COLVILLE RIVER FISH STUDY

1986 ANNUAL REPORT

FINAL REPORT

NOVEMBER 1987

Prepared by Entrix, Inc.

for ARCO Alaska, Inc.

North Slope Borough

and

City of Nuiqsut

ASSESSMENT OF THE COLVILLE

RIVER FALL FISHERY IN 1986

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1.0 INTRODUCTION

A multi-year fishery assessment of the Colville River was initiated in 1985. Key participants in the multi-year study include ARCO Alaska, Inc., the North Slope Borough, and the City of Nuiqsut. In the first year of study (1985) a literature review of Colville River fishes was completed (Moulton and Carpenter 1986), a biological program to evaluate fish distribution, relative abundance, and movements in the Colville delta was conducted (Fawcett, et al. 1986), and an assessment was undertaken to estimate total effort and total catch of the summer and fall fisheries of the Colville delta (Moulton et al. 1986). These three reports are assembled as chapters 1, 2, and 3 of the 1985 Annual Report.

Moulton, et al. (1986) provided estimates of total effort and total catch of the Colville River fall fishery in 1985. George and Nageak (1986) and George and Kovalsky (1986) provide additional information on catch rates and other aspects of the Nuiqsut-based fishery in 1984 and 1985. While the Helmericks fall fishery at the Colville delta has a well-documented history of over thirty years of records (Craig and Haldorson 1981; Gallaway et al. 1983; and Moulton, et al. 1986), the estimates of total effort and total catch in 1985 represented the first assessment of all fall fishing activity in the Colville river downstream of the Itkillik River. The fall fishery in 1985 had an estimated total effort of approximately 2,650 net-days and produced estimated total catches of 70,000 Arctic cisco and 33,000 least cisco (Moulton, et al. 1986).

This report provides the results of the second year of study (1986) of the multi-year study. The primary objective of the second year of study was to estimate the total effort and total catch for the Colville River fall fishery of 1986. Secondary objectives were to gather specific information characterizing the fishery: size and location of nets, species composition, catch rate and fish length by mesh size, age composition of the catch, and seasonal variation in the catch. Tags released from various tagging programs, primarily in the Prudhoe Bay region, were collected from fishermen to determine fish movements.

The information developed in this study can be used to make recommendations on fishing strategy to help optimize harvest, as baseline data from which year-to-year variations of the fishery can be documented, and ultimately may provide a basis for evaluating any potential long-term impacts on the fishery as a result of development in the region.

2.0 METHODS

2.1 Study Area

The study area included the Colville River from the Itkillik River downstream to Harrison Bay (Figure 1). The study area was divided into four areas based on those areas of concentrated fishing effort: (1) the Outer Colville Delta; (2) the Upper Nigliq Channel near Nuiqsut; (3) the Nanuk area of the Nigliq Channel; and (4) the Nigliq Delta.

Field personnel conducted surveys, interviewed fishermen, and sampled the catch within the study area. The three Nigliq Channel areas (Upper Nigliq, Nanuk, and Nigliq Delta) were surveyed by personnel based in Nuiqsut. The Outer Delta area was surveyed by personnel based in a cabin in the delta.

2.2 Fishery Assessment

The assessment and monitoring of the fall under-ice fishery began in early October and continued through November 16. Catch and effort data from the Helmericks fishery in the delta area were provided by J. Helmericks (1986).

2.2.1 Effort

(a) Definition of Effort

Gill nets were used exclusively in the fall fishery. A standard unit of effort was defined as a net-day and consisted of a 60-ft (20 m) gill net fished for 24 hours. Net depth was considered a fixed variable in the calculation of effort, since most nets were of comparable depth (6 or 8 feet).

(b) Estimation of Total Effort

Total effort in each of the four main areas was determined by the following method. Each individual net was identified and tracked throughout the entire time the net was fishing. This method chronicled the start and end dates of fishing for each net, net location(s), net length, and mesh size. In all of the areas this method was employed successfully and resulted in a virtually complete census of fishing effort. A key component of the successful use of this method was fishermen cooperation, which was high in 1986.

2.2.2 Catch Sampling

Catches were sampled whenever possible for species composition, number of fish caught, and fork length to the nearest mm. Fish were also examined for tags, fin clips, and dye marks. Whenever possible, tagged fish were measured to the nearest mm (fork length) and the date, location of capture, and species were recorded. Occasionally tags were removed

Cape Halkett

HARRISON BAY

OUTER DELTA

Main Channel

East Channel

NIGLIQ DELTA

Fish Creek

NANUK

UPPER NIGLIQ

Nuiqsut

COLVILLE RIVER

Kachemach River

Miluveach River

Itkillik River

Ocean Point

Map of Colville River
Study Area.

ENTRIX   FIGURE 1

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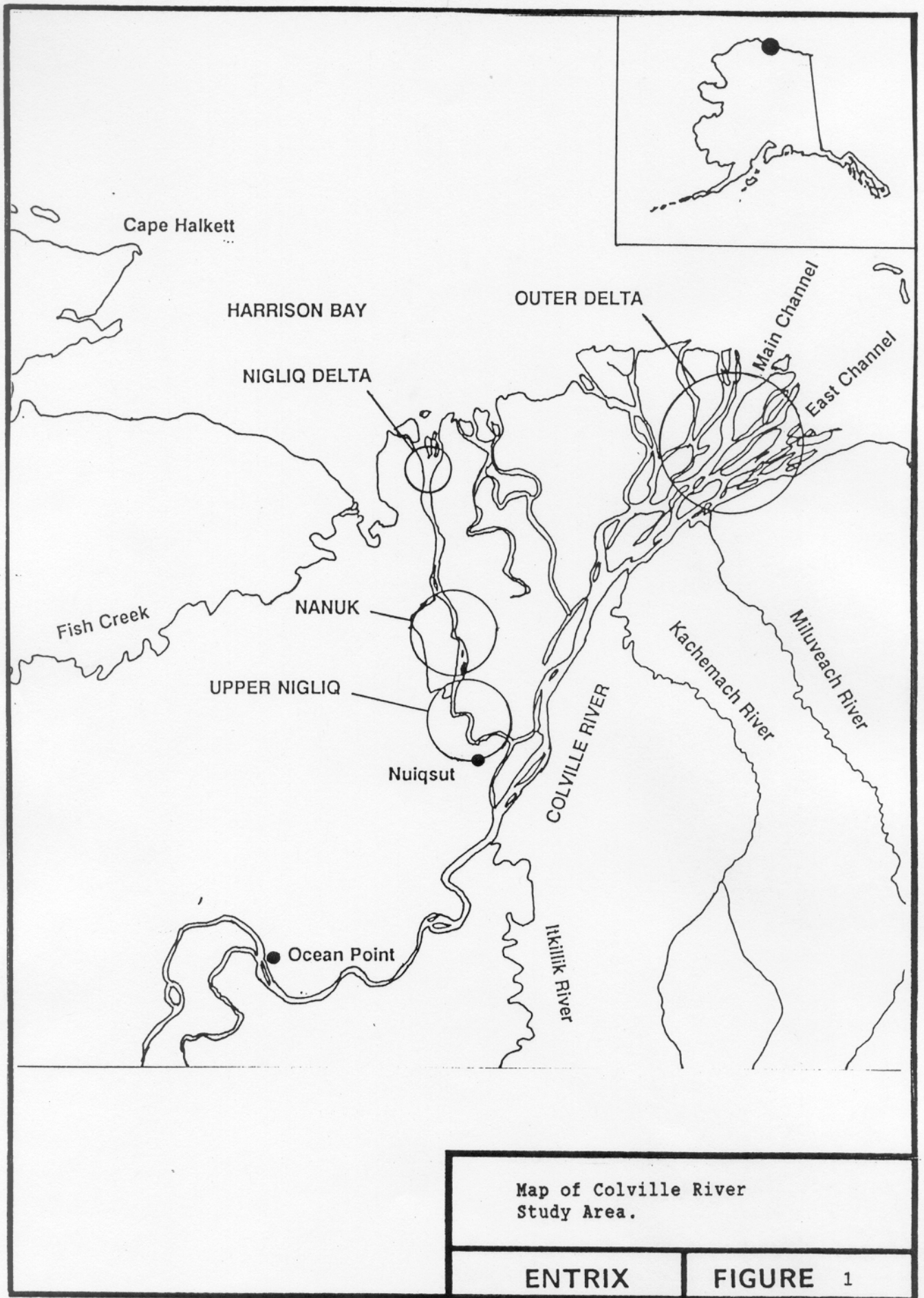
from the fish by the fisherman, which led to incomplete information for some of the recaptured tagged fish. A reward system for the return of tags was employed to facilitate tag returns.

Whenever catch data were collected, effort data were also recorded so that catch-per-unit-effort (CPUE) could be calculated for the net set. Effort data recorded included set duration, net length, and mesh size. In some instances more than one net and mesh size were fished as a single unit by a fisherman. When possible, catch data were separated by net and mesh size.

Otoliths were obtained from 199 Arctic cisco captured in 3.0-inch mesh nets to determine the age composition of the Arctic cisco catch. Aging was completed by the cross-sectional burn technique and is consistent with the methodology used to age Arctic cisco of the Colville River in 1985 (Fawcett, et al. 1986).

2.2.3 Test Fishing

Various mesh sizes were evaluated in the fall fishery by assisting local fishermen with setting and checking of test nets. Test nets were given to the local fishermen in exchange for daily information on the catch (number and fork length by species) from each mesh size. The gill nets were 60 ft in length and were either 3.0 (76 mm) or 3.25 (82 mm) inch stretched mesh.

2.2.4 Salinity Measurements

During October, salinity measurements were taken with a YSI Model 33 salinometer. Salinity profiles were measured daily from October 9-28 at the Upper Nigliq area, from October 17-28 at Nanuk and every other day from October 17-26 at the Nigliq Delta.

2.3 Data Management and Analysis

2.3.1 Data Collection

Field personnel kept a field notebook (log) of information relating to fishing activity and transferred the log information onto custom data forms. Logs and data sheets were checked for accuracy prior to data entry. Field personnel also prepared survey maps showing the location of fishing activity within the study area.

2.3.2 Data Entry

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

2.3.3 Analysis

(a) Effort

Effort was calculated in net-days by using the start and end dates for each individually-tracked net. Effort data was corrected for the various net lengths used in the fishery by standardizing net length to 60 ft.

(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
Ci = catch in the ith sample
Fi = 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 Ci = total catch in ith interval
Fi = total effort for ith interval

There was minor effort expended with 2.5 inch mesh in the Upper Nigliq area with the net checked sporadically, thus CPUE estimates for this mesh size were not obtained. To obtain the catch rate used for estimating the total catch, the catch rates for 3.0 inch mesh were adjusted using the ratio of the catch in the 2.5 inch mesh to the catch in the fisherman's two 3.0 inch mesh nets for the one day in which the catch from all three nets were sampled. The adjustment was 0.898 for Arctic cisco and 12.3 for least cisco.

Reduced sampling effort in the Nanuk area also necessitated more extrapolation from measured CPUE data. In this region some effort was expended with 2.5 and 3.25 inch mesh, but these were not covered in the fishery samples. Catch rates for these mesh sizes were estimated by adjusting the 3.0 inch mesh catch rates by a factor determined from the relative

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catch rates of these meshes in the Upper Nigliq region. To develop CPUE for 2.5 and 3.25 inch meshes, the 3.0 inch CPUE was multiplied by 0.898 and 0.375, respectively, for Arctic cisco and 12.3 and 0.295 for least cisco.

3.0 RESULTS

3.1 Location and Duration of Fishing Effort

In 1986, approximately 25 fishing groups participated in the under-ice fishery, down slightly from the 30 groups identified in 1985. Effort was concentrated in four main areas: the Upper Nigliq area near Nuiqsut, the Nanuk region (near Nanuk Lake on the Nigliq Channel), the Nigliq Delta (at Wood's Camp) and in the Outer Colville Delta. There was some fishing effort in the Fish Creek and upper Colville River areas, particularly early in the season, but, as in 1985, these areas were not surveyed to concentrate the sampling effort in the areas of greatest fishing effort.

In 1986, fishing began in the Upper Nigliq Channel during the first week of October, but was interrupted by overflow during the first and second week of the month. Fishing was delayed in the other areas until the second week of October because of overflow. After travel on the ice became safe, fishing continued in all areas until approximately November 16.

Gill nets of 3.0 to 3.5 inch stretched mesh were the most commonly used gear, with some 2.5 inch mesh also used. A few fishermen tried fishing with 4.0 inch mesh, a common mesh size in the summer whitefish fishery, but no arctic or least cisco were caught.

