

# WEST COAST REGION FISHERIES

**An evaluation of exploitation rate on cutthroat trout in a large lake of Vancouver Island:  
Comox Lake.**

*by*

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*V.3 (updated Feb 2021)\**

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\*This report and underlying analyses have been revised and updated since its original completion in 2018, in order to address an underlying error identified in the capture histories and parameter derivation, as well as to incorporate ageing data from 2017 and a number of additional recaptures that were reported by anglers through the years 2019 and 2020

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## **ABSTRACT**

Cutthroat trout from Comox Lake were captured and tagged through the spring, summer, and fall periods of 2016 and 2017. A sub-sample of captured individuals were marked using pit tags and a combination of low-reward and high-reward floy tags. Fish sampling information was used to develop life history parameter estimates for cutthroat trout including relationships for growth, maturity, vulnerability, and fecundity.

In the spring periods of 2017 and 2018, portable pit array antennas were established in several of the primary cutthroat trout spawning streams to monitor fish movements and survival. The resultant angler tag-reports together with the mark-resight/recapture data derived from pit array detections and our own recaptures during sampling intervals were used to model survival and its subcomponents of natural mortality and fishing mortality.

A series of models were evaluated for realism and parsimony. The most parsimonious model estimates for instantaneous fishing mortality ( $F$ ) ranged from 0.14 - 0.16, and instantaneous natural mortality ( $M$ ) ranging from 0.62 - 0.81.

Together, this information was used to support an age-structured yield-per recruit analysis to evaluate the sustainability of the current exploitation rate, the suitability and effectiveness of current regulations, and the simulation of alternative regulations.

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## 1.0 INTRODUCTION

Adfluvial coastal cutthroat trout (*Oncorhynchus clarkii clarkii*) are the focal fishery in many of the large lakes on Vancouver Island. Where they co-occur with kokanee, sockeye salmon (*Oncorhynchus nerka*) and/or threespine stickleback (*Gasterosteus aculeatus*), cutthroat trout are normally piscivorous and can attain large sizes, attracting substantial levels of recreational fishing effort (Kehler 2013).

Much of the existing information on piscivorous cutthroat trout of Vancouver Island large lakes comes from fishery-dependent surveys based on creel returns (Lough 1991, Narver 1975), or on snorkel and electrofishing surveys of specific life stages of cutthroat trout while in tributaries (Lough 1991, Lough et al. 2011a and 2011b, Lough and Hay 2012). While these surveys have often been reasonably intensive, they provide either incomplete or indirect monitors of the underlying stock. Moreover, the interpretation of these investigations is limited either by the potential for bias (e.g. size-related bias and hyper-stability of catchability from fishery dependant surveys) or the uncertainties in our understanding of cutthroat trout life history (e.g. rearing use of tributaries by juveniles, or spawner residence time amongst adults).

While there have been numerous gillnet sampling efforts on the large lakes of Vancouver Island, the sampling approach has tended to mirror the standards set for small lakes assessments in BC, whereby a small number of floating and sinking experimental gillnets are set overnight. However, fish population sampling that occurs without consideration of a potentially non-uniform temporal-spatial distribution will provide highly variable or biased estimates of population parameters, and in ways that are difficult to recognize or account for. There are few examples in the literature of sympatric cutthroat trout and kokanee/sockeye populations in large lake ecosystems (Appendix A). However, the limited information available suggests that cutthroat trout in these systems may have a complex life history, with spatial-temporal distribution patterns that vary by size (~age) and by season. Our understanding of these patterns in the large lakes of Vancouver Island is poor, and thus presents an interesting challenge to stock assessment.

In 2015, the Provincial Fisheries Program partnered with the BC Conservation Foundation to complete an evaluation of a potential abundance-based sampling approach for piscivorous cutthroat trout monitoring in large lakes of Vancouver Island (Atkinson 2015). Survey crews completed intensive sampling across Sproat Lake during the summer months using variable-mesh horizontal gillnets suspended for 24 hours at multiple depth-strata through the limnetic portion of

the lake. Sampling locations were randomly selected, and results were stratified by depth to establish measures of catch-per-unit-effort (CPUE). Concurrent sampling was also completed along lake margins to represent littoral habitats and provide a contrast between the systematic limnetic sampling results and the more traditionally-sampled lake shoreline habitats. The observed fish distribution patterns were consistent with the findings previously described in other jurisdictions (Appendix A) and underscored the importance of cautious interpretation when considering historically completed low-intensity and/or shoreline-based sampling (i.e. variable CPUE resulting from patchy distribution and non-uniform spatial distribution by fish size). However, the investigations also determined that overall densities of cutthroat trout from the limnetic portion of the lake were extremely low, and the detection of meaningful differences in overall stock abundance between surveys using the standardized approach would require unrealistic sampling intensities (Atkinson 2015).

Our objective in this project was to investigate the use of exploitation rate and yield-per-recruit analysis as an alternative stock assessment approach for piscivorous cutthroat trout in the large lakes of Vancouver Island. This approach represents a departure from the more traditional abundance-based approaches that have been used in the Region, but was considered to potentially have several advantages including 1) the utilization of available or easily obtainable life history information, 2) logistical practicability and repeatability, and 3) establishment of a more quantitative approach to fisheries management decisions, and in a manner that allows for information sharing and comparison between or within lakes.

Comox Lake (2,100 ha, mean depth 61 m) supports one of the highest use lake-fisheries on Vancouver Island, generating roughly 6,500 angler days in 2011 (Vancouver Island Lakes Questionnaire [VILQ]; Kehler 2013). The fishery is driven primarily by the capture of large bodied cutthroat trout (~60%) and has traditionally been quite harvest-oriented. Following a series of public concerns about declining catch rates and fish size, fisheries regulations were implemented in 2013 which prohibited the harvest of cutthroat trout under 30 cm or over 50 cm annually, together with an annual bait ban and single barbless hook requirement. The effectiveness of these regulations has not been assessed.

## 2.0 METHODS

### 2.1 Fish Sampling

Sampling for cutthroat trout was completed using a variety of methods during the investigation, in part evolving as our understanding of sampling logistics and capture efficiency improved.

Three gear types were utilized including:

- trap-nets – two sizes of trap-nets were used (8 ft<sup>3</sup> and 6.5 ft<sup>3</sup>) with ¾” stretch mesh #10-gauge, 150 ft centre leads and 15 ft wing leads;
- fyke nets – 4 ft diameter with ¾” mesh and 75’ centre leads; and
- micro-trolling – angling with multiple small-sized lures clipped directly to downrigger lines across a range of depths.

During the period from April 6-15, 2016, three trap-nets and two fyke nets were fished at locations in the southern half of the lake for a total of 24 net-days and 14 net-days respectively. On July 20, 2016, micro-troll sampling was completed for 4.5 hours across a large section of the lake. Gear was frequently retrieved to check for fish captures, and UTM locations and depth information were noted where fish captures occurred.

During the period from October 24-28, 2016, three trap-nets were fished at locations in the southern half of the lake for a total of 15 net-days. On October 25, micro-trolling was also utilized briefly for 1.5 hours but no fish were captured. During the five-week period from March 8 to April 12, 2017, three trap-nets were fished at six locations across the entire lake and for a total of 96 net-days. With the exception of Cruikshank River which was continually trap-netted at this time (35 net-days), the average net-days per site in spring 2017 was 12.2 net-days (range 7-14).

Comprehensive information on sampling location details and results is provided in Figure 1, Table 1 and Appendix B. Trap-nets and fyke nets were checked every 24-72 hours based on sampling conditions and capture rates and adjusted each time to ensure they were continuing to fish effectively. Fork lengths of all captured fish were measured to the nearest millimetre and a sub-sample were weighed to the nearest gram. Sub-samples of cutthroat trout also had scale samples collected for age analysis. Despite the use of trap-nets as a non-lethal collection approach, a small number of cutthroat trout mortalities occurred. These fish were measured for fork length, weight, sex, maturity, stomach contents and had both otoliths and scales collected.

All age analyses was completed by the Freshwater Fisheries Society of BC (FFSBC) ageing lab in Abbotsford, BC.

Cutthroat trout over 250 mm (as well as 6 individuals between 230-250 mm) had a Floy-tag inserted at the base of their dorsal fin. Several types of floy tags were used through the course of the project, including orange floy tags in spring-2016, green floy tags with the caption “\$\$ REWARD” in fall-2016, and pink “high-reward” floy tags with the caption “\$100 REWARD” in fall-2016 and spring-2017. All floy tags included a phone number for the regional fish and wildlife office. Beginning in the summer of 2016, the majority of cutthroat trout over 200 mm fork length also had a uniquely coded passive integrated transponder (PIT) tag inserted into the dorsal sinus cavity next to their dorsal fin (23 mm HDX). All fish that received pit tag and/or floy tags were adipose fin-clipped prior to release as a secondary mark to support potential tag-loss evaluations.

A number of the cutthroat trout that were caught and released during spring sampling were expressing milt or eggs and so were identified positively as either male or female; however, it is recognized that males are more likely to have been expressing and therefore were more readily identifiable. When they occurred, recaptures were noted and their tag information, fork length, condition and when possible, sex were recorded prior to release.

All other fish species were enumerated, with a sub-sample measured for fork length and weight. Surface water temperatures were periodically recorded using a hand-held thermometer to the nearest 0.5°C.

A number of approaches were taken to promote awareness of the tagging program and reporting of tagged fish by anglers. Approaches included 1) posters displayed at local tackle shops and the Comox Lake boat launches, 2) project updates at meetings of the Courtenay and District Fish and Game Protective Association (CDFGPA) and in their newsletters, 3) media releases, 4) interviews with the local radio-station, 5) advertisements in the Campbell River Mirror newspaper, 6) project information included in the 2017-19 Fisheries Regulations Synopsis, and 7) project information posted online at the FFSBC website and in angler discussion forums.

## **2.2 Pit-Array Monitoring**

To support the establishment of total mortality and natural mortality estimates, three fixed receiver stations were installed in the spring periods of 2017 and 2018 to monitor for movement of pit-tagged fish into spawning tributaries. Two stations were established in major tributaries of the Cruikshank River watershed (one in Comox Creek and one in Reese Creek), and a third station was established in the Upper Puntledge River mainstem. Locations were chosen based on ease of access and their previous identification as important spawning streams for cutthroat trout (Lough 2011a; Figure 1). Each fixed station had a Hobo Water Temperature Pro v2 Data Logger installed, which collected water temperature data throughout the study period.

The pit tag-arrays were built as “pass over” full stream arrays with either one or two antennas per site. Antennas were built using 12/3 power cord in a loop with a looped distance of 16-18 m (32-36 m total cable length) and a loop width of 90 cm. Antennas were plugged into either an Oregon RFID ATC Auto Tuner or Easy Tuner depending on the configurations of the site, with tuners installed above the high-water mark. Belden 9207 (100 ohm, 20 AWG) Twinax cable was used to connect the tuning boxes to the readers. The Twinax cable lengths varied between the two antennas from 5 to 20 m. Stations were run by either one or two Oregon RFID Long Range HDX Multiplex Readers and powered by three 12V, 31 series AGM deep cycle batteries (connected in parallel). Antenna read range was tested with a dummy pit-tag and was 60-80 cm vertical height above the antenna which included most, or all, of the water column.

Two antennas were run in parallel approximately 30 m apart at the upper Puntledge River site in 2017 and 2018, and at the Comox Creek site in 2018. These stations were run with the Readers set up in a “master/slave” orientation, which allows for synchronous scanning cycles (40 ms) and prevents noise interference between the two antennas. The use of two antennas at these sites allowed for the evaluation of movement direction and array efficiency. In 2017, the stations at Comox Creek and Reese Creek each used only a single antenna which supported the detection of pit-tagged fish for mortality estimation, but not movement or efficiency evaluations. Data downloads and battery changes were completed roughly once per week, and when necessary, adjustments were made to ensure that antennas were in-tune and vertical read-range was satisfactory.

The upper Puntledge River fixed receiver station was installed on March 21, 2017 approximately 1.6 km upstream of Comox Lake, and left in place until May 1, 2017. The Comox Creek array was installed on March 30, 2017 and maintained until May 12, 2017 at a location roughly 3.6 km upstream of Comox Lake. Heavy snow loads prevented access to the Reese Creek site until later in the season, and so this array was installed on April 7, 2017 and maintained until May 12, 2017 at a location roughly 7.0 km upstream of Comox Lake (Figure 1).

In 2018, the pit-array stations were initiated on February 8 at Upper Puntledge, on February 9 at Comox Creek, and on April 4 at Reese Creek. Once installed, arrays were maintained until their removal on May 7, 2018.

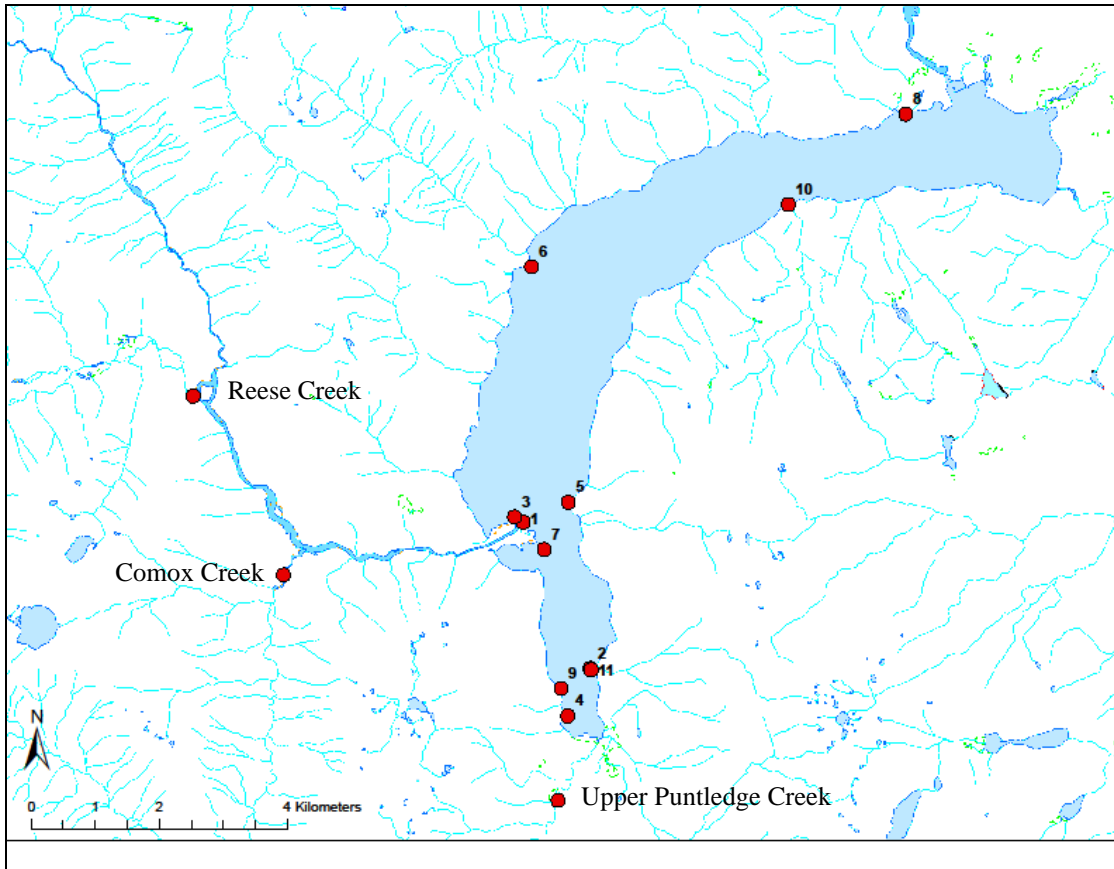


Figure 1. Comox Lake fish sampling (numbered) and pit-array fixed station locations. Location labels are consistent with locations referenced in Table 1.

Table 1. Location and effort summary for fish sampling and pit arrays.

Location*	Effort	Set Date	Removal Date	Description	Sampling Days	Zone	Easting	Northing
1	TN2	2016-04-06	2016-04-15	Cruikshank outlet	9	10	341806	5494441
2	TN1	2016-04-06	2016-04-15	near stream outlet on se shore	9	10	342762	5492128
3	FN1	2016-04-07	2016-04-14	north of Cruikshank outlet	7	10	341737	5494428
3	FN2	2016-04-07	2016-04-14	100m north of FN1	7	10	341676	5494530
4	TN3	2016-04-08	2016-04-14	west shore and north of U Puntledge	6	10	342384	5491403
1	TN2	2016-10-24	2016-10-28	Cruikshank outlet	4	10	341806	5494441
5	TN3	2016-10-24	2016-10-28	across the lake from Cruikshank	4	10	342526	5494724
6	TN1	2016-10-24	2016-10-27	near Pearce Creek outlet	3	10	342095	5498403
1	TN1	2017-03-08	2017-04-12	Cruikshank outlet	35	10	341806	5494441
7	TN2	2017-03-08	2017-03-15	south of Cruikshank outlet	7	10	342117	5494005
8	TN3	2017-03-09	2017-03-21	west of pilings	12	10	348033	5500539
9	TN4	2017-03-15	2017-03-29	southwest end of lake on west shore	14	10	342293	5491834
10	TN5	2017-03-22	2017-04-05	near stream outlet on se shore	14	10	346145	5499210
11	TN6	2017-03-29	2017-04-12	southeast trib	14	10	342776	5492107
Comox Cr	Pit Array	-	-	Comox Cr	-	10	338033	5493772
Reese Cr	Pit Array	-	-	Reese Cr	-	10	336737	5496611
Upper Puntledge	Pit Array	-	-	Upper Puntledge	-	10	342175	5490098

\*location references are consistent with labelled locations in Figure 1

### 2.3 Mark-Recapture

A Barker model is used to support estimation of total annual survival ( $S$ ) for the Comox Lake cutthroat trout population (Amstrup et al 2005). Within this model, the population is considered to be closed and so the associated fidelity parameters ( $F$  and  $F'$ ) can be ignored (i.e.  $F = F' = 1$ ). Reported recaptures by anglers between primary sampling sessions are used to derive the recovery parameter ( $f$ ) for fish that have floy tags and is assumed to be constant through time. Most reported recaptures by anglers represent harvested fish, so for modelling purposes all reported recaptures were treated as harvest-based mortalities. Two pairs of re-sighting parameters were included ( $P$  and  $P'$ ) to reflect the associated 're-sight' probabilities during periods of pit-tag array monitoring in 2017 and 2018.

The Barker model capture histories for each fish were considered to be independent and the full likelihood given by the multinomial product of capture history probabilities (Amstrup et al 2005) as

Eq. 1. 
$$L_{Barker} = \prod_{j=1}^n p_j$$

Rosenkranz et al (1999) found that tag-loss rates were less than 7.5 % in all years in their mark-recapture work on cutthroat trout from Florence Lake in Alaska. This is similar to the estimate of 7.0 % reported for rainbow trout in the mark-recapture study completed on Kootenay Lake (Thorley and Andrusak 2017). While no tag-loss was directly observed in the Comox Lake project, the number of individuals that were recaptured and checked for tag loss was small. Accordingly, a conservative value of 7 % tag loss ( $d$ ) was included within the model.

Reporting rate ( $\lambda$ ) is assumed to be 100% for all high reward tags (\$100). For tags that were not marked as high-reward (including orange and green floy tags), the reporting rate was assumed to be 75% based on anecdotal reports of fish which were known to have been captured but not reported to our office. However, a reporting rate parameter was included within the model to allow for sensitivity evaluation on model outputs.

To be conservative, the annual recovery rate ( $f$ ; *~angler capture rate*) was considered to be directly related to the annual exploitation rate ( $u$ ; Pollock et al 1991), and where  $u$  was assumed to be constant throughout the year such that exploitation in any portion of a year was given by  $u$  times the fraction of year for that time period ( $t_x$ ). The recovery parameter ( $f_x$ ) was then linked to annual exploitation through the equation

Eq. 2. 
$$f_x = t_x * [u\lambda(1 - d)]$$

The annual exploitation rate ( $u$ ) and the expectation of dying from natural causes ( $v$ ; finite natural mortality rate as defined in Pollock et al 1991) were then derived through their relationship with total annual survival ( $S$ ) by the equation

Eq. 3. 
$$S = 1 - u - v$$

For the purposes of this investigation, the Comox Lake cutthroat trout fishery was considered to be a Type I fishery in which the periods of natural and fishing mortality occur sequentially rather than concurrently (see Section 2.4.3). Accordingly, the instantaneous natural mortality rate ( $M$ ) was related to annual exploitation rate ( $u$ ) and the finite natural mortality rate ( $v$ ) by the equation from Ricker (1975)

Eq. 4. 
$$v = (1 - e^{-M}) * (1-u)$$

The second component of the model is a prior distribution for **instantaneous natural mortality** to help support convergence of model outputs. Harding et al (1999, 2009) estimated instantaneous natural annual mortality rates ( $M$ ) to be 0.44, 0.63, 0.67 for three adfluvial lacustrine cutthroat

trout populations in Alaska. Empirical approaches to instantaneous natural mortality estimation were also explored using information from Comox Lake cutthroat trout on maximum age ( $t_{max}$ ), growth parameters ( $K$  and  $L_{inf}$ ) and/or mean annual water temperature, and generated estimates of  $M$  between 0.27 to 0.66 (Alverson and Carney 1975; Pauly 1980; Hewitt and Hoenig 2005; Then et al 2015). The mean of the pooled Alaskan lakes and empirical estimates is 0.53 with a standard deviation of 0.14 (CV = 0.26). These estimates were assumed to be normally distributed and used to establish a prior likelihood for incorporation into the model whereby mean instantaneous natural mortality ( $M^*$ ) was set at 0.53 and with a standard deviation ( $\sigma_{M^*}$ ) of 0.14.

