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Status of anadromous Arctic charr (*Salvelinus alpinus*) of the Hornaday River, Northwest Territories, as assessed through community-based sampling of the subsistence fishery, August-September 1990-1998

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ABSTRACT

Anadromous (searun) Arctic charr spawn and over-winter in the Hornaday River. This stock has been subject to subsistence fishing since the 1940's, a commercial fishery between 1968-1986, and a sport fishery between 1972-1978. The estimated annual harvest averaged 1 800 charr (4 200 kg) between 1968-1974 (includes subsistence, commercial and sport fisheries), 3 800 charr (8 700 kg) between 1975-1986 (includes subsistence, commercial and sport fisheries), and 2 400 charr (5 600 kg) between 1987-1998 (subsistence fishery only). A standardized, long-term monitoring program has been in place since 1990, during which catch and biological data were collected by the community charr monitors. Downturns in mean age, mean length, and catch-per-unit-effort that were observed during the 1995-1997 period were thought to be indications that the stock was being over-fished. This prompted the community to prepare and implement their five year Paulatuk Charr Management Plan, which closed part of the river to fishing and limits the total take to 1 700 charr per year, or 11.3% of the estimate of stock size from 1986. Since the Plan was put in place, catch-per-unit-effort, age and length data have been encouraging but continued monitoring of this fishery is needed to further evaluate trends in the stock and monitor compliance with the Management Plan.

RÉSUMÉ

L'omble chevalier anadrome (de mer) fraie et hiverne dans la rivière Hornaday. Ce stock a fait l'objet d'une pêche de subsistance à partir des années 1940, d'une pêche commerciale de 1968 à 1986 et d'une pêche sportive de 1972 à 1978. La récolte annuelle moyenne a été estimée à 1 800 ombles (4 200 kg) de 1968 à 1974 (pêches de subsistance, commerciale et sportive), à 3 800 ombles (8 700 kg) de 1975 à 1986 (pêches de subsistance, commerciale et sportive), et à 2 400 ombles (5 600 kg) de 1987 à 1998 (pêche de subsistance seulement). Un programme normalisé à long terme de contrôle est en place depuis 1990. Il comporte la capture de poissons et la collecte de données biologiques par des membres de la communauté. Des fléchissements de l'âge moyen, de la longueur moyenne et des captures par unité d'effort ont été notés de 1995 à 1997 et ont été perçus comme une indication d'une surpêche du stock. En réaction à ce phénomène, la communauté a élaboré et instauré un plan quinquennal de gestion de l'omble de la Paulatuk qui a donné lieu à une interdiction de la pêche dans une partie de la rivière et à la limitation des prises à 1 700 ombles par an, ou 11,3% de l'effectif estimé du stock en 1986. Les données sur les captures par unité d'effort, l'âge et la longueur s'améliorent depuis l'application du plan, mais il faudra maintenir la surveillance de cette pêche afin d'évaluer plus complètement les tendances du stock et contrôler la conformité au plan de gestion.

INTRODUCTION

The Hornaday River originates approximately 100km due north of Dease Arm on Great Bear Lake, NT, and flows northwest for 280 km through the Melville Hills before emptying into Darnley Bay. It's lower reaches are shown on Figure 1. Anadromous Arctic charr, *Salvelinus alpinus*, occur in the Hornaday River downstream of La Ronciere Falls (Reist et al. 1997). This waterfall is 23 m high, and located 45 km from the mouth of the Hornaday River. Non-anadromous charr are also found in lakes draining into the Hornaday mainstream, such as Seven Islands Lake and Rummy Lake (MacDonell 1996,1997).

Searun Arctic charr over-winter in the mainstem Hornaday River, downstream of the Falls. They utilize eight or more deep pools of the river for over-wintering and for spawning (MacDonell 1996; 1997; Harwood unpubl. data), including the deep pool at the base of La Ronciere Falls. Rearing areas used by the mainstem anadromous stock are not known.

Residents of Paulatuk, an Inuvialuit community of 280 people 14 km west of the mouth of the Hornaday River, have harvested Arctic charr from this system since the community was first settled in the early 1940's. To this day, Arctic charr of the Hornaday River provide an important source of protein for the growing human population of Paulatuk.

In 1968, a commercial fishery with an initial annual quota of 2,300 kg was established on the Hornaday River. The quota was raised to 4,500 kg in 1974 and to 6,800 kg in 1976 (Kristofferson et al. 1989). Although the commercial fishery produced fairly steadily at first, declining catches in the early 1980's led residents to express concern about the state of the stock. In 1987, the commercial fishery on the Hornaday River was closed in response to those concerns, and has remained closed ever since. There are no plans to resume commercial fishing at this time.

In 1972, a small sport fishery was established on the Hornaday River by the Paulatuk Hunters and Trappers Committee (HTC), and this operated until 1978. At present, there is a limited sport fishery at the mouth of the Hornaday River during late summer, primarily by transient and permanent non-native residents of Paulatuk. The catch and possession limits for the Hornaday River sport fishery are some of the most restrictive in the NT, having been reduced to 1 and 1, respectively, in 1994/95. The Paulatuk HTC members have recently expressed interest in closing the Hornaday River to all sport fishing. Within Tuktut Nogait National Park, sport fishing for charr is not allowed on the Hornaday or it's tributaries.

A number of studies have been conducted on the charr of the Hornaday River. The commercial catches were sampled in 1973, 1974, 1979, 1981 and 1983 (Kristofferson et al. 1989) and test-netting was conducted in fall 1981 (Kristofferson et al. 1989). A full-span conduit weir was installed in August 1986 (MacDonell 1986) and again in August

1987 (MacDonell 1989). Although both weirs washed-out due to high water flows before the entire run could be enumerated, an extrapolation from the 1986 study was possible and produced an estimate of stock size of 16 000 charr. The weir data were recently re-examined and the estimate from that weir study revised to 15 000 (A. Kristofferson, pers. comm.).

To find an alternative source of charr for the people of Paulatuk, test fisheries were conducted at the Brock River in 1987, the Horton River in 1988 (130 km to the northwest of Paulatuk), Balaena Bay in 1989 (80 km to the north of Paulatuk), Tom Cod Bay in 1989 (40 km to the west of Paulatuk) and Pearce Point in 1997. While small numbers of charr were found at these locations, these sites were either too distant, too difficult to access or too small to be considered as a viable alternative fishery (MacDonell 1986, 1989).

The Paulatuk Hunters and Trappers Committee (PHTC), with assistance from the Dept. of Fisheries and Oceans (DFO), and funding from the Fisheries Joint Management Committee (FJMC), have conducted a community-based monitoring program on the subsistence fishery beginning in 1990. Changes in the average length, age and catch-per-unit-effort over the years provide insight into the health and status of the stock. This monitoring program is only one of several charr management initiatives underway by the harvesters of Paulatuk. The objective of this study is to assess the status of the stock and to describe the characteristics of the fishery, over the long term.

METHODS

The Monitors

Two fishermen were hired each year, from 1990 through 1998, to collect information about the fishery and biological data from the fish caught. The monitors were selected by the Paulatuk HTC, and they started work once families from Paulatuk moved to the seasonal fishing camps at the mouth of the Hornaday River. The monitors visited each fisherman's camp each day throughout the duration of the fishery, to sample the catch and interview each fisherman.

The monitors were tasked with keeping records of total number of charr caught, as well as the number, length and mesh size of the gillnets used, and the location and duration of each set. The monitors also weighed and measured approximately 50% of the catch during the period from 1990-1998, and sampled a further 15% of the catch for length, weight, sex, maturity, stomach contents and aging structures. Sagittal otoliths were removed from this latter group, placed in a scale envelope for age determination. All age determinations were conducted by G. Carder of DFO's Freshwater Institute, according to Nordeng (1961). For the aged sample, sex, maturity, and stomach contents were also determined. Tag recaptured fish were included in the dead sample. DFO biologists provided sampling materials and instructions prior to the start of each field season.

Data Analysis

Data were entered on to a Lotus 123 spreadsheet, and statistical analyses conducted using SAS version 6.11 on a PC (SAS 1990) and followed Sokal and Rohlf (1981).

Each year, total harvest was obtained from the monitor's records. Harvest statistics from fisheries that took place at other times of the year (e.g. under-ice in fall, at the estuary in spring) were obtained from the Inuvialuit Harvest Study (IHS) annual reports (Fabijan 1997; Inuvialuit Harvest Study, unpubl. data). The combination of these data sets was used to estimate the total annual removal of charr from the Hornaday River stock during subsistence fisheries from 1986-1998.

Because different mesh sizes have been used in this subsistence fishery, a multiple t-test in PROC ANOVA was used to examine potential differences in the mean fork length of charr caught using 114 mm (4 ½"), 127 mm (5") and 140 mm (5 ½") mesh gillnets. Frequency histograms depicting the fork length of charr caught with the different mesh sizes were constructed.

For each set of each net, catch per unit effort (CPUE) was calculated as the number of charr/100 m/24 h. The daily mean CPUE for all nets was calculated, and then plotted separately for each year from 1990-1998. Records for individual fishermen were examined and plotted for cases where CPUE data were collected throughout the fishery and in consecutive years from 1996 to 1998.

