Comox Lake
Fish and Fisheries Assessment
Project Summary,
Fisheries Management
and Enhancement Plan

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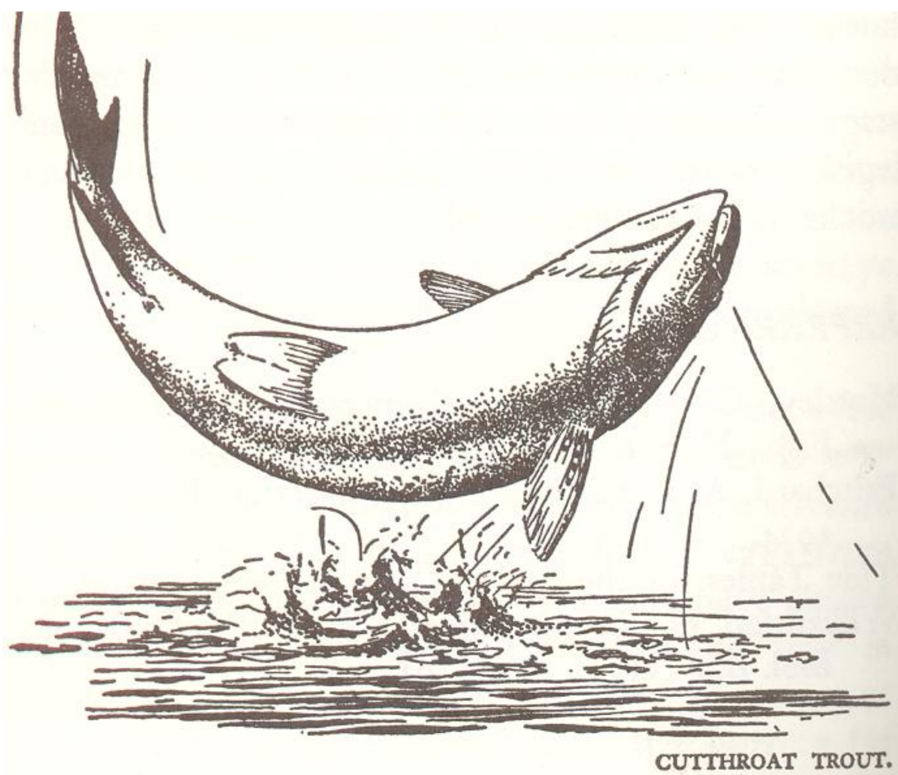

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Acknowledgements

This project was made possible because of the generous financial and volunteer support provided by the Courtenay and District Fish and Game Protective Association. The Association provided the majority of the funding for the fisheries and stock assessments conducted over this 2-year project, and numerous Association volunteers contributed their time and boats to conduct angler counts and interviews, and assist with fish stock assessments. In addition to implementing field work, volunteers also sat on a special sub-committee and dedicated many hours to reviewing technical data, and identifying fisheries management strategies including innovative regulations to provide long-term, sustainable fishing opportunities at Comox Lake. Members of the subcommittee included: Ray Rogers, Joe Franceschini, Larry Church, Larry Peterson, Nick Strusi and George Reid.

I would sincerely like to thank the following individuals without whom this project would not have been possible: Meinhard Klein for his consistent support and guidance throughout the duration of this project and assistance in forming the subcommittee; Ray Rogers for his help and encouragement during the critical early states of the project; Joe and Jacqueline Franceschini for their countless hours in the field and gracious hospitality to Fisheries staff and contractors during the field season; Larry Church and Steve Burtenshaw who provided much needed assistance with electrofishing surveys, and George Reid who provided insight and guidance on project design, and critical comments on data analysis, summary and the final report. My sincere thanks also to John Shepherd who invited me to speak to the Association in 2009 about Comox Lake and who, as a result of that invitation, is responsible for initiating this work.

Finally, I would like to recognize the Public Conservation Assistance Fund for contributing funding for a snorkel survey of Comox Lake tributaries, and my colleagues Brendan Anderson and Terry Nielsen for their valuable assistance in the field.

Project Summary

I identified Comox Lake as a high priority lake during the initial stages of the large lakes planning process implemented by the Vancouver Island Fish and Wildlife Branch in 2008. My preliminary analyses highlighted a number of issues regarding the Comox Lake fishery including a 10% drop in angler effort from 2002 to 2006; a 25% drop in catch over that same period; and a 20% decrease in angler success (Aitzhanova, et al. 2003, Andrews, 2007). The last stock assessment at the lake was conducted ~50 years ago, consequently, I found no recent information on the status of the wild cutthroat trout in this lake and, therefore, no way to determine if current regulations were effective at both providing opportunities, and conserving stocks.

The Fish and Wildlife Branch and the Courtenay and District Fish and Game Protective Association partnered in 2009 to implement detailed surveys and assessments to establish the fishery and stock status at Comox Lake. Our project consisted of angler counts to determine angler effort on the lake; angler interviews to collect catch and harvest data; stock assessments including gillnetting, snorkel and electrofishing surveys, a hydro acoustic assessment to determine prey availability for predaceous cutthroat trout, and the completion of a habitat assessment on a tributary to Comox Lake. Our work highlighted a number of concerns with the fishery and stock including: low angler success (0.52 fish/angler day); high angler harvest of small, immature cutthroat trout; and a lack of large (>400 mm; 16"), mature cutthroat in the fishery (see summary table below). Despite the fact that our hydro acoustic assessment confirmed an abundance of prey, snorkel surveys confirmed the average size of spawning adults at only ~400 mm.

In 2010, the Comox Lake Fisheries subcommittee undertook a detailed review of the results of our assessments and decided that in order to increase angler catch, success, and average fish size, cutthroat trout must be allowed to spawn at least once before entering the fishery. To enable that, our subcommittee developed a regulation requiring anglers to release all cutthroat <300 mm (12"). We also decided the existing regulation requiring anglers to release all trout >500 mm (20") should be extended for the entire year to protect large fish. In addition to recommended regulations changes, our subcommittee also identified a number of projects to monitor the fishery and stocks at Comox Lake. Details of these projects, along with summaries of our data are provided in the following report.

