NASS RIVER STEELHEAD LIFE HISTORY CHARACTERISTICS PERTAINING TO THE NASS HABITAT CAPABILITY MODEL

C.K. Parken[1]

British Columbia
Ministry of Environment, Lands and Parks
Fisheries Branch
Skeena Region
PO Box 5000
Smithers, B.C.
V0J 2N0

Skeena Fisheries Report SK#110

July, 1997

[1] Cascadia Natural Resource Consulting, PO Box 4456, Smithers, B.C., V0J 2N0

Abstract

Information on populations of adult summer (Cranberry River, Damdochax Creek, Kwinageese River, Meziadin River, Nass River fishwheels) and winter (Chambers Creek, Ishkheenickh River, Tseax River) steelhead in the Nass River watershed was gathered from a variety published technical reports and unpublished data from the Skeena Region Ministry of Environment, Lands and Parks files (Smithers). The information was pooled among years (1974-1996) and sampling methods (angling, tangle nets fishwheels etc.) to increase sample sizes and improve inferences on the life history characteristics specific to the Nass habitat capability model. Male and female steelhead were generally similar in body size within tributary populations. Among summer steelhead, Damdochax steelhead were similar in body size to Kwinageese and Meziadin steelhead, however Damdochax steelhead were larger than Cranberry steelhead. Winter steelhead populations were similar in body size, and they were generally larger than summer steelhead populations. The mean length of male summer steelhead ranged from 68.3 cm (Cranberry River) to 78.4 cm (Damdochax Creek), whereas the mean length of male winter steelhead ranged from 73.2 cm (Ishkheenickh River) to 79.7 cm (Tseax River). The mean length of female summer steelhead ranged from 68.7 cm (Cranberry River) to 74.5 cm (Damdochax Creek), whereas the mean length of female winter steelhead ranged from 72.8 cm (Tseax River) to 87.0 cm (Chambers Creek). Mean smolt age ranged from 3.00 years (Meziadin River) to 3.74 years (Damdochax Creek) and steelhead were most frequently freshwater age 3 or 4 in the Nass River watershed. Fecundity estimates ranged from 2597 eggs/fish (Cranberry River) to 4264 eggs/fish (Chambers Creek) and were generally higher for winter than summer steelhead, due to the larger body size of winter steelhead.

Life history characteristics and provincial biostandards were used to estimate the relative productivity of Nass River steelhead populations. Winter steelhead populations were generally more productive than summer steelhead populations due to larger body size. For winter steelhead, Chambers Creek (Beverton-Holt A = 0.80) was the most productive and Tseax River (A = 0.59) was the least productive. Among summer steelhead, the Meziadin River population was the most productive (A = 0.74) and the Cranberry River population was the least productive (A = 0.35). Life history model estimates (i.e. recruits per spawner, allowable harvest rates, Beverton-Holt's A value) were lower when calculated with updated biostandards than with biostandards used in the Skeena steelhead carrying capacity model.

Monte Carlo simulations indicated the high variability in the updated biostandards increased the probability of populations not meeting sufficient recruitment levels for replacement due to natural (random) variability. The most sensitive life history model parameter was mean smolt age, followed by egg-to-fry

survival, smolt-to-adult survival and female length, when older biostandards were used (from 1992). However, when the variability of the updated biostandards was incorporated, the most sensitive parameter was smolt-to-adult survival, followed by egg-to-fry survival, mean smolt age and female length. Mean smolt age was probably underestimated for Nass River populations because of limitations in scale aging techniques and the short growing season that probably exists for a number of rearing streams in the Nass River watershed. These negative bias errors in mean smolt age result in overestimates of recruits per spawner, allowable harvest rates and Beverton-Holt's A value.

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1.0.0.0 Introduction

Little information exists on summer and winter steelhead (*Oncorhynchus mykiss*) in the Nass River watershed (Alexander and Koski 1995; Koski and English 1996). Fisheries research in the Nass River watershed has been hindered by the remoteness, poor access and high glacial turbidity in the mainstem river and tributaries. Several technical reports have examined the run-timing (Link *et al*. 1993; Link and English 1994, Link 1995), juvenile distribution and stock productivity (Sebastian 1987, Triton 1994a, Triton 1994b, Bustard 1995), and life history characteristics (i.e. Schultze 1981; Lough 1983; Alexander and Koski 1995, Koski and English 1996) of Nass River steelhead. However, additional life history information that has not been summarized existed in report appendixes and in the Ministry of Environment, Lands and Parks (MOELP) Skeena Region data files.

Recent interest and research on Nass River steelhead is directly related to treaty negotiations with the Nisga'a Tribal Council. The Nisga'a are actively involved in subsistence/traditional use fisheries that capture summer and winter steelhead in the mainstem Nass River and tributaries (Bocking and English 1993; Bocking and English 1994a; Bocking and English 1994b; Koski and English 1996). The B.C. Fisheries Branch is currently developing a habitat capability model to estimate conservation goals, allowable harvest rates and surplus steelhead production. The model predictions will aid the Province in the final treaty negotiations process and future fisheries management.

The Nass River habitat capability model relies on life history information, such as female length, fecundity and mean smolt age to predict conservation goals, allowable harvest rates and productivity estimates. These estimates may vary between tributary populations due to a combination of environmental or genetic factors (Waples 1995). Environmental factors, such as growth season length influence juvenile rearing conditions and the duration of stream residence required for steelhead (Bocking and English 1992; Tautz *et al*. 1992) and Atlantic salmon (*Salmo salar*; Symons 1979) to grow to smolt size. Similarly, genetic factors or a combination of genetic and environmental factors may influence differences in adult body size (Leider *et al*. 1986; Bjornn 1987; Hooton *et al*. 1987; Burgner *et al*. 1992; Evenson and Ewing 1992) or fecundity (McGregor 1986; DuBois *et al*. 1989) between steelhead populations. Therefore, the life history characteristics of Nass River steelhead were examined by tributary population.

The objectives of this report were:

1) to summarize the available life history data, such as female length, estimated fecundity and mean smolt age by tributary population for the Nass River habitat capability model;
2) to examine the productivity and allowable harvest rates for populations with available empirical data;
3) and to examine the sensitivity of productivity parameters and estimate the uncertainty in predicting allowable harvest rates.

2.0.0.0 Study Area

The Nass River originates in the Skeena Mountains of north western British Columbia and flows southwest for approximately 400 km into Portland Inlet (Figure 1). The Nass River watershed is the third largest watershed entirely contained within British Columbia and drains approximately 20 500 km^2 (Alexander and Koski 1995). The Nass River has nine main tributaries: Ishkheenickh, Tseax, Tchitin, Cranberry, White, Meziadin, Bell-Irving and Kwinageese rivers and Damdochax Creek. Common fish species in the Nass River watershed include sockeye salmon (*O. nerka*), chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), steelhead trout, cutthroat trout (*O. clarki*), Rocky Mountain whitefish (*Prosopium williamsoni*), bull char (*Salvelinus confluentus*), Dolly Varden char (*S. malma*), largescale sucker (*Catostomus macrocheilus*), redside shiner (*Richardsonius balteatus*), peamouth chub (*Mylocheilus caurinus*) and northern squawfish (*Ptychocheilus oregonesis*; McPhail and Carveth 1994). In contrast to the nearby Skeena River watershed, lake trout, (*S. namaycush*), lake whitefish (*Coregonus clupeaformis*), pygmy whitefish (*Prosopium coulteri*), lake chub (*Couesius plumbeus*), longnose dace (*Rhinichthys cataractae*), white sucker (*Catostomus commersoni*) and burbot (*Lota lota*) have not been reported in the Nass River watershed (McPhail and Carveth 1994). The Nass River watershed lies within two ecoprovinces (Coastal Mountains and Sub-Boreal Interior) and contains six biogeoclimatic zones: Alpine Tundra, Sub-Boreal Spruce, Engelmann Spruce-Subalpine Fir, Interior Cedar-Hemlock, Mountain Hemlock, Coastal Western Hemlock (Pojar and Nuzsdorfer 1988).

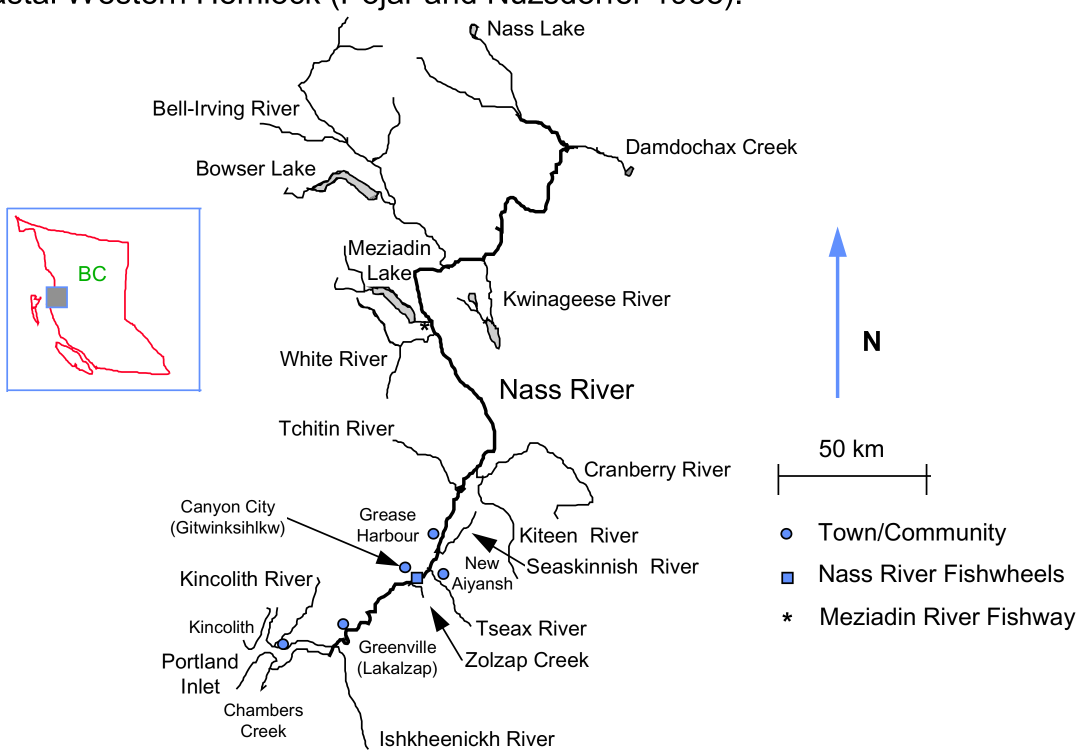

Figure 1. The Nass River watershed and major tributaries.

3.0.0.0 Methods

3.1.0.0 Life History Characteristics

A number of sources were investigated to collect data related to the sex, length, freshwater age and ocean age of Nass River steelhead. The data sources included technical reports and unpublished data found in MOELP files, which included data collected by using a variety of methods (angling, tangle nets, fishwheels etc.). Often, partial data were available, such as sex and length but not age, and thus analyses were limited by small samples.

There were suspected discrepancies with one of the data sources. Scale samples collected by LGL Ltd. at the Nass River fishwheels (1992-1994) were suspected to be under-aged and therefore samples were re-aged by the Fisheries Branch office in Smithers (Skeena Region). Scale samples collected during the 1993 telemetry project (Alexander and Koski 1995) and archived at the Fisheries and Oceans Canada scale lab (FOC; Pacific Biological Station, Nanaimo, B.C.) were incomplete or did not correspond with the LGL Ltd. data files (R.C. Bocking, personal communication). However, the mean smolt age of the 1993 telemetry steelhead aged at the FOC scale lab (3.2 years; n=48; Koski and English 1996) was similar to the mean smolt age of the re-aged samples (3.22 years; n=27). Therefore, for steelhead sampled during the 1993 telemetry program, the LGL Ltd. data set was used instead of the re-aged data set because the differences between the mean smolt age were small and the LGL Ltd. data set was complete.

Scale ages were used to estimate life history characteristics, such as mean smolt age, but under-aging errors lead to overestimated life history model estimates (Bocking and English 1992). Scale ages may be biased low (under-aged) by the absence of the first annulus (Hooton *et al*. 1987) or by the absence of scales being formed during the first year (Jensen and Johnsen 1982; Hooton *et al*. 1987). From a large sample of Vancouver Island steelhead, evidence for the incomplete scale formation at age 1 was supported by the wide range of circuli counts from the scale focus to the first observed annulus (Hooton *et al*. 1987). Jensen and Johnsen (1982) reported a range of 10 to 77 percent of Atlantic salmon from a cold (water temperatures exceed 6.5^0 C for less than 70-80 days) Norwegian river formed scales during their first year. On Vancouver Island, freshwater age 0+ steelhead as large as 46 mm were found devoid of scales (Hooton *et al*. 1987). In Damdochax Creek (Triton 1994a) and Kwinageese River (Triton 1994b), some yearling steelhead (> 70 mm) had not formed the first annulus and scale ages would be underestimated as 0+. The absence of scale formation in the first year or the first annulus may result in the freshwater ages of some Nass River steelhead being underestimated by one year.

Non-parametric Mann-Whitney U-tests were used to test size (fork length) differences between adult male and female steelhead in tributary populations because of the non-normal length distributions (Zar 1984). The lengths of male and female steelhead were compared between rivers using a non-parametric Kruskal-Wallis test because of the non-normal length distributions of male and female steelhead and unequal sample sizes (Zar 1984). If the Kruskal-Wallis test indicated differences in steelhead fork length between rivers, then steelhead lengths were compared graphically using Tukey notched box plots (Chambers *et al*. 1983; Haas and McPhail 1991). For summer steelhead sampled at the fishwheels, the lengths of males and females were compared between sexes with t-tests and between years with an ANOVA test where Tukey's HSD test was used for *post hoc* comparisons (Zar 1984). Parametric tests were used instead of the non-parametric alternatives for fishwheel samples because the samples were approximately normally distributed, in contrast to the tributary samples and did not violate the assumptions of the parametric tests. Mann-Whitney U tests were used to make comparisons between the size of summer steelhead sampled at the fishwheels and summer steelhead sampled in the tributaries (Cranberry, Damdochax, Kwinageese and Meziadin) for males and females.

Fecundity was estimated using the regression developed for Skeena River summer steelhead by Wilkman and Stockerl (1981),

(equation 1) $$\text{number of eggs/steelhead} = 0.5e^{(2.099*\ln(\text{mean length}) - 5.156)}$$

because a fecundity regression did not exist for either Nass River summer or winter steelhead. The mean smolt ages were compared between tributary populations using an ANOVA test. The mean lengths of steelhead were compared between freshwater and ocean age groups using an ANOVA test and *post hoc* comparisons were made using Tukey's HSD test. All statistical comparisons were performed using SPSS computer software (Anonymous 1996).

3.2.0.0 Steelhead Productivity and Allowable Harvest Rates

The relationship between spawner stock size and the number of recruits in the Nass River was assumed to be similar to the Beverton-Holt relationship. Ricker (1975) described the Beverton-Holt relationship as:

(equation 2) $$R = P/\ (1 - A*(1-P/P_r))$$

where R was the number of recruits, P was the number of spawning adults, A was a measure of stock productivity (Beverton-Holt's A value) and P_r was the number of spawning adults at replacement (carrying capacity; K). Keogh River winter steelhead had an asymptotic stock-recruitment relationship that resembled the Beverton-Holt stock-recruit curve (Tautz *et al*. 1992; Ward 1996). Also, Bjornn (1987) reported that the stock-recruitment relationship for Clearwater River summer steelhead (Idaho) followed the Beverton-Holt relationship.

In addition to Beverton-Holt's A value, steelhead stock productivity was also described as the number of recruits produced per adult spawner when the number of adult spawners was at Maximum Sustainable Yield (MSY). Calculation of the number of recruits per spawner and the allowable harvest rate was required to estimate Beverton-Holt's A value.

The number of recruits per spawner at MSY was calculated using survival rate estimates at each of the life history stages (Figure 2). The number of eggs per steelhead was calculated using the aforementioned fecundity relationship (Wilkman and Stockerl 1981) and mean female length. Tautz *et al*. (1992) estimated the egg-to-fry survival rate (S_1) as 10 percent for Keogh River winter steelhead and applied the estimate to Skeena River summer steelhead. The fry-to-smolt survival rate (S_2) was calculated using the relationship described by Tautz *et al*. (1992) derived from Keogh River winter steelhead and used to estimate the fry-to-smolt survival rate of Skeena River summer steelhead:

(equation 3) $$S_2 = e^{-0.7174 * (\text{mean smolt age})}$$

Tautz *et al*. (1992) estimated the smolt-to-adult survival rate (S_3) as 14 percent which was the geometric mean of estimates of Keogh River winter steelhead. Egg-to-fry and smolt-to-adult survivals were assumed density independent and smolt-to-adult survival was density dependent for summer and winter steelhead (Bjornn 1987; Tautz *et al*. 1992). Survival rate estimates based on Keogh River winter steelhead may not accurately reflect survival rates for Nass River summer or winter steelhead because of geographical disparity and differences in life history. However, the Keogh River survival rate estimates were the best available data to model Nass River steelhead.

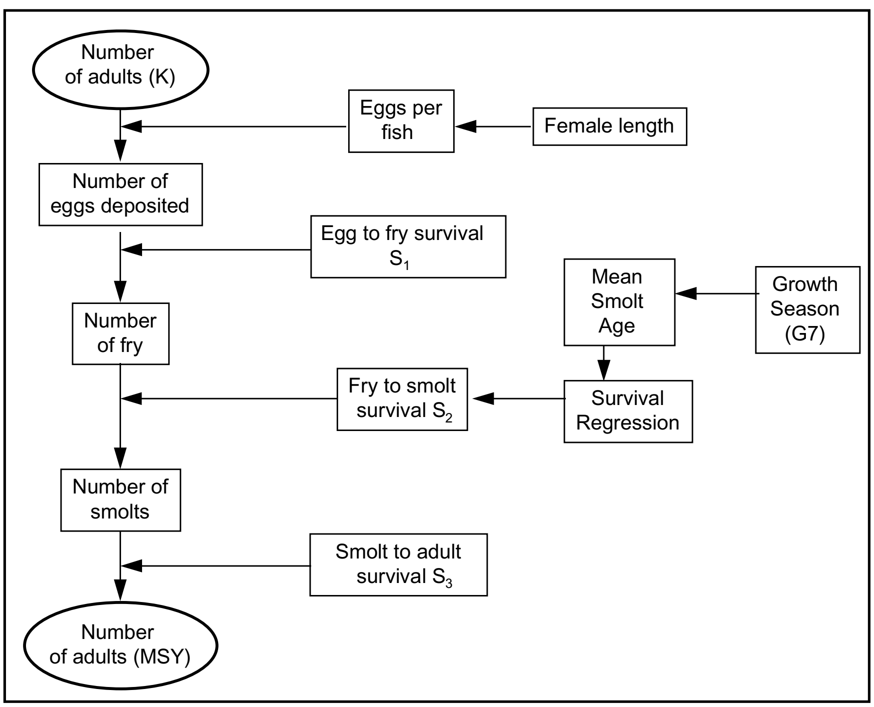

Figure 2. Semelparous steelhead life history model used to estimate steelhead productivity and allowable harvest rates by Tautz *et al*. (1992).

