COLVILLE RIVER FISH STUDY

Assessment of the Colville River Fall Fishery
1985 - 1987

FINAL REPORT
JUNE 1988

Prepared for

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

ASSESSMENT OF THE COLVILLE RIVER FALL FISHERY 1985 - 1987

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ASSESSMENT OF THE COLVILLE RIVER FALL FISHERY 1985 - 1987

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EXECUTIVE SUMMARY

INTRODUCTION

The Colville River on the Alaskan Arctic Coastal Plain supports substantial populations of Arctic cisco (Coregonus autumnalis), least cisco (C. sardinella), broad whitefish (C. nasus), humpback whitefish (C. pidschian), and Dolly Varden char (Salvelinus malma) that have historically been harvested by native people (Murdoch 1884; Steffanson 1913). In contrast to the commercial fishery, for which there is an abundance of data, there is scant information on harvest levels for subsistence fisheries in the remainder of the Colville drainage (Craig and Haldorson 1981; George and Kovalsky 1986; George and Nageak 1986). The harvest from the village fishery is retained for food, trade, or other subsistence uses.

The primary objectives of this study were to (1) obtain estimates of the total effort and catch for the fall fishery in the delta, including harvests of both the village of Nuiqsut and the commercial fishery, and (2) evaluate the effects of these harvest levels on the stocks. The lack of information on harvest levels, coupled with concern for possible effects on the fish stocks from coastal developments around the Prudhoe Bay oilfields, prompted this effort to evaluate current harvest levels and develop recommendations for future management strategies.

METHODS

The study area included the Colville River from the Itkillik River downstream to Harrison Bay. The study area was divided into four areas based on known areas of concentrated fishing effort. Monitoring of the fall under-ice gill net fishery began in early October and continued through mid-November from 1985 to 1987. Within the four main areas each 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 locations, net length, and mesh size; thus, there was a virtually complete census of fishing effort.

During the main fishing season, village and commercial catches were sampled daily 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 catch data were collected, set duration, net length, and mesh size data were also recorded so that catch

rates could be calculated for the net set. In 1986 and 1987, otoliths were obtained from Arctic cisco captured in 76-mm (3.0 inch) stretched mesh nets to evaluate the age composition of the Arctic cisco catch. In 1987, otoliths were also collected from least cisco caught in 76-mm mesh. Aging was completed by the cross-sectional burn technique. Fish used for aging were selected from 76-mm mesh nets because it is the most common mesh size used in the fishery.

Effort was calculated in net-days by using the start and end dates for each individually-tracked net. The catch rate was estimated by treating each individual sample (usually the catch from one net on a given day) as an independent sample. The total effort expended by each mesh size in each area and the associated estimated catch rates were calculated for each 10-day interval during the fishing season, starting on October 1. Estimated catches for each mesh size by 10-day interval were then calculated and summed to provide the estimates of total catch. In many cases in the Outer Colville Delta, especially in 1986 and 1987, complete counts of total catch were obtained from individual fishermen.

In 1984 and 1985, the release and subsequent recapture of a substantial number of tagged cisco by studies near Prudhoe Bay (Moulton et al. 1936; Envirosphere 1987) allowed an estimate of the total number of fish available to the fishery. Tagging was suspended following 1985, so subsequent evaluation of population size was based on changes in catch rate in the fishery.

RESULTS

Distribution of Fishing Effort. The number of Nuiqsut fishing groups (a family or group of families fishing cooperatively) participating in the under-ice fishery decreased from 30 in 1985 to 25 in 1986 and increased to 34 in 1987. Fishing effort was concentrated on the Upper Nigliq area because of its proximity to town.

A 49 percent decrease in total effort from 1985 to 1986 in the Outer Colville Delta was caused by reduced effort by the commercial fishery and the lack of Nuiqsut fishing in the East Channel. The 32 percent increase from 1986 to 1987 was primarily caused by increased commercial fishing, since the village effort decreased markedly. The commercial fishery accounted for 34i 23 and 39 percent of the total effort expended in the fall fishery from 1985 to 1987.

Arctic cisco, the target species, dominated the catch, comprising about 75 percent of the total catch over the survey period. Least cisco was the dominant incidental species, with small broad whitefish caught in the Nigliq Channel and humpback whitefish caught in both the Nigliq Channel and Outer Colville Delta. Fourhorn sculpin was the

only other species taken consistently, but it was rarely utilized.

Comparative Catch Rates. The mean catch rates of both Arctic cisco and least cisco are higher in the Outer Colville Delta than in the Upper Nigliq area. Within the Nigliq Channel, mean catch rates of Arctic cisco were highest near the Nigliq Delta and declined upstream near the village. Least cisco mean catch rates showed the opposite trend, being highest near the village and decreasing downstream.

The highest catch rates for Arctic cisco during the three year survey period were recorded in 1986 in the Outer Delta and the Nigliq Delta. These catch rate patterns were interpreted as indicating that Arctic cisco abundance was highest in 1986 compared to the other two years.

Estimated Total Catch. The total catch of Arctic cisco in the Colville region has declined during the survey period. While the catch decreased approximately 10 percent from 1985 to 1986, it was accompanied by a 38 percent reduction in total effort. The 23 percent reduction in catch from 1986 to 1987 was accompanied by a 61 percent increase in total effort, reflecting the overall reduced catch rate. Conversely, the least cisco total catches have followed the direction of the effort, although not the same magnitude of change, decreasing by 53 percent from 1985 to 1986 and increasing 12 percent from 1986 to 1987.

Age Composition. The age composition of Arctic cisco caught in 76-mm mesh was dominated by ages 6 and 7 in 1986 and ages 7 and 8 in 1987, reflecting the strength of the 1979 and 1980 year-classes in the fishery. In three previous years for which age data from the fishery are available (1976-1978), age-5 or 6 has dominated, although other ages often comprised major portions of the catch. The 1976-1978 data also show changes in age structure likely resulting from strong and weak year-classes moving through the fishery. Since Arctic cisco mature at age-8 or older, the fishery harvests immature fish.

In 1987, least cisco captured in 76-mm mesh were dominated by ages 9 to 12 with ages 8 and 13 to 15 also common. Full recruitment occurred at age 9, at a mean fork length of 308 M.M. No single age group was dominant after full recruitment. Since anadromous least cisco mature at age 7 or 8 (Craig and Haldorson 1981) and fishing occurs after the spawning season, the fishery harvests least cisco that have spawned at least once.

Tag Returns. During the three-year survey, over 2,870 tags were returned from fish tagged in various studies in the Beaufort Sea coastal region since 1976, with over 65 percent

of these tags being returned by the commercial fishery. The rate of tag recapture for Arctic cisco and least cisco from the various release years was calculated to evaluate the persistence of tags in the population. For least cisco, the tags decreased at a mean rate of 28 percent per year, while Arctic cisco tags decreased by nearly 70 percent per year for the first three years, then were absent from the population. The rate of decline for tagged least cisco is considered to be an indication of total mortality, plus tag shedding, but for Arctic cisco is support for the Mackenzie-origin hypothesis of Arctic cisco inhabiting-the Colville River.

In all three years, Arctic cisco tagged in the Arctic National Wildlife Refuge were recaptured during the fall fishery. In 1987 a least cisco tagged in the 1987 Camden Bay study was recaptured in the East Channel. The recoveries of Arctic cisco released in the eastern Beaufort Sea may represent the extent of eastward movement by Colville area fish during the summer feeding period and/or movement of adult fish from the Mackenzie River region to the Colville region.

Population Estimates and Trends. There was an estimated 16.5 percent increase in the number of catchable Arctic cisco between 1984 and 1985 as the abundant 1978 year class grew into harvestable size. In 1986, the more abundant 1979/1980 year-classes were almost fully recruited into the fishery and by 1987 the catches were dominated by the 1980 year-class.

The catch rates in the commercial fishery, which have been used as Arctic cisco abundance indices for the Colville region (Gallaway et al. 1983), indicate the relative strength of these year-classes. Contrary to the population estimates, the Arctic cisco catch rate decreased almost 13 percent between 1984 and 1985, although the catch rates were high compared to the historical average. In both years the fishery was dominated by the 1978 year-class with larger members of the 1979 year-class available in 1985. In 1986, when the 1979 and 1930 year-classes entered the fishery, the catch rates were the highest in the 21-year record. There was a 58 percent decrease from 1986 to 1987 as the 1979 year-class and larger members of the 1980 year-class moved out of the fishery, however, the catch rate was the second highest on record.

The least cisco catch rates in the commercial fishery have fluctuated less dramatically than the Arctic cisco catch rates because the population has a greater range of ages in the harvestable stock and the catches are less influenced by individual year-classes. The basic pattern has been a gradual, but significant, increase in catch rate over the last 21 years.

Historical Catch Levels. Catch data are available from the commercial fishery for the last 21 years, while the village of Nuiqsut was founded at its present site in the early 1970's. It is likely that the current levels of effort were reached beginning in the mid to late 1970's as the village stabilized and fishing patterns became established. Over the last ten years, the mean annual commercial catch has been 22,300 Arctic cisco (SD=8,587) and 21,500 least cisco (SD=9,252). If it is assumed that the ratio of village to commercial catch observed from 1985 to 1987 represented an average condition, then the commercial harvest has averaged 46 percent of the Arctic cisco catch and-59 percent of the least cisco catch, and the mean annual catches for the village and commercial fisheries for the last ten years were 48,500 Arctic cisco and 36,400 least cisco. As evident from the 1985 to 1987 estimates and historical pattern of catch rates, there is substantial variation between years.

DISCUSSION

Variability in Effort and Catch. During the three years of survey, both village and commercial fishing effort fluctuated drastically. Village effort fluctuated primarily because of competing requirements for time, including employment, or lack of employment, and pursuit of other resources. The early fishing period coincides with whaling season and hunting and processing of whales in 1986 and 1987 likely reduced the early and mid October effort in those two years. The commercial effort responded to both catch rate and market conditions. The fisherman sets a desired catch level based on anticipated markets (within a maximum harvest quota) and adjusts effort based on the observed catch rate. The high catch rate in 1986 allowed reaching a desired harvest with minimal effort.

The increase in Arctic cisco catch rate from 1985 to 1986, resulting in the highest catch rate seen in the commercial fishery in 21 years of record, was caused by the full recruitment of the 1979 and 1980 year-classes into the fishery. There was a pool of Arctic cisco that were inaccessible to 76-mm mesh nets in 1985, but these grew to a harvestable size in 1986. This group of fish dominated fish samples in Beaufort Sea coastal studies between 1982 and 1985 (Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton and Fawcett 1984; Moulton et al. 1986). The data also indicate that few young fish entered the region from-1981 to 1984, thus few are available to recruit into the fishery. The 1987 catch continued to be composed of 1980 and 1979 year class fish that remained in the Colville region prior to maturation, these will likely be gone in 1988. The catch rate of Arctic cisco in the commercial fishery declined 58 percent between 1986 and 1987 and will likely decline farther in 1988. The catch rates will remain

low until fall, 1990 or 1991, when the 1985 year class begins to enter the fishery. The catches will remain stable for several years in the early to mid-1990,ls because young Arctic cisco showed apparent strong recruitment into the region from 1985 to 1987.

Impact of Fishery on Stocks. The exploitation rate on Arctic cisco cannot yet be accurately estimated. The estimated harvest of Arctic cisco in 1985, 70,400 fish, represented approximately 6 percent of the harvestable Arctic cisco, assuming that all of the released tagged Arctic cisco in the Prudhoe Bay area 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 moving eastward to the Mackenzie River, then the proportion of the population in the Colville would decrease and the harvest rate on those fish utilizing the Colville Delta would increase.

Evidence of substantial eastward movement by Arctic cisco is beginning to emerge as sampling effort increases in the eastern Beaufort Sea. In 1986 and 1987, twelve Arctic cisco tagged in the Prudhoe Bay region were recovered in Canada after being at large 1 to 6 years. There is also westward movement of large Arctic cisco from the Mackenzie region into the Colville region during the summer, as evidenced by the recapture of Arctic cisco tagged east of Kaktovik.

For least cisco, the Pattern is more clear. Virtually all least cisco tagged near Prudhoe Bay entered the Colville Delta in late summer and were vulnerable to the fishery (Moulton et al. 1986). The estimated harvest of 33,400 anadromous least cisco in 1985 represented approximately 10 percent of the harvestable fish. The catch rates of least cisco in the 1986 commercial fishery increased slightly over those in 1985, indicating that the harvestable population was of similar size in both years. The total catch, however, decreased over 50 percent because of the reduced effort, thus the 1986 exploitation rate may have been around 5 percent. Using the same reasoning for 1937 (commercial fishery catch rates approximately 18 percent less than 1985 levels while total catch was 46 percent less), the exploitation rate was likely between 5 and 10 percent.

SUMMARY AND RECOMMENDATIONS

The three years of investigation on the Colville River cisco fishery reveals that the harvest levels are presently within an acceptable range. The stocks do not exhibit characteristics often seen in over-fished populations and the catch rates of both Arctic cisco and least cisco are high compared to the previous twenty years of record. As discussed, the recent high catch rates for Arctic cisco were a result of a high recruitment of young in 1980; since this

group of fish has grown out of the fishery, catches are predicted to decline in 1988 and remain low until the 1985 to 1987 year-classes reach harvestable size. At that time, around 1990, catches should increase and remain stable for several years.

Because the present harvest levels appear to be within an acceptable range, i.e. are not adversely affecting stock levels, it is recommended that no changes be made in the management of the fishery at this time. Monitoring of the fishery should focus on estimating effort, catch rates and age structure so that the effects of increased fishing effort or harvest level will not go undetected. Monitoring of juvenile abundance and age or size structure would also allow predicting the future direction of catch rates based on abundant or weak year-classes.

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INTRODUCTION

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The primary objectives of this study were to (1) obtain estimates of the total effort and catch for the fall fishery in the delta, including harvests of both the village of Nuiqsut and the commercial fishery, and (2) evaluate the effects of these harvest levels on the stocks. The lack of information on harvest levels, coupled with concern for possible effects on the fish stocks from coastal developments around the Prudhoe Bay oilfields, prompted this effort to

[1] Historically, fish of the genus Salvelinus caught along the Beaufort and Bering sea coasts of Alaska have been identified as Actic char (S. alpinus). Morrow (1980) and Behnke (1980; 1984) demonstrated that thewse fish are identical to the northern form of Dolly Varden char (S. malma). Behnke (1980; 1984) points out that these char are identical to Dolly Varden char from the type locality in Kamchatka. Because the weight of recent taxonomic evidence appears to favor the S. malma designation, these fish are called Dolly Varden char in this report.

evaluate current harvest levels and develop recommendations for future management strategies.

The evaluation of fishery harvest on Arctic cisco and least cisco in the Colville region assumes that the Arctic cisco are derived from spawning stocks in the Mackenzie River and that the young fish recruit into the Colville region early in life, as described in Gallaway et al. (1983). The recruitment of age 0 Arctic cisco into the Colville River region is thought to be by passive transport in westerly currents generated by the predominantly easterly winds in the Beaufort Sea region. The strength of the recruitment may be related to the percentage of easterly winds from June to September (Fechhelm and Fissel 1988). The Arctic cisco are assumed to return to the Mackenzie River at maturity to spawn. The anadromous least cisco population being harvested is assumed to spawn and overwinter entirely in the Colville Delta and lower river (Moulton et al. in prep.).

METHODS

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.

Effort Estimation

The assessment and monitoring of the fall under-ice fishery based in Nuiqsut began in early October and continued through mid-November from 1985 to 1987. Gill nets were used exclusively. The standard unit of effort was a net-day, defined as an 18-m (60-ft) 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 (1.8 or 2.4 m).

Within the four main areas each net was identified and monitored throughout the entire time the net was fishing. This method chronicled the start and end dates of fishing for each net, net locations, net length, and mesh size. Thus, except for a few cases noted later, there was a virtually complete census of fishing effort.

During the main fishing season, village catches were sampled daily 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 applied by other fisheries studies in the region. Whenever possible, tagged fish were measured to the nearest mm and the date, location of capture, and species were recorded. A reward system was used to encourage tag returns. Whenever catch data were collected, set duration, net length, and mesh size data were also recorded so that catch-per-unit-effort (CPUE) could be calculated for the net set.

Daily catch and effort by individual net from the commercial fishery in the Outer Colville Delta were provided by the commercial fisherman. The commercial fisherman also provided weekly length frequencies by species for each mesh size. Lengths were taken from 50 fish selected randomly on each Monday of the fishing season.