Eq. 5.

$$L_{Mprior} = \left[ \frac{1}{\sigma_{M^*} \sqrt{2\pi}} \exp\left(-\frac{(M - M^*)^2}{2\sigma_{M^*}^2}\right) \right]$$

One element of uncertainty within the assessment approach is the consideration of **post-spawner mortality**. Fish capture and tagging efforts were completed across multiple seasons (spring, summer, and fall), but were most efficient during the spring period when fish are concentrating near the mouths of tributaries. However, there is a risk that many of the tagged fish are concentrating in these locations as pre-spawners and that there may be a substantial level of spawning-related mortality shortly after tagging and release. If not accounted for, the effect of fish falling out of the ‘fishable’ population shortly after tagging would be an underestimation of exploitation rate.

Investigations on the cutthroat trout populations of Yellowstone Lake found mean rates of post-spawning mortality to be 13%, 29%, 31% and 48% over different survey periods and locations (mean of 0.3 with standard deviation of 0.14; *in* Gresswell 1994). In order to address this possibility in our dataset, models were evaluated in which survival was treated as constant ( $S.dot$ ) and compared against models in which survival was allowed to vary in the second quarter of each year (April through June;  $S.time$ ). In the subset of models with time-varying survival, we also explored the influence of a prior likelihood function in which the probability of post-spawn mortality ( $psm$ ) for the three-month period from April through June was set at 0.30 ( $psm^*$ ) and with a standard deviation of 0.140 ( $\sigma_{psm^*}$ ; CV = 0.47).

Eq. 6. 
$$L_{psm\ prior} = \left[ \frac{1}{\sigma_{psm^*} \sqrt{2\pi}} \exp\left(-\frac{(psm - psm^*)^2}{2\sigma_{psm^*}^2}\right) \right]$$

The overall likelihood was then the product of the related component likelihoods

Eq. 7. 
$$L_{total} = L_{Barker} * L_{m\ prior} * L_{psm\ prior}$$

Maximum likelihood estimates of instantaneous fishing mortality ( $F$ ) and instantaneous natural mortality ( $M$ ) were then established by searching over the underlying model parameters ( $psm$ ,  $S$ ,  $f$ ,  $P$ ,  $P'$ , and capture probabilities  $p_1, p_2, \dots, p_n$ ) using non-linear search software.

Confidence intervals on the model estimates were established using the likelihood profile method (Hilborn and Mangel 1997). Using the maximum log likelihood from the total likelihood calculation, denoted as  $LL(E)_{max}$ , and holding all other parameters at their optimal values, we can solve for the confidence bounds of  $E$  noting that

Eq. 8. 
$$2*(LL(E)_{max} - LL(E)) \approx \chi^2$$

and where  $\chi^2$  has one degree of freedom (i.e.  $\chi^2 = 3.8415$ ).

Additional overarching assumptions within the survival model are as follows:

- 1) There is no permanent (or significant) emigration of tagged fish from the lake. As such, all tagged fish, if alive, are considered to be vulnerable to both recapture during sampling sessions and vulnerable to anglers. Potential movements by fish into tributaries for reasons of spawning or foraging are considered to be transitory and ignored here for purposes of establishing recapture probabilities and exploitation rates.
- 2) Tagged fish are representative of the overall population and fish tagging does not affect survival or behaviour. Additionally, tagged fish are assumed to mix freely within the population and subsequent recaptures or angler-encounters represent a random sample. The validity of this assumption was not tested explicitly but appears reasonable based on observed movement of fish within the study (details provided in this report).

- 3) Survival and the associated sub-components for natural and fishing mortality are assumed to be constant over the years of investigation, as well as invariant by sex and age, or at least within the size and age classes included within the tagging investigation (sub-adults and adults >200 mm).
- 4) Sampling periods (tagging and recapture) are considered to be instantaneous.
- 5) Exploitation rates (or fishing effort) at Comox Lake were not artificially increased as a result of the investigation and the opportunity to obtain a high-value reward. While it is not possible to verify this assumption directly, the potential for exploitation pressure to have meaningfully increased is considered low given the overall magnitude of the Comox Lake fishery (~6,500 angler-days annually). Moreover, the degree to which this might occur would result in a slight overestimate of exploitation rate and would therefore err on the side of conservatism from a fisheries management perspective.

## 2.4 Yield-Per-Recruit Analysis

An age-structured model is used to evaluate the influence of different fishing rates and regulation suites on cutthroat trout. One of the underlying assumptions is that the population is currently at equilibrium. Information on cutthroat trout life history parameters (growth, fecundity, vulnerability and maturity) is derived from direct sampling of the population and/or supported by other sources of information. Estimates of exploitation rate and natural mortality rate are obtained through the mark-recapture analysis of the angler-reward tagging study detailed previously.

### 2.4.1 Life History Parameters

**Growth** is described by a von Bertalanffy growth curve using the equation

Eq. 9. 
$$l_t = l_{inf} (1 - e^{-K(t-t_o)})$$

where  $l$  is fork length in cm. Data to establish this relationship were taken directly from Comox Lake sampling efforts.

**Fecundity** is assumed to be a power relationship with length and modelled on the equation

Eq. 10. 
$$fecundity_a = Fc * l^{Fp}$$

where  $l$  is mean length at a given age, and  $F_c$  and  $F_p$  are constants. Data to establish this relationship was based on the results of a lacustrine adfluvial cutthroat trout population in Florence Lake, Alaska (n=71; Foster 2003) together with a sample of cutthroat trout collected from Horne Lake on Vancouver Island in 2017 as part of a broodstock investigation (n=12; FFSBC *unpub. data*). The fish size distributions of these two datasets were non-overlapping and thus provided complimentary information across the range of fish sizes that were of interest in this project. The parameter values that best fit the combined dataset were  $F_C = 0.1338$  and  $F_P = 2.3365$  ( $r^2=0.9189$ ).

Fecundity-by-age is a key element in the yield-per-recruit model and as such, it is important to also incorporate information on **maturity**. To do this, we summarised the observations of fish that were expressing gametes during spring collections, the detections of fish from pit-array monitoring (assumed to represent spawning behaviour), and those fish which had spawning checks identified during scale-analysis. Of particular interest in this evaluation was the maturity schedule of females.

We analysed the proportion of fish identifiable as mature by size-bin relative to the total number of fish that were captured. Maturity was assumed to follow a logistic relationship using the equation

Eq.11.

$$M_L = \frac{1}{1 + e^{(M1 - M2 * L)}}$$

where  $M_L$  is the proportion of mature fish captured within a given size range,  $L$  is the mid-point length of the size range (in units of cm), and  $M1$  and  $M2$  are constants derived through log transformation and linear regression.

**Vulnerability** ( $V_L$ ) to angling is assumed to be a logistic relationship of the same form as described above, but substituting parameters  $V_L$ ,  $V1$  and  $V2$  to reflect the relative vulnerability of fish at a given size range ( $V_L$ ) and where  $V1$  and  $V2$  are constants that provide the best fit to the data. As an initial approach, the age distribution data from a previous investigation of anglers' catch at Comox Lake (Lough 2010; n=91) was compared to the expected age distribution of the

population given our estimate of total mortality from this survey ( $Z$ ), and by setting vulnerability of the oldest age class (7 years) to 100%. This approach assumes that total mortality was similar in 2009 to levels of 2016-17 but seems reasonable given the relatively consistent effort estimates over recent years (four survey estimates between the years 2006-2011 ranging from 5,568 to 6,530; Michalski and Fosker 2013).

As a supplementary approach, I also evaluated the number of angler-reported recaptures from 2016-2018 by size-bin relative to the number of fish that had been marked and released. Fish that were tagged and released in the spring of 2016 were considered to remain in their respective size-bins during the remainder of the 2016 angling year, but their individual sizes were then increased by one calendar year (using the derived parameters of the von Bertalanffy growth equation; Section 3.3.1) and their abundance reduced in a knife edge manner by the total mortality estimate (Section 3.2) with each effect occurring on January 1, 2017 and then again on January 1, 2018. Fish that were tagged and released in the summer of 2016, the fall of 2016, and the spring of 2017 were aggregated and considered to remain in their respective size bins and without losses due to mortality through the 2017 angling year, and treated similarly with respect to knife-edge growth and abundance effects on January 1, 2018.

The resulting estimates of fish reported as recaptures by anglers relative to the number of fish at-large in a given size-bin were then scaled and used to establish a gear selection function based on the logistic equation described above.

Within the model, all fish which are captured and legally harvestable are considered to be harvested. To account for the potential impact of **catch-and-release mortality** ( $h$ ) amongst fish which must be released by regulation, a range of mortality rates from 0.05 to 0.40 were used to represent the range of survival expectations under either restrictive (e.g. bait ban with single barbless hook) or liberal gear regulations. These values reflect the range of observations described in the literature (Loftus et al 1988, Titus and Vanicek 1988).

#### 2.4.2 Equilibrium Calculations - Unexploited

Equilibrium calculations are completed using the Botsford 'incidence function' approach detailed in Bison et al (2003) and Walters and Martell (2004). Using this approach, an age-structured model is developed and relative survivorship by age is combined with age-related values for

growth, fecundity, maturity and vulnerability to determine equilibrium incidence functions ( $\phi$ ). Each incidence function is the weighted sum over all ages to a maximum longevity of 9 years ( $t_{max}$ ) for a quantity such as eggs produced per recruit ( $\phi_\epsilon$ ), or individuals in the population per recruit ( $\phi_N$ ). Maximum longevity was set at  $t_{max} = 9$  years based on a review of age information from across the large lakes of Vancouver Island and mainland BC Coast (maximum age of 8 observed in samples), and the point at which < 1% of the population is expected to remain in an unexploited population given the derived estimates of natural mortality from this investigation (Section 3.2).

**Survivorship** ( $s$ ) to age ( $a$ ) is given by the recursive relationships

Eq. 12.  $s_1 = 1,$  and

Eq. 13.  $s_a = s_{a-1} e^{-M} (1 - (uv_a r_a + huv_a(1-r_a)))$  for  $a > 1$

where  $u$  is the annual exploitation rate for fully vulnerable fish,  $v_a$  is a scalar for vulnerability at a given age,  $r$  is a fixed value which indicates that a fish of a given age (~size) may be legally retained by regulation ( $r = 1$ ) or must be released ( $r = 0$ ), and  $h$  is a rate of handling mortality for fish that are caught-and-released. In the case of an unexploited fishery ( $u=0$ ), all the elements within parentheses fall out of the equation and survival is strictly a function of instantaneous natural mortality ( $M$ ).

For the purposes of this model,  $R$  is the number of age 1 cutthroat trout ('recruits'). **Recruitment** at unfished equilibrium ( $R_o$ ) is given by the equation

Eq. 14.

$$R_o = \frac{N_o}{\phi_N}$$

where  $N_o$  is the equilibrium stock size (individuals of age 1 and greater in the population) fixed at a value of 1, and  $\phi_N$  is the number of individuals in the population per recruit when  $u = 0$ , where

Eq. 15.  $\phi_N = \sum_{i=1}^a s_a$

Since the incidence function  $\phi_N$  is driven entirely by natural mortality, and fecundity and maturity by age are established independently, these relationships functionally establish the survival rate of eggs to recruits (age 0 to 1) for the population when in unfished equilibrium.

The average annual production of eggs at unfished equilibrium ( $\epsilon_o$ ) can then be established by

Eq. 16.

$$\epsilon_o = R_o * \phi_\epsilon$$

where the incidence function for eggs per recruit is given by the equation

Eq. 17.

$$\phi_\epsilon = \sum_{i=1}^a s_a * fecundity_a * maturity_a$$

For the purposes of the model we assume a Beverton-Holt stock-recruitment relationship in which one year old cutthroat trout are the ‘recruits’ ( $R$ ) and the ‘stock’ is the number of eggs produced annually ( $\epsilon$ ; as per Goodyear 1980), such that

Eq. 18.

$$R = \frac{\alpha \epsilon}{1 + b \epsilon}$$

The productivity parameter ( $\alpha$ ) can be derived using the unfished equilibrium estimates for recruits and egg production by the equation

Eq. 19.

$$\alpha = K \frac{R_o}{\epsilon_o}$$

where  $K$  is a ‘compensation ratio’ (Goodyear 1980, Walters and Martell 2004). Values of  $K$  were estimated by Myers et al (1999) and defined as the maximum number of stock produced per unit of stock over its lifetime (referred to as  $\hat{a}$  in that paper). For salmonids, the maximum number of stock produced per unit of stock annually ( $\tilde{\alpha}$ ) ranged by species from values of 2.5 to 7.3 with an

overall value of 4.2 for the Salmonidae family (Myers et al 1999). Assuming instantaneous natural mortality rates ( $M$ ) of between 0.4 and 0.7 for cutthroat trout, this would suggest a ‘compensation ratio’ of between 8.3 to 12.7 based on the equation in Myers et al (1999) where

Eq. 20.

$$K = \frac{\tilde{\alpha}}{(1 - e^{-M})}$$

Given the uncertainty associated with this parameter and its influence on stock resilience, a conservative value of  $K = 9$  was used for purposes of analysis. To evaluate the potential influence of this parameter on model outcomes (and the possibility that Vancouver Island’s low productivity waters may dampen the compensatory resilience of fish populations), we also investigated the sensitivity of model outputs to this parameter across a range to  $0.5 * K$ .

By rearranging the Beverton-Holt equation from above, we can then solve for the density dependence term ( $b$ ) as

Eq. 21.

$$b = \left( \frac{\frac{\alpha \epsilon_o}{R_o} - 1}{\epsilon_o} \right)$$

#### 2.4.3 Equilibrium Calculations - Exploited

Although the fishery for cutthroat trout is extended throughout much of the year in Comox Lake (Michalski and Fosker 2013), model dynamics are based on a Type I fishery in which natural mortality occurs separately in time from fishing mortality (Ricker 1975) and the two are treated in an additive manner when considering total mortality. Either a Type I (discrete) or Type II (continuous) fishery can be incorporated into the model, however it appears that spawning-related mortality may be a prominent component of overall natural mortality, and largely occurring over a discrete time interval (Section 2.2). Annual exploitation rate ( $u$ ) is therefore related to instantaneous fishing mortality ( $F$ ) by the equation

Eq. 22.

$$u = 1 - e^{-F}$$

For any state of equilibrium, average egg production ( $\epsilon$ ) must equal the average number of recruits ( $R$ ) multiplied by the incidence function for eggs per recruit ( $\phi_\epsilon$ ),

Eq. 23.

$$\epsilon = R * \phi_\epsilon$$

This relationship can be substituted into the Beverton-Holt equation from above and rearranged to solve for the equilibrium number of recruits in the presence of a fishery ( $R_F$ )

Eq. 24.

$$R_F = \frac{\alpha \phi_\epsilon - 1}{b \phi_\epsilon}$$

Equilibrium catch (~yield;  $C_F$ ) under a given level of exploitation, can then be calculated to reflect the relative number of fish caught, including both fish that are harvested and those that are caught-and-released, as

Eq. 25.

$$C_F = u * R_F \sum_{i=1}^a s_a * v_a$$

where  $s$  reflects the survivorship of the population under a given exploitation rate, age-dependant vulnerability ( $v_a$ ) to angling, catch and release mortality, and size regulations.

In a similar manner, the equilibrium catch of ‘quality-sized’ fish which are greater than 40 cm (~age 6 and older) can be evaluated to consider the influence of alternative fishing regulations

Eq. 26.

$$C_Q = u * R_F \sum_{i=6}^a s_a * v_a$$

and equilibrium number of fish harvested (assuming all legally retainable fish are retained) can be evaluated using

Eq. 27.

$$C_H = u * R_F \sum_{i=1}^a s_a * r_a * v_a$$

where  $r$  is a scalar of either one or zero to reflect size-based fishing regulations.

### 3.0 RESULTS

#### 3.1 Fish Sampling

In the spring period of 2016, 90 cutthroat trout were captured in trap-nets or fyke nets with all 90 being successfully released. Floy tags were inserted into 56 fish (orange floy tags with the phone number for the fish and wildlife office but no indication of reward on the tag). Only one pit tag was deployed during this sampling period. Mean size of cutthroat trout captured was 271 mm with a range of 82-535 mm.

Additional species captured in the spring of 2016 included 39 juvenile coho (*Oncorhynchus kisutch*; length range 62-144 mm); 71 Dolly Varden (*Salvelinus malma*; length range 101-362 mm); 17 kokanee (length range 74-189 mm); 5 rainbow trout (*Oncorhynchus mykiss*) of which two were given orange floy tags (length range 183-250 mm); 14 coastrange sculpin (*Cottus aleuticus*), and 6 threespine stickleback.

On July 20 2016, micro-trolling resulted in the capture of two cutthroat trout at depths of 60 and 80 ft. Each fish was tagged with a pit tag and given an orange floy tag. Lengths were 335 and 481 mm.

In the fall period of 2016, 96 cutthroat trout were captured in trap-nets with 91 successfully released and 5 sampling mortalities. Reward floy-tags were inserted into 31 fish (5 green tags indicating “\$\$ REWARD” but with no reward value indicated, and 26 pink tags indicating “\$100 REWARD”). Pit tags were inserted into 53 of the cutthroat. Mean size of cutthroat trout captured was 238 mm with a range of 120-432 mm.

Additional species captured in the fall of 2016 included 92 coho (length range 70-108 mm but also including three adults 590-666 mm); 65 Dolly Varden of which seven were given green Floy-tags (length range 96-437 mm); 21 kokanee (length range 124-227 mm); 9 rainbow trout of which three were given Floy-tags (two green tags and one pink tag; length range 162-353 mm); and one summer steelhead with length 670 mm. No fish were captured using micro-trolling at this time.

In the spring period of 2017, 124 cutthroat trout were captured in trap-nets with 120 successfully released and 4 sampling mortalities. Included amongst the captures were three previously tagged

cutthroat trout (2 of which were originally tagged in spring 2016 and one of which was originally captured by micro-trolling in July 2016). All three of these recaptures had retained their orange floy tags since release. High reward pink tags (“\$100 REWARD”) were inserted into 64 fish (including one of the recaptured fish that had previously been tagged with an orange floy tag). Pit tags were inserted into 64 of the cutthroat. Mean size of cutthroat trout captured was 288 mm with a range of 86-576 mm.

Additional species captured in the spring of 2017 included one chinook (*Oncorhynchus tshawytscha*; 102 mm), 135 juvenile coho (length range 70-135 mm); 52 Dolly Varden (length range 114-351 mm); 104 kokanee (length range 76-164 mm); 7 rainbow trout of which one was given a high reward pink Floy-tag (length range 103-307 mm); 11 coastrange sculpin and 8 threespine stickleback.

No cutthroat trout were captured that had evidence of tag loss (i.e. fish that were captured with an adipose-clip but with a missing floy tag or pit tag). Comprehensive length and age information is available in Appendix B and the summary length information is provided in Figure 2.

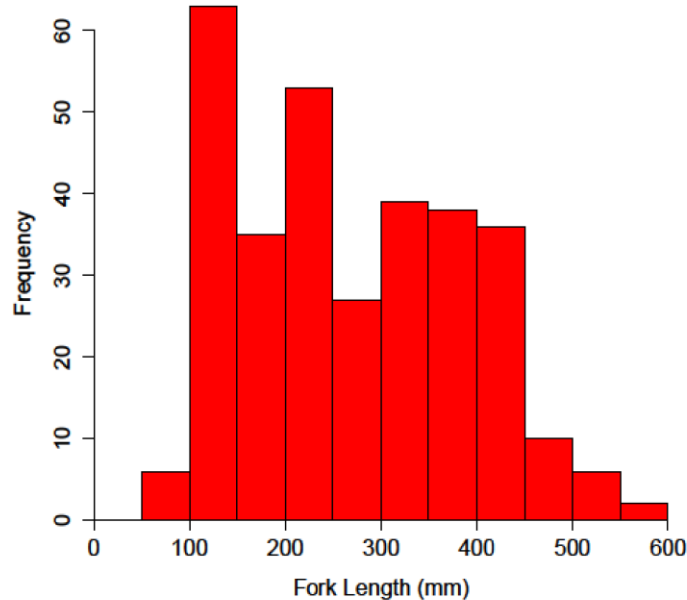


Figure 2. Length frequency distribution for cutthroat trout captured during 2016-2017 sampling (n=312).

### 3.2 Pit-Array Monitoring

Water temperatures through the period of pit-array monitoring increased fairly steadily across all streams with the largest overall range in the lake-fed Upper Puntledge River (range of 4.0 – 10.0°C), and less so in the snowpack and glacially-fed Comox and Reese Creeks (range of 3.5 – 7.8°C and 4.3-7.8°C respectively). Cruickshank River discharge was near or greater than mean annual discharge (17.1 m<sup>3</sup>/s) throughout most of the pit array monitoring period in 2017, but more variable in 2018 (Figure 3).