Tautz *et al*. (1992) estimated the mean smolt age using the growth season length (G7; number of days with water temperature > 7^{O} C), but since G7 data were not available for Nass River tributaries, the mean smolt age was estimated from adult scales. Hooton *et al*. (1987) and Jensen and Johnsen (1982) discussed some of the negative biases in using adult scales to estimate freshwater ages of steelhead and Atlantic salmon, respectively. However, Bocking and English (1992) illustrated both methods were reasonably similar for B.C. steelhead.

After the survival rate estimates were calculated, the number of recruits per spawner at MSY (RPS) was calculated as:

(equation 4) $$RPS = 1 * \text{Number of eggs/steelhead} * S_1 * S_2 * S_3$$

The relationship between the number of recruits per spawner and the allowable harvest rate (μ_{msy}) was given by Ricker (1975) as:

(equation 5) $$\mu_{msy} = (RPS - 1) / RPS$$

Given the allowable harvest rate, Beverton-Holt's A value was calculated using the equation (Ricker 1975):

(equation 6) $$A = 1 - (1 - \mu_{msy})^2$$

In addition, updated biostandards were used to include the most recent survival estimates and a wider range of environmental variability to make comparisons to the results of the biostandards used by Tautz *et al*. (1992). The Keogh River egg-to-fry survival was estimated as the geometric mean of data collected from 1976 to 1982 (0.058; Ward and Slaney 1993). Smolt-to-adult survival was estimated as the geometric mean of data collected from 1976 to 1993 (0.104; Ward and Slaney 1988; B. Ward, personal communication). These survival estimates were considerably lower than the estimates used by Tautz *et al*. (1992) to estimate stock productivity and allowable harvest rates for Skeena River steelhead.

3.3.0.0 Uncertainty and Sensitivity Analysis

The uncertainty in the life history model estimates (i.e. recruits per spawner, allowable harvest rate, Beverton-Holt's A value) were illustrated by the graphical distribution of the estimate's variance. The distribution of the life history model estimate's variance was dependent upon the distribution and amount of variance in the life history parameters (female length, mean smolt age, egg-to-fry survival, smolt-to-adult survival) involved in the estimate's calculations. *Monte Carlo* sampling was used to estimate the distribution of a life history model estimate's variance (Sargent and Wainwright 1996).

With *Monte Carlo* sampling, the empirical life history model parameters and their distribution were treated as the population and a large number of resamples were randomly drawn with replacement. The resamples were slightly and randomly different from the original life history model parameter and thus were analogous to a series of independent random samples. After many resamples, a frequency distribution was constructed of the life history model estimates. The frequency distribution indicated the probability of observing a life history model estimate within a specified range (Sargent and Wainwright 1996).

The statistical distributions of the life history parameters were estimated from the distributions of observed data and from the shape of distributions reported in the literature. The distribution of female lengths for populations with large samples (pooled among years and ocean age groups) did not follow a typical statistical distribution. Therefore, female length was assumed to follow a distribution similar to the observed length frequency histogram for 2 cm categories. Female lengths were pooled over a period from 1974 to 1996 and were influenced by environmental and ocean age variability. However, for populations with small samples ($n < 20$; Meziadin, Chambers, Ishkheenickh, Tseax) a normal distribution was assumed around the mean female length. Female lengths were not partitioned by ocean age for analyses because of small samples (for some groups) and high inter-annual variability in the proportion of ocean aged steelhead which results from variable recruitment or environmental conditions (Hooton *et al* 1987; Ward and Slaney 1988; Ward 1989; Ward 1996).

The statistical distribution of fry-to-smolt survival was assumed to be dependent upon the distribution of mean smolt age and the variability resulting from the regression estimation (equation 2). Variability in fry-to-smolt survival was dependent on the additive measurement error (variability in mean smolt age; normally distributed) and multiplicitive variability (regression estimation). Bradford (1995) reported that additive measurement error and multiplicitive variability may cause the statistical distribution of survival rates to be between normal and lognormal distributions. Although fry-to-smolt survivals estimated from the regression developed for Keogh River winter steelhead may not accurately resemble survivals for Nass River winter or summer steelhead, it was the best available estimator for fry-to-smolt survival rates to model Nass River steelhead.

Egg-to-fry survival data (1976-1982; Ward and Slaney 1993) were assumed to follow a lognormal distribution (Bradford 1995). The observed distribution of empirical data were not statistically tested because of low sample size (n=7). The geometric mean and standard deviation of the data were used as the distributional parameters for egg-to-fry survival. Smolt-to-adult survivals were also estimated from Keogh River winter steelhead (1977-1983, Ward and Slaney 1988; 1976-1993, unpublished data, B. Ward, personal communication) and were modeled by a lognormal distribution (Peterman 1981; Bradford 1995). The geometric mean and standard deviation were used as the distributional parameters for smolt-to-adult survival. Although Keogh River winter steelhead smolt-to-adult and egg-to-fry survival rates may not be indicative of the survival estimates for Nass River summer or winter steelhead because of geographical disparity and life history differences, they were the best available data to model Nass River steelhead.

The sensitivity of the life history model estimates was dependent upon the life history parameters involved in the calculations (equations 4, 5 and 6). The sensitivity of a parameter indicates the amount of uncertainty in the life history model estimates resulting from the uncertainty in the measurement of the parameter and from the model sensitivity. Model sensitivity was the overall effect of changes in the value of the parameter on the life history model estimate (Sargent and Wainwright 1996). Thus, some parameters may have a higher influence (more sensitive) on the uncertainty in the life history model estimate than other parameters. By using the empirical data for female length, mean smolt age, egg-to-fry and smolt-to-adult survivals, the *Monte Carlo* simulations estimated the average life history model estimates expected given escapement under the environmental conditions that existed when the data were collected (NRC 1996).

Sensitivity was calculated by computing the rank correlation coefficients between the life history parameters and the life history model estimates during *Monte Carlo* simulations. Correlation coefficients indicated the degree to which life history parameters and model estimates change together (Sargent and Wainwright 1996). Therefore high correlation coefficients indicated a high contribution to the variance in the life history model estimate. Positive coefficients indicated that increases in life history parameters resulted in increases in life history model estimates. The parameter's contribution to the variance in the model estimate was calculated by squaring the rank correlation coefficient (Sargent and Wainwright 1996).

4.0.0.0 Results

4.1.0.0 Life History Characteristics

4.1.1.0 Summer Steelhead

4.1.1.1 Bell-Irving River

Information on the adult size and migration timing of Bell-Irving River steelhead was limited to a steelhead telemetry project (Alexander and Koski 1995). Alexander and Koski (1995) sampled a single female (76 cm) and a single male (74 cm) at the Nass River fishwheels on July 22 and August 10, 1993, respectively. The estimated fecundity for Bell-Irving steelhead was 3211 eggs/fish (equation 1), based on the length of the 76 cm female. The female was freshwater age 2 and ocean age 2+, but the freshwater age may be negatively biased. Scale age data were not available for the male.

4.1.1.2 Cranberry River

Information and data for adult Cranberry River steelhead was from a steelhead telemetry project (Alexander and Koski 1995), memorandum letters and scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). At the Nass River fishwheels, Cranberry River steelhead were sampled from July 23 to September 30, 1993 (Alexander and Koski 1995). Steelhead were sampled in the Cranberry River on November 1, 1996, October 20, 1995, October 22, 1980, October 30 to November 28, 1979, September 19 to 21, 1978, September 17, 1977 to April 16, 1978, April 3, 1977, October 30, 1975, and November 7, 1974 (Appendix A). Of the 157 steelhead sampled, 157 had length data, 136 had scale age data and 136 had length and scale age data (Appendix A).

Male (mean = 68.3 cm) and female (mean = 68.7 cm) Cranberry River steelhead were similar in size (Mann-Whitney U = 2975, P = 0.764; Table 1). The length distribution of male and female steelhead illustrated males were similar in size to females (Figure 3). Among ocean age 1+, males (mean = 68.5 cm) were larger than females (mean = 58.1 cm; Mann-Whitney U = 243.5, P = 0.004). However, ocean age 2+ males (mean = 76.4 cm) and females (mean = 74.2 cm) were similar in size (Mann-Whitney U = 476, P = 0.212). The fork lengths of male summer steelhead differed between populations (Kruskal-Wallis = 10.458, P = 0.015; Table 1) and the fork lengths of female summer steelhead differed between populations (Kruskal-Wallis = 8.206, P = 0.042; Table 1). The Kruskal-Wallis results for male and female summer steelhead indicated at least one of the populations (and not necessarily all the populations) was different from another population.

Table 1. A summary of the mean, standard error, standard deviation and range in fork lengths for male and female summer steelhead in Cranberry, Damdochax, Kwinageese and Meziadin rivers.

	Summer Steelhead Population				*Kruskal-Wallis*
	Cranberry	**Damdochax**	**Kwinageese**	**Meziadin**	***P* values**
Female					
Mean fork length(cm)	68.7	74.5	72.5	71.4	0.042
Standard error (cm)	1.11	1.05	1.64	2.39	
Standard deviation (cm)	9.37	5.97	9.00	7.56	
Size range (cm)	53-89	61-86	53-89	62-82	
Sample size	72	33	30	10	
Male					
Mean fork length(cm)	68.3	78.4	70.0	69.7	0.015
Standard error (cm)	1.04	2.67	1.96	4.93	
Standard deviation (cm)	9.59	12.50	12.39	12.08	
Size range (cm)	52-88	53-99	51-97	58-89	
Sample size	85	22	40	6	
Mann-Whitney U *P* values	0.764	0.055	0.421	0.515	

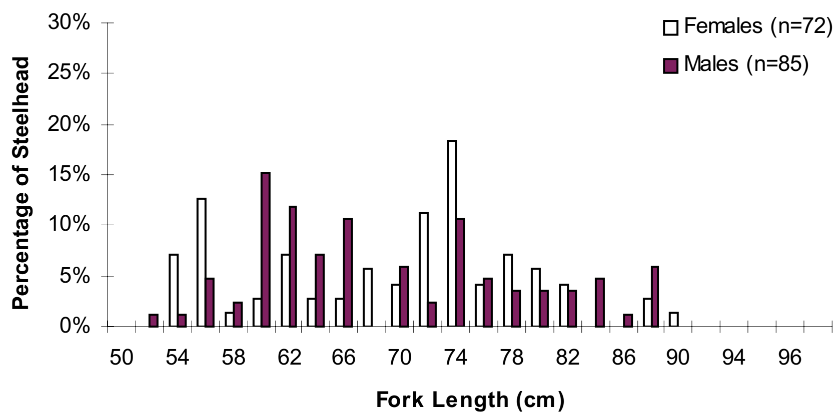

Figure 3. Percentage of male and female Cranberry River steelhead by 2 cm categories of fork length.

The length distributions of Nass River summer steelhead were visually compared between rivers with notched Tukey box plots (Figure 4). Male and female steelhead were pooled to increase sample sizes for comparisons, since the fork lengths were similar between male and female summer steelhead (Table 1). Damdochax steelhead were similar in size to Kwinageese and Meziadin steelhead, however, Damdochax steelhead were larger than Cranberry steelhead (Figure 4).

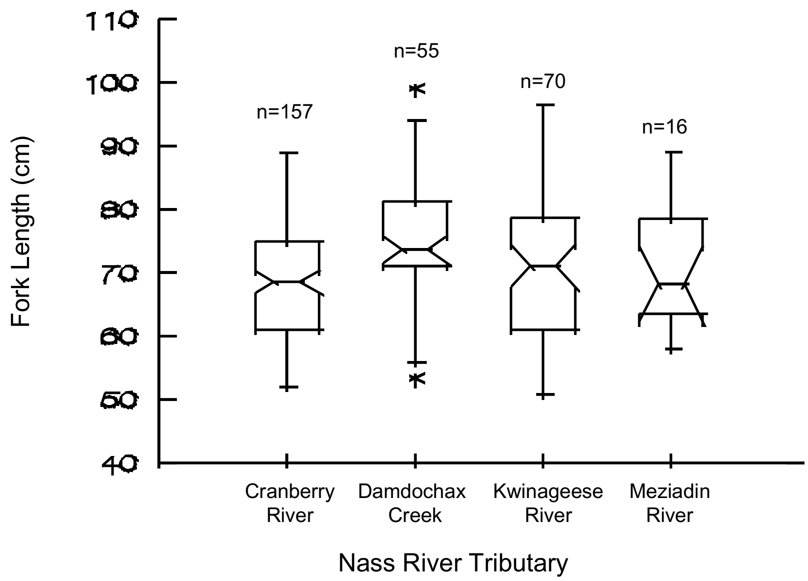

Figure 4. Notched Tukey box plots of summer steelhead length (cm) for Nass River tributaries. The extent of the box represented the 25th and 75th percentiles, the lines (whiskers) extending from the boxes represent the data range and the asterisks (*) represent statistical outliers. Nonoverlapping notches between each river indicate a statistical difference at a rough 5% significance level (Chambers *et al*. 1983; Haas and McPhail 1991).

The estimated fecundity of Cranberry River steelhead was 2597 eggs/fish (equation 1). Five percent of Cranberry River steelhead were repeat spawners (4 females and 3 males) and four percent had regenerated scales during the freshwater growth period. The mean smolt age was 3.53 years, with 48, 51 and 1 percent of steelhead being freshwater age 3, 4 and 5, respectively (Table 2). The mean smolt age of Cranberry River steelhead differed from Meziadin River steelhead (ANOVA, F = 4.34, P = 0.001; Tukey HSD = 0.53, P = 0.002), but was similar to the mean smolt age of Damdochax Creek and Ishkheenickh, Kwinageese and Tseax river steelhead (Tukey HSD, P > 0.05; Table 2). Freshwater age 3 adult steelhead were similar in size to freshwater age 4 adult steelhead (t-test = 0.474, P = 0.636; Table 3). Forty-five (45), 50, 3 and 2 percent of Cranberry River steelhead were ocean age 1+, 2+, 3+ and 4+, respectively. Ocean age 1+ steelhead were significantly smaller than ocean age 2+ steelhead (t-test = 17.339, P <0.0005; Table 3). Ocean ages 3+ and 4+ were excluded from the analysis because of small samples (Table 3).

Table 2. A summary of the mean, standard error, standard deviation and range in smolt age for steelhead in the Cranberry (Cran.), Damdochax (Damd.), Ishkheenickh (Ishk.), Kwinageese (Kwin.), Meziadin (Mez.) and Tseax rivers.

	Steelhead Population						***ANOVA***
	Cran.	**Damd.**	**Ishk.**	**Kwin.**	**Mez.**	**Tseax**	***P* values**
Mean smolt age (yrs)	3.53	3.74	3.44	3.53	3.00	3.38	0.001
Standard error (yrs)	0.05	0.11	0.12	0.07	0.16	0.13	
Standard deviation (yrs)	0.52	0.59	0.51	0.50	0.63	0.50	
Age range (yrs)	3-5	2-5	3-4	3-4	2-4	3-4	
Sample size	131	27	18	57	16	16	

Table 3. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Cranberry River summer steelhead.

	Freshwater Age			Ocean Age			
	3	4	5	1+	2+	3+	4+
Mean length (cm)	68.8	68.0	66.0	59.6	75.1	74.2	84.7
Standard error (cm)	1.15	1.23	NA	0.51	0.73	1.71	1.70
Standard deviation (cm)	9.16	10.10	NA	4.01	6.05	3.41	2.94
Length range (cm)	53-88	53-89	NA	53-74	63-89	71-79	81-86
Sample size	63	67	1	61	68	4	3

4.1.1.3 Kiteen River

The Kiteen River is a major tributary to the Cranberry River (Figure 1; Sebastian 1987). Information on the adult size and age of Kiteen River steelhead was from scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). Steelhead were sampled on December 2, 1984, August 24, 1982 and on April 3, 1977. Two of the three steelhead sampled were female. The male steelhead was 81 cm, but female lengths were not recorded. Scale ages were available for two steelhead, both freshwater age 3 and ocean age 2+. Kiteen River steelhead may be similar to Cranberry steelhead because of the proximity of the two streams, however comparisons were limited by small samples.

4.1.1.4 Damdochax Creek

Information on adult steelhead in the Damdochax Creek was from a steelhead telemetry project (Alexander and Koski 1995), memorandum letters and scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). One Damdochax Creek steelhead was captured at the Nass River fishwheels on July 26, 1993 (Alexander and Koski 1995). Steelhead were sampled in the Damdochax Creek from September 6 to October 28, 1996, on May 4, 1994, May 1979 and from October 1 to December 7, 1979 (Appendix A). Of the 74 steelhead sampled, 55 had length data, 31 had scale age data and 12 had length and scale age data (Appendix A).

Male (mean = 78.4 cm) and female (mean = 74.5 cm) Damdochax Creek steelhead were similar in size (Mann-Whitney U = 251.5, $P = 0.055$; Table 1). The length distribution of male and female steelhead illustrated that males were slightly larger than females (Figure 5). Statistical comparisons were not made between sexes within ocean age groups because of small samples. The fork lengths of male summer steelhead differed between populations (Kruskal-Wallis = 10.458, $P = 0.015$; Table 1) and the fork lengths of female summer steelhead differed between populations (Kruskal-Wallis = 8.206, $P = 0.042$; Table 1). The Kruskal-Wallis results for male and female summer steelhead indicated at least one of the populations (and not necessarily all the populations) was different from another population. Damdochax steelhead were similar in size to Kwinageese and Meziadin steelhead, however Damdochax steelhead were larger than Cranberry steelhead (Figure 4).

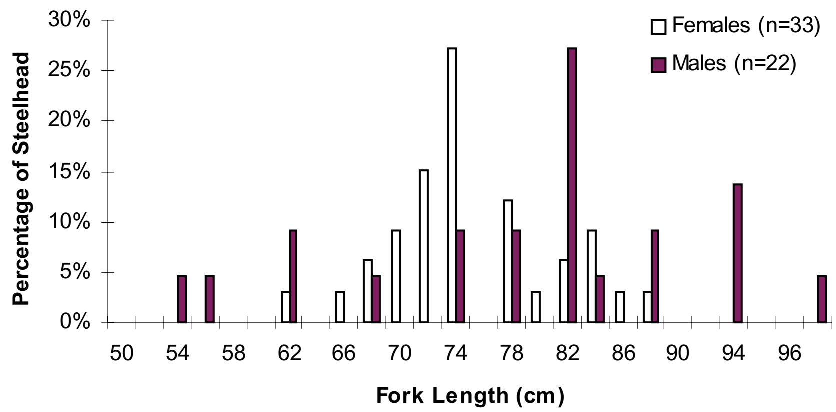

Figure 5. Percentage of male and female Damdochax Creek steelhead by 2 cm categories of fork length.

The estimated fecundity of Damdochax Creek steelhead was 3079 eggs/fish (equation 1). Thirteen (13) percent of Damdochax Creek steelhead were repeat spawners (3 females and 1 male) and 13 percent had regenerated scales during the freshwater growth period. The mean smolt age was 3.74 years, with 4, 22, 70 and 4 percent of steelhead being freshwater age 2, 3, 4 and 5, respectively (Table 2). The mean smolt age of Damdochax Creek steelhead differed from Meziadin River steelhead (ANOVA, F = 4.34, P = 0.001; Tukey HSD = 0.74, P < 0.0005), but was similar to the mean smolt age of Cranberry, Ishkheenickh, Kwinageese and Tseax river steelhead (Tukey HSD, P > 0.05; Table 2). The mean length of adult steelhead was similar between freshwater age 3 and 4, although the samples were small (t-test = 1.505, P = 0.183; Table 4). Ten (10), 74, 10 and 6 percent of Damdochax Creek steelhead were ocean age 1+, 2+, 3+ and 4+, respectively. The mean length of adult steelhead at different ocean ages was not tested because of small samples for ocean age 1+, 3+ and 4+ (Table 4).

