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Harvest, catch-effort, and biological information of Arctic Char (*Salvelinus alpinus*) collected from subsistence harvest monitoring programs at Hornaday River, Lasard Creek, and Tippitiuyak, Darnley Bay, Northwest Territories

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

Harvest, catch-effort, and biological information of Arctic Char (*Salvelinus alpinus*) collected from a standardized subsistence harvest monitoring program at the mouth of the Hornaday River (1990–2013), Lasard Creek (2011–2013), and at Tippitiuyak (Tippi) (2012–2013), Darnley Bay, Northwest Territories were analyzed to inform the population assessment of char from the Hornaday River. Additionally, biological data periodically collected mainly from the commercial fishery between 1973 and 1989 were compared to more recent data. The annual patterns in catch-effort and length, weight, and age-related metrics do not indicate current signs of overharvest or deteriorating stock status and suggest the level of harvest is sustainable. Median annual catch-per-unit-effort demonstrated a sinusoidal pattern over time with an increasing trend between 2011 and 2013. Length and weight data both appeared temporally stable with increasing proportions of larger sizes in recent years. Length and weight were not considerably different between sexes, although males attained larger sizes and greater mass, and had a higher growth rate. Median age was relatively stable over time with the proportion of older aged individuals increasing in recent years. A likely non-representative age sample of the population combined with the relatively short life-span of char in this stock produced high estimates of annual mortality. In some years, more char were harvested at Lasard Creek than Hornaday River with peaks in catch-effort that were sometimes higher at Lasard suggesting this area can be a more productive fishing location than Hornaday during the summer. Furthermore, population demographics were similar between both locations. Preliminary information showed that ‘blue char’, a type of char reportedly different from those associated with the Hornaday River and of unknown origin, captured at Tippi had similar length, weight, and age characteristics to char from the Hornaday River.

Information sur la récolte, les prises par unité d'effort et la biologie de l'omble chevalier (*Salvelinus alpinus*) recueillie dans le cadre des programmes de surveillance des pêches de subsistance dans la rivière Hornaday, le ruisseau Lasard et à Tippitiuyak, dans la baie Darnley, dans les Territoires du Nord-Ouest

RÉSUMÉ

On a analysé les renseignements sur la récolte, les prises par unité d'effort et la biologie de l'omble chevalier (*Salvelinus alpinus*) recueillis dans le cadre d'un programme normalisé de surveillance des pêches de subsistance mené à l'embouchure de la rivière Hornaday (1990–2013), dans le ruisseau Lasard (2011–2013) et à Tippitiuyak (Tippi) (2012–2013), dans la baie Darnley, dans les Territoires du Nord-Ouest, afin d'orienter l'évaluation de la population d'ombles de la rivière Hornaday. Les données biologiques recueillies périodiquement, provenant essentiellement de la pêche commerciale entre 1973 et 1989, ont été comparées aux données plus récentes. Les tendances annuelles des prises par unité d'effort et des paramètres de longueur, de poids et liés à l'âge n'indiquent aucun signe actuel de surpêche ou de détérioration de l'état du stock, et permettent de penser que le niveau de récolte est durable. Les prises par unité d'effort médianes annuelles décrivent une courbe sinusoïdale au fil du temps et révèlent une tendance à la hausse entre 2011 et 2013. Les données sur la longueur et sur le poids paraissent toutes deux stables dans le temps, et on constate une augmentation des proportions d'individus de grande taille dans les dernières années. La longueur et le poids varient peu entre les sexes, bien que les mâles atteignent de plus grandes tailles et une plus grande masse. Leur taux de croissance est également plus élevé. L'âge médian demeure relativement stable au fil du temps, et l'on observe dans les dernières années une augmentation de la proportion d'individus âgés. Un échantillon d'âge de la population, sans doute non représentatif, combiné à la durée de vie passablement courte des ombles de ce stock, a donné des estimations élevées de la mortalité annuelle. Certaines années, les captures d'omble ont été plus nombreuses dans le ruisseau Lasard que dans la rivière Hornaday, et les pics des prises par unité d'effort y étaient parfois plus élevés. Il est donc possible que la production de poisson y soit plus élevée que dans la rivière Hornaday durant l'été. De plus, la démographie de la population est semblable aux deux endroits. Selon l'information préliminaire recueillie, l'« omble bleu », un type d'omble apparemment différent de celui de la rivière Hornaday et d'origine inconnue qui a été capturé à Tippi, présente des caractéristiques comparables à celles de l'omble de la rivière Hornaday en termes de longueur, de poids et d'âge.

INTRODUCTION

Anadromous Arctic Char (*Salvelinus alpinus*) is an important subsistence resource for the residents of Paulatuk, Northwest Territories, with the majority of the harvest occurring in the marine waters along the eastern shores of Darnley Bay during the summer by gill nets (Figure 1). Arctic Char from the Hornaday River are the most important stock for Paulatuk harvesters, and catches occur mainly at the mouth of the river during the char's upstream migration in August. Arctic Char are also harvested during the winter, typically from mid-October to November, in deep pools in the Hornaday River delta (local name for this area is Nuvukpaaluk) and the upstream area of the river that is locally known as Coalmine (Figure 1). The only other known stock of anadromous Arctic Char in the area, smaller in size relative to the Hornaday, originates from the Brock River system (Roux et al. 2011a) which is situated north of the Hornaday River (Figure 1).

The freshwater habitat occupied by Arctic Char in the Hornaday River occurs between the wide (approximately 12 km at its widest point), shallow and multi-channel gravel/ sand delta where the river drains into Darnley Bay, and La Roncière Falls, a high (23–38 m) impassable barrier to fish located approximately 70 river km upstream. The river provides migratory, spawning and overwintering habitat for adult Arctic Char, and is presumably a nursery/ rearing area for juveniles. Anadromous Arctic Char from this population do not spawn every year after reaching sexual maturity, and, in years when spawning occurs, most fish will remain in the river all summer and spawn in the fall (Harwood and Babaluk 2014). Purported spawning areas are the spring-fed pools in the river situated in a stretch of river between Coalmine and Akluk Creek (MacDonell 1996, MacDonell 1997, Harwood and Babaluk 2014), and possibly the pool at the base of La Roncière Falls. A large proportion of the 14,670 km^2 drainage area of the river is situated in Tuktut Nogait National Park with the western border of the park intersecting the river approximately 18 river km downstream of the falls (Figure 1).

The marine habitat of anadromous Arctic Char from the Hornaday and Brock rivers provides important feeding areas necessary to acquire energy for survival, growth and reproduction. During the summer, Arctic Char feed on invertebrates (e.g., amphipoda) and fish (e.g., sandlance *Amodytes* sp., and Capelin *Mallotus villosus*) (C. Gallagher pers. obs. and Harwood and Babaluk 2014) presumably in nearshore areas of the eastern coast of Darnley Bay as far as Pearce Point in the Amundsen Gulf (Harwood and Babaluk 2014) (Figure 1). The timing of seaward migrations is positively correlated with the timing of ice breakup in the bay (Harwood 2009). A summary of some of the ecological characteristics of Darnley Bay is provided by Paulic et al. (2012, and references therein).

Since Paulatuk was settled in the 1940s, Arctic Char has always provided an important contribution to the subsistence economy of the community. A commercial fishery, initiated to promote economic opportunities for Paulatuk, operated between 1968 and 1986 (Figure 2). The commercial fishery was ceased in 1987 due to diminishing subsistence and commercial catches, and reduced size of individual fish, and has remained unopened since. During this period of time, test fisheries were conducted in other areas such as the Brock River (1987), Horton River (1988), Balaena Bay (1989), and Tom Cod Bay (1989) to find alternate sources of Arctic Char for the community (MacDonell 1989).

The decline in the fishery at the Hornaday River prompted the establishment of the Hornaday River Char Monitoring Program in 1990. The program collects harvest, biological, and catch-per-unit-effort (CPUE, starting in 1997) data annually from the subsistence fishery at the mouth of the Hornaday River during the summer when the char migrate from the sea back to freshwater; data are used to examine trends in relative abundance and population demographics. The Hornaday River char stock is managed cooperatively by Paulatuk Hunters Trappers Committee, Fisheries Joint Management Committee, Fisheries and Oceans Canada, and Parks Canada via the Paulatuk Char Working Group which implemented the Paulatuk Char Management Plan in 1998. A voluntary total allowable harvest for the stock was set at 1,700 fish by the working group in 1998, and was raised to 1,800 fish in 2013 due to increased demands.

Presently, the summer harvest of Arctic Char occurs in the south-western area of Darnley Bay in Argo Bay (Egg Island) and Tippitiuyak, and along the eastern coast of the bay at the mouth of the Hornaday (specifically, mainly near the mouth of the east channel of the delta and infrequently in the area near Kraut Channel) and near the mouth of Lasard Creek. The initial recommended harvest of 1,700 was intended for the capture of Arctic Char from all locations in Darnley Bay as it was assumed that the majority of harvested char were from the Hornaday River stock as no other information was available to suggest otherwise.

In recent years, it has been reported that residents of Paulatuk have been shifting more of their fishing effort for Arctic Char to the Lasard Creek area, near the mouth of the Brock River (Figure 1). Prior to Boguski et al. (2015) and Harris et al. (2016), the extent of mixing between char from the Hornaday and the Brock systems was unknown, although a tag return in 1996 did suggest movement of fish between both systems (Roux et al. 2011a). In 2011, harvest monitoring was expanded to include the mouth of Lasard Creek. Although Arctic Char were still harvested at the mouth of the Hornaday River in the summer and in the river itself in the fall/ winter, it was unclear to what extent the shift in harvest location altered the harvest rate of Arctic Char originating from both rivers.

The Paulatuk Hunters and Trappers Committee and Paulatuk Char Working Group have requested an increase in the voluntary harvest level to meet the subsistence needs of the community. As a result, Fisheries and Oceans Canada Resource Management has requested information on the current stock status of Arctic Char from the Hornaday River.

OBJECTIVES

Use data collected from multiple sampling programs to inform the population assessment of Arctic Char from the Hornaday River stock; specifically:

- Summarize harvest, CPUE (1997–2013), and biological data (1990–2013) collected from the Hornaday River Char Monitoring Program;
- Summarize unpublished biological data collected from the commercial fishery (1973, 1974, 1979, 1981, 1983 and 1986), multi-mesh gill nets (test fishery) set at the mouth of the Hornaday River (1981), and subsistence fishery (1988 and 1989) to compare with more recent data;
- Examine for temporal trends over time in CPUE and biological information to obtain an indication of current stock status;
- Summarize harvest, catch-effort, and biological data collected from the Lasard Creek Char Monitoring Program (2011–2013);
- Compare the harvest, catch-effort, and biological information (length and age demographics) of Arctic Char captured from the mouth of the Hornaday River and Lasard Creek to evaluate whether the fishery and population demographic information were considerably different between locations; and
- Provide preliminary biological information on a type of char captured at Tippi described by locals as ‘blue char’, which are reportedly morphologically different from the Arctic Char associated with the Hornaday River and are of unknown origin, and determine whether these differed from Arctic Char captured at the Hornaday River.

METHODS

HARVEST MONITORING

Mouth of the Hornaday River

Two harvesters from the community of Paulatuk (not always the same people or the same combination of people every year) were employed to record information on a standardized form about their own fishing and that of others at camps near the mouth of the river. The responsibilities of the monitors were to record the daily total number of Arctic char captured from individual gill nets, and the soak time (starting in 1997), length and mesh size (stretch) of each net. Catch data were only collected in a way that allowed for calculating the number of individual harvesters as of 1996. Harvesters were very supportive of the monitoring program and it is assumed that a large majority of the catch were enumerated. Whenever possible, a random subsample of the catch was processed for biological information throughout the approximate three week duration of the fishery.

Biological sampling of a fish entailed taking either;

1) a complete dead-sample (target sample size ≥200) or

2) a length-and-weight-only sample (target sample size between 200 and 300).

For the complete dead-sample, monitors were required to assign a unique sample number to the fish on a small envelope and record date of capture, length (± 1 mm), weight (± 50 g), sex (male or female), and the mesh size it was captured with (did not occur in 1996 and 1997). Monitors recorded sexual maturity as either ‘immature’ or ‘mature’ (starting in 1996) where an ‘immature’ fish was either sexually immature or a mature individual that was resting and would not spawn in the current year, while a mature fish would spawn in the current year. Maturity was recorded in this manner to avoid difficulties in distinguishing between immature and resting gonads. Sagittal otoliths were collected for ageing purposes (with exception of 2011) and placed in a scale envelope. Starting in 2009, a small piece of caudal fin was taken from a proportion of the complete dead-sampled fish and placed in a 2 ml vial containing 95% ethanol for genetic mixed-stock fishery analysis.

For length-and-weight-only samples, the monitors were required to record the date of capture, and the length and weight of a fish. Length-and-weight-only samples were not taken between 1998 and 2001 (inclusive), and the mesh size used to capture the fish was only recorded starting in 2012.

Mouth of Lasard Creek

The annual monitoring program at Lasard Creek was initiated in 2011 and was modeled after the one at the Hornaday River. The main difference between these two programs is their timing which coincides with when harvesting occurred at respective locations. Although harvesting in the area of Lasard Creek usually began after ice break-up (approximately end of June), the monitoring program started approximately mid-July when catches of Arctic Char began to increase and lasted until early to mid-August. Thus, monitoring at Lasard Creek did not occur during the entire fishery at this location unlike the Hornaday. Typically, there was an approximately one to two week period when both monitoring programs would be simultaneously operating. Data collected at Lasard Creek were the same type as those collected at the Hornaday, i.e., total harvest, catch-effort and biological information (complete dead-sample, including genetics, and length-and-weight-only sample). Although collected subsequent to the final year used in the population assessment, the paucity of fecundity information justifies including the data in this report in order to document this life history parameter. Ovaries from a small number of current-year spawners were collected in 2014 and 2015 (n= 6 from Lasard

Creek, n= 1 from Hornaday River; approximately third week of July) to estimate fecundity. Ovaries were prepared, and oocytes fully counted and measured in a manner consistent with Chavarie et al. (2015).

Tippitiuyak (Tippi)

The monitor at Tippi was tasked with collecting information from fish captured in their own gill nets, typically beginning in mid-July until mid-August. There were no other harvesters in the immediate area to collect additional information from. Each Arctic Char was sampled for length, weight, sex, maturity, otoliths, and fin clip for genetic analysis. Additionally, each sample on the data sheet was identified as either a 'river char' (local name given to an Arctic Char considered to have morphological characteristics consistent with those originating from or harvested at the Hornaday River) or a 'blue char'.

SAMPLING AT THE HORNADAY RIVER PRIOR TO 1990

Biological sampling of the commercial harvest occurred in 1973, 1974, 1979, 1981, and 1983 and 1986. Data collected were length, weight, otoliths, sex (not all years and no maturity except for a subsample in 1986), and mesh size (Appendix 1. Table 1). Gill nets were used to harvest fish in all years except in 1986 when fish were commercially harvested while a conduit weir was deployed to attempt to estimate population abundance (MacDonnell 1986). The length data from the total sample of fish that were measured in the weir study (see MacDonnell 1986) was not included in this report because the raw data was not available. It is noted that the age data collected using the weir in 1986 was from a length stratified sample (five cm intervals) and not a random sample, hence some comparisons should be treated cautiously in certain instances (e.g., age frequency but not growth). Accordingly, the mortality estimate was not compared to other years. Due to the low sample size in 1973 (n= 66), these data were combined with 1974.

A test fishery was conducted presumably at the mouth of the Hornaday River in 1981 (August 26 to 29) using multi-mesh gill nets (38, 64, 89, 114, 149 mm mesh). Data collected were length, weight, otoliths, sex, and maturity (Appendix 1. Table 1). Although results are presented, comparisons to the time series from the Hornaday Char Monitoring Program and sampling of the commercial fishery should be treated cautiously due to the differences in gill net selectivity.

Arctic Char were sampled for length, weight, otoliths, and sex (not maturity) from the subsistence harvest (gill nets) in 1988 (August 25 to September 2) and 1989 (August 14 to 18) (Appendix 1. Table 1). Due to the low sample size in 1988 (n= 17), these data were combined with 1989 (n= 299). No CPUE data were available from fisheries investigations prior to 1990.

AGEING

Ageing of otoliths collected between 1990 and 2012 was conducted by the same reader where otoliths were aged whole under a dissecting microscope using a reflected light source with annuli interpreted according to Nordeng (1961). Otoliths collected from all locations in 2013 and from Tippi in 2012, were aged by a different reader who used a combination of preparation methods (whole and thin sectioned) to count annuli using a dissecting microscope (Leica model MZ 12.5) with a reflected light source. Otoliths collected prior to 1990 were presumably aged by the same reader who aged samples between 1990 and 2012 using the whole method.

ANALYSIS

The total number of Arctic Char harvested during the Hornaday River and Lasard Creek monitoring programs was tabulated from individual catch records. CPUE data was calculated separately for each sampling year at both sites and for each mesh size as the number of Arctic Char captured per 100 m of net fished for 24 hours in order to remain consistent with previously published reports (Harwood 1999, Harwood 2009). Non parametric statistics (Mann-Whitney or

Kruskal-Wallis) were used to evaluate for differences between or among mesh sizes that were used >5 times in a single year (see Zhu et al. [in prep.] for more robust analyses of catch-effort data).

Using the complete dead-sample data, length was examined separately for females and males captured among mesh sizes for samples size ≥10 for each sampling year. A Shapiro-Wilk test was used to determine whether the lengths among mesh sizes for both sexes were normally distributed. Testing for differences in length between or among mesh size depended on whether the data followed a parametric (analysis of variance/ two tailed t-test) or non-parametric (Mann-Whitney or Kruskal-Wallis) distribution. Differences between females and males were examined among mesh sizes using a t-test.

The lengths of the complete dead-sample and the length-and-weight-only sample were examined statistically in order to test for differences which would suggest a degree of bias between sampling methods. Because the length-and-weight-only samples among years did not follow a parametric distribution, non-parametric tests were used to examine for differences in length between sample types.

For each sampling year, length frequency distributions (10 mm bins) were created for females and males, and the total complete dead-sample. Additionally, length frequency distributions were created for the total complete dead-sample and length-and-weight only sample separately, and both sample types combined (to provide a more representative sample of harvested Arctic Char).

Some of the graphics illustrating the results of biological information were based on pooled mesh size information. This was done because:

1) the majority of sampling years for both females and males were no different among/ between mesh sizes,
2) there were relatively small differences in results (e.g., length) between mesh sizes, and
3) even among the larger mesh size, which mostly had low sample size to test statistically, the length values overlapped considerably with smaller mesh sizes.

The length-weight relationship was examined separately for females and males. Data were $\log_{10}$ transformed to linearize the relationship in order to use analysis of covariance (ANCOVA) to test for differences in weight between sexes using length as a covariate. The length-weight relationship was illustrated with a power regression and equation. Fulton's condition factor was calculated:

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

where W= weight in grams and L= fork length in millimeters, and plotted against sampling year. The proportion of females and males was calculated and statistically tested in each sampling year to determine if there was a departure from a binomial proportion of 0.5 (i.e., 1:1) (Rohlf and Sokal 1995) which could indicate differences in the relative number of males and females that have undertaken seaward migration in a given year. The frequency of 'mature' char was tabulated among age classes for both sexes to infer age-at-maturity because it was not possible to determine age-at-50%-maturity because the proportion of sexually immature and adult resting fish was not known.

Age frequency distributions were created for females, males, and for the total dead-sample separately for each sampling year. Kruskal-Wallis/ Mann-Whitney tests were used to examine for differences in age among/ between mesh with sufficient sample size for both females and males. Length-at-age scatterplots were generated for females and males for each sampling year (see Zhu et al. [in prep.] for additional growth information). Mean (± 95% C.I.) length at ages 6–9, which consistently constituted the majority (average= ~80%) of age classes among years, were plotted against sampling year in order to examine for inter-annual variation in growth.

To evaluate for changes over time, the relationships between year and CPUE (114 mm mesh only because it consistently had high sample size among all years), length, weight, condition and age for data collected between 1990 and 2013 were statistically evaluated using a local polynomial least squares fit (LOWESS) (Cleveland 1979) using R (R Development Core Team 2008).

The survival rate (S) was calculated for females, males, and the total sample captured at the mouth of the Hornaday River and Lasard Creek for each sampling year using the age data according to Robson and Chapman (1961):

$$S = \left(\frac{T}{\sum N + T - 1}\right)$$

$$T = \sum_{x=0}^{k} x(N_x)$$

where N= total number of fish fully recruited to the gear (modal age +1), and x is the sequential coded age (first age is 0, second is 1, third is 2, etc…) of those fully recruited. The standard error of S (SE_S):

$$SE_S = \sqrt{S\left(S - \frac{T-1}{\sum N + T - 2}\right)}$$

and 95% confidence intervals= S ± 1.96(SE_S) were also estimated. Annual mortality (A, 1-S) and instantaneous mortality (Z, -$\log_e$(1-A)) were calculated. Survival/ mortality was not estimated for females in 2007 and 2009, and for males in 2006 due to low sample size (<5) of modal age + 1 year-classes.

RESULTS

HORNADAY RIVER MONITORING

Fishery timing and gear type

In most years between 1990 and 2013, the monitoring program at the Hornaday started between July 28 and August 5 (Figure 3). However, the program started and finished early in 1998 (July 19–August 6), and started and finished late in 2007 (August 31–September 16). The duration of monitoring activities for most years was approximately three weeks, although efforts in 1999 occurred over a shorter amount of time (12 days).

Mesh sizes used in the fishery were 76 mm (3”; 1995 only), 114 mm (4.5”), 127 mm (5.0”), 133 mm (5.25”), 140 mm (5.5”) and 152 mm (6”), although the predominant mesh used were 114 and 127 mm, which accounted for 47.8% and 33.8%, respectively, of fish harvested between 1990 and 2013. While the 114 mm mesh was used in all years, the 127 mm mesh not used in 1994 and 2011. The length of the majority (92.7%) of gill nets deployed by harvesters measured 47.2 m (50 yards).

Number of harvesters and total catch

The number of harvesters that fished at the mouth of the Hornaday during the summer was relatively constant between 1996 and 2005, with the exception of 1998 (n= 9 harvesters), averaging 13 people per year (Figure 4). The majority of harvesters only set one net while multiple net sets were infrequent. A noticeable decline was evident starting in 2006 where an average of seven people fished per year (Figure 4).

The annual total number of Arctic Char harvested at the mouth of the Hornaday River between 1990 and 2004 was approximately 1,000, with the exception of 1990 and 1995–1998 where harvests were closer to 1,500 with a considerably higher catch in 1995 (2,113) (Table 1). After 2004, harvest declined to approximately between 200 and 350 fish per year, except in 2010 (n= 693) and 2013 (n= 492) (Table 1).

Catch-effort

CPUE varied among years ranging in median value from 4.2 (2006 and 2007) (note, a low CPUE would be expected in 2007 if monitoring occurred late in the year and may have missed the run) to 63.6 char/100 m/24 hours (2008) (Table 2) (Appendix 1. Figure 1). A considerable proportion of the catch-effort records between 1997 and 2013 were zero (23%). No statistically significant differences in CPUE were detected in the majority of sampling years among or between mesh sizes with the exception of 2005, 2004, 2002, 1999, 1998 and 1997 (Figure 5) (Appendix 2. Table 1). Pair-wise tests of mesh sizes for these six sampling years revealed no differences in CPUE between 114 and 127 mm mesh with the exception of 2005, 2004 and 1999. In 2004 and 1999, CPUE in 114 mm (median= 16.9 and 33.9, respectively) was greater than 127 mm (median= 4.2 and 12.7, respectively), while the opposite occurred in 2005 where CPUE in 114 mm (median= 4.2) was smaller than 127 mm (median= 8.5) mesh (Appendix 2. Table 2). All mesh sizes from the pair-wise testing >127 mm had significantly lower CPUE compared to 114 mm and were significantly lower than 127 mm in 2002, 1998 and 1997 (Table 2, Appendix 2. Table 2).

CPUE from the 114 mm mesh and year were weakly positively correlated with year between 1997 and 2013 (F= 6.7; d.f.= 1,936; r= 0.084; p= 0.01). The time-series trend from the most abundant and consistently used mesh sizes (114 and 127 mm) showed a moderately sinusoidal pattern with peaks in median values in 1999, 2000, 2003, 2008, and 2011–2013 with relatively low values in 1997, 2001, 2004–2007, and 2009–2010 (Figure 6).

Biological characteristics

Between 1990 and 2004, the number of fish that were completely dead-sampled averaged nearly 230 per year, while the prevalence of years with relatively small sample sizes (approximately <100) increased afterwards (2005–2007, 2009 and 2010) (Table 3). For both sample types, there have been increased inconsistencies in the number of Arctic Char sampled for biological information after 2003/ 2004 (Table 3).

Length

Length of males and females among mesh sizes and sampling years were mainly normally distributed (Appendix 2. Table 3). For females, the only instances where significant differences in length were detected between mesh sizes with sufficient sample size (see Table 3) was in 2002 (114 mm < 133 mm mesh), 1995 (114 mm < 127 mm mesh), 1991 (114 mm > 127 mm, and 127 mm < 140 mm mesh), and 1990 (114 mm < 127 mm, and 114 mm < 140 mm mesh). The difference in length between these mesh sizes were small, averaging 43 mm (range= 19–62 mm) (Table 4). For males, 1998 was the only year where length was significantly different between certain mesh sizes (114 mm < 140mm, and 127 < 140 mm mesh) (Appendix 2. Table 3), with differences equal to approximately 51 mm (Table 4).

Statistically significant, albeit minimal, differences in length between males and females in at least one mesh size were detected in 11 of the 22 years where mesh was measured. No difference between the sexes was detected in 1994, 1995, 2002, 2005–2009, and 2012 (Appendix 2. Table 4). Among years with significant differences, males were on average 27 mm (range= 8 to 44 mm) longer than females (Table 4). Only in 1990 was the average length of females (593 mm) significantly greater than males (545 mm) (127 mm mesh only).

The subsistence fishery harvested Arctic Char mainly between 524 and 610 mm in length. The length distribution of females and males demonstrated that a higher proportion of males, starting at approximately the 620–629 mm length interval, attained larger sizes compared to females (Figure 7) (32% male vs. 20% female were ≥620 mm based on total sample).

The lengths from the total complete dead-sample differed from the length-and-weight-only sample in most years between 2002 and 2013 (Appendix 2. Table 5). In the instances where there was a significant difference, the mean lengths of the complete dead-sample were always greater than the length-and-weight-only sample by an average of 24 mm (range= 16–31 mm) (see Table 4) with a greater proportion of smaller length classes observed in the length-and-weight-only sample (Figure 8).

A significant positive correlation was observed between year and fork length (F= 471.6; d.f.= 1,13139; r= 0.19; p< 0.0001) (Appendix 2. Figure 1). The time-series of length (both sample types combined) demonstrated relatively similar median lengths (range= 550–575 mm) and overlapping quartiles from 1990 to 2002 (Figure 9). Between 2003 and 2006, median length increased and distributions became increasingly skewed toward larger sizes. A decrease in median length accompanied by a greater distribution among smaller sizes occurred in 2007 up to 2009 and was followed by an increase in median length and greater proportion of larger sizes up to 2013 (Figure 8 and 9).

Weight and condition

The weight of Arctic Char harvested among years was predominantly between 1,500 and 3,000 g and highly correlated with length (Figure 10). ANCOVA revealed significant differences between males and females in 10 of the 24 sampling years (Table 5). In years 1993, 1997, 2001–2005, and 2010, males were heavier at a given length than females. The differences in the mean weight between the sexes in these years averaged 400 g (range= 173–515 g) (Figure 11). As length and weight were highly correlated, the time-series for weight demonstrated a similar pattern to length with relatively similar weights from 1990 to 2002, an increasing trend up to 2006, a decrease between 2007 and 2009 followed by an increase up to 2013 (Figure 11) (F= 449.9; d.f.= 1,13139; r= 0.217; p< 0.0001) (Appendix 2. Figure 1).

Among years, median condition ranged between 1.14 and 1.37 and followed a sinusoidal pattern between 1990 and 2013 (Figure 12) that has demonstrated an increasing trend over time (F= 584.5; d.f.= 1,13139; r= 0.206; p< 0.0001) (Appendix 2. Figure 1) (both sample types combined). Years where Arctic Char had relatively high condition (median K ≥1.3) were 1992, 1993, 1998–2001, 2008, and 2010–2012.

Age

The sample size of the age data used in the assessment was less than the complete dead-sample because either not all otoliths were readable or because of rare instances where no otoliths were found in the envelope (Table 6). The total number of samples was low (<100) among some of the more recent sampling years 2006, 2007, 2009 and 2011. With the exception of 1990 (female 114 mm < 140 mm, 127 mm < 140 mm; male 127 mm < 140 mm mesh), 1991 (female 114 mm > 127 mm, 127mm < 140 mm mesh), 1992 (both sexes 114 mm < 127 mm mesh), and 1998 (male 127 mm < 140 mm mesh), mesh size used by harvesters did not appear to have a considerable effect on the age of fish that were captured (Appendix 2. Table 6). Because there were few instances of differences between mesh used among years and the median differences in ages caught among mesh were relatively small, all age data from the various mesh sizes were pooled for females and males separately.

In six of the 24 sampling years (1995–1998, 2004 and 2012), significant differences in median age were detected between males and females (Table 7); however, the median ages were equal with the exception of 1995 where females caught were older than males (8 vs 6 years). In general, for both sexes, most age classes harvested in the fishery ranged between 5 and 8 years. The shape of age frequency distributions were typically either skewed towards younger ages (<7 years; e.g., 2007–2012) or bell-shaped (e.g., 1999), and similar between sexes (Figure 13).

Over time, median age was mainly distributed over a narrow range (5.5 to 8 years) (Figure 14). Although age was weakly correlated with year between 1990 and 2013 ($F= 4.1$; $d.f.= 1,5157$; $r= 0.028$; $p= 0.044$) (Appendix 2. Figure 1), a sinusoidal pattern was evident with peaks in age observed in 1993–1994 and 2005–2006 and a trough in 1996 and 2008. A low median age (range= 5.5–6 years) with distribution skewed towards younger ages was evident from 2007 to 2009. Since then, the frequency of individuals in older age classes has increased (Figure 13).

Among the more abundant ages, typically ≥6 years, different proportions of year classes were present in the fishery among years. Arctic Char 6 years of age were of low relative abundance in both 1993 and 2003 (~5%) but gradually increased in subsequent years to make up between 35 and 45% of the annual sample (Figure 15). Fish 7 years of age declined in their relative proportion from 1990 (30%) to 1996 (13%), gradually increased up to 40% and remained high in abundance until 2005 when a decline was evident from 2006 to 2009 (10%) followed by a dramatic increase in 2010 and 2012 (40%) (Figure15). Ages 8 and 9 showed a similar pattern among years where relatively high values were observed in the early-mid 1990s and early 2000s, and low values from approximately 1996–2002 and 2007–2012 (Figure 15).

Growth

Size-at-age plots revealed a wide range of sizes within an age class in many of the sampling years (Figure 16). In some years among abundant age classes (e.g., 6–8 years), a wide range of lengths (up to 400 mm) was observed (e.g., age 7 in the year 2000), while in other years there was a smaller range (65 mm range of age 7 in the year 2007). Males tended to reach larger sizes-at-age than females beginning at approximately 6 to 7 years of age and reached greater asymptotic lengths, however in some years there did not appear to be a considerable difference between the sexes (1992, 1997, 2003, and 2005) (Figure 16). Inter-annual mean length for age 6, 7 and 9 increased in the late 1990s and was followed by (starting in ~2000) either no considerable change in length (age 6 and 7) or a moderate/ slide decrease (age 9) (Figure 17). The mean length of age 8 did not did not change considerably among years, apart from outliers (lower values) in 2007 and 2008.

Mortality

Annual mortality increased from 1990 (0.55) to 2004 (0.74), apart from deviations in 1993, 1995 and 1996 (Table 9, Figure 18). From 2005 to 2008, mortality decreased to a low of (0.38) and has subsequently been increasing (0.69 in 2013). Females and males followed a similar pattern, although in most years differences in annual mortality between sexes were evident (e.g., 1990–1998, 2003–2013).

Sex ratio, maturity, and fecundity

Females and males were found in equal proportion in most years between 1990 and 2006, with the exception of 1992, 1994, 1995, 2000, 2001, and 2004 where males tended to outnumber females. Since 2007, with the exception of 2010, males have consistently outnumbered females, averaging approximately 66% of the sample (Figure 19).

The large majority of Arctic Char were categorized as 'immature', while those identified as 'mature' were observed only periodically and typically constituted <5% of the sample (Table 8). Only in 2006 and 2010 were higher numbers (>10) of mature individuals observed. When the combined sample of all mature individuals was examined among age classes, the majority of Arctic Char identified as 'mature' were between 6 (males) and 7 (females) years of age (Figure

20). Fecundity ranged between 1,770 and 3,081 eggs per fish and was positively correlated with length (r^2= 0.92) (Figure 21). The diameter of oocytes averaged (± 1 S.D.) 3.4 ± 0.34 mm.

