	80-119	120-149	
	9/9-9/11	30-79	80-119	120-149	
Broad whitefish	7/3-7/12		50-109	110-149	
	7/15-7/19		60-119	120-159	
	7/22-7/26	40-59	60-119	120-159	
	7/29-8/2	40-79	80-129	130-159	
	8/8-8/9	40-79	80-129	130-159	
	8/12-8/16	40-79	80-139	140-179	
	8/19-8/23	40-79	80-139	140-179	
	8/26-8/30	40-89	90-139	140-179	
	9/2-9/6	40-89	90-139	140-179	
	9/9-9/11	40-89	90-139	140-179	
Humpback whitefish	7/22-7/26		60-109	110-149	
	7/29-8/2		60-109	110-149	
	8/8-8/9	40-59	60-109	110-149	
	8/12-8/16	40-69	70-109	110-149	
	8/19-8/23	40-79	80-109	110-149	
	8/26-8/30	40-79	80-119	120-159	
	9/2-9/6	40-79	80-119	120-159	
	9/9-9/11	40-79	80-119	120-159	

Table A-49. Biological data for arctic cisco used in length-weight analyses, aging, and mean length at age.

STATION	DATE	SPECIES	LENGTH	WEIGHT	SEX	MAT	AGE
3	08/27/85	101	62	0	I	1	
3	08/27/85	101	64	0	I	1	
3	08/27/85	101	64	0	I	1	0
3	08/27/85	101	65	0	I	1	[illegible]
3	08/27/85	101	67	0	I	1	0
3	08/27/85	101	67	0	I	1	
3	08/27/85	101	68	0	I	1	0
3	08/27/85	101	68	0	I	1	0
3	08/27/85	101	71	3	I	1	[illegible]
3	08/27/85	101	71	0	I	1	
1	08/26/85	101	73	3	I	1	0
3	08/27/85	101	73	0	I	1	[illegible]
3	08/27/85	101	74	3	I	1	[illegible]
3	08/27/85	101	74	3	I	1	
3	08/27/85	101	75	3	I	1	[illegible]
3	08/27/85	101	75	0	I	1	[illegible]
3	08/27/85	101	76	4	I	1	0
3	08/27/85	101	76	3	I	1	0
3	08/27/85	101	76	4	I	1	0
1	08/26/85	101	78	4	I	1	[illegible]
3	08/27/85	101	80	4	I	1	0
3	08/27/85	101	80	4	I	1	[illegible]
3	08/27/85	101	80	0	I	1	0
1	08/26/85	101	82	5	I	1	1
3	08/27/85	101	83	0	I	1	[illegible]
3	08/27/85	101	89	6	I	1	
1	08/26/85	101	97	8	I	1	[illegible]
3	08/27/85	101	98	8	I	1	[illegible]
1	07/25/85	101	100	7	I	1	[illegible]
2	09/10/85	101	103	11	I	1	2
1	08/30/85	101	105	10	I	1	2
1	07/19/85	101	110	9	I	1	2
3	08/23/85	101	112	12	I	1	2
1	08/26/85	101	114	12	I	1	2
1	09/09/85	101	119	14	I	1	2
1	08/26/85	101	129	18	I	1	2
3	09/03/85	101	132	18	I	1	2
1	08/26/85	101	135	21	F	1	2
1	07/19/85	101	145	22	I	1	3
3	08/16/85	101	146	25	F	1	3
1	07/19/85	101	150	23	I	1	3
1	07/19/85	101	150	25	I	1	3
1	08/02/85	101	150	29	I	1	3
3	08/16/85	101	155	33	F	1	[illegible]
3	08/16/85	101	159	30	F	1	3
1	08/02/85	101	160	35	M	1	3
1	07/23/85	101	161	31	F	1	3
3	08/16/85	101	168	38	F	1	3
3	08/16/85	101	169	43	F	1	3
3	08/16/85	101	170	42	M	1	[illegible]

Table A-49 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
3	08/16/85	101	173	47	M	1	
3	08/16/85	101	173	41	F	1	
3	08/16/85	101	175	46	I	1	[illegible]
3	08/16/85	101	178	53	F	1	[illegible]
3	08/16/85	101	180	51	F	1	[illegible]
3	08/16/85	101	182	49	M	1	[illegible]
3	08/16/85	101	184	52	M	1	[illegible]
3	08/16/85	101	188	64	M	1	[illegible]
1	08/26/85	101	207	84	M	1	[illegible]
3	08/12/85	101	226	113	M	1	[illegible]
3	08/16/85	101	232	118	M	1	[illegible]
1	09/03/85	101	242	135	F	1	[illegible]
1	09/11/85	101	248	153	F	1	[illegible]
1	09/11/85	101	250	148	M	1	[illegible]
3	08/27/85	101	261	165	F	1	[illegible]
3	09/03/85	101	263	182	M	1	[illegible]
2	08/16/85	101	265	194	M	2	[illegible]
1	08/26/85	101	265	187	F	1	[illegible]
3	09/03/85	101	275	204	M	1	[illegible]
3	09/03/85	101	279	204	M	1	[illegible]
1	08/26/85	101	280	205	F	1	[illegible]
311	09/05/85	101	280	206	M	1	[illegible]
1	07/19/85	101	281	201	F	2	[illegible]
1	08/26/85	101	284	227	F	1	[illegible]
1	09/03/85	101	287	233	F	1	[illegible]
3	08/16/85	101	292	261	F	1	[illegible]
3	09/03/85	101	292	227	F	1	[illegible]
3	08/23/85	101	294	271	F	1	[illegible]
3	09/03/85	101	294	261	M	1	[illegible]
1	07/26/85	101	295	226	M	1	[illegible]
3	08/23/85	101	295	267	M	1	[illegible]
311	09/05/85	101	299	275	M	2	[illegible]
311	09/05/85	101	301	271	M	1	5
311	09/05/85	101	307	304	F	2	[illegible]
1	08/26/85	101	310	309	M	1	[illegible]
1	08/26/85	101	311	348	F	1	[illegible]
311	09/05/85	101	317	317	F	2	6
1	09/10/85	101	318	339	M	1	6
2	08/28/85	101	323	397	F	1	6
1	09/10/85	101	327	349	F	1	6
311	09/05/85	101	328	364	M	2	6
1	09/10/85	101	328	399	M	1	7
311	09/05/85	101	330	391	M	1	6
2	09/10/85	101	330	360	M	1	[illegible]
3	08/23/85	101	331	422	M	1	6
1	08/23/85	101	333	366	M	2	6
1	08/26/85	101	335	389	F	1	[illegible]
1	09/10/85	101	337	462	M	1	[illegible]
1	09/10/85	101	338	424	F	1	[illegible]
2	08/23/85	101	343	395	M	2	[illegible]

Table A-49 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
[illegible]	08/26/85	101	343	478	M	2	[illegible]
H	10/15/85	101	344	506	F	1	
1	09/02/85	101	347	447	M	3	[illegible]
311	09/05/85	101	351	506	F	2	[illegible]
H	10/15/85	101	356	560	M	1	[illegible]
H	10/15/85	101	358	641	M	2	[illegible]
1	08/26/85	101	360	565	M	2	[illegible]
H	10/15/85	101	360	602	M	1	[illegible]
H	10/15/85	101	366	593	F	2	[illegible]
H	10/15/85	101	366	613	F	2	[illegible]
H	10/15/85	101	366	605	F	1	[illegible]
H	10/15/85	101	368	660	M	1	[illegible]
H	10/15/85	101	372	664	F	2	[illegible]
H	10/15/85	101	374	669	F	2	[illegible]
H	10/15/85	101	376	632	F	2	[illegible]
H	10/15/85	101	382	755	F	2	[illegible]
H	10/15/85	101	382	605	F	2	[illegible]
H	10/15/85	101	382	714	F	2	[illegible]
H	10/15/85	101	383	698	F	2	[illegible]
H	10/15/85	101	384	705	M	2	[illegible]
H	10/15/85	101	388	624	F	2	[illegible]
H	10/15/85	101	389	815	F	2	[illegible]
H	10/15/85	101	395	774	F	2	[illegible]
H	10/15/85	101	396	794	F	2	[illegible]
H	10/15/85	101	400	722	F	2	[illegible]
H	10/15/85	101	400	891	F	2	[illegible]
H	10/15/85	101	406	831	F	2	[illegible]
H	10/15/85	101	410	937	F	2	[illegible]
H	10/15/85	101	410	828	F	2	[illegible]
H	10/15/85	101	413	849	F	2	[illegible]
H	10/15/85	101	416	885	F	2	[illegible]
H	10/15/85	101	420	922	F	2	[illegible]
1	09/10/85	101	427	870	F	2	13
H	10/15/85	101	435	970	F	2	[illegible]
[illegible]	10/18/85	101	445	0			[illegible]
[illegible]	10/15/85	101	[illegible]	1245	F	[illegible]	[illegible]
151	10/15/84	101	305	264	M		

Table A-50. **Biological data for least cisco used in length-weight analyses, aging, and mean length at age.**

STATION	DATE	SPECIES	LENGTH	WEIGHT	SEX	MAT	AGE
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	65	2	I	1	1
3	07/19/85	105	72	3	I	1	1
3	07/19/85	105	75	3	I	1	1
3	07/19/85	105	75	3	I	1	1
3	07/19/85	105	75	3	I	1	1
3	07/19/85	105	75	4	I	1	1
3	07/19/85	105	75	4	I	1	1
3	07/19/85	105	75	3	I	1	1
3	07/19/85	105	80	4	I	1	1
3	07/19/85	105	80	4	I	1	1
3	07/19/85	105	80	4	I	1	1
3	07/19/85	105	80	4	I	1	1
3	07/19/85	105	85	4	I	1	1
3	07/19/85	105	90	5	I	1	2
3	07/19/85	105	95	4	I	1	1
3	07/19/85	105	105	9	I	1	2
1	07/19/85	105	110	10	I	1	2
1	07/19/85	105	110	10	I	1	2
1	07/19/85	105	110	10	I	1	2
1	07/19/85	105	110	9	I	1	2
1	07/19/85	105	110	9	I	1	2
3	07/19/85	105	110	10	F	1	2
1	07/19/85	105	115	10	I	1	2
1	07/19/85	105	120	12	I	1	2
1	07/19/85	105	120	11	I	1	2
203	07/12/85	105	121	14	I	1	2
1	08/26/85	105	123	16	I	1	2
202	07/12/85	105	126	16	I	1	2
3	07/19/85	105	135	18	I	1	3
1	07/19/85	105	140	20	I	1	3
3	07/19/85	105	140	19	I	1	3
203	07/12/85	105	144	25	I	1	3
1	07/19/85	105	145	21	I	1	3
3	07/25/85	105	147	24	M	1	3
3	08/16/85	105	154	31	F	1	3
1	07/19/85	105	155	29	I	1	3
3	08/16/85	105	155	32	M	1	3
3	08/16/85	105	155	32	M	1	3
3	08/09/85	105	162	35	I	1	3
3	08/16/85	105	162	39	I	1	3
3	08/16/85	105	168	41	F	1	3
3	08/16/85	105	177	50	F	1	4
1	07/19/85	105	180	51	F	1	4
1	07/23/85	105	180	46	F	1	4
3	08/16/85	105	182	54	F	1	4

Table A-50 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
1	08/02/85	105	190	63	M	1	
3	08/16/85	105	195	63	F	1	
3	07/25/85	105	198	67	F	1	3
1	08/02/85	105	200	67	F	1	5
3	08/23/85	105	203	75	F	1	5
2	07/19/85	105	210	0	I	1	4
3	08/16/85	105	220	94	F	1	[illegible]
3	08/16/85	105	227	114	M	1	[illegible]
3	08/16/85	105	229	125	F	1	6
1	08/02/85	105	232	94	M	1	[illegible]
2	07/25/85	105	234	121	F	1	[illegible]
311	09/05/85	105	234	116	M	3	[illegible]
3	08/23/85	105	235	121	M	3	6
3	08/23/85	105	240	135	M	1	[illegible]
2	08/16/85	105	241	142	F	1	[illegible]
3	08/23/85	105	241	150	F	5	[illegible]
3	08/23/85	105	242	134	M	3	5
3	08/23/85	105	242	140	F	5	6
3	08/16/85	105	243	124	F	1	[illegible]
3	08/23/85	105	245	145	M	3	[illegible]
3	08/23/85	105	247	157	M	3	5
3	08/23/85	105	248	166	F	5	[illegible]
3	08/16/85	105	256	167	F	1	7
3	08/23/85	105	257	163	F	5	7
2	08/16/85	105	258	164	F	2	7
3	08/23/85	105	265	172	M	3	6
3	08/23/85	105	265	208	M	3	5
3	08/16/85	105	270	208	M	3	7
3	08/23/85	105	272	207	F	5	6
1	08/26/85	105	273	214	F	1	6
311	09/05/85	105	274	184	M	3	8
1	08/26/85	105	275	212	F	1	8
3	08/23/85	105	278	223	M	3	7
1	08/26/85	105	280	229	F	2	9
203	08/08/85	105	282	206	F	3	8
3	08/23/85	105	282	236	F	2	8
3	08/16/85	105	283	267	F	3	10
1	08/16/85	105	285	223	M	3	[illegible]
1	08/16/85	105	298	297	F	3	[illegible]
2	08/16/85	105	298	276	F	4	[illegible]
2	08/16/85	105	304	280	M	2	[illegible]
1	09/03/85	105	304	296	F	3	[illegible]
1	08/02/85	105	308	273	F	3	9
3	09/03/85	105	308	301	F	5	9
1	08/26/85	105	312	301	F	2	9
3	08/23/85	105	312	325	F	5	[illegible]
3	09/03/85	105	312	283	F	5	9
3	09/03/85	105	313	303	F	3	[illegible]
1	08/26/85	105	315	326	F	2	14
3	09/03/85	105	316	319	F	3	9

Table A-50 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
2	09/04/75	105	319	364	F	3	9
1	09/04/85	105	319	312	F	3	17
2	08/16/85	105	321	352	F	4	12
2	08/23/85	105	323	316	F	2	10
1	09/04/85	105	324	359	F	3	11
1	09/03/85	105	326	392	F	3	9
3	08/16/85	105	327	344	M	3	13
3	08/23/85	105	328	330	F	5	8
1	08/26/85	105	330	355	F	2	9
1	09/04/85	105	331	381	F	5	13
3	08/09/85	105	332	418	F	3	11
1	08/26/85	105	340	465	F	3	12
1	09/03/85	105	343	382	F	3	12
1	08/26/85	105	345	428	F	5	[illegible]
2	08/09/85	105	352	456	F	2	21
1	08/26/85	105	353	423	F	2	16
205	09/03/85	105	355	501	F	4	15
1	09/04/85	105	357	540	F	3	17
1	09/03/85	105	358	513	F	3	14
1	08/30/85	105	360	510	F	2	[illegible]
3	08/23/85	105	363	434	F	2	15
203	09/02/85	105	373	560	M	2	[illegible]

Table A-51. Biological data for broad whitefish used in length-weight analyses, aging, and mean length at age.

STATION	DATE	SPECIES	LENGTH	WEIGHT	SEX	MAT	AGE
3	07/19/85	103	129	21	I	1	[illegible]
2	07/15/85	103	83	5	I	1	
2	07/19/85	103	83	4	I	1	1
2	07/19/85	103	94	7	I	1	1
2	07/19/85	103	336	507	M	3	7
2	07/19/85	103	75	2	I	1	1
1	07/19/85	103	290	260	M	3	6
1	07/19/85	103	165	43	I	1	3
1	07/19/85	103	135	25	I	1	1
1	07/19/85	103	130	19	I	1	2
1	07/19/85	103	110	12	I	1	1
1	07/19/85	103	100	10	I	1	1
3	07/19/85	103	205	88	M	1	4
3	07/19/85	103	210	87	M	1	3
3	07/19/85	103	140	21	I	1	2
3	07/19/85	103	125	17	I	1	2
3	07/19/85	103	110	11	I	1	
3	07/19/85	103	105	8	I	1	1
3	07/19/85	103	80	3	I	1	1
3	07/19/85	103	95	8	I	1	1
3	07/19/85	103	115	14	I	1	1
3	07/19/85	103	110	14	I	1	1
3	07/19/85	103	100	8	F	1	1
3	07/19/85	103	100	9	I	1	1
3	07/19/85	103	95	7	I	1	1
3	07/19/85	103	95	9	I	1	1
3	07/19/85	103	85	5	I	1	1
1	07/23/85	103	177	58	M	1	3
1	07/23/85	103	166	46	M	1	3
1	07/23/85	103	153	33	F	1	3
1	07/23/85	103	138	27	F	1	2
1	07/23/85	103	140	27	M	1	2
1	07/23/85	103	135	25	M	1	2
1	07/23/85	103	92	7	I	1	1
1	07/23/85	103	88	5	I	1	1
1	07/23/85	103	175	50	F	1	3
1	07/23/85	103	205	91	M	1	4
1	07/23/85	103	272	218	M	1	6
1	07/23/85	103	175	53	M	1	3
1	07/23/85	103	176	58	F	1	3
1	07/23/85	103	176	59	M	1	3
1	07/23/85	103	114	13	I	1	1
1	07/23/85	103	106	11	I	1	1
1	07/23/85	103	113	13	I	1	1
1	07/23/85	103	87	6	I	1	1
3	07/23/85	103	300	308	M	1	7
1	07/24/85	103	107	10	I	1	1
1	07/24/85	103	85	5	I	1	1
1	07/24/85	103	190	72	F	1	[illegible]
1	07/24/85	103	186	64	F	1	[illegible]

Table A-51 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
[illegible]	07/24/85	[illegible]	[illegible]	[illegible]	M	[illegible]	
1	07/24/85	103	205	93	F	1	4
1	07/24/85	103	375	521	M	2	5
1	07/24/85	103	395	664	M	2	5
1	07/24/85	103	400	718	M	2	8
3	07/25/85	103	206	94	M	1	4
3	07/25/85	103	220	112	F	1	4
1	07/25/85	103	183	65	M	1	3
1	07/25/85	103	182	69	F	1	3
1	07/25/85	103	200	83	M	1	4
1	07/25/85	103	247	160	M	1	4
1	07/25/85	103	322	387	M	2	7
1	07/25/85	103	365	585	M	1	5
2	07/25/85	103	158	38	F	1	3
2	07/25/85	103	166	50	M	1	3
2	07/25/85	103	290	284	F	1	6
2	07/25/85	103	267	236	F	1	6
2	07/25/85	103	296	307	M	1	6
2	07/25/85	103	368	583	M	1	5
2	07/25/85	103	356	582	M	2	7
3	07/26/85	103	390	655	F	2	8
3	07/26/85	103	360	517	M	1	6
2	07/26/85	103	338	405	F	1	7
1	07/26/85	103	275	248	M	1	6
1	07/26/85	103	210	93	F	1	4
1	07/26/85	103	282	233	M	1	6
1	07/26/85	103	230	128	F	1	4
1	07/26/85	103	225	129	F	1	4
1	07/26/85	103	220	100	M	1	4
1	07/26/85	103	232	133	M	1	4
1	07/26/85	103	200	88	F	1	4
1	08/02/85	103	298	330	M	1	6
1	08/02/85	103	324	425	M	1	7
2	08/02/85	103	280	255	F	1	6
2	08/02/85	103	277	241	M	1	6
3	08/02/85	103	295	317	M	1	7
3	08/02/85	103	265	207	M	1	6
3	08/02/85	103	271	232	M	1	5
3	08/02/85	103	271	253	F	1	6
3	08/02/85	103	199	87	M	1	3
661	08/08/85	103	157	43	M	1	2
661	08/08/85	103	253	172	F	1	6
661	08/08/85	103	248	162	M	1	4
205	08/08/85	103	176	57	F	1	3
205	08/08/85	103	164	41	M	1	2
205	08/08/85	103	274	221	F	1	6
205	08/08/85	103	349	497	M	1	7
[illegible]	08/08/85	103	156	37	M	1	2
205	08/08/85	103	134	20	F	1	2
205	08/08/85	103	123	15	F	1	1

Table A-51 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
[illegible]	[illegible]	103	108	[illegible]	I	[illegible]	
204	08/09/85	103	94	7	I	1	
3	08/09/85	103	405	768	M	1	[illegible]
1	08/09/85	103	253	182	F	1	[illegible]
1	08/09/85	103	298	320	M	1	[illegible]
1	08/09/85	103	170	54	F	1	[illegible]
205	08/13/85	103	132	21	I	1	[illegible]
205	08/13/85	103	120	17	I	1	[illegible]
205	08/13/85	103	135	22	I	1	[illegible]
205	08/13/85	103	133	21	I	1	[illegible]
202	08/13/85	103	121	17	I	1	[illegible]
202	08/13/85	103	118	16	I	1	[illegible]
661	08/13/85	103	162	40	F	1	[illegible]
203	08/14/85	103	315	357	M	[illegible]	[illegible]
2	08/16/85	103	203	82	F	1	[illegible]
1	08/26/85	103	305	341	M	1	[illegible]
1	08/26/85	103	212	97	F	1	[illegible]
3	08/26/85	103	362	543	M	1	[illegible]
3	08/26/85	103	345	442	F	1	[illegible]
3	08/26/85	103	435	1192	F	2	[illegible]
3	08/26/85	103	488	1473	F	2	[illegible]
3	08/27/85	103	361	507	F	1	[illegible]
3	08/27/85	103	391	755	F	1	[illegible]
2	08/28/85	103	323	355	F	1	[illegible]
205	08/30/85	103	220	117	F	1	[illegible]
205	08/30/85	103	280	260	F	1	[illegible]
205	08/30/85	103	273	224	M	1	[illegible]
205	08/30/85	103	281	246	M	1	[illegible]
205	08/30/85	103	322	393	M	1	[illegible]
205	08/30/85	103	348	510	M	1	[illegible]
2	08/23/85	103	358	510	M	1	[illegible]
203	08/30/85	103	440	1092	M	1	[illegible]
203	09/03/85	103	359	529	M	1	[illegible]
203	09/03/85	103	430	917	M	2	[illegible]
203	09/04/85	103	341	448	M	1	[illegible]
203	09/04/85	103	351	454	M	1	7
203	09/04/85	103	310	326	M	1	[illegible]
3	09/04/85	103	513	1985	M	4	[illegible]
314	07/21/85	103	545	0	F	3	[illegible]
314	07/21/85	103	540	0	M	3	19
314	07/21/85	103	525	0	F	3	20
314	07/21/85	103	490	0	F	3	[illegible]
314	07/21/85	103	575	0	M	3	[illegible]
314	07/21/85	103	535	0	M	3	19
314	07/21/85	103	505	0	M	3	[illegible]
314	07/21/85	103	530	0	F	3	[illegible]
314	07/24/85	103	495	0	F	3	[illegible]
714	07/24/85	103	525	0	M	3	[illegible]
314	07/24/85	103	530	0	M	3	[illegible]
314	07/24/85	103	530	0	M	3	[illegible]

Table A-51 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
314	07/24/85	103	540	0	M	3	
314	07/24/85	103	600	0	M	3	
314	07/24/85	103	635	0	M	3	[illegible]
314	07/24/85	103	650	0	F	3	[illegible]
299	07/24/85	103	475	0	M	3	[illegible]
299	07/24/85	103	490	0	M	3	[illegible]
299	07/24/85	103	490	0	M	3	[illegible]
299	07/24/85	103	490	0	M	3	[illegible]
299	07/24/85	103	495	0	M	3	[illegible]
299	07/24/85	103	525	0	M	3	[illegible]
299	07/24/85	103	525	0	M	3	[illegible]
299	07/24/85	103	535	0	M	3	[illegible]
299	07/24/85	103	540	0	F	3	[illegible]
299	07/24/85	103	540	0	M	3	[illegible]
299	07/24/85	103	570	0	M	3	[illegible]
622	07/25/85	103	525	0	F	3	[illegible]
622	07/25/85	103	535	0	M	3	[illegible]
622	07/25/85	103	535	0	M	3	[illegible]
638	07/27/85	103	480	0	M	3	[illegible]
638	07/27/85	103	500	0	M	3	[illegible]
638	07/27/85	103	500	0	M	3	[illegible]
638	07/27/85	103	510	0	M	3	[illegible]
638	07/27/85	103	515	0	F	3	[illegible]
638	07/27/85	103	515	0	M	3	[illegible]
638	07/27/85	103	525	0	M	3	[illegible]
638	07/27/85	103	535	0	M	3	[illegible]
638	07/27/85	103	555	0	M	3	[illegible]
624	07/29/85	103	460	0	M	3	[illegible]
624	07/29/85	103	480	0	F	3	[illegible]
624	07/29/85	103	485	0	M	3	[illegible]
624	07/29/85	103	500	0	F	3	13
624	07/29/85	103	500	0	M	3	15
624	07/29/85	103	500	0	M	3	[illegible]
624	07/29/85	103	510	0	F	3	16
624	07/29/85	103	515	0	M	3	[illegible]
624	07/29/85	103	525	0	F	3	20
624	07/29/85	103	530	0	F	3	23
624	07/29/85	103	535	0	F	3	19
624	07/29/85	103	565	0	F	3	20
748	08/01/85	103	530	0	M	3	19
748	08/01/85	103	480	0	M	3	23
748	08/01/85	103	495	0	F	3	29
748	08/01/85	103	480	0	F	3	13
748	08/01/85	103	550	0	F	3	17
748	08/01/85	103	520	0	M	3	17
748	08/01/85	103	540	0	M	3	19
748	08/01/85	103	520	0	M	3	28
748	08/01/85	103	535	0	F	3	[illegible]
748	08/01/85	103	620	0	F	3	25
748	08/01/85	103	580	0	F	3	[illegible]

Table A-51 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
748	08/01/85	103	500	0	F	3	[illegible]
748	08/01/85	103	510	0	F	3	[illegible]
748	08/01/85	103	550	0	M	3	[illegible]
748	08/01/85	103	525	0	F	3	[illegible]
748	08/01/85	103	620	0	F	3	[illegible]
748	08/01/85	103	575	0	M	3	[illegible]
751	07/29/85	103	565	0			[illegible]
751	07/29/85	103	580	0			[illegible]
751	07/29/85	103	517	0			[illegible]
751	07/29/85	103	568	0			[illegible]
300	08/03/85	103	495	0	M	3	[illegible]
300	08/03/85	103	495	0	F	3	[illegible]
300	08/03/85	103	595	0	M	3	[illegible]
300	08/03/85	103	485	0	M	3	[illegible]
300	08/03/85	103	605	0	F	3	[illegible]
624	08/08/85	103	585	0	M	3	[illegible]
312	08/08/85	103	475	0	F	3	[illegible]
312	08/08/85	103	555	0	F	3	[illegible]
312	08/08/85	103	495	0	F	3	[illegible]
300	08/25/85	103	365	0	M	1	

Table A-52. **Biological data for humpback whitefish used in length-weight analyses, aging, and mean length at age.**

STATION	DATE	SPECIES	LENGTH	WEIGHT	SEX	MAT	[illegible]
1	07/24/85	104	69	3	I	1	
1	07/23/85	104	70	3	I	1	[illegible]
1	07/23/85	104	72	3	I	1	[illegible]
1	07/23/85	104	73	3	I	1	[illegible]
1	07/23/85	104	77	4	I	1	[illegible]
1	07/24/85	104	80	4	I	1	[illegible]
1	07/24/85	104	82	4	I	1	[illegible]
204	08/09/85	104	84	5	I	1	[illegible]
1	07/23/85	104	85	5	I	1	
3	07/25/85	104	85	5	I	1	[illegible]
1	07/23/85	104	88	6	I	1	[illegible]
1	07/23/85	104	90	6	I	1	[illegible]
1	07/23/85	104	90	6	I	1	[illegible]
1	07/19/85	104	95	6	I	1	[illegible]
1	07/23/85	104	95	7	I	1	[illegible]
1	07/24/85	104	100	8	I	1	[illegible]
1	07/23/85	104	102	8	I	1	[illegible]
3	07/25/85	104	102	10	I	1	[illegible]
1	08/02/85	104	105	11	I	1	
3	07/25/85	104	110	12	I	1	[illegible]
1	07/23/85	104	115	15	I	1	[illegible]
1	07/23/85	104	120	16	M	1	[illegible]
3	07/25/85	104	122	16	I	1	[illegible]
3	07/25/85	104	122	17	I	1	[illegible]
2	07/25/85	104	122	16	I	1	[illegible]
661	08/08/85	104	126	18	I	1	[illegible]
1	07/23/85	104	128	20	M	1	[illegible]
1	08/02/85	104	130	20	I	1	[illegible]
205	08/14/85	104	131	19	I	1	[illegible]
204	08/13/85	104	132	18	I	1	[illegible]
2	08/09/85	104	133	24	F	1	[illegible]
1	07/26/85	104	141	26	F	1	[illegible]
2	08/09/85	104	142	27	I	1	[illegible]
2	08/09/85	104	144	28	I	1	[illegible]
1	07/19/85	104	149	29	I	1	[illegible]
2	08/09/85	104	159	36	I	1	[illegible]
3	08/16/85	104	164	40	M	1	[illegible]
3	08/16/85	104	164	40	M	1	[illegible]
2	08/16/85	104	165	37	M	1	[illegible]
3	07/25/85	104	166	46	M	1	[illegible]
3	07/26/85	104	166	42	F	1	[illegible]
3	08/02/85	104	170	50	M	1	[illegible]
1	08/09/85	104	170	51	I	1	[illegible]
2	08/16/85	104	172	42	M	1	[illegible]
3	08/16/85	104	173	46	F	1	[illegible]
3	08/09/85	104	175	53	M	1	[illegible]
3	08/16/85	104	176	54	F	1	[illegible]
1	07/26/85	104	182	59	F	1	[illegible]
2	08/09/85	104	191	64	I	1	[illegible]
1	07/19/85	104	195	74	I	1	[illegible]

Table A-52 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
2	08/09/85	104	[illegible]	[illegible]	[illegible]		
2	08/09/85	104	200	78	F	1	[illegible]
1	07/19/85	104	201	104	M	1	[illegible]
3	08/30/85	104	208	89	I	1	4
1	07/26/85	104	212	97	M	1	[illegible]
1	07/19/85	104	220	104	M	1	[illegible]
1	07/26/85	104	224	113	F	1	4
1	07/26/85	104	225	117	F	1	5
3	08/26/85	104	230	123	F	1	5
3	08/26/85	104	231	115	F	1	[illegible]
1	08/09/85	104	232	127	M	1	5
3	08/27/85	104	232	136	M	1	6
3	07/25/85	104	237	141	F	1	5
2	08/16/85	104	239	132	M	1	[illegible]
1	07/26/85	104	240	145	F	1	[illegible]
3	08/27/85	104	240	129	F	1	4
3	08/27/85	104	242	142	F	1	[illegible]
1	09/11/85	104	254	179	I	1	[illegible]
3	07/25/85	104	257	175	M	1	6
205	08/30/85	104	261	176	M	1	[illegible]
2	07/26/85	104	262	171	M	1	7
1	07/26/85	104	264	182	F	1	[illegible]
2	09/04/75	104	268	194	F	1	5
3	08/26/85	104	270	225	M	1	[illegible]
204	08/30/85	104	272	206	M	1	[illegible]
204	08/30/85	104	272	209	M	1	[illegible]
3	08/27/85	104	273	199	M	1	[illegible]
3	08/28/85	104	273	206	M	1	
205	08/14/85	104	274	220	F	1	6
311	09/05/85	104	274	204	F	1	[illegible]
2	08/16/85	104	281	244	F	1	[illegible]
205	08/14/85	104	282	215	F	1	[illegible]
2	07/26/85	104	283	226	F	1	[illegible]
3	08/27/85	104	292	264	M	1	7
205	08/14/85	104	303	270	F	1	6
3	08/02/85	104	307	270	F	1	7
203	08/08/85	104	310	300	M	1	[illegible]
203	09/02/85	104	310	318	M	1	[illegible]
2	07/26/85	104	319	320	M	1	7
3	09/03/85	104	331	281	M	1	7
204	08/09/85	104	332	417	F	1	7
205	08/14/85	104	352	520	M	1	9
2	08/23/85	104	361	577	F	2	10
2	07/25/85	104	365	614	M	3	[illegible]
2	07/23/85	104	366	608	M	3	[illegible]
1	07/26/85	104	373	666	F	3	[illegible]
205	08/08/85	104	382	697	F	3	[illegible]
2	08/09/85	104	385	636	F	2	[illegible]
3	08/23/85	104	405	820	F	2	[illegible]
661	08/08/85	104	408	719	M	3	

Table A-52 (Continued)

Station	Date	Species	Length (mm)	Weight (g)	Sex	Maturity	Age
3	[illegible]/25/85	104	41[illegible]	[illegible]	[illegible]		
[illegible]	08/13/85	104	425	71[illegible]	[illegible]	3	[illegible]
204	09/02/85	104	433	840	M	2	[illegible]
203	08/09/85	104	435	942	F	3	[illegible]
361	08/08/85	104	447	852	[illegible]	[illegible]	-

Table A-53. Length-weight relationships and analysis of covariance comparisons for tagged and untagged fish captured in the Colville River and delta.

		N	Slope	Constant
	Arctic cisco			
	untagged fish:			
NS	mature female	28	3.64	-6.565
	mature male	10	3.62	-6.515
NS	all female	55	3.45	-6.078
	all male	38	3.42	-6.021
*	mature female + male	38	3.62	-6.518
	immature female + male	55	3.36	-5.875
*	immature, unknown sex	29	2.98	-5.057
	all together	122	3.28	-5.670
	tagged fish:			
	tagged & recaptured 1985	150	3.14	-5.317
NS	tagged & recaptured 1984[a]	88	3.43	-6.027
	tagged 1984, recaptured 1985	42	3.58	-6.419
	Least Cisco			
	untagged fish:			
NS	mature female	41	3.08	-5.186
	mature male	14	3.21	-5.509
NS	all female	60	3.29	-5.717
	all male	21	3.29	-5.724
NS	mature female & male	55	3.16	-5.399
	immature female & male	26	3.32	-5.776
*	immature, unknown sex	40	3.02	-5.179
	all together	121	3.26	-5.63
	tagged fish:			
NS	tagged & recaptured 1985	429	3.06	-5.134
	tagged 1984, recaptured 1985	312	3.19	-5.465

Table A-53 (Continued)

	N	Slope	Constant
Broad Whitefish			
NS [all female[b]	39	3.26	-5.590
all male[b]	61	3.18	-5.399
* [all female & male	100	3.20	-5.437
immature, unknown sex	38	3.44	-5.954
all together	138	3.26	-5.591
Humpback Whitefish			
NS [all female[b]	32	3.25	-5.587
all male[b]	36	3.17	-5.392
NS [all female & male	68	3.20	-5.468
immature, unknown sex	37	3.20	-5.461
all together	105	3.20	-5.474

*Significantly different at p=0.05

[a]data from 1984 Lisburne study (Moulton, Fawcett and Carpenter 1985)

[b]too few mature fish were examined to calculate separate equations for mature female and male fish.

APPENDIX B

APPENDIX FIGURES

LIST OF APPENDIX FIGURES (continued)

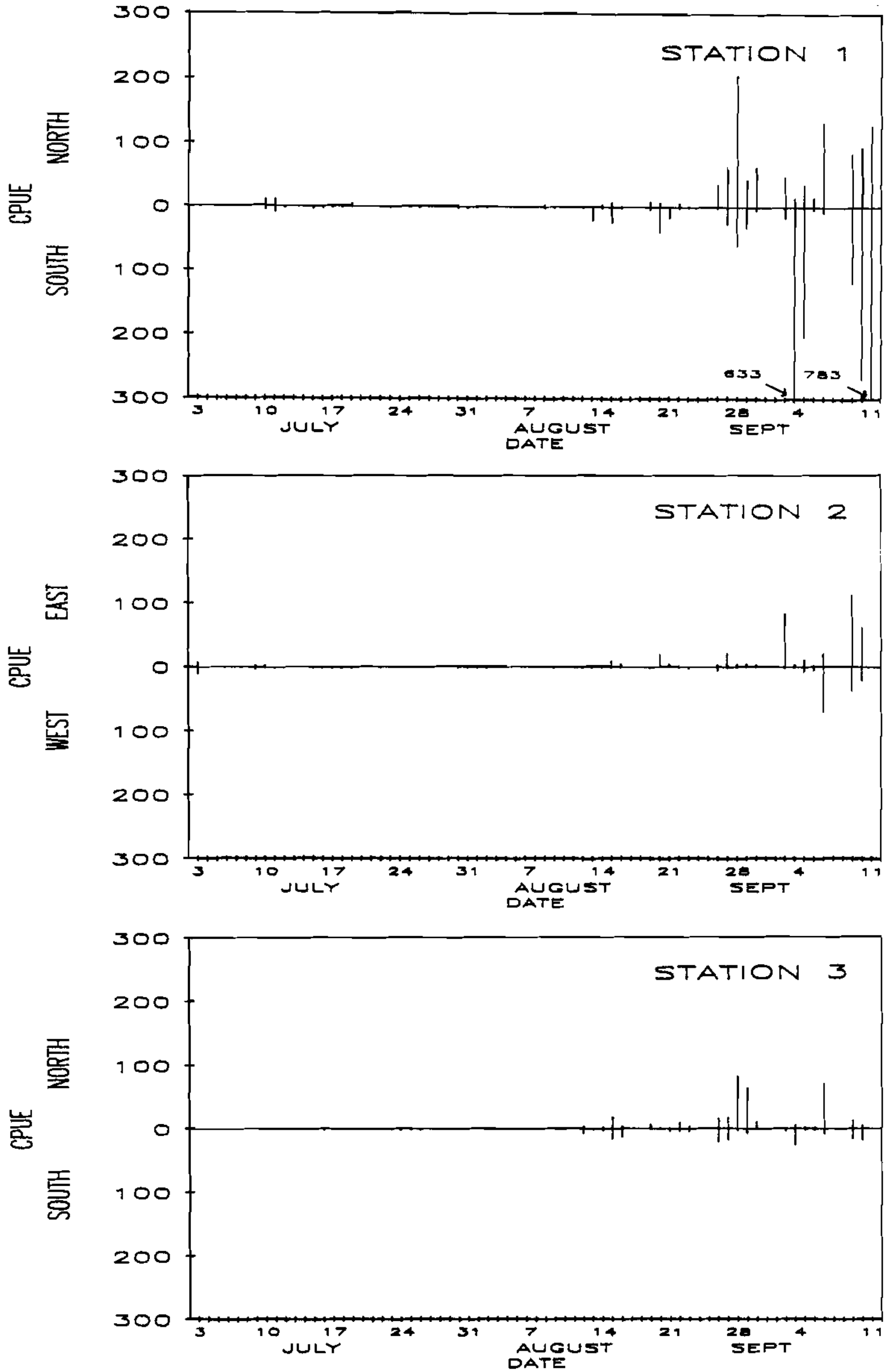


Figure B-1. Daily CPUE (no./24 hr.) of all arctic cisco by side of net at delta stations.

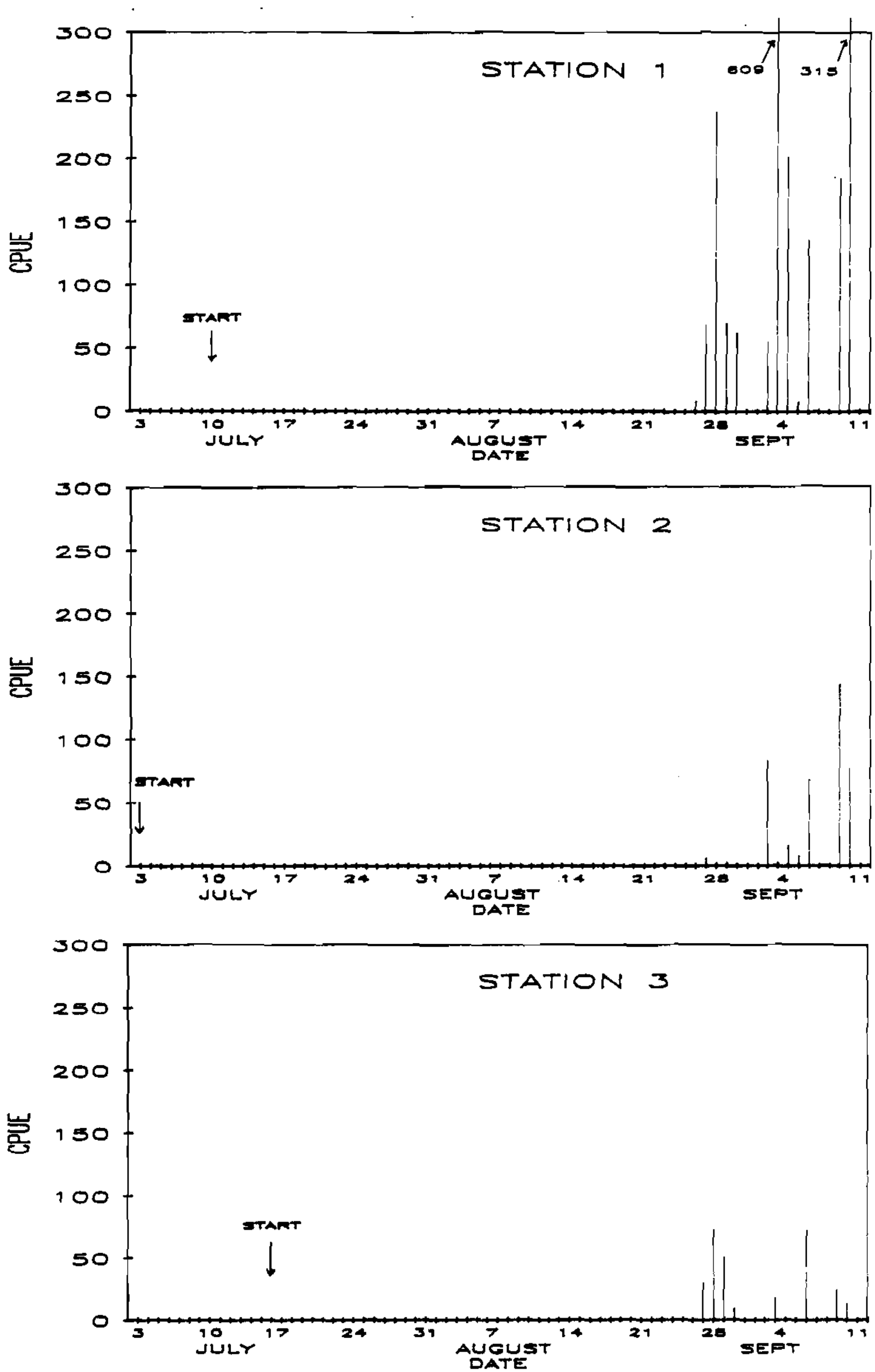


Figure B-2. Daily CPUE (no./24 hr) of small (<120 mm) arctic cisco at delta stations.

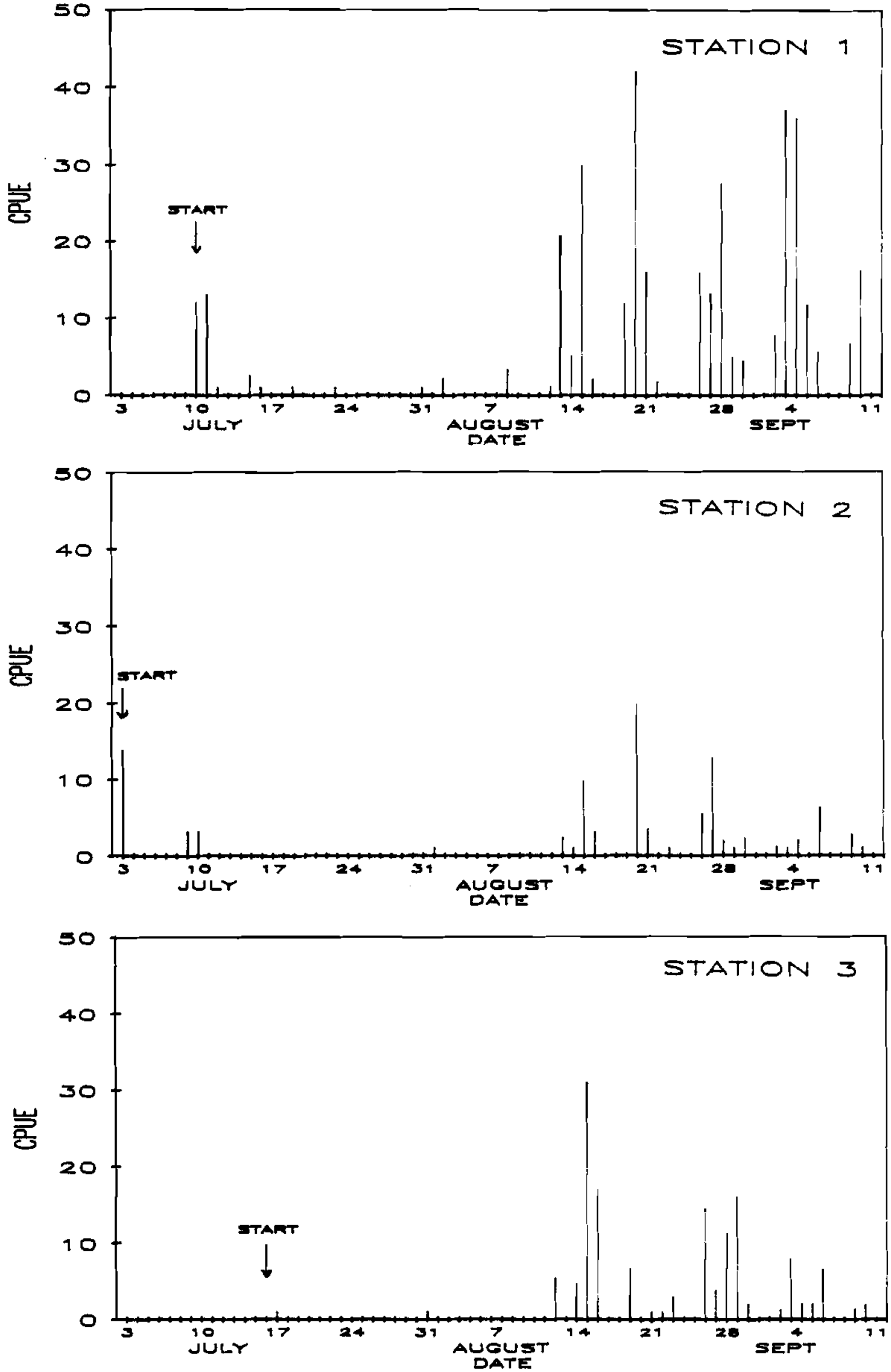


Figure B-3. Daily CPUE (no./24 hr) of medium (120-249 mm) arctic cisco at delta stations.