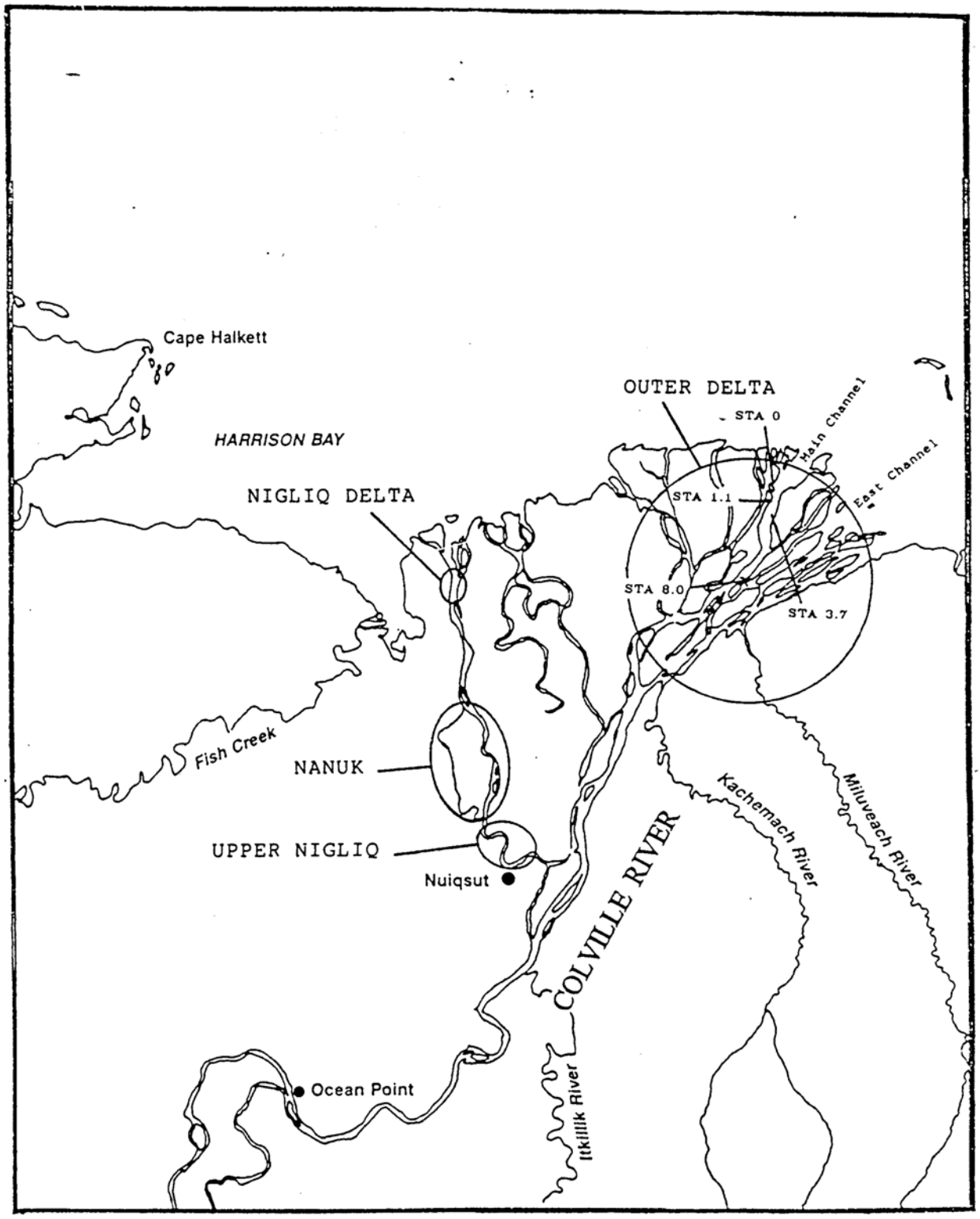


Figure 1. Colville River study region showing major survey areas.

In 1986 and 1987, otoliths were obtained each year from 200 randomly-selected Arctic cisco captured in 76-mm (3.0-inch) stretched mesh nets to evaluate the age composition of the Arctic cisco catch. In 1987, otoliths were also collected from 200 least cisco caught in 76-mm mesh. Aging was completed by the cross-sectional burn technique (Beamish and Chilton 1982).

In 1986 and 1987, the effectiveness of various mesh sizes was evaluated by assisting local fishermen with setting and checking of test nets. Test nets (18-m long, 76-mm and 82-mm stretched mesh) were given to local fishermen in exchange for daily information on the catch from each mesh size.

Salinity Measurements

In 1987, salinity was measured from October 23 to 30 at three stations (Stations 1.1, 3.7 and 8.0, Figure 1) near the mouth of the Main Channel in the Outer Colville Delta between river kilometer 1.1 and 8.0, while catch rates were recorded from four stations between river kilometer 0 (Station 0) and 8.0. The salinity and catch rate data were collected when and where fishing activity allowed, not through a pre-determined sampling design; thus, the information is temporally and spatial sporadic. Measurements were taken at 1.0 m intervals from just uder the ice to the bottom with a YSI Model 33 salinometer.

Mean salinity was calculated as the mean value of the salinity recordings starting at 2.0 m below the surface of the ice. There was normally a low salinity layer just under the ice (see Appendix), however, the nets were suspended below this layer, thus any fish in this layer were not represented in the catch. Nets were normally hung off bottom to avoid fourhorn sculpin, but at least 1.0 m below the ice to avoid freezing the float line into the under side of the ice.

Data Analysis

Effort was calculated in net-days by using the start and end dates for each individually-tracked net. Effort data were corrected for the various net lengths and set durations used in the fishery by standardizing net length to 18 m and set duration to 24 h.

The CPUE was estimated by treating each individual sample (usually the catch from one net on a given day) as an independent sample. The total effort expended by each mesh size in each area and the associated estimated CPUE were calculated for each 10-day interval during the fishing season, starting on October 1. Estimated catches for each mesh size by 10-day interval were then calculated and summed to provide the estimates of total catch. In some cases, CPUE was not

measured for a mesh size in a given area for each 10-day interval because of low fishing effort. In these instances, CPUE was estimated from adjacent time periods or by extrapolating from the relative catch rate of that mesh in nearby fishing areas. In one case, the East Channel of the Outer Colville Delta in 1985, effort data were not available but the fisherman returned 150 tags. In this case, the total catch was estimated from the ratio of tagged to untagged fish caught in the commercial fishery, which operated nearby in the same channel.

In many cases in the Outer Colville Delta, especially in 1986 and 1987, complete counts of total catch were obtained. These instances of actual counts, rather than estimated catches, are identified when the data are utilized.

In both the village and commercial fishery, 76-mm mesh nets were the preferred gear. Catch rate indices used for comparisons among areas and years and evaluation of changes in length distributions were based on 76-mm mesh.

Instantaneous mortality rates for least cisco in the Colville Delta were estimated using two independent sets of data: (1) the annual decrease in tagged least cisco that have been released in the Prudhoe Bay region since 1980 and (2) the decrease in age frequency after full recruitment to the fishery. The partitioning of the instantaneous mortality rates in a fishery is expressed by the following equation (Ricker 1975):

$$Z = F + M$$

where Z = total mortality
F = fishing mortality
M = natural mortality

Other parameters needed to estimate the instantaneous mortality rates include the annual mortality rate (A) and the exploitation rate (u). The relationships between these parameters are:

$$A = 1-e^{-z}$$
$$u = (F/Z)(1-e^{-z})$$

The total annual mortality rate (A) was estimated from the annual decline in tag returns from a given release year over subsequent years and from the decrease in age frequency after full recruitment (Ricker 1975). In both cases, the natural log of the recapture or age frequency was regressed on the year of observation and the slope was taken as an estimate of Z (Ricker 1975). The rate of exploitation (u) was calculated as that portion of the total stock that is harvested by the fishery. The estimates of A and u were used to calculate the instantaneous rates.

In 1984 and 1985, the release and subsequent recapture of a substantial number of tagged cisco by studies near Prudhoe Bay (Moulton et al. 1986, Envirosphere 1987) allowed an estimate of the total number of fish available to the fishery. Tagging was suspended following 1985, so subsequent evaluation of population size was based on changes in catch rate in the fishery. The method for estimating population size was the same used by Craig and Haldorson (1981) for Colville River Arctic and least cisco and was based on analysis techniques described in Ricker (1975, p. 78). One adjustment, however, must be made to the total number of tags released. Fish used for tagging were captured by fyke net while tagged fish were recaptured by gill net. The number of tags released was corrected to the number of tags vulnerable to gill nets as described in Ricker (1975, p. 93-95).

RESULTS

Distribution of Fishing Effort

The number of Nuiqsut fishing groups (a family or group of families fishing cooperatively) participating in the under-ice fishery fluctuated from 30 in 1985 to 25 in 1986 and back up to 34 in 1987. Effort was concentrated in the four main survey areas: the Upper Nigliq area near Nuiqsut, the Nanuk area (near Nanuk Lake on the Nigliq Channel), the Nigliq Delta and in the Outer Colville Delta. There was some fishing effort on Fish Creek and on the upper Colville River, particularly early in the season with the effort directed at Arctic grayling and large broad whitefish, but these areas were not surveyed in order to concentrate the sampling effort on the cisco fishery.

Fishing effort was concentrated on the Upper Nigliq area because of its proximity to town (Table 1). Fishing on the Nigliq Channel began at Nuiqsut when the ice became safe enough to set nets, usually in early October. The first net was set on October 2 in 1985, October 3 in 1986 and October 8 in 1987, with the differences due to annual differences in the time of ice formation. Fishing in other Nigliq Channel areas was delayed until the second or third week of October because of overflow or unsafe ice conditions, then fishing continued until approximately November 20. Fishing effort on the Nigliq Channel was greatest in mid-October to early November, then decreased by mid-November (Figure 2). By mid-November, daylight is reduced and the thickness of the ice interferes with operation of the nets.

The most popular mesh size is 76-mm stretched mesh (Table 2). In 1985, the second most frequently used mesh was 64 mm (2.5 inch, 23 percent), but use of this mesh declined in the following two years. In contrast, 83-mm (3.25-inch) mesh increased from 9 percent of the effort in 1985 to 13 and 29 percent in 1986 and 1987. Some effort was expended with 102-mm (4.0-inch) mesh, a popular mesh in the summer fishery, but it proved ineffective at catching ciscos.

During 1985 to 1987, the fishery in the Outer Colville Delta was comprised of 2 to 6 groups from Nuiqsut who stayed at fish camps and the commercial fishery at Colville Village. The Main Channel received the most effort by Nuiqsut residents while the East Channel was fished only by the commercial fishery in 1986 and 1987 (Table 1). One Nuiqsut group fished the East Channel in 1985. In all three years over 76 percent of the effort in the Main Channel was with 76 mm mesh. The remainder of the effort was spread between 64, 83, 89 and 102-mm mesh.

Table 1. Total estimated fishing effort in the Colville Delta fall fishery, 1985-1987 (effort in net-days, i.e. 24 h per 18 m of net, all meshes combined).

Survey Area	1985	1986	1987
Nigliq Channel			
Upper Nigliq	870	592	961
Nanuk	--	216	236
Nigliq Delta	340	97	90
AREA TOTAL	1,210	905	1,287
Outer Colville Delta			
Main Channel			
Village	318	365	89
Commercial	480	38	0
East Channel			
Village	225	0	0
Commercial	428	340	890
AREA TOTAL	1,451	743	979
TOTAL EFFORT	2,661	1,648	2,266

Table 2. Percentage of effort expended by various gill net mesh sizes in the Nigliq Channel, 1985-1987.

Stretched Mesh (mm)	1985 Effort In Net Days	%	1986 Effort in Net Days	%	1987 Effort in Net Days	%
60	39	4	0	0	0	0
64	184	23	69	8	58	6
70	0	0	0	0	30	3
76	346	43	638	70	448	48
83	74	9	114	13	274	29
89	170	21	80	9	124	13

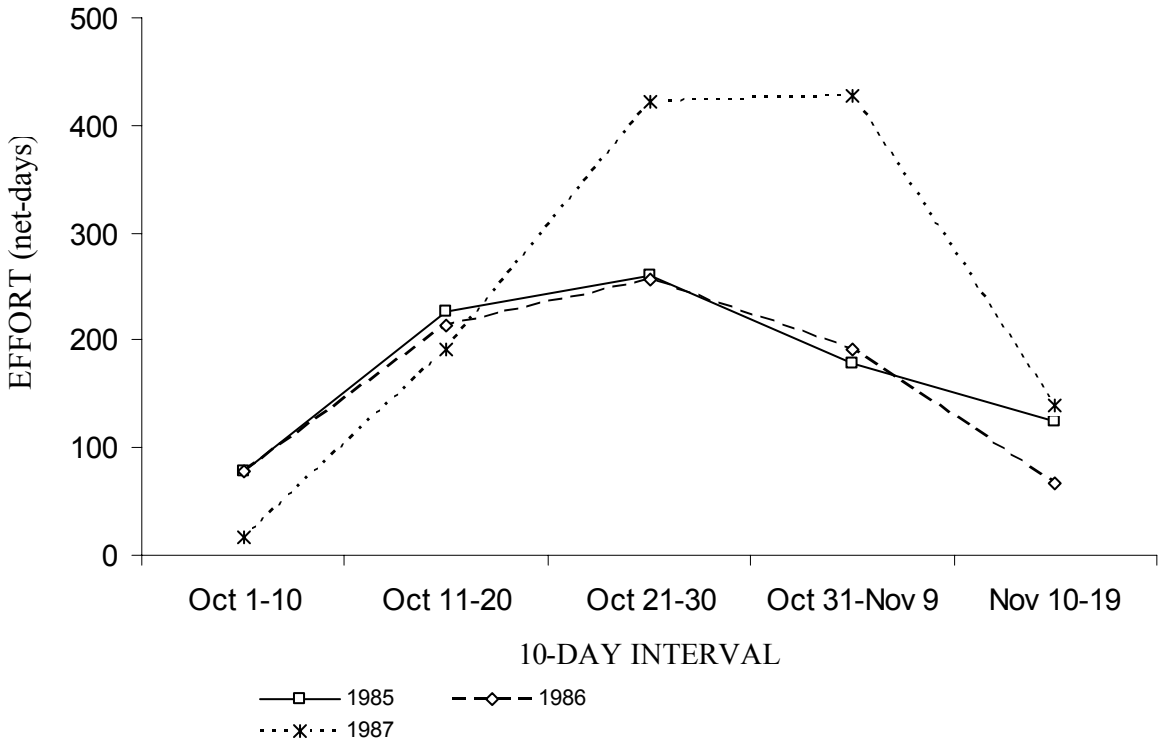


Figure 2. Fishing effort in the Upper Nigliq area by 10-day interval, 1985-1987.

The total effort in the Outer Colville Delta decreased 49 percent from 1985 to 1986, then increased 32 percent in 1987 (Table 1). The decrease in effort from 1985 to 1986 was caused by reduced effort by the commercial fishery and the lack of Nuiqsut fishing in the East Channel. The increase in effort from 1986 to 1987 was primarily caused by increased commercial fishing, since the village effort decreased markedly. The commercial fishery accounted for 34, 23 and 39 percent of the total effort expended in the fall fishery from 1985 to 1987.

The reduction in village effort from 1985 to 1986 resulted from (1) an injury to one of the main fishermen, (2) non-participation by another major fisherman because of employment commitments, and (3) transfer of effort to process a bowhead whale. In the commercial fishery, the high catch rate of Arctic cisco resulted in an acceptable harvest with reduced effort. The increase in effort from 1986 to 1987 resulted from (1) an increased effort in the Upper Nigliq (Figure 2) caused by reduced employment opportunities in Nuiqsut and (2) increased effort in the commercial fishery because of the lower catch rate on Arctic cisco and better market conditions. Effort by villagers in the Outer Colville Delta in 1987, however, continued to decrease and was only 16 percent of the effort recorded in 1985. The reduction in village effort in the Outer Delta was mainly a result of economic conditions, including employment commitments and lack of snow machines.

Catch Composition

Arctic cisco, the target species, dominates the catch, comprising about 75 percent of the total catch over the survey period (Table 3). Least cisco is the dominant incidental species, with small broad whitefish caught in the Nigliq Channel and humpback whitefish caught in both the Nigliq Channel and Outer Colville Delta. Fourhorn sculpin is the only other species taken consistently, but it is rarely utilized.

In 1986 and 1987, Bering cisco (Coregonus laurettae) comprised a minor, but unquantified, component of the catch. The species had been virtually absent from the commercial catches since the 1979-1980 season (J. Helmericks, pers. comm.) and was only encountered in and immediately upstream of the East Channel. In 1986, 44 fish visually identified as Bering cisco by the commercial fisherman were obtained to verify the identification. Gill raker counts indicated nearly complete separation between 30 visually-identified Arctic cisco and the 44 Bering cisco, only one (or 2 percent) of the Bering cisco was mis-identified. The results were virtually identical to those reported in Craig

Table 3. Catch contribution by species as observed during fisherman interviews, by percent contribution of village catch (does not include commercial fishery).