Table 4. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Damdochax Creek summer steelhead.

	Freshwater Age			**Ocean Age**			
	2	**3**	**4**	**1+**	**2+**	**3+**	**4+**
Mean length (cm)	67.0	83.8	73.2	61	73.8	94	85
Standard error (cm)	NA	6.73	3.82	NA	1.81	NA	1.30
Standard deviation (cm)	NA	11.66	8.54	NA	5.12	NA	1.84
Length range (cm)	NA	71-94	61-85	NA	67-85	NA	84-86
Sample size	1	3	5	1	8	1	2

4.1.1.5 Kwinageese River

Information on adult steelhead in the Kwinageese River was from a steelhead telemetry project (Alexander and Koski 1995), a technical report (Schultze 1981), memorandum letters and scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). One Kwinageese River steelhead was sampled at the Nass River fishwheels on August 9, 1993 (Alexander and Koski 1995). Steelhead were sampled in the Kwinageese River on October 19, 1995, October 12 to 13, 1982, and October 16 to 18, 1981 (Appendix A). Of the 70 steelhead sampled, 70 had length data, 59 had scale age data and 59 had length and scale age data (Appendix A).

Male (mean = 70.0 cm) and female (mean = 72.5 cm) Kwinageese River steelhead were similar in size (Mann-Whitney U = 532.5, $P = 0.421$; Table 1). The length distribution of male and female steelhead illustrated males were similar in size to females (Figure 6). Ocean age 1+ males and females were similar in size (Mann-Whitney U = 29.5, $P = 0.138$). Among ocean age 2+ steelhead, males (mean = 82.4 cm) were larger than females (mean = 72.8 cm; Mann-Whitney U = 19.5, $P < 0.0005$). The fork lengths of male summer steelhead differed between populations (Kruskal-Wallis = 10.458, $P = 0.015$; Table 1) and the fork lengths of female summer steelhead differed between populations (Kruskal-Wallis = 8.206, $P = 0.042$; Table 1). The Kruskal-Wallis results for male and female summer steelhead indicated at least one of the populations (and not necessarily all the populations) was different from another population, although Kwinageese steelhead were similar in size to Cranberry, Damdochax and Meziadin steelhead (Figure 4).

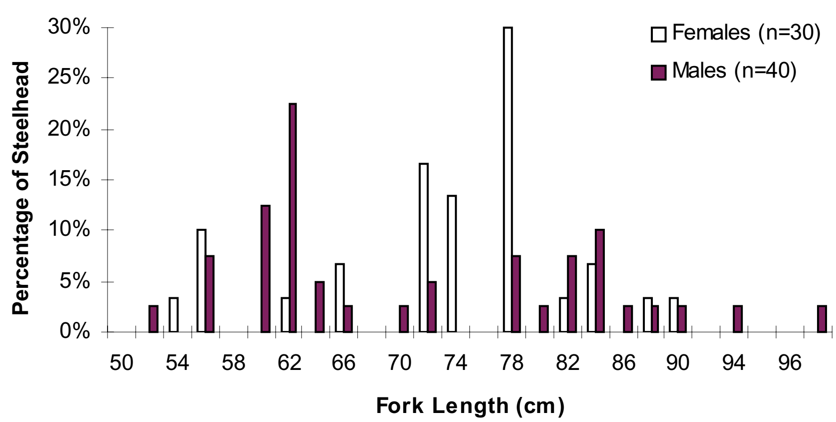

Figure 6. Percentage of male and female Kwinageese River steelhead by 2 cm categories of fork length.

The estimated fecundity of Kwinageese River steelhead was 2908 eggs/fish (equation 1). Five percent of Kwinageese River steelhead were repeat spawners (1 female and 2 males) and four percent had regenerated scales during the freshwater growth period. The mean smolt age was 3.53 years, with 47 and 53 percent of steelhead being freshwater age 3 and 4, respectively (Table 2). The mean smolt age of Kwinageese River steelhead differed from Meziadin River steelhead

(ANOVA, F = 4.34, *P* = 0.001; Tukey HSD = 0.53, *P* = 0.006), but was similar to the mean smolt age of Damdochax Creek and Cranberry, Ishkheenickh and Tseax river steelhead (Tukey HSD, *P* > 0.05; Table 2). Adult Kwinageese River steelhead with freshwater age 4 (mean = 72.4 cm) were larger than steelhead with freshwater age 3 (mean = 65.7 cm; t-test = 2.440, *P* = 0.018; Table 5). Forty-four (44), 48 and 8 percent of Kwinageese River steelhead were ocean age 1+, 2+ and 3+, respectively. The mean length of adult steelhead was significantly different between ocean ages (ANOVA, F = 73.77, *P* < 0.0005) and *post hoc* tests (Tukey HSD) indicated the mean length of adults increased with ocean age (*P* < 0.0005; Table 5).

Table 5. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Kwinageese River summer steelhead.

	Freshwater Age		Ocean Age		
	3	4	1+	2+	3+
Mean length (cm)	65.7	72.4	59.9	75.8	87.9
Standard error (cm)	2.10	1.80	1.03	1.15	3.65
Standard deviation (cm)	10.89	9.85	5.25	6.09	8.15
Length range (cm)	51-94	56-97	51-76	61-89	76-97
Sample size	27	30	26	28	5

4.1.1.6 Meziadin River

Information on adult steelhead size and age in the Meziadin River was from the Meziadin River fishway (unpublished data; M.R. Link, personal communication; Figure 1), DNA tissue sampling in 1996 and a steelhead telemetry project (Alexander and Koski 1995). Steelhead were sampled at the Meziadin River fishway from September 17 to 22, 1996. From October 9 to 22, 1996, nine steelhead were sampled in the Meziadin River downstream of Meziadin Lake. Meziadin River steelhead were sampled at the Nass River fishwheels on August 3 and 5, 1993 (Alexander and Koski 1995). Length and scale age data were available for all 16 steelhead sampled (Appendix A).

Male (mean = 69.7 cm) and female (mean = 71.4 cm) Meziadin River steelhead were similar in size (Mann-Whitney U = 24, *P* = 0.515; Table 1). The length distribution of male and female steelhead illustrated that males were similar in size to females (Figure 7). Statistical comparisons were not made between sexes within ocean age groups because of small samples. The fork lengths of male summer steelhead differed between rivers (Kruskal-Wallis = 10.458, *P* = 0.015; Table 1) and the fork lengths of female summer steelhead differed between populations (Kruskal-Wallis = 8.206, *P* = 0.042; Table 1). The Kruskal-Wallis results for male and female summer steelhead indicated at least one of the populations (and not necessarily all the populations) was different from another population, although Meziadin steelhead were similar in size to Cranberry, Damdochax and Kwinageese steelhead (Figure 4).

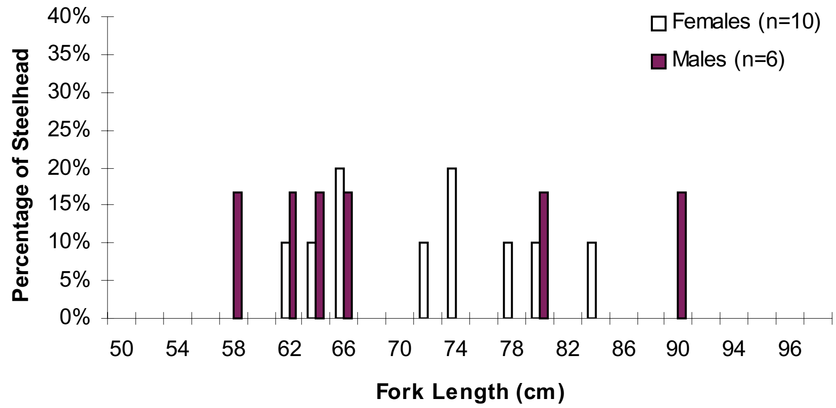

Figure 7. Percentage of male and female Meziadin River steelhead by 2 cm categories of fork length.

The estimated fecundity of Meziadin River steelhead was 2816 eggs/fish (equation 1). Six percent of Meziadin River steelhead were repeat spawners (1 male) and none of the 16 steelhead had regenerated scales. The mean smolt age was 3.00 years, with 19, 62 and 19 percent of steelhead being freshwater age 2, 3 and 4, respectively (Table 2). The mean smolt age of Meziadin River steelhead differed from Cranberry, Damdochax and Kwinageese river steelhead (ANOVA, F = 4.34, P = 0.001; Tukey HSD = 0.53, P = 0.002, Tukey HSD = 0.74, P < 0.0005, and Tukey HSD = 0.53, P = 0.006, respectively), but was similar to the mean smolt age of Ishkheenickh and Tseax river steelhead (Tukey HSD = 0.44, P = 0.140, and Tukey HSD = 0.38, P = 0.337, respectively; Table 2). The mean length of adult steelhead was similar between freshwater age 2, 3 and 4 (ANOVA, F = 0.904, P = 0.429; Table 6). Fifty (50), 44 and 6 percent of Meziadin River steelhead were ocean age 1+, 2+ and 3+, respectively. Ocean age 2+ steelhead were significantly larger than ocean age 1+ steelhead (t-test = 7.514, P < 0.0005; Table 6).

Table 6. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Meziadin River summer steelhead.

	Freshwater Age			Ocean Age		
	2	3	4	1+	2+	4+
Mean length (cm)	75.7	68.4	73.7	63	77	89
Standard error (cm)	6.44	3.05	1.76	0.85	1.75	NA
Standard deviation (cm)	11.15	9.63	3.06	2.41	4.65	NA
Length range (cm)	63-84	58-89	71-77	58-66	71-84	NA
Sample size	3	10	3	8	7	1

4.1.1.7 Seaskinnish River

Information on the adult size and migration timing of Seaskinnish River steelhead was limited to a steelhead telemetry project (Alexander and Koski 1995). Alexander and Koski (1995) sampled one male (75 cm) at the Nass River fishwheel on August 28, 1993. The steelhead had regenerated the freshwater growth portion of the scale, but was ocean age 2+.

4.1.1.8 Zolzap Creek and Slough

Information on the adult size and migration timing of Zolzap Creek steelhead was limited to a steelhead telemetry project (Alexander and Koski 1995). Alexander and Koski (1995) sampled one female (77 cm) at the Nass River fishwheels on August 16, 1993. The estimated fecundity for Zolzap Creek steelhead was 3300 eggs/fish (equation 1), based on the length of the 77 cm female. The steelhead was freshwater age 4 and ocean age 3+, but the freshwater age may be negatively biased.

4.1.1.9 Nass River Fishwheels

Information on steelhead captured at the Nass River fishwheels was obtained from Koski and English (1996) and from LGL Ltd. files (R.C. Bocking, personal communication). From 1992 to 1996, steelhead were sampled at the fishwheels from late June to early September (Link *et al*. 1993; Link and English 1994; Koski and English 1996). Length and sex data were from LGL Ltd. files (R.C. Bocking, personal communication; n=18, 78, 111 and 416 for 1992, 1993, 1994 and 1996, respectively) whereas age data were from Koski and English (1996; n=16, 48 and 4 for 1992, 1993 and 1994, respectively) and Skeena Region MOELP data files (n=382 for 1996).

From 1992 to 1994, male and female steelhead were similar in size (t-test $P > 0.05$; Table 7), but differed in size for 1996 (t-test = 2.247, $P = 0.025$). Male steelhead were similar in size between years (ANOVA, F = 1.74, $P = 0.159$; Table 7). Female steelhead differed in size between years (ANOVA, F = 3.945, $P = 0.009$), and *post hoc* tests indicated 1993 females differed from those in 1992 (Tukey HSD = 7.82, $P = 0.011$) and 1996 (Tukey HSD = 3.68, $P = 0.034$), but all other years were similar (Tukey HSD, $P > 0.05$). The Tukey box plot indicated steelhead (pooled males and females) sampled at the fishwheels were graphically similar in size between 1992, 1993, 1994 and 1996 (Figure 8). When pooled among years, male steelhead sampled at the fishwheels (mean = 70.4 cm) were similar in size to pooled male steelhead sampled in the tributaries (Cranberry, Damdochax, Kwinageese and Meziadin; mean = 70.3 cm; Mann-Whitney U = 24167, $P = 0.549$). However, female steelhead sampled at the fishwheels (mean = 69.2 cm) differed in size to pooled female steelhead sampled in the tributaries (mean = 70.9 cm; Mann-Whitney U = 19663, $P = 0.049$), although the magnitude of differences was small.

Table 7. A summary of the mean, standard error, standard deviation and range in fork lengths male and female summer steelhead sampled at the Nass River fishwheels in 1992, 1993, 1994 and 1996.

	1992	**1993**	**1994**	**1996**	***ANOVA P* values**
Female					
Mean fork length(cm)	64.6	72.5	69.1	68.8	0.009
Standard error (cm)	1.98	1.51	1.03	0.55	
Standard deviation (cm)	7.40	10.14	8.18	7.87	
Size range (cm)	52-73	51-97	48-88	50-89	
Sample size	14	45	63	207	
Male					
Mean fork length(cm)	61.3	68.1	70.1	70.8	0.159
Standard error (cm)	4.49	1.63	1.48	0.70	
Standard deviation (cm)	9.18	8.92	10.12	10.07	
Size range (cm)	52-71	48-80	54-91	48-97	
Sample size	4	30	47	209	
t-test P values	0.452	0.061	0.562	0.025[1]	

1. T-test *p*-value for equal variances not assumed. The t-test is robust to deviations from the assumption of equal variance when samples sizes are approximately equal (Zar 1984).

The estimated fecundity of steelhead sampled at the fishwheels in 1996 was 2605 eggs/fish (equation 1). In 1996, 14 of the 382 steelhead sampled (4%; 8 males, 5 females and 1 unknown) were repeat spawners and 58 (15%) had regenerated scales. Scale samples collected at the fishwheels from 1992 to 1994 were re-aged by the Fisheries Branch office in Smithers (Skeena Region) because the samples aged by the DFO scale lab were suspected to be under-aged. However, not all the samples were available at the DFO scale lab and therefore the sample sizes differed from the results reported in Table 4 of Koski and English (1996). The mean smolt ages of steelhead sampled at the fishwheels and re-aged were 3.29 years (standard error = 0.13) for 1992 (n=14), 3.22 years (standard error = 0.08) for 1993 (n=27), and 3.23 years (standard error = 0.05) for 1994 (n=73). Koski and English (1996) reported the mean smolt age of steelhead was 2.8 in 1992 (n=16), 3.2 in 1993 (n=48) and 3.8 years in 1994 (n=4). In 1996, the mean smolt age was 3.27 years (n=325; standard error = 0.025, standard deviation = 0.46) and 0.3, 72.6, 26.8 and 0.3 percent of steelhead were freshwater age 2, 3, 4 and 5, respectively.

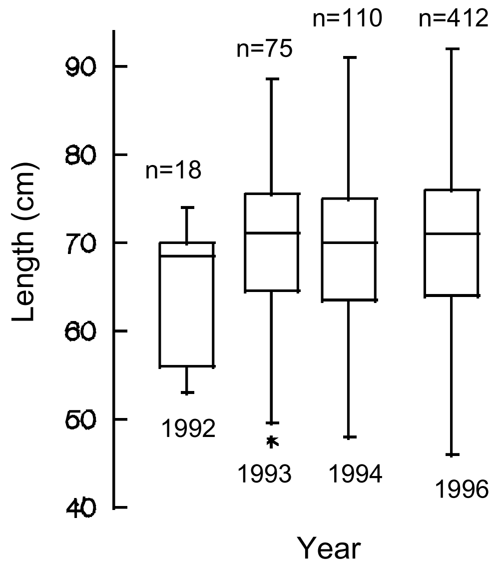

Figure 8. Tukey Box Plots for summer steelhead sampled at the Nass River fishwheels for 1992, 1993, 1994 and 1996.
The extent of the box represented the 25th and 75th percentiles, the lines (whiskers) extending from the boxes represent the data range and the asterisks (*) represent statistical outliers.

In 1996, male and female steelhead were similar in size at ocean age 1+, 3+ and 4+ (Mann-Whitney U = 1195, P = 0.84, Mann-Whitney U = 23.5, P = 0.27, Mann-Whitney U = 8.5, P = 0.73, respectively), but males (mean = 74.3 cm) were larger than females (mean = 72.1 cm) at ocean age 2+ (Mann-Whitney U = 6154, P < 0.0005; Table 8). Among males, length increased with ocean age (ANOVA, F = 115.90, P < 0.0005; Tukey HSD, P < 0.025), but was similar between ocean age 3+ and 4+ (Tukey HSD = 0.61, P = 0.997; Table 8). Adult male steelhead were similar in size between freshwater age 3 and 4 (t-test = 1.45, P = 0.151). Among females, length increased with ocean age (ANOVA, F = 76.96, P < 0.0005; Tukey HSD, P < 0.025), but was similar between ocean age 3+ and 4+ (Tukey HSD = 0.01, P = 0.999). Adult female steelhead were similar in size between freshwater age 3 and 4 (t-test = 0.52, P = 0.604). Statistical comparisons of lengths were not performed on freshwater and ocean age steelhead collected from 1992 to 1994 because the age data (Table 4 in Koski and English 1996) were not linked to the length data in the LGL Ltd. files.

Table 8. Size, standard error (SE), standard deviation (SD), range and sample size of steelhead sampled at the Nass River fishwheels (1996) at freshwater and ocean age.

Freshwater Age	Sex		Ocean Age				All
			1+	2+	3+	4+	
2	Female	Length (cm)	NA	65.0	NA	NA	65.0
		Sample size	NA	1	NA	NA	1
3	Female	Length (cm)	58.3	72.0	74.25	84.0	69.0
		SE (cm)	0.92	0.47	2.10	1.0	0.69
		SD (cm)	5.06	4.46	4.19	1.41	7.70
		Range (cm)	50-69	56-82	70-80	83-85	50-85
		Sample size	30	89	4	2	125
	Male	Length (cm)	59.3	74.1	82.2	86.0	70.8
		SE (cm)	1.06	0.64	4.52	5.00	0.88
		SD (cm)	5.70	5.54	10.10	7.07	9.23
		Range (cm)	48-71	57-85	74-96	81-91	48-96
		Sample size	29	75	5	2	111
4	Female	Length (cm)	61.7	73.1	80.0	NA	69.7
		SE (cm)	1.00	0.76	0.00	NA	1.05
		SD (cm)	3.73	3.96	0.00	NA	6.90
		Range (cm)	57-69	64-78	80-80	NA	57-80
		Sample size	14	27	2	NA	43
	Male	Length (cm)	61.8	73.4	78.3	80.5	73.1
		SE (cm)	1.97	1.03	8.86	4.50	1.25
		SD (cm)	3.95	5.81	17.73	6.36	8.18
		Range (cm)	57-65	61-91	59-97	76-85	57-97
		Sample size	4	32	4	2	43
5	Female	Length (cm)	NA	67	NA	NA	67
		Sample size	NA	1	NA	NA	1
All (includes steelhead with regenerated scales)	Female	Length (cm)	58.7	72.1	77.1	77.8	NA
		SE (cm)	0.70	0.38	1.81	4.27	NA
		SD (cm)	4.97	4.32	4.78	8.54	NA
		Range (cm)	50-69	56-82	70-83	66-85	NA
		Sample size	51	127	7	4	NA
	Male	Length (cm)	59.3	74.3	81.3	83.3	NA
		SE (cm)	0.82	0.54	3.62	3.17	NA
		SD (cm)	5.65	6.18	11.99	6.34	NA
		Range (cm)	48-78	49-92	59-97	76-91	NA
		Sample size	48	130	10	4	NA

4.1.2.0 Winter Steelhead

4.1.2.1 Chambers Creek

Information on adult steelhead size in Chambers Creek was limited to a single study by Bustard (1995). From May 8 to 9, 1994, Bustard (1995) sampled eight male and four female winter steelhead in Chambers Creek. Length data were available for the 12 steelhead, but scale age data were not collected (Appendix A). The skewed sex ratio (one female: three males) was hypothesized to indicate spawning was in progress at this time and that some of the females had emigrated from Chambers Creek (Bustard 1995).