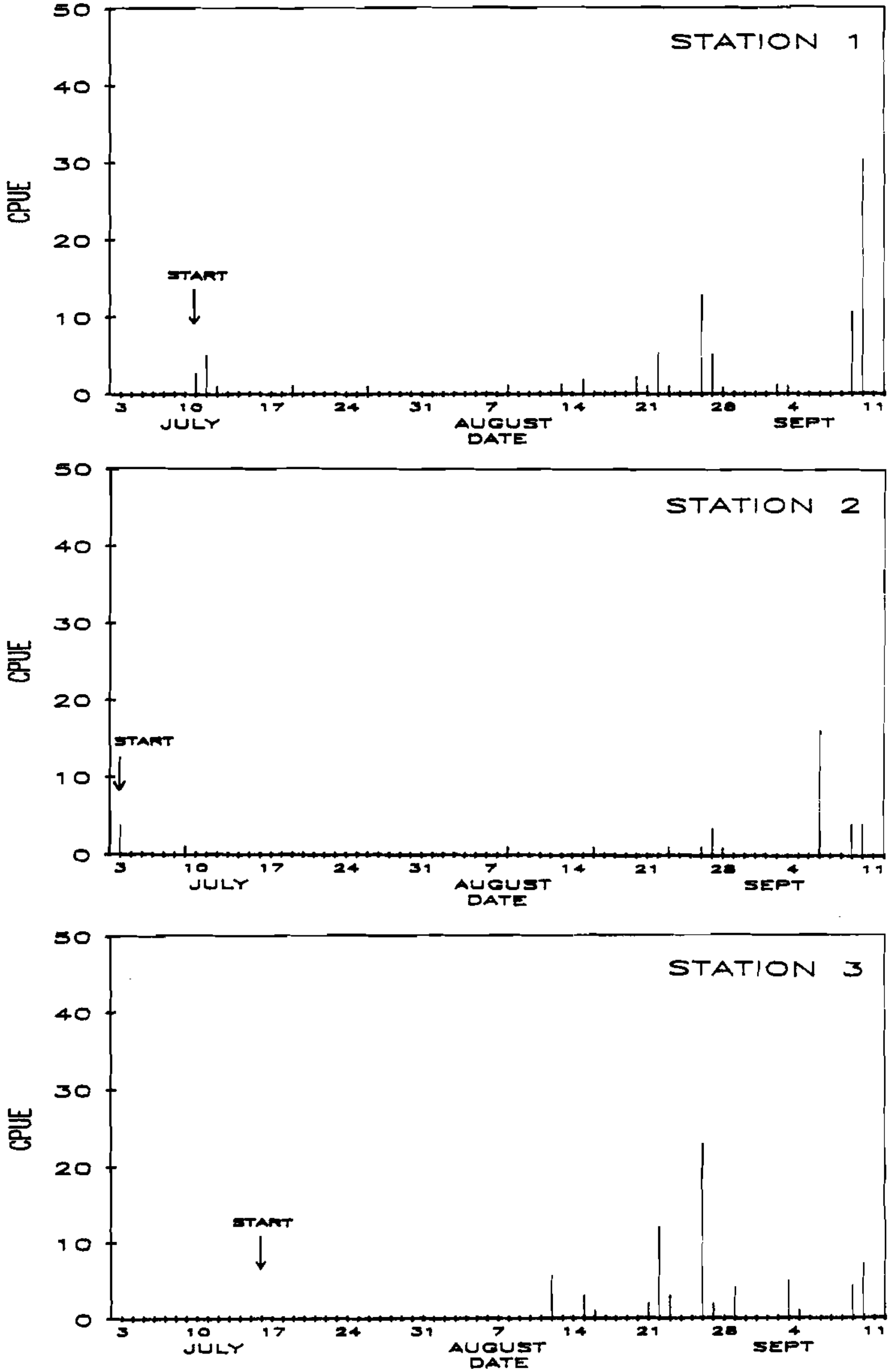


Figure B-4. Daily CPUE (no./24 hr.) of large (≥250 mm) arctic cisco at delta stations.

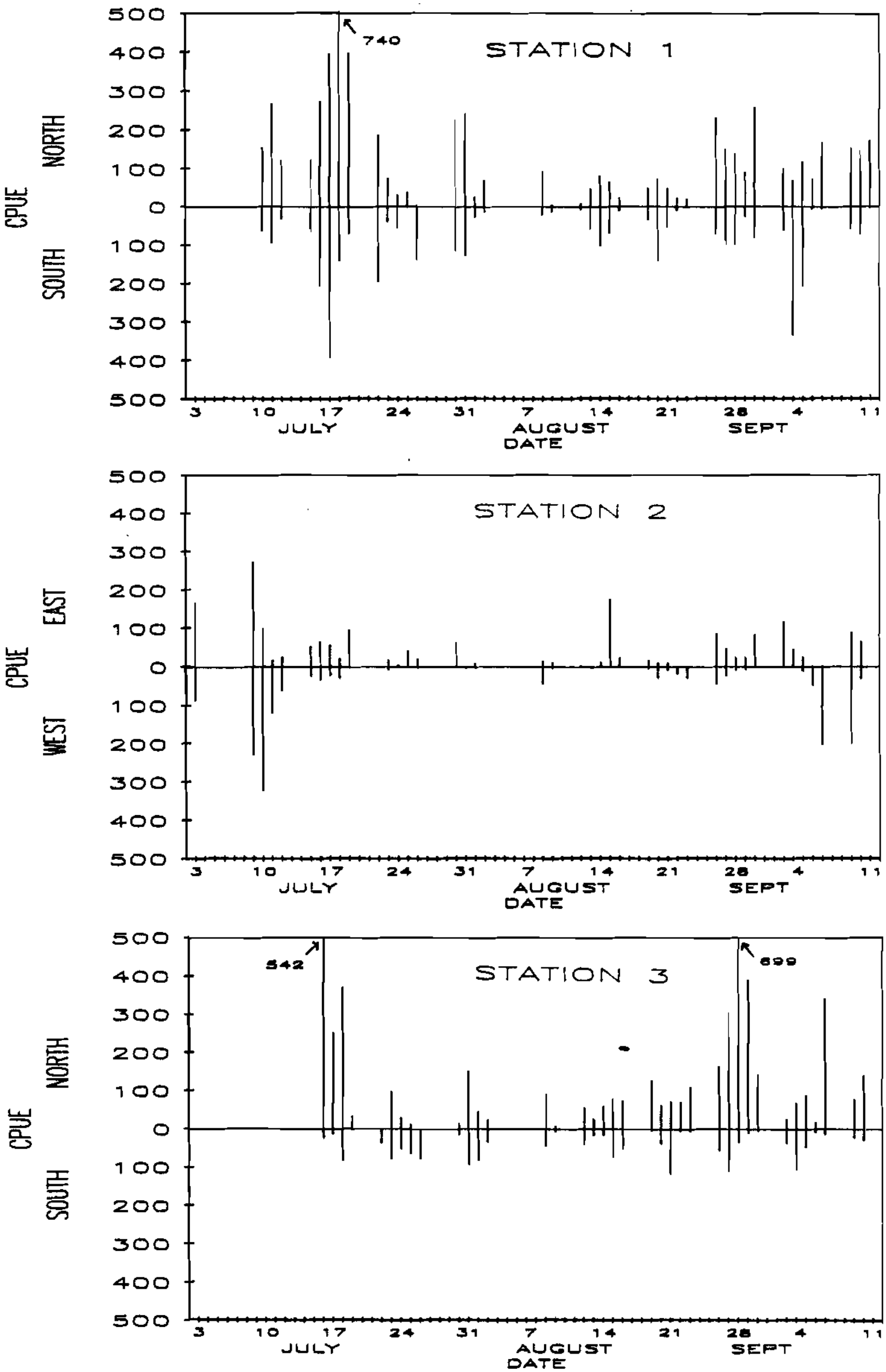


Figure B-5. Daily CPUE (no./24 hr.) of all least cisco by side of net at delta stations.

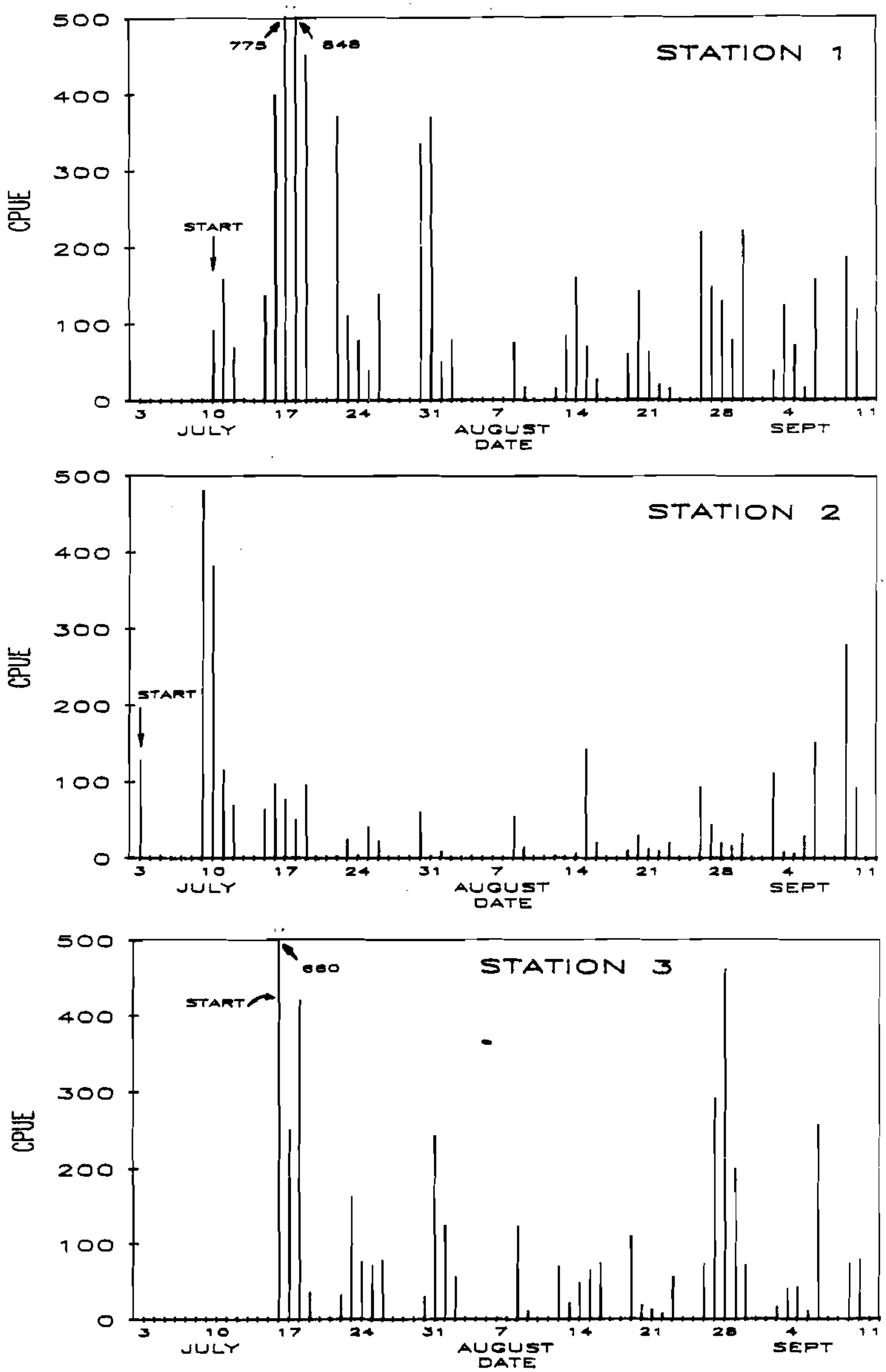


Figure B-6. Daily CPUE (no./24 hr) of small (<120 mm) least cisco at delta stations.

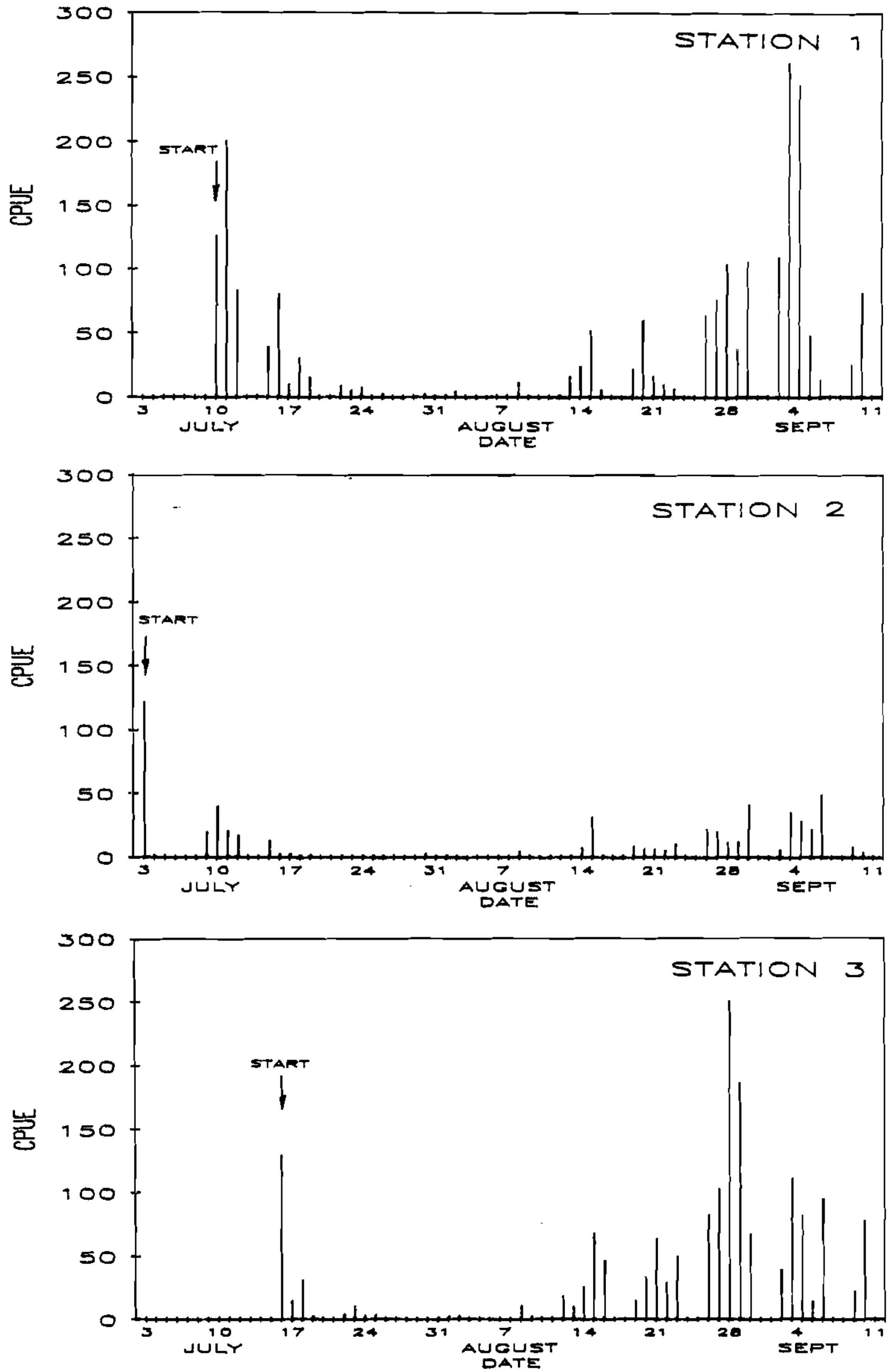


Figure B-7. Daily CPUE (no./24 hr) of medium (120-249 mm) least cisco at delta stations.

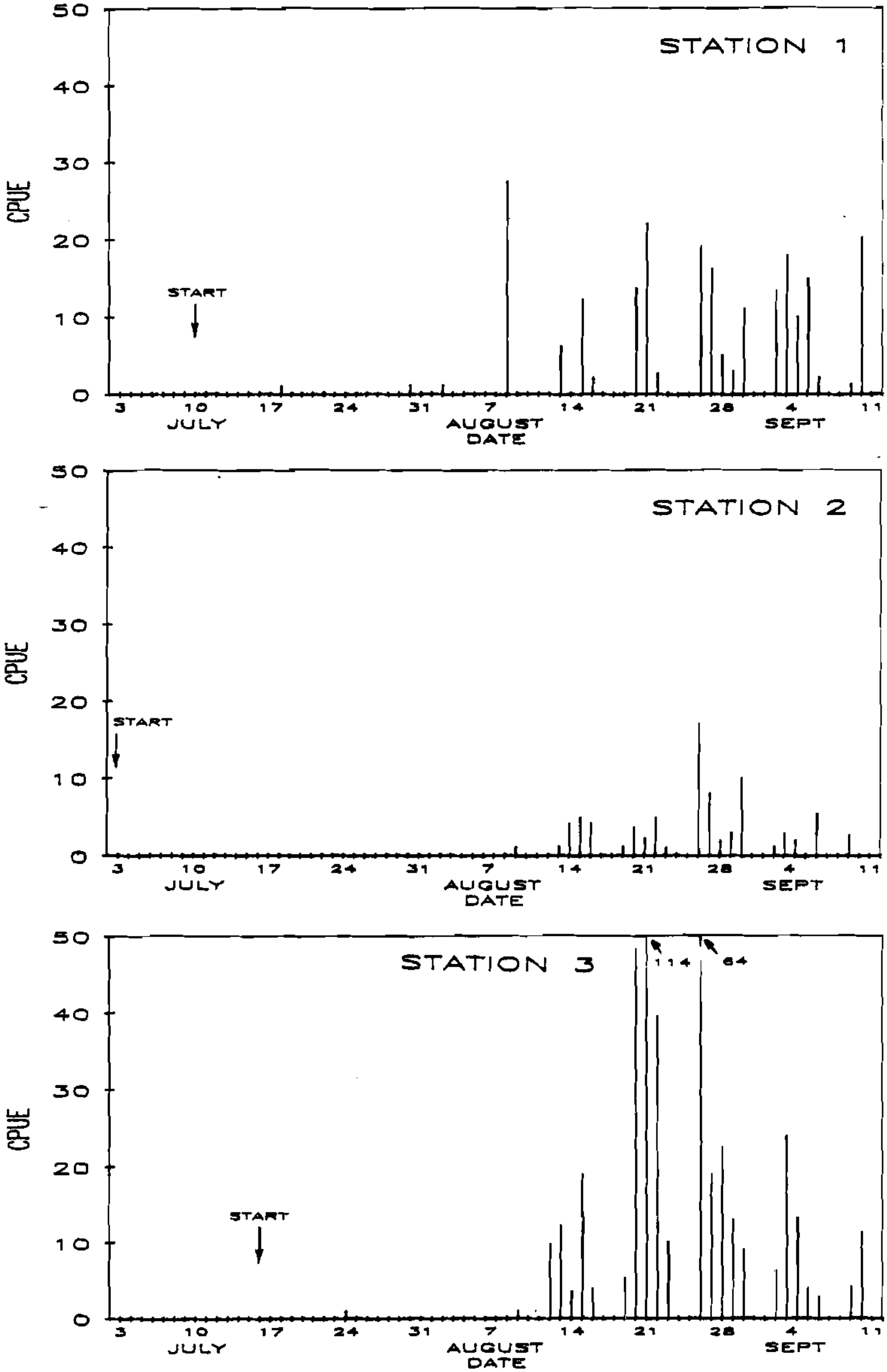


Figure B-8. Daily CPUE (no./24 hr.) of large (≥250 mm) least cisco at delta stations.

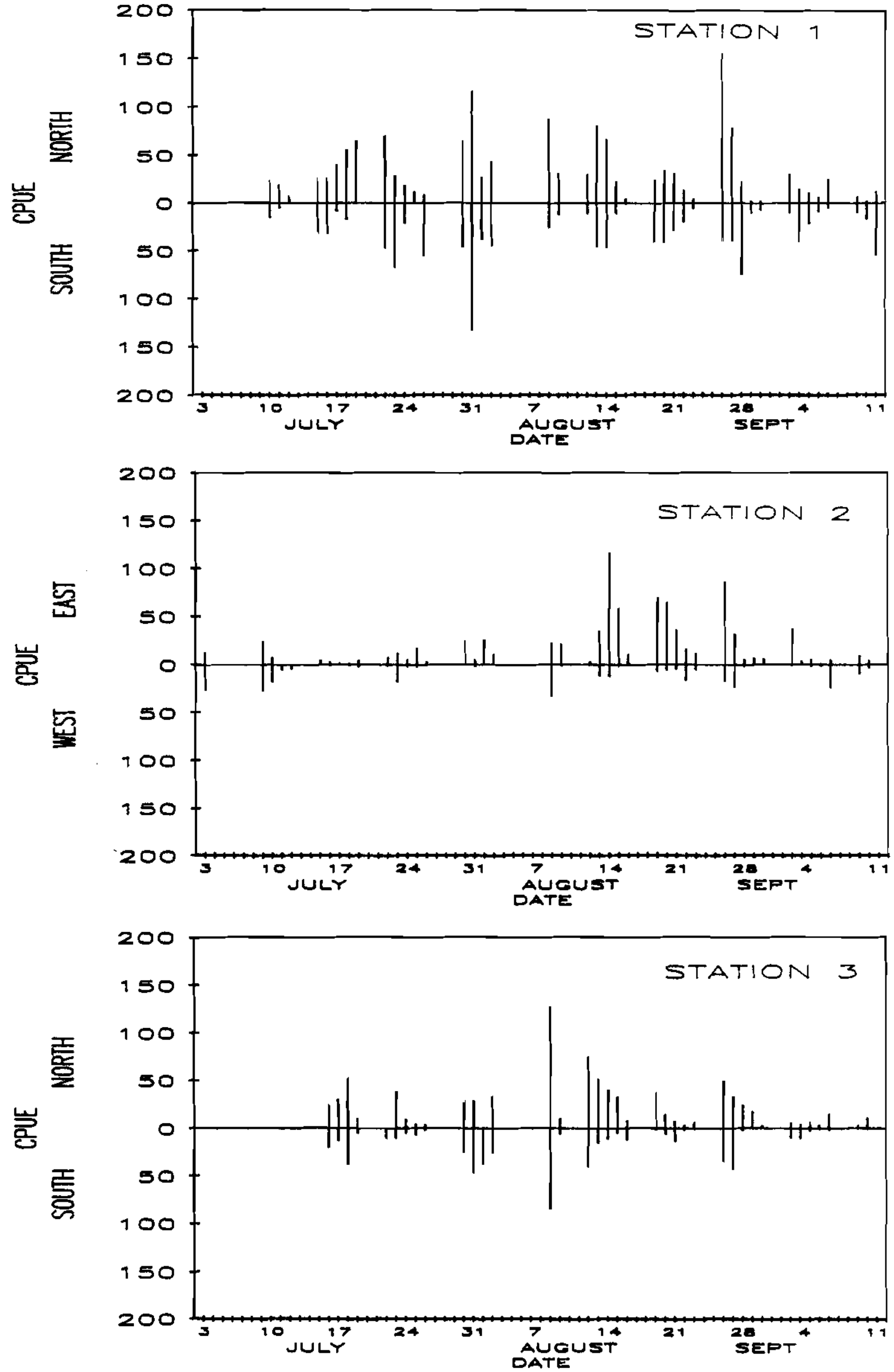


Figure B-9. Daily CPUE (no./24 hr.) of all broad whitefish by side of net at delta stations.

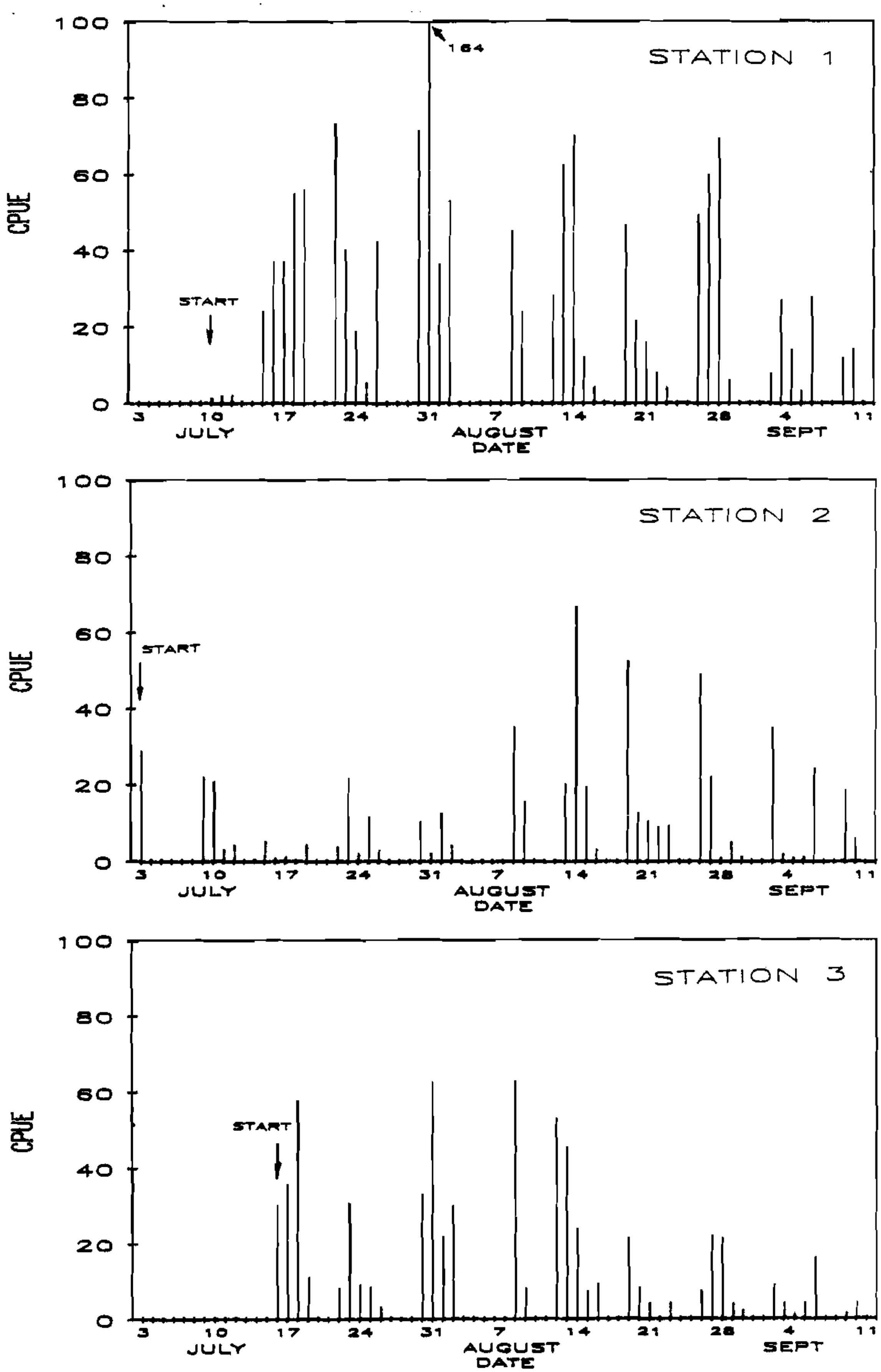


Figure B-10. Daily CPUE (no./24 hr) of small (<120 mm) broad whitefish at delta stations.

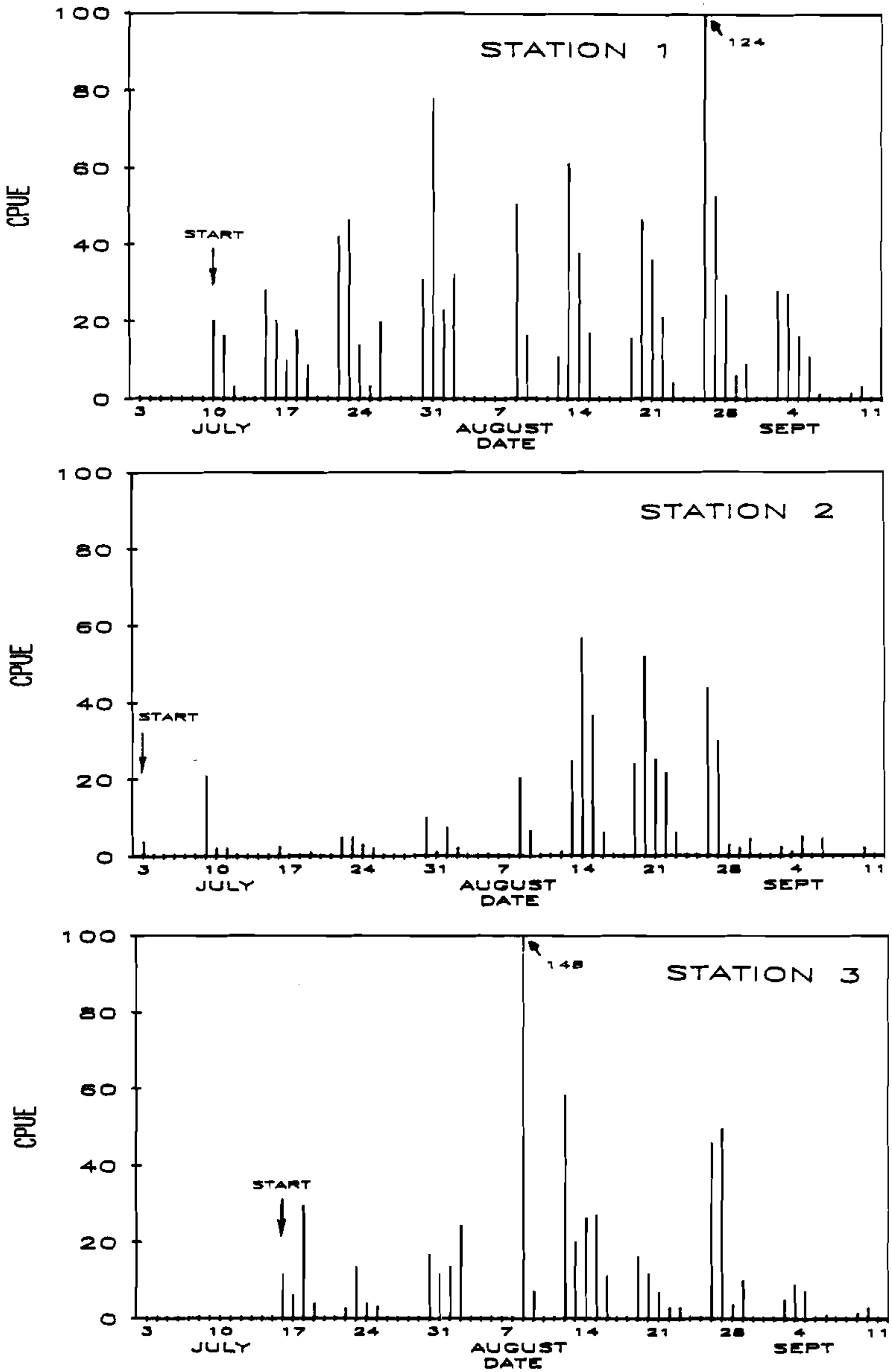


Figure B-11. Daily CPUE (no./24 hr) of medium (120-249 mm) broad whitefish at delta stations.

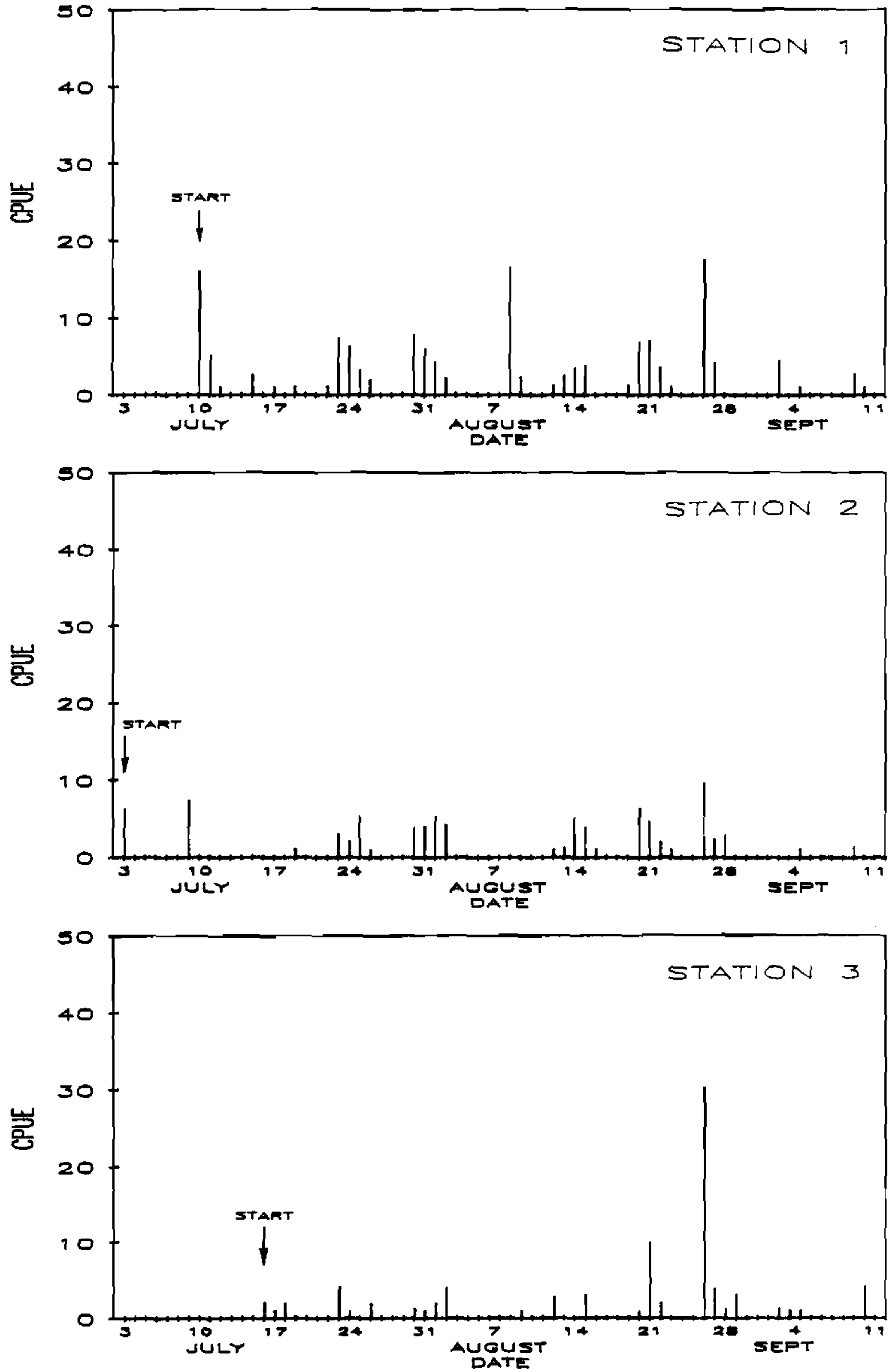


Figure B-12. Daily CPUE (no./24 hr.) of large (≥250 mm) broad whitefish at delta stations.

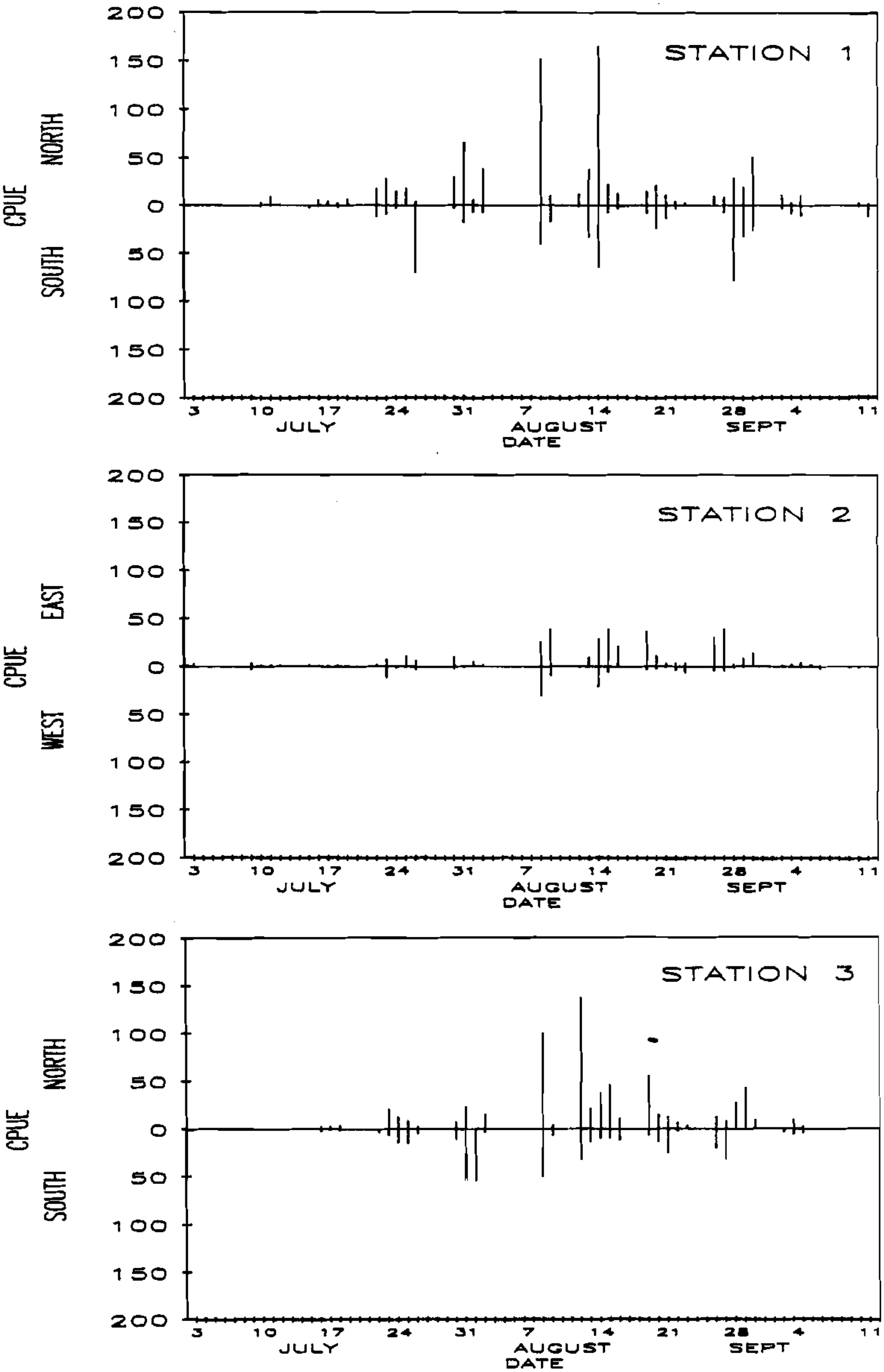


Figure B-13. Daily CPUE (no./24 hr.) of all humpback whitefish by side of net at delta stations.

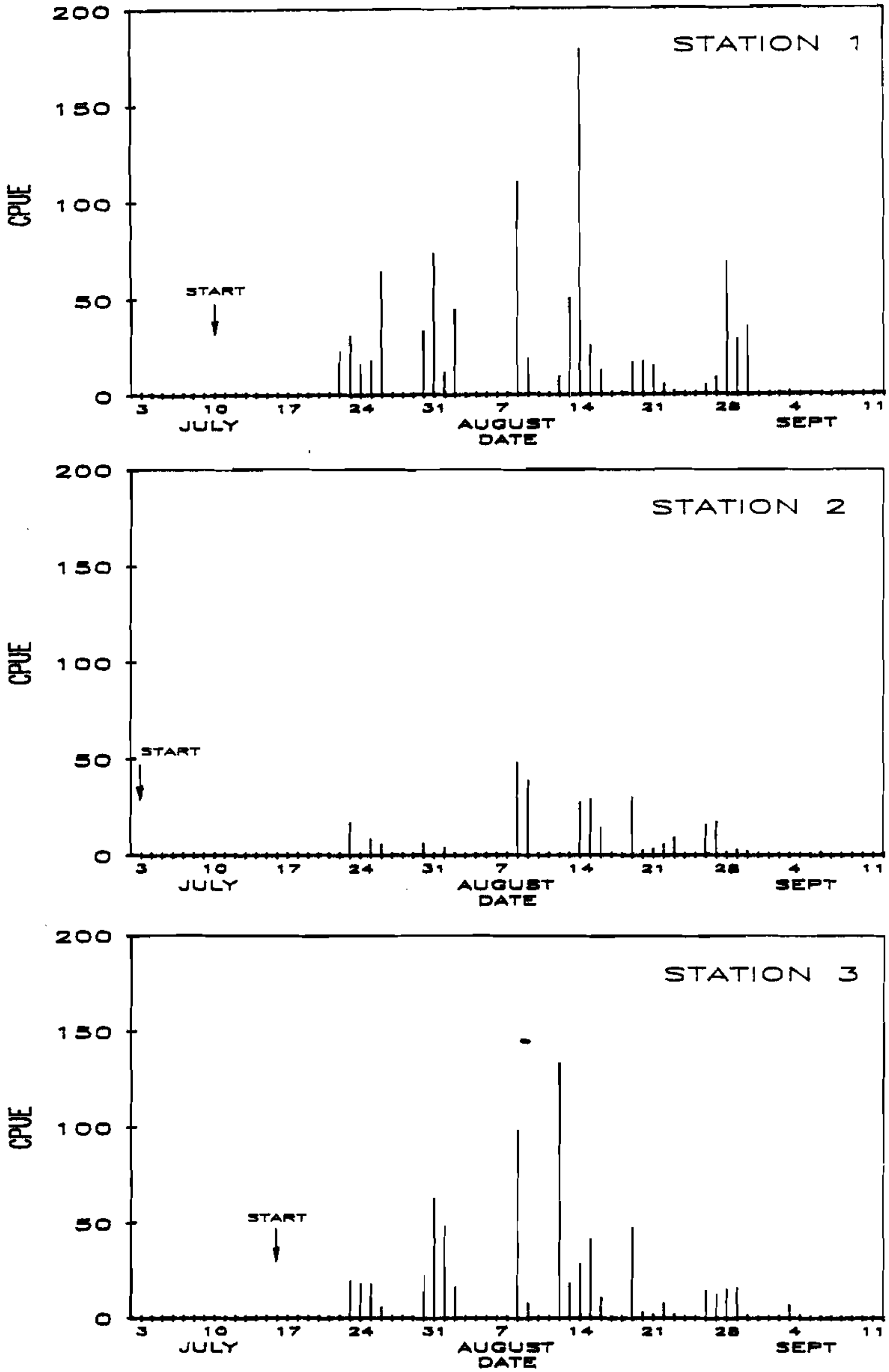


Figure B-14. Daily CPUE (no./24 hr) of small (<120 mm) humpback whitefish at delta stations.

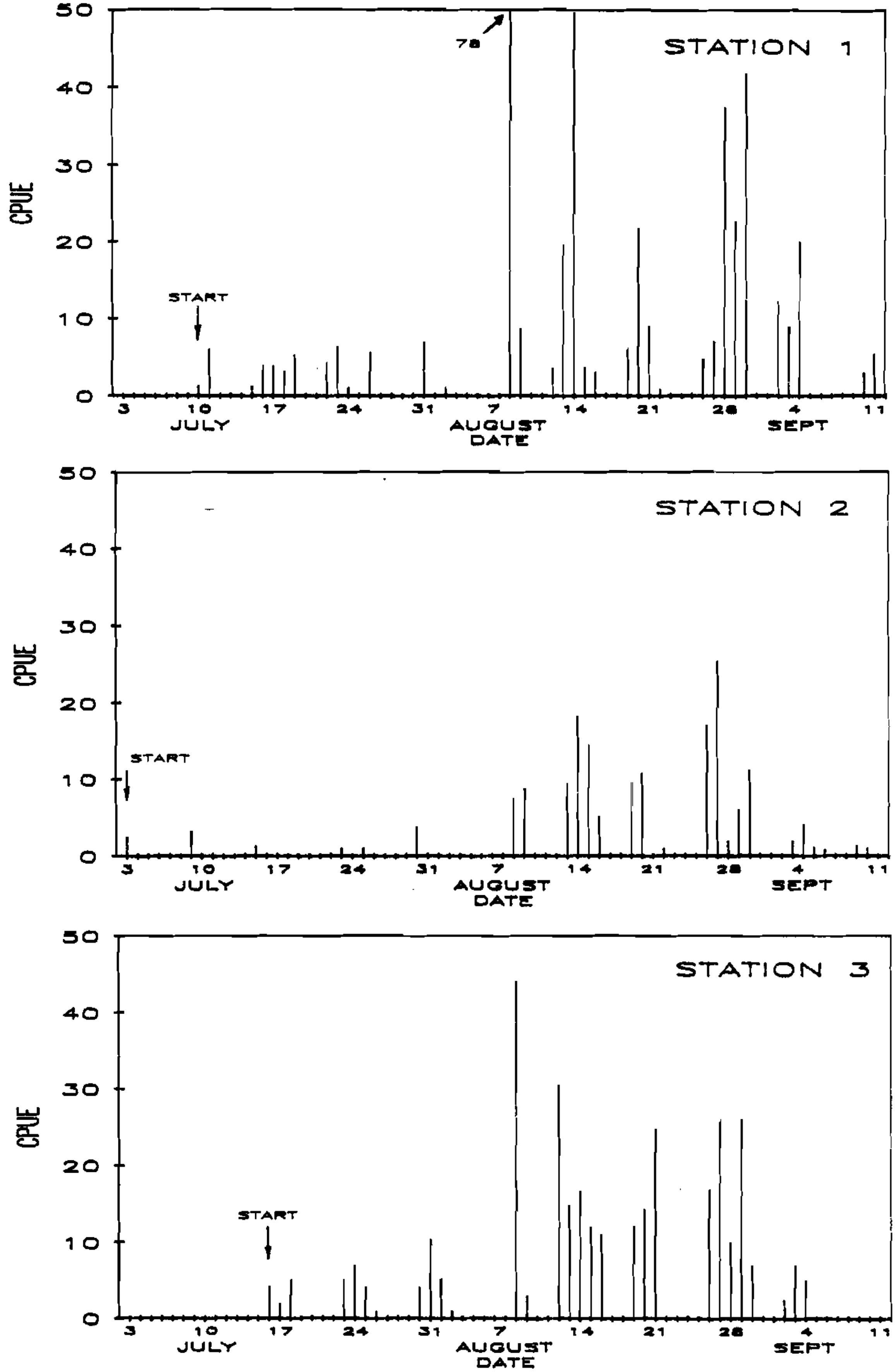


Figure B-15. Daily CPUE (no./24 hr) of medium (120-249 mm) humpback whitefish at delta stations.

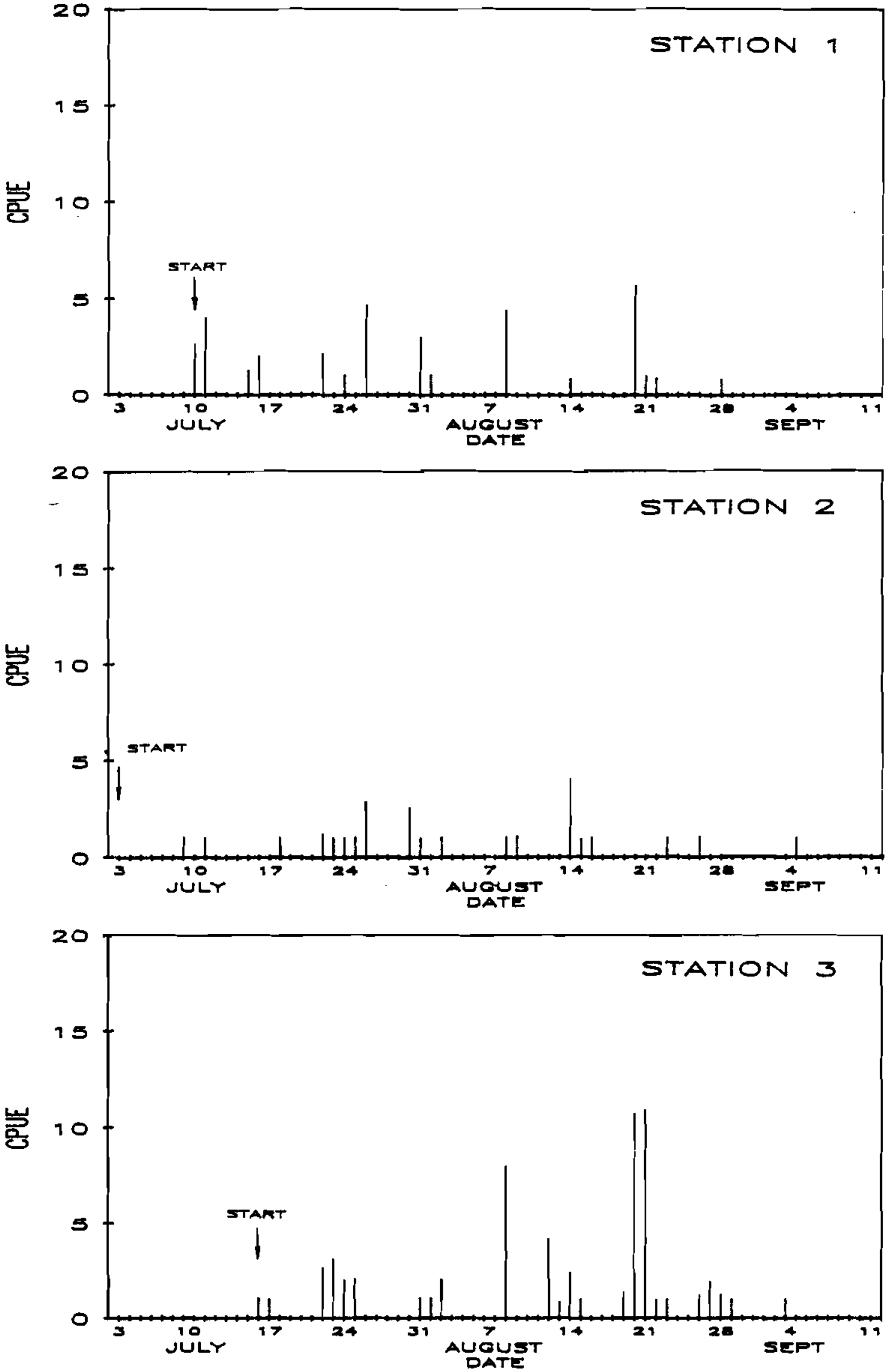


Figure B-16. Daily CPUE (no./24 hr.) of large (≥250 mm) humpback whitefish at delta stations.