SAMPLING AT THE HORNADAY RIVER PRIOR TO 1990

The length data from the commercial harvest was mainly distributed among size-classes similar to ones observed in the Hornaday Char Monitoring Program, although the proportion of relatively large-size char (≥600 mm) declined between 1973/74 (48%) and 1986 (14%) (note, the proportion of char >600 mm that were measured during the weir study, regardless of whether the fish was retained for the commercial harvest, accounted for <3% of the sample MacDonnell (1986)) (Figure 8 and 9). Similarly, the median weight of char also declined (Figure 11), although condition was >1 in most years (Figure 12). Age data from the commercial fishery demonstrated a similar range of ages to the Hornaday Char Monitoring Program although a higher proportion of younger ages (<6 years) was evident in 1973/74 and 1979, while a high proportion of older fish (>9 years) were observed in 1983 (Figure 14). The test fishery in 1981 captured mainly small/ young char (Figure 9) and is likely not a representative sample of the population. Annual mortality ranged between 0.43 and 0.54 with no evident trend between 1973/74 and 1983 (Figure 18).

The length/ weight information collected from the subsistence sample in 1988/89 was similar to monitoring data in 1990 while modal age was lower in 1990, although this data may not be comparable to any of the sampling years from the Hornaday Char Monitoring Program due to bias introduced by the relatively narrow window of sampling time (4 days). Sizes and ages were distributed mainly between 550–700 mm in length (Figure 8) and 6–10 years (Figure 14), respectively, with larger char harvested in the 127 mm (average= 605 mm) compared to the 114 mm (average= 513 mm) mesh (U= 4038, p> 0.001).

LASARD CREEK MONITORING

Fishery timing and gear type

Monitoring occurred from July 16 to August 8, 2011 (24 days), July 16 to August 9, 2012 (25 days), and July 19 to August 16, 2013 (29 days). Mesh sizes used by the harvesters at Lasard Creek were mainly 127 mm and 140 mm, which accounted for 75.9 and 20.3%, respectively, of all net sets monitored and 77.6 and 20.2%, respectively, of all fish completely dead-sampled between 2011 and 2013. Unlike the Hornaday, the 114 mm mesh size was infrequently used at Lasard Creek (3.8% of all net sets between 2011 and 2013). The lengths of nets used at Lasard were similar to the ones used at the Hornaday (47.2 m in 67.1% of all net sets among years).

Number of harvesters and total catch

The number of harvesters in 2011, 2012 and 2013 was 4, 12, and 5, respectively, which was typically lower than at the Hornaday where 8, 7 and 8 harvesters, respectively, were observed. All harvesters set only one net a day apart from one individual in 2011 that set two nets. The number of Arctic Char harvested in 2011, 2012, and 2013 was 606, 358, and 207, respectively, which was typically higher than the Hornaday where 368, 241 and 492, respectively, were harvested.

Catch-effort

Median CPUE did not vary considerably among sampling years and few instances of zero catch were observed (n= 8 of 158 net sets monitored over three sampling years) (Table 10). Where statistical comparisons were possible, no significant differences in CPUE were observed between the 140 mm and 127 mm mesh (U= 465, p= 0.06) (Figure 22) (Table 10). No significant differences in CPUE from the 127 mm mesh were detected among the three sampling years (X^2= 2.2, p= 0.3).

Median daily CPUE values started low at the beginning, increased by the end of August, decreased thereafter, and increased again by mid-August (Figure 23). However, in 2012, CPUE peaked by July 28, then decreased and remained stable up to the end of the monitoring program (Figure 23). Although differences in the mesh size used between the Hornaday River (mainly 114 mm) and Lasard Creek (mainly 127 mm) precluded robust analysis of catch rates between sites, the pattern in CPUE over time between locations when monitoring efforts overlapped revealed similar values (Figure 23). The peak median CPUE of both locations occurred on different dates yet their value was similar between sites in 2012 and 2013 (~100 Arctic Char/ 100 m/24 hours). Peak CPUE was higher at Lasard Creek in 2011 (144 versus 93 Arctic Char/ 100 m/24 hours).

Biological characteristics

The number of complete dead-sampled Arctic Char ranged between 289 and 110 while the length-and-weight only sample ranged between 43 and 104 individuals per year (Table 11). Given the low sample sizes among/ between mesh size in most sampling years statistical analyses were not performed to test for sex-specific effects of mesh size on length (Appendix 2. Table 7) or age (with the exception of 127 and 140 mm mesh in 2011).

Mean length among years for both sexes was relatively consistent ranging between 568 and 581 mm for females, and 589 and 626 mm for males in the 127 mm mesh size. While no differences in length were detected in 2012, mean length of males was significantly larger (albeit minimal, ~40 mm) than females captured in the 127 mm mesh in 2011 and 2013, and the 140 mm mesh in 2011 (Table 12). No differences in length from fish captured in the 127 mm mesh were detected among years for females (X^2= 3.6, p= 0.16) however significant differences were detected for males (X^2= 6.6, p= 0.038), with post-hoc testing demonstrating greater sizes in 2011 compared to 2012 (U= 1476, p= 0.02).

Length frequency distributions of harvested fish were unimodal with most individuals falling within the 520 and 720 mm size range; patterns were similar among years (Figure 24). Similar to the Hornaday, a greater proportion of males were observed among larger size-classes (>620 mm). No differences in length were found between the complete-dead sample and the length-and-weight-only sample, apart from 2013 where smaller-sized individuals were more prevalent in the length-and-weight-only sample (Figure 25, Appendix 2. Table 8).

With the exception of 2011 where median length (combined sampled types) of fish at Lasard was slightly greater than the Hornaday, demonstrated by the higher proportion of larger size fish (Figure 25) (U= 39992, p= 0.03), no differences between sites within sampling year were detected.

The paucity of data only allowed for examining for an effect of mesh size on age between the 127 and 140 mm mesh in 2011 (Table 13). An effect for females was observed where older ages were detected in the 140 mm mesh (U= 727, p= 0.01) (median age for 127 and 140 mm was 6 and 7 years, respectively), but not for males (U= 3507, p= 0.3). When examining for differences in age between females and males within a mesh size, no differences were found with the exception of the 127 mm mesh in 2011 which had significantly older males (U= 2200, p= 0.009).

Ages in the Lasard Creek sample ranged between 4 and approximately 10 years with modal values of 7 or 8 years for both females and males (Figure 26). A significantly older median age was observed in 2012 compared to 2011 (U= 11110, p= 0.001), and 2013 compared to 2012 (U= 6985 p< 0.001). Comparing ages between Hornaday River and Lasard Creek was only possible for 2012 and 2013 because no otoliths were collected in 2011 at the Hornaday. The age structure between sites appeared similar (Figure 26) and with no differences in median age in 2011 (U= 6674, p= 0.06) and 2013 (U= 18224, p= 0.24).

A significantly higher proportion of males (65.4%) was present in the sample at Lasard Creek in 2011, while the opposite was observed in 2012 (38.2%). In 2013, no significant difference in the proportions between sexes was detected. The results from 2012 and 2013 at the Lasard Creek area differed from the Hornaday where males were more abundant than females between 2011 and 2013. Similar to the Hornaday, the majority of fish examined for maturity were immature with only a few (≤5) mature females and males captured in 2012 (Table 8).

Annual mortality values for females in 2011, 2012, and 2013 were 0.69, 0.94, and 0.67 respectively, while those of males were 0.82, 0.79, and 0.55 respectively (Table 9). The mortality values from the Hornaday River in 2012 were similar (female= 0.91, male= 0.81) to Lasard Creek, while the 2011 mortality data from Lasard Creek were mid-way between the 2010 and 2012 values from the Hornaday (note that no data from 2011 were available for the Hornaday). In 2013, female mortality was similar between sites (~0.64) while a higher estimate for males was observed in the Hornaday River sample (0.76 vs. 0.55).

SAMPLING AT TIPPITIUYAK (TIPPI)

The harvest monitoring of Arctic Char at Tippi occurred between July 18 and August 9, 2012, and July 11 and August 18, 2013. Five net sets in 2012 yielded a total of eight char (five of these were identified as 'blue char') in 2012. In 2013, twelve net sets resulted in the capture of 62 char (48 of these were identified as 'blue char') (Table 10). The mesh size used to capture fish in 2012 was 114 mm while the 127 mm mesh was used in 2013. Information on CPUE was only recorded in 2013 and all net sets were of short duration (median= 3.5 hours, minimum and maximum= 1 and 9 hours) using both 49.7 m (75%) and 19.9 m (25%) long nets, yielding a median of 4 char per net set. Instances of zero catches were mistakenly not recorded. Bycatch species in 2013 (only year when this was recorded) were 'flounder' (presumed to be mainly *Liopsetta glacialis*, n= 7) and Broad Whitefish (*Coregonus nasus*) (n= 34).

The sample of 'blue char' from 2012 and 2013 taken at Tippi averaged 586 mm (range= 430–730 mm) in length and 2,266 g (range= 1,000–5,400 g) with the proportion between males (0.43) and females (0.57) not significantly different from 0.5. Five out of 20 males and two out of 27 females were identified as 'mature' while all others were 'immature'. The length frequency distribution of 'blue char' did not appear to differ considerably from 'river char' captured at Tippi (Figure 27), although the sample size of the latter was low (n= 11). Compared to the fish captured at mouth of the Hornaday River, the size distribution of 'blue char' appear to be very similar (Figure 27) with no significant differences in length (U= 9068, p= 0.69).

DISCUSSION

STOCK STATUS OF ARCTIC CHAR FROM THE HORNADAY RIVER

The trends in the catch-effort and biological data since the early 1990s for the population of Arctic Char from Hornaday River indicate stock status is stablegre The reported size of the harvest of anadromous Arctic Char by residents from Paulatuk between 2003 and 2013, which has varied between 479 and 1,793 (Lea unpubl. rep.), does not appear to have had a detrimental effect on the population suggesting the present level of harvest is likely sustainable. Zhu et al. (in prep.) also concluded the harvest level was sustainable (i.e., was below maximum sustainable yield) after using various population models to evaluate stock status. Some of the biological data from sampling years prior to 1990 indicated a decline in stock status between 1973/74 and 1986 and suggest the combined commercial and subsistence harvest during this time frame was not sustainable.

Relatively high median catch-effort observed in recent years (>2010) was accompanied with stable length distributions that demonstrated an increasing trend in the proportion of large-size (≥600 mm) char. It is noted that the increase in these sizes may be linked to the increase in the proportion of males in the sample (discussed below), which tend to attain larger sizes than females. Similarly, median weight has remained stable without any obvious signs of decline. However, weight was lower between 1973/74–1986 when the commercial harvest was highest compared to recent years. The interpretation that stable or increasing length and weight are indicative of a positive stock status is supported by Johnson (1989) who found reductions in sizes of char in the final stages of population decline in Nauyuk Lake. Similarly, Dempson et al. (2008) demonstrated that decline in weight was a strong indicator of intense harvest in a population of Arctic Char from northern Labrador, although the interrelationship between harvest and changing environmental conditions were unknown. Gallagher and Dick (2010) also observed an increase in the proportion of larger sizes and mean weight in the population of Arctic Char from the Sylvia Grinnell River that had experienced relatively high levels of harvest. Finally, a long-term monitoring program for Arctic Char in Tatik Lake (Kuujjua River) where it was determined that population status was stable also demonstrated temporal stability in length (Harwood et al. 2013).

Similar to length and weight, the median age remained relatively stable over time with the proportion of older aged individuals increasing in recent years. However some variability was seen in the frequency distributions which were skewed towards younger ages from 2007 to 2009. The shift towards younger ages in these years could indicate higher mortality of older char or a poor recruitment of juveniles ~6 to 7 years earlier. Shifts toward younger ages in heavily exploited populations of anadromous char have been observed by Johnson (1989) and Gallagher and Dick (2010), although age demographics appeared stable in other intensively harvested populations (e.g., Dempson et al. 2008). The length-at-age of Arctic Char from the Hornaday River has not changed considerably over the past ten years, although it has increased relative to the early 1990s (Harwood 2009), suggesting stability in the population. The sensitivity of this metric to exploitation has been demonstrated through other studies such as Dempson et al. (2008) who found modest increases and Gallagher and Dick (2010) who found more substantial increases in char populations after periods of relatively high harvests. The monitoring program for char in Tatik Lake demonstrated increases in length-at-age which appeared to be linked to enhanced environmental productivity (Harwood et al. 2013).

Instantaneous rate of mortality calculated using three population models (Zhu et al. [in prep.]) and the Robson-Chapman method (utilizing age data) resulted in a wide range of mortality estimates. Values from a depletion-based stochastic stock reduction analysis and a surplus production model were similar to one another among years and suggested the instantaneous mortality in 2013 was approximately 0.38. However, higher estimates were observed in most years using statistical catch-at-age and Robson-Chapman models, with mortality values in 2013 equal to 0.53 and 1.17, respectively. The Robson-Chapman model was highly variable over the time series and demonstrated an increasing trend in mortality in recent years, albeit still within range of past values, which stand in contrast to the decreasing trends observed in values estimated using the three population models. The high estimates of mortality from the Robson-Chapman method compared to the modelling are likely related to the gear used to collect the samples and the parameterization used in the model. The highly selective gillnets that predominantly consisted of a single mesh size may have not have been efficient in catching larger-sized/ older fish in the population resulting in an underrepresentation of older ages which would overestimate mortality (Jonsson et al. 2013). Furthermore, this could have been compounded with sampling and ageing issues (DFO 2016). Although the values observed using the Robson-Chapman method may not be accurate, higher instantaneous rates of mortality compared to other Arctic char populations is possible given that the Hornaday River stock undertakes long migrations in freshwater (up to 70 km), and rears and overwinters in riverine rather than the lacustrine habitat that is typically associated with this species. Such habitats tend to be more unpredictable (Wetzel 2001) and natural mortality is expected to be more variable/ higher (Jensen 1994).

BIOLOGICAL CHARACTERISTICS OF ARCTIC CHAR FROM THE HORNADAY RIVER

The biological characteristics of Arctic Char harvested from the Hornaday River suggested that length and weight were not considerably different between males and females, although males attained larger sizes and greater mass. Length-at-age comparison between sexes revealed that males grew faster than females in most sampling years starting at approximately age 6 to 7, which is presumably the age where at least ≥50% individuals in the stock attain sexual maturation. Divergence in growth rates between females and males upon reaching sexual maturity with males demonstrating a higher post-maturation growth rate is consistent with Grainger (1953), and Martin and Tallman (2013). Although sample size was small (n= 7), preliminary estimates of fecundity were lower compared to anadromous char in the eastern Canadian Arctic (~1,800–7,400 eggs, fork length ~450–665 mm) (Loewen et al. 2010) and northern Labrador (2,613–9,245 eggs, fork length 410–610 mm) (Dempson and Green 1985).

Harwood (2009) demonstrated a strong positive correlation between earlier timing of break-up of land-fast ice in East Amundsen Gulf and somatic condition factor of char from the Hornaday River. A similar observation was made for anadromous char from Tatik Lake (Harwood et al. 2013). Additionally, Harwood (2009) and Harwood et al. (2013) hypothesized that increases in growth rates of Arctic Char from the Hornaday River and Tatik Lake, respectively, since the 1990s were associated with increased feeding opportunities due to earlier break up. In most years since 2008, condition factor has been relatively high suggesting increased feeding opportunity. Currently, there is no evidence of a trend in poor feeding conditions which may negatively affect life history processes for anadromous Arctic Char in Darnley Bay.

Char from the Hornaday River stock are generally short-lived relative to other exploited stocks of Arctic Char with only 9.5% of fish reaching ages ≥9 years for the samples collected over the past five years (2009–2013). This is considerably lower compared to other populations throughout the Canadian Arctic such as Tatik Lake (49% based on three sampling years using 114 mm mesh subsistence gill nets; Harwood et al. 2013), Cambridge Bay (98% from Ekalluk River and 99% from Surrey River based on five sampling years using 140 mm mesh commercial gill nets; L.N. Harris, DFO, pers. comm.), Qasigiyat Lake (~86% based on five sampling years using 140 mm mesh gill nets; Martin and Tallman 2013), Isuituq (93% based on six sampling years using 140 mm mesh gill nets; Harris and Tallman 2010), Sylvia Grinnell River (76% based on two sampling years using mainly 102–140 mm mesh subsistence gill nets; Gallagher and Dick 2010), and Corbett Inlet (80% based on one year of sampling using 139–159 mm mesh commercial gill nets; Carder and Stewart 1989). One exception is the mixed stocks of commercially harvested char in northern Labrador, which are a combination of lacustrine and riverine stocks, where catches are dominated by char aged 7–10 years (Dempson et al. 2008). The age-related life history characteristics of the Hornaday River stock including growth rate, which is higher compared to other char stocks in the western Arctic (Harwood 1999), suggest the stock may not be as vulnerable to declines compared to other populations given the likely capacity for high productivity based on a risk assessment tool (productivity–susceptibility analysis) proposed by Roux et al. (2011b).

The incidence of significant differences in the proportion of males (higher) and females (lower) in the fishery have increased over time, particularly after 2006. In partially migratory salmonid populations, it is females that typically predominate among migrants and males among residents (Jonsson and Jonsson 1993, Hendry et al. 2004). In Arctic Char populations with both female and male residents coexisting with anadromous forms, sex ratios for residents are still biased towards males (Loewen et al. 2010). It has not been confirmed whether Arctic Char from the Hornaday River are partially anadromous, thereby exhibiting both resident and anadromous life histories, although land-locked and or possibly resident populations have been located in the watershed (Akluk Creek, Seven Islands Lake, and Rummy Lake) (MacDonnell 1996, MacDonnell 1997). Additionally, genetic data suggest the presence of populations of possibly landlocked/ resident char in the watershed which are distinct from anadromous char (Harris et al. 2016).

Near-equal proportions of males and females, which were mainly observed in the Hornaday stock between 1990 and 1999, have also been observed in Arctic Char from multiple populations (Johnson 1980), although a statistically significant greater proportion of males have been observed in some instances (e.g., one of three sampling years at the Sylvia Grinnell River had 59.3% males; Grainger 1953). The male bias in the Hornaday River samples suggests that anadromy has increasingly benefitted males over time, although the reason for this is unknown. Whether it is indicative of fewer females going to sea, a decrease in the number of males adopting a resident life history, an increased prevalence of consecutive-year skip migrations in females (highly unlikely), incorrect assignment of sex by monitors, a greater proportion of females during initial upstream movements (see Dempson and Green 1985) prior to the start of monitoring efforts, or a combination of these requires further study. However, interesting discrepancies regarding sex ratios were observed between the Hornaday River and Lasard Creek in two of three sampling years, with a greater proportion of females in 2012 and a similar proportion of both sexes in 2013 at Lasard Creek. The lack of a consistent annual pattern for sex ratios at Lasard Creek combined with the consistent pattern observed at the Hornaday River could indicate differences in the spatial/ temporal patterns of coastal movements between female and male char during the summer. The observed change in temporal pattern in sex ratios for this stock also underscores the importance of improving our understanding of the interrelationship of life history and sex ratios at all life stages (Ohms et al. 2014) for this stock.

Improvements can be made to the collection of biological information as monitors appear to have biased their sampling in some years. In a perfectly random situation one would expect the complete dead-sample and the length-and-weight-only sample to be no different from one another. This was not always the case as the complete-dead sample tended to favor larger/ older individuals. Examining the trend in length characteristics from the combination of both types of samples helps alleviate this issue as it is assumed that pooled values provide a more accurate representation of the sizes of fish that were harvested. Additionally, ensuring monitoring efforts are initiated at the start of the upstream migration and completed following the end of migration is paramount in evaluating temporal trends. Some years, 2007 in particular, may be limited for use in assessment because the program may have missed the main run of fish moving upstream thus biasing CPUE and samples of fish towards lower/ smaller values.

MONITORING PROGRAMS AT LASARD CREEK AND TIPPITIUYAK

The results of biological sampling conducted at Lasard Creek demonstrated that char from this location had similar biological characteristics (length, weight, age) to those from the Hornaday River with the exception of sex ratios in two of three years. This is not surprising given the results from Boguski et al. (2015) and Harris et al. (2016) which demonstrated that the vast majority of char harvested at Lasard Creek originated from the Hornaday River. Additionally, evidence of gene flow between the Brock and Hornaday stocks (Boguski et al. 2015, Harris et al. 2016) should result in morphological and demographic characteristics that do not differ substantially between populations (Taylor et al. 2006).

There were more people fishing/ higher total harvest at Lasard Creek compared to the Hornaday River in two of three monitoring years, indicating Lasard Creek can be a more important location for harvest during the summer (based solely on total harvest). Although tabulated harvest numbers from the monitoring programs at Lasard Creek and Hornaday River are not directly comparable to the tabulated reported estimates of harvest by Lea (unpubl. rep.), our results are consistent with Lea (unpubl. rep.) who demonstrated that the proportion of the total reported harvest for anadromous Arctic Char at Lasard Creek had increased relative to that of the Hornaday River, particularly after 2008. The decrease in the number of char harvested at the mouth of the Hornaday since approximately 2005 suggest that people shifted to catching char at locations other than the mouth of the Hornaday during the summer given the recommended harvest level of 1,700 was still consistently achieved (or close to it) every year.

Although catch-rates were similar/ comparable between sites, peaks in CPUE were sometimes higher at Lasard Creek suggesting this area may periodically be a more productive fishing location than the mouth of the Hornaday River. If fishing occurs earlier at Lasard Creek (relative to Hornaday River), CPUE is higher, and more people go to this location, it is possible that the community would achieve the summer harvest level sooner thereby leaving fewer fish available to harvest at the mouth of the Hornaday River thereby contributing to a reduced harvest at the Hornaday.

The harvest monitoring at Tippi has documented that catches of Arctic Char in this area of Darnley Bay are lower than the eastern coast which is consistent with Lea (unpubl. rep.), although catches of 'blue char' are reported to be more common at Tippi compared to other places during the summer (Tony Green, Paulatuk, pers. comm.). Samples of 'blue char' taken in 2012 and 2013 appeared to have similar length, weight, and age characteristics to Arctic Char sampled at the mouth of the Hornaday River. It was previously reported that 'blue char' were considerably larger than those identified as Arctic Char (Kavik-Axys 2012) however our preliminary results do not support this. Additionally, some residents of Paulatuk believe 'blue char' could be a species of Pacific salmon (Kavik-Axys 2012), however preliminary genetic results indicate that the 'blue char' samples collected in 2012 and 2013 belonged to the genus *Salvelinus* (R. Bajno, DFO, pers. comm). Further research on 'blue char' is required including a traditional knowledge study, morphometric/ meristic analysis, diet analyses, and a comprehensive genetic study.

CONCLUSION

The subsistence fishery for Arctic Char in Darnley Bay during the summer occurs predominantly along the eastern shores between the mouth of the Hornaday River and Lasard Creek using 114 mm and 127 mm stretch mesh gill nets set perpendicular from shore. The fishery primarily harvests char between 524 and 610 mm in length (1,500–3,000 g in weight), and 5 and 8 years of age that are mainly either non-spawning adults or juveniles. The community of Paulatuk has identified the Hornaday River stock of anadromous char as a high priority to collect standardized annual fisheries information for population assessment purposes in order to promote the sustainable harvest and conservation of the stock.

The long time-series (relative to other anadromous stocks of *S. alpinus* in the Arctic) of fisheries information collected by the Hornaday River Char Monitoring Program has provided data to evaluate temporal trends in catch-effort and biological parameters which has contributed to population modelling as a means to assess stock status and the effect of harvest (Zhu et al. [in prep.]). Monitoring data from recent years demonstrated increased relative abundance/ catch-effort and sizes/ weight of individual fish relative to early 2000s and 1970/80s (biological data only). The results suggest the stock is currently stable and that the present level of harvest is sustainable. These results are consistent with Zhu et al (in prep.) who determined the current level of harvest was sustainable.

Increasing the scope of data collection to other harvesting locations in recent years has improved our understanding of both the fishery for and biology of char in Darnley Bay. The similarity in stock composition between char captured at Hornaday River and Lasard Creek where the majority of the summer harvest occurs allows for more informed decisions regarding to how to move forward with future monitoring along the eastern coast of Darnley Bay. Continued biological sampling at both locations in the summer may be redundant, however one of the priorities for Lasard Creek should be ensuring accurate harvest reporting if this location becomes increasingly important for harvesting. Initiating the monitoring effort at Tippi in west Darnley Bay has provided preliminary data on 'blue char' which will improve our understanding regarding the diversity of *Salvelinus* in Darnley Bay with the addition of further samples to provide more comprehensive biological information (e.g., morphological data) in future years.

The harvest monitoring information has provided a valuable data set that has improved our understanding of the temporal variation in biology/ life history parameters of Arctic Char from the Hornaday River. Further work is necessary to examine abiotic factors (e.g., climate data, river discharge information, marine productivity) on vital rates such as recruitment, growth, and mortality. Continued support from the harvesters of Paulatuk and co-management bodies will ensure the success and continuation of the monitoring program(s) for Arctic Char.

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TABLES AND FIGURES

Table 1. Total catches of Arctic Char enumerated by the harvest monitoring programs at the mouths of the Hornaday River (1990–2013) and Lasard Creek (2011–2013), and at Tippitiuyak (2012–2013) during the summer.

Year	Hornaday	Lasard	Tippitiuyak
2013	492	207	62[a]
2012	241	358	8[b]
2011	368	606	
2010	693		
2009	271		
2008	394		
2007	214		
2006	121		
2005	358		
2004	1,000		
2003	929		
2002	753		
2001	881		
2000	898		
1999	746		
1998	1,210		
1997	1,311		
1996	1,493		
1995	2,113		
1994	900		
1993	790		
1992	938		
1991	1,068		
1990	1,383		

[a] n= 48 ‘blue char’; 14 ‘river’ Arctic Char
[b] n= 5 ‘blue char’; 3 ‘river’ Arctic Char

Table 2. Median catch-per-unit-effort of Arctic Char (# Arctic Char/100 m/24 hours), with number of net sets in brackets, harvested at the mouth of the Hornaday River among mesh sizes and sampling years.*

Year	Mesh (mm)					Total
	114	127	133	140	152	
2013	25.4 (40)	12.7 (9)				25.4 (49)
2012	40.0 (15)	50.8 (7)				44.5 (22)
2011	40.3 (34)					40.3 (34)
2010	10.9 (46)	9.5 (95)		8.5 (36)	0 (7)	8.9 (184)
2009	9.3 (32)	10.6 (24)		14.5 (3)		10.2 (59)
2008	63.6 (22)	23.3 (4)				63.6 (26)
2007	4.2 (57)	4.2 (9)	8.5 (17)		14.8 (5)	4.2 (88)
2006	5.1 (33)	4.2 (30)	4.2 (22)	4.2 (2)	6.8 (16)	4.2 (103)
2005	4.2 (48)	8.5 (51)	21.2 (6)			8.5 (105)
2004	16.9 (55)	4.2 (92)		8.5 (92)		8.5 (238)
2003	27.5 (24)	12.7 (64)	0 (15)	21.2 (21)		16.9 (124)
2002	16.9 (46)	25.4 (52)	4.2 (21)	4.2 (14)		16.9 (133)
2001	8.5 (146)	12.7 (55)				12.7 (201)
2000	14.8 (75)	14.3 (20)				14.8 (95)
1999	33.9 (47)	12.7 (15)		8.5 (61)		12.7 (123)
1998	21.2 (56)	21.2 (87)		10.6 (74)		16.9 (217)
1997	12.7 (161)	12.0 (188)		4.2 (52)		8.5 (401)

114 mm = 45”; 127 mm = 5.0”, 133 mm = 5.25”, 140 mm = 5.5”, 152 mm = 6.0”
* no CPUE data available prior to 1997.

Table 3. Number of Arctic Char harvested at the mouth of the Hornaday River among years that were complete dead-sampled, sampled for length-and-weight-only, and the combined total of both sample types. The complete dead-sample was divided between females / males (F / M) among gill net mesh sizes.

Year	Complete dead-sample									Length and Weight	Total
	Mesh (mm)							Total	Total		
	114	127	133	140	152	?	NR	F/M	Complete		
2013	75 / 106	1 / 11		4 / 3				80 / 120	200	200*	400
2012	32 / 54	36 / 39						68 / 93	161	80*	241
2011	29 / 59							29 / 59	88	139	227
2010	19 / 23	34 / 48		28 / 22			1	81 / 93	175	288	463
2009	2 / 3	7 / 36		0 / 4				9 / 43	52	155	207
2008	54 / 90							54 / 90	144	222	366
2007	7 / 17	7 / 6	4 / 8				1	18 / 31	50	8	58
2006	18 / 14	10 / 0	4 / 2		2 / 4	0 / 1		34 / 21	55	63	118
2005	22 / 18	31 / 36						53 / 54	107	96	203
2004	30 / 52	30 / 52		27 / 49				87 / 153	240	89	329
2003	37 / 47	35 / 33	6 / 8	0 / 6		11 / 3		89 / 97	186	348	534
2002	34 / 37	35 / 48	23 / 16	1 / 4				93 / 105	198	363	561
2001	64 / 110	39 / 62						103 / 172	275	0	275
2000	88 / 134	26 / 43						114 / 177	291	0	291
1999	61 / 67	10 / 13		3 / 3			2	74 / 73	159	0	159
1998	18 / 23	47 / 49		21 / 25				86 / 97	183	0	366
1997								105 / 100	205	326	736
1996								85 / 103	188	347	723
1995	87 / 73	82 / 57						169 / 130	299	640	1238
1994	115 / 92			7 / 0				122 / 92	214	176	604
1993	8 / 11	54 / 51		48 / 47				110 / 109	219	571	1009
1992	38 / 35	43 / 88		10 / 5				91 / 128	219	721	1159
1991	15 / 28	53 / 57		48 / 53		3 / 3		119 / 141	260	722	1242
1990	62 / 40	11 / 18		32 / 29				105 / 87	192	787	1171

?= unknown mesh size
NR= not recorded
Mesh size not recorded in 1996 and 1997.
*2013: 23.6% in 114 mm; 19.3% in 127 mm; 70.0% unknown mesh size
*2012: 90% in 114 mm; 10% in 127 mm.

Table 4. Mean length (1 standard deviation in brackets) of Arctic Char harvested at the mouth of the Hornaday River among years that were complete dead-sampled, sampled for length-and-weight-only, and the combined total of both sample types. The complete dead-sample was divided between females / males (F / M) among mesh sizes. Statistically significant differences between females and males are highlighted in grey (see Appendix 2. Table1).

Year	Complete dead-sample							Length and weight	Total
	Mesh size (mm)					Total	Total		
	114	127	133	140	152	F / M	complete		
2013	585 / 612	556 / 620		615 / 650		586 / 614	603	587	595
	(45 / 69)	(- / 69)		(41 / 14)		(45 / 68)	(61)	(59)	(61)
2012	584 / 580	594 / 592				589 / 585	587	567	580
	(51 / 72)	(39 / 52)				(45 / 64)	(57)	(50)	(55)
2011	591 / 611	582 / 627				590 / 613	606	584	592
	(27 / 47)	(11 / 55)				(26 / 48)	(43)	(49)	(48)
2010	585 / 593	569 / 601		581 / 589		577 / 596	587	571	577
	(49 / 74)	(39 / 53)		(63 / 45)		(51 / 57)	(55)	(64)	(61)
2009	671 / 597	555 / 578		- / 546		581 / 576	577	547	555
	(14 / 65)	(38 / 39)				(61 / 41)	(44)	(55)	(54)
2008	555 / 560					555 / 560	558	527	539
	(58 / 65)					(58 / 65)	(62)	(55)	(60)
2007	508 / 536	533 / 571	564 / 606			530 / 561	546	533	544
	(68 / 56)	(37 / 39)	(40 / 80)			(54 / 66)	(67)	(58)	(65)
2006	590 / 591	592 / -	611 / 624		651 / 660	596 / 604	599	603	601
	(61 / 81)	(52 / -)	(65 / 97)		(56 / 65)	(58 / 81)	(67)	(98)	(85)
2005	580 / 609	588 / 612				584 / 611	598	600	599
	(42 / 53)	(45 / 57)				(43 / 55)	(51)	(60)	(56)
2004	590 / 614	590 / 617		603 / 632		594 / 621	611	611	611
	(51 / 64)	(29 / 59)		(44 / 65)		(42 / 63)	(58)	(65)	(60)
2003	590 / 620	605 / 630	641 / 610	- / 676		597 / 624	611	583	593
	(45 / 59)	(43 / 61)	(59 / 50)	(- / 71)		(47 / 61)	(56)	(51)	(54)
2002	582 / 593	594 / 604	618 / 606	624 / 599		596 / 600	598	571	581
	(79 / 67)	(55 / 63)	(62 / 36)	(- / 80)		(67 / 61)	(64)	(64)	(65)
2001	561 / 580	566 / 592				563 / 584	576	NA	576
	(39 / 74)	(56 / 66)				(46 / 71)	(64)		(64)
2000	558 / 571	566 / 592				557 / 577	569	NA	569
	(65 / 77)	(72 / 57)				(67 / 73)	(71)		(71)
1999	554 / 583	589 / 583		479 / 457		556 / 578	598	NA	568
	(65 / 72)	(62 / 60)		(94 / 130)		(68 / 75)	(72)		(72)
1998	528 / 543	555 / 545		554 / 595		549 / 557	554	NA	554
	(51 / 74)	(70 / 95)		(85 / 66)		(70 / 86)	(79)		(79)
1997						542 / 569	555	546	549
						(58 / 71)	(66)	(53)	(58)
1996						558 / 556	556	565	562
						(64 / 92)	(80)	(84)	(83)
1995	570 / 592	593 / 586				581 / 589	585	551	562
	(65 / 91)	(68 / 96)				(67 / 93)	(79)	(90)	(88)
1994	558 / 574			596 / -		561 / 574	567	569	568
	(62 / 90)			(44 / -)		(62 / 90)	(76)	(92)	(83)
1993	550 / 594	557 / 556		567 / 584		561 / 572	566	573	571
	(39 / 29)	(47 / 105)		(50 / 71)		(48 / 87)	(70)	(59)	(62)
1992	546 / 566	572 / 574		532 / 532		556 / 570	564	557	559
	(70 / 51)	(52 / 54)		(76 / 42)		(64 / 53)	(58)	(60)	(59)
1991	583 / 598	542 / 588		556 / 569		551 / 580	567	540	547
	(67 / 79)	(52 / 83)		(54 / 52)		(57 / 73)	(68)	(65)	(67)
1990	536 / 560	593 / 545		598 / 616		561 / 575	567	552	555
	(52 / 98)	(65 / 52)		(62 / 113)		(64 / 100)	(82)	(79)	(80)

NA= not applicable; sample not taken.