Species	Nigliq Channel 1985	1986	1987	Outer Colville Delta 1985	1986	1987
Arctic cisco	69.5%	95.9%	71.8%	62.1%	74.6%	75.1%
Least cisco	14.8	3.8	18.7	37.0	24.4	21.5
Broad whitefish	15.1	0.3	5.5	0.1	0.007	0
Humpback whitefish	0.5	0.03	3.8	0.7	0.9	1.4
Rainbow smelt	0.2	0.04	0.01	0.1	0.1	2.0
Round whitefish	0	0.01	0	0	0	0
Dolly Varden char	0	0	0.03	0	0.007	0
Saffron cod	0	0	0.04	0	0	0
Burbot	0	0	0.06	0	0	0
Fourhorn sculpin	*	*	*	*	*	*
Total Examined Catch	2,705	8,952	6,826	5,510	15,328	6,190

* Fourhorn sculpin always present but not counted

and Haldorson (1981). The length frequency of 50 Bering cisco caught in 76-mm mesh gill nets reflected the observation that Bering cisco are stouter or thicker for a given length than Arctic cisco, an observation noted by J. Helmericks (pers. comm.) and documented in Craig and Haldorson (1981).

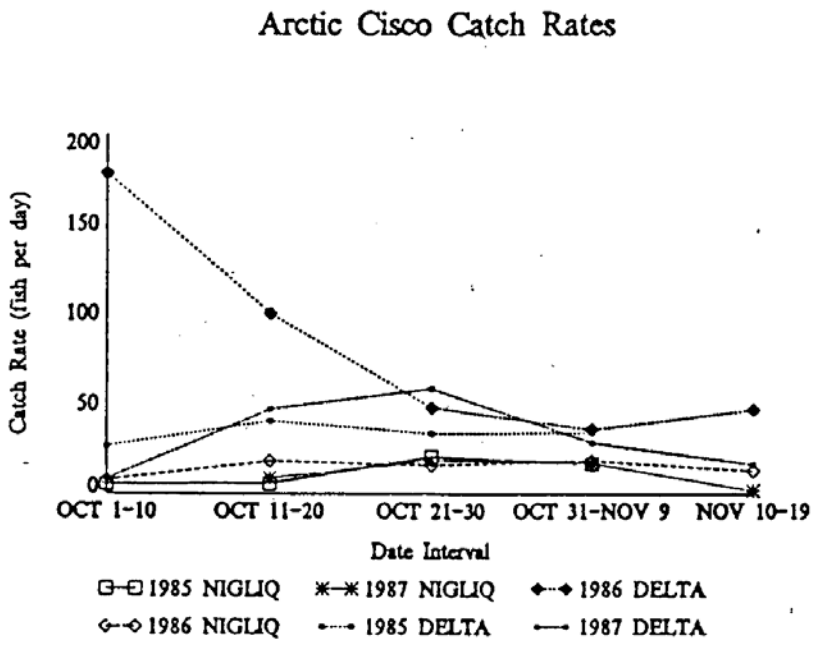
Comparative Catch Rates

The mean catch rates of both Arctic cisco and least cisco are higher in the Outer Colville Delta than in the Upper Nigliq area (Figure 3). In this example, the mean catch rates for each 10-day period from the commercial fishery in the East Channel of the Outer Delta are used as an index because they are the most complete record from the Outer Colville Delta over the three survey years. Within the Nigliq Channel, total mean catch rates of Arctic cisco were highest near the Nigliq Delta and declined near the village (Upper Nigliq) (Table 4). Least cisco total mean catch rates showed the opposite trend, being highest near the village and decreasing downstream. Catch rates of Arctic cisco at the Nigliq Delta were similar to those observed in the Outer Colville Delta, but least cisco catch rates in all areas of the Nigliq Channel were well below those recorded in the Outer Delta (Table 4). As will be seen, these differential catch rates between species and areas were largely a function of salinity.

The highest total mean catch rates for Arctic cisco during the three year survey period were recorded in 1986 in the Outer Delta and the Nigliq Delta (Table 4), although the catch rates reported by George and Kovalsky (1986) for village fishermen on the Main Channel in 1985 were of similar magnitude. Arctic cisco catch rates were highest during the first two ten-day periods of 1986 in the Outer Colville Delta, and remained high for the duration of the season (Figure 3). In 1987, catch rates approached those recorded in 1986 only during the third ten-day period. Catch rates in 1985 and 1987 were similar in the Upper Nigliq and Outer Delta (East Channel). These catch rate patterns were interpreted as indicating that Arctic cisco abundance was highest in 1986 compared to the other two years.

For least cisco, when mean catch rates in the Outer Delta were high, those in the Upper Nigliq were low, and vice versa. This pattern likely indicated annual shifts in distribution of this species within the delta rather than changes in absolute abundance.

While most nets were checked on a daily or every other day basis, nets sometimes remained unchecked for several days. Catch rates declined as the length of time between net checks increased (Figure 4).



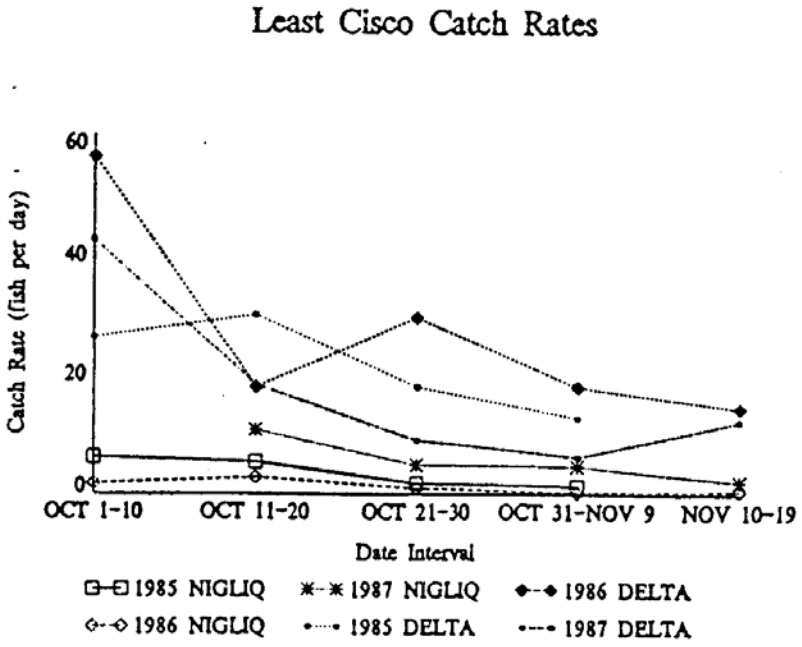
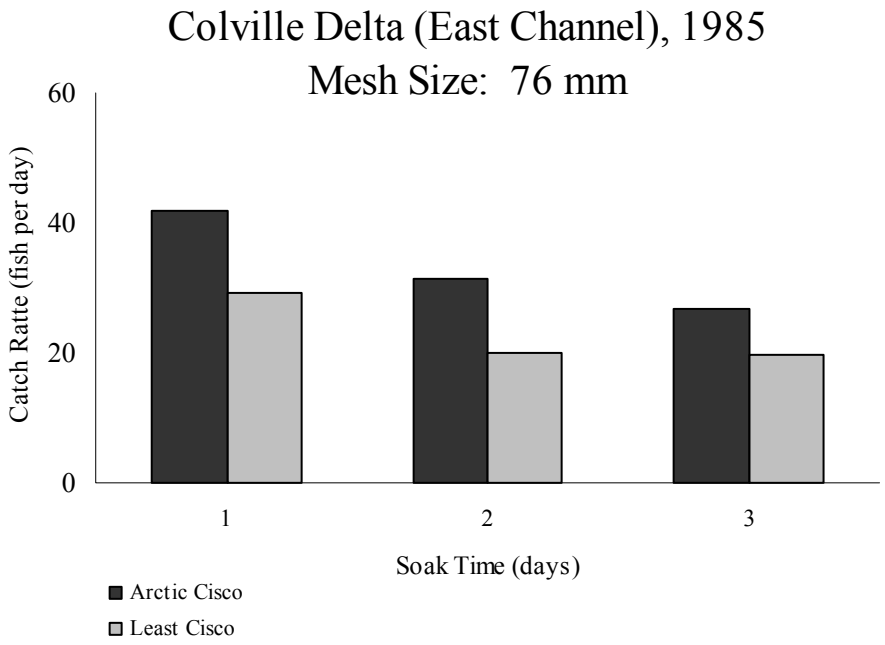


Figure 3. Comparative catch rates of Arctic cisco and least cisco in the Outer Colville Delta and Nigliq Channel by time interval, 1985-1987.

Table 4. Total mean catch rate (fish per day) of Arctic cisco and least cisco in 76-mm mesh gill nets in the Colville Delta fall fishery, 1985-1987.

Area	Arctic Cisco 1985	1986	1987	Least Cisco 1985	1986	1987
Nigliq Channel (all village effort)						
Upper Nigliq	12.1	17.1	11.5	3.6	1.8	5.5
Nanuk	--	27.9	43.0	--	0.9	2.8
Nigliq Delta	--	78.5	39.3	--	0.03	1.1
Outer Colville Delta						
Main Channel						
Village	76.1	62.0	47.6	47.4	18.3	15.4
Commercial	31.5	74.5	--	23.8	30.0	--
East Channel						
Commercial	33.5	81.5	31.6	21.7	27.2	17.7



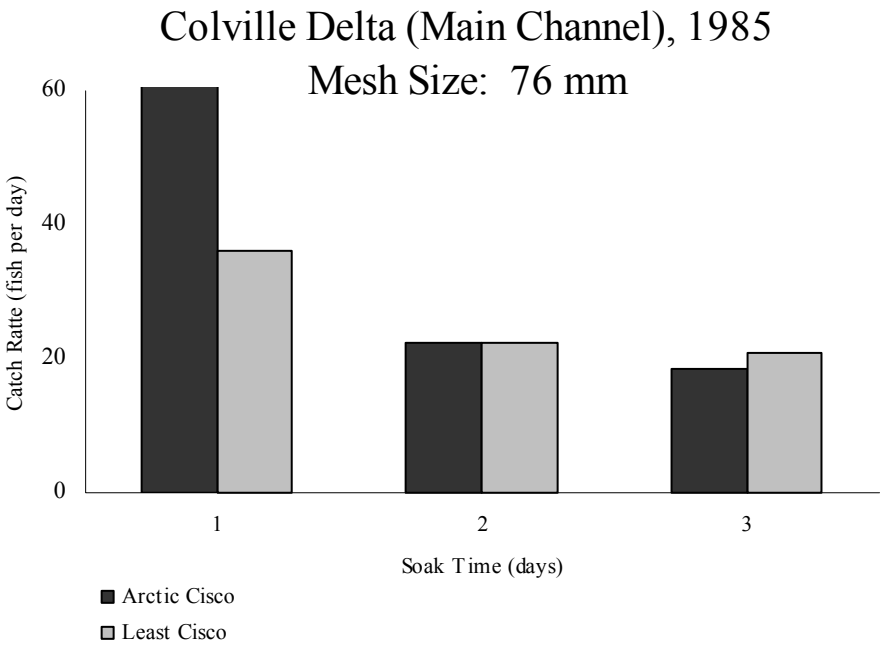


Figure 4. Catch rates of Arctic cisco and least cisco based on the number of days between net checks (i.e. soak time) in the Colville Delta commercial fishery.

Estimated Total Catch

The total catch of Arctic cisco in the Colville region has declined during the survey period (Table 5). While the catch decreased approximately 10 percent from 1985 to 1986, it was accompanied by a 38 percent reduction in total effort. The 23 percent reduction in catch from 1986 to 1987 was accompanied by a 61 percent increase in total effort, reflecting the overall reduced catch rate. Conversely, the least cisco total catches have followed the direction of the effort, although not the same magnitude of change, decreasing by 53 percent from 1985 to 1986 and increasing 12 percent from 1986 to 1987 (Table 5).

The majority of the village catch of Arctic cisco comes from the Nigliq Channel, which annually provided 57, 56 and 78 percent of the village harvest from 1985 to 1987. As reflected by the relative catch rates and estimated effort, this high contribution results from intensive fishing effort near the village.

Age Composition

The age composition of Arctic cisco in the fishery was dominated by ages 6 and 7 in 1986 and ages 7 and 8 in 1987, reflecting the strength of the 1979 and 1980 year classes in the fishery (Figure 5). These two year classes have dominated the age composition of Arctic cisco captured in summer coastal studies in the region for several years (Moulton et al. 1986). In three previous years for which age data from the fishery are available (1976-1978), age-5 or 6 has dominated, although other ages often comprised major portions of the catch (Figure 5). The 1976-1978 data also show changes in age structure likely resulting from strong and weak year classes moving through the fishery. Since Arctic cisco mature at age-8 or older (Craig and Haldorson 1981), the fishery harvests immature fish.

The contribution of each year class to the fishery was examined by partitioning the catch into year classes based on the age distribution of the sampled catch (Table 6). Ages obtained from surface-read otoliths by Craig and Haldorson (1981) and catch rate data from Gallaway et al. (1983) were used to partition the 1976 to 1978 Arctic cisco catches from the commercial fishery into year class contributions. The analysis indicated that the contribution to the high catch rates in 1986 was primarily from the 1979 and 1980 year classes, and these year classes continued to dominate the fishery in 1987, although at reduced catch rates. The high catch rates shown by the 1979 and 1980 year classes were unprecedented in the 20 years of data on the commercial fishery. The catch rates for the 1979 and 1980 year classes in 1986 (99 and 80 fish per day,

Table 5. Total estimated catch of Arctic cisco and least cisco in the Colville Delta fall fishery, 1985-1987.

Area	Arctic Cisco 1985	1986	1987	Least Cisco 1985	1986	1987
Nigliq Channel (all village catch)						
Upper Nigliq	17,878	8,238	10,331	1,871	1,329	4,483
Nanuk	--	4,636	3,310	--	440	124
Nigliq Delta	8,500	5,924	2,635	0	38	74
Outer Colville Delta						
Main Channel						
Village	12,397	14,724*	4,571*	8,698	4,998*	1,433*
Commercial	10,321*	1,839*	0	8,657*	578*	0
East Channel						
Village	7,906	0	0	5,245	0	0
Commercial	13,357*	27,617*	27,494*	8,939*	8,422*	11,939*
Total	70,359	62,978	48,341	33,410	15,805	18,053

* Entire catch counted

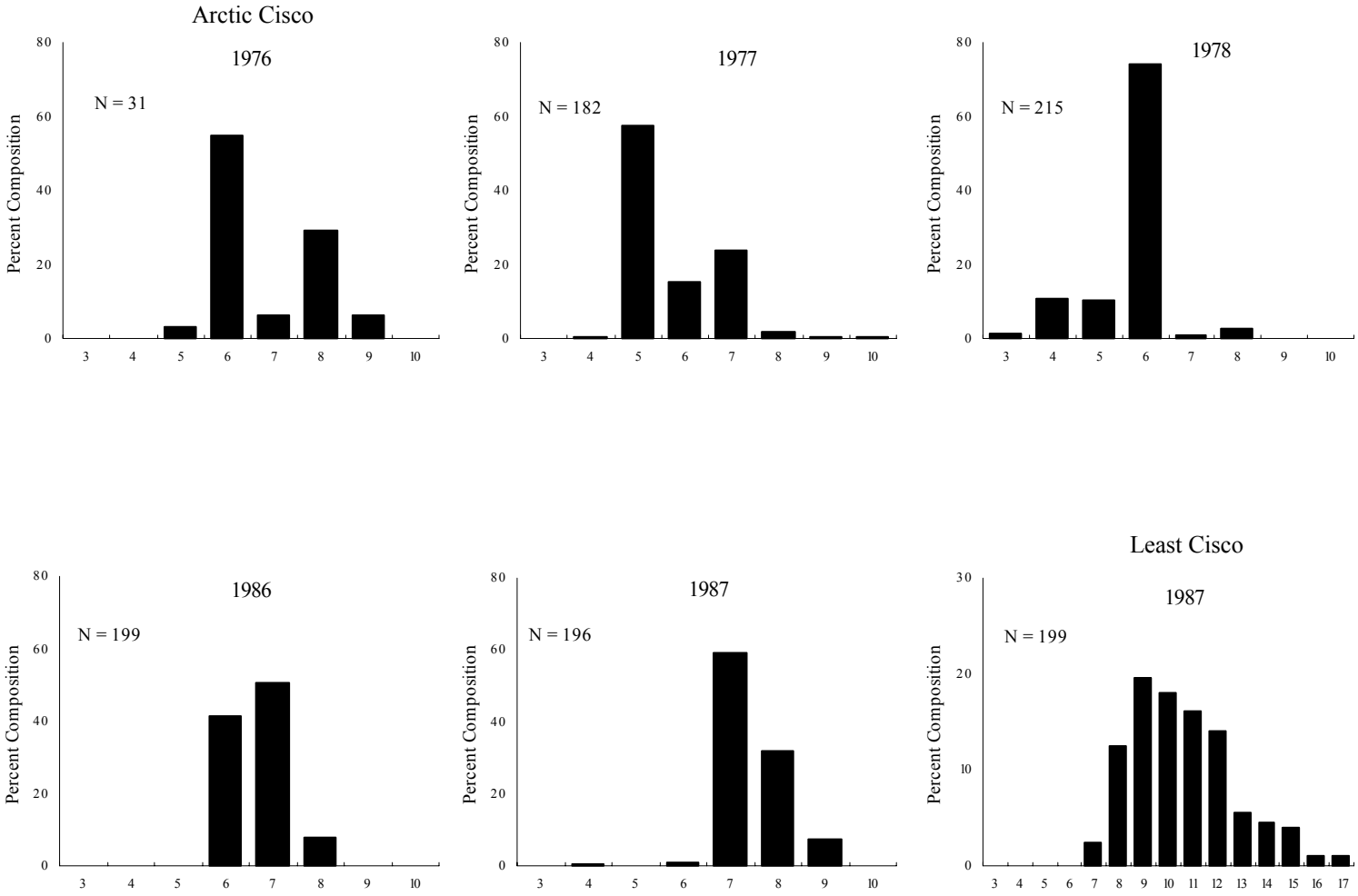


Figure 5. Age composition of Arctic cisco captured in 76 mm mesh nets, Colville Delta in 1976-1978 and 1986-1987 and least cisco captured in 1987.