The mean fork length, round weight, age and condition factor were calculated and tabulated for each year of the study from 1990-1998. Data from the 1973-1989 studies (Kristofferson et al. 1989) were also entered into the database and the same basic statistics were calculated.

To evaluate the representativeness of the aged sample (n=1779) with respect to the larger sample of measured and weighed charr (n=6 254), the length-frequency distributions of both groups were compared (by year) using a Kolmogorov-Smirnov two-tailed test.

The length-frequency distribution of the upstream migrants (sexes pooled) by 10 mm length class was constructed for each year from 1990-1998, and for charr that were enumerated through the weir in 1986 (MacDonell 1986). Age-frequency distributions of the upstream migrants caught in the fishery were constructed for each year from 1990-1998. Modal length and age were calculated for each year of the upstream fishery, as was percent of charr in the sample exceeding 600 mm in fork length.

PROC GLM (General Linear Models) was used to compare the mean length of charr caught in the fishery among years, by sex. A Duncan's Multiple Range Test was then used to examine the relationship between the mean annual fork length values for years tested.

A Kolmogorov-Smirnov test was used to compare the age-frequency distribution of males and females, by year. Pair-wise comparisons of the age-frequency distribution between years was conducted using a Kolmogorov-Smirnov test, separately for the sexes.

A catch curve was constructed by plotting the running average of three age frequencies against log age. Instantaneous mortality rate (Z), was then calculated using a least squares regression on the descending limb of the catch curve. Only age groups that were fully recruited into the catch were used (7,8 or 9 through 11, 12 or 13 y) following Ricker (1975). Annual survival rate (S) and annual mortality rates (A) were also calculated.

Relative condition factor (K), a measure of the relative robustness of the fish, was determined by the following formula (Anderson and Gutreuter 1983):

$$K = \frac{W \times 10^5}{L^3}$$

where W = round weight in g and L = fork length in mm.

Mean length at age was calculated for each year of monitoring and tabulated along with mean length at age data from the earlier data (Kristofferson et al. 1989) and the 1986 weir study (MacDonell 1986).

RESULTS

Time and Location of Fishing

The present day subsistence fishery takes place at three different times of the year. The majority (60%) of the take comes from the mouth of the river during August when the charr are moving upstream. This is the fishery that the monitors concentrated on. An additional 20% comes from the downstream migration in spring and another 20% from the under-ice fishery at the over-wintering pools. Mono-filament gillnets (4 ½", 5" and 5 ½" mesh size) are used in this fishery (Fig. 2), with 9-18 fishermen setting one or two 30-50 m nets each.

The Harvest

The numbers of charr known or estimated to have been harvested from the Hornaday stock between 1973-1998 are shown on Table 1. Most of the subsistence data for the years 1968-1986 was estimated on the basis of local recollection (Noel Green, pers. comm.), the size of the human population at the time, and by extrapolation of data available for 1978 and 1979 (Fig. 3). Commercial and sport data were obtained from DFO records and Kristofferson et al. (1989).

The estimated annual harvest averaged 1 800 charr (4 200 kg) between 1968-1974 (includes subsistence, commercial and sport fisheries), 3 800 charr (8 700 kg) between 1975 - 1986 (includes subsistence, commercial and sport fisheries), and 2 400 charr (5 600 kg) between 1987 - 1998 (subsistence fishery only). The peak harvests in the 31 y period on Table 1 were 4 726 charr (11 000 kg) in 1976 and 5 280 (12 100 kg) in 1982.

Subsistence harvests between 1996 and 1998 averaged 1875, lower than the mean of 2 400 for the 1987-1998 period. This is thought to be due to community-based initiatives restricting the catch (to 1 700 per year) and closing certain areas (between Coalmine and Aklak Creek) to under-ice fishing (PHTC 1999). The catch of charr from the Hornaday by sport fishermen has been less than 1% of the take in the last three decades.

The average annual harvest for the period 1987-1998 represents 16% of the 1986 estimate of stock size of 15 000 charr (A. Kristofferson, pers. comm.; MacDonell 1986). The Paulatuk Charr Management Plan (PHTC 1999) harvest guideline of 1 700 charr represents 11.3% of that 1986 estimate of stock size. The exploitation rate at the time of the 1986 weir count was 18%.

Catch-Per-Unit-Effort

The duration of the summer fishery ranged from 21 to 26 days in length (Table 2; Fig. 4). Considering only the upstream migration, 82% of all charr caught in 1990-1997 were caught between August 6 and 23. In 1998, the run was early, with 71% of the catch being taken in July. This was similar to early runs noted that year in neighbouring charr rivers (DFO Inuvik, unpublished data).

Between 1990 and 1998, the CPUE for the subsistence fishery averaged 24.7 charr/100 ms/24 h, but this varied among years (range: 13.2 to 39.9 charr/100 m/24 h). The years with the highest mean CPUE were 1990, 1991 and 1992, after which time mean CPUE decreased in each consecutive year from 1993 through 1997 inclusive. Mean CPUE for the 1998 fishery showed a modest increase compared with 1993-1997.

Individual CPUE records were collected from 24 different fishermen between 1996-1998. However, only four fished throughout the fishery in each of 1996, 1997 and 1998. The CPUE from three of these showed the same trend as the overall mean CPUE, with a steady increase in CPUE from 1996 through 1997 and 1998 (Figure 5).

Biological Assessment

Length

The length-frequency histograms of charr caught using three different mesh sizes are shown on Fig. 6. The gillnet mesh size in which 1399 dead sampled charr were caught was recorded in 1990-1995, and 1998. Mean fork lengths of charr caught using each of these mesh sizes were compared. Although larger mesh tended to catch larger charr, the differences in mean length were not statistically significant (F=1.92, df=1 398, p>F=0.1472; mean FL using 114 mm mesh = 567 mm, n=605; mean FL using a 127 mm mesh = 572 mm, n=504; mean FL using a 140 mm mesh = 577 mm, n=290).

The annual length-frequency distributions are shown in Fig. 7. The mean and modal fork length of the charr caught in the upstream subsistence fisheries increased in the years 1990 through 1994, and then decreased from 1995 through 1997 (Table 3). The mean fork length of male charr varied among years (F=3.17, df=986, p>F=0.0001), with 1995 through 1997 being lower in the range than 1990-1994. A similar result was found with the females (F=4.74, df=991, p>F=0.0001), with 1997 being the year with the lowest mean length.

The percent of charr greater than 600 mm in the sample ranged between 16.4% and 36.0% between 1990-1998 (Table 3). For comparison, the percent of charr >600 mm in length at the weir enumeration was <3% (MacDonell 1986). The fishery clearly removes the larger, older fish from the stock (Fig. 8).

Age

A sub-sample of 1 779 charr were aged for this study. The youngest fish caught in this fishery was 2 y (n=1), while the oldest was 13 y (n=4). Charr are recruited to this fishery at age 5 y, while the age at first trip to sea appears to be age 3 (J. Babaluk, pers. Comm.). Few of the charr caught in the fishery (e.g. 7%) are aged 10 y or older, with the majority (79%) being aged 5-8 y.

Many more charr were weighed and measured than were aged, so the representativeness of the smaller aged sample had to be evaluated. The length-frequency distribution of the measured- only charr was compared with the length-frequency distribution of charr that were weighed, measured and aged. The aged sample was found to representative of all charr sampled in all years (p<0.05) except 1991 (KS_a=2.226, n=982, p>KS_a =0.0001) and 1995 (KS_a=2.826, n=939, p> KS_a=0.0001). In those years, the aged sample appeared biased toward larger charr, and thus ageing results for 1991 and 1995 must be interpreted accordingly.

The age-frequency distributions of charr caught in the fishery are shown on Figure 9. Comparing these between years revealed 1995 to 1997 as the most different from 1990 to 1994 (Table 4). The mean and modal age of charr caught in this fishery showed the same trend as fork length, increasing through 1990-1994, decreasing through 1995-1997, and increasing again in 1998 (Table 3). This pattern held true for both sexes (Fig. 10).

The mean age of males and females were not statistically different in any given year from 1990 through 1994 ($p>T>0.05$). In 1995, 1996, and 1997, however, the mean age of males was lower than that of females taken in the same fishery in the same year, and these differences were all statistically significant (1995, F test for unequal variances, $F=1.66$, $df = 109, 150$, $p>F=0.0038$, T unequal var = 3.3130, $df=197,8$, $p>T=0.0004$; 1996, $F=1.53$, $df=80,97$, $p>F=0.0446$, T unequal = 3.07, $df=152, 9$, $p>T=0.0025$; 1997, T equal var =2.651, $df=182$, $p>T=0.0094$). By 1998, the mean age of males and females was not statistically different ($T=1.6909$, $df=169,0$, $p>T=0.0927$).

Growth and Condition

There was considerable variation in the length-at-age for charr from the upstream fishery, characteristic of this species Johnson (1991). For example, for the 570 mm size class in 1995, fish ranged in age from 4-10 y. This variation was typical throughout all years and size classes of the fishery.

Mean length-at-age for the monitoring period has been tabulated along with that from the stratified dead sample from the 1986 weir study (Table 5). Trends are difficult to assess because of the size variation within any given age class. However, the mean length-at-age for 1998 was lower for all ages in 1998 than in 1997. This aspect should continue to be monitored. The growth rate of Hornaday charr is higher than that of charr from neighbouring systems on Victoria Island (Fig. 11).

