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Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/051

UPDATE ASSESSMENT OF THE CAMBRIDGE BAY ARCTIC CHAR FISHERY, 1960 TO 2009

Ekalluk River Arctic Char Salvelinus alpinus. *Photo by Jean-Sebastien Moore.*

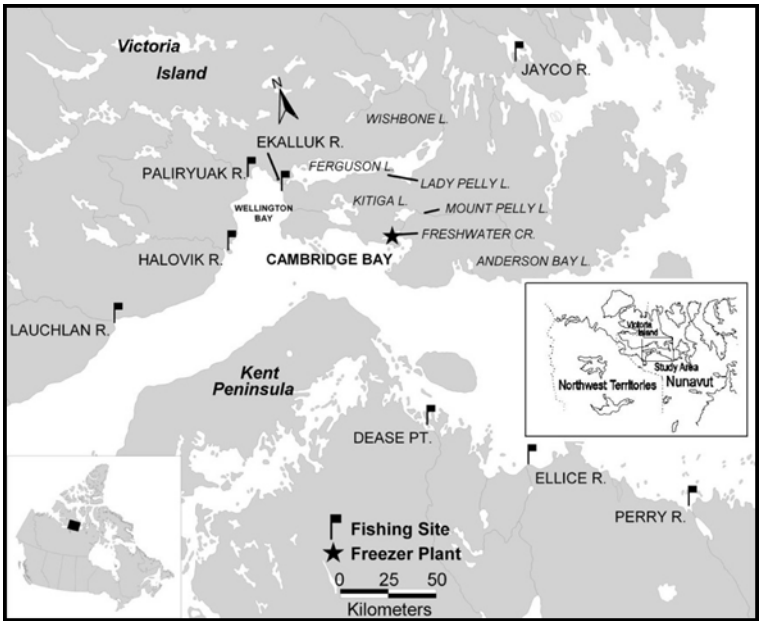

Figure 1. Map of the Cambridge Bay area showing commercial fishing locations for anadromous Arctic Char.

Context:

The Cambridge Bay Arctic Char commercial fishery was last assessed in 2004 (DFO 2004). In 2009, Fisheries and Aquaculture Management Sector of Fisheries and Oceans Canada (DFO) requested science advice on the current status and sustainable harvest levels for the Cambridge Bay commercial fishery stocks. Updated information from 2004-2009 concerning the status of Arctic Char stocks harvested from the Ekalluk, Paliryuak, Halovik, Lauchlan, Ellice and Jayco rivers was reviewed in 2010 and the current status of these char stocks, with regard to their response to harvest, is presented.

SUMMARY

- Arctic Char in the Cambridge Bay region of Nunavut is a valuable resource that has been harvested commercially since 1960.
- Trends in age, fork length, round weight and condition data from commercial fish samples were evaluated and indicate that the commercial fishery has had little impact on char from the Ekalluk, Paliryuak (Surrey), Halovik (Thirty Mile), Lauchlan (Byron Bay) and Jayco river stocks that make up the Cambridge Bay Arctic Char fishery.
- Current levels of harvest are likely sustainable. Low risks of over exploitation are predicted for the next 10 years at these five locations if current rates of harvest remain unchanged.

- Ellice River was last fished in 1999. The response of char to the Ellice River fishery, as indicated by trends in age data, may indicate a moderate risk of over-exploitation if historic rates of harvest were to recommence.
- Abundance estimated from weir enumeration data are severely outdated. Indices of abundance using fisheries catch-per-unit-effort (CPUE) data are not available for the Cambridge Bay commercial Arctic Char fisheries. Consecutive weir enumerations and annual site-specific fishing effort data would allow a more comprehensive assessment of fishery impacts.

INTRODUCTION

Arctic Char, *Salvelinus alpinus*, in the Cambridge Bay region of Nunavut is a valuable resource, historically used for subsistence purposes that has also been harvested commercially since 1960. An assessment of the Cambridge Bay Arctic Char fishery was conducted in January 2010. Day and Harris (2013) provide the technical details and the full list of cited material for this assessment. The proceedings report summarizes the key discussions of the meeting (DFO 2010). This Science Advisory Report summarizes the main conclusions and advice from the science peer review.

The Fishery

Historically, eight river systems in the Cambridge Bay area were commercially fished, including the Ekalluk, Paliryuak (Surrey), Halovik (30 Mile) and Lauchlan (Byron Bay) rivers flowing into Wellington Bay; Freshwater Creek flowing into Cambridge Bay; the Jayco River flowing into Albert Edward Bay; and the Ellice and Perry rivers, located southeast on the mainland (Figure 1). Over the years, several other sites were periodically fished, including Dease Point (Kulgayuk River) on the mainland, Padliak Inlet on Victoria Island, Elu Inlet, Starvation Cove on the south coast of Victoria Island, HTA Lake (Takyoknitok) on the southeast coast of Victoria Island. These have included both weir and gillnet fisheries, the specific details of which are described by Day and Harris (2013).

Commercial fishing for Arctic Char first began at Cambridge Bay in 1960, with a gillnet operation on Freshwater Creek. In 1962, the commercial fishery was relocated (due to evidence of a declining stock at that location) to the mouth of the Ekalluk River, where it empties into Wellington Bay. As the fishery developed, other sites, such as those described above, were utilized. Initially, an “area” quota was established for Wellington Bay, but the decline in the fishery at Ekalluk River, where most of the fishing took place, necessitated the establishment of “river-specific” quotas to distribute fishing effort.

A comprehensive description of the historical harvest, quota adjustments and methods used since the inception of the fishery are presented in Day and Harris (2013). Overall, in 2009, 32,392 kg of Arctic Char were harvested from a combined quota of 53,500 kg.

Ekalluk River

The Ekalluk River has been commercially fished since 1962 almost exclusively using gill nets under a variety of quotas. Annual harvest from 1999 to 2009 averaged 14,425 kg, under a 20,000 kg quota. The 2009 harvest was 12,666 kg.

Paliryuak (Surrey) River

Commercial fishing first took place here with gillnets in the spring of 1968. Since then, it has been fished under a variety of quotas. Currently, this river is fished under a quota of 9,100 kg

and the average annual harvest from 1999 to 2009 (excluding 2003 when no fishing occurred) was 7,441 kg per year. Harvest at Paliryuak River was 8,657 kg in 2009.

Halovik (Thirty Mile) River

Commercial fishing at the Halovik River began in the spring of 1968 using gillnets. This fishery has been fished under a variety of quotas and has been subjected to periodic closures. This fishery has been harvested by weir in the fall from 1994 to the present under a 5,000 kg quota. Average annual harvest for the period 1999 to 2009 inclusive was 6,045 kg. Harvest at Halovik River in 2009 was 4,555 kg.