Male (mean = 79.1 cm) and female (mean = 87.0 cm) Chambers Creek steelhead were similar in size (Mann-Whitney U = 8, *P* = 0.171; Table 9). The length distribution of male and female steelhead illustrated that females were generally larger than males (Figure 9). The fork lengths of male winter steelhead were similar between populations (Kruskal-Wallis = 2.453, *P* = 0.293; Table 9) and the fork lengths of female winter steelhead were similar between populations (Kruskal-Wallis = 5.160, *P* = 0.076; Table 9).

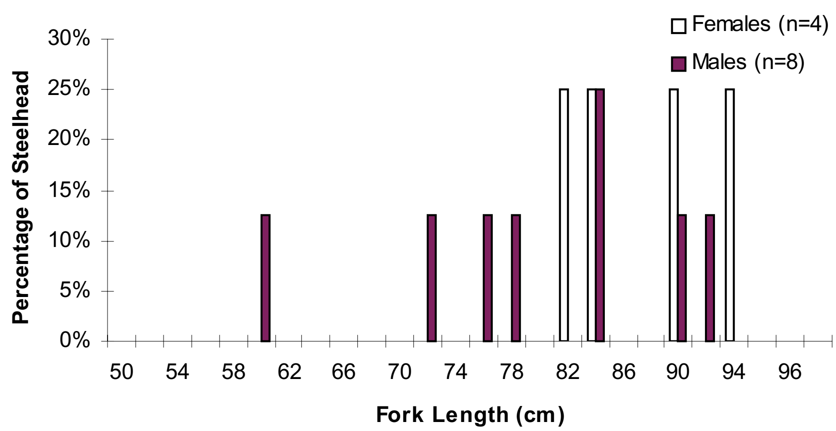

Figure 9. Percentage of male and female Chambers Creek steelhead by 2 cm categories of fork length.

The estimated fecundity of Chambers Creek steelhead was 4264 eggs/fish (equation 1). The mean smolt age and mean lengths at different ocean ages were not examined due to the absence of scale age data.

Table 9. A summary of the mean, standard error, standard deviation and range in fork lengths for male and female winter steelhead in Chambers Creek, Ishkheenickh River and Tseax River.

	Winter Steelhead Population			***Kruskal-Wallis***
	Chambers	**Ishkheenickh**	**Tseax[1]**	***P* values**
Female				
Mean fork length(cm)	87.0	80.2	72.8	0.076
Standard error (cm)	2.74	1.93	4.86	
Standard deviation (cm)	5.48	8.21	9.71	
Size range (cm)	81-93	64-88	62-83	
Sample size	4	18	4	
Male				
Mean fork length(cm)	79.1	73.2	79.7	0.293
Standard error (cm)	3.76	3.59	3.58	
Standard deviation (cm)	10.6	9.48	10.75	
Size range (cm)	59-92	66-91	63-94	
Sample size	8	7	9	
Mann-Whitney U *P* values	0.171	0.101	0.246	

1. Tseax River steelhead consisted of winter and summer steelhead

4.1.2.2 Ishkheenickh River

Information on Ishkheenickh River steelhead was from memorandum letters and from scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). Steelhead were sampled on April 20, 1994, May 7, 1990, April 15 and May 22, 1987, May 5 1985, April 25, 1982, and on May 6 and 13, 1978 (Appendix A). Of the 48 steelhead sampled, 25 had length data, 21 had scale age data, but only 4 had length and scale age data (Appendix A).

Male (mean = 73.2 cm) and female (mean = 80.2 cm) Ishkheenickh River steelhead were similar in size (Mann-Whitney U = 36, *P* = 0.101; Table 9). The length distribution of male and female steelhead illustrated males were similar in size to females (Figure 10). Statistical comparisons were not made between sexes within ocean age groups because of small samples. The fork lengths of male winter steelhead differed between populations (Kruskal-Wallis = 2.453, *P* = 0.293; Table 9) and the fork lengths of female winter steelhead differed between populations (Kruskal-Wallis = 5.160, *P* = 0.076; Table 9).

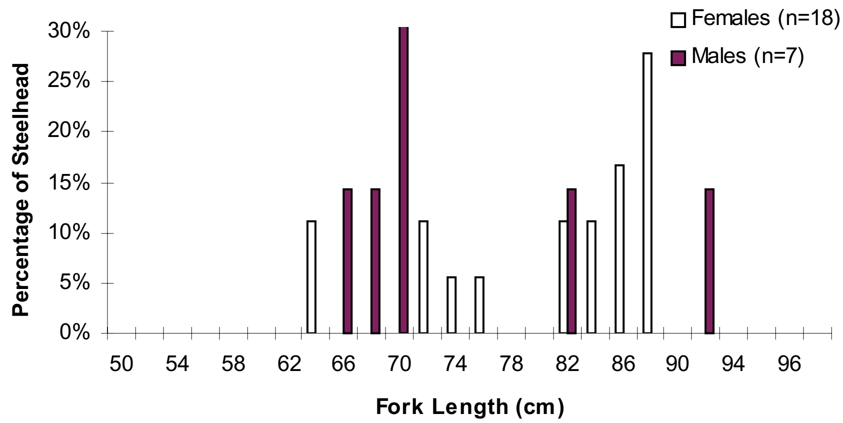

Figure 10. Percentage of male and female Ishkheenickh River steelhead by 2 cm categories of fork length.

The estimated fecundity of Ishkheenickh River steelhead was 3594 eggs/fish (equation 1). Twenty-three (23) percent of Ishkheenickh River steelhead were single repeat spawners (3 females, 1 male and 1 unknown sex), 5 percent were double repeat spawners (unknown sex) and 16 percent had regenerated scales during the freshwater growth period. The mean smolt age was 3.44 years, with 56 and 44 percent of steelhead being freshwater age 3 and 4, respectively (Table 2). The mean smolt age of Ishkheenickh River steelhead was similar to mean smolt ages of steelhead from the Cranberry, Damdochax, Kwinageese, Meziadin or Tseax rivers (Tukey HSD, $P > 0.05$; Table 2). Twenty-four (24), 66, 5 and 5 percent of Ishkheenickh River steelhead were ocean age 1, 2, 3 and 4, respectively. Statistical comparisons of lengths were not performed on freshwater and ocean age steelhead because of small samples (n=4; Table 10).

Table 10. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Ishkheenickh River winter steelhead.

	Freshwater Age		Ocean Age	
	3	4	2	3
Mean length (cm)	74.9	68.1	68.1	74.9
Standard error (cm)	8.9	0.85	0.85	8.9
Standard deviation (cm)	12.6	1.2	1.2	12.6
Length range (cm)	66-84	67-69	67-69	66-84
Sample size	2	2	2	2

4.1.2.3 Tseax River

Summer and winter steelhead occur sympatrically in the Tseax River. However, only 3 of 16 steelhead were identified as summer steelhead, thus the summer steelhead were pooled with the winter steelhead for analyses. Information on adult steelhead in the Tseax River was from a steelhead telemetry project (Alexander and Koski 1995), memorandum letters and scale cards in the Skeena Region MOELP Fisheries Branch files (Smithers). At the Nass River fishwheels, Tseax River summer steelhead were sampled on August 13 and 14, 1993 (Alexander and Koski 1995). Steelhead were sampled in the Tseax River on April 16, 1987, April 30 1978 and on June 1, 1975 (Appendix A). Of the 17 steelhead sampled, 13 had length data, 17 had scale age data, but only 5 had corresponding length and scale age data (Appendix A) because scale data were not linked to sex and length data.

Male (mean = 79.7 cm) and female (mean = 72.8 cm) Tseax River steelhead were similar in size (Mann-Whitney U = 10.5, $P = 0.246$; Table 8). The length distribution of male and female steelhead illustrated males were similar in size to females (Figure 11). Statistical comparisons were not made between sexes within ocean age groups because of small samples. The fork lengths of male winter steelhead were similar between populations (Kruskal-Wallis = 2.453, $P = 0.293$; Table 9) and the fork lengths of female winter steelhead were similar between populations (Kruskal-Wallis = 5.160, $P = 0.076$; Table 9).

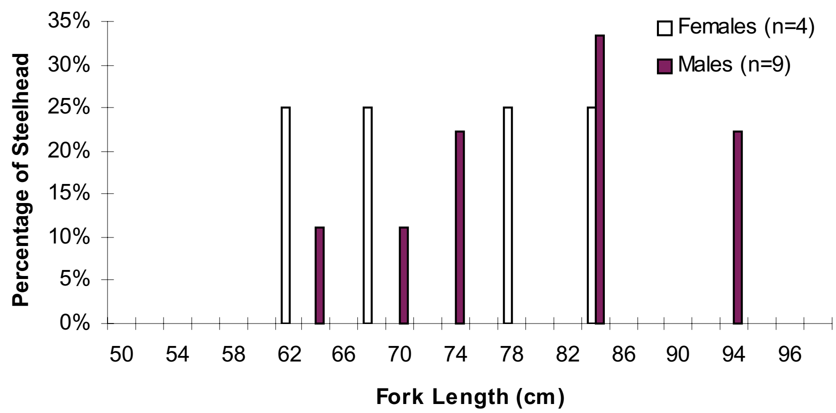

Figure 11. Percentage of male and female Tseax River steelhead by 2 cm categories of fork length.

The estimated fecundity of Tseax River steelhead was 2933 eggs/fish (equation 1). Twelve (12) percent of Tseax River steelhead were repeat spawners (1 male and 1 unknown sex) and 12 percent had regenerated scales during the freshwater growth period. The mean smolt age was 3.40 years, with 62 and 38 percent of steelhead being freshwater age 3 and 4, respectively (Table 2). The mean smolt age of Tseax River steelhead was similar to the mean smolt ages of steelhead from Damdochax Creek and the Cranberry, Ishkheenickh, Kwinageese or Meziadin rivers (Tukey HSD, $P > 0.05$; Table 2). Forty-seven (47), 41 and 12 percent of Tseax River steelhead were ocean age 1, 2 and 3, respectively. Statistical comparisons of lengths were not performed on freshwater and ocean age steelhead because of small samples (n=4; Table 11).

Table 11. A summary of the mean, standard error, standard deviation and range in adult fork lengths by freshwater and ocean age for Tseax River steelhead.

	Freshwater Age		Ocean Age	
	3	4	2	3
Mean length (cm)	62.5	77.0	72.4	62
Standard error (cm)	0.71	3.38	3.48	NA
Standard deviation (cm)	0.50	5.86	7.77	NA
Length range (cm)	62-63	74-84	63-84	NA
Sample size	2	3	5	1

4.1.3.0 Summary of Life History Characteristics

Winter steelhead populations generally had higher fecundity estimates than summer steelhead populations due to the larger body size of winter than summer steelhead (Table 12). The mean smolt ages were generally similar between populations, but Meziadin differed from Cranberry, Damdochax and Kwinageese populations. The majority of steelhead were freshwater age 3 and 4. Freshwater age 2 steelhead were rare in most populations except for Meziadin where they consisted of 19 percent of the population. Also, freshwater age 5 steelhead were rare. The majority of steelhead were ocean age 1+ and 2+, whereas ocean age 3+ and 4+ were rare among populations.

Table 12. A summary of the estimated fecundity, mean smolt age (MSA), percentages of repeat spawners, percentage of freshwater (FW) age 2, 3, 4, and 5, and ocean (SW) age 1+, 2+, 3+ and 4+ for steelhead in the Cranberry (Cran.), Kwinageese (Kwin.), Meziadin (Mez.), Ishkheenickh (Ishk.), and Tseax rivers, Damdochax (Damd.) and Chambers (Cham.) creeks and the Nass River fishwheels (Fishwh.).

	Summer Steelhead					Winter Steelhead		
	Cran.	Damd.	Kwin.	Mez.	Fishwh. (1996)	Cham.	Ishk.	Tseax
Estimated fecundity (eggs/fish)	2597	3079	2908	2816	2605	4264	3594	2933
MSA (years)	3.53	3.74	3.53	3.00	3.27	NA	3.44	3.40
Repeat spawners (%)	5	13	5	6	4	NA	23	12
FW age 2 (%)	0	4	0	19	0	NA	0	0
FW age 3 (%)	48	22	47	62	73	NA	56	62
FW age 4 (%)	51	70	53	19	27	NA	44	38
FW age 5 (%)	1	4	NA	NA	0	NA	0	0
SW age 1+ (%)	45	10	44	50	26	NA	24	47
SW age 2+ (%)	50	74	48	44	67	NA	66	41
SW age 3+ (%)	3	10	8	6	5	NA	5	12
SW age 4+ (%)	2	6	0	0	2	NA	5	0

For winter steelhead populations, ocean age 1, 2, 3 and 4 were placed in the 1+, 2+, 3+ and 4+ categories.

4.2.0.0 Steelhead Productivity and Allowable Harvest Rates

4.2.1.0 Biostandards Used by Tautz *et al*. (1992)

Steelhead productivity (equation 6) was examined for semelparous (excluding repeat spawners) life history conditions. However repeat spawners were included in the estimates of mean female length, since scale age data did not exist for many steelhead. The most productive summer steelhead population was the Meziadin (A = 0.95) and the least productive populations were the Cranberry and Damdochax (A = 0.89; Table 13). The productivity of Kwinageese (A = 0.91) summer steelhead was similar to Cranberry and Damdochax steelhead (Table 13). The productivity of summer steelhead was generally less productive than winter steelhead. For winter steelhead, Ishkheenickh steelhead (A = 0.95) were more productive than Tseax steelhead (A = 0.93; Table 13). The mean smolt age of Chambers Creek winter steelhead was unknown, since scale age data did not exist. If the mid-point of the mean smolt age of Ishkheenickh and Tseax river steelhead was used as an estimate for Chambers Creek, then the productivity of Chambers steelhead (A = 0.96) was higher than both Ishkheenickh and Tseax steelhead (Table 13).

For summer steelhead, the allowable harvest rates (equation 5) ranged from a low of 66 percent for Cranberry steelhead to a high of 79 percent for Meziadin steelhead (Table 13). The allowable harvest rates for Damdochax (67%) and Kwinageese (70%) steelhead were similar to Cranberry steelhead (66%). The allowable harvest rates for Ishkheenickh and Tseax river steelhead were 77 and 73 percent, respectively (Table 13). Chambers Creek steelhead had an allowable harvest rate of 81 percent when the estimated mean smolt age was 3.41 years.

Table 13. Estimates of summer and winter steelhead population productivity as measured by recruits per spawner (RPS), Beverton-Holt's A value and allowable harvest rates (μ_{msy}) and calculated from biostandards used by Tautz *et al*. (1992).

Population	Mean Smolt Age (yr)	n	Mean Female Length (cm)	n	RPS	μ_{msy}	A
Summer steelhead							
Cranberry	3.53	131	68.7	71	2.97	0.66	0.89
Damdochax	3.74	27	74.5	32	3.03	0.67	0.89
Kwinageese	3.53	57	72.5	30	3.33	0.70	0.91
Meziadin	3.00	16	71.4	10	4.71	0.79	0.95
Winter steelhead							
Chambers	*3.41*[1]	*0*	87.0	4	*5.32*	*0.81*	*0.96*
Ishkheenickh	3.44	18	80.2	18	4.39	0.77	0.95
Tseax	3.38	16	72.8	4	3.74	0.73	0.93
Pooled summer steelhead							
Fishwheels (1996)	3.27	325	68.8	202	3.59	0.72	0.92

1. Chambers Creek mean smolt age was estimated as the mid-point of Ishkheenickh and Tseax rivers.

<u>4.2.2.0 Updated Biostandards</u>

Steelhead productivity was examined for semelparous (excluding repeat spawners) life history conditions with updated biostandards (egg-to-fry and smolt-to-adult survival) from Keogh River winter steelhead. The updated biostandards produced lower estimates of recruits per spawner, allowable harvest rates and Beverton-Holt A values than estimates yielded from the biostandards used by Tautz *et al*. (1992; Table 14). The number of recruits per spawner (equation 4) were less than half (42%) of the estimates from the Tautz *et al*. (1992) biostandards. The allowable harvest rates and Beverton-Holt A values were reduced by up to 70 and 61 percent of the estimates calculated from the Tautz *et al*. (1992) biostandards (Table 14). For summer steelhead populations, Meziadin was the most productive and Cranberry was the least productive whereas for winter steelhead populations, Chambers was the most productive and Tseax was the least productive.

Table 14. Estimates of summer and winter steelhead population productivity as measured by recruits per spawner (RPS), allowable harvest rates (μ_{msy}) and Beverton-Holt's A value and calculated from updated Keogh River biostandards. The % change indicates the proportional difference from values calculated with biostandards from Tautz *et al*. (1992).

Population	Mean Smolt Age (yr)	n	Mean Female Length (cm)	n	RPS	μ_{msy} (% change)	A (% change)
Summer steelhead							
Cranberry	3.53	131	68.7	71	1.24	0.20 (-70%)	0.35 (-61%)
Damdochax	3.74	27	74.5	32	1.27	0.21 (-69%)	0.38 (-57%)
Kwinageese	3.53	57	72.5	30	1.39	0.28 (-60%)	0.48 (-47%)
Meziadin	3.00	16	71.4	10	1.97	0.49 (-38%)	0.74 (-22%)
Winter steelhead							
Chambers	*3.41*[1]	*0*	87.0	4	*2.23*	*0.55 (-32%)*	*0.80 (-17%)*
Ishkheenickh	3.44	18	80.2	18	1.84	0.46 (-40%)	0.70 (-26%)
Tseax	3.38	16	72.8	4	1.57	0.36 (-51%)	0.59 (-37%)
Pooled summer steelhead							
Fishwheels (1996)	3.27	325	68.8	202	1.50	0.34 (-53%)	0.56 (-39%)

1. Chambers Creek mean smolt age was estimated as the mid-point of Ishkheenickh and Tseax rivers.

4.3.0.0 Uncertainty and Sensitivity Analysis

4.3.1.0 Uncertainty

The median values from the *Monte Carlo* simulations were similar to the life history model estimates calculated using the mean and geometric mean life history parameters (Table 15). However, the *Monte Carlo* simulations and frequency distributions illustrated the median and mean values were not in the categories that contained the most frequent (probable) life history model estimates. The skewed graphical distributions of allowable harvest rates and Beverton-Holt A values illustrated strong outliers (Figure 12). These large negative outliers biased the mean estimated allowable harvest rate and Beverton-Holt A value and therefore, the median estimates are more appropriate estimators than the mean estimates.