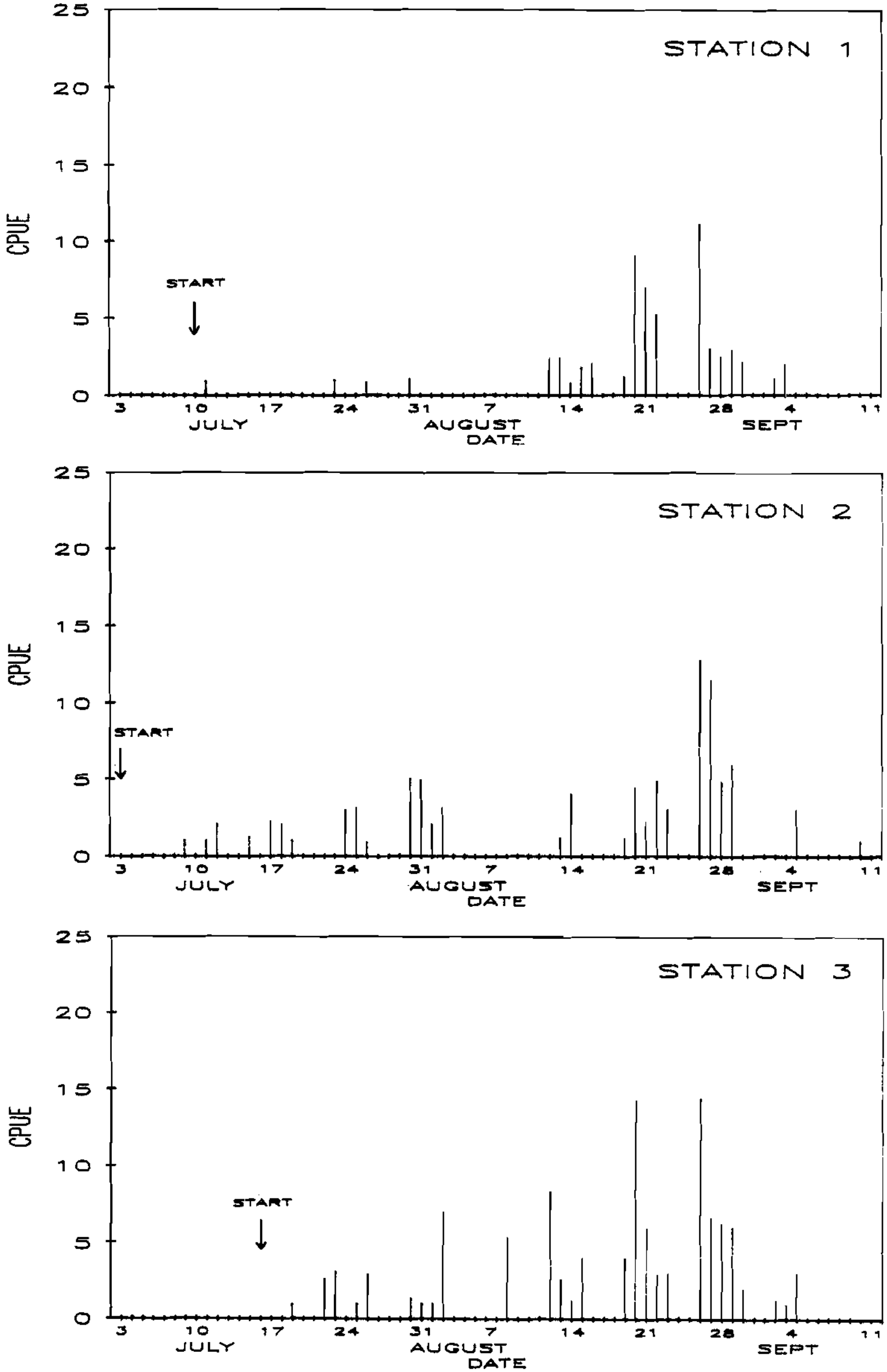


Figure B-17. Daily CPUE (no./24 hr.) of char at delta stations.

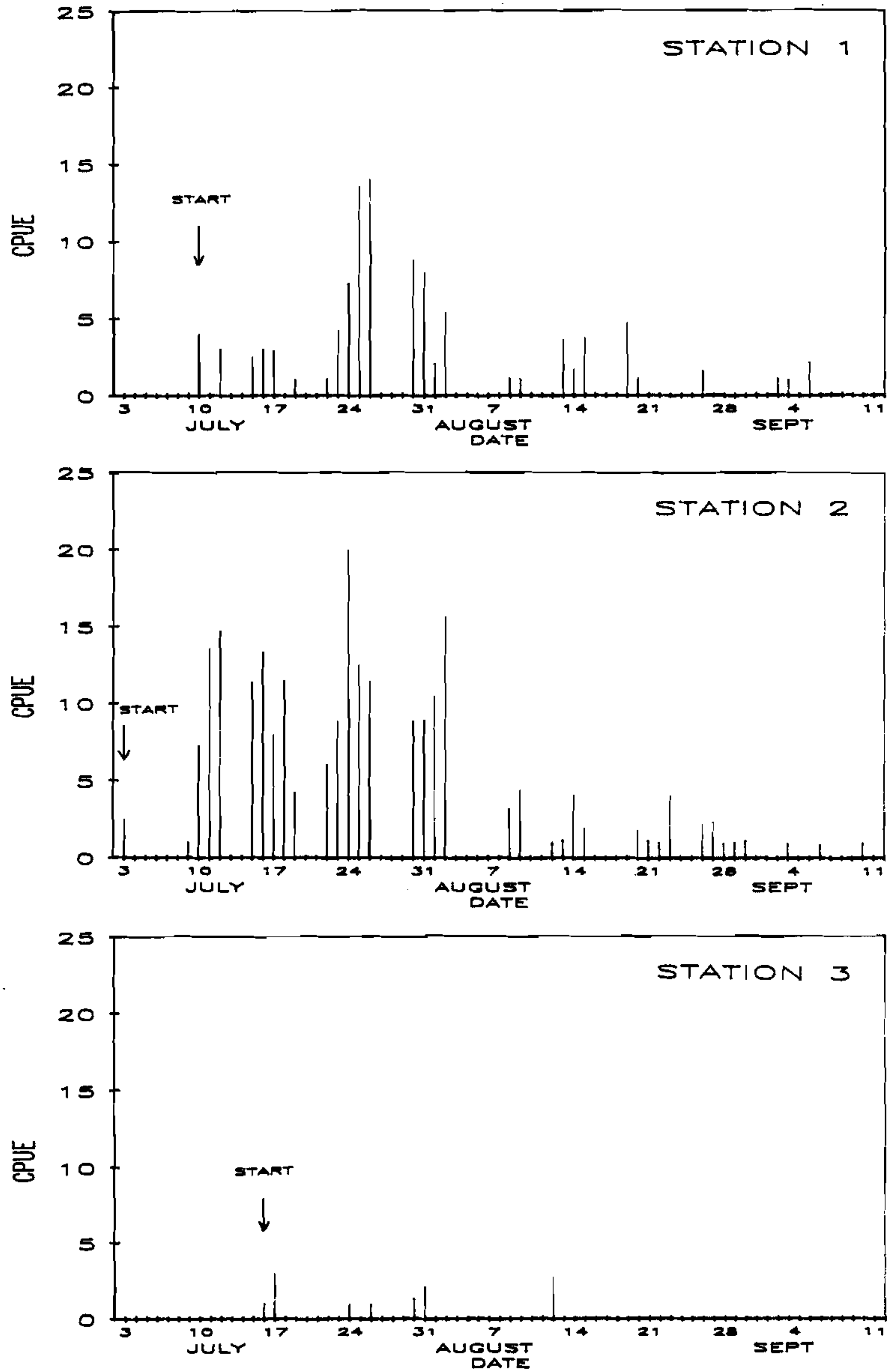


Figure B-18. Daily CPUE (no./24 hr.) of arctic grayling at delta stations.

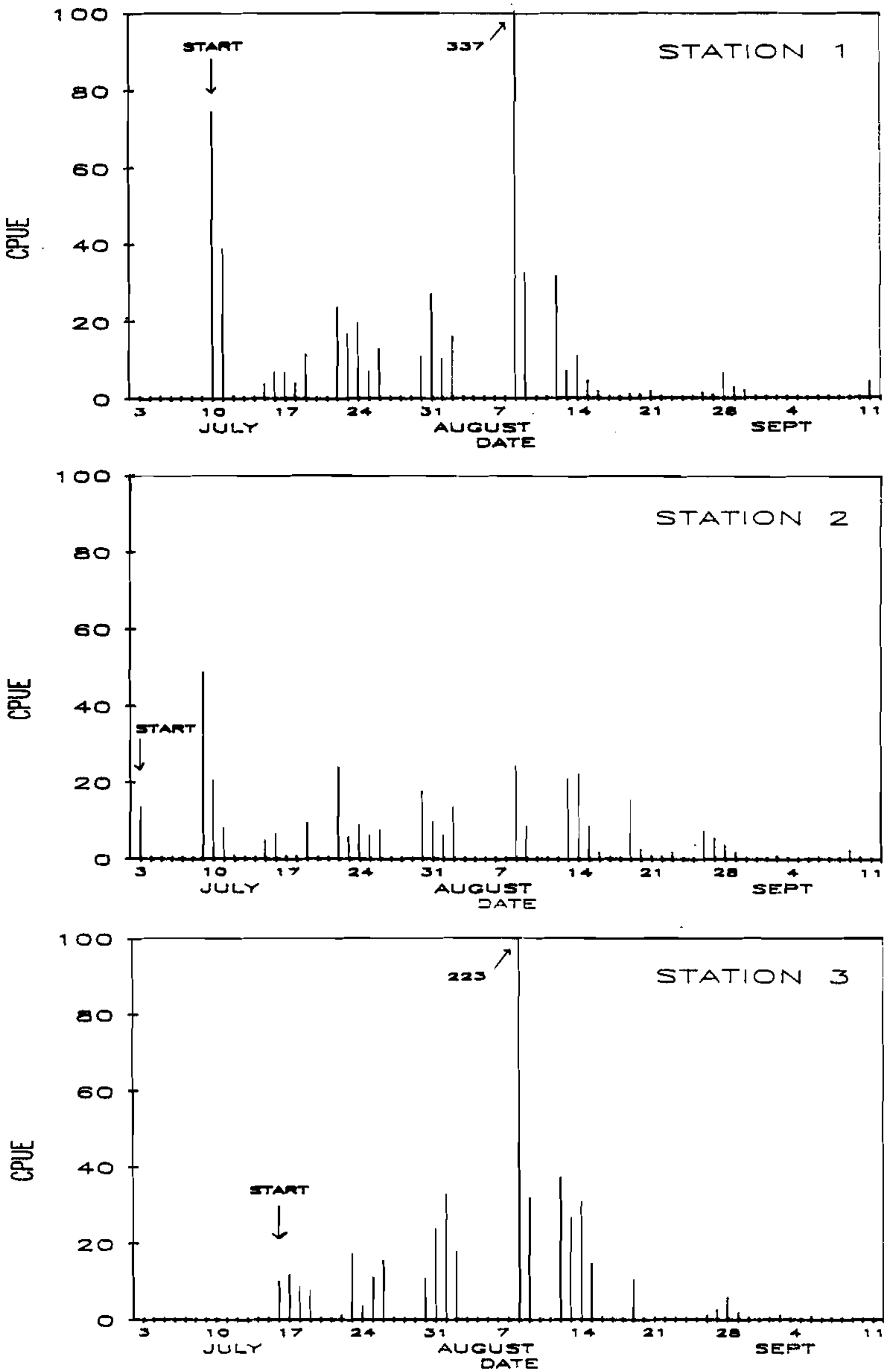


Figure B-19. Daily CPUE (no./24 hr.) of round whitefish at delta stations.

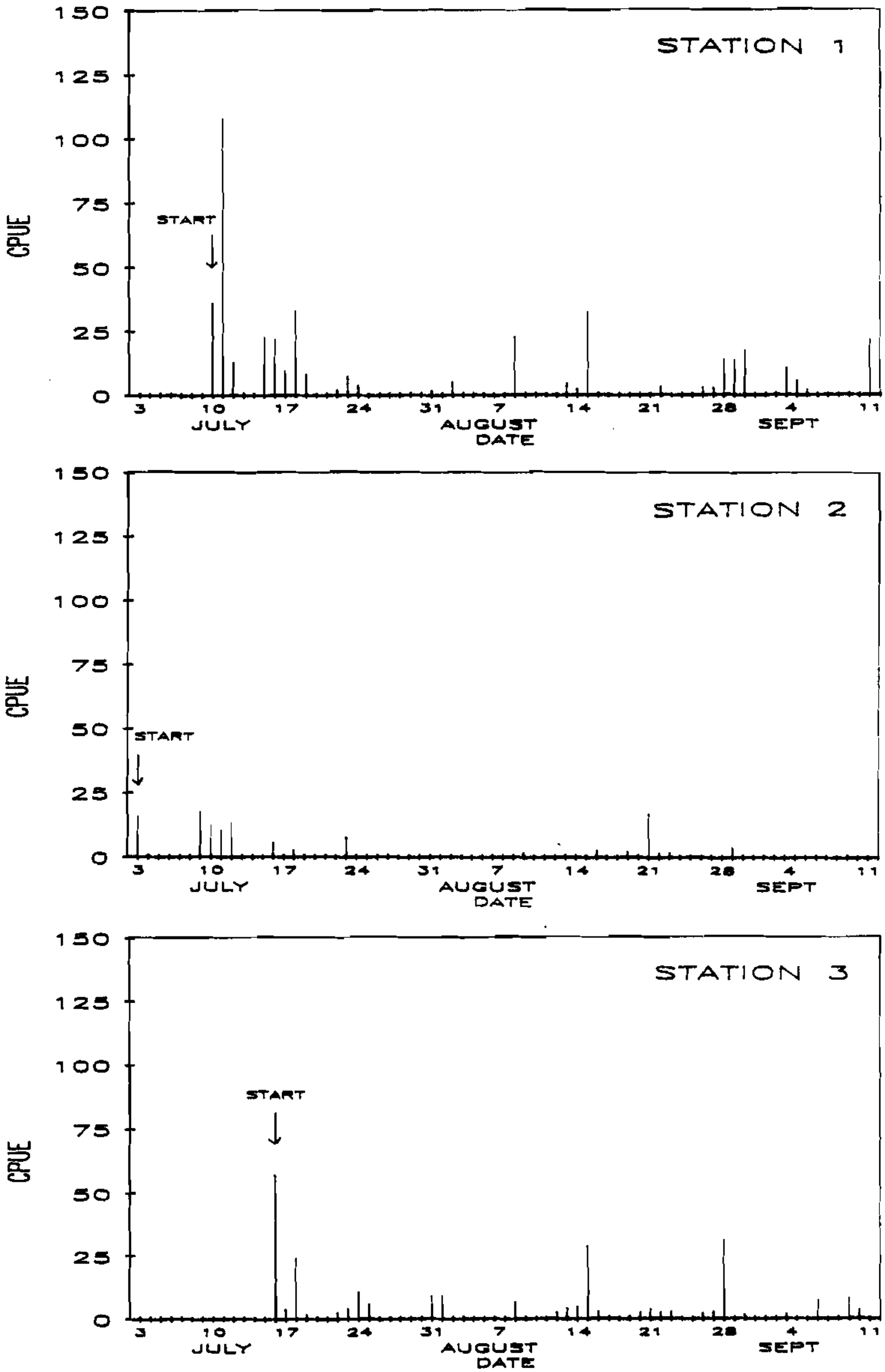


Figure B-20. Daily CPUE (no./24 hr.) of rainbow smelt at delta stations.

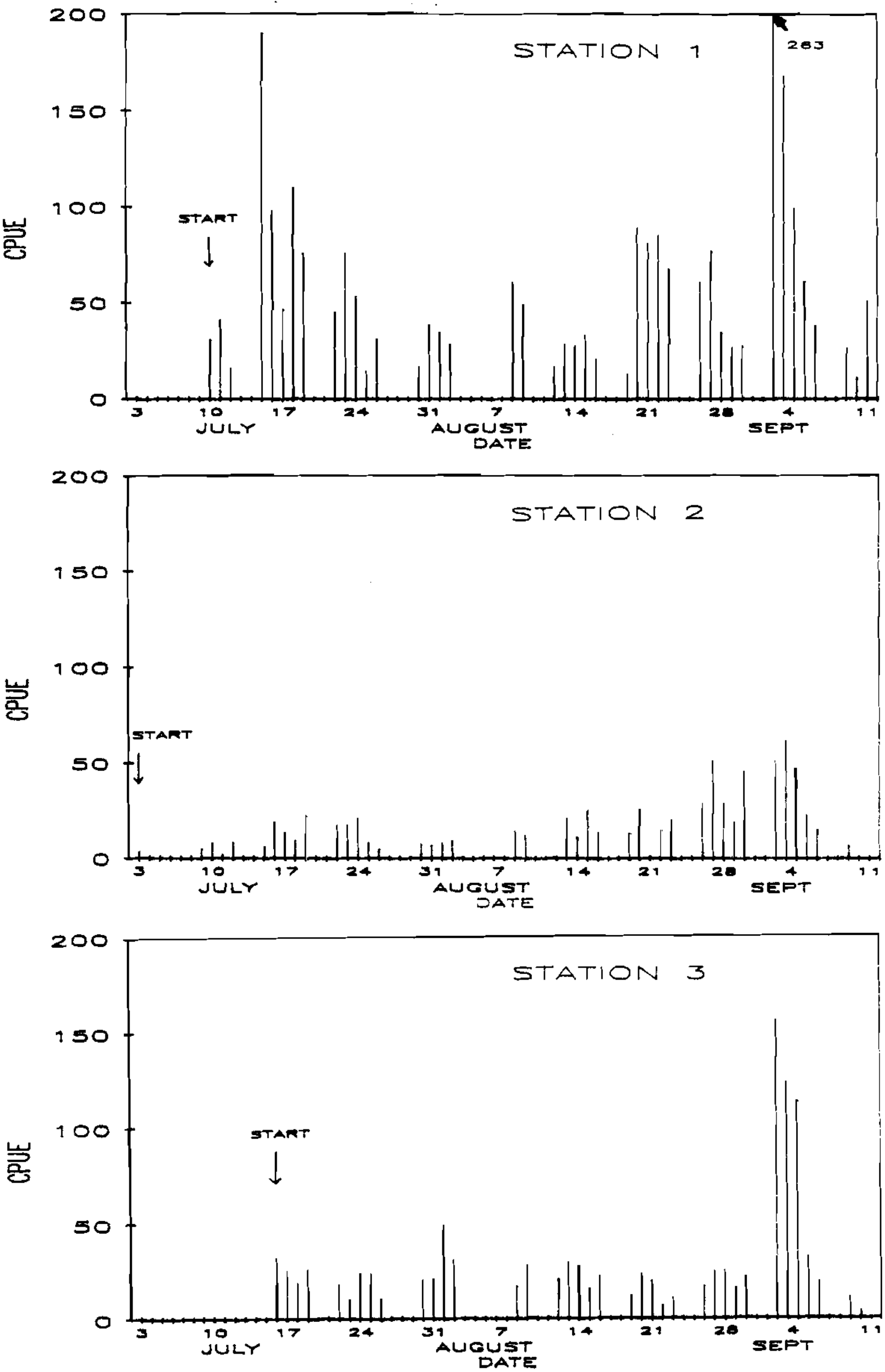


Figure B-21. Daily CPUE (no./24 hr.) of fourhorn sculpin at delta stations.

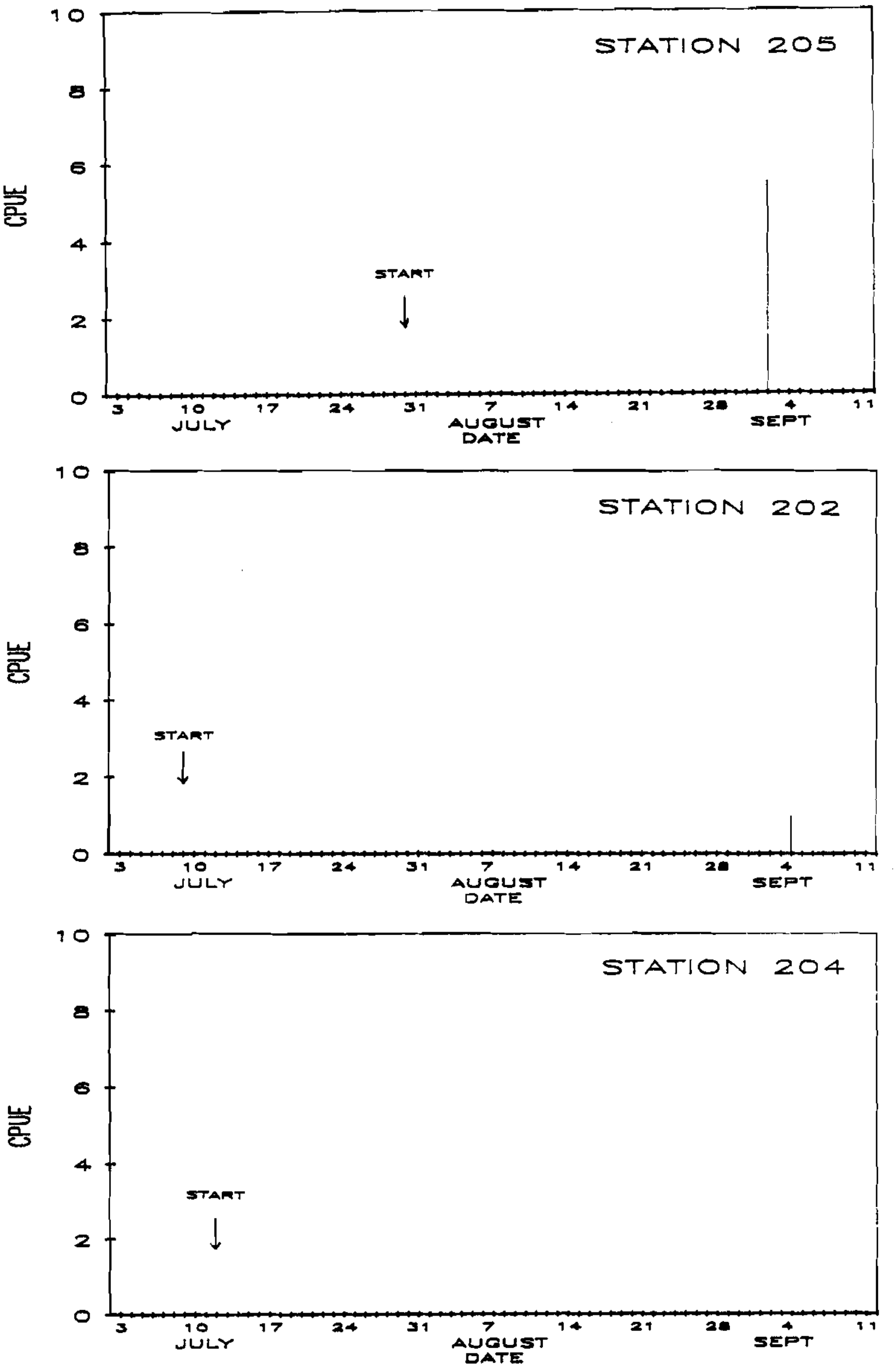
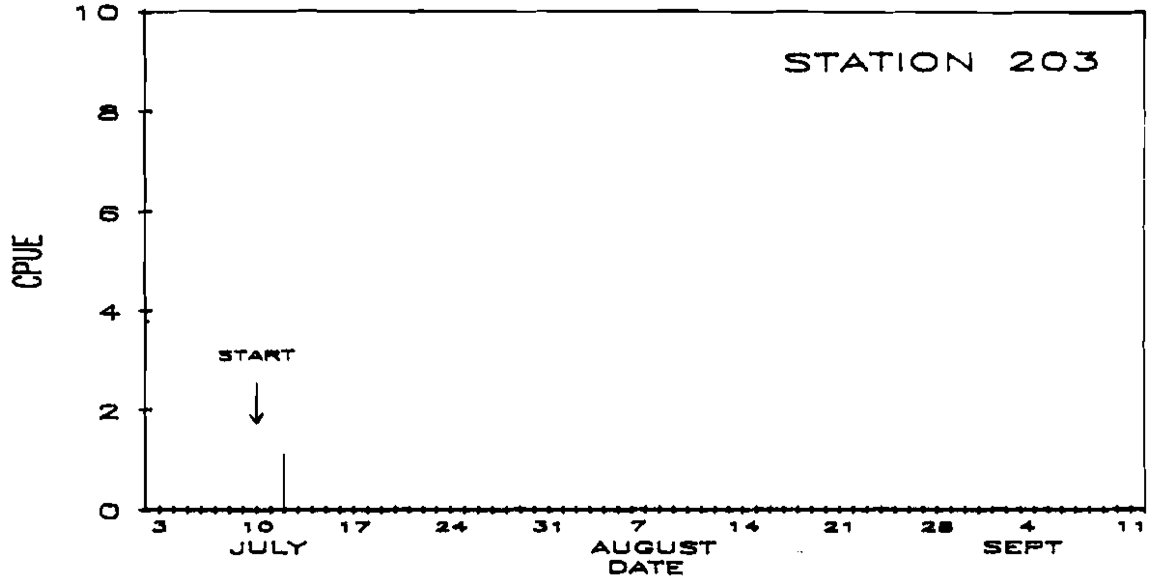


Figure B-22. Daily CPUE (no./24 hr.) of small (<120 mm) arctic cisco at lower river stations 205, 202 and 204.



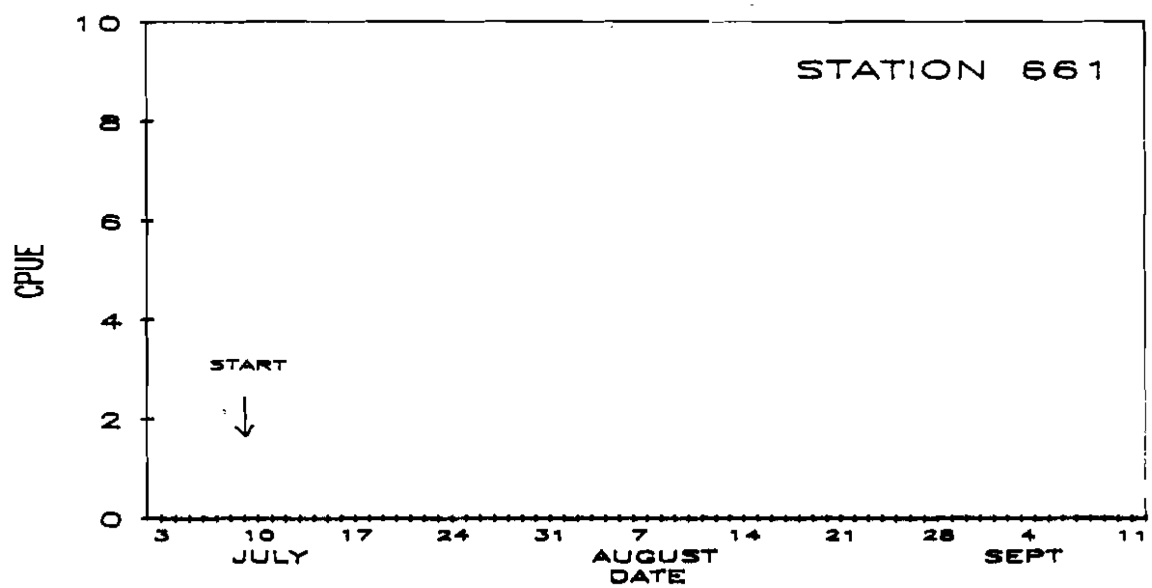
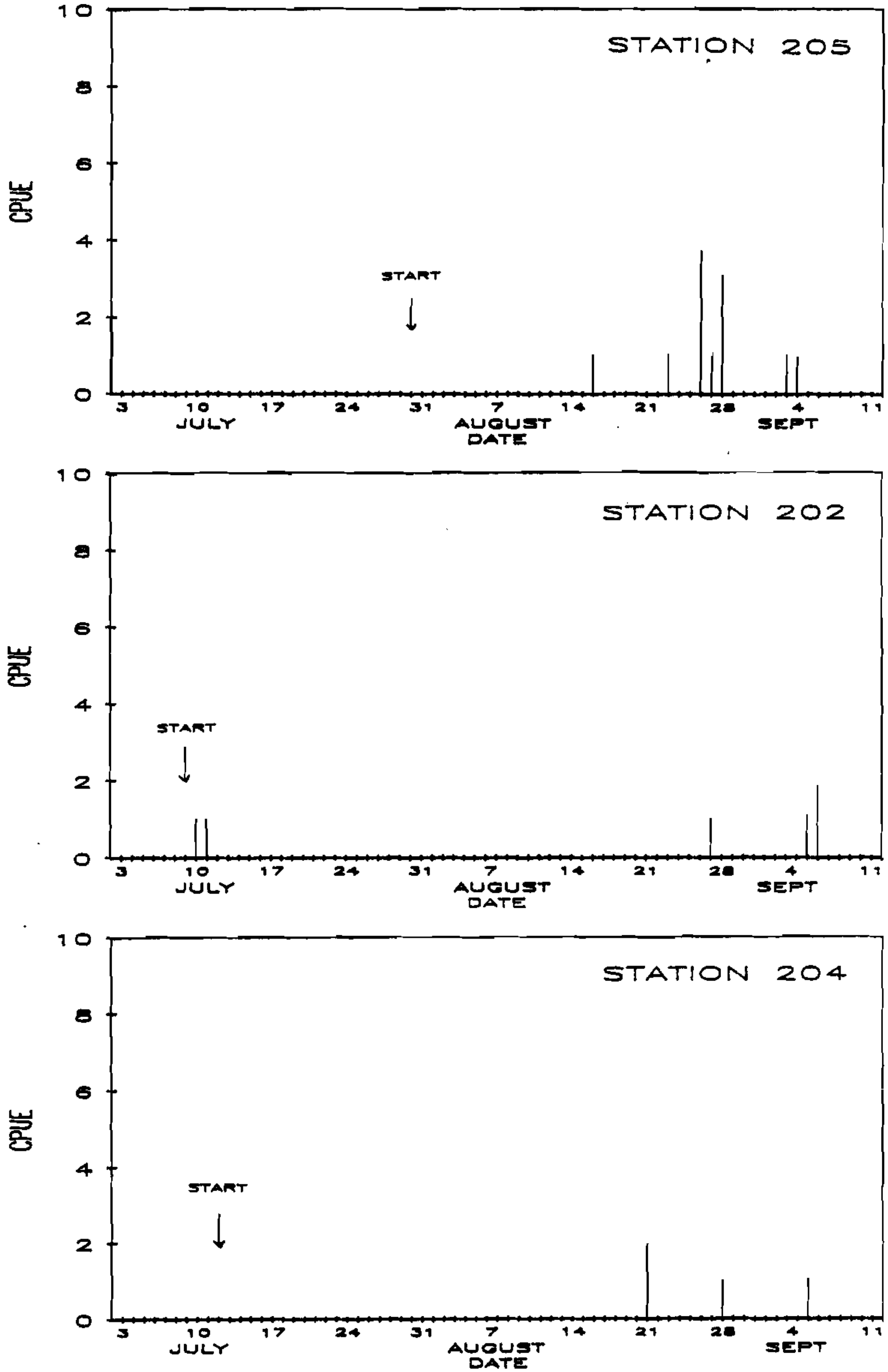


Figure B-23. Daily CPUE (no./24 hr.) of small (<120 mm) arctic cisco at lower river stations 203 and 661.



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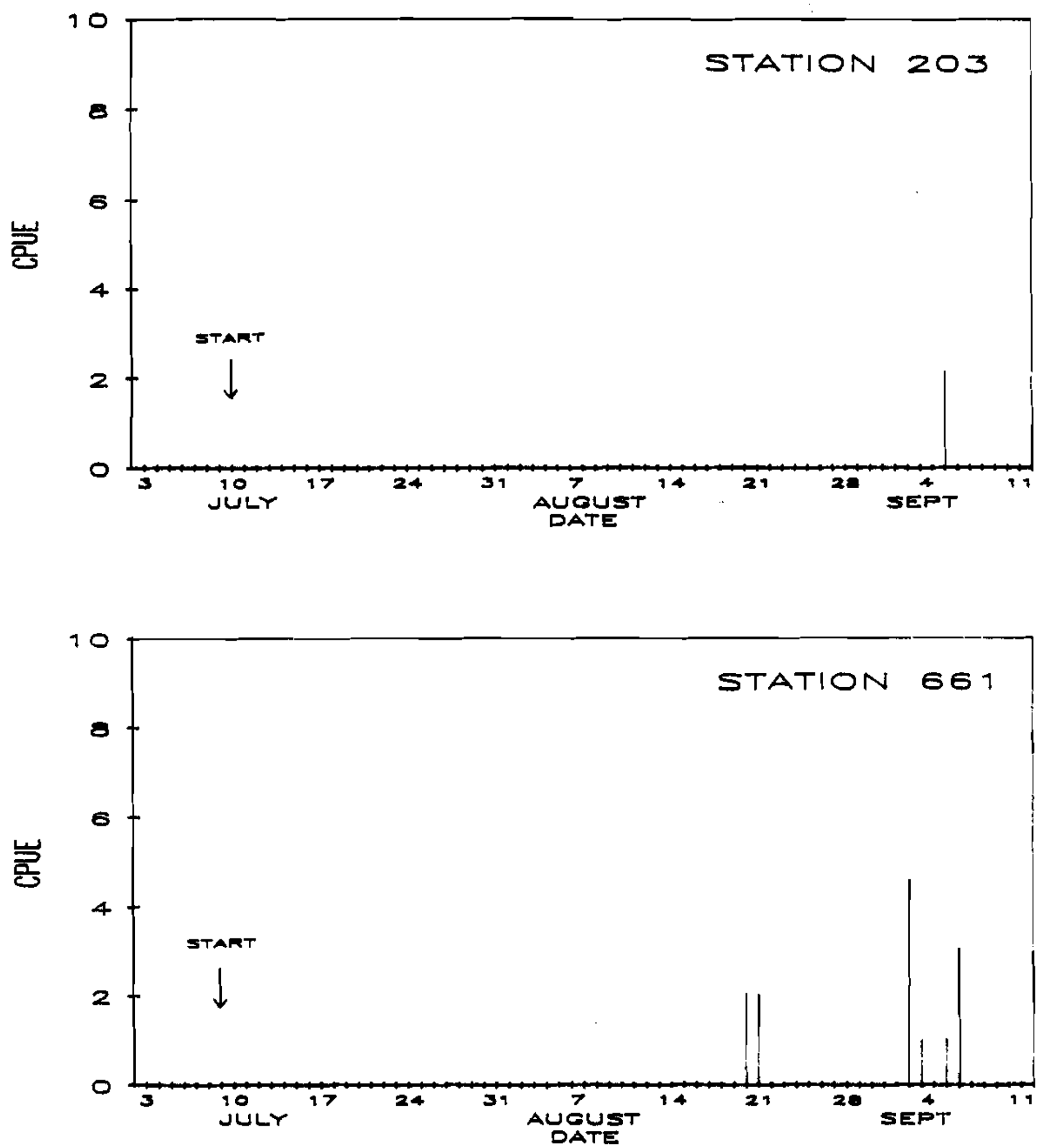

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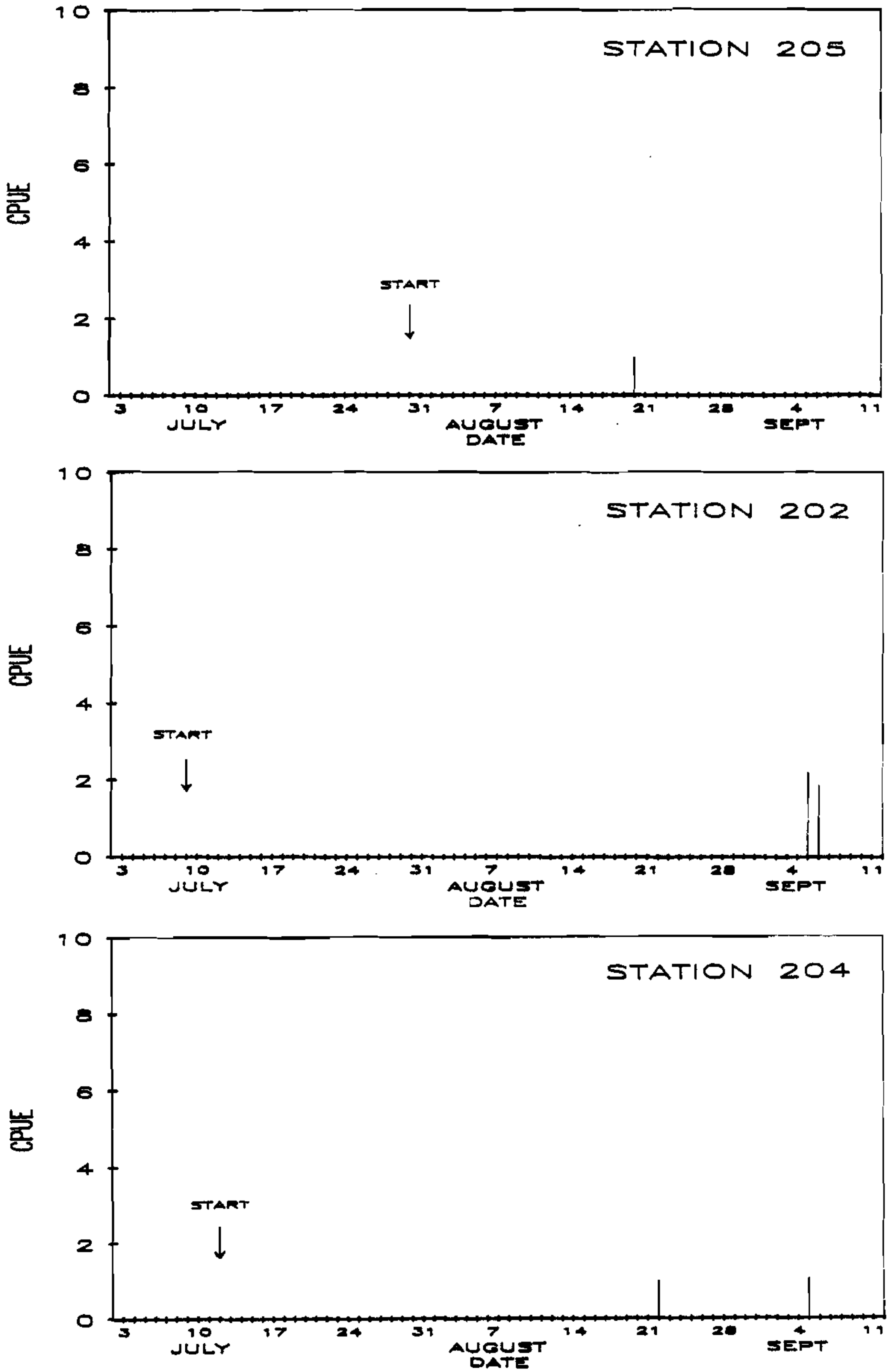

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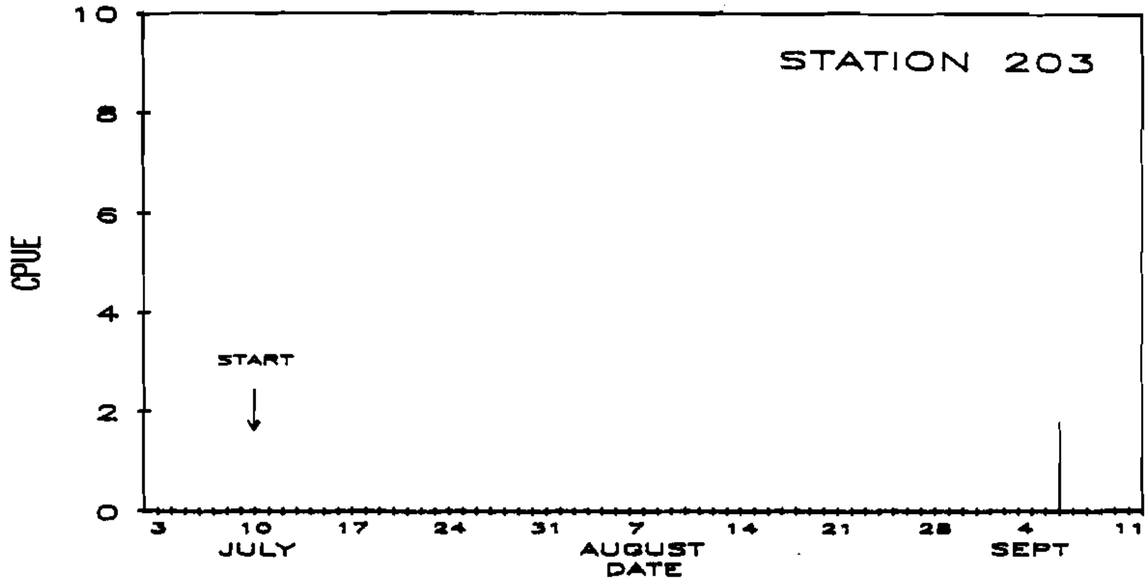

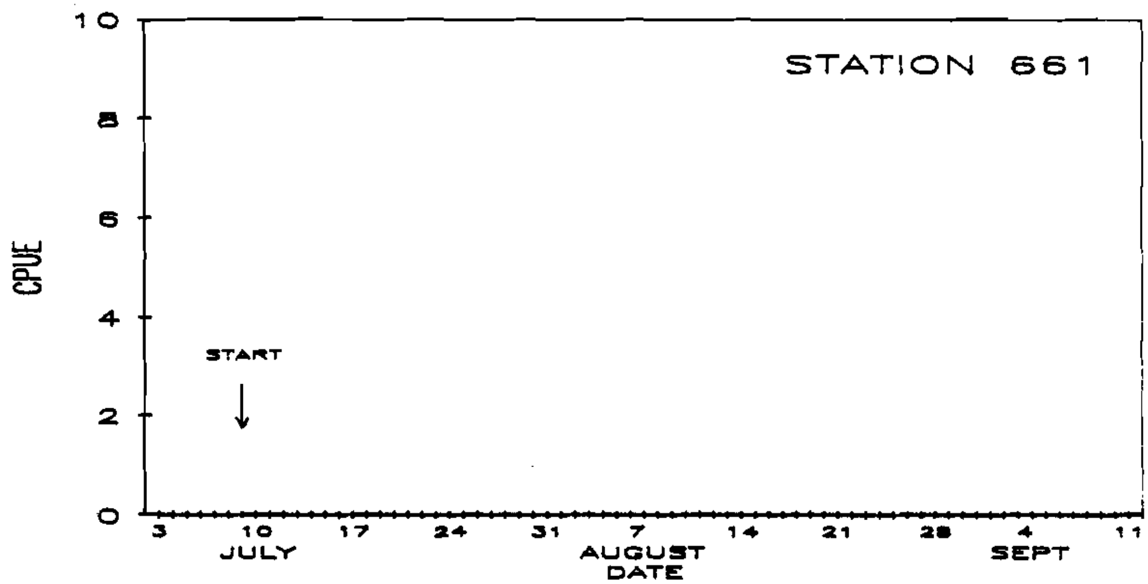

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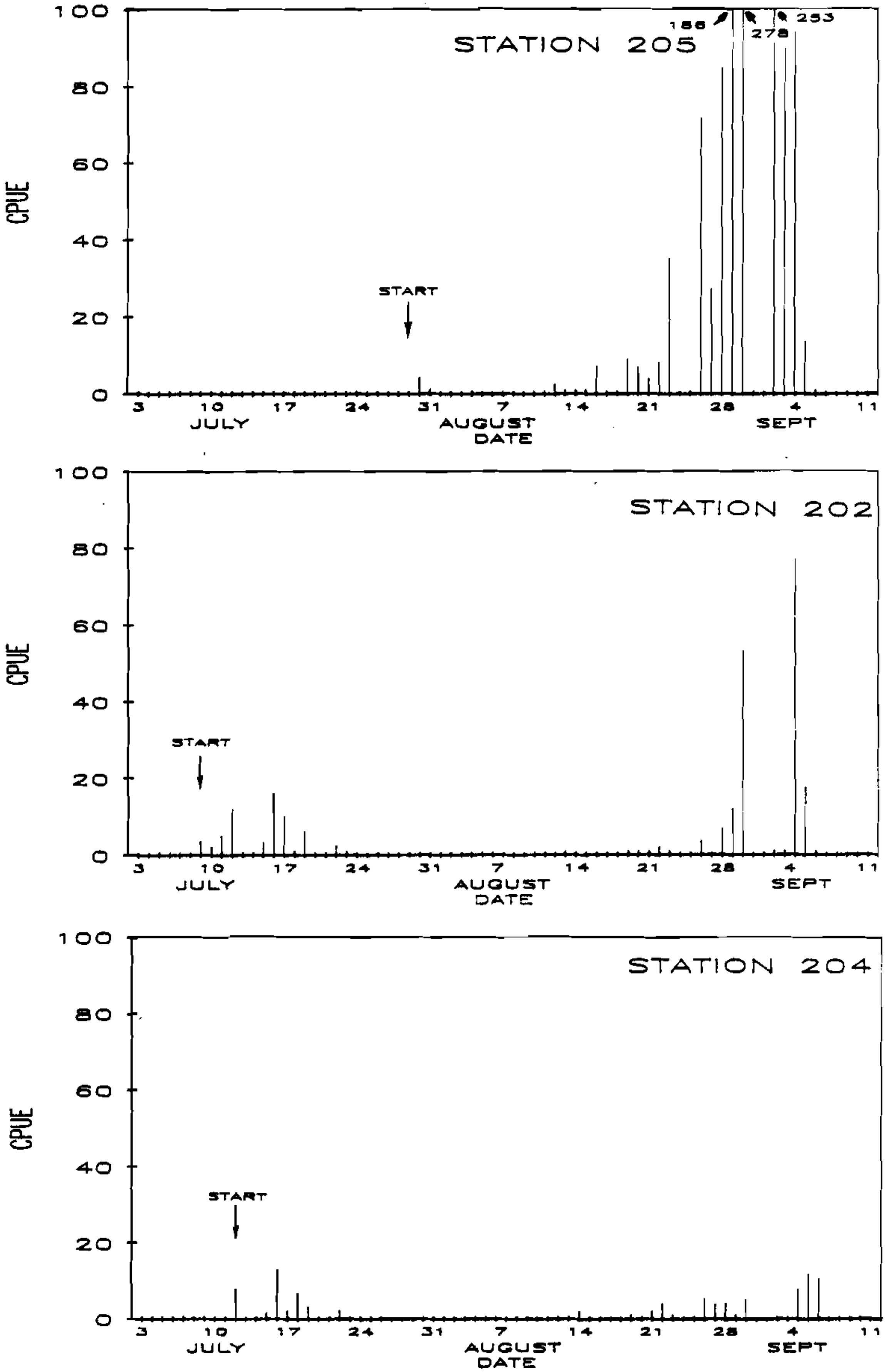