Lauchlan River (Byron Bay)

The Lauchlan River was first fished for commercial purposes in 1970. Quotas have been variable throughout the history of the fishery. With the exception of years 2000 and 2002 when no fishing occurred, annual harvest for the period 1999 to 2008 averaged 3,843 kg under a 2,400 kg quota (not including 2004 when the fishery was opened under a 9,100 kg quota). No fishing occurred at this location in 2009.

Ellice River

Commercial fishing began at this mainland site in the fall of 1971 with an initial quota of 22,700 kg and a harvest of 12,820 kg. Several quota adjustments have been implemented throughout the history of this fishery. With the exception of 1999, when 4,497 kg of char were harvested, there has been no fishing at this site since 1997. This is a direct result of the transportation costs of harvesting char from this location and the noticeable whiter, less marketable flesh of these fish.

Perry River

Perry River, located on the mainland east of Ellice River, was first fished commercially in fall of 1977. Since the inception of this fishery, Arctic Char were only harvested in six different years. The current quota is 6,500 kg, however this system has not been harvested since 1991 primarily due to the cost of transporting the catch to the community of Cambridge Bay, and inclement weather often experienced there in fall. That year, 600 kg of Arctic Char were taken.

Jayco River

Jayco River was first fished commercially in 1975 using gill nets. Since 1980, the harvest at there has been taken, for the most part, by weir during the fall upstream run. The quota at this location was increased to 17,000 kg in 1994, during which time 16,290 kg were harvested. This quota has remained and the average annual harvest at this site over the years 1994 to 2009 inclusive was 12,531 kg. The 2009 harvest was reported to be 6,514 kg, as a result of inclement weather.

Species Biology

Arctic Char spawn in the fall, usually late September or early October, over gravel beds. Spawning takes place in lakes because most Arctic rivers freeze completely to the bottom in winter. Anadromous Arctic Char overwinter in freshwater systems and undertake downstream spring migrations to the sea for foraging purposes. Some individuals, however, may not migrate to sea the year that they spawn (Johnson 1989). These migrations (i.e., spring downstream migrations to the sea and fall upstream migrations to freshwater) are the target of the

Cambridge Bay commercial fishery and are composed largely of char that are not current-year spawners (L.N. Harris, unpublished data).

In the Nayuak Lake system on the Kent Peninsula, Gyselman (1994) found that overall fidelity of Arctic Char to this system was quite low (approximately 50%) and that straying must therefore be relatively high although current-year spawners showed a higher tendency to return to this system. Kristofferson et al. (1984) and Dempson and Kristofferson (1987) reported pervasive straying based on recapture locations of fish tagged at several locations within the Cambridge Bay region. They reported that Arctic Char were recaptured at all fishing sites in subsequent years, which included the Ekalluk, Paliryuak, Lauchlan and Halovik rivers and these results are consistent with the findings of other authors who reported low fidelity of non-spawning char to natal spawning grounds (Gyselman 1994). During open-water periods fish travelling long distances of up to 550 km have been documented from tag returns but this distance may not have been traveled in a single year (Gyselman 1994). Dempson and Kristofferson (1987) found that ocean migrations of both Labrador and Cambridge Bay char were influenced by many factors including local marine environmental conditions, availability of marine food resources, fish size, fish sex, maturation state and proximity to other river systems.

Very limited data are available on the genetic stock structure of Cambridge Bay Arctic Char. The only study to date, which assessed variation in allozyme loci, found little variation among Arctic Char populations within and between river systems (Kristofferson 2002). This is consistent with a high degree of straying among systems and indicates the harvests of Arctic Char at discrete fishing location are composed of a mixture of stocks. This may also suggest fidelity to natal sites in the Cambridge Bay area is likely low.

Eggs hatch in the spring and in most systems char are ready to take their first migration to sea at age 4-5 years and a size of 150-250 mm (Johnson 1980). Mean length of spawners in the Cambridge Bay area was 657 mm and ranged from 459 mm to 850 mm, and age at first maturity was reached at approximately 9 or 10 years (A. Kristofferson, unpubl. data). Mean age of spawners was 14.5 years and ranged from 9 to 21 years (Kristofferson 2002). Females generally carry 3,000 to 5,000 eggs (Scott and Crossman 1998). Arctic Char are iteroparous (capable of spawning more than once in a lifetime) though they do not appear to spawn in consecutive years. They are susceptible to the commercial fishery multiple times throughout their life during the upstream or downstream migrations.

ASSESSMENT

The assessment of Cambridge Bay Arctic Char is based largely on population parameter data obtained from an annual fish plant sampling program conducted in co-operation with DFO, the Ekaluktutiak Hunters and Trappers Organization (EHTO) and Kitikmeot Foods Ltd. Sampling methods are described in detail by Kristofferson and Carder (1980). Briefly, Arctic Char from active commercial fishing locations are delivered to the fish plant where as many as 200 char from each location are measured for fork length and dressed weight. Otoliths are also removed from each fish for later aging. Sampling dates and fishing gear used are provided by Day and Harris (2013).

Catch-Per-Unit-Effort and Abundance

Catch-per-unit-effort (CPUE) data, an index of abundance commonly used in fisheries science, is not available for commercial harvests of Cambridge Bay char fisheries. This is unfortunate because it limits the amount of information that could be generated from modeling exercises such as Virtual Population Analysis (VPA). This information may serve as an index of abundance and its availability should, therefore, be investigated.

Abundance information is limited to single year weir enumerations of the upstream migration of four commercially fished Cambridge Bay sites (Ekalluk, Jayco, Halovik and Lauchlan Rivers) and three upstream weir enumerations of Freshwater Creek which has not been commercially fished since 1961). Data to evaluate annual variation in abundance for each of the river systems are unavailable. The two years of sampling in the Jayco were not comparable as the 1980 count was considered incomplete.

Abundance estimates combined with average weights of Arctic Char sampled during upstream weir enumerations were used to crudely estimate exploitation rates for fisheries with enumeration data. This was done by applying an estimated total biomass (the number of fish enumerated x the average weight of enumerated fish) against the biomass of Arctic Char harvested to determine an approximate rate of exploitation. For example, at the Ekalluk River in 1979, 183,203 fish were enumerated with an average weight of 2.01 kg (estimated from 2,123 fish). That year, 15,806 kg of Arctic Char were commercially harvested resulting in an exploitation rate of 4.1% of the available biomass. Applying these same calculations resulted in exploitation rates of the total available biomass of 4.2%, 11.1% and 34% for the Jayco (1981), Halovik (1981) and Lauchlan (1983) rivers respectively. To our knowledge, these estimated exploitation rates may represent the only information available on sustainable harvest rates of anadromous Arctic Char populations.