3.2 Estimated Fishing Effort

(a) Nigliq Channel

Fishing effort on the upper Nigliq showed a similar pattern to that observed in 1985, beginning on October 3, peaking in late October to early November, then decreasing in mid-November. Only one group was still fishing at the end of the survey on November 16. Eleven groups were identified in 1986, accounting for an estimated 592 net-days of total effort (Table 1).

Fishing effort in the Nanuk area began on October 12 when the channel was considered safe for travel by snow machine. This area was included as part of the Upper Nigliq area in 1985. Six groups fished at Nanuk in 1986, accounting for 216 net-days of total effort (Table 1). Upper Nigliq and Nanuk together were utilized by 16 fishing groups (one group fished in both locations) and accounted for 808 net-days of effort. This compares to an estimated 25 groups expending 870 net-days in 1985 (Table 2).

The Nigliq Delta was fished by two groups from October 10 to November 13. This year the fishermen commuted to the area from town rather than from a nearby fish camp. An estimated 97 net-days of effort were expended in this area in 1986, compared to about 340 net-days in 1985 (Table 2). One of the primary fishermen in the 1985 fishery was unable to participate in 1986 because of an injury sustained just prior to the fishing season--this was the primary factor for the reduced effort in 1986.

Table 1. Total estimated effort in the Nigliq Channel by 10-day period, 1986.

Area and Mesh Size (inches)	Oct 1-Oct-10	Oct 11-Oct-20	Oct 21-Oct-30	Oct 31-Nov-09	Nov 10-Nov-19	Mesh Total	Effort Total
Upper Nigliq							
2.50	8.0	10.0	10.0	10.0	7.0	45.0	
3.00	54.7	115.5	116.5	84.8	33.2	404.7	
3.25	8.0	20.0	20.0	11.0	4.0	63.0	
3.50	7.0	10.7	25.7	24.7	11.7	79.7	592.4
Nanuk							
2.50	0.0	5.3	13.3	5.3	0.0	24.0	
3.00	0.0	38.0	61.7	48.3	12.0	160.0	
3.25	0.0	9.0	10.0	8.0	0.0	27.0	
4.00	0.0	5.3	0.0	0.0	0.0	5.3	216.3
Nigliq Delta							
3.00	0.0	5.7	36.7	25.0	6.0	73.3	
3.25	0.0	1.0	10.0	10.0	3.0	24.0	97.3

(b) Outer Colville Delta

The fishery in the Outer Colville Delta was again comprised of groups from fish camps and Colville Village. The Main (Kupigruak) Channel received an estimated 403 net-days of effort by six groups while the East Channel was fished only by the Helmericks (Table 2). The groups identified in 1985 as Fisherman A and B again were active in the Main Channel, although both showed a decrease in effort from the 1985 level (Table 2). Fisherman A used 3.0, 3.25 and 3.5 inch mesh, with 74 percent of the effort being with 3.0 inch mesh. Fisherman B used 3.0 inch mesh exclusively. Fisherman D did not fish in the Colville region in 1985, but fished with 2.5, 3.0, 3.5 and 4.0 inch mesh in 1986. The 1985 effort by Fishermen E and F was low and occurred primarily after the survey was completed, thus it was not measured. Over 78 percent of the effort in the Main Channel was with 3.0 inch mesh.

Fisherman C, who fished in the East Channel in 1985, did not participate in the 1986 fishery because of other time commitments. Thus, all the effort in the East Channel in 1986 was by Helmericks. The Helmericks fishery expended approximately 340 net-days of effort in the East Channel, all with 3.0 inch mesh. On the Main Channel, the Helmericks effort was 20 net-days of 3.0 inch mesh and 17.5 net-days of 3.5 inch mesh. This compares to total efforts of 428 net-days on the East Channel and 480 net-days on the Main Channel in 1985. The total effort in the Outer Colville Delta decreased from 1451 net-days in 1985 to 743 net-days in 1986 (Table 2). The decrease in effort was primarily due to the reduced effort by the Helmericks fishery and Fisherman B, and the decision by Fisherman C not to fish in 1986.

3.3 Catch Composition

(a) Nigliq Channel

For the Nigliq Channel as a whole, Arctic cisco comprised more than 90 percent of the sampled catch over the entire season. As in 1985, the earliest fishing effort in the upper Nigliq included some catch of least cisco and broad whitefish. During the 10-day period from October 11-20 Arctic cisco were less than 90 percent of the catch at upper Nigliq and Nanuk in all sampled meshes. During subsequent periods the percent of Arctic cisco rose to over 90 percent in all areas and meshes.

(b) Outer Colville Delta

Complete catch records were obtained from two of the six groups fishing in the outer Colville Delta and nearly complete records were obtained from the remaining four groups. The sampled catch was dominated by Arctic cisco in all time periods and meshes except one (Tables 3 and 4). The percent of Arctic cisco in the catch was higher in 1986 than in 1985, for example the Helmericks' East Channel catch (all 3.0 inch mesh) was almost 77 percent Arctic cisco compared to 60 percent in 1985. Similarly, Fisherman A's catch in 3.0 inch

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Table 2. Total estimated fishing effort in the Colville River fall fishery,
1985-1986 (effort in net-days, all meshes combined).

SurveyArea	1985	1986
Nigliq Channel		
Upper Nigliq	870	592
Nanuk	---	216
Nigliq Delta	340	97
AREA TOTAL	1,210	905
Outer Colville Delta		
East Channel		
Helmericks	428	340
Fisherman C	225	0
Main Channel		
Helmericks	480	38
Fisherman A	50	40
Fisherman B	268	86
Fisherman D	0	85
Others	---	154
AREA TOTAL	1,451	743
TOTAL EFFORT	2,661	1,648

Table 3. Sampled catch of Arctic cisco and least cisco by mesh size and
10-day interval in the outer Colville Delta, 1986.

Area and Mesh Size (inches)	Oct 1-Oct-10	Oct 11-Oct-20	Oct 21-Oct-30	Oct 31-Nov-09	Nov 10-Nov-19
Arctic Cisco					
Main Channel					
Helmericks					
3.00	---	1,052	319	---	---
3.50	---	313	155	---	---
Others					
3.00	---	4,438	5,478	638	585
3.25	---	354	---	---	---
3.50	---	42	28	155	150
East Channel					
Helmericks 3.00	8,011	13,026	3,730	1,360	1,490
Least Cisco					
Main Channel					
Helmericks					
3.00	---	157	409	---	---
3.50	---	3	9	---	---
Others					
3.00	---	427	2,634	420	239
3.25	---	6	---	---	---
3.50	---	2	3	6	8
East Channel					
Helmericks 3.00	2,535	2,164	2,523	713	487

Table 4. Percent of Arctic cisco in outer Colville Delta sampled catch by 10-day interval and mesh size, 1986.

Area and Mesh Size (inches)	Oct 1-Oct-10	Oct 11-Oct-20	Oct 21-Oct-30	Oct 31-Nov-09	Nov 10-Nov-19	Overall
Main Channel						
Helmericks						
3.00	---	87	44	---	---	71
3.50	---	99	95	---	---	98
Others						
3.00	---	91	67	60	71	74
3.25	---	98	---	---	---	98
3.50	---	93	85	87	81	85
East Channel						
Helmericks						
3.00	76	86	60	66	75	77

mesh on the Main channel was 90 percent Arctic cisco, compared to 67 percent in 1985.

Bering cisco comprised a minor component of the Helmericks' East Channel catch, but this species was not reported in the Main Channel catches. Helmericks provided 44 Bering cisco for further analysis. Results of gill raker counts indicated nearly complete separation between visually-identified Arctic cisco and Bering cisco, only one (or 2 percent) of the Bering cisco was mis-identified (Figure 2). The results are virtually identical to those reported in Craig and Haldorson (1981) for 23 Bering cisco. The length frequency of 50 Bering cisco caught in 3.0 inch gill nets (Figure 2) reflects the observation that Bering cisco are stouter or thicker for a given length than Arctic cisco, an observation also documented in Craig and Haldorson (1981).

3.4 Catch per Unit Effort (CPUE)

(a) Upper Nigliq

The catches from five nets in the upper Nigliq area were used to evaluate catch rates for this study area. The nets used for the evaluation were monitored continuously from early October to the end of sampling in mid-November. One of the two fishermen who cooperated in the determination of index catch rates set his three nets (two were 3.0 inch mesh, one was 3.25 inch mesh) at the downstream end of the upper Nigliq fishing area, the other one set his two nets (one was 3.0 inch mesh, the other was 3.5 inch mesh) at the upstream end of the fishing area. These nets accounted for over 25 percent of the total effort in the upper Nigliq area. The daily catch rates, seasonal averages, and correlation between the 3.0 inch mesh nets all indicate that the nets responded similarly during the fishing period and are likely reflecting real differences in fish abundance and distribution (Tables 5 and 6). From these data, it is considered that the CPUE estimates generated from the net surveys (Table 7) adequately represent catch rates in the upper Nigliq region.

The 1986 CPUE for Arctic cisco in 3.0 inch mesh was higher in the early season than in 1985, but later in the season the rates for the two years were comparable (Table 8). The season-long CPUE in 1986 increased slightly from the previous year, with 14.5 Arctic cisco per net compared to 12.1 per net-day in 1985. For least cisco, the overall CPUE in 3.0 inch mesh decreased in 1986, with 1.2 per net-day compared to 3.6 per net-day in 1985. Daily catch rates in 3.0 inch mesh nets in the Upper Nigliq were mostly lower than daily catch rates in the Nanuk and Nigliq Delta during 1986 (Figure 3).

(b) Nanuk

The catch rates used to develop catch estimates for the Nanuk region were derived from data gathered from catches sampled during the season. These sampled catches represented 10 percent of the total effort expended in the Nanuk region. In 1986, data from the Nanuk region was separated from upper Nigliq data because there was distinct physical separation
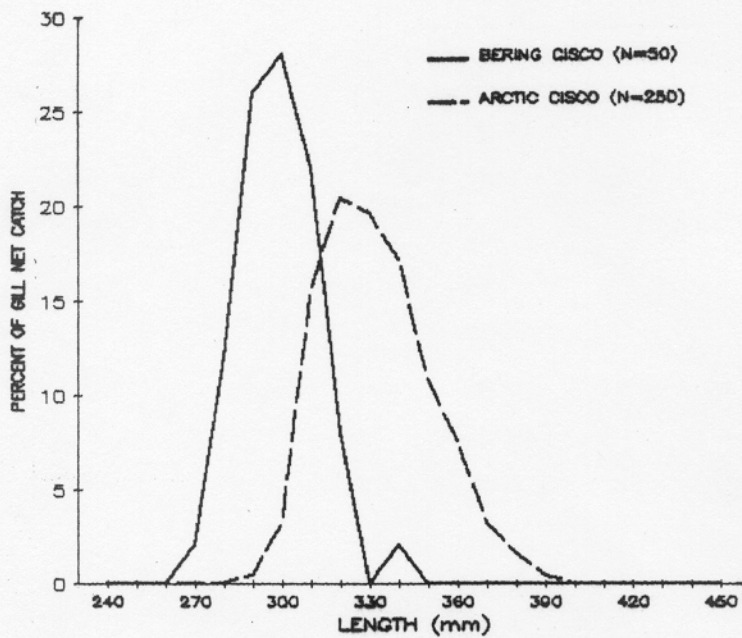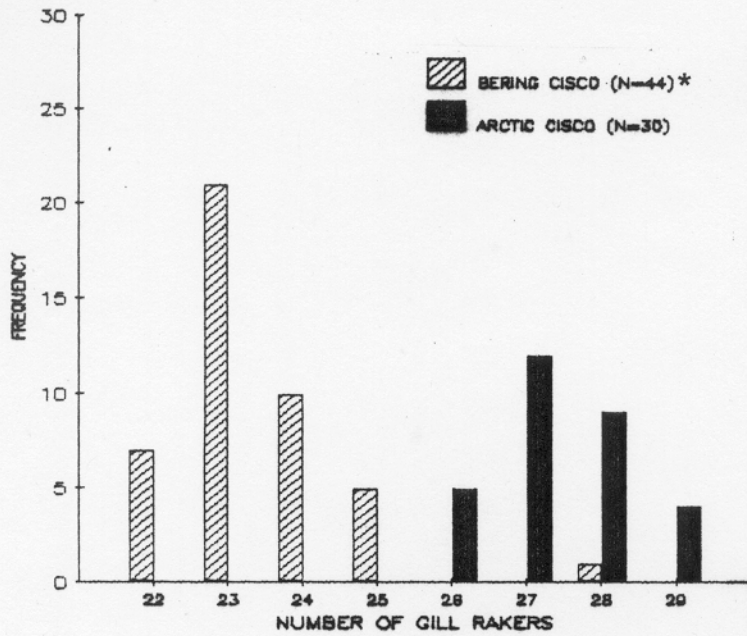
*Visually identified as Bering cisco, thus one was a mis-iden-tified Arctic cisco.