Table 6. Contribution of different year-classes to the commercial fishery by age.

Year Class	Catch Rate at Age 3	4	5	6	7	8	9	10	11
Fishing Years 1976 to 1978									
1967	-	-	-	-	-	-	1.7	0.3	0
1968	-	-	-	-	-	7.8	0.3	0	-
1969	-	-	-	-	1.7	0.8	0	-	-
1970	-	-	-	14.8	12.4	0.3	-	-	-
1971	-	-	0.9	8.1	0.1	-	-	-	-
1972	-	0	30.2	7.2	-	-	-	-	-
1973	0	0.3	1.0	-	-	-	-	-	-
1974	0	1.0	-	-	-	-	-	-	-
Fishing Years 1986 and 1987									
1978	-	-	-	-	-	15.7	6.3	-	-
1979	-	-	-	-	99.0	26.2	-	-	-
1980	-	-	-	80.4	49.0	-	-	-	-
1981	-	-	0	0.8	-	-	-	-	-
1982	-	0	0	-	-	-	-	-	-
1983	0	0.4	-	-	-	-	-	-	-

1976 to 1978 data from Craig and Haldorson (1981)

respectively) both exceeded the previous record high total catch rate (76 fish per day in 1981, Gallaway et al. 1983).

In 1987, least cisco captured in 76 mm mesh were dominated by ages 9 to 12 (67 percent, N=199) with ages 8 (13 percent) and 13 to 15 (14 percent) also common (Figure 5). Full recruitment occurred at age 9, at a mean fork length of 308 mm. No single age group was dominant after full recruitment. Since anadromous least cisco mature at age 7 or 8 (Craig and Haldorson 1981) and fishing occurs after the spawning season, the fishery harvests least cisco that have spawned at least once.

The changes in age composition of Arctic cisco within the Colville River delta were reflected in the size of fish captured in the fisher. In 1985, when the 1978 year class supported the fishery, the catches in 76-mm mesh were dominated by fish in the 330 to 340 mm length range, while catches in 83 and 89-mm mesh were dominated by fish greater than 350 mm (Figure 6). In 1986, when the 1979 and 1980 year classes first recruited into the fishery, smaller fish dominated the catches (310 to 330 mm in 76-m mesh, under 350 mm in 83 and 89-mm mesh). Increased size of these two year classes and lack of new recruits led to an increase in size in 1987. Least cisco, which have a more uniform age distribution, did not show such a size fluctuation (Figure 7).

Relationship of Catch Rates with Salinity

In 1987, Arctic cisco in the Outer Colville Delta were found to associate with salinities of 24 to 26 ppt and avoid salinities greater than 27 ppt (Figure 8). At the downstream stations (Station 0, 1.1 and 3.7), catch rates were initially high when salinity was between 24 and 26 ppt. On October 27, salinity increased to 27 ppt at Station 1.1 and catch rates at Stations 0 and 1.1 decreased from around 100 fish per net-day to near zero. Concurrently, salinity at Station 8.0 increased from 23 ppt to 24 ppt and catch rates increased four-fold as fish presumably moved upstream to avoid the higher salinities moving up the delta. Subsequently, salinity at Station 3.7 declined from near 25 ppt to 24 ppt and catch rates gradually increased as Arctic cisco dispersed back downstream.

Tag Returns

During the three-year survey, over 2,870 tags were returned from fish tagged in various studies in the Beaufort Sea coastal region since 1976; over 65 percent of these tags were returned by the commercial fishery. The rate of tag

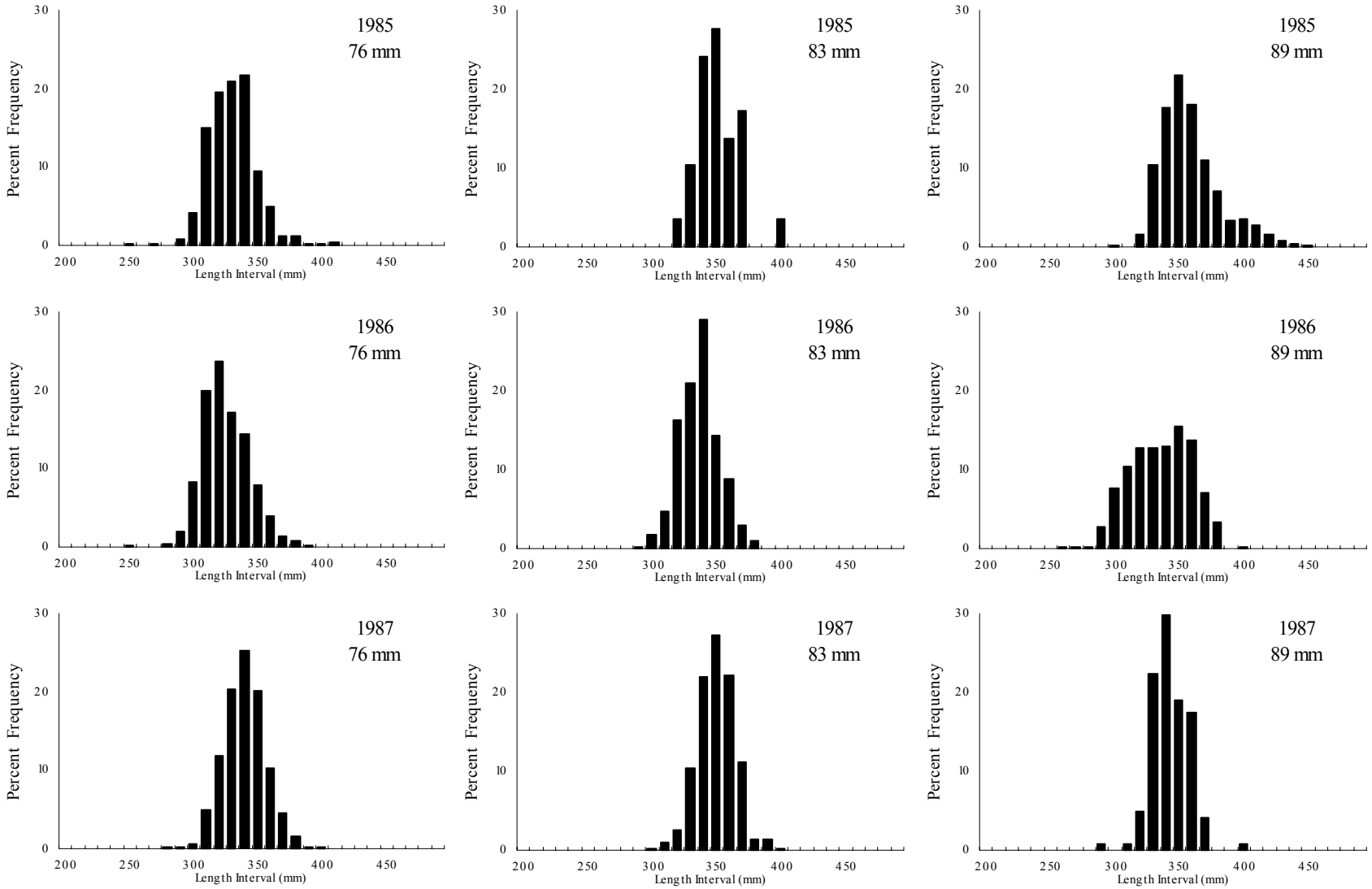


Figure 6. Length frequencies of Arctic cisco caught in three different mesh sizes in the Colville River fall fishery, 1985-1987.

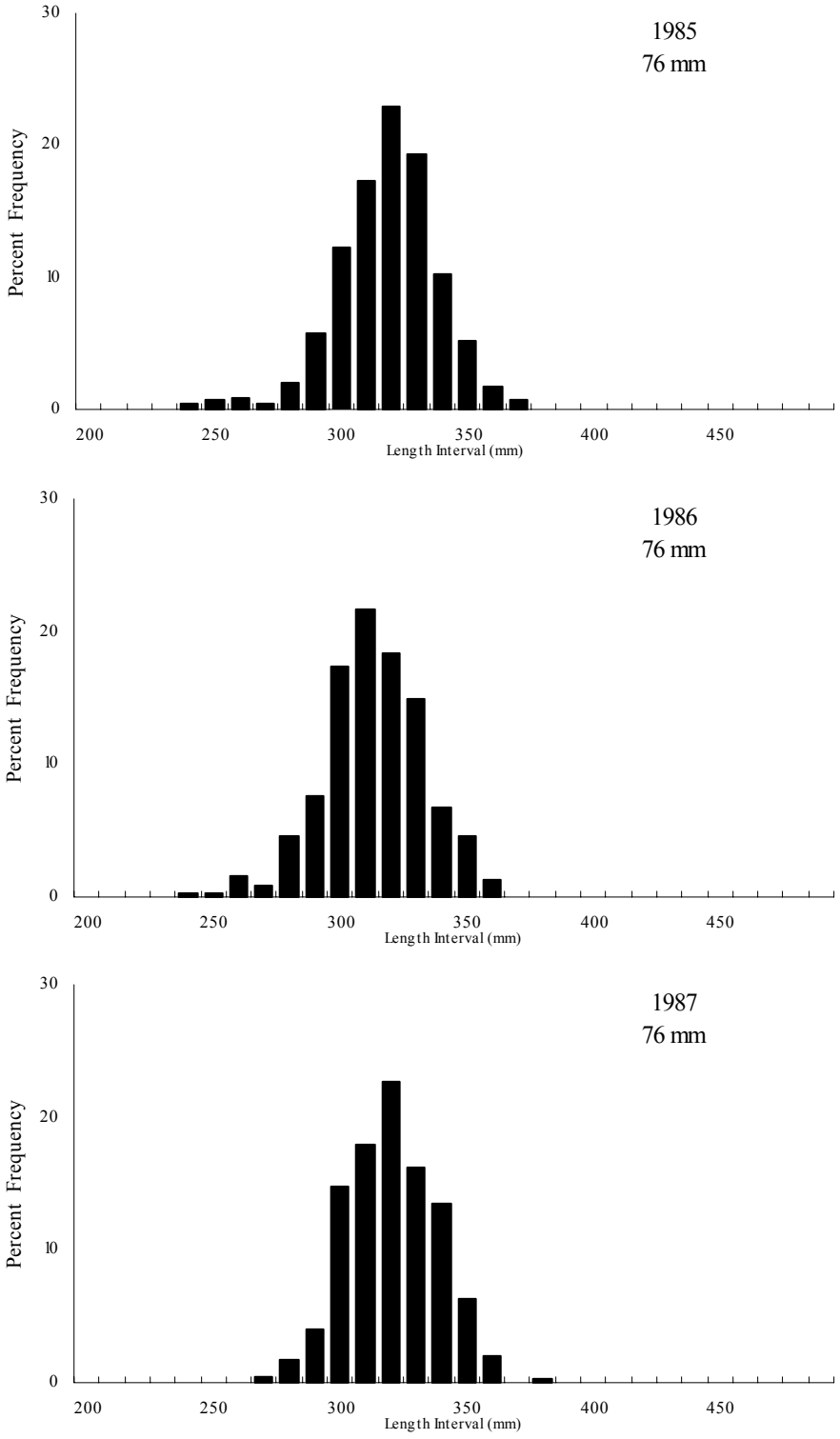


Figure 7. Length frequencies of least cisco caught in 76-mm mesh gill nets in the Colville River fall fishery, 1985 to 1987.

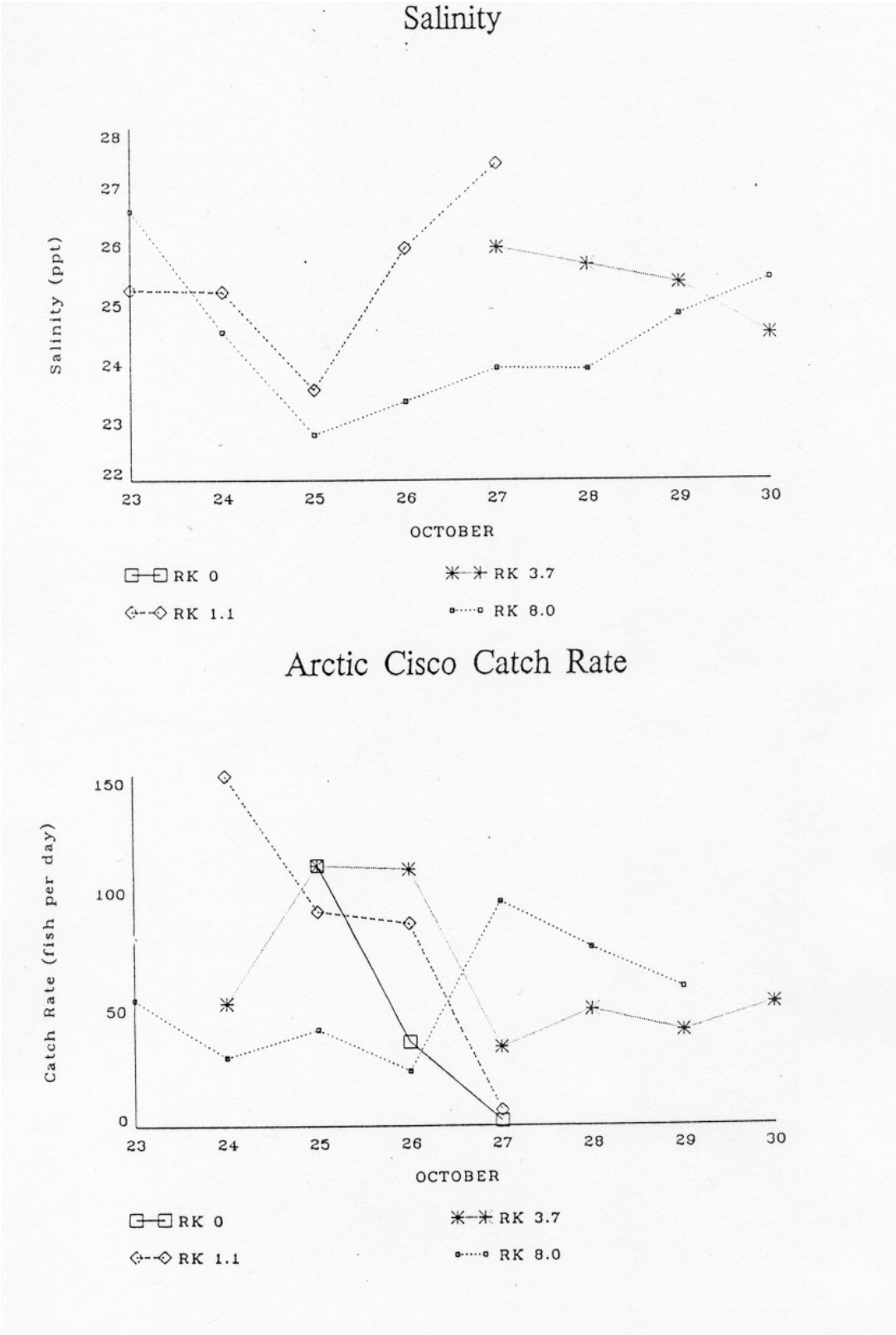


Figure 8. Response of Arctic cisco to salinity in the Outer Colville Delta, October 23-30, 1987.

recapture for Arctic cisco and least cisco from the various release years was calculated to evaluate the persistence of tags in the population (Figure 9). For least cisco, the tags decreased at a mean rate of 28 percent per year (SD = 20.7), while Arctic cisco tags decreased by nearly 70 percent per year (SD = 15.0) for the first three years, then were absent from the population. The rate of decline for tagged least cisco is considered to be an indication of total mortality, plus tag shedding (a more detailed analysis of mortality rates is presented later). The rapid loss of tagged Arctic cisco supports the Mackenzie-origin hypothesis of Arctic cisco inhabiting the Colville River. Arctic cisco utilizing the Colville region are thought to leave the area when they reach maturity at age 8 and return to the Mackenzie River to spawn, thus they are vulnerable to the fishery for only two to three years (from ages 5 or 6 to age 8).