Comox Lake Fisheries and Stock Information and Management Objectives Summary

Lake	Comox
Planning Unit:	Campbell/Oyster
Watershed:	Puntledge
Land Use:	Logging; BC Hydro dam at the outlet of the lake.
Fish Species:	cutthroat and rainbow trout, Dolly Varden char, and Chinook salmon
Stock Status:	declining
Key Streams:	Upper Puntledge and Cruickshank Rivers, Comox and Rees Creeks

Comox Lake Fisheries and Stock Information and Management Objectives Summary

Fisheries Summary* Angler Effort (average 2009/2010)	5,600 days
Projected Effort Trend to 2020:	declining
Total Catch (2006):	3,240
Projected Catch Trend to 2020:	declining
Angler Success (catch/day) (average 2009/2010)	0.52 fish/angler day
Projected Success Trend to 2020 at current regulations:	declining
Maximum Sustainable Effort	~7,000 angler days
Maximum Catch	~9,000 fish
Maximum Harvest	~2,700 fish
Angler Success at Maximum Effort	1.3 fish/angler day
Stock Summary:	Fish sampling was conducted in 1948, 1951, 1953, 1993, 2009 and 2010. In 2009/10 cutthroat sampled and averaged~300 mm; almost 90% of cutthroat captured in gillnets were immature and the average size of cutthroat captured by anglers is <300 mm. Rainbow trout and Dolly Varden are also present in the fishery; a hydro acoustic survey estimated at ~10 million kokanee with only age 1+ fish sampled.
Management Objectives Summary:	1. Fisheries management efforts should focus on cutthroat. 2. Increase angler effort from ~6,000 to ~7,000 angler days/year. 3. Increase angler catch success from 0.5 fish/angler day to 1.3 fish/angler day. 4. Implement mandatory release of cutthroat <30 cm to protect first time spawners. 5. Extend bait ban; single, barbless hook and mandatory release of trout >50 cm all year (currently Nov 1-Apr 30). 6. Implement conservation regulations if angler effort exceeds the maximum allowable effort. 7. Do not exceed the maximum allowable harvest of 30% of catch as determined by angler surveys.
Operational Plan Summary:	1. Test regulation for 4 years beginning in 2012 2. Monitor angler satisfaction beginning 2011 and extend through 4 year regulation test period. 3. Adjust regulations if required and as dictated by results of angler effort and angler success monitoring programs. 4. Repeat spawner count on index streams spring 2014. 5. Repeat gillnetting assessment every three years beginning in 2013. 6. Request Fisheries and Oceans discontinue coho stocking in all Comox Lake inlet tributaries.

*projections based on data from the VILQ 1986 – 2006 using a polynomial trend line projected to 2020. Increasing is defined as ≥10% increase from 2006 to 2020; decreasing is defined as ≥10% decrease from 2006 – 2010; stable is defined as ≤10% increase or decrease from 2006 – 2020.

Part 1 - Comox Lake Fish and Fishery Assessment

1.0 Introduction

Comox Lake is one of 16 large lakes[1] in the Vancouver Island Region. Located approximately 6 km west of Courtenay at an elevation of 138 meters, Comox Lake lies within the Coastal-Douglas Fir biogeoclamatic zone in the Campbell Oyster Planning Unit (PU) (Figure 1). The lake has a surface area of 2,100 hectares, a perimeter of 41.4 km and is, on average, 61 meters deep (Table 1). Much of the flow into the lake is glacial in origin and while surface temperatures can exceed 20^{0}C, hypolimnion temperatures remain between 5-6 ^{0}C throughout the year (Ministry of Environment, 2009). With a Total Dissolved Solid (TDS) of 22 parts per million (ppm), Comox Lake is, like most large lakes in the region, oligotropic[2].

FIGURE 1. Location of Comox Lake watershed including major tributaries (Source: Google Earth, 2011).

[1] Large lakes are defined as lakes >1,000 ha. Large lakes are dominated by a pelagic food web which includes a piscivore which is a target species (i.e. kokanee, sockeye, stickleback preyed on by trout or char). These lakes rarely involve fish culture programs and management involves lake-specific data collection, analysis, regulations, and occasionally even licenses (e.g. Kootenay and Shuswap Lakes).

[2] An oligotrophic lake is one with low primary productivity as a result of low nutrient content. These lakes have low algal production, and consequently, often have very clear waters with high drinking-water quality.

TABLE 1. Planning unit (PU), water body ID number, surface area, perimeter, depth, pH, TDS, secchi depth, approximate length and survey years at Comox Lake (Source: Province of BC files, Nanaimo).

Planning Unit (PU)	Water-body ID	Surface Area (ha)	Perimeter (km)	Max Depth (m)	Mean Depth (m)	pH	TDS	Secchi Depth (m)	~Length (km)	Survey Years*
Campbell-Oyster	01005 COMOX	2,100	40.7	109	61	7.1	22	10	15.2	1948;1951; 1975;1980; 1990

*Survey years include only those years reported in the Fish Information Summary System (FISS) when the lake was assessed for physical characteristics and chemical parameters.

Major tributaries to Comox Lake include the Cruikshank and Upper Puntledge Rivers, and Comox, Rees, Perseverance and Toma creeks (Figure 1). The Cruikshank and Upper Puntledge Rivers are both 4th order streams with drainage areas of 214 km^2 and 96 km^2 respectively (Russell et al, 1990). Perseverance and Toma Creeks are, 3' tributaries with drainage areas <25 km^2 and the 1' and 2' tributaries to these systems are unusable or inaccessible by fish due to excessive gradients (Russell et al, 1990).

Water levels in Comox Lake are controlled by the Comox Dam which is operated in accordance with the 2004 BC Hydro Water Use Plan for the Puntledge River System (BC Hydro, 2004). Prior to dam construction in 1913 by Wellington Collieries, steelhead trout and chinook salmon were present in the watershed above Comox Lake (Angus Commission, 1962). A fishway constructed as part of the original dam prevented some fish passage for a number of years, however, that structure has since been modified to address some structural problems. Cutthroat and rainbow trout, Dolly Varden, kokanee salmon, coast range sculpin, and threespine stickleback are found in Comox Lake while inlet tributaries including the Cruikshank and Upper Puntledge Rivers contain cutthroat, Dolly Varden, sculpins and stickleback. Steelhead fry have been released into the Cruikshank system, and coho salmon are currently stocked into a number of streams within the watershed including streams above the lake (FISS-Province of BC files, Nanaimo; Puntledge Hatchery, Courtenay).

