Observations of Size-at-Age for Sockeye Salmon (*Oncorhynchus nerka*) Smolts from Henderson Lake, British Columbia (1977-2016)

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FISHERIES AND AQUATIC SCIENCES 1314

2020

Observations of Size-at-Age for Sockeye Salmon (*Oncorhynchus nerka*) Smolts from Henderson Lake, British Columbia (1977-2016)

by

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ABSTRACT

Hyatt, K. D., Stiff, H. W. and Rankin, D. P. 2020. Observations of Size-at-Age for Sockeye Salmon (*Oncorhynchus nerka*) Smolts from Henderson Lake, British Columbia (1977-2016). Can. Data Rep. Fish. Aquat. Sci. 1314: v + 83 p.

Personnel from the Salmon in Regional Ecosystems Program (SIRE-P) and its predecessors have conducted annual sampling of juvenile salmon (*Oncorhynchus nerka*) migrating seaward from Henderson Lake in most years between 1977 and 2016. Observations of biological traits of smolts (e.g. size at sea entry) help inform ongoing research into the likely origins of large variations in production exhibited by Sockeye Salmon populations in freshwater and marine ecosystems in Canada's Pacific region. For Henderson Lake, smolts were collected from a fyke net and/or rotary screw trap for one or more dates during the spring migration period (April to early June) at the outlet of the lake (Henderson River). Individual fish from sample collections were processed and measured for fork length and weight, and scales were taken. Fish weight (wet weight in grams) and length (fork length in mm) were obtained from either fresh, frozen or preserved samples but all observations here are expressed as fresh measure equivalents. Summary statistics of size-at-age of Sockeye Salmon smolts are tabulated in this report by survey date and age. A consistent annual index of Henderson Lake Sockeye smolt size was identified for the predominant age 1 class of migrants, based on a subset of the sample observations collected between April 14th (10th percentile) and May 26th (90th percentile) of each year. The all-year weighted averages for fork length and wet weights of age 1.0 Sockeye smolts exiting Henderson Lake were 7.3 ± 1.3 cm and 3.5 ± 1.8 grams respectively. The weighted averages for fork length and wet weights of age 2.0 Sockeye smolts were 8.4 ± 0.9 cm and 5.2 ± 2.0 grams respectively.

RÉSUMÉ

Hyatt, K. D., Stiff, H. W. and Rankin, D. P. 2020. Observations of Size-at-Age for Sockeye Salmon (*Oncorhynchus nerka*) Smolts from Henderson Lake, British Columbia (1977-2016). Can. Data Rep. Fish. Aquat. Sci. 1314: v + 83 p.

Les employés du Programme du saumon dans les écosystèmes régionaux et leurs prédécesseurs ont effectué des échantillonnages annuels de saumons juvéniles (*Oncorhynchus nerka*) qui dévalaient du lac Henderson la plupart des années entre 1977 et 2015. L'observation des caractéristiques biologiques des saumoneaux (p. ex. la taille à l'entrée en mer) aide à orienter les recherches en cours sur les origines probables des grandes variations de la production des populations de saumon rouge dans les écosystèmes d'eau douce et marins de la région du Pacifique du Canada. Dans le cas du lac Henderson, les saumoneaux ont été capturés à l'aide d'un verveux à une ou plusieurs dates durant la migration printanière (d'avril à début juin) à la sortie du lac (rivière Henderson). Les poissons individuels ont été traités; on a mesuré leur longueur à la fourche et leur poids, et prélevé des écailles. Le poids (poids humide en grammes) et la longueur (longueur à la fourche en mm) du poisson ont été obtenus à partir d'échantillons frais, congelés ou conservés, mais toutes les observations sont exprimées ici en équivalents de mesures fraîches. Des statistiques sommaires sur la taille selon l'âge des saumoneaux rouges sont présentées dans le présent rapport par date de relevé et par âge. Un indice annuel uniforme de la taille des saumoneaux rouges du lac Henderson a été établi pour la classe d'âge 1 prédominante des migrateurs, d'après un sous-ensemble des observations des échantillons recueillies entre le 14 avril (10e centile) et le 26 mai (90e centile) de chaque année. Les moyennes sur toute l'année pour la longueur à la fourche et le poids humide des saumoneaux rouges d'âge 1 quittant le lac Henderson étaient de 7,3 ± 1,3 cm et 3,5 ± 1,8 grammes respectivement. Les moyennes sur toute l'année pour la longueur à la fourche et le poids humide des saumoneaux rouges d'âge 2 étaient de 8,4 ± 0,9 cm et de 5,2 ± 2,0 grammes respectivement.

INTRODUCTION

The Salmon in Regional Ecosystems Program (SIRE-P), and its predecessors, have been involved in a series of short- to medium-term studies spanning a roughly forty-year interval focused on more than thirty Sockeye salmon conservation units (CUs) in Canada's Pacific region. Funding of short-term studies has been received from a variety of federal, provincial and industry sources with interests in salmon enhancement (Hyatt et al. 1984, 2004, 2005a; Hyatt and Stockner 1985), stock assessment (Hyatt and Steer 1987; Hyatt et al. 1989, 1994, 2000; McCreight et al. 1994; Hyatt and Rankin 1999), habitat and stock restoration (Johannes et al. 1999, 2002; Hyatt et al. 2003; Hyatt and Stockwell 2019), climate change (Hyatt et al. 2005b, 2005c, 2015b, 2016a, 2018a; Stiff et al. 2018) and food-web research (McQueen et al. 2007; Hyatt et al. 2005b, 2011, 2016b, 2016c, 2018b). Although most of these programs – focused on individual Sockeye CUs – have been completed and terminated within less than five years, a few of these Sockeye CUs, associated with each of several distinctive freshwater and marine adaptive zones (Holtby and Ciruna 2007), have been subjects of sufficient interest to permit assembly of longer term (>25 years) data sets on life-stage specific biological traits and abundance. Multidecadal patterns of annual production variations exhibited as total returns of adults (i.e. catch plus escapement) by these CUs have been documented by Hyatt et al. (2016a, 2018a) in DFO's State of the Pacific Ocean reports, but assembly and documentation of associated abundance and biological trait observations by life-stage (e.g. Hyatt et al. 2019a, 2019b) remains a work in progress to make these data more widely available to the scientific community (e.g. Hyatt et al. 2015a, 2015b; Stiff et al. 2018).

The results reported here are derived from projects designed to deliver on a variety of objectives but now comprise a sufficiently long time series of obervations to have utility as a basis for analysis of lake carrying capacity (e.g. Hyatt et al. 2011) and identification of the factors operating to control salmon production variations in either freshwater (e.g. Hyatt and Rankin 1999) or marine ecosystems (e.g. Hyatt et al. 2015b).

In this report we summarize observational data collected to assess biological traits (size and age) of Sockeye salmon smolts sampled during spring seaward migrations from Henderson Lake from 1977-2015. Smolt catch and effort data are analyzed to derive a consistent, representative estimate of mean annual Henderson Lake Sockeye smolt size by age class. The relationship with pre-smolt length was used to extend the smolt length time-series to 2016, for which smolt size data were not available.

This report includes:

(1) a general map of sampling locations;

(2) smolt catch and effort summary tables and plots;

(3) plots of length/weight regressions and frequency distributions; and

(4) plots and tables of observed (sampled) and "best" (filtered) estimates of smolt size by year and age.

STUDY AREA

Henderson Lake, located on the west coast of Vancouver Island (49°05'N x 125°02'W; elev. 1 m), is a moderately deep, oligotrophic waterbody (mean depth 97 m; max depth 250 m) with a surface area of approximately 1,545 hectares, draining a 150 km^2 watershed (Figure 1) (Stockner and Shortreed 1983; Rutherford et al. 1986). The lake's principal tributary is Clemens Creek which drains an area of 135 km^2 into the head end of Henderson Lake (Tschaplinski and Hyatt 1990). The 1 km outlet – Henderson River – connects the lake with Barkley Sound via Uchucklesit Inlet and Alberni Inlet (Figure 2).

SALMON ENHANCEMENT

Between 1992 and 2006, the Uchucklesaht First Nation operated the Henderson Lake hatchery, a salmon enhancement facility located at the head end of the lake, releasing up to 2 million Sockeye fry and 100,000 Chinook fry annually between 1994 and 2008 (Hyatt et al. 2016b). As part of the Salmon Enhancement Program (SEP), DFO personnel added inorganic nutrients to Henderson Lake on an annual basis in 1976-1997, 1999, and 2007 to indirectly stimulate juvenile Sockeye salmon production via phyto- and zooplankton growth (ibid).

METHODS

Readers are encouraged to review Hyatt et al. (1984), Rankin et al. (1994) and MacLellan and Hume (2010) for details regarding smolt sample acquisition and processing methods. However, the general methodology for the Henderson Lake system is outlined briefly here.

Smolt surveys were conducted during April through May (or early June). Survey timing was designed to encompass the period of peak smolt migrations (Rankin et al. 1994). Smolts captured during these surveys include: large numbers of Sockeye (*Oncorhynchus nerka*), and smaller numbers of Coho (*O. kisutch*), and Chinook (*O. tshawytsha*). The results presented here are limited to Sockeye smolts as samples of other species collected were not processed.

Beginning in 1977, migrating smolts were captured in Henderson River via fyke-net, a variable-mesh trawl net, 2 x 2 x 7.5 m length (Gjernes 1979; Rankin et al. 1994). On any given sampling date, the fyke-net was set one hour before sunset for a duration of 3 to 4 hours and checked at half-hour intervals as per the guidelines outlined in Hyatt et al. (1984). The sampling period is variable but includes the time of peak diel smolt migration activity (Wood et al. 1993).

A sample size of 100-200 Sockeye smolts per sample night was recommended for each date sampled. If fewer than 100 smolts were caught during the first 4 hours of sampling, the net was left for the remainder of the night (about 6 hours) and retrieved in the morning. All fish captured and retained were classified by species and preserved with labels identifying system, date, start and stop time, set number, species counts, initials of collection crew and total number of collections obtained during each survey date.

Sampled fish were generally preserved in buffered 3.7% formaldehyde (formalin) for at least five weeks prior to laboratory processing for species, length, weight and scales. Alternatively, fish were preserved in 70% ethyl alcohol (ethanol), and, in some cases, frozen prior to chemical preservation. Subsequently, in the laboratory at the Pacific Biological Station (PBS), fish were identified to species, and Sockeye smolts were weighed to 0.01 g and measured to 1 mm.

PBS crews performed all smolt sampling via fyke netting between 1977 and 2015. Crews from the Uchuklesaht First Nation operated a rotary screw trap for sampling in a subset of eight years, in four of which fyke net samples were also taken by DFO personnel. All smolt samples were preserved and processed in the PBS laboratory using a metric measuring board and electronic balance to determine fork lengths and preserved weights. Preserved smolt weights were converted to standardized fresh weights (Rankin et al. 1994) and are reported as such here.

Age of fish was determined from scale analysis in the PBS Aging Lab. Between 1977 and 1986, all fish captured and retained were scale-sampled for age analysis. After 1986, scale sampling was focused on fish in the overlapping size range of 75 – 90 mm, with few fish <70 mm or >90 mm in fork length scale-sampled. Age proportions from scale data by year, month and 5 mm length class were used to classify unaged fish to age class.[1]

Processed smolt data were compiled and analyzed using SAS® statistical software to tabulate summary statistics for fork length, preserved and standardized fresh weights, and smolt condition factor[2] by year, sample date and age class. Sample dates were converted to day-of-year[3] for inter-annual comparisons. Univariate statistical procedures were used to detect and correct or exclude erroneous data from summary analyses. Analysis of variance and paired t-tests were used to test for differences in size statistics between the fyke-net (trawl) and rotary-screw trap gear types for common sample dates. Linear models were assessed to provide RST-to-trawl forklength calibration coefficients, to account for possible size bias in the data for years where sampling was limited to RST gear. Summary plots include:

(1) Weekly sample size, as an indicator of outmigration run-timing (ages pooled);
(2) Length and weight frequency distributions and regressions (by age class); and
(3) Trends in mean length (cm) and standardized fresh weight (g) over time (by age).[4]

The above analyses were used to identify a defensible and reproducible annual indicator of Henderson Lake Sockeye smolt size for covariation analyses (e.g. Hyatt et al. 2011).

Years for which Sockeye smolt size data were insufficient or unavailable were infilled with estimates based on linear regression analysis of smolt length as a function of pre-smolt (fry) forklength estimates from representative acoustic trawl surveys (ATS) during the previous winter or fall[5], where available. Pre-smolt abundance effects were assessed by including an indicator of pre-smolt population size (unpub. data) in a step-wise regression analysis. Inter-annual temporal effects were assessed by including ocean entry year in the model.

Non-parametric test statistics were calculated over the resulting 40-year time-series for detection of trends (Mann-Kendall (MK)) and step changes in the mean (“regime shifts”) (Kundzewicz and Robson 2000). Regime shift detection using sequential t-test analysis was applied after

[1] Unaged fish <70 mm or >100 mm were classified as Age 1 and Age 2, respectively, unless otherwise specified by field personnel in sample meta-data.
[2] Fulton fish condition factor (K) is an index of fish ‘health’ that relates fish weight to length, and is influenced by age of fish, sex, season, maturation stage, fullness of gut, type of food consumed, amount of fat reserve, and degree of muscular development (Fulton 1902; *in* Barnham and Baxter 1998). $K = 10^5 \times W / L^3$, where W = Standard weight (g) and L = forklength (cm). K generally ranges from 0.5 (“poor condition”) to 2.0 (“good condition”), with $K <= 1$ for long, thin fish such as salmonid fry and smolts.
[3] For leap years, day-of-year was advanced by one day beginning in March to account for February 29th.
[4] For some figures, the Fulton fish condition factor (K) is multiplied by 10 for plotting purposes.
[5] Winter pre-smolt (fry) size and abundance estimates from Hyatt et al. (2016b) and K. Hyatt, DFO Pacific Biological Station (unpub. data).

prewhitening using a target P = 0.05, cutoff length = 10 years, tuning constant = 2 and a subsample size = 6 years (STARS 6.2 software: Rodionov 2004).

RESULTS

The total annual number of Sockeye smolts sampled, with associated statistics of fork length and standardized weight are summarized in Table 1 by year and age, and tabulated by sample date in Appendix I. The gear-specific frequency of sampling dates is listed in Table 2, indicating fyke-net ("trawl") sampling efforts and rotary screw trap (RST) sampling in Henderson River. Sample meta-data, including (where available) total catch and total fish sampled by date, sample site, gear type, sampling agency and fish preservative type, are listed in Appendix VIII[6].

A mean annual total of 285 fish were sampled over 39 years (1977-2015). Smolt sampling effort was limited to one date in 1977, 2006, and 2009, and limited to <25 total fish in 1977, 1987, 2001, 2006, and 2012 (Appendix I). Figure 3 summarizes the variable range of dates sampled annually, with overlays of mean fork length and standard weight, by date and age class.

As an indicator of seasonal smolt catch and relative abundance, sample size (count of Sockeye smolts retained by age) and percent of total annual retained catch are charted by year and sample date in Appendix III. Within-year seasonal trends in mean length and weight at age are presented in Appendix IV. The all-year trend in within-season smolt size at age is plotted for length and weight observations and fish condition in Figure 4.

Rotary-screw trap (RST) gear was utilized in 1994-1998, 2003-2005, and provided a high frequency of biosamples (nearly daily) across the outmigration period (Appendix II). Fyke-net sampling occurred, on average, twice per year (maximum three times), but did not occur in 1996, 1997, 2004, and 2005, when RST sampling was employed. Years in which both fyke-net and RST sampling occurred include 1994, 1995, 1998, and 2003 (Table 2).

RST sample dates for which trawl samples were also available (12May94, 26May94, 30Apr95, 18Apr98) permitted a comparative analysis of fish size to assess potential bias associated with gear type, controlled for time of year. Significant differences between gear types were found within years: RST-caught fish were 1.5 mm and 0.4 g larger than trawl-caught fish in 1994 ($P = 0.06$, $n \geq 255$), 5.5 mm and 0.5 g larger in 1995 ($P < 0.001$, $n \geq 49$), but 4.2 mm and 1.1 g smaller in 1998 (Table 3, Figure 5). However, the years-combined results, necessarily based on sparse data (n = 3 years), were inconclusive: The linear relation between trawl and RST size data was statistically significant for fork length correlations ($r = 0.99$, $P = 0.015$; Figure 6: top), yielding a potential transfer function to convert RST fork length to trawl lengths if necessary, but coefficient significance tests[7] for the linear model could not be rejected ($P \geq 0.10$), suggesting insufficient differences between the limited size observations to be statistically quantified.

Standard weight relations were similarly uninformative regarding the gear effect on size (Figure 6: bottom). Thus, for the purposes of this report, no gear conversion adjustments were applied to individual fish size data, and the data from both gears were combined for intra- and inter-annual summarization, as annual overall size differences were small (0-5% in length; 3-20% in weight).

[6] Smolt data are available upon request. Contact Kim.Hyatt@dfo-mpo.gc.ca.

[7] The slope coefficient was tested for significant difference from 1 (H_0: b = 1), which would indicate a gradient in sizes between gears, and the intercept was tested for significant difference from 0 (H_0: a = 0), which would indicate an absolute difference in mean size between gears.

However, caution should be exercised regarding any inter-annual size comparisons that include years for which RST gear was extensively used (1994-1998, 2003-2005) as these estimates may be slightly inflated relative to the extensive trawl-based time-series obtained at Henderson Lake and other Sockeye lake systems, including Great Central and Sproat lakes (Hyatt et al. 2019a; 2019b).

Annual size-at-age frequency distributions for fork length, standard weight, and fish condition (K) are organized in Appendix V. These indicators are graphically summarized across all years and sampling sites in Figure 7. The annual absolute deviations from the multi-year average, displaying inter-annual differences in Age 1 mean size and fish condition, are shown in Figure 8.

Statistical relations and corresponding regression and correlation coefficients for Sockeye length-weight relationships (by year and age) are summarized in Appendix VI. The multi-year length-weight at age relationships are presented in Figure 9.

The multi-year seasonal distribution of smolts retained is plotted in Figure 10. Statistical quantiles of migration timing – based on day-of-year – are compared in Table 4 for (a) all available years, versus: (b) "well-sampled" years with a minimum of two sample dates, and (c) rotary screw trap data only (i.e. 1994-1998, 2003-2005). Median date of migration was day 128 (May 8th) for all distributions, indicating about 50% of Henderson migrants were tallied by May 8th, with 90% of migrants tallied between day 104 and day 146 (April 14th – May 26th) (Figure 10). Omitting years for which the number of sample dates < 2 (1977, 2006, 2009), or for which total sample size of fish < 20 (1977, 2006, 2012), did not alter median "migration timing" or percentile statistics (Table 4, middle).

Thus, the 1st and 99th day-of-year percentiles (day 104 - 146: April 14th to May 26th) of the mid-90% of migration observations, representing ~90% of the smolt sample observations (Table 4, bottom), were subsequently used as cutoff dates to subset the sample data to obtain statistical metrics associated with a consistent inter-annual indicator for Age 1 smolt size (Table 5)[8]. Implementing this rule based on sample timing did not eliminate any years from analysis, and did not alter median "migration timing" or percentile statistics.

Mean annual smolt fork length for age 1 fish (pooled across gear types) was linearly correlated with mean annual pre-smolt (fry) length (Figure 11, top). Two data points based on pre-smolt survey data from the previous summer were treated as outliers (1998, 1999) and omitted from the final length relation (a = 6.62, b = 1.016, r = 0.90, P = 0.001, n = 31).

Annual smolt length was also negatively correlated with a pre-smolt abundance index (Figure 11, bottom; r = -0.45, P = 0.005, n = 32). However, step-wise regression analysis including both predictors (standardized), an interaction term, and Year (to accommodate annual temporal correlation) retained only pre-smolt fork length as a significant predictor of annual Henderson Sockeye smolt length (Table 6).

The pre-smolt-to-smolt length model was used to attempt to corroborate mean annual smolt fork length for years where sampling effort was non-existent (2016), or limited to one date (1977, 2006, and 2009), or <25 total fish (1977, 1987, 2001, 2006, and 2012) (Table 1). The predictor variable, pre-smolt fork length, was not available for 1977, 2006, or 2012. Predictive estimates for other years are listed in Appendix VII, but were not used to adjust final smolt size values for any years in this report. For smolt year 2016, for which biosample data were unavailable, the

[8] Insufficient Age 2 data exist on an annual basis to characterize Henderson Age 2 smolt size trends.

model estimated Henderson age 1 smolt mean length to be 76.1 mm based on pre-smolt fork length, which converted to 3.6 g standard weight based on the multi-year length/weight relation for age 1 smolts (Figure 9).

Best estimates of mean annual Sockeye smolt size were consolidated in Table 5. The filtered sample size was reduced by 853 age 1 smolts and eight age 2 smolts (~8%), for a total of 10,270 age 1 and 109 age 2 fish samples. This resulted in a slight increase (0.1 g) in estimated age 1 fish weight only; all other statistics were unchanged from the observed dataset. Mean smolt sizes are plotted in Figure 12, by age, overlaid with the filtered (mid-90th percentile) sample dates.[9]

A linear time trend was evident for age 1 smolt fork length estimates but not standard weight, and non-parametric Mann-Kendall trend statistics were not significant for these indicators at the α=0.05 level (Table 7). Both mean lengths and weights of age 1 smolts were found to be statistically smaller after 1999 according to nonparametric cumulative deviation and rank sum test statistics (Table 7), with a possible regime shift in fork length in 2009 (Figure 13). Autocorrelation was evident for both variables.

DISCUSSION

Sampling Effort

Henderson Lake Sockeye smolts were generally sampled twice a year (range: 1-3 dates annually) during April and May via fyke-net for most of the time-series. Sampling frequency was highest between 1994-1998 and 2003-2005, when rotary-screw trap (RST) gear was implemented, providing, in some years, near-continuous or at least weekly sampling effort (mean 13 days, range 6-26 days per year; Table 2, Figure 3). Fyke-net sampling occurred in four of the eight RST years, but with sufficient temporal overlap with RST gear for comparison of size selectivity (to control for in-season fish growth (Figure 4)) in only three years. While significant differences in fork length and standard weight between gears were apparent within years (Table 3, Figure 5), the effect was not systematic across all years (Figure 6). Thus, no conclusions were drawn with respective to a gear effect on fish size, no calibrations were applied to RST data to convert the size data to the longer fyke-net time-series, and pooled size data were used in all analyses in this report. That is not to say that a size-effect does not exist, and another approach might be to apply a year-specific linear adjustment to the RST size data, assuming differences in RST gear operations may have yielded different efficiencies. However, that approach would not be applicable to five of the eight years when fyke-net sampling did not occur or overlap.

Smolt Migration

For years of low survey frequency (one date, or two dates close together), it may be initially unclear whether the sampling effort occurred at a representative point of smolt outmigration (e.g. 2006 and 2009, for which the sole biosample survey occurred in mid-April, or 1977, when the single survey occurred on May 18th). To determine whether the sample data for these instances were likely representative of that year's outmigration, the 90th percentile of the all-year migration timing was derived to quantify the "peak migration period", and survey dates falling within that period were considered representative.

Tallying the frequency of sample dates (day-of-year) across all ocean entry years, weighted by sample size, yields a coarse indicator of smolt migration abundance (assuming catch is

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[9] Predictive estimates for 2016 are represented by hollow squares in the length and weight time-series.

proportional to abundance, and effort is roughly equivalent across dates)[10]. This indicator can be restricted to years where the number of sample dates exceeds a certain annual minimum (e.g. two sample dates). The resultant "smolt migration timing" statistics indicate that, over the range of well-sampled years, Henderson smolt migration tends to peak in May (median date: May 8th), with 90% of migrants tallied between April 14th and May 26th (Figure 10). Mean, median and variance statistics did not vary significantly when years were restricted to those with a minimum of two sample dates, or years where near-continuous sampling was available via rotary-screw trap gear (Table 4).

Migration timing exhibited – where sampling occurred continuously – mainly unimodal abundance patterns, with some possible exceptions (e.g. 1994, 2004, 2005), characterized by a pulse of smolts migrating in late-April, followed by another pulse in mid-to-late May (Appendix III). Overall, age 1 fish comprised 99% of migrants, and age 2 fish just 1%, though age 2's were captured in less than half of the years sampled (Table 1). The occurrence and proportion of age 2 fish did not display a consistent seasonal timing pattern between years.

Smolt Size and Condition

The mean length and standard weight of age 1 fish for all available years (1977-2015) were 7.3 ± 1.3 cm and 3.4 ± 1.7 g, respectively (N = 11,123; Table 1). Ninety-five percent of age 1 fish were less than 9.2 cm in fork length and 6.4 g in weight. Age 2 fish averaged slightly larger, at 8.4 ± 0.9 cm and 5.2 ± 2.0 g (N = 117).

There was significant variation in mean smolt size between years. Age 1 fish averaged < 2.0 g – approximately one standard deviation below the all-year average weight – in 1983, 1986, 1995, 2000, 2002, 2003, 2005, and 2009-2014 (Figure 3 (top); Table 1). Large age 1 smolts, averaging > 6.0 g, occurred in 1987, 1988, and 1992, and 2008 (Figure 8, Appendix IV).

Fulton's fish condition factor (K) – which expresses the relationship between fish length and weight – may provide more insight into fish health and survival than either size factor alone.[11] Mean fish condition for age 1 and age 2 fish was K=0.8 (Figure 7, Table 1), which is likely typical for freshwater stages of juvenile salmonids. Fulton's K largely reflected inter-annual length and weight variation, with higher fish condition for most years between 1988-1999, followed by generally lower fish condition since then (worst condition year: 2000), with the exception of above-average condition in 2008-2010 and 2013 (Figure 8, Table 1). Maximum age 1 fish condition occurred in 2010.

The length/weight curves of Henderson Lake Sockeye are nearly identical for both age classes: fresh standard weight (g) is approximately equivalent to 0.008 times the fork length (cm) cubed (Figure 9). Summary data in Table 5 reasonably replicate previous analyses for ocean entry years 2008-2013 (Hyatt et al. 2016b).

Annual deviations in mean size for age 1.0 and age 2.0 smolts covary positively ($r = 0.8$, $P < 0.01$) for the $n = 15$ years for which two-year-old fish were encountered, suggesting similar

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[10] This is due to the practice of retaining a maximum sample size of fish for a given sample date. The actual catch on any date-specific sampling trip was occasionally far higher than the maximum of one hundred fish retained. Consequently, the observations here will generally conceal the timing of peak migration which tends to occur over a much shorter period than suggested by the annual plots in Appendix II.

[11] Hyatt et al. (2016b) review the limnological and food-web structure data for Barkley Sound lakes, including Henderson Lake (2008-2013) for insight into the magnitude and sources of inter-annual and inter-lake differences in carrying capacity for juvenile Sockeye.

foraging conditions and growth in Henderson Lake for both age classes during the seasons prior to their seaward migration as smolts.

Seasonal Trends in Smolt Size

Over all years, smolt size tends to increase for both age classes as the season progresses ($P < 0.01$; Figure 4), though many years are characterized by no size changes or slight decreases (e.g. 1995, 1998, 2005; Appendix IV). Diminishing mean size over the season potentially signifies a tendency towards earlier seaward migration of larger smolts (Wood et al. 2003).

Best Estimates of Annual Smolt Size

Almost 40 years of data indicate that biosamples collected between mid-April to late May are most representative of the size of fish of the dominant age 1 class. As overall mean, median and variance statistics did not vary significantly when years were restricted to those with a minimum of two or more sample dates (Table 4), and within-year seasonal trends in size were generally weak for age 1 Sockeye (Appendix III), it may be surmised that one or more sample dates in that time-period are likely sufficient to characterize Henderson Sockeye smolt size, at least for the predominant age 1 class, provided it is based on a reasonable aggregate sample size (e.g. 20-100 fish).

For years in which age 1 smolt size observations were unavailable (2016), size estimates were provided based on statistical relationships with pre-smolt (fry) Sockeye length. The inverse relationship between final age 1 smolt size and pre-smolt abundance (Figure 11) suggests a density dependence effect. However, this abundance index was evidently not as important as pre-smolt size for the years in which all three variables were available, and was not retained in the model determined by stepwise regression. Year also did not appear to be an important factor. Predicted age 1 smolt length and weight for 2016 fell close to the long-term size means, with large error terms (Figure 12, top).

Best estimates of age 2 smolts were simply based on all available sample data (Figure 12, bottom), however these statistics should be used with caution due to low sample size in most years. Missing annual age 2 smolt sizes were not generated, due to insufficient data.

While time trends in the annual length and weight data were weak or non-existent for age 1 fish, there was statistical evidence of a decrease in size after 1999 (Table 7), and a possible regime shift in fork length as of 2009 (Figure 13).

The resulting time-series of best estimates for age 1 and age 2 Henderson Lake Sockeye smolts (Table 5, Figure 12) will provide a basis for further analysis and identification of the factors operating to control salmon production variations in freshwater or marine ecosystems.

ACKNOWLEDGEMENTS

Many individuals have been involved over the several decades of field sample acquisition, laboratory processing or data assembly on abundance and biological traits of juvenile Sockeye salmon. The authors wish to thank, in alphabetical order, S. Baillie, K. Cooke, C. Cooper, B. Cousens, J. Candy, T. Cone, I. Cuthbert, R. Ferguson, T. Gjernes, B. Hanslit, M. Johannes, J. Lane (and members and staff of the Uchucklesaht First Nation and Nuu-Chah-Nulth Tribal Council Fisheries - Uu-a-thluk), A. Keitla, J. Manzer, C. McConnell, I. Miki, S. Murdoch, A. Phillips, J. Radziul, D. Rutherford, T. Shardlow, K. Simpson, G. Steer, R. Traber, P. Tschaplinski, V. Walker, and M. C. Wright for their efforts in supporting one or more phases of

this work. T. Gjernes, in particular, counselled Dr. Hyatt in 1980 on the need for DFO Science to expand time series observations of abundance and biological traits of Sockeye salmon populations and associated environmental conditions in areas outside of the Fraser basin as a source of information to improve our understanding of the role of factors, other than harvest, in driving annual variations in total returns of adult salmon.

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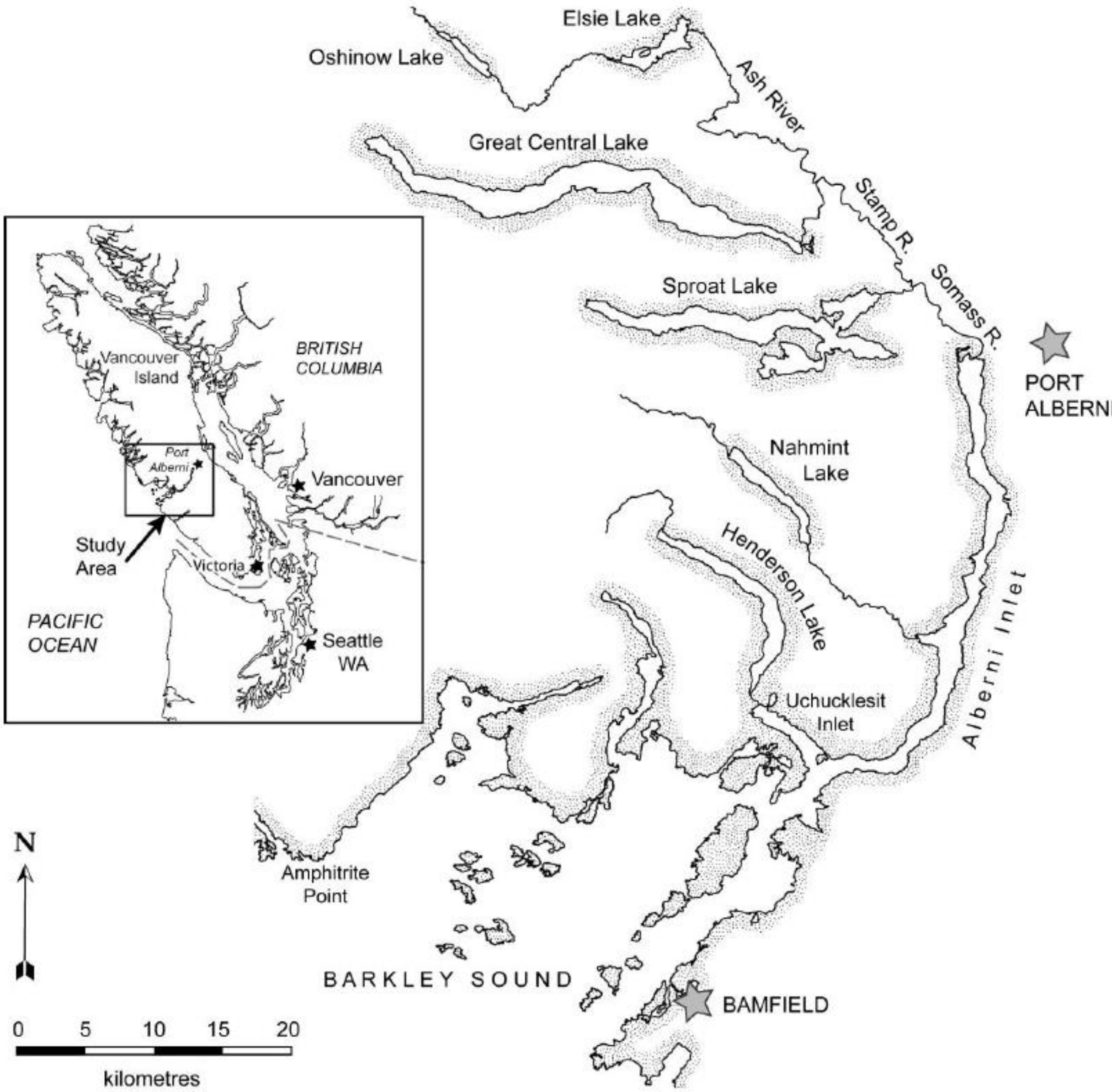

Figure 1. Location of Barkley Sound study lakes (including Henderson Lake) on the west coast of Vancouver Island, B.C.

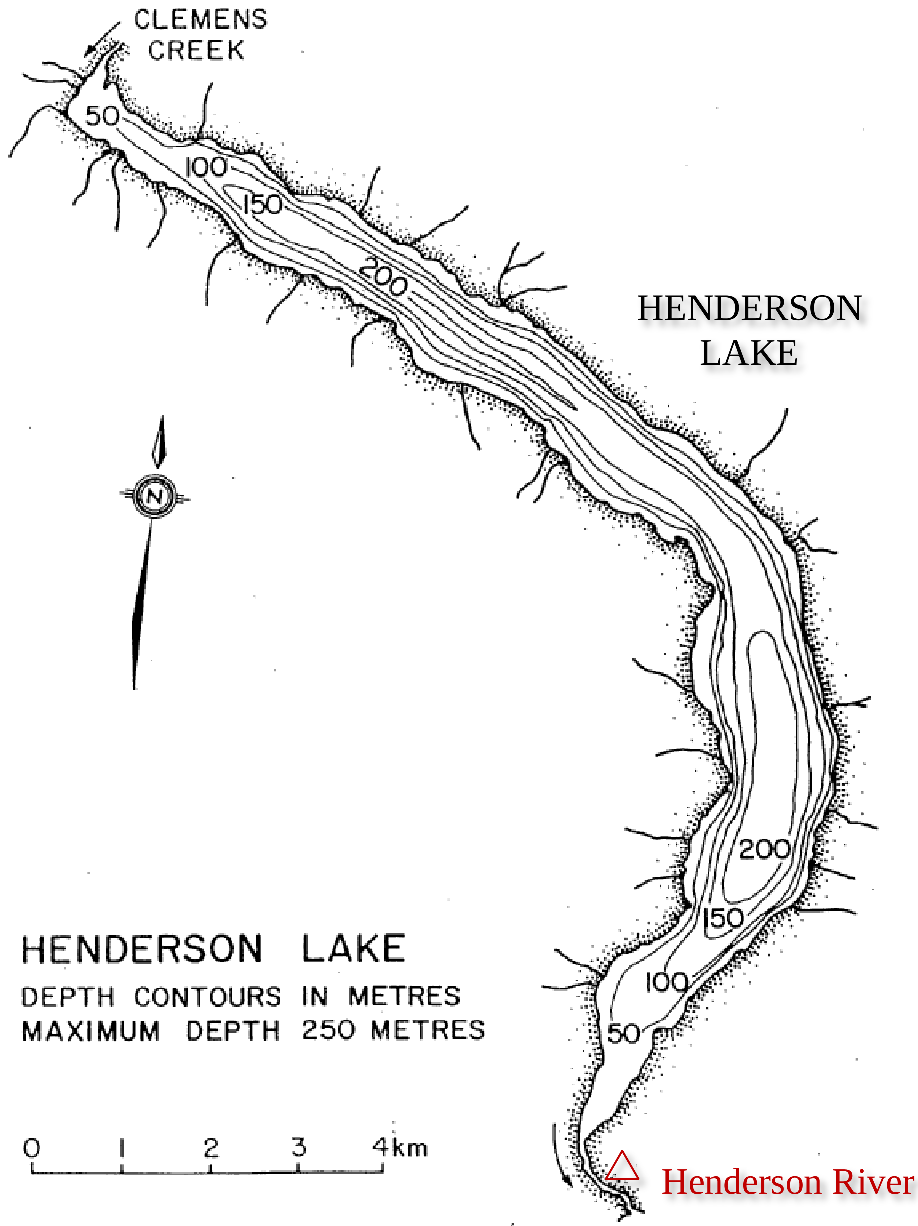

Figure 2. Henderson Lake and Henderson River smolt sampling site △. Arrows show direction of flow and smolt outmigration.

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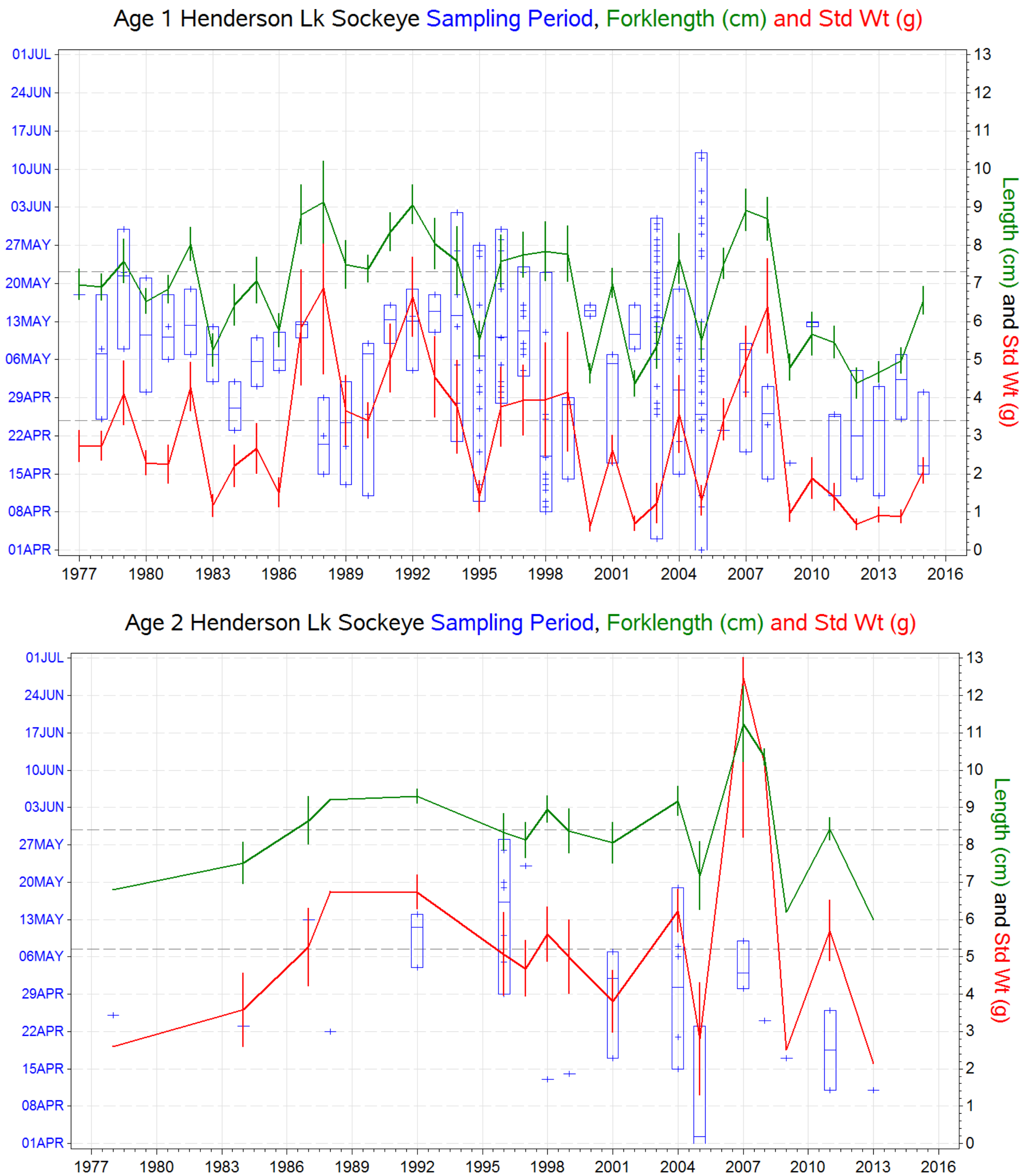


Figure 3. Henderson Lake Sockeye annual smolt sampling range (blue boxes; sample dates indicated by + symbol), mean fork length ±1 standard deviation (cm; green dashed line), mean standard fresh weight ±1 standard deviation (grams; red bars), by ocean entry year. Horizontal dashed lines: all-year mean length and weight. Top: Age 1; bottom: Age 2.