Table 5. Mean (1 standard deviation in brackets) weight of females, males and the total sample of Arctic Char captured at the mouth of the Hornaday River in each sampling year and the test statistic and p-value of analysis of covariance use to determine whether weight, using length as a covariate, was significantly different (highlighted in grey) between females and males.

Year	Female	Male	Total*	Test statistic and p-value
2013	2,291 (549)	2,715 (866)	2,469 (771)	F= 3.4; d.f.= 1,197; p= 0.07
2012	2,671 (593)	2,777 (958)	2,581 (788)	F= 2.9; d.f.= 1,158; p= 0.09
2011	2,749 (412)	3,171 (745)	2,682 (654)	F= 1.8; d.f.= 1,85; p= 0.19
2010	2,583 (783)	3,007 (906)	2,695 (902)	F= 7.7; d.f.= 1,171; p= 0.006
2009	2,384 (950)	2,268 (586)	2,063 (603)	F= 0.003; d.d.= 1,49; p= 0.9
2008	2,365 (763)	2,431 (950)	2,151 (819)	F= 0.04; d.f.= 1,141; p= 0.84
2007	1,887 (589)	2,089 (705)	1,969 (671)	F= 1.2; d.f.= 1,46; p= 0.28
2006	2,677 (854)	2,853 (988)	2,882 (1078)	F= 0.3; d.f.= 1,52; p= 0.59
2005	2,241 (427)	2,756 (712)	2,561 (679)	F= 14.7; d.f.= 1,104; p< 0.001
2004	2,411 (499)	2,884 (785)	2,722 (774)	F= 12.0; d.f.= 1,237; p= 0.001
2003	2,442 (624)	2,929 (880)	2,503 (688)	F= 9.0; d.f.= 1,183; p= 0.003
2002	2,482 (741)	2,655 (798)	2,364 (830)	F= 7.8; d.f.= 1,195; p= 0.006
2001	2,366 (588)	2,785 (985)	2,628 (880)	F= 5.2; d.f.= 1,272; p= 0.02
2000	2,305 (925)	2,622 (1,137)	2,498 (1,068)	F= 0.5; d.f.= 1,288; p= 0.48
1999	2,457 (862)	2,853 (1,125)	2,662 (1,024)	F= 0.3; d.f.= 1,154; p= 0.56
1998	2,316 (846)	2,513 (1,049)	2,420 (962)	F= 1.97; d.f.= 1,180; p= 0.16
1997	1,830 (586)	2,258 (926)	1,970 (689)	F= 12.6; d.f.= 1,202; p< 0.001
1996	2,118 (759)	2,249 (1,184)	2,288 (1,090)	F= 1.5; d.f.= 1,185; p= 0.22
1995	2,482 (744)	2,736 (1,196)	2,392 (1,061)	F= 1.1; d.f.= 1,293; p=0.29
1994	2,305 (679)	2,583 (1,167)	2,457 (1,025)	F= 0.05; d.f.= 1,211; p= 0.83
1993	2,238 (569)	2,607 (923)	2,511 (746)	F= 5.8; d.f.= 1,215; p= 0.02
1992	2,204 (714)	2,415 (758)	2,279 (747)	F= 3.1; d.f= 1,216; p= 0.08
1991	2,068 (671)	2,465 (954)	2,060 (746)	F= 1.3; d.f.= 1,257; p= 0.26
1990	2,219 (722)	2,537 (1215)	2,203 (915)	F= 0.2; d.f.= 1,189; p= 0.64

*Complete dead-sample, and length-and-weight-only sample combined.

Table 6. Number of otoliths of female / male (F / M) Arctic Char harvested at the mouth of the Hornaday River that were aged among gill net mesh sizes and sampling years.

Year	Mesh size							Total	Total
	114	127	133	140	152	?	NR	F / M	complete
2013	73 / 105	1 / 11		4 / 3				78 / 117	195
2012	31 / 50	35 / 38						66 / 88	154
2011									0
2010	19 / 23	33 / 45		27 / 22			1	79 / 90	170
2009	2 / 2	7 / 36		0 / 4				9 / 42	51
2008	52 / 86							52 / 86	138
2007	5 / 16	4 / 6	0 / 5				1	9 / 27	36
2006	16 / 14	10 / 0	4 / 2		2 / 4	0 / 1		32 / 21	53
2005	22 / 18	31 / 34						53 / 52	105
2004	30 / 51	30 / 52		27 / 48				87 / 151	238
2003	37 / 47	33 / 32	6 / 8	0 / 5		11 / 3		83 / 95	178
2002	34 / 37	35 / 48	23 / 14	1 / 4				92 / 103	195
2001	60 / 108	39 / 62						99 / 170	269
2000	87 / 129	26 / 43						113 / 172	285
1999	57 / 64	10 / 13		3 / 3			1	70 / 80	151
1998	16 / 22	43 / 47		19 / 24				78 / 93	171
1997								90 / 94	184
1996								81 / 98	179
1995	75 / 68	76 / 42						151 / 110	261
1994	96 / 84			7 / 0				103 / 84	187
1993	7 / 10	47 / 44		40 / 45				94 / 99	193
1992	34 / 32	37 / 81		8 / 5				79 / 118	197
1991	13 / 27	50 / 48		47 / 49				112 / 126	238
1990	55 / 36	9 / 17		27 / 25				91 / 78	169

?= unknown mesh size

NR= not recorded

Table 7. Median age of female, male and the total sample Arctic Char captured at the mouth of the Hornaday River in each sampling year and the test statistic and p-value of Mann-Whitney test used to determine if female and male ages were significantly different (highlighted in grey).

Year	Female	Male	Total	Test statistic, p-value
2013	8	8	8	U= 3954, p= 0.1
2012	7	7	7	U= 3465, p= 0.02
2010	7	6.5	7	U= 3193, p= 0.2
2009	6	6	6	U= 141, p= 0.2
2008	6	5	5.5	U= 1833, p= 0.06
2007	6	6	6	U= 95, p= 0.3
2006	8	8	8	U= 324, p= 0.8
2005	7	8	8	U= 1283, p= 0.5
2004	8	8	8	U= 5149, p= 0.004
2003	7	8	8	U= 3585, p= 0.3
2002	7	7	7	U= 4383, p= 0.3
2001	7	6	6	U= 7657, p= 0.2
2000	7	7	7	U= 8666, p= 0.1
1999	6	6	6	U= 2774, p= 0.9
1998	7	7	7	U= 3001, p= 0.042
1997	6	6	6	U= 3401, p= 0.014
1996	6	6	6	U= 3010, p= 0.004
1995	8	6	7	U= 6142, p< 0.001
1994	8	8	8	U= 3806, p= 0.15
1993	8	8	8	U= 4077, p= 0.12
1992	7	7	7	U= 4260, p= 0.28
1991	7	7	7	U= 6576, p= 0.35
1990	7	7	7	U= 3465, p= 0.79

Table 8. Frequency of maturity stage+ for female and male Arctic Char sampled at the mouth of the Hornaday River and the Lasard Creek area among sampling years.

Year	Hornaday River				Lasard Creek			
	Female		Male		Female		Male	
	Immature	Mature	Immature	Mature	Immature	Mature	Immature	Mature
2013	80	0	120	0	91*	0	108	0
2012	68	0	93	0	63	5	40	2
2011	29	0	59	0	100	0	189	0
2010	68	13	73	20				
2009	9	0	43	0				
2008	51	2	89	1				
2007	18	0	29	3				
2006	14	20	20	1				
2005	53	0	52	2				
2004	86	1	152	1				
2003	88	1	97	0				
2002	93	0	105	0				
2001	99	4	170	2				
2000	113	1	169	8				
1999	74	0	84	0				
1998	81	5	94	3				
1997	102	3	92	8				
1996	81	4	101	2				

[+] *Immature= either a resting adult or a juvenile; Mature= current-year-spawner*

** Data of 90 females were originally recorded as 'mature' and was likely made in error.*

Table 9. Robson-Chapman estimates of survival (S) (95% confidence intervals in brackets), annual mortality (A), and instantaneous mortality (Z) of females, males, and the total sample of Arctic Char collected by the harvest monitors at the mouth of the Hornaday River and Lasard Creek area among sampling years. Low sample size of females in 2007 and 2009, and of males in 2006 precluded analyses. No 2011 Hornaday age data were available.

Year	Hornaday River									Lasard Creek								
	Female			Male			Total			Female			Male			Total		
	S	A	Z	S	A	Z	S	A	Z	S	A	Z	S	A	Z	S	A	Z
2013	0.40 (0.2)	0.60	0.92	0.24 (0.16)	0.76	1.43	0.31 (0.12)	0.69	1.34	0.33 (0.17)	0.67	1.11	0.45 (0.18)	0.55	0.80	0.42 (0.12)	0.58	0.87
2012	0.09 (0.12)	0.91	2.44	0.19 (0.17)	0.81	1.66	0.13 (0.10)	0.87	2.01	0.06 (0.11)	0.94	2.89	0.21 (0.22)	0.79	1.54	0.12 (0.11)	0.88	2.11
2011										0.31 (0.23)	0.69	1.16	0.18 (0.11)	0.82	1.69	0.22 (0.10)	0.78	1.50
2010	0.43 (0.21)	0.57	0.83	0.33 (0.33)	0.67	1.10	0.43 (0.27)	0.57	0.85									
2009				0.43 (0.27)	0.57	0.85	0.45 (0.22)	0.55	0.80									
2008	0.63 (0.11)	0.37	0.46	0.57 (0.10)	0.43	0.55	0.62 (0.07)	0.38	0.48									
2007				0.67 (0.25)	0.33	0.41	0.55 (0.22)	0.45	0.60									
2006	0.31 (0.26)	0.69	1.18				0.26 (0.18)	0.74	1.34									
2005	0.43 (0.15)	0.57	0.84	0.53 (0.18)	0.47	0.63	0.42 (0.10)	0.58	0.86									
2004	0.36 (0.30)	0.64	1.01	0.04 (0.03)	0.96	3.15	0.22 (0.10)	0.78	1.50									
2003	0.17 (0.11)	0.83	1.77	0.81 (0.09)	0.19	0.21	0.24 (0.16)	0.76	1.42									
2002	0.30 (0.13)	0.70	1.21	0.38 (0.14)	0.63	0.98	0.35 (0.09)	0.65	1.04									
2001	0.30 (0.21)	0.70	1.20	0.32 (0.09)	0.68	1.14	0.31 (0.07)	0.69	1.18									
2000	0.28 (0.15)	0.72	1.28	0.32 (0.08)	0.68	1.14	0.34 (0.06)	0.66	1.09									
1999	0.38 (0.14)	0.62	0.97	0.34 (0.13)	0.66	1.08	0.36 (0.09)	0.64	1.01									
1998	0.20 (0.09)	0.80	1.61	0.37 (0.15)	0.63	0.99	0.36 (0.10)	0.64	1.02									
1997	0.45 (0.11)	0.55	0.79	0.33 (0.14)	0.67	1.12	0.40 (0.09)	0.60	0.91									
1996	0.65 (0.10)	0.35	0.43	0.53 (0.13)	0.47	0.63	0.58 (0.10)	0.42	0.54									
1995	0.17 (0.13)	0.83	1.76	0.38 (0.12)	0.62	0.96	0.23 (0.11)	0.77	1.46									
1994	0.28 (0.13)	0.72	1.29	0.53 (0.10)	0.47	0.64	0.38 (0.10)	0.62	0.97									
1993	0.22 (0.17)	0.78	1.53	0.30 (0.14)	0.70	1.20	0.27 (0.11)	0.73	1.31									
1992	0.55 (0.13)	0.45	0.59	0.33 (0.13)	0.67	1.12	0.43 (0.06)	0.57	0.84									
1991	0.74 (0.05)	0.26	0.30	0.44 (0.16)	0.56	0.81	0.45 (0.05)	0.55	0.80									
1990	0.77 (0.06)	0.23	0.26	0.48 (0.13)	0.52	0.73	0.45 (0.09)	0.55	0.80									

Table 10. Median catch-per-unit-effort of Arctic Char (# Arctic Char/ 100 m/ 24 hours), with number of net sets in brackets, at the Lasard Creek area among mesh sizes and sampling years.

Year	Mesh size (mm)			Total
	114	127	140	
2013		26.2 (25)	25.0 (3)	25.6 (28)
2012		32.8 (34)	30.6 (8)	32.8 (42)
2011	73.5 (6)	26.2 (21)	56.2 (21)	36.2 (88)

Table 11. Number of Arctic Char harvested at the Lasard Creek area among years that were complete dead-sampled, sampled for length-and-weight-only, and the combined total of both sample types. The complete dead-sample was divided between females / males (F / M) among gill net mesh sizes.

Year	Complete dead-sample					Length and weight	Total
	Mesh size (mm)			Total F / M	Total complete		
	114	127	140				
2013		91 / 108		91 / 108	200	43	243
2012		64 / 37	4 / 5	68 / 42	110	103	213
2011	4 / 9	58 / 106	38 / 74	100 / 189	289	104	393

Table 12. Mean length (1 standard deviation in brackets) of Arctic Char harvested from the Lasard Creek area among years that were complete dead-sampled, sampled for length-and-weight-only, and the combined total of both sample types. The complete dead-sample was divided between females / males (F / M) among mesh sizes. Statistically significant differences between females and males with adequate sample size (n>10) are highlighted in grey.

Year	Complete dead-sample					Length and weight	Total
	Mesh size (mm)			Total F / M	Total complete		
	114	127	140				
2013		581 / 626 [a]		581 / 626	605	544	594
		(45 / 62)		(45 / 62)	(59)	(72)	(65)
2012		573 / 589 [b]	563 / 632	573 / 594	581	588	584
		(61 / 77)	(69 / 50)	(61 / 75)	(67)	(59)	(63)
2011	550 / 585	568 / 610 [c]	585 / 624 [d]	574 / 614	600	599	600
	(20 / 44)	(39 / 61)	(61 / 62)	(49 / 61)	(60)	(54)	(58)

[a] t (197)= -5.7, p> 0.001
[b] U= 1047, p= 0.33
[c] U= 1511, p> 0.001
[d] U= 731, p> 0.001

Table 13. Number of otoliths and median age in brackets of female / male (F / M) Arctic Char harvested at the Lasard Creek area that were aged among gill net mesh sizes and sampling years.

Year	Mesh size			Total F / M	Total complete
	114	127	140		
2013*		91 / 108		91 / 108	200
		(8 / 8)		(8 / 8)	(8)
2012		60 / 31	4 / 5	64 / 36	100
		(7 / 7)	(7 / 7)	(7 / 7)	(7)
2011	4 / 9	56 / 103	37 / 74	97 / 186	283
	(7 / 6)	(6 / 7)	(7 / 7)	(7 / 7)	(7)

* one otolith sample did not have sex information

Figure 1. Location where Hornaday and Brock rivers, known to provide critical freshwater habitat for anadromous Arctic Char populations, drain into Darnley Bay, and the site where harvest monitoring at the mouth of the Hornaday River and Lasard Creek, and Tippitiuyak (Tippi) occur. Dashed line is the border of Tuktut Nogait National Park. Images provided by Google Earth.

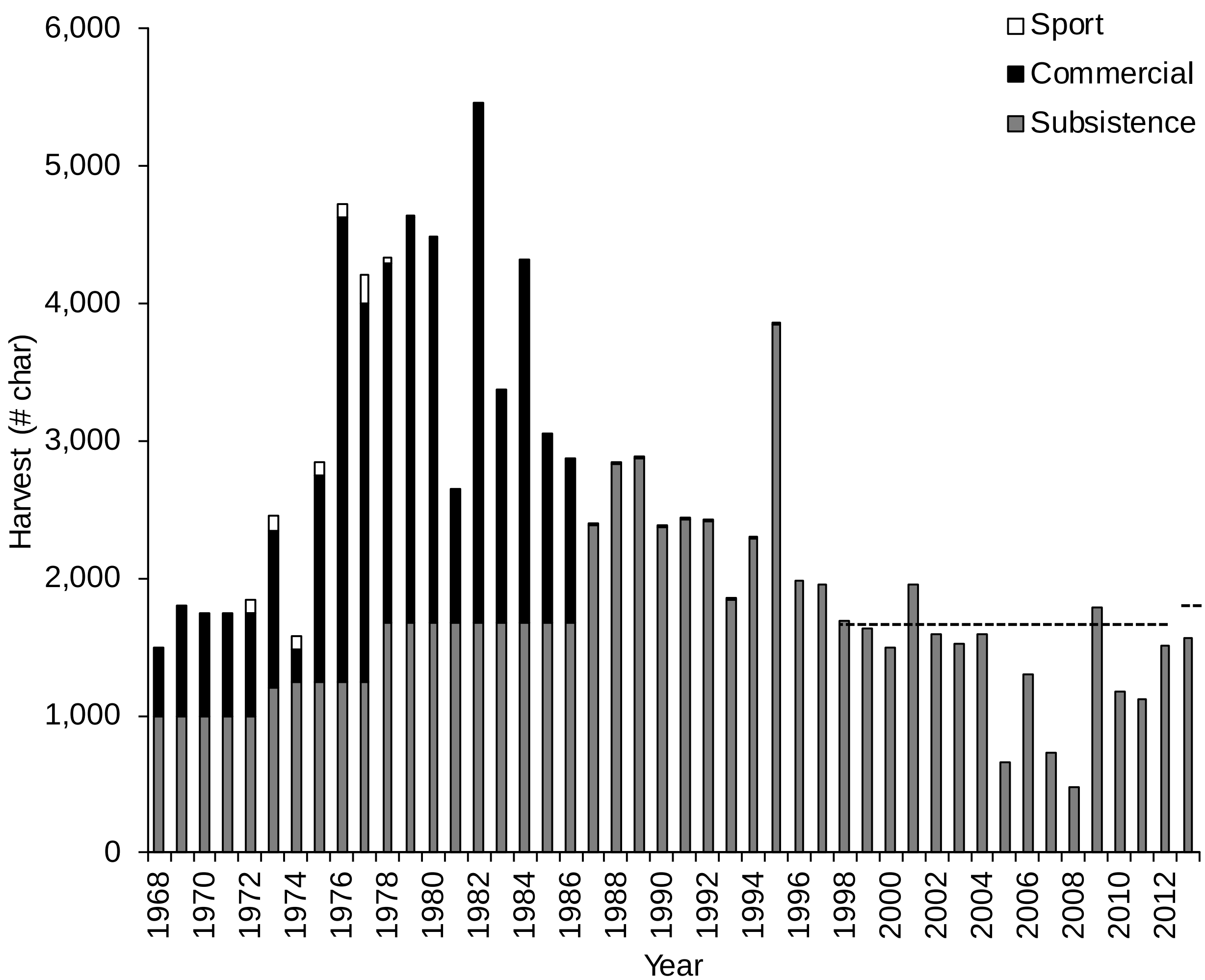


Figure 2. Estimated harvest of anadromous Arctic Char from 1968 to 2013. Dashed line is the voluntary total allowable harvest: 1,700 annually fish between 1998 and 2012, and 1,800 fish in 2013. Note: the commercial quota between 1968 and 1973= 2,300 kg (~1,000 char); 1974 and 1975= 4,500 kg (~1,950 char); 1976 to 1986= 6,800 kg (~2,950 char).

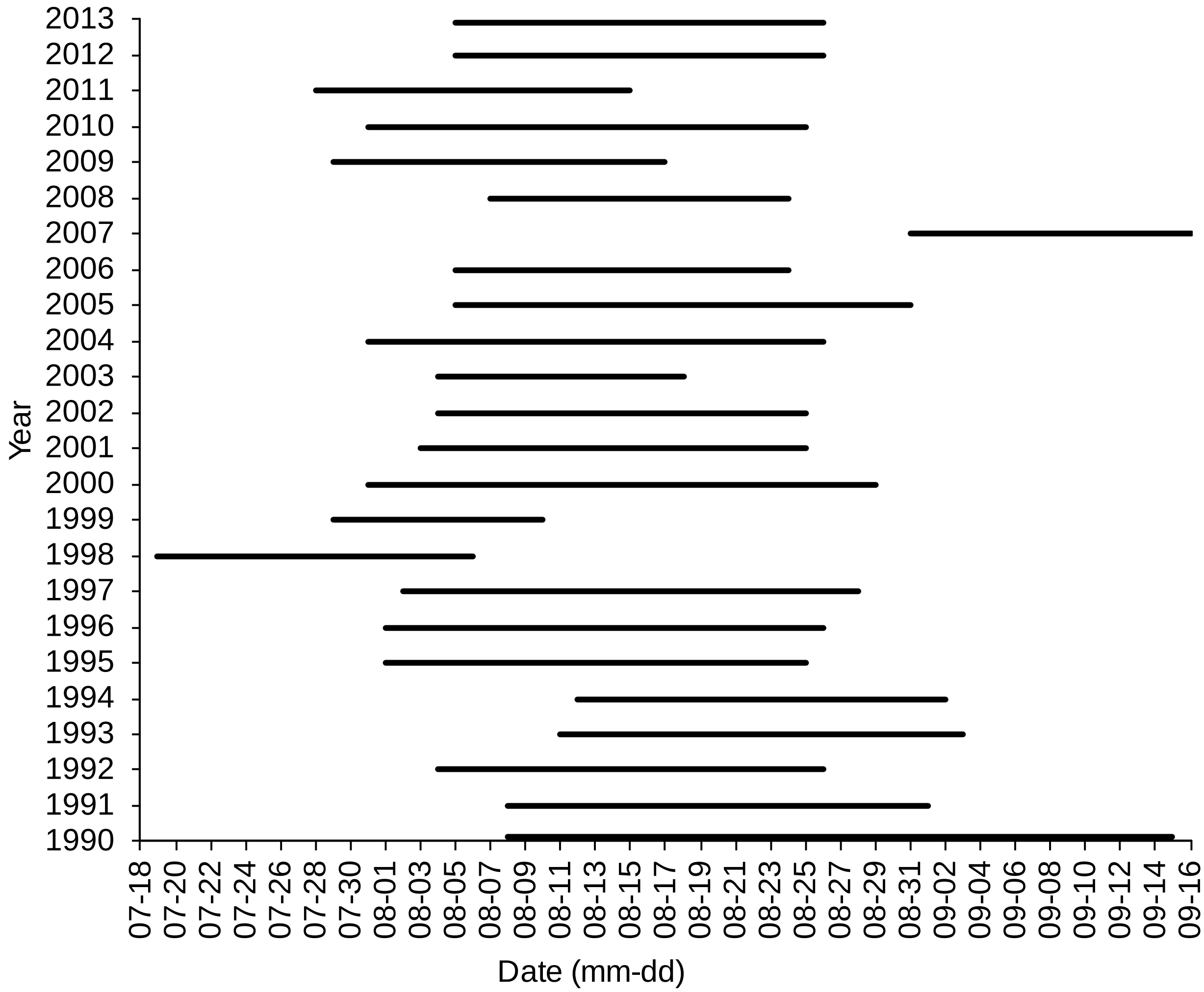


Figure 3. Chronology of the Hornaday River Char Monitoring Program between 1990 and 2013.

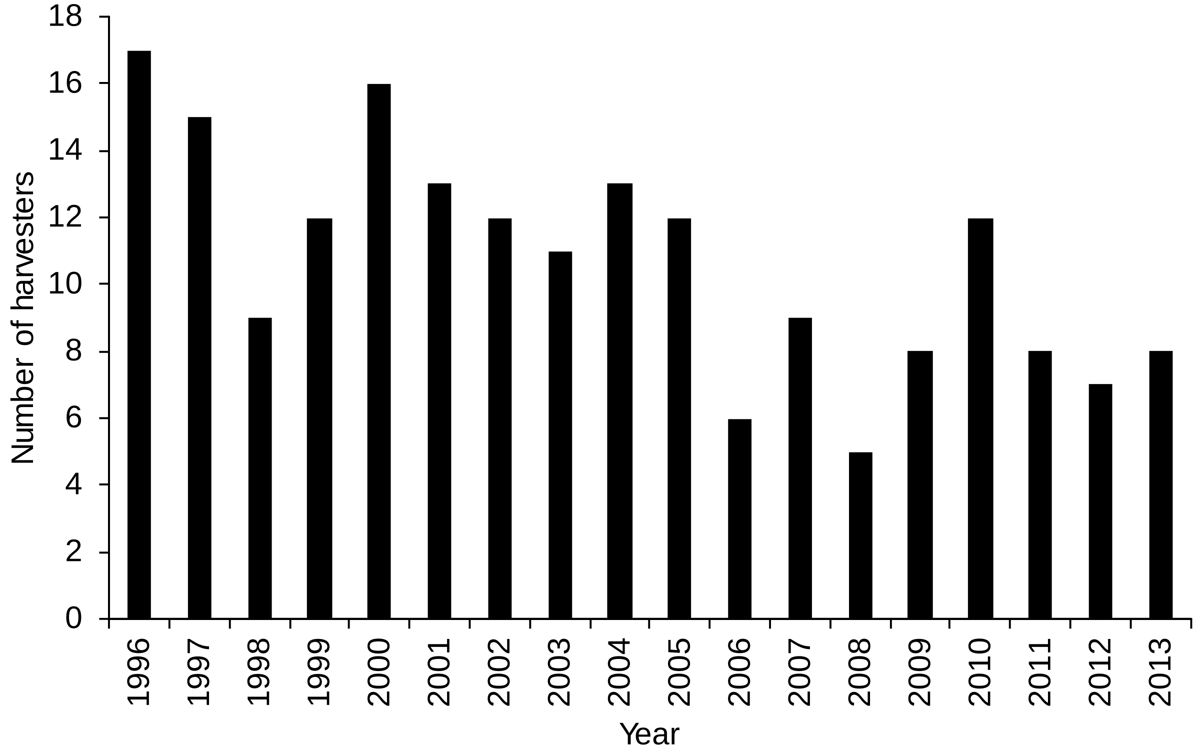


Figure 4. Number of harvesters at the mouth of the Hornaday River between 1996 and 2013.

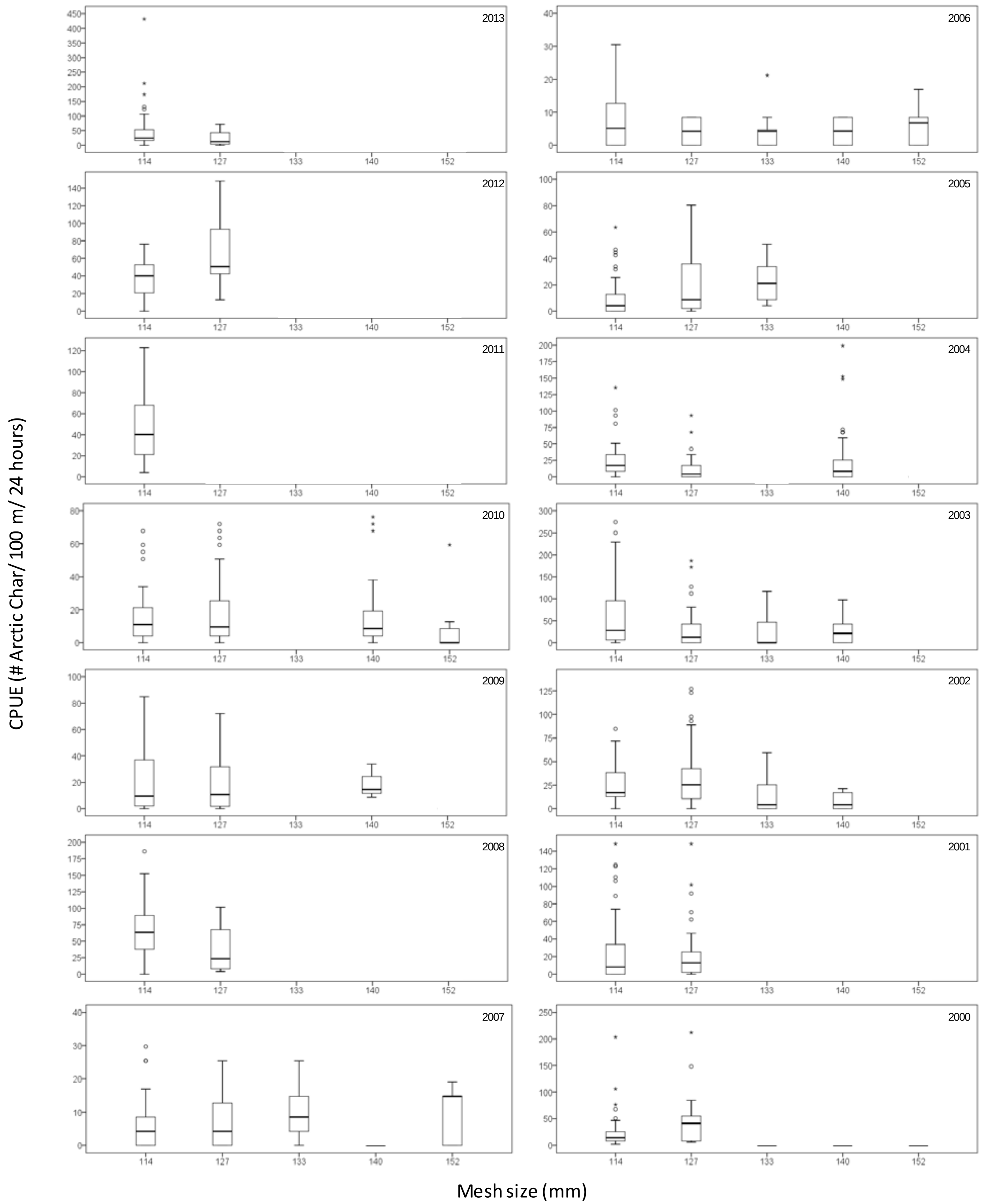


Figure 5. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of catch-per-unit-effort (CPUE) of Arctic Char harvested at the mouth of the Hornaday River among mesh sizes for each sampling year.

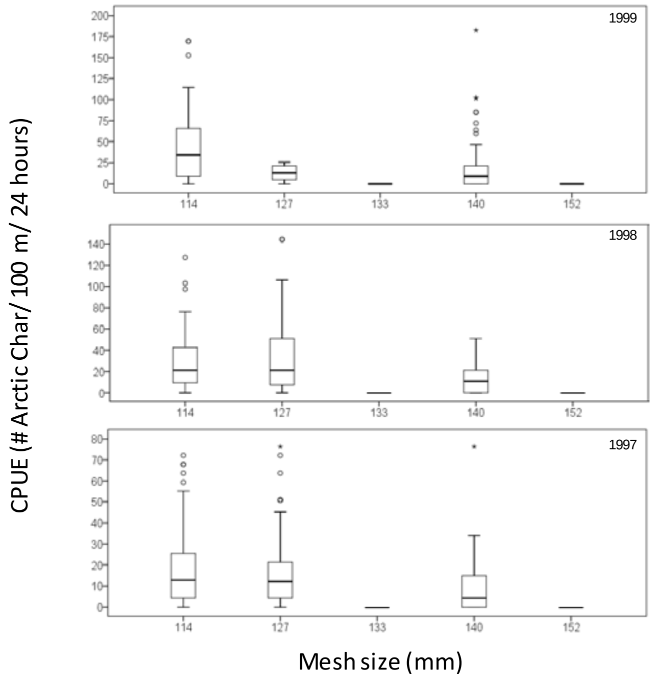


Figure 5. Continued.