Sex and Maturity

Sex and maturity data were collected opportunistically. These data were unavailable from the plant sampling program as the plant usually received dressed fish (i.e., without viscera and gills). Data collected from 1972 to 2006 from six rivers were pooled to provide a general description for the Cambridge Bay fishery. Data indicate that on average, females mature approximately one year earlier than do males (10.7 years for females versus 11.7 years for males). The ranges of mean age, length and weight of the different maturity stages of char are very broad. Some char may mature at a very young ages and small sizes and some relatively old char may remain immature. Interpretation of maturity data is complicated by the difficulty in distinguishing mature resting char from large immature char through visual observation of the gonads.

Sex and maturity stage analyses for pooled data suggest that approximately 64 % of female char and 70 % of male char in commercial Cambridge Bay harvests are immature fish. However, the majority of assessment data were collected prior to 1990 when higher frequencies of immature fish were observed. Recent maturity assessments for fisheries in the Halovik (2006) and Jayco (2005) rivers found that 100 % of harvested char were mature indicating that maturity rates of char have increased as the fishery developed. The stability in char population parameters observed for five of the six fisheries during earlier years of the fishery indicates that 1) the harvest of char prior to maturity did not adversely affected the sustainability of Cambridge Bay char fisheries at that time or 2) that there is little correlation between char production and brood stock abundance and that other factors ultimately determine char abundance in the Cambridge Bay area.

Stock Trends in Biological Characteristics

Age Trends

Mean ages varied without trend providing no evidence for an impact in response to harvest (Figure 2). Peaks and troughs in mean age plots were somewhat synchronous for the Wellington Bay fisheries but much less so for fisheries in the Ellice and Jayco rivers. For example, all Wellington Bay fisheries demonstrated a relatively large peak of older ages

centered around 1985 and 1986 which suggests that annual recruitment of char in this area is highly variable and perhaps driven by large scale climate factors.

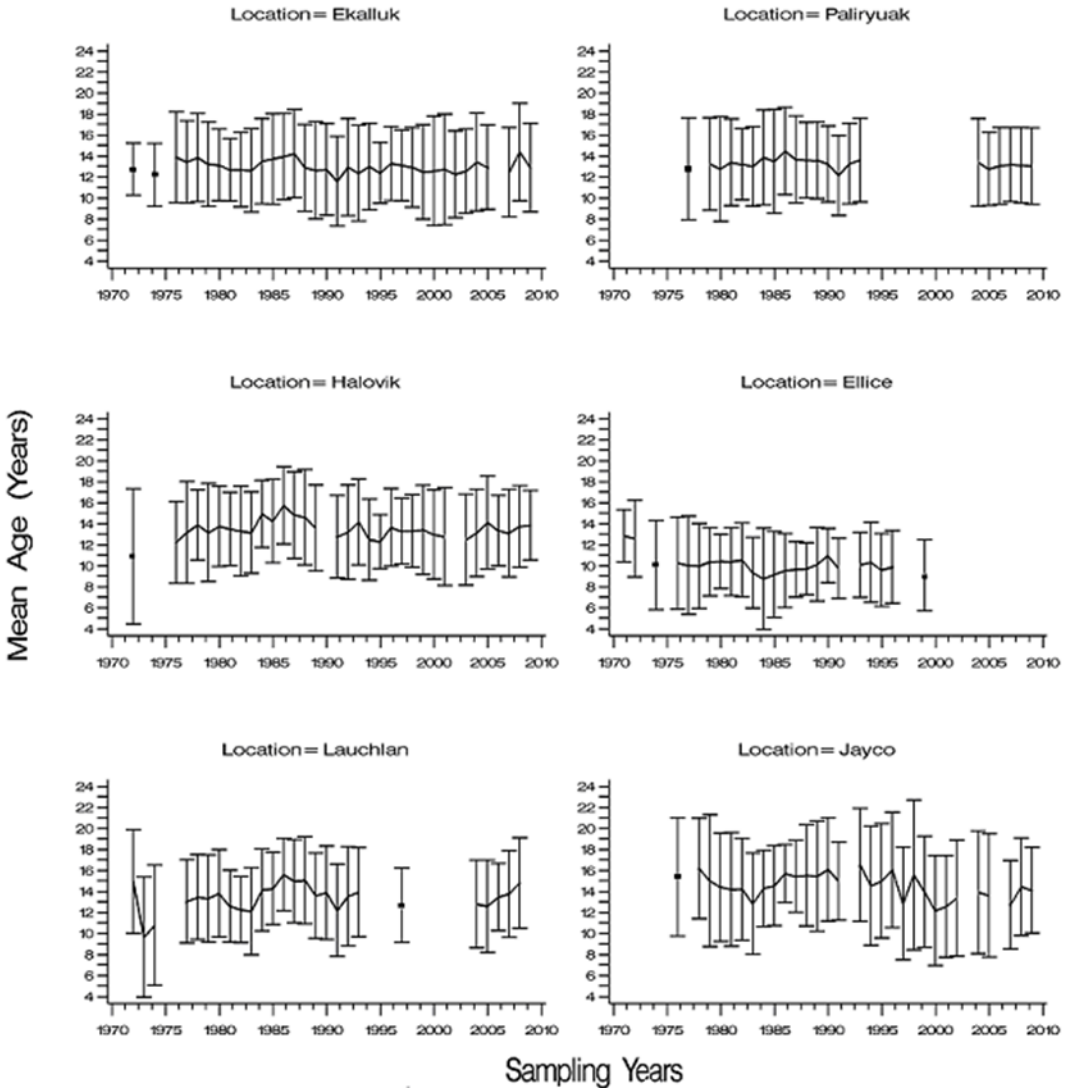

Figure 2. Mean age (± 2 standard deviations) of anadromous Arctic Char sampled from the commercial fishery harvest in Cambridge Bay, Nunavut.