Gill raker counts and length frequency distribution of Bering and Arctic Cisco from the East Channel, Outer Colville Delta,

ENTRIX   FIGURE 2

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Table 5. Comparison of daily and mean catch rates for three index
nets in the upper Nigliq area, 1986 (3.0 inch mesh).

| | Downstream | | | Upstream |
| | Index Net 1 | Index Net 2 | | Index Net 3 |
Date	Daily CPUE	Daily CPUE		Daily CPUE
Oct 11	13.7	2.1		---
Oct 12	7.5	3.8		2.5
	24.0	12.0		---
Oct 13	4.8	5.1		11.0
Oct 14	15.4	27.7		22.5
Oct 15	36.5	31.5		33.3
Oct 16	34.6	35.3		21.6
Oct 17	15.3	25.3		28.2
Oct 18	16.0	14.4		9.0
Oct 19	19.0	15.2		4.5
Oct 20	19.8	22.4		18.8
Oct 21	4.6	19.2		5.3
Oct 22	---	---		---
Oct 23	17.5	20.0		10.5
Oct 24	---	---		---
Oct 25	11.0	17.6		19.5
Oct 26	---	---		---
Oct 27	10.5	5.2		3.0
Oct 28	---	---		---
Oct 29	---	---		---
Oct 30	7.0	---		---
Oct 31	---	8.6		15.4
Nov 01	---	---		---
Nov 02	12.0	21.2		---
Nov 03	---	---		18.0
Nov 04	12.5	15.2		---
Nov 05	---	---		---
Nov 06	---	10.0		19.5
Nov 07	---	15.7		---
Nov 08	---	---		---
Nov 09	---	16.3		---
Nov 10	---	13.6		---
Nov 11	---	---		---
Nov 12	---	---		---
Nov 13	---	10.1		---
Nov 14	---	---		---
Nov 15	---	11.2		---
Nov 16	---	---		---
Mean =	15.7	15.8		15.2
Std. Dev. =	8.9	8.6		9.1
N =	18.0	24.0		16.0

Std. Dev. = standard deviation; N = number of catch samples

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Table 6. Correlation among Arctic cisco catch rates for three 3.0-inch mesh index nets used to estimate catch in the Upper Nigliq region, 1986.

Net Pairs	Correlation	df [1]	Critical Value [2]	Reject/ Not Reject [3]
Net 1 vs Net 2	0.68	17	0.456	R
Net 1 vs Net 3	0.60	14	0.497	R
Net 2 vs Net 3	0.71	15	0.487	R

[1] df = degrees of freedom

[2] Critical values for $P<0.05$

[3] Reject (R) or not reject (NR) null hypothesis. Null hypothesis is that there is no correlation between index catch rates.

Table 7. CPUE in the Nigliq Channel by area, species and mesh size for each 10-day interval, 1986
(CPUE in fish/24 hr/60 ft of net).

Area and Mesh Size (inches)	Oct 1 - Oct 10			Oct 11 - Oct 20			Oct 21 - Oct 30			Oct 31 - Nov 9			Nov 10 - Nov 19		
	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
Arctic Cisco															
Upper Nigliq															
(2.50) [1]	(6.6)			(16.4)			(14.3)			(16.6)			(11.5)		
3.00	7.4	7.2	3	18.3	12.0	40	15.9	13.5	14	18.5	11.5	13	12.8	2.7	4
(3.25) [2]	(9.4)			9.4	7.0	11	5.8	3.1	4	3.8	1.8	5	5.6	3.3	3
(3.50) [2]	(7.9)			7.4	4.4	9	10.8	12.0	6	11.2	13.9	7	11.7	7.2	3
Nanuk															
(2.50) [1]	---	---	0	(25.8)			(9.4)			(35.9)			(19.2)		
3.00	---	---	0	28.7	0.0	1	10.5	0.7	2	40.0	31.4	5	21.4	10.7	4
(3.25) [1]	---	---	0	(10.8)			(3.9)			(15.0)			(8.0)		
Nigliq Delta															
(3.00) [2]	---	---	0	(57.8)			57.8	18.4	8	54.5	28.7	16	147.0	112.3	8
(3.25) [2]	---	---	0	(36.8)			36.8	11.6	6	62.3	41.8	8	67.1	33.5	4

Table 7. continued.

Area and Mesh Size (inches)	Oct 1 - Oct 10			Oct 11 - Oct 20			Oct 21 - Oct 30			Oct 31 - Nov 9			Nov 10 - Nov 19		
	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
							Least Cisco								
Upper Nigliq															
(2.50) [1]	(20.9)			(33.2)			(12.3)			(2.5)			(6.1)		
3.00	1.7	2.0	3	2.7	2.3	40	1.0	1.0	14	0.2	0.3	13	0.5	0.2	4
(3.25) [2]	(0.9)			0.9	1.1	11	0.4	0.5	4	0.0	0.0	5	0.0	0.0	3
(3.50) [2]	(1.6)			1.6	2.2	9	0.3	0.4	6	0.3	0.8	7	0.6	0.1	3
Nanuk															
(2.50) [1]	---	---	0	(36.9)						(12.3)			(7.4)		
3.00	---	---	0	3.0	0.0	1	0.0	0.0	2	1.0	1.5	5	0.6	0.7	4
(3.25) [1]	---	---	0	(0.9)						(0.3)			(0.2)		
Nigliq Delta															
(3.00) [2]	---	---	0	(0.07)			0.07	0.2	7	0.7	1.4	16	0.2	0.4	6
3.25	---	---	0	---	---	0	0.0	0.0	6	1.3	2.0	8	0.5	1.2	4

[1] Calculated CPUE
[2] CPUE from next 10-day period used to calculate catch
CPUE = catch per unit effort, SD = standard deviation, N = number of catch samples

Table 8. Comparison of Arctic cisco CPUE in 3.0-inch mesh in the Upper
Nigliq area by 10-day period, 1985-1986.

10-Day Period	1985			1986		
	CPUE	SD	N	CPUE	SD	N
Oct. 1-10	5.4	3.8	19	7.4	7.2	3
Oct. 11-20	5.8	4.9	17	18.3	12.0	40
Oct. 21-30	20.6	2.9	3	15.9	13.5	14
Oct. 31 - Nov. 9	16.6	7.6	2	18.5	11.5	13
Nov. 10 - 19	---	---	0	12.8	2.7	4

CPUE = catch per unit effort
SD = standard deviation
N = number of samples
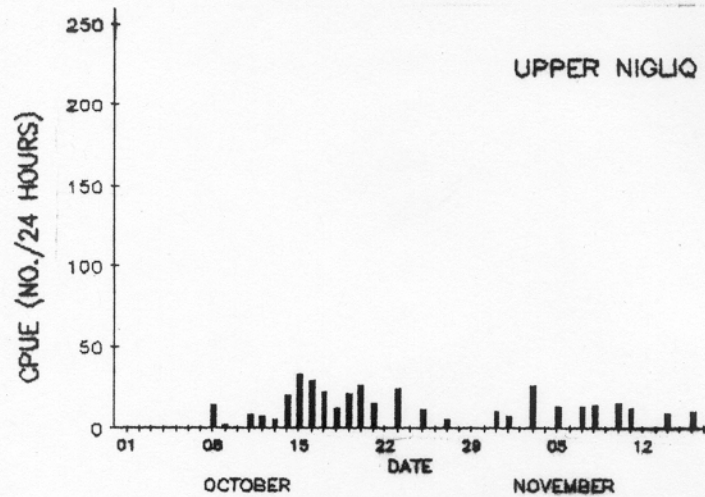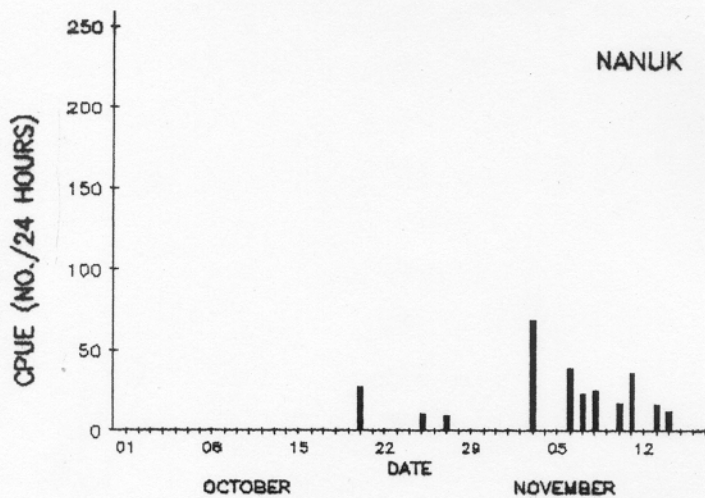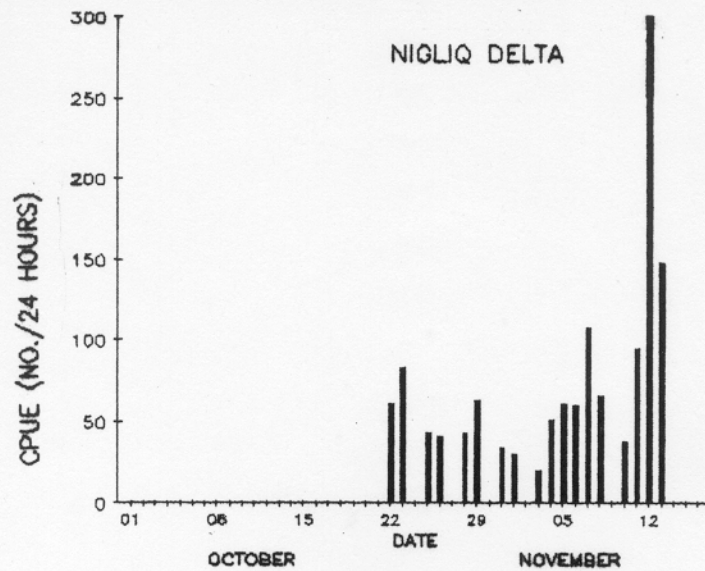
Daily CPUE of Arctic cisco in the Nigliq Channel by area for 3.0-inch mesh gill nets.

ENTRIX   FIGURE 3

between the two areas and noticeable differences in catch rates, with Arctic cisco catches normally higher and least cisco catches lower in the Nanuk region (Table 7). The overall CPUE for 3.0 inch mesh in the Nanuk region was 25.2 Arctic cisco per net-day, compared to 14.5 per net-day in the upper Nigliq. Catch rates for least cisco were much lower at Nanuk, with 0.4 per net-day compared to 1.2 per net-day at upper Nigliq.

(c) Nigliq Delta

The catch rates used to develop catch estimates for the Nigliq delta were also derived from data gathered from sampled catches. In this study area 74 percent of the total effort was sampled. Catch rates were constant during the first two 10-day periods in which fishing occurred then increased substantially during the last period before fishing was suspended on November 13 (Table 7, Figure 3). The catch rate in this region is the highest for the Nigliq Channel, with a season-long average of 86.4 Arctic cisco per net-day in 3.0 inch mesh.

(d) Outer Colville Delta

Fisherman A, who provided a complete catch record, had a mean catch rate of 161.0 Arctic cisco per net-day for 3.0 inch mesh (st. dev. = 81.7, n = 20). This rate is twice as high as the 80.3 Arctic cisco per net-day (st. dev.= 33.5, n = 21) recorded for the same location and time period in 1985. For least cisco, the mean catch rate in 3.0 inch mesh was 14.2 per net-day (st. dev.= 10.3, n = 20) in 1986, a substantial decrease from the 45.4 least cisco per net-day in 1985.

The mean CPUE for the Helmericks' East Channel effort (3.0 inch mesh) was 92.8 Arctic cisco and 27.8 least cisco per net-day while the overall CPUE for both East and Main channels was 91.7 Arctic cisco and 28.0 least cisco. The catch rates for Arctic cisco are over 3.5 times higher than in 1985, when the overall CPUE was 26.1 Arctic cisco per net-day. The 1986 least cisco CPUE was up slightly from the rate of 19.4 per net-day recorded in 1985. The Arctic cisco catch rate in 1986 was higher than 1985 for each of the 10-day periods, but the difference was greatest in the first three weeks of October (Table 9).

3.5 Estimated Total Catch

(a) Upper Nigliq

The total catch in the upper Nigliq region was estimated from the index catch rates observed in sampled nets and the total effort as determined from the observed period of fishing for each net. Total catch in the upper Nigliq region in 1986 is estimated to be 8,238 Arctic cisco and 1,329 least cisco (Table 10). This compares to catch estimates of 17,900 Arctic cisco and 2000 least cisco in this region (plus Nanuk) in 1985.