2.0 Study Background

I began my analysis of fish stocks and fisheries at large lakes as part of the Vancouver Island Large Lakes Plan implemented by the Ministry of Forests, Lands and Natural Resource Operations in 2008.[3] My preliminary analyses showed that Comox Lake sustained the 2nd highest level of angler effort of any regional large lake. I also found a number of issues regarding the Comox Lake fishery, however, including a 10% drop in angler effort from 2002 to 2006; a 25% drop in catch over that same period (Figure 2); and a 20% decrease in angler success (Figure 3) (Aitzhanova, et al. 2003, Andrews, 2007).

[3] The Vancouver Island Large Lakes Plan was initiated in 2008 in response to the identification of large lakes management as a provincial priority by the BC Government in 2007 (Ministry of Environment, 2007).

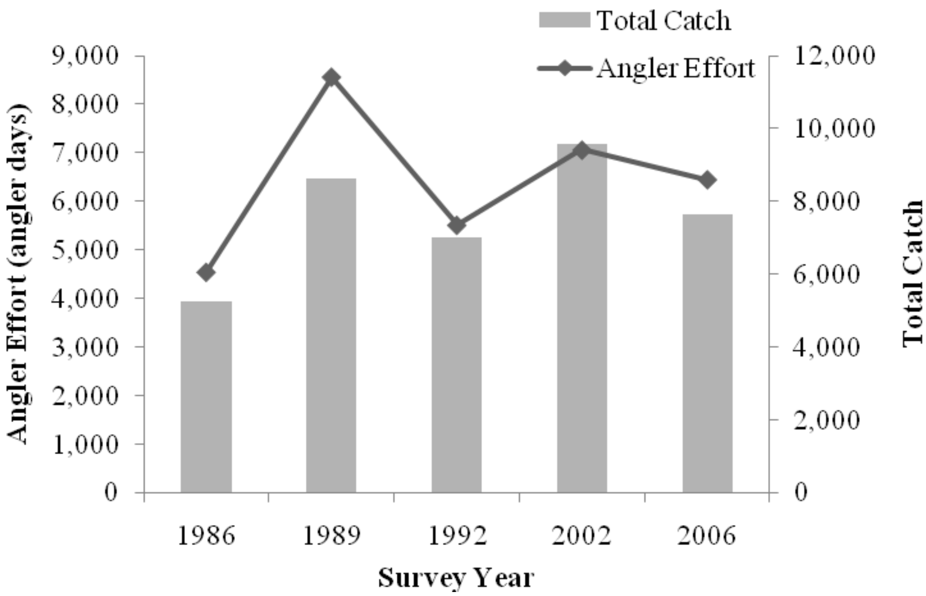

FIGURE 2. Angler effort (angler days) and total catch of rainbow trout, cutthroat trout, and Dolly Varden char at Comox Lake 1986-2006 (Source: Aitzhanova, et al. 2003, Andrews, 2007).

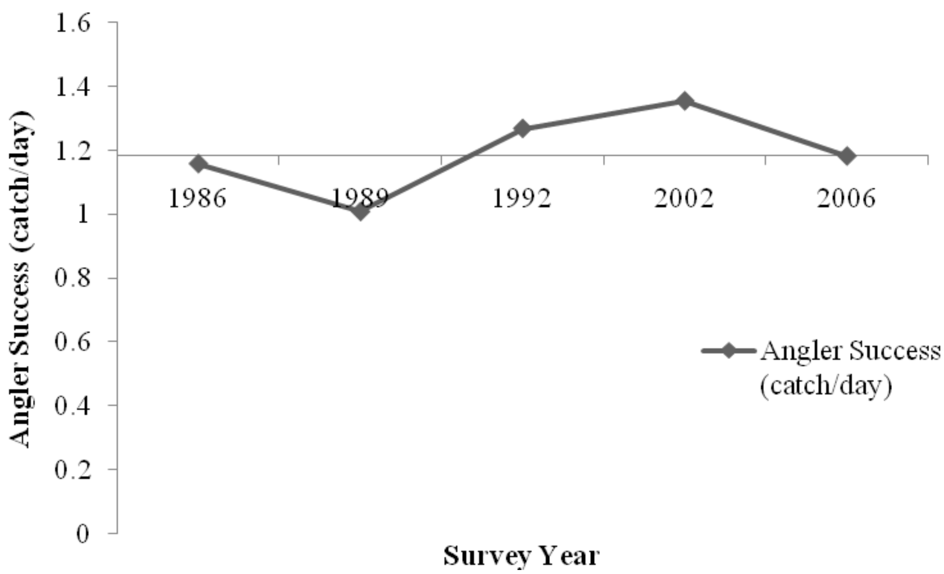

FIGURE 3. Angler success (catch/angler day) at Comox Lake 1986-2006 compared to average angler success for the entire survey period. (Data are from Aitzhanova, et al. 2003, Andrews, 2007).

Fewer anglers should catch more fish and have higher success rates if stocks are stable. Unfortunately, the most recent gillnet assessment of Comox Lake was conducted in 1953, consequently, there was no way to assess fisheries stock status at the lake. Instead, I used data from the Vancouver Island Lakes Questionnaire (Aitzhanova, et al. 2003, Andrews, 2007), to determine trends in angler catch and effort over the past ~20 years, as well as to define the maximum catch and effort available at Comox Lake (Figure 4). If there is too much effort, there is the potential to overfish stocks. In recent years, angler effort at Comox Lake has been below the maximum, however, angler catch and effort in the late 1980's and into the 2000's exceeded that maximum which is likely what lead to the decline in angler effort and angler success evident in 2006 (Figure 3).