*Table 1. Cambridge Bay Arctic Char (*Salvelinus alpinus*) fisheries risk levels. Strong modal age classes (greater than or equal to 20 % of the harvest) by fishing period and fishery with a level of risk of overexploitation if harvest rates continue at present levels.*

Location	Period	Strong Modal Age Classes	Risk Level (over 10 years)
Ekalluk	1971-1980 1981-1990 1991-2000 2001-2009	12-16 12-14 11-14 11-14	Low to Moderate
Ellice	1971-1980 1981-1990 1991-2000 2001-2009	8-13 7-12 8-11 Not fished	Moderate
Halovik	1971-1980 1981-1990 1991-2000 2001-2009	11-15 13-17 11-15 11-14	Low
Jayco	1971-1980 1981-1990 1991-2000 2001-2009	15-16 13-16 10-15 11-14	Low
Lauchlan	1971-1980 1981-1990 1991-2000 2001-2009	8-14 11-16 12-13 11-15	Low
Paliryuak	1971-1980 1981-1990 1991-2000 2001-2009	Not fished 12-15 13 12-14	Low

[1] fished five of ten years during this period.

Age trends were also examined as the presence of strong modal age classes by Day and de March (2004). Day and Harris (2013) updated the earlier results with data from 2004 to 2009 for (Table 1). With respect to the Ekalluk River plant samples, between 1971 and 2009, the number of strong modal age classes decreased slightly from ages 12-16 in early years of the fishery to ages 11-14 in recent years. In the Ellice River plant samples, there are no longer strong modal age 12 and 13 year old age classes. In the Halovik River, the catch was composed of modal age classes of 11-15 and has remained relatively constant with the exception of the 1981-1990 period when older modes were present and younger modes were missing. In the Jayco River, the number of strong modal age classes decreased slightly from age 15-16 in early years of the fishery to age 11-14 in recent years. In the Lauchlan River, the presence of strong modal age classes has been similar among fishing periods between 1981 and 2009 with strong modes ranging from age 11 to 16. In the earlier period of 1971-1980, Lauchlan River samples had noticeably younger modes (8 -14) at the start of the fishery. Strong

modal age classes of Paliryuak River char have remained stable at 12-15 for fishing periods between 1981 and 2009.

A level of risk of overexploitation, if harvest rates continue at current levels, was assigned to six Cambridge Bay fisheries (Table 1) based on the trends in average age and strong modal age classes. Risk levels assigned to all fisheries were low with the exception of the Ellice River. This fishery was assigned a moderate level of risk based on its consistent decline in modal age. During the 1990s the fishery was composed almost entirely of fish which were younger than the mean age of maturity of Cambridge Bay char. The moderate Ellice River level of risk is somewhat mitigated by the fact that it has been fished only once since 1999.

Relative risk assessments based on intrinsic stock productivity predicted from first age of maturity and growth rate, suggest that Paliryuak and Jayco river char stocks are less productive and therefore, have a higher potential risk of overexploitation than do other stocks in the Cambridge Bay area (Roux et al. 2011).

Length Trends

Mean lengths varied without trend providing no evidence for an impact in response to harvest (Figure 3). The trends were characterized by peaks and troughs which occurred during similar sampling years among the Wellington Bay and Jayco River fisheries but in this respect, were much less similar for the Ellice River fishery (Figure 3).

Weight Trends

Mean round weight for char in the Ekalluk, Paliryuak, Lauchlan and Jayco rivers varied without trend providing no evidence for an impact in response to harvest (Figure 4). This finding may suggest stability in response to harvest. Mean round weights of char increased throughout sampling years in the Halovik River and increased from 1987 onward in the Ellice River. Increases in mean char weight at length in later years of the fishery may are perhaps due to recent warming of the Cambridge Bay area climate which may have improved growing temperatures, feeding duration at sea and the productivity of the char forage base. The mean round weight trends in all fisheries were characterized by peaks and troughs which occurred during similar sampling years among the Wellington Bay and Jayco River fisheries but in this respect, were much less similar for the Ellice River fishery.

Condition Trends

Condition factors were calculated for each char sampled as:

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

where W and L are the round weight (g) and fork length (mm) of each individual fish, respectively. Condition trends (Figure 5) closely mirrored trends for mean fork length, mean age and mean weight. Ellice and Halovik char condition increased over the time series (Figure 5). This may indicate that condition trends are the result of an unknown combination of differences in site specific environmental growing conditions and harvest pressures.