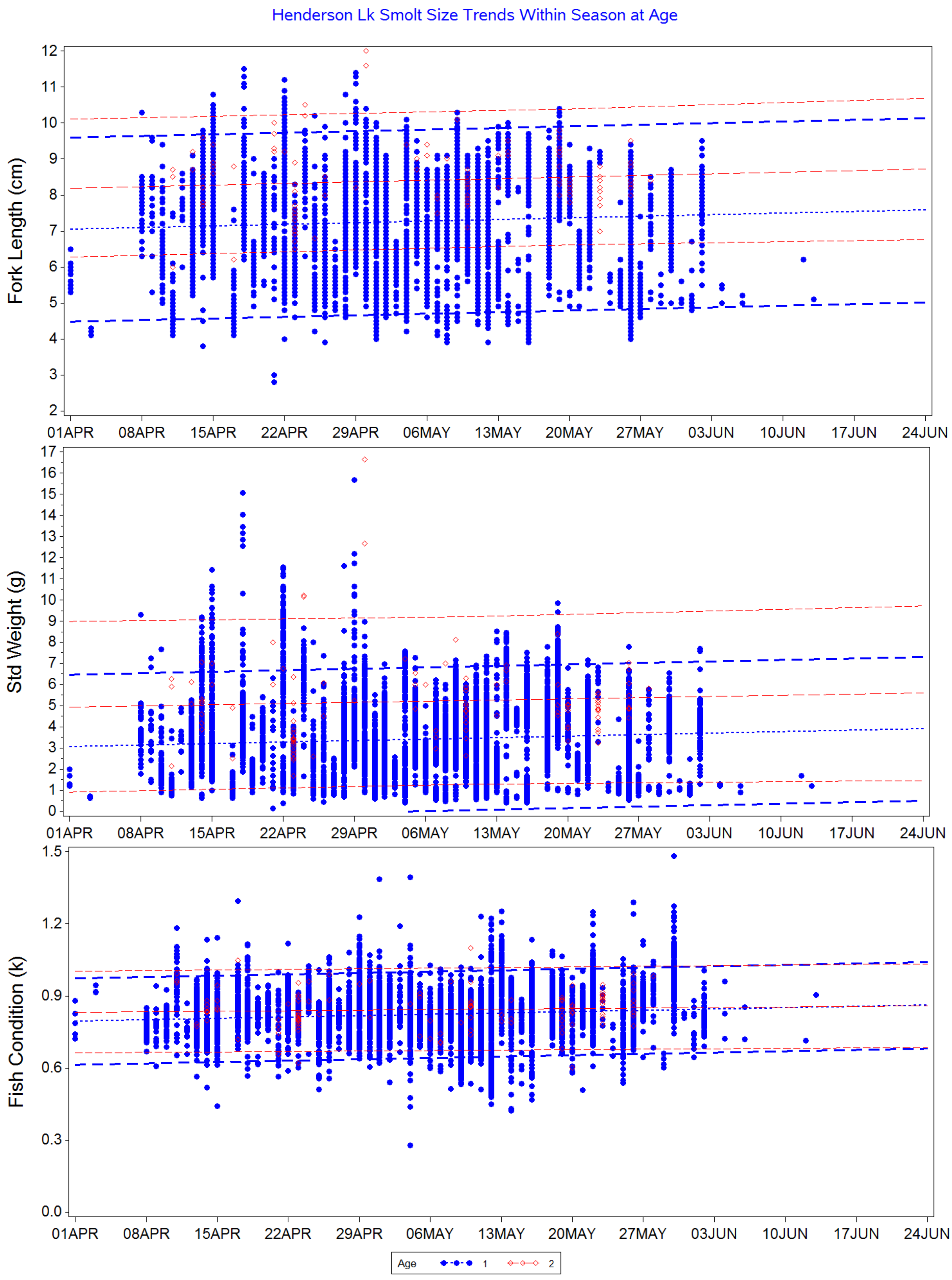


Figure 4. Trends in within-season smolt length (top), weight (middle), and in fish condition (bottom), by age class, all years and sample sites.

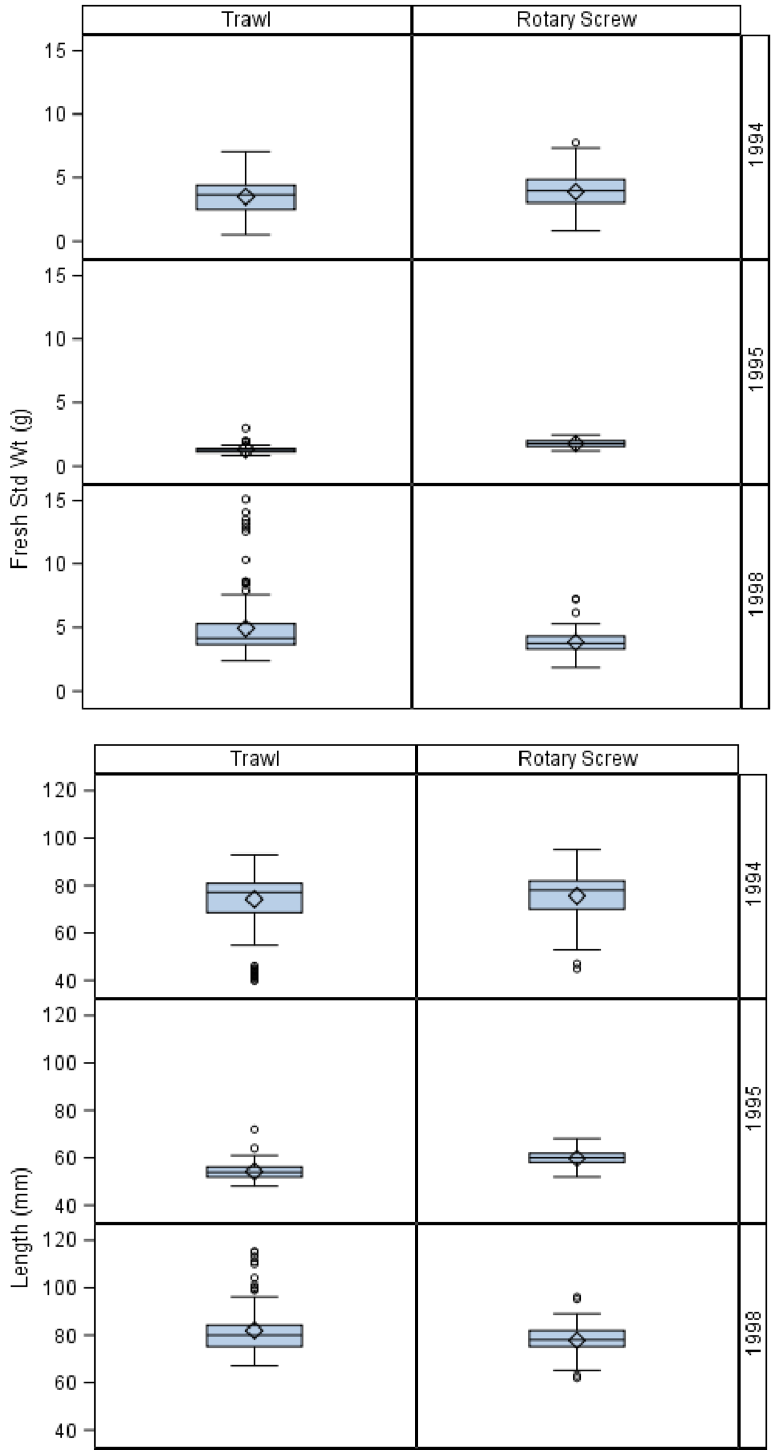
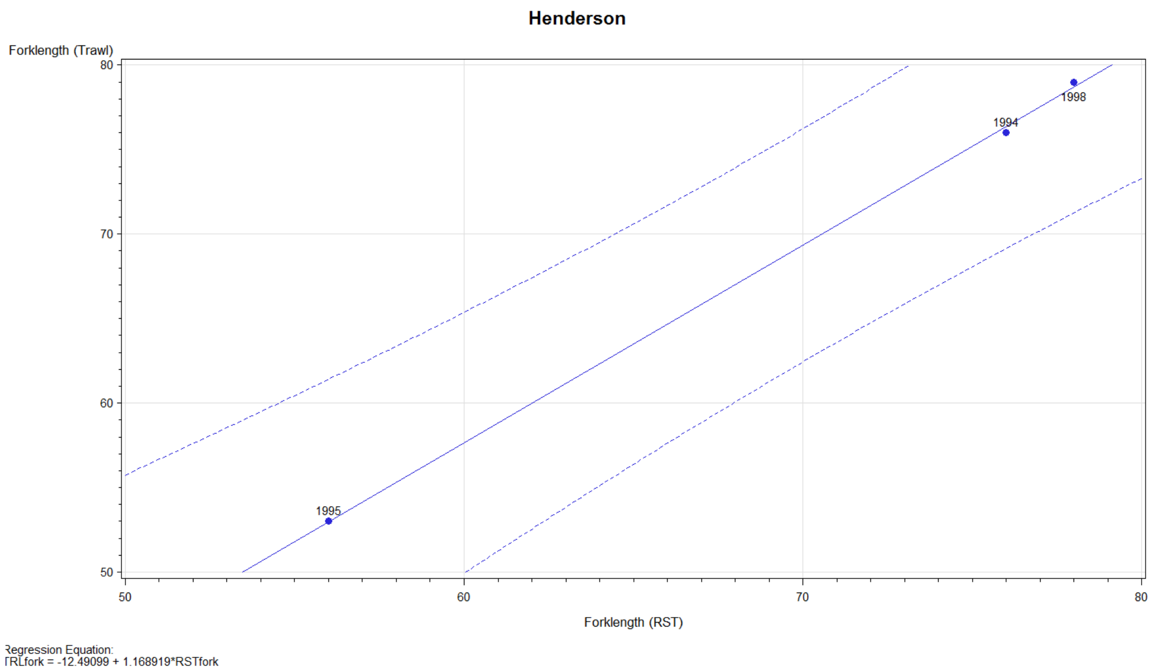


Figure 5. Comparison of smolt size (standard fork length, standard fresh weight), by gear type (trawl versus rotary screw trap), 1994, 1995, 1998. See Table 3 for statistics.



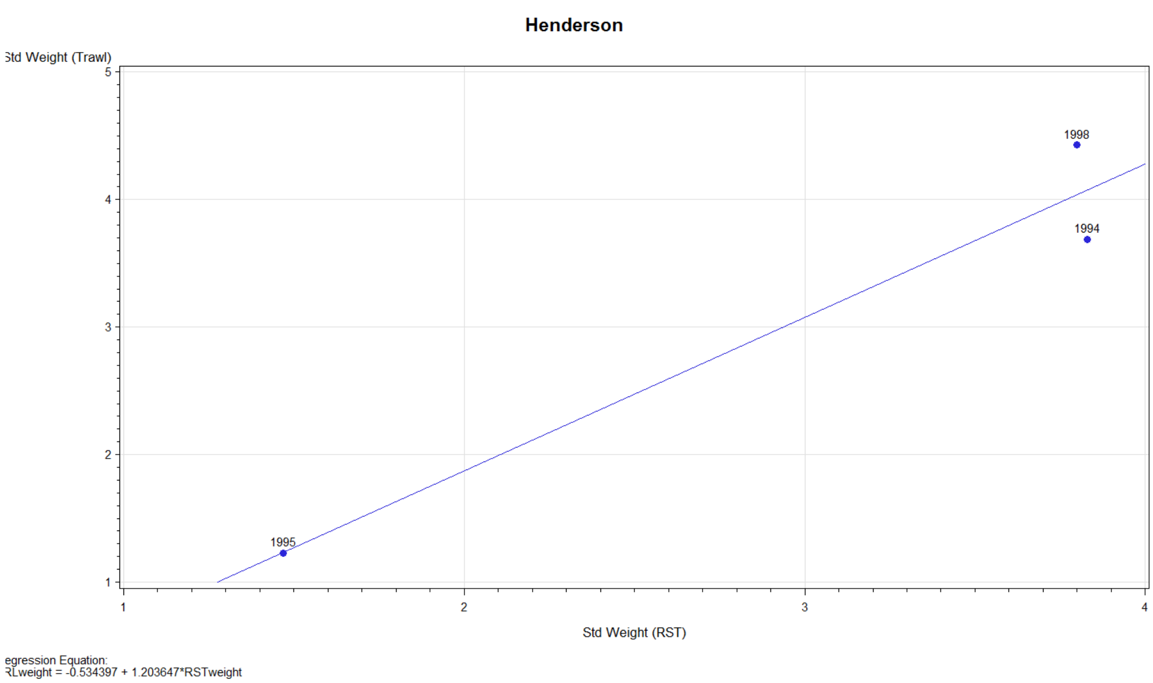
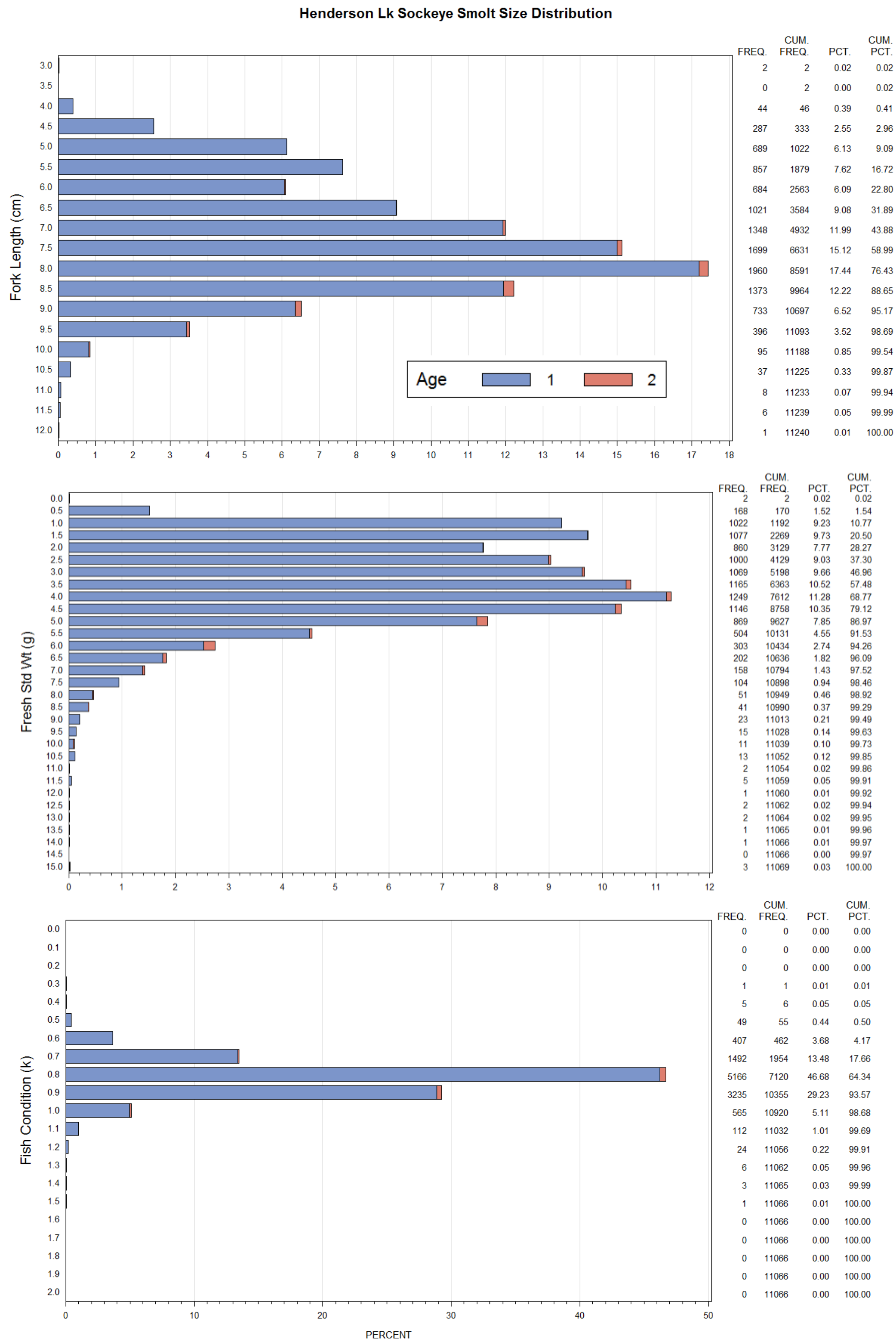


Figure 6. Linear relations smolt size (standard fork length, standard fresh weight), by gear type (trawl versus rotary screw trap), 1994, 1995, 1998.

Top: Trawl Fork Length = 1.17 • RST Fork Length – 12.5 (H_0: a = 0, P = 0.10; H_0: b = 1, P = 0.10)
Bottom: Trawl Std Weight = 1.20 • RST Std Weight – 0.53 (H_0: a = 0, P > 0.20 ; H_0: b = 1, P > 0.50)



Fork Length (cm)	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
3.0	2	2	0.02	0.02
3.5	0	2	0.00	0.02
4.0	44	46	0.39	0.41
4.5	287	333	2.55	2.96
5.0	689	1022	6.13	9.09
5.5	857	1879	7.62	16.72
6.0	684	2563	6.09	22.80
6.5	1021	3584	9.08	31.89
7.0	1348	4932	11.99	43.88
7.5	1699	6631	15.12	58.99
8.0	1960	8591	17.44	76.43
8.5	1373	9964	12.22	88.65
9.0	733	10697	6.52	95.17
9.5	396	11093	3.52	98.69
10.0	95	11188	0.85	99.54
10.5	37	11225	0.33	99.87
11.0	8	11233	0.07	99.94
11.5	6	11239	0.05	99.99
12.0	1	11240	0.01	100.00

Fresh Std Wt (g)	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0.0	2	2	0.02	0.02
0.5	168	170	1.52	1.54
1.0	1022	1192	9.23	10.77
1.5	1077	2269	9.73	20.50
2.0	860	3129	7.77	28.27
2.5	1000	4129	9.03	37.30
3.0	1069	5198	9.66	46.96
3.5	1165	6363	10.52	57.48
4.0	1249	7612	11.28	68.77
4.5	1146	8758	10.35	79.12
5.0	869	9627	7.85	86.97
5.5	504	10131	4.55	91.53
6.0	303	10434	2.74	94.26
6.5	202	10636	1.82	96.09
7.0	158	10794	1.43	97.52
7.5	104	10898	0.94	98.46
8.0	51	10949	0.46	98.92
8.5	41	10990	0.37	99.29
9.0	23	11013	0.21	99.49
9.5	15	11028	0.14	99.63
10.0	11	11039	0.10	99.73
10.5	13	11052	0.12	99.85
11.0	2	11054	0.02	99.86
11.5	5	11059	0.05	99.91
12.0	1	11060	0.01	99.92
12.5	2	11062	0.02	99.94
13.0	2	11064	0.02	99.95
13.5	1	11065	0.01	99.96
14.0	1	11066	0.01	99.97
14.5	0	11066	0.00	99.97
15.0	3	11069	0.03	100.00

Fish Condition (k)	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0.0	0	0	0.00	0.00
0.1	0	0	0.00	0.00
0.2	0	0	0.00	0.00
0.3	1	1	0.01	0.01
0.4	5	6	0.05	0.05
0.5	49	55	0.44	0.50
0.6	407	462	3.68	4.17
0.7	1492	1954	13.48	17.66
0.8	5166	7120	46.68	64.34
0.9	3235	10355	29.23	93.57
1.0	565	10920	5.11	98.68
1.1	112	11032	1.01	99.69
1.2	24	11056	0.22	99.91
1.3	6	11062	0.05	99.96
1.4	3	11065	0.03	99.99
1.5	1	11066	0.01	100.00
1.6	0	11066	0.00	100.00
1.7	0	11066	0.00	100.00
1.8	0	11066	0.00	100.00
1.9	0	11066	0.00	100.00
2.0	0	11066	0.00	100.00

Figure 7. Henderson Lake Sockeye smolt size distribution, all years, sites, and gears. Standard fork length (cm, top), standard fresh weight (g, middle), Fulford fish condition factor (K, bottom).

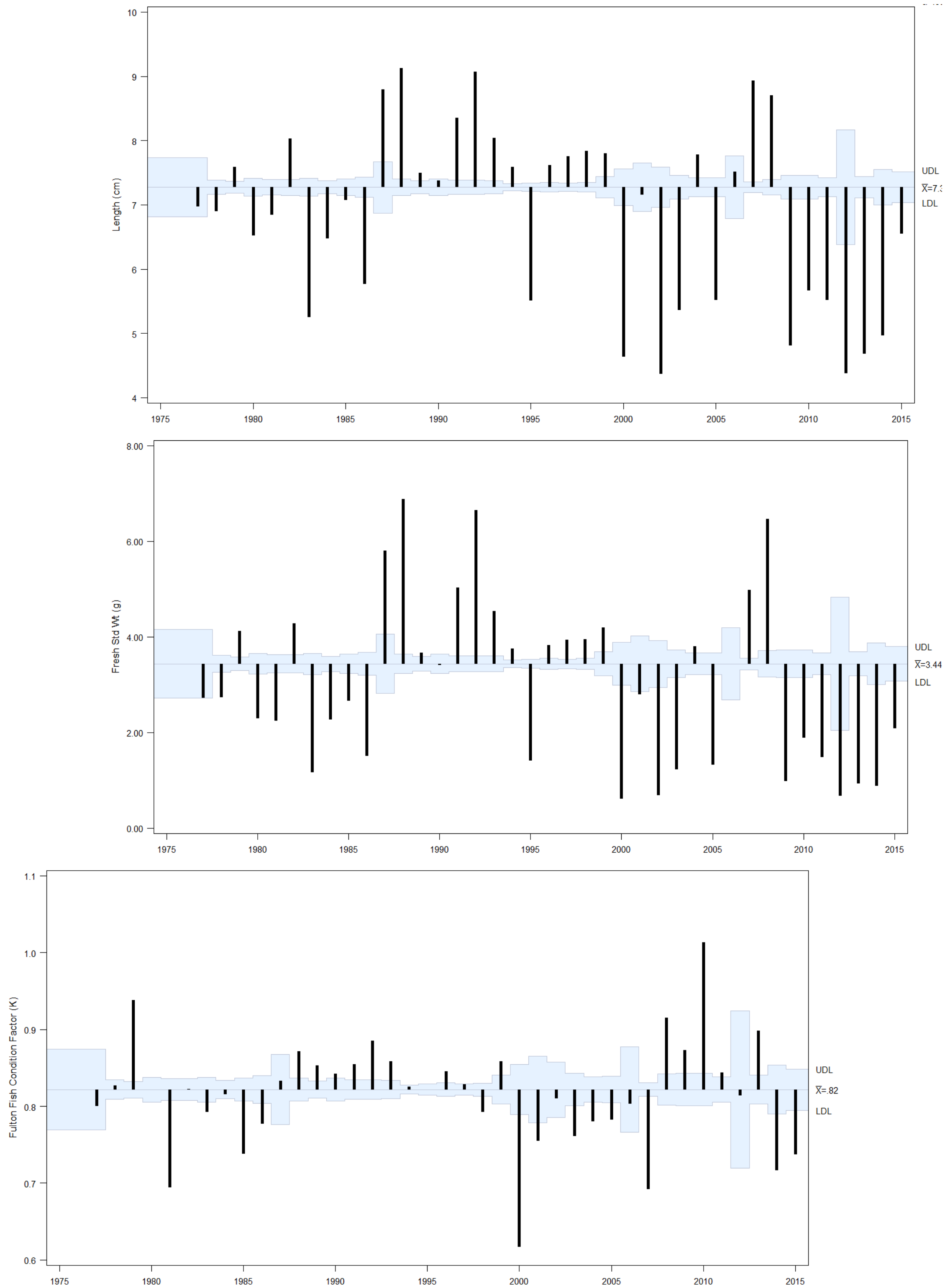
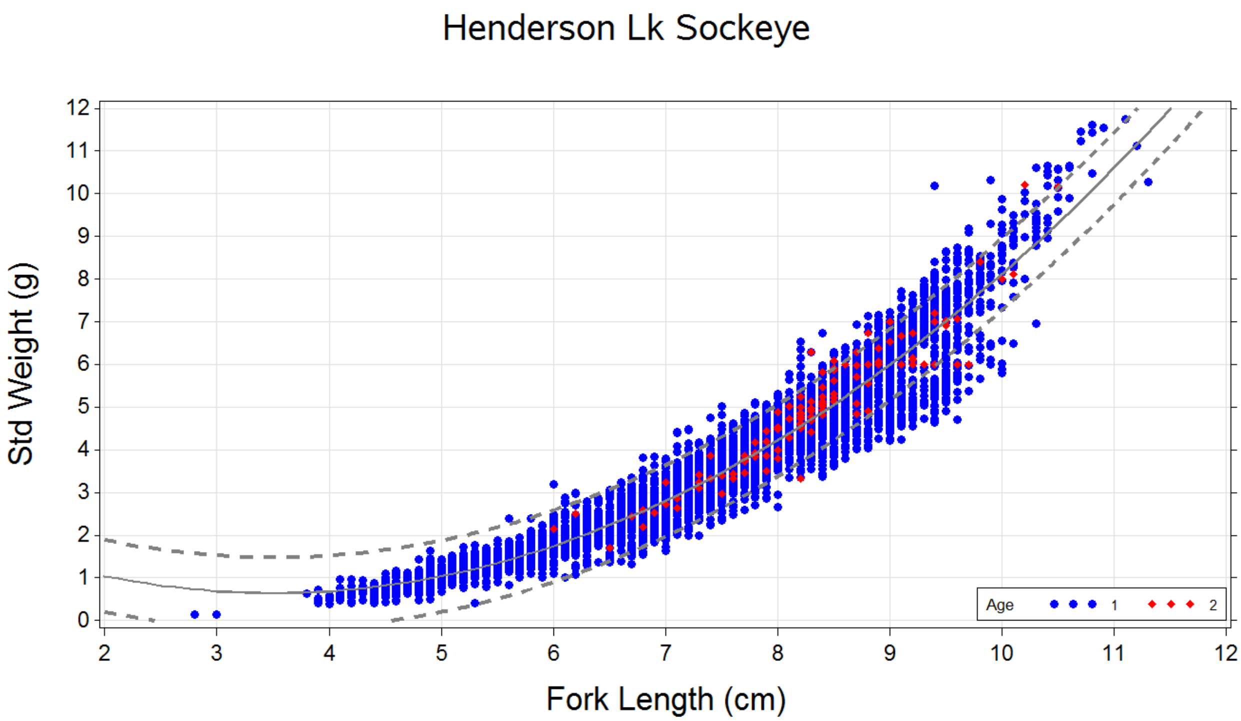


Figure 8. Absolute deviation of annual mean length (top), standard weight (middle), and fish condition factor (bottom) from the overall multi-year averages for Age 1 Henderson Lake Sockeye smolts, by ocean entry year.



	Age							
	1				2			
	a	b	Rsq	N	a	b	Rsq	N
Stock								
Henderson Lk	0.0082	3.000	0.96	10939	0.0085	2.994	0.90	113

Figure 9. Henderson Lake Sockeye smolt length/weight relationship, by age, all years.
Model: Std Weight (g) = a • Fork Length (cm) ^{b}

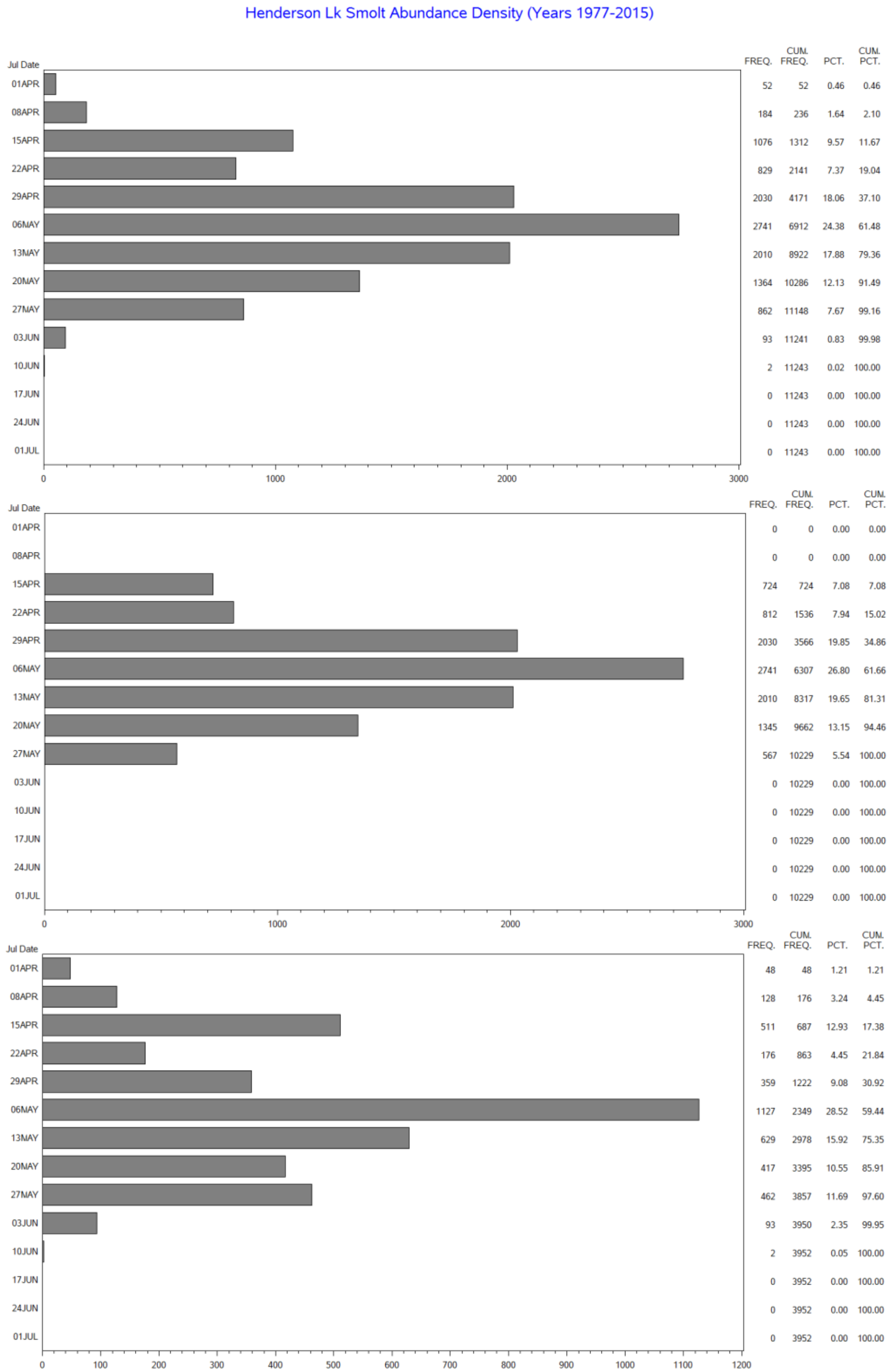


Figure 10. Henderson Lake Sockeye smolt “abundance distribution” (i.e. frequency of sample dates (day of year), weighted by sample size), across all years (top), mid-90th percentile of date where the minimum number of sample dates >= 2 (middle), rotary screw trap data only (1994-1998, 2003-2005, bottom). See Table 4.

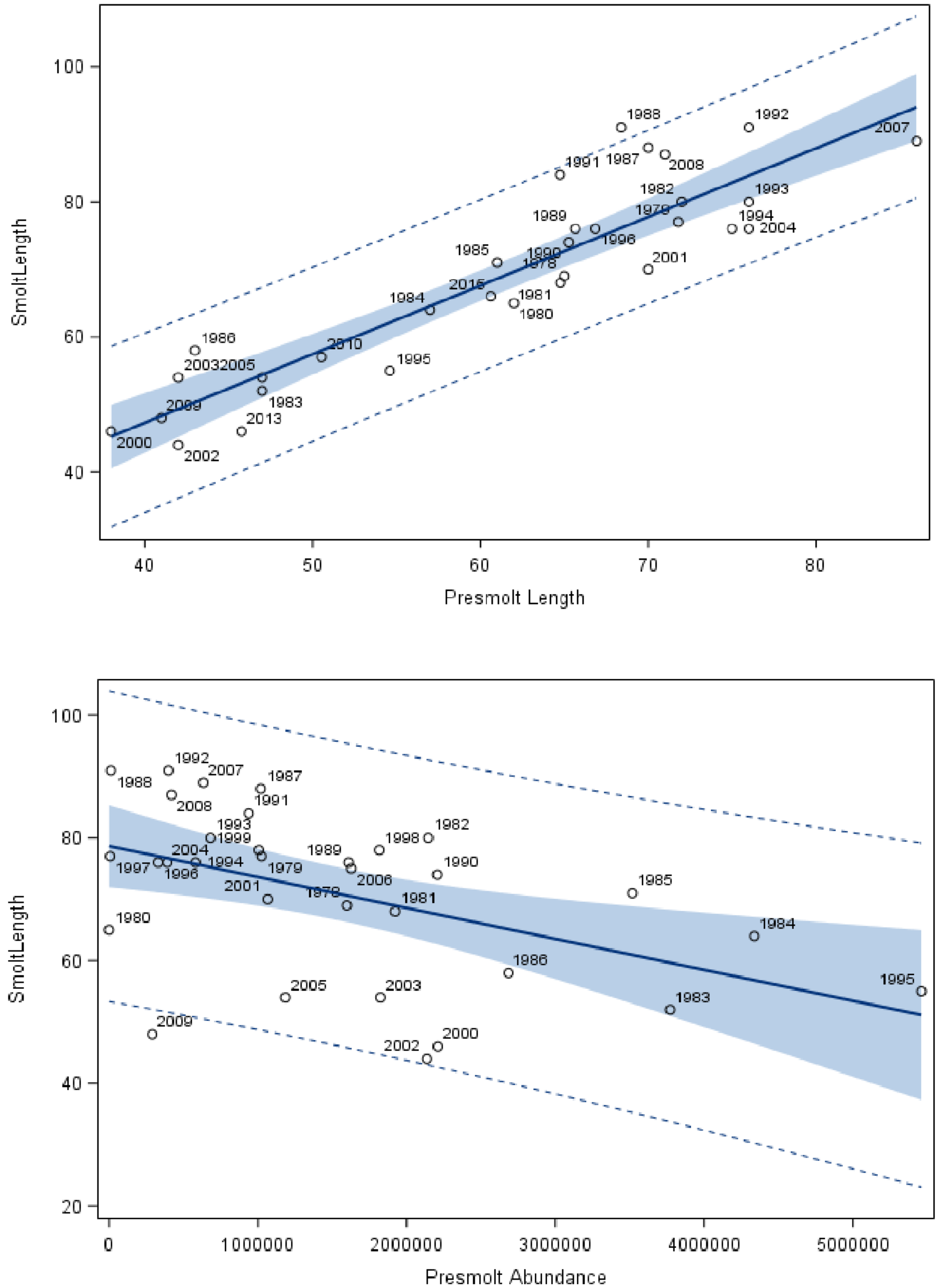


Figure 11. Ordinary least squares linear relationship for age 1 fork length as a function of pre-smolt (fry) fork length (top: r = 0.90; P < 0.001; N = 31; 1998 and 1999 presmolt size outliers omitted), and pre-smolt abundance (bottom: r = -0.45; P < 0.005; N = 32).

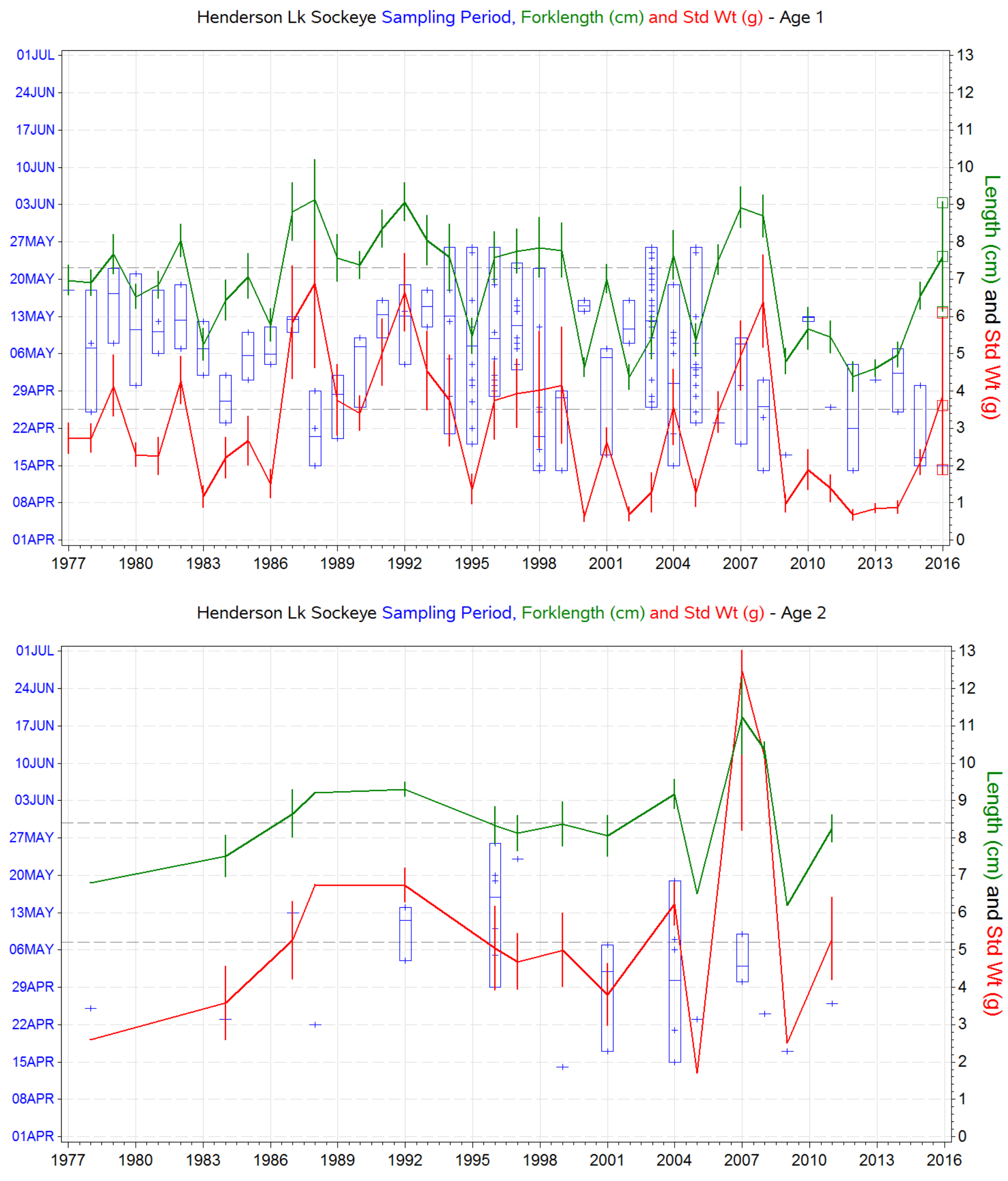


Figure 12. Best estimates of Henderson Lake Sockeye mean annual smolt size (solid lines) based on sampling effort (blue boxes) between April 14th and May 26th for age 1 smolts (top), with predictive estimates for ocean entry years 2016 (empty squares). Age 2 (bottom) based on all available samples. See Table 5 for details.

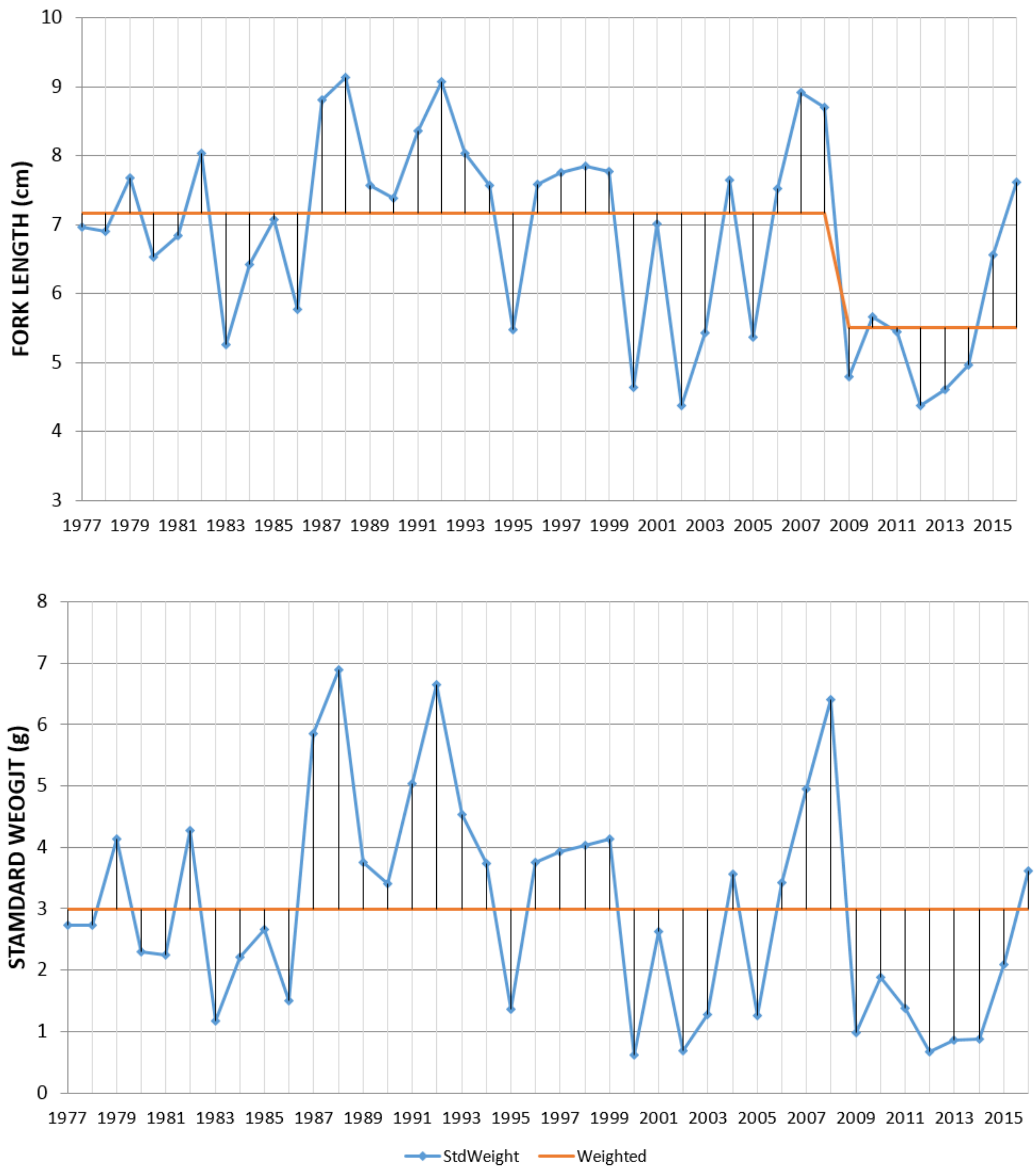


Figure 13. Trend analysis for best estimates (Table 5) of Henderson Lake Sockeye fork length (top) and standard fresh weight (bottom). Indicates potential step-change in fork length as of 2009.