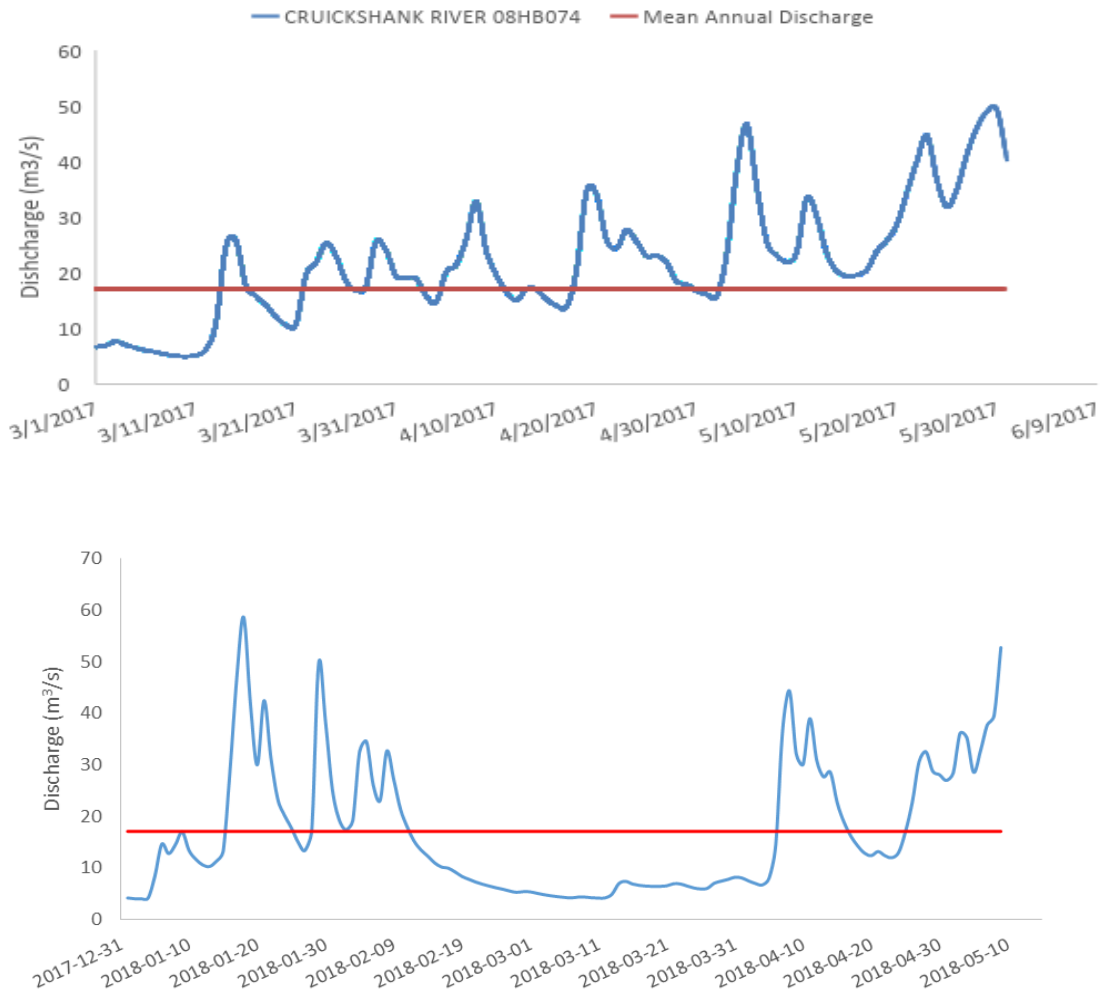


Figure 3. Cruickshank River discharge during the period of 2017 and 2018 pit array monitoring (m<sup>3</sup>/s; WSC Station 08HB074).

A total of 127 cutthroat trout were pit-tagged during the 2016 and 2017 sampling sessions. Of those, 15 individuals were detected at one of the three fixed stations operated in the spring of

2017 (eight at Comox Creek, five at the upper Puntledge River station and two at the Reese Creek station), and 13 individuals were detected in the spring of 2018 (four in the Upper Puntledge, seven in Comox Creek, and 1 in Reese Creek). Amongst the 13 individuals located in the spring of 2018 were 7 individuals that had also been detected in 2017 (54%), and all of these were relocated in the same spawning stream in their first and second years of detection.

Amongst the individuals detected in 2017 and 2018, there were 88 and 274 individual detections registered respectively, with 92% occurring between the hours of 20:00 and 07:00 hours in each year. This is consistent with the findings of Jones (1976) who noted night-time spawning in cutthroat trout at Petersburg Creek, Alaska and a return during daylight hours to Petersburg Lake.

Table 2. Summary of Cutthroat Trout detected on fixed station arrays in the spring of 2017 and 2018.

Capture Date*	Capture FL (mm)*	Capture Location**	MR_CT#	Sex	Pit Tag	Pit Array	First Date of Detection	Inter-annual Repeat
2017-03-15	470	1	229		982.000404705560	Comox	2017-04-05	
2017-03-29	480	1	256	f	982.000364564175	Comox	2017-04-07	y
2017-03-27	395	10	255	m	982.000403039987	Comox	2017-04-09	
2017-03-24	440	1	249	m	982.000404705544	Comox	2017-04-15	y
2017-03-31	370	11	259		982.000403037478	Comox	2017-04-15	y
2017-03-24	437	1	252	f	982.000404705566	Comox	2017-04-18	y
2017-03-31	432	1	261	m	982.000364565527	Comox	2017-04-20	
2017-03-15	443	7	231	f	982.000404705568	Comox	2017-05-02	
2017-03-24	387	1	250	m	982.000404705597	Reese	2017-04-10	
2017-03-10	376	8	214	m	982.000404705591	Reese	2017-04-20	
2017-03-15	514	8	226		982.000404705576	Upper Puntledge	2017-03-31	
2016-10-25	350	6	158		982.000404705590	Upper Puntledge	2017-04-01	
2017-03-24	430	9	248	m	982.000404705614	Upper Puntledge	2017-04-06	y
2017-03-20	408	9	245	f	982.000404705581	Upper Puntledge	2017-04-12	y
2017-04-10	304	11	274		982.000403041155	Upper Puntledge	2017-05-01	y
2017-03-24	440	1	249	m	982.000404705544	Comox	2018-03-11	y
2017-03-10	526	1	218	f	982.000404705538	Comox	2018-03-15	
2017-03-31	404	1	262	m	982.000403040960	Comox	2018-03-21	
2017-03-29	480	1	256	f	982.000364564175	Comox	2018-03-25	y
2017-03-21	455	1	247	f	982.000404705613	Comox	2018-03-31	
2017-03-24	437	1	252	f	982.000404705566	Comox	2018-04-04	y
2017-03-31	370	11	259		982.000403037478	Comox	2018-04-13	y
2017-04-03	404	1	267	m	982.000403030332	Reese	2018-04-26	
2017-03-20	408	9	245	f	982.000404705581	Upper Puntledge	2018-03-13	y
2017-04-10	304	11	274		982.000403041155	Upper Puntledge	2018-04-01	y
2017-03-20	455	9	243	m	982.000404705608	Upper Puntledge	2018-04-06	
2017-03-24	430	9	248	m	982.000404705614	Upper Puntledge	2018-04-07	y
2017-04-05	542	11	271	f	982.000403034516	Upper Puntledge	2018-04-28	

\*Capture Date, FL and Location refer to the original timing of fish capture and tagging.

\*\*Location references are consistent with Figure 1

### 3.3 Mark-Recapture

In total, 176 cutthroat trout were tagged with either a pit-tag, a floy tag, or both. Within the database, each of these fish was given a unique identifier from 100 through 275 that was independent of their pit or floy tags numbers ('MR\_CT#' in Table 2 and Appendix B). This allowed for clear tracking of individuals over time in the eventuality of tag loss/replacement, but also provided a unique identifier that could be shared within reports and yet did not disclose the identification of tag-reward numbers.

All available mark-recapture and mark-resight information was utilized within the survival models to support estimation of total survival. As of the time of reporting, this included fifteen and thirteen individuals that were detected at fixed station pit-arrays in spring-2017 and spring-2018 respectively, three direct recaptures of fish during Ministry-led sampling sessions, and twenty-two cutthroat trout that were caught and reported by anglers. One rainbow trout was also captured and reported by an angler. Four of the twenty-two floy-tagged fish that were captured and reported by anglers were released alive, of which three could have been legally retained (>30 cm and <50 cm).

Table 3 provides the parameter estimates and information on model fitting for the variety of modelled situations that were considered. There is little appreciable difference between the joint likelihood estimates for finite natural mortality rate ( $v$ ; range of 0.40 to 0.47) and annual exploitation ( $u$ ; range from 0.13 to 0.15). Models 1 through 5 allowed survival in the second quarter of each year to differ from the remainder of the year in order to evaluate the potential influence of post-spawn mortality and loss of newly-tagged fish in the population shortly after release. The resultant estimates from Models 1 through 5 are not significantly different from those in which survival was treated as constant (Models 6 and 7). So, while the probability of mortality during the spring-period April through June in Comox Lake appears to be in the range of 0.14-0.32 ( $psm$ ), its effect on the subsequent recaptures and harvest of fish that were tagged in the spring does not appear to be significant. Four of the five most parsimonious models (Models 3-7) included either the use of prior-likelihoods for natural mortality and/or post-spawn mortality, or a fixed mortality rate in the spring which may suggest some limited strength in the dataset. However, none of these five models provided a significant improvement over Model 6 which did not incorporate prior information and for which annual survival was treated as constant.

With respect to the estimates of fishing mortality ( $F$ ) and natural mortality ( $M$ ), there appears to be limited difference across the range of models as the 95% confidence limits on estimates of  $F$  and  $M$  overlap considerably, and with only modest differences in AIC.

Overall, the most parsimonious model (Model 5) incorporated prior information for both instantaneous natural mortality and post-spawner mortality and produced estimates of instantaneous natural mortality of 0.62 ( $M$ ; 95% CI of 0.44-0.81) and instantaneous fishing mortality of 0.15 ( $F$ ; 95% CI of 0.09-0.23), resulting in a total annual mortality ( $A$ ) of 0.53. This corresponds to annual exploitation estimate of 0.14 ( $u$ ; 95% CI of 0.09-0.21).

Amongst the fish that were recaptured directly or those that were reported by anglers and included recapture location information, there appeared to be a range of movements. In six of the eighteen cases where location information was available from anglers, there were minimal distances (~1 km) between original and secondary capture locations and over periods of time that ranged from three to thirty-four months. In the remaining twelve of the eighteen events, fish were relocated in different portions of the lake ranging from modest distances across the width of the lake to substantial distances across the long axis of the lake (~2.5 – 5 km).

Some evidence of mixing was also available through evaluation of the pit array detections. Amongst the eleven individual fish that were detected in the Comox Creek array in 2017 and 2018, eight were originally tagged at the mouth of the Cruikshank River (Location 1 in Figure 1); one was tagged along the same shoreline but 0.4 km further south of the Cruikshank River (Location 7); one was tagged at a tributary outlet across the lake and 2.4 km away (Location 11); and one was tagged across the lake and 6.8 km away (Location 10). Of the three fish that were detected in the Reese Creek pit array, two had been tagged near the mouth of the Cruikshank River (Location 1), and one had been tagged nearly across the entire lake at a tributary outlet 9.4 km away (Location 8).

Of the seven fish that were detected at the Upper Puntledge pit-array, none had originally been captured at the mouth of the Cruikshank River, however one fish which had been tagged the previous fall (2016) at a location 7.0 km away near the outlet of Pearce Creek (Location 6) was ultimately recaptured by an angler near the mouth of the Cruikshank; two fish had been tagged 0.9 km away from the outlet of the Upper Puntledge River near a small tributary outlet (Location

11); three fish had been tagged 0.8 km away along the southwest shoreline; and one fish had been tagged at the far end of the lake 12.7 km away near a small tributary outlet (Location 8).

Amongst the three individuals that were recaptured during Ministry-led sampling efforts, one was trap-netted in the spring of 2016 and 2017 on either side of the south end of the lake (Location 2 and then 9); one was trap-netted in the spring of 2016 and again in 2017 at the same location (Location 11); and one was recaptured by trap-net at the north end of the lake in 2017 (Location 8) only a small ways from its original capture location where it had been caught by micro-trolling in the summer of 2016.

Table 3. Survival model outputs.

		S.time (survival rate from April-June allowed to differ from remainder of year)					S.dot (constant annual survival)	
		Model 1. Barker with no priors	Model 2. Barker with prior information on M (M*=0.53 and cv=0.26)	Model 3. Barker with prior information on psm (psm*=0.30 and cv=0.47)	Model 4. Barker with no prior information, but with psm fixed at 0.3	Model 5. Barker with prior information on both M and psm as per Models 2 and 3.	Model 6. Barker with no priors	Model 7. Barker with prior information on M (M*=0.53 and cv=0.26)
S (annual survival; S = 1 - u - v)		0.386	0.467	0.380	0.395	0.466	0.390	0.468
psm (post-spawn mortality probability)		0.154	0.139	0.249	0.300	0.320	na	na
p.2 (summer 2016 capture probability)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
p.3 (fall 2016 capture probability)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
p.4 (spring 2017 capture probability)		0.049	0.044	0.048	0.045	0.040	0.048	0.043
u (annual fishing mortality rate)		0.142	0.125	0.151	0.150	0.136	0.146	0.127
v (finite natural mortality rate)		0.472	0.408	0.470	0.455	0.398	0.464	0.405
P.2017 (2017 pit array)		0.187	0.177	0.206	0.215	0.212	0.197	0.183
P.2017* (2017 pit array)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
P.2018 (2018 pit array)		0.243	0.187	0.257	0.172	0.122	0.244	0.189
P.2018* (2018 pit array)		0.000	0.000	0.000	0.213	0.239	0.000	0.000
reporting rate (l)	fixed	0.75	0.75	0.75	0.75	0.75	0.75	0.75
d (tag loss)	fixed	0.07	0.07	0.07	0.07	0.07	0.07	0.07
n (conditional natural mortality)		0.550	0.466	0.553	0.535	0.460	0.543	0.464
A (annual total mortality)		0.614	0.533	0.620	0.605	0.534	0.610	0.532
Z (instantaneous total mortality)		0.952	0.760	0.969	0.928	0.763	0.941	0.760
M (instantaneous natural mortality)		0.799	0.627	0.806	0.766	0.616	0.783	0.624
F (instantaneous fishing mortality)		0.154	0.133	0.163	0.162	0.146	0.158	0.136
F L95%CL		0.095	0.082	0.100	0.099	0.089	0.096	0.080
F U95%CL		0.239	0.207	0.255	0.255	0.230	0.249	0.215
M L95%CL		0.563	0.458	0.568	0.519	0.440	0.560	0.802
M U95%CL		1.082	0.812	1.089	1.065	0.807	1.047	0.461
number of parameters		11	11	11	10	11	10	10
LL		-219.015	-218.626	-218.150	-219.194	-217.580	-219.130	-218.681
AIC		460.030	459.251	458.300	458.388	457.159	458.261	457.362
dAIC		2.87	2.09	1.14	1.23	0.00	1.10	0.20

### 3.4 Yield-Per-Recruit Analysis

#### 3.4.1 Life History Parameters

The von Bertalanffy **growth** parameters that best described the available age and length data were  $l_{inf} = 103$  cm,  $K = 0.107$  and  $t_o = -0.158$  (n=127). The model fit with 95% confidence intervals is presented in Figure 4. The mean growth trajectory shows unusual linearity and is considered to likely reflect of a shift to piscivory at intermediate age classes (~sigmoidal growth).

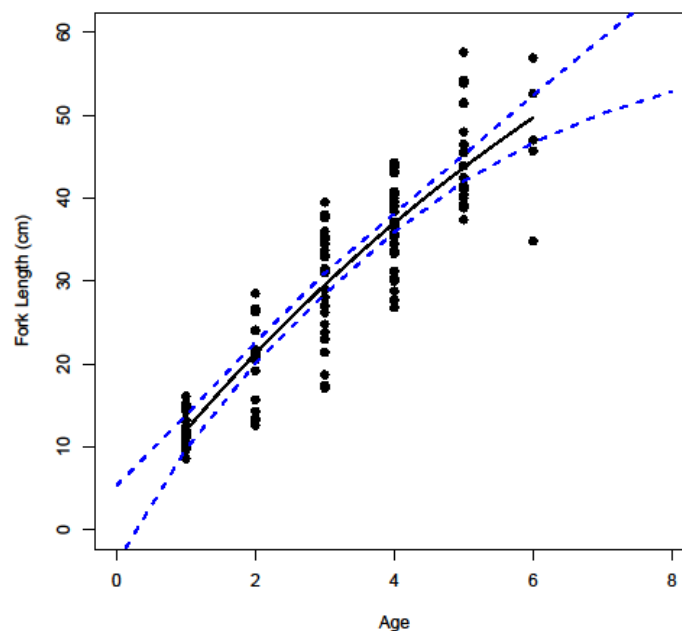


Figure 4. Von Bertalanffy growth curve with 95% confidence intervals for Comox Lake cutthroat trout captured in 2016 and 2017 (n=127).

Because the majority of fish sampling that occurred was live-release, we have limited direct information on sex and **maturity**. Of the 213 cutthroat trout that were caught during spring sampling in 2016 and 2017, the smallest fish that was visibly expressing was a 303 mm male. As well, a 304 mm cutthroat trout captured in the spring of 2017 was subsequently detected in the Upper Puntledge River pit-tag array and is assumed to have been spawning. As indicated previously, the reliance on expression of gametes to confirm sex and maturity status is biased towards males as they are more likely to be identified due to their longer period of expression. It appears however that size of maturity in cutthroat trout is similar between sexes, with some

findings suggesting that maturation in females occurs at smaller sizes than males (*in* McIntyre and Rieman 1995; Lough et al 2011b) or larger (Foster 2003), but with significant size overlap in all cases. Our approach is to aggregate information across both sexes and establish a single maturity relationship that is considered to be reflective of both males and females.

Accordingly, the observations of gamete expression are summarized here together with information from the pit-array detections (assumed to represent spawning fish), to promote an overall understanding of maturity schedules. None of the 109 cutthroat that were less than 300 mm showed evidence of maturity (0%), 3 of the 26 fish between 300-349 mm (12%), 9 of 31 fish between 350-399 mm (29%), 15 of 31 fish between 400-449 mm (48%), 5 of 8 fish between 450-499 mm (63%), and 6 of 8 fish between 500-599 mm (75%) showed evidence of maturity. None of the 10 cutthroat trout identified as mature females were less than 374 mm.

Age analysis indicates that most of the cutthroat trout for which there is evidence of spawning behaviour would be at least four years old (pit-array detections, expression of gametes or kelt condition on capture, or spawning checks). Only 2 of 24 fish that were captured as three year-olds showed evidence of spawning in that year (8%), while only 1 of 63 fish that were captured and aged as 4 years or older had a spawning check identified in their third year (2%). Additionally, only 4 of the 21 five-year olds and 1 of the 5 six-year olds had spawning checks identified in the preceding year, suggesting that they were maiden fish (81%, 374-576 mm and 80%, 348-569 mm respectively). There was no evidence of skip-spawning within the age analysis however, it is recognized that sample sizes are small.

Based on the proportions of identifiable mature fish by length, a maturity function was developed where the best estimates of  $M1$  and  $M2$  were 6.17 and 0.14. This relationship was visually evaluated against the other information detailed above on maturity-by-age and appeared to be a reasonable reflection of the overall information. The maturity function was incorporated into the yield-per-recruit model as a multiplier to fecundity in order to scale the reproductive potential for a given age (~length).

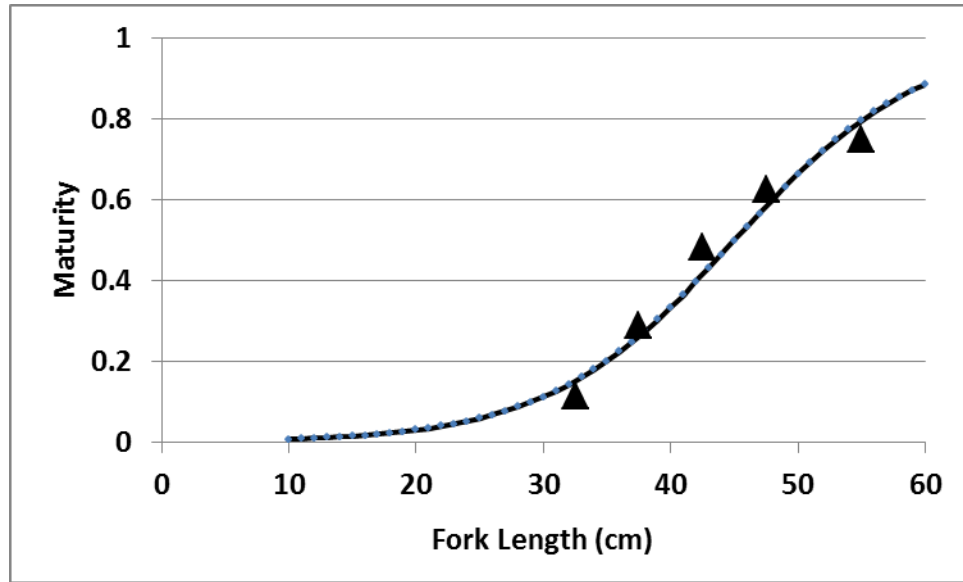


Figure 5. Logistic model for cutthroat trout maturity as a function of size. Data points are proportion mature by size-bin (5 or 10 cm).