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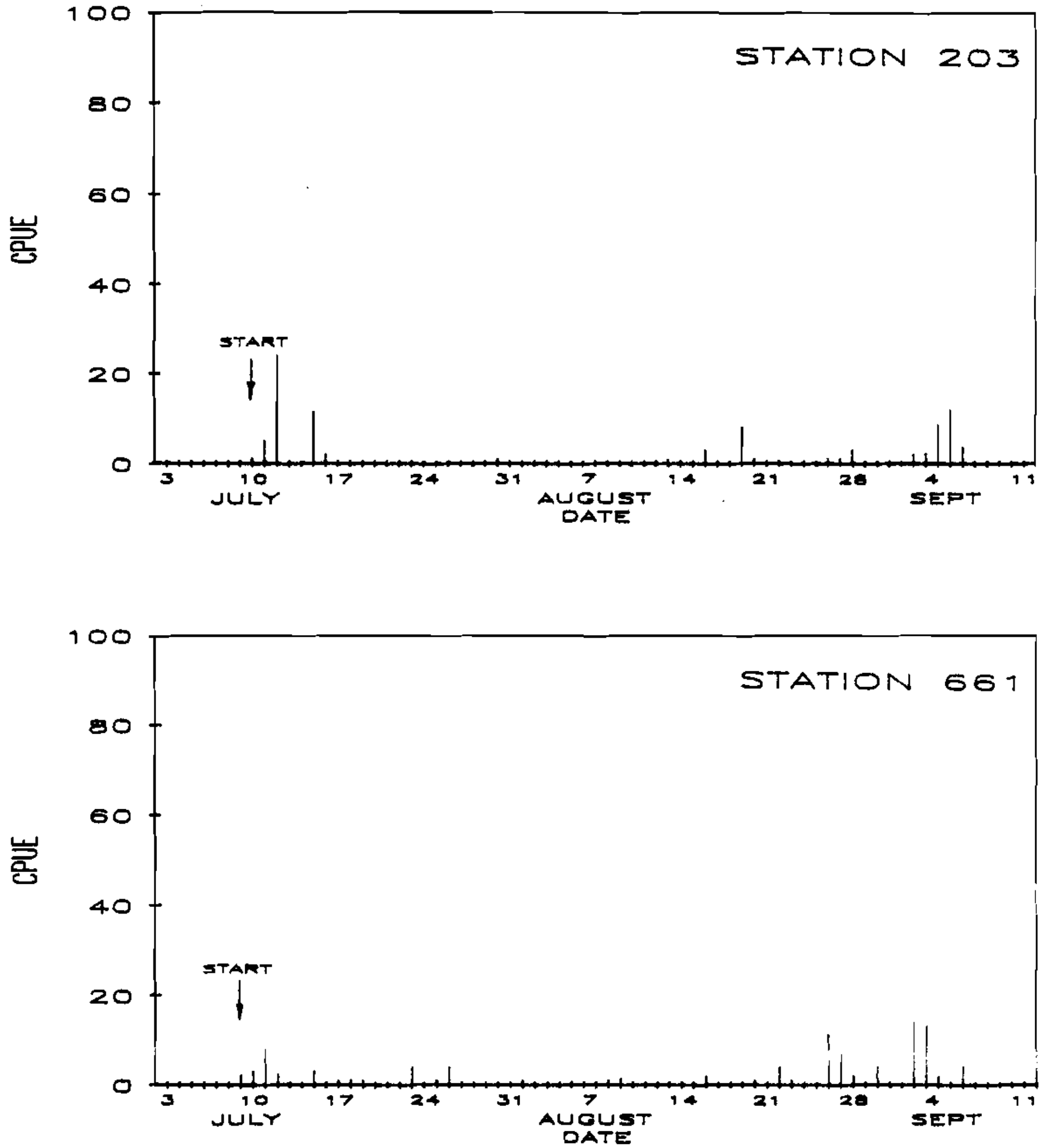

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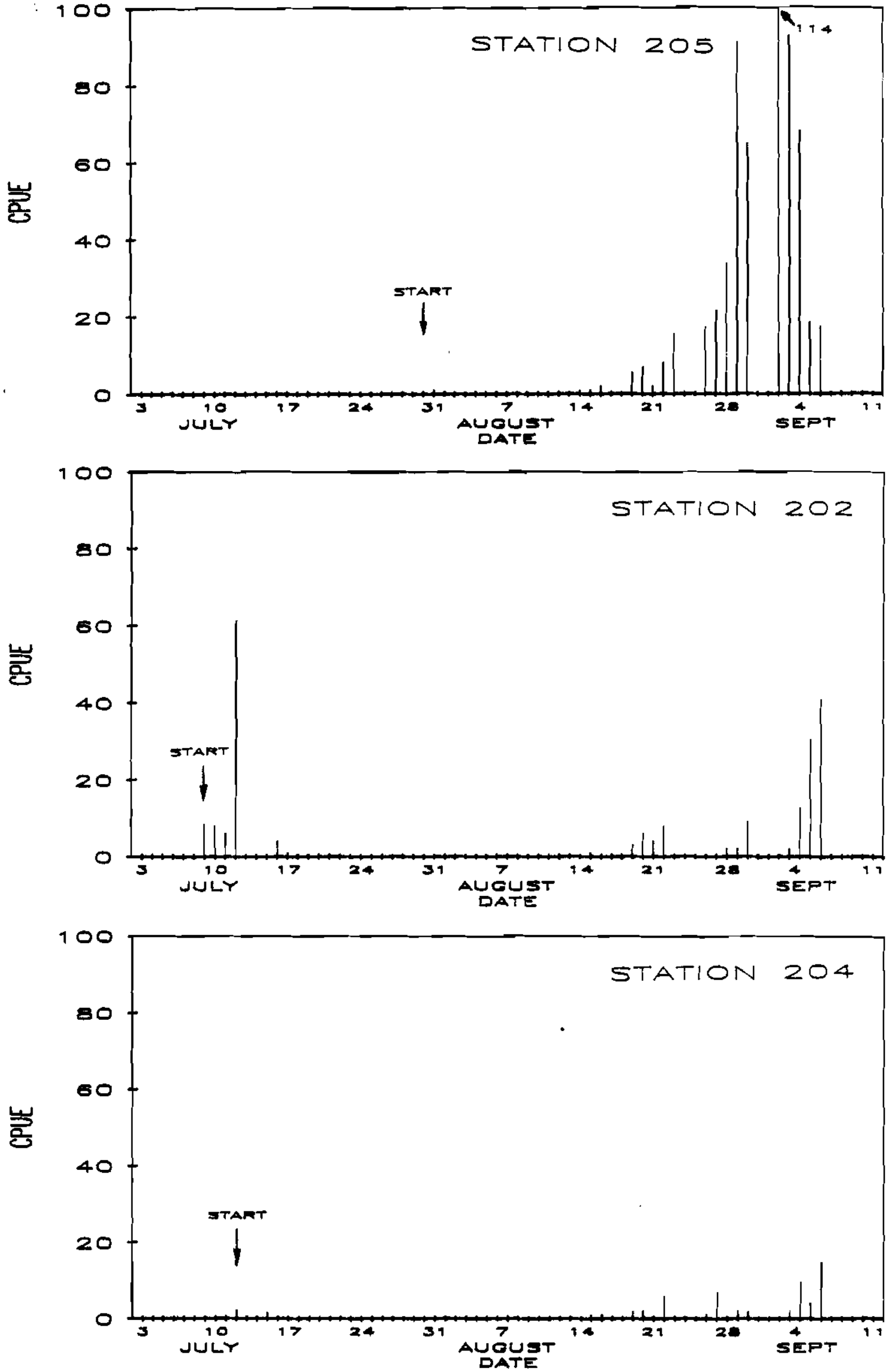

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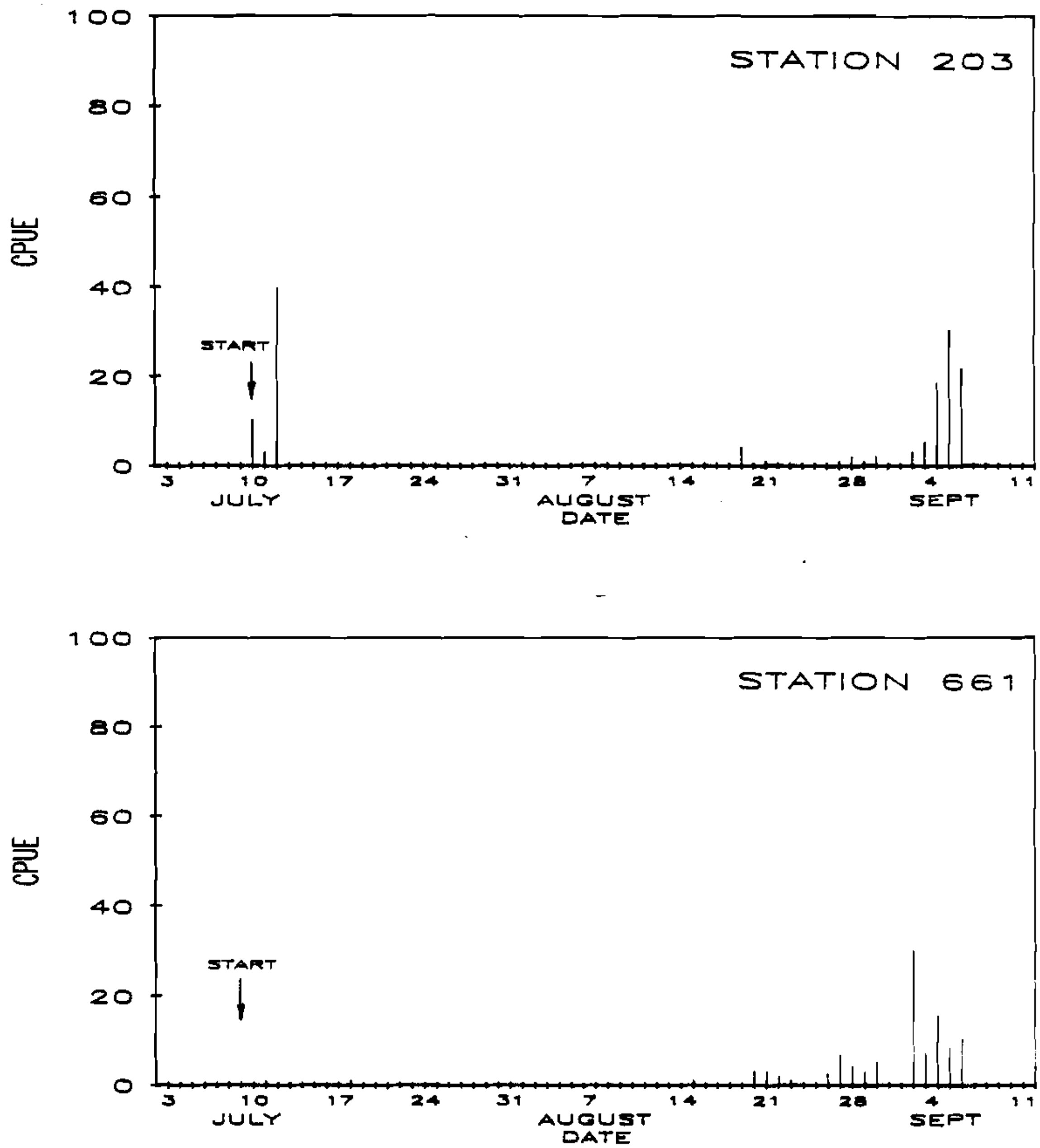
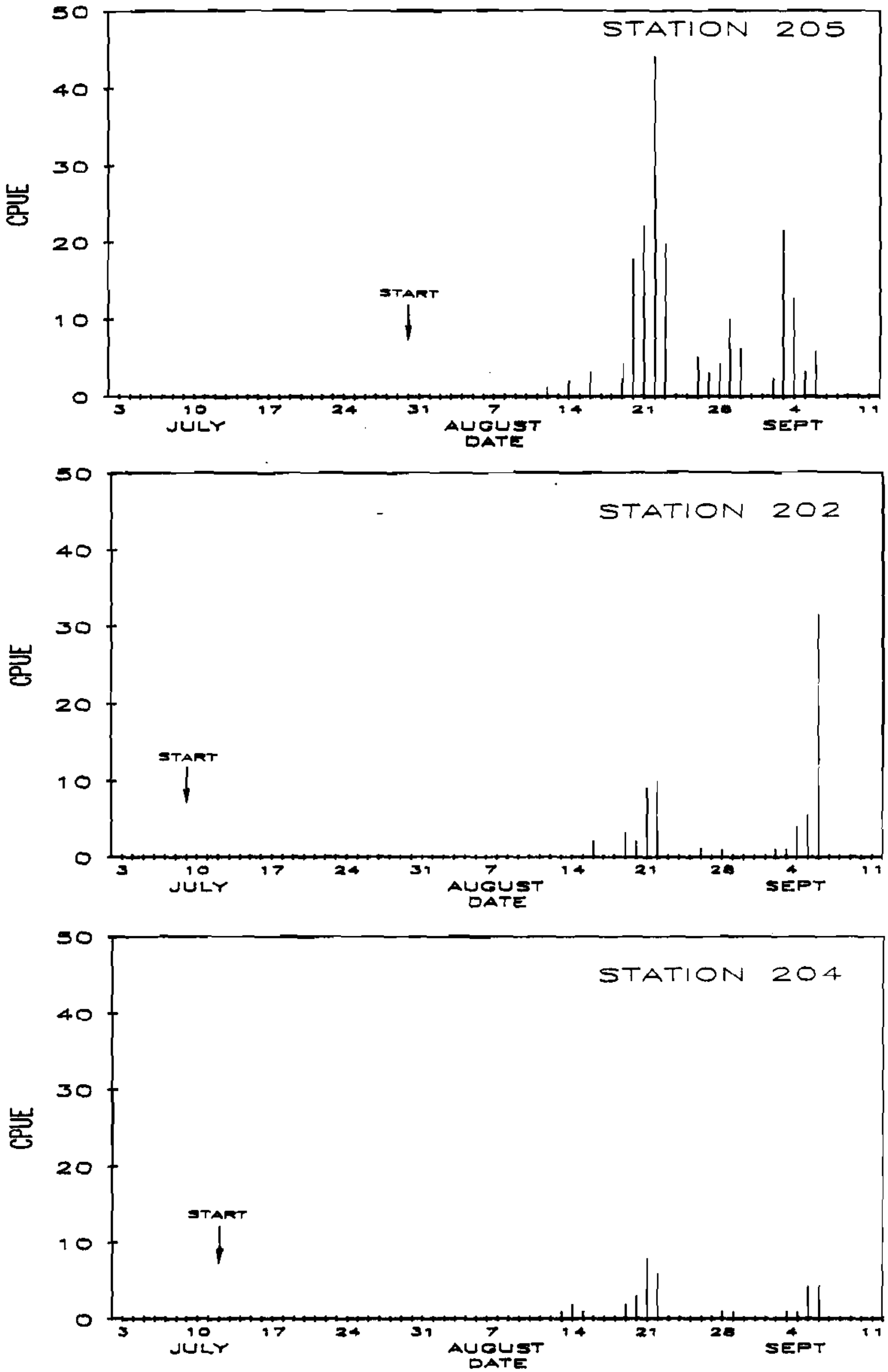


Figure B-31. Daily CPUE (no./24 hr.) of medium (120-249 mm) least cisco at lower river stations 203 and 661.



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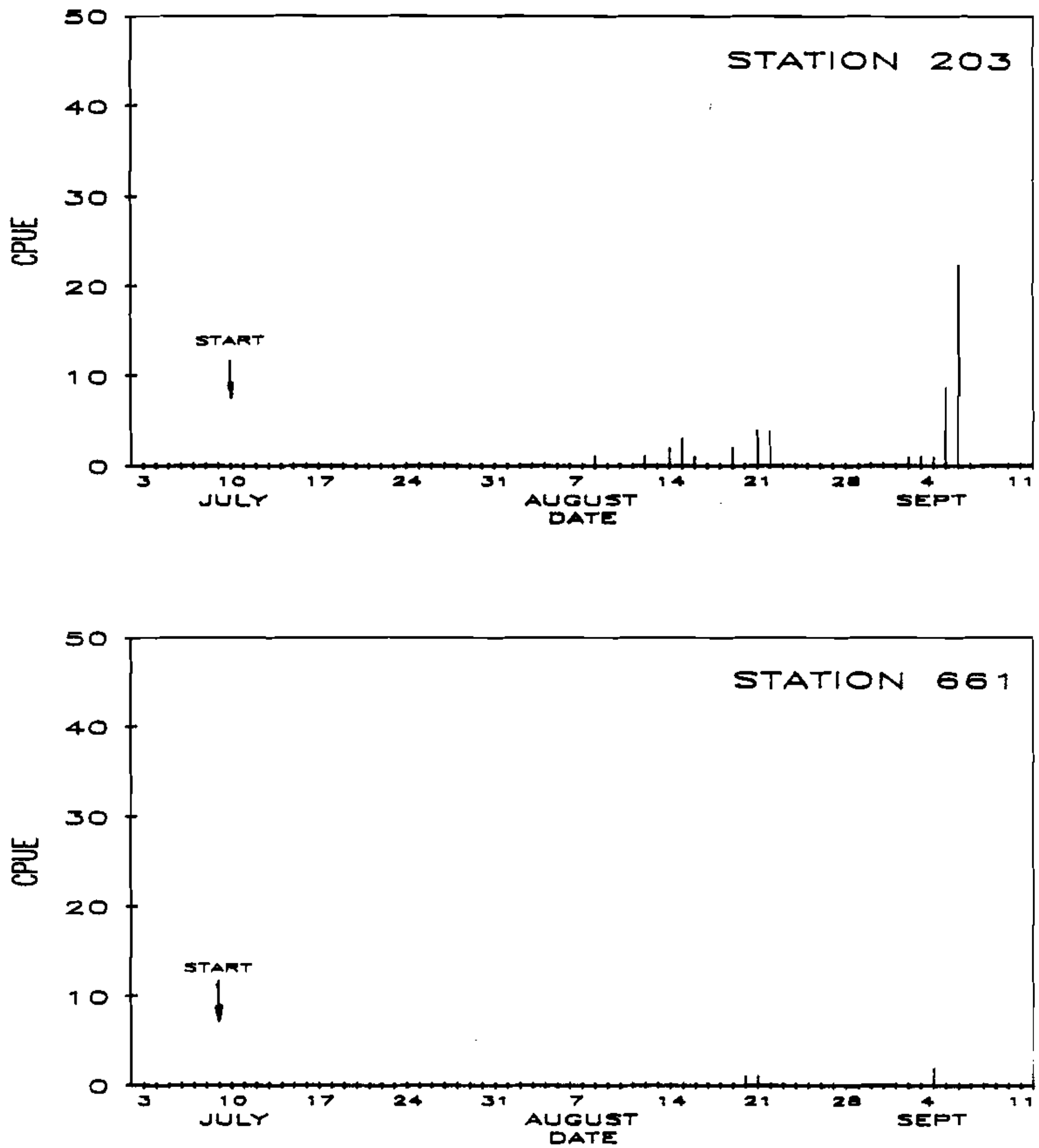

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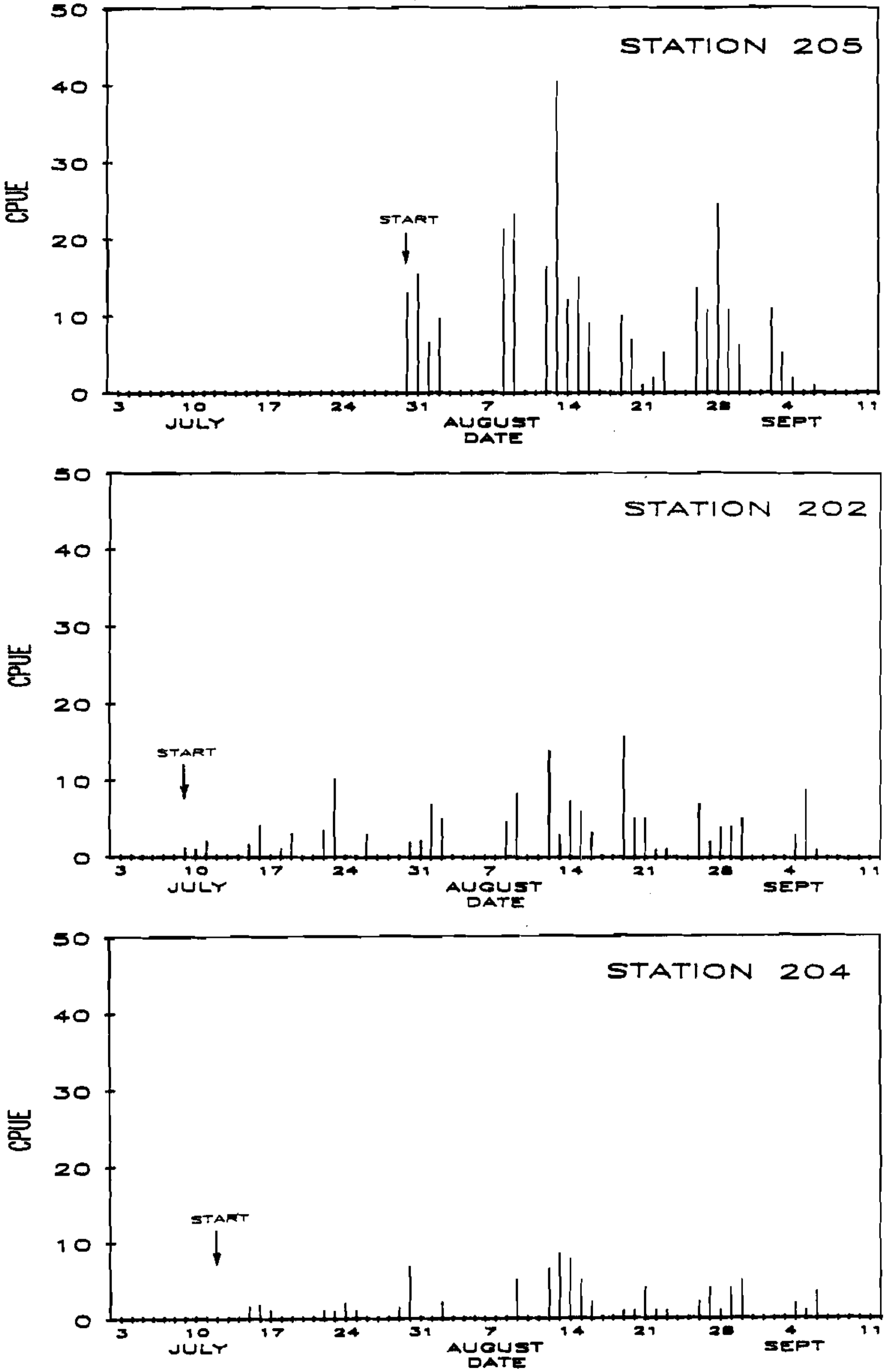

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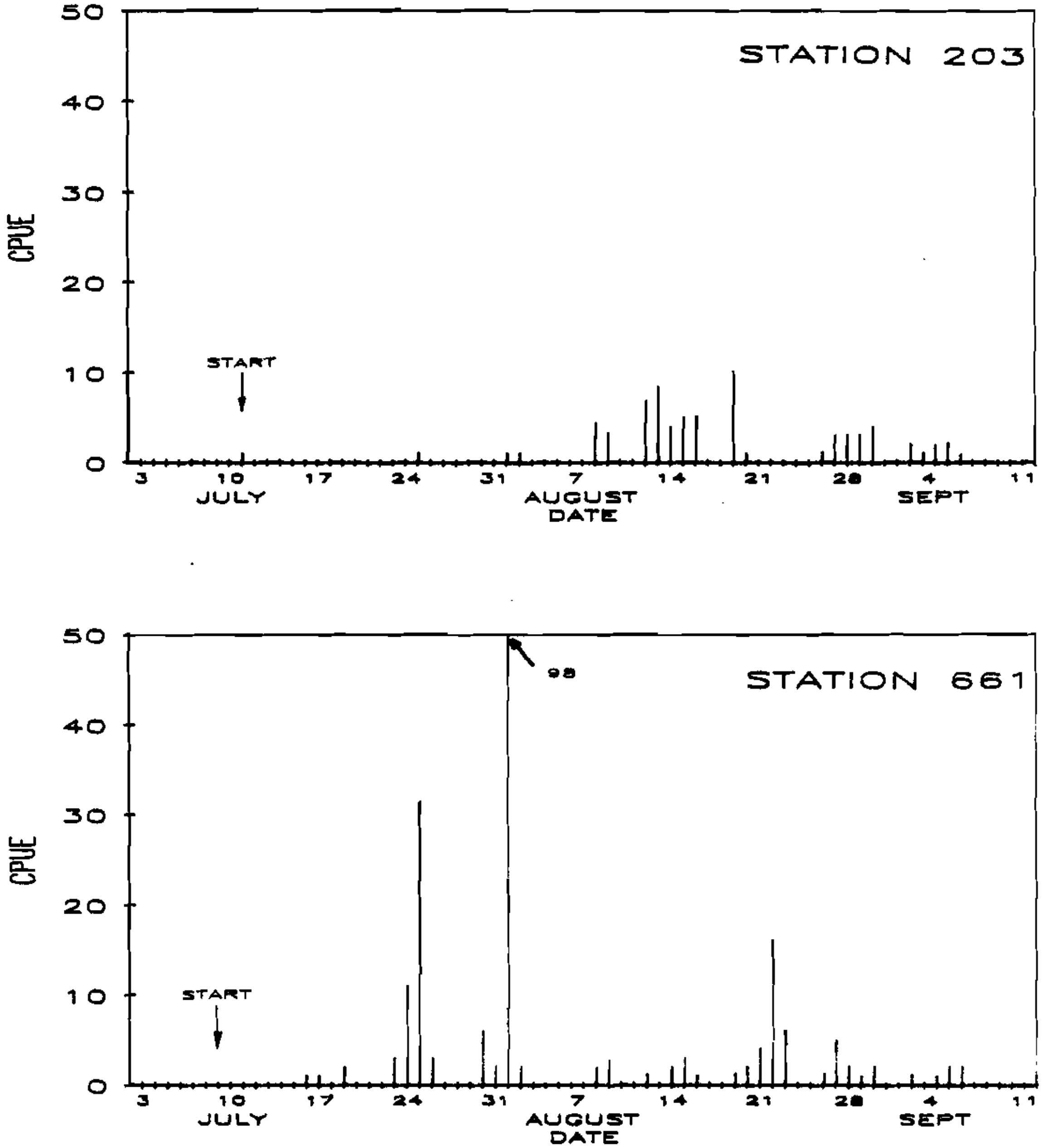

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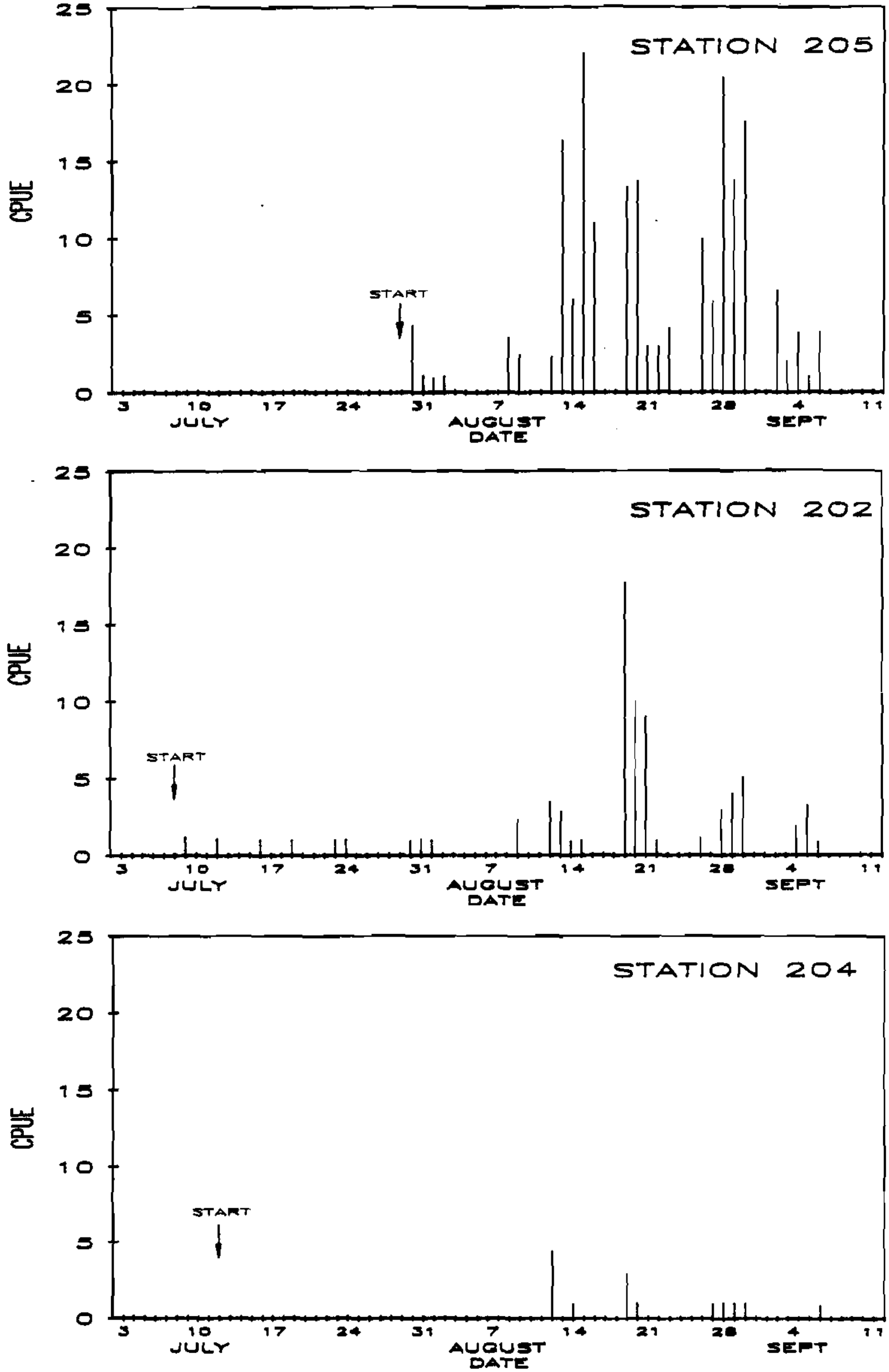

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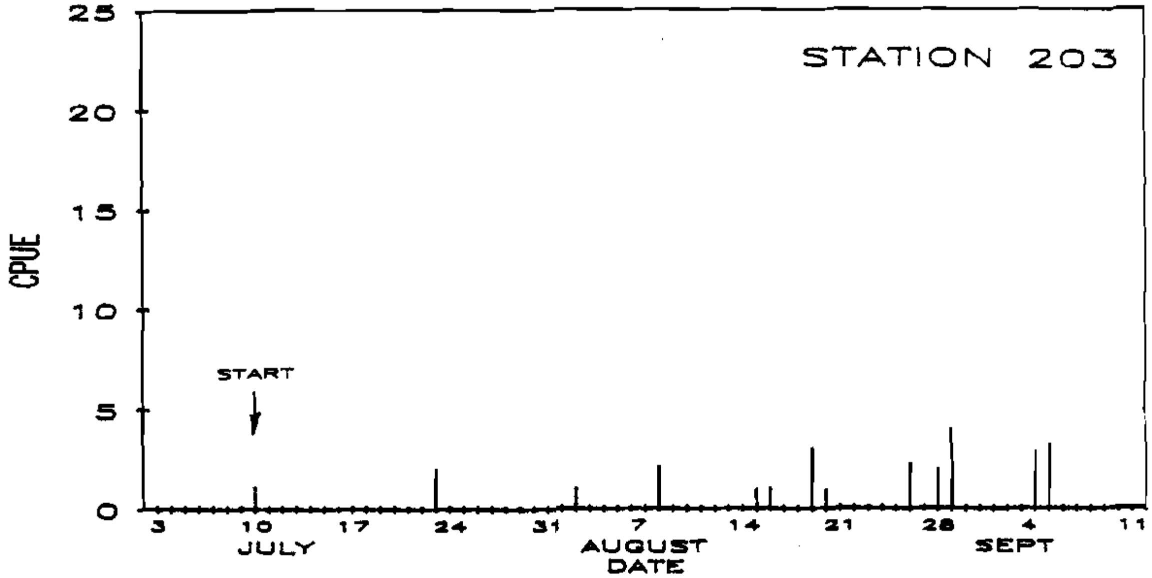

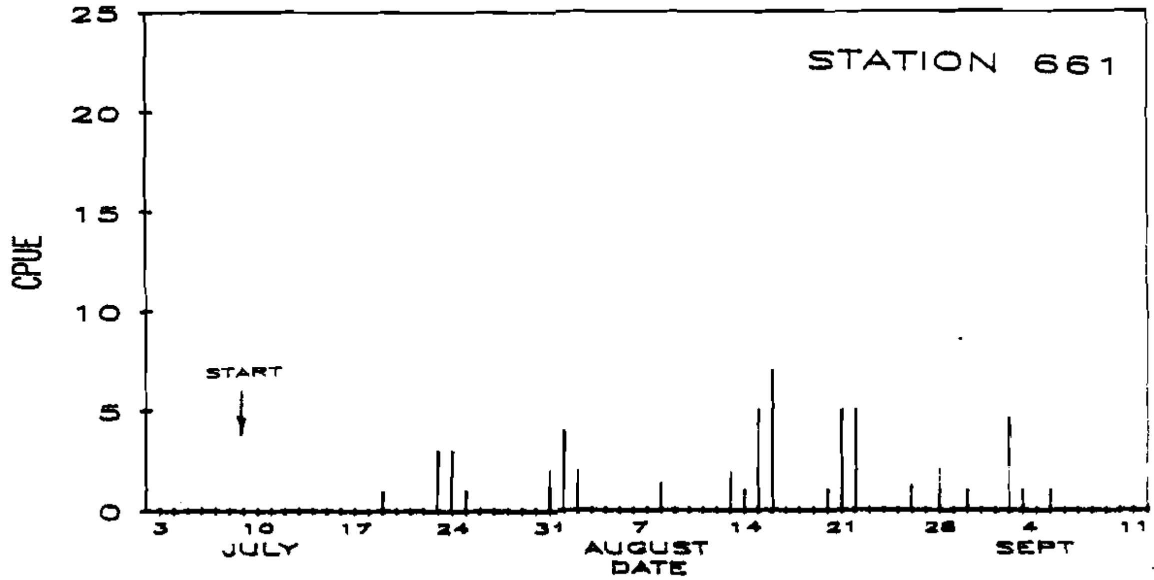

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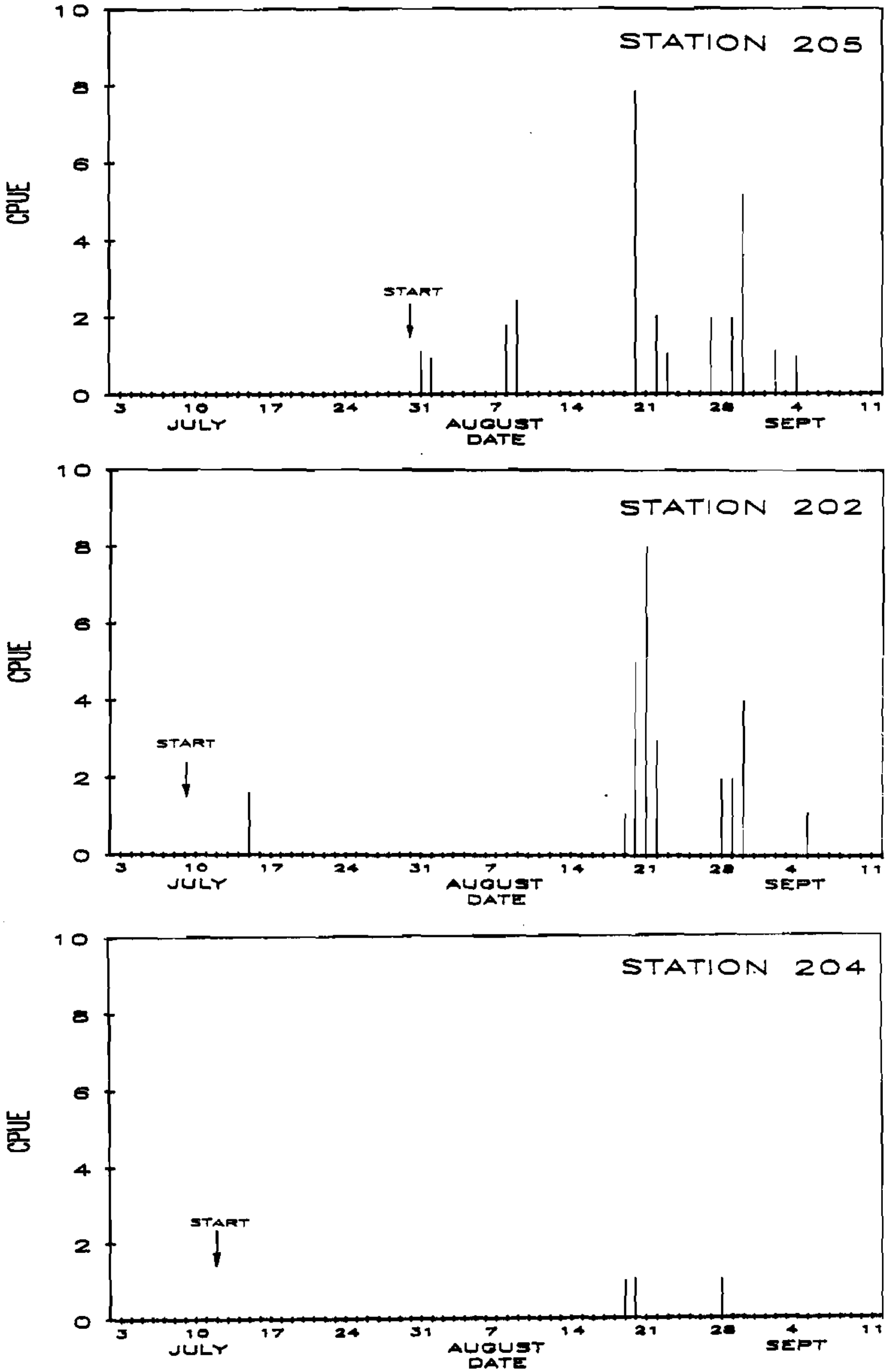

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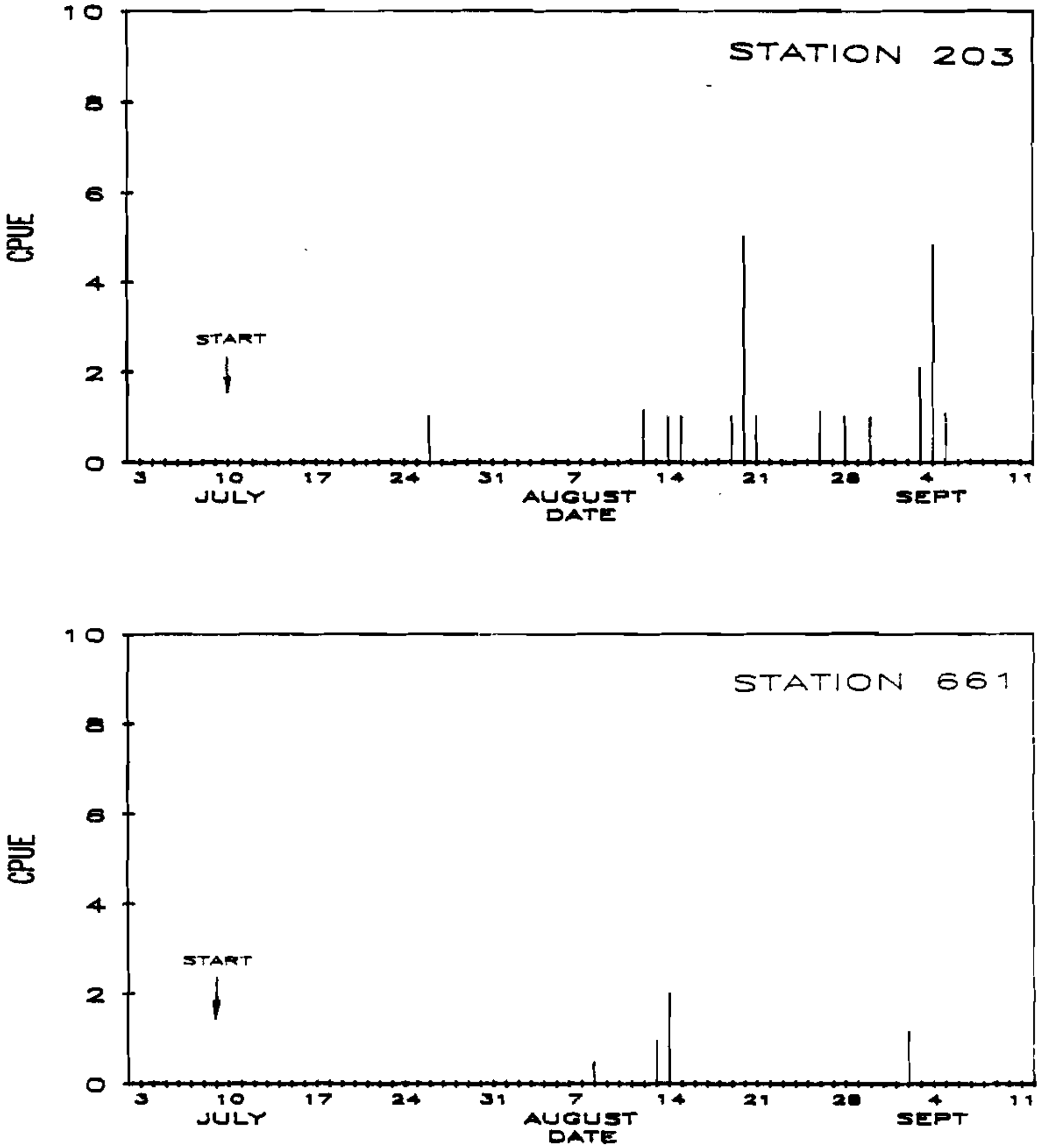

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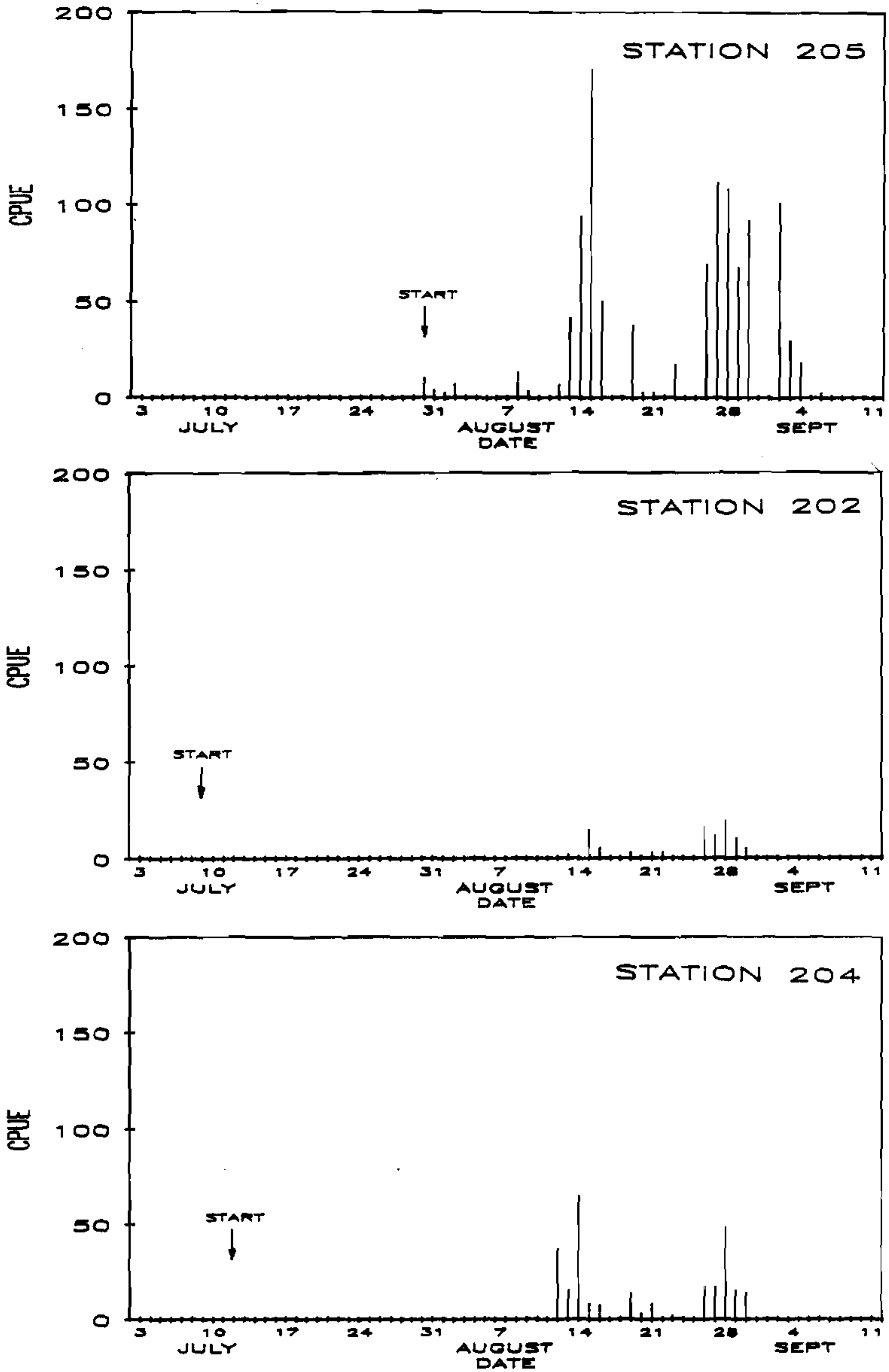

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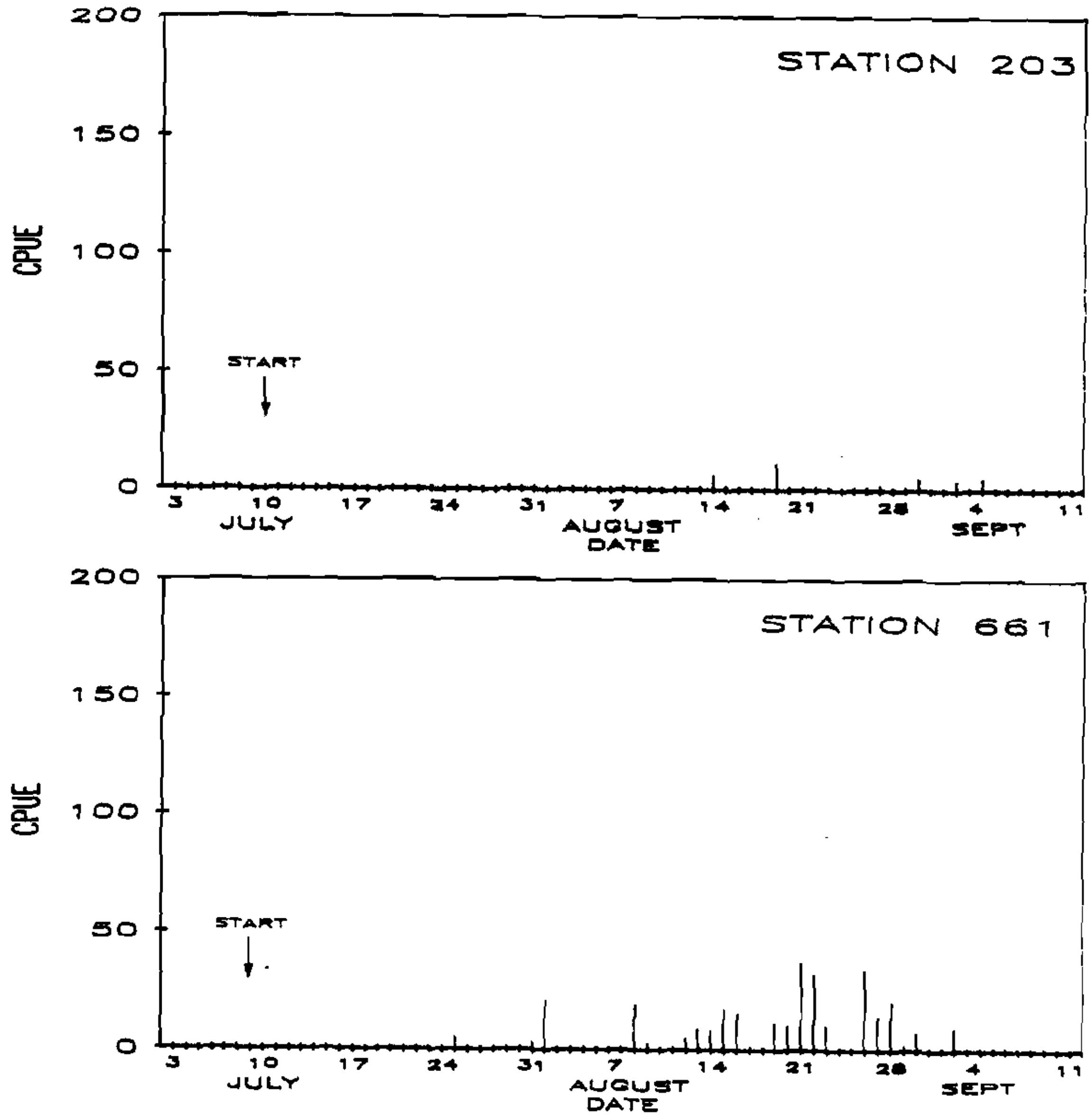