The uncertainty in the life history model estimates, as indicated by the frequency distribution of the results, followed a similar pattern between Nass River steelhead populations. Therefore the results from the simulation for Cranberry River (Figure 12) were discussed but the same general patterns existed for the other populations (Appendix B-H). Estimates of recruits per spawner greater than 0 and less than 1 illustrated conditions where the population failed to meet sufficient recruitment levels for replacement due to natural (random) variability (Figure 12A). These conditions led to negative harvest rate and Beverton-Holt A value estimates. The probability of these conditions occurring differed between populations where the lower productivity populations had higher chances of not achieving replacement levels. The higher chances of the least productive populations (Cranberry and Damdochax) not meeting the replacement requirements suggested they may be more sensitive to harvest pressures than the more productive populations (Chambers and Meziadin; Table 15).

Beverton-Holt's A value had the widest range of estimates, but the frequency distribution implied higher estimates near 1 were more likely than lower estimates near 0 (Figure 12C). The simulations for recruits per spawner indicated that random variation resulting from sampling and environmental variability may lead to conditions where the populations produced insufficient recruitment for replacement (Table 15). The distribution of recruits per spawner was negatively skewed (Figure 12A) and indicated the categories with the highest probabilities were for conditions where the recruits per spawner were insufficient for replacement. Allowable harvest rates estimates were negatively skewed (Figure 12B), with the frequencies increasing near 0.66 and then decreasing near 1.

Table 15. *Monte Carlo* estimates and model sensitivities of recruits per spawner, allowable harvest rates and Beverton-Holt's A value calculated with updated Keogh River biostandards for steelhead in Chambers Creek, the Nass River fishwheels (1996), Cranberry River, Damdochax Creek and Kwinageese, Meziadin, Ishkheenickh and Tseax rivers.

Life History Model		Summer Steelhead					Winter Steelhead		
Parameter		Cran.	Damd.	Kwin.	Mez.	Fishwheels	*Cham*.*	Ishk.	Tseax
	Number of trials	10000	10000	10000	10000	10000	*10000*	10000	10000
Recruits Per Spawner (RPS)	Median	1.26	1.28	1.42	1.95	1.46	*2.17*	1.78	1.53
	Mean	2.17	2.17	2.36	3.33	2.44	*3.63*	2.98	2.62
	Standard error	0.03	0.03	0.03	0.05	0.03	*0.05*	0.04	0.04
	Standard deviation	3.09	2.87	3.10	4.70	3.29	*5.06*	4.16	3.64
	Number of trials with RPS < 1	4092	4035	3661	2580	3512	*2142*	2805	3350
Allowable Harvest Rate	Median	0.20	0.22	0.29	0.49	0.31	*0.54*	0.44	0.35
	Mean	-0.35	-0.31	-0.21	0.12	-0.13	*0.27*	0.08	-0.12
	Standard error	0.02	0.02	0.02	0.01	0.01	*0.01*	0.01	0.02
	Standard deviation	1.76	1.79	1.71	1.25	1.49	*0.88*	1.13	2.05
Beverton-Holt's A Value	Median	0.37	0.39	0.50	0.74	0.53	*0.79*	0.69	0.58
	Mean	-3.91	-3.91	-3.38	-1.35	-2.50	*-0.32*	-1.12	-4.44
	Standard error	0.23	0.29	0.36	0.20	0.29	*0.06*	0.09	1.87
	Standard deviation	23.13	28.99	36.11	20.24	28.94	*6.32*	8.78	186.6
Sensitivity (Rank correlation)	Smolt-Adult Surv.	0.67	0.68	0.68	0.65	0.68	*0.69*	0.68	0.67
	Egg-Fry Surv.	0.54	0.54	0.55	0.52	0.55	*0.56*	0.56	0.56
	Mean Smolt Age	-0.34	-0.39	-0.35	-0.42	-0.32	*-0.35*	-0.35	-0.33
	Female Length	0.27	0.16	0.24	0.21	0.26	*0.12*	0.20	0.27
Contribution to Variance (%)	Smolt-Adult Surv.	47.9	49.6	48.9	46.5	49.5	*51.0*	44.7	47.8
	Egg-Fry Surv.	31.6	31.6	31.9	29.6	32.4	*34.1*	33.1	33.0
	Mean Smolt Age	12.7	16.1	13.2	19.1	11.1	*11.1*	13.0	11.5
	Female Length	7.8	2.7	6.1	4.8	7.0	*7*	4.1	4.8

* Scale age data were not available for Chambers Creek steelhead, therefore the mean smolt age was estimated as the midpoint of Ishkheenickh and Tseax steelhead (3.41 years, standard deviation = 0.50 years).

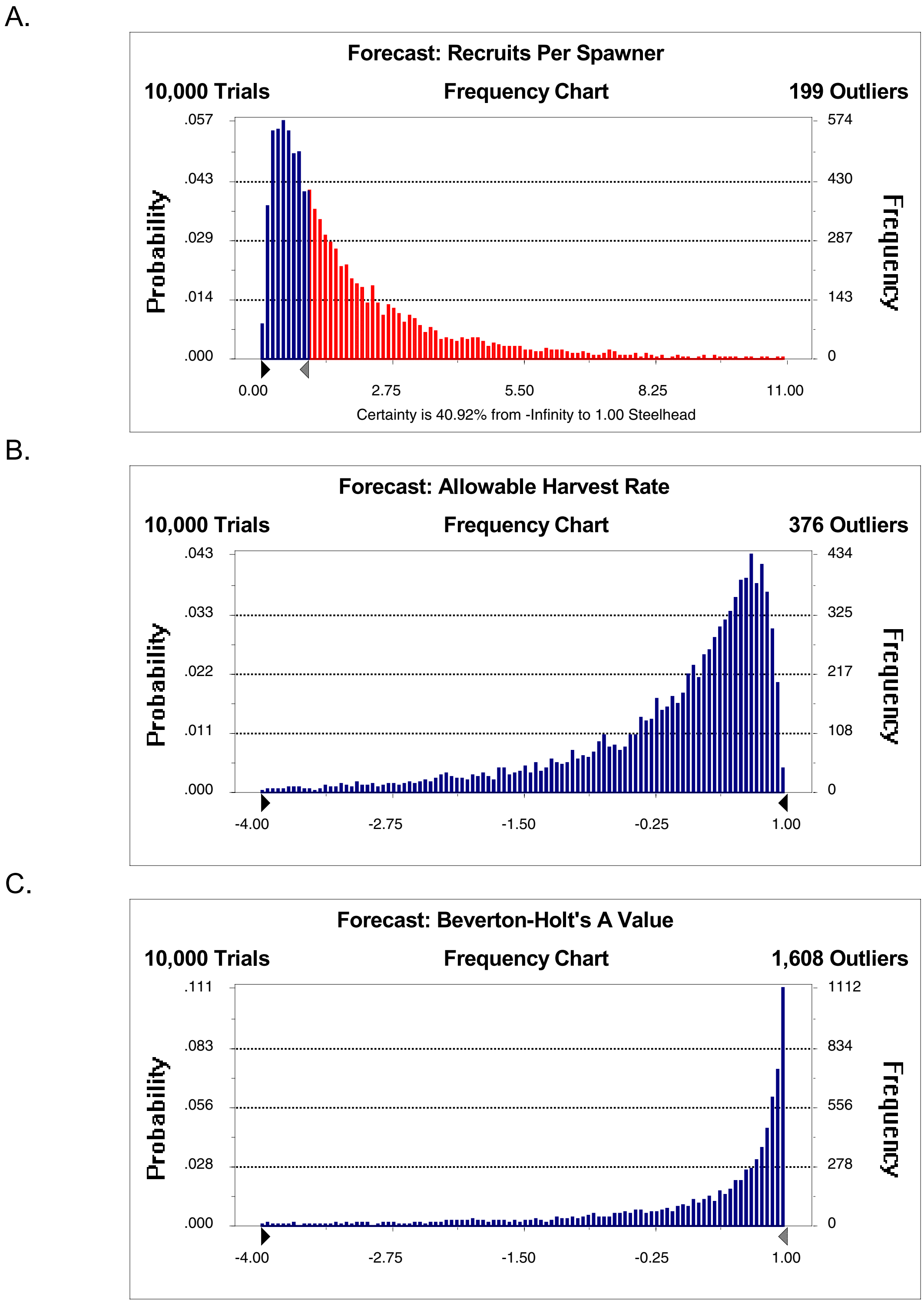

Figure 12. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Cranberry River steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

4.3.2.0 Sensitivity

Four different modeling scenarios were compared to examine the relative effects of variability in biostandards (egg-to-fry and smolt-to-adult survival) on the life history model estimates and how the variability affected parameter sensitivity. The first scenario assumed egg-to-fry and smolt-to-adult survival rates were Poisson distributed (10% and 12%, respectively). The Poisson distribution was used because rates (proportions) could be described with a Poisson distribution (Sargent and Wainwright 1996). The second scenario differed from the first by using observed egg-to-fry survival rates from the Keogh River (Ward and Slaney 1993; 1976-1982) and assumed the data were lognormally distributed. Bradford (1995) examined the distributions of egg-to-fry survivals of Pacific salmon and concluded the survival rates could be described with a lognormal distribution. The third scenario differed from the first by using observed smolt-to-adult survival from the Keogh River (Ward and Slaney 1988; B. Ward, personal communication; 1976-1993). Peterman (1981) and Bradford (1995) examined the smolt-to-adult survival rates in Pacific salmon and concluded the rates could be described with a lognormal distribution. The fourth scenario differed from the first by using observed egg-to-fry and smolt-to-adult survival data from the Keogh River and developing a probability distribution for those values.

Table 16. Effects of variability in life history model parameters on the probability of Cranberry River steelhead having insufficient recruits per spawner for replacement (RPS<1) and the effects on model sensitivity and variance in life history model estimates.

	Parameter	Scenario			
		1	2	3	4
Number of trials		10000	10000	10000	10000
Number of trials with RPS < 1		1182	3429	2237	4092
(Percentage with recruitment failure)		11.8%	34.3%	22.4%	40.9%
Sensitivity (Rank correlation)	Smolt-Adult Surv.	0.44	0.36	0.76	0.67
	Egg-Fry Surv.	0.49	0.69	0.37	0.54
	Mean Smolt Age	-0.53	-0.44	-0.39	-0.34
	Female Length	0.42	0.35	0.30	0.27
Contribution to Variance (%)	Smolt-Adult Surv.	21.8	13.8	60.6	47.9
	Egg-Fry Surv.	26.4	51.8	14.3	31.6
	Mean Smolt Age	31.9	20.9	15.7	12.7
	Female Length	19.9	13.5	9.4	7.8

Variability in egg-to-fry survival had a larger effect on increasing the chances of the population having insufficient recruitment for replacement (scenario 2) than smolt-to-adult survival (scenario 3; Table 16). As expected, when the variability of both parameters was included (scenario 4), the chances of the population having insufficient recruitment for replacement were much greater (approximately four fold) than the scenario where the biostandard variability was excluded (scenario 1; Table 16). Therefore by excluding the variability in the biostandards, the life history model estimates may be overestimated and resemble the 'stable environment' conditions rather than the average estimates expected for environmental conditions that existed when the data were collected.

In the absence of observed variability in biostandards (scenario 1), mean smolt age was the most sensitive parameter, followed by egg-to-fry survival, smolt-to-adult survival and female length (Table 16). When the variability of the biostandards was included separately (scenarios 2 and 3), the biostandard became the most sensitive parameter, but mean smolt age was the second most sensitive parameter and female length was the least sensitive parameter for both conditions (Table 16). When the variability in egg-to-fry and smolt-to-adult survival was modeled (scenario 4), smolt-to-adult survival was the most sensitive parameter followed by egg-to-fry survival, mean smolt age and female length (Table 16).

Errors in mean smolt age were investigated by increasing the mean smolt age value by 0.2 year increments. The 0.2 year increment approximates the error in the life history model estimates if 20 percent of the steelhead were under-aged by one year. Hooton *et al*. (1987) and Tautz *et al*. (1992) discussed the negative bias in the freshwater ages determined from adult scales for steelhead rearing in streams with short growing seasons.

Table 17. The effect of increasing estimates of mean smolt age (MSA) on recruits per spawner (RPS), Beverton-Holt's A value and allowable harvest rates (μ_{msy}) for Cranberry River steelhead. Light shading indicates estimates based on current mean smolt age estimates.

MSA	RPS	A	μ_{msy} (%)
3.33	3.43	0.92	71
3.53	2.97	0.89	66
3.73	2.57	0.85	61
3.93	2.23	0.80	55
4.13	1.93	0.73	48
4.33	1.67	0.64	40
4.53	1.45	0.52	31

Errors in estimating the mean smolt age from adult scales may have a pronounced effect on the life history model estimates (Table 17). Since adult scales were suspected to have a negative bias in freshwater ages, improved scale reading techniques or adjustments for a missing first annulus may demonstrate that the current mean smolt age was underestimated. Thus, if the actual mean smolt age was older than current estimates, then the number of recruits per spawner, stock productivity and allowable harvest rate estimates would currently be overestimated (Table 17). An ultra-conservative approach must be used when interpreting the life history model estimates since these negative biases in mean smolt age probably exist in the current estimates.

5.0.0.0 Discussion

5.1.0.0 Life History Characteristics

The similar size of male and female Nass River steelhead was inconsistent with the results of other studies. However, males were larger than females for ocean age 1+ Cranberry River steelhead, ocean age 2+ Kwinageese River steelhead and ocean age 2+ steelhead sampled at the Nass River fishwheels in 1996. Steelhead were not pooled among rivers because the size at ocean age may differ between rivers for summer and winter steelhead populations (Hooton *et al*. 1987). Size differences between males and females may have been compromised by pooling steelhead among years and ocean ages, since the proportion of the returning adult population in different ocean age groups may vary between years and sexes (Whately 1977; Chudyk *et al*. 1977; Whately *et al*. 1978; Chudyk and Whately 1980; O'Neill and Whately 1984; Hooton *et al*. 1987; Ward and Slaney 1988). Larger males than females at a given ocean age were similar to the results reported for Skeena River steelhead in the Tyee test fishery (Chudyk 1976), Kitsumkalum River (Lough and Whately 1984), Kispiox River steelhead (Whately 1977), Babine River (Narver 1969), as well as steelhead in Copper Creek (Chudyk and Walsh 1982; Queen Charlotte Islands (QCI)), Yakoun River (de Leeuw 1987; QCI), Vancouver Island (Hooton *et al*. 1987) and Keogh River (Ward and Slaney 1988).

The length of adult steelhead in the Cranberry, Kwinageese, and Meziadin rivers and Nass River fishwheels (1996) increased with ocean age, consistent with the results of other studies. Summer steelhead sampled in the Tyee test fishery (Chudyk 1976) and in the Zymoetz River (Chudyk and Whately 1980) also increased in adult length with increases in ocean age. For winter steelhead on the Queen Charlottes, adult steelhead length increased with ocean age in the Yakoun River (de Leeuw 1987) and Copper Creek (Chudyk and Walsh 1982). Similarly, summer and winter steelhead from Vancouver Island also increased in length with ocean age (Hooton *et al*. 1987). Ward and Slaney (1988) also reported adult length increased with ocean age for Keogh River winter steelhead.

Adult size was similar between freshwater ages for summer steelhead in the Cranberry, Damdochax and Meziadin rivers and Nass River fishwheels (1996), but increased with freshwater age for Kwinageese steelhead. In the Kalama River, Washington, Leider *et al*. (1986) reported similar adult lengths between freshwater ages for summer and winter steelhead. Chudyk (1976) reported Skeena River summer steelhead length increased with freshwater age. Although, Ward and Slaney (1988) reported the size of adult Keogh River steelhead decreased as freshwater age increased, but noted that adult length increased with freshwater age for ocean age 2+ steelhead and was similar between freshwater ages for ocean age 3+ steelhead. Sample sizes from some Nass River tributaries were too small to permit similar statistical comparisons within ocean age groups. Since tributary samples were pooled across years, the inter-annual variation in adult length may have compromised the differences between freshwater age categories (Leider *et al*. 1986; Hooton *et al*. 1987).

Damdochax Creek steelhead were similar in size to Kwinageese and Meziadin river steelhead, but larger than Cranberry River steelhead. Therefore, differences in adult size may exist between Nass River populations. The results should be considered cautiously until sample sizes within returning adult years are large enough to compare lengths between different populations, but within an ocean age group. The differences may reflect variation in the proportion of ocean aged adults or variation in recruitment, since the data were pooled among years and not all tributaries were sampled during the same year.

The range in the estimated fecundity of Nass River summer steelhead was generally lower than the range for Skeena River summer steelhead. In the Nass River, estimated fecundity ranged from 2597 eggs/fish (Cranberry River) to 3079 eggs/fish (Damdochax Creek). Sebastian (1987) estimated the average fecundity of Cranberry River steelhead was 2300 eggs/fish. Similar estimates of fecundity were reported for other Skeena River tributary populations: Kitwanga and Kitseguecla (2615 eggs/fish), upper Sustut and Kluatantan (2644 eggs/fish), Babine (2762 eggs/fish), lower Sustut (2853 eggs/fish) and Kispiox (2906 eggs/fish; Tautz *et al*. 1992). Other Skeena River summer steelhead populations had lower estimated fecundities than Nass River summer steelhead (i.e. Morice = 1868, Bulkley = 2374, Zymoetz = 2444; Tautz *et al*. 1992). The range in fecundity of Nass River winter steelhead (Tseax = 2933 to Chambers = 4264 eggs/fish) was higher than the range estimated for Skeena River summer steelhead (Tautz *et al*. 1992).

The frequency of repeat spawning summer steelhead in the Nass River was similar to the results reported from the Skeena River. The frequency of repeat spawning summer steelhead ranged from 5 percent (Cranberry and Kwinageese) to 13 percent (Damdochax) in the Nass watershed. The low percentage of repeat spawning summer steelhead in the Nass River was similar to the results reported for Skeena River steelhead populations in the Sustut River (1.2-6%; Saimoto 1995, Parken and Morten 1996), Kitsumkalum River (2.6%; Lough and Whately 1984), Bulkley River (3.4%; O'Neill and Whately 1984), Suskwa River (3.8%; Chudyk 1978), Morice River (6.6%; Whately *et al*. 1978) and Babine River (6.9%; Narver 1969; Whately and Chudyk 1979). However, the percentage of repeat spawners was reported to be substantially higher in the Kispiox River (17.6%; Whately 1977) and the Zymoetz River (29%; Chudyk and Whately 1980). Hooton *et al*. (1987) reported approximately 7 percent of Vancouver Island summer steelhead were repeat spawners which was similar to the 6 percent reported for Kalama River summer steelhead (Leider *et al*. 1986). Comparisons of the frequency of repeat spawners between rivers should be made cautiously because the sampling occurred during different time periods and the results may partially reflect variable recruitment or ocean survival (Ward and Slaney 1988).

A higher percentage of repeat spawners observed in winter than summer steelhead in the Nass River was similar to the results reported for steelhead in other areas. Hooton *et al*. (1987) reported a higher percentage of repeat spawners among winter (10%) than summer (7%) steelhead on Vancouver Island. Similarly, Leider *et al*. (1986) reported winter steelhead had a higher percentage of repeat spawners (11%) than summer steelhead (6%) in the Kalama River, Washington. Among winter steelhead, the percentage of repeat spawners ranged from 12 (Tseax) to 23 percent (Ishkheenickh) in the Nass River tributaries. In the Queen Charlotte Islands, the percentage of repeat spawners for winter run steelhead was 4.5 percent in the Mamin River (de Leeuw 1986a), 12.1 percent in the Yakoun River (de Leeuw 1987) and 25.6 percent in Deena Creek (de Leeuw 1986b). Repeat spawner frequencies among Nass River winter steelhead were similar to results reported from the Keogh River (8.1% for males and 11.6% for females; Ward and Slaney 1988), but lower than results from Petersburg Creek, Alaska (38.3%; Jones 1977).