To the extent that it occurs, skip-spawning in cutthroat would serve to reduce the overall productivity (resilience) of the stock and provide model results that are less conservative than necessary. While the yield-per-recruit model does not directly account for the possibility of skip-spawning, we believe this possibility is reflected indirectly within the maturity schedule through the inadvertent lumping of ‘resting’ fish with immature fish (Figure 5). In so doing, we recognize that the proportion of fish that are considered ‘mature’ at even larger size classes (40-60 cm) may appear rather low (30-90%). However, these results are consistent with observations from other populations which have noted the occurrence of alternate year spawning and in a manner that is sometimes pronounced (Shepard et al 1984; *in* Gresswell 1994; Foster 2003). The work by Foster (2003) in Florence Lake, Alaska demonstrated an asymptotic maturity in male cutthroat trout of 100% but only 80% in females. This appears consistent with our results in which 7 of the 21 individuals detected at pit-array fixed stations appeared to be repeat spawners appearing in both the 2017 and 2018 detections (size range 304-480mm at the time of their spring 2017 capture), while 6 individuals were only detected in spring 2018 despite having ranged in size from 404-542mm on their initial capture in spring 2017.

The **vulnerability** relationship developed using the 2009 age-distribution data from angler-derived captures and the estimate of total instantaneous mortality from this study ( $Z= 0.76$ ) was best described by the values 6.71 and 0.18 for  $S1$  and  $S2$  respectively. The ‘apparent’ estimate of

total mortality ( $Z$ ) based on a catch-curve analysis of the angler-derived samples from 2009 would be 0.48 over ages 2-7 and with a high correlation coefficient ( $r^2=0.9862$ ). This value differs significantly from the mark-recapture estimate of  $Z = 0.76$  derived from this study and is considered evidence for a size-related bias in the fishery-dependant data. The strength of the linear relationship in the 2009 angler-derived data is notable as we believe it may mistakenly have promoted plausibility.

The second approach to establishing vulnerability using reported recaptures from this study (2016-2018;  $n=17$ ) and the number of tagged fish at-large and available for recapture, used three length categories: 200-299 mm ( $n=31$ ), 300-399 mm ( $n=107$ ), and  $>400$  mm ( $n=86$ ). The aggregate recaptures in these categories from amongst years 2016-2018 were 0, 10, and 7 suggesting low vulnerability of fish at sizes less than 300 mm but not a clear difference in vulnerability between intermediate (300-400 mm) and larger sizes ( $>400$  mm). The parameters that best described this selectivity function were then 37.1 and 0.08 for S1 and S2 respectively.

The corresponding lengths at 50% vulnerability using the two different approaches from above were 372 mm and 470 mm respectively. Given that the two approaches produced fairly different logistic relationships and sizes at 50% vulnerability, and that the angler recapture approach was based on a fairly small number of data points, the preferred estimates for use in the yield-per-recruit analysis were those based on the comparison with 2009 angler returns. These estimates are also considered to be more conservative as they allow for higher vulnerability amongst smaller-sized fish ( $<300$  mm).

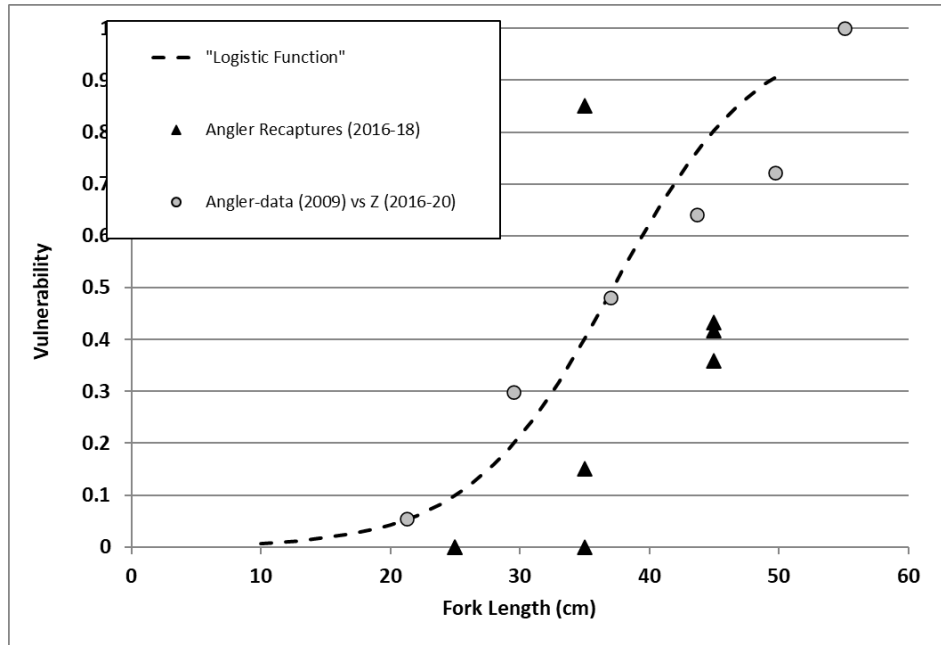


Figure 6. Vulnerability of cutthroat trout to angling as a function of size. Triangles are the proportion of tagged fish recaptured by anglers in 2016, 2017, and 2018, and circles represent vulnerability based on a comparison of age distribution data from 2009 angler-catch and the 2016-20 estimate of total mortality.

### 3.4.2 Equilibrium Calculations

Following the establishment of input parameters for natural mortality, recruitment, growth, fecundity, maturity, vulnerability, and catch and release mortality (detailed previously), the yield-per-recruit model was then used to establish equilibrium calculations across an array of exploitation rates and fisheries regulations. In some cases, input parameter values that were considered highly uncertain, were modified to assess their influence on model outputs.

The results are provided in Figures 7-8 and Table 4. Unless otherwise indicated, all scenarios presented in the following figures reflect the use of a catch-and-release mortality rate ( $h$ ) of 5% reflecting a bait-ban and use of single barbless hooks and reflect minimum size restrictions ranging from 0 mm (no size-based regulations) to 800 mm (~catch-and-release; 'C&R').

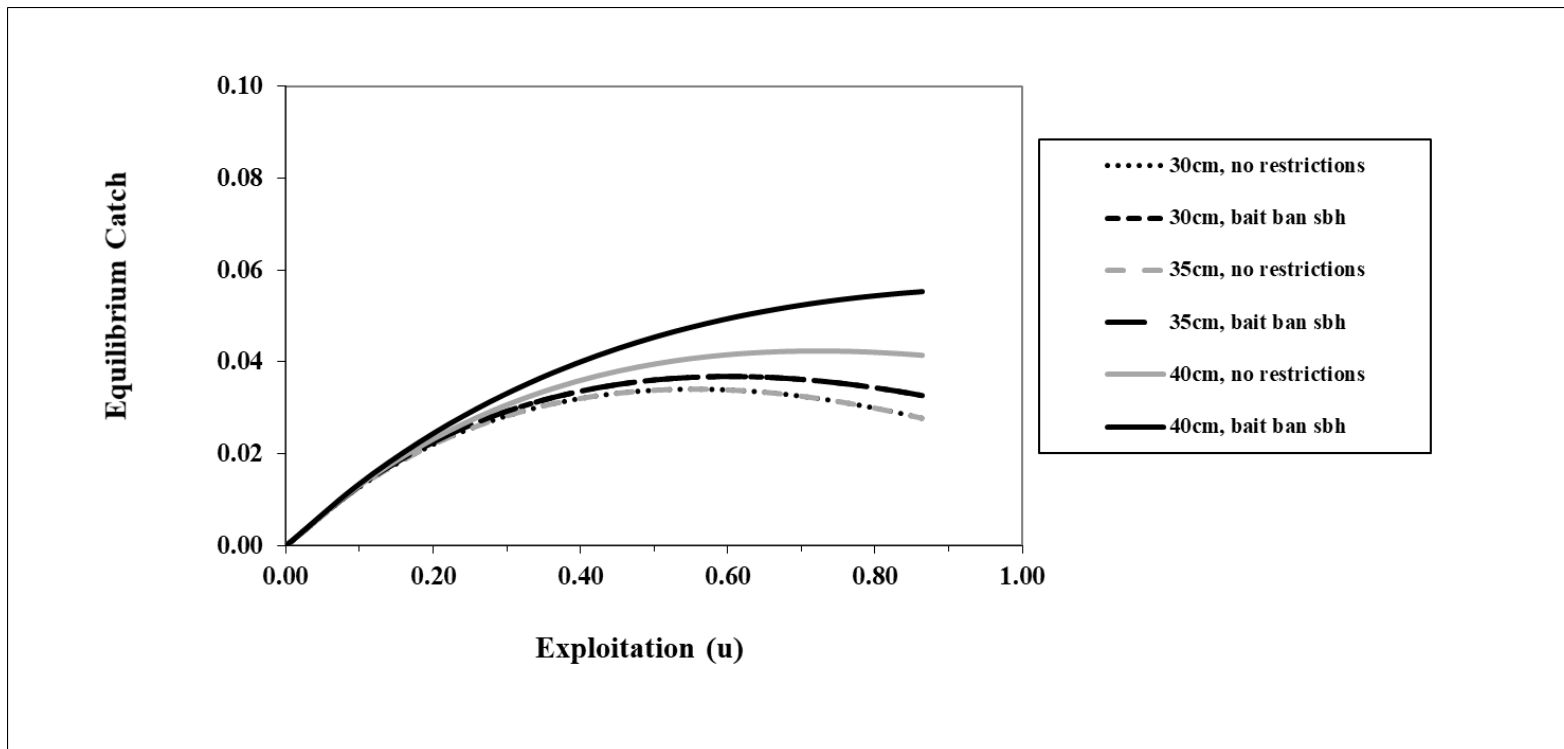


Figure 7. Equilibrium catch as a function of annual exploitation, minimum size restrictions, and the effect of catch-and-release mortality ( $h$ ). Scenarios utilize a catch-and-release mortality rate ( $h$ ) of 5% reflecting a bait-ban with single barbless hook, or 40% when unrestricted.

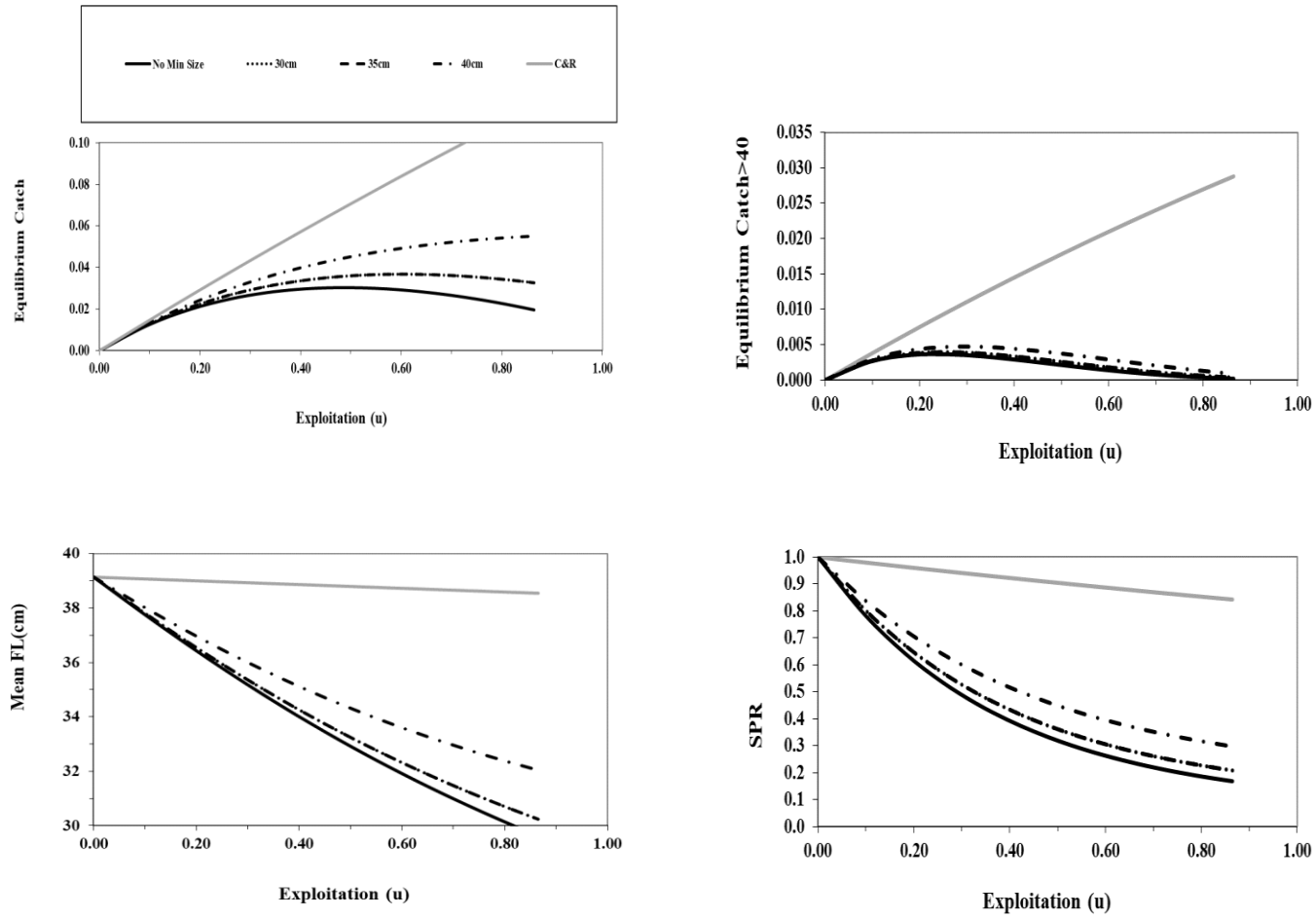


Figure 8. Equilibrium catch (top left); equilibrium catch of fish  $>40$ cm (top right); mean fork length of fish available for capture (bottom left); and spawning potential ratio (bottom right). Each graphic is presented as a function of annual exploitation ( $u$ ) and minimum size restrictions.

Table 4. Spawning potential ratios (SPR) across different combinations of exploitation ( $u$ ) and minimum size restrictions. All scenarios assume a bait-ban with single barbless hook restriction. Shaded areas represent values below the Target Reference Point (0.5; light grey) and Limit Reference Point (0.4; dark grey) as detailed in Section 4.2.

u	F	Minimum Size									
		0 mm	200 mm	250 mm	300 mm	350 mm	400 mm	450 mm	500 mm	550 mm	600 mm
0.10	0.10	0.79	0.79	0.80	0.81	0.81	0.84	0.89	0.93	0.93	0.98
0.18	0.20	0.64	0.64	0.65	0.67	0.67	0.73	0.81	0.88	0.88	0.96
0.26	0.30	0.54	0.54	0.54	0.57	0.57	0.64	0.74	0.83	0.83	0.95
0.33	0.40	0.46	0.46	0.47	0.50	0.50	0.57	0.69	0.80	0.80	0.94
0.39	0.50	0.40	0.40	0.41	0.44	0.44	0.52	0.64	0.77	0.77	0.92
0.45	0.60	0.35	0.35	0.36	0.39	0.39	0.48	0.61	0.74	0.74	0.91
0.50	0.70	0.32	0.32	0.33	0.36	0.36	0.45	0.58	0.72	0.72	0.90
0.55	0.80	0.29	0.29	0.30	0.33	0.33	0.42	0.56	0.70	0.70	0.90
0.59	0.90	0.27	0.27	0.28	0.31	0.31	0.40	0.54	0.69	0.69	0.89
0.63	1.00	0.25	0.25	0.26	0.29	0.29	0.38	0.52	0.68	0.68	0.88
0.67	1.10	0.23	0.23	0.24	0.27	0.27	0.36	0.51	0.66	0.66	0.88
0.70	1.20	0.22	0.22	0.23	0.26	0.26	0.35	0.50	0.66	0.66	0.87
0.73	1.30	0.21	0.21	0.22	0.25	0.25	0.34	0.49	0.65	0.65	0.87
0.75	1.40	0.20	0.20	0.21	0.24	0.24	0.33	0.48	0.64	0.64	0.86
0.78	1.50	0.19	0.19	0.20	0.23	0.23	0.32	0.47	0.63	0.63	0.86
0.80	1.60	0.19	0.19	0.20	0.23	0.23	0.32	0.46	0.63	0.63	0.85
0.82	1.70	0.18	0.18	0.19	0.22	0.22	0.31	0.46	0.62	0.62	0.85
0.83	1.80	0.18	0.18	0.18	0.22	0.22	0.30	0.45	0.62	0.62	0.85
0.85	1.90	0.17	0.17	0.18	0.21	0.21	0.30	0.45	0.61	0.61	0.84
0.86	2.00	0.17	0.17	0.18	0.21	0.21	0.30	0.45	0.61	0.61	0.84

## 4.0 DISCUSSION

Comox Lake supports one of the highest intensities of angler effort amongst large lakes of Vancouver Island (~3.0 angler-days/ha; VILQ results Kehler 2013). This is second only to Horne Lake, which has a fishing intensity of ~3.2 angler-days/ha. The current fisheries regulations for cutthroat trout in Comox Lake are an inverted slot with no retention permitted below 30 cm or above 50 cm. There is also a gear restriction requiring the use of single barbless hooks and prohibiting the use of bait. Using the results of the yield-per-recruit model and the estimates of exploitation rate from the tag reward study, we can evaluate the influence and effectiveness of these regulations, as well as alternative combinations of exploitation rate and regulatory approaches.

Three **performance measures** are used to evaluate fishery performance and sustainability, and in consideration of the estimated exploitation rate from this investigation. These are 1) yield, 2) spawning potential ratio, and 3) the ratio of instantaneous fishing mortality relative to instantaneous total mortality. Each of these is discussed in detail in the following sections.

### 4.1 Yield

Yield and yield-per-recruit are presented in relative units of ‘catch’ in the model outputs rather than conversion to weight (biomass), in order to better reflect the objectives of a recreational vs. commercial fishery. The relative values of catch or catch-per-recruit can then be evaluated directly under different combinations of exploitation and/or fishing regulations, and in a way that is independent of the requirement to know absolute abundance. Similarly, relative changes to sub-components of the fishery such as mean fish length or other metrics can be evaluated.

For analyses that produce outputs in terms of relative yield or catch,  $F_{max}$  ( $\sim u_{max}$ ) is identifiable as the exploitation rate that generates maximum yield, and beyond which there is a risk of growth overfishing (Gabriel and Mace 1999). The risk of growth overfishing would be particularly concerning if the participants in the fishery place a high value on the capture of larger-sized fish.

The first scenario that we evaluated was the potential influence of bait restrictions and the requirement to use single barbless hooks. The question is whether differences in catch-and-release mortality rates that might be expected with different gear types ( $h = 0.05-0.40$ ), may create differences in population level response. What is evident in Figure 7 is that the influence of catch-and-release mortality makes very little difference to fishery outcomes when implemented with

low (or no) size restrictions. In part, this is a function of the model which assumes that all captured fish are harvested if legally permitted. However, the low influence of catch-and-release mortality under these size restrictions is in part also a function of fish's vulnerability to angling.

In Figure 8, it can be seen that there is little difference in any of the measures of fishery performance between the unregulated fishery (no size limits) and one in which a minimum size restriction of 30 cm is in place. In part, this is a function of the apparently low vulnerability of cutthroat trout less than 30 cm in Comox Lake (based on tag-returns and the supporting information from previous angler capture investigations at Comox Lake and Cowichan Lake; Lough et al 2011a and 2011b, Michalski and Fosker 2013).

The apparent lack of influence of a 30 cm minimum size restriction is also due to a disconnect with the size-at-maturity (Figure 5). In their work on Comox Lake and Cowichan Lake, Lough et al (2011a and 2011b) found that 30 cm is most reflective of a *minimum* size at maturity which is consistent with the results of this investigation (Section 3.3.1; Figure 5). In combination, the low vulnerability of cutthroat trout that are smaller than 30 cm and their low likelihood of having reached maturity, means that the 30 cm minimum size restriction in place on Comox Lake cutthroat is not likely to produce a meaningful influence on fishery performance.

However, when considering the influence of gear restrictions and the 30 cm size restriction, there are two things to keep in mind. Firstly, the bait and gear restrictions currently in place on Comox Lake are one of the factors that underlie the current exploitation rate, since exploitation rate is a function of angler effort and catchability ( $q$ ), which in part is a function of gear restrictions. Secondly, the model outputs are fairly sensitive to the vulnerability function and this function is not based on a robust dataset. If for example, we have underestimated the vulnerability of fish to angling at sizes of less than 30 cm, then there would start to be a greater divergence between the influence of a 30 cm minimum size restriction compared to an unrestricted fishery (see further discussion in Section 4.2). These factors should be considered and evaluated as more information becomes available.

Reviewing the model output results presented in Figures 7 and 8 provide a number of additional insights. The estimated annual exploitation rate ( $u$ ) at Comox Lake was 0.14 with 95% confidence intervals of 0.09-0.21. The upper bound of this estimate is well below  $u_{max}$  (~0.60) for the 30 cm minimum fisheries with gear restrictions, and so the potential elimination of gear

restrictions at Comox Lake should be considered with this in mind. The risk of approaching or exceeding  $u_{max}$  is that growth overfishing may occur, but this may be less of a concern if the objective is to promote a primarily harvest-oriented fishery rather than one in which higher catch rates and/or size of catch are the main objectives.