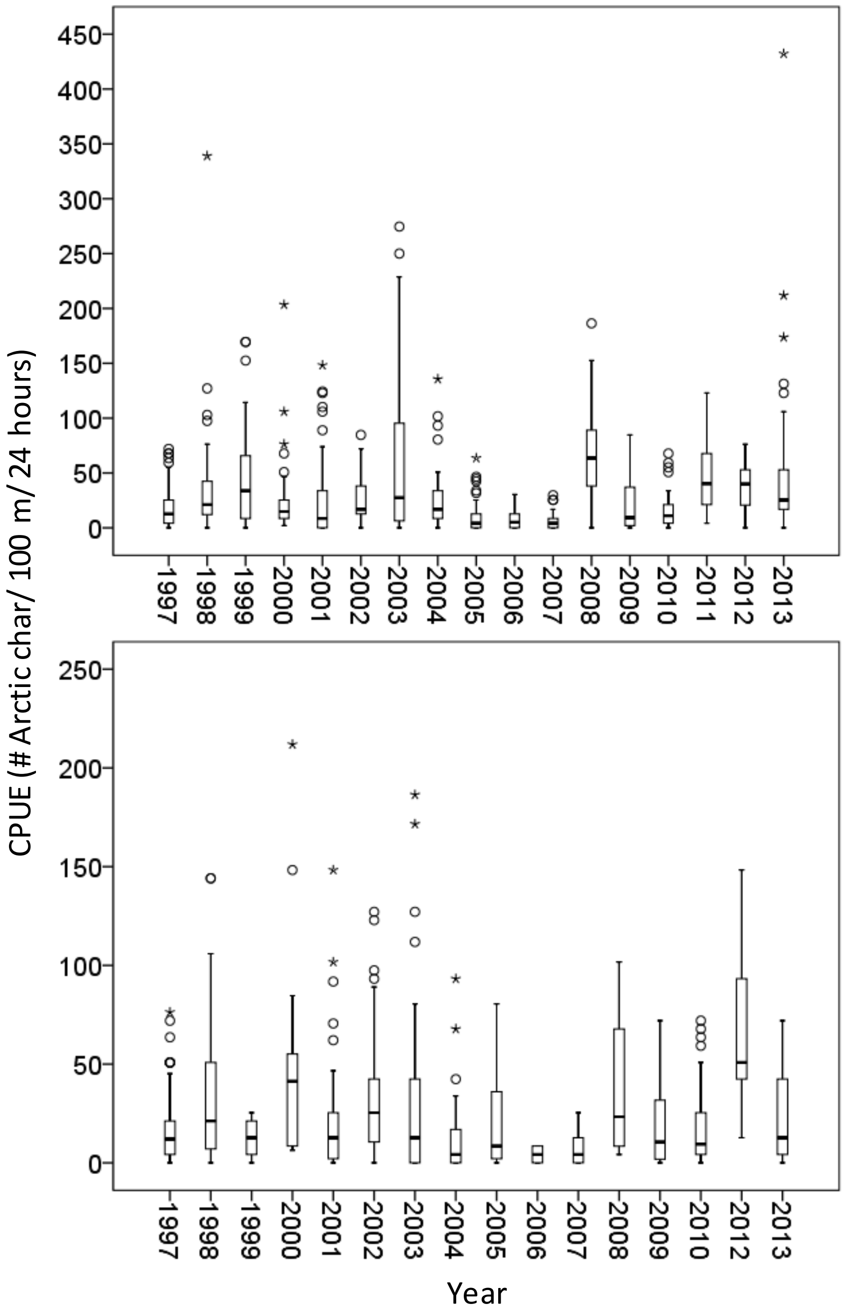


Figure 6. Box plot of catch-per-unit-effort (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of Arctic char captured in 114 mm (top) and 127 mm (bottom) mesh gill nets by harvesters monitored at the mouth of the Hornaday River between 1997 and 2013. Note, the 127 mm mesh was not used in 2011.

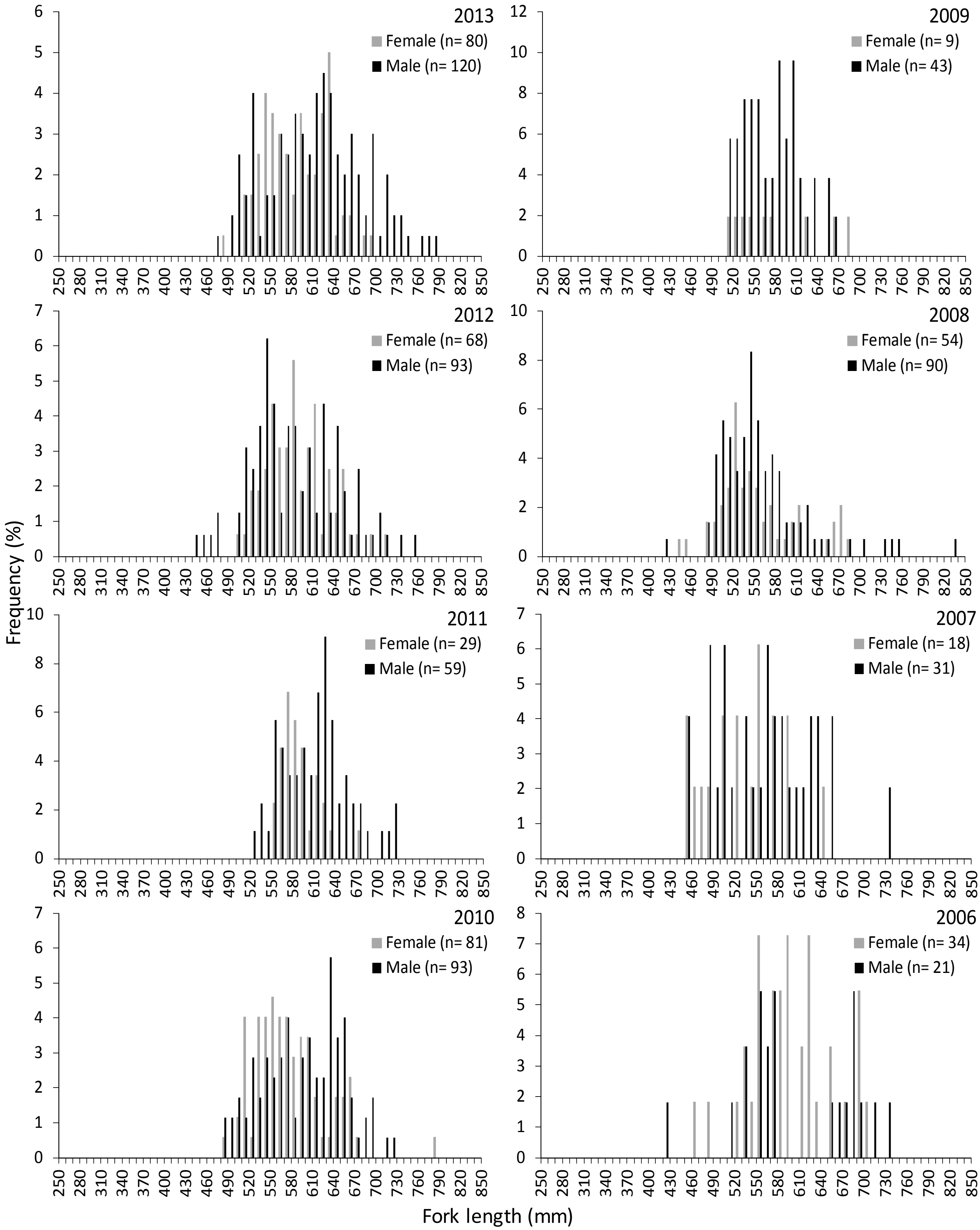


Figure 7. Fork length frequency distribution of female and male Arctic Char sampled at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013.

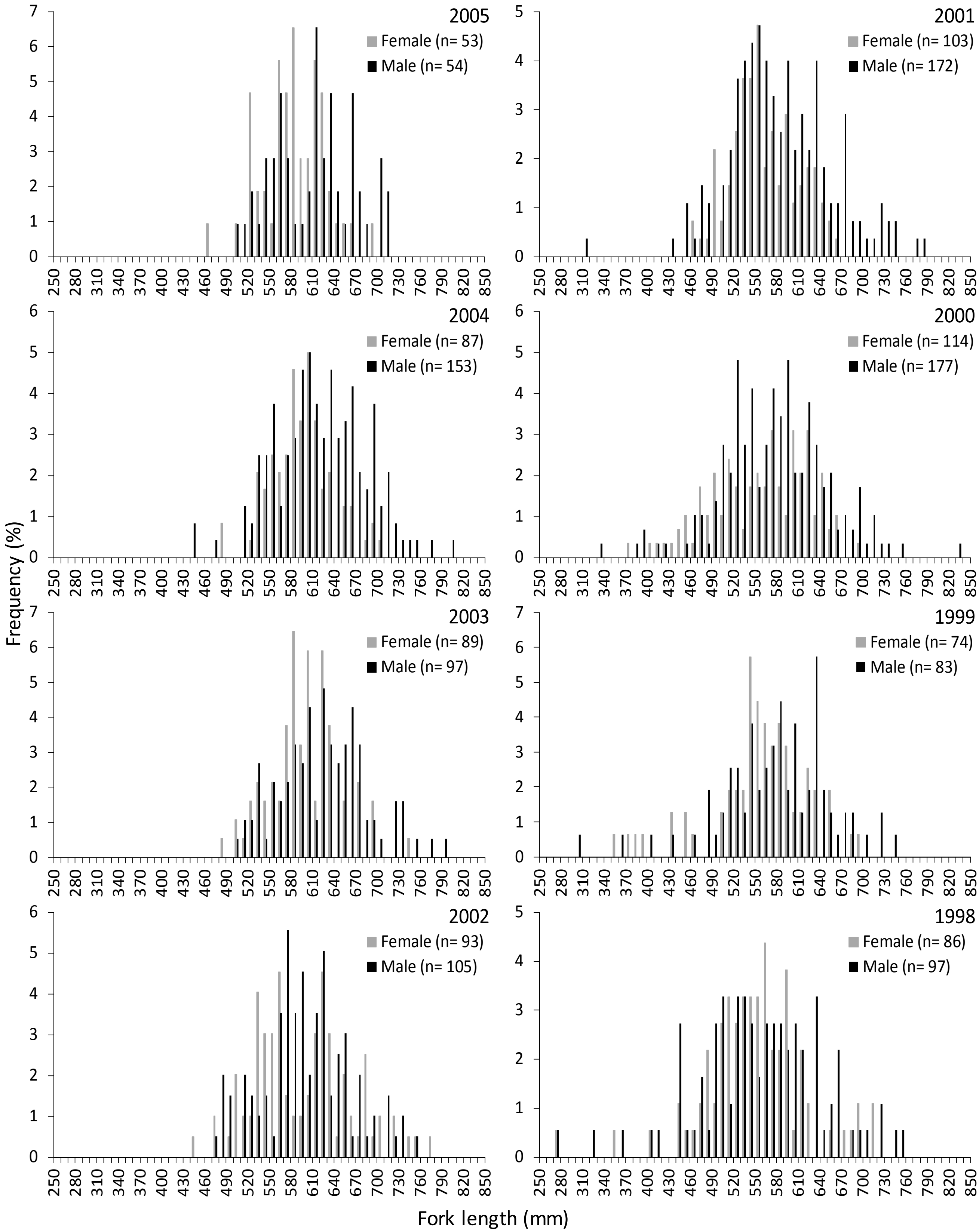


Figure 7. Continued.

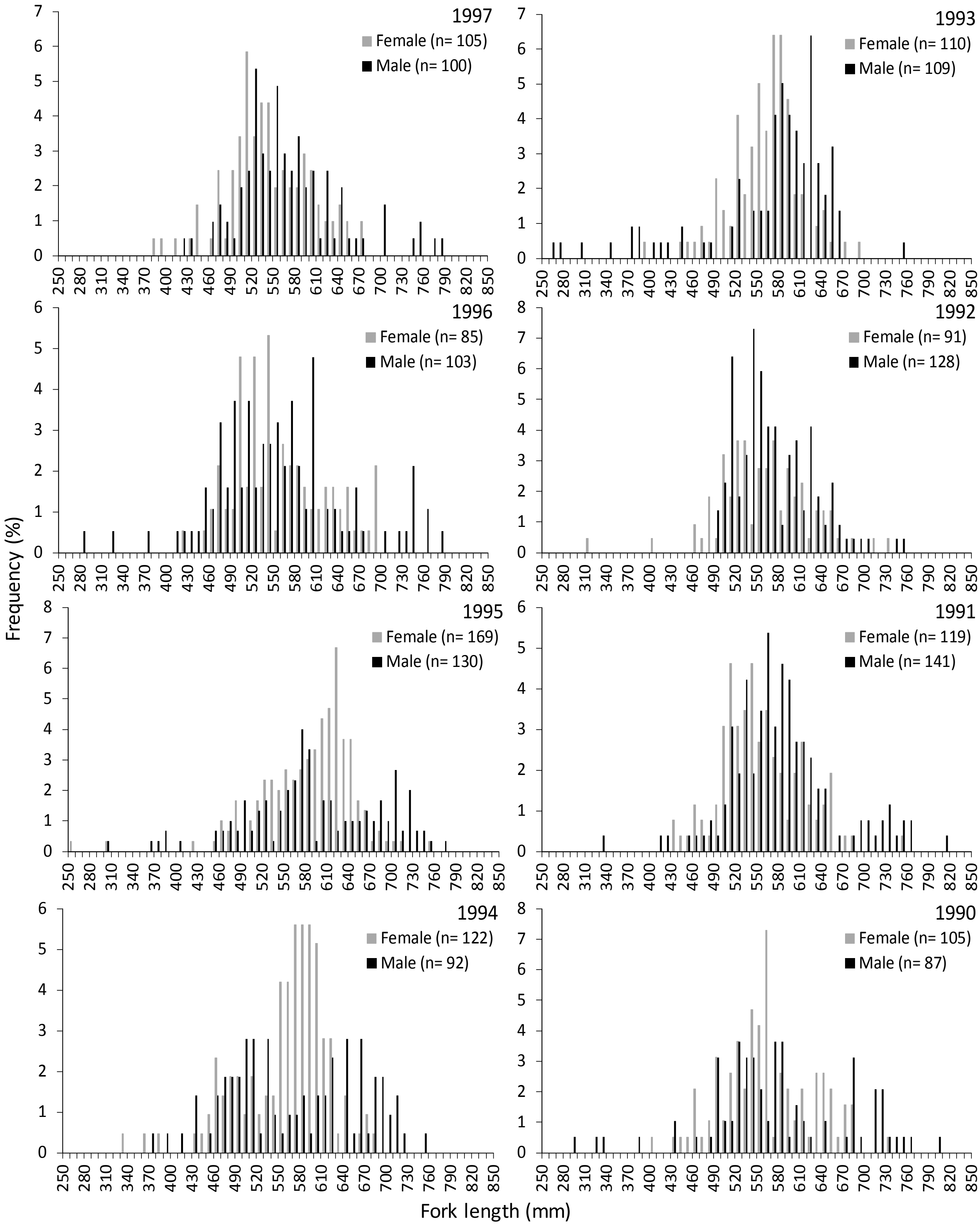


Figure 7. Continued. Note, in 1995 there was n= 1 female Arctic Char that was <250 mm which was not included in the figure.

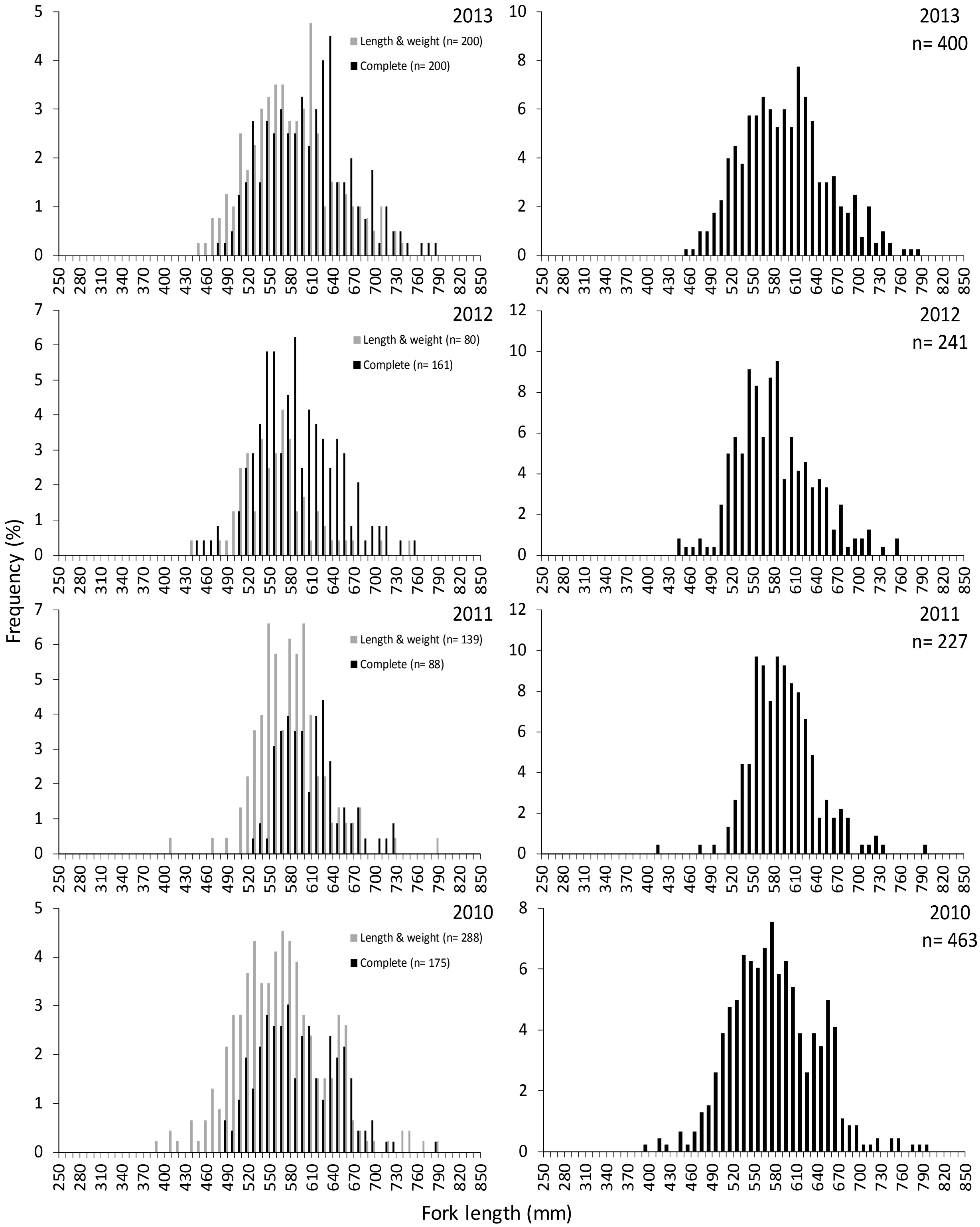


Figure 8. Fork length frequency distribution of Arctic Char sampled for length-and-weight only, and for a complete suite of biological information (left), and their combined sample (right) at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013, and other periodic sampling programs between 1973 and 1989. Note, a length-and-weight-only sample was not taken between 1998 and 2001.

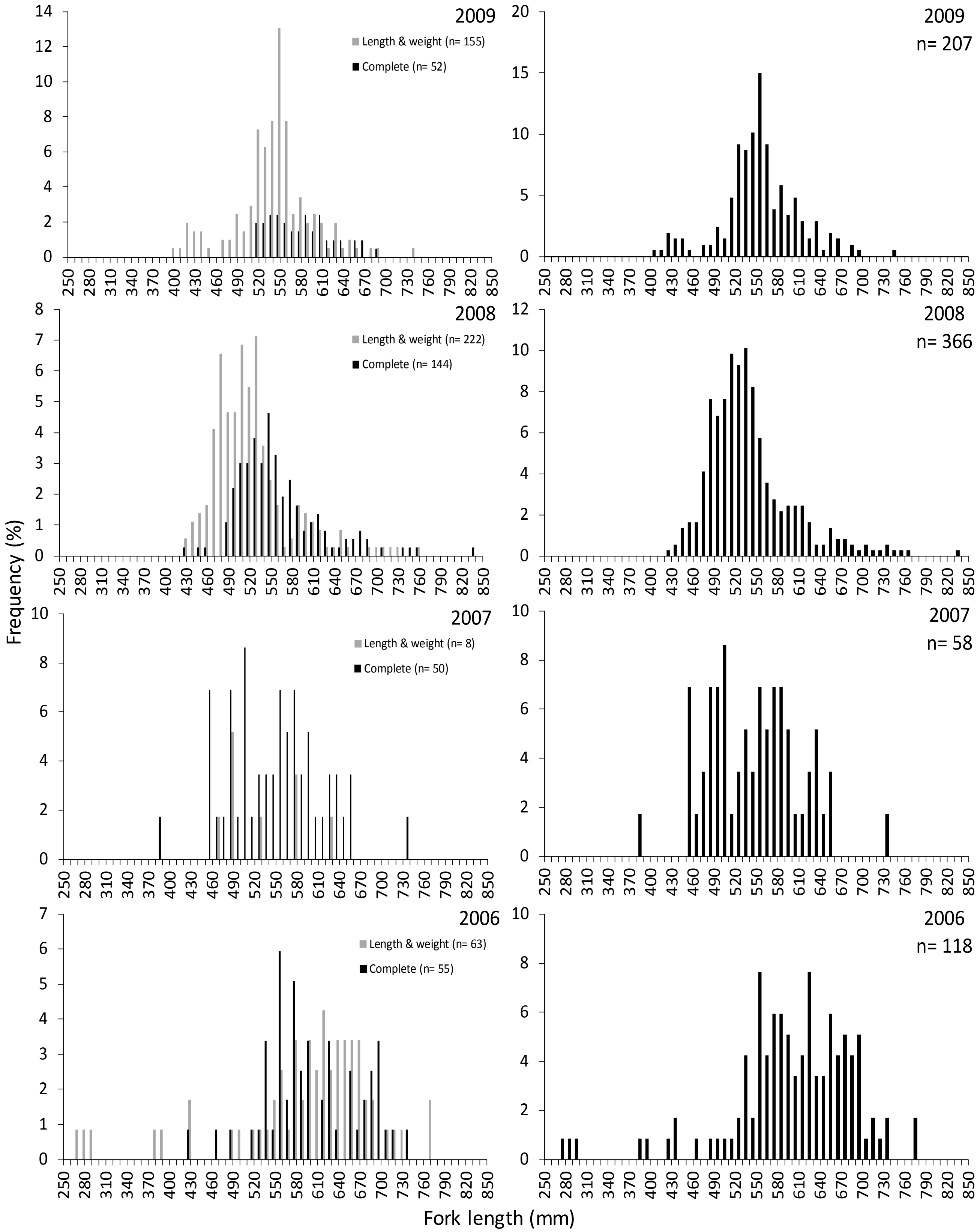


Figure 8.Continued.

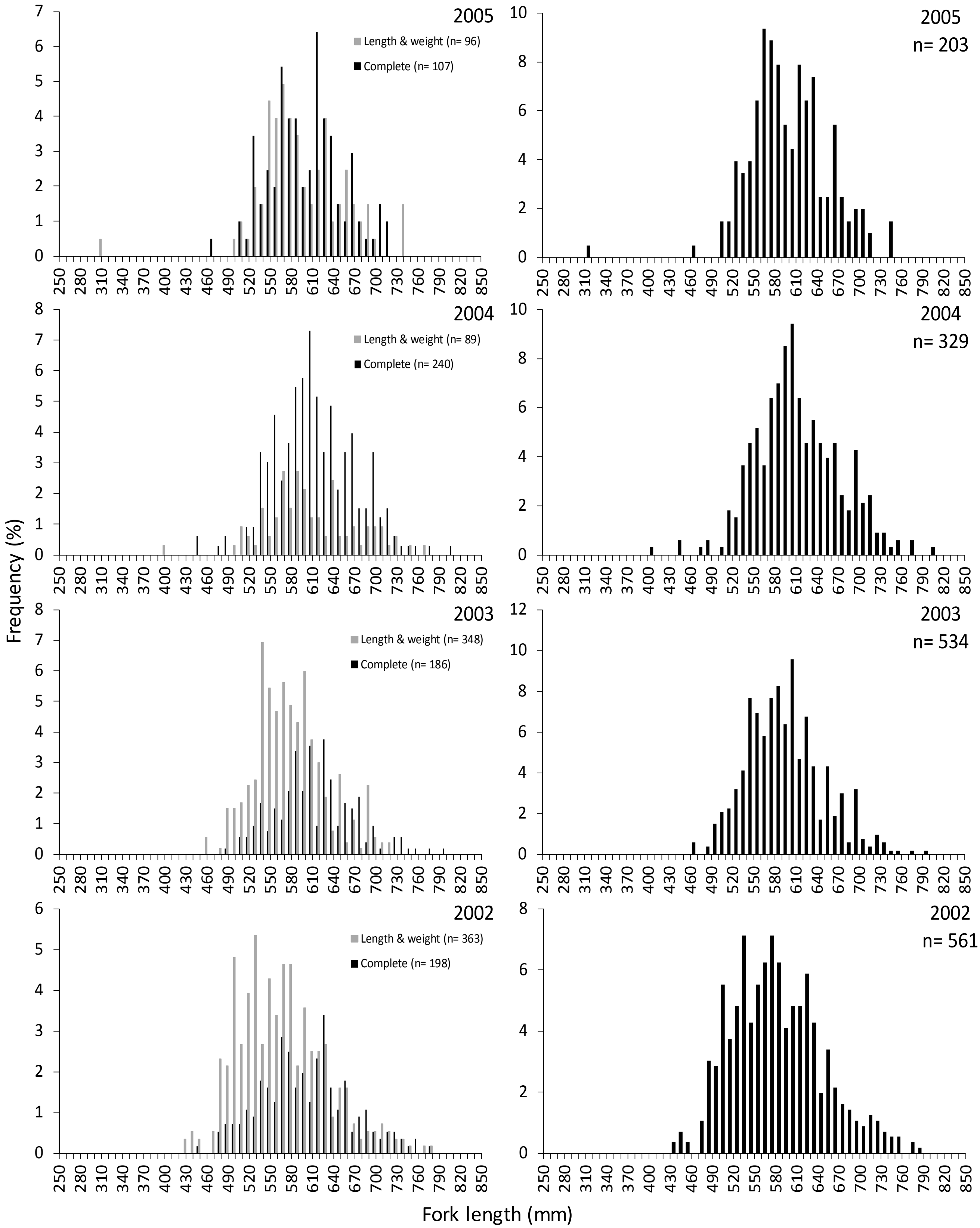


Figure 8.Continued.

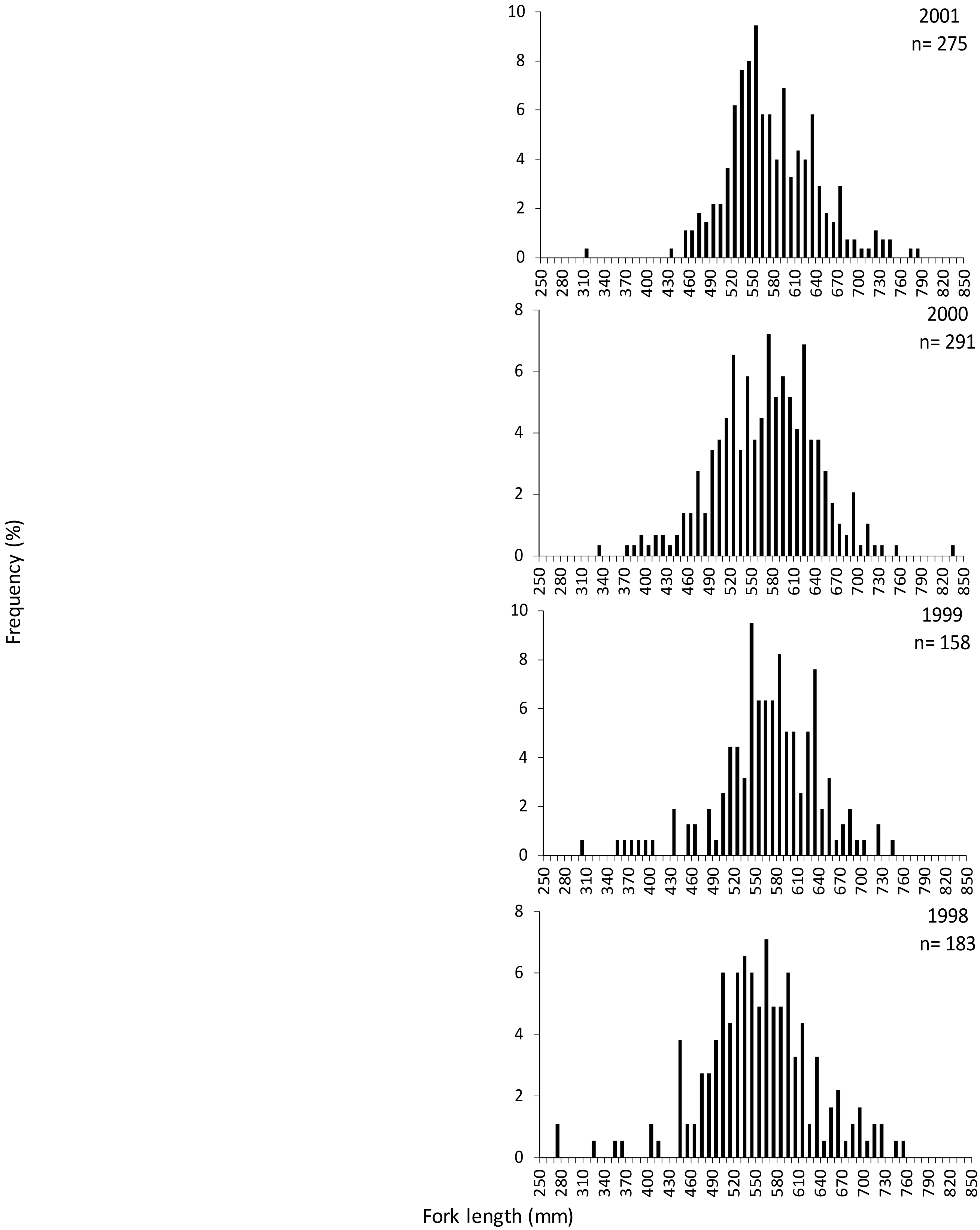
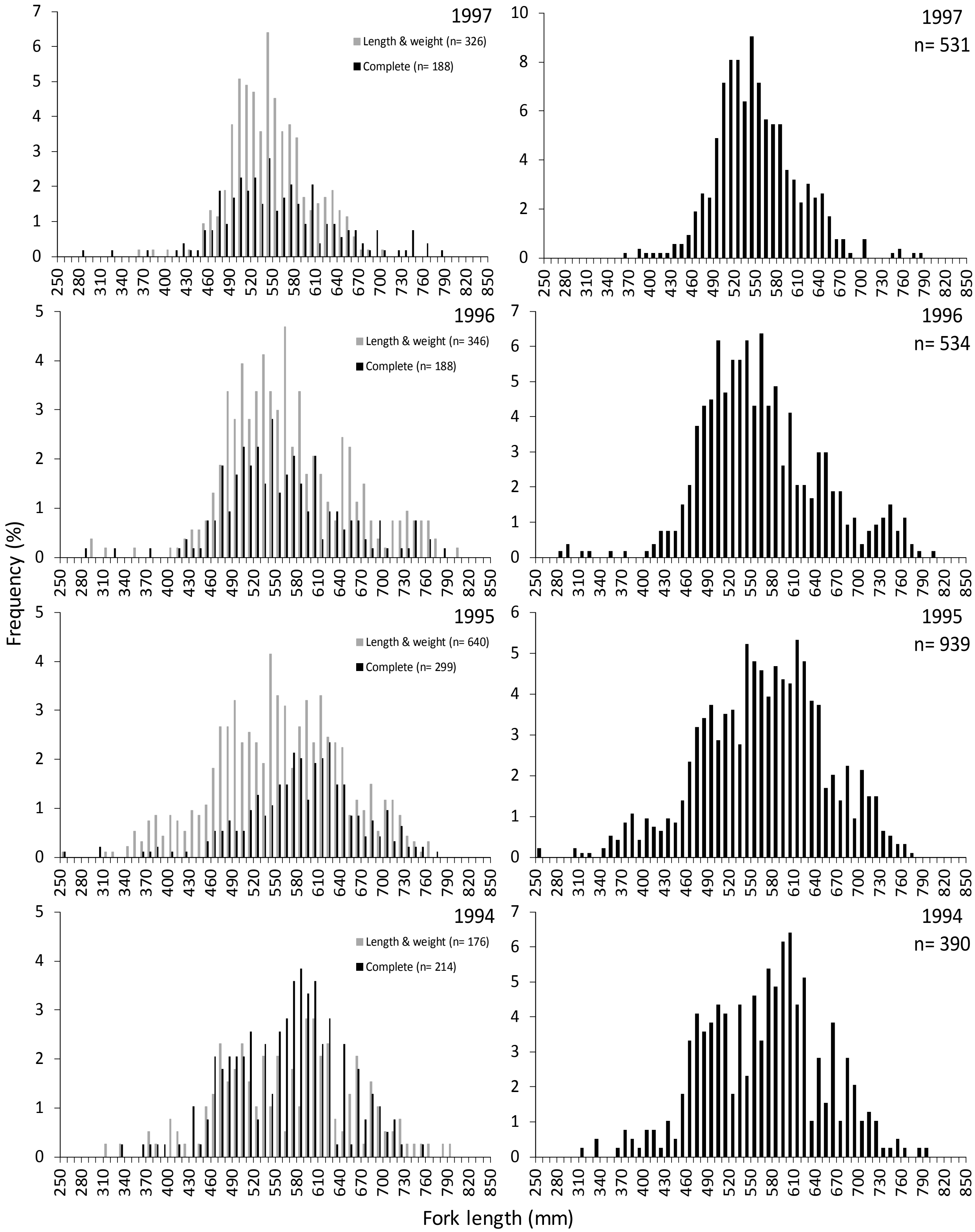


Figure 8. Continued. Note, a length-and-weight-only sample was not taken between 1998 and 2001.