The range in mean smolt age, as calculated from adult scales, from the Nass River was generally lower than the range reported from the Skeena River. The mean smolt age of Nass River summer steelhead ranged from 3.00 years in the Meziadin River to 3.74 years in the Damdochax Creek. Skeena River summer steelhead ranged in smolt age from 3.45 years (Buck Creek) to 5.68 years (Goathorn Creek; Bocking and English 1992). The mean smolt age of Cranberry River steelhead from adult scales (3.53 years) was slightly higher than Sebastian's (1987) mean smolt age estimate (3.30 years) based on the length of the growth season. Tautz *et al*. (1992) estimated the mean smolt age of Skeena River summer steelhead ranged from 3.3 years (Babine River) to 4.5 years (upper Sustut River) based on the length of the growth season.

The mean smolt age of Nass River steelhead should be interpreted cautiously because of the limitations in freshwater aging. For example, some proportion of steelhead may not have formed scales during the first year (Jensen and Johnsen 1982; Hooton *et al*. 1987) or may not have formed the fist annulus because of short growing seasons in rearing areas (Hooton *et al*. 1987; Tautz *et al*. 1992; Triton 1994a, 1994b).

5.2.0.0 Steelhead Productivity and Allowable Harvest Rates

The range of productivities and allowable harvest rates for Nass River summer steelhead populations were similar to the range described for Skeena River summer steelhead by Tautz *et al*. (1992) when calculations were made with identical biostandards. However, comparisons between the Nass and Skeena rivers should be made cautiously because the mean smolt age of Nass River steelhead was estimated from adult scales whereas the mean smolt age of Skeena River steelhead was estimated from growth season data. Bocking and English (1992) illustrated that mean smolt age predicted from the growth season length was slightly lower than estimates from adult scales and thus, the growth season predictor may overestimate productivity and allowable harvest rates (Tautz *et al*. 1992).

The productivity of Nass River summer steelhead ranged from a low in Cranberry River and Damdochax Creek (A = 0.89) to a high in Meziadin River (A = 0.95). In the Skeena River, steelhead from the upper and lower Sustut (A = 0.54, 0.73 respectively), Kitwanga (A = 0.64), Morice (A = 0.67), Zymoetz (A = 0.73), Kitseguecla (A = 0.83) and Suskwa (A = 0.84) rivers were less productive than Nass River summer steelhead (Tautz *et al*. 1992). Nass River steelhead productivities were similar to steelhead in the Bulkley (A = 0.87), Kispiox (A = 0.88) and Babine (A = 0.93) rivers (Tautz *et al*. 1992).

Nass River winter steelhead had similar productivity estimates (A value range, 0.93 to 0.96) to Keogh River winter steelhead and Babine River summer steelhead. In the Keogh River, winter steelhead productivity (A=0.93) was estimated from observed spawner and recruit abundances (Ward 1996). Tseax (A = 0.93) and Ishkheenickh (A = 0.95) steelhead had higher productivity estimates than Skeena River summer steelhead in the Suskwa, Bulkley and Kispiox rivers. When the mean smolt age was estimated at 3.41 years, Chambers Creek steelhead had a higher productivity estimate (A = 0.96) than Babine River steelhead (A = 0.93; Tautz *et al*. 1992). Nass River winter steelhead had higher productivity estimates than Nass River summer steelhead because female winter steelhead were larger than summer steelhead, which resulted in higher fecundity estimates. On Vancouver Island, Hooton *et al*. (1987) also reported winter steelhead were larger than summer steelhead.

The range of allowable harvest rates estimated for Nass River summer steelhead were similar to the results for Skeena River summer steelhead. Allowable harvest rates of Cranberry (μ_{msy} = 0.66), Damdochax (μ_{msy} = 0.67), Kwinageese (μ_{msy} = 0.70) and Meziadin (μ_{msy} = 0.70) steelhead were similar to estimates for Bulkley (μ_{msy} = 0.65), Kispiox (μ_{msy} = 0.66) and Babine (μ_{msy} = 0.73) steelhead (Tautz *et al*. 1992). Nass River summer steelhead had higher allowable harvest rates than upper Sustut (μ_{msy} = 0.32), Kluatantan (μ_{msy} = 0.39), Kitwanga (μ_{msy} = 0.40), Morice (μ_{msy} = 0.43), lower Sustut and Zymoetz (μ_{msy} = 0.48), Kitseguecla (μ_{msy} = 0.58) and Suskwa (μ_{s} = 0.60) steelhead (Tautz *et al*. 1992). Sebastian (1987) suggested Cranberry steelhead may be fairly susceptible to overharvest, but did not estimate a sustainable harvest rate.

Allowable harvest rate estimates for winter steelhead in the Tseax (μ_{msy} = 0.73) and Ishkheenickh (μ_{msy} = 0.77) rivers were similar to the estimates for Keogh River winter steelhead (μ_{msy} = 0.74; estimated from observed stock-recruitment data; Ward 1996) and Babine River summer steelhead (μ_{msy} = 0.73; Tautz *et al*. 1992). When the mean smolt age was estimated at 3.41 years for Chambers Creek, the allowable harvest rate (μ_{msy} = 0.81) was higher than the results reported for Babine River summer steelhead (Tautz *et al*. 1992).

Stock-recruitment estimates from modeling exercises should always be interpreted cautiously when large assumptions are made regarding the data the model was based on (Hilborn and Walters 1992; NRC 1996). Stock recruitment analysis for Nass River steelhead was based on life history parameters measured for Keogh River winter steelhead and fecundities based on Skeena River summer steelhead. Large geographical and life history differences may exist between Nass and Keogh river steelhead, and therefore the results must be interpreted cautiously and the model results should only be used in an ultra-conservative fashion until they can be substantiated. Ward (1996) cautioned that stock-recruitment analysis of steelhead was influenced by environmental variability and age-at-return variation and that these factors decreased the stock-recruitment model's ability to predict the abundance of returning adults. Ward (1996) also demonstrated that stock recruitment parameters estimated in the absence of environmental variability overestimated allowable harvest rates, but cautioned that simple inclusion of the variability continued to produce harvest rate estimates that would lead to over-exploitation in some years. Iteroparity, variable age-at-return, and variable smolt age may be evolutionary strategies of steelhead that counter the effects of variable adult returns resulting from environmental variation (Hooton *et al*. 1987; NRC 1996).

5.3.0.0 Uncertainty and Sensitivity Analysis

Monte Carlo simulations indicated a wide range in the variability around estimates of recruits per spawner, allowable harvest rates and Beverton-Holt A values. The distributions were skewed and resembled the variability of the two most sensitive parameters (smolt-to-adult and egg-to-fry survival). The median values from the simulations were similar to the estimates calculated from the updated biostandards, however median and mean values did not occur in the frequency categories with the highest probabilities. Insufficient recruitment levels for replacement in some years (trials), as predicted by the simulations, was consistent with the results observed at the Keogh River (Ward 1996). *Monte Carlo* simulation results resembled the measurement and environmental variability that existed when the data were collected (NRC 1996).

Smolt-to-adult survival was the most sensitive parameter followed by egg-to-fry survival, mean smolt age and female length when the updated biostandards were used. The high variability in smolt-to-adult and egg-to-fry survival (approximately an order of magnitude) contributed to the higher sensitivity for these parameters than mean smolt age and female length. When the variability in the biostandards was excluded, mean smolt age was the most sensitive parameter for estimating the life history model estimates which was consistent with the results of Bocking and English (1992). Although mean smolt age was not as sensitive as the biostandards, small changes may have substantial effects on the life history model estimates. Current estimates of mean smolt age were likely underestimated for populations that rear in streams with short growing seasons (Hooton *et al*. 1987; Tautz *et al*. 1992). Thus, the actual mean smolt age estimates for some Nass River tributaries may be higher and the life history model estimates may be lower than the estimates based on adult scales. Until the negative bias in adult scale ages is examined for Nass River steelhead, an ultra-conservative approach should be used when interpreting the life history model estimates.

6.0.0.0 Recommendations

1. Future research should examine the relationship between the number of circuli formed and length of growth season (G7), the proportion of steelhead in a year class that form a first annulus with G7, the proportion of steelhead that form scales by G7 and fork length.

2. Future research should validate smolt ages determined from adult scales. Also, each of the negative biases and their interaction with growth season length should be investigated. Research should focus on developing a correction factor (or equation) for the percentage of steelhead without a distinguishable first annulus or that do not form scales in their first year with the length of the growth season (possibly measured by G7, G6.5, or degree days). Alternatively, the research may focus on improving the scale reading methods for streams with short growth seasons.

3. Since the data from adult scales were influential in the Nass habitat capability model estimates, some level of quality control and quality assurance in scale aging must be maintained to decrease the variance in scale ages between different scale aging agencies.

4. Distinctions must be made between summer and winter steelhead in rivers that harbor sympatric populations.

5. A fecundity regression should be developed for Nass River summer and winter steelhead (possibly separate regressions if samples are sufficient). Data sources include the Nisga'a Tribal Council catch monitoring program and mortalities at the fishwheels.

6. Steelhead captured at the fishwheels should be marked with a numbered tag. Tag recoveries in the tributaries and catch monitoring programs could help describe run-timing and in-river exploitation rates.

7. Detailed population and biostandard monitoring should be continued at the Keogh River to help refine the Nass habitat capability model estimates.

8. Life history model estimates should be recalculated when new data are available.

7.0.0.0 Acknowledgments

A large portion of the data summarized in the report were the result of numerous person-years of effort by Fisheries Branch staff of the Ministry of Environment, Lands and Parks. The direction, coordination and efforts of all staff involved over the years was appreciated. I thank Ron Tetreau for aging steelhead scales in a timely fashion and assistance with the MOELP scale archives. Bob Bocking, Bill Koski, Michael Link, LGL Ltd. and the Nisga'a Tribal Council are thanked for providing data for steelhead sampled at the fishwheels and the 1993 telemetry project. I thank Ken Belford for collecting steelhead samples from Damdochax Creek. Bruce Ward provided the egg-to-fry survival and smolt-to-adult survival data from Keogh River winter steelhead. I thank Krista Morten for assistance with data entry, data analysis and suggestions on earlier drafts. I thank Dana Atagi for assistance with the Skeena Region MOELP branch files and for the many useful comments and advice during data analysis and critical reviews. I thank Dr. Ted Down for securing funding for the preparation of this review. Funding for the preparation of this review was provided by the Common Land Information Base.

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8.0 Appendix

Appendix A. Information on adult steelhead and rainbow trout sampled in Nass River tributaries.

Steelhead ages were reported with the number of winters spent in freshwater before the decimal point followed by the number of winters spent in the ocean. A + identifies a summer steelhead with some scale growth after its last winter in the ocean. In contrast, winter steelhead do not have a + because they entered freshwater near the end of the winter. An S identifies a previous spawning event and represents 1 ocean year and an R represents regenerated scales that could not be used to determine age. A steelhead age 3.2S1+ was a summer steelhead that spent 3 winters in freshwater before smolting and then spent 2 winters in the ocean before its first spawning run and then spent another winter in the ocean before making its second spawning migration. The steelhead was freshwater age 3 and ocean age 4. Steelhead ages that were not linked to length or sex data were summarized in a box beside the sampling date and related information.

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Bell Irving	July 22/1993	s	f	76.0	2.2+	Alexander and Koski, 1995	Sept. 14/1995
Bell Irving	Aug. 10/1993	s	m	74.0	NA	Alexander and Koski, 1995	Sept. 14/1995
Chambers	May 8-9/94	s	f	81.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	f	84.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	f	90.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	f	93.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	59.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	71.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	76.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	78.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	84.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	84.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	89.0		Bustard 1995	Feb. /1995
Chambers	May 8-9/94	s	m	92.0		Bustard 1995	Feb. /1995
Cranberry	Nov. 1/1996	s	m	78.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	69.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	68.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	54.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	73.0	4.1S1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	67.0	R.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	78.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	77.0	R.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	59.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	74.0	4.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	68.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	58.0	4.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	73.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	57.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	74.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	78.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	75.0	4.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	66.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	76.0	4.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	60.0	4.1+	Memo to file/DNA sampling	Nov. /1996

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Cranberry	Nov. 1/1996	s	m	79.0	4.1S1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	53.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	61.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	81.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	73.0	4.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	72.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	58.0	3.1+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	m	88.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Nov. 1/1996	s	f	77.0	3.2+	Memo to file/DNA sampling	Nov. /1996
Cranberry	Oct. 20/1995	s	f	71.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	75.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	85.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	72.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	71.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	83.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	79.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	55.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	73.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	74.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	72.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	76.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	60.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	52.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	62.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	70.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	64.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	f	73.0		raw data/DNA sampling	
Cranberry	Oct. 20/1995	s	m	76.0		raw data/DNA sampling	
Cranberry	Aug. 30/1993	s	m	66.0	3.2+	Alexander and Koski, 1995	Sept. 14/1995
Cranberry	Aug. 7/1993	s	m	76.0	4.2+	Alexander and Koski, 1995	Sept. 14/1995
Cranberry	July 23/1993	s	f	71.0	3.2+	Alexander and Koski, 1995	Sept. 14/1995
Cranberry	Sept. 30/1993	s	f	65.0	NA	Alexander and Koski, 1995	Sept. 14/1995
Cranberry	1980/1981	s	m	73.7	3.2+	Scale Cards/MOELP files	
Cranberry	1980/81	s	f	74.9	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1979	s	m	76.2	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1979	s	m	58.4	3.1+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1979	s	f	73.7	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1979	s	m	55.9	3.1+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1979	s	m	53.3	3.1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	m	73.7	3.1S1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	m	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	72.4	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	73.7	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	63.5	4.1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	78.7	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	68.6	3.2+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	m	61.0	3.1+	Scale Cards/MOELP files	
Cranberry	Oct. 31/1979	s	f	73.7	4.1+	Scale Cards/MOELP files	

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Cranberry	Oct. 31/1979	s	m	71.1	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	f	53.3	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	m	61.0	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	f	73.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	f	53.3	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	m	66	5.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	f	55.9	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	m	78.7	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	m	?	?	Scale Cards/MOELP files	
Cranberry	Nov. 1/1979	s	m	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	m	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	f	66.0	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	m	58.4	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	m	68.6	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	f	73.7	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	m	66.0	R.1+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	m	68.6	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 2/1979	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 7/1979	s	m	68.6	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 27/1979	s	f	53.3	?	Scale Cards/MOELP files	
Cranberry	Nov. 27/1979	s	m	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 27/1979	s	m	63.5	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 27/1979	s	m	61.0	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	m	86.4	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	f	81.3	4.2S1+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	f	54.6	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	f	71.1	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	m	55.9	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	m	63.5	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 28/1979	s	m	81.3	3.2+	Scale Cards/MOELP files	
Cranberry	Sept. 19/1978	s	f	73.7	3.2+	Scale Cards/MOELP files	
Cranberry	Sept. 20/1978	s	m	83.8	4.2+	Scale Cards/MOELP files	
Cranberry	Sept. 20/1978	s	m	86.4	3.2+	Scale Cards/MOELP files	
Cranberry	Sept. 21/1978	s	m	83.8	4.2+	Scale Cards/MOELP files	
Cranberry	Sept. 17/1977	s	m	78.7	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 5/1977	s	f	81.3	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 5/1977	s	f	88.9	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 14./1977	s	f	71.1	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 14/1977	s	f	81.3	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 15/1977	s	f	78.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 15/1977	s	f	71.1	R.2+	Scale Cards/MOELP files	
Cranberry	Nov. 15/1977	s	f	73.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 15/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 15/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	55.9	R.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	m	86.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	m	73.7	4.2+	Scale Cards/MOELP files	

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Cranberry	Nov. 16/1977	s	f	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	m	66.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	78.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	m	66.0	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	61.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	73.7	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 16/1977	s	f	76.2	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	63.5	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	f	86.4	4.2S1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	f	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	f	86.4	4.2S1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	r		26.5	5	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	69.8	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	66.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	83.8	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	66.0	3.2+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	86.4	4.2+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	58.4	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	61.0	3.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	66.0	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 17/1977	s	m	63.5	3.1+	Scale Cards/MOELP files	
Cranberry	Oct. 3/1977	s	m	59.0	3.1+	Scale Cards/MOELP files	
Cranberry	April 2/1978	s	f	77.0	3.2+	Scale Cards/MOELP files	
Cranberry	April 2/1978	s	f	74.0	3.2+	Scale Cards/MOELP files	
Cranberry	April 2/1978	s	m	62.0	4.1+	Scale Cards/MOELP files	
Cranberry	April 2/1978	s	m	63.0	4.2+	Scale Cards/MOELP files	
Cranberry	April 2/1978	s	f	71.0	3.1S1+	Scale Cards/MOELP files	
Cranberry	April 16/1978	s	f	73.7	4.2+	Scale Cards/MOELP files	
Cranberry	April 16/1978	s	m	81.3	3.2+	Scale Cards/MOELP files	
Cranberry	April 16/1978	s	f	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	April 16/1978	s	m	58.4	3.1+	Scale Cards/MOELP files	
Cranberry	April 3/1977	s	m	55.9	4.1+	Scale Cards/MOELP files	
Cranberry	April 3/1977	s	m	59.0	4.1+	Scale Cards/MOELP files	
Cranberry	Oct. 30/1975	s	f	63.5	4.1+	Scale Cards/MOELP files	
Cranberry	Nov. 7/1974	s	f	68.0	3.2+	Scale Cards/MOELP files	
Damdochax	Sept. 6/1996	s	m	73.66		Belford-data/MOELP files	
Damdochax	Sept. 9/1996	s	m	81.28		Belford-data/MOELP files	
Damdochax	Sept. 11/1996	s	u			Belford-data/MOELP files	
Damdochax	Sept. 15/1996	s	f	71.12		Belford-data/MOELP files	
Damdochax	Sept. 15/1996	s	m	93.98		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	f	71.12		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	m	81.28		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	m	99.06		Belford-data/MOELP files	