Table 9. Helmericks catch rate for Arctic and least cisco by 10-day interval, 1985-1986.

| 10-Day Period | Arctic Cisco | | | | | | Least Cisco | | | | | |
| | 1985 | | | 1986 | | | 1985 | | | 1986 | | |
	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
					East Channel							
Oct. 1-10	26.4	12.9	30	178.0	60.3	18	26.2	14.2	30	56.3	20.1	18
Oct. 11-20	40.3	17.9	22	99.4	33.6	42	29.9	17.9	22	17.8	12.4	42
Oct. 21-30	33.6	16.2	28	47.7	23.2	26	17.9	8.7	28	29.6	8.2	26
Oct. 31 - Nov. 9	33.8	15.1	17	35.8	17.4	8	12.7	5.6	17	17.9	7.5	8
Nov. 10 - 19	---	---	0	46.4	31.1	4	---	---	0	14.3	2.9	4
					Main Channel							
Oct. 1-10	60.5	25.3	18	---	---	0	43.4	9.8	18	---	---	0
Oct. 11-20	35.4	22.4	17	112.5	46.4	3	25.7	6.9	17	15.3	6.7	3
Oct. 21-30	21.9	14.3	22	36.4	19.8	3	17.8	6.8	22	44.6	21.5	3
Oct. 31 - Nov. 9	8.0	2.8	15	---	---	0	8.4	3.6	15	---	---	0
Nov. 10 - 19	---	---	0	---	---	0	---	---	0	---	---	0

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

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Table 10. Estimated Arctic cisco and least cisco catch in the Nigliq Channel by mesh size for each 10-day interval, 1986 (based on effort presented in Table 1 and CPUE in Table 7).

Area and Mesh Size (inches)	Oct 1-Oct 10	Oct 11-Oct 20	Oct 21-Oct 30	Oct 31-Nov 9	Nov 10-Nov 19	Total
Arctic Cisco						
Upper Nigliq						
2.50	53	164	143	166	81	
3.00	405	2,114	1,852	1,569	425	
3.25	75	188	116	42	22	
3.50	52	79	278	277	137	
Subtotal:	585	2,545	2,389	2,054	665	8,238
Nanuk						
2.50	0	137	125	190	0	
3.00	0	1,091	648	1,932	257	
3.25	0	97	39	120	0	
Subtotal:	0	1,325	812	2,242	257	4,636
Nigliq Delta						
3.00	0	329	2,121	1,363	882	
3.25	0	37	368	623	201	
Subtotal:	0	366	2,489	1,986	1,083	5,924
				Total Nigliq Catch:		18,798
Least Cisco						
Upper Nigliq						
2.50	167	332	123	25	43	
3.00	93	312	117	17	17	
3.25	7	18	8	0	0	
3.50	11	17	8	7	7	
Subtotal:	278	679	256	49	67	1,329
Nanuk						
2.50	0	196	0	65	0	
3.00	0	114	0	48	7	
3.25	0	8	0	2	0	
Subtotal:	0	318	0	115	7	440
Nigliq Delta						
3.00	0	1	3	18	1	
3.25	0	0	0	13	2	
Subtotal:	0	1	3	31	3	38
				Total Nigliq Catch:		1,807

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(b) Nanuk

The total estimated catches in this region were 4,636 Arctic cisco and 440 least cisco (Table 10). Total catch in the Nanuk region was estimated as in the upper Nigliq region. Because of the reduced sampling effort in this region, more extrapolation of CPUE was necessary. The combined catch estimates for both upper Nigliq and Nanuk region for 1986 were 12,874 Arctic cisco and 1,769 least cisco. These represent catch decreases of 28 and 12 percent from 1985 to 1986, while fishing effort decreased by 7 percent (Table 2).

(c) Nigliq Delta

The catch in the Nigliq Delta was also estimated from the mean CPUE for each 10-day period and the total effort during each period. For this area, the total catch in 1986 was 5,924 Arctic cisco and 38 least cisco (Table 10). In 1985, the catch was estimated to be 8,500 Arctic cisco and 0 least cisco, thus there was a 30 percent decrease in the estimated catch in this region between the two years. The fishing effort in this area, however, declined by 72 percent from 1985 to 1986 (Table 2).

(d) Outer Colville Delta

The estimated total harvest from the outer Colville Delta in 1986 is 44,180 Arctic cisco and 13,998 least cisco (Table 11). In 1985 the comparable total catches were 43,981 Arctic cisco and 31,539 least cisco for this study region (Table 12). As indicated in Section 3.2, the fishing effort declined 49 percent from the 1985 level of effort (Table 2).

Virtually complete records were obtained from fisherman in the outer Colville Delta in 1986, thus the need for estimating catches was minimal. Over 90 percent of the delta catch was sampled by survey personnel. Catch records were complete for Fisherman A and Helmericks. For Fisherman B, 8 of 55 net pulls (15 percent) were not sampled, these catches were estimated by averaging the catch rates from the preceding and subsequent days (Appendix Table 1). Similar methods were used to estimate the various missed records from Fishermen D, E and F. Fishermen D and E reported significant catches after the survey personnel left, these fisherman estimates are included in the total but are unverified.

By actual count the Helmericks fishery harvested 29,456 Arctic cisco and 9,000 least cisco and Fisherman A caught 4,789 Arctic cisco and 552 least cisco, all meshes combined (Table 11). Both showed an increase in Arctic cisco harvest, but a decrease in least cisco compared to 1985 (Table 12). Fisherman B showed a 38 percent decrease in total catch of Arctic cisco and 59 percent reduction in least cisco catch, but this was combined with a 68 percent reduction in effort.

Table 11. Total Arctic cisco and least catch by fisherman in the
Outer Colville Delta, 1986.

Fishing Location	Total Effort (net-days)	Estimated Catch	
		Arctic Cisco	Least Cisco
Main Channel			
Helmericks [1]	37.5	1,839	578
Fisherman A [1]	40.4	4,789	552
Fisherman B	86.0	5,760	2,825
Fisherman D	85.0	2,680	1,120
Fisherman E	143.1	1,213	325
Fisherman F	11.0	282	176
Subtotal:	403.0	16,563	5,576
East Channel			
Helmericks [1]	340.0	27,617	8,422
Outer Delta Total:	743.0	44,180	13,998

[1] actual reported catch

Table 12. Total estimated catch of Arctic cisco and least cisco
in the Colville Delta fall fishery, 1985-1986.

Area	Arctic Cisco		Least Cisco	
	1985	1986	1985	1986
Nigliq Channel				
Upper Nigliq	17,878	8,238	1,871	1,329
Nanuk	---[2]	4,636	---[2]	440
Nigliq Delta	8,500	5,924	0	38
Outer Colville Delta				
East Channel				
Helmericks	13,357	27,617	8,939	8,422
Fisherman C	7,906	0	5,245	0
Main Channel				
Helmericks	10,321	1,839	8,657	578
Fisherman A	3,141	4,789	1,803	552
Fisherman B	9,256	5,760	6,895	2,825
Others	---[1]	4,175	---[1]	1,621
TOTAL HARVEST	70,359	62,978	33,410	15,805

[1] unmeasured

[2] included in Upper Nigliq catch

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3.6 Size and Species Selectivity by Mesh Size

(a) Nigliq Channel

The mean size of Arctic cisco sampled in the Upper Nigliq area ranged from 328.1 mm in 3.0-inch mesh nets to 341.5 mm in 3.5-inch mesh nets (Table 13). Length frequency histograms (Figure 4) showed that few Arctic cisco less than 300 mm were caught in the Upper Nigliq in 3.0-inch mesh nets, few fish less than 320 mm in 3.25-inch mesh nets, and few less than 330 mm in 3.5-inch mesh nets. In the Nanuk area the mean lengths (Table 13) and length frequency histograms (Figure 5) were similar for both 3.0 and 3.5-inch mesh nets. In the Nigliq Delta Arctic cisco sampled from 3.0 and 3.5-inch mesh nets had mean sizes of 325.7 mm and 342.3 mm. Length frequency histograms for Arctic cisco in the Nigliq Delta showed a pattern of increasing size with increasing mesh size (Figure 6).

Least cisco exhibited a similar pattern of increasing mean length with increasing mesh size (Figure 7). Least cisco had a mean length of 321.3 mm in 3.0-inch mesh nets in the Upper Nigliq and 337.2 mm for 3.25-inch mesh nets in that area.

As previously mentioned in Section 3.4 (a), Arctic cisco comprised over 90 percent of the catch for the Nigliq Channel as a whole. Because there are few large least cisco caught in the Nigliq Channel during the fall fishery, the mesh size of nets used by fishermen in 1986 (mostly 3.0, 3.25, or 3.5-inch mesh) did not play an important role in determining the composition of the catch; the catch rates of least cisco were low for these mesh sizes (Table 7). Only in the 2.5-inch mesh nets during the first two 10-day intervals did the catch rates of least cisco approach or exceed those for Arctic cisco. However, the catch composition for all meshes was dominated by Arctic cisco during those two periods because effort with 2.5-inch mesh nets was a minor component of total effort.

(b) Outer Colville Delta

The mean size of Arctic cisco sampled in the Outer Colville Delta ranged from 331.7 mm in 3.0-inch mesh nets to 352.0 mm in 3.5-inch mesh nets (Table 13).Length frequency histograms (Figure 8) showed that few Arctic cisco less than 310 mm were caught in 3.0-inch mesh nets, few fish less than 320 mm in 3.25-inch mesh nets, and few less than 330 mm in 3.5-inch mesh nets.

In the Outer Colville Delta the mesh size of the net is an important determinant of the species composition of the catch. Overall, the percent Arctic cisco caught in nets averaged 70 percent in 3.0-inch mesh nets while in 3.25 and 3.5-inch mesh nets the percent was consistently higher, between 81 and 99 percent (Table 4). Thus, the percent catch of Arctic cisco (the target species) was much higher in the 3.25 and 3.5-inch mesh nets, as the catch of the less-desirable least cisco was reduced. However, catch rates of Arctic cisco also declined dramatically when the larger mesh nets were fished (Table 14). There appears to be a trade-off: reducing the catch of the less-desirable least cisco by using larger mesh nets also

Table 13. Mean length of Arctic cisco by area and mesh size, 1985 and 1986.

Area and Mesh Size (in.)	1985		1986	
	Mean Length (mm)	N	Mean Length (mm)	N
Upper Nigliq [1]				
3.00	335.8	199	328.1	724
3.25	352.6	29	341.6	143
3.50	361.2	230	341.5	124
Nanuk				
3.00	---	---	325.7	72
3.50	---	---	327.7	153
Nigliq Delta				
3.00	---	---	324.8	95
3.25	---	---	342.3	66
Outer Colville Delta [2]				
3.00	329.8	188	331.7	245
3.25	---		341.5	182
3.50	354.6	277	352.0	41