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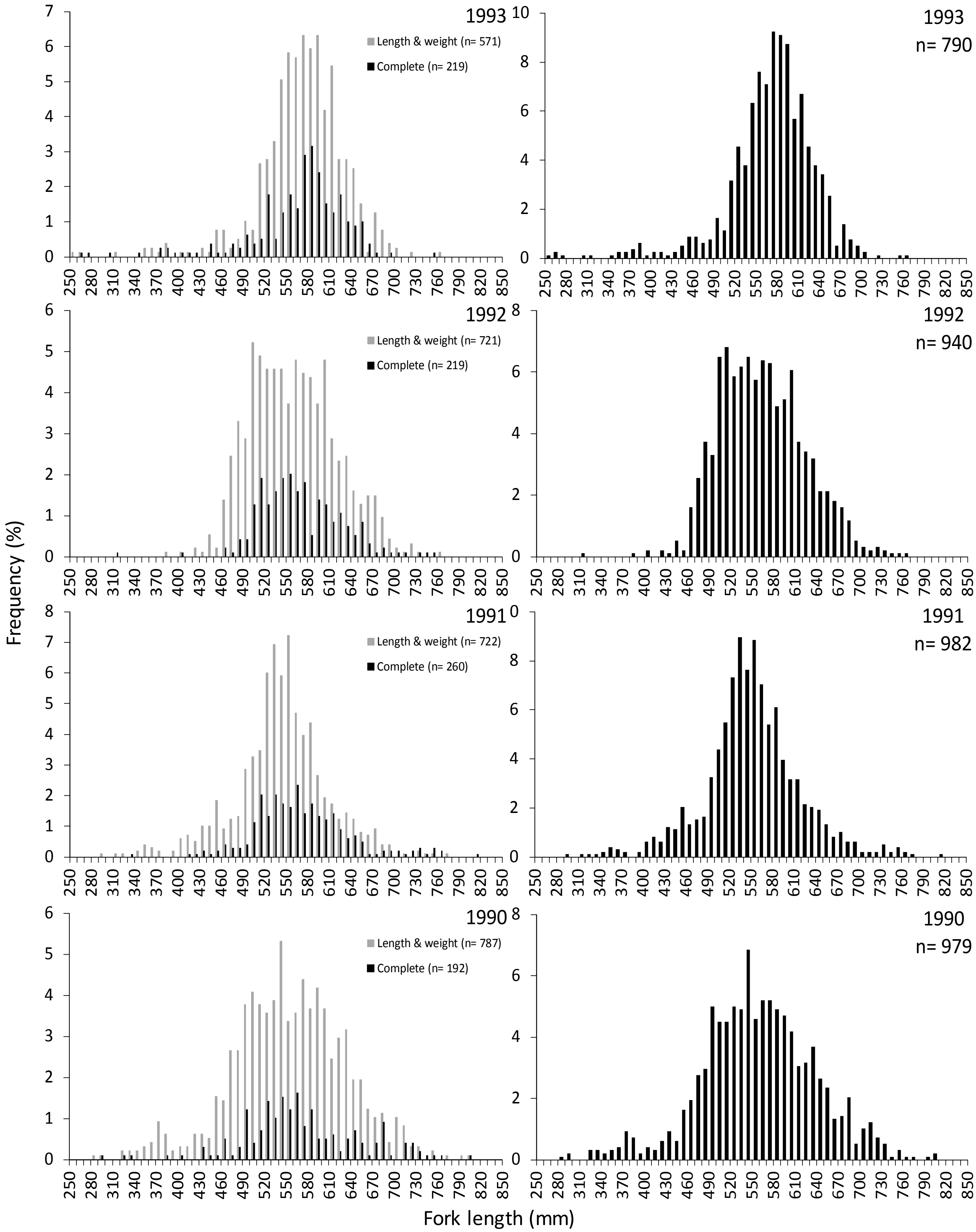


Figure 8.Continued.

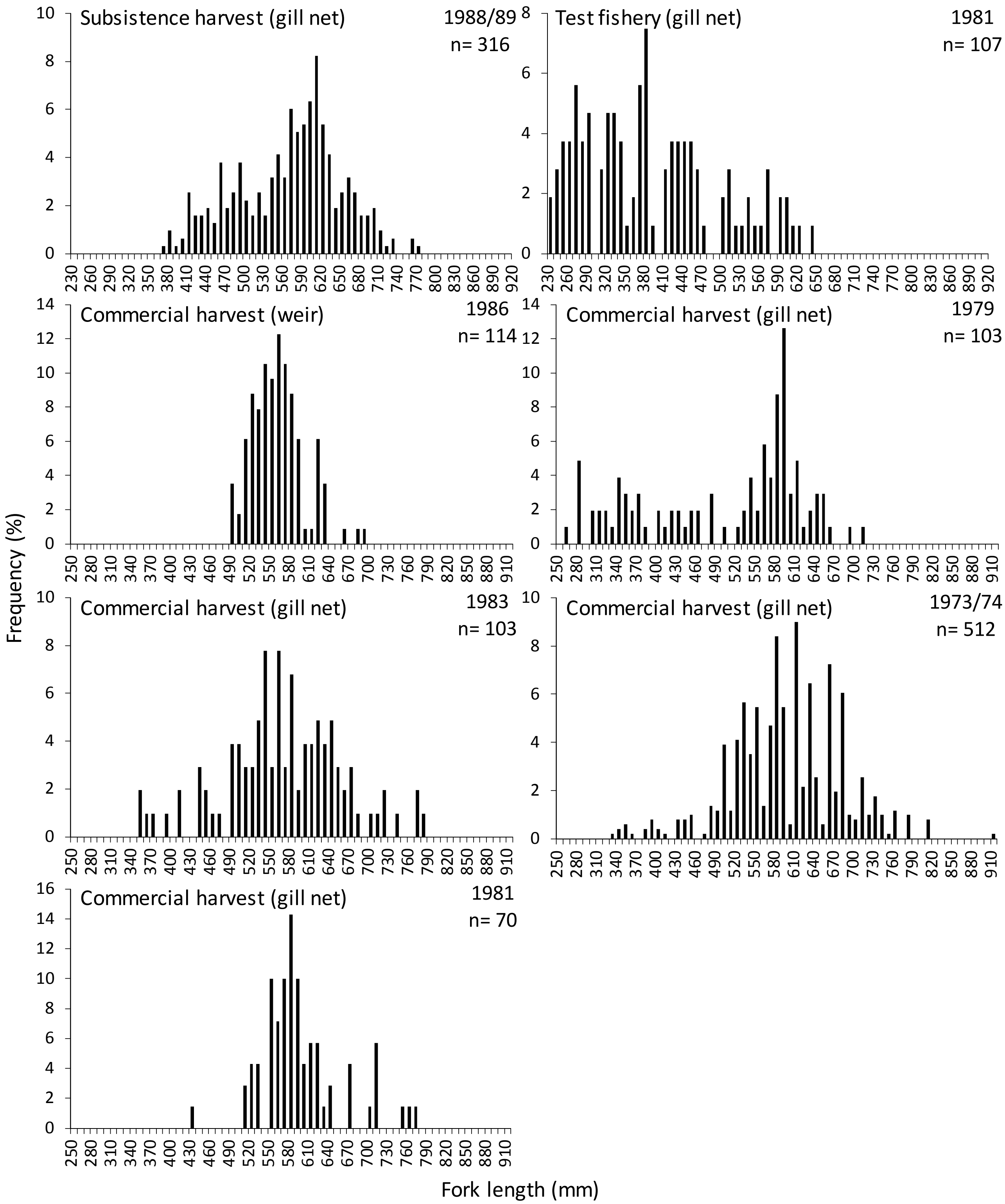


Figure 8.Continued.

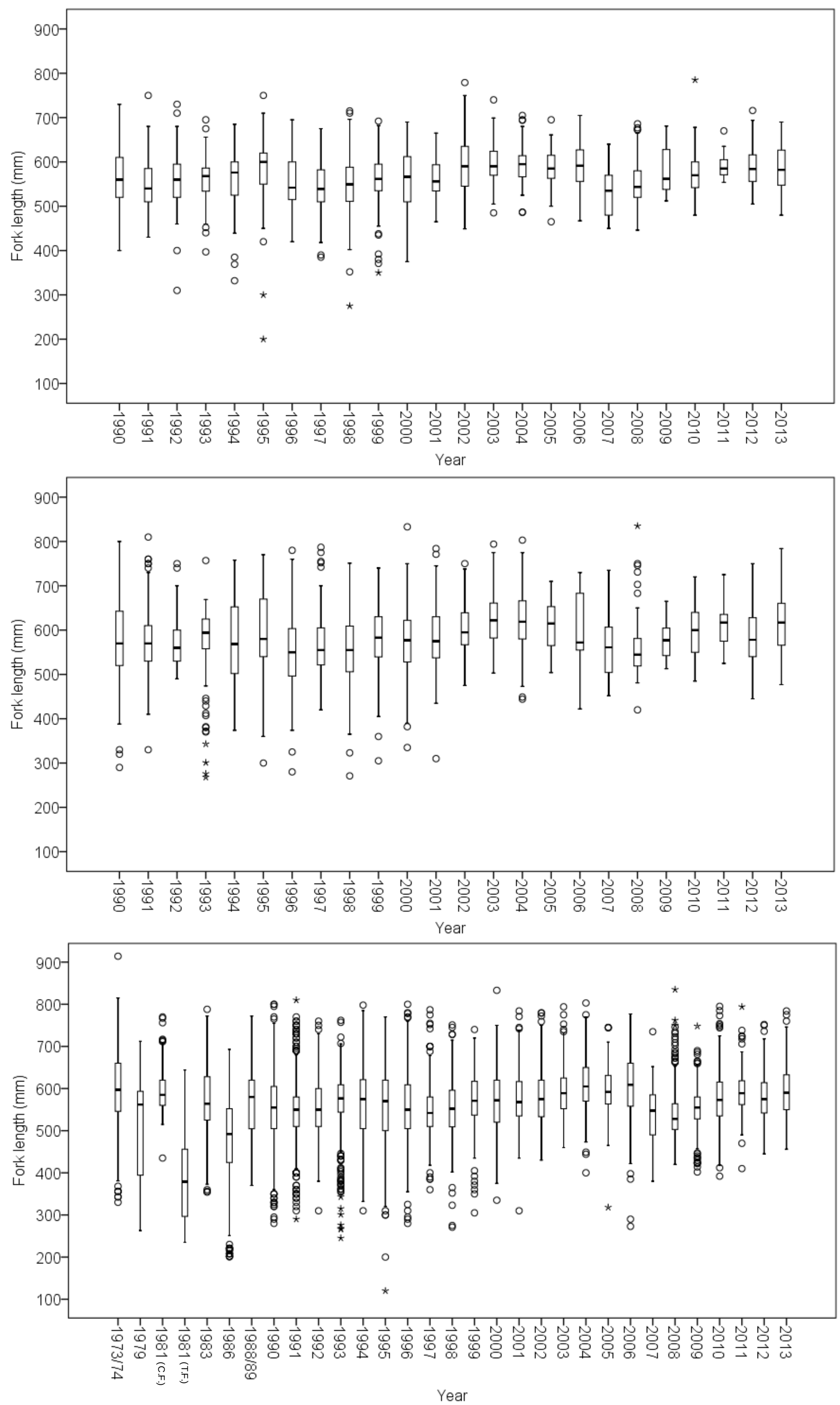


Figure 9. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of fork length of (top) female, (middle) male, and the (bottom) total sample of Arctic Char sampled at the mouth of the Hornaday River between 1990 and 2013, and other periodic sampling programs between 1973 and 1989. Note 1981: C.F.= commercial fishery, T.F.= test fishery.

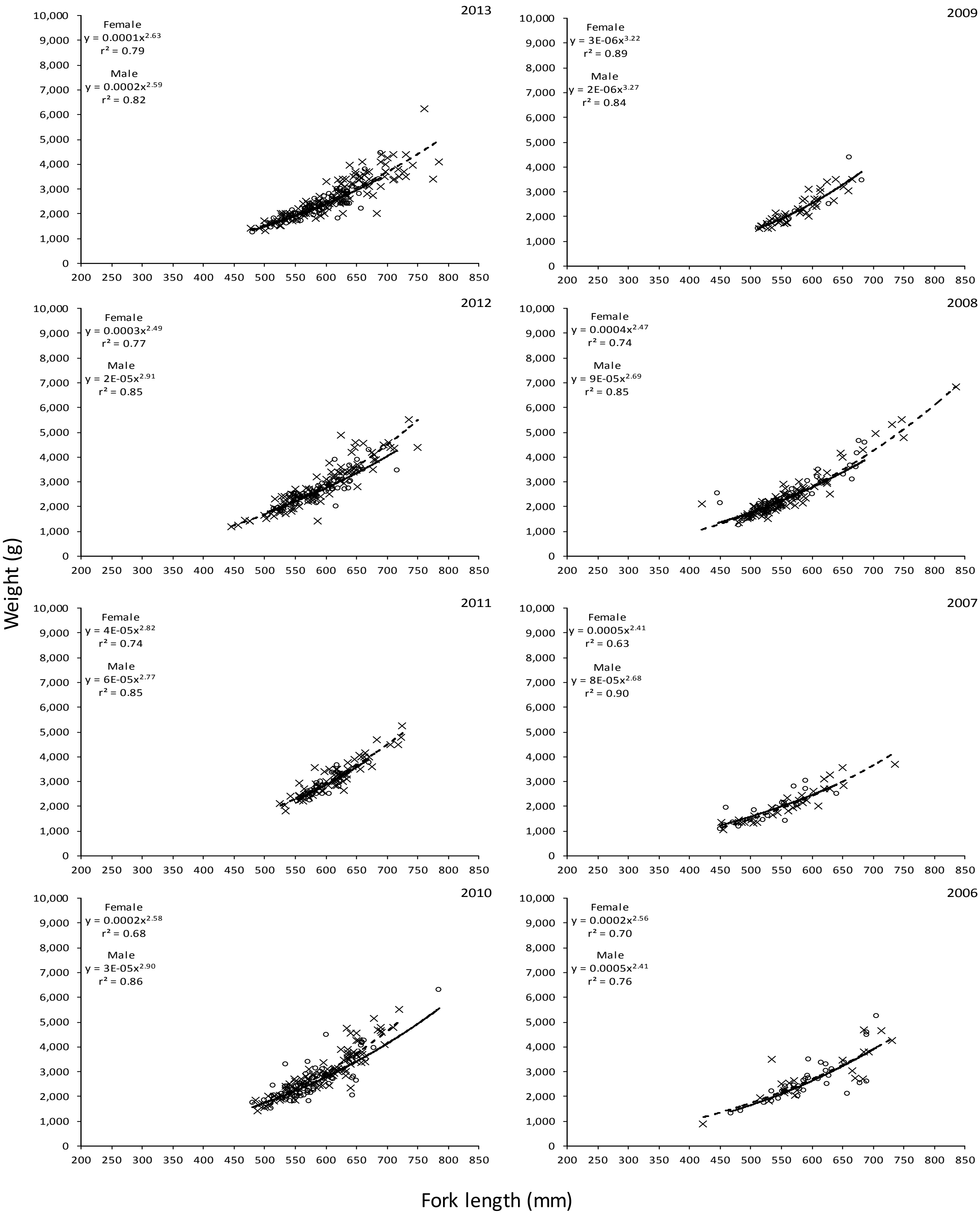


Figure 10. Scatter plot of fork length and weight with power regression line of female (○; solid line) and male (x; dashed line) Arctic Char sampled at the mouth of the Hornaday River between 1990 and 2013.

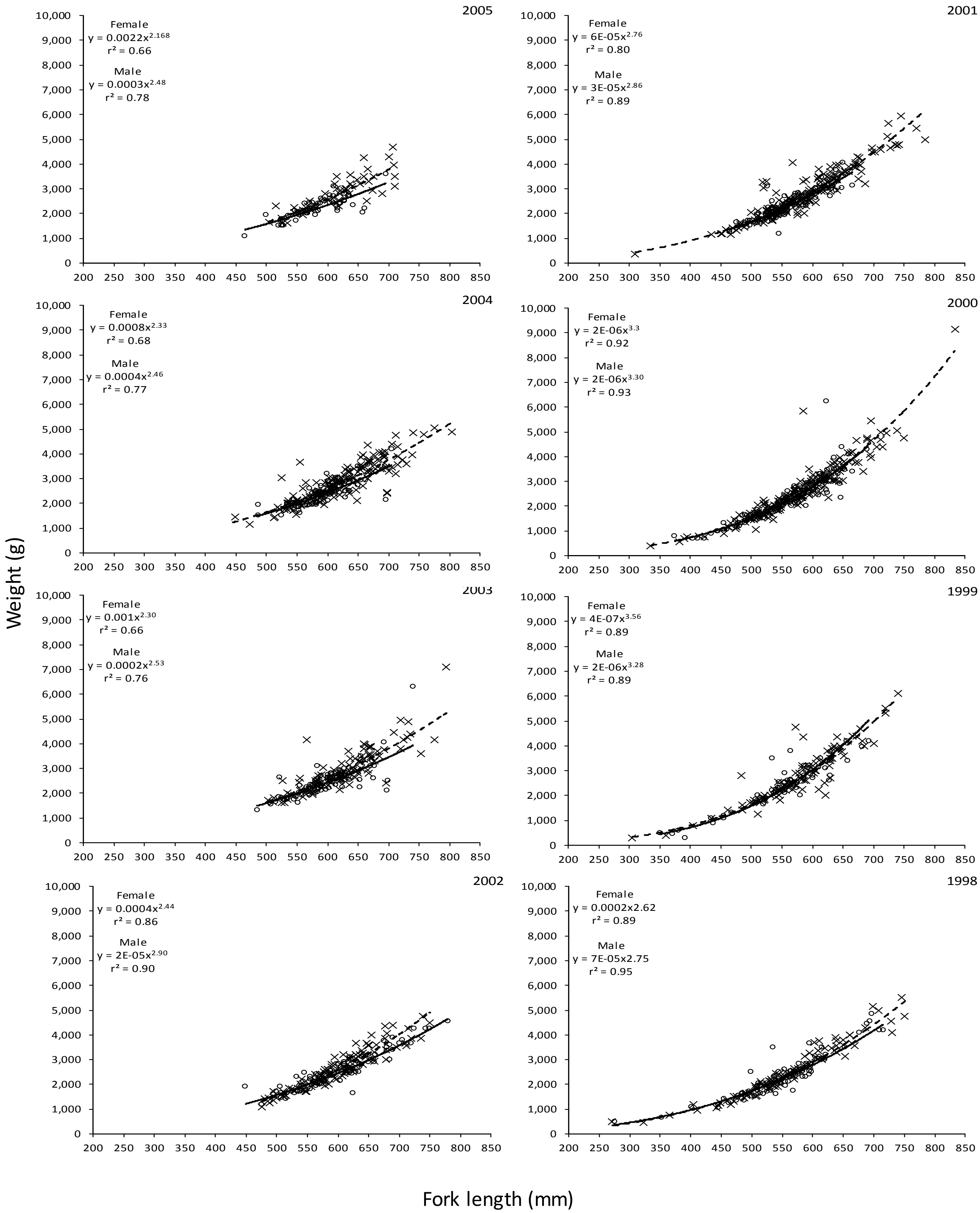


Figure 10. Continued.

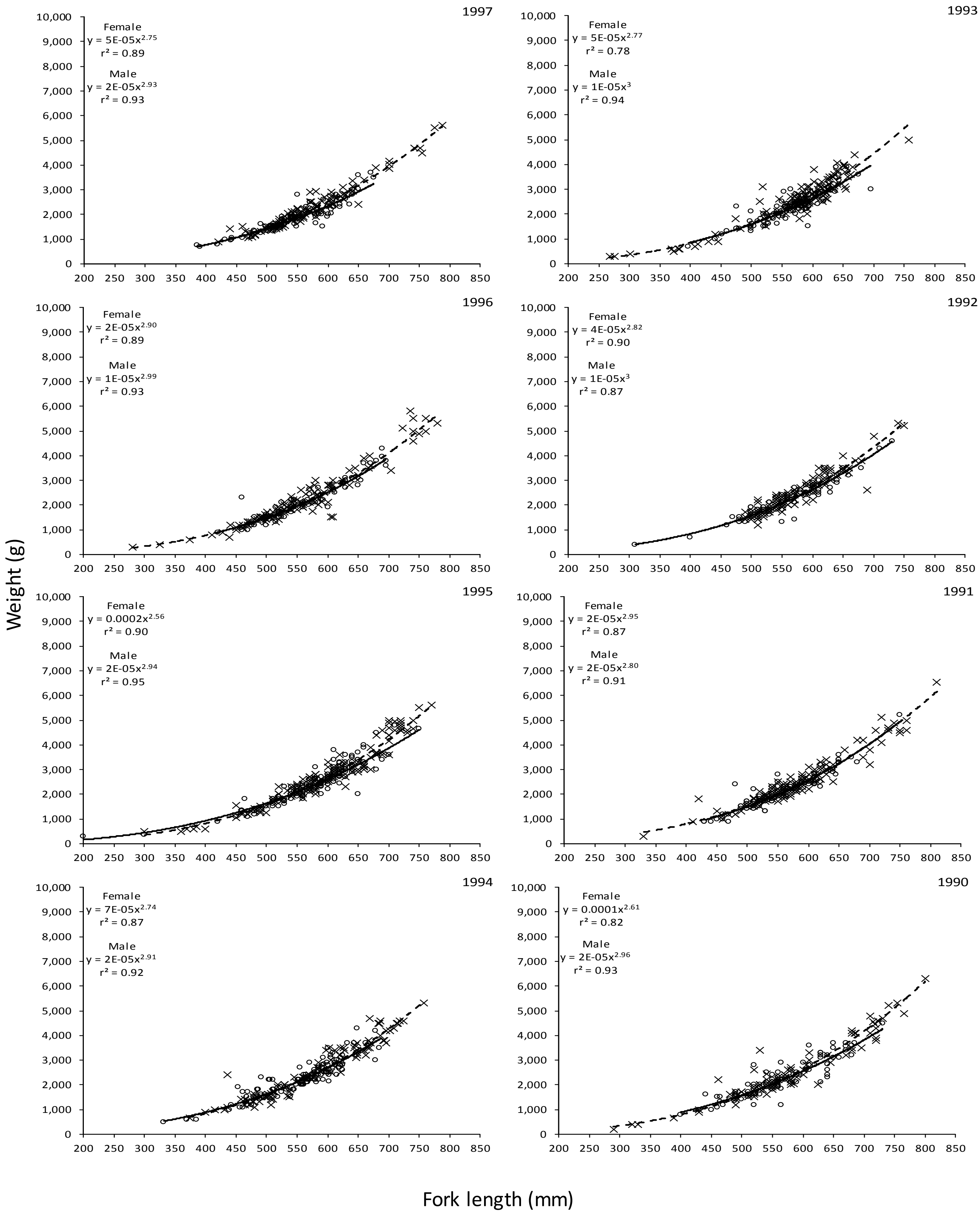


Figure 10. Continued.

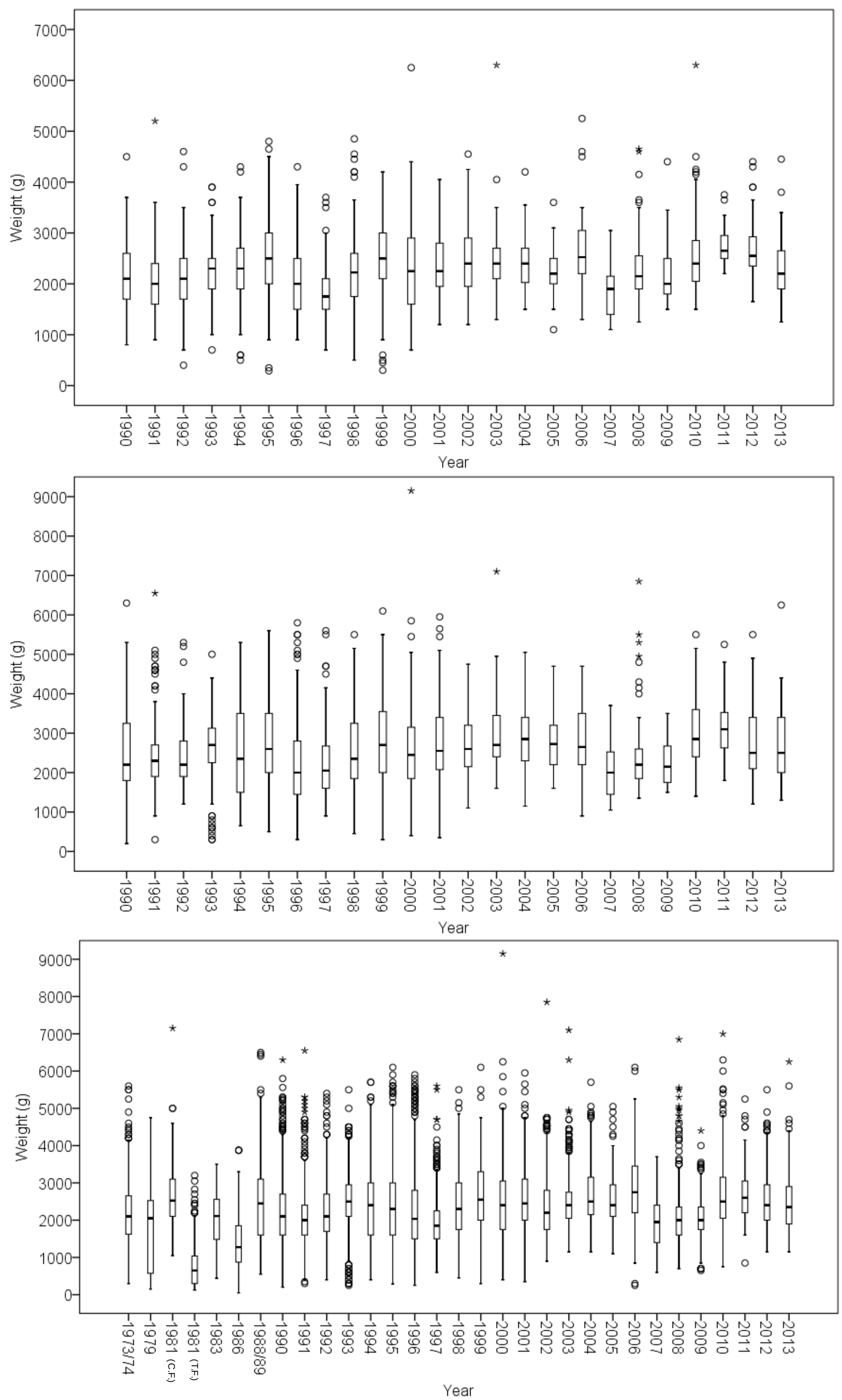


Figure 11. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of weight of (top) female, (middle) male, and the (bottom) total sample of Arctic Char harvested at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013, and other periodic sampling programs between 1973 and 1989. Note 1981: C.F.= commercial fishery, T.F.= test fishery.

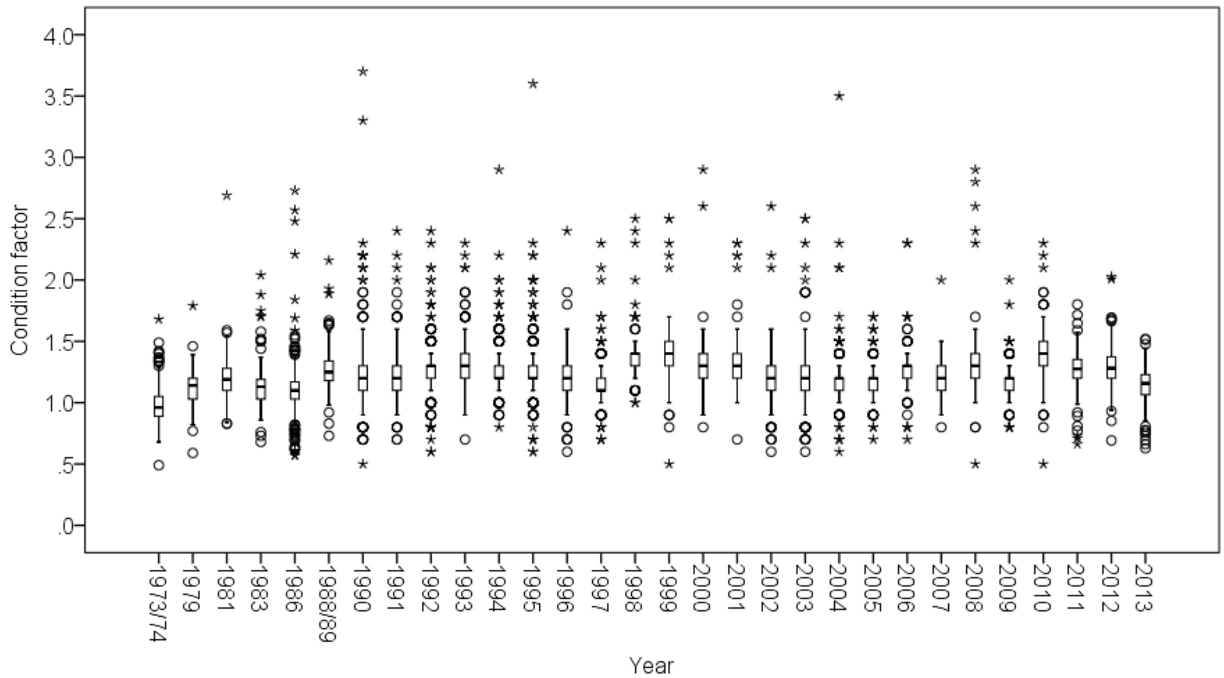


Figure 12. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of condition factor of Arctic Char sampled at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013, and other periodic sampling programs between 1973 and 1989. Note, the 1981 commercial and test fishery samples were combined.

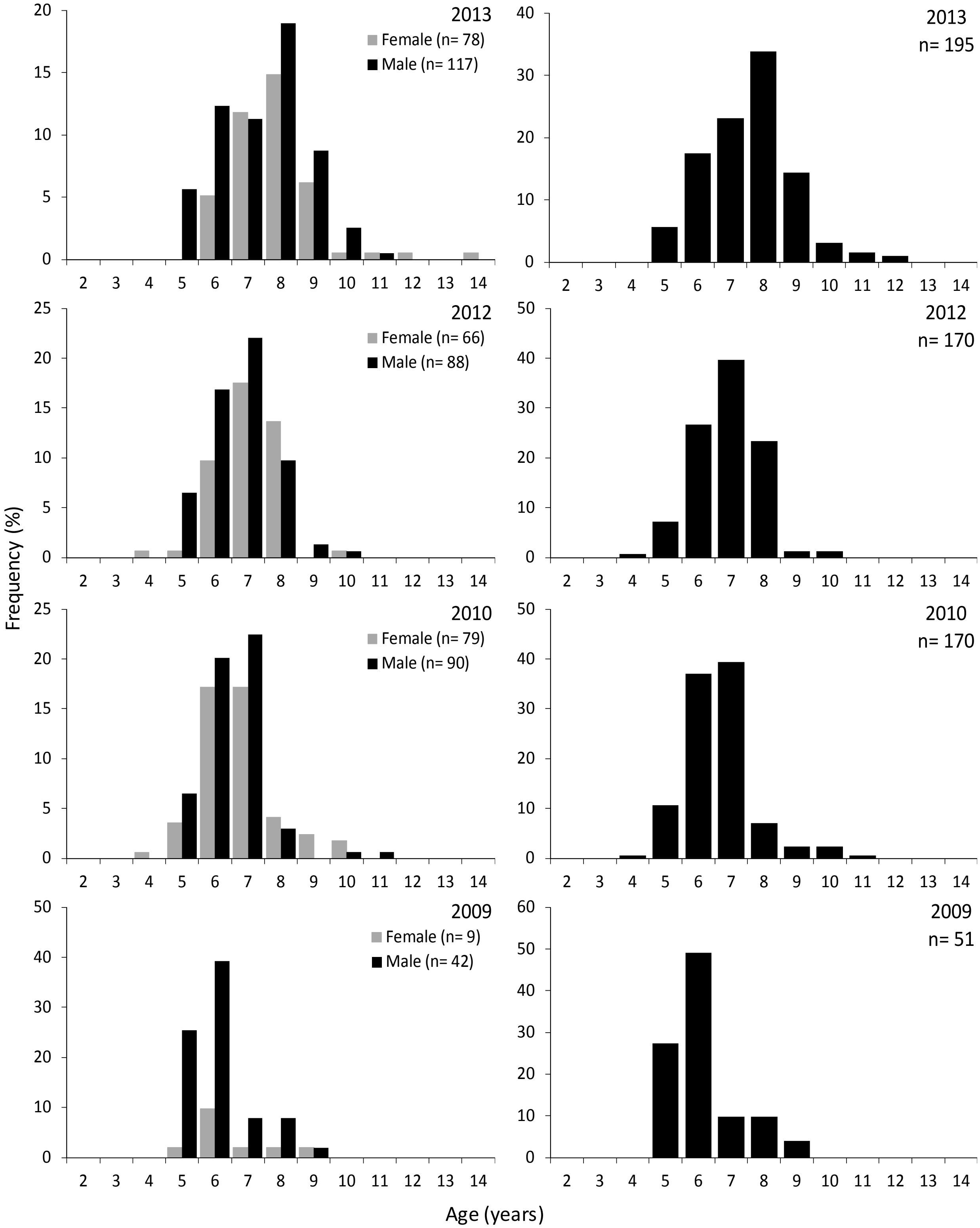


Figure 13. Age frequency distribution of female and male (left), and the total sample (right) of Arctic Char sampled at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013, and the total sample from other periodic sampling programs between 1973 and 1989 Note, no age data available for 2011.