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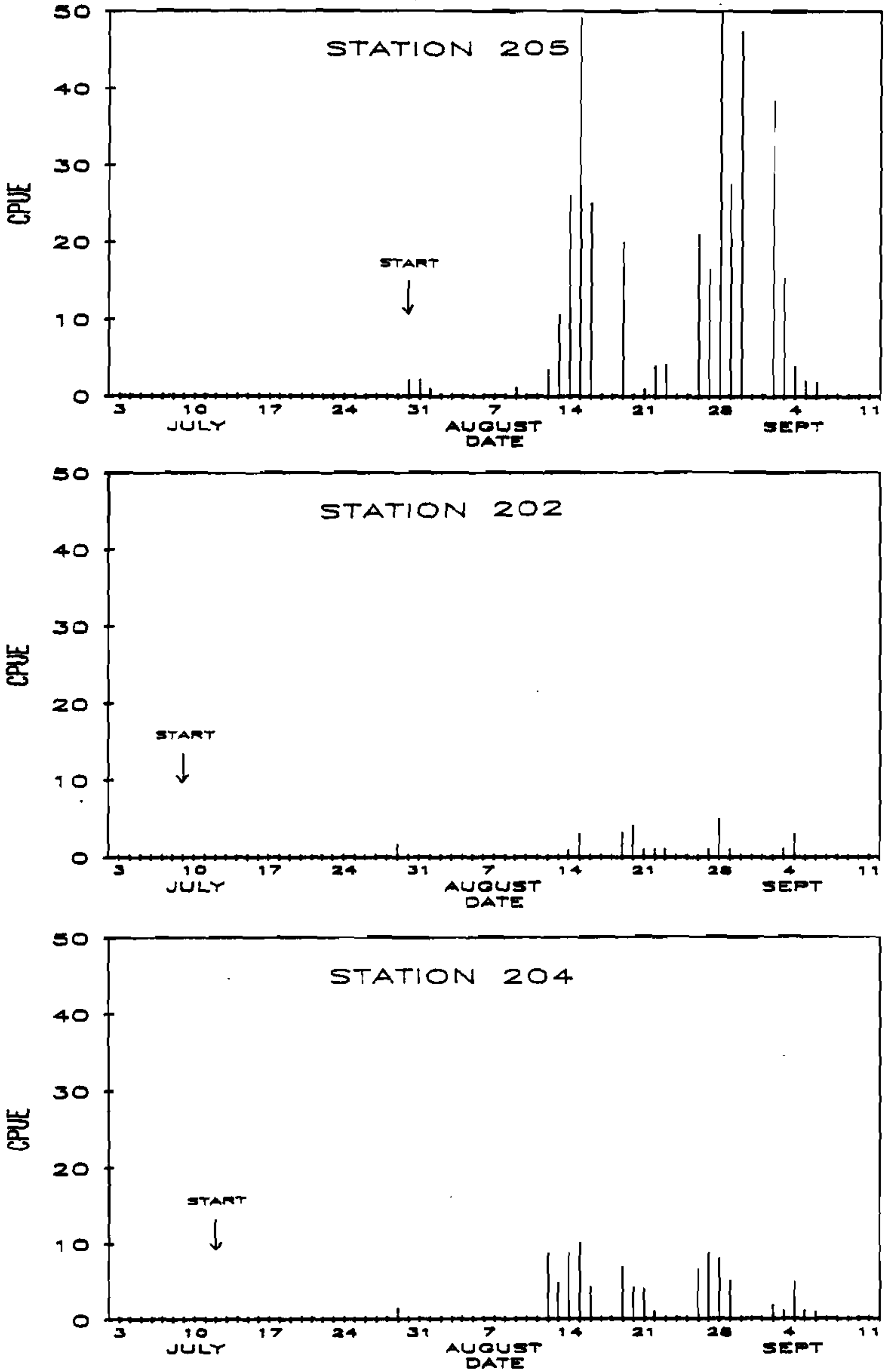

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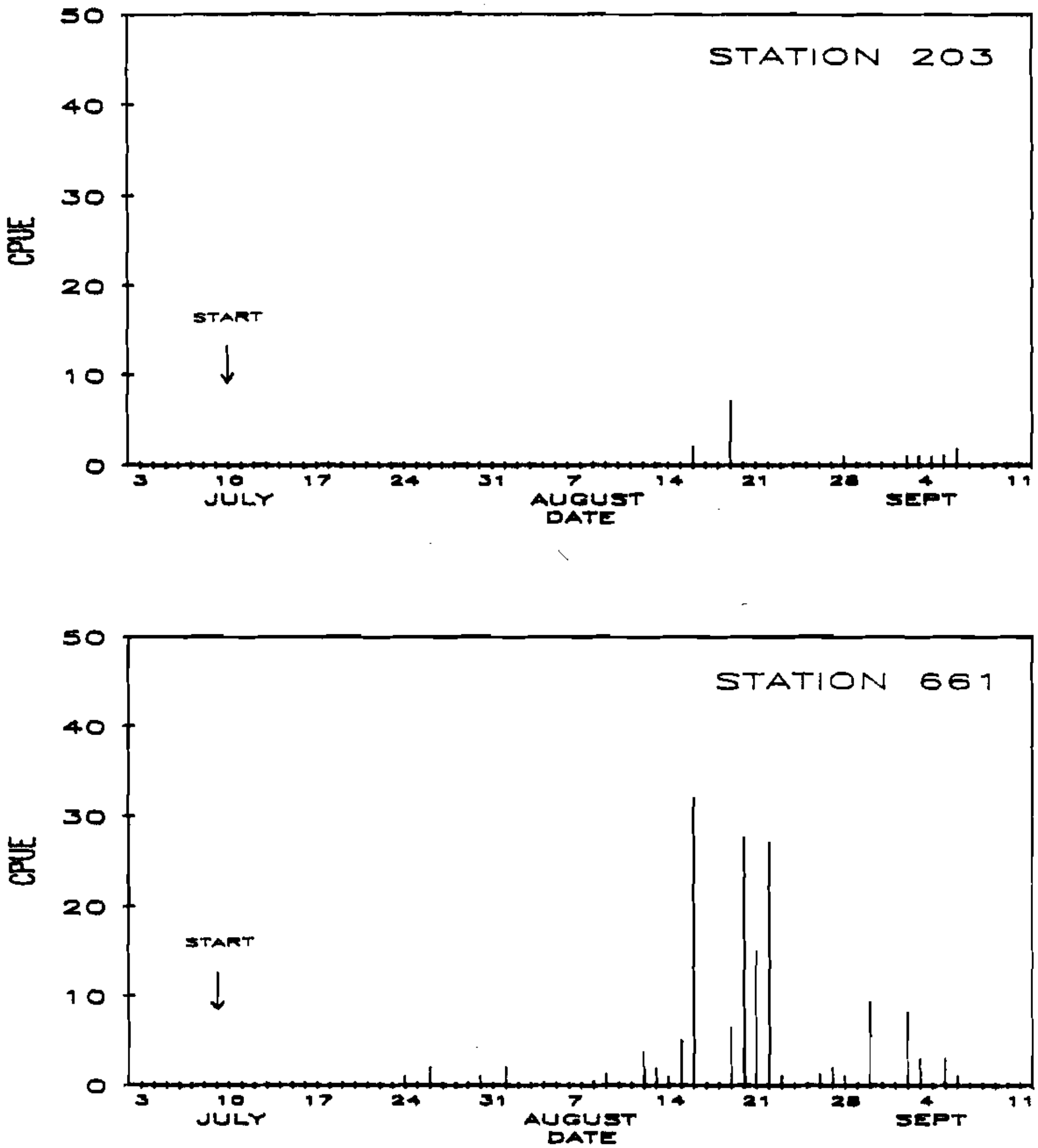

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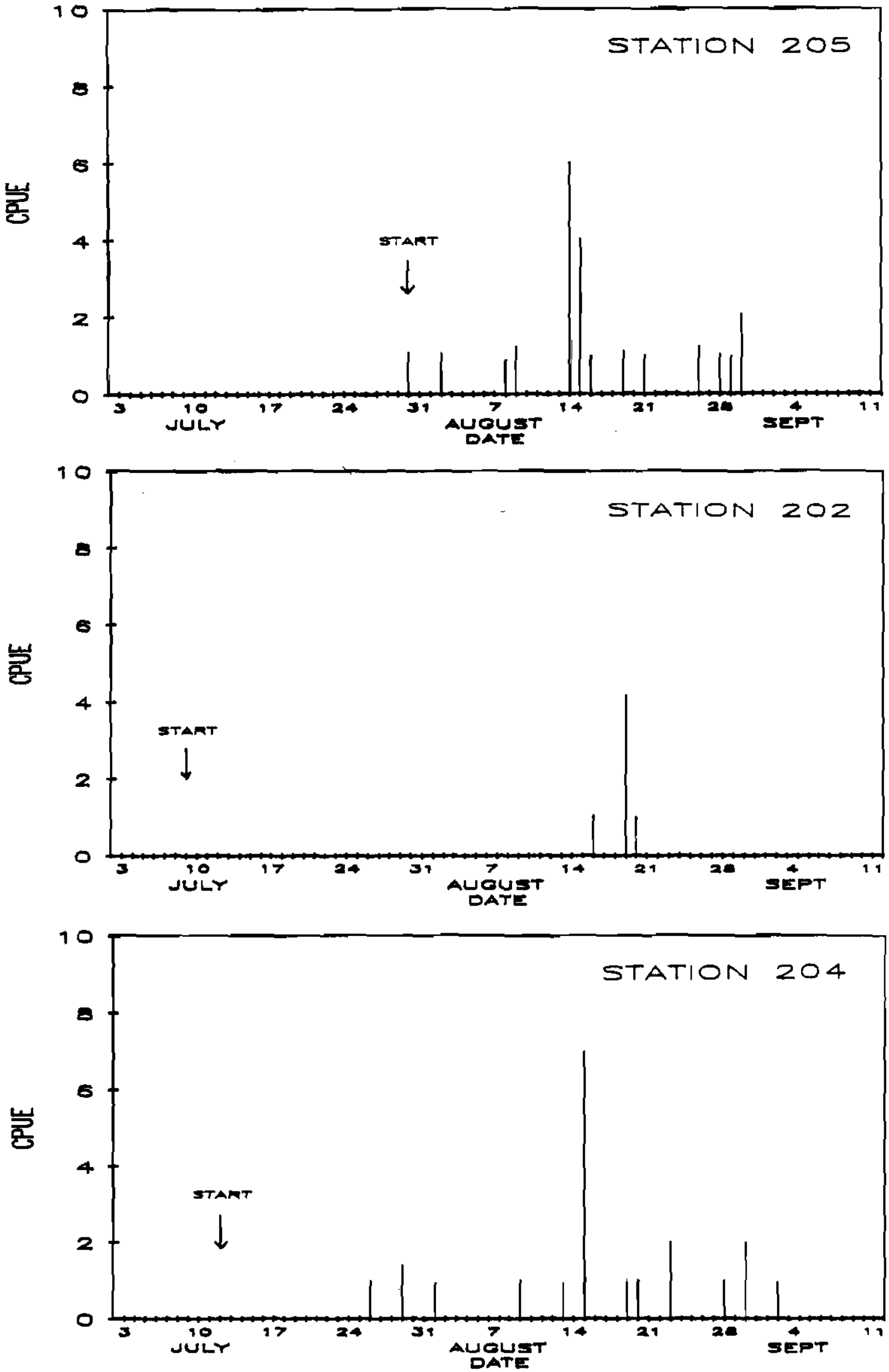

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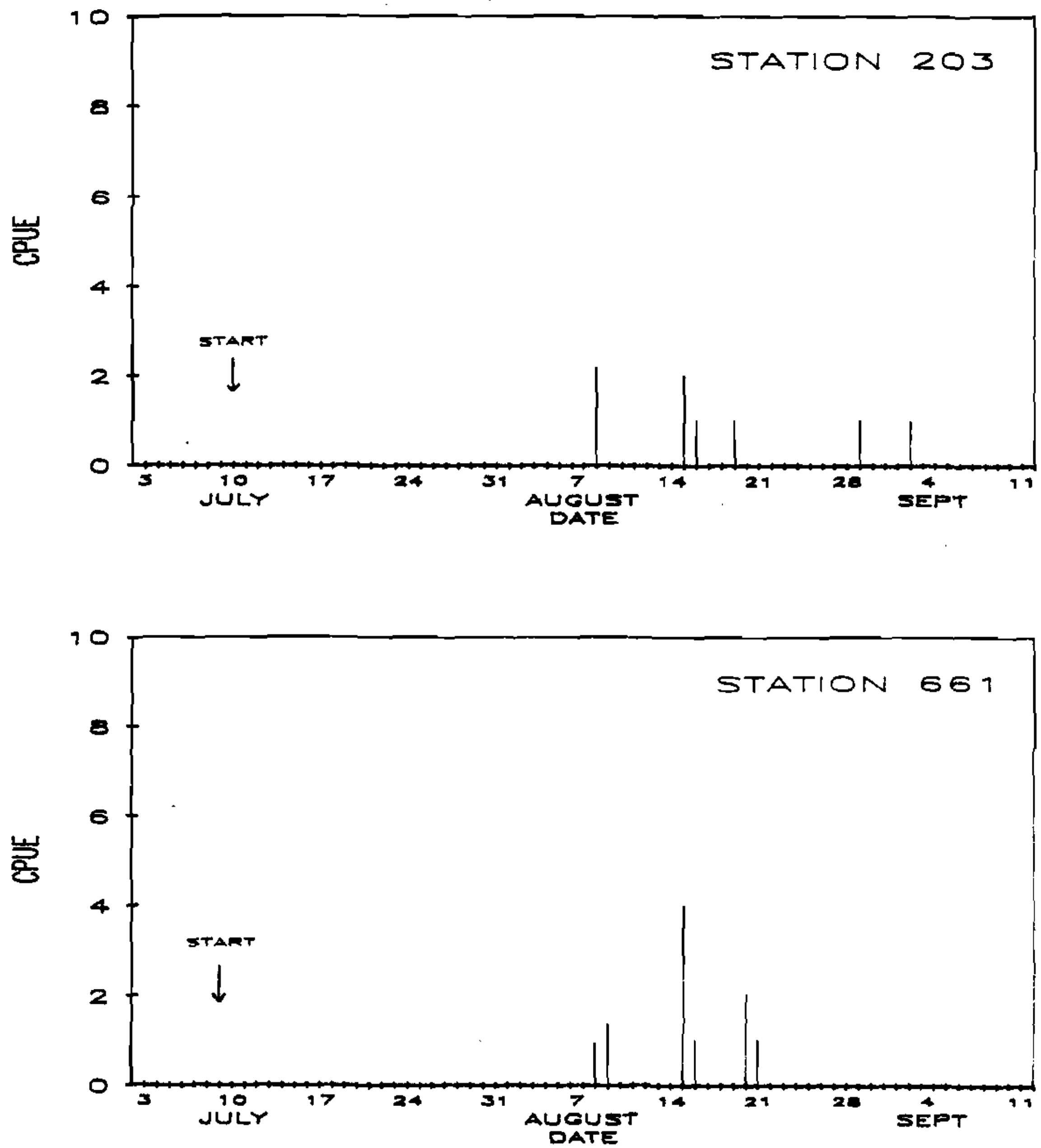

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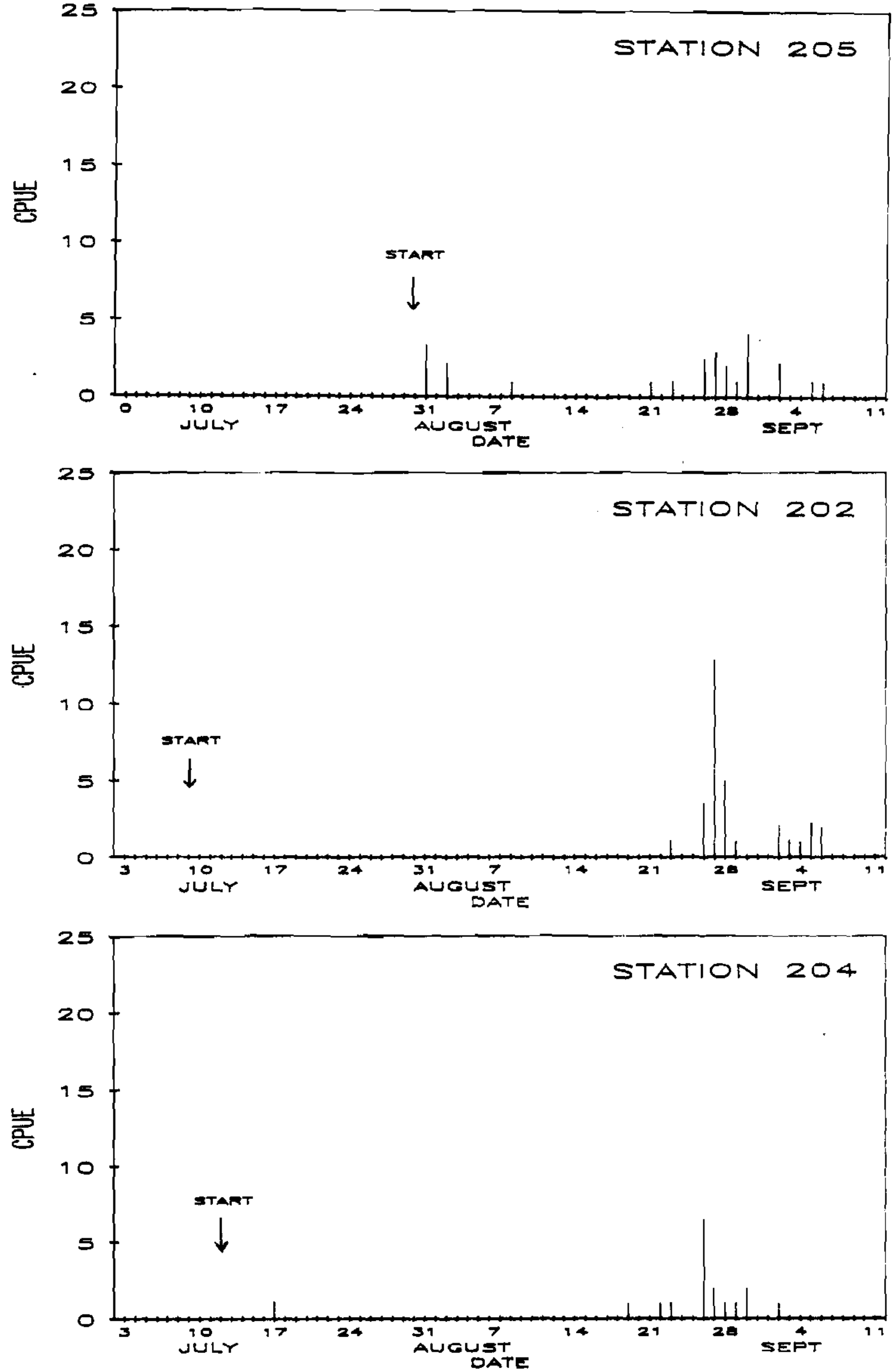

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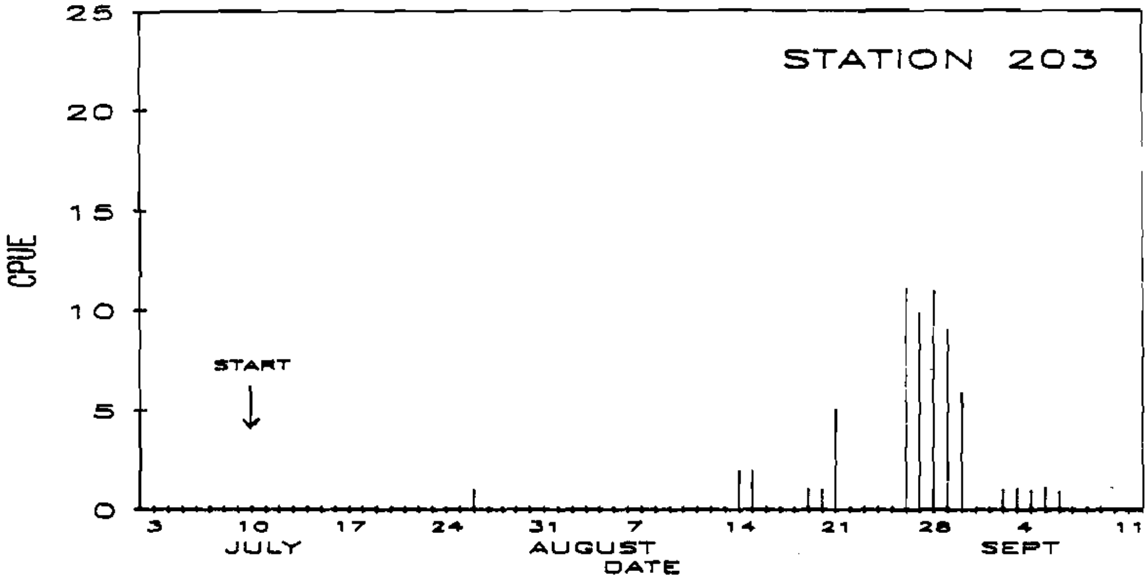

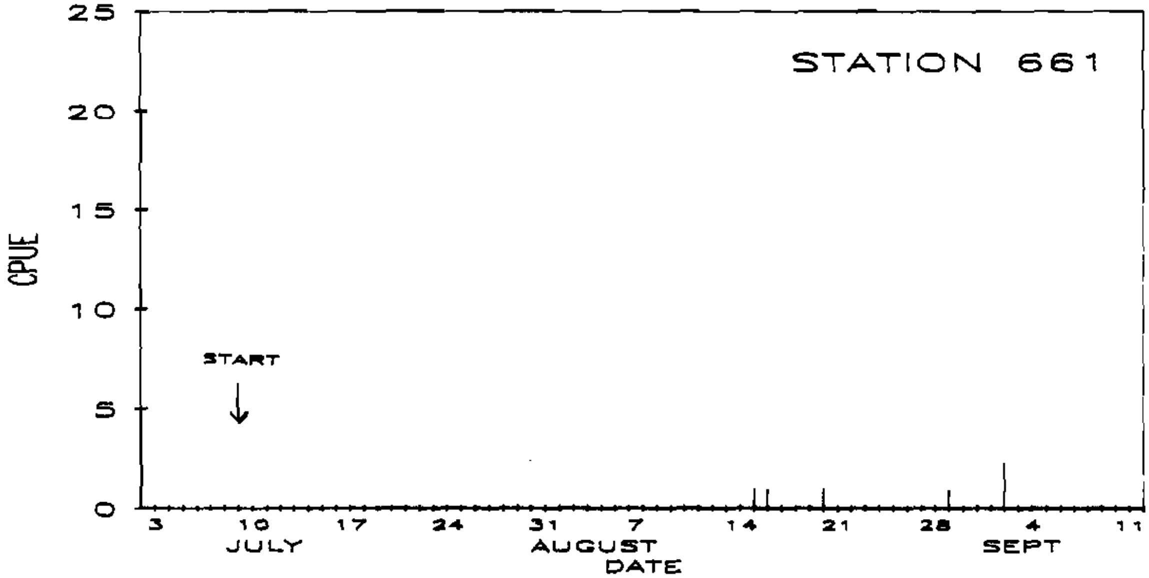

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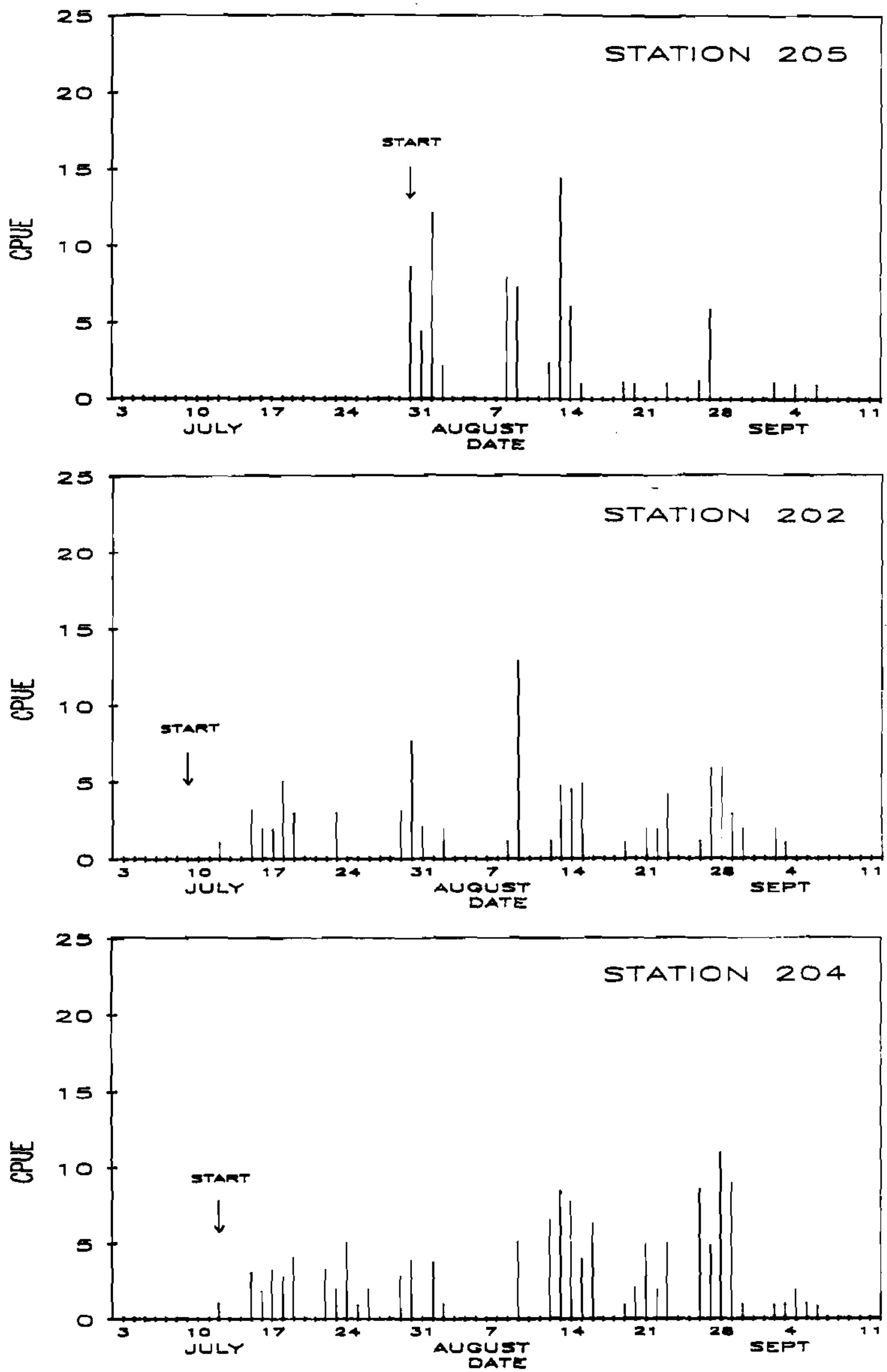

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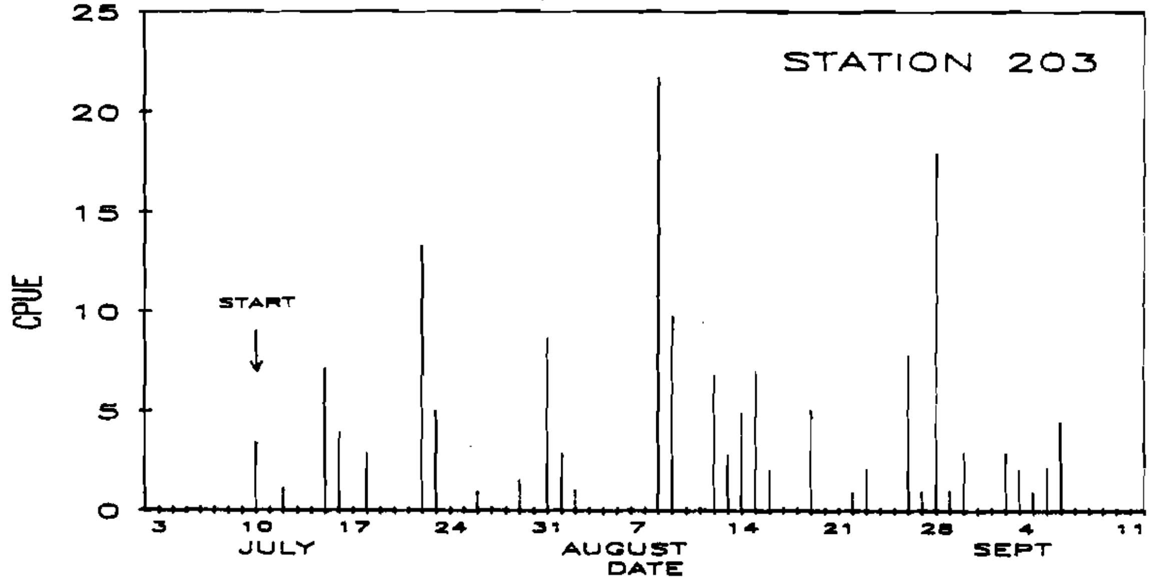

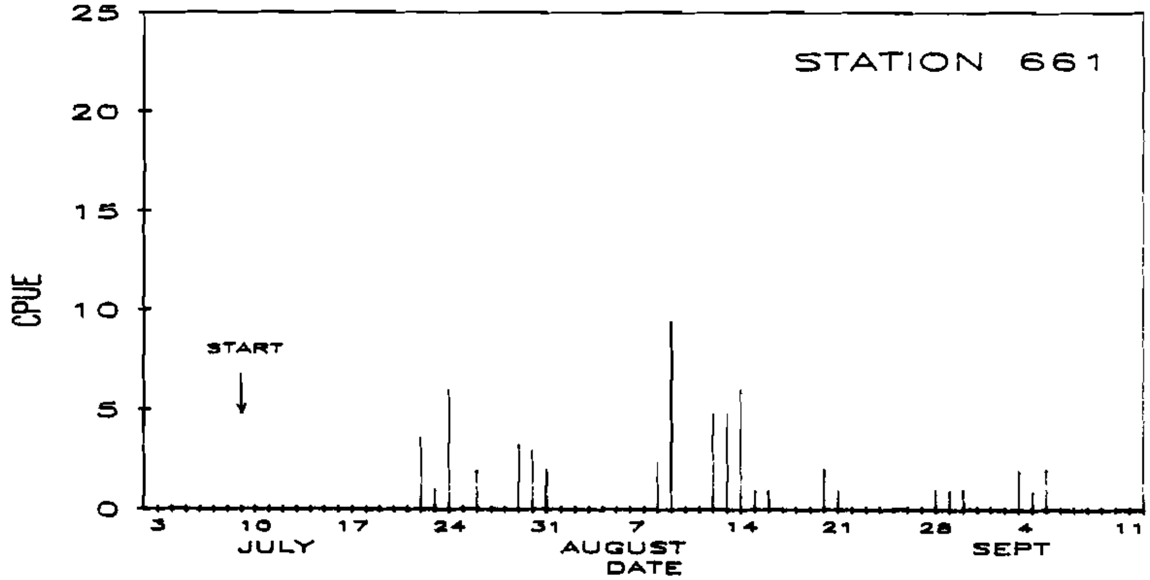

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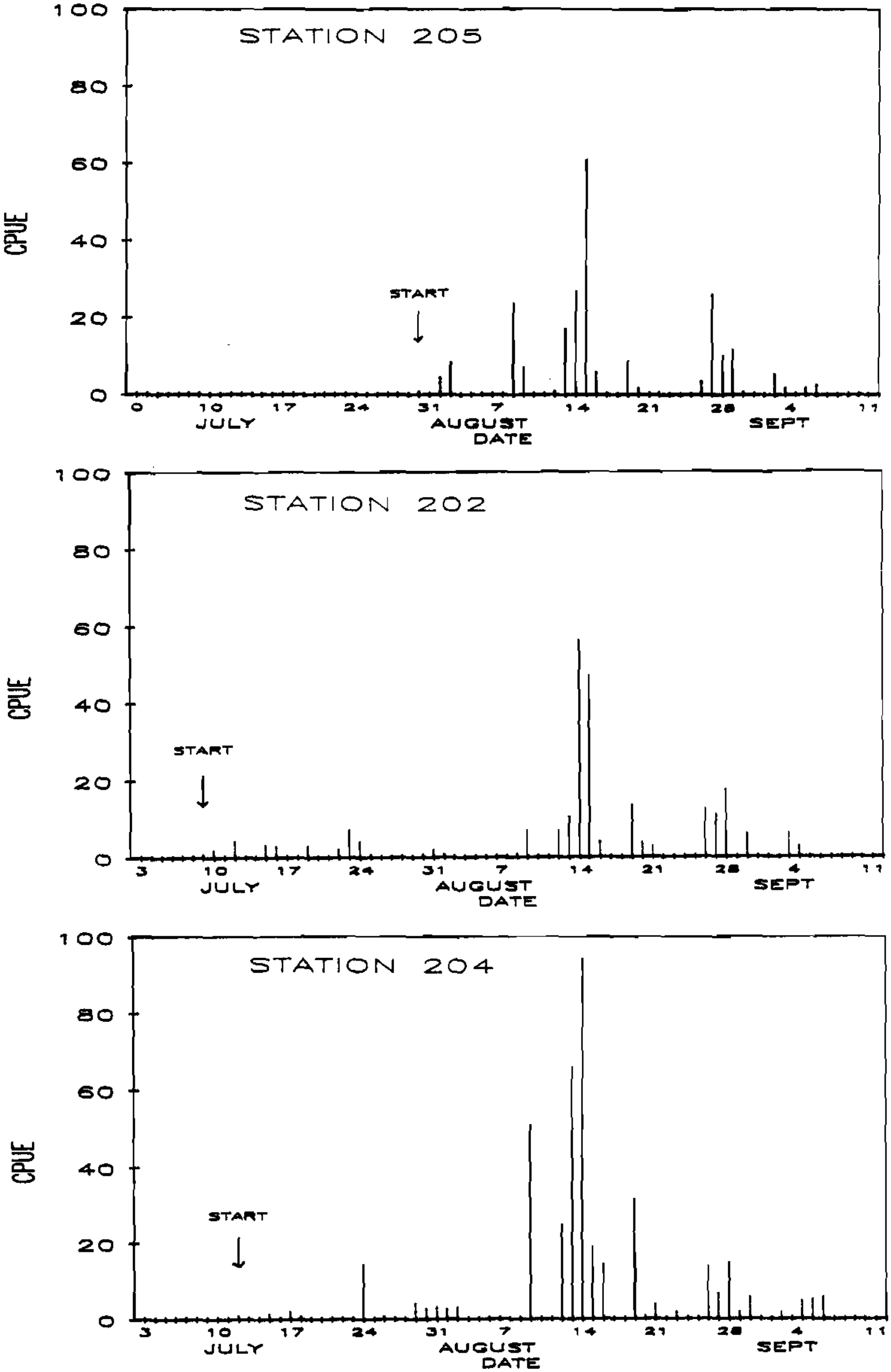

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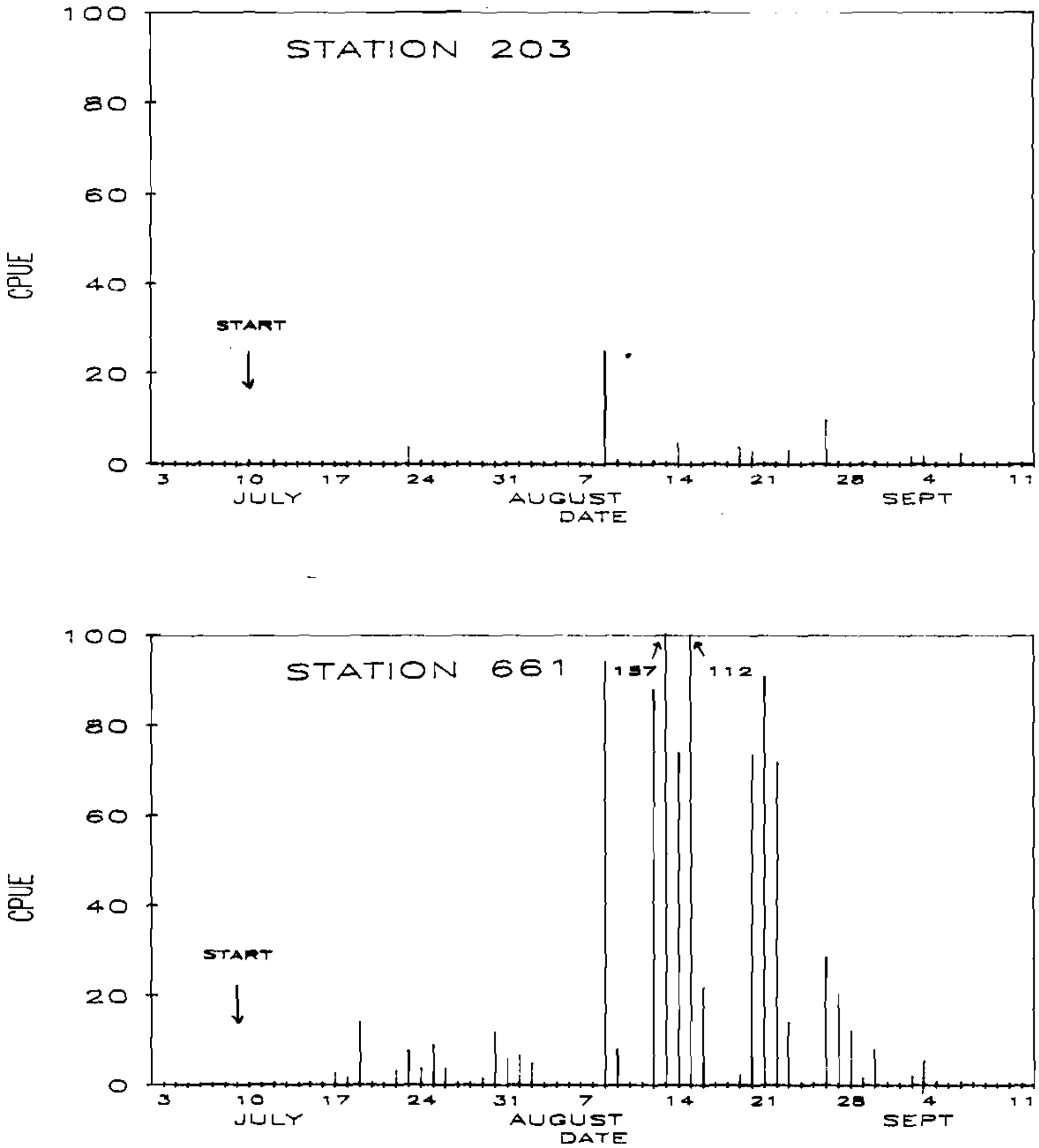

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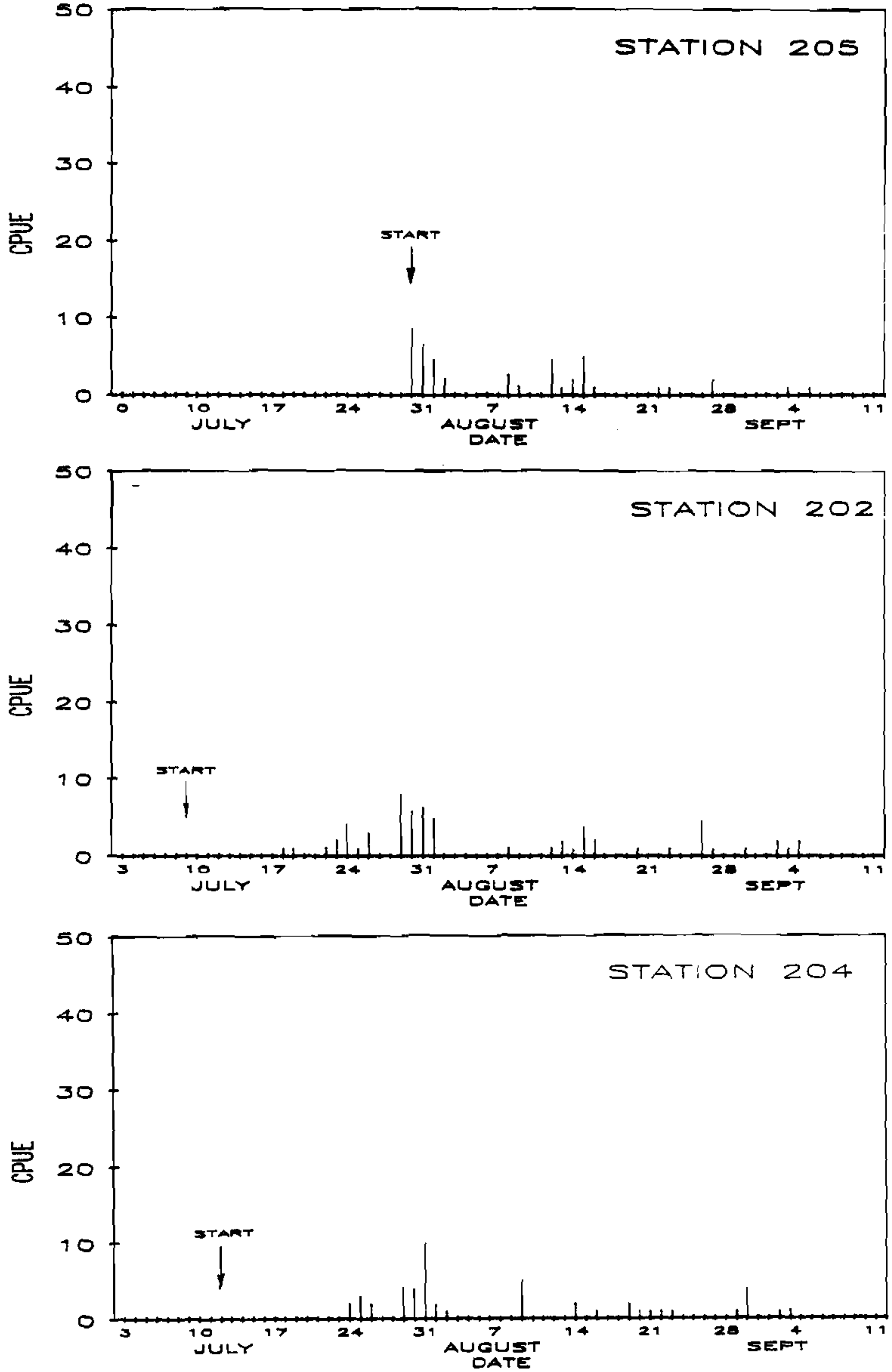

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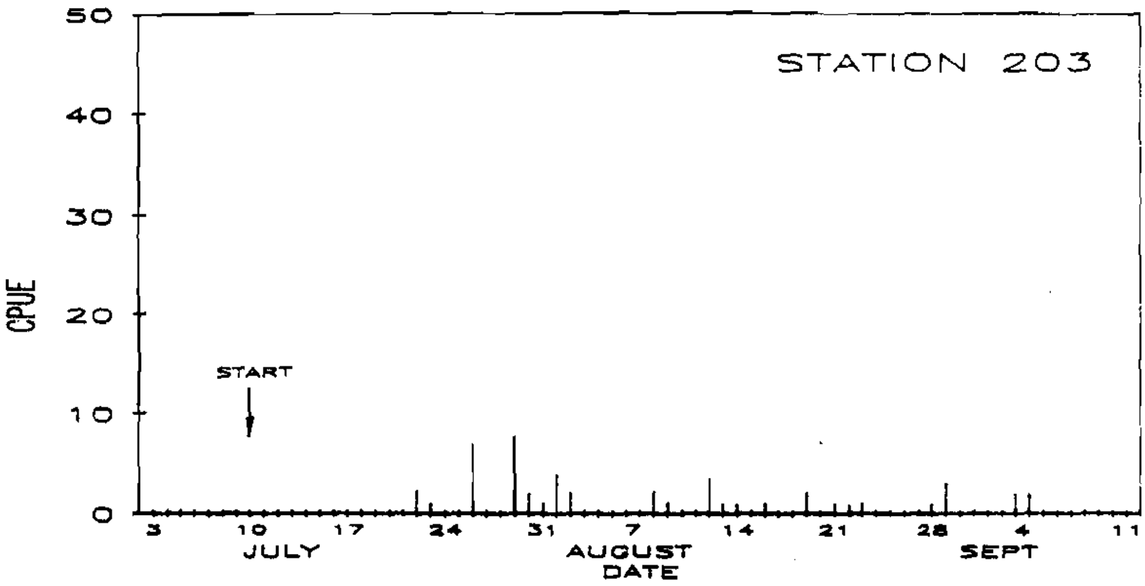

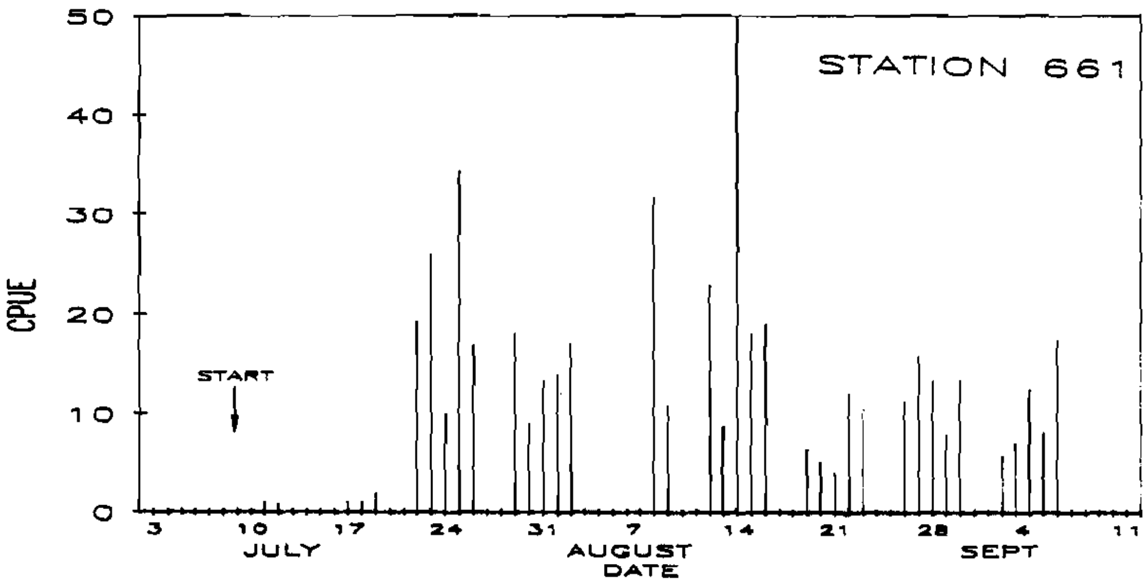

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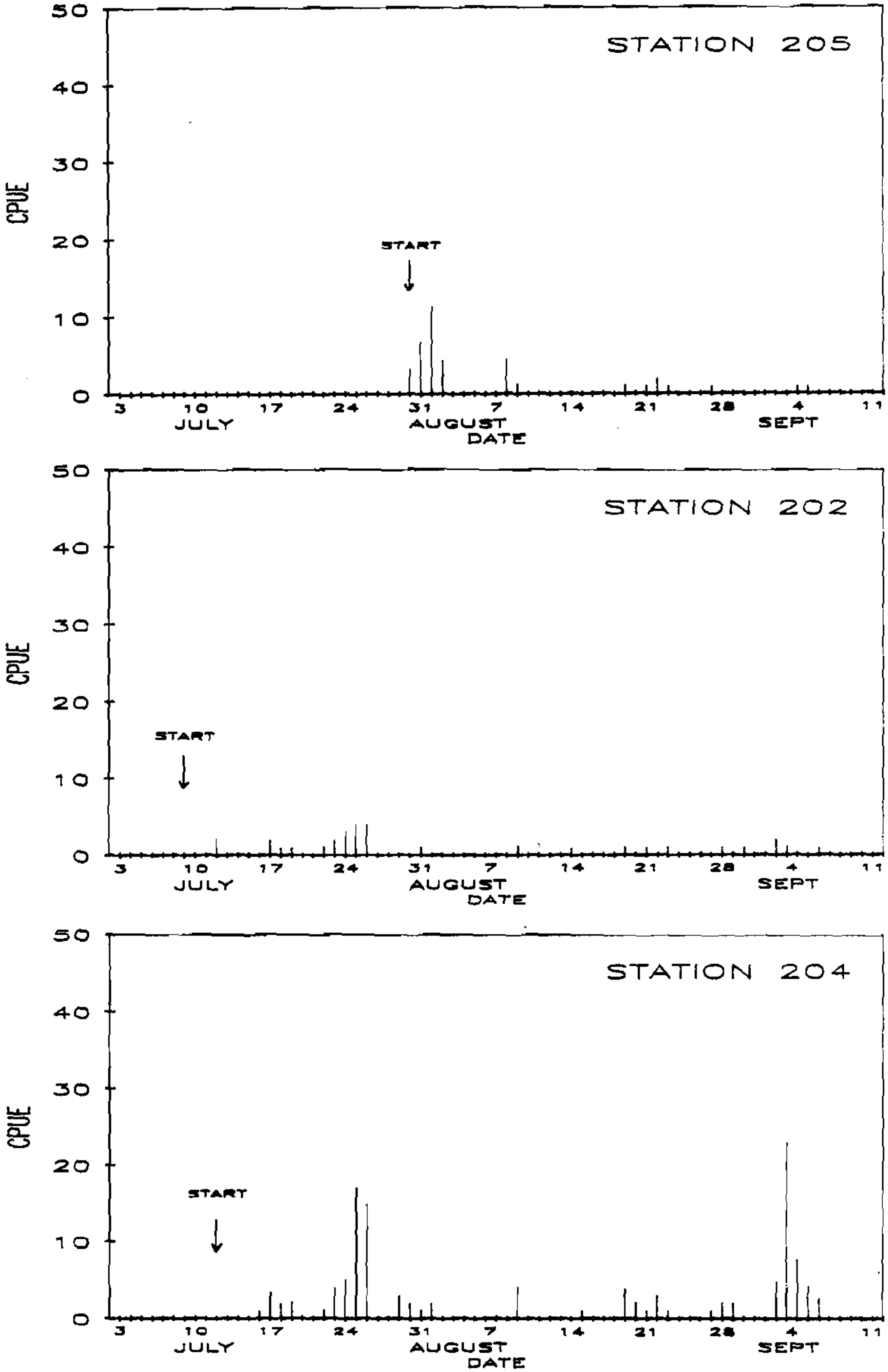
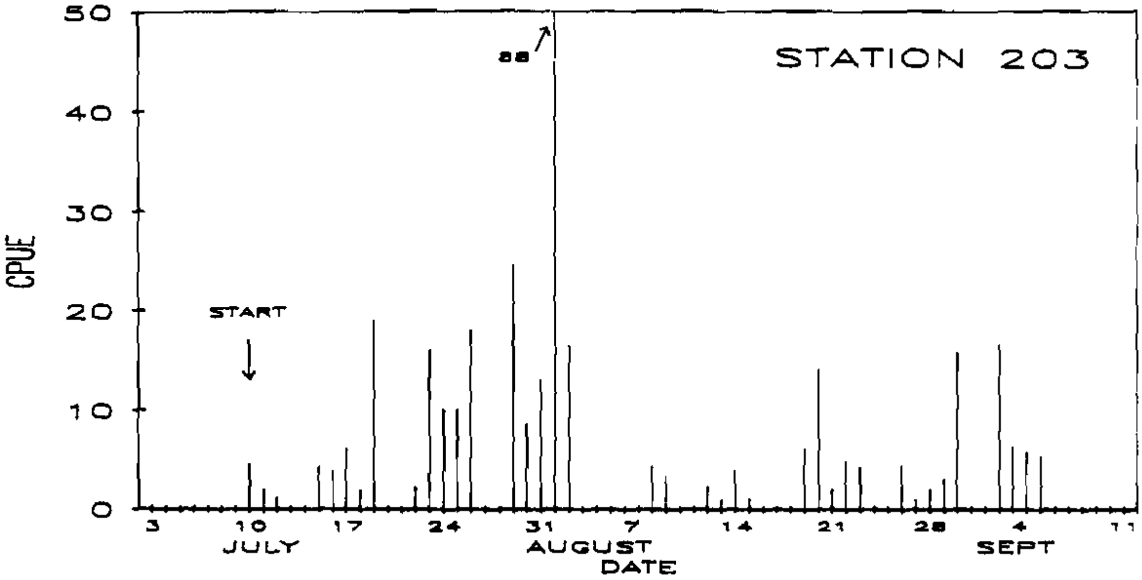


Figure B-54. Daily CPUE (no./24 hr.) of longnose sucker at lower river stations 205, 202 and 204.