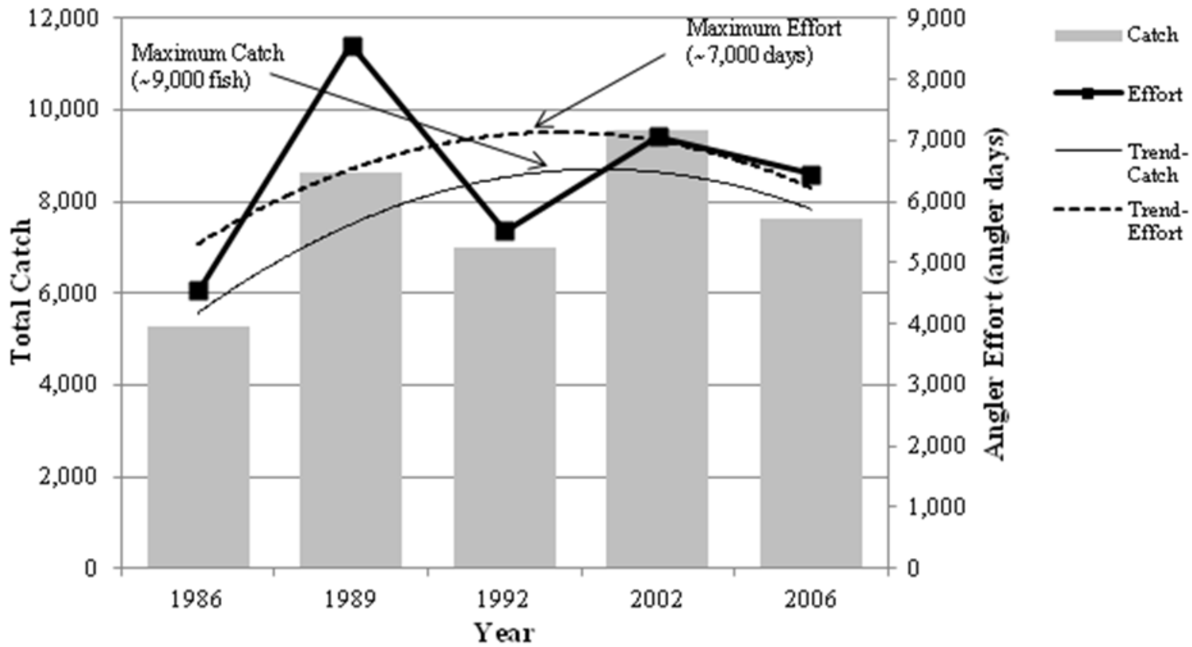

FIGURE 4. Angler effort (angler days) and total catch during each survey year, maximum catch and maximum effort for the entire survey period 1986 – 2006 at Comox Lake 1986 - 2006 (Source: Aitzhanova, et al. 2003, Andrews, 2007).

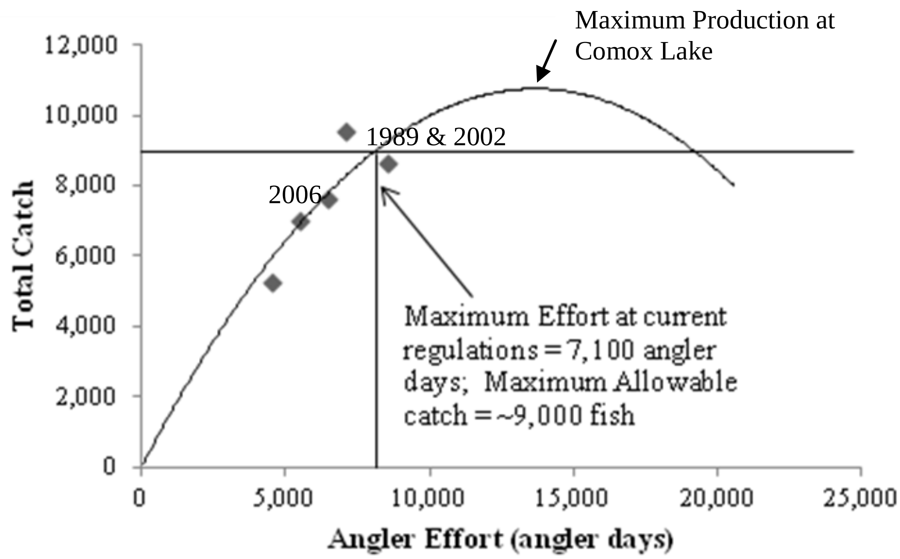

FIGURE 5. Angler effort (angler days) and total catch during each survey year, maximum catch and maximum effort for the entire survey period 1986 – 2006 at Comox Lake 1986 – 2006. Note: apex of curve is the maximum catch available at Comox Lake; angler catch and effort approached this in 2002 but fell back in 2006 indicating a decline in fisheries stocks. (Source: Aitzhanova, et al. 2003, Andrews, 2007).

3.0 Study Objectives and Activities

I provided a summary of the Comox Lake stock and fisheries data to the Courtenay Fish and Game Protective Association in early 2009 and in April of that year the Association voted to provide funds and volunteers to support a study to fill data and information gaps and develop management objectives for Comox Lake. I worked with the Association's Conservation Committee to identify the following project objectives and activities:

1. Determine angler effort and catch and success rates at Comox Lake by:
    a. Conducting instantaneous angler counts at random times throughout the year.
    b. Conducting creel surveys of a minimum number of anglers to determine angler catch and success.
2. Determine stock status of sportfish species in Comox Lake by:
    a. Collecting life history data on angler-caught sport fish.
    b. Conducting a gillnet assessment to collect life history and stock status data and compare current stock status to historic gillnetting results.
    c. Designing and conducting other studies as required including spawning and electrofishing surveys and habitat assessments.
3. Determine stock levels and size distribution of forage species (kokanee; stickleback) in Comox Lake by conducting a hydro acoustic survey and trawl assessment.
4. Develop fisheries management objectives and strategies for Comox Lake by:
    a. Reviewing fisheries and stock status data and determining if the fishery is sustainable.

   b. Identifying appropriate fisheries management targets (e.g. angler catch success rates).
   c. Reviewing stock status data and developing new regulations as required to address existing or potential conservation concerns.
5. Determine, in conjunction with the Association, management objectives and, where necessary, regulations changes to ensure sustainable fisheries at Comox Lake.
6. Design programs to monitor angling statistics and targets, and stock status to be implemented by the Ministry and/or Courtenay Fish and Game Protective Association.