During the monitoring period, the average weight per charr ranged from a low of 1 970 g (1997) to a high of 2 510 g (1993)(Table 3). The condition of charr caught in the upstream migration fishery ranged from the lowest value of $K=1.15$ in 1997 to the highest value of $K=1.37$ in 1998. Charr condition varied among years for both sexes (females, $F=8.41$, $df=989$, $p>F=0.0001$; males, $F=8.42$, $df=984$, $p>F=0.0001$), with condition being significantly higher in 1998 than any of the other years from 1990-1997. The years with the lowest mean condition values were 1996 and 1997. Differences among years are thought to reflect differences in quality or quantity of food available to the charr during the important summer feeding period (Dutil 1984).

Ice conditions in 1993 and 1998 were particularly light (Canadian Ice Service, Environment Canada), with break-up of the land-fast ice in 1998 being approximately three weeks early (Harwood et al. in press; Skinner et al. 1998). Early break-up in 1998 appears to have enhanced ecosystem productivity, although the causative factors and mechanisms are not clear. Data from other species is instructive as to the situation in 1998 (e.g. ringed seals condition, Pacific salmon distribution, bearded seals habits and distribution, Arctic charr from the Holman area, Dolly Varden charr in the Rat River, Harwood, unpubl. data; Harwood et al. in press). These all reaffirm the observation at the Hornaday that 1998 was a year of particularly high marine productivity.

The importance of the marine feeding to Hornaday charr was underscored during the 1997 tagging study at Pearce Point. The first migrant charr caught at Pearce Point in late July 1997 were emaciated, but within two weeks, the charr were fat and had taken on the silver colouration typical of searun charr (C. Ruben, pers. comm.). Eight of the tagged charr were recaptured at the tagging site, six on the same day that they were tagged, one was recaptured two days later, and one was recaptured two weeks later. Overall 14% of the charr tagged at Pearce Point were caught on average 21 days later, at the mouth of the Hornaday River. A further 15 tags, or 8% of tags estimated to be remaining, were caught at the mouth of the Hornaday the following August. Pearce Point appears to be an important summer feeding area for Hornaday River charr.

Sex Ratio

The sex ratio of the catch varied from 41.6% to 56.5% females between 1990-1998, but there were no obvious temporal trends (Table 6). The proportion of females was highest during 1994 and 1995. The percentage of females is similar to that reported by MacDonell (1986) during the 1986 weir enumeration. This measure can be highly variable both within and among stocks (A. Kristofferson, pers. Comm.).

Mortality

Instantaneous mortalities (Z) calculated from the catch curves for 1990-1998 (Table 7) varied from a low of 0.50 in 1996 to a high of 0.97 in 1998. For the weir study in 1986, the Z value was 0.40. Mortality rates for the years 1973-1983 commercial fishing data ranged from 0.31 (1973) to a high of 0.59 (1981)(Kristofferson et al. 1989).

Maturity and Spawning

Less than 1% of the charr caught in the weir (MacDonell 1986) and in the 1990-1997 fisheries were current-year spawners. Usually less than five are caught per year, and often none are reported. In 1998, the number of current-year spawners that were caught was higher (n=19), although this still represented only a small portion of the catch (1.5%).

Because of limited opportunities to sample charr that are in spawning condition, little is known about their reproductive parameters and behaviour. Data that are available suggest the age at first spawning is 7 to 8 years (Harwood, unpubl. data). Only one current year spawner has been sampled from the spawning areas. This was a 9 y old female caught at La Ronciere Falls in September 1997 (MacDonell 1997). Age at first maturation in this stock appears to be younger than that for slower growing stocks to the east (e.g. Nauyuk Lake, age 10, Johnson 1980).

We have only anecdotal data about whether or not charr from the Hornaday River go to sea in their spawning year. In 1997, it appeared that the current year spawners did not go to sea, as some were observed at La Ronciere Falls during July. Red charr have also been reported at this location in July of other years, by Parks Canada staff (J. Nakimayak, pers. comm) and by pilots (DFO Inuvik, unpubl. data). These findings are consistent with preliminary results from otolith microchemistry analyses (J. Babaluk, pers. comm.). In July 1998, however, no current year spawners were found at the Falls spawning area, suggesting that at least in 1998, current year spawners did go to sea. This may explain their increased prevalence in the 1998 upstream migration fishery.

SUMMARY AND CONCLUSIONS

The average annual harvest of 2400 charr between 1987 and 1998 represents 16% of the size of the stock estimated (15 000) estimated in 1986. The Paulatuk Charr Management Plan guideline (PHTC 1999) of a harvest of 1 700 charr annually represents 11.3% of this estimate. This meant a 33% reduction in the annual take for the fishermen.

The estimated harvest rate at the time of the 1986 weir count was approximately 18% of the estimated stock size at the time. During the commercial fishing period, with the combination of commercial and subsistence fishery catches, the harvest rate may have been as high as 30%. Present harvest rates appear to be lower than that of two decades ago.

Johnson (1980) found an annual exploitation rate of 11% to be excessive for charr at Nauyuk Lake in the central Arctic. This rate led to a steady decline in the size of the stock. It is likely that the faster growing Arctic charr of the Hornaday River can sustain a rate of exploitation greater than this. Given that the Hornaday charr stock was harvested beyond 20% for a number of years, and given that charr remained available to a subsistence fishery in the decade following this level of fishing, it appears that the safe harvest level of 10% implicated by Johnson's (1980, 1989) work at Nauyuk Lake may be conservative when applied to the Hornaday River charr stock.

In recent years, biological indicators and reports from the local people that harvest Hornaday charr for food suggest that removals may have been more than the stock could sustain. It does appear that fishing during the 1970's and 1980's, which included commercial and subsistence fishing, has led to the progressive removal of the largest and oldest fish. This was the catalyst for the development and implementation of the Paulatuk Charr Management Plan 1998-2002 (PHTC 1999). The highlights of the Plan include harvest restrictions and closure of certain critical habitats to fishing. The community has complied with the Plan for three consecutive years, and the results from the 1998 monitoring study are encouraging.

More stringent harvest restrictions may be necessary in the future. It is recommended that the basic annual monitoring and sampling program continue, to (1) monitor the status of the stock, (2) collect the relevant data to manage the stock, and (3) monitor compliance with the Paulatuk Charr Management Plan (PHTC 1999).

Further research and management activities which are recommended are:

- continuation of otolith microchemistry work to examine life history characteristics,
- tagging and tracking studies to locate and study critical riverine habitats,
- confirmation of the contribution of progeny from Seven Islands and Rummy Lakes charr to the mainstem Hornaday charr stock,
- development of a system to administer and assist fishermen with fishing in alternate areas, and
- Continuation of water quality and quantity monitoring at the Hornaday River.

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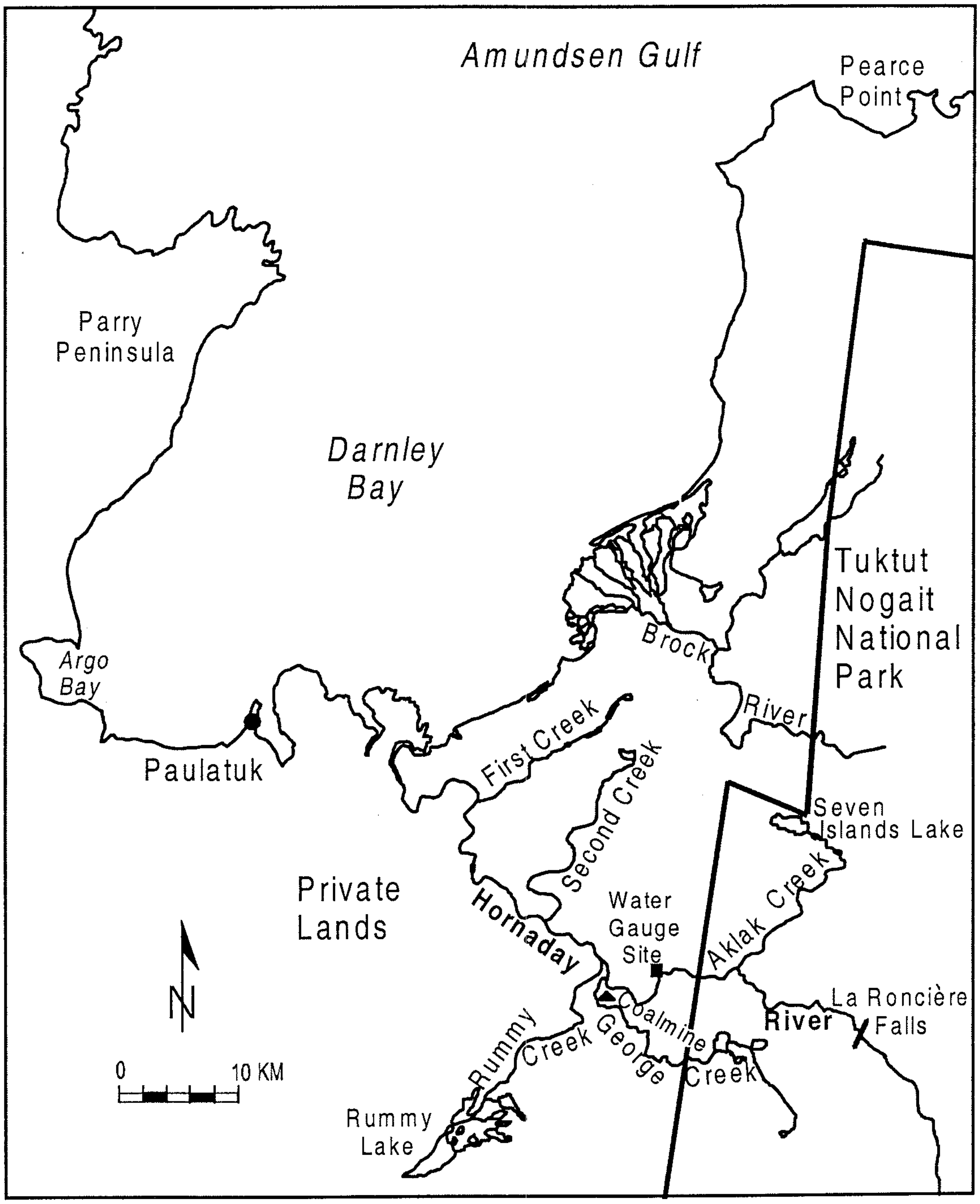

Fig. 1. The lower Hornaday River.