TABLES

	Age																			
	1										2									
		Length (cm)				Fresh Std Wt (g)						Length (cm)				Fresh Std Wt (g)				
	N	P05	AVG	P95	SD	AVG	P95	SD	K	Pct %	N	P05	AVG	P95	SD	AVG	P95	SD	K	Pct %
Year																				
1977	19	6.3	7.0	7.7	0.4	2.7	3.6	0.4	0.80	100										
1978	309	6.3	6.9	7.5	0.3	2.7	3.4	0.4	0.83	100	1	6.8	6.8	6.8		2.6	2.6		0.82	0
1979	442	6.6	7.6	8.4	0.6	4.1	5.4	0.8	0.94	100										
1980	200	6.0	6.5	7.0	0.3	2.3	2.9	0.3	0.82	100										
1981	264	6.2	6.8	7.4	0.4	2.2	3.0	0.5	0.69	100										
1982	252	7.3	8.0	8.6	0.4	4.3	5.3	0.6	0.82	100										
1983	196	4.6	5.2	5.9	0.4	1.2	1.7	0.3	0.79	100										
1984	347	5.5	6.4	7.2	0.5	2.2	3.1	0.5	0.81	96	16	6.7	7.5	8.9	0.6	3.6	6.4	1.0	0.83	4
1985	223	6.0	7.1	7.9	0.6	2.7	3.7	0.7	0.74	100										
1986	163	5.2	5.8	6.5	0.4	1.5	2.1	0.4	0.78	100										
1987	23	7.7	8.8	9.7	0.8	5.8	8.1	1.5	0.84	92	2	8.2	8.7	9.1	0.6	5.3	6.0	1.0	0.81	8
1988	235	7.1	9.1	10.5	1.1	6.9	10.6	2.3	0.87	100	1	9.2	9.2	9.2		6.7	6.7		0.87	0
1989	397	6.5	7.5	8.4	0.6	3.7	5.0	0.9	0.85	100										
1990	232	6.7	7.4	7.9	0.4	3.4	4.0	0.5	0.84	100										
1991	326	7.5	8.4	9.1	0.5	5.0	6.3	0.9	0.85	100										
1992	325	8.1	9.1	9.8	0.5	6.6	8.1	1.0	0.89	99	4	9.1	9.3	9.5	0.2	6.7	7.2	0.4	0.84	1
1993	360	6.9	8.0	9.0	0.7	4.5	6.2	1.0	0.86	100										
1994	1,291	6.0	7.6	8.7	0.9	3.8	5.5	1.2	0.83	100										
1995	954	4.8	5.5	6.4	0.5	1.4	2.2	0.4	0.82	100										
1996	634	6.4	7.6	8.6	0.7	3.8	5.5	1.0	0.84	95	36	7.7	8.3	9.5	0.5	5.1	7.0	1.1	0.86	5
1997	914	6.7	7.7	8.6	0.6	3.9	5.5	0.9	0.83	99	12	7.0	8.1	8.8	0.5	4.7	5.6	0.7	0.87	1
1998	692	6.6	7.8	9.1	0.8	3.9	6.1	1.5	0.79	100	2	8.7	8.9	9.2	0.4	5.6	6.1	0.7	0.78	0
1999	140	6.4	7.8	8.7	0.7	4.1	5.7	1.6	0.86	95	8	7.7	8.4	9.6	0.6	5.0	7.1	1.0	0.84	5
2000	49	4.3	4.6	5.0	0.2	0.6	0.8	0.1	0.62	100										
2001	24	6.5	7.0	7.4	0.4	2.6	3.1	0.4	0.76	86	4	7.5	8.0	8.8	0.5	3.8	4.9	0.8	0.72	14
2002	40	3.9	4.4	4.9	0.3	0.7	1.0	0.2	0.81	100										
2003	114	4.5	5.4	6.7	0.6	1.2	2.5	0.5	0.76	100										
2004	175	6.5	7.6	8.7	0.7	3.6	5.0	1.0	0.78	91	17	8.6	9.2	10.0	0.4	6.2	8.0	0.6	0.81	9
2005	180	4.8	5.5	6.4	0.5	1.3	2.0	0.4	0.78	98	3	6.5	7.2	8.2	0.9	2.8	4.5	1.5	0.71	2
2006	17	6.8	7.5	8.3	0.4	3.4	4.8	0.5	0.80	100										
2007	607	7.9	8.9	9.6	0.5	4.9	6.5	0.9	0.69	100	3	10.1	11.2	12.0	1.0	12.5	16.7	4.3	0.85	0
2008	290	7.7	8.7	9.5	0.6	6.4	8.1	1.2	0.92	99	2	10.2	10.3	10.5	0.2	10.2	10.2	0.0	0.92	1
2009	116	4.4	4.8	5.5	0.3	1.0	1.5	0.2	0.87	99	1	6.2	6.2	6.2		2.5	2.5		1.05	1
2010	116	4.6	5.7	6.5	0.6	1.9	2.8	0.5	1.01	100										
2011	181	4.9	5.5	6.1	0.4	1.4	1.9	0.3	0.84	98	4	8.0	8.4	8.7	0.3	5.7	6.3	0.8	0.95	2
2012	5	3.8	4.4	4.8	0.4	0.7	0.8	0.1	0.81	100										
2013	148	4.3	4.7	5.1	0.3	0.9	1.3	0.2	0.90	99	1	6.0	6.0	6.0		2.1	2.1		0.99	1
2014	51	4.2	5.0	5.4	0.3	0.9	1.1	0.2	0.72	100										
2015	72	5.8	6.6	7.1	0.3	2.1	2.6	0.3	0.74	100										
All	11123	4.9	7.3	9.2	1.3	3.4	6.4	1.7	0.82	4E3	117	6.8	8.4	10.0	0.9	5.2	8.1	2.0	0.84	56

Table 1. Henderson Lake Sockeye annual smolt size statistics (standard fork length (cm), standard fresh weight (g)), by age, sites pooled.

	Gear Type			
	Trawl		Rotary Screw	
	Dates	%	Dates	%
Year				
1977	1	100		
1978	3	100		
1979	3	100		
1980	2	100		
1981	3	100		
1982	2	100		
1983	2	100		
1984	2	100		
1985	2	100		
1986	2	100		
1987	2	100		
1988	3	100		
1989	3	100		
1990	3	100		
1991	2	100		
1992	3	100		
1993	2	100		
1994	3	33	6	67
1995	3	23	10	77
1996			12	100
1997			10	100
1998	2	15	11	85
1999	2	100		
2000	2	100		
2001	2	100		
2002	2	100		
2003	1	4	25	96
2004			7	100
2005			26	100
2006	1	100		
2007	3	100		
2008	3	100		
2009	1	100		
2010	2	100		
2011	2	100		
2012	2	100		
2013	2	100		
2014	2	100		
2015	2	100		
ALL	77	91	107	91

Table 2. Henderson Lake Sockeye annual smolt sampling frequency (dates per year), by gear type.

------------------------- Sockeye Stock=Henderson Lk Year=1994 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable ForkLength
Classified by Variable Method

Method	N	Mean
Trawl	408	74.213235
Rotary Screw	255	75.619608

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	310.375603	310.375603	3.3893	0.0661
Within	661	60530.550490	91.574206		

------------------------- Sockeye Stock=Henderson Lk Year=1994 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable FreshStdWeight
Classified by Variable Method

Method	N	Mean
Trawl	408	3.510918
Rotary Screw	255	3.903387

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	24.171159	24.171159	15.2086	0.0001
Within	661	1050.533015	1.589309		

------------------------- Sockeye Stock=Henderson Lk Year=1995 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable ForkLength
Classified by Variable Method

Method	N	Mean
Rotary Screw	49	59.734694
Trawl	50	54.260000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	741.738071	741.738071	49.3755	<.0001
Within	97	1457.171020	15.022382		

------------------------- Sockeye Stock=Henderson Lk Year=1995 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable FreshStdWeight
Classified by Variable Method

Method	N	Mean
Rotary Screw	49	1.774161
Trawl	50	1.315249

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	5.211842	5.211842	46.5077	<.0001
Within	97	10.870210	0.112064		

------------------------- Sockeye Stock=Henderson Lk Year=1998 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable ForkLength
Classified by Variable Method

Method	N	Mean
Trawl	126	81.904762
Rotary Screw	127	77.740157

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	1096.986435	1096.986435	17.8756	<.0001
Within	251	15403.282340	61.367659		

------------------------- Sockeye Stock=Henderson Lk Year=1998 -------------------------

The NPAR1WAY Procedure

Analysis of Variance for Variable FreshStdWeight
Classified by Variable Method

Method	N	Mean
Trawl	126	4.940384
Rotary Screw	127	3.846672

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Among	1	75.658813	75.658813	23.2715	<.0001
Within	251	816.036434	3.251141		

Average scores were used for ties.

Table 3. Comparison of smolt size (standard fork length, standard fresh weight), by gear type (trawl versus rotary screw trap), 1994, 1995, 1998.

Henderson Lk Smolt Abundance Density (Years 1977-2015)

Sample Dates (Day of Year, Weighted by #Fish)											
Min	Mean	Max	Std	P01	P05	P10	Med	P90	P95	P99	#Fish
82	126	164	12	99	104	108	128	142	146	150	11,243

Henderson Lk Smolt Abundance Density (RST Data Only - Years 1994-1998, 2003-2005)

Sample Dates (Day of Year, Weighted by #Fish)											
Min	Mean	Max	Std	P01	P05	P10	Med	P90	P95	P99	#Fish
82	126	164	14	91	103	104	128	146	147	153	3,952

Henderson Lk Smolt Abundance Density (Years Where #Dates >= 2)

Sample Dates (Day of Year, Weighted by #Fish)											
Min	Mean	Max	Std	P01	P05	P10	Med	P90	P95	P99	#Fish
82	126	164	12	99	104	108	128	142	146	150	11,090

Henderson Lk Smolt Abundance Density (Mid-90th% for Years Where #Dates>1 & TotFish>20)

Sample Dates (Day of Year, Weighted by #Fish)											
Min	Mean	Max	Std	P01	P05	P10	Med	P90	P95	P99	#Fish
104	127	146	10	104	108	112	128	141	145	146	10,224

Table 4. Henderson Lake Sockeye smolt "migration timing" statistics, including minimum, mean, maximum day of year, standard deviation (days), median (50th percentile) and other percentiles, weighted by sample size.

Top-to-bottom: (1) all available years; (2) rotary screw trap data only (1994-1998, 2003-2005); (3) all years where number of sample dates >= 2; (4) all years where sample dates >=2 and total fish >=20 and filtered for mid-90th percentile of dates.

Median date of migration (128 = May 8th) is consistent across all runs, with 90% of smolts captured between day 104 and day 146 (i.e. Apr 14th - May 26th).

[Note: April 1st = 91; May 1st = 121; May 10th = 130; May 26th = 146; Jun 1st = 152]

	Age																			
	1										2									
		Length (cm)				Fresh Std Wt (g)				Pct		Length (cm)				Fresh Std Wt (g)				Pct
	N	P05	AVG	P95	SD	AVG	P95	SD	K	%	N	P05	AVG	P95	SD	AVG	P95	SD	K	%
Year																				
1977	19	6.3	7.0	7.7	0.4	2.7	3.6	0.4	0.80	100										
1978	309	6.3	6.9	7.5	0.3	2.7	3.4	0.4	0.83	100	1	6.8	6.8	6.8		2.6	2.6		0.82	0
1979	300	6.8	7.7	8.5	0.5	4.1	5.4	0.8	0.91	68										
1980	200	6.0	6.5	7.0	0.3	2.3	2.9	0.3	0.82	100										
1981	264	6.2	6.8	7.4	0.4	2.2	3.0	0.5	0.69	100										
1982	252	7.3	8.0	8.6	0.4	4.3	5.3	0.6	0.82	100										
1983	196	4.6	5.2	5.9	0.4	1.2	1.7	0.3	0.79	100										
1984	347	5.5	6.4	7.2	0.5	2.2	3.1	0.5	0.81	96	16	6.7	7.5	8.9	0.6	3.6	6.4	1.0	0.83	4
1985	223	6.0	7.1	7.9	0.6	2.7	3.7	0.7	0.74	100										
1986	163	5.2	5.8	6.5	0.4	1.5	2.1	0.4	0.78	100										
1987	23	7.7	8.8	9.7	0.8	5.8	8.1	1.5	0.84	92	2	8.2	8.7	9.1	0.6	5.3	6.0	1.0	0.81	8
1988	235	7.1	9.1	10.5	1.1	6.9	10.6	2.3	0.87	100	1	9.2	9.2	9.2		6.7	6.7		0.87	0
1989	295	6.4	7.6	8.5	0.6	3.8	5.3	0.9	0.85	74										
1990	230	6.7	7.4	7.9	0.4	3.4	4.0	0.5	0.84	99										
1991	326	7.5	8.4	9.1	0.5	5.0	6.3	0.9	0.85	100										
1992	325	8.1	9.1	9.8	0.5	6.6	8.1	1.0	0.89	99	4	9.1	9.3	9.5	0.2	6.7	7.2	0.4	0.84	1
1993	360	6.9	8.0	9.0	0.7	4.5	6.2	1.0	0.86	100										
1994	1,217	6.0	7.6	8.7	0.9	3.7	5.5	1.2	0.83	94										
1995	756	4.8	5.5	6.3	0.5	1.4	2.1	0.4	0.81	79										
1996	592	6.4	7.6	8.6	0.7	3.7	5.5	1.0	0.84	88	35	7.7	8.3	9.5	0.5	5.0	7.0	1.1	0.86	5
1997	914	6.7	7.7	8.6	0.6	3.9	5.5	0.9	0.83	99	12	7.0	8.1	8.8	0.5	4.7	5.6	0.7	0.87	1
1998	537	6.6	7.8	9.3	0.8	4.0	6.3	1.6	0.80	77										
1999	140	6.4	7.8	8.7	0.7	4.1	5.7	1.6	0.86	95	8	7.7	8.4	9.6	0.6	5.0	7.1	1.0	0.84	5
2000	49	4.3	4.6	5.0	0.2	0.6	0.8	0.1	0.62	100										
2001	24	6.5	7.0	7.4	0.4	2.6	3.1	0.4	0.76	86	4	7.5	8.0	8.8	0.5	3.8	4.9	0.8	0.72	14
2002	40	3.9	4.4	4.9	0.3	0.7	1.0	0.2	0.81	100										
2003	92	4.7	5.4	6.7	0.6	1.3	2.5	0.5	0.75	81										
2004	175	6.5	7.6	8.7	0.7	3.6	5.0	1.0	0.78	91	17	8.6	9.2	10.0	0.4	6.2	8.0	0.6	0.81	9
2005	115	4.8	5.4	5.9	0.4	1.3	1.8	0.4	0.81	63	1	6.5	6.5	6.5		1.7	1.7		0.62	1
2006	17	6.8	7.5	8.3	0.4	3.4	4.8	0.5	0.80	100										
2007	607	7.9	8.9	9.6	0.5	4.9	6.5	0.9	0.69	100	3	10.1	11.2	12.0	1.0	12.5	16.7	4.3	0.85	0
2008	290	7.7	8.7	9.5	0.6	6.4	8.1	1.2	0.92	99	2	10.2	10.3	10.5	0.2	10.2	10.2	0.0	0.92	1
2009	116	4.4	4.8	5.5	0.3	1.0	1.5	0.2	0.87	99	1	6.2	6.2	6.2		2.5	2.5		1.05	1
2010	116	4.6	5.7	6.5	0.6	1.9	2.8	0.5	1.01	100										
2011	176	4.9	5.4	6.1	0.4	1.4	1.9	0.4	0.84	95	2	8.0	8.3	8.5	0.4	5.3	6.1	1.1	0.94	1
2012	5	3.8	4.4	4.8	0.4	0.7	0.8	0.1	0.81	100										
2013	102	4.3	4.6	5.0	0.2	0.9	1.1	0.1	0.87	68										
2014	51	4.2	5.0	5.4	0.3	0.9	1.1	0.2	0.72	100										
2015	72	5.8	6.6	7.1	0.3	2.1	2.6	0.3	0.74	100										
2016			7.6		1.5	3.9		2.1												
All	10270	5.0	7.3	9.3	1.3	3.5	6.5	1.8	0.82	4E3	109	7.0	8.4	10.0	0.9	5.2	8.1	2.0	0.84	53

Table 5. Statistics associated with best estimates of Henderson Lake Sockeye annual (ocean entry year) smolt size (standard fork length (cm), standard fresh weight (g)), based on sampling effort between April 14th and May 26th each year, gears combined. Smolt size for 2016 estimated based on pre-smolt fork length and all-year length-weight relation.

Number of Observations Read	40
Number of Observations Used	28
Number of Observations with Missing Values	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	4544.60551	1136.15138	28.28	<.0001
Error	23	924.07306	40.17709		
Corrected Total	27	5468.67857			

Root MSE	6.33854	R-Square	0.8310
Dependent Mean	70.10714	Adj R-Sq	0.8016
Coeff Var	9.04122		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	361.85501	282.83663	1.28	0.2135
Year	Smolt Year	1	-0.14680	0.14200	-1.03	0.3120
STD_PresmoltLength	Presmolt Length	1	11.28705	1.46363	7.71	<.0001
STD_Presmolts	Presmolt Abundance	1	-2.27205	1.58507	-1.43	0.1652
STD_Presmolt_Length_x_Abund	Presmolt x Abund	1	-0.49199	1.97672	-0.25	0.8057

Table 6. Statistics associated with predictive regression analysis of best estimates (Table 5) of Henderson Lake Sockeye fork length as a function of year, pre-smolt fork length, pre-smolt abundance, and an interaction term. Only Presmolt Length was retained as a predictor at the $\alpha = 0.05$ level.

Fork Length		Critical values			
	Test statistic	a=0.10	a=0.05	a=0.01	Result
Mann-Kendall	-1.6	1.6	2	2.6	NS
Spearman's Rho	-1.7	1.6	2	2.6	S (0.1)
Linear regression	-2.1	1.7	2	2.7	S (0.05)
Cusum	7	7.7	8.6	10.3	NS
Cumulative deviation	1.4	1.1	1.3	1.5	S (0.05)
Worsley likelihood	3.3	2.9	3.2	3.8	S (0.05)
Rank Sum	-2.8	1.6	2	2.6	S (0.01)
Student's t	4.2	1.7	2	2.7	S (0.01)
Median Crossing	1.4	1.6	2	2.6	NS
Turning Point	-2	1.6	2	2.6	S (0.05)
Rank Difference	-2.3	1.6	2	2.6	S (0.05)
Auto Correlation	2.5	1.6	2	2.6	S (0.05)

Standard Weight		Critical values			
	Test statistic	a=0.10	a=0.05	a=0.01	Result
Mann-Kendall	-1.8	1.6	2.0	2.6	S (0.1)
Spearman's Rho	-2.0	1.6	2.0	2.6	S (0.1)
Linear regression	-1.6	1.7	2.0	2.7	NS
Cusum	7.0	7.7	8.6	10.3	NS
Cumulative deviation	1.3	1.1	1.3	1.5	S (0.05)
Worsley likelihood	2.9	2.9	3.2	3.8	S (0.1)
Rank Sum	-2.9	1.6	2.0	2.6	S (0.01)
Student's t	2.3	1.7	2.0	2.7	S (0.05)
Median Crossing	2.1	1.6	2.0	2.6	S (0.05)
Turning Point	-2.0	1.6	2.0	2.6	S (0.05)
Rank Difference	-2.5	1.6	2.0	2.6	S (0.05)
Auto Correlation	2.6	1.6	2.0	2.6	S (0.01)

Table 7. Statistics associated with time trend analysis of best estimates (Table 5) of Henderson Lake Sockeye fork length (top) and standard fresh weight (bottom). S = significant (probability level). NS = not significant.

APPENDIX I – Sample Statistics by Date and Age

Appendix I. Annual Sockeye smolt size statistics by sample site, age class, and sample date.

		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1977	18MAY77	19	7.0	7.7	0.09	2.7	3.6	0.10	0.80	100									
	ALL	19	7.0	7.7	0.09	2.7	3.6	0.10	0.80	100									
1978	Date																		
	25APR78	104	6.9	7.6	0.04	2.6	3.5	0.04	0.78	34	1	6.8	6.8		2.6	2.6		0.82	0
	08MAY78	99	6.9	7.7	0.03	2.8	3.9	0.04	0.84	32									
	18MAY78	106	6.8	7.5	0.03	2.8	3.7	0.04	0.86	34									
	ALL	309	6.9	7.6	0.02	2.7	3.7	0.02	0.83	100	1	6.8	6.8		2.6	2.6		0.82	0
1979	Date																		
	08MAY79	100	7.8	9.0	0.05	3.9	5.9	0.08	0.81	23									
	22MAY79	200	7.6	8.8	0.04	4.3	6.4	0.06	0.96	45									
	30MAY79	142	7.4	8.6	0.05	4.1	6.3	0.07	1.00	32									
	ALL	442	7.6	8.7	0.03	4.1	6.3	0.04	0.94	100									
1980	30APR80	100	6.7	7.3	0.03	2.4	3.2	0.03	0.80	50									
	21MAY80	100	6.4	7.0	0.03	2.2	2.9	0.03	0.84	50									
	ALL	200	6.5	7.2	0.02	2.3	3.1	0.02	0.82	100									
1981	Date																		
	06MAY81	110	6.9	7.4	0.03	2.5	3.3	0.04	0.78	42									
	12MAY81	125	6.9	7.6	0.03	1.9	2.9	0.04	0.58	47									
	18MAY81	29	6.6	7.3	0.06	2.5	3.2	0.06	0.86	11									
	ALL	264	6.8	7.6	0.02	2.2	3.3	0.03	0.69	100									
1982	Date																		
	07MAY82	141	7.9	9.0	0.04	4.2	6.1	0.06	0.84	56									
	19MAY82	111	8.2	8.8	0.03	4.4	5.4	0.05	0.80	44									
1982		252	8.0	9.0	0.03	4.3	5.9	0.04	0.82	100									
1983	Date																		
	02MAY83	100	5.5	6.1	0.04	1.3	1.8	0.02	0.79	51									
	12MAY83	96	5.0	6.1	0.04	1.0	1.8	0.03	0.79	49									
	ALL	196	5.2	6.1	0.03	1.2	1.8	0.02	0.79	100									
1984	Date																		
	23APR84	188	6.5	7.5	0.04	2.2	3.4	0.04	0.80	52	16	7.5	8.9	0.14	3.6	6.4	0.25	0.83	4
	02MAY84	159	6.4	7.4	0.04	2.2	3.5	0.04	0.83	44									
	ALL	347	6.4	7.5	0.03	2.2	3.4	0.03	0.81	96	16	7.5	8.9	0.14	3.6	6.4	0.25	0.83	4
1985	Date																		
	01MAY85	107	7.3	8.1	0.05	2.9	4.0	0.05	0.73	48									
1985	10MAY85	116	6.9	8.3	0.06	2.5	4.1	0.06	0.74	52									
	ALL	223	7.1	8.3	0.04	2.7	4.1	0.04	0.74	100									
1986	Date																		
	04MAY86	117	5.7	6.8	0.04	1.5	2.6	0.03	0.77	72									
	11MAY86	46	5.8	7.6	0.08	1.6	3.8	0.07	0.79	28									
	ALL	163	5.8	7.1	0.03	1.5	3.0	0.03	0.78	100									
1987	Date																		
	10MAY87	4	8.6	9.1	0.33	5.3	6.0	0.55	0.81	16									
	13MAY87	19	8.8	9.9	0.18	6.0	8.5	0.36	0.84	76	2	8.7	9.1	0.45	5.3	6.0	0.73	0.81	8
	ALL	23	8.8	9.9	0.16	5.8	8.5	0.31	0.84	92	2	8.7	9.1	0.45	5.3	6.0	0.73	0.81	8

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		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1988	15APR88	73	9.1	10.8	0.11	6.6	11.4	0.24	0.86	31									
	22APR88	143	9.1	10.9	0.09	6.9	11.5	0.19	0.87	61	1	9.2	9.2		6.7	6.7		0.87	0
	29APR88	19	9.4	11.3	0.28	7.7	11.7	0.56	0.90	8									
	ALL	235	9.1	11.1	0.07	6.9	11.5	0.15	0.87	100	1	9.2	9.2		6.7	6.7		0.87	0
1989	Date																		
	13APR89	102	7.3	8.3	0.05	3.4	4.9	0.07	0.87	26									
	20APR89	90	7.4	8.6	0.06	3.4	5.4	0.08	0.83	23									
	02MAY89	205	7.7	8.9	0.04	3.9	6.3	0.07	0.86	52									
	ALL	397	7.5	8.8	0.03	3.7	6.1	0.05	0.85	100									
1990	Date																		
	11APR90	2	7.5	7.5	0.05	3.6	3.8	0.18	0.88	1									
1990	26APR90	30	7.1	8.0	0.08	3.3	4.4	0.10	0.91	13									
	09MAY90	200	7.4	8.0	0.02	3.4	4.2	0.03	0.83	86									
	ALL	232	7.4	8.0	0.02	3.4	4.2	0.03	0.84	100									
1991	Date																		
	09MAY91	126	8.1	9.2	0.04	4.6	6.9	0.08	0.85	39									
	16MAY91	200	8.5	9.6	0.03	5.3	7.3	0.05	0.85	61									
	ALL	326	8.4	9.4	0.03	5.0	7.3	0.05	0.85	100									
1992	Date																		
	04MAY92	102	8.8	9.9	0.06	6.0	7.5	0.10	0.88	31	1	9.4	9.4		7.2	7.2		0.87	0
	14MAY92	82	9.1	10.0	0.04	6.7	8.5	0.10	0.88	25	3	9.3	9.5	0.12	6.6	6.9	0.22	0.83	1
	19MAY92	141	9.3	10.3	0.03	7.1	9.4	0.07	0.89	43									
1992		325	9.1	10.1	0.03	6.6	8.7	0.06	0.89	99	4	9.3	9.5	0.09	6.7	7.2	0.22	0.84	1
1993	Date																		
	11MAY93	160	7.9	9.1	0.05	4.3	6.8	0.09	0.86	44									
	18MAY93	200	8.2	9.5	0.04	4.7	7.1	0.07	0.85	56									
	ALL	360	8.0	9.3	0.03	4.5	6.9	0.06	0.86	100									
1994	Date																		
	21APR94	14	6.2	8.8	0.50	2.6	6.3	0.52	0.82	1									
	28APR94	246	7.9	9.6	0.05	4.0	7.0	0.08	0.79	19									
	05MAY94	144	7.8	9.2	0.05	4.1	6.8	0.08	0.83	11									
	12MAY94	300	8.0	9.3	0.03	4.4	7.0	0.05	0.86	23									
	18MAY94	150	7.4	8.6	0.05	3.5	5.5	0.07	0.85	12									
1994	26MAY94	363	7.1	9.0	0.05	3.0	6.2	0.06	0.82	28									
	02JUN94	74	7.9	9.5	0.09	4.1	7.7	0.14	0.81	6									
	ALL	1,291	7.6	9.2	0.02	3.8	6.8	0.03	0.83	100									
1995	Date																		
	10APR95	50	6.1	6.9	0.06	1.8	2.8	0.06	0.80	5									
	13APR95	50	6.0	6.7	0.06	1.7	2.6	0.05	0.81	5									
	19APR95	50	6.1	6.7	0.06	1.9	2.5	0.05	0.83	5									
	22APR95	50	5.7	6.5	0.07	1.5	2.2	0.05	0.80	5									
	27APR95	43	5.7	6.7	0.07	1.6	2.5	0.06	0.82	5									
	30APR95	49	6.0	6.8	0.05	1.8	2.5	0.05	0.82	5									
	01MAY95	50	5.4	7.2	0.06	1.3	3.0	0.05	0.81	5									

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		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1995	04MAY95	189	5.4	6.6	0.03	1.2	2.4	0.02	0.79	20									
	11MAY95	102	5.3	6.5	0.04	1.1	2.1	0.03	0.74	11									
	16MAY95	98	5.2	7.4	0.04	1.3	3.5	0.03	0.90	10									
	25MAY95	74	5.5	7.8	0.04	1.3	4.4	0.05	0.81	8									
	26MAY95	51	5.3	6.1	0.04	1.3	1.8	0.03	0.89	5									
	27MAY95	98	5.3	7.4	0.03	1.3	3.3	0.03	0.89	10									
	ALL	954	5.5	6.8	0.02	1.4	2.5	0.01	0.82	100									
1996	Date																		
	28APR96	27	7.2	8.4	0.12	3.3	5.0	0.19	0.84	4									
	29APR96	59	7.4	8.5	0.09	3.9	6.7	0.14	0.95	9	1	8.2	8.2		5.2	5.2		0.95	0
	30APR96	39	7.1	8.5	0.09	3.3	6.0	0.13	0.91	6									
1996	01MAY96	39	7.3	8.4	0.10	3.5	5.5	0.15	0.89	6									
	02MAY96	45	6.9	8.1	0.10	2.9	4.6	0.13	0.85	7									
	05MAY96	60	7.8	8.8	0.08	4.0	6.7	0.14	0.83	9	3	8.8	9.0	0.10	5.8	6.5	0.50	0.85	0
	10MAY96	188	7.6	8.9	0.04	3.5	5.8	0.06	0.80	28	12	8.1	8.7	0.12	4.7	6.3	0.30	0.87	2
	19MAY96	22	8.3	9.1	0.11	4.5	5.8	0.19	0.80	3	4	8.6	9.8	0.40	5.7	8.4	0.92	0.86	1
	20MAY96	57	8.0	9.4	0.06	4.2	6.8	0.13	0.81	9	7	8.2	8.4	0.08	4.4	5.1	0.26	0.81	1
	26MAY96	56	8.2	9.2	0.08	4.6	6.7	0.13	0.83	8	8	8.6	9.5	0.17	5.5	7.0	0.34	0.88	1
	28MAY96	23	7.5	8.5	0.13	4.0	5.8	0.22	0.94	3	1	8.4	8.4		5.8	5.8		0.98	0
	30MAY96	19	7.5	8.6	0.14	3.7	6.1	0.21	0.86	3									
	ALL	634	7.6	9.0	0.03	3.8	6.3	0.04	0.84	95	36	8.3	9.8	0.08	5.1	8.4	0.18	0.86	5
1997	03MAY97	34	6.3	6.7	0.06	2.0	2.6	0.05	0.83	4									
	04MAY97	61	6.8	7.0	0.01	2.6	3.2	0.03	0.82	7									
	07MAY97	81	7.1	7.3	0.01	3.0	3.7	0.02	0.83	9									
	08MAY97	158	7.5	7.6	0.01	3.4	3.8	0.02	0.82	17									
	09MAY97	258	7.8	8.0	0.01	3.9	4.6	0.02	0.82	28									
	14MAY97	79	8.1	8.1	0.01	4.4	4.9	0.02	0.83	9									
	15MAY97	45	8.2	8.2	0.01	4.5	4.9	0.04	0.81	5									
	16MAY97	66	8.3	8.4	0.01	4.7	5.2	0.03	0.83	7									
	22MAY97	124	8.5	8.9	0.01	5.3	6.4	0.04	0.85	13									
	23MAY97	8	9.0	9.2	0.04	5.8	6.8	0.33	0.86	1	12	8.1	8.8	0.13	4.7	5.6	0.21	0.87	1
	ALL	914	7.7	8.9	0.02	3.9	6.2	0.03	0.83	99	12	8.1	8.8	0.13	4.7	5.6	0.21	0.87	1
1998	08APR98	44	7.8	10.3	0.10	3.8	9.3	0.18	0.77	6									
	09APR98	17	7.9	9.6	0.20	4.0	7.2	0.35	0.76	2									
	10APR98	13	7.9	9.4	0.21	3.9	7.7	0.38	0.76	2									
	12APR98	11	7.7	8.6	0.21	3.5	4.9	0.25	0.75	2									
	13APR98	70	7.7	9.1	0.07	3.5	5.3	0.10	0.76	10	2	8.9	9.2	0.25	5.6	6.1	0.51	0.78	0
	14APR98	91	7.9	9.7	0.06	3.7	6.3	0.09	0.73	13									
	15APR98	110	7.6	9.3	0.07	3.7	7.4	0.10	0.81	16									
	18APR98	253	8.0	11.3	0.05	4.4	13.5	0.12	0.83	36									
	25APR98	8	8.2	10.2	0.33	4.4	8.0	0.59	0.77	1									
	26APR98	15	8.7	9.9	0.15	5.1	7.4	0.24	0.78	2									
	11MAY98	19	8.0	8.9	0.11	4.1	5.9	0.18	0.77	3									

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		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1998	22MAY98	41	7.0	9.3	0.12	2.9	6.9	0.18	0.79	6									
	ALL	692	7.8	10.3	0.03	3.9	10.3	0.06	0.79	100	2	8.9	9.2	0.25	5.6	6.1	0.51	0.78	0
1999	Date																		
	14APR99	12	7.1	8.2	0.23	2.9	4.7	0.28	0.81	8	8	8.4	9.6	0.21	5.0	7.1	0.35	0.84	5
	29APR99	128	7.8	10.2	0.06	4.3	12.2	0.14	0.86	86									
	ALL	140	7.8	10.2	0.06	4.1	12.2	0.13	0.86	95	8	8.4	9.6	0.21	5.0	7.1	0.35	0.84	5
2000	Date																		
	14MAY00	26	4.6	5.2	0.05	0.6	1.0	0.03	0.62	53									
	16MAY00	23	4.6	5.2	0.05	0.6	0.8	0.03	0.62	47									
	ALL	49	4.6	5.2	0.04	0.6	1.0	0.02	0.62	100									
2001	17APR01	2	7.4	7.6	0.15	2.9	3.1	0.22	0.70	7	1	8.8	8.8		4.9	4.9		0.72	4
	07MAY01	22	7.0	7.4	0.08	2.6	3.2	0.08	0.77	79	3	7.8	8.0	0.15	3.4	3.8	0.24	0.72	11
	ALL	24	7.0	7.6	0.08	2.6	3.2	0.08	0.76	86	4	8.0	8.8	0.27	3.8	4.9	0.41	0.72	14
2002	Date																		
	08MAY02	27	4.4	5.4	0.06	0.7	1.4	0.04	0.82	68									
	16MAY02	13	4.2	4.8	0.08	0.6	0.9	0.04	0.79	33									
	ALL	40	4.4	5.4	0.05	0.7	1.4	0.03	0.81	100									
2003	Date																		
	03APR03	4	4.2	4.3	0.04	0.7	0.7	0.02	0.93	4									
	26APR03	3	4.9	4.9	0.00	0.8	0.9	0.04	0.72	3									
	27APR03	3	5.1	5.4	0.17	1.0	1.2	0.13	0.73	3									
2003	28APR03	3	4.8	4.9	0.06	0.8	0.8	0.04	0.70	3									
	01MAY03	2	4.8	4.9	0.05	1.0	1.1	0.09	0.85	2									
	06MAY03	18	5.5	6.6	0.10	1.3	2.3	0.09	0.78	16									
	09MAY03	8	5.0	5.5	0.13	0.9	1.2	0.07	0.73	7									
	11MAY03	5	5.7	6.4	0.28	1.6	2.2	0.28	0.82	4									
	12MAY03	3	4.9	5.0	0.09	0.8	0.9	0.05	0.69	3									
	13MAY03	1	6.7	6.7		2.5	2.5		0.82	1									
	14MAY03	4	6.6	6.9	0.23	2.5	3.1	0.33	0.85	4									
	15MAY03	9	5.3	6.2	0.22	1.2	1.8	0.19	0.71	8									
	16MAY03	10	5.8	6.9	0.18	1.5	2.5	0.16	0.76	9									
	18MAY03	2	5.3	5.5	0.15	1.1	1.2	0.05	0.72	2									
2003	19MAY03	2	5.2	5.3	0.10	1.0	1.1	0.04	0.73	2									
	20MAY03	3	5.1	5.3	0.12	1.0	1.1	0.07	0.74	3									
	21MAY03	3	5.5	6.3	0.41	1.3	2.0	0.38	0.72	3									
	22MAY03	3	5.7	5.9	0.15	1.4	1.7	0.19	0.74	3									
	24MAY03	5	5.5	5.8	0.15	1.2	1.3	0.07	0.72	4									
	25MAY03	3	5.5	6.2	0.36	1.3	2.0	0.37	0.75	3									
	26MAY03	2	5.5	5.6	0.05	1.4	1.5	0.05	0.85	2									
	27MAY03	2	5.4	6.0	0.55	1.2	1.7	0.48	0.72	2									
	28MAY03	4	5.1	5.3	0.05	1.1	1.2	0.03	0.79	4									
	30MAY03	1	5.0	5.0		0.9	0.9		0.74	1									
	31MAY03	2	5.3	5.6	0.30	1.2	1.4	0.22	0.82	2									

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		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
2003	01JUN03	9	5.3	6.7	0.21	1.1	2.5	0.18	0.73	8									
	ALL	114	5.4	6.9	0.06	1.2	2.7	0.05	0.76	100									
2004	Date																		
	15APR04	45	7.8	8.7	0.08	4.0	5.0	0.13	0.84	23	5	8.9	9.4	0.15	6.2	7.0	0.20	0.89	3
	21APR04	27	7.7	9.0	0.15	3.4	5.0	0.19	0.75	14	4	9.5	10.0	0.18	6.5	8.0	0.50	0.74	2
	06MAY04	20	7.9	8.7	0.14	3.9	5.0	0.24	0.77	10	2	9.2	9.4	0.15	6.0	6.0	0.00	0.76	1
	08MAY04	24	7.4	8.7	0.12	3.2	5.0	0.17	0.77	13	1	9.0	9.0		7.0	7.0		0.96	1
	09MAY04	25	7.3	8.4	0.11	2.9	4.0	0.15	0.72	13									
	10MAY04	22	7.3	8.0	0.09	3.1	5.0	0.17	0.77	11									
	19MAY04	12	8.4	9.1	0.17	4.5	5.0	0.23	0.75	6	5	9.2	9.6	0.13	6.0	6.0	0.00	0.77	3
	ALL	175	7.6	9.0	0.05	3.6	5.0	0.08	0.78	91	17	9.2	10.0	0.09	6.2	8.0	0.14	0.81	9
2005	23MAR05	1	5.2	5.2		1.1	1.1		0.78	1	2	7.5	8.2	0.70	3.3	4.5	1.15	0.76	1
	25MAR05	19	5.9	6.5	0.09	1.6	2.4	0.11	0.78	10									
	27MAR05	6	6.3	6.7	0.14	1.5	1.9	0.14	0.61	3									
	29MAR05	10	5.8	6.6	0.20	1.3	1.8	0.13	0.61	5									
	01APR05	10	5.8	6.5	0.11	1.5	2.0	0.15	0.79	5									
	09APR05	1	5.3	5.3		1.4	1.4		0.94	1									
	11APR05	3	5.4	5.6	0.12	1.3	1.6	0.15	0.86	2									
	23APR05	1	5.5	5.5		1.0	1.0		0.60	1	1	6.5	6.5		1.7	1.7		0.62	1
	25APR05	21	5.4	7.4	0.12	1.2	3.0	0.10	0.75	11									
	28APR05	14	5.3	5.9	0.09	1.2	1.8	0.08	0.79	8									
	30APR05	6	5.4	5.7	0.13	1.2	1.4	0.08	0.76	3									
2005	02MAY05	11	5.5	6.5	0.14	1.3	2.2	0.12	0.75	6									
	03MAY05	12	5.4	5.9	0.11	1.4	1.8	0.08	0.90	7									
	04MAY05	21	5.3	6.0	0.08	1.3	1.8	0.05	0.84	11									
	06MAY05	6	5.5	7.3	0.38	1.5	3.4	0.38	0.87	3									
	08MAY05	2	5.5	5.6	0.05	1.1	1.2	0.05	0.67	1									
	13MAY05	16	5.3	5.7	0.07	1.3	1.7	0.06	0.84	9									
	25MAY05	3	5.3	5.5	0.09	1.2	1.4	0.09	0.81	2									
	26MAY05	2	5.1	5.3	0.15	1.1	1.2	0.10	0.80	1									
	29MAY05	5	5.4	5.8	0.14	1.0	1.2	0.07	0.63	3									
	31MAY05	1	5.1	5.1		1.1	1.1		0.83	1									
	01JUN05	2	5.1	5.2	0.10	1.1	1.2	0.05	0.87	1									
2005	04JUN05	3	5.3	5.5	0.15	1.2	1.3	0.03	0.84	2									
	06JUN05	2	5.1	5.2	0.10	1.0	1.2	0.15	0.79	1									
	12JUN05	1	6.2	6.2		1.7	1.7		0.71	1									
	13JUN05	1	5.1	5.1		1.2	1.2		0.90	1									
	ALL	180	5.5	7.3	0.04	1.3	3.0	0.03	0.78	98	3	7.2	8.2	0.52	2.8	4.5	0.86	0.71	2
2006	Date																		
	23APR06	17	7.5	8.3	0.10	3.4	4.8	0.13	0.80	100									
	ALL	17	7.5	8.3	0.10	3.4	4.8	0.13	0.80	100									
2007	Date																		
	19APR07	3	8.7	9.0	0.13	4.2	4.5	0.16	0.63	0									
	30APR07	72	9.0	10.4	0.07	5.8	9.0	0.12	0.80	12	2	11.8	12.0	0.20	14.7	16.7	2.00	0.89	0

(Continued)

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		Age																	
		1									2								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
2007	09MAY07	532	8.9	10.0	0.02	4.8	6.6	0.04	0.68	87	1	10.1	10.1		8.1	8.1		0.79	0
	ALL	607	8.9	10.0	0.02	4.9	7.0	0.04	0.69	100	3	11.2	12.0	0.58	12.5	16.7	2.47	0.85	0
2008	Date																		
	14APR08	56	9.0	9.8	0.07	6.8	9.2	0.15	0.91	19									
	24APR08	68	8.7	9.8	0.07	6.1	8.7	0.15	0.92	23	2	10.3	10.5	0.15	10.2	10.2	0.02	0.92	1
	01MAY08	166	8.6	9.9	0.04					57									
	ALL	290	8.7	9.8	0.03	6.4	9.1	0.11	0.92	99	2	10.3	10.5	0.15	10.2	10.2	0.02	0.92	1
2009	Date																		
	17APR09	116	4.8	5.8	0.03	1.0	1.8	0.02	0.87	99	1	6.2	6.2		2.5	2.5		1.05	1
	ALL	116	4.8	5.8	0.03	1.0	1.8	0.02	0.87	99	1	6.2	6.2		2.5	2.5		1.05	1
2010	12MAY10	25	4.8	5.3	0.07	1.3	1.6	0.05	1.10	22									
	13MAY10	91	5.9	6.6	0.04	2.1	3.2	0.05	0.99	78									
	ALL	116	5.7	6.6	0.05	1.9	3.1	0.05	1.01	100									
2011	Date																		
	11APR11	5	5.8	6.1	0.09	1.5	1.8	0.08	0.75	3	2	8.6	8.7	0.10	6.1	6.3	0.18	0.96	1
	26APR11	176	5.4	6.9	0.03	1.4	2.9	0.03	0.84	95	2	8.3	8.5	0.25	5.3	6.1	0.78	0.94	1
	ALL	181	5.5	6.9	0.03	1.4	2.9	0.03	0.84	98	4	8.4	8.7	0.15	5.7	6.3	0.40	0.95	2
2012	Date																		
	14APR12	3	4.4	4.8	0.30	0.7	0.8	0.05	0.90	60									
	04MAY12	2	4.4	4.6	0.20	0.6	0.7	0.14	0.69	40									
	ALL	5	4.4	4.8	0.17	0.7	0.8	0.06	0.81	100									
2013	11APR13	46	4.8	5.3	0.04	1.1	1.8	0.03	0.96	31	1	6.0	6.0		2.1	2.1		0.99	1
	01MAY13	102	4.6	5.1	0.02	0.9	1.2	0.01	0.87	68									
	ALL	148	4.7	5.3	0.02	0.9	1.5	0.02	0.90	99	1	6.0	6.0		2.1	2.1		0.99	1
2014	Date																		
	25APR14	20	5.1	5.7	0.07	0.9	1.2	0.03	0.70	39									
	07MAY14	31	4.9	5.6	0.06	0.8	1.4	0.03	0.73	61									
	ALL	51	5.0	5.7	0.05	0.9	1.4	0.02	0.72	100									
2015	Date																		
	15APR15	65	6.6	7.2	0.04	2.1	2.8	0.04	0.74	90									
	30APR15	7	6.3	7.0	0.22	2.0	2.7	0.21	0.75	10									
	ALL	72	6.6	7.2	0.04	2.1	2.8	0.04	0.74	100									

APPENDIX II – Sample Statistics by Date and Gear Type

Appendix II. Smolt sample size (number of fish) and percent of total retained catch, by year, sample date, and gear type, for years where both fyke net (trawl) and rotary screw trap were employed.