4.0 Methods

4.1 Data Collection

Instantaneous Angler Counts and Creel Surveys

We divided Comox Lake into 3 sections to determine if fishing pressure differed between areas on the lake (Figure 6). Volunteers conducted roving creels 4 times per month - twice on week days, and twice on weekends and/or holidays in 2009 and 2010 (Appendix 1). This creel schedule was determined by randomly selecting weekdays and weekend days throughout the year, and assigning random start times within daylight hours on those days.

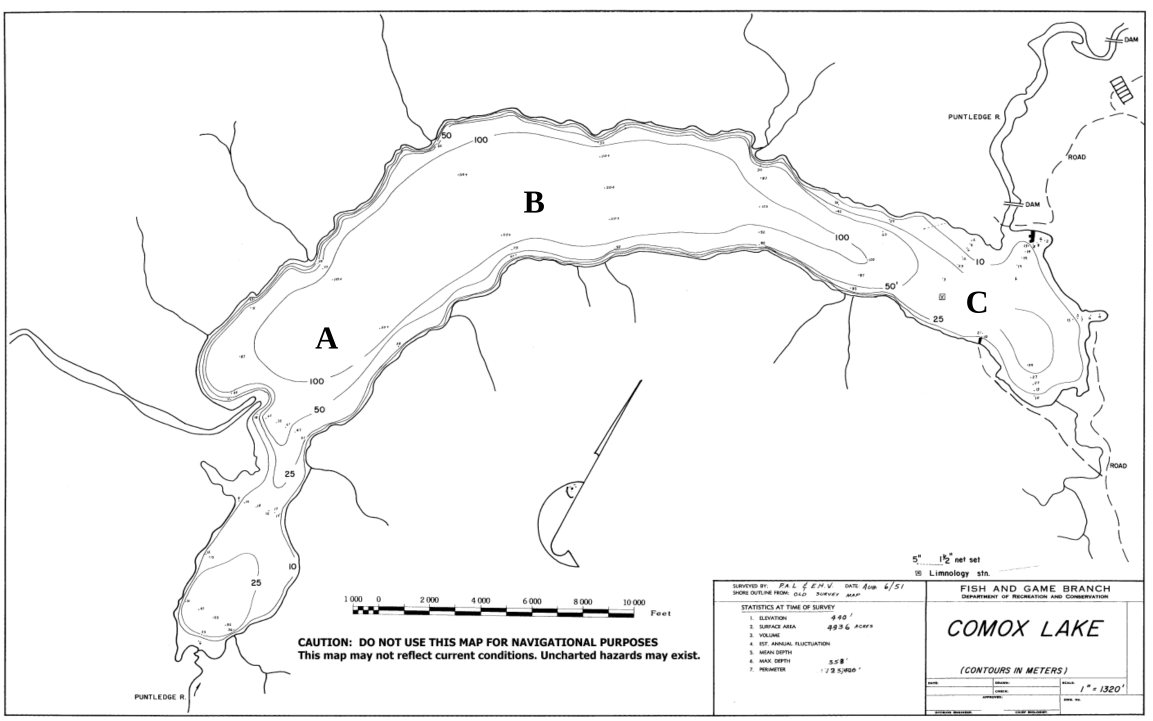

FIGURE 6. Bathymetric map of Comox Lake with lake sections A, B, C defined for stratifying results of roving creel (Source: Province of BC, Nanaimo).

Volunteers completed a circuit of Comox Lake and recorded the number of boats and anglers in each section then went back and interviewed up to 10% of the anglers counted.

Volunteers recorded catch data, recorded water and air temperatures, noted weather conditions and took scale samples of angler-caught fish. A number of Association members also kept records of their catches and provided scale samples for the study.

4.2 Data Analyses

Fisheries Statistics

I used the data collected during the instant counts to calculate expanded catch and effort statistics (Appendix 2). I assumed the creel sampling expansion included all anglers who fished and caught fish outside the defined sampling time. I kept data and scale samples collected during the creels separate from all other data and scale samples collected in order to conduct an analysis of angler-caught vs. gillnet caught fish. I also kept interview data from creeled anglers separate from that recorded in angler records by Association members so I could compare catch statistics of Association members, with those of the general angling pubic.

Scale Samples and Snorkel Surveys

Scales were analyzed by Lew Carswell and MJ Lough Environmental Consultants in 2009, and by MJ Lough Environmental Consultants in 2010. In addition to reading and analyzing fish scales, MJ Lough Environmental Consultants completed snorkel surveys in the spring of 2011 to document the spawning behaviour of cutthroat trout in Comox Lake tributaries (Lough, 2011). MJ Lough Environmental Consultants provided 2 reports (Lough 2010 and Lough 2011) and I have included summaries of these studies in the following report.

Comox Lake Hydro Acoustic and Trawl Assessment

Dale Sebastian and David Johner of the Ministry of Environment, Stock Assessment Branch conducted a hydro acoustic and trawl assessment to estimate densities of forage species, primarily kokanee salmon and stickleback in Comox Lake. Assessments were conducted over a 2-night period in July, 2009. During the assessments, transects of the lake were completed so that fish densities could be estimated. A trawl assessment was then conducted to sample fish for biological information. Mr. Sebastian and Mr. Johner presented their results at a meeting of the Courtenay Fish and Game Protective Association in May, 2009; a final report of their findings is forthcoming.

Gillnet Assessments

Historic gillnet assessments did not identify locations of net sets so I contacted Dale Sebastian to determine if concentrations of large-bodied fish had been found during the hydro acoustic assessment. Mr. Sebastian suggested sampling Section B of Comox Lake as he had found large fish, likely trout and/or Dolly Varden, close to shore in that location (Figure 6).

We followed Resource Inventory Standards Committee (RISC) standards and set one floating and one sinking net overnight in that location in 2009 and again in 2010. We recorded our sampling location with a GPS so future gillnet assessments can be conducted at that location.