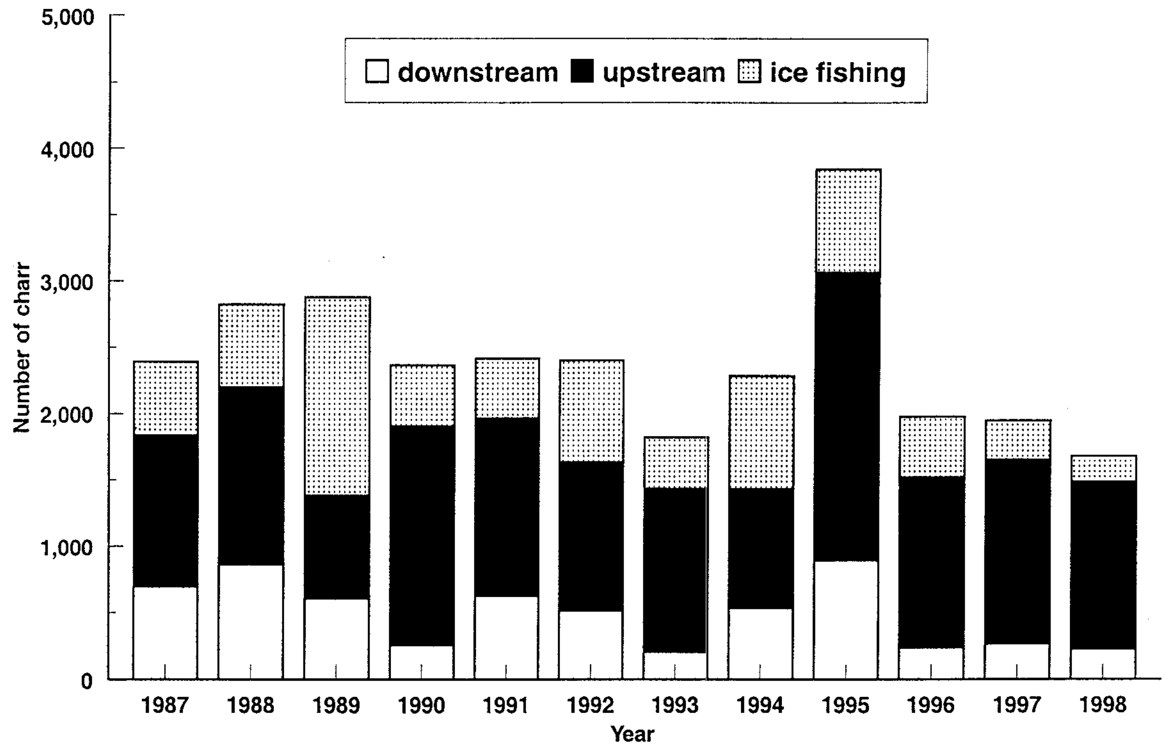

Fig. 2 . Seasonal harvest patterns of the subsistence charr fishery at the Hornaday River, 1990-1998