In all three years, Arctic cisco tagged in the Arctic National Wildlife Refuge were recaptured during the fall fishery. One 376 mm Arctic cisco was released in Beaufort Lagoon on July 10, 1985 and recaptured that October in the Outer Colville Delta. Three additional fish (317, 320, and 331 mm) were released on August 30–31, 1986 at Oruktalik Lagoon, with one recaptured in October 1986 and the other two in October 1987, all in the Outer Delta. In 1987, a 308 mm least cisco tagged on August 18, 1987 in Camden Bay was recaptured in October in the East Channel. The recoveries of Arctic cisco released in the eastern Beaufort Sea may represent either the extent of eastward movement by Colville area fish during the summer feeding period and/or movement of adult fish from the Mackenzie region to the Colville region.

Population Estimates and Trends

There was an estimated 16.5 percent increase in the number of catchable Arctic cisco between 1984 and 1985 (Table 7). Concurrently, the estimated number of Arctic cisco greater than 250 mm only increased by 9.9 percent because in 1984 there was a much larger pool than in 1985 of uncatchable (but greater than 250 mm) Arctic cisco, which by 1985 had grown large enough to be captured by the mesh sizes used in the fishery (Figure 10).

The two size modes apparent in the 1984 and 1985 released fish length frequency (Figure 10) correspond to the 1978 year class (320-340 mm in 1985) and 1979/1980 year classes (a single mode at 270-310 mm in 1985), as described from otolith analysis (Moulton et al. 1986). In 1986, the

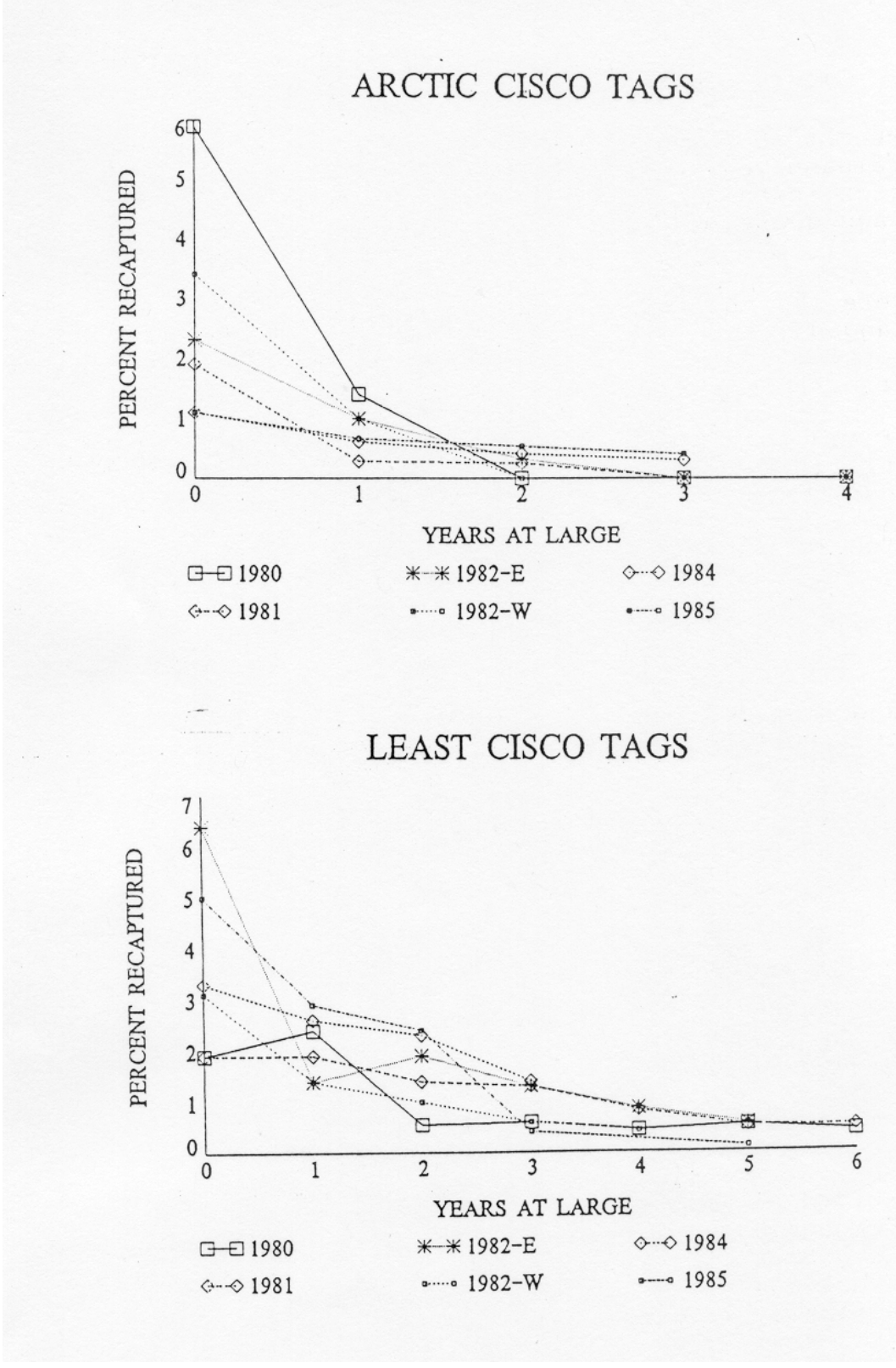


Figure 9. Decline in Arctic cisco and least cisco tag returns by year of release, 1980-1985.

Table 7. Estimates of the nuumber of least cisco and Arctic cisco available to 76 mm mesh gill nets and number greater than 250 mm in the Colville region, 1984-1985.

	1984		1985	
	Number	95% Confidence Interval	Number	95% Confidence Interval
LEAST CISCO				
Number of Tags Released (fish >250 mm)	14,126[a]		9,915[b]	
Number of Catchable Tags (M)	(14,126)(1-.302)[c] = 9860		(9915)(1-.173)[c] = 8200	
Number of Tags Caught (R)	304		472	
Catch Sampled (C)	13,076		19,186	
Estimate of Catchable Fish (N)[d]	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
ARCTIC CISCO				
Number of Tags Released (fish >250 mm)	5,840[a]		11,695[b]	
Number of Catchable Tags (M)	(5840)(1-.462)[c] = 3142		(11,695)(1-.379)[c] = 7263	
Number of Tags Caught (R)	88		170	
Catch Sampled (C)	27,686		26,819	
Estimate of Catchable Fish (N)[d]	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

[a]From Moulton et al. (1986)

[b]From Envirosphere (1987)

[c]Gear Selectivity correction factor calculated as in Ricker (1975)

[d]From $N = \frac{(M+1)(C+1)}{(R+1)}$ where M = number of fish tagged
C = catch sampled
R = number of recaptured tags

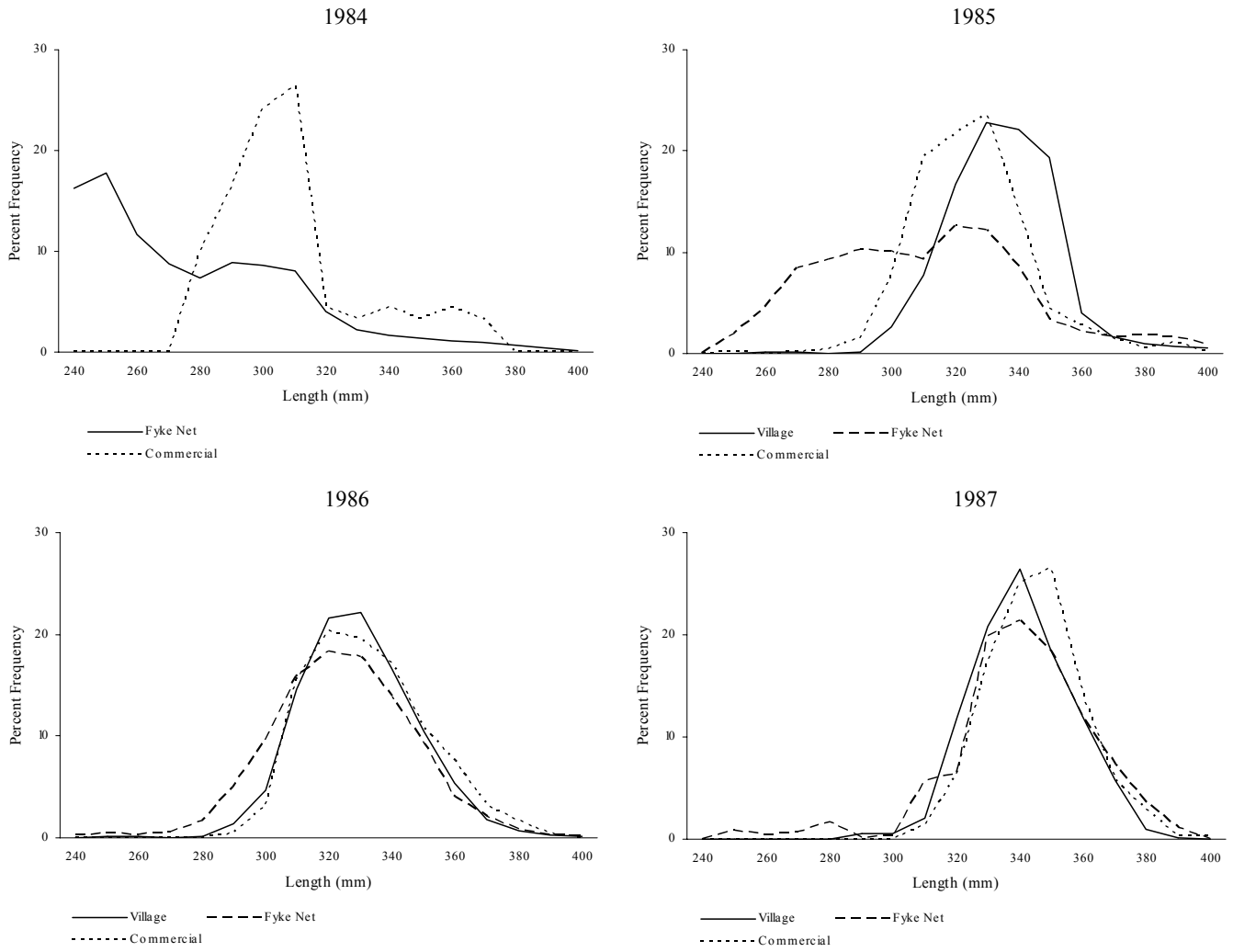


Figure 10. Length frequencies of Artic cisco released from fyke nets near Prudhoe Bay compared to those caught by gill net in the Colville Delta commercial fishery, 1984-1987.

1979/1980 year classes were almost fully recruited into the fishery and by 1987 the catches were dominated by the 1980 year class.

The catch rates in the commercial fishery, which have been used as Arctic cisco abundance indices for the Colville region (Gallaway et al. 1983), indicate the relative strength of these year classes (Figure 9). While the population estimates increased, the Arctic cisco catch rate decreased almost 13 percent between 1984 and 1985, although the catch rates were high compared to the historical average. In both years the fishery was dominated by the 1978 year class with larger members of the 1979 year class available in 1985. In 1986, when the 1979 and 1980 year classes entered the fishery, the catch rates were the highest in the 21-year record. Although there was a 58 percent decrease from 1986 to 1987 as the 1979 year class and larger members of the 1980 year class moved out of the fishery, the 1987 catch rate was the second highest on record.

The least cisco catch rates in the commercial fishery have fluctuated less dramatically than the Arctic cisco catch rates (coefficient of variation for least cisco = 0.53, for Arctic cisco = 0.76) because the population has a greater range of ages in the harvestable stock and the catches are less influenced by individual year classes (Figure 11). There were high catches in 1969-1970 and 1982-1983 that may indicate unusually abundant year classes, but the basic pattern has been a gradual, but significant ($r = 0.49$, sig. at $a=0.05$), increase in catch rate over the last 21 years.

The tagging conducted in the region between 1976 and 1985 has provided data from which population estimates for least cisco can be generated for every year except 1980 and 1983 (tagging was not conducted in those years). The information from tags released from 1976 to 1979 were used by Craig and Haldorson (1981) to generate population estimates, and the estimates for 1984 and 1985 are provided above. Applying the mean gear selectivity correction factor to the tag release/recapture data for 1981 and 1982 allows similar estimates to be generated for those years as well. The data indicate that for the ten years between 1976 and 1985, the least cisco population fluctuated as follows:

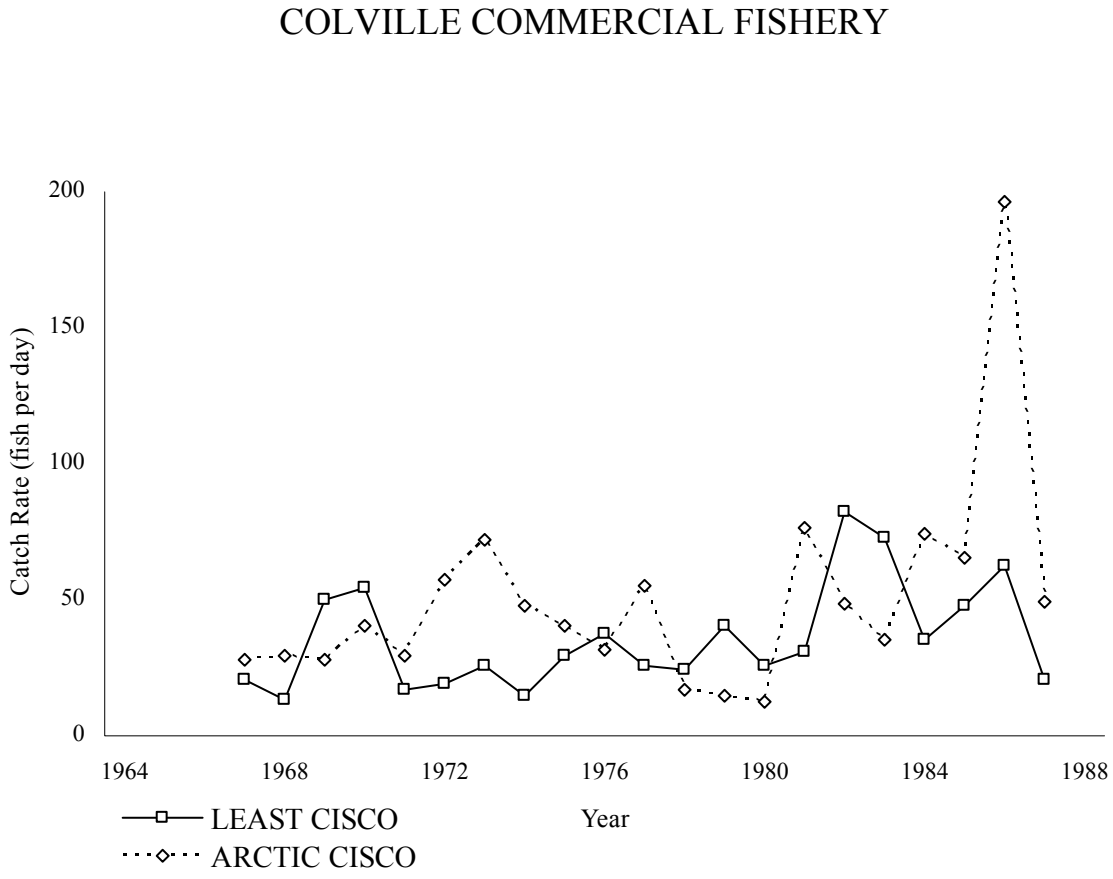


Figure 11. Catch rates of Arctic cisco and least cisco in the Colville Delta commercial fishery, 1967-1987.

Year	Population Estimate	95 Percent Confidence Interval
1976	305,000	271,000-343,000
1977	355,000	145,000-888,000
1978	434,000	311,000-629,000
1979	1,773,000	1,010,000-3,626,000
1980	-	-
1981	792,000	649,000-974,000
1982	329,000	291,000-374,000
1983	-	-
1984	423,000	378,000-472,000
1985	333,000	304,000-364,000

The wide confidence limits in the 1977 to 1979 data result from a low number of tag returns, and the high estimate in 1979 may reflect a high incidence of non-reporting or missed tags in that year. The apparent high abundance in 1979 is not reflected in the catch rate for that year (Figure 11).