While the existence of a 30 cm minimum size restriction appears to have little demonstrable influence on fishery performance, it may be having a negative impact on angler experience or even participation. Wilson et al (2016) estimated the value of a released fish as 9% of a harvested fish for rainbow trout in lakes of the BC interior. This is similar to the findings of Carter and Liese (2014), who found that anglers fishing for red snapper and groupers in south-eastern United States placed a value on harvested fish at more than eight times that of a released fish. Communication with participants in the Comox Lake fishery and their expressed behaviour through harvest vs release of tagged fish, suggests that anglers at Comox Lake are quite harvest-oriented, with relatively few anglers volitionally releasing fish that are legally retainable. It may be that the alleviation of release requirements on Comox Lake may promote higher levels of angler participation, even perhaps if those release requirements were having little meaningful impact on anglers' choices or experience.

If there were a desire to promote either higher catch rates and/or increase the size of fish in the catch (at the expense of harvest opportunity), then the current exploitation rate may be too near the target for  $u_{max40}$  of 0.26, given the existing size regulations (Figure 8). Thus, if the optimization of larger-sized fish in the catch is a primary objective, then consideration may be given to an increased size for retention to either 40 cm ( $u_{max40} = 0.33$ ) or 45 cm ( $u_{max40} = 0.39$ ). However, when minimum sizes are greater than 45 cm, values of  $u_{max}$  and  $u_{max40}$  are higher than would be realistically expected, suggesting that minimum size restrictions of 45 cm or greater may be equivalent to a catch-and-release restriction in terms of fishery performance and catch expectations over the likely range of exploitation levels.

To evaluate the potential influence of the 50 cm maximum size restriction, modelled scenarios were evaluated across a range of criteria including catch, catch of quality-sized fish, spawning potential ratio (see below) and mean size of fish in the population. Based on this analysis, it appears that the requirement to release all cutthroat trout over 50 cm makes no difference to fishery outcomes over any combination of exploitation rates.

In other anadromous lakes of Vancouver Island there are often noted requirements to release all trout above 50 cm in an effort to protect steelhead from retention (through misidentification as large resident rainbow). However, that is not the case in Comox Lake as the 50 cm size restriction strictly references cutthroat trout. As such, none of the previously discussed analyses included consideration of a maximum size and were instead focussed on minimum size restrictions.

#### **4.2 Spawning potential ratio (SPR)**

SPR is used to evaluate the risk of recruitment overfishing and can be derived directly from the yield-per-recruit model by the equation

$$SPR = \phi_{eF} / \phi_e$$

where  $\phi_{eF}$  is eggs-per-recruit at equilibrium when under a given exploitation rate, and  $\phi_e$  is eggs-per-recruit at equilibrium when unfished ( $F=0$ )

Based on the limited data available, a precautionary reference point of  $u_{40\%SPR}$  is recommended here as the limit reference point (LRP; Gabriel and Mace 1999). This is slightly more conservative but consistent with the recommendations in Walters and Martell (2004) who suggested that values of  $SPR < 30\%$  represent an increased risk of recruitment overfishing, and values of  $SPR < 50\%$  may result in “long-term changes in the community structure that can lead to apparent compensatory declines in recruitment”. Accordingly, it is also recommended that  $u_{50\%SPR}$  be used as a target reference point (TRP).

Based on the results of this study, the estimated exploitation rate of  $u= 0.14$  results in a SPR of just under 74% across minimum size restrictions of 30 cm or less (to unrestricted), and therefore succeeds in meeting or exceeding the target reference point. Only the uppermost end of the 95% confidence interval for exploitation rate ( $u=0.21$ ) begins to approach the TRP values of  $SPR=50\%$  (Figure 8 and Table 4).

Askey et al (2006) and Cox (2000) derived relationships for relative vulnerability across a number of lacustrine rainbow trout populations in the interior of BC, producing estimates for size at 50% vulnerability which ranged from 20.5 cm to 34.5 cm. Our estimate of 37.2 cm at 50% vulnerability is large relative to this range, which may suggest some weakness in our data or perhaps that anglers' behaviour is selecting for larger fish within the Comox Lake population. It

is likely that cutthroat trout in the large lakes of Vancouver Island undergo a size-related shift in habitat usage from largely littoral habitats to more use of the limnetic portions of the lake as they shift towards piscivory at sizes of 25 - 30 cm (Appendix A). This behaviour would promote an incomplete spatial overlap between cutthroat trout above and below the size at piscivory, and the degree to which anglers are preferentially targeting larger fish may then reduce their likelihood of encountering smaller sized-fish. Nevertheless, to evaluate the implications of potentially underestimating vulnerability at a given size in our model, yield-per-recruit analyses were rerun with a much lower size at 50% vulnerability (25 cm) and within this approach, the SPR was still greater than the TRP given no size restrictions and an annual exploitation rate of 0.14 (SPR= 0.57).

### **4.3 F/M**

The ratio of  $F/M$  can be derived directly from the results of the tag-return program and mark-recapture analysis, and so provides a performance measure that is independent of the yield-per-recruit model and the potential influences of its parameter uncertainty. Lester et al (2014) investigated the compensatory influence of density-dependant early survival and growth rate in fishes and suggested that values of  $F/M < 0.75$  appear to be sustainable across a range of teleosts when a species demonstrates a plastic response to exploitation, with a size-at-maturity that remains fairly constant under exploitation, and where the species has the capacity to increase annual immature growth rate by at least two-fold in response to exploitation. They note that this relationship appears to hold even when harvest of immature individuals is permitted to occur.

While the compensatory growth potential of juvenile cutthroat trout is unclear, rainbow trout are noted as having demonstrated a nearly two-fold growth compensation in Post et al (1999; *in* Lester et al 2014). The development of information for juvenile growth compensation amongst cutthroat trout on Vancouver Island would be a valuable undertaking and would support the establishment of a species-specific reference point for  $F/M$  based on the methods outlined in Lester et al (2014). Given our current uncertainty, we recommend that a limit reference point of  $F/M = 0.5$  be utilized, consistent with the recommendations of Walters and Martell (2002) and Lester et al (2014). Our estimated values for  $F$  and  $M$  of 0.15 and 0.62 respectively, produce an estimated ratio of  $F/M = 0.24$  which is significantly less than the LRP. All other evaluated survival models produced ratios of  $F/M$  that were even lower (range of 0.19-0.22).

#### 4.4 Other Findings and Consideration of Assumptions

The visual outputs of the yield-per-recruit model provide an opportunity to assess the potential trade-offs between catch, harvest, and size of fish under various exploitation rates and fisheries regulations. These visuals are well-suited to public engagement sessions and identification of angler interests. However, one of the key considerations within the yield-per-recruit approach is the assumption of equilibrium, meaning that both the current exploitation rate and the fish population dynamics have stabilized and are in a period of balance. One of the potential difficulties associated with this assumption is the risk that a population may have been previously overexploited and currently remains depressed or is recovering. In this case, the current and observable exploitation rate may be seemingly sustainable when in fact it may be preventing or slowing population recovery. In the case of Comox Lake, this possibility is considered to be low given the time-series of angler effort estimates from VILQ surveys (1986 through 2011) and their relative stability.

The second potential risk of the equilibrium assumption involves the use of the recruitment compensation parameter ( $K$ ) to establish the compensatory increases in juvenile survival under various exploitation rates. The difficulty is that within the model, current conditions (i.e. growth rates and the resultant maturity and fecundity) are utilized first to establish stock-recruitment levels but under an assumption of zero exploitation, when in fact the currently observed growth rates (and resultant juvenile survival) are already reflective of an exploited condition and thus may already represent some level of density-dependant response. The extent to which this may be occurring, would serve to overestimate the potential compensatory ability of the population.

It is interesting to note that spawning potential ratio is related to the lifetime egg production *per recruit*, and so neither of the metrics used to evaluate fishery sustainability in this project (SPR or F/M) is sensitive to changes in recruitment compensation ratio ( $K$ ) or other density-dependant compensation mechanisms. However, in a similar manner to what was described above, the currently observed growth rates (and the resultant maturity and fecundity) are used to establish the “unexploited” egg production of the population when establishing the SPR, and so may provide an elevated estimate of baseline productive capacity.

One of the interesting products of this investigation was the disparity between our observed survival through mark-recapture and the *apparent* survival from the 2009 angler-derived age distribution. The mark-recapture estimates of total mortality from this study ( $Z= 0.76$ ) are much

higher than what is apparent from the catch-curve of angler-derived cutthroat trout in 2009 ( $Z=0.48$ ; Lough 2010) despite the very high correlation coefficient of that data ( $r^2=0.99$ ). This appears to perhaps be evidence for size-related bias in angler-derived catch data in which larger (~older) fish are disproportionately represented in the catch and/or smaller (~younger) fish are disproportionately under-represented.

This disparity between angler-derived age distribution and mark-recapture estimates of survival were used in this study to support vulnerability parameter estimation. This approach is premised on an assumption of equilibrium where exploitation rates and the resultant age-structure are considered to have been stable over the years of consideration. However, the model outputs are fairly sensitive to the effects of the vulnerability function and fairly small changes in 50% vulnerability (e.g. from near 35 cm to 25 cm) result in potentially different perspectives with respect to both optimal and sustainable exploitation rates. It is important to strengthen the understanding of this relationship going forward (e.g. through evaluation on other systems) but also to recognize that the vulnerability of a population to angling is in part a reflection of 1) angler behaviour and their preferential targeting of fish based on size (whether intentional or not) and 2) the fish's behaviour and spatial distribution (e.g. ontogenetic habitat shifts with size; refer to Appendix A). The extent to which either or both of these dynamics may be consistent across large lake cutthroat fisheries of Vancouver Island is currently unclear.

One of the considerations when completing a 'high-reward' tagging program is whether the implementation of a reward opportunity may itself elevate the level of fishing activity. It is conceivable that communication amongst anglers about high-rewards having been paid out, might change the behaviour of a fishery either increasing the number of individuals that participate or the intensity of participation by individuals. In this project, there would be no ability to evaluate the extent to which this was occurring. However, our assumption has been that the potential increase in *relative* exploitation rate as a result of the high-reward tagging program is not likely to be significant given the large overall scale of the fishery in the base case (~6,500 angler-days). Moreover, any artificial inflation of exploitation levels during the period of assessment would serve to generate management approaches that are more conservative, and thus erring in the direction of population sustainability.

## 5.0 RECOMMENDATIONS

- Continued investigations into life history characteristics of cutthroat trout populations in the large lakes of Vancouver Island (growth, natural mortality, maturity, vulnerability, and fecundity). By developing an understanding of the extent to which these characteristics are consistent or variable from lake to lake, we may begin to generalize findings more broadly and support the development of an information-based approach to fisheries management across the large lakes of the Region.
- The establishment of exploitation rate for Comox Lake together with an understanding of fishing effort from the VILQ allows for the calculation of catchability ( $q = F / \text{angler-days per ha} = 0.048$ ). Estimation of exploitation rates for other cutthroat trout populations in large lakes of Vancouver Island together with their VILQ estimates of angler effort could be used to establish additional catchability estimates and may eventually support the extension of findings to lakes where no information for exploitation rate is available (or where estimates are not current), but for which we have information on angling effort. Recognizing that catchability varies inversely with abundance, it may be particularly of interest to complete exploitation rate investigations in lakes expected to represent a contrast in terms of fish densities.
- It is recommended that the pit-tag monitoring arrays at Comox Lake be maintained for as long as needed to provide continued detections of pit-tagged fish from this project. The resulting information will continue to refine and improve survival estimates, but will also likely provide additional insights into maturation, repeat-spawning rates and site fidelity.
- Obtaining quantitative information on cutthroat trout juvenile growth potential would support the refined estimation of limit reference points for  $F/M$  as per the methods in Lester et al (2014).
- The visual outputs of the yield-per-recruit model provide an opportunity to assess the potential trade-offs between catch, harvest, and fish-size under various exploitation rates and fisheries regulations. These visuals are very well-suited to public engagement sessions and can be used to support the identification of fishing regulations that best match the interests of an angling community from amongst the range of sustainable choices (e.g. harvest vs. trophy-oriented fisheries, or objectives that are intermediate between the two).
- The use of exploitation rate in combination with easily obtainable life history parameters has provided a significant advancement beyond the previous attempts at abundance-based management for Comox Lake cutthroat trout. We anticipate that the completion of similar

assessments in other waters of the Region will rapidly enable the extension and integration of results between and across systems and promote the development of additional insights into the behaviour of both the fish and angler populations.

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## **APPENDIX A**

### **Information review and life history considerations for stock assessment of piscivorous cutthroat trout in the large lakes of Vancouver Island**

**Information review and life history considerations for stock assessment of piscivorous  
cutthroat trout in the large lakes of Vancouver Island**

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There are fifteen large lakes ( $\geq 1,000$  ha) on Vancouver Island, all of which have cutthroat trout (Table A1). Annually, these lakes support approximately 40-60,000 angler-days and represent 12-21% of the total estimated angler effort on Vancouver Island lakes. Included amongst them, are three of the most significant fisheries on Vancouver Island (Comox, Cowichan, and Sproat Lakes; Lough 2010; Kehler 2013).

In eleven of the large lakes on Vancouver Island, cutthroat trout co-occur with sockeye and/or kokanee. Threespine stickleback (*Gasterosteus aculeatus*) may also form a significant prey item of piscivorous cutthroat trout, and co-occurs with cutthroat in eleven of the fifteen lakes (Table A1). Of the fifteen large lakes on Vancouver Island, Victoria Lake may be the only one which does not have either sockeye/kokanee or threespine stickleback.

There are few examples in the literature of piscivorous cutthroat populations in sympatry with kokanee/sockeye in large lake ecosystems. As such, much of the background information in this review comes from a small number of systems. Where appropriate, I have included supplemental information from other lake systems where cutthroat trout are piscivorous on other species or where they remain largely insectivorous.

The limited information available suggests that cutthroat trout have a complex life history, with spatial-temporal distribution patterns that vary by size and by season. Our understanding of these patterns in the large lakes of Vancouver Island is poor, and thus presents an interesting challenge to stock assessment.



**Table A1. Summary information for large lakes of Vancouver Island (adapted from Michlski and Fosker 2013 and Kehler 2013).**

Lake Name	Surface Area (ha)	Max. Depth (m)	Mean Depth (m)	TDS (ppm)	Cutthroat	Rainbow	Steelhead	Chinook	Chum	Coho	Pink	Sockeye	Kokanee	Threespine Stickleback	Angler-Days (2011)
Alice	1,084	71	31	46	x		x	x		x		x			599
Buttle	3,095	121	61	40	x	x								x	2,924
Campbell (Lower)	2,694			40	x	x	x							x	4,511
Campbell (Upper)	2,978	40	12	56	x	x								x	4,455
Comox	2,100	109	61	22	x	x	x	x	x	x			x	x	6,599
Cowichan	6,204	152	50		x	x	x	x	x	x			x	x	12,502
Elsie	1,107	21	8	32	x	x	x			x		x	x		752
Great Central	5,085	250	124	20	x	x	x	x	x	x	x	x	x	x	3,425
Henderson	1,545	250	97	63	x	x	x	x	x	x	x	x	x	x	14
Huaskin	2,120	175	65		x		x	x		x			x		-
Kennedy	6,475	145	38	21	x		x	x		x		x	x	x	1,211
Nimpkish	3,653	320	122	17	x		x	x	x	x	x	x	x	x	56
Sproat	3,775	195	74	32	x	x	x			x		x	x	x	4,998
Victoria	1,576	110	43	35	x	x									835
Woss	1,366	155	65		x	x	x	x		x		x	x	x	42

### **In-migration from Tributaries**

The greatest information base for piscivorous adfluvial cutthroat trout is from Lake Washington, in Washington State. Cutthroat trout in Lake Washington (9,495 ha) attain large sizes (>400 mm) as a result of their piscivory on juvenile sockeye and longfin smelt (*Spirinchus thaleichthys*; Nowak and Quinn 2002). Cutthroat trout leave their natal streams and enter Lake Washington at sizes of about 150 mm when they are two years old (Nowak *et al.* 2004). Initially, they occupy the littoral zones of the lake where they are primarily insectivorous and make only limited use of forage fish (Nowak *et al.* 2004).

Based on interpretation of scale samples, Lough (1991) indicated that cutthroat trout of Sproat Lake largely entered the lake as yearlings (1+). Similar analysis by Narver (1975) on cutthroat trout scales of Great Central Lake suggested a period of slow growth for the first two to three years followed by rapid growth. It was unclear if this shift in growth rates was related to changes in habitat or forage, but Narver hypothesized that this shift in growth rate corresponded to timing of lake entry.

In their work on Ruby Lake (446 ha) on the Sunshine Coast, Wightman and Taylor (1980) used scale analysis on cutthroat trout scales and suggested that trout were entering the lake primarily as two year olds (range of 1+ to 3+), and that size at the time of lake entrance seemed to be positively related to survival with a critical size threshold of 80-90 mm. In Ruby Lake, cutthroat trout are piscivorous and co-occur with kokanee, but primarily feed on three-spine sticklebacks, attaining sizes of up to 600 mm (Wightman and Taylor 1980).

The variability of cutthroat age at timing of lake-entrance is an important consideration when completing stock assessment work on the overall population. The incomplete or variable recruitment of an age class(es) into the lake, and in ways that may be related to growth rates (i.e. selective for faster growing individuals), complicates the collection and interpretation of data.

### **Littoral vs. Limnetic Habitat Use**

As the cutthroat trout in Lake Washington grow, they become increasingly piscivorous and migrate to the limnetic zone of the lake, generally by the time they reach 250 mm in length. While some smaller cutthroat trout do migrate earlier to the limnetic zone the reverse seems to rarely occur, with few large fish (>250 mm) remaining in the littoral zone (Nowak *et al.* 2004).

Nowak and Quinn (2002) used ultrasonic transmitters to track the movements of 14 large cutthroat trout in Lake Washington (>400 mm). The trout spent time in the littoral zone of the lake only in spring and only during the daylight hours, but were otherwise in the limnetic zone of the lake (Nowak and Quinn 2002). Nowak *et al.* (2004) described this migration from the shallow lake margins to open water as an ontogenetic shift amongst fish sizes between 200-300 mm.

In Bear Lake, Idaho (28,000 ha) cutthroat trout showed a similar movement pattern in a system with no kokanee or sockeye (Ruzycski *et al.* 2001). Here, the larger trout (>400 mm) switch from a largely insectivorous diet to an increasingly piscivorous diet of sculpins and whitefish, and occupy waters below the epilimnion from July through to destratification, and then limnetic waters closer to the surface (2-15 m) during the remaining months of the year (winter-June). Cutthroat trout smaller than 400 mm were in limnetic waters above the thermocline from June through to November, and then were presumed to be foraging for spawning sculpins in the littoral portions of the lake in spring.

In Strawberry Reservoir, Utah (6,100 ha), where cutthroat trout co-occur with kokanee but appear to not rely on them as a forage base, some cutthroat attain large sizes through cannibalism. Baldwin *et al.* (2002) used ultrasonic telemetry to follow the movements of seven large cutthroat trout (475-502 mm) and found that during the early summer period, fish primarily occupied the limnetic portions of the lake and at depths near the thermocline (10-15 m). However, after about mid-August, the large cutthroat began to utilize a wider range of depths, with an apparent shift towards the littoral waters of the lake by the fall.

A recent survey on Horne Lake (961 ha), Vancouver Island showed a higher than usual incidence of large cutthroat trout during littoral sampling (Silvestri *unpubl. data.* 2013). The large cutthroat trout were captured in November while actively foraging on spawning kokanee. Previous sampling efforts on this lake had been completed using the same gear and in the same locations but occurred earlier in the season (Silvestri *pers. comm.*). This corresponds to anecdotal observations of angler effort distribution during the fall in other lakes of Vancouver Island, where anglers targeting cutthroat trout may focus their efforts spatially (either in-lake or in tributaries) presumably to take advantage of cutthroat trout foraging concentrations.

Smaller-sized cutthroat trout (<200mm) have an inconsistent and uneven spatial distribution within large lakes, potentially occurring in tributary habitats, the littoral zone and/or the limnetic

zone of lakes, and in a manner that may differ from lake to lake. Similarly, the spatial distribution of larger cutthroat trout during the spring and fall appears to be variable with the potential for highly clumped distribution patterns as they focus on specific forage opportunities in the littoral portions of the lake.

### **Piscivory**

Cutthroat trout are sympatric with rainbow and/or steelhead in all of the large lakes of Vancouver Island (Table A1). Nilsson and Northcote (1981) noted an increased tendency towards piscivory by cutthroat trout when sympatric with rainbow trout in BC lakes, together with evidence of spatial segregation and attainment of larger sizes by cutthroat. The relative importance of different forage species in the large lakes of Vancouver Island may differ from lake to lake, and perhaps seasonally within lakes. As well, the variability of forage populations over time (e.g. sockeye returns) may have implications for cutthroat trout population dynamics that should be considered and interpreted accordingly.

In Lake Crescent (2,076 ha), Washington, Pierce (1984) found that cutthroat trout shift their diet from invertebrates to forage fish at sizes of 305 mm, after which they feed almost exclusively on kokanee and attain sizes of >500 mm.

In Lake Washington, cutthroat trout prey actively on juvenile sockeye and appear to be actively selecting for larger fish while in the limnetic zone. During their time in the littoral zone cutthroat trout that were smaller than 300 mm foraged on sockeye fry (24-40 mm), however there was a virtual absence of sockeye fry in the stomachs of larger cutthroat trout (>300 mm) from either the littoral or limnetic zones despite their co-occurrence in time and space (Nowak *et al.* 2004). Meanwhile, yearling sockeye (60-140 mm) were much more prominent in the diets of cutthroat >200 mm, particularly in the winter and spring periods, prior to smoltification.