[1] included Nanuk area in 1985
[2] excluding Helmericks
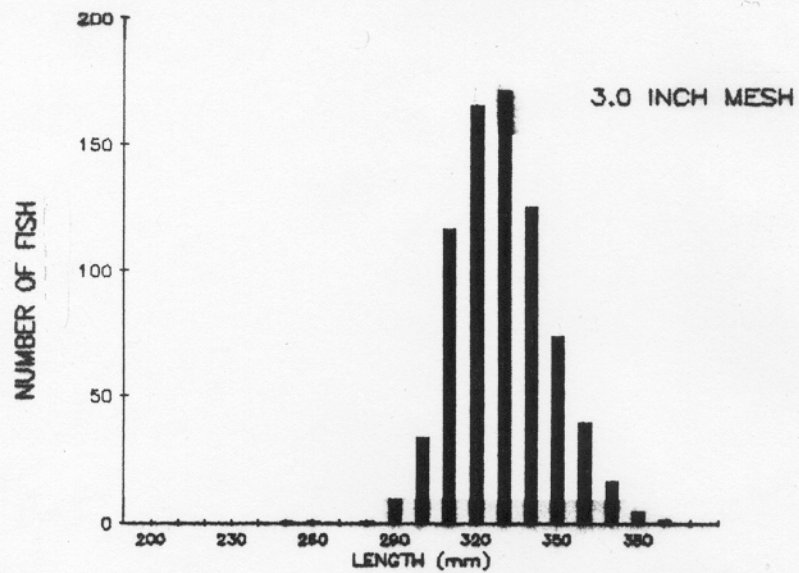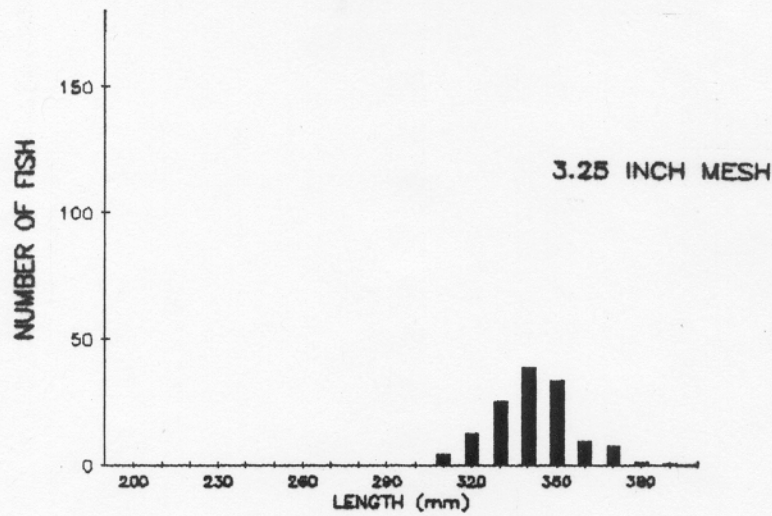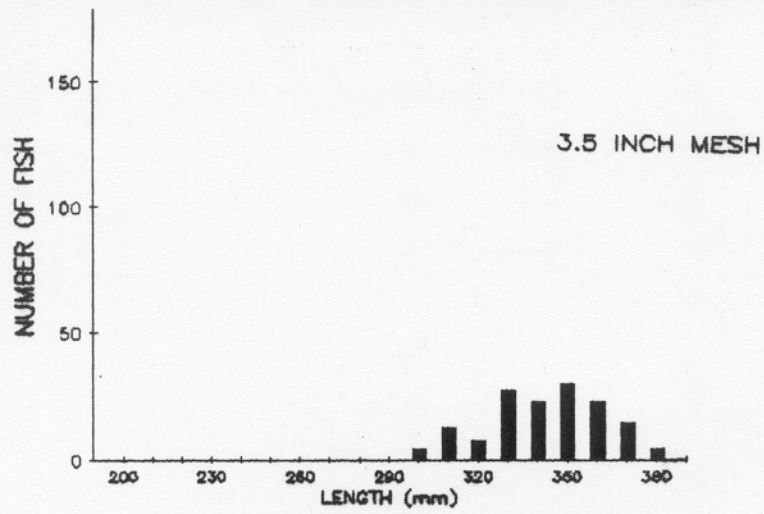
Length frequencies of Arctic cisco in the Upper Nigliq area by mesh size.

ENTRIX   FIGURE 4
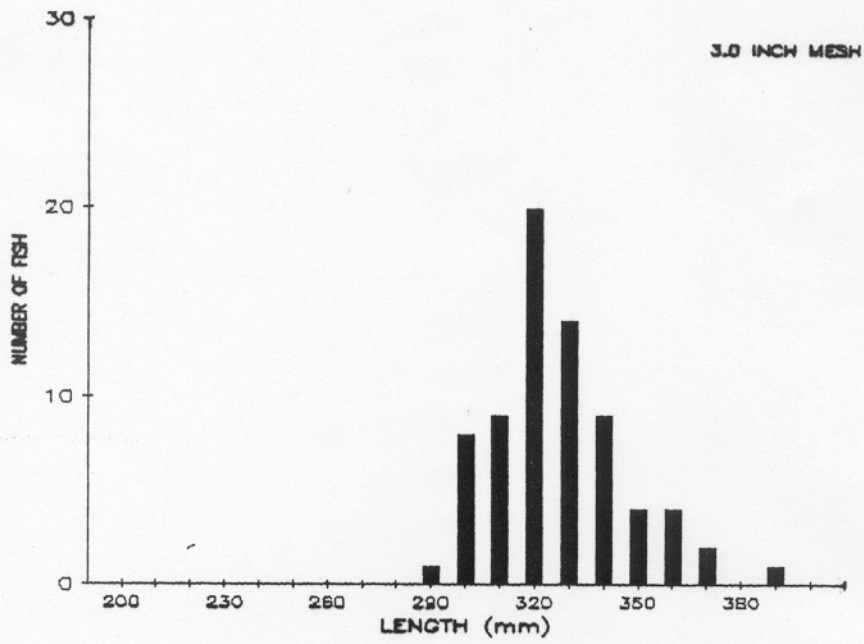
Length frequencies of Arctic cisco in the Nanuk area by mesh size.

ENTRIX

FIGURE 5

30
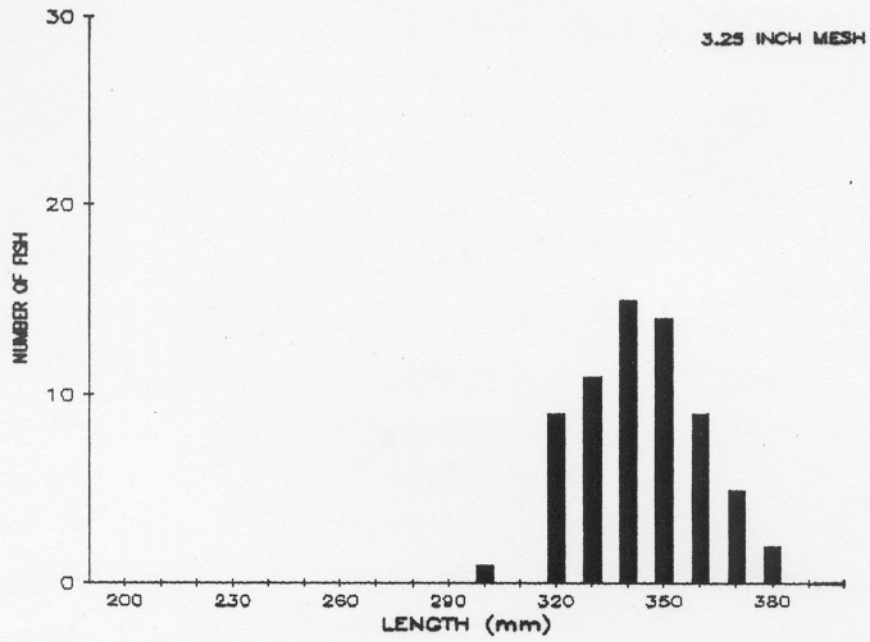
Length frequencies of Arctic cisco in the Nigliq Delta by mesh size.
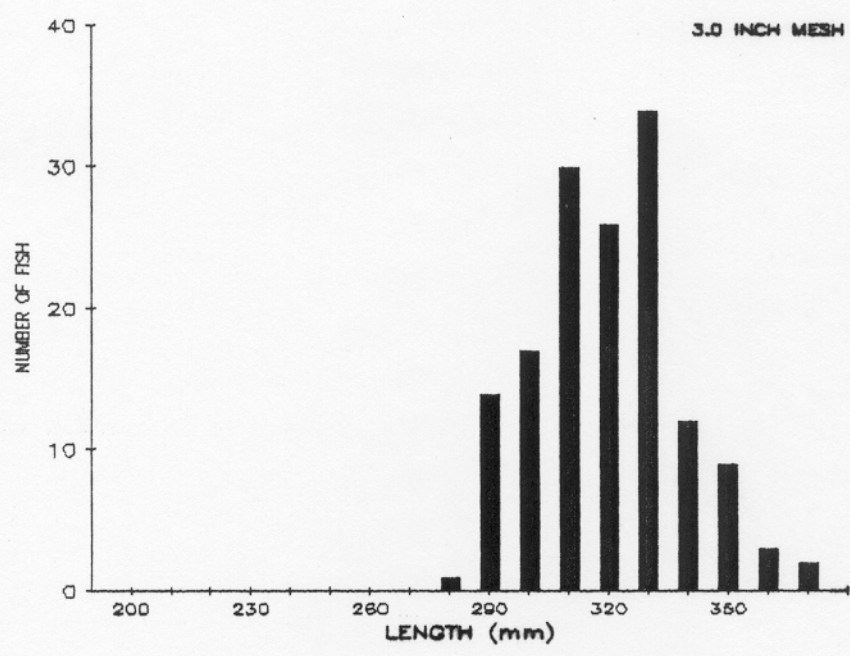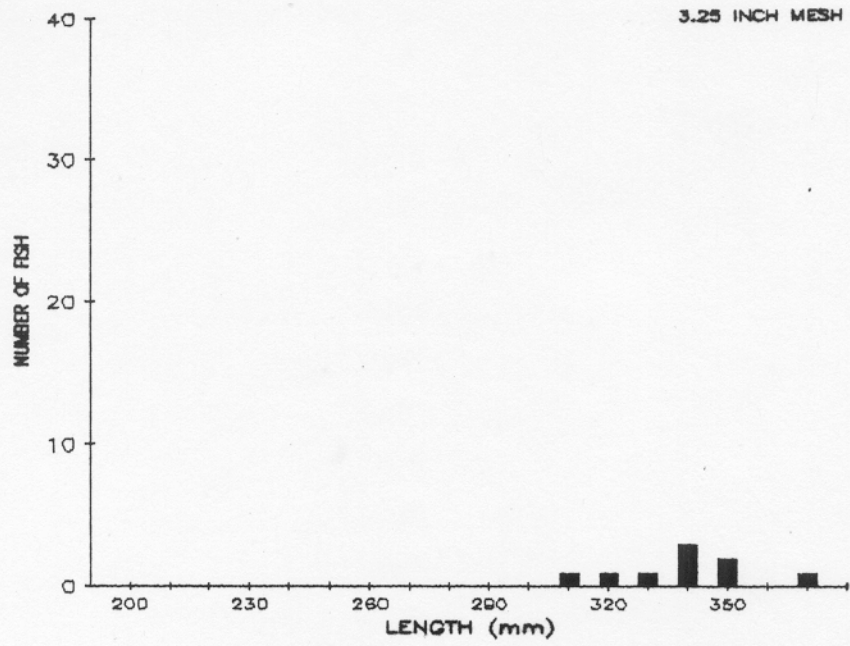
Length frequencies of least cisco in the Nigliq Channel by mesh size.