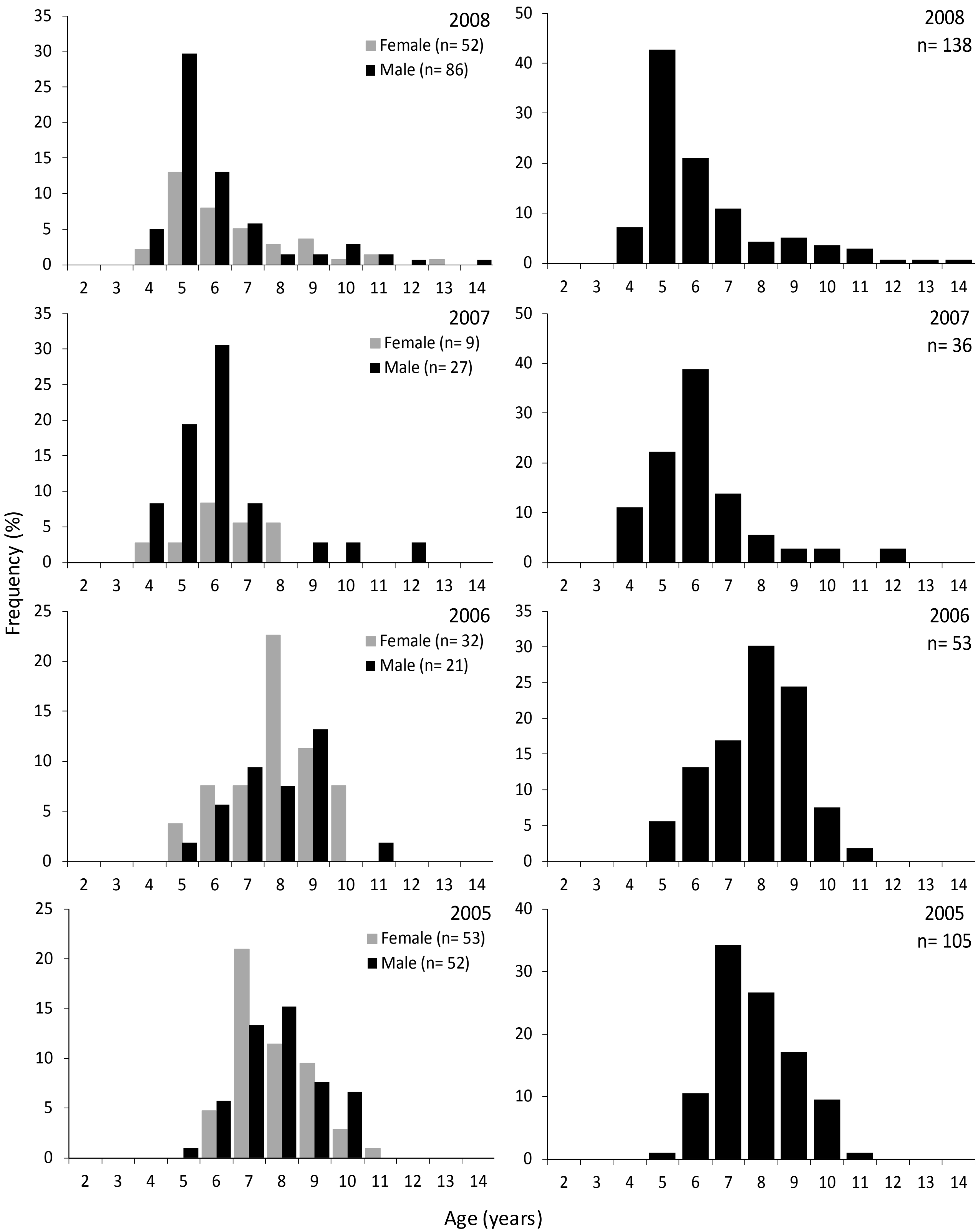
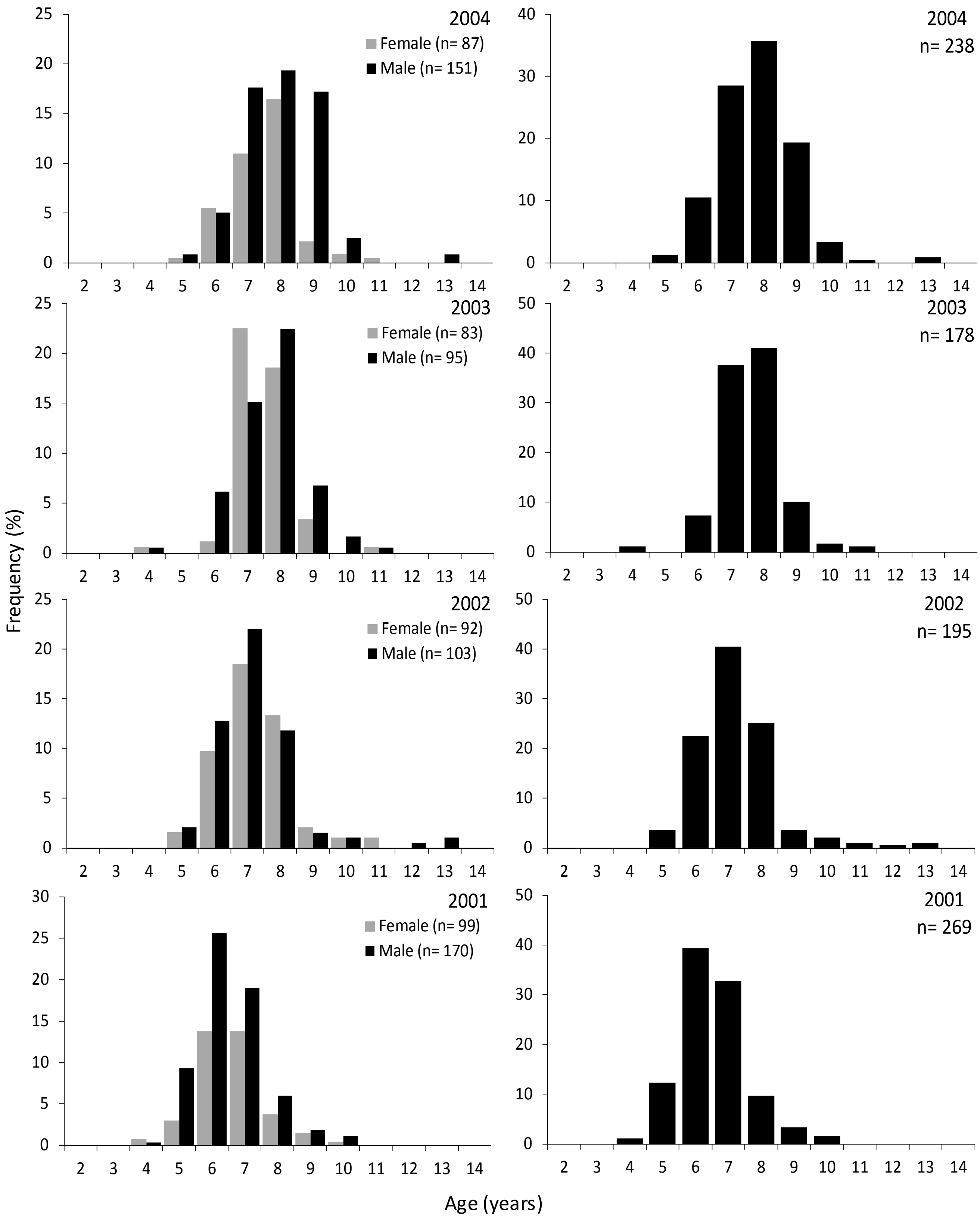


Figure 13. Continued.



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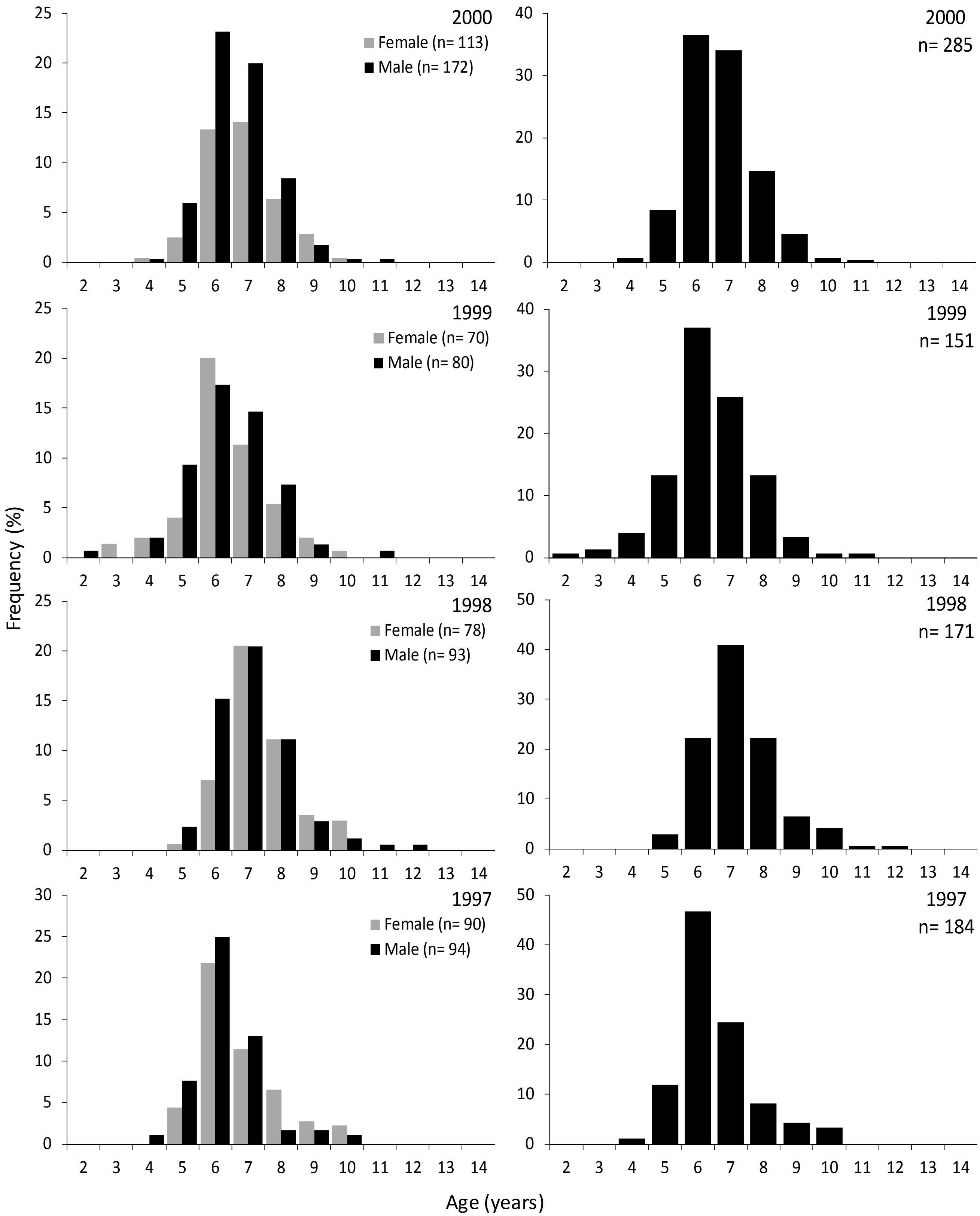

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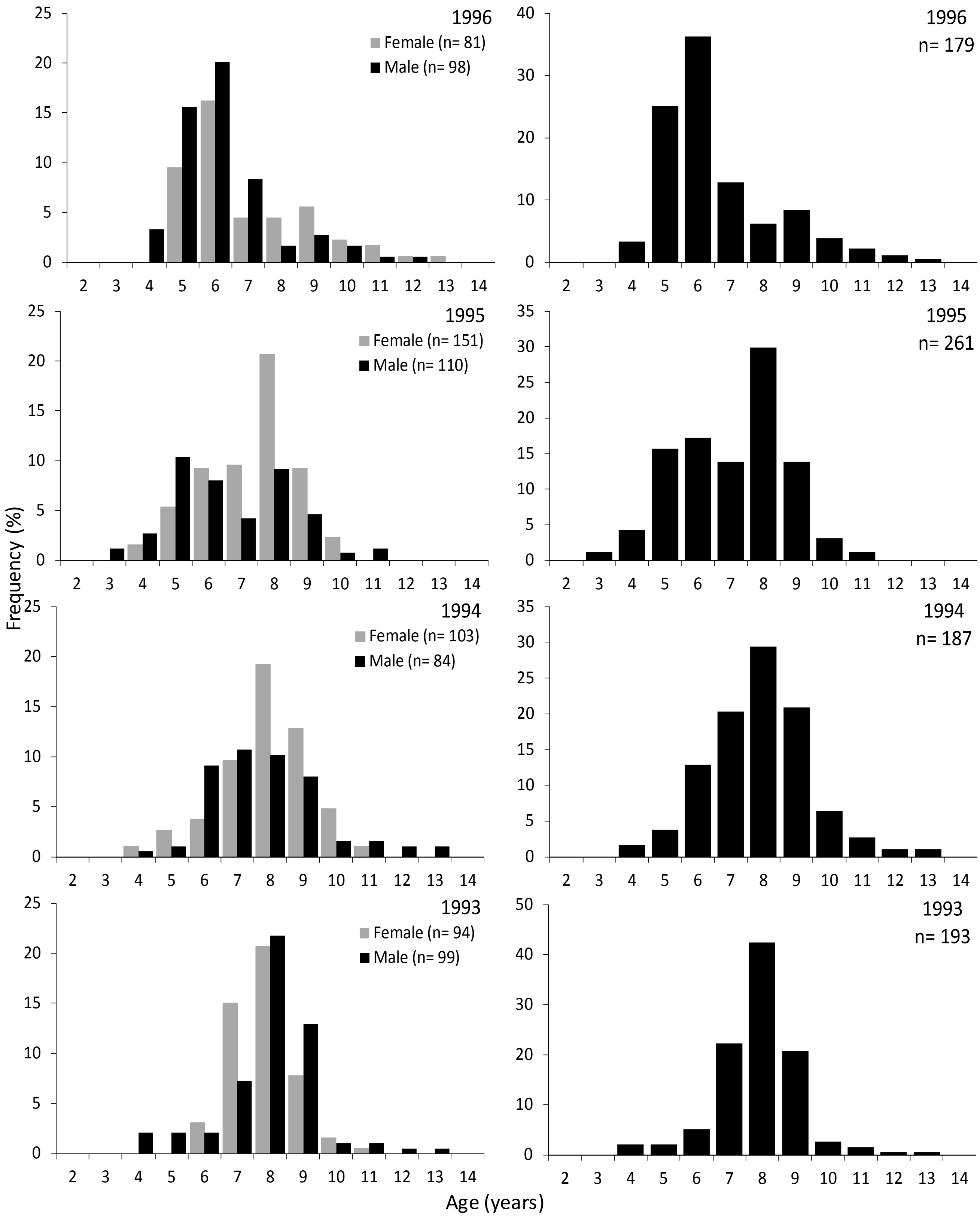


Figure 13. Continued.

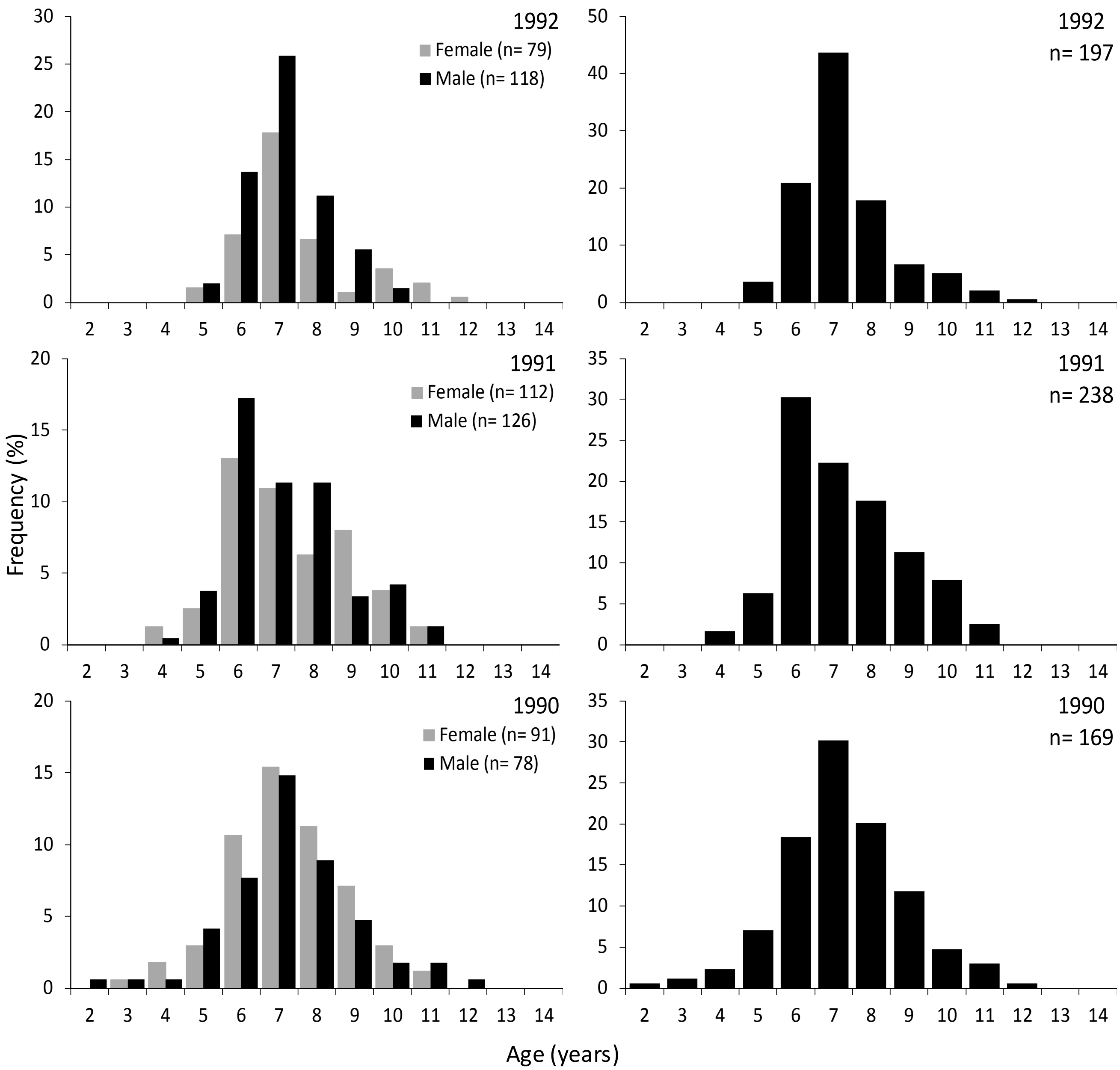


Figure 13. Continued.

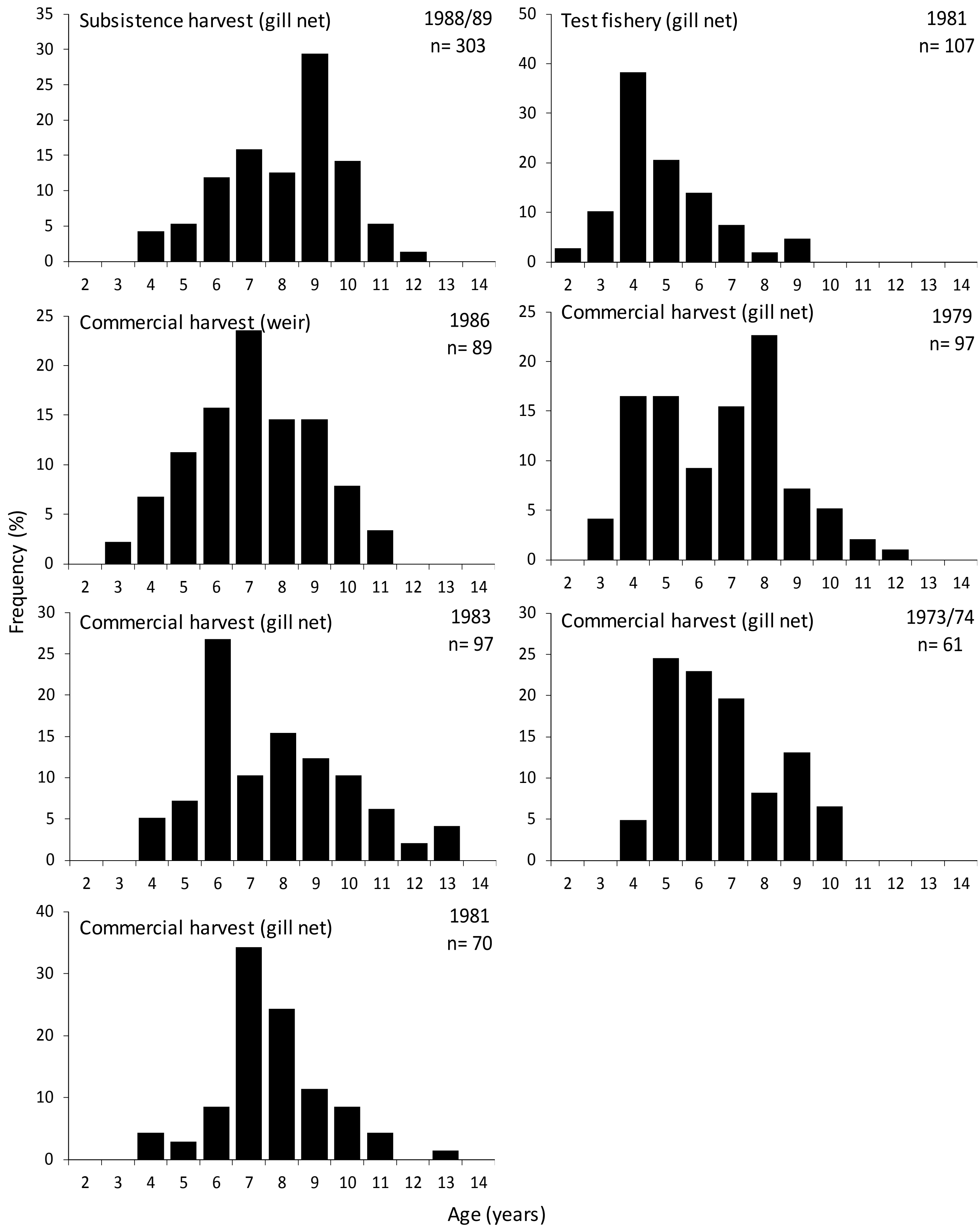


Figure 13. Continued.

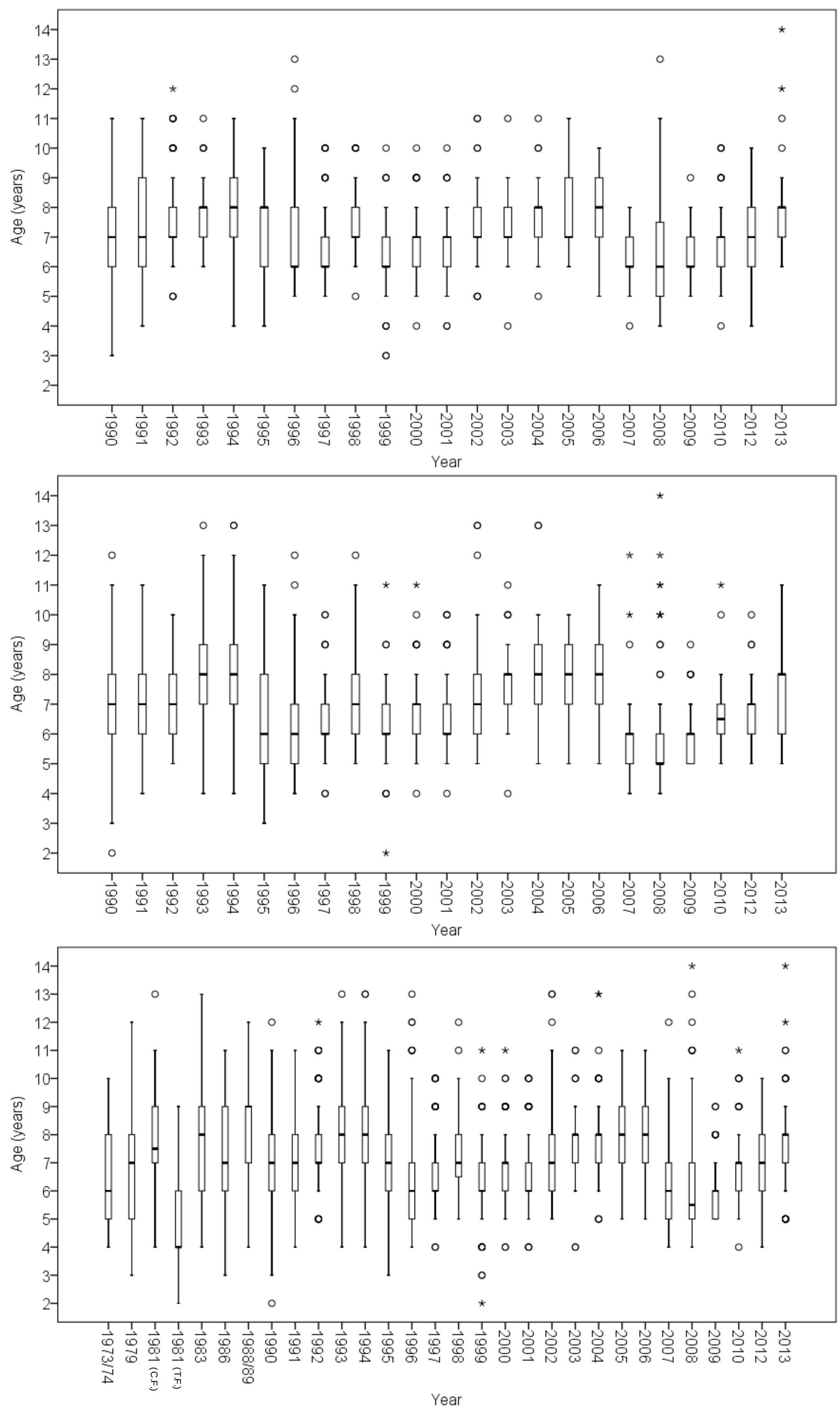


Figure 14. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of age of (top) female, (middle) male, and the (bottom) total sample of Arctic Char harvested at the mouth of the Hornaday River by the harvest monitors between 1990 and 2013, and other periodic sampling programs between 1973 and 1989. Note 1981: C.F.= commercial fishery, T.F.= test fishery.

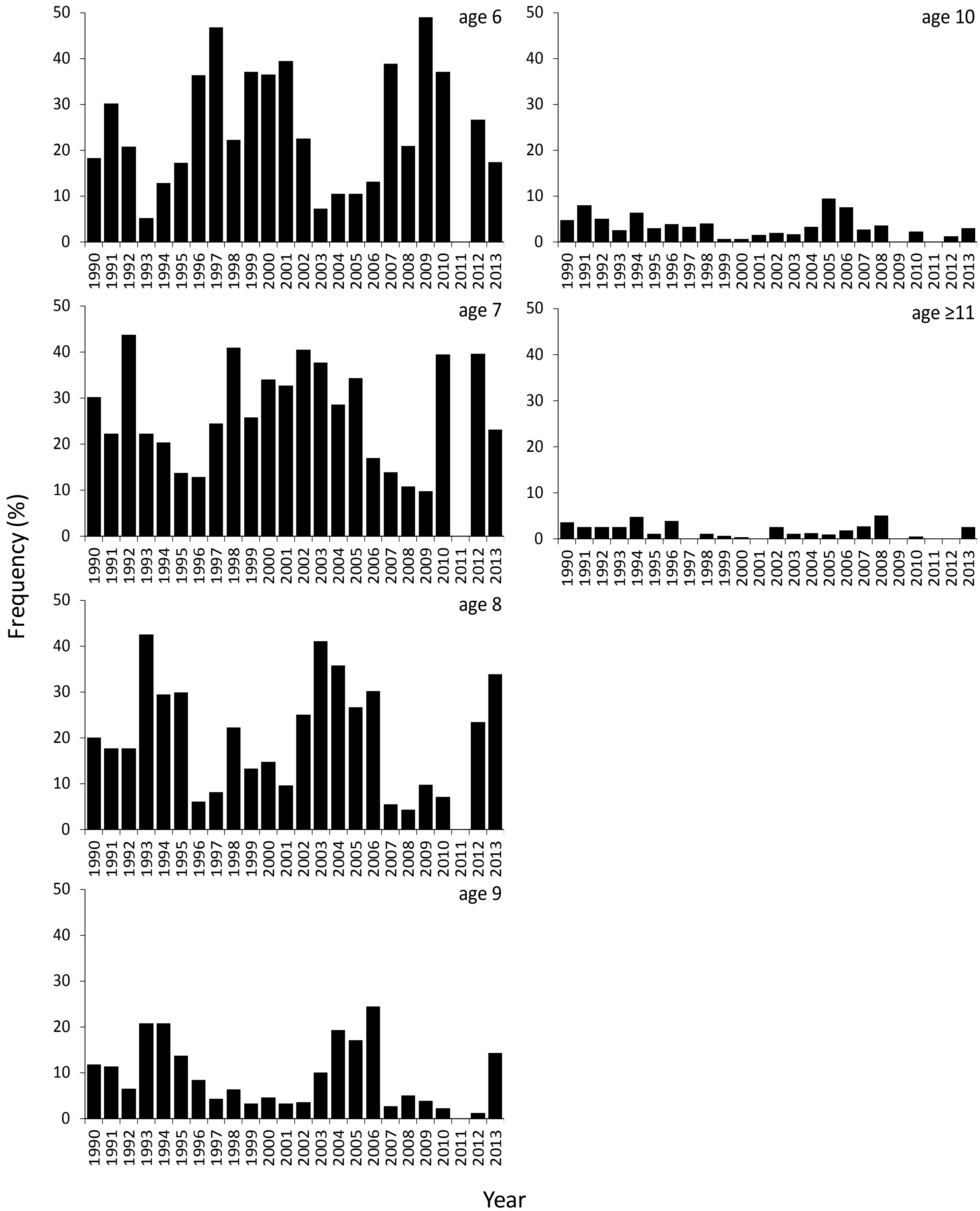


Figure 15. Proportion of an individual age class (≥6 years) in a sample of Arctic Char harvested at the mouth of the Hornaday River among sampling years (1990–2013). Note, no age data available for 2011.

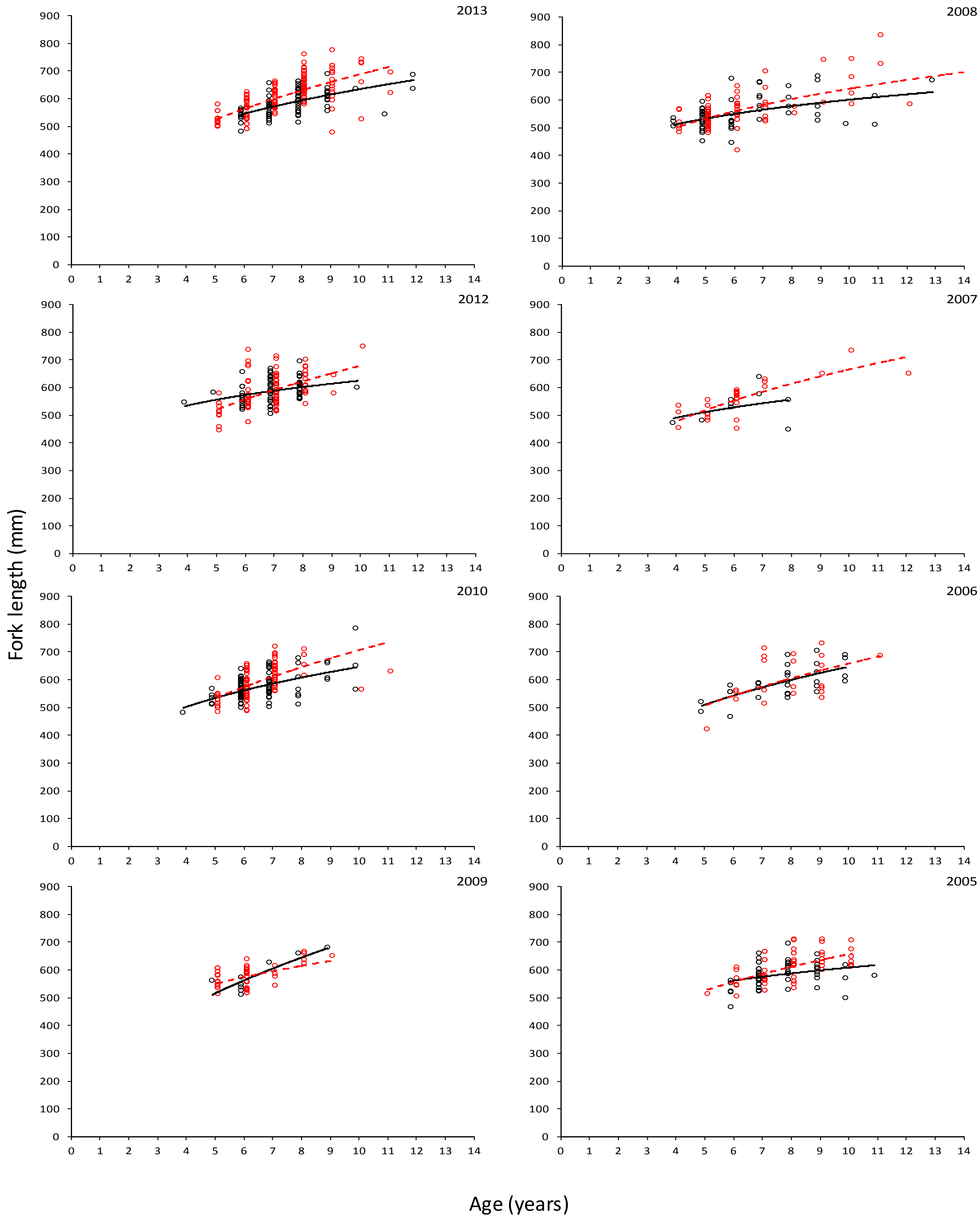


Figure 16. Length-at-age of female (black open circle; solid line regression) and male (red open circle; dashed line regression) Arctic Char sampled at the mouth of the Hornaday River between 1990 and 2013. Note, no age data available for 2011.