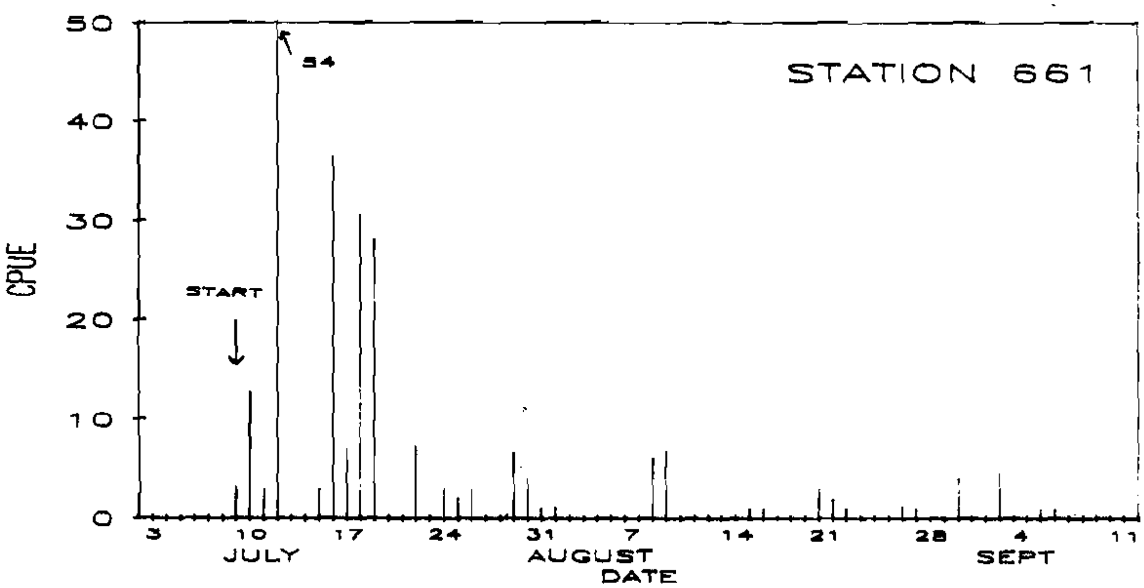


Figure B-55. Daily CPUE (no./24 hr.) of longnose sucker at lower river stations 203 and 661.

CHAPTER 3

ASSESSMENT OF THE COLVILLE RIVER FISHERY IN 1985

Prepared by

Lawrence L. Moulton
L. Jay Field
and
Selena Brotherton

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1.0 INTRODUCTION

The Colville River supports substantial populations of ciscos, whitefishes and char that are harvested by people from all parts of the Alaskan North Slope (Murdoch 1884, Steffanson 1922). The Helmericks fishery that has operated in the Colville delta for over thirty years has a well-documented history because of the detailed catch records maintained by the participants in the fishery. Details of this fishery are presented in Craig and Haldorson (1981) and Gallaway et al. (1983). Aside from this fishery, for which there is an abundance of data, there is scant information on harvest levels for fisheries in the Colville drainage. Craig and Haldorson (1981) estimated that the Helmericks fishery accounted for approximately half of the total delta harvest. In a preliminary survey of the Nuiqsut-based fishery, George and Nageak (1985) reported on the characteristics of the summer and fall fishery and details of the catch rate for one fishing group.

The primary objective of this study was to obtain an initial estimate of total effort and total catch for the summer and fall fisheries. Secondary objectives were to gather specific information needed to characterize the fishery. This included collecting information on the size and location of nets, differences in species composition, catch rate and fish length by mesh size, age distribution of the catch and seasonal variation in the catch. In addition, tags released from various tagging programs, primarily in the Prudhoe Bay region, were collected from the fishermen.

The information developed in this study can be used to make recommendations on fishing strategy to help optimize harvest. Such recommendations may include selection of mesh sizes to reduce catch of undesireable species and select for the larger individuals of the target species - this would reduce mortality on incidental species and reduce the work needed to obtain the desired harvest.

2.0 METHODS

2.1 STUDY AREA

The study area included the Colville River from the delta to upstream of Ocean Point and the Fish Creek drainage (Figure 1). The study area was subdivided into sections: (1) outer Colville Delta, including the delta and both the Main (Kupigruak) and East (Colville) channels upstream to Pisiktagvik; (2) lower Colville River, from Pisiktagvik to the Itkillik River; (3) upper Colville, from the Itkillik River to Ocean Point; (4) inland, upstream from Ocean Point; (5) Nigliq Channel (referred to as the Nechelik Channel on most area maps), from the Nigliq delta to the junction of the channel with the main river upstream of the village; and (6) Fish Creek.

Field personnel conducted observational surveys and interviewed local fishermen to determine patterns of fishing effort and catch within the study area. The heavily fished areas were surveyed more frequently than areas that received little or sporadic fishing effort. The Nigliq Channel received more utilization than did other areas within the study area, due to its proximity to Nuiqsut.

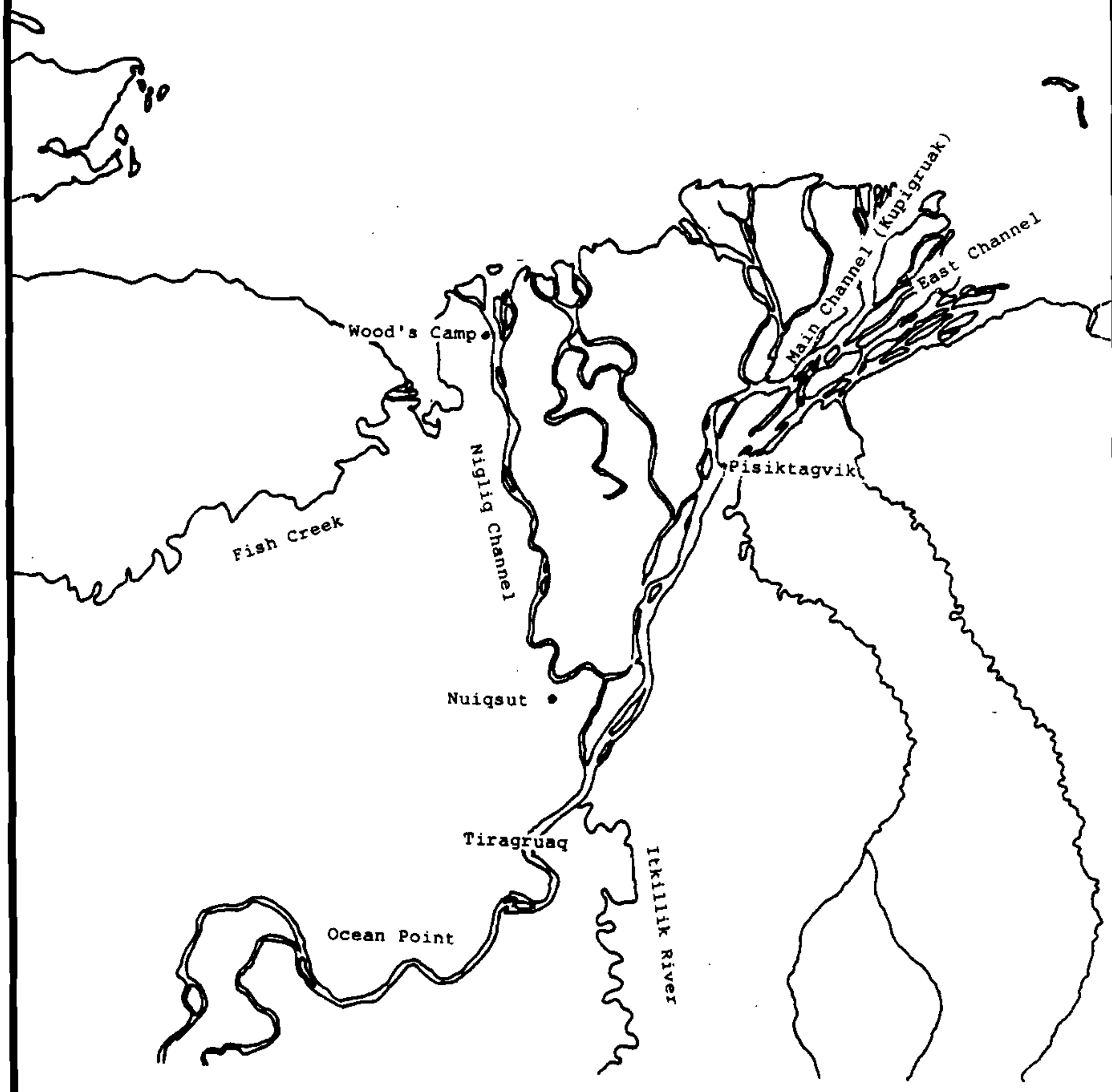
2.2 SUMMER FISHERY ASSESSMENT

The assessment of the summer fishery began in early July, with the fishery beginning on the Nigliq channel, and continued until early September, just prior to freeze-up. Thus, sampling occurred throughout the entire summer fishing season.

2.2.1 Effort

(a) Definition of Effort

Gill nets were used in both the summer and fall fisheries. A unit of effort was defined as a net-day, based on a 60-ft (20 m) gill net fished for 24



Map of Colville River study area.

ENTRIX | FIGURE 1

hours. Net depth was not considered in the calculation of effort, since most nets were of comparable depth (6 or 8 feet).

(b) Estimation of Total Effort

Two methods were used to estimate the total effort in each area during the fishing season: periodic net counts and interviews with local fishermen. The net count method provided a simple means of keeping track of fishing activity patterns without identifying individual nets.

Interviews with fishermen provided more detailed and continuous information on effort in each area over the fishing season, including mesh size and net length. Interviews were conducted using the following methods: (1) Interviews of returning fishermen were conducted at the Nuiqsut boat launch on the Nigliq Channel. This technique was effective because the Nuiqsut boat launch is the major point of access for fishermen into the fishery from Nuiqsut. (2) Fishermen were sometimes accompanied on trips to check their nets and interviews were conducted when fishermen were encountered during net count surveys. This provided survey personnel with first-hand data of net location, effort (number of nets, net length, mesh size), and catch. (3) Occasional visits to fishermen's residences were made to interview fishermen and sample their catch. (4) Telephone interviews of fishermen were also conducted to obtain information on effort and catch.

2.2.2 Catch Sampling

Catches were sampled whenever possible for species composition, number, and fork length to the nearest 5 mm. Whether the catch was sampled directly at the fishing site, the boat landing, or the fisherman's home, often determined the nature of the catch data that could be obtained. Catches from several nets (and sometimes days) would frequently be combined, making it difficult to separate catch information by mesh size. Also, particularly in the summer fishery, nets of different mesh sizes were sometimes joined together into a single net. In the case of these combined catches, information on the total catch was collected along with effort data (number of net-days by mesh size).

Otoliths were collected from some large broad and humpback whitefish to supplement age-length data for the biological study (Chapter 2). Fish for otolith collection were purchased from local fishermen.

2.2.3 Tag Recovery

A reward system was established to facilitate the return of tags from fishermen. Whenever possible, information collected included date and location of capture, species, length, weight, sex, and maturity.

2.3 FALL FISHERY ASSESSMENT

Monitoring of the fall under-ice fishery began on the Nigliq Channel near Nuiqsut in early October and continued until November 19. Catch and effort data from the outer Colville Delta fishery were provided by C. George (George and Kovalsky 1986) and J. Helmericks (1985).

2.3.1 Effort

The definition of effort and methods of estimation were the same as for the summer fishery (Section 2.2.1).

2.3.2 Catch Sampling

Catch sampling procedures were identical to the summer fishery assessment (Section 2.2.2).

2.3.3 Test Fishing

Two multi-panel gill nets were given to a local fisherman to use in exchange for daily information on the catch (number and fork length by species) from each mesh size. Each net had three 20-foot panels of different mesh. The small mesh net had mesh sizes of 0.75 (19 mm), 1.50 (38 mm), and 2.25 (57 mm) inches, and the large mesh net had mesh sizes of 3.00 (76 mm), 3.75 (95 mm), and 4.50 (114 mm) inches. The nets were set with extra weights to keep the nets fishing on the bottom.

2.4 DATA MANAGEMENT AND ANALYSIS

2.4.1 Data Collection

Field personnel kept a notebook (log) of information relating to fishing activity in addition to collecting detailed catch-effort information on custom data forms. Notebooks and data forms were checked, prior to data entry, for any missing or unusual values.

2.4.2 Data Entry

Catch and effort data were double-entered using customized data entry and error-checking programs. The log book data and the catch-effort data were entered into a microcomputer database management system (dBASE III). Copies of the database were maintained on floppy disks, hard disk, and magnetic tape.

2.4.3 Analysis

(a) Effort

Estimation of effort from net count data was calculated using the formula:

$$F = \sum_{i=1}^{n} [((N_i + N_{i+1})/2) * (D_{i+1} - D_i)]$$

where F = estimated effort in net-days
N_i = number of nets in count on the *ith* day of sampling
D_i = day of count on *ith* day of sampling
n = total number of days sampled

This assumes that each net counted was 60 ft in length.

(b) Catch Per Unit of Effort

Catch per unit of effort (CPUE) was estimated by two methods: average CPUE and total CPUE. Average CPUE was calculated by treating each individual sample (usually the catch from one net on a given day) as an independent sample and using the formula:

$$\text{Average CPUE} = \sum_{i=1}^{N} (C_i/F_i)/N$$

where N = number of samples
C_i = catch in the *ith* sample
F_i = effort on the *ith* sample

Total CPUE was calculated by dividing the total catch for a given time interval by the total effort:

$$\text{Total CPUE} = \frac{C_i}{F_i}$$

where C_i = total catch in *ith* interval
F_i = total effort for *ith* interval

(c) Estimation of Average Weight

Average weights by species group were calculated from length frequency distributions using weights for individual fish estimated from species length-weight relationships from the biological study (Chapter 2).

(d) Estimation of Total Catch from CPUE Data

Average catch per unit effort data were used to estimate catch by time interval and mesh size when adequate numbers of samples were available. Total

CPUE was used to estimate total catches when insufficient data were available to use average CPUE or to compare with results from other studies.

(e) Estimation of Total Catch from Tag Recovery Data

Total catch data and tag recovery information were available from two of the fishermen on the outer Colville Delta in the fall fishery. The total catch by species and total number of tags from the 1985 Endicott study (Envirosphere 1986) from both fishermen were combined to calculate a ratio of total catch to total number of tags. This ratio was then used to estimate total catch for other fishermen or for an area, based on the number of 1985 Endicott tags recaptured by a fisherman or returned from an area. This calculation assumes that the proportion of tagged fish in the population remains the same from area to area, that the catchability of tagged fish is the same for all mesh sizes and that the fishermen return all tagged fish caught from each area.

(f) Mortality Rates

Mortality rates for arctic and least cisco in the Colville Delta were estimated using data obtained from tag/recapture studies. The partitioning of the total annual mortality in a fishery is expressed by the following equation (Ricker 1975):

$$A = u + v$$

where A = annual mortality rate
u = the exploitation rate (fishing mortality)
v = natural mortality rate

The rate of exploitation (u) was calculated as that portion of the total stock that is harvested by the fishery (Ricker 1975). The total annual mortality rate was estimated by the decay of tag recaptures from a given release year over subsequent years (Ricker 1975). The natural rate of mortality was estimated by subtracting the estimated fishing mortality from the estimated annual mortality.

3.0 RESULTS

3.1 SUMMER FISHERY ASSESSMENT

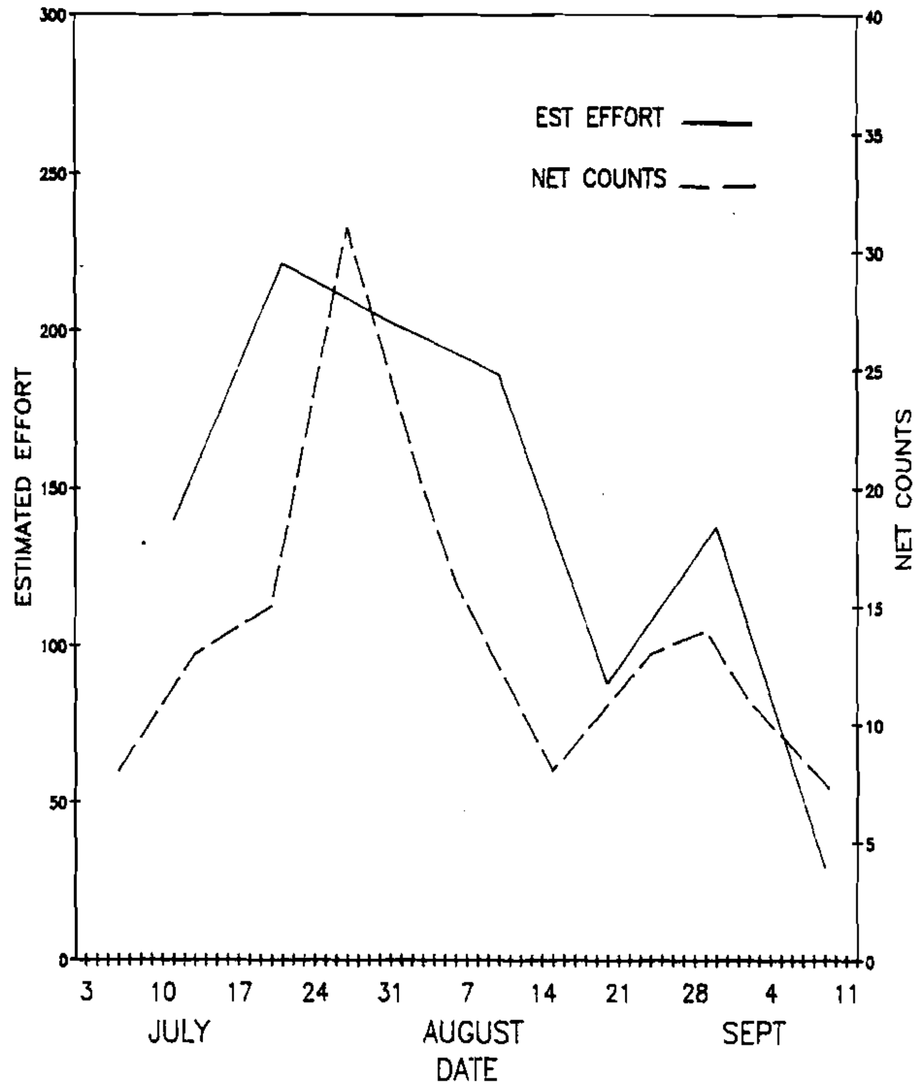
3.1.1 Estimated Fishing Effort

The summer fishery began in early July and extended until early September when high water and the beginning of freeze-up ended the open-water fishing season. Effort in the fishery was concentrated in three areas: the Nigliq channel, the upper Colville (primarily Tiragruaq region), and Fish Creek. About 20 groups of fishermen were active in the summer fishery. Gill nets with 5.0-inch mesh were the main fishing gear. Net length ranged from 50 to 100 ft, but 60-ft nets were the most common.

Total fishing effort (net-days) was estimated by area and mesh size from interviews with fishermen (Appendix Table A-1). Effort was also estimated by frequent net counts in each area (Appendix Table A-2). Most of the fishing effort was concentrated in the Nigliq channel within an easy commute of the village. The results from the two techniques of estimation show similar patterns of fishing effort: fishing began in early July, reached a peak around the end of July, and remained high until the middle of August (Figure 2). Based on the interview and net count techniques, total estimated effort was approximately 1,000 net-days. J. Helmericks (Colville Village, pers. comm., 1985) reported an additional 120 net-days of fishing effort in the lower Nigliq region during the latter part of July.

The upper Colville region also received considerable use (about 150 net-days), with the greatest amount of effort occurring in August. The shallowness of the Nigliq channel between Nuiqsut and the main river channel probably limited access to the upper Colville. As a result, most of the nets were fished from fish camps.

While only a small total amount (34 net-days) of fishing effort took place on Fish Creek, as soon as the Colville Delta was ice free, several groups traveled to fish camps at Fish Creek.



Seasonal variation in summer fishing effort based on estimated effort from interviews and net counts.

ENTRIX	FIGURE 2

3.1.2 Sampling Effort

The large geographic area and logistical difficulties made it impossible to collect data from all areas on a continuous basis. An attempt was made to allocate the sampling effort in proportion to the distribution of fishing activity. The sampling effort was greatest on the Nigliq channel, partly due to the proximity to town, and represented about 10 percent of the total estimated fishing effort in that area. The percentage of estimated effort sampled was greater for the upper Colville and Fish Creek areas, but rather than indicating better coverage of these areas it probably indicates under-estimation of total fishing effort.

Several fishermen used nets that contained more than one mesh size, and, as a result, catches from different mesh sizes were frequently combined in the catch samples. This, along with the generally low catch rates, resulted in sample sizes too small to compare catch rates by mesh size. Examination of the limited data suggests no major difference in catch by mesh size.

3.1.3 Catch

Broad whitefish was the primary target species of the summer fishery and dominated the catch in all areas, accounting for almost 80 percent of the total catch sampled (Table 1). Char were also important, particularly on the upper Colville, where they represented 23 percent of the catch. Humpback whitefish, pink salmon, and arctic grayling were minor components of the catch.

Catch rates were highest for broad whitefish in the Nigliq channel during early July, averaging 4.9 fish per net-day, dropped during late July, increased in early August, and then generally declined until the end of the season (Table 2). Few samples were taken from the upper Colville area during July, but it appears that the catch of broad whitefish per net-day was highest in late July, dropped to a low point in early August, and then increased until early September. All of the samples from the Fish Creek area were collected during a one week period from July 28 to August 3. While the catches sampled

Table 1. Species composition by area from catch samples in the summer fishery.

Species	Nigliq N	Nigliq %	Colville N	Colville %	Fish Creek N	Fish Creek %
Broad whitefish	281	86.7	164	67.8	51	100
Humpback whitefish	15	4.6	3	1.2		
Arctic cisco	1	<1	---			
Least cisco	---		1	<1		
Char	17	5.2	56	23.1		
Pink salmon	1	<1	12	5.0		
Chum salmon	6	1.9	1	<1		
Grayling	---		5	2.1		
Boreal smelt	2	<1	---			
Northern pike	1	<1	---			
Total	324		242		51	

N = number of fish in catch samples.

Table 2. Mean catch per unit effort (CPUE) by area and 10 day interval in the summer fishery for 3 species.

Interval Date	N	Broad Whitefish CPUE	Broad Whitefish SD	Char CPUE	Char SD	Humpback Whitefish CPUE	Humpback Whitefish SD
Nigliq							
7/6-7/15	15	4.9	3.1	0.0	0.0	0.0	0.1
7/16-7/25	4	1.9	1.4	0.0	0.0	0.8	1.0
7/26-8/4	3	4.4	4.8	0.0	0.0	0.1	0.2
8/5-8/14	3	3.5	0.4	0.1	0.2	0.2	0.3
8/15-8/24	5	1.9	1.4	0.9	1.1	0.2	0.4
8/25-9/3	8	1.5	1.4	0.2	0.3	0.3	0.7
9/4-9/11	2	1.1	0.5	0.0	0.0	0.0	0.0
Colville							
7/6-7/15	0	---	---	---	---	---	---
7/16-7/25	5	8.0	2.1	2.0	1.9	0.2	0.4
7/26-8/4	1	2.7	0.0	1.6	0.0	0.0	0.0
8/5-8/14	7	2.8	2.5	0.3	0.5	0.1	0.1
8/15-8/24	3	1.8	1.0	3.9	5.0	0.0	0.0
8/25-9/3	2	5.9	4.4	0.3	0.4	0.0	0.0
9/4-9/11	1	6.4	0.0	0.4	0.0	0.0	0.0
Fish Creek							
7/6-7/15	---						
7/16-7/25	---						
7/26-8/4	12	5.3	8.7	0.0	0.0	0.0	0.0
8/5-8/14	---						
8/15-8/24	---						
8/25-9/3	---						
9/4-9/11	---						

N = number of catch samples

CPUE = Catch per unit effort (number of fish/net-day)

SD = standard deviation

were similar to the other regions, catches as high as 70 fish per day were reported. The overall average catch rates were similar at all areas, with a mean catch rate of approximately 3 to 5 broad whitefish per net-day.

Humpback whitefish occurred infrequently in the catches, accounting for less than 5 percent of the total catch sampled from the Nigliq channel.

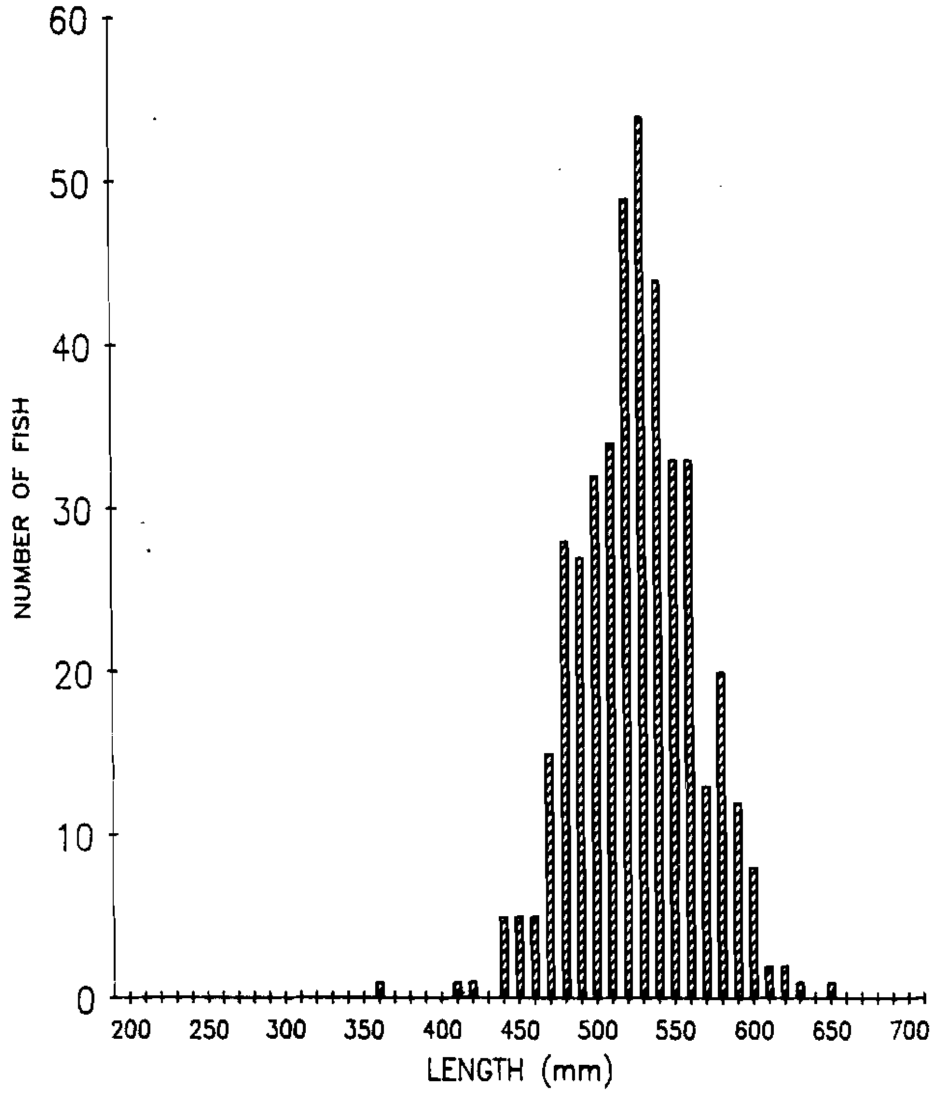
Few char were caught in the Nigliq channel (Table 2). Most of the char were taken in nets on the upper Colville from late July to late August. Catch per unit effort was generally less than 2 fish/net-day.

3.1.4 Size and Age Composition

Broad whitefish in the catch samples of the summer fishery ranged in size from 365 to 650 mm (Figure 3) with a mean of 529 mm (Table 3). Age determination based on otolith samples from the catch indicate the catch is dominated by fish older than age-10 (Figure 4). This is consistent with the age-length relationship developed in Chapter 2. The mean size in the catch appeared to decrease slightly over the course of the summer from 540 mm in early July to 510 mm at the end of August (Appendix Table A-3). The average weight (based on weights estimated from length-weight relationships) of broad whitefish was 2.0 kg (4.4 lbs). The average size of char in the samples was about 600 mm, with a minimum size of 520 mm and a maximum of 765 mm (Table 3).

3.1.5 Estimated Total Catch

Based on estimates of total effort and the average catch per effort observed for each species during ten day intervals, total estimated catches were calculated for each area (Table 4). According to these estimates, approximately 3,600 broad whitefish were taken in the summer fishery on the Nigliq channel. The upper Colville and the Fish Creek areas accounted for another 600 and 200 broad whitefish respectively. These are conservative estimates as the actual fishing effort was probably underestimated, particularly in the upper Colville and Fish Creek regions. The total estimated catch of broad whitefish in all areas was at least 9,000 kg

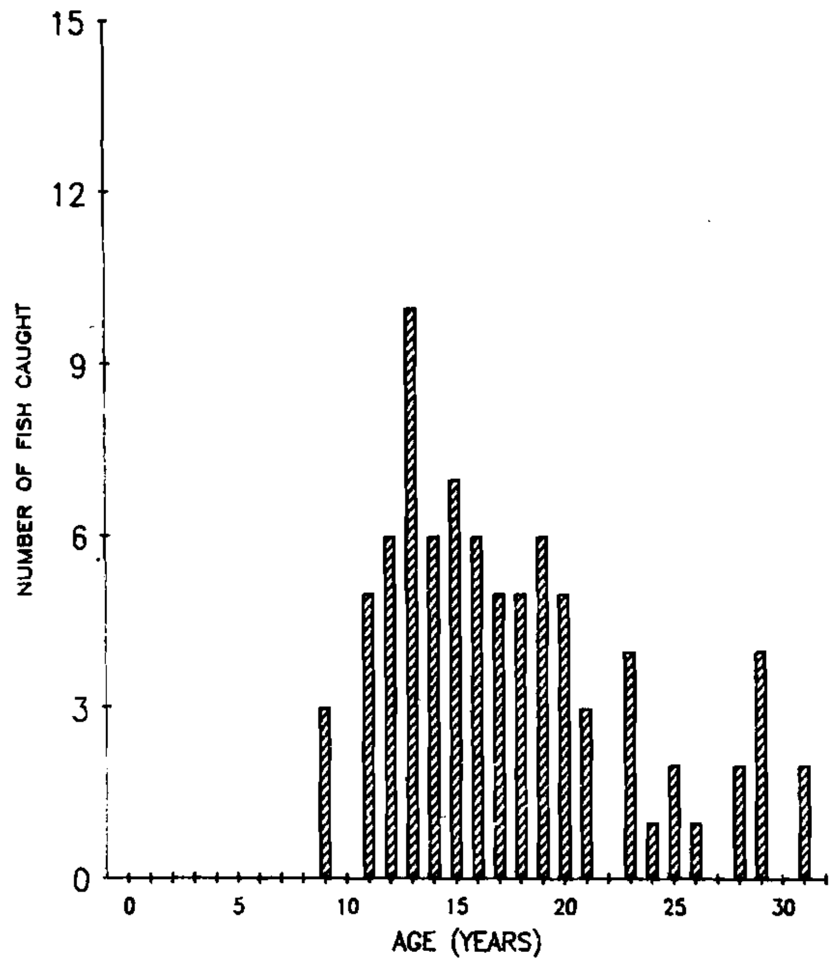


Length frequency of broad whitefish sampled from the summer catch.

ENTRIX | FIGURE 3

Table 3. Mean length (mm) of major species in catch samples for the summer fishery (all areas and mesh sizes combined).

Species	Length Mean (Range)	Number
Broad whitefish	529 (365-650)	426
Humpback whitefish	439 (405-525)	20
Char	600 (520-765)	31
Pink salmon	524 (475-595)	19



Age frequency of broad whitefish sampled in the summer catch.

ENTRIX

FIGURE 4

Table 4. Estimated catch of broad whitefish (BWF), char, and humpback whitefish (HBWF) by 10 day interval and area (all mesh sizes combined) in the summer fishery.

Interval	Estimated Effort	CPUE[1]			Estimated Catch		
		BWF	Char	HBWF	BWF	Char	HBWF
Nigliq							
7/6-7/15	139.6	4.9	0.0	0.0	684	0	0
7/16-7/25	221.2	1.9	0.0	0.8	420	0	177
7/26-8/4	202.6	4.4	0.0	0.1	891	0	20
8/5-8/14	186.0	3.5	0.1	0.2	651	19	37
8/15-8/24	87.9	1.9	0.9	0.2	167	79	18
8/25-9/3	138.0	1.5	0.2	0.3	207	28	41
9/4-9/11	29.8	1.1	0.0	0.0	33	0	0
Total	1005.1				3,053	126	293
					600(est)[2]		
		Total Nigliq Catch			3,653		
Colville							
7/6-7/15[3]	1.0	---	---	---	---	---	---
7/16-7/25	20.0	8.0	2.0	0.2	160	40	4
7/26-8/4	18.0	2.7	1.6	0.0	49	29	0
8/5-8/14	47.1	2.8	0.3	0.1	132	14	5
8/15-8/24	24.3	1.8	3.9	0.0	44	95	0
8/25-9/3	30.3	5.9	0.3	0.0	179	9	0
9/4-9/11	5.0	6.4	0.4	0.0	32	2	0
Total	145.7				596	189	9
Fish Creek							
7/26-8/4	34.0	5.3	0.0	0.0	180	0	0

[1]CPUE = catch per unit effort (number of fish/net-day)

[2]estimated Helmericks catch

[3]no catches from this area sampled during this interval.

(20,000 lbs). An estimated 300 char and 300 humpback whitefish were caught in all areas combined.

3.2 FALL FISHERY ASSESSMENT

Approximately 30 fishing groups were identified in the fall under-ice fishery. Effort was concentrated in three areas: the upper Nigliq channel (within 15 to 20 minutes of Nuiqsut by snow machine), the lower Nigliq delta (Woods Camp), and the outer Colville Delta including both the main (Kupigruak) and the east channels. There was also a small amount of effort on the upper Colville and in the Fish Creek area, but these areas were not covered in this study in order to concentrate sampling effort in the areas of greatest fishing effort.

Fishing commenced in early October as soon as the river ice was considered safe for travel (about 3 to 4 inches in thickness). During the first couple of weeks while the ice was still relatively thin, some nets were moved to different locations in search of better fishing holes. By the third week of October most nets remained in the same location. Most fishermen checked their nets at least every other day except during high wind and extreme cold, or when overflow conditions made travel unsafe.

Gill nets of 2.5 to 3.5 inches (stretched mesh) were the standard gear used in the fishery, with 3.0-inch mesh the most common.

3.2.1 Estimated Fishing Effort

(a) Nigliq Channel

Fishing effort on the upper Nigliq began about October 2, was greatest during late October and early November, and remained at a relatively high level throughout the season (Appendix Table A-4). All nets in this area were fished by fishermen who commuted from Nuiqsut. A low level of effort continued beyond the end of the study (November 20). About 25 groups participated in the fishery on the upper Nigliq and accounted for almost 900 net-days of total fishing effort.

The lower Nigliq area was fished by about 4 groups from the first week of October until the first week of November. Approximately 350 net-days of fishing effort occurred in this area, about 40 percent of the upper Nigliq total.

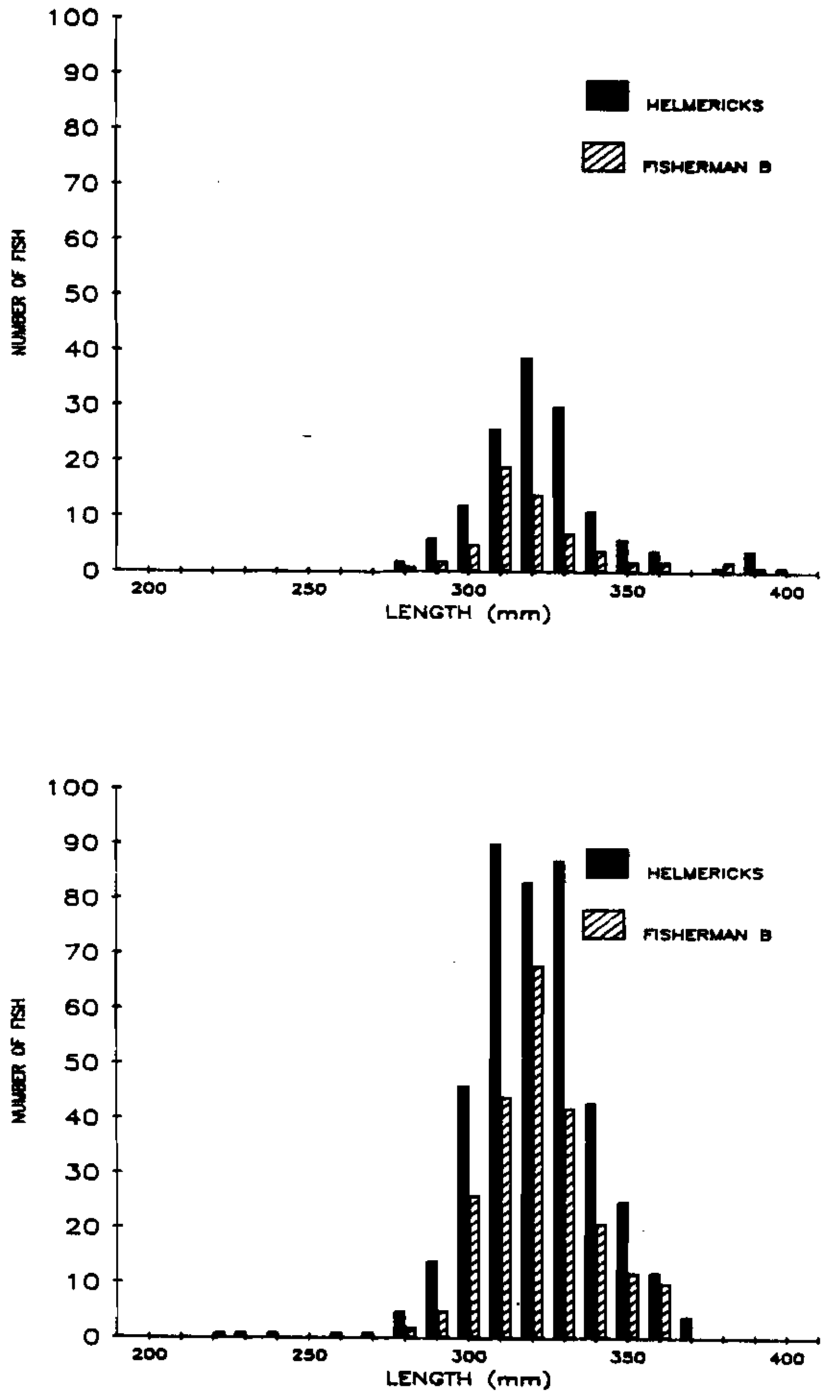
(b) Outer Colville Delta

The fishery in the outer Colville Delta region was comprised of groups from fish camps or Colville Village. The main (Kupigruak) channel received an estimated 800 net-days of effort by 3 groups compared to about 650 net-days on the east channel by 2 groups (Appendix Table A-5). Effort was greatest in both areas during the last two weeks of October. Most of the nets were out of the water by the end of the first week in November. On the east channel, both Helmericks and Fisherman C used all 3.0-inch mesh nets. On the main channel, Helmericks used five 3.0-inch and one 3.5-inch mesh nets and Fisherman A used 2.5, 3.0, and 3.5-inch mesh nets. The nets used by Fisherman B were reported to be 2.5-inch mesh but were not actually measured (George and Kovalsky 1986). However, length frequency distributions for recaptured tagged arctic and least cisco from Fisherman B are nearly identical with Helmericks' recaptures (Figure 5). Since Helmericks used primarily 3.0-inch mesh nets (10 of 11 nets), it is likely that Fisherman B was also using 3.0-inch mesh nets, and this will be assumed to be the case in the remainder of this report.

3.2.2 Sampling Effort

(a) Nigliq Channel

About 13 percent of the upper Nigliq total estimated effort was sampled (Appendix Table A-5), but most of the samples came from the first three weeks of fishing activity. Test fishing results provided an additional 25 net-days of sampling from the upper Nigliq. Due to logistical difficulties, little information was collected from the lower Nigliq fishery.



Length frequency of tagged arctic cisco (top) and least cisco (bottom) recaptured by Helmericks and Fisherman B.

ENTRIX	FIGURE 5

(b) Outer Colville Delta

Complete catch records were obtained from 2 of the 3 fishermen with nets on the main channel of the Colville. Catch records from one of the two fishermen on the east channel provided coverage of over 65 percent of the total effort on the east channel.

3.2.3 Catch Composition

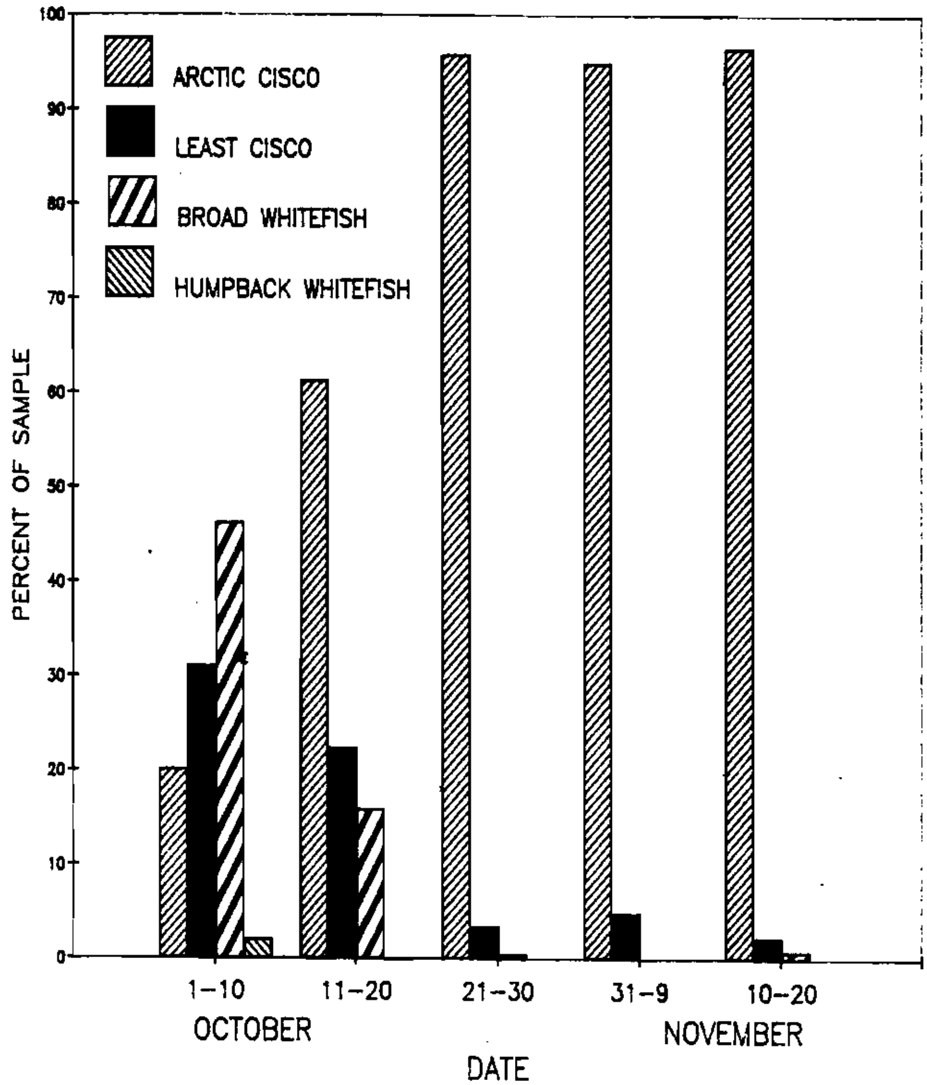
Arctic cisco was the primary target species in the fall under-ice fishery, while least cisco was considered a less desirable co-occurring species. Small broad whitefish were important early in the fishery on the upper Nigliq channel.

(a) Upper Nigliq Channel

In early October, broad whitefish were the most abundant species in the catch from the upper Nigliq channel, representing over 45 percent of the total catch sampled (all mesh sizes combined) (Figure 6). Least cisco were second in abundance (30 percent), while arctic cisco accounted for only 20 percent of the total catch in the initial ten day period. However, from late October until the end of the fishing season, the total catch was comprised of about 95 percent arctic cisco, while least cisco accounted for the remaining portion of the catch. Broad whitefish had essentially disappeared from the catch by late October and presumably had moved further upstream.