During the summer period in Lake Washington, Beauchamp *et al.* (1992) found that the diet of cutthroat trout smaller than 350 mm was primarily zooplankton, and that at sizes greater than 350 mm, the trout primarily consumed forage fish.

Cartwright *et al.* (1998) evaluated the intensity of cutthroat trout predation on stocked juvenile sockeye in Margaret Lake (62 ha), Alaska, and found that it was potentially significant. Sockeye made up a significant proportion of the diet for large cutthroat from the time of stocking

(April/May) through June, before and after which three-spine stickleback were a more prominent component of the diet (Cartwright *et al.* 1998).

A similar pattern was seen by Narver (1975) on Great Central Lake, where sockeye juveniles were most prominent in the diet of cutthroat trout during the period of smolt outmigration (May 24 - June 13), while three-spine sticklebacks were less prominent in the overall diet but utilized throughout the sampling period (mean size 50 mm, range of 30-75 mm; sampling period from May 24-August 10). The overall degree of piscivory in diet of cutthroat trout from Great Central Lake appeared significant with fish present in 35% of the sampled stomachs (Narver 1975).

In Lake Washington, Nowak *et al.* (2004) found that cutthroat trout periodically shifted their foraging emphasis from sockeye to longfin smelt during times of high smelt abundance.

### **Spatial-temporal Distribution Within the Limnetic Zone**

During the stratified periods of the year, Nowak and Quinn (2002) found that large cutthroat trout in Lake Washington were in the limnetic portions of the lake and primarily occupied depths just below the thermocline where temperatures remained fairly stable at 7-10°C (mean depth 15.7 m) while avoiding the uppermost surface waters where temperatures reached 23°C. The authors found only limited indications of diel vertical movements (mean depths of 13-17 m during night and day respectively), and found little relation between depth and light levels seasonally (Nowak and Quinn 2002).

This is similar to the findings elsewhere where larger cutthroat trout occupied waters just below the epilimnion during stratification in Bear Lake (Ruzycki *et al.* 2001) and until early August in Strawberry Reservoir (Baldwin *et al.* 2002). However, the fish in Strawberry Reservoir did shift towards a diel vertical movement pattern by late summer (Baldwin *et al.* 2002).

There appears to be little use of lake-bottom by cutthroat trout while in the limnetic portion of the lakes. Nowak *et al.* (2004) found little representation of benthic prey in the diets of pelagic trout in Lake Washington and captured few trout in their bottom trawl sampling. Similarly, the telemetry work completed on large cutthroat trout from Strawberry Reservoir and Lake Washington indicated limited movement into the waters below the metalimnion during summer (Baldwin *et al.* 2002; Nowak and Quinn 2002 respectively).

Horizontal movement of ultrasonically tagged trout in Lake Washington showed relatively consistent swimming speeds between day and night with considerable overall distances suggesting little evidence for home ranges (Nowak and Quinn 2002). The work by Baldwin *et al.* (2002) on Strawberry Reservoir also found extensive horizontal movement by large cutthroat trout while in the limnetic zone of the lake; however, their work suggested diel differences in swimming speed, with greater movement rates during daylight periods.

One of the most substantial standardised fish sampling efforts on large lakes of Vancouver Island has been the completion of hydroacoustic assessments and associated trawling by the Department of Fisheries and Oceans (DFO) as part of their sockeye assessment efforts. However, the work by Hyatt (1990) shows an insignificant number of cutthroat trout captured in trawl sampling across multiple large lakes on Vancouver Island. This may be related to the specific gear dimension of the trawl used by Hyatt (1990; 7.5 m long, and 2 x 2 m opening), but is consistent with the findings by Narver (1975) who identifies an extremely low catch rate for cutthroat trout in Great Central Lake despite intensive seining efforts (5 trout captured in 220 beach seines) and trawl-sampling over various depths and times using a large trawl (3 x 6 m opening). The dearth of cutthroat trout captured within the seining effort may reflect a relatively short period of residency by cutthroat in the littoral portions of the lake, but the low capture success by trawling is likely a reflection of the overall low densities of cutthroat within the lakes and/or a low vulnerability of cutthroat to the particular gear specifications used (e.g. trawl speed, net dimensions). This is consistent with the findings of work by Atkinson (2015) during the pelagic gillnet sampling efforts in Sproat Lake.

### **Spawning**

The spawning period for cutthroat trout in Sproat Lake has been well described through surveys of Taylor River, its primary inlet. Lough and Hay (2011) conducted weekly snorkel surveys through the lower section of the river from late-February through early June and described the spawning period as extending from mid-April through to the end of May with a peak count of roughly 350 cutthroat trout. Cutthroat trout were observed throughout the survey period but with the initial increase in apparent abundance beginning near the end of March and then returning to near-absence by early June. Creel returns and seining efforts in the lower Taylor River suggested that spawning cutthroat were generally 6-7 years old, though scale analysis suggested that some fish had first spawned at 4 years of age (Lough 1991). Spawning sizes in 2012 were visually estimated by snorkel surveyors and were generally greater than 400 mm (Lough and Hay 2012).

Lough *et al.* (2011a) completed a similar series of snorkel surveys through the period from March through June on tributaries of Comox Lake (Reese, Puntledge and Comox Creeks). They estimated a total spawning population within these tributaries of 1700 fish (based on redd counts) with a size range of 300-550 mm. Peak spawning varied by system occurring between mid-March through to mid-April and at water temperatures of between 3.0 - 5.8°C.

A similar investigation was completed by Lough *et al.* (2011b) on the tributaries of Cowichan Lake. They surveyed sections of Robertson, Sutton, Nixon and Shaw Creeks from late-February through late-May. Spawner timing varied somewhat between tributaries but generally began in late-March and with periods of peak spawning occurring in the first part of April when water temperatures were between 3.5 - 5.9°C. The total estimated spawning population across these four streams was roughly 1300 fish and with a size range of 300-650 mm.

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## **APPENDIX B**

### **Comox Lake Fish Sampling and Recapture Data**

Effort – capture method and location (trapnet - TN; fyke net – FN, micro-trolling, angler)

MR\_CT# - the unique identification number for an individual cutthroat trout

Sp – species

FL – fork length in millimetres

Wt – weight in grams

Pit Array –detection in 2017 or 2018 at Upper Puntledge River, Comox Creek, or Reese Creek

Mort –mortality (includes sampling mortality or angler harvest)

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-07	100	CT	1	332	310		orange					
TN1	2016-04-07		DV	1	189								
TN1	2016-04-07		DV	1	275								
TN1	2016-04-07		CT	1	109								
TN1	2016-04-07		DV	1	353								
TN1	2016-04-07		DV	1	181								
TN1	2016-04-07		DV	1	186								
TN1	2016-04-07		CT	1	91								
TN1	2016-04-07		CO	1	103								
TN1	2016-04-07		DV	1	146								
TN1	2016-04-07		DV	1	144								
TN2	2016-04-07	101	CT	1	425			orange					5
TN2	2016-04-07	102	CT	1	317	330		orange					
TN2	2016-04-07		CT	1	110								
TN2	2016-04-07		CO	1	87	760						adipose clip	
TN2	2016-04-07	103	CT	1	388			orange					5
TN2	2016-04-07	104	CT	1	404		m	orange				milt expressing	
TN2	2016-04-07	105	CT	1	374	480		orange					5
TN2	2016-04-07	106	CT	1	388	600		orange					5
TN2	2016-04-07	107	CT	1	334	390		orange					4
TN2	2016-04-07		CO	1	95								
TN2	2016-04-07		CO	1	100								
TN2	2016-04-07	108	CT	1	332	420		orange					
TN2	2016-04-07		DV	1	128								
TN2	2016-04-07		CT	1	96								
FN1	2016-04-08		SC	1	81								
FN1	2016-04-08		DV	1	220								
FN1	2016-04-08	109	CT	1	384	530		orange					4
FN1	2016-04-08		CO	1	92								
FN1	2016-04-08		CO	1	87								
FN1	2016-04-08		SC	1	64								
TN1	2016-04-08	110	CT	1	290	220		orange					3
TN1	2016-04-08	111	CT	1	277	200		orange					4
TN1	2016-04-08		DV	1	207								
TN1	2016-04-08		DV	1	337								
TN1	2016-04-08		DV	1	155								
TN1	2016-04-08		CT	1	187	55							3
TN1	2016-04-08		CO	1	80								
TN1	2016-04-08		CO	1	84								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-08		CT	1	122								
TN1	2016-04-08		DV	1	117								
TN1	2016-04-08		DV	1	127								
TN1	2016-04-08		KO	1	128								
TN1	2016-04-08		DV	1	113								
TN1	2016-04-08		DV	1	101								
TN1	2016-04-08		CT	1	213	80							2
TN1	2016-04-08		DV	1	188								
TN1	2016-04-08	112	CT	1	394	540		orange					
TN1	2016-04-08		CT	1	113								
TN1	2016-04-08		CO	1	83								
TN1	2016-04-08		SC	1	81								
TN1	2016-04-08		CT	1	214	80							3
TN1	2016-04-08		DV	1	272								
TN1	2016-04-08	113	CT	1	333	345		orange					4
TN1	2016-04-08		CT	1	174								3
TN1	2016-04-08	114	CT	1	344	400		orange					
TN1	2016-04-10		DV	1	281								
TN1	2016-04-10		DV	1	330								
TN1	2016-04-10		DV	1	294								
TN1	2016-04-10		DV	1	236								
TN1	2016-04-10		DV	1	165								
TN1	2016-04-10		DV	1	192								
TN1	2016-04-10		DV	1	204								
TN1	2016-04-10		DV	1	160								
TN1	2016-04-10		DV	1	243								
TN1	2016-04-10		DV	1	163								
TN1	2016-04-10		DV	1	120								
TN1	2016-04-10	115	CT	1	356	435		orange					4
TN1	2016-04-10	116	CT	1	248	120		orange					3
TN1	2016-04-10		DV	1	291								
TN1	2016-04-10		CO	1	144								
TN1	2016-04-10	117	CT	1	303	270		orange					4
TN1	2016-04-10	118	CT	1	346	350		orange					
TN1	2016-04-10	119	CT	1	353	410		orange					
TN1	2016-04-10	120	CT	1	300	230		orange					4
TN1	2016-04-10		CT	1	213	85							
TN1	2016-04-10	121	CT	1	366	400	m	orange				expressing	4
TN1	2016-04-10		RB	1	250	165		orange					

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-10	122	CT	1	348	390		orange					6
TN1	2016-04-10		RB	1	240	135		orange					
TN1	2016-04-10	123	CT	1	457	850	f	orange				spent	6
TN1	2016-04-10		SC	1	70								
TN3	2016-04-10		DV	1	270								
TN3	2016-04-10		DV	1	230								
TN3	2016-04-10		DV	1	237								
TN3	2016-04-10		DV	1	283								
TN3	2016-04-10		DV	1	207								
TN3	2016-04-10		CO	1	116								
TN3	2016-04-10	124	CT	1	303	235	m	orange				expressing	4
TN3	2016-04-10		RB	1	216	80							
TN3	2016-04-10	125	CT	1	400	635		orange					5
TN3	2016-04-10		SC	1	62								
FN1	2016-04-10		CT	1	113								
FN1	2016-04-10		DV	1	127								
FN1	2016-04-10		SC	1	86								
FN2	2016-04-10		DV	1	145								
FN2	2016-04-10	126	CT	1	376	470		orange					
FN2	2016-04-10		CT	1	227	100							
FN2	2016-04-10		DV	1	360								
FN2	2016-04-10		DV	1	160								
FN2	2016-04-10		DV	1	227	135							
FN2	2016-04-10		SC	1	72								
TN2	2016-04-10		DV	1	362								
TN2	2016-04-10	127	CT	1	535	1710	f	orange	982.000403042394				
TN2	2016-04-10	128	CT	1	341	390		orange					
TN2	2016-04-10	129	CT	1	368	355		orange					4
TN2	2016-04-10		CO	1	93								
TN2	2016-04-10		CT	1	97								1
TN2	2016-04-10	130	CT	1	444	900		orange					
TN2	2016-04-10		SC	1	75								
TN2	2016-04-10		CT	1	119								
TN2	2016-04-10		TSB	1	67								
FN1	2016-04-11		DV	1	186								
FN1	2016-04-11		DV	1	142								
FN1	2016-04-11		CT	1	82								
FN1	2016-04-11		CO	1	82								
TN2	2016-04-11		CT	1	140	25							

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN2	2016-04-11	131	CT	1	407	680		orange					
TN1	2016-04-11		KO	1	127								
TN1	2016-04-11		KO	1	138								
TN1	2016-04-11		KO	1	143								
TN1	2016-04-11		CO	1	115								
TN1	2016-04-11		KO	1	186								
TN1	2016-04-11	132	CT	1	404	650		orange					5
TN1	2016-04-11		CT	1	208	85							2
TN1	2016-04-11		SC	1	72								
TN3	2016-04-11		KO	1	74								
TN2	2016-04-13	133	CT	1	370	520		orange					4
TN2	2016-04-13	134	CT	1	333	350		orange					4
TN2	2016-04-13	135	CT	1	374	460	f	orange				expressing	5
TN2	2016-04-13	136	CT	1	352	390		orange					
TN2	2016-04-13	137	CT	1	391	620		orange					
TN2	2016-04-13	138	CT	1	412	540		orange					5
TN2	2016-04-13		DV	1	190								
TN2	2016-04-13		RB	1	183								
TN2	2016-04-13		DV	1	127								
TN2	2016-04-13		CT	1	157								2
TN2	2016-04-13		CT	1	132								2
TN2	2016-04-13		KO	1	175								
TN2	2016-04-13		CO	1	62								
TN2	2016-04-13		CT	1	118	14.3							1
TN2	2016-04-13		CT	1	105	8.7							
FN1/FN2	2016-04-13		KO	1	100								
FN1/FN2	2016-04-13		RB	1	192								
FN1/FN2	2016-04-13		KO	1	146								
FN1/FN2	2016-04-13		KO	1	144								
FN1/FN2	2016-04-13		CT	1	135								2
FN1/FN2	2016-04-13		DV	1	155								
FN1/FN2	2016-04-13		TSB	1	62								
FN1/FN2	2016-04-13		CT	1	92								
FN1/FN2	2016-04-13		KO	1	92								
FN1/FN2	2016-04-13		SC	1	71								
FN1/FN2	2016-04-13		SC	1	89								
FN1/FN2	2016-04-13		SC	1	69								
TN1	2016-04-13		CT	1	171	49							3
TN1	2016-04-13	139	CT	1	240	120		orange				possible hybrid	2

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-13		DV	1	285								
TN1	2016-04-13		DV	1	295								
TN1	2016-04-13		DV	1	270								
TN1	2016-04-13		DV	1	330								
TN1	2016-04-13		DV	1	210								
TN1	2016-04-13		DV	1	287								
TN1	2016-04-13	140	CT	1	392	590	m	orange					5
TN1	2016-04-13	141	CT	1	238	100		orange					3
TN1	2016-04-13	142	CT	1	410	580	m	orange					5
TN1	2016-04-13		KO	1	142								
TN1	2016-04-13	143	CT	1	280	205		orange				possible hybrid	3
TN1	2016-04-13	144	CT	1	371	470	f	orange					4
TN1	2016-04-13	145	CT	1	415	740		orange					5
TN1	2016-04-13	146	CT	1	312	300		orange					4
TN1	2016-04-13	147	CT	1	230	105		orange					3
TN1	2016-04-13	148	CT	1	288	225		orange					4
TN1	2016-04-13		KO	1	187								
TN1	2016-04-13		CT	1	143	25							2
TN3	2016-04-13		DV	1	241								
TN3	2016-04-13		DV	1	267								
TN3	2016-04-13		DV	1	177								
TN3	2016-04-13		DV	1	314								
TN3	2016-04-13		DV	1	341								
TN3	2016-04-13		KO	1	127								
TN3	2016-04-13		DV	1	198								
TN3	2016-04-13		DV	1	330								
TN3	2016-04-13		DV	1	230								
TN3	2016-04-13		CO	1	90							adipose clip	
TN3	2016-04-13		CT	1	128								
TN3	2016-04-13		DV	1	284								
TN3	2016-04-13		DV	1	280								
TN3	2016-04-13		DV	1	268								
TN2	2016-04-14	149	CT	1	310	270		orange					3
TN2	2016-04-14		CO	1	133								
TN2	2016-04-14	150	CT	1	429	840		orange					
FN1/FN2	2016-04-14		DV	1	252								
FN1/FN2	2016-04-14		TSB	1	61								
TN1	2016-04-14		KO	1	153								
TN1	2016-04-14		KO	1	189								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-14		DV	1	183								
TN1	2016-04-14		DV	1	210								
TN1	2016-04-14	151	CT	1	285	200		orange					
TN1	2016-04-14		CO	1	95								
TN1	2016-04-14		CT	1	133	19							
TN1	2016-04-14	152	CT	1	262	150		orange					3
TN1	2016-04-14		CT	1	126	19							2
TN3	2016-04-14		TSB	1	50								
TN3	2016-04-14		CT	1	156	36							
TN2	2016-04-15		CO	1	86								
TN2	2016-04-15		CO	1	106								
TN2	2016-04-15		CO	1	102								
TN2	2016-04-15		CO	1	116								
TN2	2016-04-15		CO	1	130								
TN2	2016-04-15		CO	1	97								
TN2	2016-04-15		CO	1	83								
TN2	2016-04-15		TSB	1	65								
TN1	2016-04-15		DV	1	172								
TN1	2016-04-15		CO	1	112								
TN1	2016-04-15		DV	1	220								
TN1	2016-04-15		CO	1	97								
TN1	2016-04-15		CO	1	84								
TN1	2016-04-15		DV	1	310								
TN1	2016-04-15		DV	1	222								
TN1	2016-04-15		CO	1	106								
TN1	2016-04-15		CO	1	78								
TN1	2016-04-15		CO	1	93								
TN1	2016-04-15		CO	1	82								
TN1	2016-04-15		TSB	1	64								
TN1	2016-04-15		CT	1	118	14.5							
TN1	2016-04-15		CT	1	108	11							
TN1	2016-04-15	153	CT	1	337	425		orange					4
TN1	2016-04-15	154	CT	1	268	175		orange					4
TN1	2016-04-15	155	CT	1	358	380		orange					4
TN1	2016-04-15		DV	1	193								
TN1	2016-04-15		CO	1	93								
TN1	2016-04-15		CT	1	106								
TN1	2016-04-15		CO	1	95								
TN1	2016-04-15		KO	1	126								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN1	2016-04-15		CO	1	90								
TN1	2016-04-15		SC	1	86								
TN1	2016-04-15		CO	1	115								
TN1	2016-04-15		CO	1	92								
TN1	2016-04-15		SC	1	83								
TN1	2016-04-15		CO	1	139							adipose clip	
TN1	2016-04-15		CO	1	93								
angler	2016-04-30	145	CT	1				orange			y		
angler	2016-05-01	153	CT	1				orange			y		
microtrolling	2016-07-20	156	CT	1	335			orange	982.0004/2563				
microtrolling	2016-07-20	157	CT	1	481		m	orange	982.000404705625				
TN1	2016-10-25	158	CT	1	350			pink	982.000404705590	U Punt - 2017		adipose clip	
TN1	2016-10-25		DV	1	175							scales	
TN1	2016-10-25		CT	1	238								
TN2	2016-10-25		DV	1	405								
TN2	2016-10-25		DV	1	272								
TN2	2016-10-25		DV	1	360								
TN2	2016-10-25		DV	1	366								
TN2	2016-10-25		DV	1	316								
TN2	2016-10-25		DV	1	317								
TN2	2016-10-25		DV	1	377							spawning colours	
TN2	2016-10-25		DV	1	397								
TN2	2016-10-25		DV	1	325								
TN2	2016-10-25		DV	1	254								
TN2	2016-10-25		DV	1	357								
TN2	2016-10-25		DV	1	333								
TN2	2016-10-25		DV	1	352								
TN2	2016-10-25		DV	1	254								
TN2	2016-10-25		DV	1	271								
TN2	2016-10-25		DV	1	185								
TN2	2016-10-25		DV	1	275								
TN3	2016-10-25		CO	1	70							no adipose clip	
TN3	2016-10-25		CO	1	79							no adipose clip	
TN3	2016-10-25		CO	1	87							no adipose clip	
TN3	2016-10-25		CO	1	82							no adipose clip	
TN3	2016-10-25		CO	1	78							no adipose clip	
TN3	2016-10-25		CO	1	77							no adipose clip	
TN3	2016-10-25	159	CT	1	240				982.000403031807				
TN3	2016-10-25	160	CT	1	217				982.000404705551				