Ministry staff and volunteers retrieved nets, recorded lengths, weights, sex and maturity, identified stomach contents and took scale samples of fish caught. Fish were cleaned and donated to the Salvation Army New Hope Centre in Nanaimo.

5.0 Results

5.1 Fisheries Statistics

Angler Effort

There were ~ 5, 630 angler days at Comox Lake between April, 2009 and December 2009 and ~5,570 angler days from January 2010 until October 2011 (Figure 7). I estimated ~6,000 angler days/year at Comox Lake which is similar to the 6,454 angler days estimated by the Vancouver Island Lakes Questionnaire in 2006 (Appendix 3).

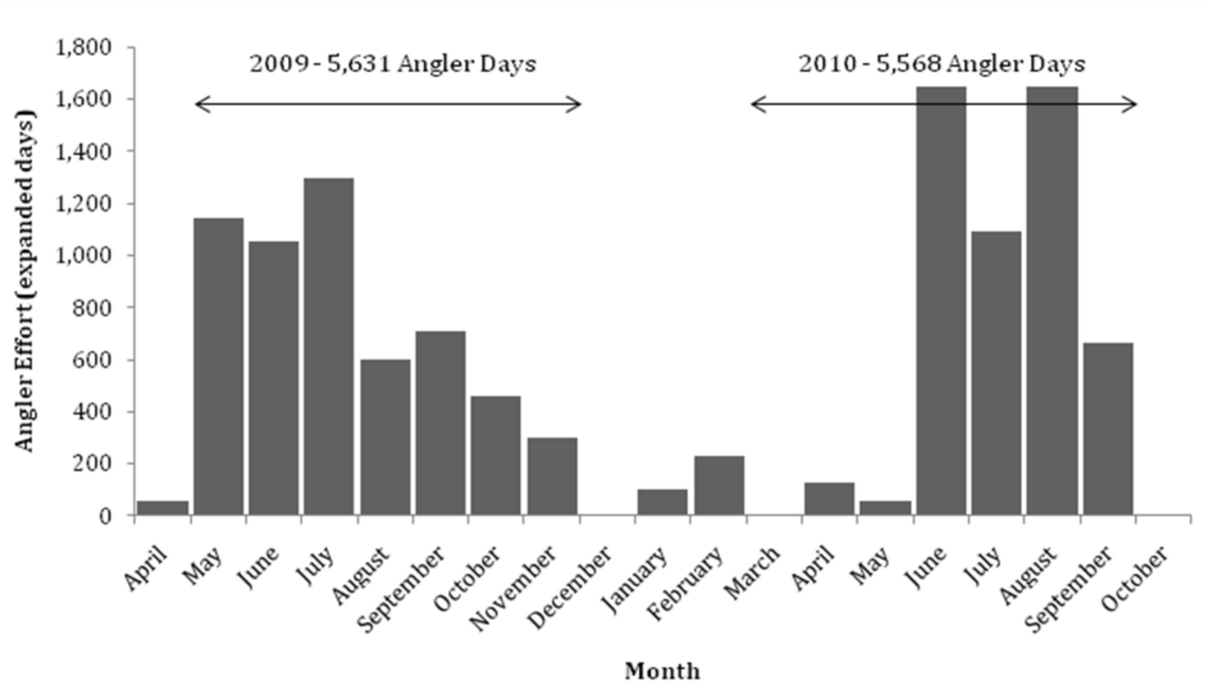

FIGURE 7. Expanded angler effort at Comox Lake April, 2009 – October 2010 (Source: expanded angler effort calculated using instantaneous angler counts conducted by Courtenay Fish and Game Club volunteers).

Approximately 65% of the angling effort occurs between from June – August (Table 2) and most of the angler effort occurs in Section A and Section C (Table 3). Almost 50% of the effort between June and August is in Section A, while 44% of the effort later in the year is in Area C (Table 4).

TABLE 2. Total and percent of angler effort by season at Comox Lake 2009 and 2010 (Source: instantaneous angler counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010).

Season	2009	2010	Total	Percent
January-May	1,206	513	1,719	15.3
June-August	2,952	4,389	7,341	65.6
September-December	1,473	666	2,139	19.1
Total	5,631	5,568	11,199	

TABLE 3. Total number and percent of anglers counted by lake section April, 2009 – October, 2010 (Source: instantaneous angler counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010).

Lake Section	Anglers Counted	Percent of Total
A	90	42.1
B	41	19.2
C	83	38.8
Total Anglers	214	

TABLE 4. Total number and percent of anglers by lake section and season January, 2009 – October, 2010 (Source: instantaneous angler counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010).

Season	Total Anglers				Percent of Total		
	A	B	C	Total	A	B	C
January-May	19	5	9	33	57.6	15.2	27.3
June-August	60	17	50	127	47.2	13.4	39.4
September-December	11	19	24	54	20.4	35.2	44.4
Total	90	41	83	214	42.1	19.2	38.8

Angler Catch

Over 80% of the total catch at Comox Lake is cutthroat trout while the remaining catch is comprised of rainbow and fish classified as “trout” (Table 5). Approximately 90% of cutthroat caught were harvested by anglers (Table 6). The harvest rate at Comox Lake is ~80% for all species.

TABLE 5. Total and percent of catch by species at Comox Lake April, 2009 – October, 2010 (Source: angler interviews conducting following instantaneous counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included).

Species	Catch			Percent of Catch		
	2009	2010	Total	2009	2010	Total
Cutthroat	87	25	112	77.7	22.3	82.4
Rainbow	0	14	14	0.0	100.0	10.3
Trout	4	6	10	40.0	60.0	7.4
Total	91	45	136			

TABLE 6. Total and percent of catch and harvest of each species caught by anglers and Courtenay Fish and Game Club Members at Comox Lake April, 2009 – October, 2010 (Source: angler interviews conducting following instantaneous counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included; Note: totals in Table 5 and 6 do not match because not all anglers told interviewers if they released fish).