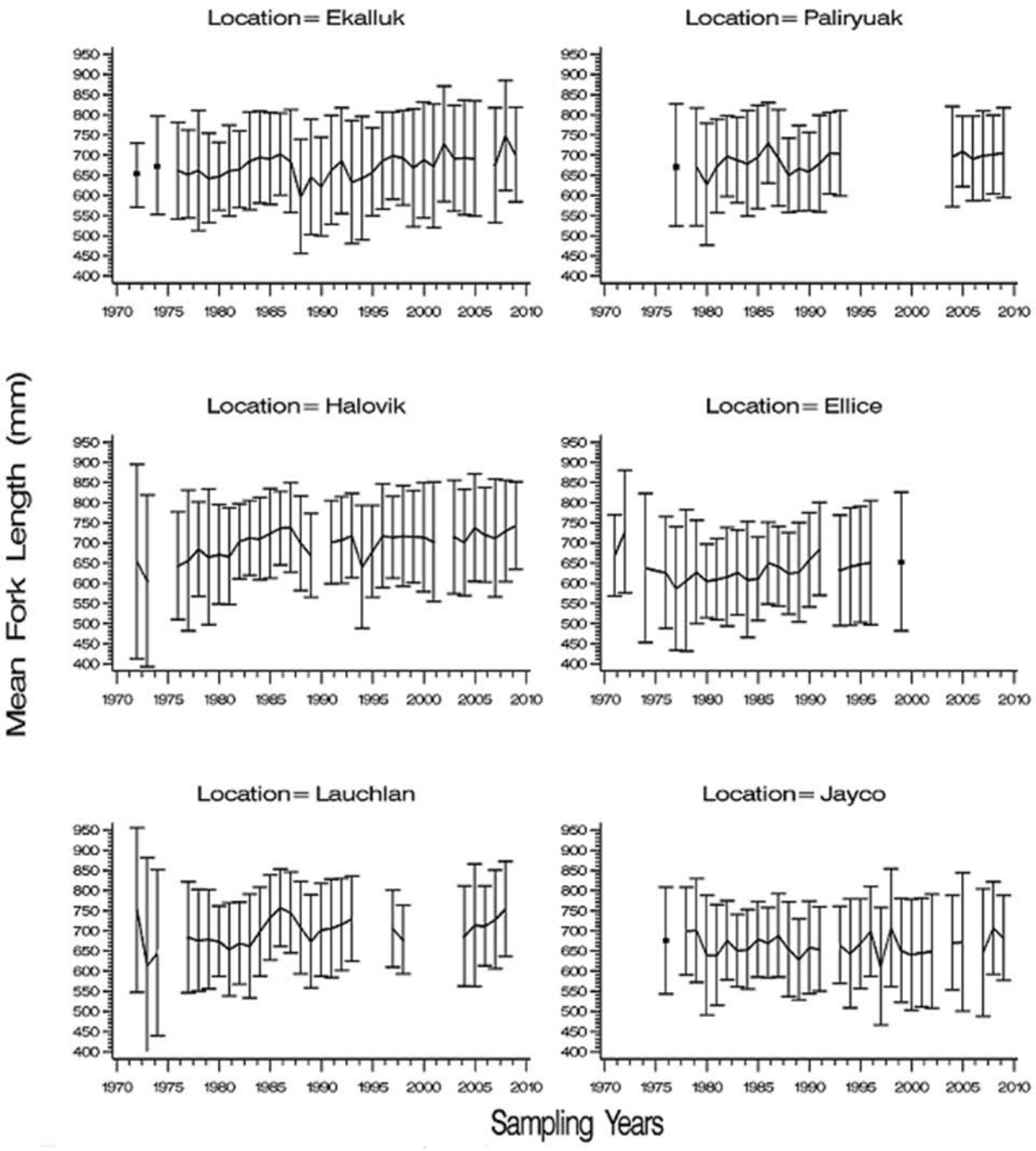

Figure 3. Mean fork length (± 2 standard deviations) of anadromous Arctic Char sampled from the commercial fishery harvest in Cambridge Bay, Nunavut.

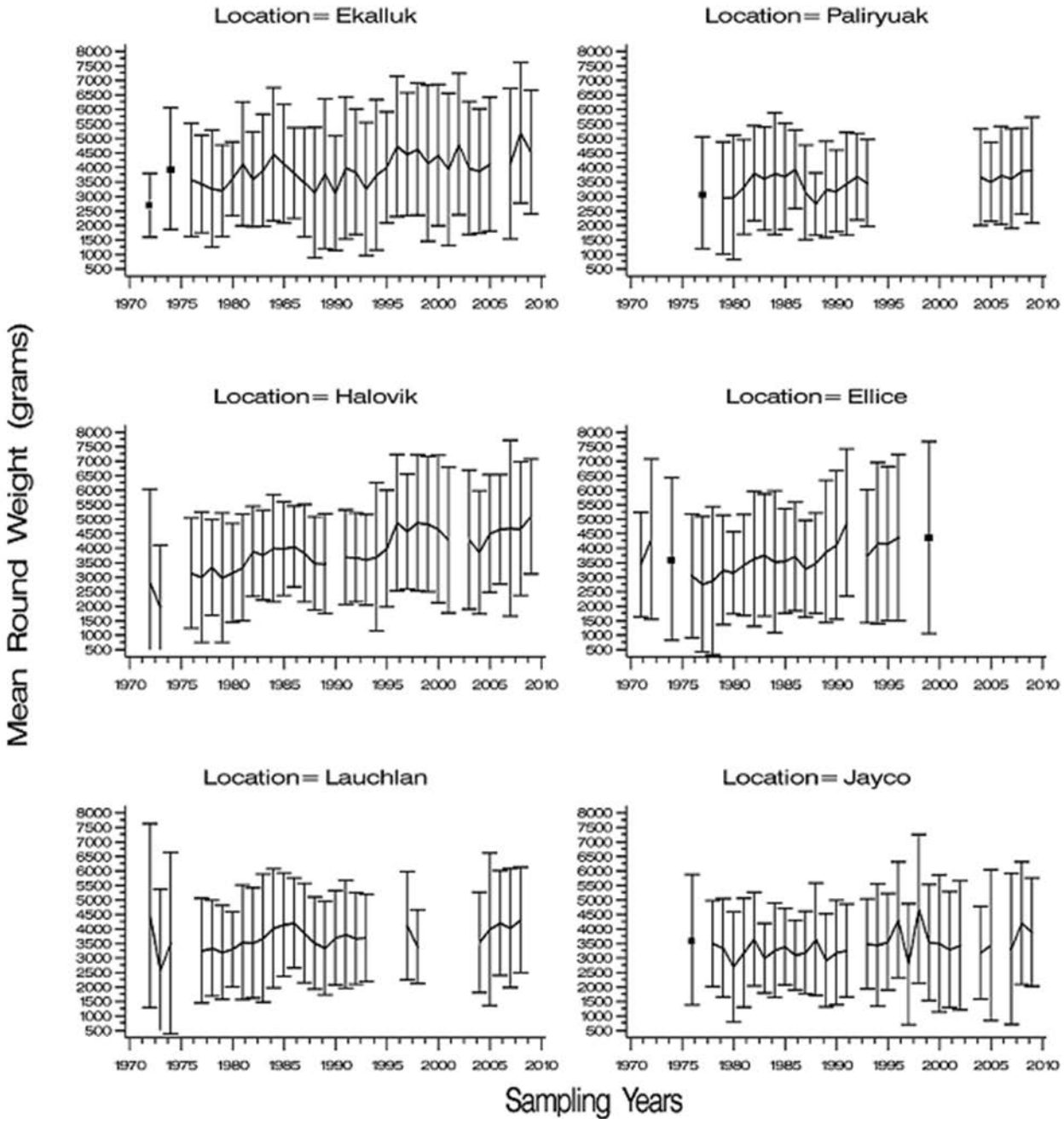

Figure 4. Mean round weight (± 2 standard deviations) of anadromous Arctic Char sampled from the commercial fishery harvest in Cambridge Bay, Nunavut.