		Gear																	
		Trawl									Rotary Screw								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1994	21APR94										14	6.2	8.8	0.50	2.6	6.3	0.52	0.82	1
	28APR94	246	7.9	9.6	0.05	4.0	7.0	0.08	0.79	19									
	05MAY94										144	7.8	9.2	0.05	4.1	6.8	0.08	0.83	11
	12MAY94	150	8.0	9.2	0.03	4.4	7.0	0.06	0.85	23	150	7.9	9.5	0.05	4.4	7.2	0.08	0.87	
	18MAY94										150	7.4	8.6	0.05	3.5	5.5	0.07	0.85	12
	26MAY94	258	7.1	9.0	0.06	3.0	5.7	0.07	0.80	28	105	7.0	8.9	0.10	3.2	6.3	0.14	0.87	
	02JUN94										74	7.9	9.5	0.09	4.1	7.7	0.14	0.81	6
	ALL	654	7.6	9.2	0.04	3.7	6.6	0.05	0.81	70	637	7.6	9.3	0.03	3.8	6.8	0.05	0.85	30
1995	Date																		
	10APR95										50	6.1	6.9	0.06	1.8	2.8	0.06	0.80	5
	13APR95										50	6.0	6.7	0.06	1.7	2.6	0.05	0.81	5
	19APR95										50	6.1	6.7	0.06	1.9	2.5	0.05	0.83	5
1995	22APR95										50	5.7	6.5	0.07	1.5	2.2	0.05	0.80	5
	27APR95										43	5.7	6.7	0.07	1.6	2.5	0.06	0.82	5
	30APR95										49	6.0	6.8	0.05	1.8	2.5	0.05	0.82	5
	01MAY95	50	5.4	7.2	0.06	1.3	3.0	0.05	0.81	5									
	04MAY95										189	5.4	6.6	0.03	1.2	2.4	0.02	0.79	20
	11MAY95	102	5.3	6.5	0.04	1.1	2.1	0.03	0.74	11									
	16MAY95	98	5.2	7.4	0.04	1.3	3.5	0.03	0.90	10									
	25MAY95										74	5.5	7.8	0.04	1.3	4.4	0.05	0.81	8
	26MAY95										51	5.3	6.1	0.04	1.3	1.8	0.03	0.89	5
	27MAY95										98	5.3	7.4	0.03	1.3	3.3	0.03	0.89	10
	ALL	250	5.3	7.0	0.03	1.2	2.9	0.02	0.82	26	704	5.6	6.8	0.02	1.5	2.5	0.02	0.82	74
1998	08APR98										44	7.8	10.3	0.10	3.8	9.3	0.18	0.77	6
	09APR98										17	7.9	9.6	0.20	4.0	7.2	0.35	0.76	2
	10APR98										13	7.9	9.4	0.21	3.9	7.7	0.38	0.76	2
	12APR98										11	7.7	8.6	0.21	3.5	4.9	0.25	0.75	2
	13APR98										72	7.7	9.2	0.07	3.6	6.1	0.11	0.76	10
	14APR98										91	7.9	9.7	0.06	3.7	6.3	0.09	0.73	13
	15APR98										110	7.6	9.3	0.07	3.7	7.4	0.10	0.81	16
	18APR98	126	8.2	11.5	0.09	4.9	14.0	0.21	0.85	36	127	7.8	9.5	0.05	3.8	7.2	0.08	0.81	
	25APR98										8	8.2	10.2	0.33	4.4	8.0	0.59	0.77	1
	26APR98										15	8.7	9.9	0.15	5.1	7.4	0.24	0.78	2
	11MAY98										19	8.0	8.9	0.11	4.1	5.9	0.18	0.77	3

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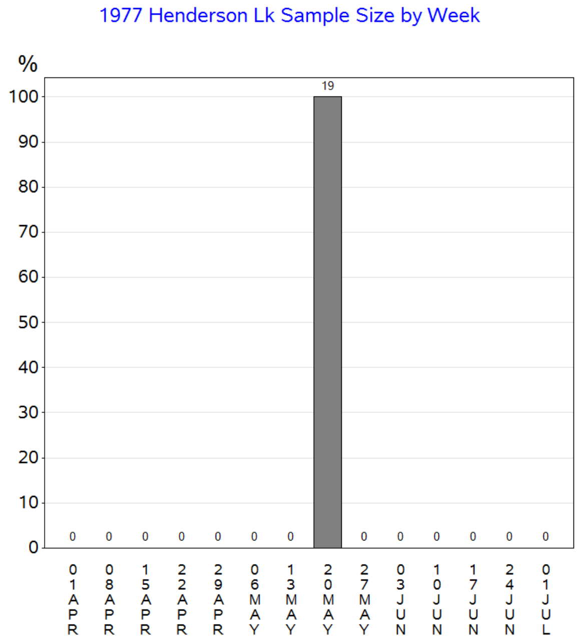
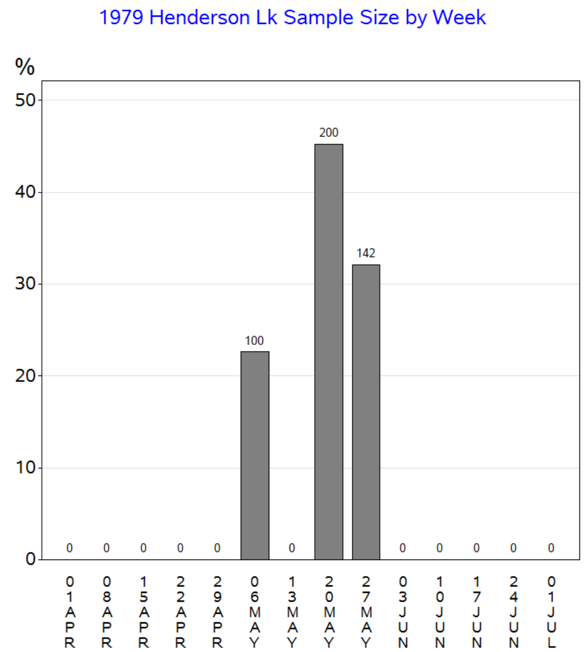
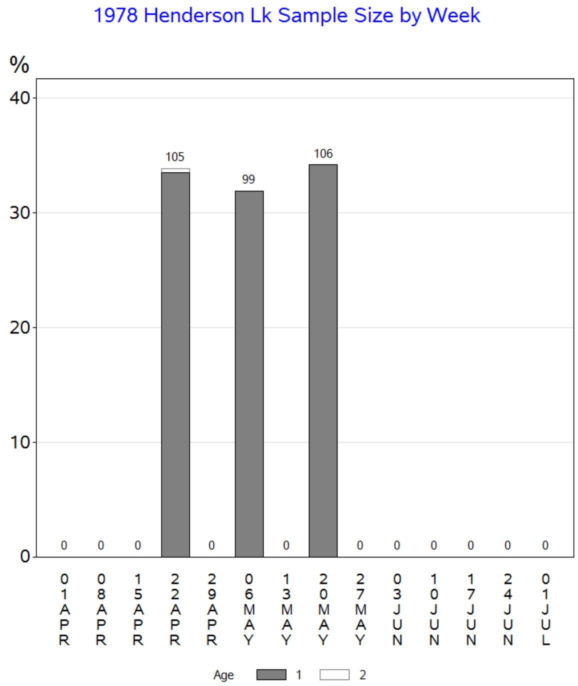
		Gear																	
		Trawl									Rotary Screw								
			Length (cm)			Fresh Std Wt (g)						Length (cm)			Fresh Std Wt (g)				
		N	AVG	P99	SE	AVG	P99	SE	K	%	N	AVG	P99	SE	AVG	P99	SE	K	%
Year	Date																		
1998	22MAY98	41	7.0	9.3	0.12	2.9	6.9	0.18	0.79	6									
	ALL	167	7.9	11.5	0.08	4.4	14.0	0.18	0.84	42	527	7.8	9.6	0.03	3.8	7.4	0.04	0.78	58
2003	Date																		
	03APR03	4	4.2	4.3	0.04	0.7	0.7	0.02	0.93	4									
	26APR03										3	4.9	4.9	0.00	0.8	0.9	0.04	0.72	3
	27APR03										3	5.1	5.4	0.17	1.0	1.2	0.13	0.73	3
	28APR03										3	4.8	4.9	0.06	0.8	0.8	0.04	0.70	3
	01MAY03										2	4.8	4.9	0.05	1.0	1.1	0.09	0.85	2
	06MAY03										18	5.5	6.6	0.10	1.3	2.3	0.09	0.78	16
	09MAY03										8	5.0	5.5	0.13	0.9	1.2	0.07	0.73	7
	11MAY03										5	5.7	6.4	0.28	1.6	2.2	0.28	0.82	4
2003	12MAY03										3	4.9	5.0	0.09	0.8	0.9	0.05	0.69	3
	13MAY03										1	6.7	6.7		2.5	2.5		0.82	1
	14MAY03										4	6.6	6.9	0.23	2.5	3.1	0.33	0.85	4
	15MAY03										9	5.3	6.2	0.22	1.2	1.8	0.19	0.71	8
	16MAY03										10	5.8	6.9	0.18	1.5	2.5	0.16	0.76	9
	18MAY03										2	5.3	5.5	0.15	1.1	1.2	0.05	0.72	2
	19MAY03										2	5.2	5.3	0.10	1.0	1.1	0.04	0.73	2
	20MAY03										3	5.1	5.3	0.12	1.0	1.1	0.07	0.74	3
	21MAY03										3	5.5	6.3	0.41	1.3	2.0	0.38	0.72	3
	22MAY03										3	5.7	5.9	0.15	1.4	1.7	0.19	0.74	3
	24MAY03										5	5.5	5.8	0.15	1.2	1.3	0.07	0.72	4
2003	25MAY03										3	5.5	6.2	0.36	1.3	2.0	0.37	0.75	3
	26MAY03										2	5.5	5.6	0.05	1.4	1.5	0.05	0.85	2
	27MAY03										2	5.4	6.0	0.55	1.2	1.7	0.48	0.72	2
	28MAY03										4	5.1	5.3	0.05	1.1	1.2	0.03	0.79	4
	30MAY03										1	5.0	5.0		0.9	0.9		0.74	1
	31MAY03										2	5.3	5.6	0.30	1.2	1.4	0.22	0.82	2
	01JUN03										9	5.3	6.7	0.21	1.1	2.5	0.18	0.73	8
	ALL	4	4.2	4.3	0.04	0.7	0.7	0.02	0.93	4	110	5.4	6.9	0.05	1.2	2.7	0.05	0.75	96

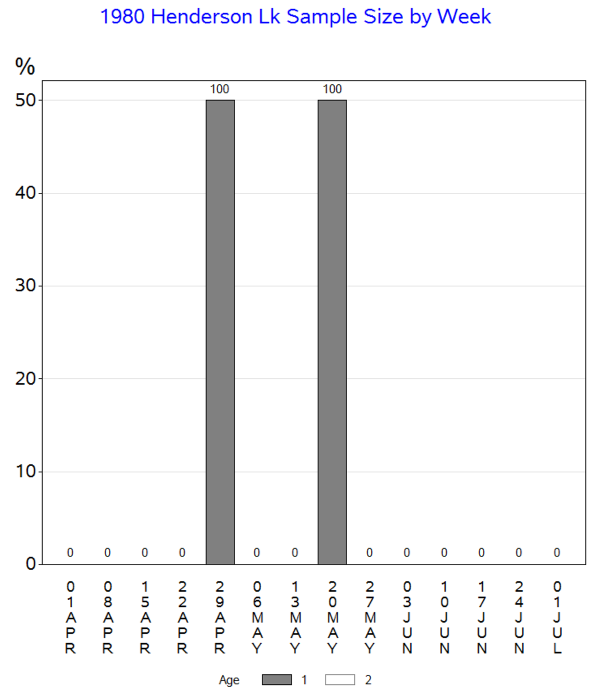
APPENDIX III – Seasonal Sample Size

Appendix III. Smolt sample size (number of fish) and percent of total retained catch, by year, sample date, and age, sample sites combined.









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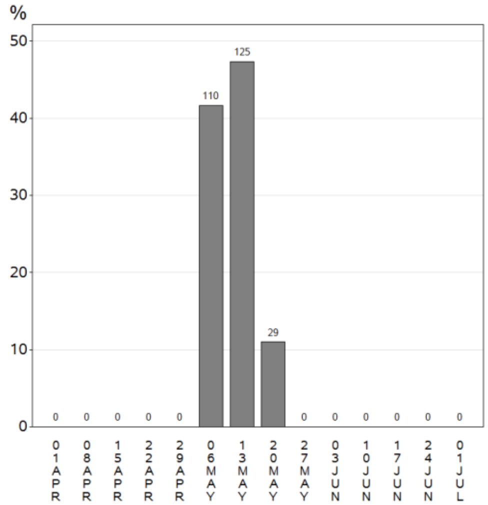
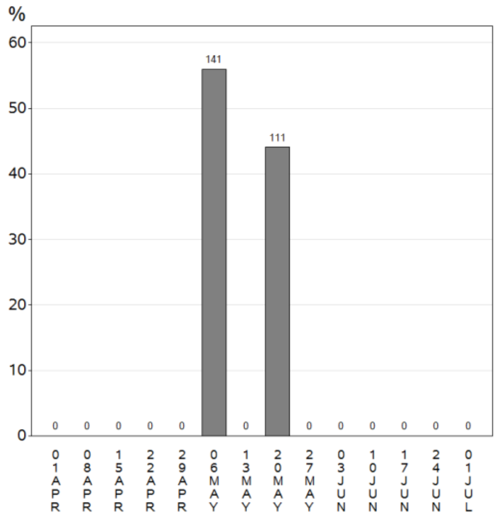
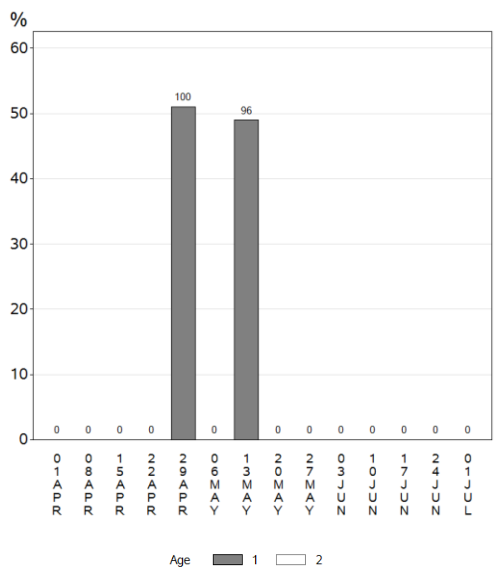
1981 Henderson Lk Sample Size by Week



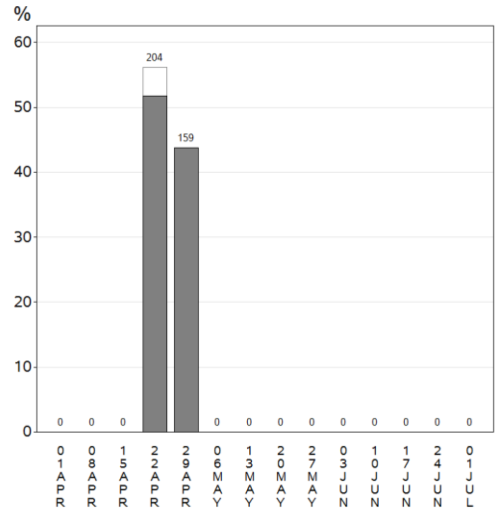
1982 Henderson Lk Sample Size by Week



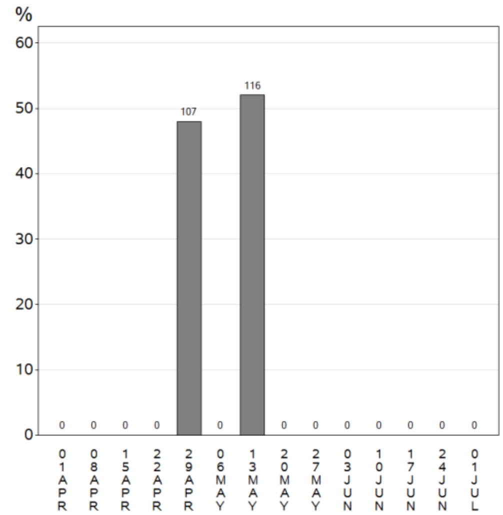
1983 Henderson Lk Sample Size by Week



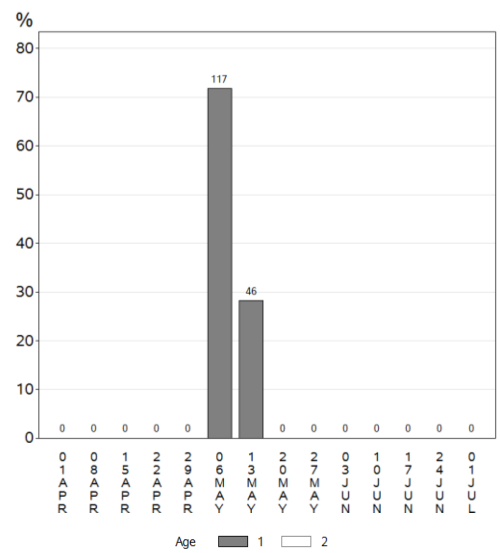
1984 Henderson Lk Sample Size by Week



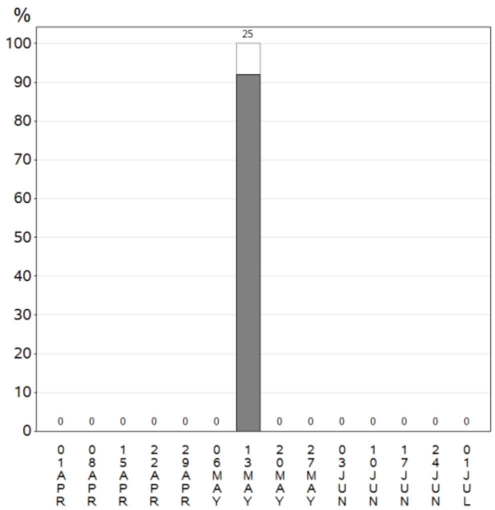
1985 Henderson Lk Sample Size by Week



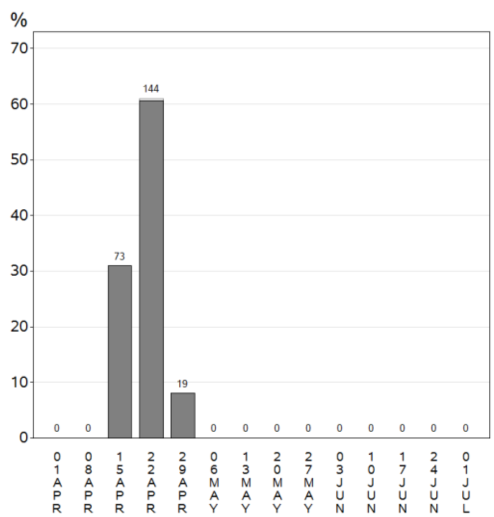
1986 Henderson Lk Sample Size by Week



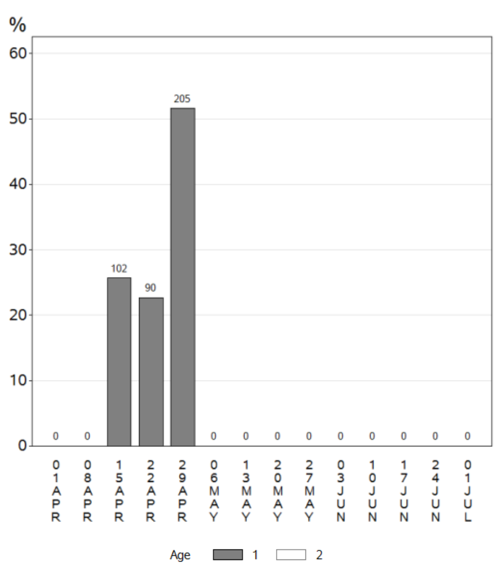
1987 Henderson Lk Sample Size by Week



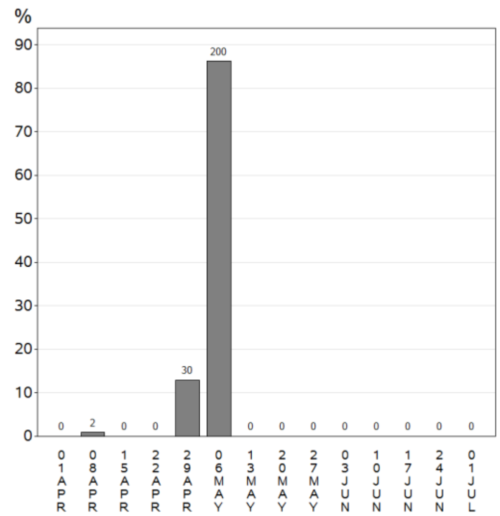
1988 Henderson Lk Sample Size by Week



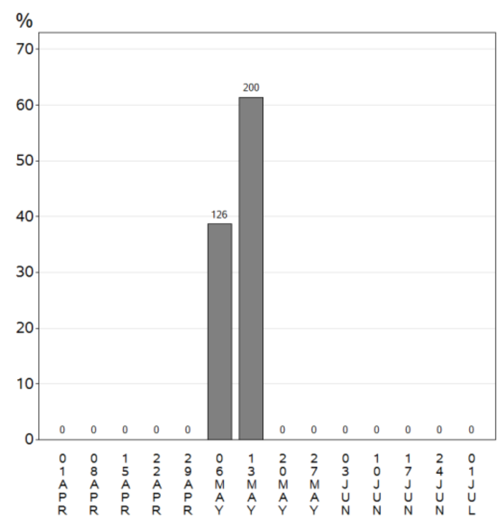
1989 Henderson Lk Sample Size by Week



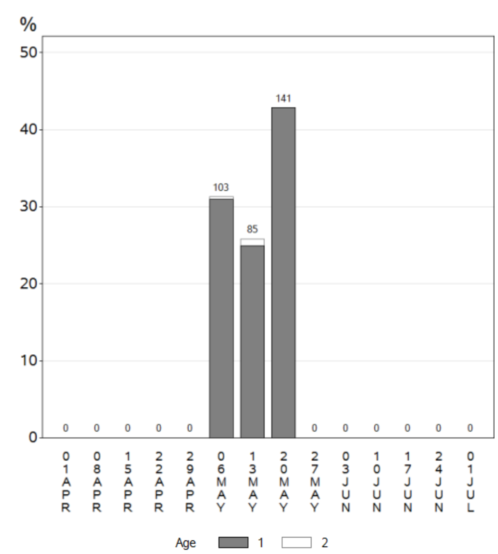
1990 Henderson Lk Sample Size by Week



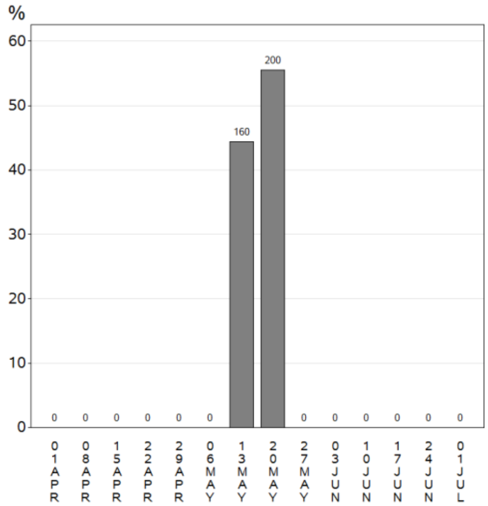
1991 Henderson Lk Sample Size by Week



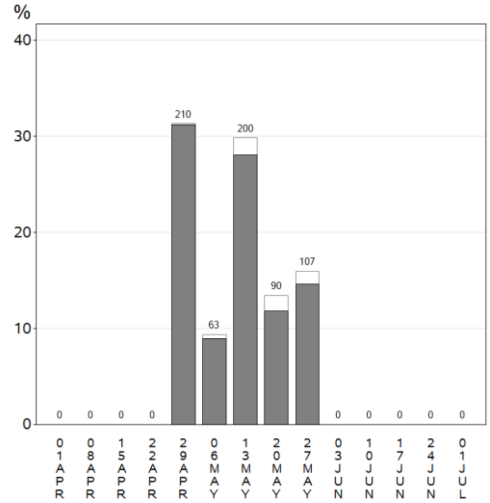
1992 Henderson Lk Sample Size by Week



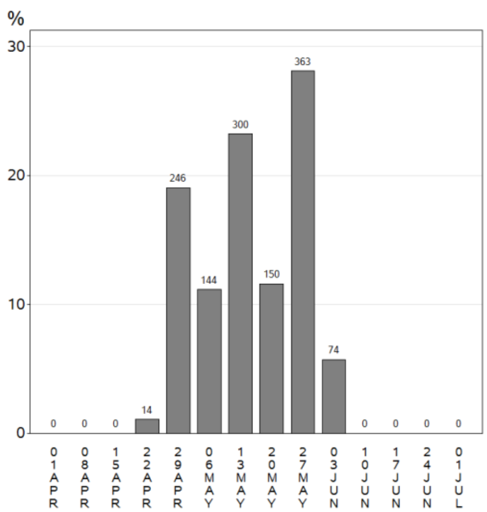
1993 Henderson Lk Sample Size by Week



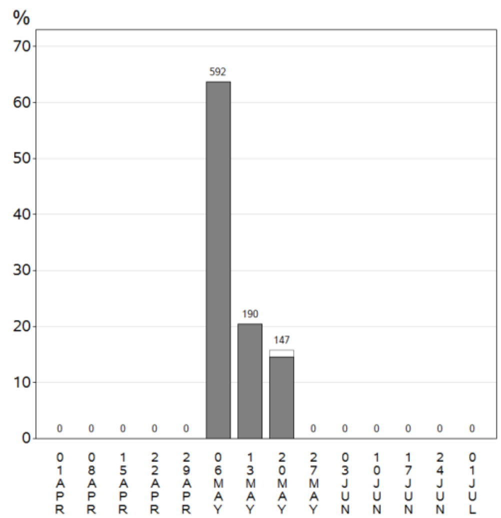
1996 Henderson Lk Sample Size by Week



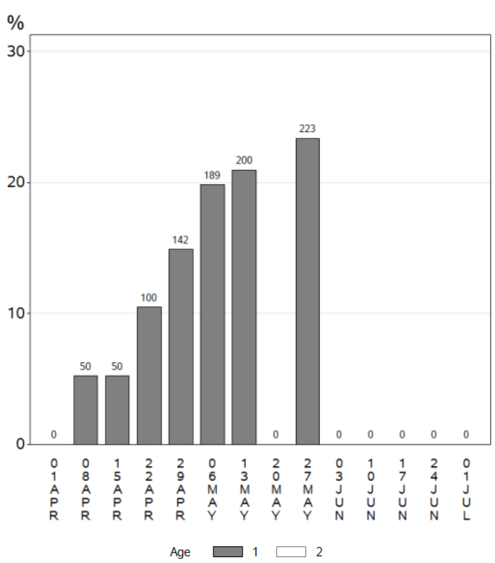
1994 Henderson Lk Sample Size by Week



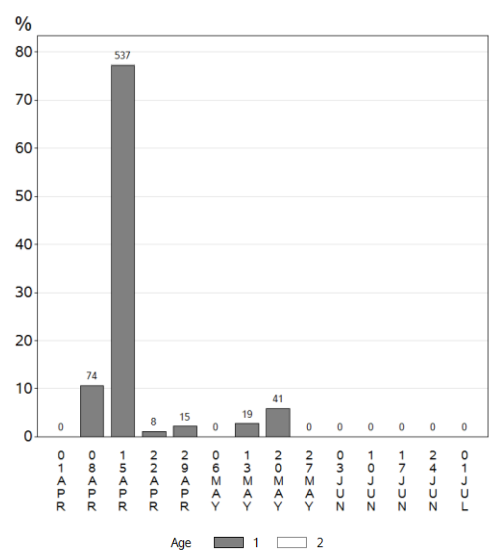
1997 Henderson Lk Sample Size by Week



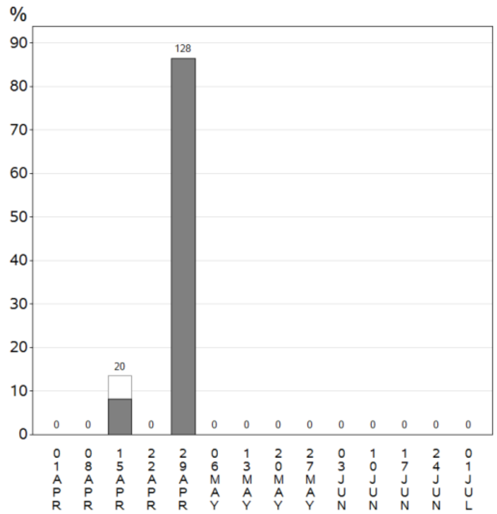
1995 Henderson Lk Sample Size by Week



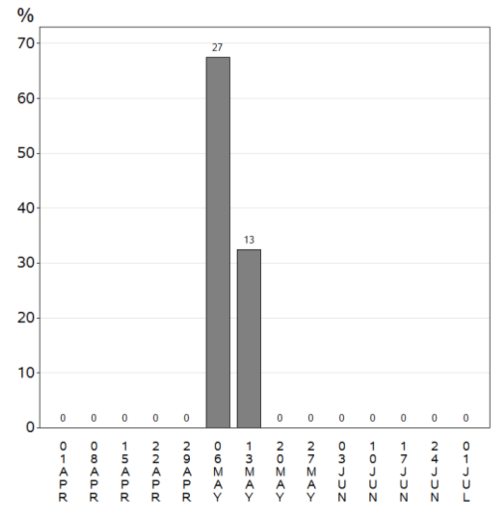
1998 Henderson Lk Sample Size by Week



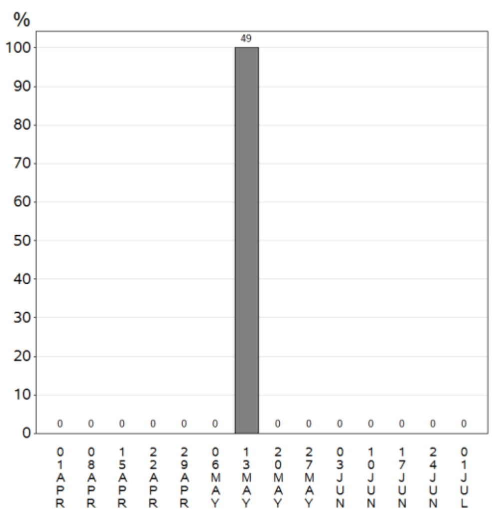
1999 Henderson Lk Sample Size by Week



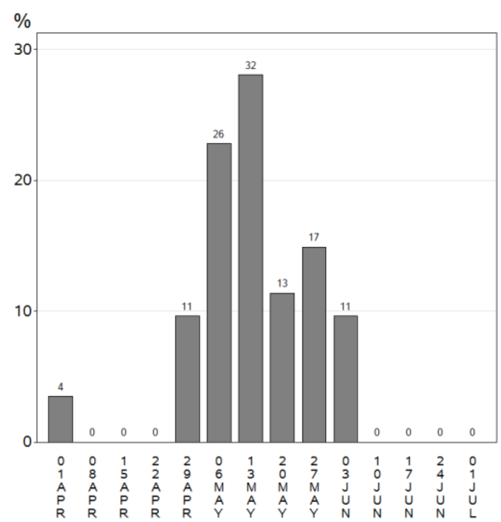
2002 Henderson Lk Sample Size by Week



2000 Henderson Lk Sample Size by Week



2003 Henderson Lk Sample Size by Week



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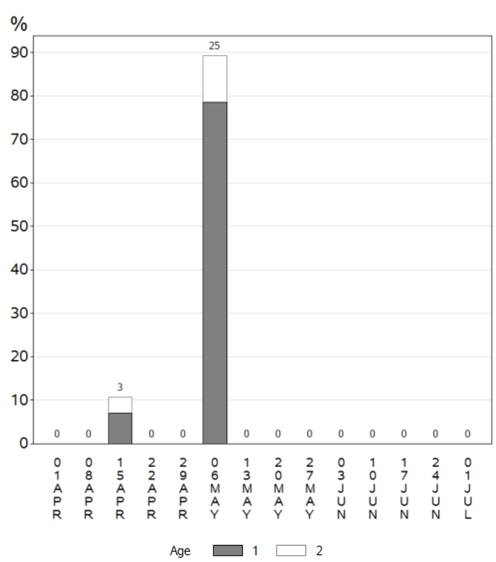
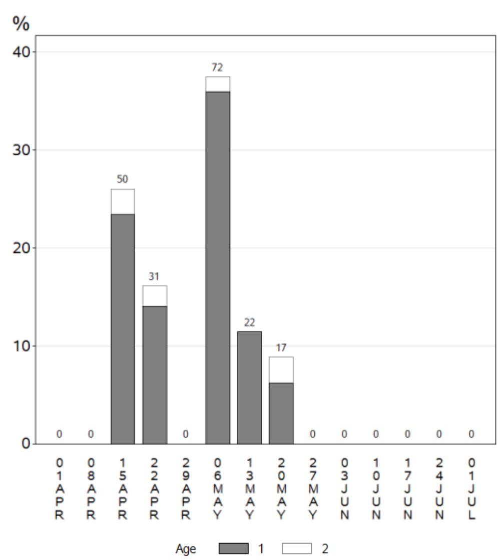
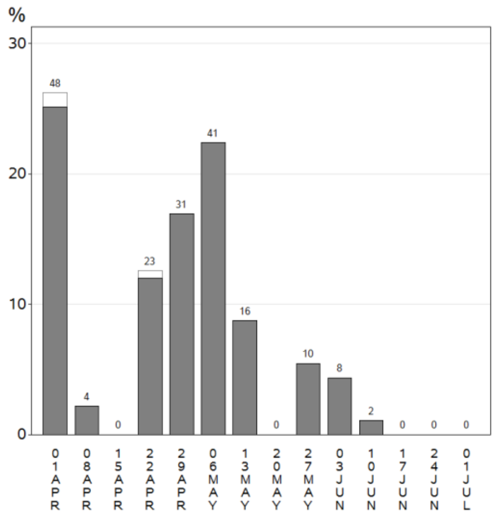