ENTRIX   FIGURE 7
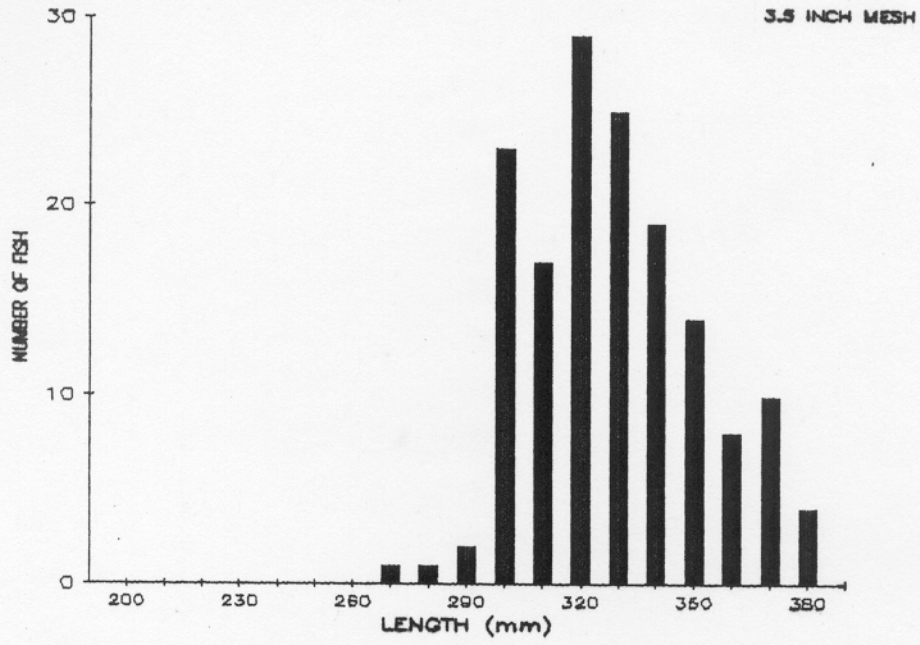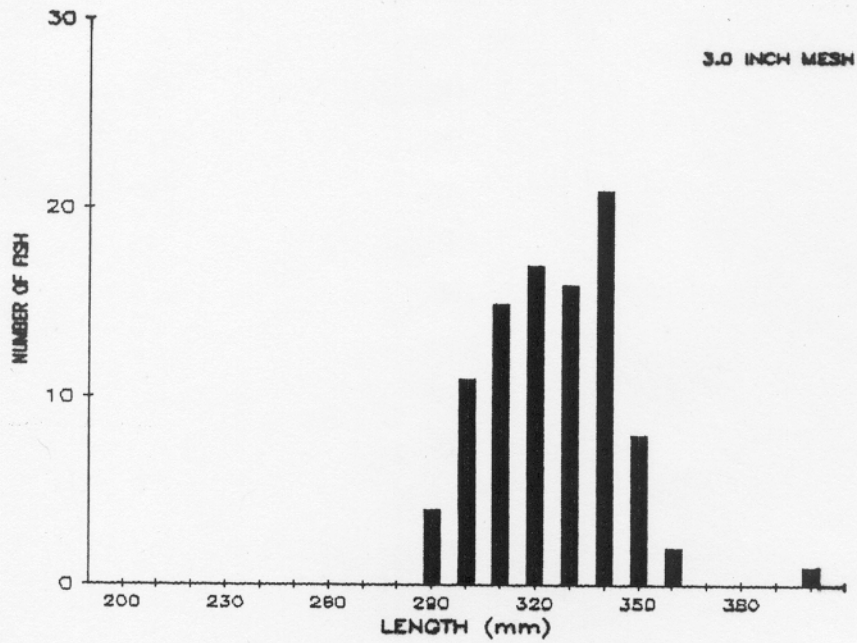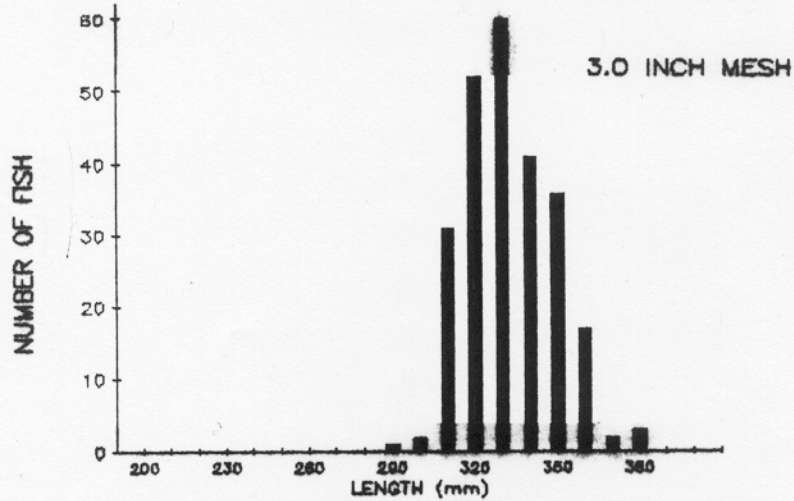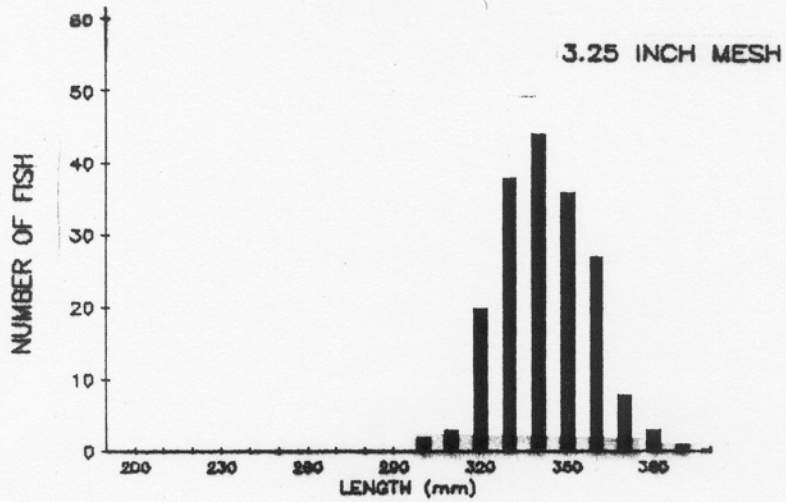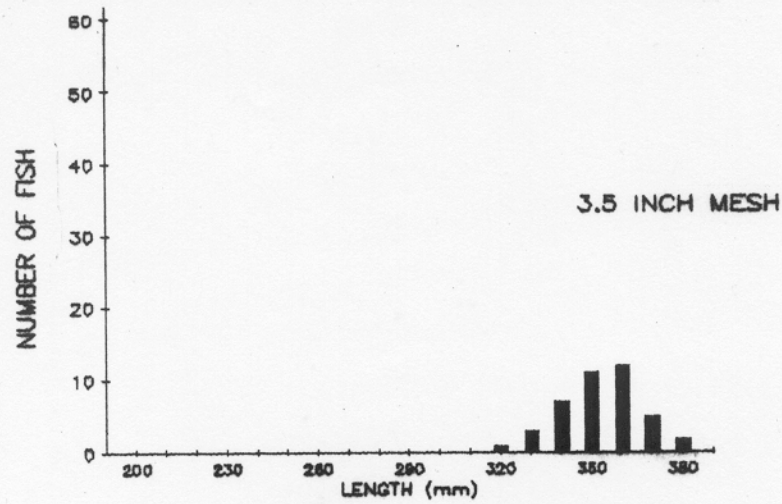
Length frequencies of arctic cisco in the Outer Colville Delta by mesh size.

ENTRIX   FIGURE   8

Table 14. CPUE in main channel Outer Colville Delta (excluding Helmericks) by species and mesh size for each 10-day interval, 1986 (CPUE in fish/24 hr/60 ft of net).

Mesh Size	Oct 1 - Oct 10			Oct 11 - Oct 20			Oct 21 - Oct 30			Oct 31 - Nov 9			Nov 10 - Nov 19		
(inches)	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
Arctic Cisco															
2.50	---	---	0	---	---	0	---	---	0	14.5	4.4	2	---	---	0
3.00	---	---	0	151.4	97.1	28	50.3	43.7	75	21.2	16.8	17	24.9	46.3	11
3.25	---	---	0	52.1	60.0	10	---	---	0	---	---	0	---	---	0
3.50	---	---	0	30.9	26.1	2	15.1	19.9	2	11.7	3.6	7	30.8	37.7	3
Least Cisco															
2.50	---	---	0	---	---	0	---	---	0	7.8	7.0	2	---	---	0
3.00	---	---	0	17.6	12.7	26	27.1	23.5	68	16.2	14.1	15	12.4	23.9	10
3.25	---	---	0	2.7	1.5	6	---	---	0	---	---	0	---	---	0
3.50	---	---	0	2.4	0.0	1	3.1	0.0	1	1.2	0.7	3	1.5	1.2	3

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

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reduces the catch of Arctic cisco. During years when the ratio of arctic to least cisco is high (such as 1986) it would not be as practical to use the larger mesh nets. The local fishermen prefer 3.0-inch mesh nets, as reflected by the much lower utilization of nets with other mesh sizes.

Gill nets are substantially more selective for particular size and age groups of fish than are fyke nets. Fyke nets are more representative of the range of size and age groups in populations, and a comparison of the catch distribution of gill nets with the catch distribution of fyke nets indicates the selectivity of the gill nets. A comparison of the size groups of Arctic cisco caught in 3.0-inch mesh gill nets with the Arctic cisco catch in fyke nets of the Endicott Monitoring Project shows that 85 percent of the Arctic cisco in the population (represented by the fyke net catch) were vulnerable to the gill-net fishery in 1986 (Figure 9). Similarly, 88 percent of the least cisco caught in fyke nets in 1986 were vulnerable to the gill-net fishery (Figure 10). The pattern for least cisco is similar to that seen in 1984 and 1985. For Arctic cisco, there was a large percentage of the population in 1984 (46 percent) and 1985 (38 percent) that was too small to be caught in by 3.0 inch gill nets (Moulton et al. 1986). The 1986 data indicate that few young Arctic cisco are available to recruit into the gill-net fishery in up-coming years. Reduced catch rates for arctic and least cisco will likely occur in the 1987 and 1988 fishing seasons. For this analysis it has been assumed that the fyke net catches of the Endicott Monitoring Project are representative of the overwintering populations of arctic and least cisco of the Colville Delta. Tag and recapture information indicates this assumption is reasonable. Most least cisco and many Arctic cisco that utilize the near-shore Beaufort Sea between the Colville Delta and Prudhoe Bay for summer feeding are known to overwinter in the Colville Delta (Moulton and Carpenter 1986). It appears that the abundant 1979 year-class of Arctic cisco mentioned by Moulton et al. (1986) was fully recruited to the fishery in 1986. Year classes after 1980 are virtually missing from the fyke net catch data.

3.7 Age Composition

A sample of 199 Arctic cisco caught in 3.0 inch mesh was obtained from the Helmericks catch for aging. The sample was composed of three ages, 6 through 8, with ages 6 and 7 dominating the sample (Table 15). This is the first instance of age-7 being the dominant age group in the Helmericks fishery. In three previous years of age analysis based on otolith readings, age-5 or 6 has dominated, although other ages often comprised major portions of the catch (Figure 11). The age-7 Arctic cisco represent the 1979 year-class, which has been dominant in the region for several years (Moulton et al. 1986) and has reached a size that is vulnerable to the gill nets used in the fishery. The 1976-1978 data (from Craig and Haldorson 1981) also show fluctuations in age structure resulting from strong and weak year classes moving through the fishery.

Another way to view the contribution of each year class to the fishery is to partition the catch into year-classes based on the age distribution of the sampled catch. The age data from Craig and Haldorson (1981) and CPUE data from Gallaway et al. (1983) were used to
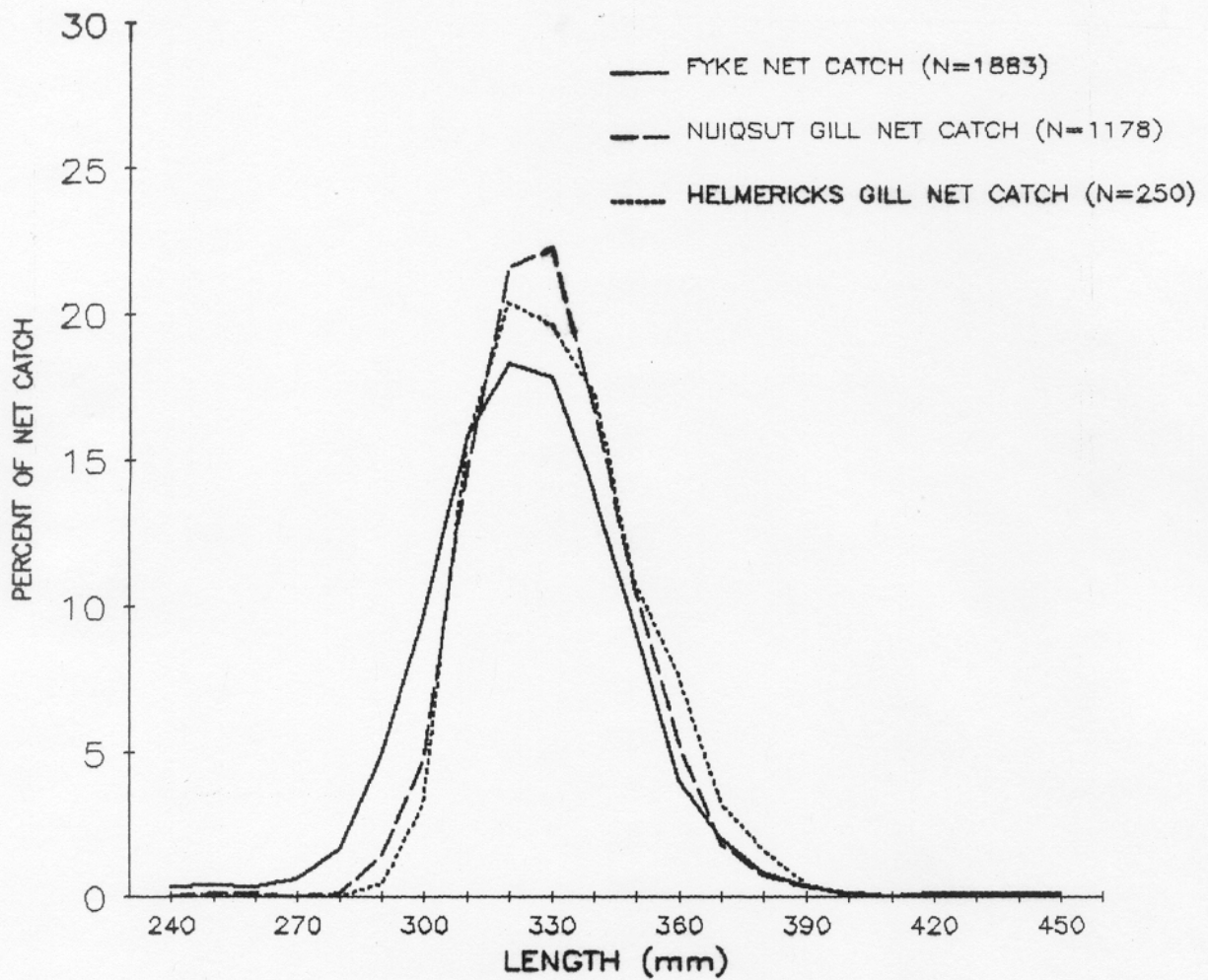
Length distribution of arctic cisco caught and released from fyke nets compared to lengths of arctic cisco caught in 3.0-inch gill nets.