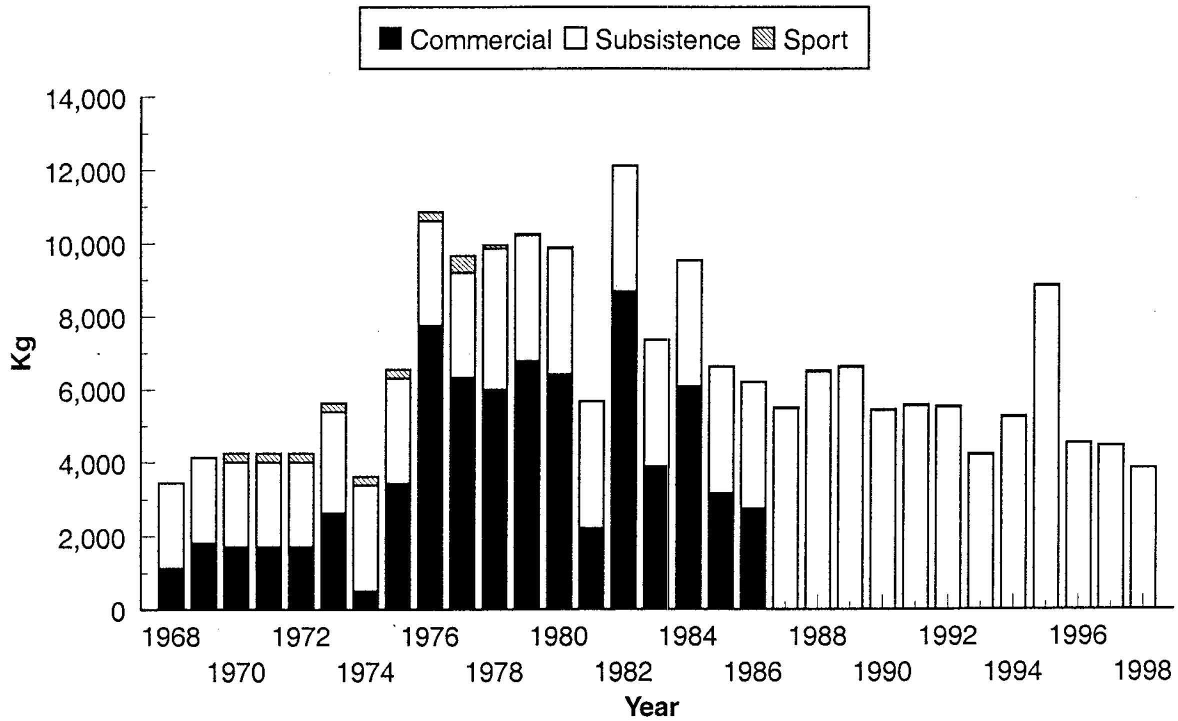

Fig. 3 . Estimated annual removal of charr from the Hornaday River, 1968-1998

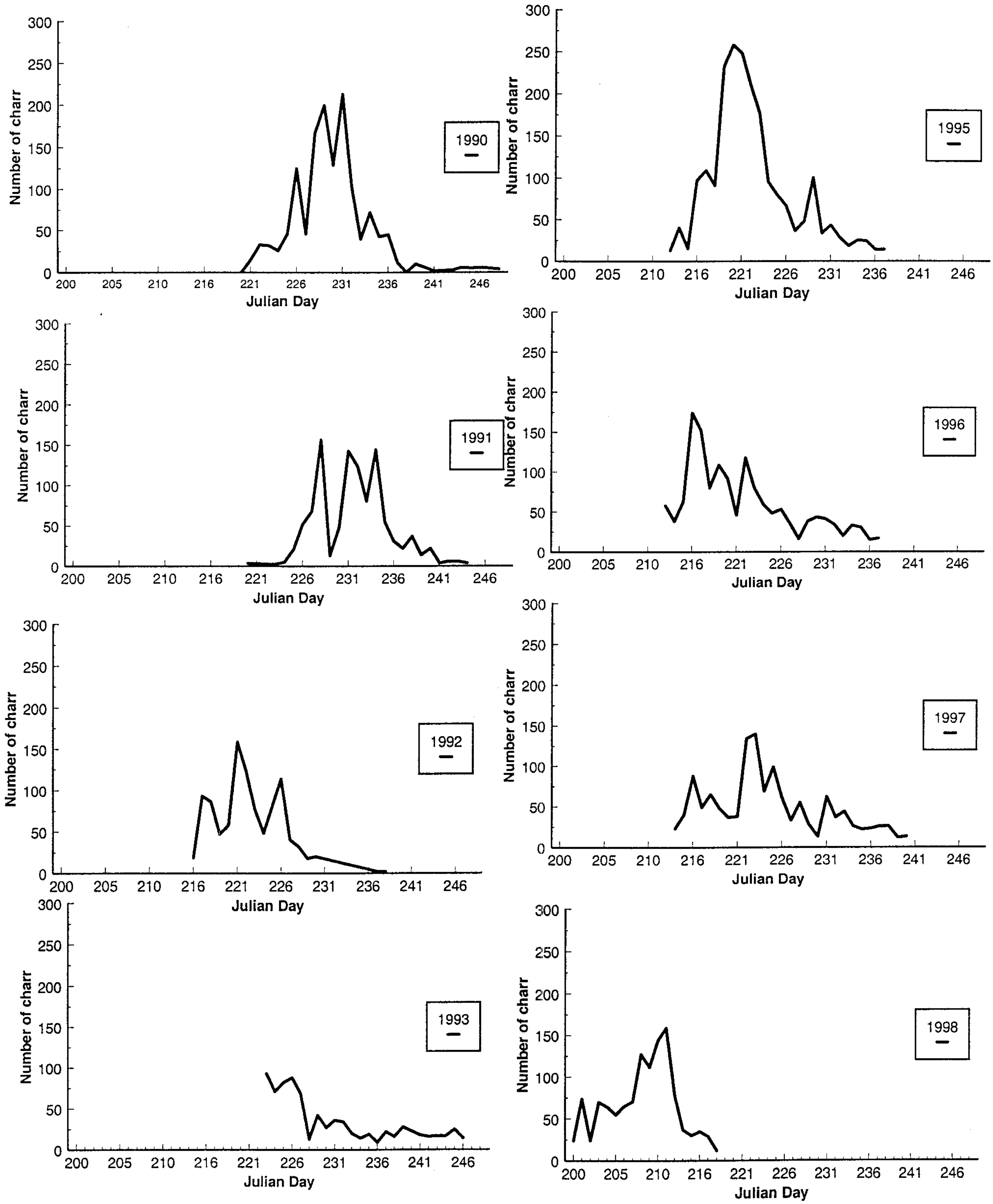

Fig. 4. Daily catch of charr at the Hornaday River, 1990-1998

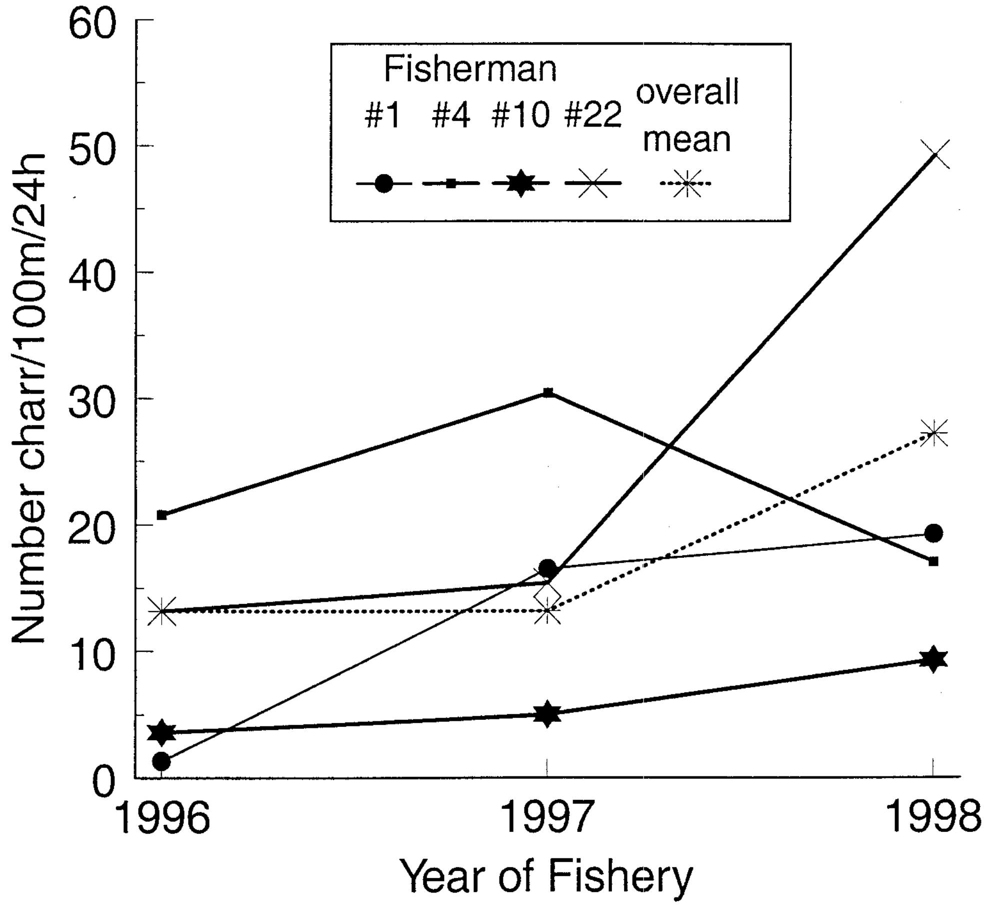

Fig. 5. Catch-per-unit- effort for individual fishermen at the Hornaday River, 1996-1998

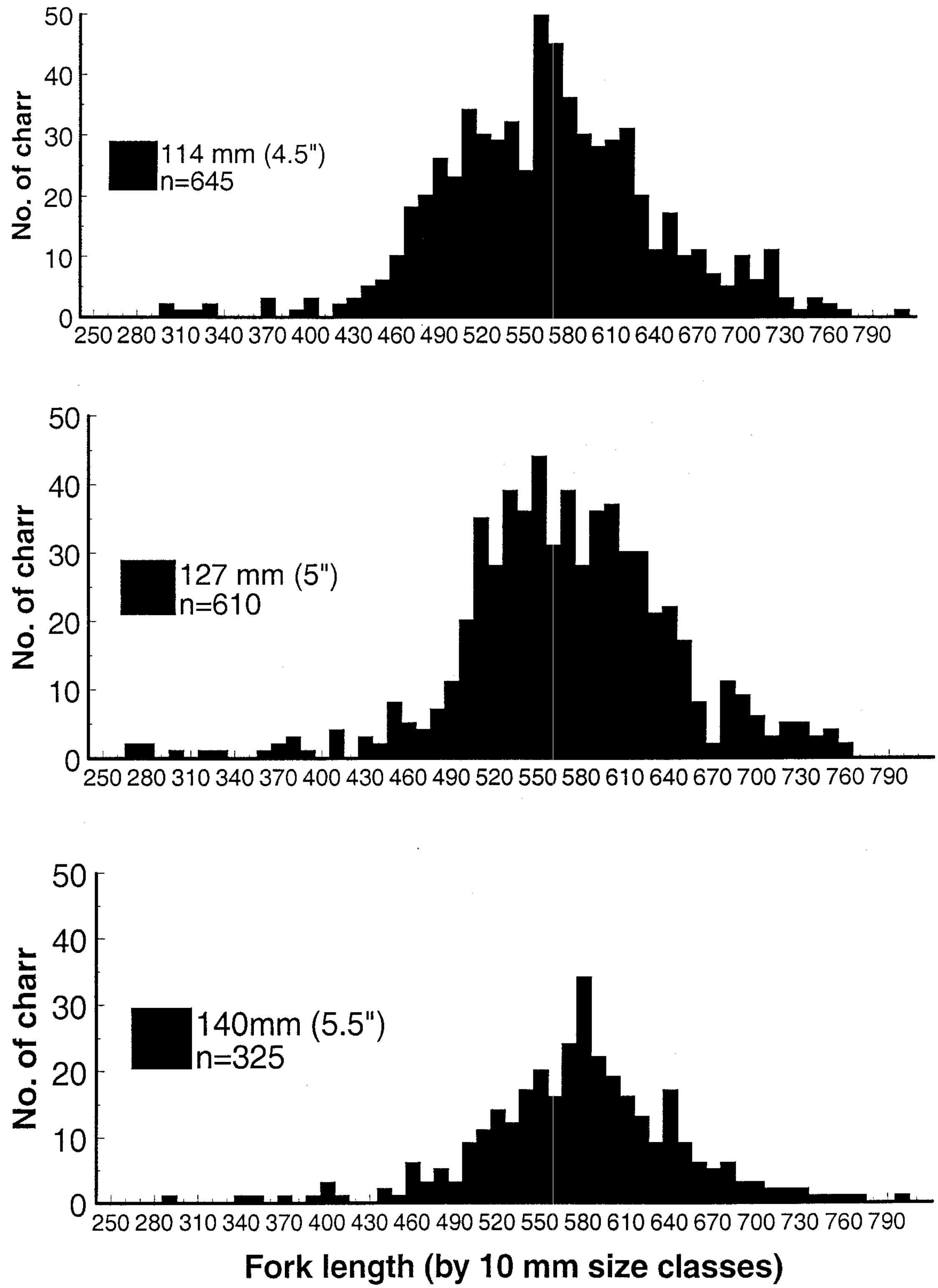

Fig. 6. Length-frequency distribution of charr caught at Hornaday River, using gillnet mesh sizes of 114mm, 127 mm, and 140 mm,1990-1998