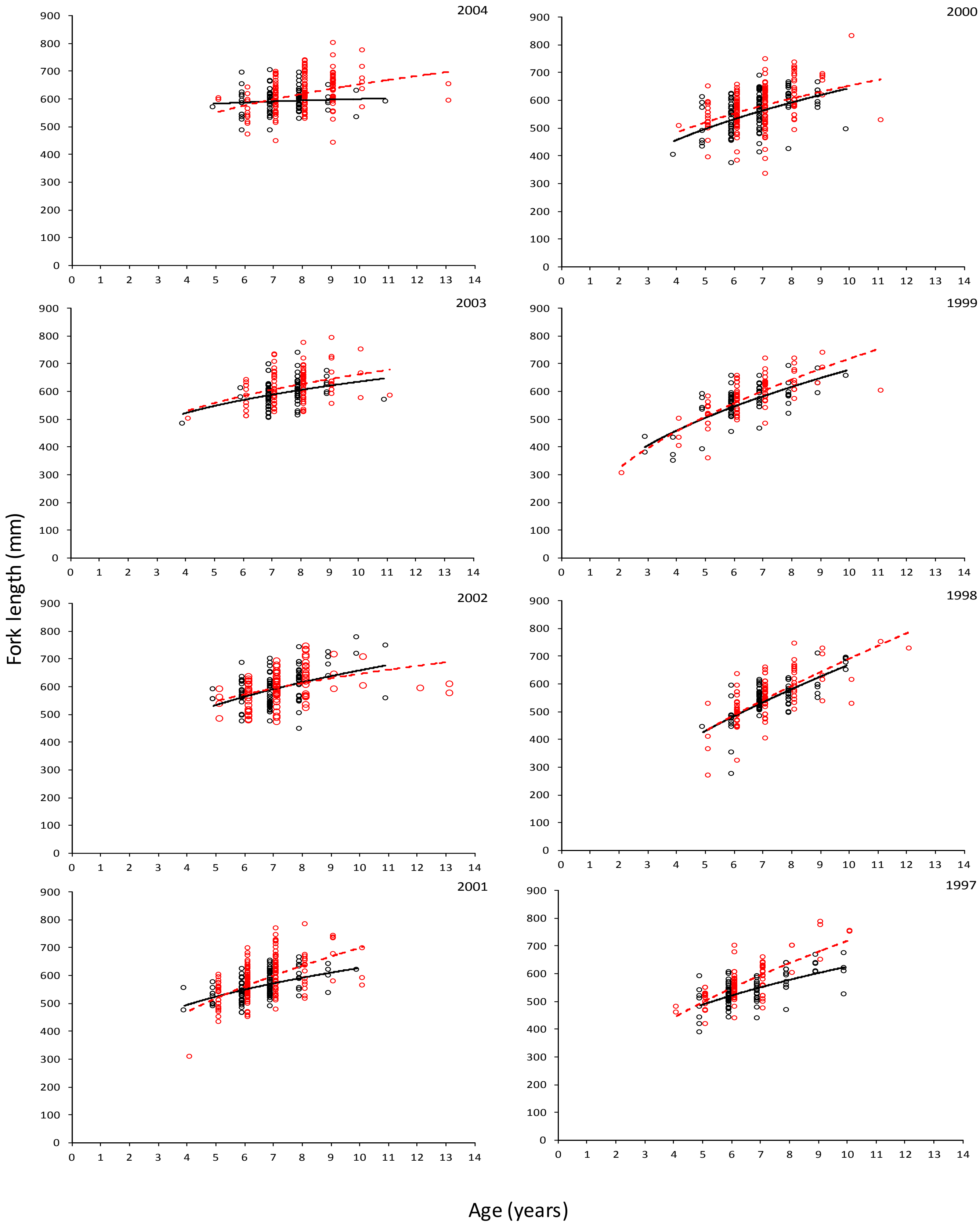


Figure 16. Continued.

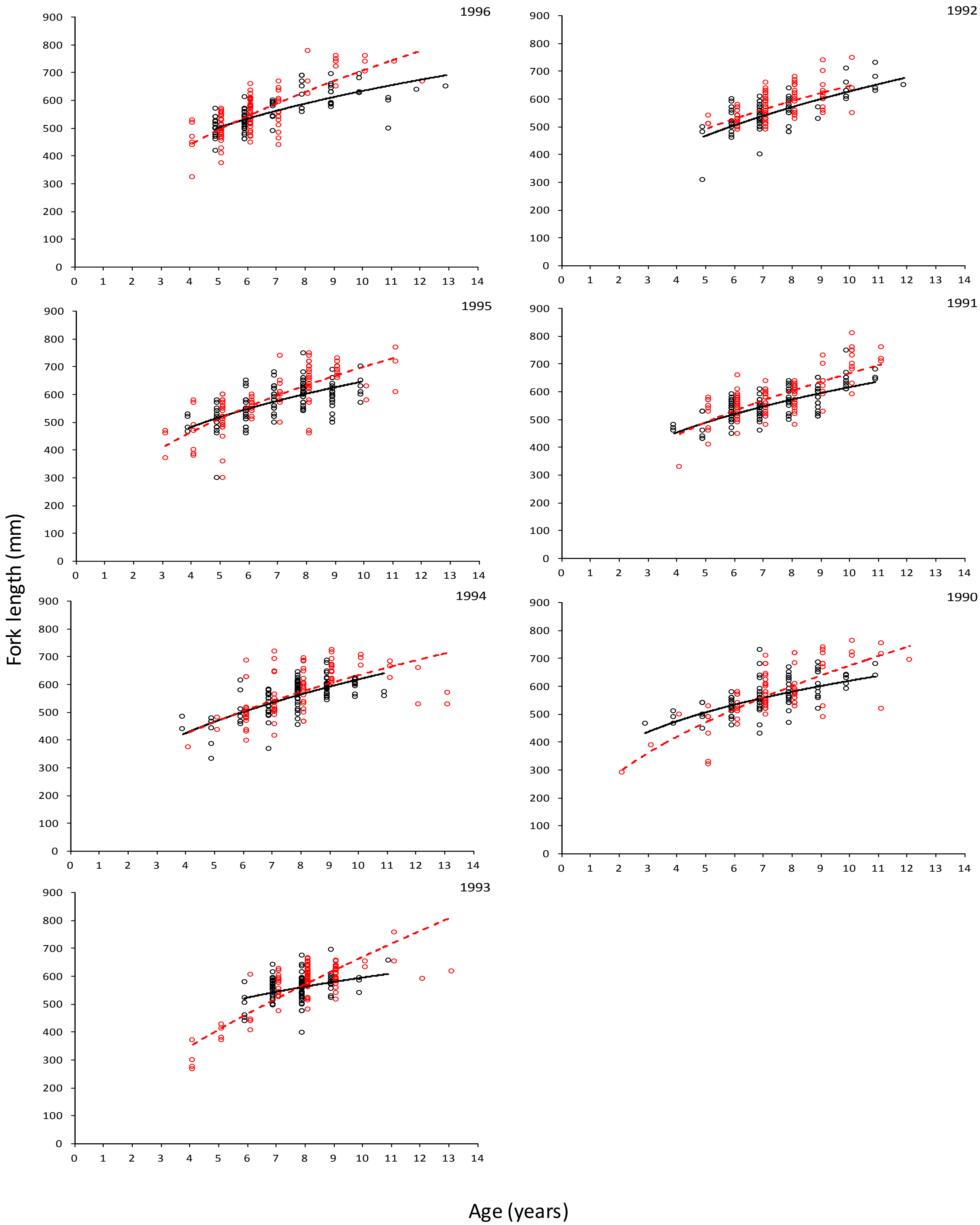


Figure 16. Continued.

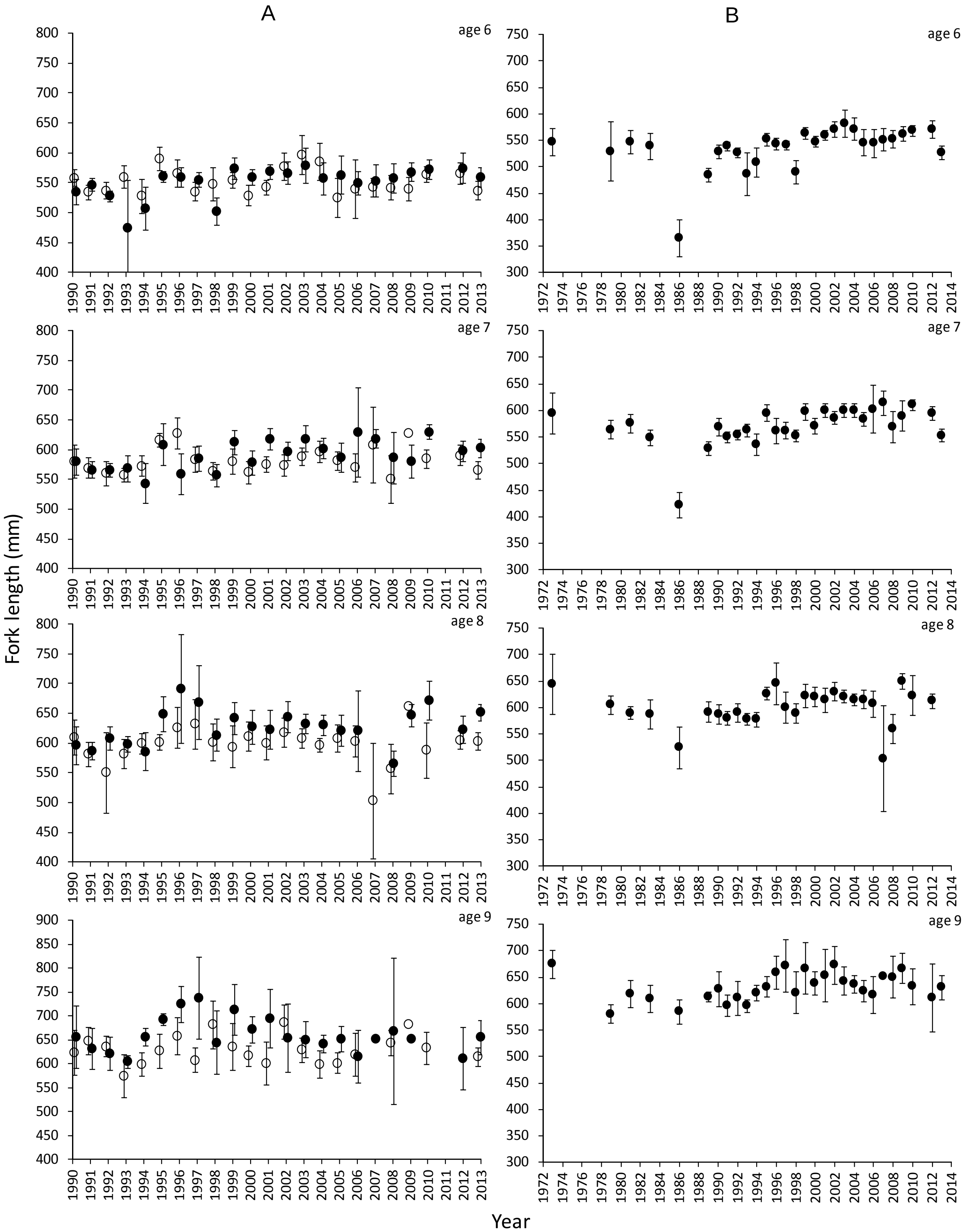


Figure 17. Mean length of ages 6, 7, 8 and 9 among sampling years, with 95% confidence intervals, of A) female (open circle) and male (closed circle) Arctic Char sampled at the mouth of the Hornaday River between 1990 and 2013, and B) Arctic Char (total dead-sample) from various sampling programs at the Hornaday River between 1972 and 2013, and other periodic sampling programs between 1973 and 1989 (total dead sample only; the 1981 commercial and test fishery samples were combined). Note, sample size was too small in 2006, 2007, and 2009 to examine sexes separately, and no age data available for 2011.

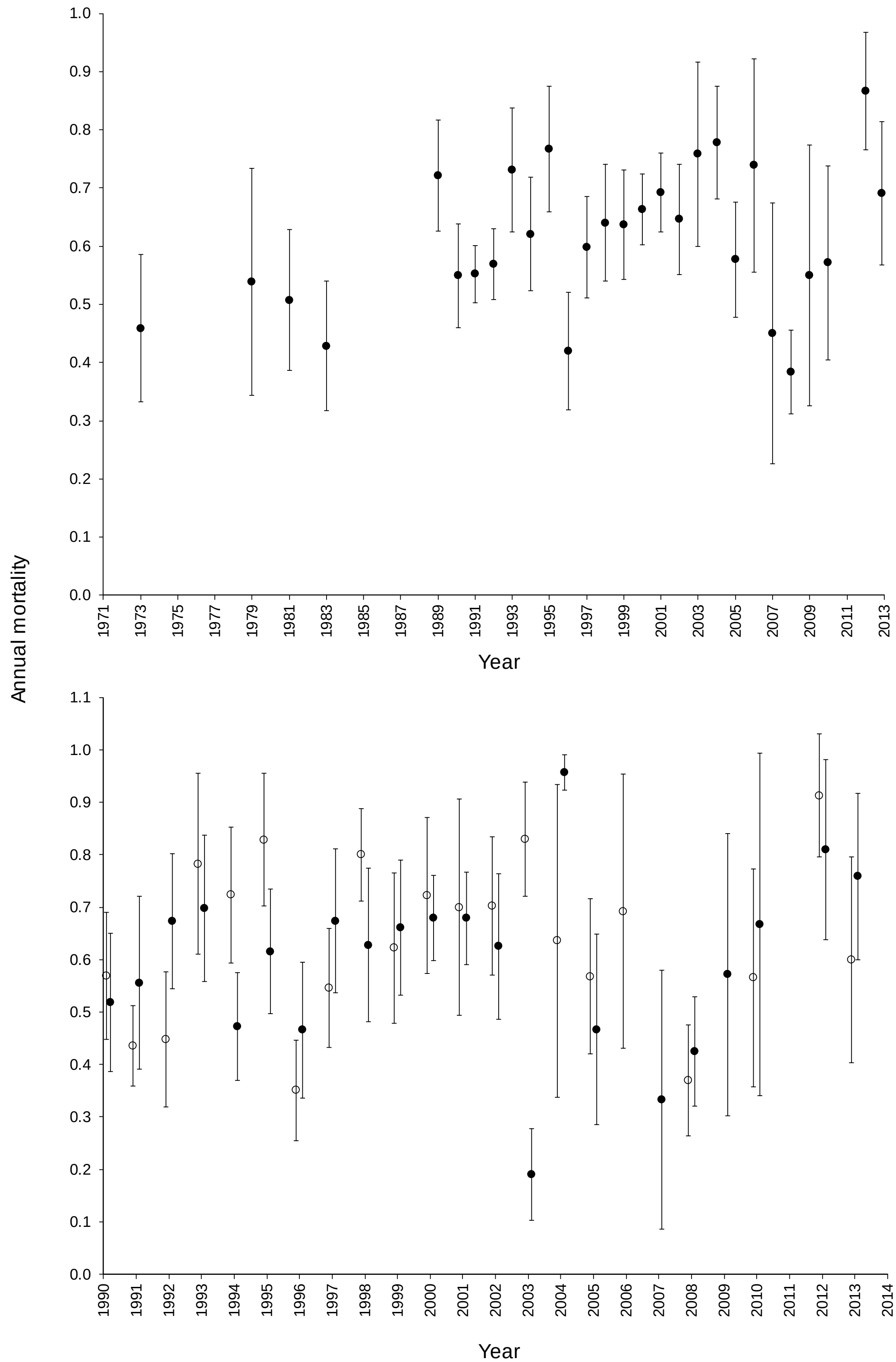


Figure 18. Annual mortality with 95% confidence intervals of (top) the total sample of and (bottom) female (○) and male (●) Arctic Char taken at the mouth of the Hornaday River between 1990 and 2013, and other periodic sampling programs between 1973 and 1989.

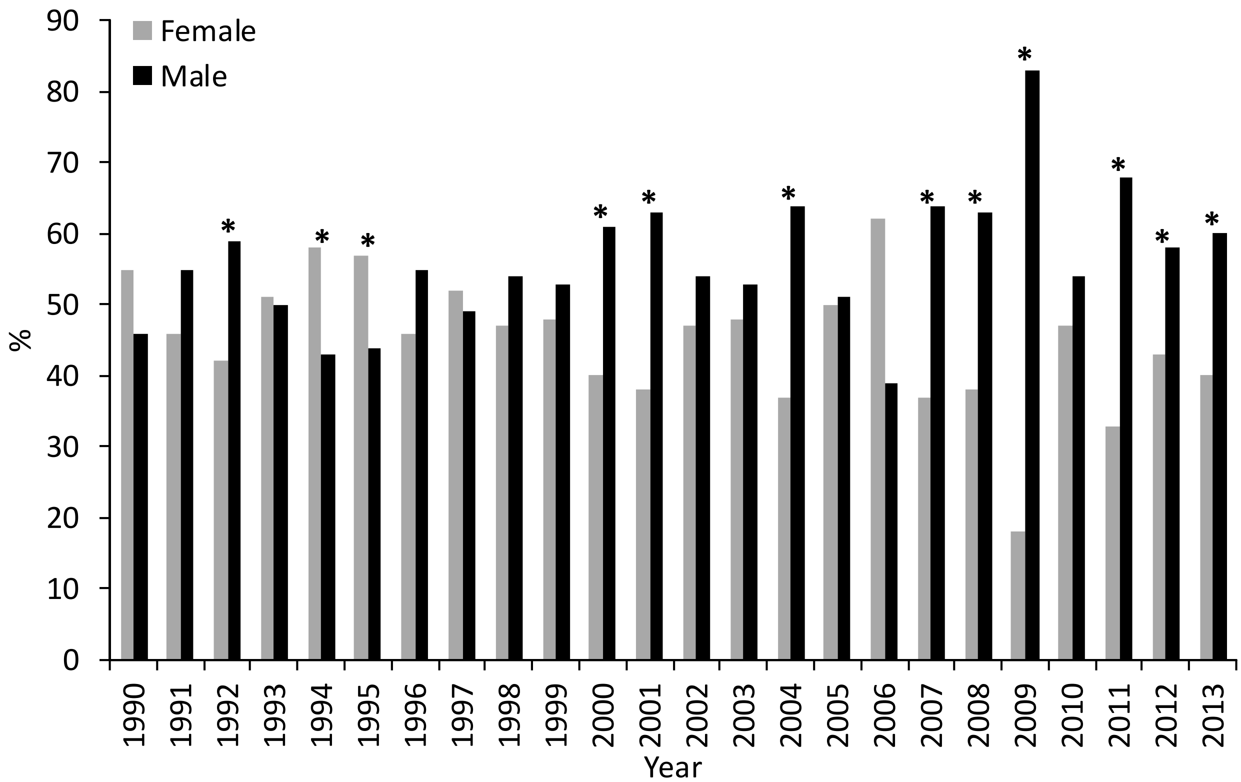


Figure 19. Percent male and female Arctic Char sampled at the mouth of the Hornaday River among years. Asterisks indicate significant departure from a binomial proportion of 0.5.

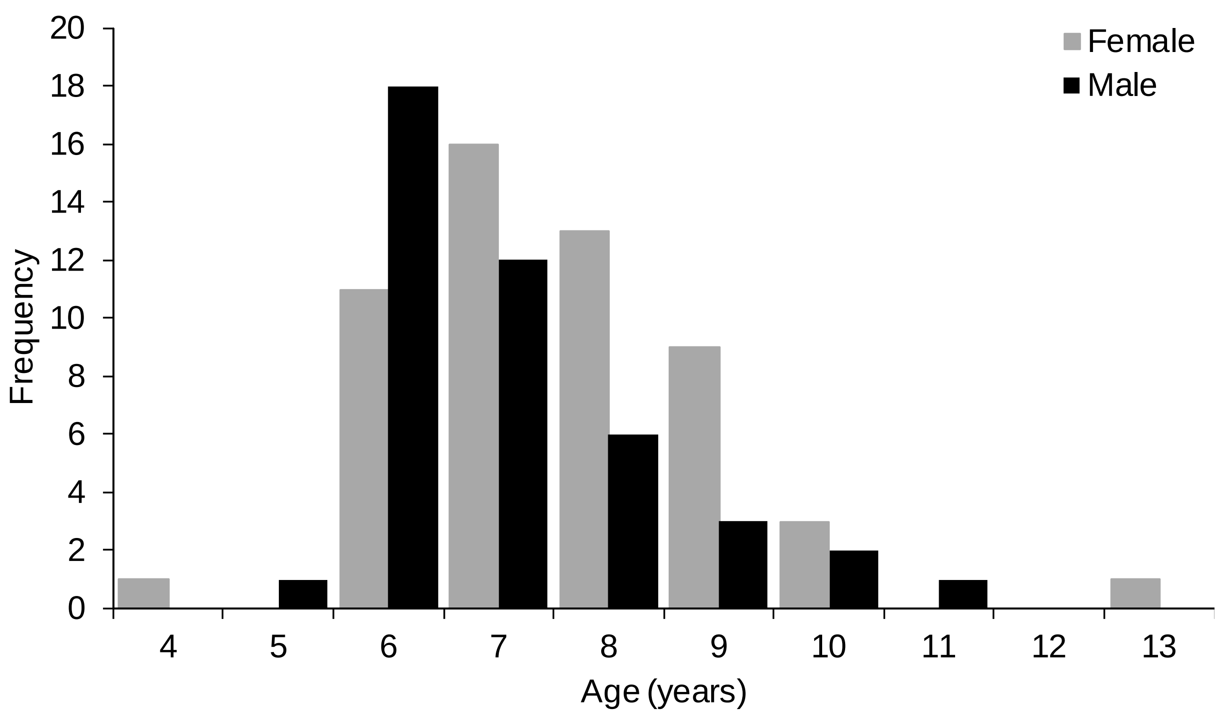


Figure 20. Frequency of Arctic char sampled at the mouth of the Hornaday River that were categorized as 'mature' among age classes. Data from all years were combined (1990–2013).

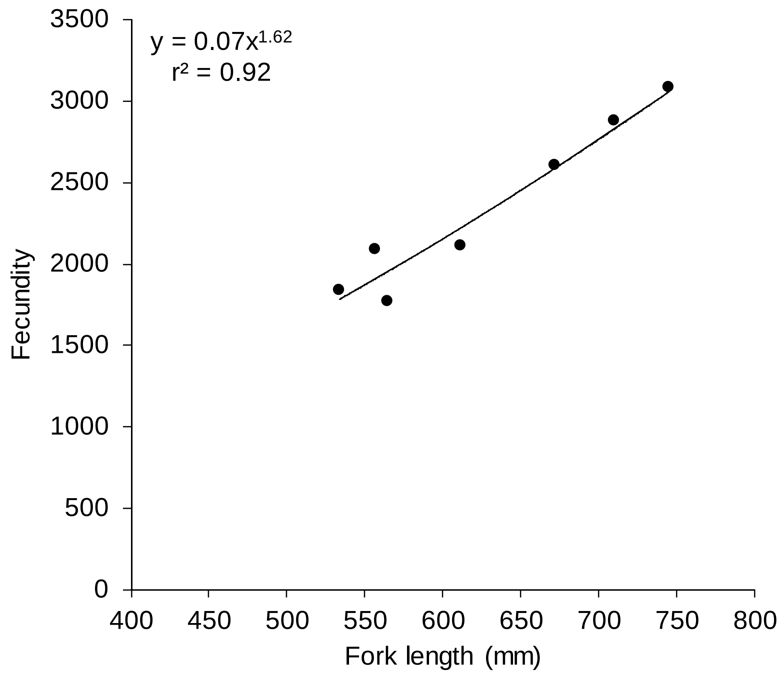


Figure 21. Fecundity plotted against fork length of mature Arctic Char captured in Darnley Bay.

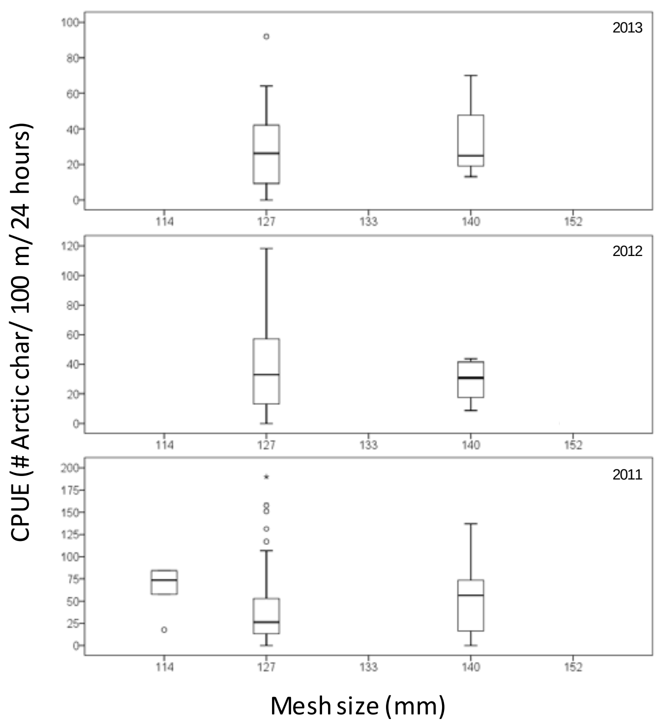


Figure 22. Box plot (median, quartiles and outliers (○, ★; values ≥1.5 x and 3 x IQR, respectively)) of catch-per-unit-effort (CPUE) of Arctic Char harvested at the mouth of Lasard Creek among mesh sizes for each sampling year.

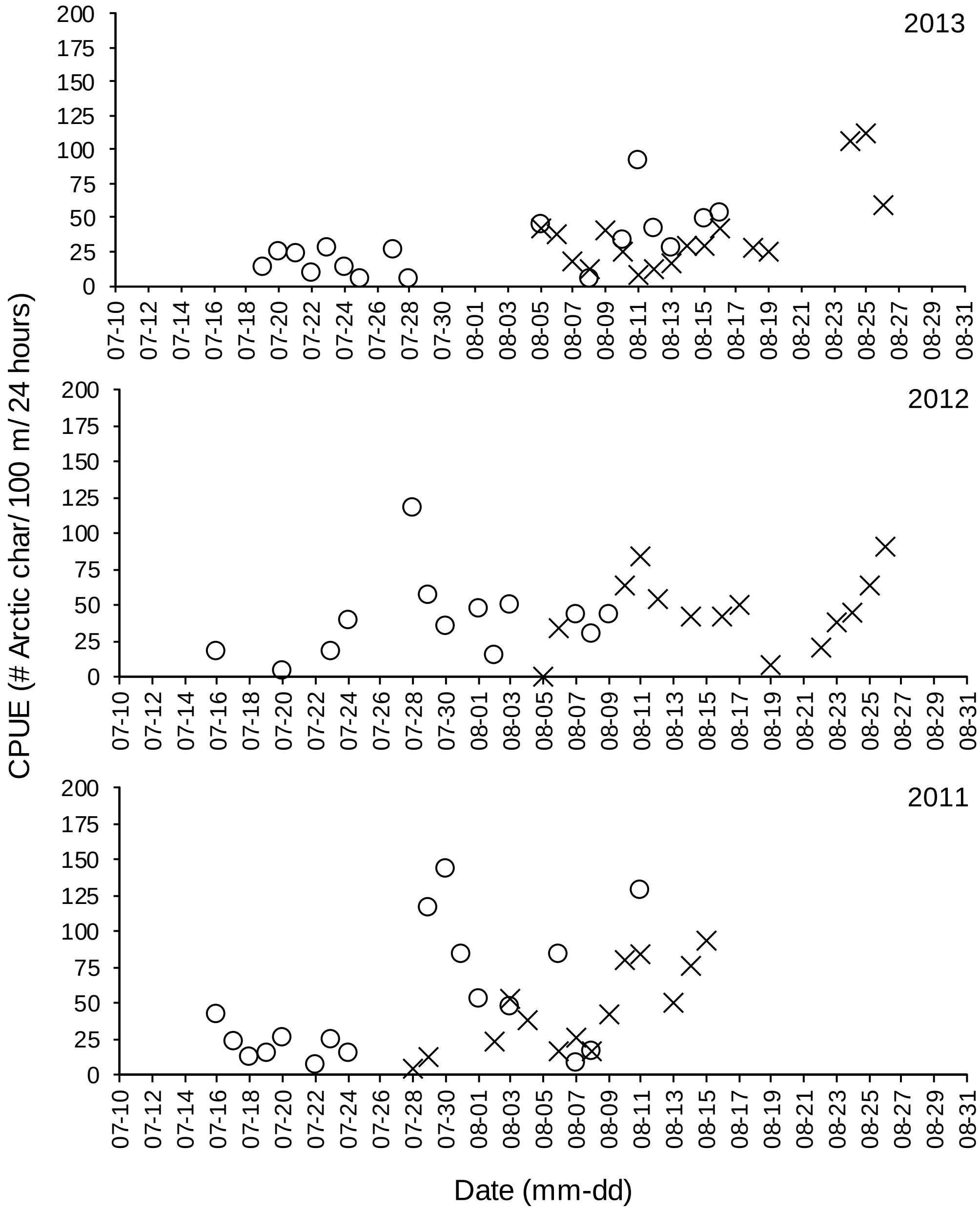


Figure 23. Daily median CPUE of (all mesh sizes combined) of the Hornaday River (x) and Lasard Creek (○).

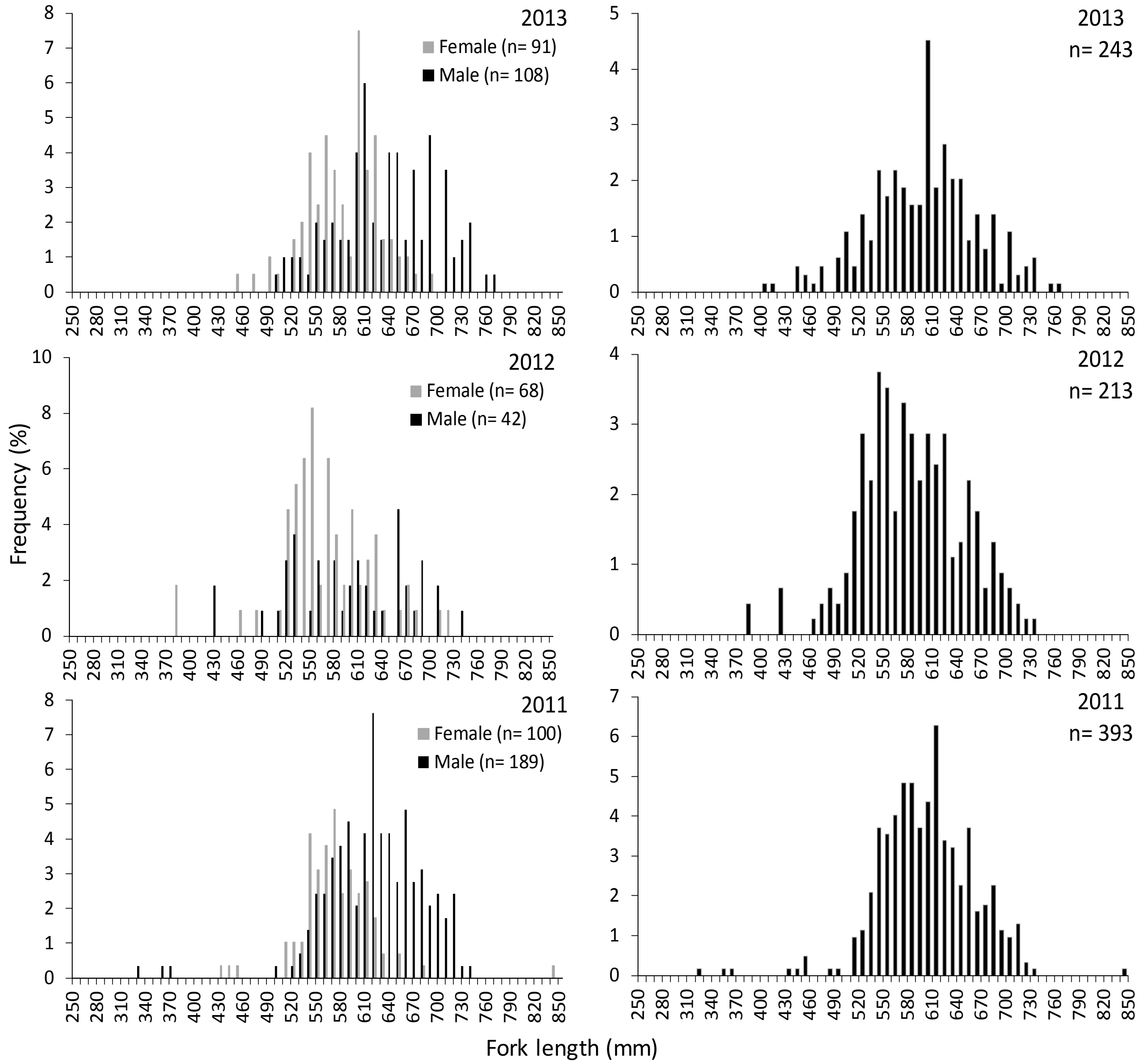


Figure 24. Fork length frequency distribution of female and male (left), and the combined sample of both sexes (right) of Arctic Char sampled at the Lasard Creek area by the harvest monitors between 2011 and 2013.