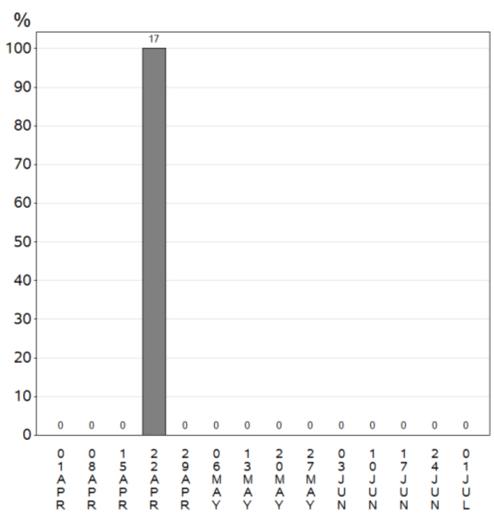
2004 Henderson Lk Sample Size by Week



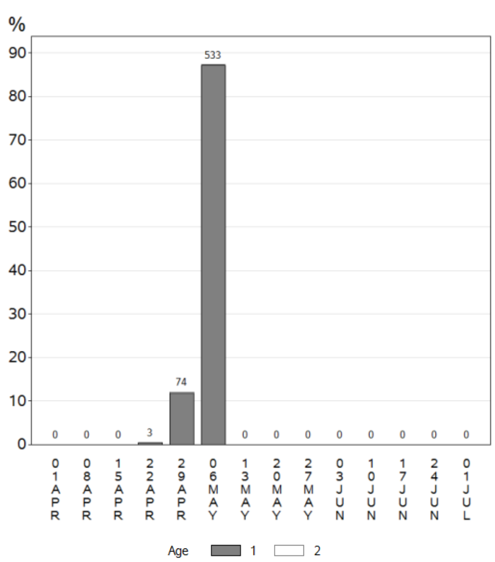
2005 Henderson Lk Sample Size by Week



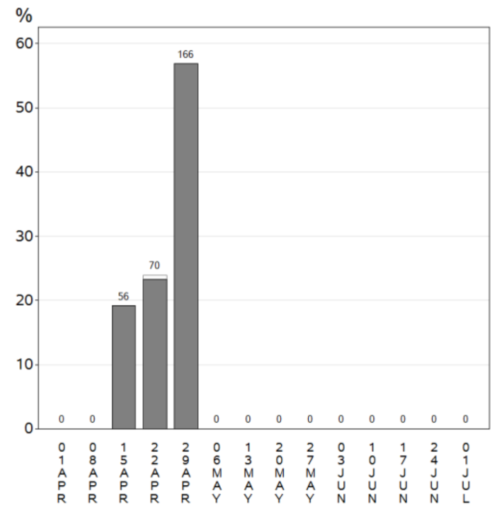
2006 Henderson Lk Sample Size by Week



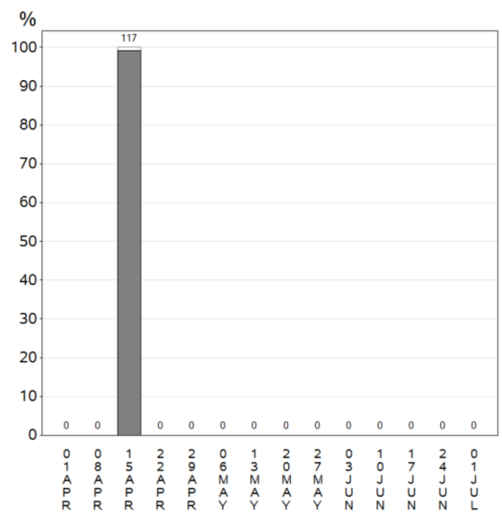
2007 Henderson Lk Sample Size by Week



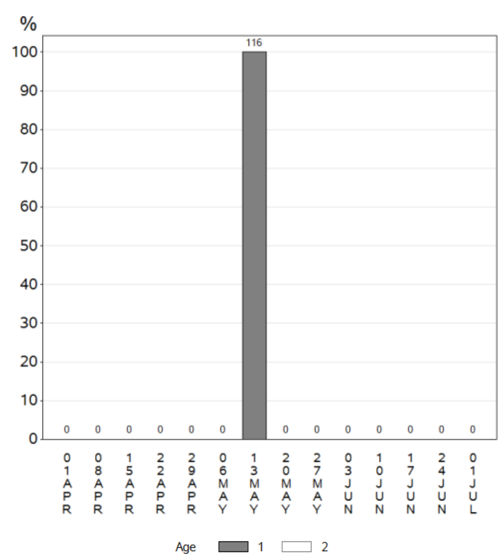
2008 Henderson Lk Sample Size by Week



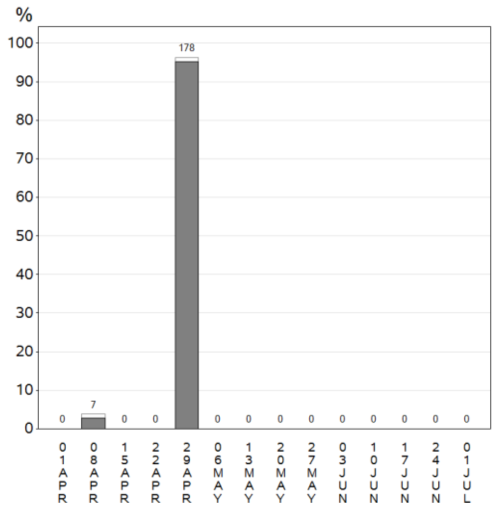
2009 Henderson Lk Sample Size by Week



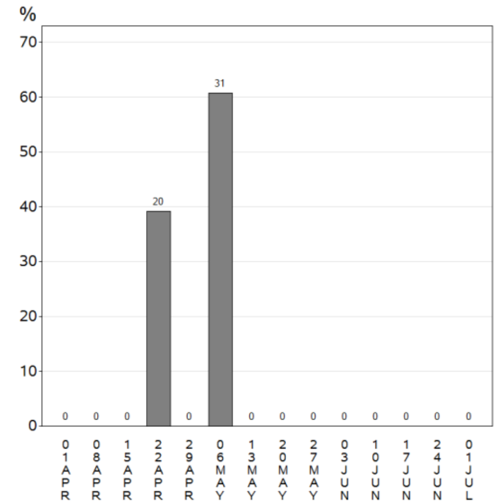
2010 Henderson Lk Sample Size by Week



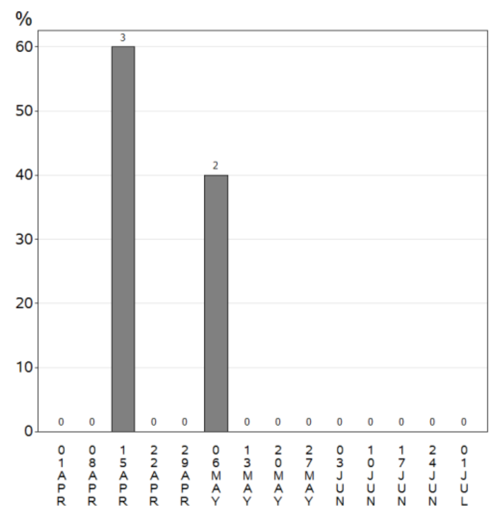
2011 Henderson Lk Sample Size by Week



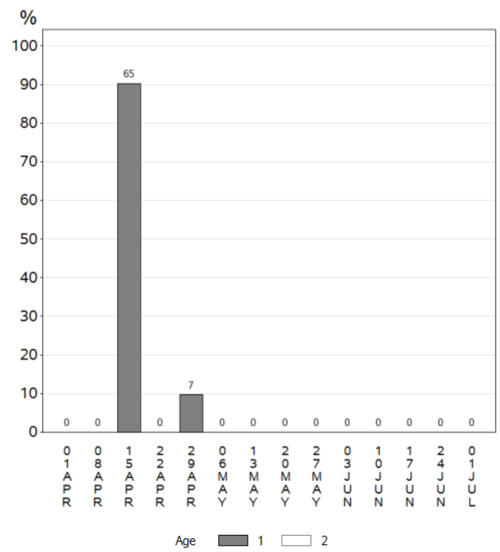
2014 Henderson Lk Sample Size by Week



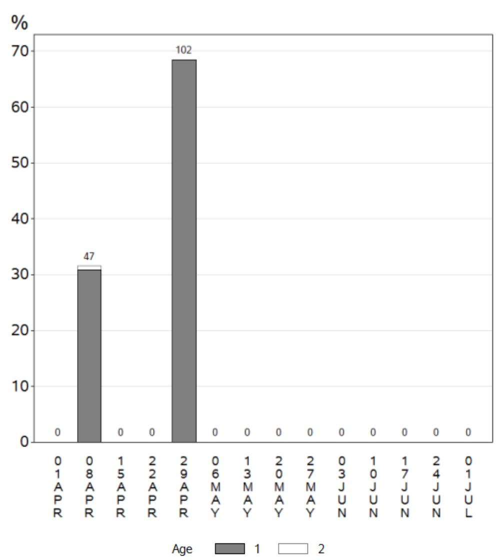
2012 Henderson Lk Sample Size by Week



2015 Henderson Lk Sample Size by Week

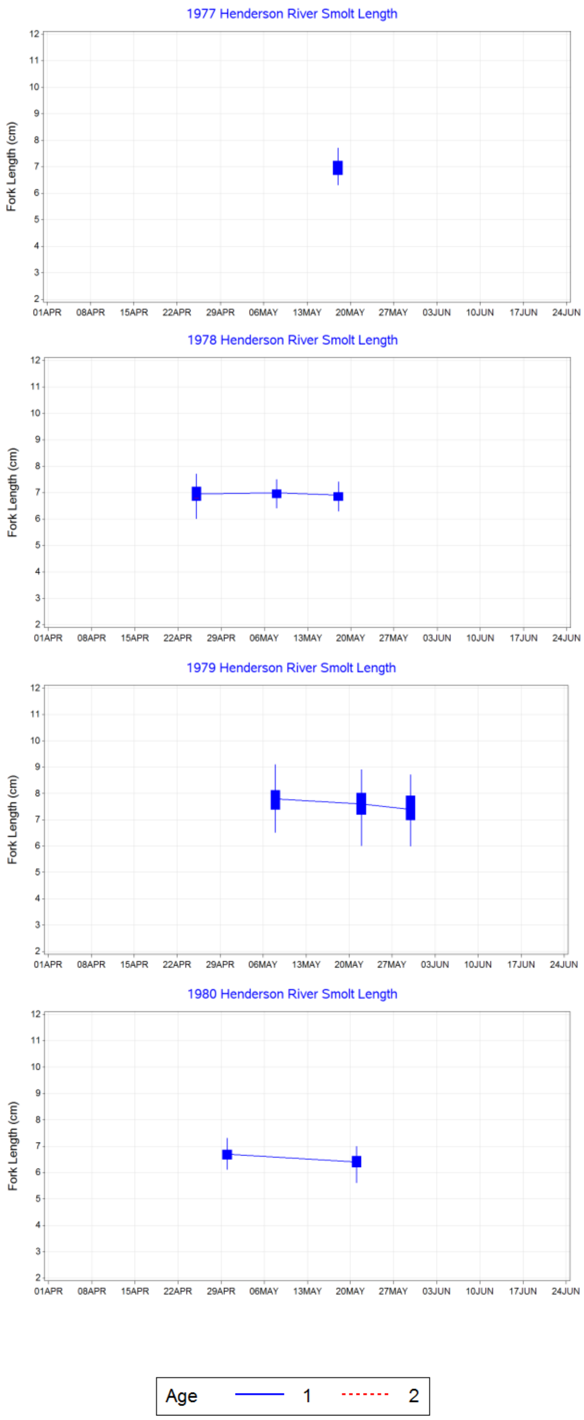


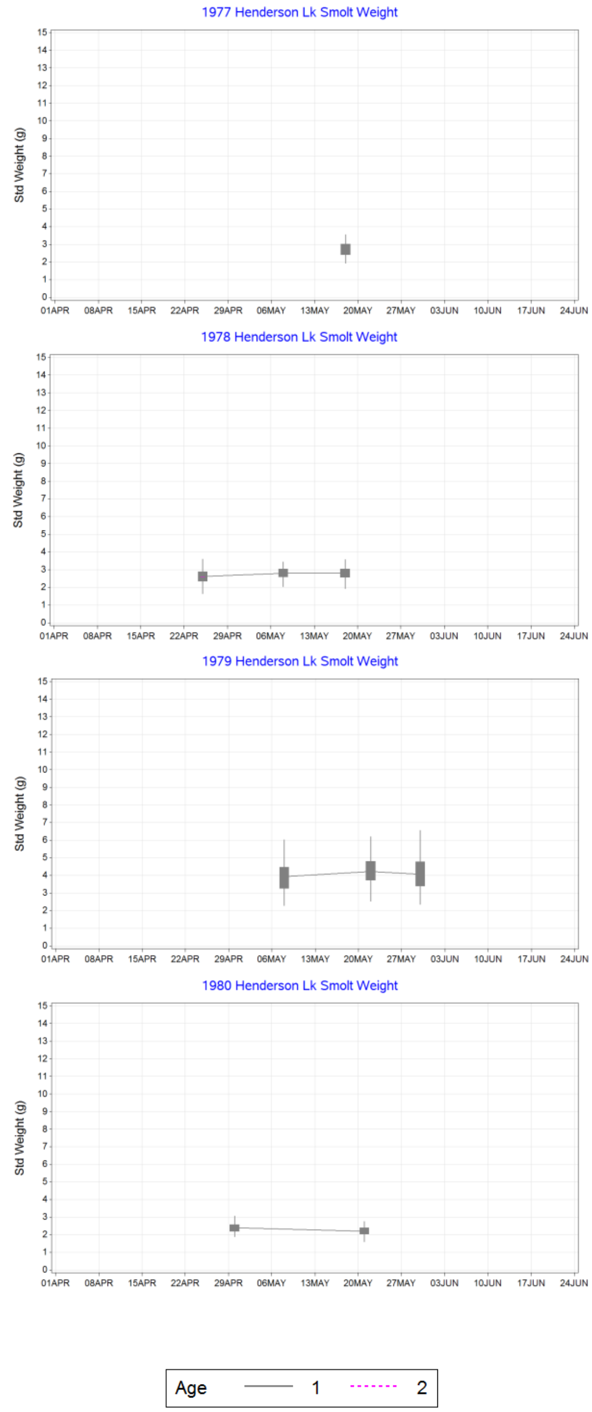
2013 Henderson Lk Sample Size by Week



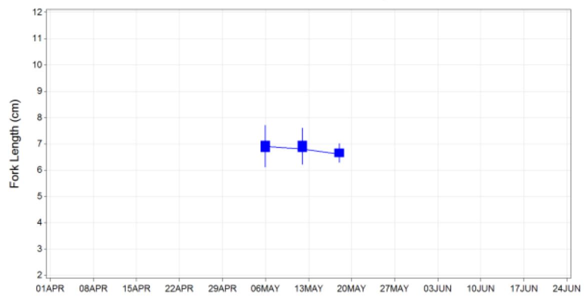
APPENDIX IV – Seasonal Trends in Size

Appendix IV. Seasonal time-trends in smolt size (Fork Length, left; Std Weight, right) by year, sample date age class, and site (Robertson Creek, Glover Creek). Box and whiskers represent quartiles and extrema, joined at median.

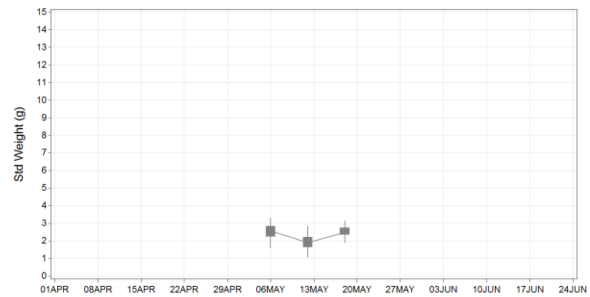




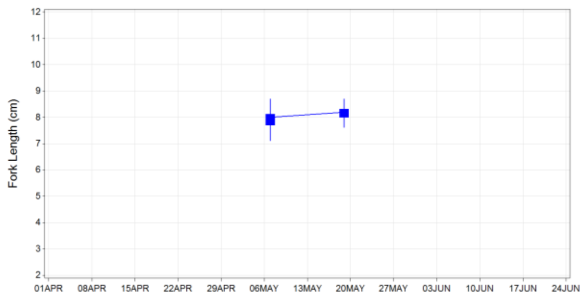
1981 Henderson River Smolt Length



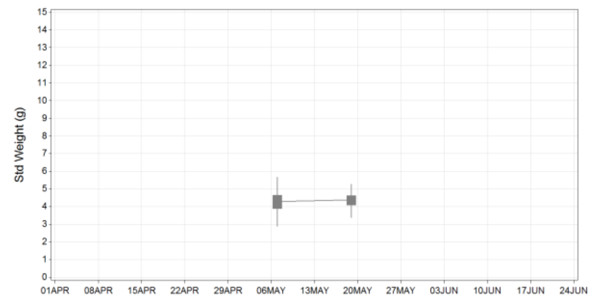
1981 Henderson Lk Smolt Weight



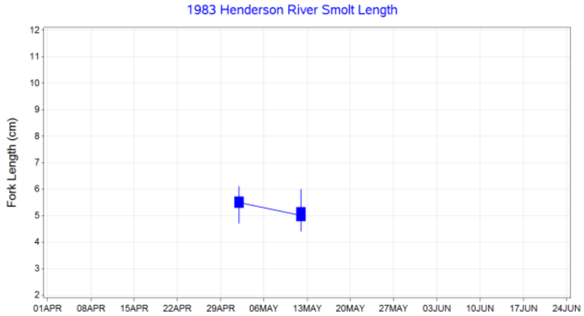
1982 Henderson River Smolt Length



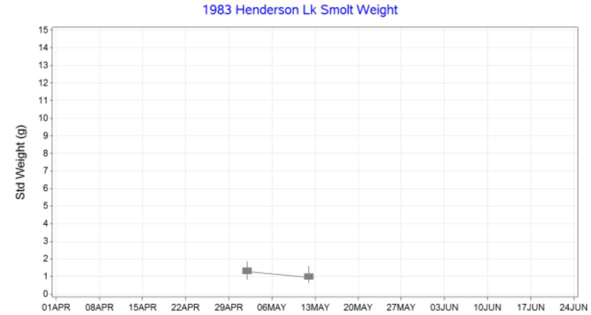
1982 Henderson Lk Smolt Weight



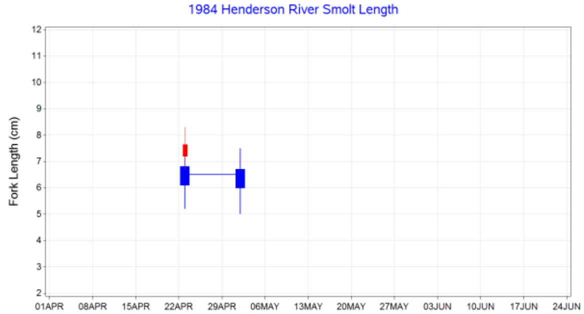
1983 Henderson River Smolt Length



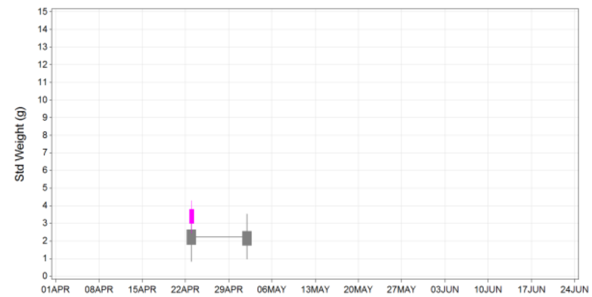
1983 Henderson Lk Smolt Weight



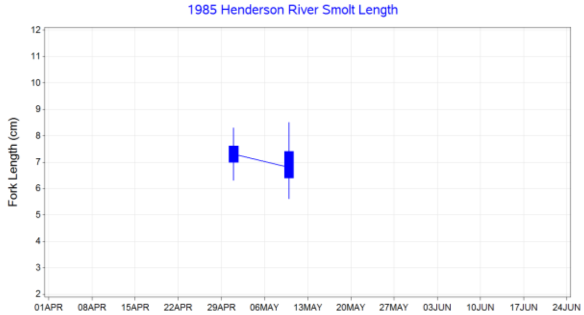
1984 Henderson River Smolt Length



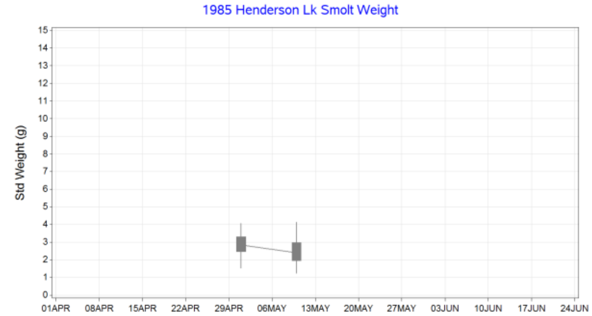
1984 Henderson Lk Smolt Weight



1985 Henderson River Smolt Length

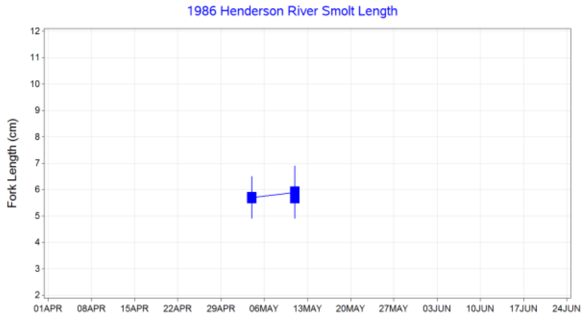


1985 Henderson Lk Smolt Weight



Age 1 2

Age 1 2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Fork Length (cm)
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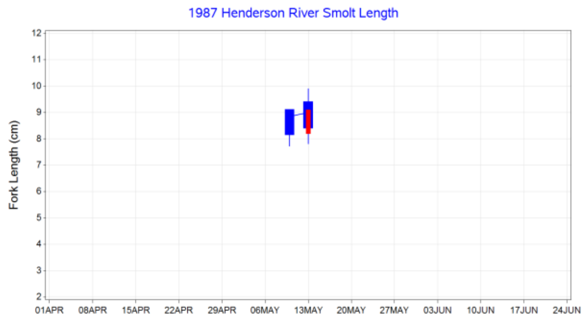
1987 Henderson River Smolt Length
Fork Length (cm)
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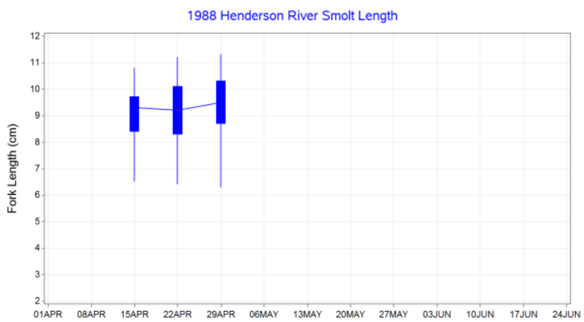
1988 Henderson River Smolt Length
Fork Length (cm)
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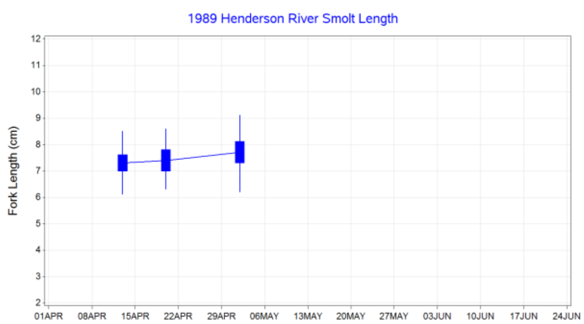
1989 Henderson River Smolt Length
Fork Length (cm)
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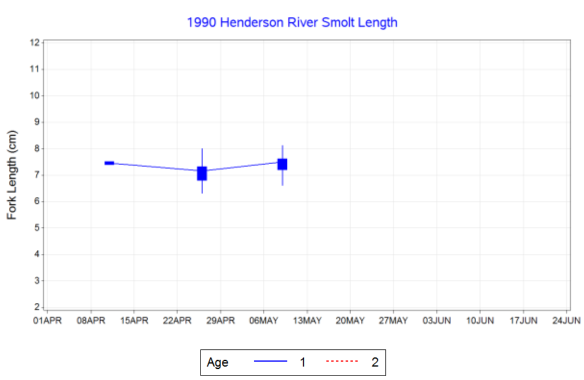
1990 Henderson River Smolt Length
Fork Length (cm)
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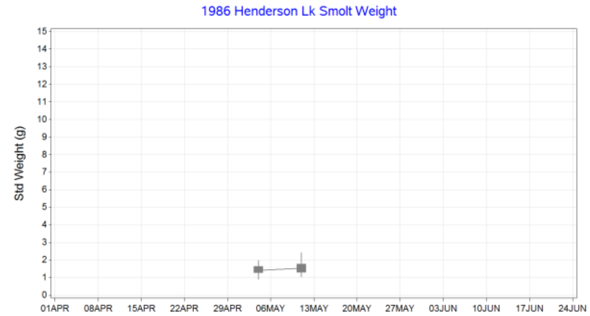
Age 1 2


1986 Henderson Lk Smolt Weight
Std Weight (g)
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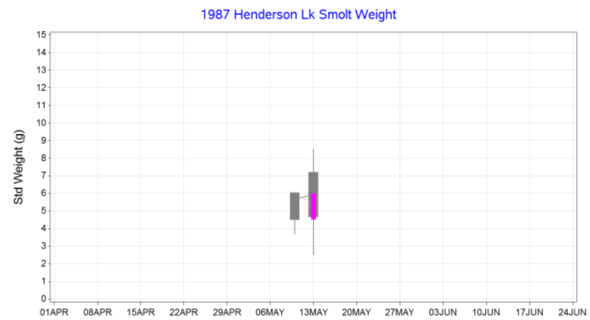
1987 Henderson Lk Smolt Weight
Std Weight (g)
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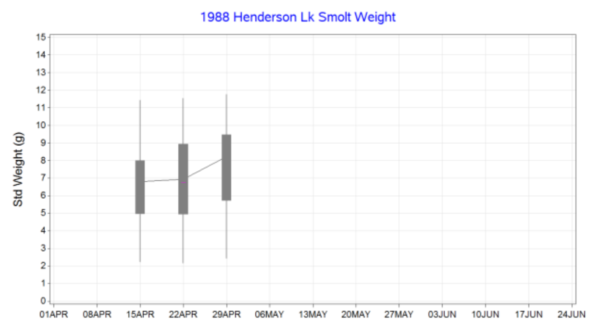
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Std Weight (g)
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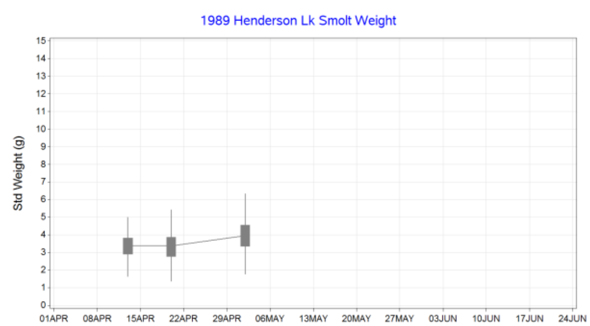
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Std Weight (g)
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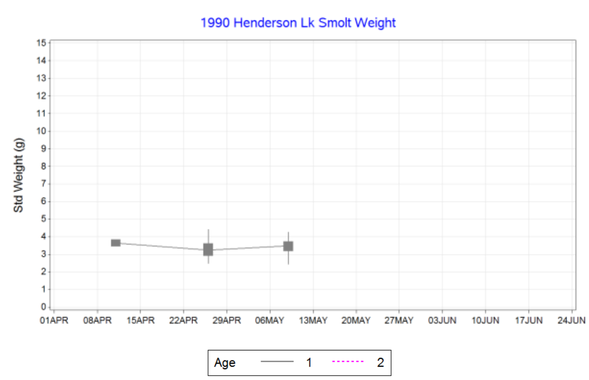
1990 Henderson Lk Smolt Weight
Std Weight (g)
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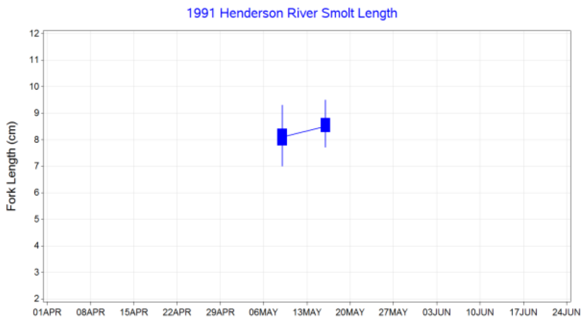
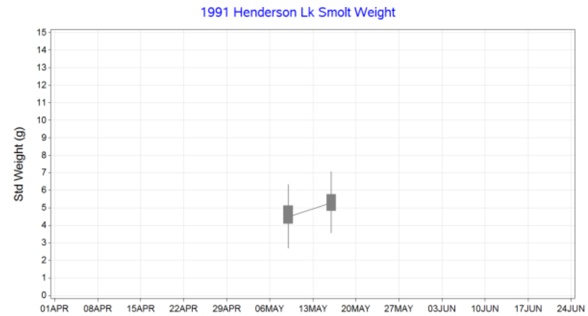
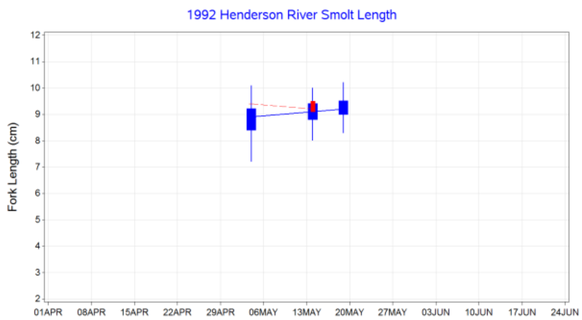
Age 1 2


1991 Henderson River Smolt Length
Fork Length (cm)


1991 Henderson Lk Smolt Weight
Std Weight (g)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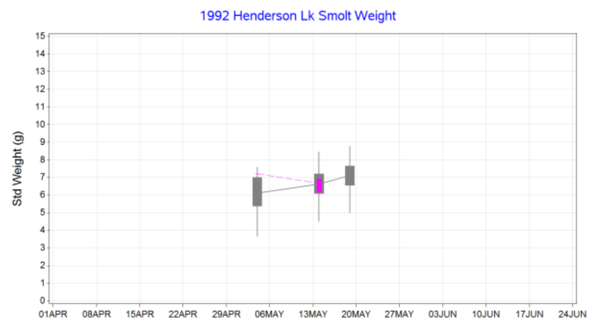
Fork Length (cm)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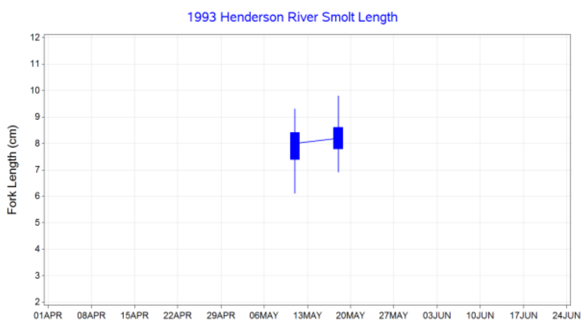
Std Weight (g)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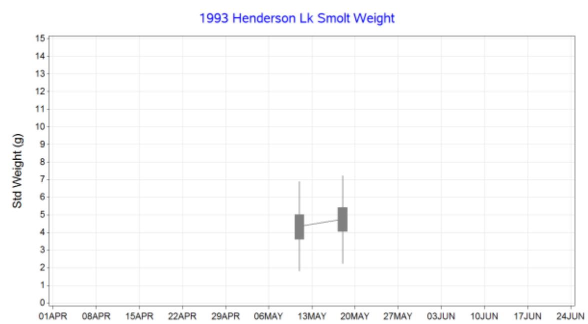
Fork Length (cm)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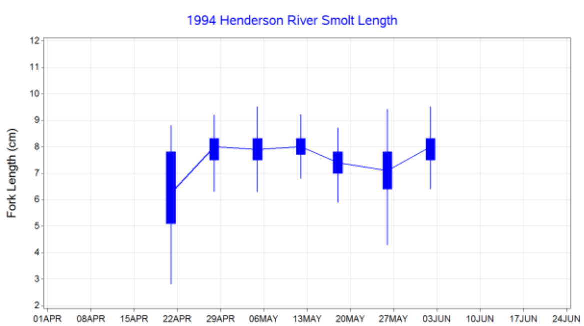
Std Weight (g)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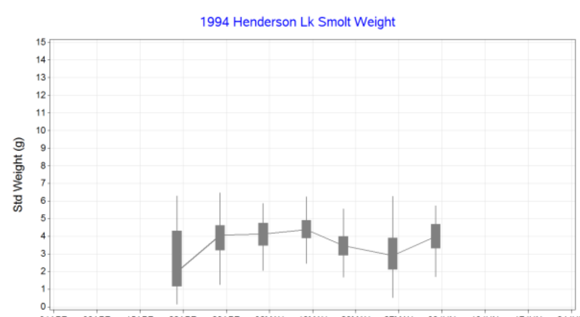
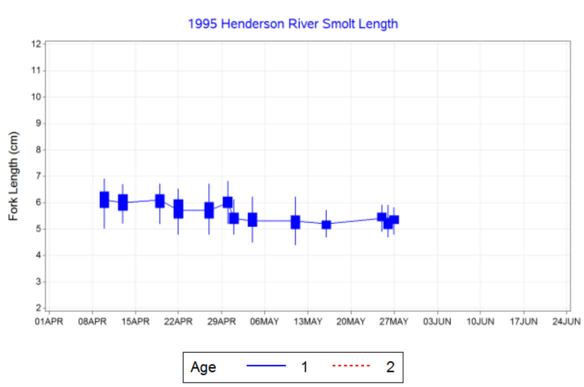
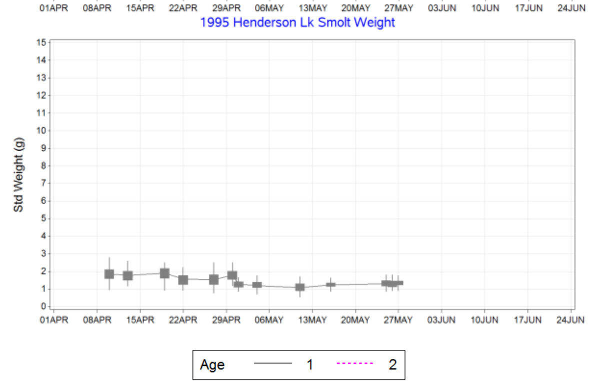
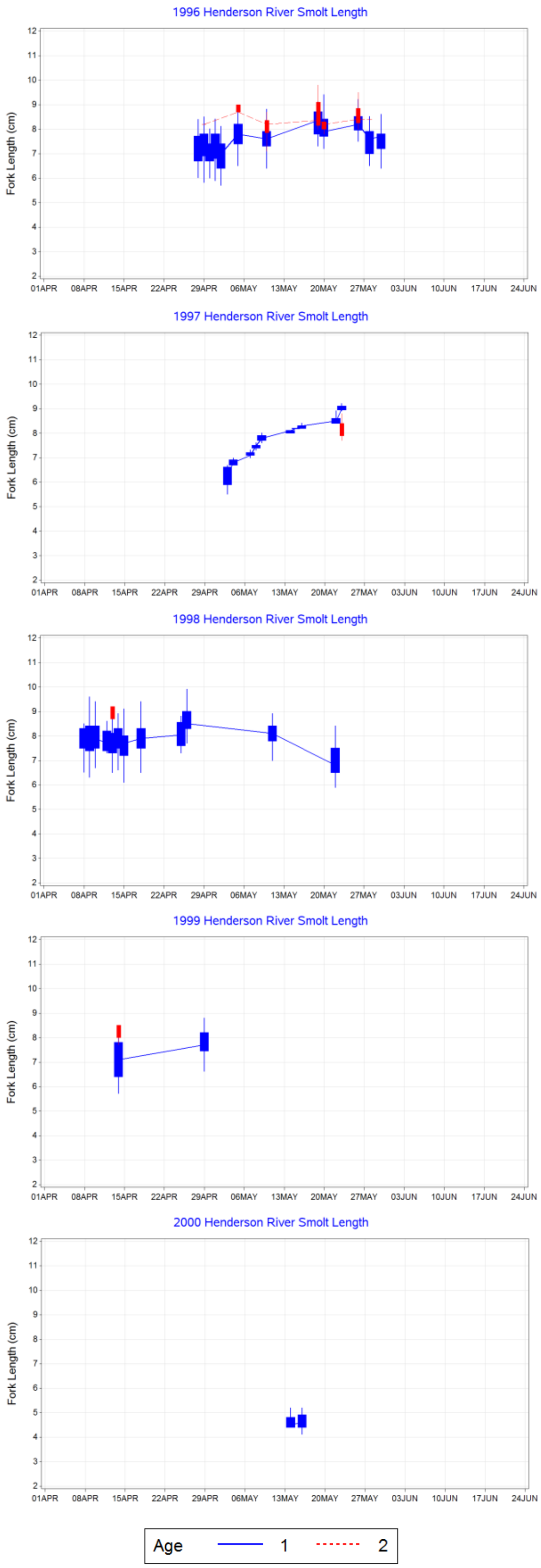
Fork Length (cm)


1994 Henderson Lk Smolt Weight
Std Weight (g)


1995 Henderson River Smolt Length
Fork Length (cm)
Age 1 2


1995 Henderson Lk Smolt Weight
Std Weight (g)
Age 1 2


1996 Henderson River Smolt Length
1997 Henderson River Smolt Length
1998 Henderson River Smolt Length
1999 Henderson River Smolt Length
2000 Henderson River Smolt Length
Fork Length (cm)
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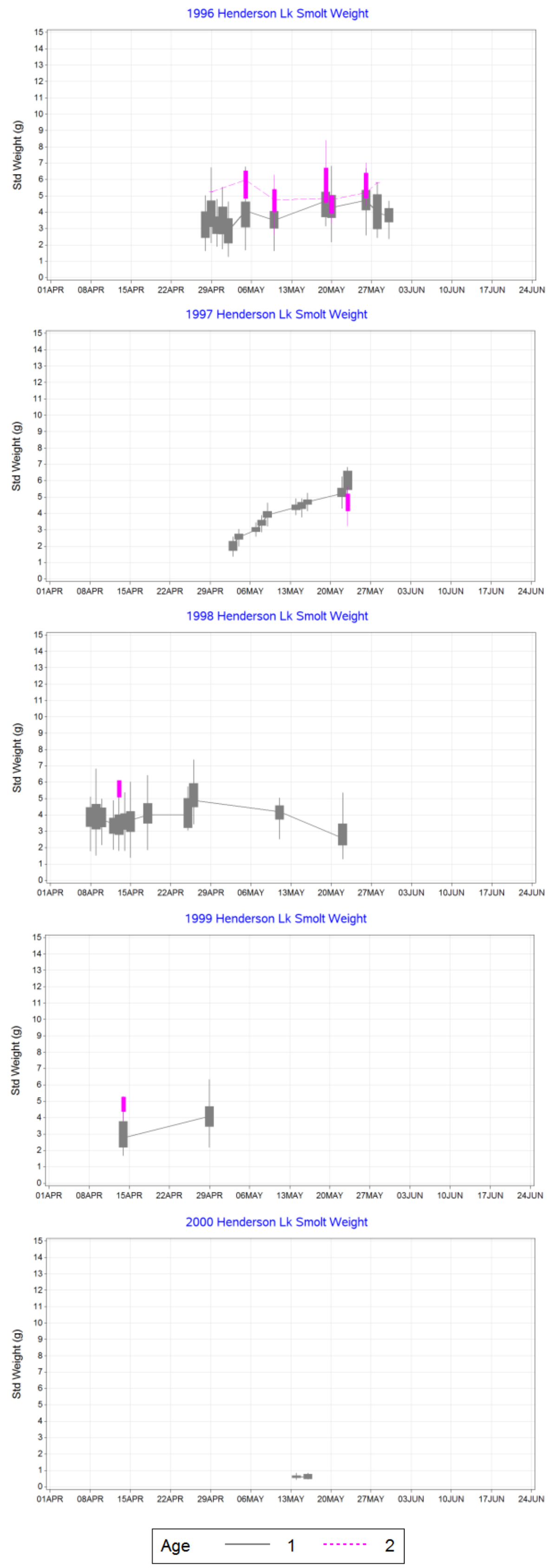
Age 1 2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1997 Henderson Lk Smolt Weight
1998 Henderson Lk Smolt Weight
1999 Henderson Lk Smolt Weight
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Std Weight (g)
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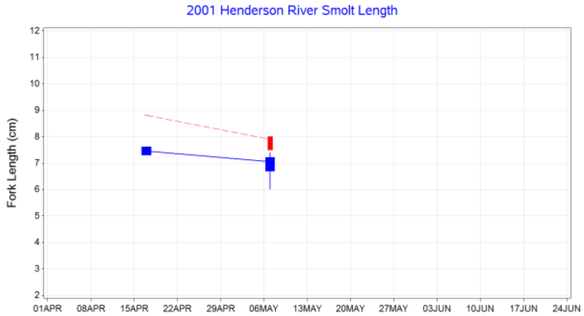
Age 1 2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Fork Length (cm)
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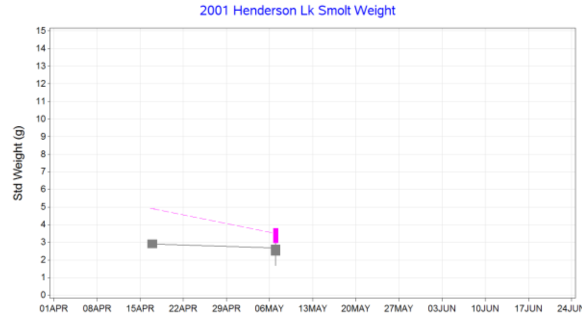
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Std Weight (g)
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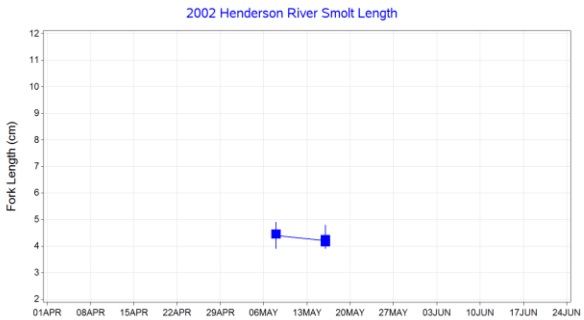
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Fork Length (cm)
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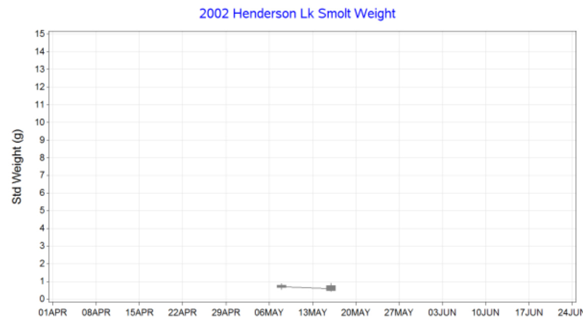
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Std Weight (g)
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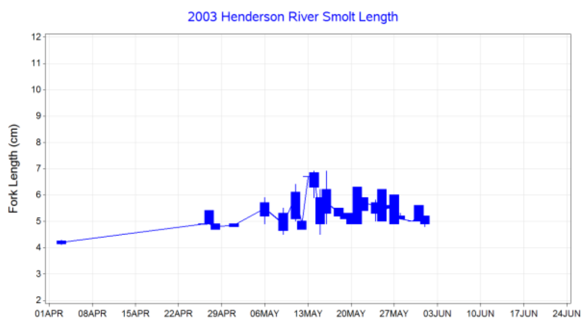
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Fork Length (cm)
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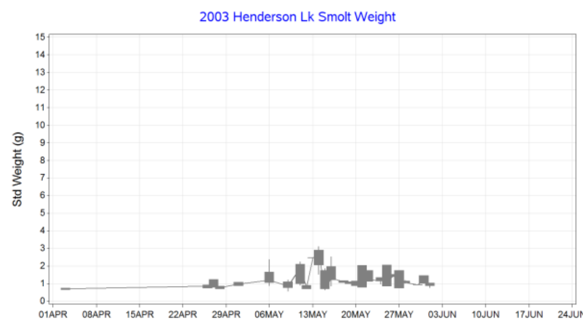
2003 Henderson Lk Smolt Weight
Std Weight (g)
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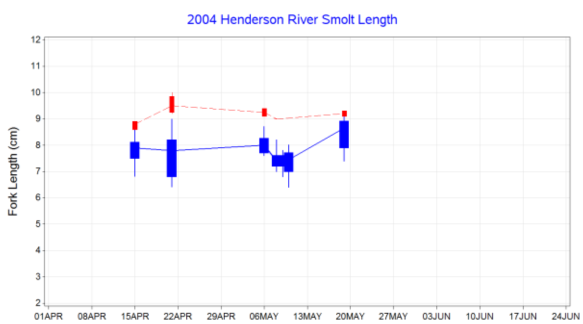
2004 Henderson River Smolt Length
Fork Length (cm)
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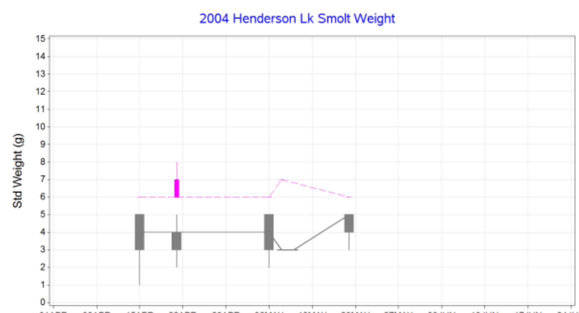
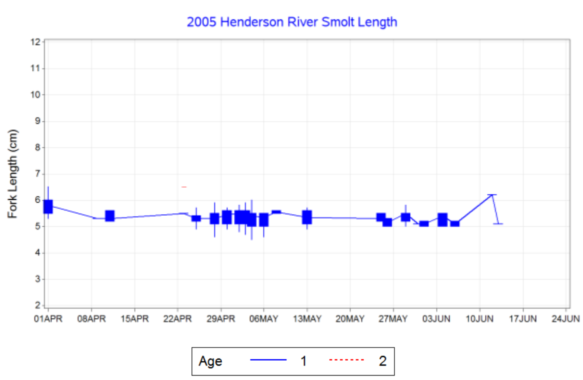
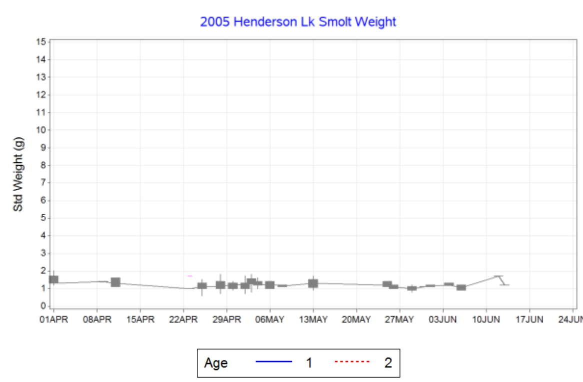
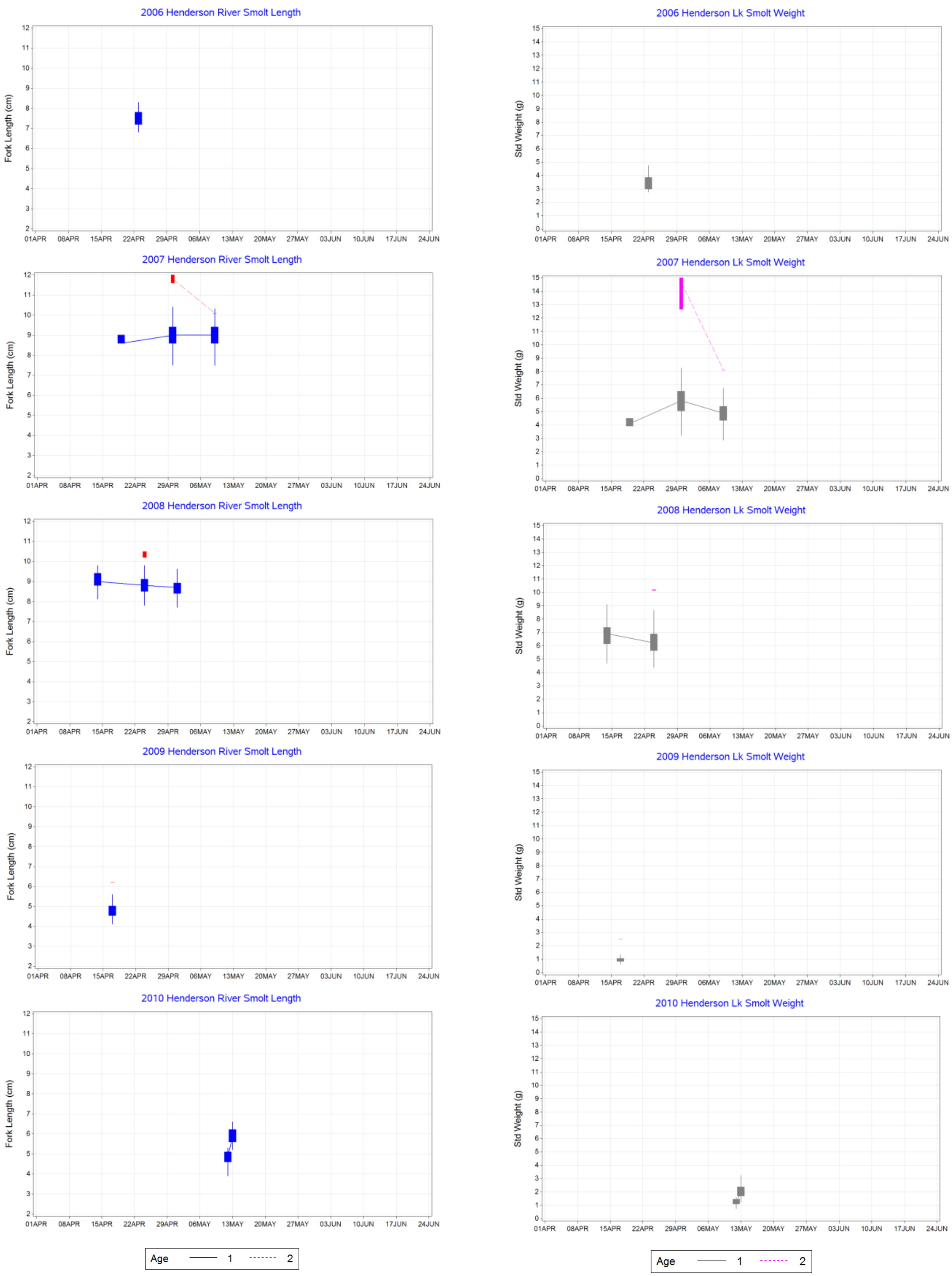
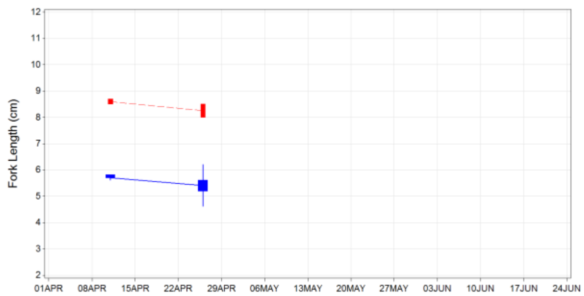