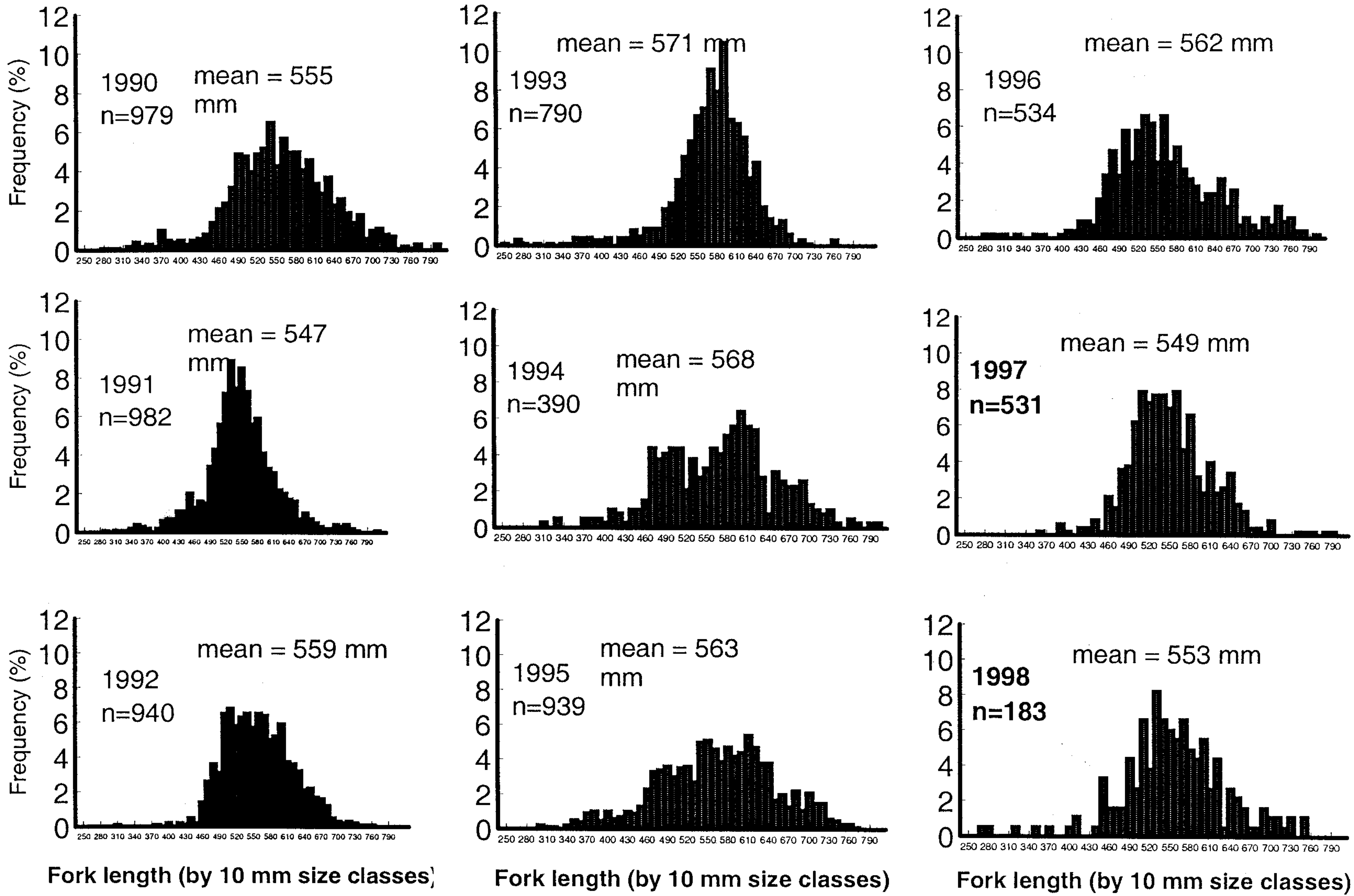

Fig. 7. Length-frequency distribution of upstream migrating charr taken in late summer subsistence fisheries at the Hornaday River, 1990-1998

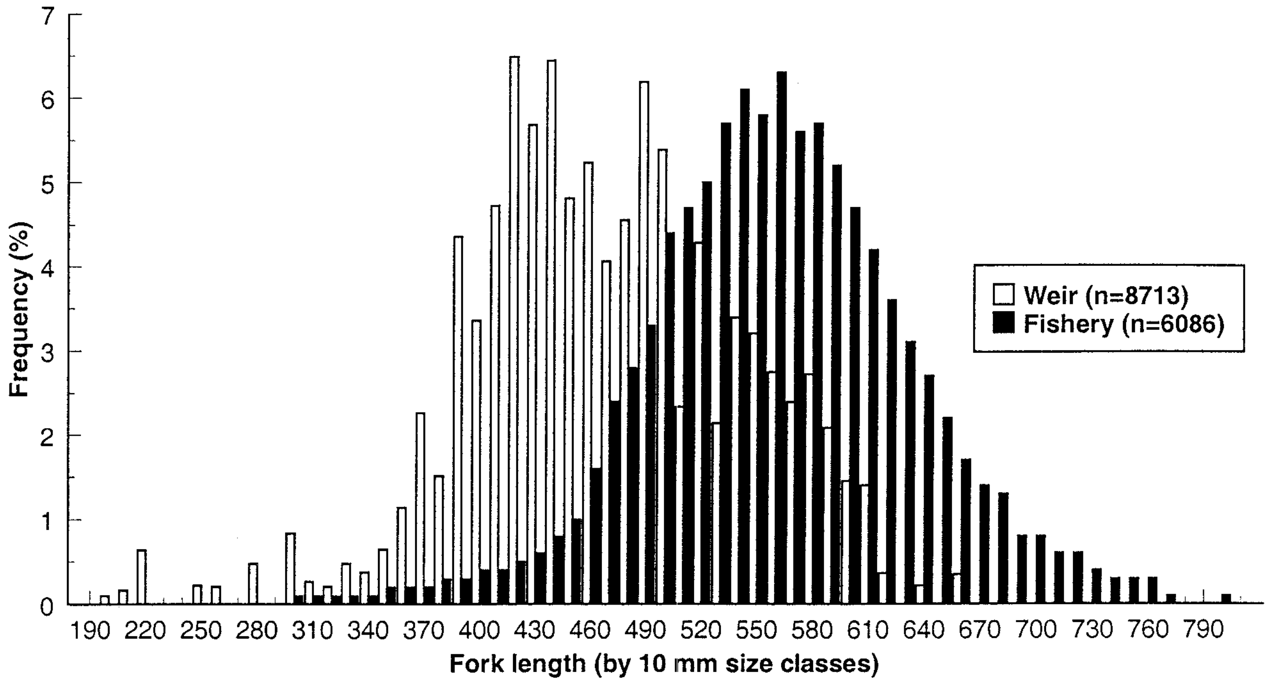

Fig. 8. Length-frequency distribution of upstream migrant charr at the Hornaday River weir enumeration (1986) and in the subsistence fishery (1990-1997)

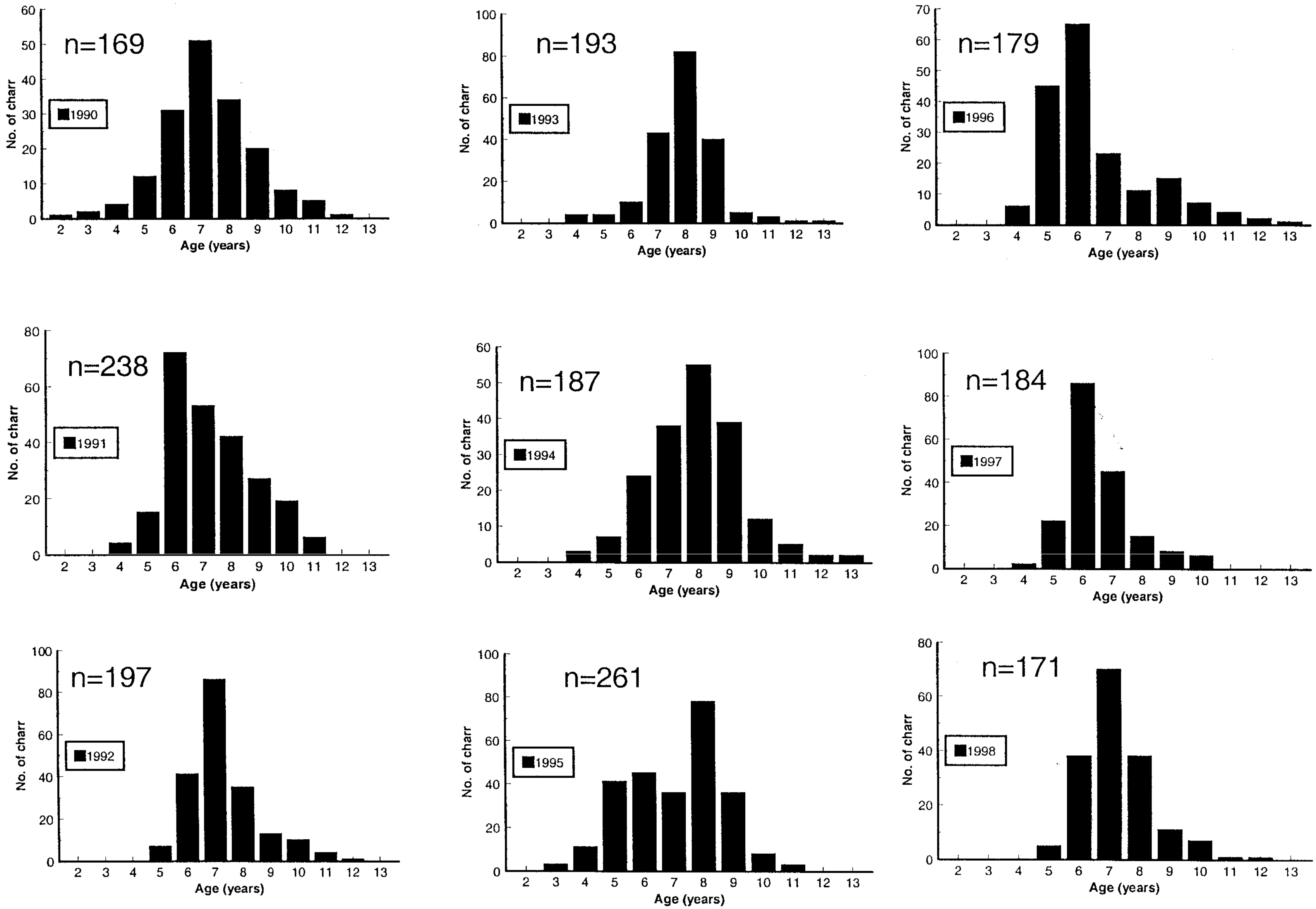

Fig. 9. Age-frequency distribution of charr caught in the upstream fishery at the Hornaday River, 1990-1998