Effects of Fishing on Populations

The population and harvest estimates generated from the 1985 data were used to estimate fishing mortality on the Arctic and least cisco stocks. In 1985, an estimated 70,400 Arctic cisco were harvested from an estimated pool of 1,139,000 catchable fish, indicating a fishing mortality on Arctic cisco of about 6 percent. An estimated 33,400 least cisco were caught from an estimated pool of 333,000 catchable least cisco, resulting in fishing mortality of approximately 10 percent.

The instantaneous total mortality for least cisco, using the decrease of tags in the population as an indicator of mortality (Figure 9), was 0.40 (r^2 = 0.962). This is equivalent to a total annual mortality of 33 percent. Given this level of Z and an exploitation rate (u) of 0.10, the instantaneous fishing mortality (F) is 0.12, and natural mortality (M) is 0.28.

Another estimate of instantaneous total mortality (Z) can be obtained from the age distribution of least cisco (Figure 5). Assuming full recruitment into the fishery at age 9 in 1987, the decrease in age groups provides an estimated Z = 0.39 (r^2 = 0.872). Exploitation rate (u) was likely less than 0.10 in 1987 because of the reduced effort and catch level (Tables 1 and 4), however, if it is assumed that the exploitation rate for 1987 is near 0.10, then again F = 0.12 and M = 0.27.

The recapture rate for tagged Arctic cisco in the commercial fishery showed a sharp decrease after the year of release,

indicating that annual mortality may be high if the 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 and return to the Mackenzie to spawn (Gallaway et al. 1983), thus the estimated annual mortality is not meaningful because of the high rate of emigration. The estimated Z for Arctic cisco, based on decrease in tag return rate, is 1.25 (r^2 = 0.997), which is equivalent to an annual mortality rate (or more accurately, loss rate) of 71.4 percent.

Historical Catch Levels

Catch data are available from the commercial fishery for the last 21 years, while the village of Nuiqsut was founded at its present site in the early 1970's. Prior to the founding of the village, many of the same fishermen used to travel to the Colville River delta in the fall to fish, but effort has increased as new families have entered the fishery. It is likely that the current levels of effort were reached beginning in the mid to late 1970's as the village stabilized and fishing patterns became established. Over the last ten years, the mean annual commercial catch has been 22,300 Arctic cisco (SD=8,587) and 21,500 least cisco (SD=9,252). If it is assumed that the ratio of village to commercial catch observed from 1985 to 1987 represented an average condition, then the commercial harvest has averaged 46 percent of the Arctic cisco catch and 59 percent of the least cisco catch, and the mean annual catches for the village and commercial fisheries for the last ten years were 48,500 Arctic cisco and 36,400 least cisco. As evident from the 1985 to 1987 estimates and historical pattern of catch rates, there was substantial variation between years.

DISCUSSION

Variability in Effort and Catch

During the three years of survey, both village and commercial fishing effort fluctuated drastically. Village effort fluctuated primarily because of competing requirements for time, including employment, or lack of employment, and pursuit of other resources. The early fishing period coincides with whaling season and hunting and processing of whales in 1986 and 1987 likely reduced the early and mid October effort in those two years. The commercial effort responded to both catch rate and market conditions. The fisherman sets a desired catch level based on anticipated markets (within a maximum harvest quota) and adjusts effort based on the observed catch rate. The high catch rate in 1986 allowed reaching a desired harvest with minimal effort.

The commercial fisherman expressed the opinion that publicity about the fishery survey caused increased village fishing effort in the Outer Colville Delta in 1985, the initial year of the study. The total catch and effort in 1985 were the highest during the survey period and it is likely that awareness of the study contributed to the high levels. As village fishing effort in the Outer Colville Delta decreased from 1985 to 1987, the commercial fishery portion of the total catch increased from 34 percent in 1985 to 47 percent and 57 percent in the following two years.

The increase in Arctic cisco catch rate from 1985 to 1986, resulting in the highest catch rate seen in the commercial fishery in 21 years of record, was caused by the full recruitment of the 1979 and 1980 year-classes into the fishery. As shown, there was a pool of Arctic cisco that were inaccessible to 76-mm mesh nets in 1985, but these grew to a harvestable size in 1986. This group of fish dominated the fish samples in Beaufort Sea coastal studies between 1982 and 1985 (Griffiths et al. 1983; Woodward-Clyde Consultants 1983; Moulton and Fawcett 1984; Moulton et al. 1986). The data also indicate, however, that few young fish entered the region from 1981 to 1984, thus few were available to recruit into the fishery. From 1985 to 1987, there were three consecutive years of moderate recruitment (Envirosphere 1987, D. Glass, Envirosphere, pers. comm.) that will allow the fishery to recover. The 1987 catch continued to be composed of 1980 and 1979 year-class fish that remained in the Colville region prior to maturation, these will likely be gone in 1988. The catch rate of Arctic cisco in the commercial fishery declined 58 percent between 1986 and 1987 and will continue to decline in 1988. Catch rates will remain low until about 1990 when the 1985 year class first recruits into the fishery.

Effect of Salinity on Winter Habitat Use

The salinity of the water in the fishing areas during the fall is another variable that influences the annual variability in catch rate because it influences the distribution of ciscoes within the delta. Arctic cisco are associated with higher salinities (21-26 ppt) while least cisco occur in greater numbers in lower salinity. If the river discharge was high prior to freeze-up, salinity remains relatively low until discharge decreases and saltwater moves upstream. In this case, least cisco catch rates are high until salinity increases, at which time Arctic cisco catch rates increase. Conversely, if discharge was low at freeze-up, saltwater moves upstream early in the fishing season and Arctic cisco catch rates increase early in the season. Under these conditions, least cisco move upstream to lower salinity water and least cisco catch rates may be low the entire season. Least cisco also appear to select areas where access to lower salinity water is maintained. Densities of least cisco are low in the Nigliq Channel, where access to low salinity water is lost soon after freeze-up because the upstream end of the channel freezes shut by mid to late October. Least cisco are most abundant in the main channels of the Colville Delta, which remain connected through the winter and provide access to a full range of salinities (fresh to seawater). In the Colville River, Arctic cisco have not been found in lower salinity water, and appear to be restricted to the outer delta channels.

Impact of Fishery on Stocks

The estimated harvest of Arctic cisco in 1985, 70,400 fish, represented approximately 6 percent of the harvestable Arctic cisco, assuming that all of the population estimated from the released tagged Arctic cisco in the Prudhoe Bay area moved to the Colville region in late summer and were vulnerable to the fall fishery. If substantial numbers of Arctic cisco moved elsewhere, such as moving eastward to the Mackenzie River, then the proportion of the population in the Colville would decrease and the harvest rate would increase. The response of the population and resulting exploitation rate to different levels of return to the Colville is as follows:

Percent Returning to Colville	Harvestable Population	Exploitation Rate (percent)
100	1,139,000	6
75	850,000	8
50	570,000	12
35	400,000	18

While data from the concurrent Endicott Study indicated that some Arctic cisco tagged in the Prudhoe Bay region moved eastward to Kaktovik during the year of tagging (two tagged Arctic cisco were recaptured in limited sampling at Kaktovik in 1985), the data were insufficient to determine if significant eastward movement occurred (Envirosphere 1987). Few large Arctic cisco use of the Sagavanirktok River delta near Prudhoe Bay for over wintering (Schmidt et al. 1987).

Evidence of substantial eastward movement by Arctic cisco, though not necessarily in the year of tagging, is beginning to emerge as sampling effort increases in the eastern Beaufort Sea. In 1986, eight Arctic cisco tagged in the Prudhoe Bay region between 1981 and 1985 were recovered at the mouth of the Babbage River in Canada after being at large 1 to 5 years with an additional recapture at Shingle Point immediately west of the Mackenzie River mouth. In 1987, three additional tagged Arctic cisco were recaptured in the Mackenzie Delta after 2 to 6 years at large (W. Bond, Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, Manitoba, pers. comm.). It is also apparent, however, that there is westward movement of large Arctic cisco from the Mackenzie region into the Colville region during the summer, as evidenced by the recapture of Arctic cisco tagged east of Kaktovik.

As can be seen, there are many uncertainties regarding the summer movements of Arctic cisco and the effects of these movements on the number of Arctic cisco that enter the Colville delta in the fall. It would be necessary to conduct a tagging study in the delta just prior to the fishery to accurately estimate the stock vulnerable to the fishery.

For least cisco, the pattern is more clear. Virtually all least cisco tagged near Prudhoe Bay entered the Colville Delta in late summer and were vulnerable to the fishery (Moulton et al. 1986). There are resident populations of least cisco in lakes and streams connected to the Colville system, but these appear to occupy different habitats than the anadromous least cisco that winter in the delta, and do not contribute significantly to the harvest. The estimated harvest of 33,400 anadromous least cisco in 1985 represented approximately 10 percent of the harvestable fish. The catch rates of least cisco in the 1986 commercial fishery increased slightly over those in 1985, indicating that the harvestable population was of similar size in both years. The total catch, however, decreased over 50 percent because of the reduced effort, thus the 1986 exploitation rate may have been around 5 percent. Using the same reasoning for 1987 (commercial fishery catch rates approximately 18

percent lower than in 1985 while total catch declined 46 percent), the exploitation rate was likely between 5 and 10 percent.

The levels of mortality observed to date for least cisco, 5 to 10 percent exploitation rate and 24 percent mean annual natural mortality (equivalent to M = 0.27), are on the low end of the ranges reported for other coregonids (Healey 1975). For example, in lake whitefish populations (Coregonus clupeaformis) in the Northwest Territories, Healey (1975) reports only 2 out of 17 estimates of natural mortality to be less than 30 percent, compared to the 24 percent estimated for Colville River anadromous least cisco. For total mortality, only 2 out of 24 estimates were 40 percent or less, compared to 32 percent in the Colville River least cisco. For fourteen exploited lakes, the total annual mortality averaged 66 percent (range: 36 to 94 percent). Healey (1980) reports that an exploitation rate of 10 percent caused virtually no change in lake whitefish populations while a rate of 20 percent caused a moderate amount of change. Substantial changes in population structure occurred at a 30 percent exploitation rate.

Another way to evaluate the current harvest rates is to compare the observed harvest to the estimated maximum sustainable yield (MSY). Beddington and Cooke (1983) described a method to estimate MSY given natural mortality and the parameter K from the von Bertalanffy growth curve. For least cisco, the best estimate for instantaneous natural mortality is 0.27. The parameter K is estimated to be 0.11 based on age-length data from the Colville region (Moulton et al. in prep.). Using tables provided in Beddington and Cooke (1983) and assuming age-8 as the initial age at recruitment (although full recruitment occurs at age 9), it is estimated that the MSY for anadromous least cisco in the Colville Delta is 14 percent of the unexploited recruited stock. The least cisco population has been harvested for generations, thus an estimate of the unexploited stock is not available. Population estimates over the last ten years (excluding the unusually high estimate in 1979)indicate that the harvestable stock has averaged 424,000 fish (SD=169,000). It is likely that the unexploited stock was greater than this level, but if we conservatively assume that the 10 yr average is nearly the unexploited stock, then the MSY would be 59,360 least cisco. The combined village and commercial harvests in 1986 and 1987 are only 27 and 30 percent of this level and the high catch in 1985 is 56 percent of the estimated MSY. Beddington and Cooke (1983) cautioned that estimates of MSY derived in this manner are only approximations and that given a full range of uncertainty, the yield will be estimated only to within a factor of two. Assuming that the above estimated MSY suffers from full over-estimation and is actually only half

of the estimated value, the 1986 and 1987 harvests are still within an acceptable range, while the 1985 harvest would have slightly exceeded the MSY. The commercial fishery catch rates, however, have remained stable or increased, indicating that the true MSY has not been exceeded by the estimated combined village and commercial annual harvest of 36,400 least cisco over the last ten years.

SUMMARY AND RECOMMENDATIONS

The three years of investigation on the Colville River cisco fishery reveals that the present harvest levels are presently within an acceptable range. The stocks do not exhibit characteristics often seen in over-fished populations and the catch rates of both Arctic cisco and least cisco are high compared to the previous twenty years of record. As discussed, the recent high catch rates for Arctic cisco were a result of a high recuitment of young in 1980. Since this group of fish has grown out of the fishery and recruitment was low from 1981 to 1984, catches are predicted to decline in 1988 and remain low until the 1985 year-class reaches a harvestable size. Catches will likely increase in 1990 and remain stable for several years because of the three consecutive years (1985 to 1987) of juvenile recruitment.

Because the present harvest levels appear to be within an acceptable range, i.e. are not adversely affecting stock levels, it is recommended that no changes be made in the management of the fishery at this time. Monitoring of the fishery should focus on estimating effort, catch rates and age structure so that the effects of increased fishing effort or harvest level will not go undetected. Monitoring of juvenile abundance and age or size structure would also allow predicting the future direction of catch rates based on abundant or weak year-classes.

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DATA APPENDIX

Observed mean catch rates (number of fish caught per net-day) of Arctic and least cisco by area, mesh size (mm) and 10-day interval in the 1985 fall fishery in the Nigliq channel.

Area	Oct 1-10			Oct 11-20			Oct 21-30			Oct 31-Nov 9			Nov 10-19		
Mesh Size (mm)	CPUE1	SD2	N3	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
UPPER NIGLIQ															
Arctic cisco															
56							11.7	4.4	4				8.0	0	1
63	5.0	5.7	4	19.3	10.0	3	32.0	0	1	32.7	21.8	3	48.2	17.7	4
76	5.4	3.8	19	5.8	4.9	17	20.6	2.9	3	16.6	7.6	2			
83				10.8	6.9	5							43.7	0	1
89	0	0	3	10.5	7.3	12	35.3	13.6	3				37.7	0	1
Least cisco															
56							0.5	0.6	4				0	0	1
63	4.6	1.1	4	3.7	1.5	3	3.0	0	1	1.5	2.2	3	1.3	1.1	4
76	6.1	8.9	19	5.3	8.4	17	1.8	1.5	3	1.3	0.4	2			
83				0.4	0.5	5							1.2	0	1
89	0.4	0.7	3	1.1	1.6	12	0.2	0.3	3				0.6	0	1

1 Mean catch rate (number of fish per net-day) for the 10-day interval

2 Standard deviation

3 Number of catch samples

Observed mean catch rates (number of fish caught per net-day) of Arctic and least cisco by area, mesh size (mm) and 10-day interval in the 1986 fall fishery in the Nigliq channel.

Area		Oct 1-10			Oct 11-20			Oct 21-30			Oct 31-Nov 9			Nov 10-19		
Mesh Size (mm)		CPUE1	SD2	N3	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
UPPER NIGLIQ																
Arctic cisco																
76		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
83					9.4	7.0	11	5.8	3.1	4	3.8	1.8	5	5.6	3.3	3
89					7.4	4.4	9	10.8	12.0	6	11.2	13.9	7	11.7	7.2	3
Least cisco																
76		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
83					0.9	1.1	11	0.4	0.5	4	0	0	5	0	0	3
89					1.6	2.2	9	0.3	0.4	6	0.3	0.8	7	0.6	0.1	3
NANUK																
Arctic cisco																
76					28.7	0	1	10.5	0.7	2	40.0	31.4	5	21.4	10.7	4
Least cisco																
76					3.0	0	1	0	0	2	1.0	1.5	5	0.6	0.7	4
NIGLIQ DELTA																
Arctic cisco																
76								57.8	18.4	8	54.5	28.7	16	147.0	112.3	8
83								36.8	11.6	6	62.3	41.8	8	67.1	33.5	4
Least cisco																
76								0.1	0.2	7	0.7	1.4	16	0.2	0.4	6
83								0	0	6	1.3	2.0	8	0.5	1.2	4

1 Mean catch rate (number of fish per net-day) for the 10-day interval
2 Standard deviation
3 Number of catch samples

Estimated Fishing Effort by Mesh Size in Nigliq Channel - 1985
(Upper Nigliq and Nanuk regions)

Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
Upper Nigliq + Nanuk						
60	4	10	10	10	5	39
64	7.3	55.3	50.8	44.3	26.7	184.4
70	0	0	0	0	0	0
76	30	86.7	115.5	58.7	55	345.9
83	6.7	16.7	16.7	16.7	16.7	73.5
89	20	48.3	51.7	33.3	16.7	170
102	6.7	0	0	0	0	6.7
unknown	4	10	16	15	5	50
Total Effort	78.7	227	260.7	178	125.1	869.5

Observed mean catch rates (number of fish caught per net-day) of Arctic and least cisco by area, mesh size (mm) and 10-day interval in the 1987 fall fishery in the Nigliq channel.