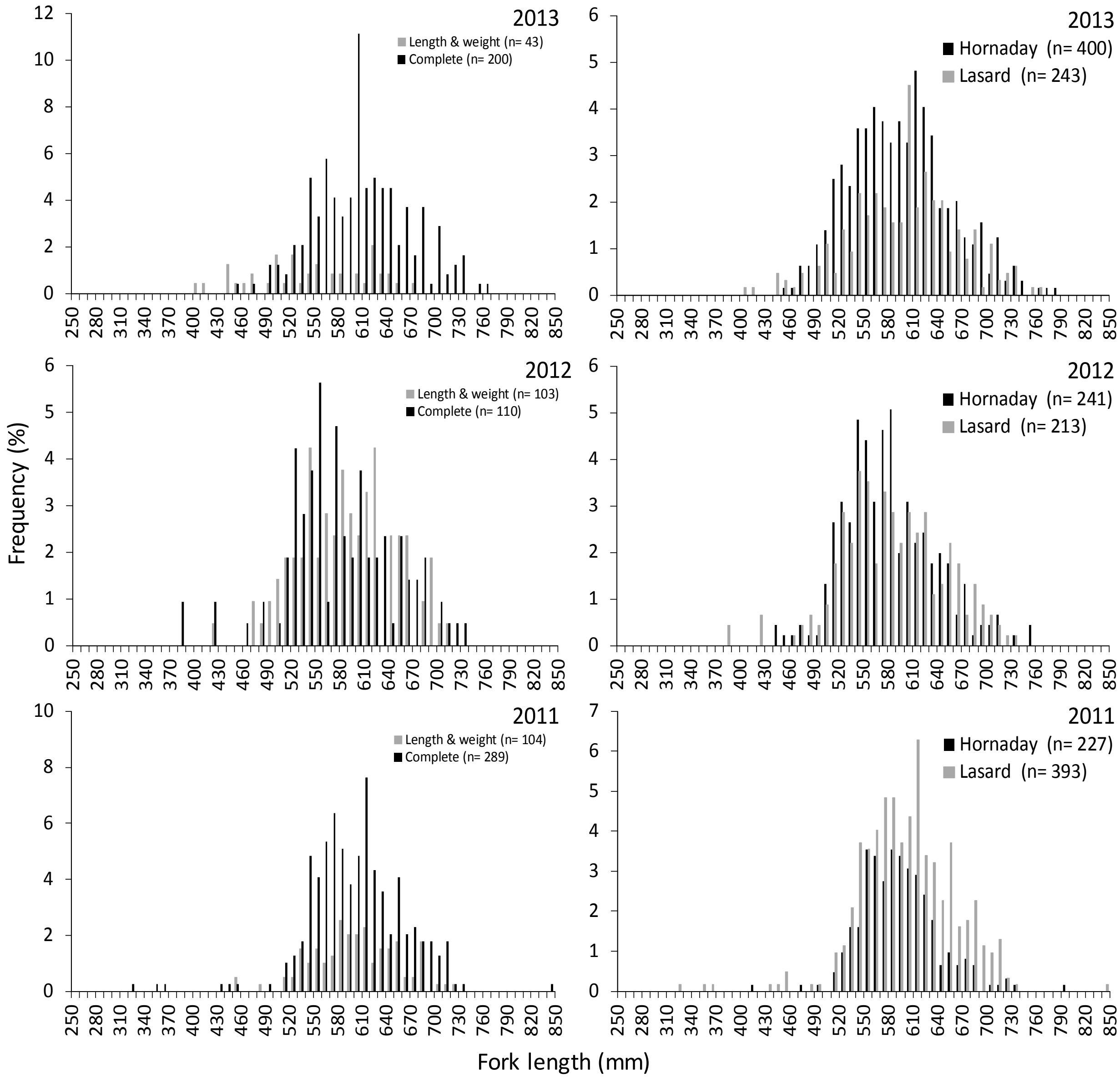


Figure 25. Fork length frequency distribution of Arctic Char sampled for length-and-weight-only, and complete dead-sampled for biological information at the Lasard Creek area (left), and how their combined sample compared with the one taken at the mouth of the Hornaday River (right) between 2011 and 2013.

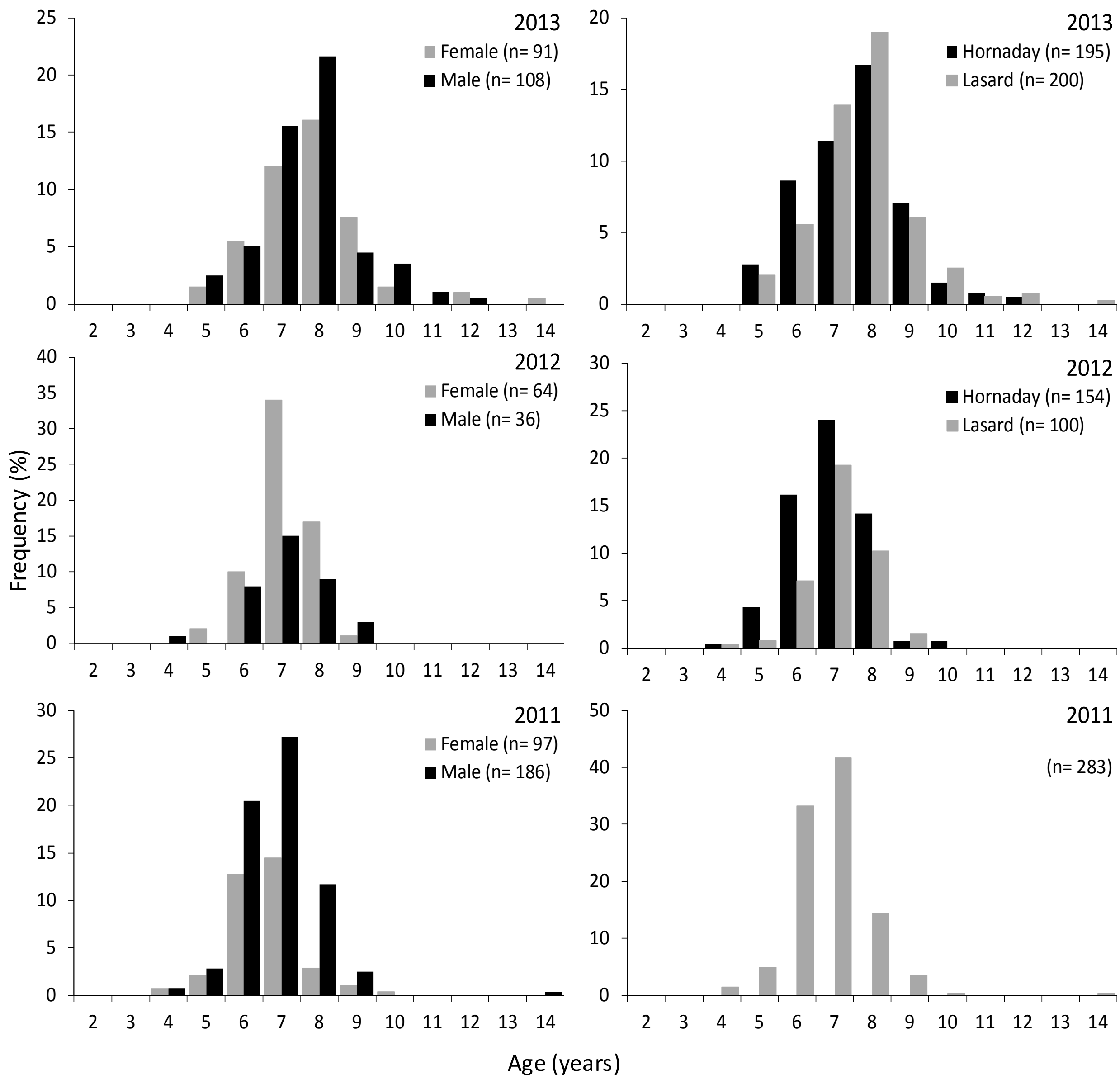


Figure 26. Age frequency distribution of female and male Arctic Char sampled at the Lasard Creek area (left)and how their combined sample compared with the one taken at the mouth of the Hornaday River (right) between 2011 and 2013. Note, no age data available for the Hornaday River in 2011; one sample in 2013 did not have sex information.

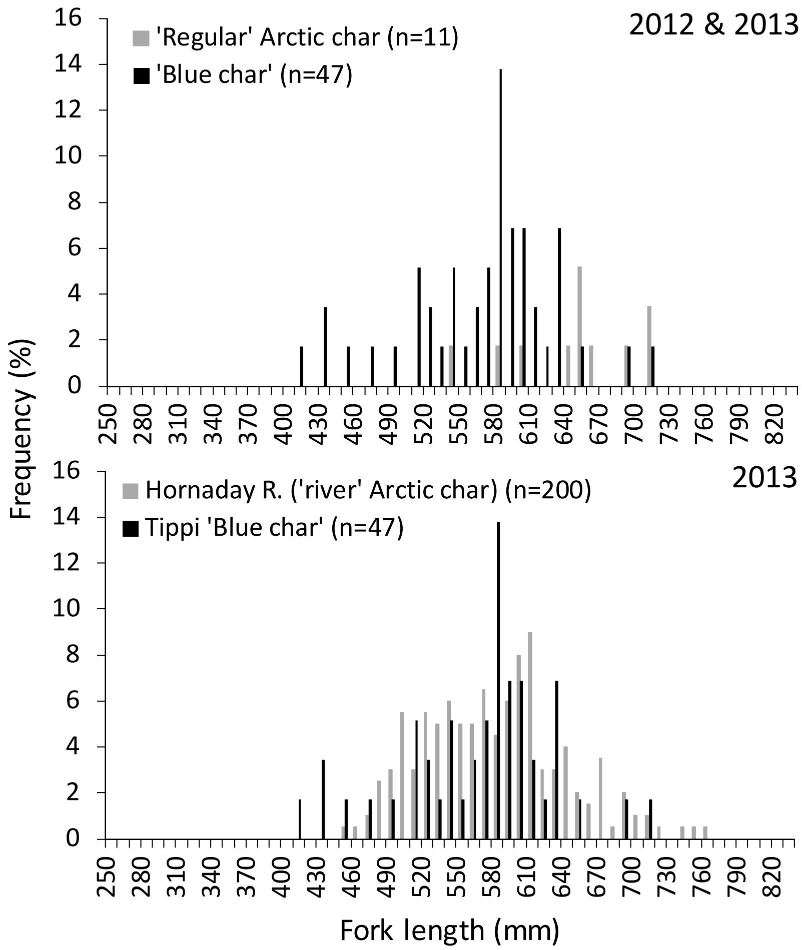
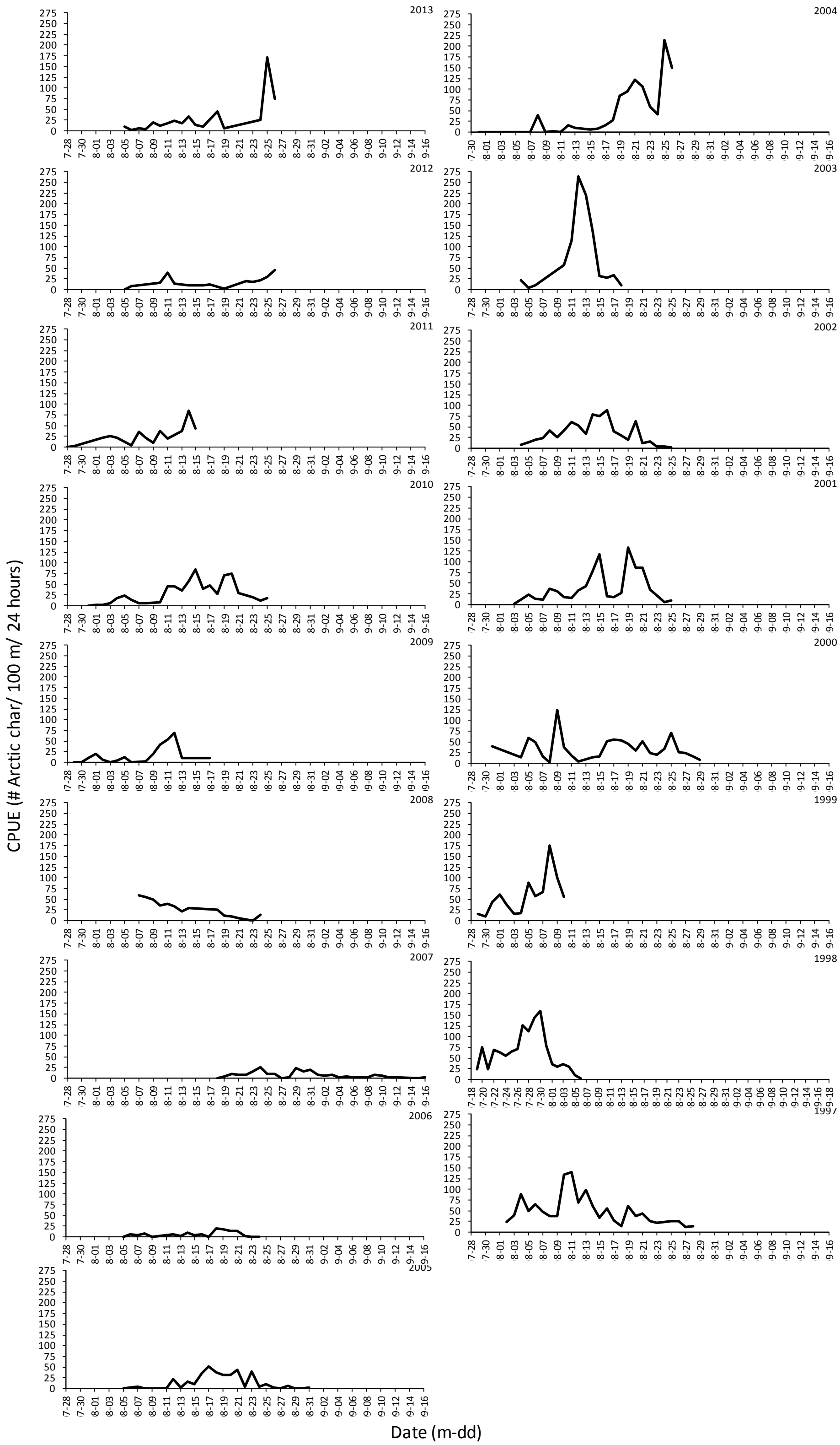


Figure 27. Fork length frequency distribution of (top) 'river' Arctic Char and 'blue char' harvested at Tippitiuyak (Tippi) in 2012 and 2013, and (bottom) 'blue char' from Tippi (2012–2013 sample) and 'river' Arctic Char from the mouth of the Hornaday River (2013 sample).

APPENDIX 1. SAMPLING DETAILS

Appendix 1. Table 1. Sample size of biological information taken from Arctic Char harvested from the Hornaday River from various types of fisheries conducted using gill nets and a weir between 1973 and 1989.

Type	Year	Fork length	Weight	Age (otoliths)	Sex	Mesh size (mm)				Weir
						114	127	133	140	
Commercial fishery	1973	66	66	61					66	
	1974	446	446						446	
	1979	103	103	97	100				103	
	1981	70	70	70	64				70	
	1983	103	91	97	90			103		
	1986	114	114							114
Sub total		*902*	*890*	*325*	*254*			*103*	*685*	*114*
Test fishery	1981	177	177	177	169					
Subsistence fishery	1988	17	17	17	17					
	1989	299	299	286	299	129	170			
Sub total		*316*	*316*	*303*	*316*	*129*	*170*			



Appendix 1. Figure 1. Daily mean catch-per-unit-effort (CPUE) of Arctic Char harvested during the Hornaday River Char Monitoring Program between 1997 and 2013 (all mesh sizes combined).

APPENDIX 2. TEST STATISTICS

Appendix 2. Table 1. Test statistics and p-value of Kruskal-Wallis (X^2) and Mann-Whitney (U) tests comparing catch-per-unit-effort among mesh sizes used by harvesters at the mouth of the Hornaday River in each sampling year between 1997 and 2013 (statistically significant differences are highlighted in grey).

Year	Statistic, p-value	Mesh (mm)
2013	U= 126, p= 0.16	114, 127
2012	U= 32, p= 0.15	114, 127
2010	X^2= 3.0, p= 0.39	114, 127, 140, 152
2009	X^2= 0.3, p= 0.86	114, 127
2007	X^2= 5.2, p= 0.16	114, 127, 133, 152
2006	X^2= 5.2, p= 0.16	114, 127, 133, 152
2005	X^2= 7.3, p= 0.03	114, 127, 133
2004	X^2= 14.8, p= 0.001	114, 127, 140
2003	X^2= 16.4, p= 0.1	114, 127, 133, 140
2002	X^2= 1116, p> 0.001	114, 127, 133, 140
2001	U= 3905, p= 0.76	114, 127
2000	U= 476, p= 0.02	114, 127
1999	X^2= 18.9, p< 0.001	114, 127, 140
1998	X^2= 20.5, p< 0.001	114, 127, 140
1997	X^2= 17.2, p< 0.001	114, 127, 140

Small sample size (n<5) 140 mm in 2006 and 2009 precluded analysis.
2011 NA because only one mesh used (114 mm). Small sample size for 127 mm in 2008 reduced number of mesh to one.

Appendix 2. Table 2. Test statistic and p-value of Mann-Whitney tests used for post-hoc analysis from statistically significant Kruskal-Wallis tests (see Table 4) from 1997, 1998, 1999, 2002, 2004 and 2005 (statistically significant differences are highlighted in grey).

Year	Mesh	Mesh (mm)		
	(mm)	114	127	133
2005	127	U= 921, p= 0.03		
	133	U= 67, p= 0.03	U= 119, p= 0.37	
2004	127	U= 1580, p< 0.001		
	140	U= 1988, p= 0.02	U= 3863, p= 0.24	
2002	127	U= 116, p= 0.57		
	133	U= 295, p= 0.01	U= 313, p= 0.004	
	140	U= 132.5, p= 0.001	U= 149, p= 0.001	U= 140, p= 0.80
1999	127	U= 178, p= 0.004		
	140	U= 787, p> 0.001	U= 380, p= 0.3	
1998	127	U= 2444, p= 0.88		
	140	U= 1351, p< 0.001	U= 2108, p< 0.001	
1997	127	U= 13894, p= 0.18		
	140	U= 2603, p< 0.001	U= 3429, p= 0.001	

Appendix 2. Table 3. Determination of whether the length information of female and male Arctic Char sampled at the mouth of the Hornaday River (complete dead sample) among mesh sizes and sampling years were parametrically (P) or non-parametrically (NP) distributed, and the test statistic and p-value of statistical test (analysis of variance, Kruskal-Wallis, Mann-Whitney) to determine whether length was significantly different among/ between gill net mesh sizes for either sex. Insufficient sample size for testing (n<10) is denoted by X. Significant differences were highlighted in grey and significant post-hoc test are shown below.

Year	Female					Male				
	Mesh (mm)				Test statistic and p-value	Mesh (mm)				Test statistic and p-value
	114	127	133	140		114	127	133	140	
2013	P	X		X		P	P		X	F= 0.1; d.f.= 1,115; p= 0.73
2012	P	P			F= 0.8; d.f.= 1,66; p= 0.38	P	P			F= 0.9; d.f.= 1,91; p= 0.35
2011	P	X				P	X			
2010	P	P		P	F= 0.7; d.f.= 2,78; p= 0.49	P	P			F= 0.4; d.f.= 2,90; p= 0.67
2009	X	X				X	P		X	
2008	NP					NP				
2007	X	X	X			P	X	X		
2006	P	P	X		F= 0.01; d.f.= 1,26; p= 0.92	P		X	X	
2005	P	P			F= 0.4; d.f.= 1,51; p= 0.53	P	P			F= 0.04; d.f.=1,52; p= 0.85
2004	P	P		P	F= 0.8; d.f.= 2,84; p= 0.45	P	P		P	F= 1.2; d.f.= 2,150; p= 0.29
2003	P	P	X		F= 1.9; d.f.= 1,70; p= 0.17	P	P	X	X	F= 0.6; d.f.= 1,78; p= 0.43
2002	NP	P	P	X	X^2= 5.9, p= 0.05	P	P	P	X	F= 0.4; d.f.= 2,98; p= 0.65
2001	P	P			F= 0.3; d.f.= 1, 101; p= 0.6	P	P			F= 1.0; d.f.= 1,170; p= 0.33
2000	P	P			F= 0.1; d.f.= 1,112; p= 0.8	P	P			F= 3.4; d.f.= 1,175; p= 0.07
1999	NP	P		X	U= 309, p= 0.14	P	P		X	F= >0.01; d.f.=1,78; p= 0.9
1998	P	NP		P	X^2= 3.5, p= 0.17	NP	P		P	X^2= 9.1, p= 0.01
1995	NP	NP			U= 2662, p= 0.004	P	P			F= 0.15; d.f.= 1,128; p= 0.7
1994	NP			X		NP				
1993	P	P		NP	X^2= 2.8, p= 0.24	P	NP		NP	X^2= 1.5, p= 0.47
1992	NP	NP		NP	X^2= 5.3, p= 0.069	P	NP		X	U= 1445, p= 0.59
1991	P	P		P	F= 3.4; d.f.=2,113; p= 0.04	NP	NP			U= 765, p= 0.76
1990	P	P		P	F=14.7, d.f.=2,102; p< 0.01	NP	P			U= 341, p= 0.75

Note, mesh size not recorded in 1996 and 1997; all samples from 152 mm mesh size were n<10.
Female 2002: 114 < 133 mm (U= 253, p= 0.025)
Female 1991: Scheffe 114 > 127 mm; 127 > 140mm
Female 1990: Scheffe 114 < 127 mm; 114 < 140 mm
Male 1998: 114 < 140 mm (U= 151, p= 0.005); 127 < 140 mm (U= 393, p= 0.01)

Appendix 2. Table 4. Test statistic and p-value of t-test or Mann-Whitney test examining whether the length of female and male Arctic Char captured in various gill net mesh sizes at the mouth of the Hornaday River were significantly different (highlighted in grey). Insufficient sample size for testing (n<10) is denoted by X.*

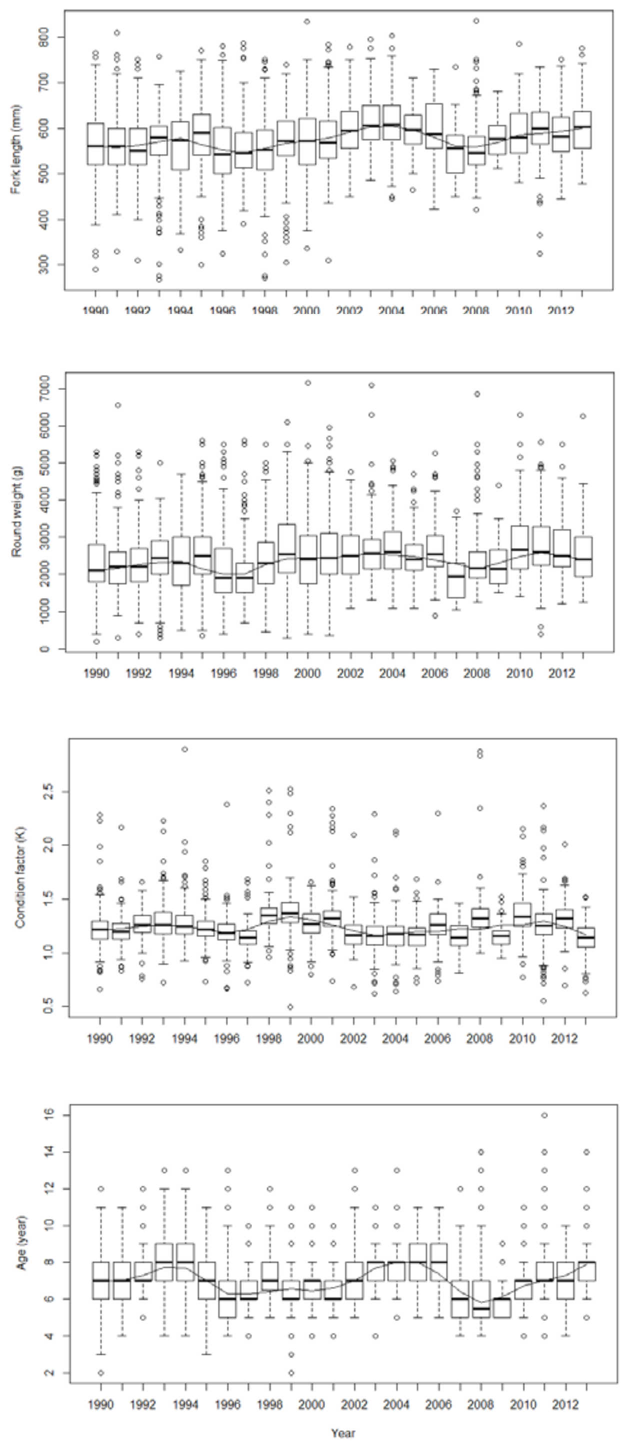
Year	Mesh (mm)			
	114	127	133	140
2013	t (179)= 3.2, p= 0.002	X	X	
2012	t (84)= -0.36, p= 0.7	t (73)= -0.16, p= 0.87		
2011	t (75)= 2.4, p= 0.018			
2010	t (40)= -0.4, p= 0.01	t (80)= -3.2, p= 0.002		
2009	X	X		
2008	U= 2336, p= 0.7			
2007	NA			
2006	t (30)= -0.06, p= 0.14		X	
2005	t (38)= -1.9, p= 0.07	t (65)= -1.95, p= 0.055		
2004	t (80)= -1.8, p= 0.07	t (80)= -2.7, p= 0.008		t (74)= -2.3, p= 0.02
2003	t (82)= -2.6, p= 0.01	t (66)= -1.99, p= 0.05	X	
2002	U= 539, p= 0.3	t (81)= -7.3, p= 0.47	t (37)= 0.77, p= 0.09	X
2001	t (172)= -2.2, p< 0.01	t (99)= -2.1, p= 0.56		
2000	t (206)= -1.3, p= 0.19	t (67)= -2.5, p= 0.04		
1999	U= 1588, p= 0.03	t (19)= 0.22, p= 0.83		X
1998	U= 192, p= 0.69	U= 1086, p= 0.63		t= (44)= 1.8, p= 0.08
1995	U= 2694, p= 0.09	U= 21559, p= 0.45		
1994	U= 4775, p= 0.23			
1993	t (17)= 2.72, p= 0.018	U= 1072, p= 0.051		U= 761, p= 0.006
1992	U= 554, p= 0.22	U= 1859, p= 0.87		
1991	U= 181, = 0.46	U= 937, p= 0.001		NA
1990	U= 1050, p= 0.19	t (27)= -2.1, p= 0.049		NA

**Although mesh size was not recorded in 1996 and 1997, no differences were detected between sexes in 1996 (U= 4227, p= 0.69), while males were significantly larger than females in 1997 (U= 4159, p= 0.01).*

Appendix 2. Table 5. Test statistic and p-value of Mann-Whitney test examining whether the length of Arctic Char harvested at the mouth of the Hornaday River that were complete dead-sampled and sampled for length- and-weight-only were significantly different in each year (highlighted in grey).*

Year	Test statistic and p-value
2013	U= 17012, p= 0.01
2012	U= 5015, p= 0.005
2011	U= 4420, p< 0.001
2010	U= 21220, p= 0.004
2009	U= 2773, p= 0.001
2008	U= 10251, p< 0.001
2007	U= 177, p= 0.62
2006	U= 1516, p= 0.24
2005	U= 5004, p= 0.75
2004	U= 10599, p= 0.92
2003	U= 22814, p< 0.001
2002	U= 26877, p< 0.001
1997	U= 30952, p= 0.15
1996	U= 30791, p= 0.31
1995	U= 73078, p< 0.001
1994	U= 18486, p= 0.76
1993	U= 61908, p= 0.8
1992	U= 72615, p= 0.07
1991	U= 74064, p< 0.001
1990	U= 68956, p= 0.06

**1998–2001 no length-and-weight-only sample was taken*



Appendix 2. Figure 1. Local polynomial least squares fit between year and fork length, round weight, condition factor, and age of Arctic Char harvested at the mouth of the Hornaday River (1990–2013). Lines are based on LOWESS smoothing. Age data for 2011 were taken from Lasard Creek which mainly consisted of char from the Hornaday River stock (Boguski et al. 2015).

Appendix 2. Table 6. Test statistic and p-value of Kruskal-Wallis or Mann-Whitney test examining whether age among mesh size were significantly different for female and male Arctic Char sampled at the mouth of the Hornaday River in each sampling year. Only mesh size with sufficient sample size (n>10) were examined. Significant differences were highlighted in grey and significant post-hoc test are shown below.

Year	Female	Male	Mesh size
2013		U= 422, p= 0.16	114, 127
2012	U= 496, p= 0.52	U= 943, p= 0.95	114, 127
2010	$X^2(2)$= 0.11, p= 0.95	$X^2(2)$= 0.22, p= 0.90	114, 127, 140
2006	U= 57, p= 0.21		114, 127
2005	U= 327, p= 0.78	U= 300, p= 0.91	114, 127
2004	$X^2(2)$= 1.47, p= 0.48	$X^2(2)$= 2.37, p= 0.31	114, 127, 140
2003	U= 538, p= 0.93	U= 670, p= 0.38	114, 127
2002	$X^2(2)$= 2.47, p= 0.29	$X^2(2)$= 0.09, p= 0.96	114, 127, 133
2001	U= 1031, p= 0.29	U= 3002, p= 0.24	114, 127
2000	U= 1071, p= 0.67	U= 2530, p= 0.36	114, 127
1999	U= 220, p= 0.23	U= 401, p= 0.84	114, 127
1998	$X^2(2)$= 3.13, p= 0.21	$X^2(2)$= 6.31, p= 0.04	114, 127, 140
1995	U= 2448, p= 0.12	U= 1227, p= 0.21	114, 127
1993	$X^2(2)$= 0.1, p= 0.94	$X^2(2)$= 1.28, p= 0.57	114, 127, 140
1992	U= 433, p= 0.017	U= 929, p= 0.013	114 < 127
1991	$X^2(2)$= 9.39, p= 0.009	$X^2(2)$= 4.0, p= 0.13	114, 127, 140
1990	$X^2(2)$= 6.49, p= 0.04	$X^2(2)$= 6.53, p= 0.04	114, 127, 140

Sample size too low to compare mesh for both sexes in 1994, 2007, and 2009, for males in 2006, and females in 2013
Single mesh size used in 2008 (114 mm)
Mesh size not recorded in 1996 and 1997
Female 1990: 114 < 140 mm (U= 505, p= 0.02); 127 < 140 mm (U= 117, p= 0.012)
Male 1990: 127 < 140 mm (U= 117, p= 0.01).
Female 1991: 114 > 127 mm (U= 171, p= 0.007); 127 < 140 mm (U= 868, p= 0.023)
Male 1998: 127 < 140 mm (U= 368, p= 0.012)

Appendix 2. Table 7. Determination of whether the length information of female and male Arctic Char sampled from the Lasard Creek area (complete dead sample) among mesh sizes and sampling years were parametrically (P) or non-parametrically (NP) distributed, and the test statistic and p-value of Mann-Whitney test to determine whether length was significantly different among/ between gill net mesh sizes for either sex. Insufficient sample size for testing (n<10) is denoted by X.

Year	Female				Male			
	Mesh (mm)			Test statistic and p-value	Mesh (mm)			Test statistic and p-value
	114	127	140		114	127	140	
2013		P				P		
2012		NP	X			P	X	
2011	X	NP	NP	U= 937, p= 0.2	X	NP	NP	U= 3344, p= 0.09

Appendix 2. Table 8. Test statistic and p-value of Mann-Whitney test examining whether the length of Arctic Char harvested from the Lasard Creek area that were complete dead-sampled and sampled for length-and weight-only were significantly different in each year (highlighted in grey).*

Year	Test statistic and p-value
2013	U= 2359, p< 0.001
2012	U= 5301, p= 0.4
2011	U= 14940, p= 0.9