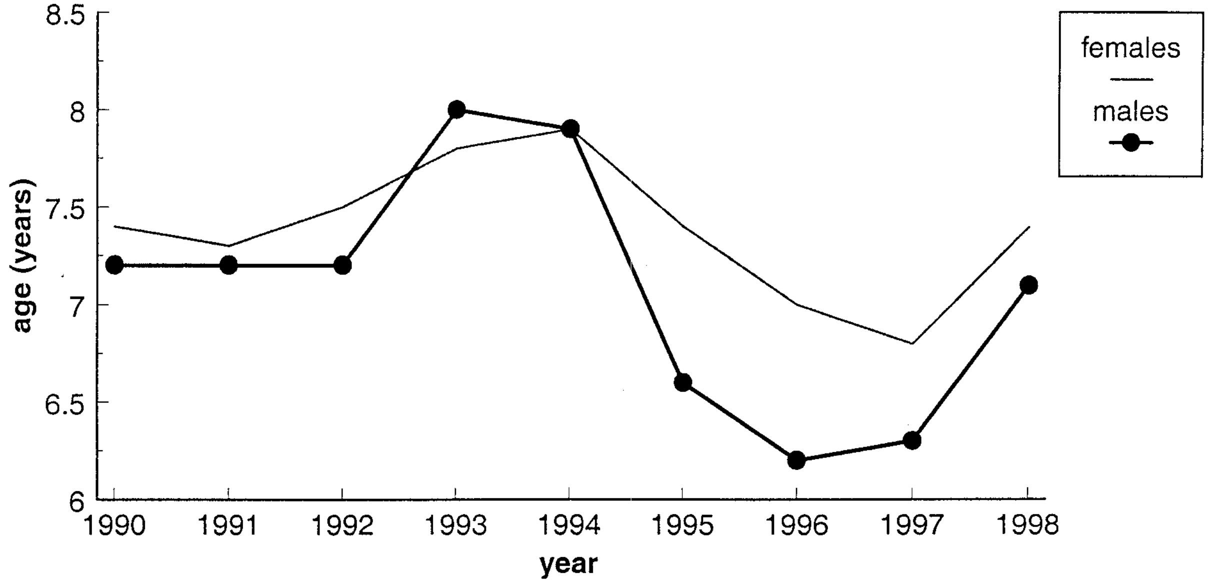

Fig. 10. Mean age of male and female upstream migrant charr sampled from the subsistence fishery at the Hornaday River, 1990-1998

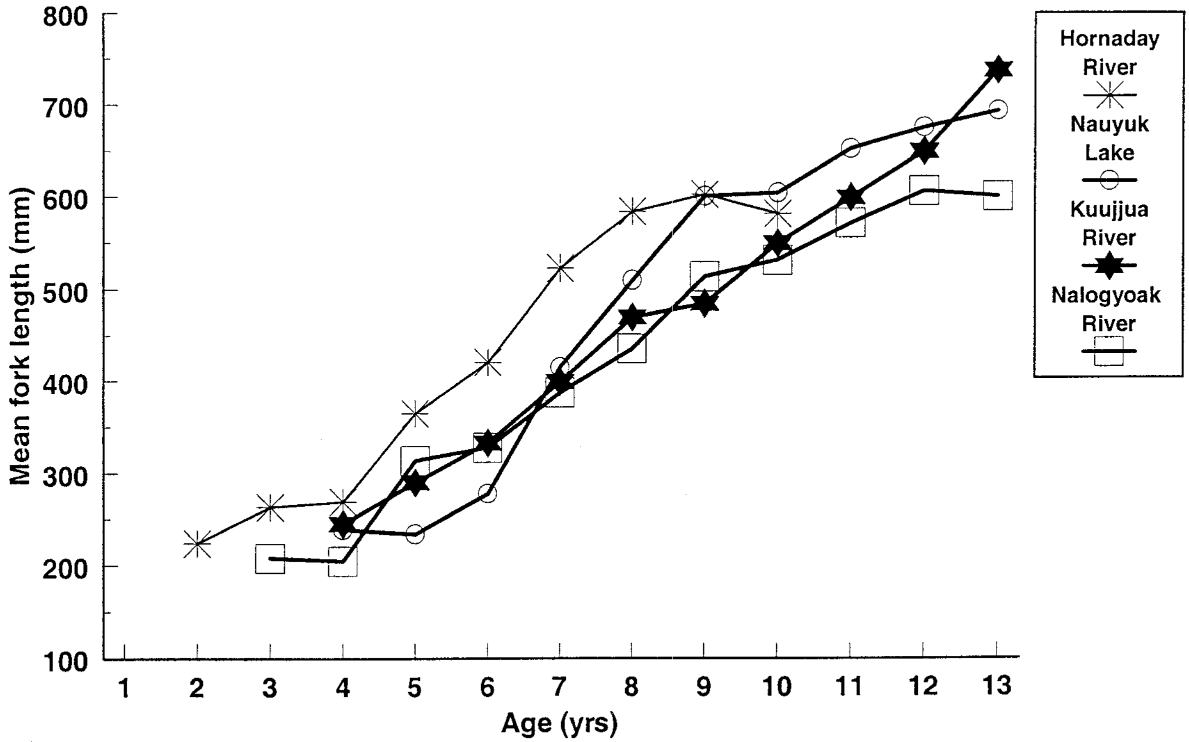

Fig. 11. Mean length at age for charr sampled at four NWT rivers

Table 1. Harvest of Arctic charr by subsistence, commercial and sport fisheries at the Hornaday River, 1968-1998 (data from DFO return records, Kristofferson et al. (1989), Inuvialuit Harvest Study annual reports, and 1990-1998 FJMC charr monitoring study)

Year	Commercial		Subsistence		Sport		TOTAL	
	no. charr	kg	no. charr	kg	no. charr	kg	no. charr	kg
1968	500	1150	1000	2300	0	0	1500	3450
1969	800	1840	1000	2300	0	0	1800	4140
1970	750	1725	1000	2300	0	0	1750	4025
1971	750	1725	1000	2300	0	0	1750	4025
1972	750	1725	1000	2300	100	230	1850	4255
1973	1151	2647	1200	2760	100	230	2451	5637
1974	229	527	1250	2875	100	230	1579	3632
1975	1500	3450	1250	2875	100	230	2850	6555
1976	3376	7765	1250	2875	100	230	4726	10870
1977	2757	6341	1250	2875	200	460	4207	9676
1978	2619	6024	1676	3856	40	92	4335	9972
1979	2954	6794	1676	3855	10	23	4640	10672
1980	2794	6426	1676	3855	10	23	4480	10304
1981	972	2236	1676	3855	0	0	2648	6090
1982	3780	8694	1676	3855	0	0	5456	12549
1983	1700	3910	1676	3855	0	0	3376	7765
1984	2650	6095	1676	3855	0	0	4326	9950
1985	1382	3179	1676	3855	0	0	3058	7033
1986	1201	2762	1676	3855	0	0	2877	6617
1987	0	0	2392	5502	10	23	2402	5525
1988	0	0	2829	6507	10	23	2839	6530
1989	0	0	2880	6624	10	23	2890	6647
1990	0	0	2369	5449	10	23	2379	5472
1991	0	0	2424	5575	10	23	2434	5598
1992	0	0	2408	5538	10	23	2418	5561
1993	0	0	1839	4230	10	23	1849	4253
1994	0	0	2290	5267	10	23	2300	5290
1995	0	0	3850	8855	10	23	3860	8878
1996	0	0	1984	4563	0	0	1984	4563
1997	0	0	1956	4499	0	0	1956	4499
1998	0	0	1686	3878	0	0	1686	3878

Table 2. Catch Per Unit Effort (CPUE) for the Hornaday River, NT
Arctic charr subsistence fishery, 1990-1998