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2016-10-25		CO	1	87							no adipose clip	
TN3	2016-10-25	161	CT	1	205				982.000404705616				
TN3	2016-10-25		CO	1	106							no adipose clip	
TN3	2016-10-25	162	CT	1	233				982.000404705626				
TN3	2016-10-25	163	CT	1	210				982.000404705622				
TN2	2016-10-25		CO	1	93							adipose clip	
TN2	2016-10-25		DV	1	183								
TN2	2016-10-25		DV	1	195								
TN2	2016-10-25		CO	1	83								
TN2	2016-10-25		DV	1	107								
TN2	2016-10-25		DV	1	343								
TN2	2016-10-25		DV	1	315								
TN2	2016-10-25		ST	1	670		f						
TN2	2016-10-25		CT	1	152								
TN2	2016-10-25		CT	1	210								
TN2	2016-10-25		CT	1	237								
TN2	2016-10-25		CT	1	222								
TN2	2016-10-25		CT	1	210								
TN2	2016-10-25		CT	1	150								
TN2	2016-10-25		CT	1	210								
TN2	2016-10-25		CT	1	170								
TN2	2016-10-25	164	CT	1	327			pink	982.000404705619				
TN2	2016-10-25	165	CT	1	335		m	pink	982.000404705539				
TN2	2016-10-25		CT	1	187								
TN2	2016-10-25		CT	1	185								
TN2	2016-10-25		CT	1	157								
TN2	2016-10-25		CT	1	163								
TN2	2016-10-25		CT	1	140								
TN2	2016-10-25		KO	1	200		f					expressing	
TN2	2016-10-25		CT	1	120								
TN2	2016-10-25	166	CT	1	367			pink	982.000404705555			adipose clip	
TN2	2016-10-25	167	CT	1	322			pink	982.000404705547			adipose clip	
TN2	2016-10-25	168	CT	1	270			green	982.000404705571				
TN3	2016-10-25		CO	1	80								
TN3	2016-10-25		CO	1	90							adipose clip	
TN3	2016-10-25		CO	1	90							adipose clip	
TN3	2016-10-25		CO	1	82							no adipose clip	
TN3	2016-10-25		CO	1	74							no adipose clip	
TN3	2016-10-25		KO	1	210		m					expressing	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2016-10-25		KO	1	124								
TN3	2016-10-25		DV	1	240								
TN3	2016-10-25	169	CT	1	345			pink	982.000404705569			adipose clip	
TN3	2016-10-25	170	CT	1	340			pink	982.000404705553			adipose clip	
TN3	2016-10-25		CO	1	83							no adipose clip	
TN3	2016-10-25		CO	1	76							no adipose clip	
TN3	2016-10-25		CO	1	74							no adipose clip	
TN1	2016-10-26		CT	1	167								
TN2	2016-10-26		DV	1	324								
TN2	2016-10-26		DV	1	437								
TN2	2016-10-26		DV	1	333								
TN2	2016-10-26		DV	1	350								
TN2	2016-10-26		DV	1	396								
TN2	2016-10-26		DV	1	332								
TN2	2016-10-26		DV	1	330								
TN2	2016-10-26		DV	1	355								
TN2	2016-10-26		DV	1	300								
TN2	2016-10-26		DV	1	342								
TN2	2016-10-26		DV	1	265								
TN2	2016-10-26		DV	1	320								
TN2	2016-10-26		DV	1	370								
TN2	2016-10-26		DV	1	380								
TN2	2016-10-26		DV	1	315								
TN2	2016-10-26		DV	1	340								
TN2	2016-10-26		DV	1	312								
TN2	2016-10-26		DV	1	310								
TN2	2016-10-26		DV	1	276								
TN2	2016-10-26		DV	1	230								
TN2	2016-10-26		DV	1	110								
TN2	2016-10-26	171	CT	1	307			green	982.000402305493				
TN2	2016-10-26	172	CT	1	275			green	982.000403029895				
TN2	2016-10-26	173	CT	1	342			green	982.000364564621				
TN2	2016-10-26	174	CT	1	280			green	982.000403037534				
TN2	2016-10-26	175	CT	1	310			pink					
TN2	2016-10-26	176	CT	1	208				982.000364567168				
TN2	2016-10-26	177	CT	1	249				982.000403034813				
TN2	2016-10-26	178	CT	1	250				982.000402305521				
TN2	2016-10-26	179	CT	1	242				982.000402106096				
TN2	2016-10-26	180	CT	1	280			pink	982.000364562068				

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN2	2016-10-26	181	CT	1	230				982.000403042144				
TN2	2016-10-26	182	CT	1	230				982.000364566955				
TN2	2016-10-26		CT	1	206								
TN2	2016-10-26		CT	1	124								
TN2	2016-10-26		CT	1	203								
TN2	2016-10-26		CT	1	212	97	f				y	immature	
TN2	2016-10-26		CT	1	212	93	f				y	50 mm SC in stomach, 30 mm UN, imm	
TN2	2016-10-26		KO	1	200		m					expressing	
TN3	2016-10-26		CO	1	666							adipose clip	
TN3	2016-10-26		CO	1	590							no adipose clip	
TN3	2016-10-26		KO	1	200		m					expressing	
TN3	2016-10-26		KO	1	210		f					expressing	
TN3	2016-10-26		KO	1	208		m					expressing	
TN3	2016-10-26		DV	1	970		m						
TN3	2016-10-26		KO	1	195		f					expressing	
TN3	2016-10-26		DV	1	230								
TN3	2016-10-26		CO	1	76							no adipose clip	
TN3	2016-10-26		CO	1	77							no adipose clip	
TN3	2016-10-26		DV	1	189								
TN3	2016-10-26		DV	1	140								
TN3	2016-10-26		CO	1	88							no adipose clip	
TN3	2016-10-26		CO	1	83							no adipose clip	
TN3	2016-10-26		CO	1	84							adipose clip	
TN3	2016-10-26		CO	1	91							no adipose clip	
TN3	2016-10-26		CO	1	77							no adipose clip	
TN3	2016-10-26		CO	1	90							no adipose clip	
TN3	2016-10-26		CO	1	87							no adipose clip	
TN3	2016-10-26		CO	1	81							adipose clip	
TN3	2016-10-26		CO	1	87							no adipose clip	
TN3	2016-10-26		CO	1	87							no adipose clip	
TN3	2016-10-26	183	CT	1	367			pink	982.000404705577				
TN3	2016-10-26	184	CT	1	375			pink	982.000404705604				
TN3	2016-10-26	185	CT	1	350			pink	982.000404705585				
TN3	2016-10-26		RB	1	330								
TN3	2016-10-26	186	CT	1	285			pink	982.000404705606				
TN3	2016-10-26	187	CT	1	293			pink					
TN3	2016-10-26		RB	1	239								
TN3	2016-10-26	188	CT	1	306			pink	982.000404705612				

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2016-10-26	189	CT	1	240				982.000404705572				
TN3	2016-10-26	190	CT	1	258			pink	982.000404705541				
TN3	2016-10-26	191	CT	1	227				982.000404705623				
TN3	2016-10-26		RB	1	205								
TN3	2016-10-26	192	CT	1	227				982.000404705564				
TN3	2016-10-26	193	CT	1	212				982.000404705565				
TN3	2016-10-26		CT	1	180								
TN3	2016-10-26		CT	1	172								
TN3	2016-10-26		CT	1	163								
TN3	2016-10-26		RB	1	162								
TN2	2016-10-27		DV	1	221								
TN2	2016-10-27		DV	1	96								
TN2	2016-10-27		DV	1	265								
TN2	2016-10-27		DV	1	261								
TN2	2016-10-27		DV	1	310								
TN2	2016-10-27		CO	1	108							no adipose clip	
TN2	2016-10-27		RB	1	280			pink	982.000404705545			Hyb? 83mm coho in stomach (H)	
TN2	2016-10-27		DV	1	361							ovipositor showing	
TN2	2016-10-27		CO	1	78							no adipose clip	
TN2	2016-10-27		CO	1	84							no adipose clip	
TN2	2016-10-27	194	CT	1	432			pink	982.000404705587				
TN2	2016-10-27	195	CT	1	235				982.000404705563				
TN2	2016-10-27		CT	1	178								
TN2	2016-10-27		CT	1	172								
TN2	2016-10-27		CT	1	130								
TN3	2016-10-27		CO	1	590								
TN3	2016-10-27		DV	1	145								
TN3	2016-10-27		CO	1	85							no adipose clip	
TN3	2016-10-27		CO	1	75							no adipose clip	
TN3	2016-10-27		CO	1	82							adipose clip	
TN3	2016-10-27		CO	1	74							no adipose clip	
TN3	2016-10-27		CO	1	73							no adipose clip	
TN3	2016-10-27		CO	1	77							no adipose clip	
TN3	2016-10-27		CO	1	86							no adipose clip	
TN3	2016-10-27		CO	1	79							no adipose clip	
TN3	2016-10-27		CO	1	81							no adipose clip	
TN3	2016-10-27		CO	1	71							no adipose clip	
TN3	2016-10-27		CO	1	76							no adipose clip	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2016-10-27		CO	1	78							no adipose clip	
TN3	2016-10-27		CO	1	80							no adipose clip	
TN3	2016-10-27		CO	1	84							no adipose clip	
TN3	2016-10-27		DV	1	410								
TN3	2016-10-27	196	CT	1	323			pink	982.000404705578				
TN3	2016-10-27	197	CT	1	330			pink	982.000404705621				
TN3	2016-10-27		RB	1	350			green	982.000404705605				
TN3	2016-10-27		RB	1	353			green	982.000404705588				
TN3	2016-10-27	198	CT	1	290			pink	982.000404705603				
TN3	2016-10-27	199	CT	1	228				982.000404705549				
TN3	2016-10-27	200	CT	1	208				982.000404705550				
TN3	2016-10-27		CT	1	158								
TN3	2016-10-27		CT	1	197								
TN3	2016-10-27		CT	1	137								
TN3	2016-10-27		CT	1	200								
TN3	2016-10-27		CT	1	197								
TN3	2016-10-27	201	CT	1	203				982.000404705543				
TN3	2016-10-27		CT	1	280	245	f				y	no atritic eggs, mature	
TN3	2016-10-27		KO	1	216		m					expressing	
TN3	2016-10-27		KO	1	210		m					expressing	
TN3	2016-10-27		KO	1	220		m					expressing	
TN3	2016-10-27		KO	1	205		m					expressing	
TN3	2016-10-27		KO	1	195		f					expressing	
TN3	2016-10-27		KO	1	208		f					expressing	
TN3	2016-10-27		KO	1	215		m					expressing	
TN1	2016-10-27		CO	1	78							no adipose clip	
TN1	2016-10-27		DV	1	351								
TN1	2016-10-27	202	CT	1	265			pink	982.000404705595				
TN1	2016-10-27		CT	1	183								
TN1	2016-10-27		CT	1	200								
TN1	2016-10-27		CT	1	143								
TN1	2016-10-27		CT	1	175	60							
TN2	2016-10-28	203	CT	1	208				982.000404705600				
TN2	2016-10-28	204	CT	1	383			pink	982.000404705611			83mm and 70mm Coho in stomach	
TN2	2016-10-28	205	CT	1	405			pink	982.000404705583				
TN2	2016-10-28	206	CT	1	306			pink	982.000404705615				
TN2	2016-10-28	207	CT	1	202				982.000404705609				
TN2	2016-10-28	208	CT	1	235				982.000404705630				

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN2	2016-10-28		RB	1	245				982.000404705598				
TN2	2016-10-28	209	CT	1	206				982.000404705620				
TN2	2016-10-28		RB	1	182								
TN2	2016-10-28		CT	1	136								
TN2	2016-10-28		CT	1	209	93	un				y	otolith sample, empty stomach, immature	
TN2	2016-10-28		CO	1	85							no adipose clip	
TN2	2016-10-28		CO	1	87							no adipose clip	
TN2	2016-10-28		CO	1	102							no adipose clip	
TN2	2016-10-28		CO	1	90							no adipose clip	
TN2	2016-10-28		CO	1	93							no adipose clip	
TN2	2016-10-28		CO	1	73							no adipose clip	
TN2	2016-10-28		CO	1	82							no adipose clip	
TN2	2016-10-28		CO	1	90								
TN2	2016-10-28		CO	1	76							no adipose clip	
TN2	2016-10-28		CO	1	72							no adipose clip	
TN2	2016-10-28		CO	1	91							no adipose clip	
TN2	2016-10-28		KO	1	202		f					expressing	
TN2	2016-10-28		KO	1	217		m					expressing	
TN2	2016-10-28		DV	1	396			green				fin ray taken	
TN2	2016-10-28		DV	1	356			green				fin ray taken	
TN2	2016-10-28		DV	1	315			green				fin ray taken	
TN2	2016-10-28		DV	1	300			green					
TN2	2016-10-28		DV	1	358			green					
TN2	2016-10-28		DV	1	307			green					
TN2	2016-10-28		DV	1	261			green					
TN2	2016-10-28		CO	1	90							no adipose clip	
TN3	2016-10-28		KO	1	207		m					expressing	
TN3	2016-10-28		KO	1	212		m					expressing	
TN3	2016-10-28		KO	1	227		m					expressing	
TN3	2016-10-28		KO	1	205		f					expressing	
TN3	2016-10-28		CT	1	146								
TN3	2016-10-28		CT	1	173							possible hybrid	
TN3	2016-10-28	210	CT	1	208	83	un		982.000403038837		y	scales + ot - Inverts in stomach, imm	
TN3	2016-10-28	211	CT	1	255			pink	982.000364565340				
TN3	2016-10-28		CO	1	108							no adipose clip	
TN3	2016-10-28		CO	1	74							adipose clip	
TN3	2016-10-28		CO	1	85							no adipose clip	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2016-10-28		CO	1	82							no adipose clip	
TN3	2016-10-28		CO	1	87							no adipose clip	
TN3	2016-10-28		CO	1	86							adipose clip	
TN3	2016-10-28		CO	1	88							no adipose clip	
TN3	2016-10-28		CO	1	84							no adipose clip	
TN3	2016-10-28		CO	1	95							no adipose clip	
TN3	2016-10-28		CO	1	102							no adipose clip	
TN3	2016-10-28		CO	1	81							no adipose clip	
TN3	2016-10-28		CO	1	85							no adipose clip	
TN3	2016-10-28		CO	1	82							no adipose clip	
TN3	2016-10-28		CO	1	83							no adipose clip	
TN3	2016-10-28		CO	1	75							no adipose clip	
TN3	2016-10-28		CO	1	93							no adipose clip	
TN3	2016-10-28		CO	1	83							no adipose clip	
TN3	2016-10-28		CO	1	94							no adipose clip	
TN3	2016-10-28		CO	1	72							adipose clip	
TN3	2016-10-28		CO	1	83							no adipose clip	
TN3	2016-10-28		CO	1	71							no adipose clip	
TN3	2016-10-28		CO	1	83							no adipose clip	
TN3	2016-10-28		CO	1	75							no adipose clip	
TN3	2016-10-28		CO	1	82							no adipose clip	
TN3	2016-10-28		CO	1	80							no adipose clip	
TN3	2016-10-28		CO	1	76							no adipose clip	
TN3	2016-10-28		CO	1	80							no adipose clip	
TN3	2016-10-28		CO	1	75							no adipose clip	
TN3	2016-10-28		CO	1	90							no adipose clip	
TN3	2016-10-28	212	CT	1	380			pink	982.000403031122				
TN1	2017-03-09		CO	1	80							no adipose clip	
TN1	2017-03-09		CO	1	78							no adipose clip	
TN2	2017-03-09		KO	1	140								
TN2	2017-03-09		DV	1	130								
TN2	2017-03-09	213	CT	1	438	840	m	pink	982.000404705558			ad clipped, not expressing, mature	
TN2	2017-03-09		DV	1	158								
TN2	2017-03-09		KO	1	100								
TN2	2017-03-09		DV	1	185								
TN2	2017-03-09		KO	1	132								
TN2	2017-03-09		CO	1	82							adipose clip	
TN2	2017-03-09		CO	1	84							adipose clip	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN2	2017-03-09		CO	1	83							adipose clip	
TN3	2017-03-10		KO	1	105							mort	
TN3	2017-03-10		KO	1	124								
TN3	2017-03-10		DV	1	283							fin ray taken	
TN3	2017-03-10	214	CT	1	376	520	m	pink	982.000404705591	Reese-2017		expressing	3
TN3	2017-03-10		DV	1	300							fin ray taken	
TN1	2017-03-10	215	CT	1	400		f	pink	982.000404705582			expressing under firm pressure	4
TN1	2017-03-10	216	CT	1	576		m	pink	982.000404705584			expressing, full spawning colour	5
TN1	2017-03-10	217	CT	1	515		m	pink	982.000404705562			expressing	5
TN1	2017-03-10	218	CT	1	526		f	pink	982.000404705538	Comox - 2018		expressing with pressure	6
TN2	2017-03-10		CO	1	80							no adipose clip	
TN2	2017-03-10		CO	1	85							no adipose clip	
TN2	2017-03-10		CO	1	95							no adipose clip	
TN2	2017-03-10		DV	1	171							fin ray taken	
TN2	2017-03-10		KO	1	130								
TN3	2017-03-13		CT	1	217	91							2
TN3	2017-03-13		CT	1	192	63							2
TN1	2017-03-13	219	CT	1	538		f	pink	982.000404705579			expressing	5
TN1	2017-03-13	220	CT	1	569		f	pink	982.000404705592			partial kelt, exp	6
TN1	2017-03-13	221	CT	1	443		m	pink	982.000404705627			expressing	4
TN1	2017-03-13	222	CT	1	465		m	pink	982.000404705559			expressing	5
TN1	2017-03-13	223	CT	1	438		un	pink	982.000404705537			not expressing	4
TN2	2017-03-13		KO	1	92								
TN2	2017-03-13		DV	1	266								
TN2	2017-03-13		DV	1	316								
TN2	2017-03-13		DV	1	172								
TN2	2017-03-13		DV	1	135								
TN2	2017-03-13		DV	1	175								
TN2	2017-03-13		DV	1	114								
TN2	2017-03-13		CT	1	111								1
TN2	2017-03-13		CT	1	140								
TN2	2017-03-13	224	CT	1	440		m	pink	982.000404705617			expressing	4
TN2	2017-03-13	225	CT	1	267		un	pink				not expressing	2
TN3	2017-03-15	226	CT	1	514		un	pink	982.000404705576	U Punt - 2017		possibly male, not exp	5
TN3	2017-03-15		DV	1	351								
TN3	2017-03-15		DV	1	330								
TN3	2017-03-15	227	CT	1	345		un	pink	982.000404705610				3

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2017-03-15		CT	1	205								2
TN3	2017-03-15		RB	1	301								
TN1	2017-03-15	228	CT	1	482		m	pink	982.000404705574				
TN1	2017-03-15	229	CT	1	470		un	pink	982.000404705560	Comox - 2017		possibly female, partial kelt, not exp	6
TN2	2017-03-15		DV	1	236								
TN2	2017-03-15		DV	1	206								
TN2	2017-03-15		DV	1	175								
TN2	2017-03-15		CT	1	130								
TN2	2017-03-15		CO	1	95							no adipose clip	
TN2	2017-03-15		CO	1	77							no adipose clip	
TN2	2017-03-15	230	CT	1	390		m	pink	982.000404705535			expressing	4
TN2	2017-03-15	231	CT	1	443		f	pink	982.000404705568	Comox-2017		not expressing	4
TN2	2017-03-15		DV	1	160								
TN2	2017-03-15		CT	1	113								1
TN2	2017-03-15	232	CT	1	406		un	pink	982.000404705536			possibly female, not exp, left max damage	
TN3	2017-03-17		KO	1	104								
TN3	2017-03-17		KO	1	98								
TN3	2017-03-17		KO	1	97								
TN3	2017-03-17		KO	1	130								
TN3	2017-03-17		KO	1	121								
TN3	2017-03-17		KO	1	95								
TN3	2017-03-17		KO	1	130								
TN3	2017-03-17		KO	1	122								
TN3	2017-03-17		KO	1	125								
TN3	2017-03-17		KO	1	93								
TN3	2017-03-17		KO	1	117								
TN3	2017-03-17		KO	1	123								
TN3	2017-03-17		KO	1	127								
TN3	2017-03-17		KO	1	95								
TN3	2017-03-17		KO	16									
TN3	2017-03-17		KO	1	133								
TN3	2017-03-17		KO	27									
TN3	2017-03-17		KO	1	81								
TN3	2017-03-17		DV	1	123								
TN3	2017-03-17		CT	1	120								1
TN3	2017-03-17		DV	1	227								
TN3	2017-03-17		DV	1	194								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2017-03-17		DV	1	321								
TN3	2017-03-17	233	CT	1	337		un	pink	982.000404705593			not exp, possibly female	3
TN3	2017-03-17	234	CT	1	360		un	pink	982.000404705599			not expressing	3
TN3	2017-03-17	235	CT	1	295			pink	982.000404705554				
TN3	2017-03-17	236	CT	1	380			pink	982.000404705602				3
TN3	2017-03-17		RB	1	289							scales taken	
TN3	2017-03-17		CT	1	354	520					y	immature, un sex, ot taken, un fish in stomach	3
TN3	2017-03-17		CT	1	430	960					y	female? Resting?, ot taken, 10 KO in stomach	4
TN4	2017-03-17		DV	1	195								
TN4	2017-03-17		DV	1	165								
TN4	2017-03-17		DV	1	152								
TN4	2017-03-17		DV	1	142								
TN4	2017-03-17		CO	1	85								
TN4	2017-03-17		CO	1	85								
TN4	2017-03-17	237	CT	1	395		m	pink	982.000404705542			expressing	3
TN4	2017-03-17	238	CT	1	406		un	pink	928.000404705546			not expressing	4
TN4	2017-03-17	239	CT	1	464		un	pink	982.000404705557			not expressing	5
TN4	2017-03-17	240	CT	1	315		un	pink	982.000404705628			not expressing	3
TN4	2017-03-17	241	CT	1	353		un	pink	982.000404705631			not expressing	4
TN3	2017-03-20		CO	1	80								
TN3	2017-03-20		KO	1	126								
TN3	2017-03-20		KO	1	95								
TN3	2017-03-20	242	CT	1	285		f	pink	982.000404705618				2
TN3	2017-03-20		KO	1	94								
TN1	2017-03-20		CT	1	154								
TN1	2017-03-20		KO	1	125								
TN1	2017-03-20		CO	1	86							no adipose clip	
TN1	2017-03-20		CO	1	89							no adipose clip	
TN1	2017-03-20		KO	1	123							no adipose clip	
TN1	2017-03-20		CO	1	80							adipose clip	
TN1	2017-03-20		CO	1	91							no adipose clip	
TN1	2017-03-20		CO	1	93							no adipose clip	
TN1	2017-03-20		CO	1	81							no adipose clip	
TN1	2017-03-20		CO	1	86							no adipose clip	
TN4	2017-03-20	140	CT	1	436	850	m	orange	982.000404705552			RECAP, not exp	
TN4	2017-03-20	243	CT	1	455		m	pink	982.000404705608	U Punt - 2018		not expressing	5