	Total Catch	Percent of Catch	Total Harvest	Percent
Cutthroat	92	86	83	94
Rainbow	6	6	1	1
Trout	9	8	4	5
Total	107		88	

Angler Success

I calculated angler success (catch/angler day) at 0.64 fish/angler day in 2009 and 0.38 fish/angler day in 2010. Together, angler success averaged 0.52 fish/angler day over the 2-year survey period (Table 7).

TABLE 7. Total catch, observed effort (instantaneous angler counts) and angler success (catch/angler day) by year from April, 2009 – October, 2010 (Source: instantaneous counts and angler interviews conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included).

Year	Total Catch	Observed Effort	Angler Success (catch/angler day)
2009	91	142	0.64
2010	46	120	0.38
Total	137	262	0.52

Total Catch and Harvest

I estimated that ~3,600 fish were caught and 2,088 fish harvested from Comox Lake in 2009, while in 2010, 2,880 fish were caught and 1,670 harvested (Figure 8).

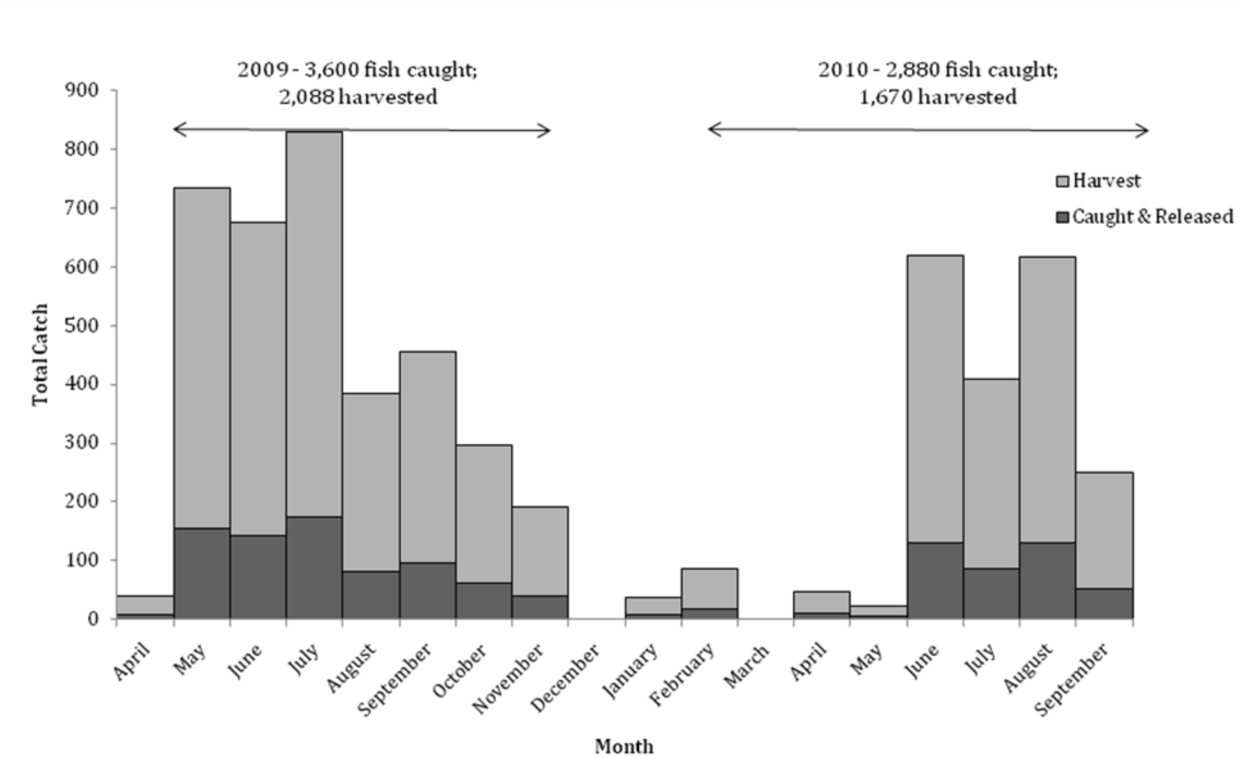

FIGURE 8. Expanded total catch and estimated harvest at Comox Lake April, 2009 – September 2010 (Source: expanded total catch and estimated harvest calculated using expanded angler effort from instantaneous angler counts, catch success rates and harvest data collected during angler interviews conducted by Courtenay Fish and Game Club, 2009 - 2010).

Size of Angler-Caught Fish

The average size of cutthroat trout caught by anglers in 2009 was 274 mm (10.7") and in 2010 was 310 mm (12.2") (Table 8). The average size of rainbow caught in 2010 was 338 mm (13.3"). Angler-caught cutthroat averaged 280 mm (11"), while rainbow averaged 338 mm over the study period.

TABLE 8. Total number, minimum, maximum and average size of cutthroat, rainbow and trout caught by anglers at Comox Lake April, 2009 – September, 2010 (Source: angler interviews conducting following instantaneous counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included).

Species	Length (mm)*											
	2009				2010				Total			
	N	Min.	Max.	Ave.	N	Min.	Max.	Ave.	N	Min.	Max.	Ave.
Cutthroat	85	150.0	445.0	274.3	19	243.0	450.0	310.0	104	150.0	450.0	280.8
Rainbow	-----	-----	-----	-----	9	250.0	400.0	338.3	9	250.0	400.0	338.3
Trout	4	150.0	230.0	210.0	-----	-----	-----	-----	4	150.0	230.0	210.0
Total	89	150.0	445.0	271.4	28	243.0	450.0	319.1	117	150.0	450.0	282.8

*Note: 300 mm ≃ 12 inches.

Size of Angler-Harvested Fish

Cutthroat harvested by anglers ranged from 150 mm (~ 6") to 445 mm (17.5") in 2009 and from 250 mm (9.8") to (17.7") in 2010 (Table 9). The average size of cutthroat harvested by anglers throughout the study period was 278.8 mm (10.9") while the average size of rainbow harvested was 320 mm (12.6").

TABLE 9. Total number, minimum, maximum and average size of cutthroat, rainbow and trout harvested by anglers at Comox Lake April, 2009 – September, 2010 (Source: angler interviews conducting following instantaneous counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included).