Area	Oct 1-10			Oct 11-20			Oct 21-30			Oct 31-Nov 9			Nov 10-19		
Mesh Size (mm)	CPUE1	SD2	N3	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N	CPUE	SD	N
UPPER NIGLIQ															
Arctic cisco															
63				7.5	0.0	1	7.8	1.8	2	17.5	13.4	2			
69							33.9	16.5	6	17.6	0.0	1			
76				8.8	6.3	19	18.6	21.1	38	17.0	11.7	17	1.8	1.1	4
83				8.0	4.0	5	8.3	7.1	9	10.8	10.7	5			
89				4.8	8.1	6	6.1	6.9	12	3.3	2.5	3	2.0	2.4	2
Least cisco															
63				27.0	0.0	1	28.5	0.7	2	6.5	4.9	2			
69							17.1	8.7	6	5.2	0.0	1			
76				10.6	8.3	19	4.8	4.6	38	4.6	4.7	17	2.1	2.8	4
83				3.3	2.8	5	1.5	2.2	9	1.1	0.7	5			
89				2.4	1.4	6	0.5	1.0	12	1.9	0.6	3	0.1	0.1	2
NANUK															
Arctic cisco															
76							43.0	28.6	14				1.5	0.4	2
89							61.3	30.1	2						
Least cisco															
76							2.8	3.8	14				0.0	0.0	2
89							1.8	2.5	2						
NIGLIQ DELTA															
Arctic cisco															
76							52.4	74.0	6	26.3	15.2	2	5.5	0.0	1
83										31.0	0.0	1			
89							46.4	19.1	2						
Least cisco															
76							0.3	0.7	6	2.6	2.0	2	0.2	0.0	1
83										0.0	0.0	1			
89							0.6	0.8	2						

1 Mean catch rate (number of fish per net-day) for the 10-day interval
2 Standard deviation
3 Number of catch samples

Estimated catch rate of Arctic cisco by mesh size in the Nigliq Channel — 1985 (Upper Nigliq + Nanuk)

	Mean Catch Rate by Time Period				
Mesh Size (mm)	Oct 1– Oct 10	Oct 11– Oct 20	Oct 21– Oct 30	Oct 31– Nov 9	Nov 10– Nov 19
60	–	–	11.7	–	8
64	5	19.3	32	32.7	48.2
70	–	–	–	–	–
76	5.4	5.8	20.6	16.6	18
83	0	10.8	28	26	43.7
89	0	10.5	35.3	36	37.7
102	0	0	0	0	0

Estimated total catch of Arctic cisco by mesh size
in the Nigliq Channel - 1985 (Upper Nigliq + Nanuk)

	Estimated Catch by Time Period					
Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
60	0	0	117	0	40	157
64	37	1067	1626	1449	1287	5465
70	0	0	0	0	0	0
76	162	503	2379	974	990	5009
83	0	180	468	434	730	1812
89	0	507	1825	1199	630	4161
102	0	0	0	0	0	0
				Area Total		16603

Estimated catch rate of least cisco by mesh size in the Nigliq Channel - 1985 (Upper Nigliq + Nanuk)

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19
60	-	-	.5	-	0
64	4.6	3.7	3	1.5	1.3
70	-	-	-	-	-
76	6.1	5.3	1.8	1.3	0
83	0	.4	0	0	1.2
89	.4	1.1	.2	0	.6
102	0	0	0	0	0

Estimated total catch of least cisco by mesh size
in the Nigliq Channel - 1985 (Upper Nigliq + Nanuk)

	Estimated Catch by Time Period					
Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
60	0	0	5	0	0	5
64	34	205	152	66	35	492
70	0	0	0	0	0	0
76	183	460	208	76	0	927
83	0	7	0	0	20	27
89	8	53	10	0	10	81
102	0	0	0	0	0	0
unknown						
				Area Total		1532

Estimated catch rate of broad whitefish by mesh size in the Nigliq Channel – 1985 (Upper Nigliq + Namuk)

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1– Oct 10	Oct 11– Oct 20	Oct 21– Oct 30	Oct 31– Nov 9	Nov 10– Nov 19
60	–	–	0	–	0
64	2.8	5.3	0	0	.6
70	–	–	–	–	–
76	10	4.7	.3	0	0
83	–	.4	–	–	1.2
89	1.2	.3	.2	–	0
102	0	0	0	0	0

Estimated total catch of broad whitefish by mesh size in the Nigliq Channel - 1985 (Upper Nigliq + Nanuk)

Mesh Size (mm)	Estimated Catch by Time Period					
	Oct 1-Oct 10	Oct 11-Oct 20	Oct 21-Oct 30	Oct 31-Nov 9	Nov 10-Nov 19	Mesh Total
60	0	0	0	0	0	0
64	20	293	0	0	16	330
70	0	0	0	0	0	0
76	300	407	35	0	0	742
83	0	7	0	0	20	27
89	24	14	10	0	0	49
102	0	0	0	0	0	0

Estimated Fishing Effort by Mesh Size in Nigliq Channel - 1986

Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	8	10	10	10	7	45
70	0	0	0	0	0	0
76	54.7	115.5	116.5	84.8	33.2	404.7
83	8	20	20	11	4	63
89	7	10.7	25.7	24.7	11.7	79.8
102	0	0	0	0	0	0
Area Total	77.7	156.2	172.2	130.5	55.9	592.5
Nanuk						
60	0	0	0	0	0	0
64	0	5.3	13.3	5.3	0	23.9
70	0	0	0	0	0	0
76	0	38	61.7	48.3	12	160
83	0	9	10	8	0	27
89	0	0	0	0	0	0
102	0	5.3	0	0	0	5.3
Area Total	0	57.6	85	61.6	12	216.2
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	5.7	36.7	25	6	73.4
83	0	1	10	10	3	24
89	0	0	0	0	0	0
102	0	0	0	0	0	0
Area Total	0	6.7	46.7	35	9	97.4

Estimated catch rate of Arctic cisco by mesh size in the Nigliq Channel - 1986.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19
Upper Nigliq					
60	-	-	-	-	-
64	6.6	16.4	14.3	16.6	11.5
70	-	-	-	-	-
76	7.4	18.3	15.9	18.5	12.8
83	9.4	9.4	5.8	3.8	5.6
89	7.4	7.4	10.8	11.2	11.7
102	-	-	-	-	-
unknown	-	-	-	-	-
Nanuk					
60	-	-	-	-	-
64	-	25.8	9.4	35.9	19.2
70	-	-	-	-	-
76	-	28.7	10.5	40	21.4
83	-	10.8	3.9	15	-
89	-	-	-	-	-
102	-	-	-	-	-
Nigliq Delta					
60	-	-	-	-	-
64	-	-	-	-	-
70	-	-	-	-	-
76	-	57.8	57.8	54.5	147
83	-	36.8	36.8	62.3	67.1
89	-	-	-	-	-
102	-	-	-	-	-

Estimated total catch of Arctic cisco by mesh size in the Nigliq Channel - 1986.

Mesh Size (mm)	Oct 1-Oct 10	Oct 11-Oct 20	Oct 21-Oct 30	Oct 31-Nov 9	Nov 10-Nov 19	Mesh Total
	Estimated Catch by Time Period					
Upper Nigliq						
60	0	0	0	0	0	0
64	53	164	143	166	81	606
70	0	0	0	0	0	0
76	405	2114	1852	1569	425	6365
83	75	188	116	42	22	443
89	52	79	278	277	137	822
102	0	0	0	0	0	0
unknown						
				Area Total		8236
Nanuk						
60	0	0	0	0	0	0
64	0	137	125	190	0	452
70	0	0	0	0	0	0
76	0	1091	648	1932	257	3927
83	0	97	39	120	0	256
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		4635
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	329	2121	1363	882	4695
83	0	37	368	623	201	1229
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		5924

Estimated catch rate of least cisco by mesh size in the Nigliq Channel - 1986.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19
Upper Nigliq					
60	-	-	-	-	-
64	20.9	33.2	12.3	2.5	6.1
70	-	-	-	-	-
76	1.7	2.7	1	.2	.5
83	.9	.9	.4	0	0
89	1.6	1.6	.3	.3	.6
102	-	-	-	-	-
unknown	-	-	-	-	-
Nanuk					
60	-	-	-	-	-
64	-	36.9	0	12.3	7.4
70	-	-	-	-	-
76	-	3	0	1	.6
83	-	.9	0	.3	.2
89	-	-	-	-	-
102	-	-	-	-	-
Nigliq Delta					
60	-	-	-	-	-
64	-	-	-	-	-
70	-	-	-	-	-
76	-	0	.07	.7	.2
83	-	0	0	1.3	.5
89	-	-	-	-	-
102	-	-	-	-	-

Estimated total catch of least cisco by mesh size in the Nigliq Channel - 1986.

Mesh Size (mm)	Estimated Catch by Time Period: Oct 1–Oct 10	Oct 11–Oct 20	Oct 21–Oct 30	Oct 31–Nov 9	Nov 10–Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	167	332	123	25	43	690
70	0	0	0	0	0	0
76	93	312	117	17	17	555
83	7	18	8	0	0	33
89	11	17	8	7	7	50
102	0	0	0	0	0	0
unknown						
				Area Total		1328
Nanuk						
60	0	0	0	0	0	0
64	0	196	0	65	0	261
70	0	0	0	0	0	0
76	0	114	0	48	7	170
83	0	8	0	2	0	11
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		441
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	3	18	1	21
83	0	0	0	13	2	15
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		36

Estimated catch rate of broad whitefish by mesh size in the Nigliq Channel - 1986.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19
Upper Nigliq					
60	-	-	-	-	-
64	0	5	0	0	0
70	-	-	-	-	-
76	0	1.2	0	.25	0
83	0	.96	0	0	0
89	0	0	0	0	0
102	-	-	-	-	-
unknown	-	-	-	-	-
Nanuk					
60	-	-	-	-	-
64	-	0	0	0	0
70	-	-	-	-	-
76	-	0	0	0	0
83	-	0	0	0	0
89	-	-	-	-	-
102	-	-	-	-	-
Nigliq Delta					
60	-	-	-	-	-
64	-	-	-	-	-
70	-	-	-	-	-
76	-	0	0	0	0
83	-	0	0	0	0
89	-	-	-	-	-
102	-	-	-	-	-

Estimated Fishing Effort by Mesh Size in Nigliq Channel - 1987

Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	2.7	10.7	24	18	3	58.4
70	0	0	16.7	13.3	0	30
76	10.2	88.7	144.3	156.3	48.5	448
83	1	65	93.3	86.7	28	274
89	1	18	41.7	33.3	30	124
102	0	3	0	0	0	3
unknown	1.3	6.7	6.7	6.7	2	23.4
Area Total	16.2	192.1	326.7	314.3	111.5	960.8
Nanuk						
60	0	0	0	0	0	0
64	0	0	24.3	30	3	57.3
70	0	0	0	0	0	0
76	0	0	59	65.3	24	148.3
83	0	0	0	0	0	0
89	0	0	12	18	0	30
102	0	0	0	0	0	0
Area Total	0	0	95.3	113.3	27	235.6
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	19	24.7	14	57.7
83	0	0	0	7	9	16
89	0	0	15	1.7	0	16.7
102	0	0	0	0	0	0
Area Total	0	0	34	33.4	23	90.4

Estimated total catch of broad whitefish by mesh size in the Nigliq Channel - 1986.

	Estimated Catch by Time Period					
Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	0	50	0	0	0	50
70	0	0	0	0	0	0
76	0	139	0	21	0	160
83	0	19	0	0	0	19
89	0	0	0	0	0	0
102	0	0	0	0	0	0
unknown						
				Area Total		229
Nanuk						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	0	0	0	0
83	0	0	0	0	0	0
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		0
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	0	0	0	0
83	0	0	0	0	0	0
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		0

Estimated total catch of Arctic cisco by mesh size in the Nigliq Channel - 1987.

Mesh Size (mm)	Oct 1-Oct 10	Oct 11-Oct 20	Oct 21-Oct 30	Oct 31-Nov 9	Nov 10-Nov 19	Mesh Total
	Estimated Catch by Time Period					
Upper Nigliq						
60	0	0	0	0	0	0
64	0	80	186	315	0	581
70	0	0	567	234	0	801
76	0	784	2684	2652	85	6205
83	0	517	773	940	0	2231
89	0	88	254	111	61	514
102	0	0	0	0	0	0
unknown						
				Area Total		10333
Nanuk						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	2538	0	37	2575
83	0	0	0	0	0	0
89	0	0	735	0	0	735
102	0	0	0	0	0	0
				Area Total		3310
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	996	649	77	1722
83	0	0	0	217	0	217
89	0	0	696	0	0	696
102	0	0	0	0	0	0
				Area Total		2635

Estimated catch rate of Arctic cisco by mesh size in the Nigliq Channel - 1987.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19
Upper Nigliq					
60	-	-	-	-	-
64	0	7.5	7.75	17.5	0
70	-	-	33.94	17.6	-
76	0	8.84	18.6	16.97	1.75
83	0	7.96	8.29	10.84	0
89	0	4.91	6.08	3.34	2.04
102	-	0	-	-	-
unknown	0	0	0	0	0
Nanuk					
60	-	-	-	-	-
64	-	-	0	0	0
70	-	-	-	-	-
76	-	-	43.02	0	1.55
83	-	-	-	-	-
89	-	-	61.25	0	0
102	-	-	-	-	-
Nigliq Delta					
60	-	-	-	-	-
64	-	-	-	-	-
70	-	-	-	-	-
76	-	-	52.41	26.28	5.51
83	-	-	-	31	0
89	-	-	46.41	0	0
102	-	-	-	-	-

Estimated catch rate of least cisco by mesh size in the Nigliq Channel – 1987.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1– Oct 10	Oct 11– Oct 20	Oct 21– Oct 30	Oct 31– Nov 9	Nov 10– Nov 19
Upper Nigliq					
60	–	–	–	–	–
64	–	27	28.5	6.5	0
70	–	–	17.14	5.2	–
76	–	10.58	4.78	4.64	2.07
83	–	3.3	1.53	1.14	0
89	–	2.37	.48	1.87	.1
102	–	0	–	–	0
unknown	–	0	0	0	0
Nanuk					
60	–	–	–	–	–
64	–	–	0	0	0
70	–	–	–	–	–
76	–	–	2.8	0	0
83	–	–	–	–	–
89	–	–	1.75	0	–
102	–	–	–	–	–
Nigliq Delta					
60	–	–	–	–	–
64	–	–	–	–	–
70	–	–	–	–	–
76	–	–	.5	2.6	.16
83	–	–	–	0	0
89	–	–	0	0	–
102	–	–	–	–	–

Estimated total catch of least cisco by mesh size in the Nigliq Channel - 1987.

Mesh Size (mm)	Estimated Catch by Time Period: Oct 1–Oct 10	Oct 11–Oct 20	Oct 21–Oct 30	Oct 31–Nov 9	Nov 10–Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	0	289	684	117	0	1090
70	0	0	286	69	0	355
76	0	938	690	725	100	2454
83	0	215	143	99	0	456
89	0	43	20	62	3	128
102	0	0	0	0	0	0
unknown						
				Area Total		4483
Nanuk						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	165	0	0	165
83	0	0	0	0	0	0
89	0	0	21	0	0	21
102	0	0	0	0	0	0
				Area Total		186
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	10	64	2	76
83	0	0	0	0	0	0
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		76

Estimated catch rate of broad whitefish by mesh size in the Nigliq Channel – 1987.

Mesh Size (mm)	Mean Catch Rate by Time Period				
	Oct 1– Oct 10	Oct 11– Oct 20	Oct 21– Oct 30	Oct 31– Nov 9	Nov 10– Nov 19
Upper Nigliq					
60	–	–	–	–	–
64	0	6	3.25	6.5	0
70	–	–	2.65	.6	–
76	0	4.37	1.22	.72	1.22
83	0	1.76	.23	.12	0
89	0	.48	.18	.6	.02
102	–	0	–	–	–
unknown	0	0	0	0	0
Nanuk					
60	–	–	–	–	–
64	–	–	0	0	0
70	–	–	–	–	–
76	–	–	.15	0	0
83	–	–	–	–	–
89	–	–	0	0	0
102	–	–	–	–	–
Nigliq Delta					
60	–	–	–	–	–
64	–	–	–	–	–
70	–	–	–	–	–
76	–	–	0	0	0
83	–	–	–	0	0
89	–	–	0	0	0
102	–	–	–	–	–

Estimated total catch of broad whitefish by mesh size in the Nigliq Channel - 1987.