2004 Henderson Lk Smolt Weight
Std Weight (g)
01APR 08APR 15APR 22APR 29APR 06MAY 13MAY 20MAY 27MAY 03JUN 10JUN 17JUN 24JUN


2005 Henderson River Smolt Length
Fork Length (cm)
01APR 08APR 15APR 22APR 29APR 06MAY 13MAY 20MAY 27MAY 03JUN 10JUN 17JUN 24JUN
Age 1 2

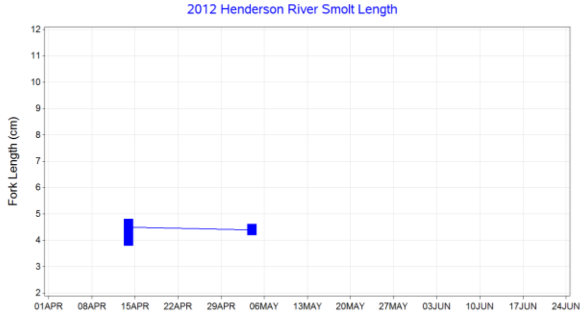

2005 Henderson Lk Smolt Weight
Std Weight (g)
01APR 08APR 15APR 22APR 29APR 06MAY 13MAY 20MAY 27MAY 03JUN 10JUN 17JUN 24JUN
Age 1 2


2006 Henderson River Smolt Length
2006 Henderson Lk Smolt Weight
2007 Henderson River Smolt Length
2007 Henderson Lk Smolt Weight
2008 Henderson River Smolt Length
2008 Henderson Lk Smolt Weight
2009 Henderson River Smolt Length
2009 Henderson Lk Smolt Weight
2010 Henderson River Smolt Length
2010 Henderson Lk Smolt Weight
Fork Length (cm)
Std Weight (g)
01APR 08APR 15APR 22APR 29APR 06MAY 13MAY 20MAY 27MAY 03JUN 10JUN 17JUN 24JUN
Age 1 2
Age 1 2

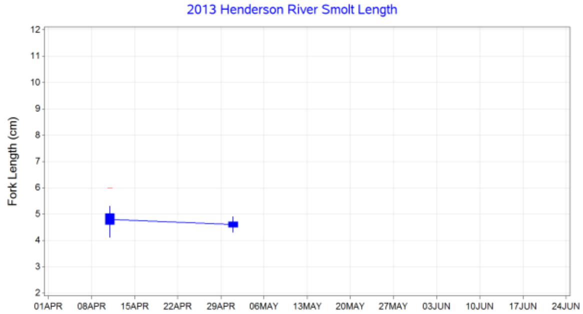
2011 Henderson River Smolt Length



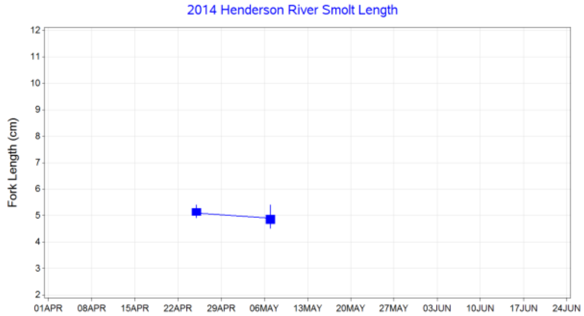
2012 Henderson River Smolt Length



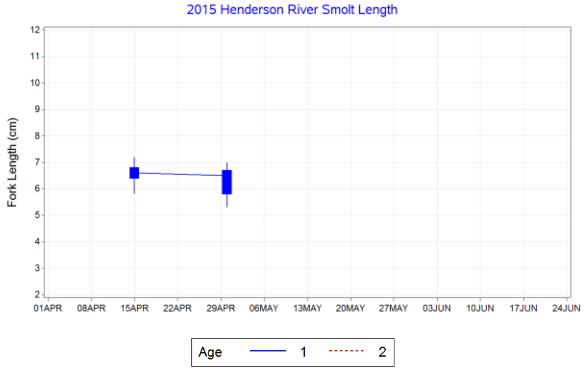
2013 Henderson River Smolt Length



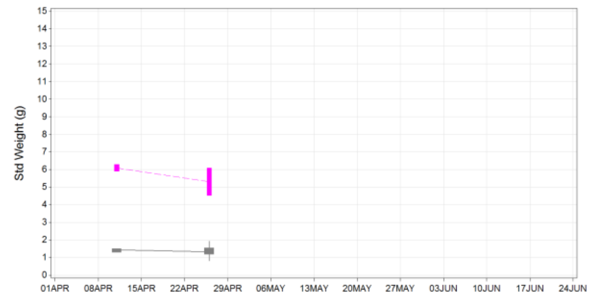
2014 Henderson River Smolt Length



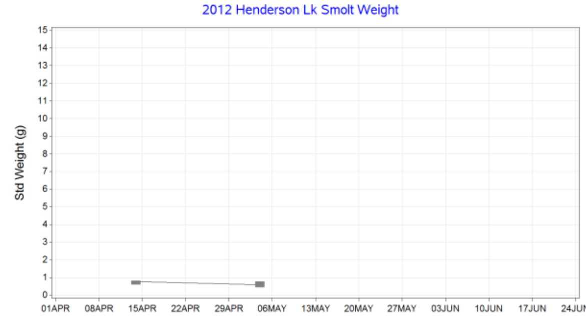
2015 Henderson River Smolt Length



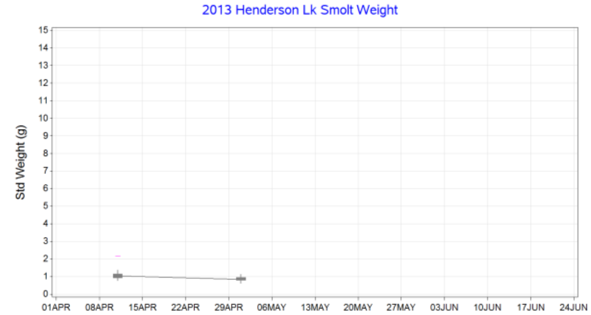
2011 Henderson Lk Smolt Weight



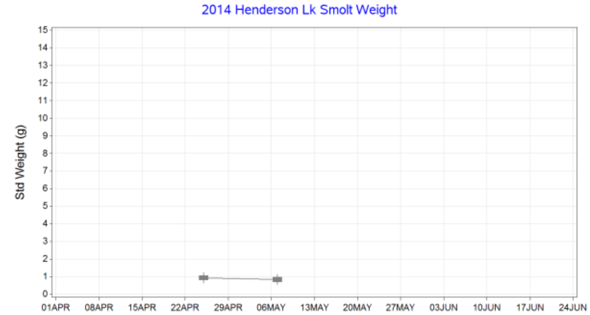
2012 Henderson Lk Smolt Weight



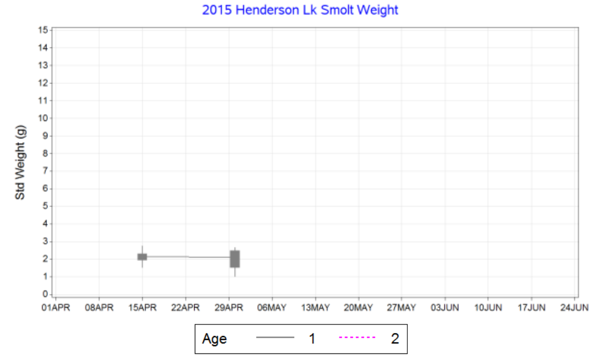
2013 Henderson Lk Smolt Weight



2014 Henderson Lk Smolt Weight

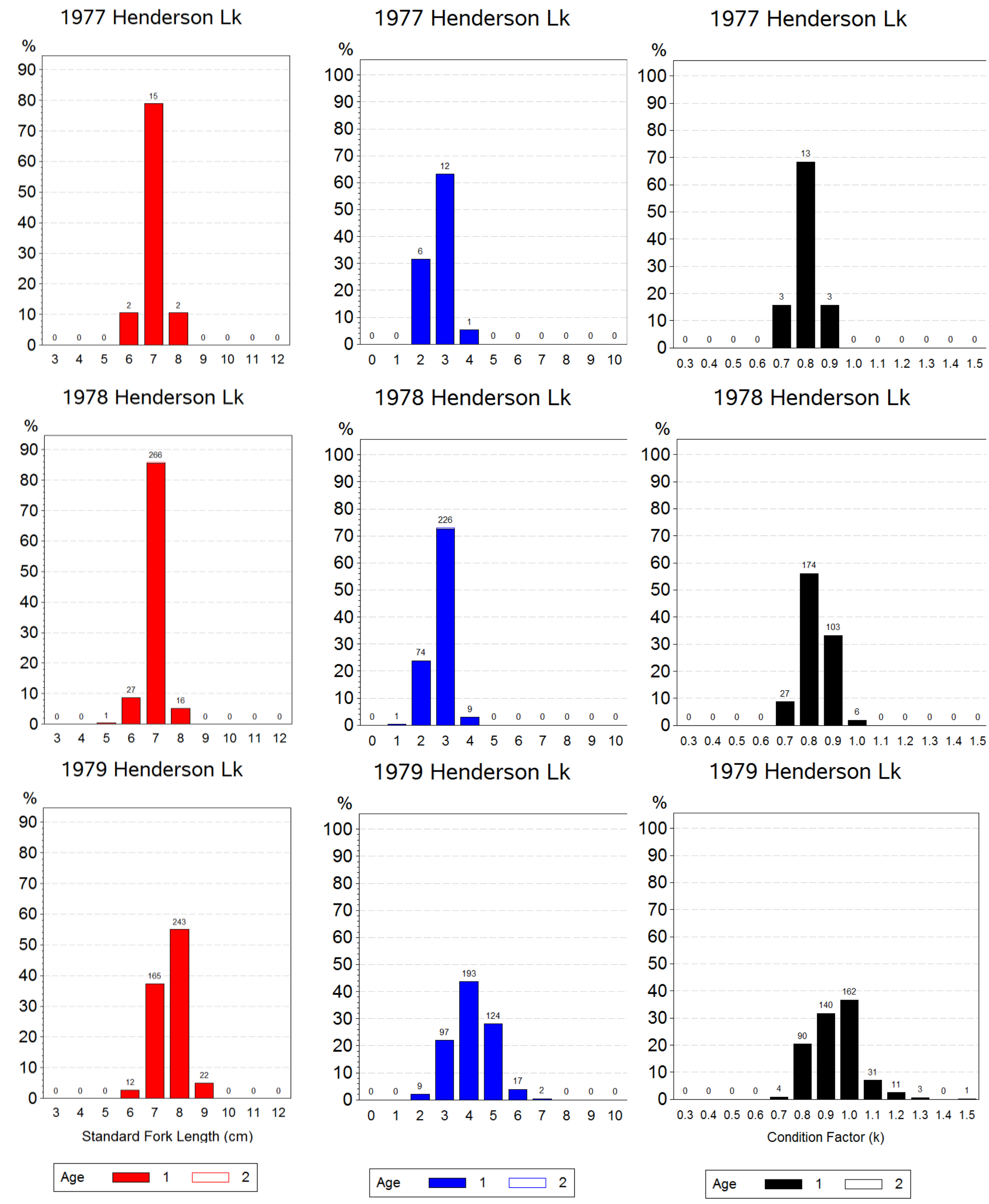


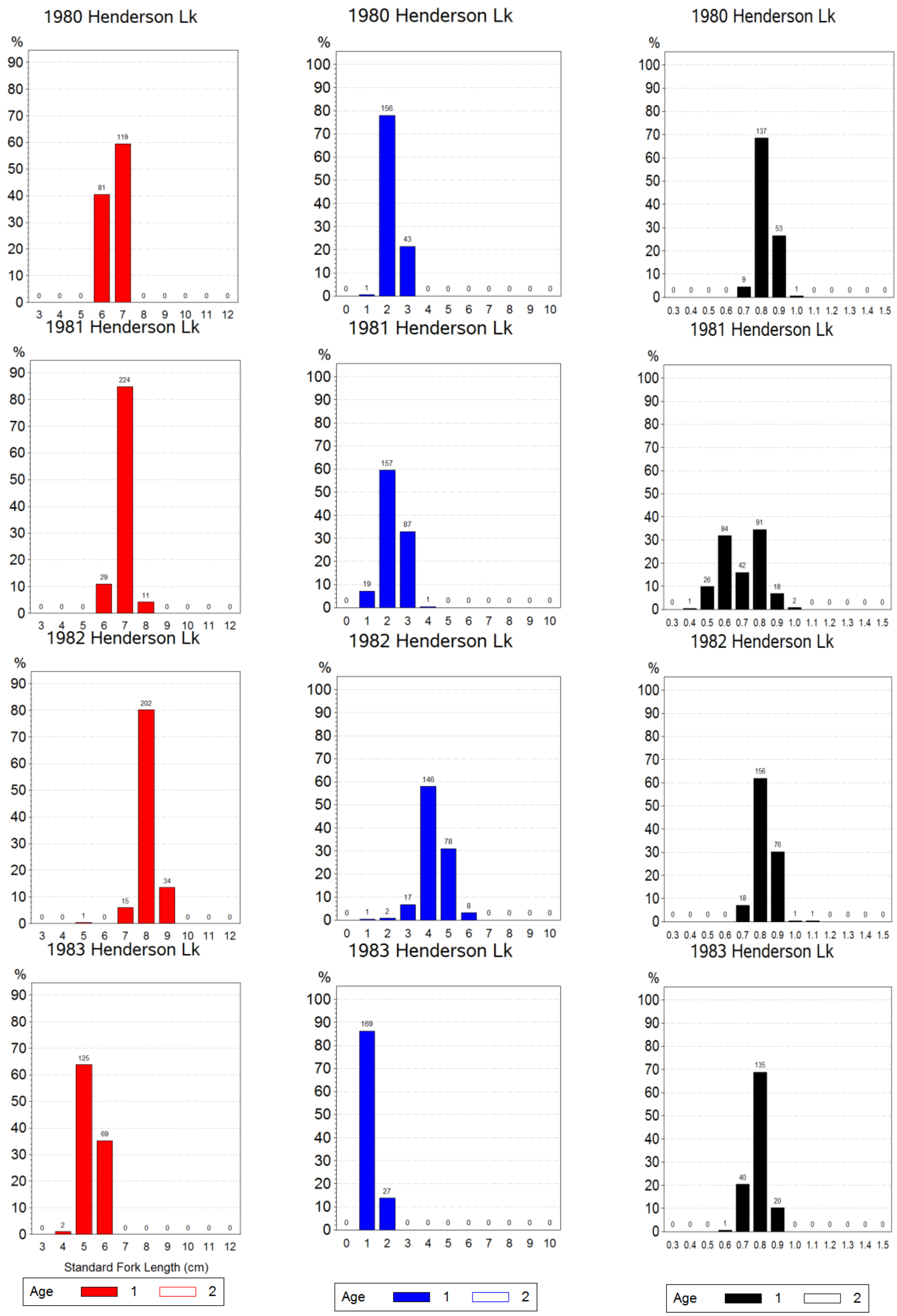
2015 Henderson Lk Smolt Weight

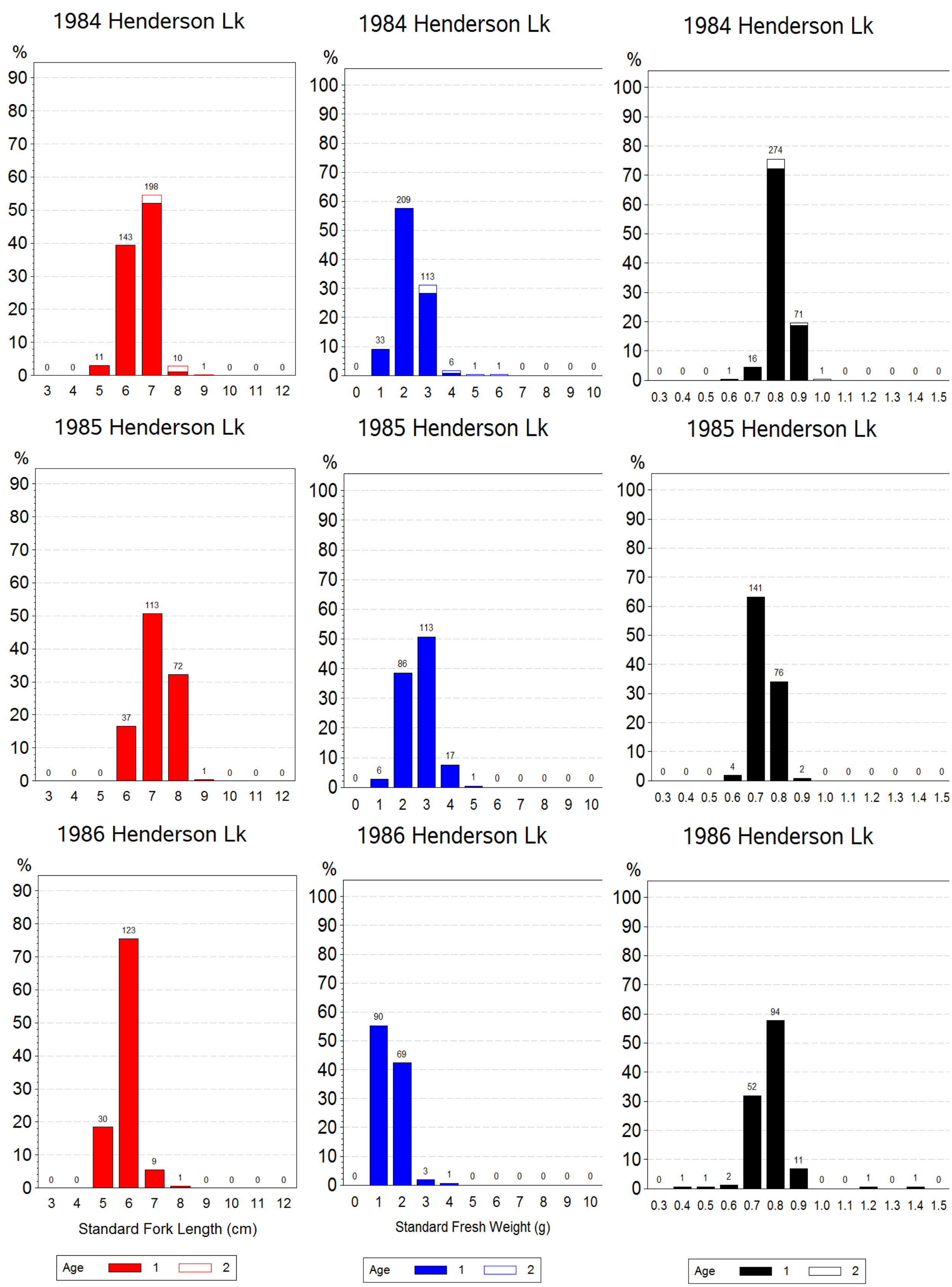


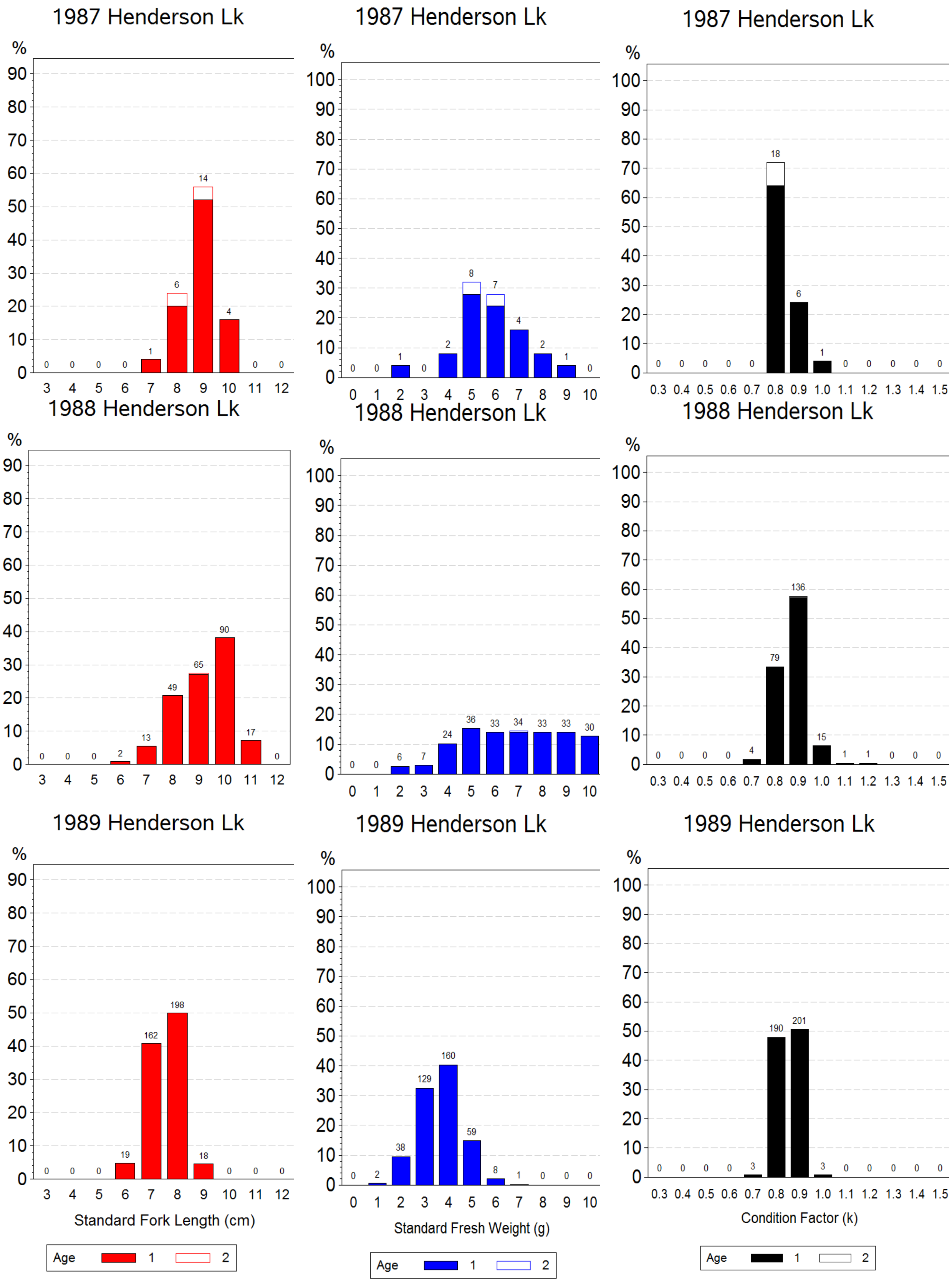
APPENDIX V – Annual Size Frequency Distributions

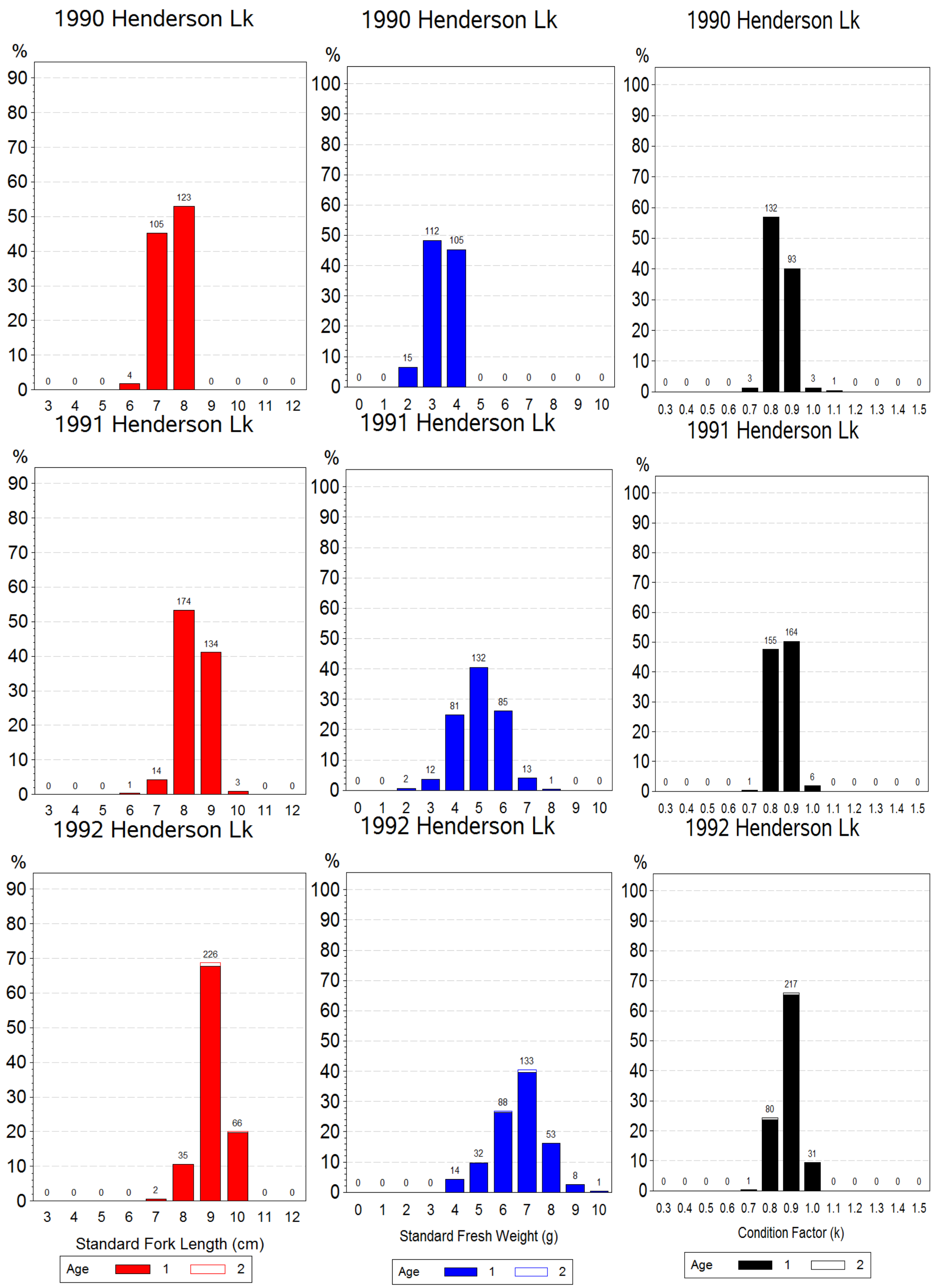
Appendix V. Henderson Lake Sockeye smolt size frequency distributions (Fork Length (cm), left; Std Weight (g), middle; Condition Factor (k), right) by year and age class.

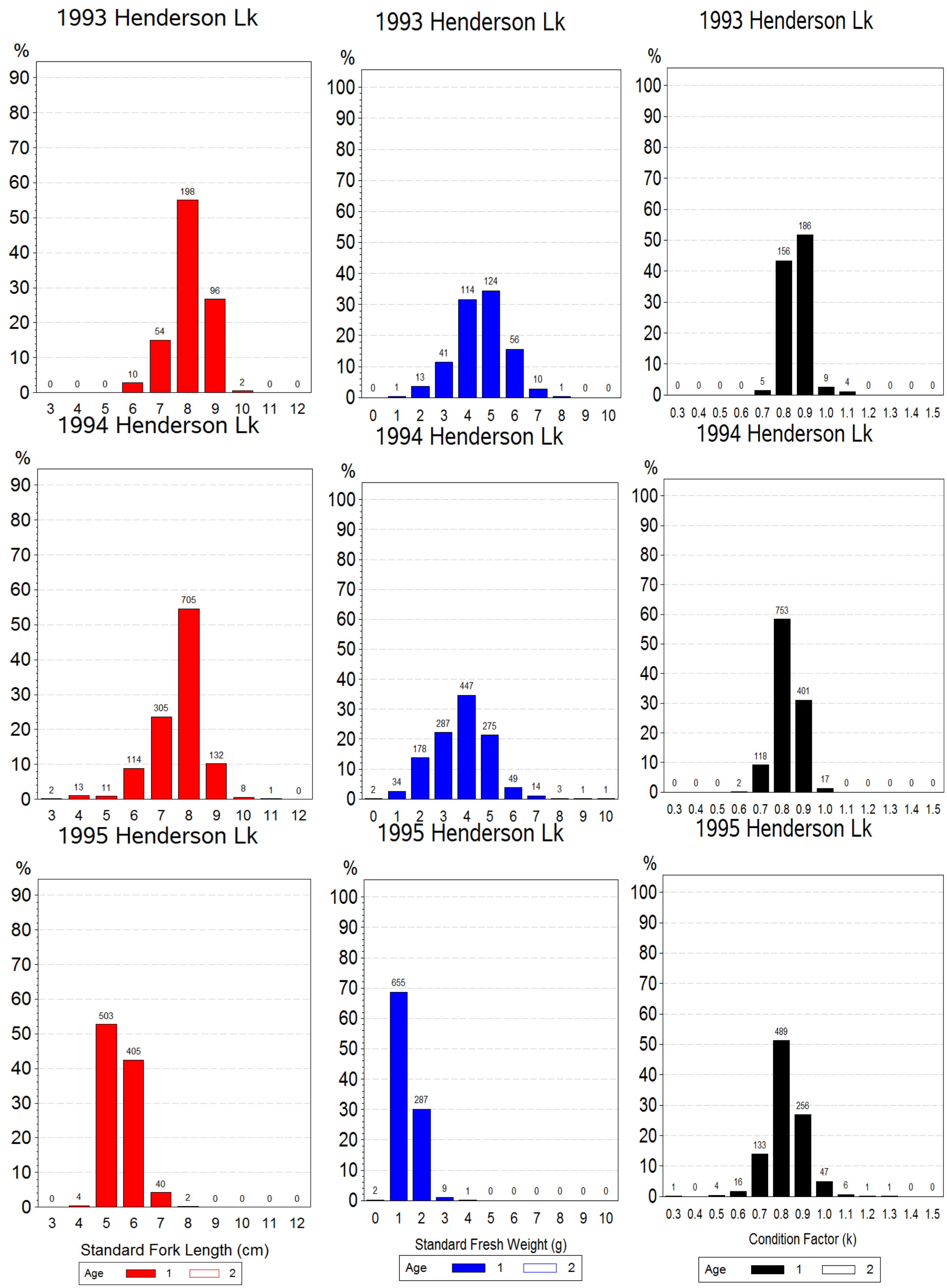


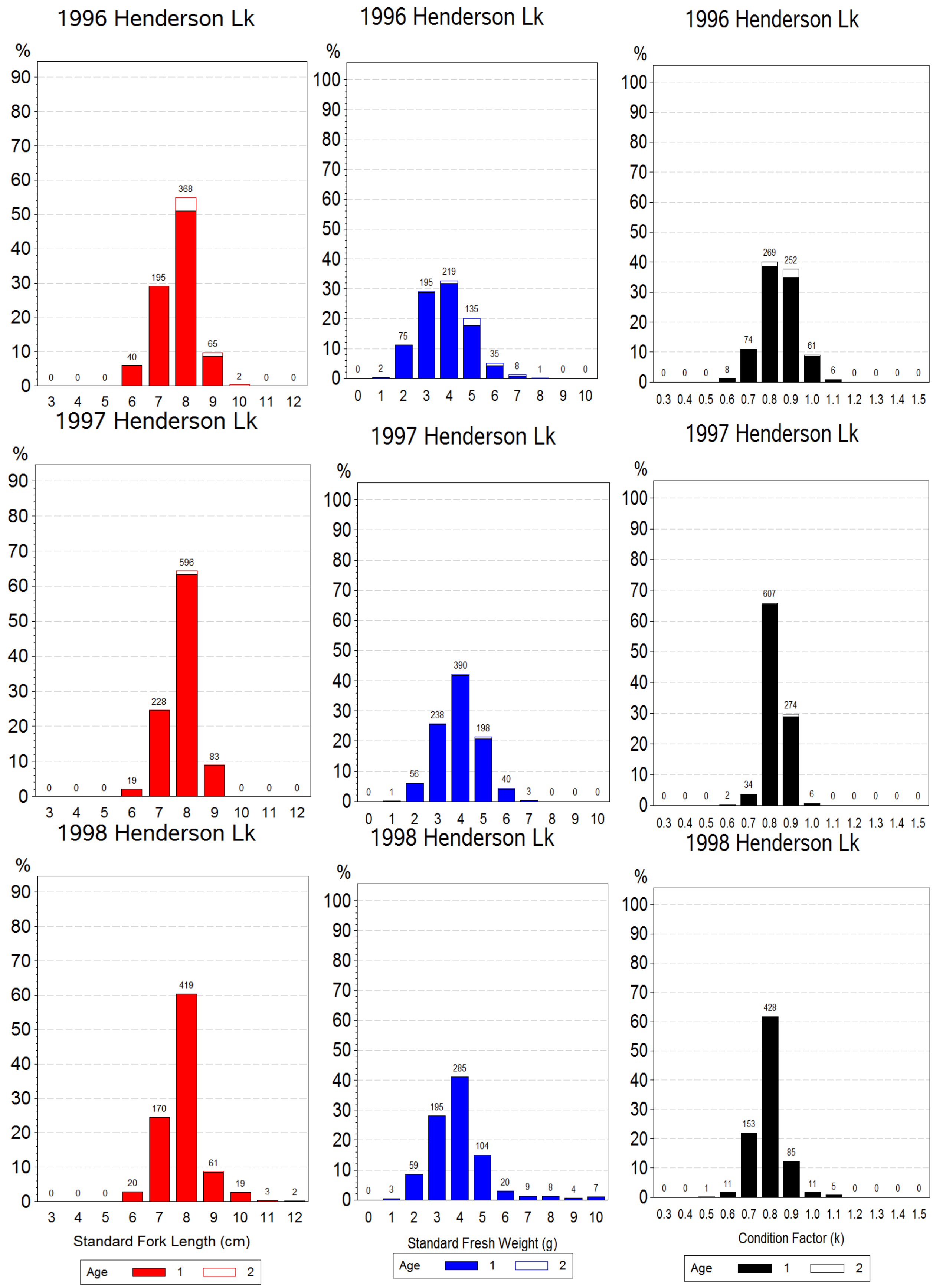

1980 Henderson Lk
1980 Henderson Lk
1980 Henderson Lk
1981 Henderson Lk
1981 Henderson Lk
1981 Henderson Lk
1982 Henderson Lk
1982 Henderson Lk
1982 Henderson Lk
1983 Henderson Lk
1983 Henderson Lk
1983 Henderson Lk
%
Standard Fork Length (cm)
Age 1 2
Age 1 2
Age 1 2