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Damdochax	Sept. 20/1996	s	m	76.20		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	m	76.20		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	f	76.20		Belford-data/MOELP files	
Damdochax	Sept. 20/1996	s	m	86.36		Belford-data/MOELP files	
Damdochax	Sept. 21/1996	s	m	81.28		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	f	76.20		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	m	83.82		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	f	66.04		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	m	53.34		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	f	76.20		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	m	86.36		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	m	81.28		Belford-data/MOELP files	
Damdochax	Sept. 24/1996	s	u			Belford-data/MOELP files	
Damdochax	Sept. 25/1996	s	f	71.12		Belford-data/MOELP files	
Damdochax	Sept. 27/1996	s	m	93.98		Belford-data/MOELP files	
Damdochax	Sept. 27/1996	s	f	68.58		Belford-data/MOELP files	
Damdochax	Oct. 5/1996	s	m	66.04		Belford-data/MOELP files	
Damdochax	Oct. 5/1996	s	u			Belford-data/MOELP files	
Damdochax	Oct. 5/1996	s	u			Belford-data/MOELP files	
Damdochax	Oct. 21/1996	s	f	71.12		Belford-data/MOELP files	
Damdochax	Oct. 23/1996	s	f	66.04		Belford-data/MOELP files	
Damdochax	Oct. 28/1996	s	m	81.28		Belford-data/MOELP files	
Damdochax	Oct. 15/1996	s	m	73.66		Belford-data/MOELP files	
Damdochax	Oct. 8/1996	s	f	76.20		Belford-data/MOELP files	
Damdochax	Oct. 6/1996	s	f	81.28		Belford-data/MOELP files	
Damdochax	Oct. 6/1996	s	f	83.82		Belford-data/MOELP files	
Damdochax	Oct. 23/1996	s	f	73.66		Belford-data/MOELP files	
Damdochax	Oct. 28/1996	s	f	68.58		Belford-data/MOELP files	
Damdochax	Oct. 28/1996	s	f	78.74		Belford-data/MOELP files	
Damdochax	May 4/1994	s	m	82.0		field notes/blood sampling	
Damdochax	May 4/1994	s	m	62.0		field notes/blood sampling	
Damdochax	May 4/1994	s	f	73.0		field notes/blood sampling	
Damdochax	May 4/1994	s	f	73.0		field notes/blood sampling	
Damdochax	May 4/1994	s	f	81.0		field notes/blood sampling	
Damdochax	May 4/1994	s	f	73.0		field notes/blood sampling	
Damdochax	May 4/1994	s	f	70.0		field notes/blood sampling	
Damdochax	May 10/1994	s	f	83.0		field notes/blood sampling	
Damdochax	July 26/1993	s	f	67.0	2.2+	Alexander and Koski 1995	
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		5.1+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		3.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		3.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	f		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.1+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	f		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	f		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	f		3.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Damdochax	May-79	s	m		4.1S1+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		R.2+	Letter to Ken Belford	July 24/1979
Damdochax	May-79	s	m		4.2+	Letter to Ken Belford	July 24/1979
Damdochax	Oct. 1/1979	r?	m	38.1		Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 1/1979	s	m	55.9		Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 1/1979	s	f	43.2		Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 1/1979	s	f	86.4	3.2S1+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 1/1979	s	f	73.7	4.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 1/1979	s	f	71.1	3.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 2/1979	s	f	73.7	R.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 2/1979	s	m	94.0	3.3+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 2/1979	s	f	72.4	4.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 3/1979	s	m	61.0	4.1+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 4/1979	s	f	85.1	4.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 5/1979	s	f	61.0		Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 6/1979	s	f	73.7	R.2+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Oct. 6/1979	s	f	83.8	R.2S1+	Memorandum/MOELP files	Oct. 29/1979
Damdochax	Dec.7/1979	s	f		4.2S+	Scale Cards/MOELP files	
Damdochax	Dec.7/1979	s	f	73.7	4.2+	Scale Cards/MOELP files	
Gingolx area	July 29/1993	s	m	73	2.2+	Alexander and Koski, 1995	Sept. 14/1995
Ishkheenickh	April 20/1994	s	m	69.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	86.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	88.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	86.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	88.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	86.0		field notes/blood sampling	
Ishkheenickh	April 20/1994	s	f	88.0		field notes/blood sampling	
Ishkheenickh	May 7/1990	s	f	81.0		STHD tagging record	June 4/1990
Ishkheenickh	May 7/1990	s	f	81.0		STHD tagging record	June 4/1990
Ishkheenickh	May 7/1990	s	f	74.0		STHD tagging record	June 4/1990
Ishkheenickh	May 7/1990	s	f	64.0		STHD tagging record	June 4/1990
Ishkheenickh	May 7/1990	s	f	64.0		STHD tagging record	June 4/1990
Ishkheenickh	May 7/1990	s	f	71.0		STHD tagging record	June 4/1990
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	f			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	m			Memorandum/MOELP files	June 5/1987
Ishkheenickh	May 22/1987	s	m			Memorandum/MOELP files	June 5/1987

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Ishkheenickh	May 22/1987	s	m			Memorandum/MOELP files	June 5/1987
Ishkheenickh	April 15/1987	s	m	91.4		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	m	81.3		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	m	68.6		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	f	86.4		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	f	71.1		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	f	83.8		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	f	86.4		Memorandum/MOELP files	June 8/1987
Ishkheenickh	April 15/1987	s	f	75.0		Memorandum/MOELP files	June 8/1987
Ishkheenickh	May 5/1985	s	f	?	R.3	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	f	?	3.2	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	f	?	3.3	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	f	?	R.2	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	f	?	3.3	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	m	?	3.3	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	f	?	3.3	Scale Cards/MOELP files	
Ishkheenickh	May 5/1985	s	m	?	?	Scale Cards/MOELP files	
Ishkheenickh	April 25/1982	s	m	66.0	3.1S1	Scale Cards/MOELP files	
Ishkheenickh	May 13/1978	s	f		4.1S1	letter to Paul Foote	July 19/1978
Ishkheenickh	May 13/1978	s	f		4.1S1	Scale Cards/MOELP files	
Ishkheenickh	May 13/1978	s	m	69.0	4.2	Scale Cards/MOELP files	
Ishkheenickh	May 6/1978	s	m	67.3	4.2	Scale Cards/MOELP files	
Ishkheenickh	May 6/1978	s	f	83.8	3.1S1	Scale Cards/MOELP files	
Kiteen	Dec. 2/1984	s	f	?	3.2+	Scale Cards/MOELP files	
Kiteen	Aug. 24/1982	s	f	?	?	Scale Cards/MOELP files	
Kiteen	April 3/1977	s	m	81.0	3.2+	Scale Cards/MOELP files	
Kwinageese	Oct. 19/1995	s	f	86.4		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	m	71.1		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	f	82.6		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	m	61.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	m	78.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	f	78.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	m	84.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	f	81.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	f	84.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	f	65.0		raw data/DNA sampling	
Kwinageese	Oct. 19/1995	s	m	85.0		raw data/DNA sampling	
Kwinageese	Aug. 9/1993	s	m	69.0	4.2+	Alexander and Koski, 1995	Sept. 14/1995
Kwinageese	Oct. 12/1982	s	f	76.2	4.2+	Kwin summary 1982	fall 1982
Kwinageese	Oct. 13/1982	s	f	71.1	3.2+	Kwin summary 1982	fall 1982
Kwinageese	Oct. 13/1982	s	m	61.0	3.1+	Kwin summary 1982	fall 1982
Kwinageese	Oct. 13/1982	r	m	39.4		Kwin summary 1982	fall 1982
Kwinageese	Oct. 13/1982	s	m	81.3	3.2+	Kwin summary 1982	fall 1982
Kwinageese	Oct. 13/1982	s	m	71.1	4.1+	Kwin summary 1982	fall 1982
Kwinageese	Oct. 16/1981	s	m	83.8	3.1S1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	88.9	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	76.2	4.1S1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	50.8	3.1+	Schultze 1981-SK-37	1981

April 15 steelhead	
No.	Age
1	3.2
1	3.3
4	4.3
1	R.2S1
1	3.2SS1

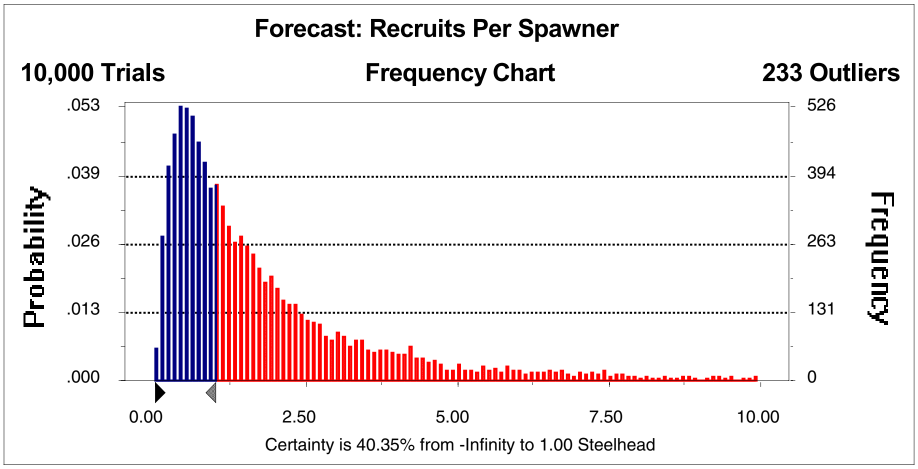
River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Kwinageese	Oct. 16/1981	s	f	76.2	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	58.4	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	63.5	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	m	58.4	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	71.1	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	71.1	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	55.9	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	61.0	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 16/1981	s	f	76.2	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	96.5	4.3+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	55.9	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	71.1	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	83.8	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	55.9	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	55.9	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	73.7	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	73.7	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	86.4	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	71.1	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	58.4	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	66.0	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	78.7	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	61.0	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	58.4	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	66.0	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	55.9	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	61.0	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	88.9	R.1S1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	61.0	4.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	81.3	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	83.8	R.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	94.0	3.3+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	55.9	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	81.3	3.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	f	76.2	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	61.0	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 17/1981	s	m	61.0	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	m	58.4	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	f	73.7	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	m	61.0	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	f	53.3	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	m	62.2	3.1+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	f	73.7	4.2+	Schultze 1981-SK-37	1981
Kwinageese	Oct. 18/1981	s	m	61.0	4.1+	Schultze 1981-SK-37	1981
Meziadin	Sept. 17/96	s	f	84.0	2.2+	fishway/scale cards	

River	Collection Date	Species s=STHD r=RBT	Sex	Length (cm)	Age	Data Source	Source Date
Meziadin	Sept. 18/96	s	f	64.5	3.1+	fishway/scale cards	
Meziadin	Sept. 20/1996	s	f	63.0	2.1+	fishway/scale cards	
Meziadin	Sept. 22/1996	s	f	65.5	3.1+	fishway/scale cards	
Meziadin	Sept. 22/1996	s	f	62.0	3.1+	fishway/scale cards	
Meziadin	Oct. 9/96	s	m	65.0	3.1+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	m	62.0	3.1+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	m	64.0	3.1+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	m	80.0	3.2+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	f	71.0	4.2+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	f	74.0	3.2+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	s	m	58.0	3.1+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 10/96	s	f	77.0	4.2+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 22/96	s	m	89.0	3.2S1+	Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	22.5		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	21.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	37.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	33.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	40.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	30.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	21.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	21.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	27.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	33.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 9/96	r	NA	45.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Oct. 22/96	r	NA	29.0		Memo to file/DNA sampling	Oct. 15/1996
Meziadin	Aug. 3/1993	s	f	73.0	4.2+	Alexander and Koski, 1995	Sept. 14/1995
Meziadin	Aug. 5/1993	s	f	80.0	2.2+	Alexander and Koski, 1995	Sept. 14/1995
Seaskinnish	Aug. 28/1993	s	m	75.0	R.2+	Alexander and Koski, 1995	Sept. 14/1995
Tseax	Aug. 13/1993	s	f	68.0	R.2+	Alexander and Koski, 1995	Sept. 14/1995
Tseax	Aug. 14/1993	s	m	63.0	3.2+	Alexander and Koski, 1995	Sept. 14/1995
Tseax	April 16/1987	s	f	83.82		Memo to file	June 8/1987
Tseax	April 16/1987	s	f	77.47		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	68.58		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	93.98		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	83.82		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	82.55		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	93.98		Memo to file	June 8/1987
Tseax	April 16/1987	s	m	83.83	4.2	Memo to file	June 8/1987
Tseax	April 30/1978	s	m	73.66	4.2+	Letter to Petrini	July 19/1977
Tseax	June 1/1975	s	f		4.2	Scale Cards/MOELP files	
Tseax	June 1/1975	s	f		3.2	Scale Cards/MOELP files	
Tseax	June 1/1975	s	f	62.0	3.1S1	Scale Cards/MOELP files	
Tseax	June 1/1975	s	f		3.2+	Scale Cards/MOELP files	
Tseax	April 30/1981	s	m	73.7	4.2	Scale Cards/MOELP files	
Zolzap	Aug. 16/1993	s	f	77.0	4.3+	Alexander and Koski, 1995	Sept. 14/1995

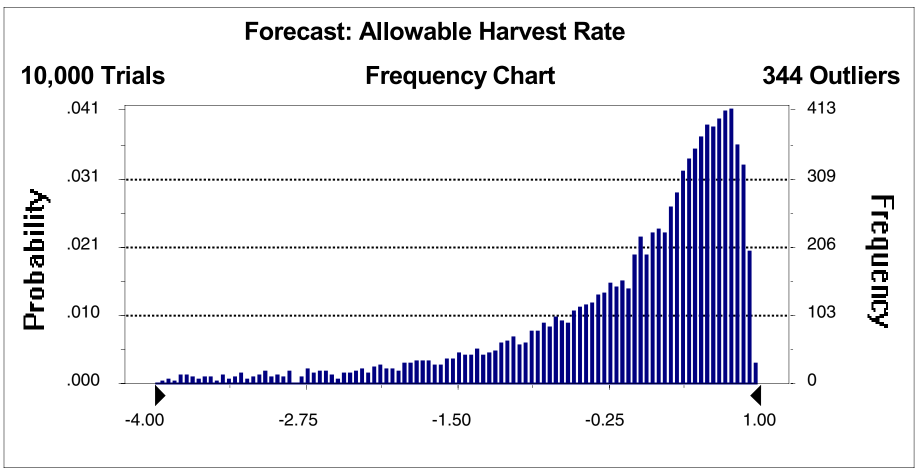
April 16 steelhead	
No.	age
5	3.3
1	3.4
1	4.2+
1	4.3
1	4.4
1	R.1S1

Appendix B. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Damdochax Creek steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

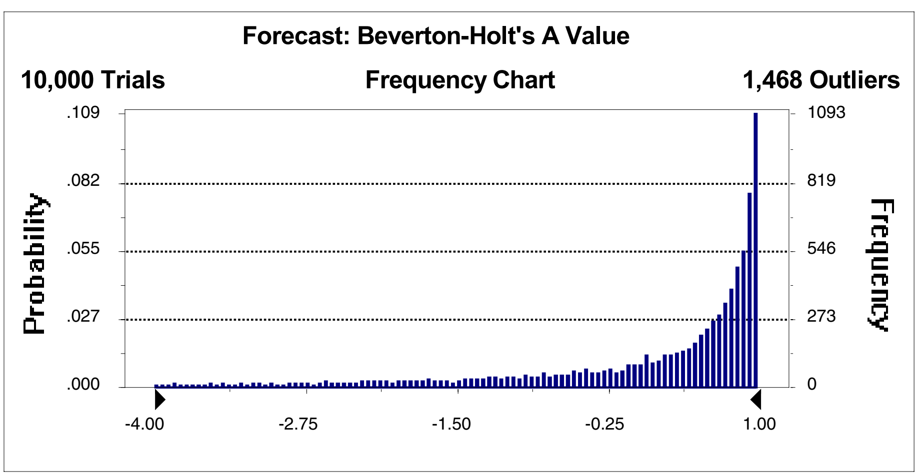
A.



B.

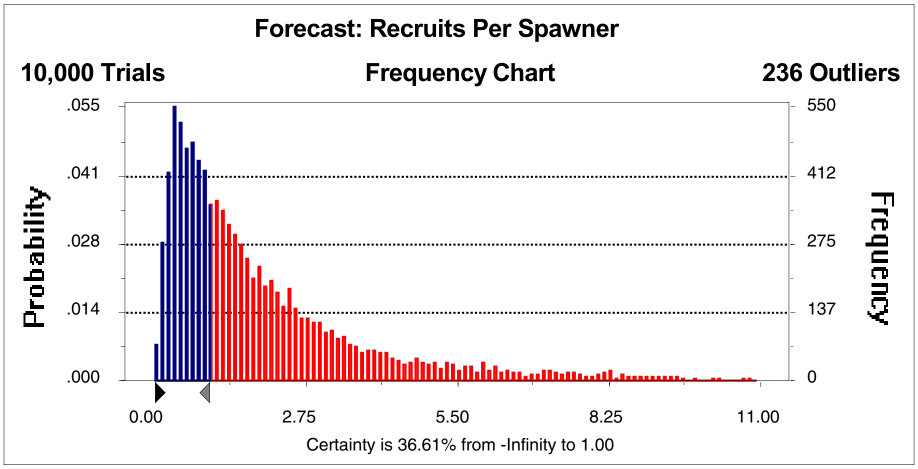


C.

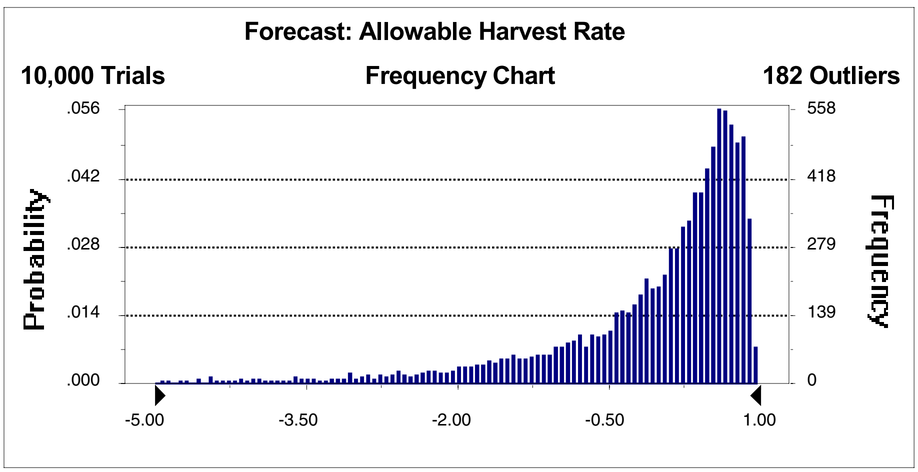


Appendix C. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Kwinageese River steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

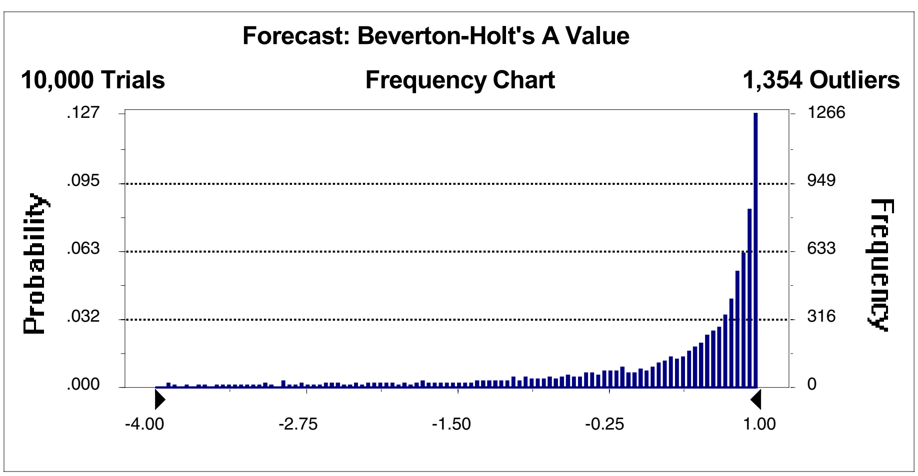
A.



B.