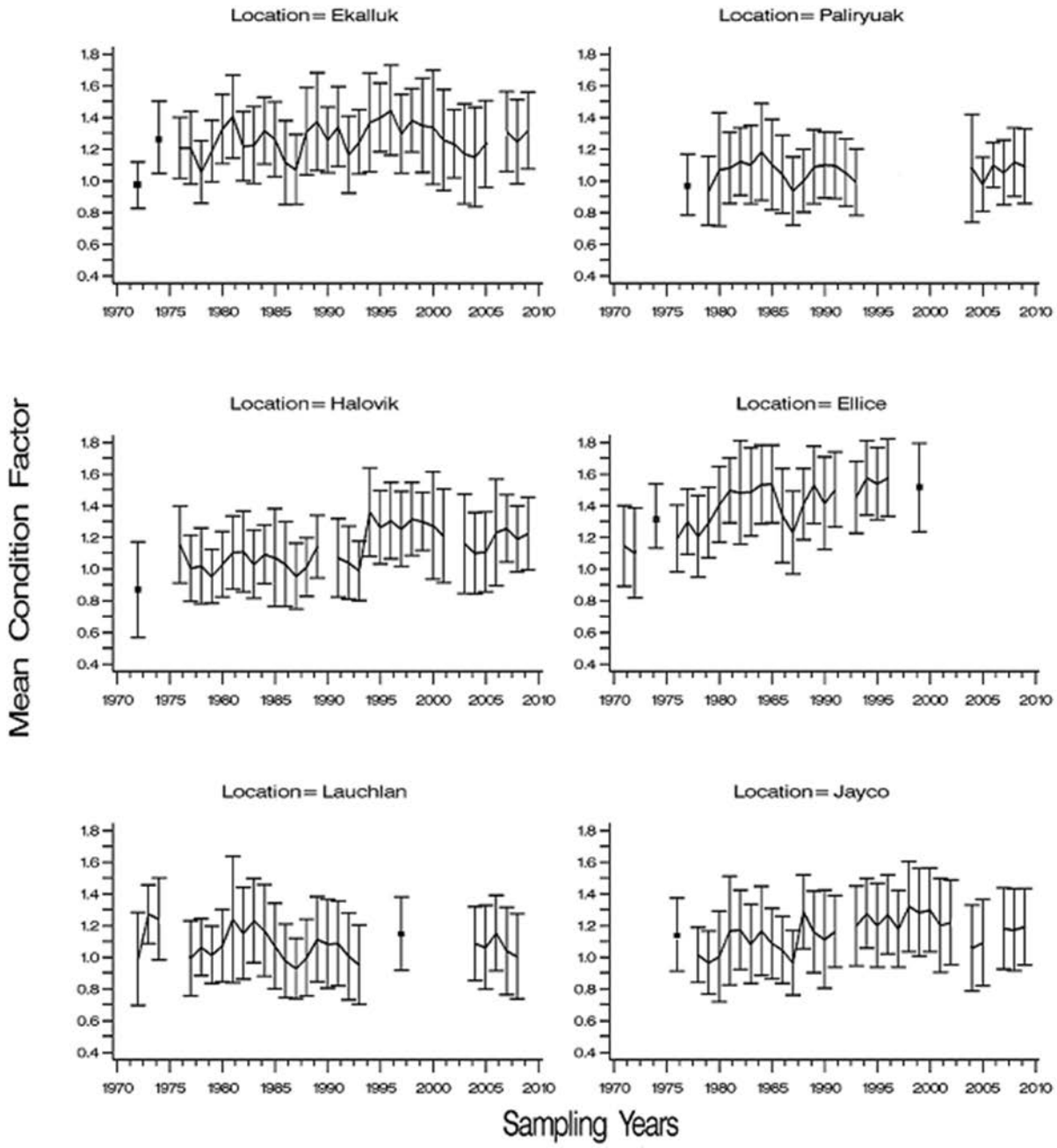

Figure 5. Mean condition factor (± 2 standard deviations) of anadromous Arctic Char sampled from the commercial fishery harvest in Cambridge Bay, Nunavut

Growth Rates

Trends in growth rates for each location were examined as plots of mean fork length at age for data were pooled from 1971-1979, 1980-1989, 1990-1999, and 2000-2009 (Figures 6, 7 and 8). There was little difference among periods in mean length at age for any location, which indicated that growth rates remained unchanged between 1971 and 2009. For several of the fisheries, (Ekalluk, Halovik, Jayco and Lauchlan), younger age classes were noted in harvests taken in earlier periods, 1971 to 1979 and 1980 to 1989, but were absent from harvests of later periods.