	Estimated Catch by Time Period					
Mesh Size (mm)	Oct 1- Oct 10	Oct 11- Oct 20	Oct 21- Oct 30	Oct 31- Nov 9	Nov 10- Nov 19	Mesh Total
Upper Nigliq						
60	0	0	0	0	0	0
64	0	64	78	117	0	259
70	0	0	44	8	0	52
76	0	388	176	113	59	735
83	0	114	21	10	0	146
89	0	9	8	20	1	37
102	0	0	0	0	0	0
unknown						
				Area Total		1230
Nanuk						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	9	0	0	9
83	0	0	0	0	0	0
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		9
Nigliq Delta						
60	0	0	0	0	0	0
64	0	0	0	0	0	0
70	0	0	0	0	0	0
76	0	0	0	0	0	0
83	0	0	0	0	0	0
89	0	0	0	0	0	0
102	0	0	0	0	0	0
				Area Total		0

Salinity measurements recorded in the Kupigruak Channel, 1987.

Date	Depth (m)	Station 1.1	Station 3.7	Station 8.0
Oct 23	1	2.2	--	2.8
	2	24.2	--	24.2
	3	25.1	--	26.0
	4	25.8	--	26.8
	5	25.8	--	27.8
	6	--	--	28.0
Oct 24	1	2.0	--	1.5
	2	24.8	--	21.2
	3	25.0	--	25.0
	4	25.2	--	25.0
	5	25.8	--	25.0
	6	--	--	26.4
Oct 25	1	2.6	--	1.5
	2	20.8	--	20.1
	3	24.0	--	23.2
	4	24.6	--	23.2
	5	24.8	--	23.3
	6	--	--	24.1
Oct 26	1	20.8	--	--
	2	23.0	--	--
	3	25.5	--	--
	4	27.1	--	--
	5	27.1	--	--
	6	27.0	--	--
Oct 27	1	7.3	5.9	4.0
	2	26.9	25.2	23.6
	3	27.0	26.2	24.0
	4	27.7	26.2	24.0
	5	27.9	26.2	24.0
	6	--	--	24.0
Oct 28	1	--	--	3.4
	2	--	--	23.0
	3	--	--	23.8
	4	--	--	24.0
	5	--	--	24.2
	6	--	--	24.5

Oct 29	1	--	5.1	3.5
	2	--	23.2	24.0
	3	--	25.8	25.0
	4	--	26.1	25.0
	5	--	26.3	25.1
	6	--	--	25.1
Oct 30	1	--	4.3	2.9
	2	--	23.5	24.7
	3	--	24.8	25.2
	4	--	24.8	25.3
	5	--	24.9	25.8
	6	--	--	26.1

Catch and effort of least cisco and Arctic cisco in the Colville River delta commercial fishery from 1967 to 1987.

		Least Cisco			Arctic Cisco		
Year	Effort (Net Days)	Total Catch	CPUE	Pop. Estimate (x1000)	Total Catch	CPUE	Pop. Estimate (x1000)
1967	774	15,944	20.6		21,904	28.3	
1968	1,427	19,122	13.4		41,954	29.4	
1969	699	35,019	50.1		19,572	28.0	
1970	562	30,629	54.5		22,705	40.4	
1971	1,422	23,890	16.8		41,380	29.1	
1972	646	12,209	18.9		37,080	57.4	
1973	993	25,222	25.4		71,595	72.1	
1974	947	14,110	14.9		44,983	47.5	
1975	759	22,466	29.6		30,967	40.8	
1976	996	37,051	37.2	305	31,673	31.8	777
1977	576	14,976	26.0	355	31,795	55.2	146
1978	1,077	25,740	23.9	434	18,094	16.8	202
1979	620	25,110	40.5	1,773	9,238	14.9	110
1980	1,209	31,459	26.0		14,657	12.1	
1981	501	15,504	30.9	792	38,176	76.2	
1982	328	27,085	82.6	329	15,975	48.7	
1983	520	37,909	72.9		18,162	34.9	
1984	371	13,076	35.2	423	27,677	74.6	978
1985	363	17,596	48.5	333	23,678	65.2	1,139
1986	151	9,000	59.6		29,456	195.1	
1987*	180	4,214	23.4		14,788	82.2	

* 1987 data do not include the effort and catches by Bud Helmericks, who operated another fishery in 1987, about 1 mile downstream from Jim's nets

Calculation of decrease in tagged least cisco in the Colville River delta commercial fishery, 1980 to 1987.

Number of tags recaptured compared to number released and catch examined for tags

Release Year	Number of Tags Released	Total Examined Catch	Number Recaptured In: 1980	1981	1982	1983	1984	1985	1986	1987
1980	1,067	31,459	32	20	8	12	3	5	2	1
1981	6,157	15,504		90	155	159	52	45	14	19
1982(E)	1,798	27,085			155	48	22	20	7	6
1982(W)	2,131	"			88	56	14	11	4	2
1983	0	37,909				—	—	—	—	—
1984	14,126	13,076					304	318	145	117
1985	9,915	17,596						436	128	140
1986	0	9,000							—	—
1987	0	11,939								—

Number of tags recaptured per 20,000 fish examined

Release Year	Number Recaptured per 20,000 fish examined In: 1980	1981	1982	1983	1984	1985	1986	1987
1980	20.34	25.80	5.91	6.33	4.59	5.68	4.44	1.68
1981		116.10	114.45	83.89	79.54	51.15	31.11	31.83
1982(E)			114.45	25.32	33.65	22.73	15.56	10.05
1982(W)			64.98	29.54	21.41	12.50	8.89	3.35
1983				—	—	—	—	—
1984					464.97	361.45	322.22	196.00
1985						495.57	284.44	234.53
1986							—	—
1987								—

Percent Recaptured

Release Year	Percent Recaptured After Years At Large 0	1	2	3	4	5	6	7
1980	1.91	2.42	.55	.59	.43	.53	.42	.16
1981	1.89	1.86	1.36	1.29	.83	.51	.52	
1982(E)	6.37	1.41	1.87	1.26	.87	.56		
1982(W)	3.05	1.39	1.00	.59	.42	.16		
1984	3.29	2.56	2.28	1.39				
1985	5.00	2.87	2.37					
Mean	3.58	2.08	1.57	1.02	.64	.44	.47	.16
SD =	1.78	.62	.73	.4	.25	.19	.07	0

Regression of recapture percent vs. years at large:

$\ln(\text{recap } \%) = 1.621 - 0.3985(\text{year at large})$ $r = -0.981$

(1982E = 1982 Endicott Baseline Study, 1982W = 1982 PBU Waterflood Monitoring Study)

Calculation of decrease in tagged Arctic cisco in the Colville River delta commercial fishery, 1980 to 1987.

Number of tags recaptured compared to number released and catch examined for tags

Release Year	Number of Tags Released	Total Examined Catch	Number Recaptured In: 1980	1981	1982	1983	1984	1985	1986	1987
1980	229	14,657	10	6	0	0	0	0	0	0
1981	1,756	38,176		62	4	4	0	0	0	0
1982(E)	439	15,975			8	4	2	0	0	0
1982(W)	435	"			12	4	0	0	0	0
1983	0	18,162				—	—	—	—	—
1984	5,840	27,677					88	42	35	24
1985	11,695	23,678						147	116	86
1986	0	29,456							—	—
1987	0	27,494								—

Number of tags recaptured per 20,000 fish examined

Release Year	Number Recaptured per 20,000 fish examined In: 1980	1981	1982	1983	1984	1985	1986	1987
1980	13.65	3.14	.00	.00	.00	.00	.00	.00
1981		32.48	5.01	4.40	.00	.00	.00	.00
1982(E)			10.02	4.40	1.45	.00	.00	.00
1982(W)			15.02	4.40	.00	.00	.00	.00
1983				—	—	—	—	—
1984					63.59	35.48	23.76	17.46
1985						124.17	78.76	62.56
1986							—	—
1987								—

Percent Recaptured

Release Year	Percent Recaptured After Years At Large 0	1	2	3	4	5	6	7
1980	5.96	1.37	.00	.00	.00	.00	.00	.00
1981	1.85	.29	.25	.00	.00	.00	.00	
1982(E)	2.28	1.00	.33	.00	.00	.00		
1982(W)	3.45	1.01	.00	.00	.00	.00		
1984	1.09	.61	.41	.30				
1985	1.06	.67	.53					
Mean	2.62	.83	.25	.06	.00	.00	.00	.00
SD =	1.86	.38	.25	.13				

Regression of recapture percent vs. years at large:

ln(recap %) = 2.277 - 1.253 (year at large) $r = -0.9987$

(1982E = 1982 Endicott Baseline Study, 1982W = 1982 PBU Waterflood Monitoring Study)

Length frequencies of Arctic and least cisco by mesh size from the Colville River village and commercial fall fisheries, 1985-1987.

Arctic cisco: 76 mm mesh

Length	1985			1986			1987		
(mm)	Village	Comm	Total	Village	Comm	Total	Village	Comm	Total
200	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0
250	1	0	1	2	0	2	0	0	0
260	0	0	0	0	0	0	0	0	0
270	1	0	1	0	0	0	0	0	0
280	0	0	0	5	0	5	2	0	2
290	4	1	5	28	1	29	1	0	1
300	18	8	26	110	8	118	5	0	5
310	69	25	94	245	39	284	36	5	41
320	88	35	123	287	51	338	76	22	98
330	95	37	132	196	49	245	108	61	169
340	95	41	136	162	43	205	121	88	209
350	32	28	60	87	27	114	74	93	167
360	14	17	31	37	19	56	37	49	86
370	4	3	7	12	8	20	17	20	37
380	5	3	8	6	4	10	3	10	13
390	1	0	1	1	1	2	0	1	1
400	1	0	1	0	0	0	0	1	1
410	2	1	3	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0
480	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0
Total	430	199	629	1178	250	1428	480	350	830

Arctic cisco: 83 mm mesh

Length (mm)	1985 Village	1985 Comm	1985 Total	1986 Village	1986 Comm	1986 Total	1987 Village	1987 Comm	1987 Total
200	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0
290	0	0	0	1	0	1	0	0	0
300	0	0	0	7	0	7	1	0	1
310	0	0	0	18	0	18	2	2	4
320	1	0	1	63	0	63	3	7	10
330	3	0	3	81	0	81	12	28	40
340	7	0	7	112	0	112	20	64	84
350	8	0	8	55	0	55	16	88	104
360	4	0	4	34	0	34	20	65	85
370	5	0	5	11	0	11	7	36	43
380	0	0	0	4	0	4	2	3	5
390	0	0	0	0	0	0	0	5	5
400	1	0	1	0	0	0	0	1	1
410	0	0	0	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0
480	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0
Total	29	0	29	386	0	386	83	299	382

Arctic cisco: 89 mm mesh

Length	1985			1986			1987		
(mm)	Village	Comm	Total	Village	Comm	Total	Village	Comm	Total
200	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0
260	0	0	0	1	0	1	0	0	0
270	0	0	0	1	0	1	0	0	0
280	0	0	0	1	0	1	0	0	0
290	0	0	0	11	0	11	1	0	1
300	1	0	1	30	0	30	0	0	0
310	0	0	0	41	0	41	0	0	0
320	11	0	11	50	0	50	1	0	1
330	64	5	69	50	0	50	6	0	6
340	105	11	116	46	5	51	27	0	27
350	116	28	144	56	5	61	36	0	36
360	93	26	119	39	15	54	23	0	23
370	46	26	72	15	13	28	21	0	21
380	26	20	46	3	10	13	5	0	5
390	14	8	22	0	0	0	0	0	0
400	9	14	23	0	1	1	0	0	0
410	13	5	18	0	0	0	1	0	1
420	5	6	11	0	0	0	0	0	0
430	3	2	5	0	0	0	0	0	0
440	1	1	2	0	0	0	0	0	0
450	0	1	1	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0
480	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0
Total	507	153	660	344	49	393	121	0	121

Least cisco: 76 mm mesh

Length (mm)	1985 Village	1985 Comm	1985 Total	1986 Village	1986 Comm	1986 Total	1987 Village	1987 Comm	1987 Total
200	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0
240	2	0	2	0	1	1	0	0	0
250	3	0	3	0	1	1	0	0	0
260	3	1	4	0	6	6	0	0	0
270	2	0	2	0	3	3	0	2	2
280	5	4	9	7	10	17	3	4	7
290	14	12	26	8	20	28	3	13	16
300	26	29	55	19	45	64	7	52	59
310	44	34	78	26	54	80	12	60	72
320	56	47	103	25	43	68	10	81	91
330	42	45	87	19	36	55	7	58	65
340	29	17	46	8	17	25	6	48	54
350	16	7	23	5	12	17	3	22	25
360	5	3	8	3	2	5	1	7	8
370	2	1	3	0	0	0	0	0	0
380	0	0	0	0	0	0	0	1	1
390	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0
480	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0
Total	249	200	449	120	250	370	52	348	400

Length frequencies of Arctic cisco caught in gill nets (76-mm mesh) and fyke nets, 1984-1987.

Length Interval (mm)	Percent of Catch										
	1984 Commercial Gill Net	1984 Fyke Net	1985 Village Gill Net	1985 Commercial Gill Net	1985 Fyke Net	1986 Village Gill Net	1986 Commercial Gill Net	1986 Fyke Net	1987 Village Gill Net	1987 Commercial Gill Net	1987 Fyke Net
240	.0	20.5	.0	.0	.0	.0	.0	.3	.0	.0	
250	.0	13.1	.0	.2	1.9	.1	.0	.4	.0	.0	.8
260	.0	10.8	.2	.0	4.5	.1	.0	.3	.0	.0	.4
270	10.2	9.8	.2	.2	8.5	.0	.0	.6	.0	.0	.7
280	17.0	11.1	.0	.4	9.3	.1	.0	1.6	.0	.0	1.7
290	25.0	10.8	.2	1.5	10.2	1.4	.4	4.9	.6	.0	.2
300	27.3	9.6	2.6	7.6	10.1	4.7	3.2	9.6	.6	.0	.3
310	4.5	4.7	7.7	19.4	9.3	14.6	15.6	15.8	2.1	1.4	5.8
320	3.4	2.5	16.7	21.7	12.6	21.6	20.4	18.3	11.9	6.3	6.5
330	2.3	1.8	22.8	23.6	12.1	22.2	19.6	17.8	20.8	17.4	19.9
340	4.5	1.5	22.1	14.1	8.6	16.7	17.2	13.9	26.5	25.1	21.4
350	2.3	1.2	19.3	4.4	3.3	10.4	10.8	9.2	18.5	26.6	18.3
360	.0	1.0	4.0	2.7	2.2	5.3	7.6	4.0	11.9	14.0	11.8
370	.0	1.0	1.6	1.5	1.7	1.8	3.2	2.0	5.8	5.7	7.2
380	.0	.5	.9	.6	1.8	.7	1.6	.8	1.0	2.9	3.5
390	.0	.1	.7	1.1	1.7	.3	.4	.3	.2	.3	1.1
400	.0	.0	.5	.2	.8	.1	.0	.1	.0	.3	.0
Sample Size	88	2388	430	474	2178	1178	250	1883	480	350	998

Length frequencies of least cisco caught in gill nets (76-mm mesh) and fyke nets, 1984-1988.

Length Interval (mm)	Percent of Catch									
	1984 Commercial Gill Net	1984 Fyke Net	1985 Village Gill Net	1985 Commercial Gill Net	1985 Fyke Net	1986 Village Gill Net	1986 Commercial Gill Net	1986 Fyke Net	1987 Village Gill Net	1987 Commercial Gill Net
240	.0	.0	.0	.3	1.8	.0	.4	.4	.0	.0
250	.3	6.0	.8	.3	2.0	.0	.4	1.0	.0	.0
260	.5	7.2	2.4	.2	2.5	.0	2.4	2.6	.0	.0
270	2.5	8.8	.4	.8	3.6	.0	1.2	4.0	.0	.6
280	5.1	11.2	1.2	1.4	5.6	.7	4.0	6.4	.5	1.1
290	10.2	13.1	5.6	7.5	9.0	9.5	8.0	10.0	7.7	3.7
300	19.1	13.2	7.2	12.5	12.8	11.5	18.0	13.9	7.7	14.9
310	23.9	12.8	16.1	21.1	15.9	20.3	21.6	16.1	19.2	17.1
320	20.1	10.9	23.7	23.5	17.6	17.6	17.2	16.7	19.2	23.1
330	12.7	8.0	16.1	16.0	13.5	23.0	14.4	13.6	17.3	16.6
340	3.3	4.7	15.3	9.4	8.2	8.1	6.8	8.5	15.4	13.7
350	2.0	2.5	7.6	4.1	4.3	6.1	4.8	3.9	5.8	6.3
360	3.0	1.0	2.0	1.4	2.0	2.0	.8	1.9	5.8	2.0
370	.0	.4	1.2	.3	.7	1.4	.0	.7	.0	.0
380	.0	.1	.4	.5	.3	.0	.0	.3	.0	.3
390	.0	.1	.0	.0	.2	.0	.0	.1	.0	.0
400	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
	393	16261	249	663	16050	148	250	10747	52	350