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN4	2017-03-20	244	CT	1	441		m	pink	982.000404705580			not exp, may have been ad clipped already?	4
TN4	2017-03-20		DV	1	182								
TN4	2017-03-20	245	CT	1	408		f	pink	982.000404705581	U Punt - 2017; U Punt 2018		kelt?	4
TN4	2017-03-20		DV	1	190								
TN4	2017-03-20		DV	1	300								
TN4	2017-03-20	246	CT	1	336		m	pink	982.000404705575				4
TN4	2017-03-20		CT	1	135								
TN4	2017-03-20		DV	1	268								
TN4	2017-03-20		DV	1	294								
TN4	2017-03-20		CO	1	96							no adipose clip	
TN4	2017-03-20		CO	1	88							no adipose clip	
TN4	2017-03-20		CO	1	87							no adipose clip	
TN4	2017-03-20		CO	1	96							no adipose clip	
TN4	2017-03-20		CO	1	101							no adipose clip	
TN4	2017-03-20		CO	1	81							no adipose clip	
TN4	2017-03-20		CO	1	82							no adipose clip	
TN4	2017-03-20		CO	1	82							no adipose clip	
incidental	2017-03-20		CT	1	450		m				y	harvested CT near launch, ot taken	
incidental	2017-03-20		CT	1	400		un				y	harvested CT near launch, ot taken	
incidental	2017-03-20		CT	1	417		m				y	harvested CT near launch, ot taken	
incidental	2017-03-20		CT	1	430		un				y	harvested CT near launch, ot taken	
TN4	2017-03-21		DV	1	241								
TN4	2017-03-21		DV	1	293								
TN4	2017-03-21		DV	1	177								
TN4	2017-03-21		DV	1	123								
TN4	2017-03-21		CO	1	85							no adipose clip	
TN4	2017-03-21		CO	1	103							no adipose clip	
TN4	2017-03-21		SC	1	65								
TN1	2017-03-21		TSB	1	43								
TN1	2017-03-21	247	CT	1	455		f	pink	982.000404705613	Comox - 2018		partial spawn	
TN1	2017-03-21		CT	1	147								
TN1	2017-03-21		CT	1	140								
TN1	2017-03-21		CT	1	177								
TN3	2017-03-21	156	CT	1	340			pink	982.000404705532			RECAP	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN3	2017-03-21		DV	1	303								
TN3	2017-03-21		CO	1	94	7.5							
TN4	2017-03-24		CT	1	117								1
TN4	2017-03-24		DV	1	278								
TN4	2017-03-24		DV	1	321								
TN4	2017-03-24		CO	1	85								
TN4	2017-03-24		DV	1	210								
TN4	2017-03-24	248	CT	1	430		m	pink	982.000404705614	U Punt - 2017, U Punt 2018			
TN1	2017-03-24	249	CT	1	440		m	pink	982.000404705544	Comox - 2017, Comox 2018		expressing	
TN1	2017-03-24	250	CT	1	387		m	pink	982.000404705597	Reese - 2017		expressing	
TN1	2017-03-24	251	CT	1	400		m	pink	982.000404705607			expressing	
TN1	2017-03-24	252	CT	1	437		f	pink	982.000404705566	Comox-2017, Comox 2018			4
TN1	2017-03-24	253	CT	1	392		m	pink	982.000404705594				
TN1	2017-03-24	254	CT	1	329		m	pink	982.000404705533			immature, pit recorded as 05532 in notes but seems to be a mistake based on download	3
TN5	2017-03-24		KO	1	140								
TN5	2017-03-24		CO	1	84								
TN4	2017-03-27		CO	1	85								
TN4	2017-03-27		CO	1	81								
TN4	2017-03-27		CO	1	77								
TN4	2017-03-27		CO	1	74								
TN4	2017-03-27		CO	1	80								
TN4	2017-03-27		CO	1	84								
TN4	2017-03-27		CO	1	90								
TN4	2017-03-27		CT	1	106								1
TN4	2017-03-27		CO	1	87								
TN4	2017-03-27		CO	1	90								
TN4	2017-03-27		CO	1	84								
TN4	2017-03-27		CT	1	125								1
TN4	2017-03-27		CT	1	136								
TN4	2017-03-27		CT	1	143								1
TN4	2017-03-27		DV	1	272								
TN5	2017-03-27		KO	1	102								
TN5	2017-03-27		CO	1	83								
TN5	2017-03-27		CO	1	87								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN5	2017-03-27	255	CT	1	395		m	pink	982.000403039987	Comox - 2017		not expressing	4
TN1	2017-03-29	256	CT	1	480		f	pink	982.000364564175	Comox - 2017; Comox 2018		gravid but not expressing	5
TN4	2017-03-29		DV	1	278								
TN4	2017-03-29		CT	1	107							immature	1
TN5	2017-03-29		KO	1	135								
TN5	2017-03-29		KO	1	132								
TN5	2017-03-29		KO	1	131								
TN5	2017-03-29		KO	1	146								
TN5	2017-03-29		KO	1	134								
TN5	2017-03-29		KO	1	125								
TN5	2017-03-29		KO	1	128								
TN5	2017-03-29		KO	1	126								
TN5	2017-03-29		KO	1	127								
TN5	2017-03-29		CO	1	87								
TN5	2017-03-29		RB	1	278							ad clipped and genetics taken	
TN6	2017-03-31		DV	1	203								
TN6	2017-03-31		SC	1	75								
TN6	2017-03-31		KO	1	120								
TN6	2017-03-31		CO	1	81							no adipose clip	
TN6	2017-03-31		CO	1	86							no adipose clip	
TN6	2017-03-31		CO	1	101							no adipose clip	
TN6	2017-03-31		CT	1	86							scales taken	1
TN6	2017-03-31		CT	1	100							scales taken	1
TN6	2017-03-31	257	CT	1	264			pink	982.000403039139			immature, genetics taken	2
TN6	2017-03-31	258	CT	1	314			pink	982.000403041646			immature, genetics taken	3
TN6	2017-03-31	259	CT	1	370			pink	982.000403037478	Comox - 2017, Comox 2018		immature, genetics taken	
TN6	2017-03-31		CT	1	113							scales	1
TN6	2017-03-31		CT	1	209							scales and genetics	2
TN6	2017-03-31		CT	1	184							scales and genetics	
TN6	2017-03-31	260	CT	1	350			pink	982.000403036122			immature, genetics taken, possible hybrid	3
TN6	2017-03-31		CT	1	213							scales and genetics	2
TN6	2017-03-31		CT	1	145							scales	1
TN6	2017-03-31		CT	1	122						y	mort, scales ot and genetics, this fish in mouth of p-0125	

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN6	2017-03-31		CT	1	128						y	mort, scales ot and genetics	
TN1	2017-03-31		KO	1	110								
TN1	2017-03-31		KO	1	138								
TN1	2017-03-31		KO	1	122								
TN1	2017-03-31		KO	1	122								
TN1	2017-03-31		CT	1	130								
TN1	2017-03-31		CO	1	90								
TN1	2017-03-31	261	CT	1	432		m	pink	982.000364565527	Comox-2017		not exp, genetics	4
TN1	2017-03-31	262	CT	1	404		m	pink	982.000403040960	Comox - 2018		exp, genetics	4
TN1	2017-03-31	263	CT	1	370		un	pink	982.000364565458			spent, genetics, possible female	4
TN5	2017-03-31		DV	1	344								
TN5	2017-03-31		CT	1	132								1
TN5	2017-03-31		CO	1	75							no adipose clip	
TN5	2017-04-03	264	CT	1	331		un	pink	982.000403031034			genetics	3
TN5	2017-04-03		CT	1	161								1
TN5	2017-04-03		CT	1	247							possible hybrid	
TN5	2017-04-03	265	CT	1	439		m	pink	982.000403031805			lft max injury, genetics, expressing	5
TN1	2017-04-03	266	CT	1	345		m	pink	982.000403036591			expressing	4
TN1	2017-04-03	267	CT	1	404		m	pink	982.000403030332	Reese - 2018		expressing	
TN1	2017-04-03		RB	1	307		un	pink	982.000403040405				
TN1	2017-04-03		RB	1	208								
TN6	2017-04-03	268	CT	1	263		un	pink	982.000403038856				2
TN6	2017-04-03	269	CT	1	241		un	pink	982.000403041662				2
TN6	2017-04-03		CO	1	97							no adipose clip	
TN6	2017-04-03		CT	1	185								
TN6	2017-04-03		CO	1	83							no adipose clip	
TN6	2017-04-03		KO	1	108								
TN6	2017-04-03		CO	1	82							adipose clip	
TN6	2017-04-03		CO	1	85							adipose clip	
TN6	2017-04-03		CO	1	83							no adipose clip	
TN6	2017-04-03		CO	1	83							no adipose clip	
TN6	2017-04-03		SC	1	81								
TN6	2017-04-03		CT	1	127								
TN6	2017-04-03		KO	1	140								
TN6	2017-04-03		CT	1	117								
TN6	2017-04-03		KO	1	130								
TN6	2017-04-03		DV	1	151								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN6	2017-04-03		KO	1	83							no adipose clip	
TN6	2017-04-03		CO	1	90							no adipose clip	
TN6	2017-04-03		CO	1	90							no adipose clip	
TN6	2017-04-03		KO	1	125								
TN6	2017-04-03		KO	1	120								
TN6	2017-04-03		CT	1	125								
TN6	2017-04-03		KO	1	101								
TN6	2017-04-03		CO	1	115							no adipose clip	
TN6	2017-04-03		KO	1	130								
TN6	2017-04-03		KO	1	120								
TN6	2017-04-03		RB	1	103								
TN6	2017-04-03		CT	1	160								
TN6	2017-04-03		CT	1	135								
TN6	2017-04-03		CO	1	83							no adipose clip	
TN6	2017-04-03		CO	1	93							no adipose clip	
TN6	2017-04-03		KO	1	103								
TN6	2017-04-03		KO	1	126								
TN6	2017-04-03		CO	1	90							no adipose clip	
TN6	2017-04-03		CO	1	90							no adipose clip	
TN6	2017-04-03		SC	1	68								
TN6	2017-04-03		DV	1	150								
TN6	2017-04-03		KO	1	125								
TN6	2017-04-03		KO	1	97								
TN6	2017-04-03		KO	1	164								
TN6	2017-04-03		CO	1	97							no adipose clip	
TN6	2017-04-03		CO	1	85							no adipose clip	
TN6	2017-04-03		CO	1	82							no adipose clip	
TN6	2017-04-03		SC	1	80								
TN6	2017-04-03		SC	1	85								
TN6	2017-04-03		SC	1	85								
TN6	2017-04-03		CT	1	144							possible hybrid	
TN6	2017-04-03		CT	1	108								
TN6	2017-04-03		CO	1	80							no adipose clip	
TN6	2017-04-03		CO	1	85							no adipose clip	
TN6	2017-04-03		CO	1	82							no adipose clip	
TN6	2017-04-03		CO	1	86							no adipose clip	
TN6	2017-04-03		CO	1	76							adipose clip	
TN6	2017-04-03		SC	1	76								
TN1	2017-04-05	270	CT	1	240		un	pink	982.000403031444			lft opercle damage,	2

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
												immature	
TN6	2017-04-05	271	CT	1	542		f	pink	982.000403034516	U Punt - 2018		not expressing	5
TN6	2017-04-05		CO	1	135								
TN6	2017-04-05		CT	1	132								
TN6	2017-04-05		CT	1	127								
TN6	2017-04-05		CO	1	101							no adipose clip	
TN6	2017-04-05		CO	1	93							no adipose clip	
TN6	2017-04-05		CO	1	86							no adipose clip	
TN6	2017-04-05		TSB	1	62								
TN6	2017-04-05		TSB	1	63								
TN6	2017-04-05		KO	1	117								
TN6	2017-04-05		CO	1	87							no adipose clip	
TN6	2017-04-05		CO	1	80								
TN6	2017-04-05		SC	1	75								
TN6	2017-04-05		KO	1	103								
TN6	2017-04-05		CO	1	84							no adipose clip	
TN6	2017-04-05		CO	1	87							no adipose clip	
TN5	2017-04-05		DV	1	138								
TN5	2017-04-05	272	CT	1	270		un	pink	982.000403032228				3
TN5	2017-04-05		KO	1	131								
TN5	2017-04-05		KO	1	110								
TN5	2017-04-05		CO	1	83							adipose clip	
TN6	2017-04-07		KO	1	98								
TN6	2017-04-07		KO	1	91								
TN6	2017-04-07		KO	1	106								
TN6	2017-04-07		KO	1	125								
TN6	2017-04-07		KO	1	130								
TN6	2017-04-07		KO	1	125								
TN6	2017-04-07		CO	1	95								
TN6	2017-04-07		CO	1	93								
TN6	2017-04-07		CO	1	84								
TN6	2017-04-07		CO	1	84								
TN6	2017-04-07		CT	1	150								1
TN6	2017-04-07		CT	1	193								
TN6	2017-04-07		CT	1	206								2
TN6	2017-04-07		CT	1	255								
TN6	2017-04-07		CO	1	105								
TN6	2017-04-07		CO	1	83								
TN6	2017-04-07		CO	1	122								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN6	2017-04-07		CO	1	112								
TN6	2017-04-07		CO	1	79								
TN6	2017-04-07		CO	1	103								
TN6	2017-04-07		CO	1	84								
TN6	2017-04-07		CO	1	83								
TN6	2017-04-07		KO	1	110								
TN6	2017-04-07		KO	1	123								
TN6	2017-04-07		CT	1	118								1
TN6	2017-04-07		DV	1	178								
TN6	2017-04-07		DV	1	177								
TN6	2017-04-07		CT	1	152								1
TN6	2017-04-07		CT	1	113								
TN6	2017-04-07		KO	1	120								
TN6	2017-04-07		CT	1	125								
TN6	2017-04-07		KO	1	104								
TN6	2017-04-07		KO	1	83								
TN6	2017-04-07		KO	1	76								
TN6	2017-04-07		KO	1	87								
TN6	2017-04-07		KO	1	82								
TN6	2017-04-07		KO	1	83								
TN6	2017-04-07		KO	1	83								
TN6	2017-04-07		KO	1	78								
TN6	2017-04-07	154	CT	1	395		m	orange				RECAP, but wrong pit recorded in notes	4
TN6	2017-04-07		KO	1	93								
TN6	2017-04-07		KO	1	86								
TN6	2017-04-07		SC	1	100								
TN1	2017-04-07		TSB	1	37								
TN1	2017-04-07		CT	1	146								
TN1	2017-04-07		CO	1	85								
TN1	2017-04-07		TSB	1	64								
TN1	2017-04-07	273	CT	1	420		m	pink	982.000403036688			expressing	
TN6	2017-04-10		TSB	1	58								
TN6	2017-04-10		KO	1	153								
TN6	2017-04-10		KO	1	106								
TN6	2017-04-10		CO	1	83								
TN6	2017-04-10		CO	1	89								
TN6	2017-04-10		CO	1	89								
TN6	2017-04-10		CO	1	101								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN6	2017-04-10		CO	1	81								
TN6	2017-04-10		CO	1	78								
TN6	2017-04-10		RB	1	159								
TN6	2017-04-10		CO	1	92								
TN6	2017-04-10		CO	1	99								
TN6	2017-04-10		SC	1	80								
TN6	2017-04-10	274	CT	1	304			pink	982.000403041155	U Punt-2017, U Punt 2018			
TN1	2017-04-10		CT	1	135								
TN1	2017-04-10		DV	1	136								
TN1	2017-04-10		CT	1	150								
TN1	2017-04-10		DV	1	290								
TN1	2017-04-10		CO	1	107								
TN1	2017-04-10		KO	1	85								
TN1	2017-04-12		CN	1	102								
TN1	2017-04-12		TSB	1	60								
TN1	2017-04-12		CT	1	147								1
TN6	2017-04-12		KO	1	92	7.5							
TN6	2017-04-12		KO	1	134	16							
TN6	2017-04-12		KO	1	108	9							
TN6	2017-04-12		KO	1	119	13							
TN6	2017-04-12		KO	1	104	7.5							
TN6	2017-04-12		CO	1	82								
TN6	2017-04-12		CO	1	87								
TN6	2017-04-12		KO	1	105	8							
TN6	2017-04-12		CO	1	93								
TN6	2017-04-12		DV	1	151								
TN6	2017-04-12		KO	1	117	12							
TN6	2017-04-12		KO	1	94								
TN6	2017-04-12		CO	1	101								
TN6	2017-04-12		CO	1	70								
TN6	2017-04-12		KO	1	92								
TN6	2017-04-12		CO	1	78								
TN6	2017-04-12		CO	1	80								
TN6	2017-04-12		CO	1	82								
TN6	2017-04-12		CO	1	105								
TN6	2017-04-12		CO	1	95							adipose clip	
TN6	2017-04-12		CO	1	86							adipose clip	
TN6	2017-04-12		CO	1	81								

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
TN6	2017-04-12		CO	1	89							adipose clip	
TN6	2017-04-12		CO	1	85								
TN6	2017-04-12		CO	1	86								
TN6	2017-04-12		CO	1	80								
TN6	2017-04-12		CO	1	85								
TN6	2017-04-12		CO	1	103								
TN6	2017-04-12		CO	1	89								
TN6	2017-04-12		CO	1	82								
TN6	2017-04-12		CO	1	83								
TN6	2017-04-12		CO	1	82								
TN6	2017-04-12		TSB	1	66								
TN6	2017-04-12		KO	1	105								
TN6	2017-04-12		KO	1	120								
TN6	2017-04-12		KO	1	96								
TN6	2017-04-12		CO	1	91								
TN6	2017-04-12		CO	1	82								
TN6	2017-04-12		CO	1	86								
TN6	2017-04-12		CO	1	86								
TN6	2017-04-12		KO	1	107								
TN6	2017-04-12		KO	1	123								
TN6	2017-04-12	275	CT	1	263			pink	982.000402305193				
TN6	2017-04-12		DV	1	205								
TN6	2017-04-12		CT	1	107								
TN6	2017-04-12		CT	1	131								
TN6	2017-04-12		KO	1	121								
TN6	2017-04-12		CO	1	79								
TN6	2017-04-12		CO	1	114								
TN6	2017-04-12		CO	1	93								
TN6	2017-04-12		CO	1	93								
TN6	2017-04-12		KO	1	117								
TN6	2017-04-12		KO	1	102								
TN6	2017-04-12		CO	1	91								
angler	2017-05-21	116	CT	1				orange			y		
angler	2017-05-28	139	CT	1				orange			n	possible hybrid	
angler	2017-06-24	246	CT					pink			y		
angler	2017-06-25	238	CT	1				pink	928.000404705546		y		
angler	2017-07-03		RB					orange			y		
angler	2017-08-03	155	CT	1				orange			y		
angler	2017-08-12	158	CT	1				pink	982.000404705590		y		

Effort	Date	MR_CT#	Sp	Count	FL	Wt	Sex	Floy Tag	Pit Tag	Pit Array	Mort	Comments	Age
angler	2017-08-21	231	CT	1				pink	982.000404705568		y		
angler	2017-08-27	185	CT	1				pink	982.000404705585		y		
angler	2017-08-27	180	CT	1				pink			y		
angler	2017-09-05	109	CT	1				orange			y		
angler	2017-10-07	260	CT	1				pink	982.000403036122		n		
angler	2017-10-27	230	CT	1				pink			y		
angler	2018-08-26	196						pink			y		
angler	2017-08-15	261	CT	1				pink			y		
angler	2018-03-30	236	CT	1				pink	982.000404705602		y		
angler	2018-05-19	258	CT					pink			y		
angler	2019-05-31	206	CT	1				pink			un	floy tag found on shore	
angler	2020-02-01	254	CT	1				pink			n		
angler	2020-04-30	111	CT	1				orange			y		
angler	2019-02-30	146	CT	1				pink			n		

## APPENDIX C

### Comox Lake Cutthroat Trout Capture Histories for Survival Modelling

ch – xxLDLD... Barker model capture history where the first 'x' indicates floy tag type (h: high reward, l: low reward, n: no tag), and the second 'x' indicates pit tag status (p: pit tag, n: no pit tag).

Capture periods 'L' extend from April 15 2016 through July 1 2020 with corresponding interval periods ('D') expressed in years as 0.29, 0.25, 0.42, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.25, 0.50, 0.25, 0.25, 0.50.

Capture probabilities for the fifth and subsequent capture periods ('L') were fixed at 0 as no sampling occurred during these times.

Values in the 'D' columns (interval periods) are 0: no detection, 1: harvest by angler, 2: catch and release by angler, or 3: pit tag array detection.