Fyke net data from 1986
Endicott Monitoring Project

ENTRIX   FIGURE   9

36
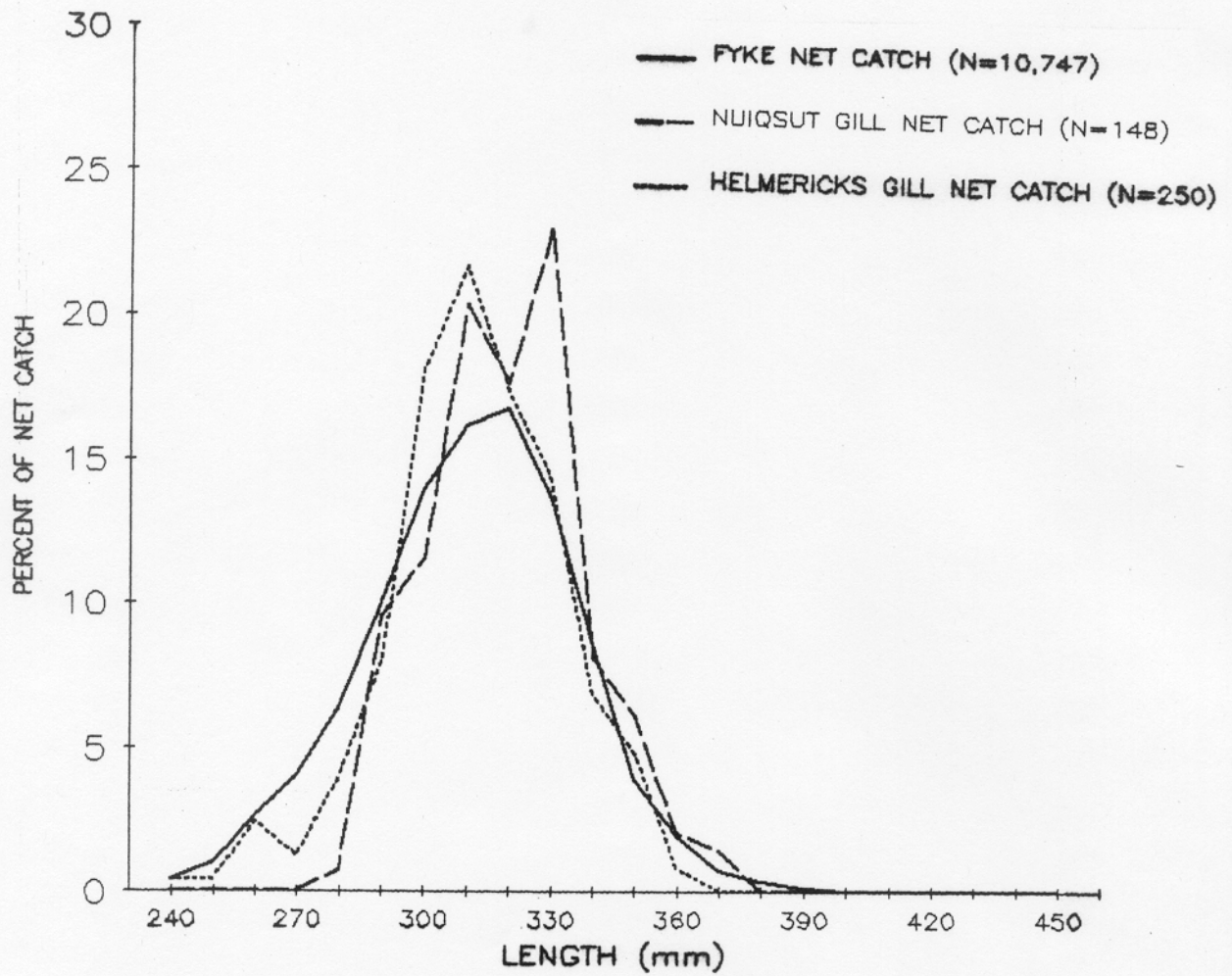
Length distribution of least cisco caught and released from fyke nets compared to lengths of least cisco caught in 3.0-inch gill nets.

Fyke Net Data from 1986
Endicott Monitoring Project

ENTRIX   FIGURE   10

Table 15. Age of Arctic cisco captured in 3.0-inch mesh gill net
as determined by otolith readings (N = 199).

Age (years)	Frequency	Mean Length (mm)	Standard Deviation
6	82	326.4	14.76
7	101	345.2	17.85
8	16	348.2	13.59
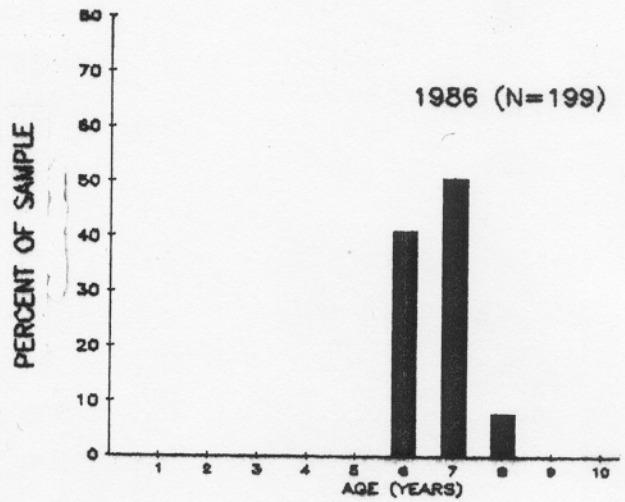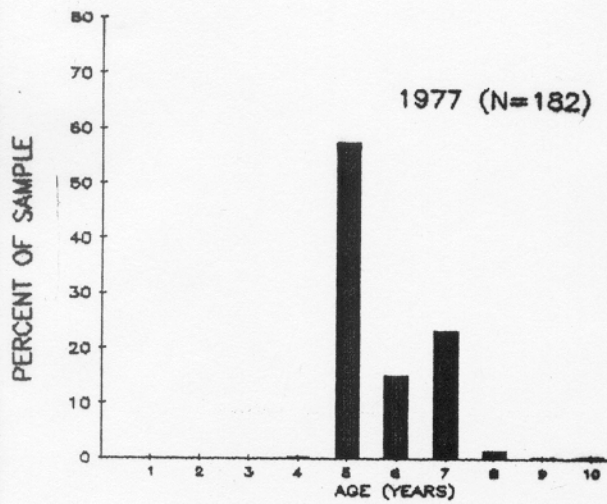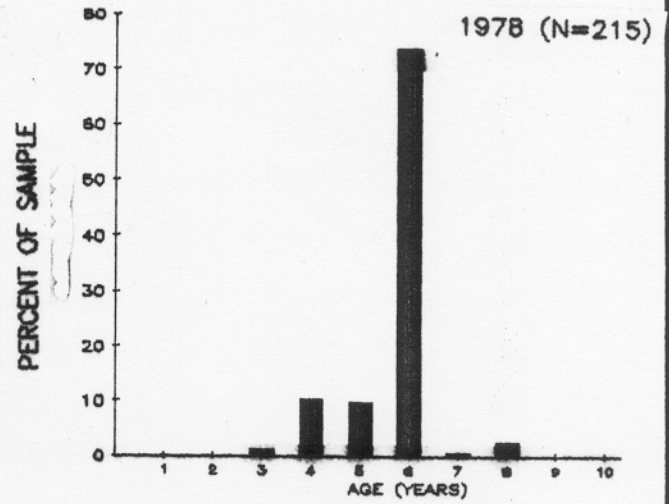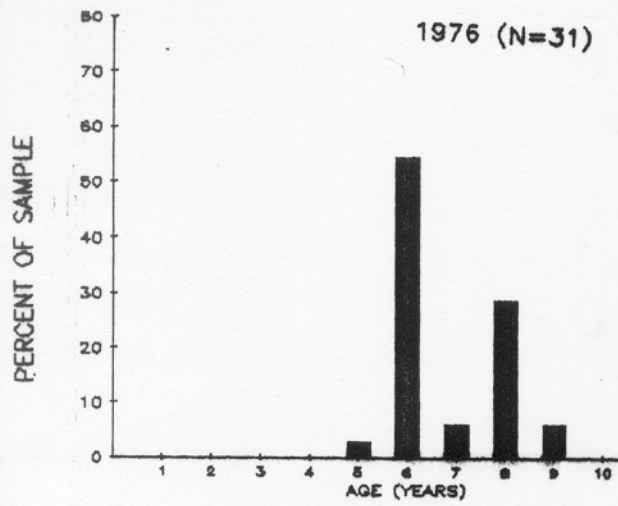
Age distribution of arctic cisco sampled from Helmericks Fishery 1976, 1977, 1978, 1986.

Data for 1976-1978 from Craig and Haldorson 1981

ENTRIX

FIGURE 11

partition the 1976 to 1978 Arctic cisco catches from the Helmericks fishery into year-class contributions (Table 16). The data from this report were used to partition the 1986 data. To maintain comparability with the Gallaway et al. (1983) data, for this analysis only, CPUE is defined as fish/24 hr/150 ft of net and was calculated by dividing total catch (29,456 Arctic cisco) by the total number of net-days (151). This analysis demonstrated that the contribution to the high CPUE in 1986 is primarily from the 1979 and 1980 year-classes. While the contribution by the 1978 year-class is high for age-8 fish, it is comparable to previous year-classes. In 1976, the catch contained a substantial number of 1968 year-class (age-8) fish, as well as age-6 fish, so occasional high catch rates of age-8 fish may be normal when a particular year-class is abundant. The high catch rates shown by the 1979 and 1980 year-classes, however, appear to be unprecedented in the twenty years of data from the Helmericks fishery. The highest CPUE previously recorded in the fishery (76.0 recorded in 1981) was eclipsed by both the 1979 and 1980 year-class catch rates in 1986. The 1986 total CPUE of 195.1 per net-day was over 2.5 times higher than the 1981 rate.

The age structure of the Bering cisco captured in the East Channel revealed further differences between this species and the Arctic cisco found in the Colville Delta. One of the 44 fish identified as Bering cisco was determined to be an Arctic cisco. Of the remaining 43, 5 were age-4, 34 were age-5, and 4 were age-6. Arctic cisco caught in 3.0-inch mesh, as indicated above, were primarily age-6 and 7. There was a noticeable difference in the otolith structure between the two species, with the Bering cisco having a more serrated edge and less well-defined annuli.

3.8 Tag Returns

A total of 242 tagged fish were recovered from the Nuiqsut-based fall fishery: 187 from the Outer Colville Delta, 13 from the Nigliq Delta, 21 from Nanuk and 21 from the Upper Nigliq. Of these tags, 147, or 61 percent, were released by the 1985 Endicott Project. The Helmericks fishery returned an additional 464 tags, 53 percent of which were 1985 Endicott tags (Table 17). One of the tags recovered by Helmericks on October 30 was from a 324 mm Arctic cisco released on August 30, 1986 at Oruklalik Lagoon, east of Jago River (D. Wiswar, USFWS, pers. comm., 1986). A similar record of tagged Arctic cisco from the Arctic National Wildlife Refuge moving into the Colville Delta to overwinter was documented in 1985 (Moulton et al. 1986).

In the Nigliq Channel (all areas combined), over 83 percent of the tags were from Arctic cisco (45 of 54 tags), which is not totally unexpected since this species represented over 90 percent of the catch in the Nigliq Channel.

The tag returns from the Helmericks fishery allow an update of an analysis presented in the 1985 fishery assessment report (Moulton et al. 1986). In that report, the tag returns from the Helmericks fishery for a six year period were summarized to calculate the rate of tagged fish in the Arctic cisco and least cisco populations disappearing over time. It is thought that the rate of decline for least cisco is an indication of total mortality (both natural and fishing), but

Table 16. Contribution of different year-classes to the Helmericks fishery
in 1976, 1977, 1978 and 1986.