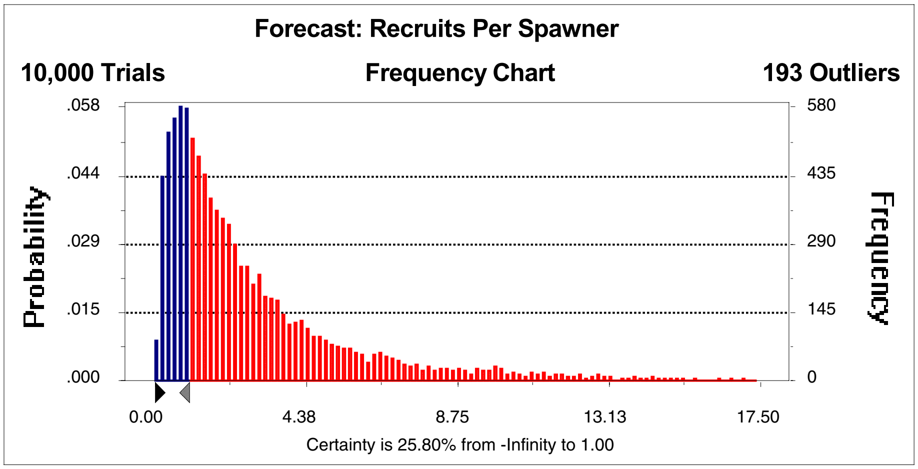


C.

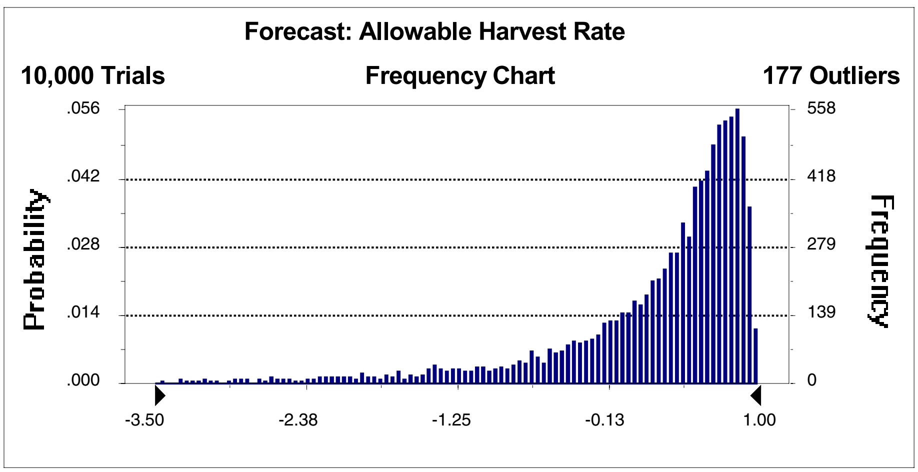


Appendix D. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Meziadin River steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

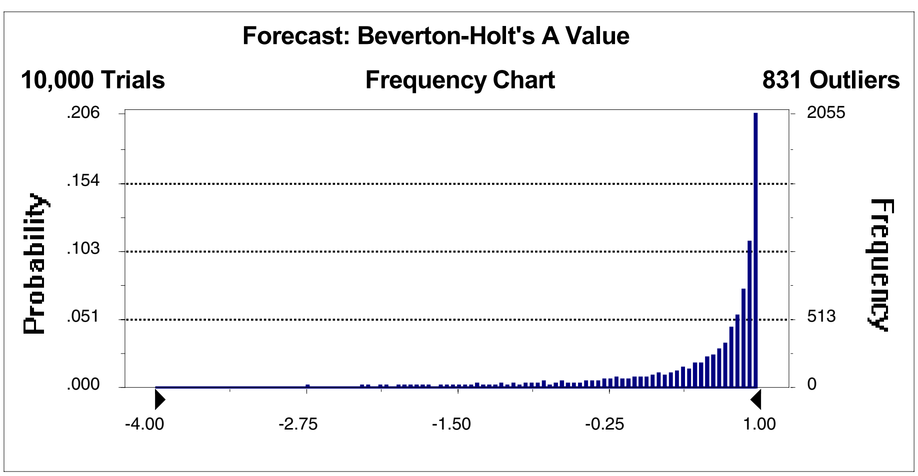
A.



B.

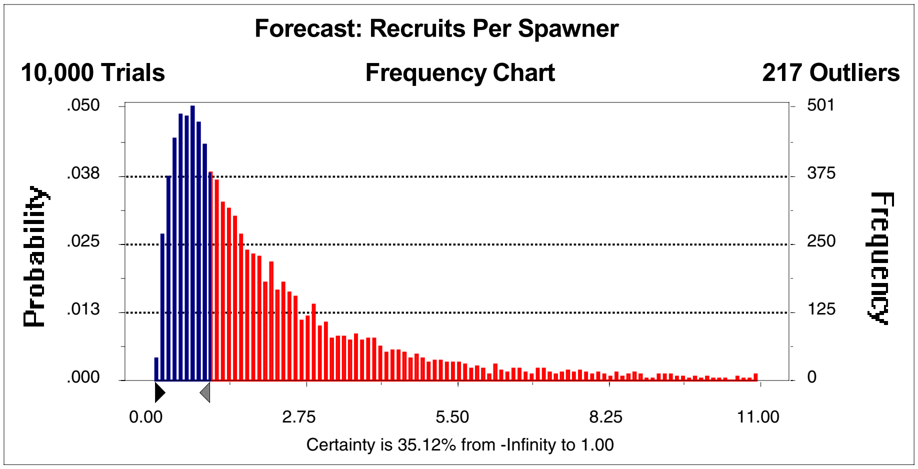


C.

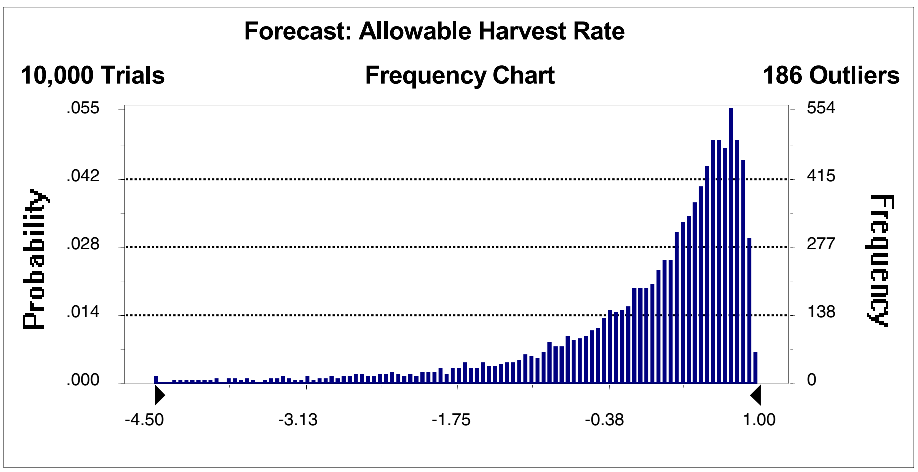


Appendix E. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for steelhead sampled at the Nass River fishwheels in 1996. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

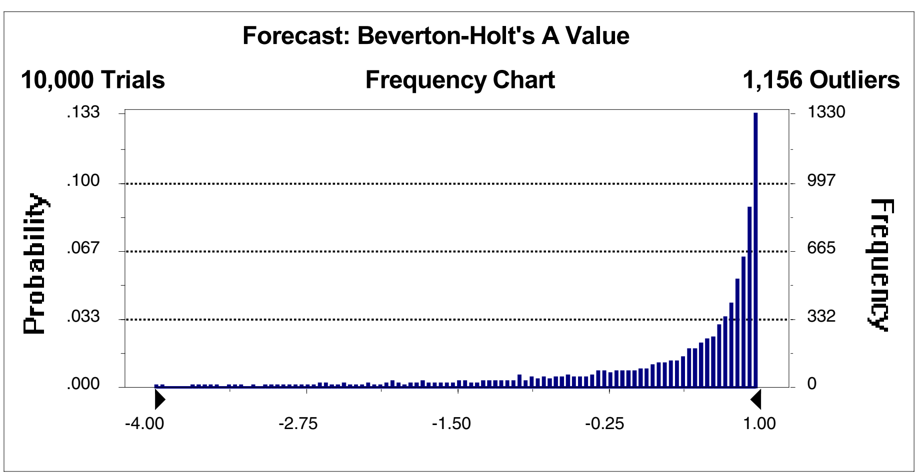
A.



B.

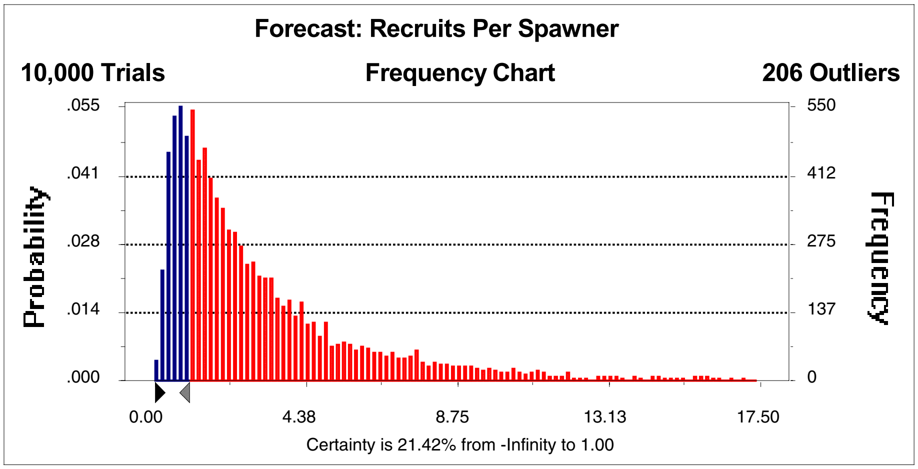


C.

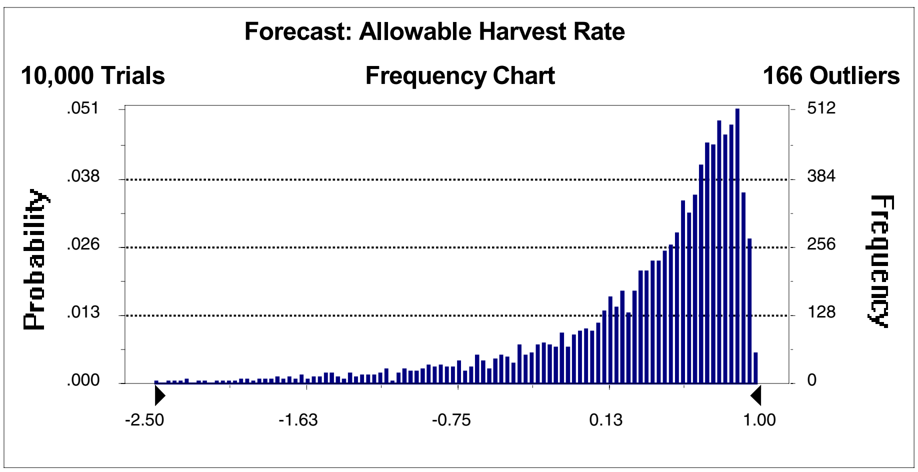


Appendix F. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Chambers Creek steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

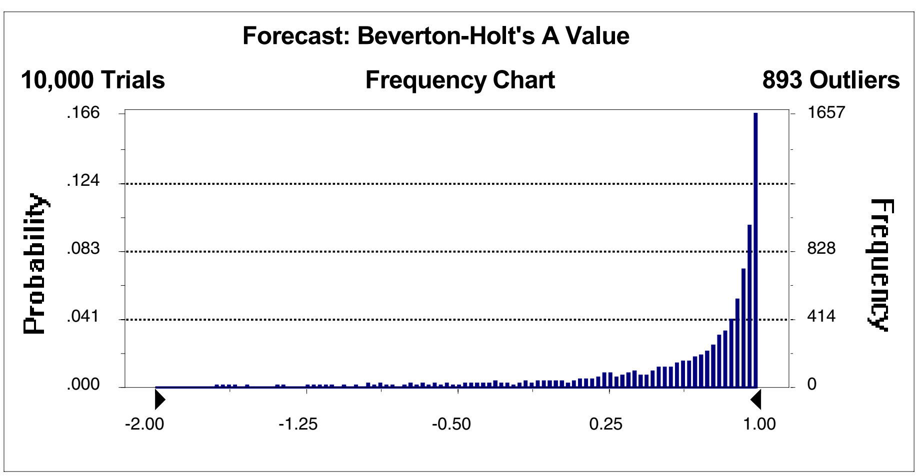
A.



B.

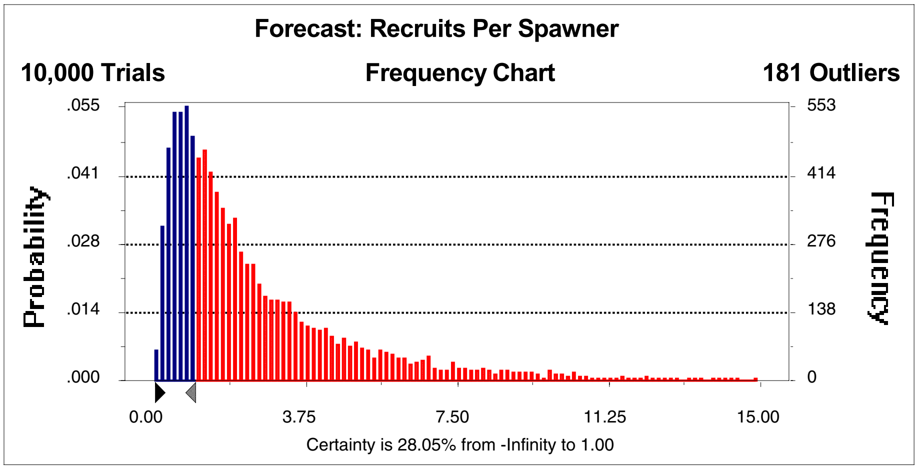


C.

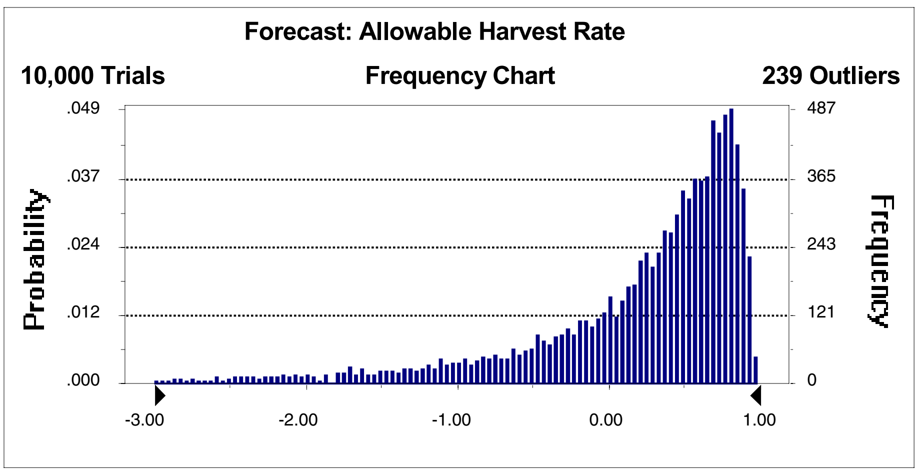


Appendix G. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Ishkheenickh River steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

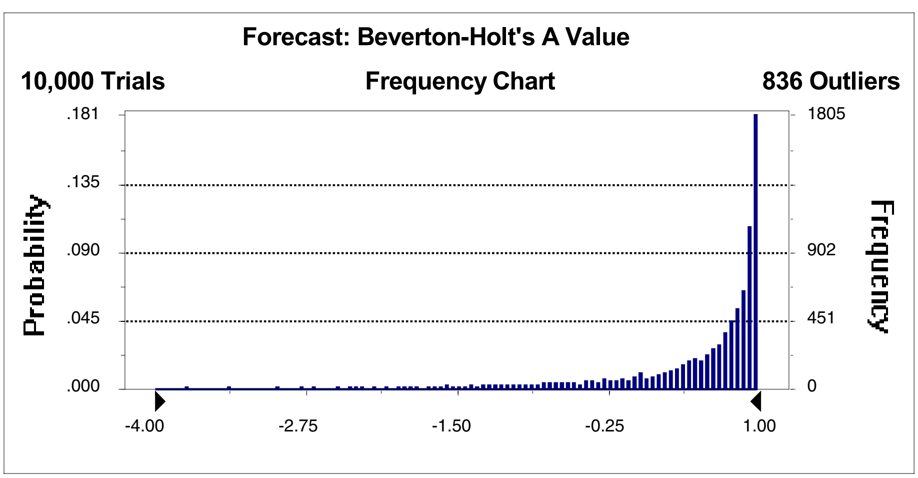
A.



B.

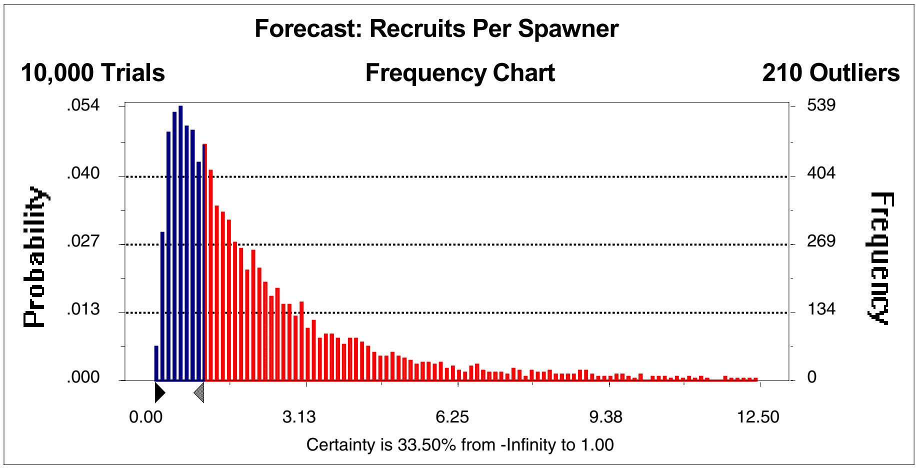


C.

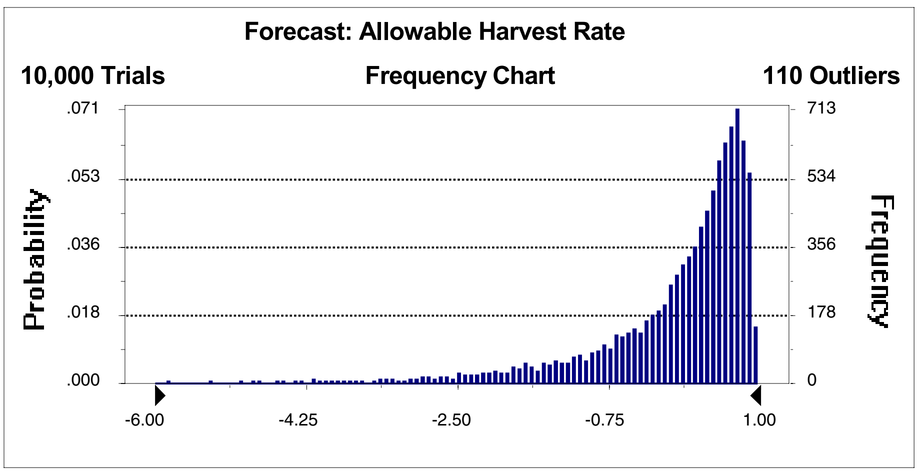


Appendix H. Probability distributions of recruits per spawner (A), allowable harvest rates (B) and Beverton-Holt's A value (C) for Tseax River steelhead. The dark shading in A indicates the probabilities of recruitment failure due to random variation.

A.



B.



C.