(b) Outer Colville Delta

Complete catch records were obtained from two of the four groups fishing on the outer Colville Delta (Table 5). On the main channel, the catches in 3.5 inch mesh nets were about 90 percent arctic cisco for both Helmericks and Fisherman A (Table 6). In Helmericks' 3.0-inch mesh nets, the catch was close to 50 percent arctic cisco and 50 percent least cisco throughout the fishing season, compared to about 65 percent arctic cisco in Fisherman A's 3.0-inch mesh nets. In 2.5-inch mesh nets (Fisherman A only), approximately equal



Catch composition of fall harvest in the Nigliq Channel.

ENTRIX

FIGURE 6

Table 5. Total catch of arctic and least cisco by mesh size (in) and 10 day interval for two fishermen in the outer Colville Delta fall fishery.

	Mesh Size	Oct 1-10	Oct 11-20	Oct 21-30	Oct 31-Nov 5	Total
ARCTIC CISCO						
Main Channel Helmericks[1]						
	3.0	3,731	2,773	2,368	602	9,474
	3.5	452	210	169	16	847
						10,321
Fisherman A[2]						
	2.5		682			682
	3.0		1,986			1,986
	3.5		473			473
						3,141
East Channel Helmericks[1]						
	3.0	3,259	4,179	3,912	2,008	13,358
LEAST CISCO						
Main Channel Helmericks[1]						
	3.0	2,987	2,550	2,393	626	8,556
	3.5	44	42	14	1	101
						8,657
Fisherman A[2]						
	2.5		692			692
	3.0		1,035			1,035
	3.5		76			76
						1,803
East Channel Helmericks[1]						
	3.0	3,009	3,006	2,157	767	8,939

[1]data from Helmericks 1985 data report

[2]data from J.C. George (North Slope Borough)

Table 6. Percent arctic cisco in outer Colville Delta catch by 10 day interval and mesh size (in).

	Oct 1-10	Oct 11-20	Oct 21-30	Oct 31- Nov 5	Overall
Main Channel					
Helmericks					
3.0	55.5	52.1	49.7	49.0	52.5
3.5	91.1	83.3	92.3	94.1	89.3
Fisherman A					
2.5		49.6			
3.0		65.7			
3.5		86.2			
East Channel					
Helmericks					
3.0	52.0	58.2	64.5	72.4	59.9

numbers of arctic and least cisco were caught. In contrast to the results from the main channel, the percentage of arctic cisco in the catch on the east channel (Helmericks, 3.0-inch mesh only) increased from about 52 percent in early October to over 70 percent by early November.

3.2.4 Catch Per Unit Effort (CPUE)

(a) Upper Nigliq

Catch per unit effort (CPUE) of arctic cisco in the upper Nigliq area increased from about 5 fish per net-day in early October to about 40 fish per net-day in early November (Table 7). Catch rates in all mesh sizes followed the same general pattern, although catch rates from 3.0-inch mesh (by far the most commonly used mesh size) were generally lower than those observed for other mesh sizes. Test fishing results showed the highest catches of arctic cisco in the 2.25-inch mesh panel: approximately 50 fish per net-day compared to about 10 fish per net-day in 3.0-inch mesh. However, it is important to note that the two test nets were set in different locations, which could have accounted for some of the observed differences in catch rates.

CPUE of least cisco was low for all mesh sizes (2.25- to 3.5-inch mesh) throughout the fall fishing season, ranging from about 5 fish per net-day in early October to less than 2 fish per net-day in November (Table 7). Test fishing results, however, showed a high CPUE of over 200 least cisco per net-day in 1.5-inch mesh and about 22 fish per net-day in 2.25-inch mesh. Catch rates declined for both mesh sizes from late October to early November, while the CPUE in the smallest mesh panel (0.75 inch) remained constant at about 18 least cisco per net-day.

A maximum CPUE of 10 broad whitefish per net-day in 3.0-inch mesh was observed in early October (Table 7). By the second 10 day period in October the CPUE declined to 5 fish per net-day. Few broad whitefish were caught after mid-October.

Table 7. Mean CPUE of arctic cisco, least cisco, and broad whitefish by mesh size and 10 day period in the upper Nigliq in the fall fishery.

Mesh Size (in.)	Oct 1-10			Oct 11-20			Oct 21-30			Oct 31-Nov 9			Nov 10-20		
	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
Arctic Cisco															
2.25	---	---	0	---	---	0	11.7	4.4	4	---	---	0	8.0	0	1
2.50	5.0	5.7	4	19.3	10.0	3	32.0	0	1	32.7	21.8	3	48.2	17.7	4
3.00	5.4	3.8	19	5.8	4.9	17	20.6	2.9	3	16.6	7.6	2	---	---	0
3.25	---	---	0	10.8	6.9	5	---	---	0	---	---	0	43.7	0	1
3.50	0.0	0.0	3	10.5	7.3	12	35.3	13.6	3	---	---	0	37.7	0	1
Least Cisco															
2.25	---	---	0	---	---	0	0.5	0.6	4	---	---	0	0	0	1
2.50	4.6	1.1	4	3.7	1.5	3	3.0	0	1	1.5	2.2	3	1.3	1.1	4
3.00	6.1	8.9	19	5.3	8.4	17	1.8	1.5	3	1.3	0.4	2	---	---	0
3.25	---	---	0	0.4	0.5	5	---	---	0	---	---	0	1.2	0	1
3.50	0.4	0.7	3	1.1	1.6	12	0.2	0.3	3	---	---	0	0.6	0	1
Broad Whitefish															
2.25	---	---	0	---	---	0	0	0	4	---	---	0	0	0	1
2.50	2.8	2.8	4	5.3	3.2	3	0	0	1	0	0	3	0.6	1.3	4
3.00	10.0	11.0	19	4.7	4.9	17	0.3	0.5	3	0	0	2	---	---	0
3.25	---	---	0	0.5	0.5	5	---	---	0	---	---	0	0	0	1
3.50	1.2	1.6	3	0.3	0.5	12	0.2	0.4	3	---	---	0	0	0	1

CPUE = catch per unit effort

SD = standard deviation

N = number of catch samples

(b) Lower Nigliq

Catch records from the lower Nigliq region were limited. Based on 4 samples, arctic cisco CPUE averaged about 25 fish per net-day, while least cisco were uncommon in the catch.

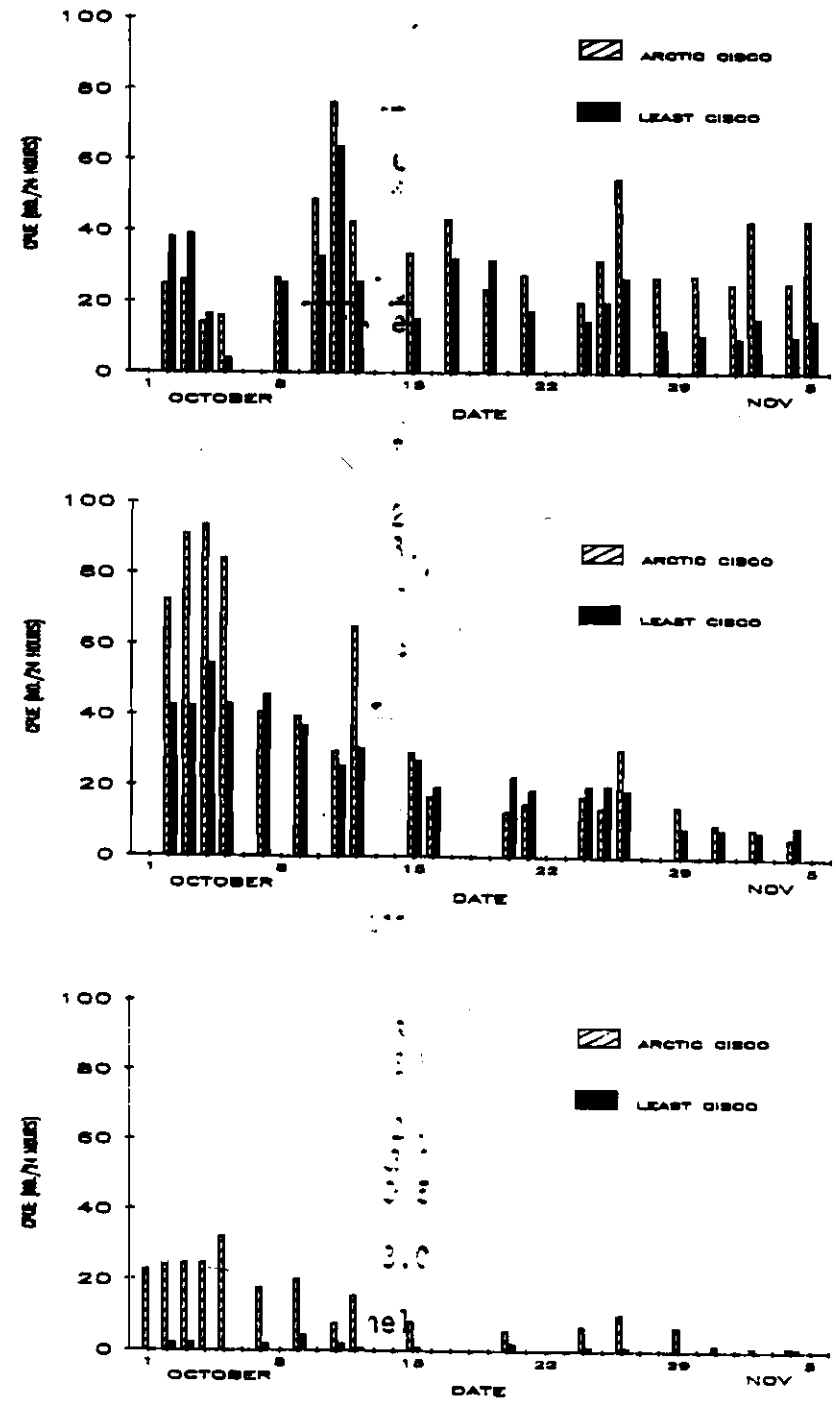
(c) Outer Colville Delta

Helmericks began fishing at the beginning of October and continued until early November on both the main (Kupigruak) and east channels of the outer Colville Delta. Arctic cisco CPUE at his main channel sites exhibited a steady decline in both 3.0- and 3.5-inch mesh nets (Figure 7). In 3.0-inch mesh nets, CPUE in early October was 60 fish per net-day, dropped to 35 fish per net-day in the second 10 day period, and in early November was about 8 fish per net-day (Table 8). Similarly, the CPUE for 3.5-inch mesh nets declined from an initial high of 24 fish per net-day to 9 fish per net-day in the second period, and further declined to about 1 fish per net-day in the final period.

In comparison, Fisherman A fished on the main channel from October 10 to 19, and during that period had an average CPUE of arctic cisco of about 100 fish per net-day in 2.5-inch mesh nets, 80 fish per net-day in 3.0-inch mesh nets, and 25 fish per net-day in 3.5-inch mesh nets. It should be noted that Fisherman A's nets were set downstream from the Helmericks nets. The downstream nets may have reduced catches in the upstream nets. However, factors such as net type, days between picking nets, the location of nets in the water column, and net mesh size can also affect gear efficiency.

Arctic cisco catch rates in Helmericks east channel nets were more consistent throughout the fishing season. The maximum CPUE was 40 fish per net-day during the second 10 days of October, while the minimum was 26 fish per net-day in early October.

CPUE of least cisco in the main channel showed a pattern similar to the CPUE of arctic cisco: Helmericks catch in 3.0-inch mesh nets declined from a high of 43 fish per net-day in early October to less than 10 fish per net-day in



Helmericks daily CPUE in Main and East channels by mesh size.

ENTRIX FIGURE 7

Table 8. Mean CPUE of arctic cisco and least cisco by fishermen, mesh size and 10 day period in the fall fishery in the outer Colville Delta.

Fisher-man	Mesh Size	Oct 1-10			Oct 11-20			Oct 21-30			Oct 31-Nov 5		
		CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
ARCTIC CISCO													
Main Channel													
Helmer-icks	3.0	60.5	25.3	18	35.4	22.4	17	21.9	14.3	22	8.0	2.8	15
	3.5	23.8	5.0	6	9.3	4.3	4	7.9	2.0	3	1.1	0.3	3
A[1]	2.5				96.8	50.8	6						
	3.0				80.3	33.5	21						
	3.5				25.3	14.1	14						
B[1]	3.0				53.8[2]	12.3	4						
East Channel													
Helmer-icks	3.0	26.4	12.9	30	40.3	17.9	22	33.6	16.2	28	33.8	15.1	17
LEAST CISCO													
Main Channel													
Helmer-icks	3.0	43.4	9.8	18	25.7	6.9	17	17.8	6.8	22	8.4	3.6	15
	3.5	1.9	1.7	6	1.4	0.6	4	0.6	0.5	3	0.1	0.1	3
A[1]	2.5				106.9	42.8	6						
	3.0				45.4	26.8	21						
	3.5				4.7	0.6	14						
B[1]	3.0				90	0	1						
East Channel													
Helmer-icks	3.0	26.2	14.2	30	29.9	17.9	22	17.9	8.7	28	12.7	5.6	17

[1] Data provided by J.C. George (North Slope Borough)
[2] Catch samples from one day only

CPUE = catch per unit effort
SD = standard deviation
N = number of catch samples

early November (Figure 7, Table 8). Fisherman A's CPUE of least cisco in 3.0-inch mesh nets (October 11 to 20) averaged 45 fish per net-day compared to 26 fish per net-day for Helmericks. The highest catch rate, however, was over 100 fish per net-day in 2.5-inch mesh nets. Few least cisco were captured in the 3.5-inch mesh nets.

East channel nets (3.0-inch mesh) had relatively constant average catches of slightly less than 30 least cisco per net-day through the first two 10 day periods in October, then catch rates decreased about 50 percent by early November.

While most nets were checked on a daily or every other day basis, sometimes nets remained unchecked for several days with apparent effects on CPUE (Table 9). In most cases, the average CPUE was considerably reduced for nets not checked every day, and the effect appeared to be most pronounced in the main channel.

3.2.5 Size Composition

(a) Arctic Cisco

The mean size of arctic cisco increased with larger mesh sizes in all areas, ranging from about 200 mm in 1.5-inch mesh nets to approximately 360 mm in 3.5-inch mesh nets (Table 10). The mean sizes of arctic cisco caught in the same mesh size appear to be similar in the different areas.

Length frequency histograms (Figures 8 and 9) show that few arctic cisco less than 300 mm in length were caught in 3.0-inch mesh nets. Few fish were less than 320 mm in 3.5-inch mesh nets, while 2.5-inch mesh nets caught fish 250 to 350 mm.

(b) Least Cisco

Least cisco exhibited a similar pattern of increasing mean length with increasing mesh size (Figures 10 and 11). Least cisco averaged 124 mm in the

Table 9. Average catch per unit effort (CPUE) of arctic and least cisco by soak time (days) in the outer Colville Delta.

	No. of Soak Days	Arctic Cisco CPUE	Arctic Cisco N	Least Cisco CPUE	Least Cisco N
<u>Main Channel</u>					
Mesh = 3.0 (in)	1	59.7	22	32.6	22
	2	22.5	30	22.3	30
	≥3	15.2	20	17.5	20
Mesh = 3.5 (in)	1	24.1	5	1.1	5
	2	8.5	7	1.3	7
	≥3	6.8	4	0.9	4
<u>East Channel</u>					
Mesh = 3.0 (in)	1	36.6	40	25.9	40
	2	32.3	41	20.5	41
	≥3	25.5	16	17.7	16

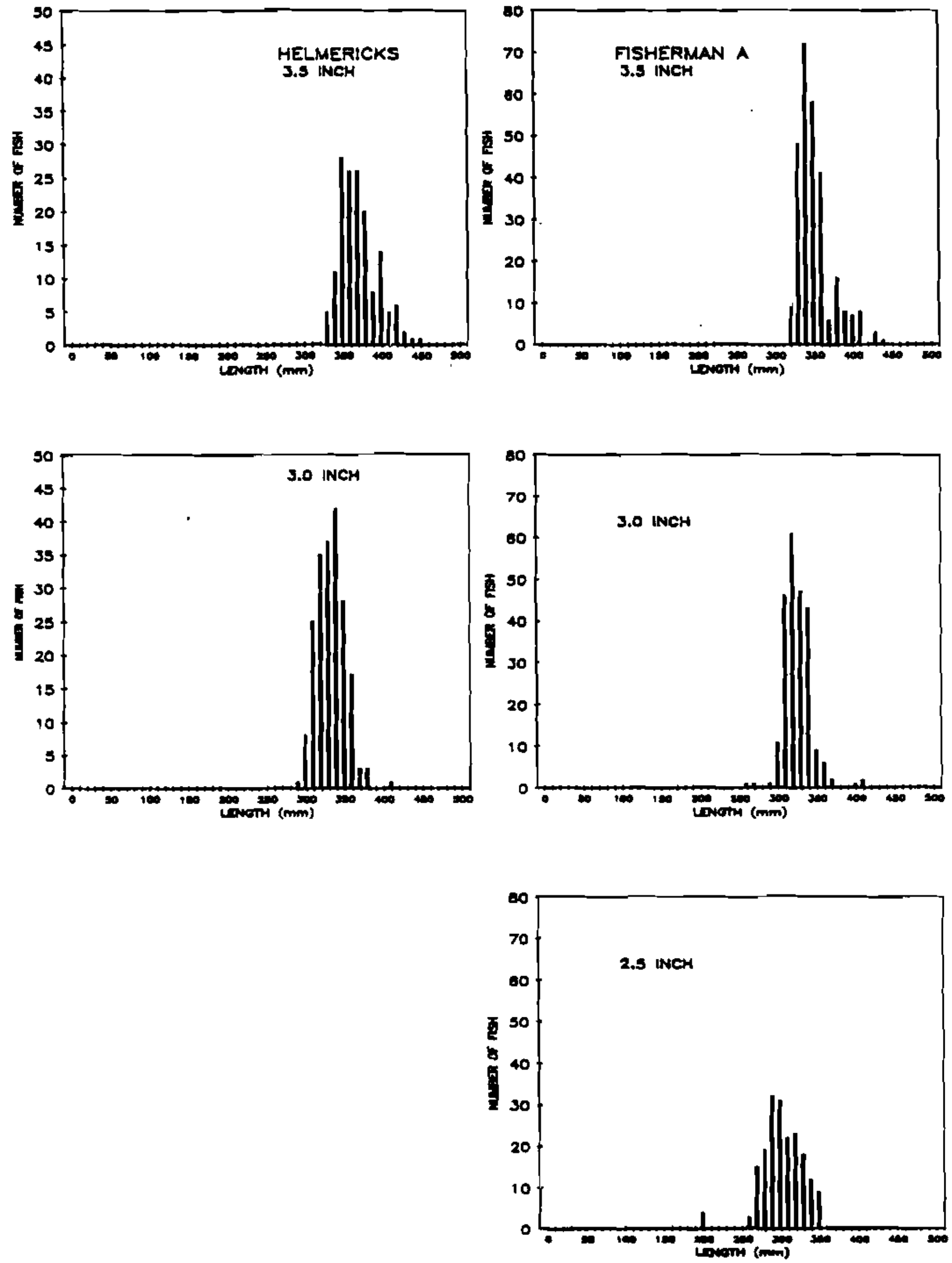
N = number of net checks.

Table 10. Mean length (mm) and estimated mean weight (g) by area and size.

Mesh Size (in)	Arctic Cisco Length (mm) Mean (Range)	Arctic Cisco Mean Weight (g)	Arctic Cisco N	Least Cisco Length (mm) Mean (Range)	Least Cisco Mean Weight (g)	Least Cisco N	Broad Whitefish Length (mm) Mean (Range)	Broad Whitefish Mean Weight (g)	Broad Whitefish N	Humpback Whitefish Length (mm) Mean (Range)	Humpback Whitefish Mean Weight (g)	Humpback Whitefish N
Upper Niglig												
0.75[1]	134 (134)		1	124.3 (95-245)	22	64						
1.50[1]	202.7 (150-325)	98	31	195.1 (155-300)	70	543	179.5 (160-195)	59	8			
2.25[1]	303.6 (240-370)	309	186	263.0 (214-315)	246	59	268.9 (207-355)	228	12			
3.00	335.8 (290-395)	423	199	311.4 (255-360)	314.2	65	309.3 (230-435)	352	92	312.5 (305-330)	329	6
3.25	352.6 (320-405)	496	29									
3.50	361.2 (300-425)	538	230	324.3 (275-375)	363.1	7	363.0 (345-375)	575	5			
Outer Colville Delta												
Helmericks												
3.0	333.6 (290-410)	415	200	318.4 (260-370)	333	200				338.9 (290-440)	441	100
3.5	371.3 (330-450)	593	153	349.7 (320-370)	450	37	322.1 (290-360)		39	398.8 (330-470)	730	64
Fisherman A												
2.5	303.5 (201-356)	310	188	288.6 (240-348)	244	290						
3.0	329.8 (258-414)	400	231	323.1 (245-376)	350	183						
3.5	354.6 (320-446)	510	277	336.3 (283-385)	401	27				397.0 (330-444)	725	9

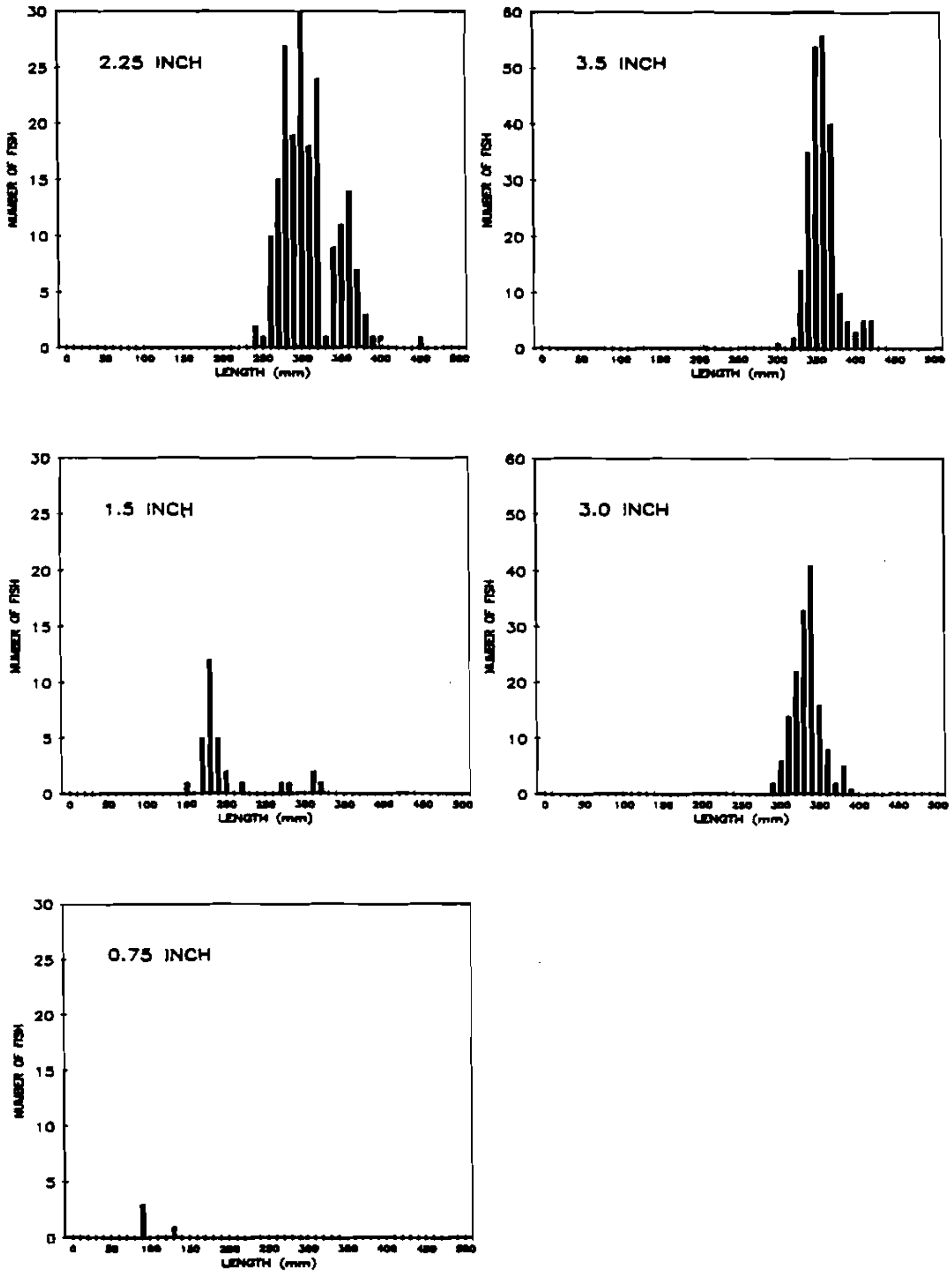
[1]Test fishing only

N = number of fish in sample



Length frequencies of arctic cisco caught by Helmericks and Fisherman A by mesh size.

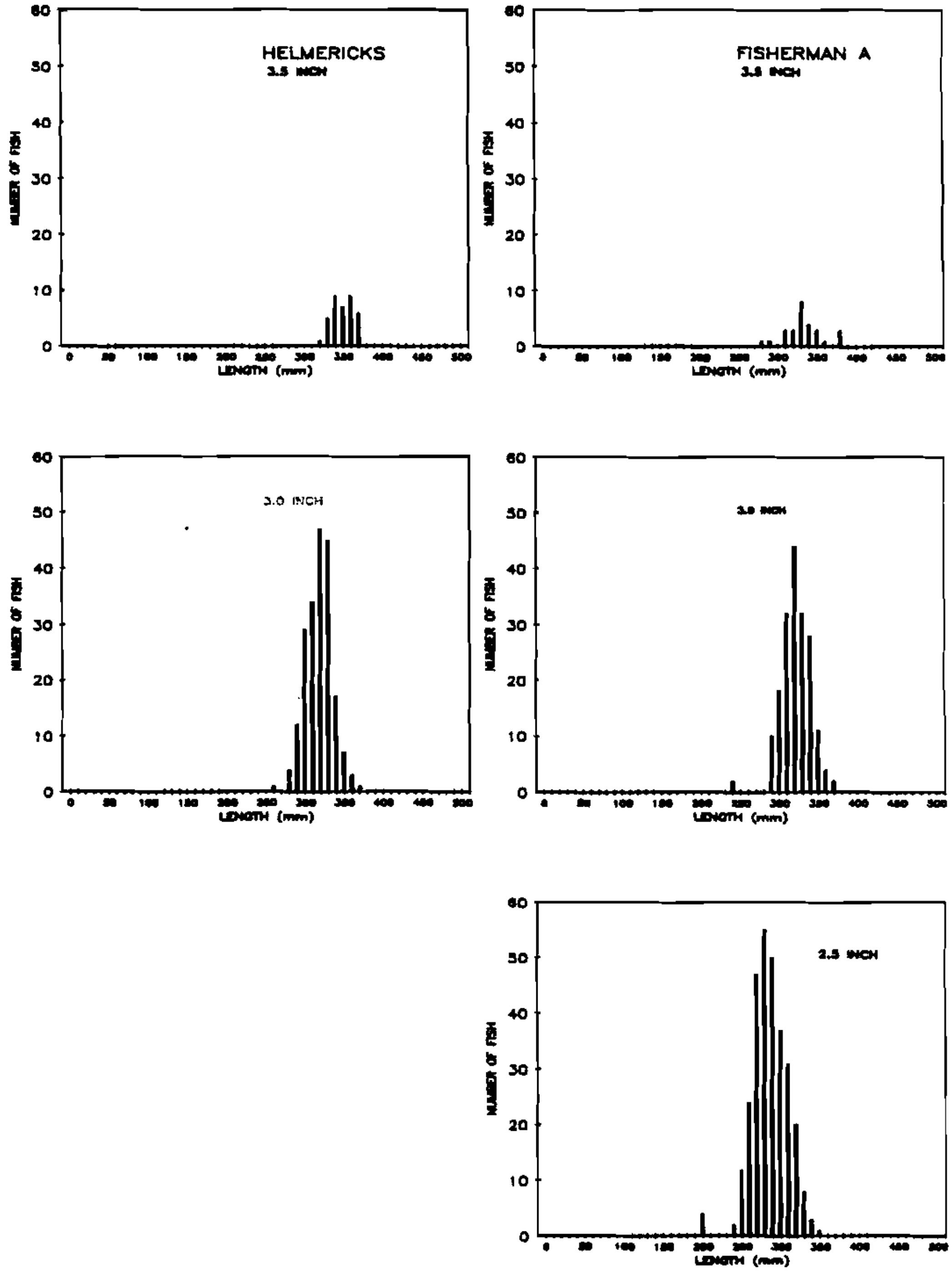
ENTRIX | FIGURE 8



Length frequencies of arctic cisco caught in Nigliq Channel by mesh size.

ENTRIX

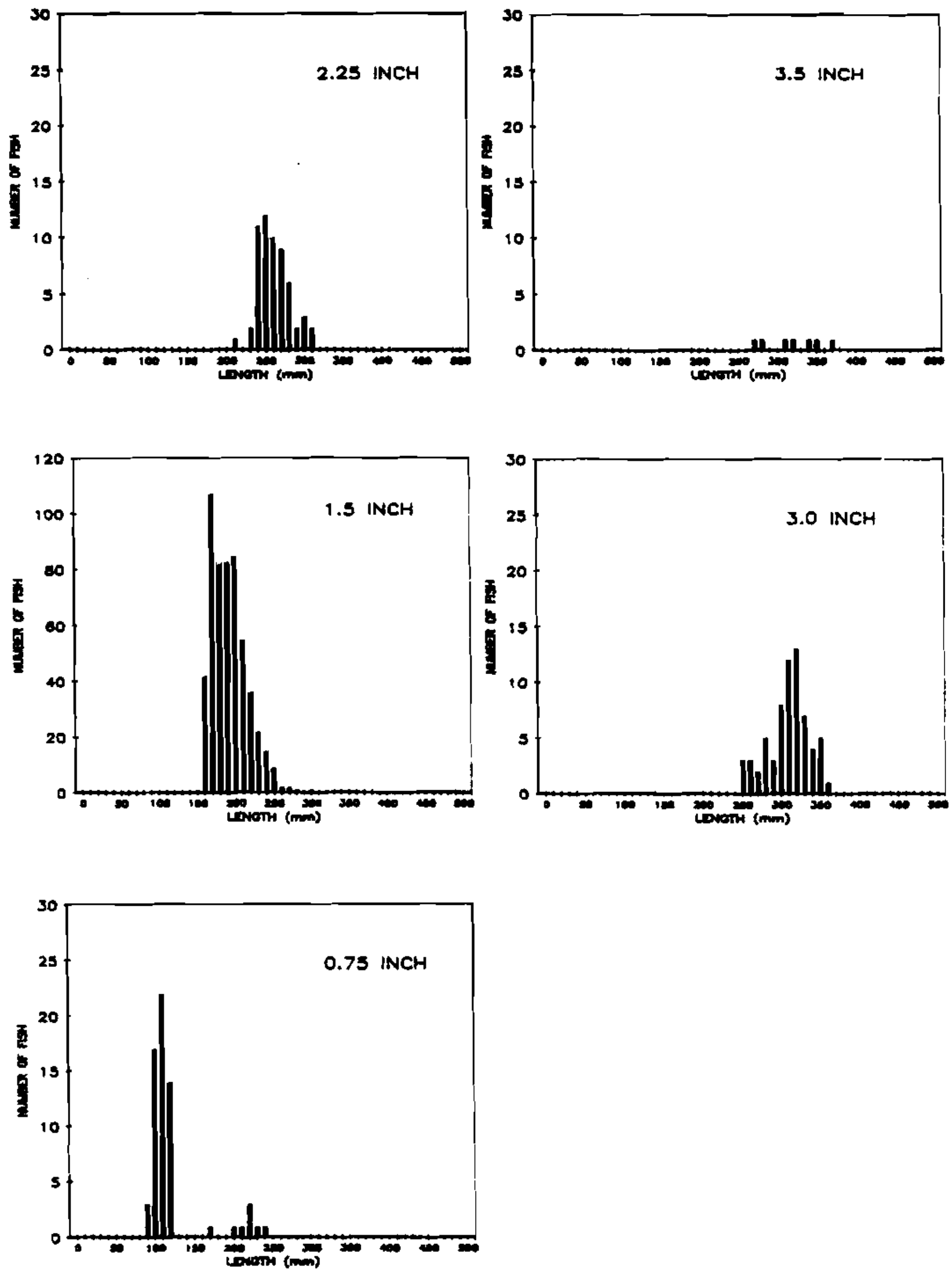
FIGURE 9



Length frequencies of least cisco caught by Helmericks and Fisherman A by mesh size.

ENTRIX

FIGURE 10



Length frequencies of least cisco caught in Nigliq Channel by mesh size.

ENTRIX | FIGURE 11

smallest mesh size nets (0.75 inch) and about 330 mm in 3.5-inch mesh nets (Table 10). Few least cisco smaller than 300 mm occurred in the catch from 3.0-inch nets, but the majority of the least cisco in the catch from 2.5-inch nets were less than 300 mm.

(c) Broad Whitefish

Broad whitefish had mean lengths of about 275 and 300 mm in 2.25- and 3.0-inch mesh in upper Nigliq nets and about 320 mm in 3.5-inch mesh nets in the outer Colville Delta. Most broad whitefish captured in the fall fishery were less than 350 mm in length.

(d) Humpback Whitefish

Humpback whitefish on the outer Colville Delta averaged 340 and 400 mm respectively in 3.0- and 3.5-inch mesh nets, and most ranged between 300 and 450 mm.

3.2.6 Tag Returns

A total of 1,704 tagged fish were recaptured in the fall fishery: 1,543 tagged fish in the outer Colville Delta, 82 tagged fish in the lower Nigliq, and 79 tagged fish in the upper Nigliq (Table 11). Over 60 percent of the recaptured fish were tagged and released by the 1985 Endicott Project.

About 25 percent of the recaptured tagged fish were arctic cisco. Recaptures on the upper Nigliq of fish tagged in 1985 were almost 70 percent arctic cisco, while on the lower Nigliq recaptures were 100 percent arctic cisco. On the outer Colville Delta, however, least cisco accounted for 60 to 80 percent of the recaptured fish tagged in 1985.

About 33 percent of recaptures of all tagged fish were released in previous years. Approximately 37 percent of the least cisco recaptures were from previous years, compared to only 19 percent of the arctic cisco.

Table 11. Summary of tag returns from the fall fishery by species, area, and year of release.

Area	Arctic Cisco				Least Cisco				Broad Whitefish				Humpback Whitefish				Unknown Species
	END85	COL85	WCC84	pre-84	END85	COL85	WCC84	pre-84	END85	COL85	WCC84	pre-84	END85	COL85	WCC84	pre-84	
Outer Colville Delta																	
Helmericks	147	3	42	0	436	9	316	84	6	0	2	0	2	1	0	1	11
Fisherman A	23	0	5	0	36	2	14	5	0	0	0	0	0	0	0	0	
Fisherman B	61	1	*	*	241	8	*	*	0	1	*	*	0	0	*	*	
Fisherman C	14	0	2	0	37	2	24	0	0	0	1	0	0	1	0	0	5
Upper Nigliq	32	1	16	1	11	0	10	0	6	1	1	0	0	0	0	0	
Lower Nigliq	60	0	15	0	0	0	4	0	1	1	1	0	0	0	0	0	
Total	337	5	80	1	761	21	368	89	13	3	5	0	2	2	0	1	16

*Only 1985 tags were returned

END85 = Endicott Project 1985
COL85 = Colville Project 1985
WCC84 = Lisburne/Waterflood 1984

The percentage of fish with Endicott 1985 tags in the total catch of arctic cisco for both Helmericks and Fisherman A on the outer Colville Delta was 0.6-0.7 percent (about one tag for every 150 arctic cisco caught). The corresponding value for least cisco was 1.9-2.5 percent (about one tag for every 45 least cisco caught).

3.2.7 Estimated Total Catch

Total catch was estimated from CPUE data for the same mesh size and period, when available (Tables 12 and 13), and from tag recapture data (Table 14).

(a) Upper Nigliq

The catch data obtained from the upper Nigliq channel fishery did not provide complete coverage of all mesh sizes during each 10 day interval, and, in addition, the number of samples used to estimate average CPUE was often quite limited. Consequently, total catch was estimated from the total CPUE for all mesh sizes combined for each 10-day period. The estimated total catch during the fall fishery on the upper Nigliq was about 18,000 arctic cisco, with the greatest number caught during late October and early November. Approximately 2,000 least cisco and 1,500 broad whitefish were also caught.

Total catch was also estimated from tag recapture data, using the proportion of recaptured (Endicott 1985 tags only) fish in the combined catches of Helmericks and Fisherman A on the lower Colville delta as the standard factor. This assumes that the percentage of tagged fish in the population available to the fishery on the Nigliq channel is the same as on the lower Colville and that the return rate of recaptured tags is similar. The estimates from this technique are considerably lower than those obtained using the CPUE data: approximately 5,200 arctic cisco and 450 least cisco.

(b) Lower Nigliq

Limited catch data were available from the lower Nigliq fishery, but catch rates of arctic cisco were known to be much higher than those reported from

Table 12. Estimated harvest in the upper Nigliq channel in the fall fishery based on total sample CPUE by 10 day interval.

Sampling Interval	Effort (net-day) Total	Sample	Sample Catch ARCS	LSCS	BWF	Estimated Catch ARCS	LSCS	BWF
10/1-10/10	78.7	30.8	120	185	275	307	473	703
10/11-10/20	227.0	48.6	483	177	126	2,256	949	676
10/21-10/30	260.7	13.7	330	12	2	6,280	228	38
10/31-11/9	178.0	8.1	172	9	0	3,780	198	0
11/10-11/20	125.1	12.2	513	13	5	5,260	133	51
Totals	869.5	113.4	1,618	396	408	17,883	1,981	1,468

ARCS = Arctic cisco

LSCS = Least cisco

BWF = Broad whitefish

Table 13. Estimated total catch of arctic cisco (ARCS) and least cisco (LSCS) by area in the fall fishery based on total CPUE data.

Fisherman	Total Effort (net-days)	Estimated Catch ARCS	Estimated Catch LSCS
Outer Colville Delta			
Main Channel			
Helmericks[1]	480.0	10,321	8,657
A[1]	49.5	3,141	1,803
B	268.4	9,256	6,895
East Channel			
Helmericks[1]	427.5	13,357	8,939
C	225.0	7,906	5,245
Upper Niqliq	869.5	17,878	1,871
Lower Niqliq	339.7	8,500	0
Total	2,659.6	70,359	33,410

[1]actual reported catch

Table 14. Estimated total catch of arctic cisco (ARCS) and least cisco (LSCS) by area in the fall fishery based on tag return data.

Fisherman	Number of Tags[1] ARCS	Number of Tags[1] LSCS	Estimated Total Catch ARCS	Estimated Total Catch LSCS
Outer Colville Delta				
Helmericks	147	436	23,678	17,596
A	23	36	3,141	1,803
B	61	241	9,623	9,905
C	14	37	2,209	1,521
Upper Nigliq	32	11	5,048	452
Lower Nigliq	60	0	9,466	0
Total	335	751	53,165	31,277

[1]Endicott 1985 tags only

the upper Nigliq fishery. Using an estimated CPUE of 25 arctic cisco per net-day (which is probably conservative), a total catch of 8,500 arctic cisco was estimated. Tag recapture data yield an estimate of about 9,750 arctic cisco and 0 least cisco.

(c) Outer Colville Delta

Complete catch and effort information was obtained from two of the four primary fishing groups on the outer Colville Delta, and these data were used to estimate the total catch by 10 day interval for the other two groups (Appendix Table A-6).

Complete catch records were provided by two of the three fishermen on the main (Kupigruak) channel of the outer Colville Delta. Helmericks' total catch was 10,321 arctic cisco and 8,657 least cisco (from five 3.0-inch and one 3.5-inch mesh nets). Helmerick's CPUE data for 3.0-inch mesh for each 10 day period (Table 8) were used to estimate the total catch for Fisherman B. The CPUE data yield estimates of about 9,256 arctic and 6,895 least cisco (Table 13). Based on the tag recapture data from Helmericks and Fisherman A, estimates of about 9,623 arctic cisco and 9,905 least cisco were obtained.

On the east channel of the outer Colville Delta, both Helmericks and Fisherman C used 3.0-inch mesh nets exclusively and their period of fishing was similar. Based on CPUE data for 10 day periods from Helmericks and estimated total effort by 10 day periods for Fisherman C, total catch for Fisherman C was an estimated 7,906 arctic cisco and 5,245 least cisco (Table 13). Using total catch and total effort for the entire fishing season, the estimates are slightly lower (7,000 arctic cisco and 4,700 least cisco). Based on total number of tagged fish recaptures (assuming the same proportions of tagged to untagged fish by species as Helmericks) and percentage of tagged fish that were arctic cisco, estimates were about 2,209 and 1,521 for arctic cisco and least cisco, respectively.

3.2.8 Estimates of Total Weight

Total weight of the catch by species from the outer Colville Delta was estimated from the average weights of fish from the different mesh sizes used (Table 15). Since the necessary data were lacking from the upper and lower Nigliq to break down the catch by mesh size, the average weight from 3.0 inch mesh nets was used to estimate weight of the total catch in these areas.

3.2.9 Population Estimates

The recapture of a substantial number of tagged cisco in the fall fishery allows an estimate of the total number of fish available to the fishery. Since similar data are available for both 1984 and 1985, changes between the two years can be evaluated. The method for estimating the population size is the same as used by Craig and Haldorson (1981) for Colville River arctic and least cisco and is based on analysis techniques described in Ricker (1975). Key data are: (1) the number of tags released, (2) the number of tags recaptured, and (3) the number of fish examined for tags. With these data, the Peterson estimator can be used to generate an estimate of catchable fish. One adjustment must be made to the total number of tags released. Fish used for tagging were captured by fyke net whereas tagged fish were recaptured by gill net. Gill nets are substantially more selective for size than are fyke nets (Figures 12 and 13). Therefore, the number of tags released must be corrected to the number of "catchable" tags in gill nets. The correction factor is calculated as demonstrated in Appendix Tables 2 and 3.

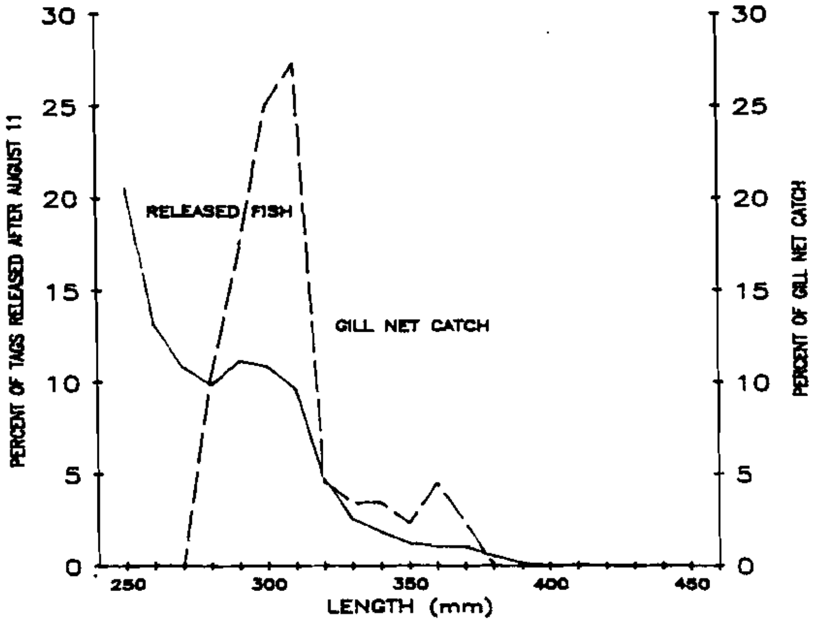
A key assumption in using the Peterson estimator is that tagged fish are well-mixed in the harvested stock. Data on tag returns from 1985 indicate that substantial mixing does occur. There are many cases where tagged arctic cisco released from the same release event (i.e. from the same station on the same day) are caught at widely separated locations (Table 16). There was also separation within the areas that is not demonstrated in the table. A similar pattern occurs with least cisco, but since least cisco were infrequently caught in the Nigliq Channel, the pattern is not as clear. For least cisco,

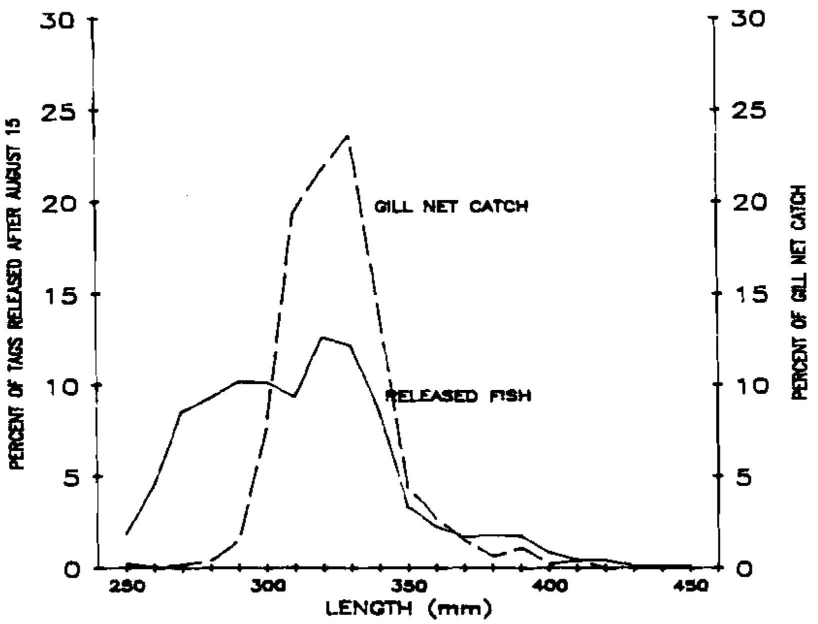
Table 15. Estimated total weight of arctic cisco and least cisco by area in fall fishery based on catch estimated by CPUE data.

Fisherman	Mesh Size (in)	Arctic Cisco: Estimated Catch[1]	Arctic Cisco: Estimated Average Weight (kg)	Arctic Cisco: Estimated Weight of catch (kg)	Least Cisco: Estimated Catch[1]	Least Cisco: Estimated Average Weight (kg)	Least Cisco: Estimated Weight of catch (kg)
Outer Colville Delta							
Main Channel							
Helmericks	3.0	9,474	.41	3,884	8,556	.32	2,738
	3.5	847	.55	466	101	.34	34
A	2.5	682	.31	211	692	.29	201
	3.0	1,986	.41	814	1,035	.32	331
	3.5	473	.55	260	76	.34	26
B	3.0	9,256	.41	3,795	6,895	.32	2,206
East Channel							
Helmericks	3.0	13,357	.41	5,476	8,939	.32	2,860
C	3.0	7,906	.41	3,241	5,245	.32	1,678
Upper Niqliq	(3.0)[2]	17,878	.41	7,330	1,871	.32	599
Lower Niqliq	(3.0)[2]	8,500	.41	3,485	0	.32	0
Total		70,359		28,962	33,410		10,673

[1]estimated catch based on CPUE data

[2]used average weight for 3.0 in. mesh.