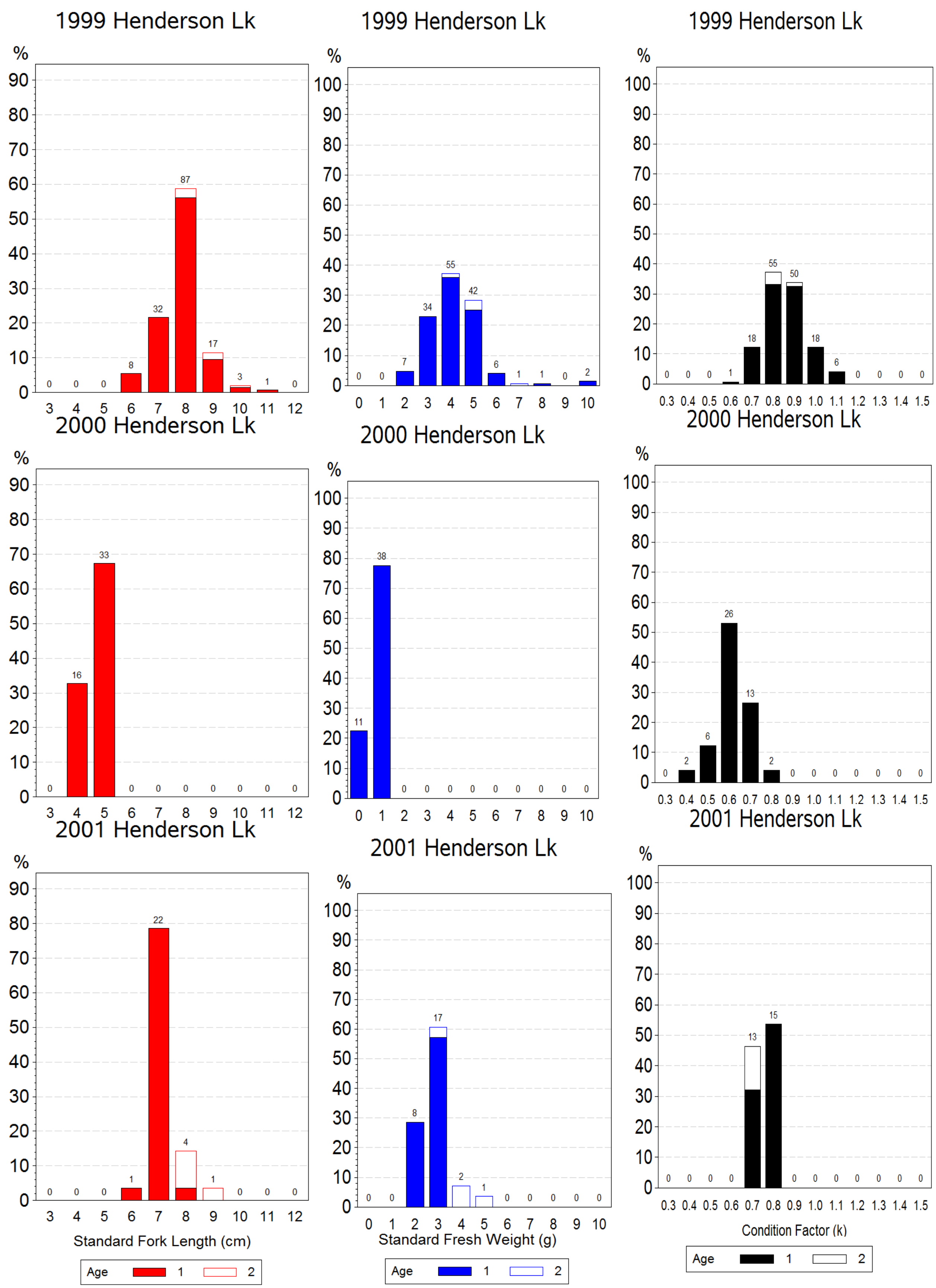

1984 Henderson Lk
1984 Henderson Lk
1984 Henderson Lk
1985 Henderson Lk
1985 Henderson Lk
1985 Henderson Lk
1986 Henderson Lk
1986 Henderson Lk
1986 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Age 1 2
Age 1 2
Age 1 2

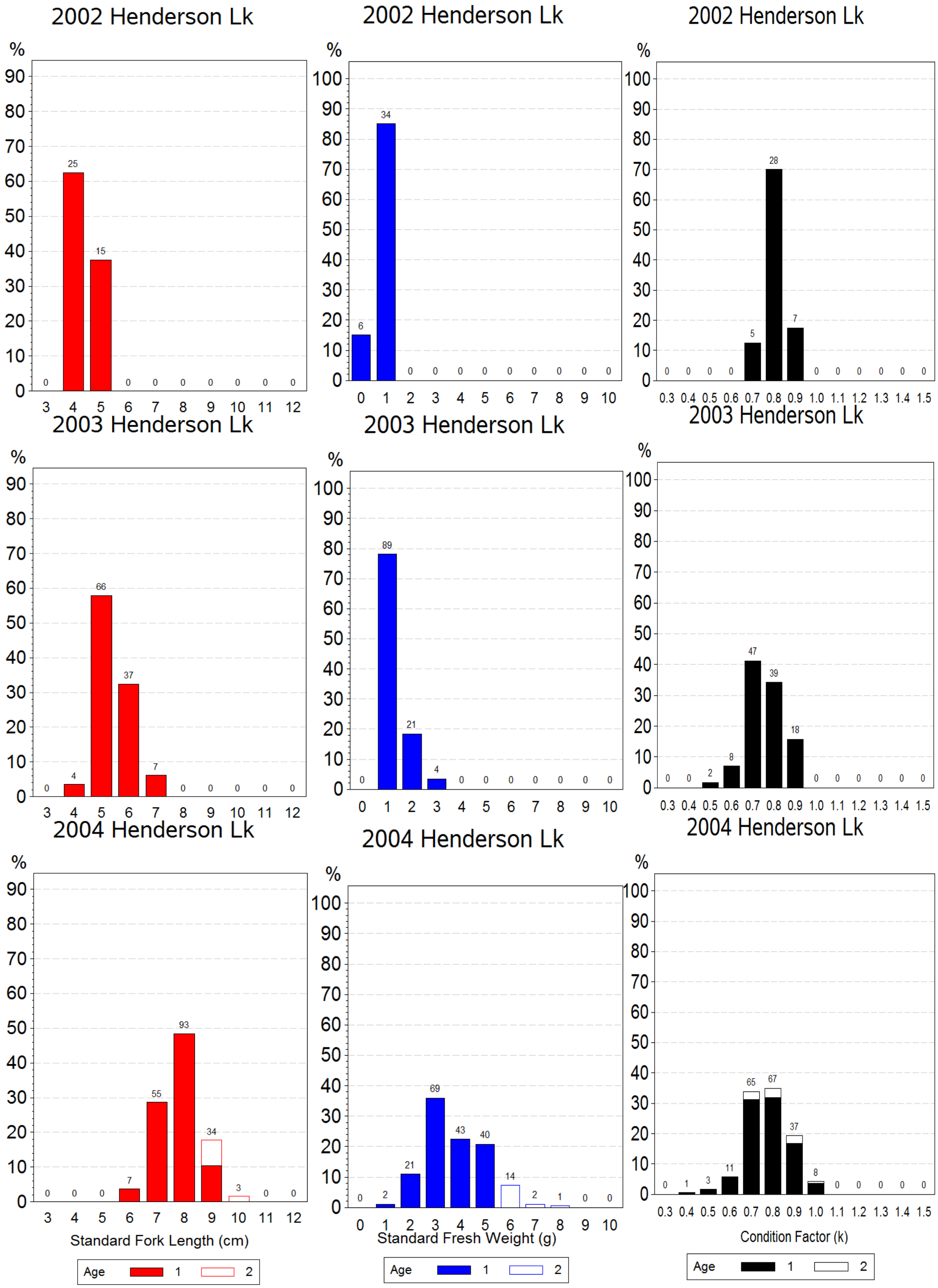

1987 Henderson Lk
1987 Henderson Lk
1987 Henderson Lk
1988 Henderson Lk
1988 Henderson Lk
1988 Henderson Lk
1989 Henderson Lk
1989 Henderson Lk
1989 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2

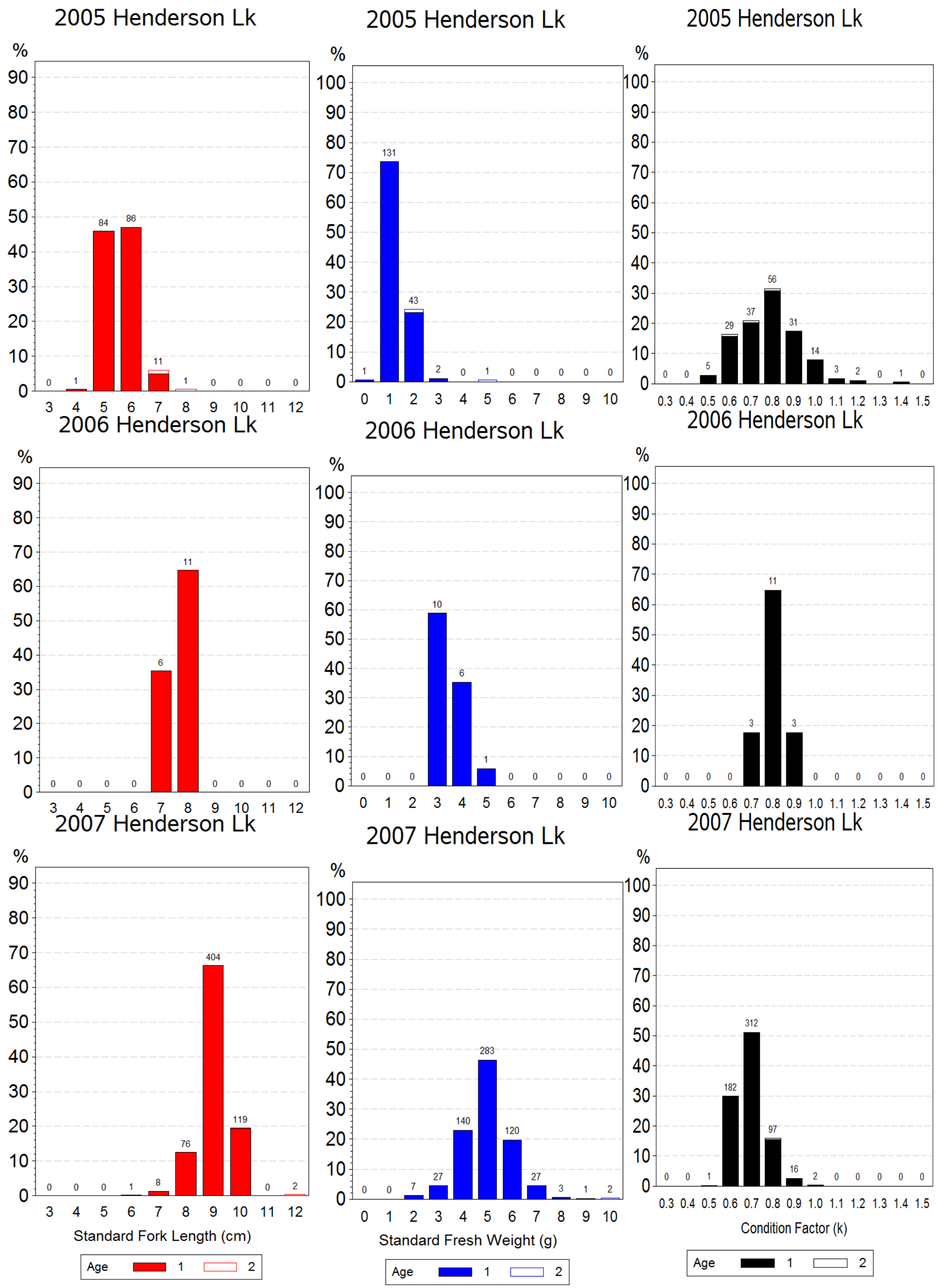

1990 Henderson Lk
1990 Henderson Lk
1990 Henderson Lk
1991 Henderson Lk
1991 Henderson Lk
1991 Henderson Lk
1992 Henderson Lk
1992 Henderson Lk
1992 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2

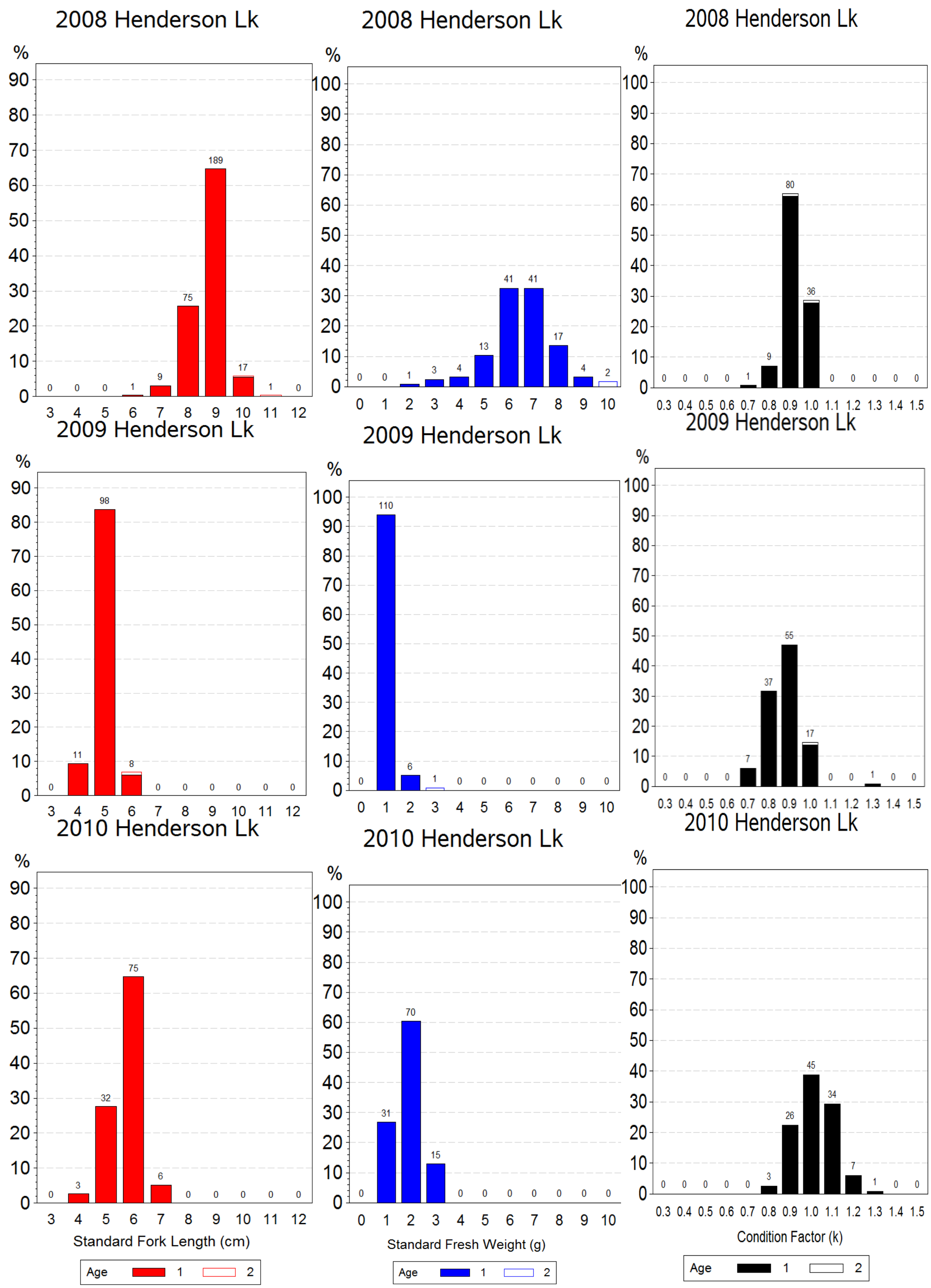

1993 Henderson Lk
1993 Henderson Lk
1993 Henderson Lk
1994 Henderson Lk
1994 Henderson Lk
1994 Henderson Lk
1995 Henderson Lk
1995 Henderson Lk
1995 Henderson Lk
%
Standard Fork Length (cm)
Age 1 2
Standard Fresh Weight (g)
Age 1 2
Condition Factor (k)
Age 1 2

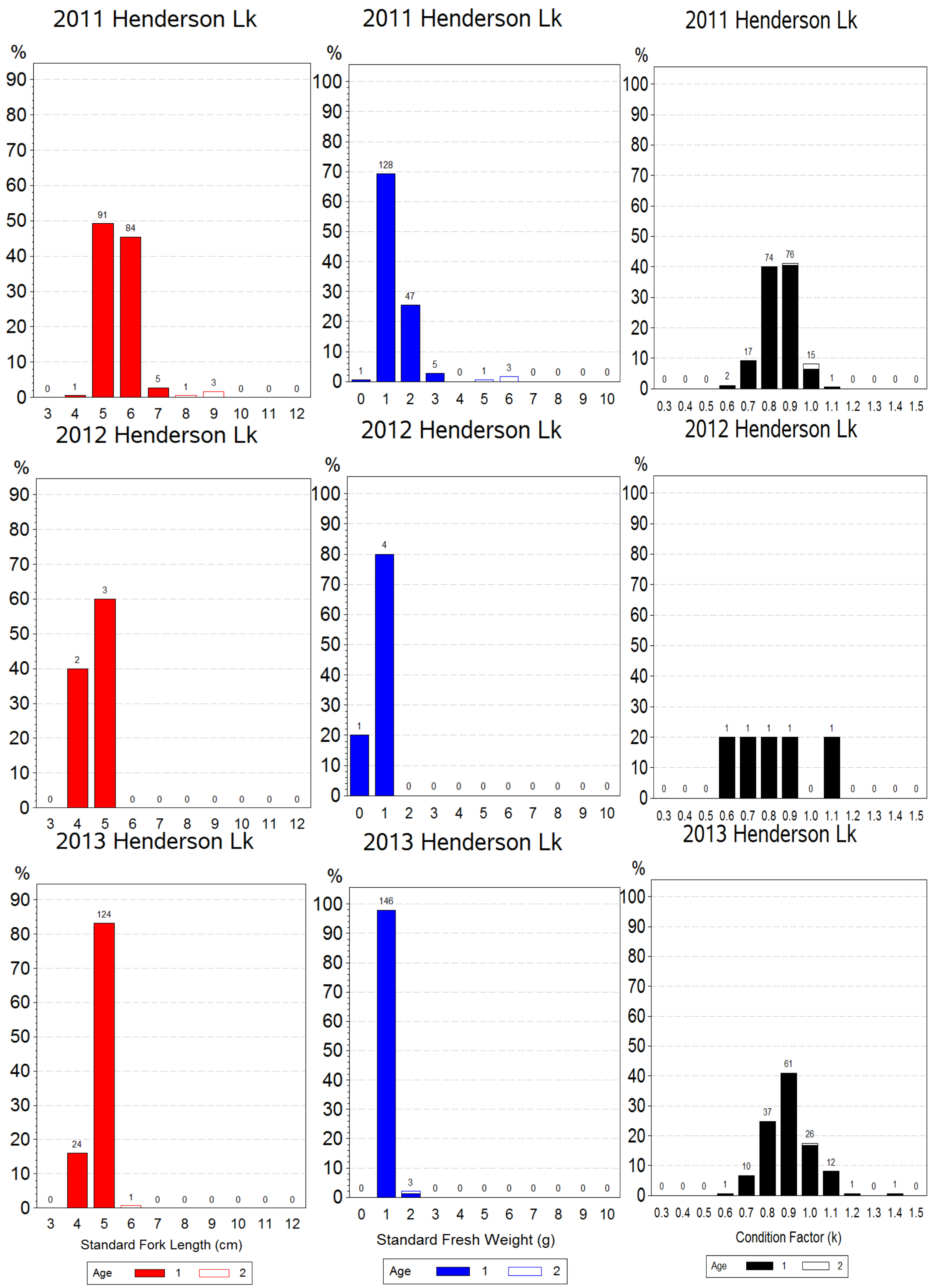

1996 Henderson Lk
1996 Henderson Lk
1996 Henderson Lk
0 0 0 40 195 368 65 2 0 0
0 2 75 195 219 135 35 8 1 0 0
0 0 0 8 74 269 252 61 6 0 0 0 0
1997 Henderson Lk
1997 Henderson Lk
1997 Henderson Lk
0 0 0 19 228 596 83 0 0 0
0 1 56 238 390 198 40 3 0 0 0
0 0 0 2 34 607 274 6 0 0 0 0 0
1998 Henderson Lk
1998 Henderson Lk
1998 Henderson Lk
0 0 0 20 170 419 61 19 3 2
0 3 59 195 285 104 20 9 8 4 7
0 0 1 11 153 428 85 11 5 0 0 0 0
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2


1999 Henderson Lk
1999 Henderson Lk
1999 Henderson Lk
2000 Henderson Lk
2000 Henderson Lk
2000 Henderson Lk
2001 Henderson Lk
2001 Henderson Lk
2001 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2

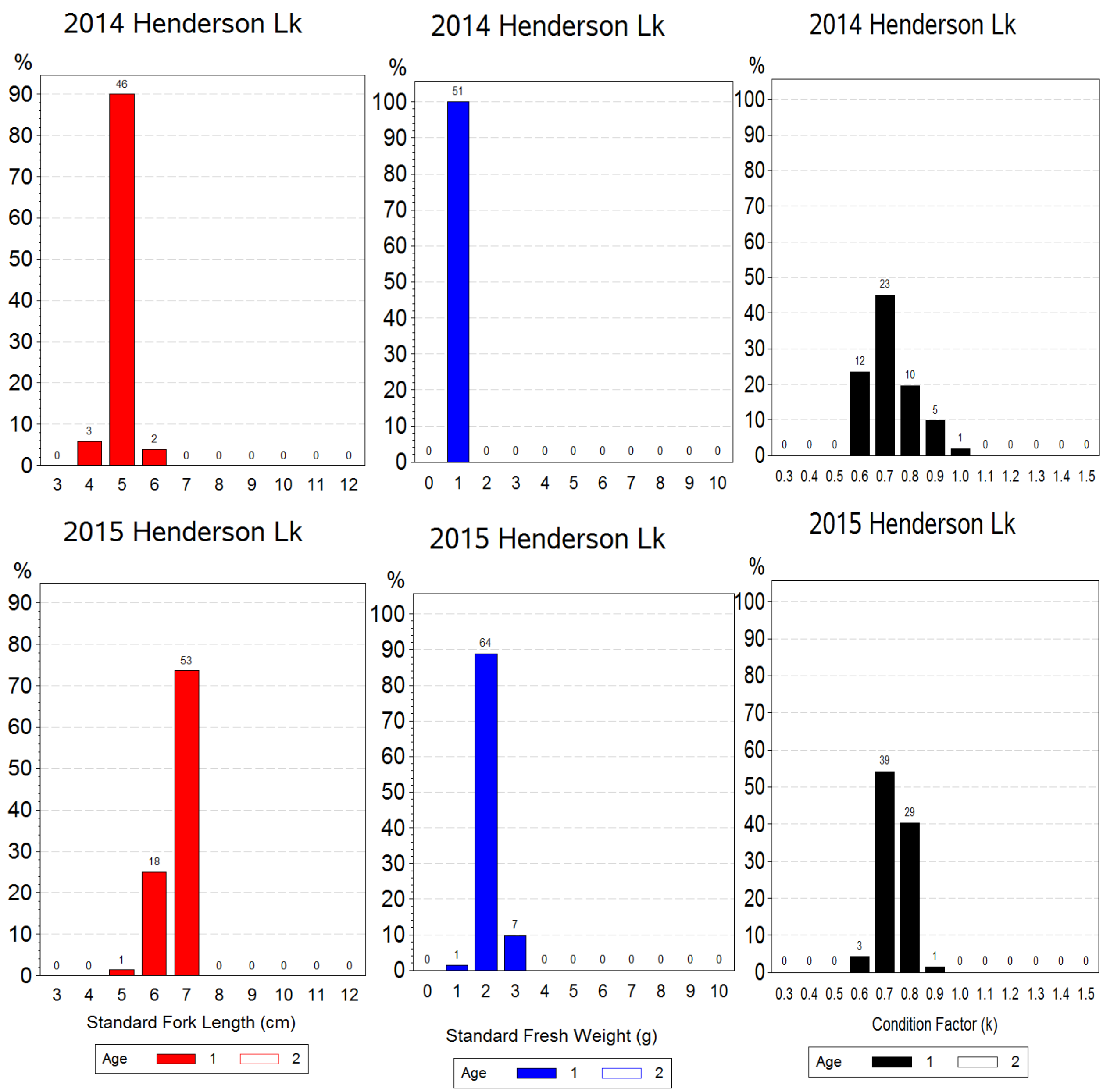

2002 Henderson Lk
2002 Henderson Lk
2002 Henderson Lk
2003 Henderson Lk
2003 Henderson Lk
2003 Henderson Lk
2004 Henderson Lk
2004 Henderson Lk
2004 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2


2005 Henderson Lk
2005 Henderson Lk
2005 Henderson Lk
2006 Henderson Lk
2006 Henderson Lk
2006 Henderson Lk
2007 Henderson Lk
2007 Henderson Lk
2007 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2


2008 Henderson Lk
2008 Henderson Lk
2008 Henderson Lk
2009 Henderson Lk
2009 Henderson Lk
2009 Henderson Lk
2010 Henderson Lk
2010 Henderson Lk
2010 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2



2011 Henderson Lk
2011 Henderson Lk
2011 Henderson Lk
2012 Henderson Lk
2012 Henderson Lk
2012 Henderson Lk
2013 Henderson Lk
2013 Henderson Lk
2013 Henderson Lk
%
Standard Fork Length (cm)
Standard Fresh Weight (g)
Condition Factor (k)
Age 1 2
Age 1 2
Age 1 2


2014 Henderson Lk
2014 Henderson Lk
2014 Henderson Lk
2015 Henderson Lk
2015 Henderson Lk
2015 Henderson Lk
%
Standard Fork Length (cm)
Age 1 2
Standard Fresh Weight (g)
Age 1 2
Condition Factor (k)
Age 1 2

APPENDIX VI – Annual Length/Weight Relations

Appendix VI. Henderson Lake Sockeye smolt length-to-weight relationships (model: Std Weight = a · ForkLength ^{b}) by ocean entry year and age class.

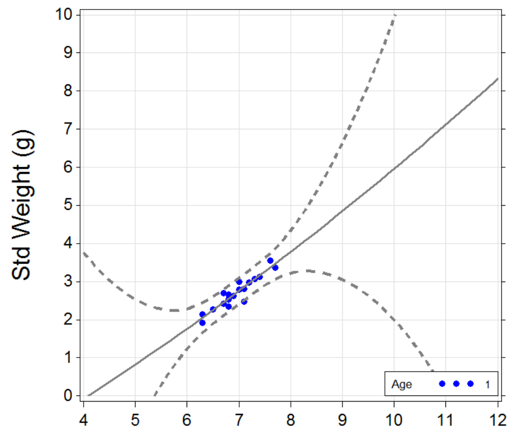
	Age							
	1				2			
	a	b	Rsq	N	a	b	Rsq	N
Year								
1977	0.0168	2.617	0.87	17				
1978	0.0120	2.805	0.81	307	2.5917	0.000		0
1979	0.0318	2.394	0.78	440				
1980	0.0202	2.518	0.84	198				
1981	0.0066	3.016	0.45	262				
1982	0.0142	2.737	0.88	250				
1983	0.0085	2.956	0.93	194				
1984	0.0083	2.988	0.96	345	0.0038	3.380	0.95	14
1985	0.0085	2.928	0.95	221				
1986	0.0141	2.654	0.79	161				
1987	0.0075	3.052	0.97	21	0.0159	2.686	1.00	0
1988	0.0093	2.967	0.97	211	6.7438	0.000		0
1989	0.0084	3.008	0.96	395				
1990	0.0136	2.758	0.87	230				
1991	0.0089	2.983	0.93	324				
1992	0.0140	2.791	0.90	323	0.0559	2.148	0.40	2
1993	0.0101	2.920	0.94	358				
1994	0.0078	3.028	0.97	1288				
1995	0.0097	2.899	0.85	952				

(Continued)

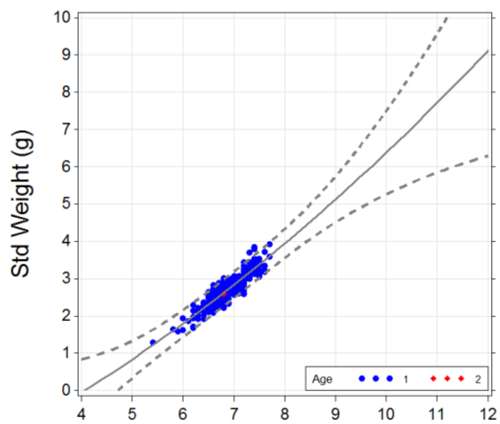
(Continued)

	Age							
	1				2			
	a	b	Rsq	N	a	b	Rsq	N
Year								
1996	0.0088	2.975	0.88	632	0.0034	3.432	0.79	34
1997	0.0073	3.058	0.95	909	0.0170	2.679	0.90	10
1998	0.0063	3.107	0.92	683	0.0044	3.261	1.00	0
1999	0.0135	2.775	0.81	136	0.0164	2.687	0.99	6
2000	0.0081	2.818	0.53	47				
2001	0.0137	2.698	0.91	22	0.0055	3.129	0.99	2
2002	0.0057	3.238	0.94	38				
2003	0.0054	3.198	0.90	112				
2004	0.0048	3.234	0.81	173	0.7637	0.946	0.22	15
2005	0.0207	2.419	0.59	173	0.0008	4.083	0.99	1
2006	0.0179	2.601	0.81	15				
2007	0.0113	2.771	0.77	605	8.1200	0.000		0
2008	0.0060	3.189	0.93	122				
2009	0.0116	2.818	0.82	114	2.5000	0.000		0
2010	0.0150	2.771	0.92	114				
2011	0.0111	2.832	0.84	179	0.0008	4.136	0.97	2
2012	0.0834	1.406	0.33	3				
2013	0.0138	2.716	0.63	146	2.1418	0.000		0
2014	0.0231	2.262	0.63	49				
2015	0.0100	2.835	0.81	70				

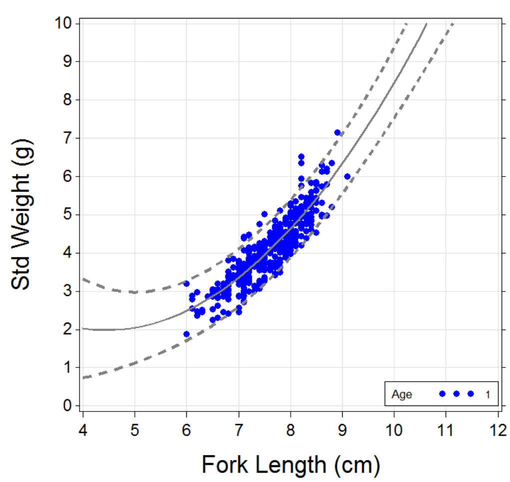
1977 Henderson Lk Sockeye



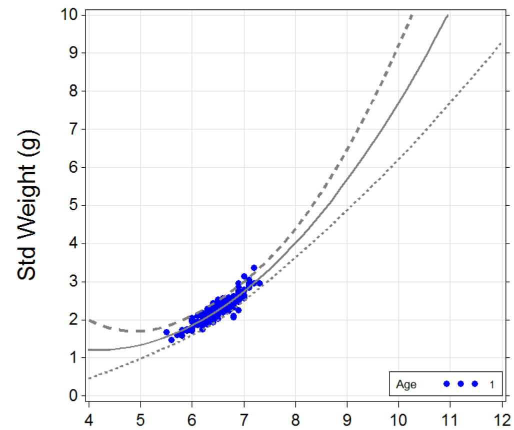
1978 Henderson Lk Sockeye



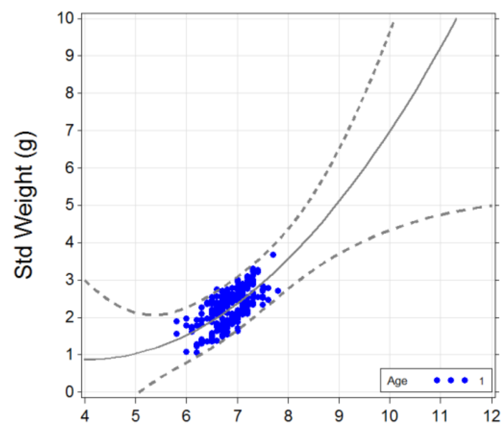
1979 Henderson Lk Sockeye



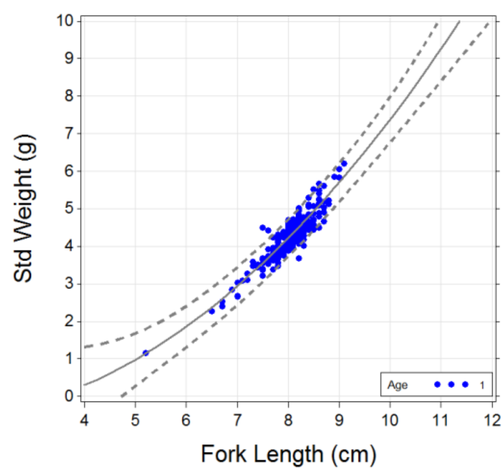
1980 Henderson Lk Sockeye

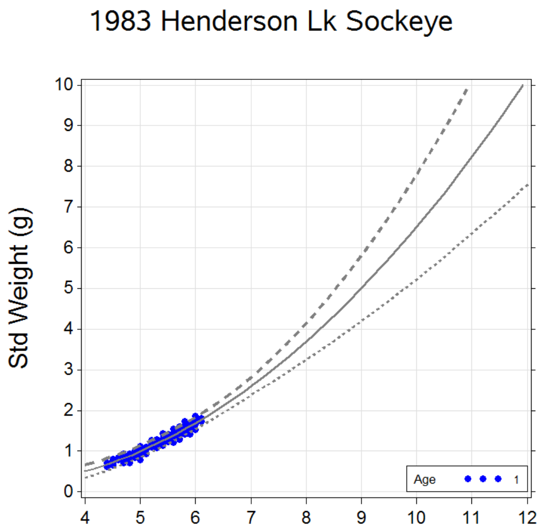


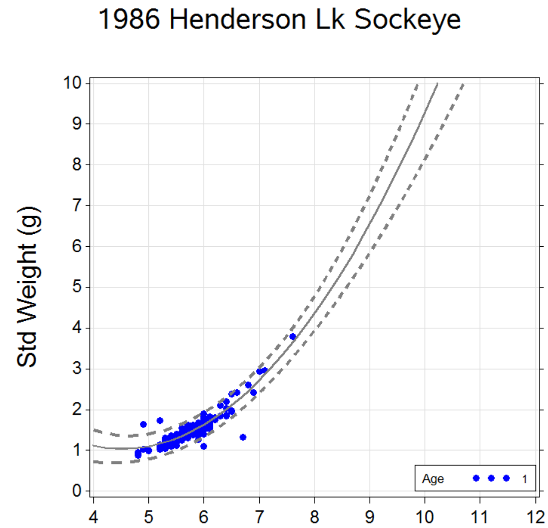
1981 Henderson Lk Sockeye

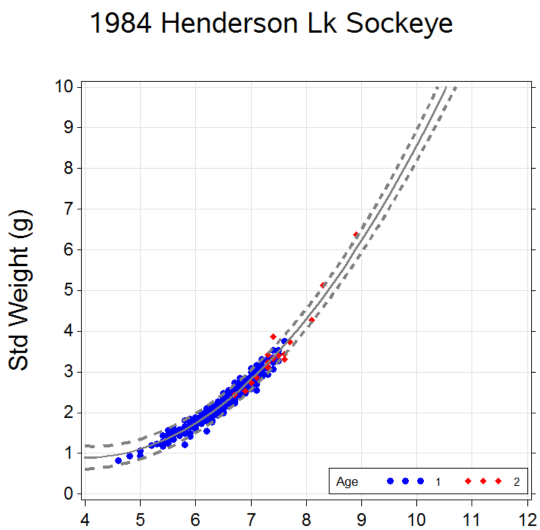


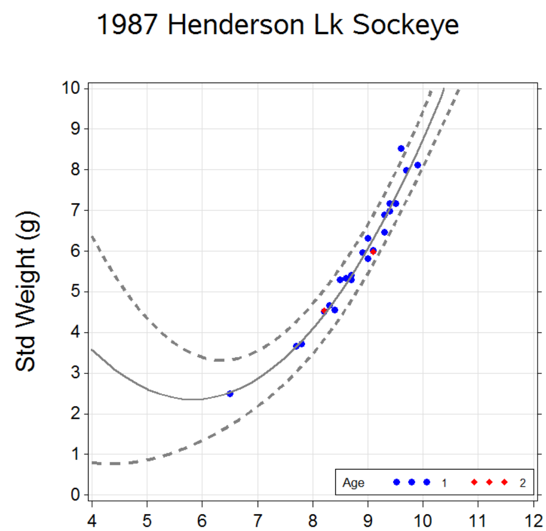
1982 Henderson Lk Sockeye

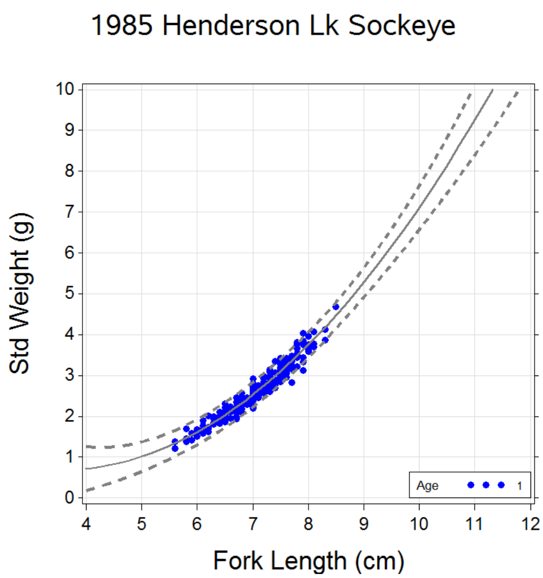


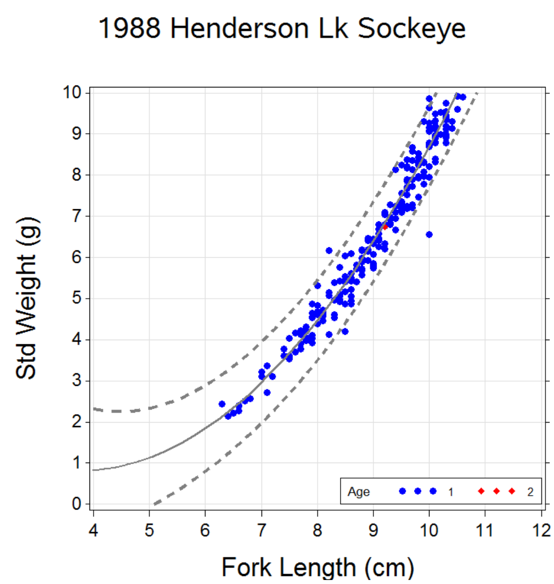

1983 Henderson Lk Sockeye
Std Weight (g)
Age 1

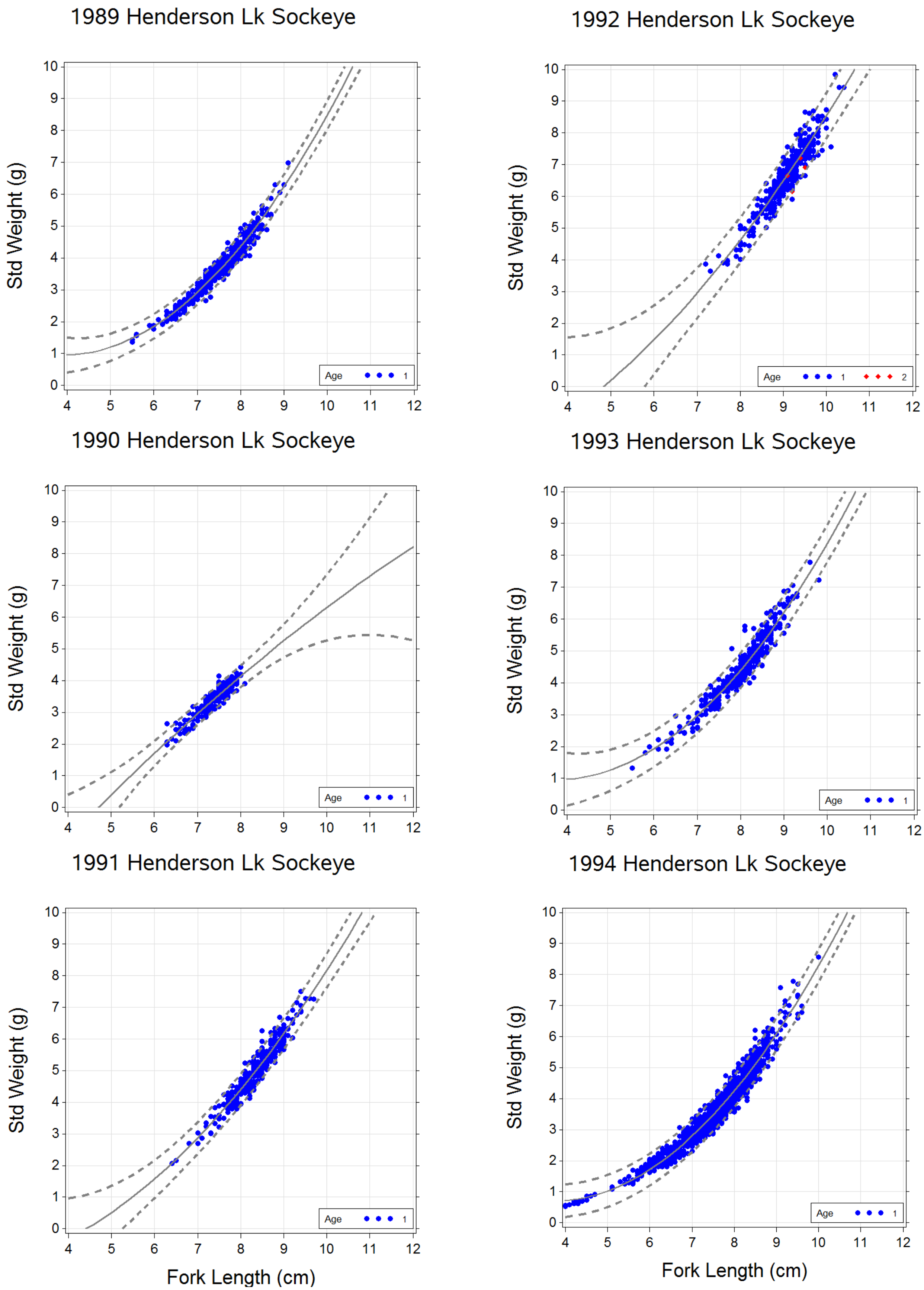

1986 Henderson Lk Sockeye
Std Weight (g)
Age 1


1984 Henderson Lk Sockeye
Std Weight (g)
Age 1 2

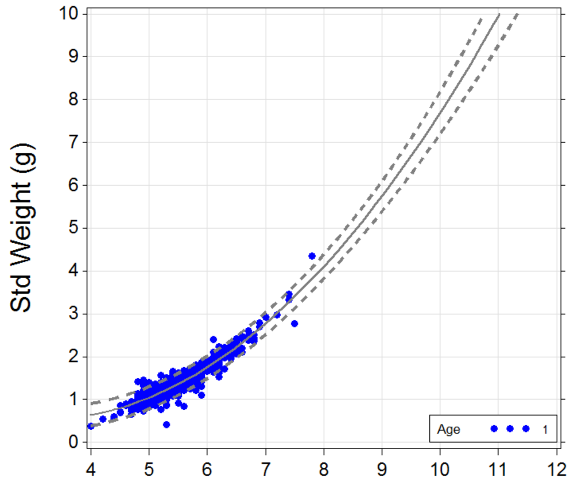

1987 Henderson Lk Sockeye
Std Weight (g)
Age 1 2


1985 Henderson Lk Sockeye
Std Weight (g)
Age 1
Fork Length (cm)

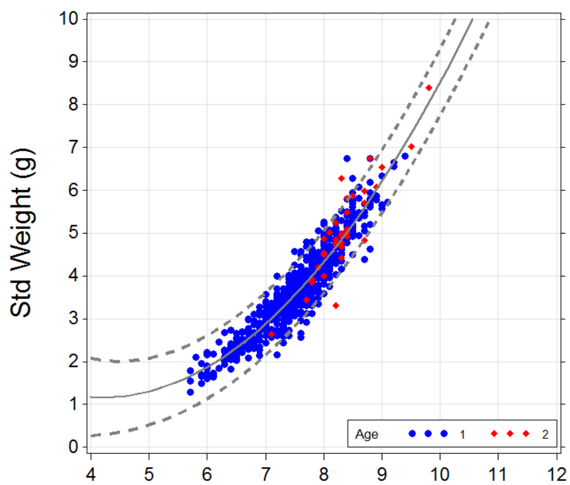

1988 Henderson Lk Sockeye
Std Weight (g)
Age 1 2
Fork Length (cm)


1989 Henderson Lk Sockeye
1992 Henderson Lk Sockeye
1990 Henderson Lk Sockeye
1993 Henderson Lk Sockeye
1991 Henderson Lk Sockeye
1994 Henderson Lk Sockeye
Std Weight (g)
Fork Length (cm)
Age
1
2