Year	No. Of fishermen	First and last fish caught in fishery		Length of Fishery (days)	Mean CPUE*
1990	nr	11-Aug	5-Sep	22	35.3
1991	nr	8-Aug	1-Sep	23	26.0
1992	nr	4-Aug	25-Aug	26	39.9
1993	nr	11-Aug	3-Sep	23	24.9
1994	nr	12-Aug	2-Sep	21	22.4
1995	18	1-Aug	25-Aug	25	19.8
1996	17	2-Aug	26-Aug	25	13.2
1997	14	2-Aug	28-Aug	27	13.2
1998	9	19-Jul	6-Aug	19	27.2

nr = not recorded
*CPUE = catch per unit effort = no. of charr/100m/24 h

Table 3. Biological data from charr sampled during commercial and subsistence fisheries at the Hornaday River, 1973-1998

Year	Season	Type	No. Of	Fork Length (mm)			Round Weight (kg)		Age (yr)			Modal	Modal	Condition			% of catch
			samples	n	mean	sd	n	mean	n	mean	sd	length (mm)	age (yr)	n	mean	sd	>600mm
1974	upstream	Commercial	43	43	614.6	72.1	43	2111				530		43	0.89	0.12	57.1
1979	upstream	Commercial	103	103	505.6	119.6	103	1733	97	6.6	2.1	590	8	103	1.11	0.15	19.4
1981	upstream	Commercial	70	70	598.9	62.5	70	2791	70	7.7	1.7	590	7	70	1.26	0.12	35.7
1983	upstream	Commercial	103	103	571.3	89.5	91	2016	97	7.7	2.3	540	6	91	1.15	0.22	37.9
1986	upstream	Commercial	114	114	562.9	39.3	114	1984				550		114	1.10	0.11	14.0
1988	upstream	Subsistence	17	17	597.5	66.7	17	2880	17	7.8	1.1	600	7	17	1.30	0.34	42.9
1989	upstream	Subsistence	299	299	565.8	82.9	299	2445	286	8.1	1.9	610	9	299	1.26	0.13	38.8
1990	upstream	Subsistence	979	979	555.3	79.6	978	2203	169	7.3	1.64	540	7	978	1.23	0.20	26.4
1991	upstream	Subsistence	982	982	547.1	66.6	981	2059	238	7.3	1.54	530	6	981	1.21	0.14	16.4
1992	upstream	Subsistence	940	940	558.6	59.3	939	2278	197	7.3	1.27	510	7	939	1.27	0.16	22.4
1993	upstream	Subsistence	790	790	570.8	62.3	789	2510	193	7.9	1.27	590	8	789	1.31	0.16	29.4
1994	upstream	Subsistence	390	390	567.7	83	390	2457	187	7.9	1.57	600	8	390	1.28	0.19	36.0
1995	upstream	Subsistence	939	939	561.9	87.9	932	2391	261	7.1	1.64	610	8	932	1.26	0.18	34.6
1996	upstream	Subsistence	535	534	562.1	83	534	2287	179	6.6	1.75	530	6	534	1.20	0.14	27.3
1997	upstream	Subsistence	531	531	549.2	58.4	530	1970	184	6.5	1.17	510	6	530	1.15	0.14	18.2
1998	upstream	Subsistence	183	183	553.5	78.9	183	2420	171	7.2	1.17	530	7	183	1.37	0.19	23.5
1973	Ice fishing	Commercial	66	66	592.6	77.2	66	2479	61	6.7	1.7	520	5	66	1.14	0.11	40.9
1974	Ice fishing	Commercial	403	403	598.1	87.1	403	2167				610		403	0.96	0.12	47.8
1993	winter fishing	Subsistence	137	137	566.9	49.3	137	2130	129	7.9	0.98	580	8	137	1.14	0.14	
1994	spring fishing	Subsistence	70	70	616.7	58.7	70	2619	60	8.0	0.85	600	8	70	1.09	0.18	

Table 4. Significance (at 5% level in bold) of between-year differences in age frequency distribution of charr caught at the Hornaday River, NT, 1990-1998 (Kolmogorov-Smirnov valuee, ,p>K_s

MALES	1990		1991		1992		1993		1994		1995		1996		1997		1998	
	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa
1990	x	x	0.7627	0.6058	0.6463	0.7978	2.3300	**0.0001**	0.8852	0.4135	1.5700	**0.0145**	2.7641	**0.0001**	2.3811	**0.0001**	0.6222	0.8336
1991			x	x	1.1088	0.1709	2.6538	**0.0001**	1.1832	0.1216	1.9695	**0.0009**	2.2981	**0.0001**	2.1707	**0.0002**	0.6011	0.8628
1992					x	x	3.1718	**0.0001**	1.5322	**0.0183**	2.2822	**0.0001**	3.3041	**0.0001**	2.8706	**0.0001**	0.4318	0.9922
1993							x	x	1.4397	**0.0317**	2.9311	**0.0001**	4.2438	**0.0001**	4.5293	**0.0001**	3.0213	**0.0001**
1994									x	x	2.0749	**0.0004**	3.2026	**0.0001**	2.9219	**0.0001**	1.4797	**0.0251**
1995											x	x	1.7283	**0.0051**	2.0477	**0.0005**	2.0825	**0.0003**
1996													x	x	1.2241	**0.0999**	2.7058	**0.0001**
1997															x	x	2.3041	**0.0001**
1998																	x	x

MALES	1990		1991		1992		1993		1994		1995		1996		1997		1998	
	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa	KSa	p>KSa
1990	x	x	0.4818	0.9744	0.5301	0.9414	1.5835	**0.0133**	1.8888	**0.0016**	1.0452	0.2246	1.7754	**0.0037**	1.5917	**0.0126**	0.8427	0.4764
1991			x	x	0.9662	0.3081	2.0969	**0.0003**	2.0408	**0.0005**	1.1674	0.1310	1.4450	**0.0307**	1.2530	0.0865	1.2916	0.0711
1992					x	x	1.8730	**0.0018**	2.3239	**0.0001**	1.5449	**0.0169**	2.2306	**0.0001**	2.0635	**0.0004**	0.5500	0.9228
1993							x	x	0.9652	0.3092	1.6313	**0.0098**	3.3249	**0.0001**	3.1836	**0.0001**	1.5868	**0.0130**
1994									x	x	1.1129	0.1679	2.9088	**0.0001**	3.1602	**0.0001**	2.0300	**0.0005**
1995											x	x	2.1039	**0.0003**	2.4252	**0.0001**	1.2312	0.0965
1996													x	x	0.8786	0.4229	2.5292	**0.0001**
1997															x	x	2.3702	**0.0001**
1998																	x	x

Table 5. Mean length-at-age for Arctic charr from the Hornaday River, 1986 and 1990-1998

AGE	1986	1990	1991	1992	1993	1994	1995	1996	1997	1998
years	(WEIR)									
2	224	(290)								
3	262	(427)					(433)			
4	269	(491)	(435)		(304)	(432)	479	456	(470)	
5	365	467	500	480	(398)	432	513	499	500	404
6	422	529	538	527	486	508	551	543	540	489
7	524	568	550	553	562	535	595	561	561	552
8	584	587	580	590	577	577	626	645	600	588
9	604	627	596	610	595	620	631	658	672	621
10	582	663	680	639	601	621	621	691	656	650
11		662	694	(670)	689	621	(700)	(613)		(751)
12		(695)		(650)	(592)	(594)		(655)		(729)
13					(617)	(550)		(650)		

(Parentheses indicate <5 fish sampled)

Table 6. Sex ratio of charr sampled from 1990-1998 subsistence fishery at the Hornaday River, 1990-1998

Year	Females	Males	Total	Percent female
1990	105	87	192	54.69
1991	119	141	260	45.77
1992	91	128	219	41.55
1993	110	109	219	50.23
1994	122	92	214	57.01
1995	169	130	299	56.52
1996	85	103	188	45.21
1997	105	100	205	51.22
1998	86	97	183	47.00

Table 7. Hornaday River Arctic charr instantaneous mortality rate (Z), annual survival rate (S) and annual mortality (A) from 1990-1998 subsistence fisheries of upstream migrants during late summer

YEAR	INTERCEP	SLOPE	Z	S	A	R^2	STDERR SLOPE	STDERR INTCEP	AGES USED
1990	10.4812	-0.84390	0.84390	0.43003	0.56997	0.9532	0.1079	1.0901	8-12
1991	7.7833	-0.51503	0.51503	0.59748	0.40252	0.9064	0.0956	0.8707	7-11
1992	10.2512	-0.82894	0.82894	0.43651	0.56349	0.9545	0.1045	1.0558	8-12
1993	11.1653	-0.89872	0.89872	0.40709	0.59291	0.8759	0.1953	2.1657	9-13
1994	10.3347	-0.77326	0.77326	0.46151	0.53849	0.9307	0.1218	1.3508	9-13
1995	9.3484	-0.71328	0.71328	0.49004	0.50996	0.7378	0.2455	2.2366	7-11
1996	6.8016	-0.50492	0.50492	0.60355	0.39645	0.9384	0.0579	0.5902	7-13
1997	8.2688	-0.66733	0.66733	0.51308	0.48692	0.9309	0.1285	1.1020	7-10
1998	11.2693	-0.96731	0.96731	0.38011	0.61989	0.9331	0.1496	1.5160	8-12