Year-Class	CPUE by Fishing Year			
	1976	1977	1978	1986
1967	1.7	0.3	0.0	
1968	7.8	0.3	0.0	
1969	1.7	0.8	0.0	
1970	14.8	12.4	0.3	
1971	0.9	8.1	0.1	
1972	0.0	30.2	7.2	
1973	0.0	0.3	1.0	
1974	0.0	0.0	1.0	
1978				15.7
1979				99.0
1980				80.4
Total CPUE:	26.9	52.4	9.6	195.1

CPUE = number of fish/24 hr/150 ft of net
Values for 1976-1978 calculated from data in Craig and Haldorson (1981)

Table 17. Tags recovered in 1986 fall fishery by area and species.

| | Outer Colville Delta | | | | | | | | | | | Nigliq Delta | | Nanuk | | Upper Nigliq | |
| | Helmericks | | A | | B | | D | | Others | | | | | | | | | |
Tag Type	Arctic	Least	Arctic	Least	Arctic	Least	Arctic	Least	Arctic	Least	Arctic	Least	Arctic	Least	Arctic	Least
85 Endicott	116	128	29	6	28	22	4	5	7	3	10	1	11	2	15	0
85 Colville	2	5	0	0	2	4	0	0	0	0	1	0	1	0	1	1
84 Waterflood	35	145	8	7	9	28	2	6	0	6	1	0	3	3	1	3
82 Waterflood	0	4	0	1	1	0	0	0	0	0	0	0	0	0	0	0
82 Endicott	0	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0
81 Waterflood	0	14	0	1	0	2	0	1	0	0	0	0	1	0	0	0
Total Tags	153	303	37	16	40	56	6	12	7	9	12	1	16	5	17	4
Total Catch	29,456	9,000	4,789	552	5,760	2,825	2,680	1,120	1,495	501	5,924	38	4,636	440	8,238	1,329

for Arctic cisco is support for the Mackenzie-origin hypothesis of Arctic cisco inhabiting the Colville River. The 1986 data are added to those summaries in Tables 18 and 19. With the reduced catch of least cisco in 1986, it also became apparent that the analysis needed to be corrected for the number of fish examined each year. Thus the present analysis includes a standardized value for the number of recovered tags: this standardized value is the number of tags recovered per 20,000 fish examined. These standardized values are then used to revise the percent reduction in tag recovery rate for each year (Tables 20 and 21). The overall values and conclusions are similar to those presented in the 1985 report--tagged Arctic cisco disappear at a high rate for two years after which none are recaptured, while tagged least cisco disappear at an average of 35 percent for four years and remain in the population for up to ten or more years. For example, in 1986 a least cisco with an Alaska Department of Fish and Game tag released in 1977 was taken in the Helmericks fishery.

3.9 Salinity Associated With Catch Rates in the Nigliq Channel

Salinity in the Nigliq Channel generally increased downstream from Nuiqsut. By the second week of October, salinity in the Upper Nigliq area near Nuiqsut was generally between 9-12 ppt at depths of 2-4.5 meters. Surface salinity (at 1 m) varied between 0.5-1.0 ppt until October 22 when it rose to 4-5 ppt. Salinities at middle and bottom of the water column at Nanuk were typically 14-15 ppt, with surface salinities between 1-9 ppt. The Nigliq Delta had the highest salinities with middle and bottom salinities generally between 18-22 ppt. The lowest salinities near the surface were 5-6 ppt.

The highest catch rates for Arctic cisco in the Nigliq Channel were associated with the highest salinities, while the highest catch rates of least cisco were associated with the lowest salinities (Table 22). The bottom, or near-bottom, salinities were used as the salinity index because the nets are set in the lower portion of the water column. During this period, there is continuous water under the ice throughout the Nigliq Channel, thus fish are able to move to the most acceptable conditions. During the fall fishing season, the areas with 18-22 ppt water appear more acceptable for Arctic cisco than areas with 10-14 ppt water.

Table 18. Number of tagged least cisco recaptured annually and number recaptured per 20,000 fish examined in the Helmericks fishery, 1980-1986.

Release Year	Release Organization	Number of Tags Released	Total Catch Examined	Number Recaptured by Year (recaptures per 20,000 fish caught)							Total Recaptured
				1980	1981	1982	1983	1984	1985	1986	
1980	LGL	1,067	31,459	32 (20.3)	20 (25.8)	8 (5.9)	12 (6.3)	3 (4.6)	5 (5.7)	2 (4.4)	82
1981	LGL	6,157	15,504		90 (116.1)	155 (114.5)	159 (83.9)	52 (79.5)	45 (51.1)	14 (31.1)	515
1982	LGL	1,798	27,085			155 (114.5)	48 (25.3)	22 (33.6)	20 (22.7)	7 (15.6)	252
1982	WCC	2,131	27,085			88 (65.0)	56 (29.5)	14 (21.4)	11 (12.5)	4 (8.9)	173
1983	---	0	37,909					---	---	---	---
1984	WCC	14,126	13,076					304 (465.0)	318 (361.4)	145 (322.2)	767
1985	ENV	9,915	17,596						436 (495.6)	128 (284.4)	564
1986	---	0	9,000							---	

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Table 19. Number of tagged Arctic cisco recaptured annually and number recaptured per 20,000 fish examined in the Helmericks fishery, 1980-1986.

| Release Year | Release Organization | Number of Tags Released | Total Catch Examined | Number Recaptured by Year (recaptures per 20,000 fish caught) | | | | | | | Total Recaptured |
				1980	1981	1982	1983	1984	1985	1986	
1980	LGL	229	14,657	10 (13.6)	6 (3.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	16
1981	LGL	1,756	38,176		62 (32.5)	4 (5.0)	4 (4.4)	0 (0)	0 (0)	0 (0)	70
1982	LGL	439	15,975			8 (10.0)	4 (4.4)	2 (1.4)	0 (0)	0 (0)	14
1982	WCC	435	15,975			12 (15.0)	4 (4.4)	0 (0)	0 (0)	0 (0)	16
1983	---	0	18,162				---	---	---	---	
1984	WCC	5,840	27,677					88 (63.6)	42 (35.5)	35 (23.8)	165
1985	ENV	11,695	23,678						147 (124.2)	116 (78.8)	263
1986	---	0	29,456							---	

Table 20. Decrease in tagged Arctic cisco captured in the Helmericks fishery after initial release year (based on recaptures per 20,000 fish caught), 1980-1986.

| Release Year | Percent Recaptured After Being At Large | | | | | | |
	0 yr	1 yr	2 yr	3 yr	4 yr	5 yr	6 yr
1980	5.9	1.4	0	0	0	0	0
1981	1.9	0.28	0.25	0	0	0	
1982 (LGL)	2.3	1.0	0.32	0	0		
1982 (WCC)	3.4	1.0	0	0	0		
1983	---	---	---	---			
1984	1.1	0.61	0.41				
1985	1.1	0.67					
Mean	2.62	0.83	0.20	0	0	0	0
SD	1.82	0.39	0.19				
Percent Decrease Per Year		68	76	100			

Table 21. Decrease in tagged least cisco captured in the Helmericks fishery
after initial release year (based on recaptures per 20,000 fish caught),
1980-1986.

Release Year	Percent Recaptured After Being At Large						
	0 yr	1 yr	2 yr	3 yr	4 yr	5 yr	6 yr
1980	1.9	2.4	0.55	0.59	0.43	0.53	0.41
1981	1.9	1.9	1.4	1.3	0.83	0.51	
1982 (LGL)	6.4	1.4	1.9	1.3	0.87		
1982 (WCC)	3.1	1.4	1.0	0.59	0.42		
1983	---	---	---	---			
1984	3.3	2.6	2.3				
1985	5.0	2.9					
Mean	3.60	2.10	1.43	0.95	0.64	0.52	0.41
SD	1.78	0.63	0.70	0.41	0.25	0.01	
Percent Decrease Per Year		42	33	32	33	19	21

4.0 SUMMARY AND DISCUSSION

As presented in the results, the catch of Arctic cisco in the Colville Delta in 1986 is estimated to be 63,000 fish, as compared to the estimated catch of 70,400 in 1985. Similarly, the catch of least cisco is estimated to be 15,800 in 1986 and 33,400 in 1985. The two major differences between the 1985 and 1986 fall fishery are (1) the 38 percent decrease in fishing effort in 1986 and (2) the phenomenal increase in the catch rate of Arctic cisco. Examples of the increase in Arctic cisco catch rate are the 158 percent increase in the Upper Nigliq/Nanuk region, the 182 percent increase in the Helmericks fishery and the 100 percent increase by Fisherman A, using 3.0-inch mesh nets in all three examples.

The reduction in effort was primarily the result of four independent events: (1) one fisherman who accounted for the majority of the effort in the Nigliq Delta in 1985 was unable to fish because of an injury, (2) fisherman C from 1985 chose not to fish because of other commitments, (3) Fisherman B reduced his fishing effort by 68 percent to devote more time to processing and preparing a bowhead whale harvested in early October and (4) Helmericks reduced his effort by 58 percent because the high Arctic cisco CPUE allowed him to reach an acceptable catch level with reduced effort. The harvest of the bowhead whale by Nuiqsut villagers also caused some of the fishermen who fish the upper Nigliq and Nanuk areas to start fishing later than normal, this probably contributed to the slight reduction in effort (7 percent) in these areas.

The increase in Arctic cisco catch rate is likely caused by the full recruitment of the 1979 and 1980 year-classes into the fishery. As demonstrated in the 1985 fishery assessment (Moulton et al. 1986), there was a pool of Arctic cisco that were inaccessible to 3.0-inch mesh nets in 1985, but would grow to harvestable size in 1986. The comparison of the sizes present in the population as opposed to the sizes caught indicate that the population was fully recruited to the fishery in 1986. It also indicates, however, that there are few younger fish available to recruit into the fishery in 1987. The age-7 fish had a mean length of 345 mm in 1986 while the mean length of age-6 fish was 326 mm. With normal summer growth, the 1987 fishery will likely be composed primarily of 1980-year class fish. As predicted in 1985 by Moulton et al. (1986) and George and Kovalsky (1986), the catch rate of Arctic cisco is expected to decrease substantially in 1987 and further in 1988 as the 1979 and 1980 year-classes leave the fishery.

In the report on the 1985 fishery, the historical data on tag returns from the Helmericks fishery were used to estimate the rate at which tagged fish disappeared from the populations (Moulton et al. 1986). The data were interpreted as indicating both total mortality rates for least cisco and support for the Mackenzie-origin hypothesis for Arctic cisco. In 1986, these estimates have been updated with an additional year of data and the data have been standardized to the catch level for each year of record. The results lead to similar conclusions as those reported in the 1985 annual report: the annual mortality rate for tagged least cisco is about 35 percent (40 percent in the 1985 annual report) for four years after release, while the tagged Arctic cisco disappear at rates of 68 and 76 percent for the first two

years and then leave the region.

The results of the 1986 assessment continue to indicate that the harvest rate is within an acceptable range and is not subjecting either population to a high level of fishing mortality. This statement is based on the following evidence:

1)   the harvestable population of Arctic cisco increased in 1986 (based on comparison of catch rates) while the total catch decreased, thus the exploitation rate decreased, possibly by 50 percent or more. The exploitation rate for Arctic cisco in 1985 was estimated to be between about 6 to 12 percent, depending on the percentage of harvestable Arctic cisco that overwintered in the Colville Delta.   Thus the exploitation rate in 1986 probably did not exceed 5 percent and have been 3 percent or less.

2)   the catch rates of least cisco in 1986 were similar to those recorded in 1985, which is interpreted as indicating that the harvestable population was of similar size in both years. The total catch , however, decreased by over 50 percent because of reduced effort. In 1985, the exploitation rate was estimated to be 10 percent, thus in 1986 the exploitation rate may have been around 5 percent.

5.0 LITERATURE CITED

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Appendix Table 1. Daily CPUE of Arctic cisco for Fisherman B in 3.0-inch
mesh nets in Outer Colville Delta, 1986.

Date	CPUE					
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6
Oct 20	146.0	175.9	177.7	---	(61.3)	(45.1)
Oct 21	110.8	116.2	128.0	201.3	82.6	57.5
Oct 22	89.4	77.9	88.8	139.2	39.9	32.7
Oct 23	64.8	81.6	96.0	80.0	35.6	43.2
Oct 24	65.8	80.8	84.0	108.0	23.4	19.8
Oct 25	61.7	76.0	72.0	78.0	32.9	30.5
Oct 26	(44.1) [1]	(53.6)	(52.1)	(62.6)	(53.9)	(49.3)
Oct 27	---	*	*	*	*	*
Oct 28	---	31.1	32.2	47.1	74.9	68.0
Oct 29	---	21.6	42.7	65.3	196.0	123.2
Oct 30	---	---	16.3	26.1	28.1	18.8

[1] Estimated by average percent decrease (28.5%) in CPUE of Nets 2 and 3

( ) estimated from preceding or subsequent daily CPUE

CPUE = catch per unit effort (fish/24 hr/60 ft of net)

--- : net not fishing

* net not checked by fisherman