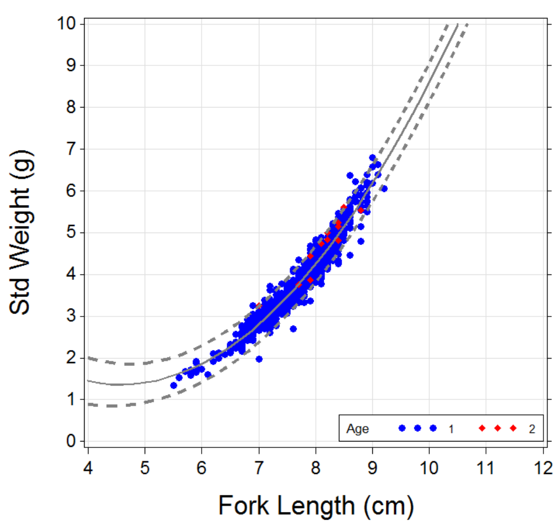
1995 Henderson Lk Sockeye



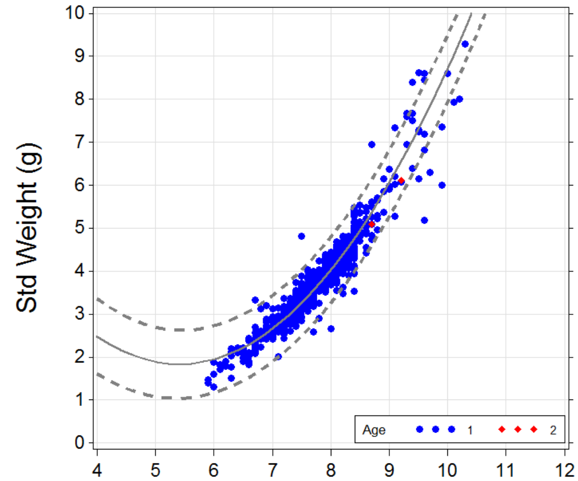
1996 Henderson Lk Sockeye



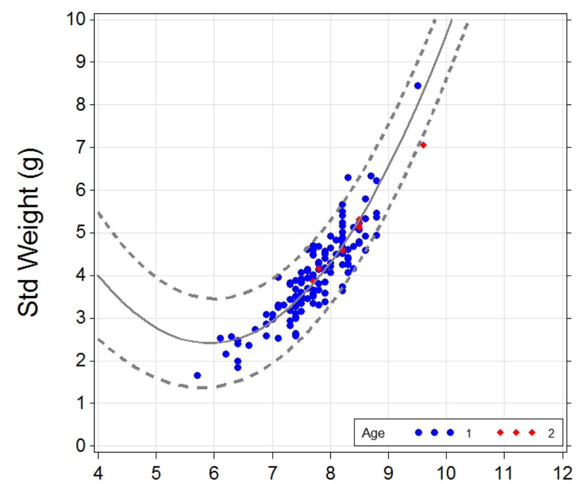
1997 Henderson Lk Sockeye



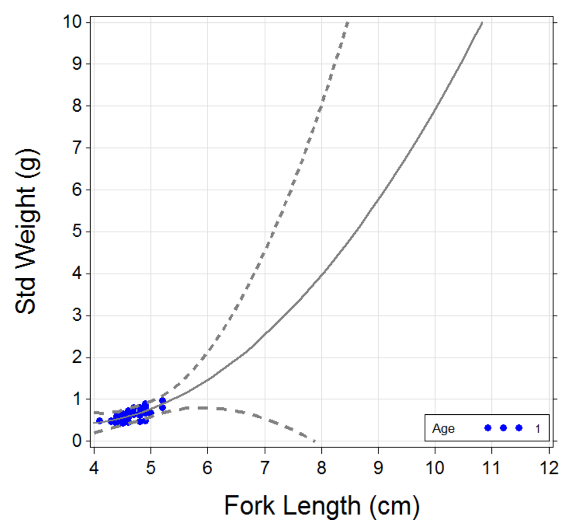
1998 Henderson Lk Sockeye



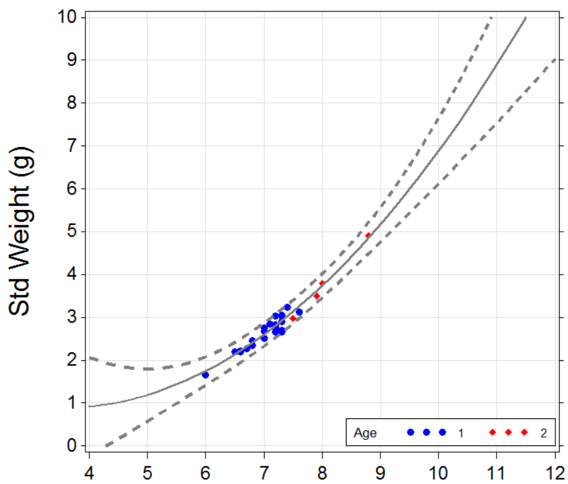
1999 Henderson Lk Sockeye



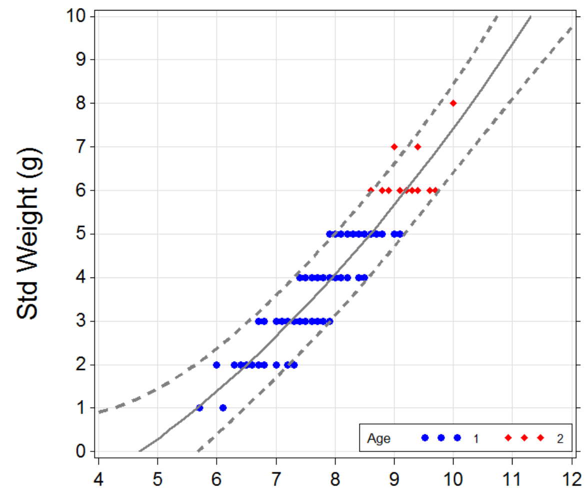
2000 Henderson Lk Sockeye



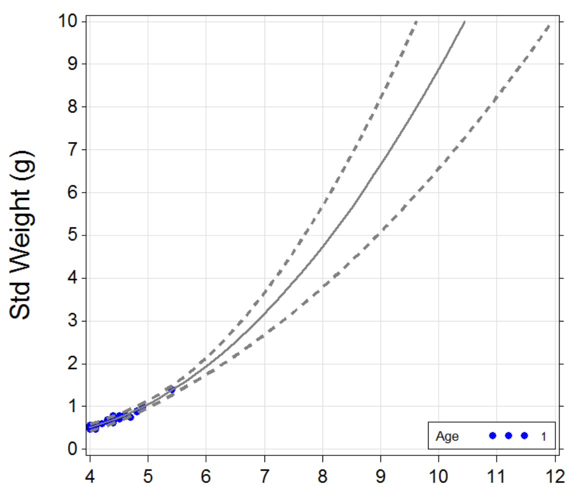
2001 Henderson Lk Sockeye



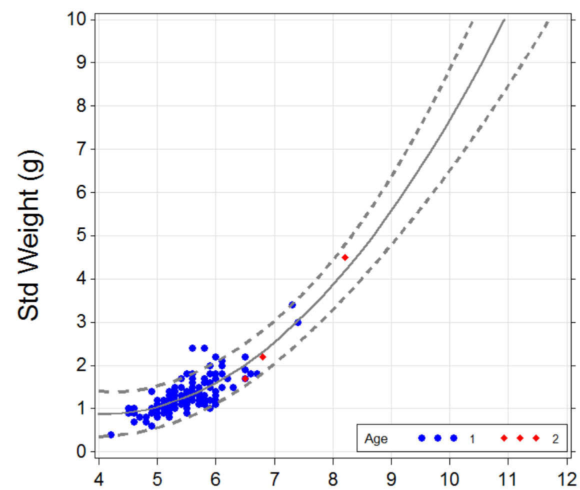
2004 Henderson Lk Sockeye



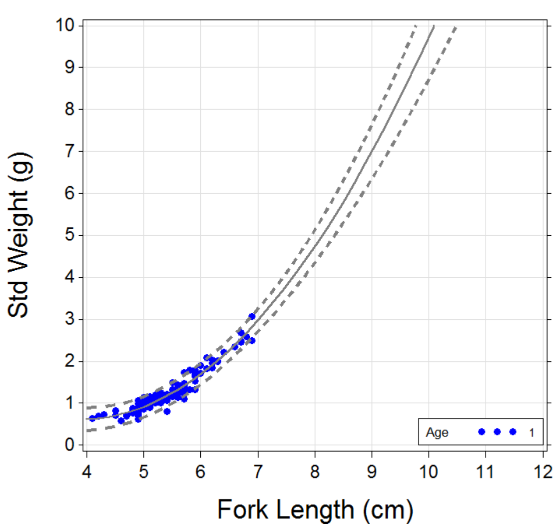
2002 Henderson Lk Sockeye



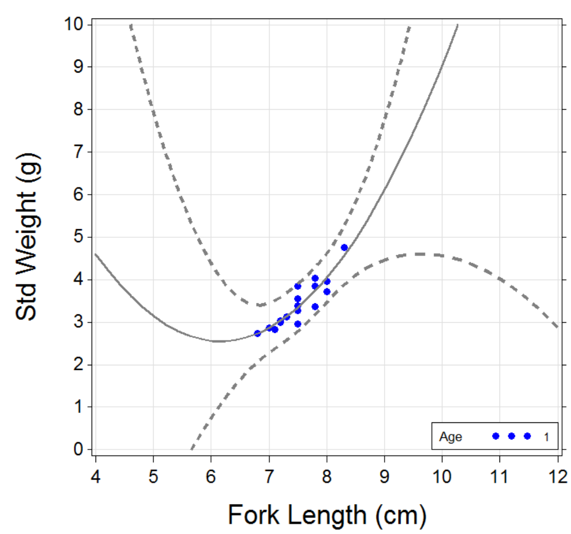
2005 Henderson Lk Sockeye

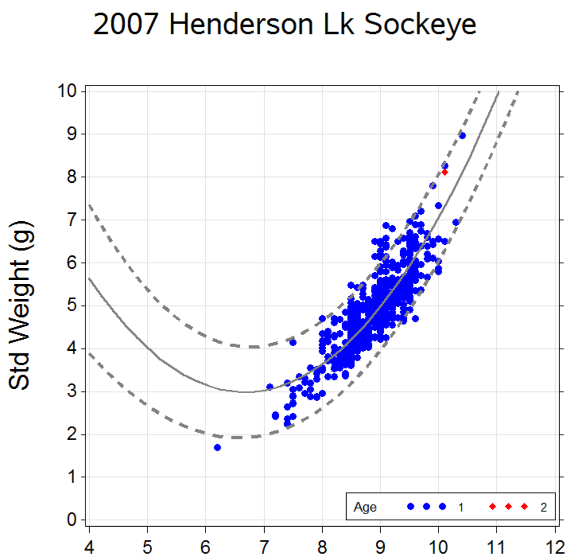


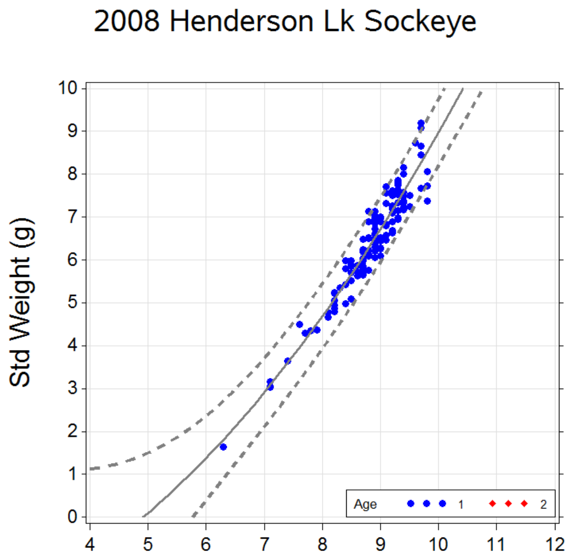
2003 Henderson Lk Sockeye

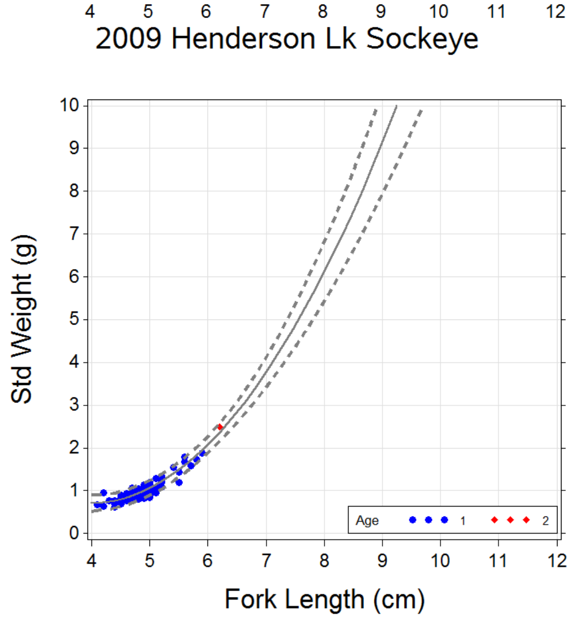


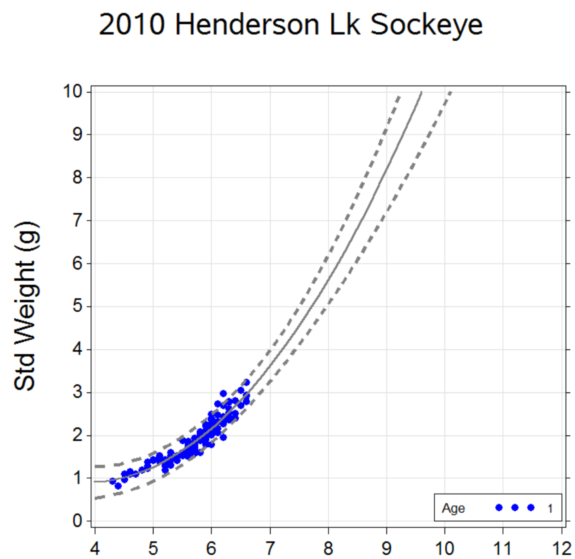
2006 Henderson Lk Sockeye

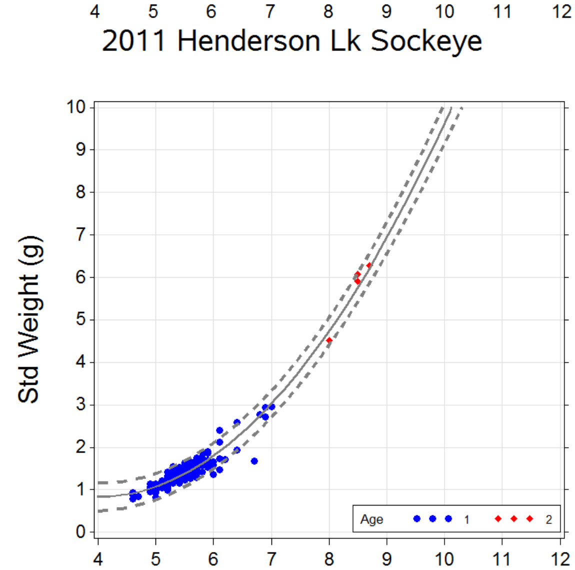


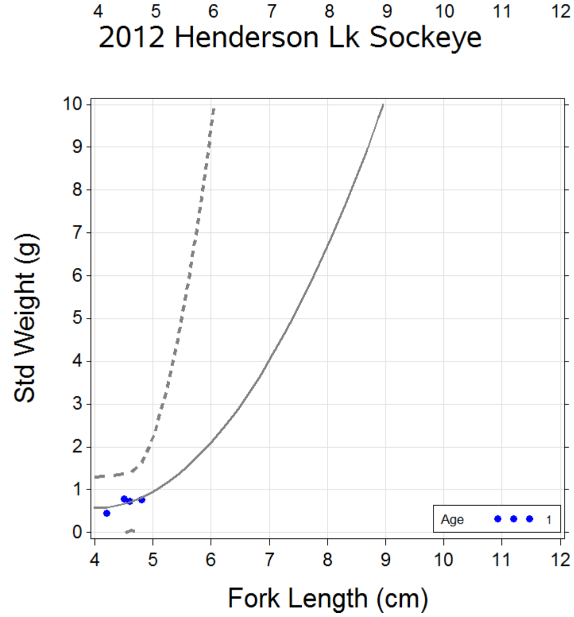

2007 Henderson Lk Sockeye
Std Weight (g)
Age 1 2


2008 Henderson Lk Sockeye
Std Weight (g)
Age 1 2

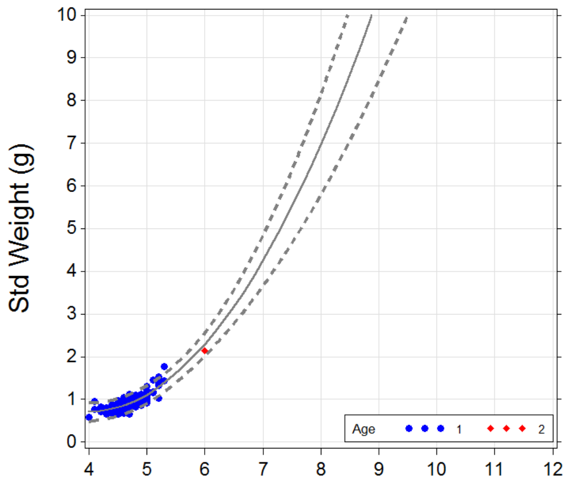

2009 Henderson Lk Sockeye
Std Weight (g)
Fork Length (cm)
Age 1 2


2010 Henderson Lk Sockeye
Std Weight (g)
Age 1

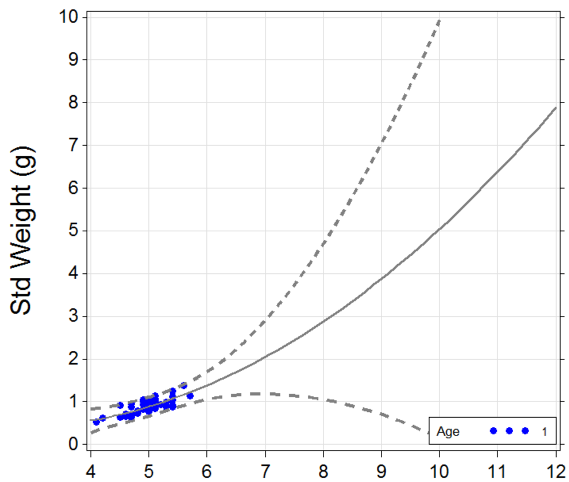

2011 Henderson Lk Sockeye
Std Weight (g)
Age 1 2


2012 Henderson Lk Sockeye
Std Weight (g)
Fork Length (cm)
Age 1

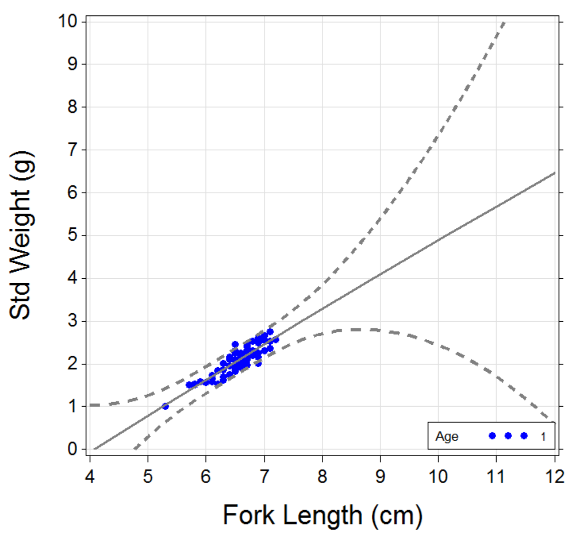
2013 Henderson Lk Sockeye



2014 Henderson Lk Sockeye



2015 Henderson Lk Sockeye



APPENDIX VII – Annual Pre-smolt & Smolt Statistics

Appendix VII. Annual Sockeye smolt and pre-smolt size statistics from ATS sample dates (acoustic-trawl surveys; K. D. Hyatt and D. P. Rankin unpub. data).

N = sample size. Length = fork length. Wt = Standard weight. EstSmoltLength = 6.62 + 1.016 * PresmoltLength (r = 0.90, P < 0.01, n = 31; Figure 11). O-E = Observed – Estimated smolt length. Est Std Weight based on EstSmoltLength and annual length-weight relations (Appendix VI), except Brood Year 2014, where EstSmoltLength based on multi-year length-weight relation (Figure 9).

Brood	ATS	ATS_N	PresmoltLength	PresmoltWt	SmoltYear	Smolt_N	SmoltLength	Est SmoltLength	O-E	Est StdWeight
1975					1977	19	70			
1976	13-Mar-78	57	65.0	2.38	1978	309	69	72.7	-3.7	3.13
1977	13-Mar-79	10	71.8	4.08	1979	300	77	79.6	-2.6	4.56
1978	27-Nov-79	85	62.0	2.27	1980	200	65	69.6	-4.6	2.67
1979	20-Oct-80	21	64.8	2.88	1981	264	68	72.4	-4.4	2.59
1980	6-Mar-82	16	72.0	3.81	1982	252	80	79.8	0.2	4.17
1981	30-Nov-82	90	47.0	0.93	1983	196	52	54.4	-2.4	1.27
1982	2-Nov-83	55	57.0	1.85	1984	347	64	64.5	-0.5	2.18
1983	28-Oct-84	51	61.0	2.33	1985	223	71	68.6	2.4	2.39
1984	18-Aug-85	556	43.0	0.78	1986	163	58	50.3	7.7	1.03
1985	2-Dec-86	6	70.0	4.28	1987	23	88	77.7	10.3	3.92
1986	16-Sep-87	5	68.4	4.23	1988	235	91	76.1	14.9	3.84
1987	22-Sep-88	20	65.7	3.40	1989	295	76	73.3	2.7	3.37
1988	23-Feb-90	82	65.3	2.88	1990	230	74	72.9	1.1	3.26
1989	5-Oct-90	36	64.7	3.52	1991	326	84	72.4	11.6	3.27
1990	12-Feb-92	4	76.0	4.56	1992	325	91	83.8	7.2	5.29
1991	25-Feb-93	30	76.0	4.62	1993	360	80	83.8	-3.8	5.02
1992	15-Feb-94	29	75.0	4.52	1994	1217	76	82.8	-6.8	4.70
1993	17-Nov-94	289	54.6	1.58	1995	756	55	62.1	-7.1	1.93
1994	11-Oct-95	59	66.8	3.77	1996	592	76	74.5	1.5	3.47
1995	4-Feb-97				1997	914	77			
1996	3-Aug-97	154		1.23	1998	537	78			
1997	15-Jun-98	115		0.62	1999	140	78			
1998	23-Aug-99	200	38.0	0.57	2000	49	46	45.2	0.8	0.57
1999	21-Nov-00	106	70.0	3.62	2001	24	70	77.7	-7.7	3.46
2000	29-Oct-01	183	42.0	0.68	2002	40	44	49.3	-5.3	1.00
2001	5-Nov-02	112	42.0	0.63	2003	92	54	49.3	4.7	0.89
2002	8-Mar-04	34	76.0	4.12	2004	175	76	83.8	-7.8	4.65
2003	30-Nov-04	80	47.0	1.02	2005	115	54	54.4	-0.4	1.24
2004	27-Sep-05				2006	17	75			
2005	25-Jan-07	9	86.0	5.61	2007	607	89	94.0	-5.0	5.62
2006	23-Aug-07	12	71.0	4.86	2008	290	87	78.8	8.2	4.33
2007	18-Nov-08	19	41.0	0.59	2009	116	48	48.3	-0.3	0.98
2008	1-Sep-90		50.5	1.54	2010	116	57	58.0	-1.0	1.95
2009					2011	176	54			
2010					2012	5	44			
2011	12-Dec-12		45.8	0.99	2013	102	46	53.1	-7.1	1.29
2012					2014	51	50			
2013	25-Nov-14		60.6	2.42	2015	72	66	68.2	-2.2	2.31
2014	25-Nov-15		68.4	3.28	2016			76.1		3.62

APPENDIX VIII – Sample Meta-Data

Appendix VIII. Sample meta-data, including total catch (where available) and total fish sampled by sample date, sample site, gear type, agency (sampling crews: PBS-DFO, RCH-DFO, HFN) and fish preservative code and type.

				FYKE		RST	
				Catch	Sampled	Catch	Sampled
Year	Date	Agency	Preservative				
1977	18MAY77	PBS	01 10% formalin		19		
1978	25APR78	PBS	01 10% formalin		105		
	08MAY78	PBS	01 10% formalin		99		
	18MAY78	PBS	01 10% formalin		106		
1979	08MAY79	PBS	00 Measured fresh		100		
	22MAY79	PBS	00 Measured fresh		200		
	30MAY79	PBS	00 Measured fresh		142		
1980	30APR80	PBS	00 Measured fresh		100		
	21MAY80	PBS	00 Measured fresh		100		
1981	06MAY81	PBS	00 Measured fresh		110		
	12MAY81	PBS	00 Measured fresh		125		
	18MAY81	PBS	00 Measured fresh		29		
1982	07MAY82	PBS	01 10% formalin		141		
	19MAY82	PBS	00 Measured fresh		111		
1983	02MAY83	PBS	00 Measured fresh		100		
	12MAY83	PBS	00 Measured fresh		96		
1984	23APR84	PBS	01 10% formalin		204		
	02MAY84	PBS	01 10% formalin		159		
1985	01MAY85	PBS	01 10% formalin		107		
	10MAY85	PBS	01 10% formalin		116		
1986	04MAY86	PBS	01 10% formalin		117		
	11MAY86	PBS	01 10% formalin		46		
1987	10MAY87	PBS	01 10% formalin		4		
	13MAY87	PBS	01 10% formalin		21		
1988	15APR88	PBS	01 10% formalin		73		
	22APR88	PBS	01 10% formalin		143		
	29APR88	PBS	01 10% formalin		19		
1989	13APR89	PBS	01 10% formalin		182		
1989	20APR89	PBS	01 10% formalin		90		
	02MAY89	PBS	01 10% formalin		205		
1990	11APR90	PBS	02 70% Ethanol		2		
	26APR90	PBS	02 70% Ethanol		30		
	09MAY90	PBS	02 70% Ethanol		200		
1991	09MAY91	PBS	01 10% formalin		126		
	16MAY91	PBS	01 10% formalin		200		
1992	04MAY92	PBS	01 10% formalin		103		
	14MAY92	PBS	01 10% formalin		85		
	19MAY92	PBS	01 10% formalin		141		
1994	21APR94	PBS	01 10% formalin				14
	28APR94	PBS	01 10% formalin	248	246		
	05MAY94	PBS	01 10% formalin				144
	12MAY94	PBS	01 10% formalin	151	150		150
	18MAY94	PBS	01 10% formalin				150
	26MAY94	PBS	01 10% formalin	255	258		105
	02JUN94	PBS	01 10% formalin				74
1995	10APR95	PBS	01 10% formalin				50
	13APR95	PBS	01 10% formalin				50
	19APR95	PBS	01 10% formalin				50
	22APR95	PBS	01 10% formalin				50
	27APR95	PBS	01 10% formalin				43
	30APR95	PBS	01 10% formalin				49
	01MAY95	PBS	02 70% Ethanol		50		
	04MAY95	PBS	01 10% formalin				189
	11MAY95	PBS	01 10% formalin		102		
1995	16MAY95	PBS	02 70% Ethanol		98		
	25MAY95	PBS	02 70% Ethanol				74
	26MAY95	PBS	01 10% formalin				51
	27MAY95	PBS	01 10% formalin				98
1996	28APR96	PBS	98 Fresh / Unk				27
	29APR96	PBS	98 Fresh / Unk				60
	30APR96	PBS	98 Fresh / Unk				39
	01MAY96	PBS	98 Fresh / Unk				39
	02MAY96	PBS	98 Fresh / Unk				45
	05MAY96	PBS	98 Fresh / Unk				63
	10MAY96	PBS	98 Fresh / Unk				200
	19MAY96	PBS	98 Fresh / Unk				26
	20MAY96	PBS	98 Fresh / Unk				64
	26MAY96	PBS	98 Fresh / Unk				64
	28MAY96	PBS	98 Fresh / Unk				24
	30MAY96	PBS	98 Fresh / Unk				19
1997	03MAY97	PBS	11 Frozen/Formalin				34
	04MAY97	PBS	11 Frozen/Formalin				61
	07MAY97	PBS	11 Frozen/Formalin				81
	08MAY97	PBS	11 Frozen/Formalin				157
	09MAY97	PBS	11 Frozen/Formalin				257
	14MAY97	PBS	11 Frozen/Formalin				79
	15MAY97	PBS	11 Frozen/Formalin				45
	16MAY97	PBS	11 Frozen/Formalin				66
	22MAY97	PBS	11 Frozen/Formalin				124
	23MAY97	PBS	11 Frozen/Formalin				24

(Continued)

				FYKE		RST	
				Catch	Sampled	Catch	Sampled
Year	Date	Agency	Preservative				
1998	08APR98	PBS	11 Frozen/Formalin				44
	09APR98	PBS	11 Frozen/Formalin				17
	10APR98	PBS	11 Frozen/Formalin				13
	12APR98	PBS	11 Frozen/Formalin				11
	13APR98	PBS	11 Frozen/Formalin				72
	14APR98	PBS	11 Frozen/Formalin				91
	15APR98	PBS	11 Frozen/Formalin				110
	18APR98	PBS	11 Frozen/Formalin		126		127
	25APR98	PBS	11 Frozen/Formalin				8
	26APR98	PBS	11 Frozen/Formalin				15
	11MAY98	PBS	11 Frozen/Formalin				19
	22MAY98	PBS	11 Frozen/Formalin		41		
1999	14APR99	PBS	01 10% formalin	26	20		
	29APR99	PBS	10 Frozen	228	246		
2000	14MAY00	PBS	10 Frozen		30		
	16MAY00	PBS	10 Frozen		28		
2001	17APR01	PBS	02 70% Ethanol	5	3		
	07MAY01	PBS	02 70% Ethanol	27	25		
2002	08MAY02	PBS	02 70% Ethanol	27	27		
	16MAY02	PBS	02 70% Ethanol	15	13		
2003	03APR03	PBS	00 Measured fresh	4	4		
	26APR03	HH	10 Frozen				3
	27APR03	HH	10 Frozen				3
	28APR03	HH	10 Frozen				3
	01MAY03	HH	10 Frozen				2
	06MAY03	HH	10 Frozen				18
2003	09MAY03	HH	10 Frozen				8
	11MAY03	HH	10 Frozen				5
	12MAY03	HH	10 Frozen				3
	13MAY03	HH	10 Frozen				1
	14MAY03	HH	10 Frozen				4
	15MAY03	HH	10 Frozen				9
	16MAY03	HH	10 Frozen				10
	18MAY03	HH	10 Frozen				2
	19MAY03	HH	10 Frozen				2
	20MAY03	HH	10 Frozen				3
	21MAY03	HH	10 Frozen				3
	22MAY03	HH	10 Frozen				3
	24MAY03	HH	10 Frozen				5
	25MAY03	HH	10 Frozen				3
	26MAY03	HH	10 Frozen				2
	27MAY03	HH	10 Frozen				2
	28MAY03	HH	10 Frozen				4
	30MAY03	HH	10 Frozen				1
	31MAY03	HH	10 Frozen				2
	01JUN03	HH	10 Frozen				9
2004	15APR04	NTC	00 Measured fresh				50
	21APR04	NTC	00 Measured fresh				31
	06MAY04	NTC	00 Measured fresh				22
	08MAY04	NTC	00 Measured fresh				25
	09MAY04	NTC	00 Measured fresh				25
	10MAY04	NTC	00 Measured fresh				22
2004	19MAY04	NTC	00 Measured fresh				17
2005	23MAR05	NTC	00 Measured fresh				3
	25MAR05	NTC	00 Measured fresh				19
	27MAR05	NTC	00 Measured fresh				6
	29MAR05	NTC	00 Measured fresh				11
	01APR05	NTC	00 Measured fresh				10
	09APR05	NTC	00 Measured fresh				1
	11APR05	NTC	00 Measured fresh				3
	23APR05	NTC	00 Measured fresh				2
	25APR05	NTC	00 Measured fresh				21
	28APR05	NTC	00 Measured fresh				14
	30APR05	NTC	00 Measured fresh				6
	02MAY05	NTC	00 Measured fresh				11
	03MAY05	NTC	00 Measured fresh				12
	04MAY05	NTC	00 Measured fresh				21
	06MAY05	NTC	00 Measured fresh				6
	08MAY05	NTC	00 Measured fresh				2
	13MAY05	NTC	00 Measured fresh				16
	25MAY05	NTC	00 Measured fresh				3
	26MAY05	NTC	00 Measured fresh				2
	29MAY05	NTC	00 Measured fresh				5
	31MAY05	NTC	00 Measured fresh				1
	01JUN05	NTC	00 Measured fresh				2
	04JUN05	NTC	00 Measured fresh				3
	06JUN05	NTC	00 Measured fresh				2
	12JUN05	NTC	00 Measured fresh				1
2005	13JUN05	NTC	00 Measured fresh				1
2007	19APR07	PBS	00 Fresh / Ethanol	3	3		
	30APR07	PBS	00 Measured fresh	74	74		
	09MAY07	PBS	00 Measured fresh	533	533		
2008	14APR08	PBS	02 70% Ethanol		56		
	24APR08	PBS	02 70% Ethanol		70		
	01MAY08	PBS	02 70% Ethanol		166		
2009	17APR09	PBS	00 Fresh / Ethanol	118	117		
2012	05MAR12	PBS	02 70% Ethanol		18		
	14APR12	PBS	02 70% Ethanol		3		
	04MAY12	PBS	02 70% Ethanol		2		
2013	11APR13	PBS	02 70% Ethanol		47		
	01MAY13	PBS	02 70% Ethanol		102		
2014	25APR14	PBS	02 70% Ethanol	61	20		
	07MAY14	PBS	02 70% Ethanol		31		
2015	15APR15	PBS	02 70% Ethanol		65		
	30APR15	PBS	02 70% Ethanol		7		
All				1,775	6,837		3,952

APPENDIX IX – Data Issues

Smolt data collected over the years have been managed in a variety of ways, but data storage is divided into two basic formats:

1. **SAS Database** - For the years 1977-1996, smolt size, age and meta-data were keypunched and uploaded into structured SAS datasets. Subsequently, SAS programming procedures for smolt data management was replaced with unstructured spreadsheet workbook files.
2. **Excel Workbooks** - As of 1997, smolt size and age data were managed in Microsoft Excel spreadsheets, in different formats and data structures. Field trip meta-data were usually stored in separate Excel spreadsheets (Survey Trip Reports, or STRs) and/or in data spreadsheets specific to stock-year-sample-date. File naming conventions and data structures were not always adhered to.

To collate all datasets into one location for compilation and analysis, a spreadsheet-based inventory was created to track the file locations and contents of the Excel workbook files. **Smolt Data Inventory.xlsx** is a meta-data inventory spreadsheet documenting the existence of smolt survey datasets based on information collated from STRs and known smolt sample spreadsheets. The Inventory spreadsheet data is organized by smolt ocean entry year, lake/stock (GCL/Sproat/Henderson only), sample site and sample date. For each record, the following variables are listed (where available): Trip, Sample Number, Sample Type (1=Smolt, 2=ATS (excluded from smolt analyses)), #Sets, SoakTime, Total Catch, Total Retained (sample), Crew or Agency, fish Preservation Code and Preservative Type (used to identify appropriate conversion to "standard" fresh weight), Gear Code and Gear Type, Size Data Resolution (individual Fish, or summarized by Date or Year), Comments, and Data Source (filename and location).

This assisted in the compilation of the smolt survey observations, i.e. the individual fish meristics, standard weights, and age data. The raw data were organized in **Smolt Size Data 1997-2018.xlsx.** The individual fish size and age data, where available, have been retrieved from the data sources identified in **Smolt Data Inventory.xlsx** and consolidated into stock-specific tabs (GCL, SPR, HEN, etc) to structure the data by Stock, Sample Date, Sample Number and Fish Number. Meta-data include Species Code, Gear Code, Site Code, Lab Processor, and Notes. Size data include ForkLength (fresh only), and may include either Preserved Wet Weight or Fresh Standard Weight, or both. Age data include (where available) Scale Book Number, Scale Number, Scale Quality and Scale Age. In the absence of scale age data, an Assigned Age may be applied. The Final Age value is set to the Scale Age or Assigned Age, and is used as the fish's age class in analyses.

Age Data - Between 1977 and 1986, all fish captured and retained were scale-sampled for age analysis. After 1986, scale sampling was reduced in scope, and focused on fish in the overlapping age range of 75 – 90 mm, with few fish <70 mm (assumed age 1) or >90 mm (assumed age 2) in fork length scale-sampled. In many cases, scale sampling did not occur at all, or was limited by sample size, or did occur but the scales were never aged. In-season analyses by sampling crews often assumed all unaged fish were age 1 (not unreasonable for Henderson Lake Sockeye), or assigned to age based on a conventional threshold that varied between years and stocks from 70 – 90 mm. The misclassification of fish age may lead to directional biases in annual smolt size summaries. If many average-sized fish are left unaged, while all small and big fish are assigned, then the mean size of age 1s will be biased downward, and age 2 mean size would be biased upward. To reduce the potential bias in age classification, the following procedures were applied to smolt survey data with missing ages (1987-2018):

1. Where Scale Age exists and is not ambiguous or erroneous, the Final Age was set to the Scale Age. An Assigned Age can be applied to overrule an erroneous or ambiguous Scale Age.
2. In the absence of Scale Age or Assigned Age, Final Age is set for very small and very large fish based on unambiguous size rules associated with fork length (e.g. If Forklength < 70 mm, Final Age = 1; If ForkLength > 100 mm, Final Age = 2, etc).
3. For mid-range sizes (70-100 mm), bimodality in the size distributions can be used to classify unaged fish to age in some years. However, high overlap in size distributions between age classes, plus a general trend for larger fish emigrating earlier in the season, required some attention to sample timing and proportions by age at specific size classes. Thus:
    a. Year-specific age proportions from scale data by year, month (April versus May/June) and 5 mm length class were used to classify unaged fish to age class. For example, if scale analysis indicated 80% of aged fish 90-95 mm in length in April 1999 were age 1, then the smallest (by weight) 8 of 10 unaged fish in that size class in 1999 were assigned age 1, and the largest 2 of 10 fish were assigned age 2. Age proportions for May-June would be applied to classify unaged fish in subsequent months. For very low sample sizes of unaged fish (e.g. <10 fish), the default age assignment was age 1 since age 1 fish are predominant in the population. In the absence of age data from scale samples for a given year, the multi-year age proportions by forklength size class were used to assign age.
    b. Fish-specific age assignments were entered into the Assigned Age column in the spreadsheet, and thereby incorporated into the Final Age value.
    c. Assigned ages for the Excel spreadsheet data (1997-2018) are recorded and annotated in **Smolt Size Data 1997-2018.xlsx**.
    d. Unassigned age classes in the mid-sized length range in the **SAS database** data (1986-1996) were programmatically defaulted to age 1, with individual fish re-assignments to age 2 as as shown below.

Data Omissions – Outliers and anomalies that were omitted from analyses included:

1. 29-Mar-05: Sample Number 1, Fish Numbers 39 – Forklength 173 mm, 8.9 g

Other

- In 2004, smolt weights were only measured to the nearest gram.
- In 2005, smolt surveys commenced in late March. For plotting purposes, March survey dates were reassigned to April 1st of the year.