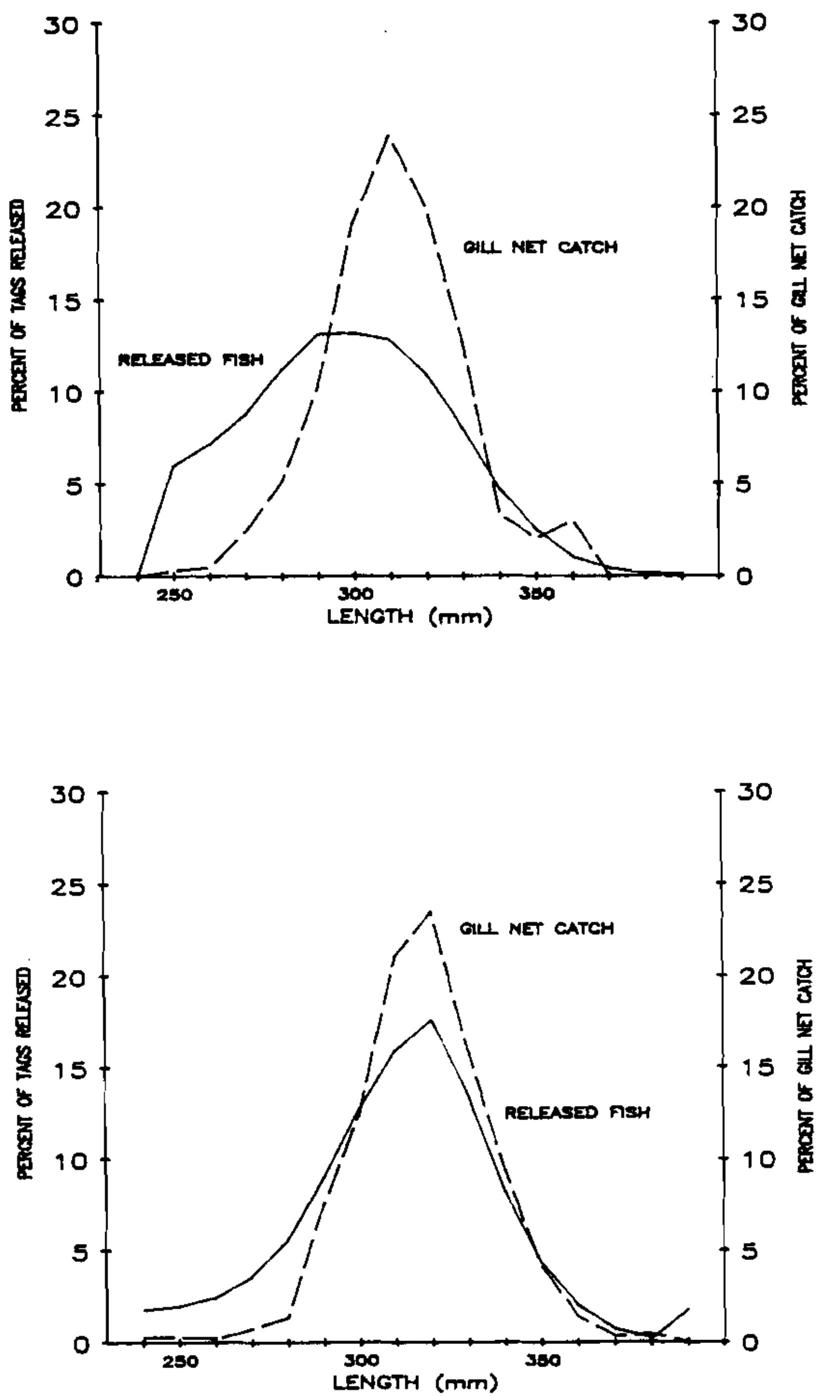




Length distribution of tagged and released arctic cisco compared to lengths of arctic cisco caught in 3.0 inch gill nets (top-1984, bottom-1985).

ENTRIX

FIGURE 12



Length distribution of tagged and released least cisco compared to lengths of least cisco caught in 3.0 inch gill nets (top-1984, bottom-1985).

ENTRIX | FIGURE 13

Table 16. Number of cases in which tagged arctic cisco released on the same day at the same station in the Endicott study area were recaptured at different areas in the Colville Delta.

Case[1]	All Recaptures in Nigliq	All Recaptures in Main Delta	Recaptures in Both Areas
3 recaptures	0	7	7
4 recaptures	0	2	4
5 recaptures	0	1	4
6+ recaptures	0	0	9

[1]Number of recaptures from the same release event (i.e. from fish released the same day at the same station).

there were 11 cases where two or more recaptures from the same release event were recaptured in both the Nigliq and Main Delta. The indication is that tagged fish released together disperse to various parts of the delta and are thus mixed with the non-tagged fish.

The estimates of catchable arctic cisco and least cisco are presented in Tables 17 and 18. The number of catchable fish was converted to number of fish greater than 250 mm (240 mm for 1985 least cisco) by applying the correction factor from Appendix Tables A-7 and A-8 to the number of catchable fish.

There is an estimated 16.5 percent increase in the number of catchable arctic cisco between 1984 and 1985 (Table 19). Concurrently, the estimated number of arctic cisco greater than 250 mm only increased by 9.9 percent. Figure 12 illustrates the reason for these annual differences--in 1984 there was a much larger pool of uncatchable arctic cisco, which by 1985 had grown large enough to be captured by gill nets. In 1985 there is still a substantial percentage of fish that will enter the fishery in 1986. The two modes apparent in the 1985 released fish length frequency likely represent the 1978 year-class (320-340 mm) and 1979 year-class (270-310 mm) as described in previous studies (Moulton and Fawcett 1984, Moulton et al. 1985).

The estimated number of catchable least cisco shows a 21 percent decrease from 1984 to 1985 (Table 19), indicating that the number of adult least cisco is in a period of decline.

3.2.10 Effects of Fishing on Mortality Rates

That portion of arctic and least cisco stocks removed by fishing was estimated for the fall fishery at the Colville Delta. Estimates of fishing mortality were based on the estimates of harvest (Table 13) and catchable fish (Table 17 and 18). In 1985, approximately 70,400 arctic cisco were harvested during the fall fishery from an estimated pool of 1,139,000 catchable arctic cisco. This indicates that annual fishing mortality on arctic cisco stocks was about 6 percent in 1985. About 33,400 least cisco were caught in the fall fishery

Table 17. Estimates of the number of arctic cisco available to 3 inch mesh gill nets and number greater than 250 mm in the Colville region.

	1984		1985	
	Number	95% Confidence Interval	Number	95% Confidence Interval
Number of Tags Released (fish >250 mm)	5,840[1]		11,695[1]	
Number of "Catchable" Tags (M)	(5840)(1-.462)[2] = 3142		(11,695)(1-.379)[2] = 7263	
Number of Tags Caught (R)	88[3]		170[4]	
Catch Sampled (C)	27,686[3]		26,819[4]	
Estimate of Catchable Fish (N)[5]	978,000	798,000-1,209,000	1,139,000	979,000-1,325,000
Estimate of Fish Greater than 250 mm	1,430,000	1,167,000-1,768,000	1,571,000	1,350,000-1,827,000

[1] From Envirosphere (1986)

[2] Correction Factor from Appendix Table A-7

[3] From Helmericks 1984 catch data

[4] From Helmericks 1985 catch data and George and Kovalsky (1986)

[5] From $N = \frac{(M + 1)(C + 1)}{(R + 1)}$

where M = number of fish tagged

C = catch sampled

R = number of recaptured tags

Table 18. Estimates of the number of least cisco available to 3 inch mesh gill nets and number greater than 250 mm in the Colville region.

	1984		1985	
	Number	95% Confidence Interval	Number	95% Confidence Interval
Number of Tags Released (fish >250 mm)	14,126[1]		9915[1]	
Number of "Catchable" Tags (M)	$(14,126)(1-.302)^2$ = 9860		$(9915)(1-.173)^2$ =8200	
Number of Tags Caught (R)	304[3]		472[4]	
Catch Sampled (C)	13,076[3]		19,186[4]	
Estimate of Catchable Fish (N)[5]	423,000	378,000-472,000	333,000	304,000-364,000
Estimate of Fish Greater than 250 mm	551,000	492,000-615,000	391,000	357,000-427,000

[1] From Envirosphere (1986)

[2] Correction Factor from Appendix Table A-8

[3] From Helmericks 1984 catch data

[4] From Helmericks 1985 catch data and George and Kovalsky (1986)

[5] From $N = \frac{(M + 1)(C + 1)}{(R + 1)}$ where M = number of fish tagged

C = catch sampled

R = number of recaptured tags

Table 19. Estimate of changes in the number of arctic and least cisco in the Colville region.

	1984	1985	Percent Change 1984 to 1985
Arctic Cisco			
Number of Catchable Fish[1]	978,000	1,139,000	+16.5
Number Greater Than 250 mm	1,430,000	1,571,000	+9.9
Least Cisco			
Number of Catchable Fish[1]	423,000	333,000	-21.3
Number Greater Than 250 mm	551,000	391,000	-29.0

[1] Based on vulnerability to 3 inch stretched mesh gill nets (see Appendix Tables A-7 and A-8)

from an estimated pool of 333,000 catchable least cisco, resulting in fishing mortality of approximately 10 percent.

The decline of tag recaptures from a given release over subsequent years is a measure of total annual mortality (Ricker 1975). Table 20 shows tag and recapture data for least cisco in the Helmericks fishery over a period of six years. The percent decrease per year of tagged least cisco in the Helmericks fishery after the initial year of release is presented in Table 21. The annual decrease in tag recaptures of least cisco for the first four years after release averages 40 percent, which indicates that total annual mortality for adult least cisco in the Colville Delta was about 40 percent. By the fifth year the number of returns is too low to be of much value. Since annual fishing mortality in 1985 was about 10 percent, the remaining 30 percent of the total annual mortality is attributed to natural mortality.

Tag and recapture data for arctic cisco in the Helmericks fishery over a six year period are presented in Table 22. The percent decrease per year of tagged arctic cisco in the Helmericks fishery after the initial year of release is shown in Table 23. The dramatic decline in tag recaptures of arctic cisco after the year of release (58 percent after the first year, 84 percent after the second year) would indicate that annual mortality for arctic cisco in the Colville Delta may be quite high if this species remains in the Colville region for its entire life cycle. However, arctic cisco utilizing the Colville Delta are thought to leave the area when they mature sexually and return to the Mackenzie River for spawning. Thus, the estimated annual mortality for arctic cisco in the Colville Delta is not meaningful if almost all arctic cisco leave the area.

Table 20. Number of tagged least cisco recaptured annually in the Helmericks fall fishery since 1980.

Release Year	Release Organization[1]	Number of Tags Released	Number Recaptured In: 1980	1981	1982	1983	1984	1985
1980	LGL	1067	32	20	8	12	3	5
1981	LGL	6157		90	155	159	52	45
1982	LGL	1798			155	48	22	20
	WCC	2131			88	56	14	11
1983	---	0				---	---	---
1984	WCC	14,126					304	318
1985	ENV	9915						436

[1] LGL = LGL Ecological Research Associates

WCC = Woodward-Clyde Consultants

ENV = Envirosphere

Data on number of LGL tags recaptured in 1980-1983 provided by B. Gallaway, LGL

Table 21. Decrease in tagged least cisco captured in the Helmericks fishery after initial release year.

Release Year	Percent Recaptured After Being At-Large					
	0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
1980	3.0	1.9	0.7	1.1	0.28	0.47
1981	1.4	2.5	2.6	0.84	0.73	
1982 (LGL)	8.6	2.7	1.2	1.1		
(WCC)	4.1	2.6	0.66	0.52		
1983	---	---	---			
1984	2.2	2.3				
1985	4.4					
Mean:	3.95	2.40	1.29	0.89	0.51	0.47
SD:	2.54	0.32	0.91	0.28	0.32	---
Percent Decrease Per Year	39.2	46.3	31.0	42.7	7.8	

Table 22. Number of tagged arctic cisco recaptured annually in the Helmericks fall fishery since 1980.

Release Year	Release Organization[1]	Number of Tags Released	Number Recaptured In: 1980	1981	1982	1983	1984	1985
1980	LGL	229	10	6	0	0	0	0
1981	LGL	1,756		62	4	4	0	0
1982	LGL	439			8	4	2	0
	WCC	435			12	4	0	0
1983	---	0				---	---	---
1984	WCC	5,840					88	42
1985	ENV	11,695						147

[1] LGL = LGL Ecological Research Associates

WCC = Woodward-Clyde Consultants

ENV = Envirosphere

Data on number of LGL tags recaptured in 1980-1983 provided by B. Gallaway, LGL

Table 23. Decrease in tagged arctic cisco captured in the Helmericks fishery after initial release year.

Release Year	Percent Recaptured After Being At-Large					
	0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
1980	4.4	2.6	0	0	0	0
1981	3.5	0.23	0.23	0	0	
1982 (LGL)	1.8	0.91	0.46	0		
(WCC)	2.8	0.92	0	0		
1983	---	---	---			
1984	1.5	0.72				
1985	1.3					
Mean:	2.55	1.08	0.17	0	0	0
SD:	1.23	0.90	0.22			
Percent Decrease Per Year		57.6	84.3	100	---	---

4.0 DISCUSSION

4.1 SUMMER FISHERY

The primary target of the summer fishery was large broad whitefish. Catch rates were generally low (2-5 fish per net-day), and fishing effort was spread out over a large area. Although most of the summer fishery for broad whitefish took place on the Nigliq Channel, considerable fishing took place on the upper Colville (primarily Tiragruak), particularly during August. Due to the greater distances involved, most people fishing on the upper Colville camped at Tiragruak or further upriver. Fishing on the upper Colville was restricted in mid to late summer by the shallowness of the channel from Nuiqsut to the main river channel. If the channel is dredged so that passage is unimpeded during low water, it is likely that fishing effort would increase on the upper Colville.

Total fishing effort was greatest on the Nigliq channel, approximately 1,000 net-days, compared to 150 net-days on the upper Colville and fewer than 50 net-days on Fish Creek. However, due to the difficulties in keeping track of fishing activity in more remote areas, it is possible that effort was underestimated by 25-30 percent for the upper Colville and Fish Creek.

Large mesh (4.5-5.5 inch stretched mesh) gill nets were the main gear in use in the summer fishery. Frequently panels of more than one mesh size were used in the same net, making it difficult to assess differences in catch between mesh sizes.

The largest catches of broad whitefish occurred primarily early in the summer, although catches continued until the end of the fishing season. The high catch rates early in the summer likely represent a migration of mature broad whitefish to upriver spawning areas while those returning in mid to late summer were mostly non-spawning mature fish.

There were some differences in catch composition between areas. The upper Nigliq catch was almost exclusively broad whitefish, while char were an important component of the catch on the upper Colville.

George and Nageak (1985), in a preliminary study of the Nuiqsut fishery, estimated that at least 1,000 broad whitefish were taken from all areas in the 1984 summer fishery. While this is considerably less than the estimated catch from 1985, the difference is mainly due to the total fishing effort reported, since estimated catch rates were comparable. Whether this apparent difference in total effort is due to an actual increase in fishing effort in 1985 is difficult to determine. At any event, it raises the point that the amount of fishing effort in a fishery such as this may vary a great deal from year to year. For example, as Craig and Haldorson (1981) suggest, the level of employment of Nuiqsut residents may influence the number of people actively involved in the fishery.

4.2 FALL FISHERY

The fall fishery was quite different from the summer fishery both in the greater concentration of fishing effort and in the much higher catch rates. The most intensive effort was on the outer Colville Delta, where four families accounted for about 1,450 net-days of fishing effort from early October to early November. The Nigliq channel had almost as much total fishing effort (1,250 net-days), but about 25 groups were involved in the fishery and it extended into late November.

Differences in catch rates and catch composition were noticeable between the Nigliq channel and the outer Colville Delta. Small broad whitefish were the dominant component of the catch on the upper Nigliq in early October, and, while they were present in outer Colville Delta catches they disappeared from the catch earlier. The upper Nigliq average catch rates for arctic cisco were relatively low (5-10 per net-day) until late October to late November when they ranged from 20-50 per net-day (comparable to catch rates on the outer Colville Delta). In addition, least cisco were present in much lower abundance in the Nigliq channel throughout the fishing season, although small least cisco were caught in large numbers in the small mesh test nets. The absence of adult least cisco may be related to the increased salinity in the Nigliq channel or to spawning activity elsewhere. By late October, salinities of 15 ppt were observed. Least cisco are apparently less tolerant of marine water than arctic cisco (Moulton, Fawcett and Carpenter 1985), although the presence of numerous small least cisco may indicate that some other factor was involved. This period (September/October) is also the main spawning period for least cisco. Ripe and spent least cisco were observed in the sampled catch at the upper Nigliq sampling area indicating that this area is used for spawning. It is possible that greater concentrations of spawning adults occurred elsewhere.

Within the outer Colville Delta, differences were noted between the catch patterns on the main (Kupigruak) channel and the east channel. Although average CPUE of arctic cisco on the main channel was much higher than on the east channel early in the season, it declined steadily until the end of fishing while catch rates in the east channel remained relatively constant. A similar, though less marked, pattern was observed in least cisco catch rates. These differences may have been the result of the greater fishing effort on the main channel compared to the east channel.

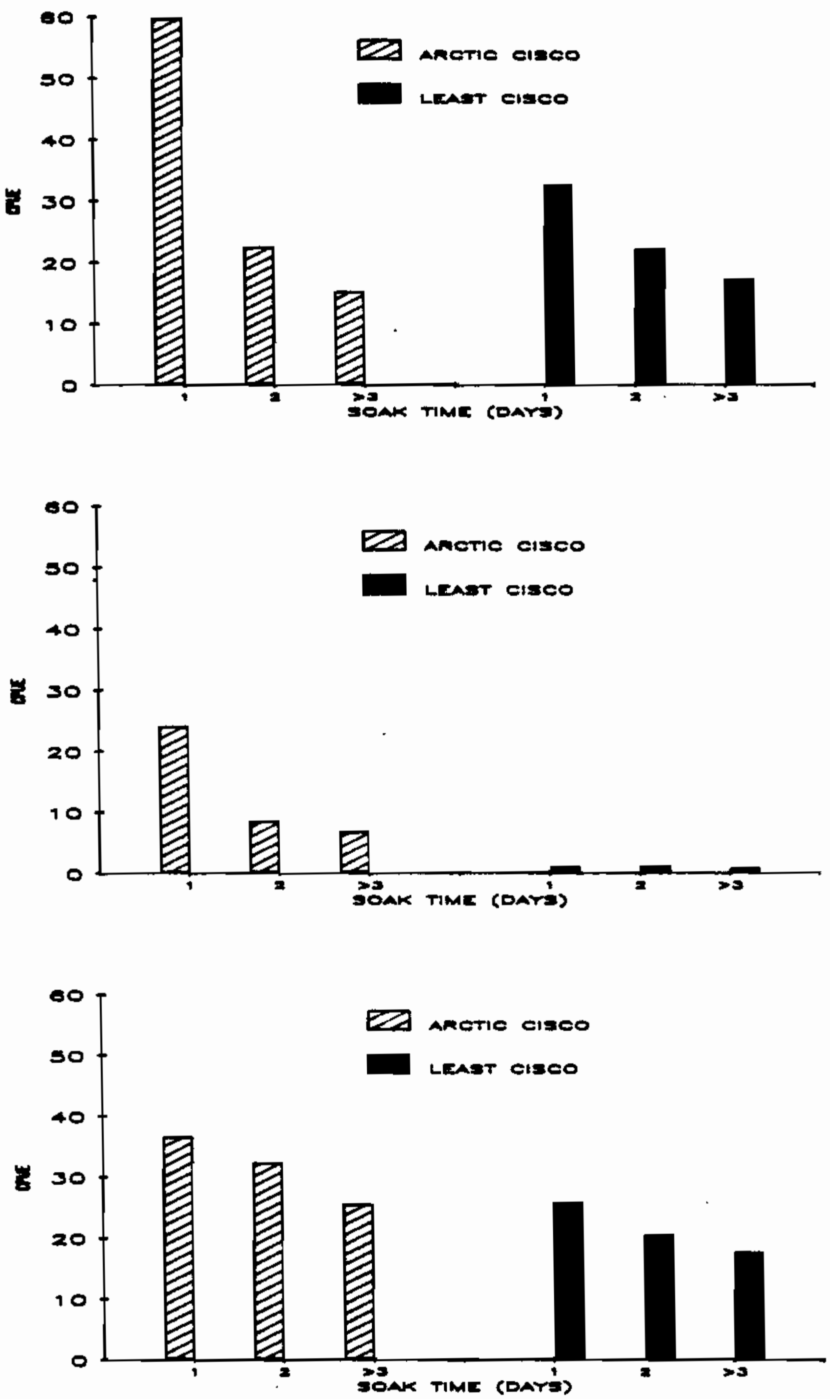
Other data also indicate that the number of nets in an area affects catch rates. On the upper Nigliq, average CPUE of arctic cisco in 3.0 inch mesh nets was considerably lower than CPUE for both smaller and larger mesh sizes. Since 3.0 inch mesh nets were by far the most common, it is possible that the other mesh sizes had less competition for small and large arctic cisco, thus accounting for their higher catch rates. On the outer Colville Delta, both Helmericks (1985) and Fisherman B (cited in George and Kovalsky 1986) noted that arctic cisco CPUE declined when another fisherman set nets downstream of their nets. No catch data were available from Fisherman B, but Helmericks' average CPUE of arctic and least cisco dropped markedly when Fisherman A set his nets further downstream. During the same time period Fisherman A's catch rate was high and Helmericks' catch rate on the east channel increased. In addition, George and Kovalsky (1986) reported that their downstream station had consistently higher catch rates than their other station about 0.4 km upstream. While this evidence is circumstantial, it indicates that intense effort in a restricted area does reduce the density of fish. As more fishermen enter the fishery, the catch rate will decline.

Another factor that had a considerable effect on catch rate was the length of time nets were allowed to fish between checking. Nets left unchecked for more than 24 hours had a much lower CPUE than nets picked every day (Figure 14). In some instances, however, the weather conditions that made it impossible to check the nets may have also influenced fish distributions.

Net selectivity due to mesh size, which was not an important factor in the summer fishery, strongly affected both species and size composition of the catch in the fall fishery. Larger mesh sizes reduced the percentage of least cisco in the catch. For example, in Helmericks 3.0 inch mesh nets, arctic and least cisco catches were about equal, while in 3.5 inch mesh nets, arctic cisco accounted for about 90 percent of the catch. In addition, larger mesh nets caught fewer small fish and greater numbers of large fish. For example, George and Kovalsky (1986) demonstrated that while the catch rate of arctic cisco decreased by 28 percent when moving from 2.5 to 3.0 inch mesh, the catch biomass remained the same. Since the size composition of the arctic cisco population in the Colville River fishery has exhibited considerable variation over the years (Gallaway et al. 1983), it may be advantageous for fishermen to use a greater number of larger mesh size nets in order to reduce the catch of least cisco (considered a less desirable species by most fishermen) and maximize their catch of large arctic cisco. Strong year classes, such as the ones that led to high catch rates in 1984 and 1985, should be increasingly vulnerable to larger mesh nets, such as 3.125 and 3.25 inch, until the fish leave the fishery.

4.3 ESTIMATES OF TOTAL CATCH

The two techniques for estimating total catch resulted in large differences in catch estimates in some cases (Table 24). For Fisherman C on the outer Colville Delta and for the fishery on the upper Nigliq, estimates based on



Arctic cisco and least cisco catch per 24-hours based on the number of days of soak time by location and mesh size.

ENTRIX | FIGURE 14

Table 24. Comparison of total catch estimates from CPUE and tag return data.

Area and Fisherman	Arctic Cisco		Least Cisco	
	CPUE	Tag Return	CPUE	Tag Return
<u>Outer Colville Delta</u>				
Main Channel				
Helmericks[1]	10,321	10,321	8,657	8,657
Fisherman A[1]	3,141	3,141	1,803	1,803
Fisherman B	9,256	9,623	6,895	9,905
East Channel				
Helmericks[1]	13,357	13,357	8,939	8,939
Fisherman C	7,906	2,209	5,245	1,521
Upper Nigliq	17,878	5,048	1,871	452
Lower Nigliq	8,500	9,466	0	0
Total	70,359	53,165	33,410	31,277

[1]actual reported catch

CPUE were considerably higher than those based on tag returns. There are several possible explanations for this discrepancy:

1. Total fishing effort may have been overestimated, resulting in inflated estimates of total catch from CPUE data. Some of the nets set may not have been fished regularly, and, as shown earlier, catch per effort declines appreciably with the number of days between emptying the net.

2. All recaptured tags may not have been returned by all the fishermen on the upper Nigliq. In other areas there were only a few fishermen, while on the upper Nigliq the effort and total catch was dispersed among a larger group. It is likely that some fishermen did not return tags and that the total number of recaptures was higher than reported.

3. There may be a higher percentage of tagged fish in the population in the lower Colville than the upper Nigliq. Since most of the tagging took place in the Prudhoe Bay area, fewer of the tagged fish may have traveled as far west as the Nigliq channel.

Overall, the catch estimates from the CPUE data are felt to be the most reliable estimates.

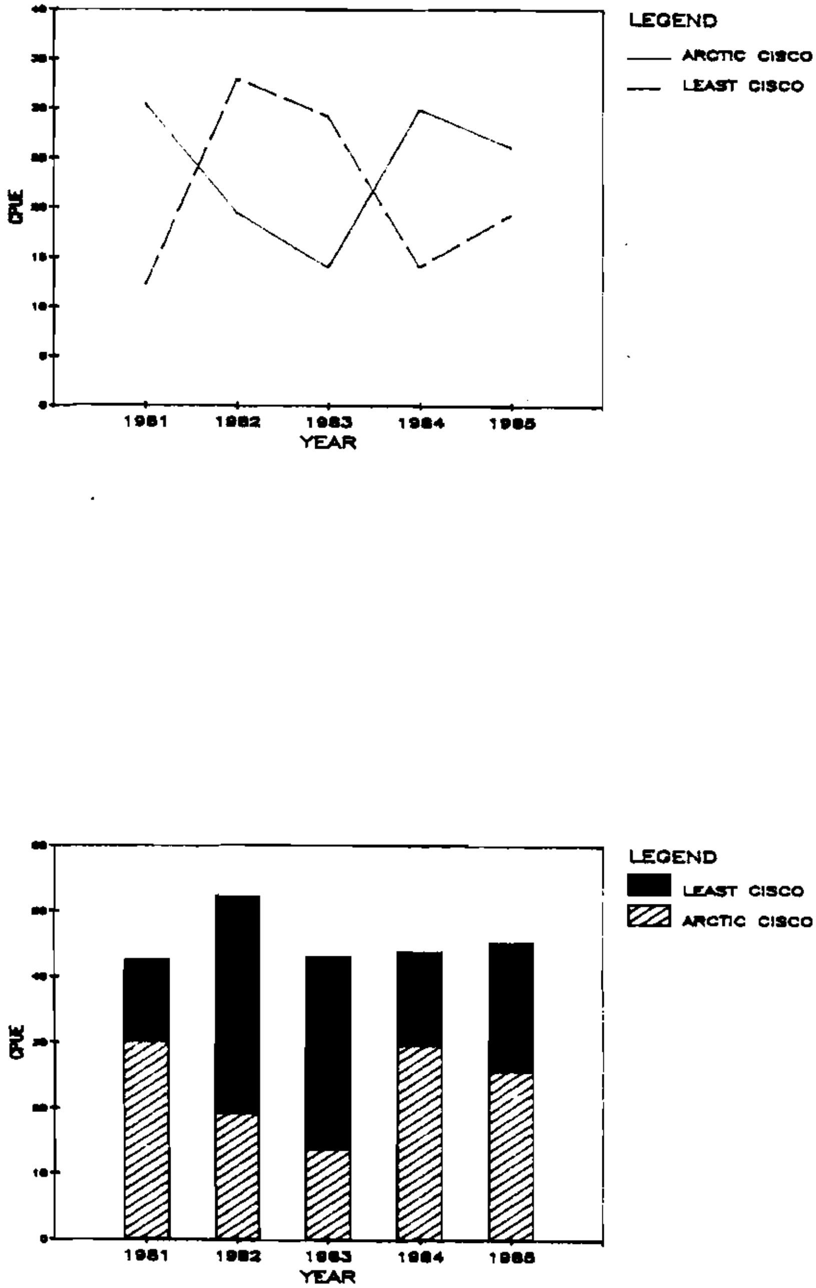
4.4 HISTORICAL PERSPECTIVE

Previous estimates of the fall Nuiqsut-based fishery have generally been based on little data. Craig and Haldorson (1981) suggested that the catch for the fishery was about equal to Helmericks' catch. George and Nageak (1985) estimated that between 6,000-9,000 arctic cisco were caught on the lower Colville Delta (exclusive of Helmericks catch) and another 1,000 on the Nigliq channel in the 1984 fall fishery, compared to almost 28,000 arctic cisco harvested by Helmericks in 1984. The results from this study suggest that both the fisheries on the lower Colville Delta and on the Nigliq channel accounted for a much greater catch of arctic cisco in 1985: approximately

15,000-20,000 arctic cisco on the lower Colville Delta and 14,000-25,000 on the Nigliq channel. Least cisco total catch was somewhat lower.

Total catch and size composition of the catch of arctic cisco has shown considerable variation over the last 20 years, giving evidence of strong and weak year classes (Gallaway et al. 1983; Moulton and Carpenter 1986). The average total catch for Helmericks over the last 20 years was 31,000 arctic cisco and 22,000 least cisco (Moulton and Carpenter 1986). In 1985 the total catch was 23,678 arctic cisco and 17,596 least cisco. While this appears to be below average for both species, fishing ended in early November, which is earlier than usual, while catch rates for arctic cisco were still high. Total CPUE (number of fish per net-day) of 26.1 for arctic cisco is high compared to historical catch rates, although it is somewhat lower than 1984 (Figure 15). Least cisco CPUE of 19.4 increased from 14.1 in 1984, but is still low compared to the CPUEs in 1982 and 1983. Data from the last 5 years show a significant inverse correlation ($r=-0.909$, $p<.05$)in CPUE for the two species, while the total CPUE for ciscos has remained stable (Figure 15).

The average size of arctic cisco in 3.0 inch mesh nets of 330 mm with the dominant length mode 300-340 mm, probably represents the abundant 1978 and larger numbers of the 1979 year class (Moulton and Fawcett 1984). Since arctic cisco begin to mature at age 7-8 (about 350 mm) (Craig and Haldorson 1981; Moulton and Carpenter 1986) and presumably return to the Mackenzie River to spawn (Gallaway et al. 1983; Moulton et al. 1985), it is likely that the contribution of the 1978 year class to the 1986 fall fishery will be considerably reduced (except perhaps in larger mesh nets). In 1986 the catch will consist primarily of the 1979 year class, which is also abundant and began to enter the fishery in 1985 (Figure 12). Since the 1979 year class may be even more abundant than the 1978 year class (Moulton and Fawcett 1984), catch rates of arctic cisco should remain high in 1986. In 1987, however, catch rates will decline substantially because, until 1985, there has not been a strong recruitment since the 1979 year class entered the region. Arctic cisco catches will likely remain low from 1987 until the early 1990's.



Helmericks CPUE for arctic and least cisco, 1981-1985.

ENTRIX

FIGURE 15

4.5 IMPACT OF FISHERY ON STOCKS

The estimated arctic cisco harvest of 70,400 fish represents approximately 6 percent of the harvestable arctic cisco. This estimate is based on the assumption that all of the released tagged arctic cisco moved to the Colville region in late summer and were vulnerable to the fall fishery. If substantial numbers of tagged arctic cisco moved elsewhere, such as remaining in the Sagavanirktok delta or moving eastward to the Mackenzie River, then the population estimate would decrease and the harvest rate would increase. The response of the population estimate and resulting exploitation rate to different levels of return to the Colville is as follows:

Percent Returning to Colville	Population Estimate	Exploitation Rate (percent)
75	850,000	8
67	760,000	9
50	570,000	12

While the data from the 1985 Endicott Study indicate that some tagged arctic cisco moved eastward to Kaktovik, the data are insufficient to determine if significant eastward movement occurred (Envirosphere 1986).

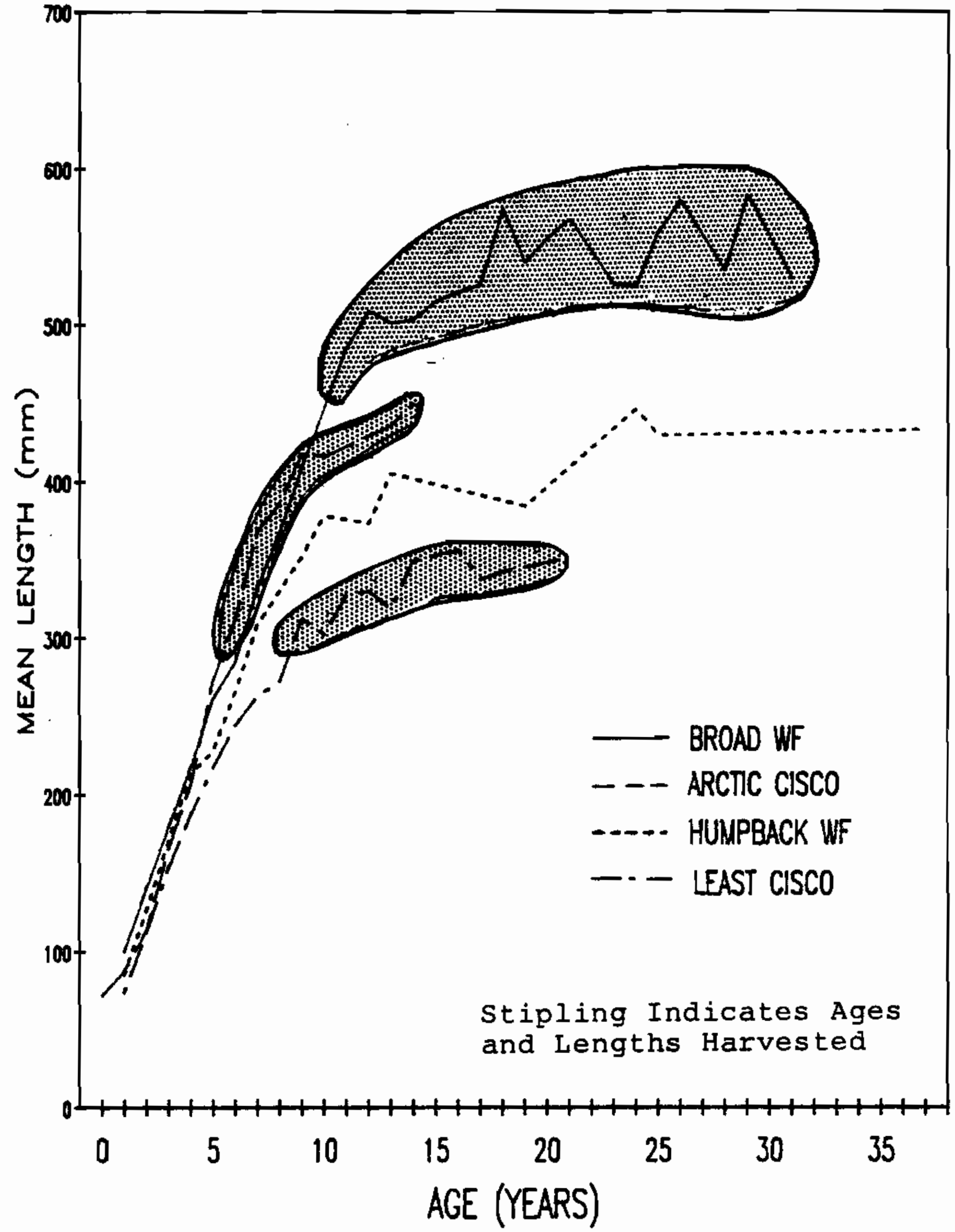
For least cisco, the pattern is more clear. There is little doubt that virtually all tagged least cisco entered the Colville delta in late summer and were vulnerable to the fishery (Moulton and Carpenter 1986). The estimated harvest of 33,400 fish represents approximately 10 percent of the harvestable fish. By following the decline of tags in the population over several years, it is estimated that the total annual mortality on adult least cisco is approximately 40 percent.

These levels of mortality are on the low end of the ranges reported for other coregonids (Healy 1975). For example, in lake whitefish populations (Coregonus clupeaformis) in the Northwest Territories, Healy (1975) reports 2 out of 17 estimates of annual natural mortality to be less than 30 percent. For total mortality, only 2 out of 24 estimates were less than 40 percent.

For fourteen exploited lakes, the total annual mortality averaged 64 percent (range: 36-94 percent). Healy (1980) reports that an exploitation rate of 10 percent causes virtually no change in lake whitefish populations while a rate of 20 percent causes a moderate amount of change. Heavy exploitation occurred at an exploitation rate of 30 percent.

A characteristic of moderately exploited populations is loss of older age groups (Healy 1980). The continued presence of substantial numbers of pre-1984 tags in the least cisco in the population and substantial numbers of fish greater than age 10 (Fawcett et al. 1986) also indicate that the present exploitation rate on the Colville River cisco populations is low (Figure 16).

The level of exploitation on broad whitefish cannot be quantitatively established at this time because there is no estimate for the total numbers of catchable fish. There is indirect evidence, however, that the exploitation rate is low. The majority of the spawning segment of the population is well upstream of Ocean Point by mid to late July (T. Bendock, ADF&G, pers. comm., 1986) and thus is not vulnerable to the majority of the fishing effort, which is concentrated in the delta. Much of the non-spawning segment of the mature broad whitefish are outside the river in Harrison Bay or adjacent coastal areas in the summer when fishing effort is greatest. It is likely that the harvest is based on sporadic interception of feeding broad whitefish with some catch of fish during early season spawning migration and outmigration and late summer return movements. The effort does not appear to be focused on any particular segment of the population, other than feeding non-spawning fish. As with least cisco, the broad whitefish catch continues to be dominated by older fish - the majority of the catch is between ages 11 and 20 (Figures 4 and 16). The majority of effort and catch is centered on the Nigliq Channel, which represents a small portion of the delta habitat - this in itself makes it extremely unlikely that the exploitation rate would have much effect on the broad whitefish population.



Mean length at age for four harvested species (based on data collected in 1985).

ENTRIX | FIGURE 16

5.0 REFERENCES

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APPENDIX A

APPENDIX TABLES

Appendix Table A-1. Estimated total effort (F_t) and sampled effort (F_s) by area, mesh size, and 10 day interval for the summer fishery.

Interval		STRETCHED MESH (inches) 3.0	4.5	5.0	5.25	5.5	Total
<u>Niglig</u>							
7/6-7/15	F_t	8.3	31.3	100.0	---	---	139.6
	F_s	4.6	9.2	16.9	0	0	30.7
7/16-7/25	F_t	9.2	41.7	160.3	---	10.0	221.2
	F_s	1.8	1.0	12.5	0	0	15.3
7/26-8/4	F_t	9.2	33.7	159.7	---	---	202.6
	F_s	1.8	1.0	12.5	0	0	15.3
8/5-8/14	F_t	9.2	33.3	143.5	---	---	186.0
	F_s	0	0	6.8	0	0	6.8
8/15-8/24	F_t	9.2	58.0	20.7	---	---	87.9
	F_s	0	5.3	4.0	0	0	9.3
8/25-9/3	F_t	9.2	71.0	25.8	16.0	16.0	138.0
	F_s	2.8	2.0	6.5	1.3	15.0	27.6
9/4-9/11	F_t	0.9	6.0	4.2	18.7	---	29.8
	F_s	0	0	0	4.0	0	4.0
Total	F_t	55.2	275.0	614.2	34.7	26.0	1005.1
	F_s	9.2	19.5	48.7	5.3	16.7	99.4
<u>Upper Colville</u>							
7/6-7/15	F_t	---	1.0	---	---	---	1.0
	F_s	0	0	0	0	0	0
7/16-7/25	F_t	---	6.0	14.0	---	---	20.0
	F_s	0	2.0	3.0	---	0	5.0
7/26-8/4	F_t	---	---	18.0	---	---	18.0
	F_s	0	---	3.0	---	0	3.0
8/5-8/14	F_t	---	---	28.4	18.7	---	47.1
	F_s	0	---	26.3	4.6	0	30.9
8/15-8/24	F_t	---	3.3	13.0	8.0	---	24.3
	F_s	0	1.7	5.4	0	0	7.1

Appendix Table A-1 (Continued)

Interval		3.0	MESH 4.5	5.0	5.25	5.50	Total
Upper Colville (cont'd)							
8/25-9/3	F_t	---	---	17.0	13.3	---	30.3
	F_s	0	---	7.0	5.4	0	12.4
9/4-9/11	F_t	---	---	5.0	---	---	5.0
	F_s	0	---	5.0	---	0	5.0
Total	F_t	---	10.3	95.4	40.0	---	145.7
	F_s	0	3.7	49.7	10.0	0	63.4
Fish Creek							
7/6-7/15	F_t	---	---	---	---	---	---
	F_s	0	0	0	0	0	0
7/16-7/25	F_t	---	---	---	---	10.0	10.0
	F_s	0	0	0	0	0	0
7/26-8/4	F_t	---	---	14.0	---	10.0	24.0
	F_s	0	0	8.2	0	8.1	16.3
8/5-8/14	F_t	---	---	---	---	---	---
	F_s	0	0	0	0	0	0
8/15-8/24	F_t	---	---	---	---	---	---
	F_s	0	0	0	0	0	0
8/25-9/3	F_t	---	---	---	---	---	---
	F_s	0	0	0	0	0	0
9/4-9/11	F_t	---	---	---	---	---	---
	F_s	0	0	0	0	0	0
Total	F_t	---	---	14.0	---	20.0	34.0
	F_s	0	0	8.2	0	8.1	16.3

Appendix Table A-2. Net counts by area and date in the summer fishery.

Nigliq		Upper Colville		Fish Creek	
Date	N	Date	N	Date	N
7/6	8	7/16	2	7/13	1
7/13	13	7/22	3	7/28	4
7/20	15	7/30	2	8/2	4
7/27	31	8/9	6[1]	8/4	2
8/3	20	8/13	4	8/6	0
8/6	16	8/17	4[1]		
8/15	8	8/25	7[2]		
8/24	13				
8/29	14				
9/2	11				
9/10	7				

N = number of nets counted

[1] includes one net upstream from Ocean Point

[2] includes 2 nets upstream from Ocean Point

Appendix Table A-3. Mean length of broad whitefish by 10 day period in the summer fishery, all areas and mesh sizes combined.

Interval	Length (mm)	N
7/6-7/15	542	147
7/16-7/25	525	52
7/26-8/4	532	91
8/5-8/14	519	52
8/15-8/24	523	4
8/25-9/3	509	80

N = number of fish in samples.

Appendix Table A-4. Total estimated fishing effort (F_t) and sampled effort (F_s) by 10 day period on the upper Nigliq during the fall fishery.

Interval		STRETCHED MESH SIZE (inches) 2.25	2.5	3.0	3.25	3.5	4.0	UNK	Total
10/1-10/10	F_t	4.0	7.3	30.0	6.7	20.0	6.7	4.0	78.7
	F_s	---	4.9	22.7	---	3.2	---	---	30.8
10/11-10/20	F_t	10.0	55.3	86.7	16.7	48.3	---	10.0	227.0
	F_s	---	3.0	19.3	8.3	18.0	---	--	48.6
10/21-10/30	F_t	10.0	50.8	115.5	16.7	51.7	---	16.0	260.7
	F_s	4.1	1.0	3.6	---	5.0	---	---	13.7
10/31-11/9	F_t	10.0	44.3	58.7	16.7	33.3	---	15.0	178.0
	F_s	---	4.4	3.7	---	---	---	---	8.1
11/10-11/20	F_t	5.0	26.7	55.0	16.7	16.7	---	5.0	125.1
	F_s	1.0	7.8	---	1.7	1.7	---	---	12.2
Total	F_t	39.0	184.4	345.9	73.5	170.0	6.7	50.0	869.5
	F_s	5.1	21.1	49.3	10.0	27.9	0.0	0.0	113.4

UNK = unknown mesh size

Appendix Table A-5. Total estimated fishing effort (net-days) by 10 day period for the outer Colville Delta fall fishery.

Interval	Fisherman	MAIN CHANNEL Mesh Size			EAST CHANNEL Mesh Size
		2.5	3.0	3.5	3.0
10/1-10/10	Helmericks	---	95.0	25.0	125.0
	A	---	---	---	---
	B	---	46.7	---	---
	C	---	---	---	36.0
10/11-10/20	Helmericks	---	125.0	25.0	125.0
	A	6.9	24.8	17.9	---
	B	---	116.7	---	---
	C	---	---	---	90.0
10/21-10/30	Helmericks	---	125.0	25.0	125.0
	A	---	---	---	---
	B	---	105.0	---	---
	C	---	---	---	90.0
10/31-11/9	Helmericks	---	50.0	10.0	52.5
	A	---	---	---	---
	B	---	---	---	---
	C	---	---	---	9.0
Totals		6.9	688.2	102.9	652.5

Appendix Table A-6. Calculation of estimated catch by 10 day interval for Fishermen B and C in the outer Colville Delta based on Helmericks average CPUE.

Interval	Effort (net-days)	Arctic Cisco Helmericks Avg. CPUE	Arctic Cisco Estimated Catch	Least Cisco Helmericks Avg. CPUE	Least Cisco Estimated Catch
Main Channel					
Fisherman B					
1	46.7	60.5	2,825	43.4	2,027
2	116.7	35.4	4,131	25.7	2,999
3	105.0	21.9	2,300	17.8	1,869
Totals			9,256		6,895
East Channel					
Fisherman C					
1	36.0	26.4	950	26.2	943
2	90.0	40.3	3,627	29.9	2,691
3	90.0	33.6	3,024	17.9	1,611
4	9.0	33.8	304	12.7	114
Totals			7,906		5,245

Appendix Table A-7. Estimated percent of tagged arctic cisco released in 1984 and 1985 that were not vulnerable to 3 inch gill net (based on method described in Ricker 1975).

	1984			1985		
Fork Length (mm)	Percent of Tags Released After August 11[1]	Percent of Gill Net Catch[2]	Percent Uncatchable	Percent of Tags Released After August 15[1]	Percent of Gill Net Catch[2]	Percent Uncatchable
250	20.5	0	20.5	1.9	0.2	1.7
260	13.1	0	13.1	4.5	0	4.5
270	10.8	0	10.8	8.5	0.2	8.3
280	9.8	10.2	0	9.3	0.4	8.9
290	11.1	17.0	0	10.2	1.5	8.7
300	10.8	25.0	0	10.1	7.6	2.5
310	9.6	27.3	0	9.3	19.4	0
320	4.7	4.5	0.2	12.6	21.7	0
330	2.5	3.4	0	12.1	23.6	0
340	1.8	3.4	0	8.6	14.1	0
350	1.5	2.3	0	3.3	4.4	0
360	1.2	4.5	0	2.2	2.7	0
370	1.0	2.3	0	1.7	1.5	0.2
380	1.0	0	1.0	1.8	0.6	1.2
390	0.5	0	0.5	1.7	1.1	0.6
400	0.1	0	0.1	0.8	0.2	0.6
410	0	0	0	0.4	0.4	0
420	0	0	0	0.4	0	0.4
430	0	0	0	0.1	0	0.1
440	0	0	0	0.1	0	0.1
450	0	0	0	0.1	0	0.1
Total			46.2			37.9

[1] Based on length frequency of captured fish, assumes released tagged fish have similar length frequency distribution. Data from mid-August to late September are used to reduce effects of growth. Based on lengths of 2388 arctic cisco in 1984 (Moulton et al. 1985) and 2178 arctic cisco in 1985 (Envirosphere 1986).

[2] Based on lengths of 88 arctic cisco in 1984 and 474 arctic cisco in 1985 caught in 3 inch stretched mesh gill net.

Appendix Table A-8. Estimated percent of tagged least cisco released in 1984 and 1985 that were not vulnerable to 3 inch gill net (based on method described in Ricker 1975).

	1984			1985		
Fork Length (mm)	Percent of Tags Released[1]	Percent of Gill Net Catch[2]	Percent Uncatchable	Percent of Tags Released[1]	Percent of Gill Net Catch[2]	Percent Uncatchable
240	0	0	0	1.8	0.3	1.5
250	6.0	0.3	5.7	2.0	0.3	1.7
260	7.2	0.5	6.7	2.5	0.2	2.3
270	8.8	2.5	6.3	3.6	0.8	2.8
280	11.2	5.1	6.1	5.6	1.4	4.2
290	13.1	10.2	2.9	9.0	7.5	1.5
300	13.2	19.1	0	12.8	12.5	0.3
310	12.8	23.9	0	15.9	21.1	0
320	10.9	20.1	0	17.6	23.5	0
330	8.0	12.7	0	13.5	16.0	0
340	4.7	3.3	1.4	8.2	9.4	0
350	2.5	2.0	0.5	4.3	4.1	0.2
360	1.0	3.0	0	2.0	1.4	0.6
370	0.4	0	0.4	0.7	0.3	0.4
380	0.1	0	0.1	0.2	0.5	0
390	0.1	0	0.1	1.8	0	1.8
Total			30.2			17.3

[1] Based on length frequency of captured fish, assumes released tagged fish have similar length frequency distribution. Based on lengths of 16,261 least cisco in 1984 (Moulton et al. 1985) and 16,050 least cisco in 1985 (Envirosphere 1986).

[2] Based on lengths of 393 least cisco in 1984 and 663 least cisco in 1985 caught in 3 inch stretched mesh gill net.