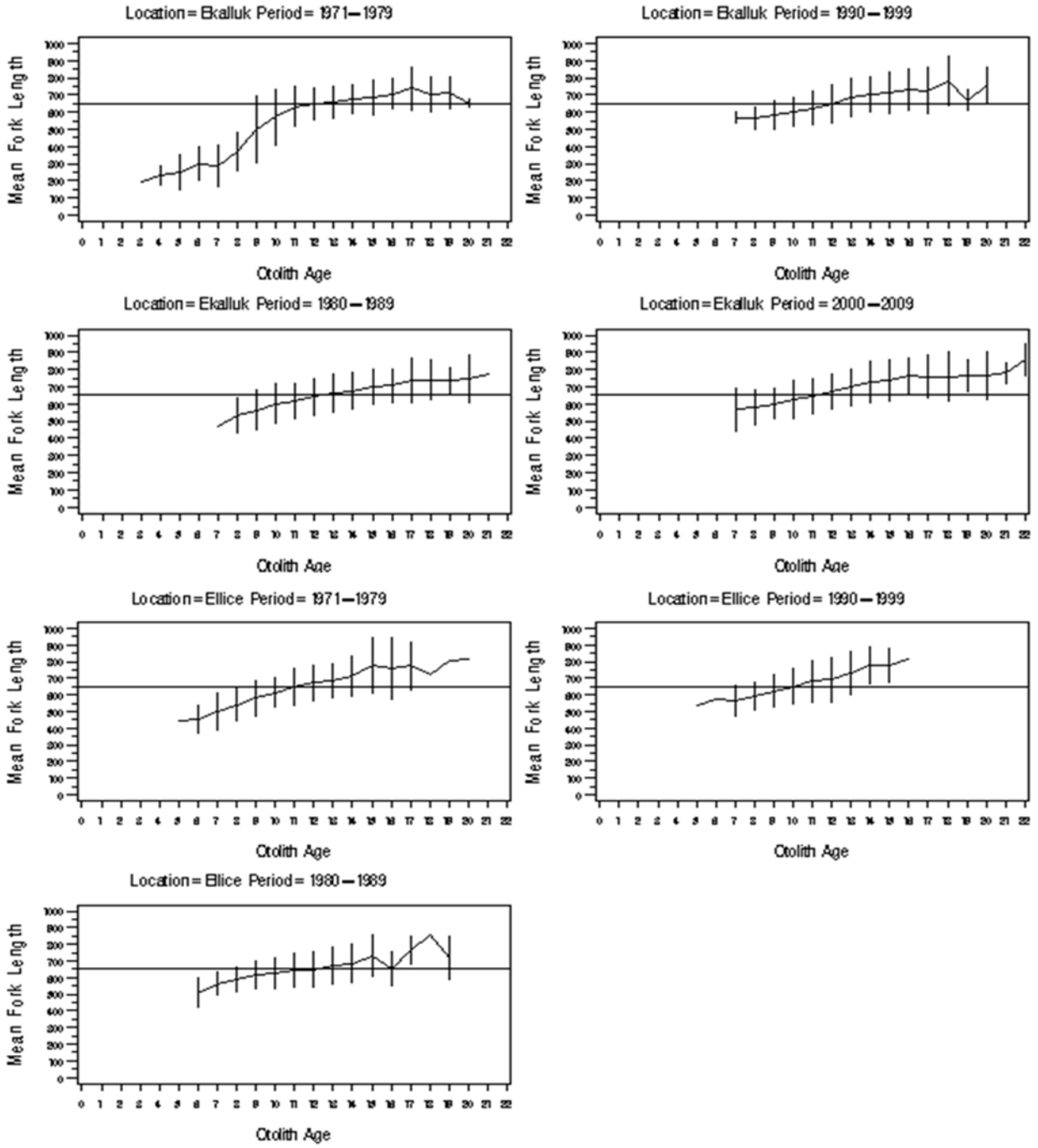

Figure. 6. Plots of mean fork length at age (± 2 standard deviations) by period for anadromous Arctic Char sampled from the Ekalluk and Ellice River commercial fisheries in Cambridge Bay, Nunavut.

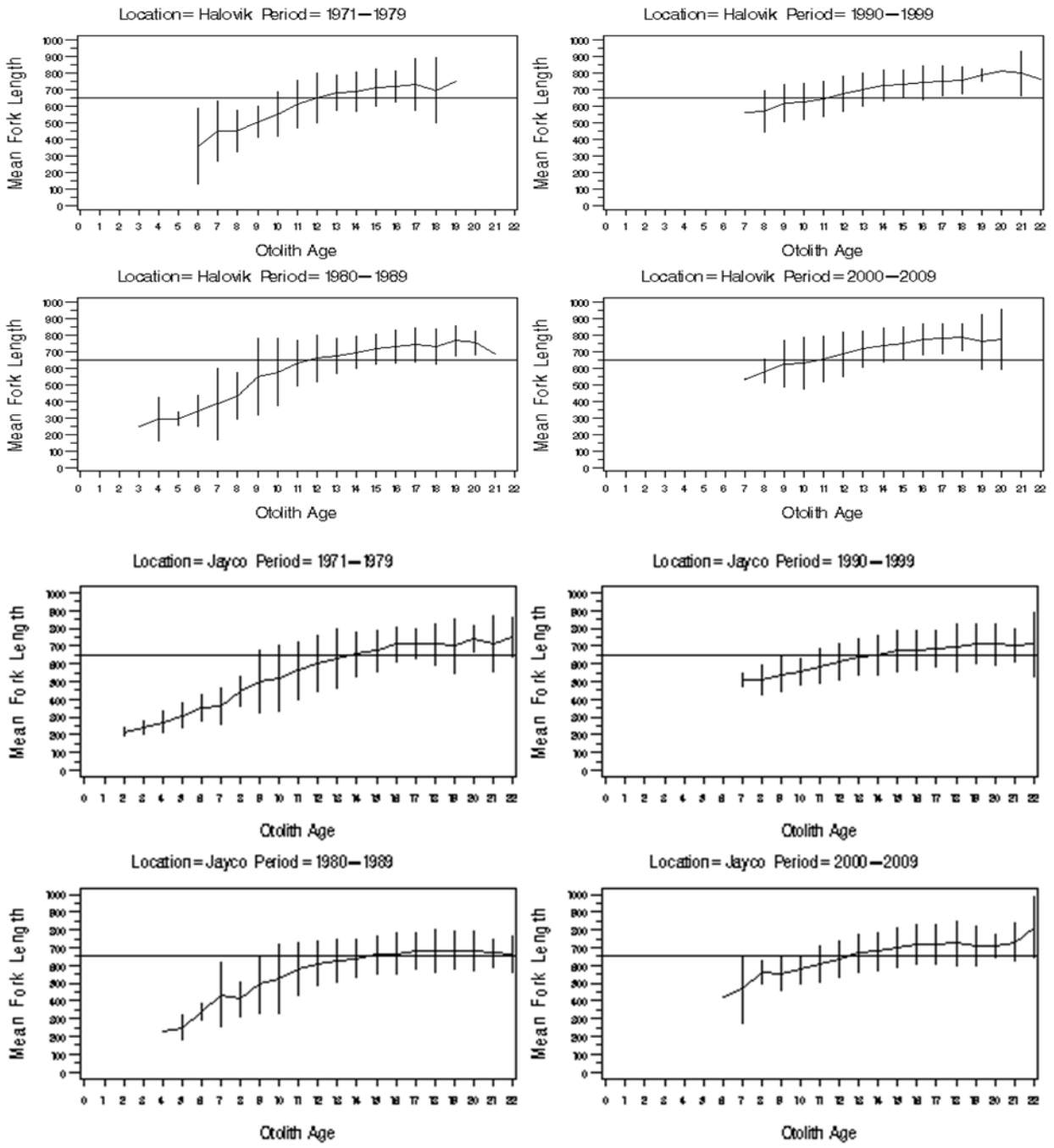

Figure. 7. Plots of mean fork length at age (± 2 standard deviations) by period for anadromous Arctic Char sampled from the Halovik and Jayco River commercial fisheries in Cambridge Bay, Nunavut.

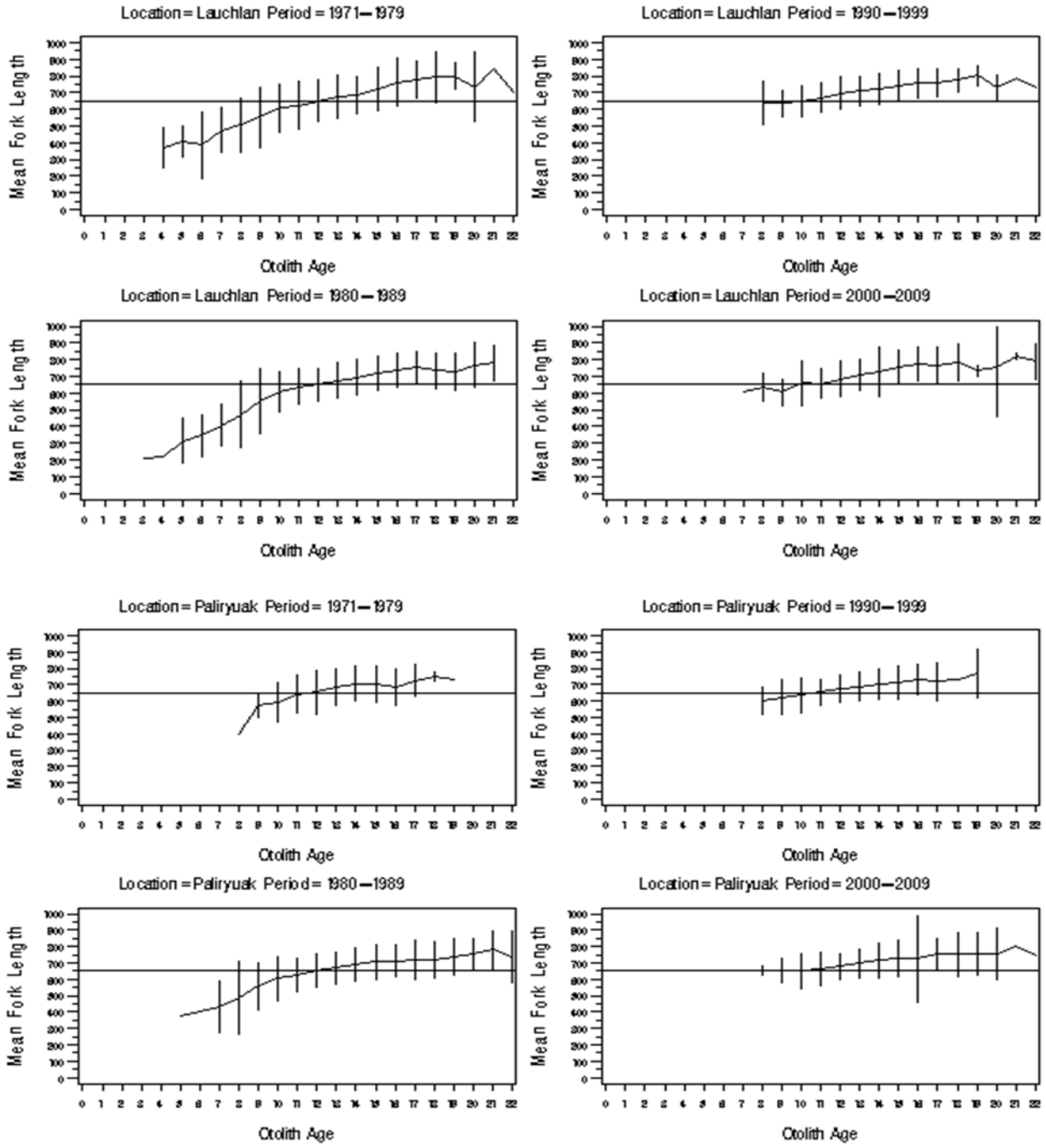

Figure. 8. Plots of mean fork length at age (± 2 standard deviations) by period for anadromous Arctic Char sampled from the Lauchlan and Paliryuak River commercial fisheries in Cambridge Bay, Nunavut.

Sources of Uncertainty

Annual CPUE, by-catch and fecundity data are not available for the Cambridge Bay fishery. These data are needed for an age structured model to predict abundance of char populations

harvested from all Cambridge Bay stocks. Stocks appear to be stable at the current harvest however estimation of an optimal sustainable yield would require more data and modelling.

CPUE estimates for each of the two gear types used (weirs and gillnets) should be standardized by concurrent fishing of both gears.

The amount of inter-annual variation in abundance for each stock is unknown. Research is required to assess this since sustainable harvest rates may be influenced more by natural variation in recruitment and growth, caused by extreme climate variation, than by the impact of exploitation.

Although fishing is directed at individual rivers during the upstream or downstream migrations, mixing of stocks occurs in the Cambridge Bay area. The genetic stock structure of Arctic Char stocks exploited by the fishery in the Cambridge Bay area is unknown. It is thus recommended that efforts to resolve population structure be initiated to determine how many and to what extent stocks/populations are potentially being harvested.

Information needed to develop a formal precautionary approach (PA) model for the management of this fishery is lacking. The information required includes catch-per-unit-effort data, fecundity, absolute abundance (or a reliable index of abundance) and analysis of stock recruitment relationships.

CONCLUSIONS

The status of Cambridge Bay commercially harvested Arctic Char stocks is stable.The Cambridge Bay commercial fishery for anadromous Arctic Char is harvesting this resource at or below a sustainable rate. In response to past and present harvest rates, population parameters varied without trend. Risk of overexploitation is predicted to be low for the next 10 years if harvest rates remain stable. Dempson et al. (2008) reported similar stability for Labrador coast Arctic Char populations subject to long term harvest pressure and environmental variability.

Further research is required to estimate annual CPUE and fecundity so that advanced fishery models can be used to estimate abundance and surplus biomass. CPUE and fecundity data are required for the prediction of abundance and surplus production and ultimately a total allowable harvest (TAH). The plant sampling program should continue and expand to include char harvested from new fishing grounds.

Future work should focus on additional weir enumerations to assess whether run sizes are temporally stable and thus whether exploitation rates have remained relatively constant over the past 15 years.

OTHER CONSIDERATIONS

Prior to the onset of the commercial fishery, it is likely that all river systems in this area were fished for food and these same systems continue to be fished for subsistence purposes along with the commercial harvest. Data on subsistence harvest are limited to the Nunavut Wildlife Harvest Study undertaken from 1996 to 2001 (Priest and Usher, 2004). Based on the harvest study and assuming similar gear and the average size of a char from the subsistence harvest is similar to the average commercially harvested size (3.5 kg), the annual subsistence harvest of Arctic Char may be approximately 22,600 kg annually which is half the size of the annual commercial harvest. Inuit traditional knowledge suggests that subsistence harvests do not necessarily occur close to Cambridge Bay but at more distant locations where hunting is being conducted. It is important to know the total amount of harvest (commercial and subsistence) and which stocks are targeted when evaluating the sustainability of each stock. Programs need to

be initiated to quantify subsistence harvest of Arctic Char for the region. These data will be important for determining rates of total allowable harvest.

Relative risk assessments based on intrinsic stock productivity predicted from first age of maturity and growth rate, suggest that the Jayco River Arctic Char stock is less productive and therefore, has a higher potential risk of overexploitation than other stocks in the Cambridge Bay area (Roux et al. 2011). Trends in population parameters of these stocks, however, are stable and this potential would only be realized if harvest rates increased.

Currently Arctic Char spawning and overwintering sites do not appear to be impacted by human activities. Arctic Char are also vulnerable to activities that could negatively impact the rivers during the downstream (ice break-up to mid-July) and upstream migrations (mid-August to mid-September). Activity that could impact the river should not occur during these migration periods.

SOURCES OF INFORMATION

This Science Advisory Report is from the January 27-28, 2010 on Cambridge Bay Arctic Char. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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ISSN 1919-5087

Correct Citation for this Publication:

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