	Length (mm)											
	2009				2010				Total			
Species	N	Min.	Max.	Ave.	N	Min.	Max.	Ave.	N	Min.	Max.	Ave.
Cutthroat	61	150.0	445.0	267.2	15	250.0	450.0	326.1	76	150.0	450.0	278.8
Rainbow	-----	-----	-----	-----	1	320.0	320.0	320.0	1	320.0	320.0	320.0
Trout	4	150.0	230.0	210.0	-----	-----	-----	-----	4	150.0	230.0	210.0
Total	65	150.0	445.0	263.7	16	250.0	450.0	325.8	81	150.0	450.0	275.9

Almost 70% of cutthroat trout harvested by anglers were <300 mm (12") and cutthroat <350 mm (~14") comprised ~87% of the harvest (Figure 9). Cutthroat trout >400 mm (15.7 ") comprised only 2% of the harvest during the study period. The mode of angler-caught cutthroat was 300 mm.

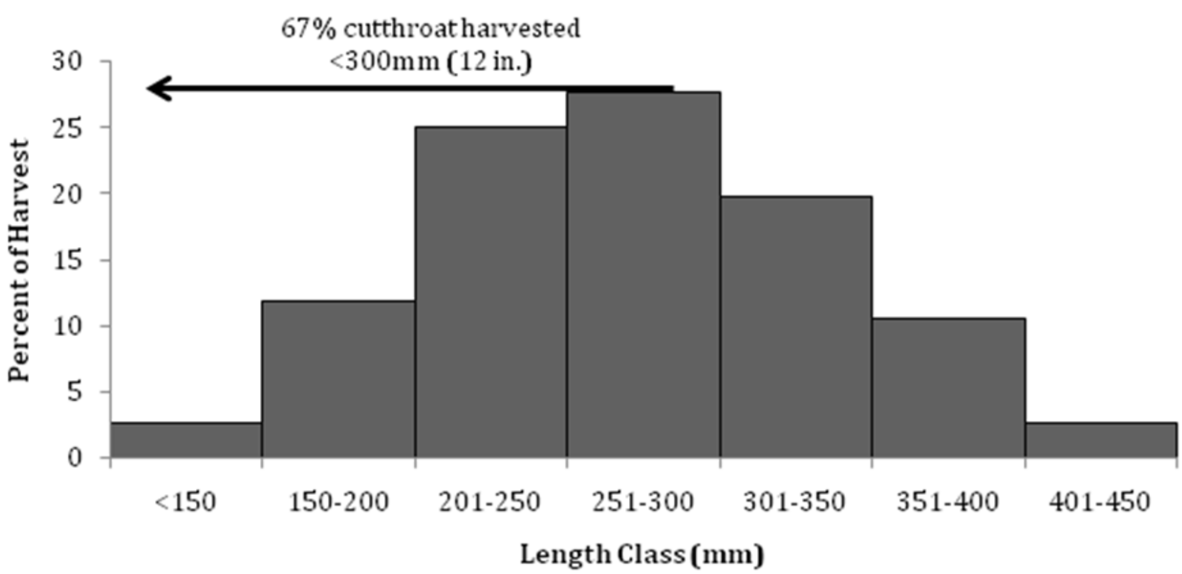

FIGURE 9. Length frequency diagram for cutthroat trout harvested by anglers at Comox Lake April, 2009 – September, 2010 (N= 76) (Source: angler interviews conducting following instantaneous counts conducted by Courtenay Fish and Game Club April, 2009 – October, 2010 and Angler Logs kept by

Courtenay Fish and Game Club May – October, 2009. Note: only catch by Fish and Game Club members that occurred on instant count days included).

5.2 Stock Status

5.2.1 Cutthroat Trout

Gillnet Catch

Thirteen cutthroat trout per net were captured in 1948, 10 were captured in 2009, and 5 in 2010 (Table 10). Catch/hour for this species was ~0.8 in 2009, and 0.35 in 2010.

TABLE 10. Catch per net of cutthroat trout captured in gillnets in Comox Lake in 1948, 1951, 1953, 2009 and 2010 (Source: FISS, Courtenay Fish and Game Club). (Note: no information on sampling methods was provided in FISS for 1948, 1951, and 1953 sampling so we assumed one net was used in these years; no assumptions regarding net soak time was made for these years so no calculation of catch/hour was possible.

Year	Total Catch	Catch/Net	Soak Time (hours)	Catch/Hour
1948	34	34	-----	-----
1951	32	32	-----	-----
1953	8	8	-----	-----
2009	19	10	25	0.76
2010	9	5	26	0.35

Fish Length

I've presented the minimum, maximum, and mean size (mm) and weight (g) of cutthroat trout captured in gillnets in Comox Lake and by electrofishing in the Cruickshank and Puntledge Rivers from 1948 -2010 in Table 11. Minimum fork length has varied from 380 mm in 1953, to 130-140 mm in recent surveys while maximum fork length has varied from 355 mm in 1948, to 560 mm in 1953. Average fork length of cutthroat captured in gillnets has stayed somewhat consistent at ~260 mm with the exception of 1953 when the average size was close to 500 mm. Note, however, that only 8 cutthroat were captured that year.

TABLE 11. Total numbers and minimum, maximum and average fork length of cutthroat trout captured by gillnet in Comox Lake in 1948, 1951, 1953, 2009 and 2010 and by electrofishing in the Upper Puntledge and Cruikshank Rivers in 1993. (Source: FISS, Province of BC files, Nanaimo, Courtenay Fish and Game Protective Association).

	1948-Oct Gillnet	1951-Aug Gillnet	1953-Jun Gillnet	1993-Nov Electrofish	2009-Aug Gillnet	2010-Aug Gillnet
Minimum Fork Length	208	165	380	170	130	140
Maximum Fork Length	355	375	560	434	425	365
Average Fork Length	276	268	496	265	226	267
Number	34	32	8	49	19	9

Length Frequency

I've shown the percent length frequency of cutthroat trout sampled in 1948, 1951, 1953, 1993, 2009 and 2010 in Figures 10 - 15. Two distinct modes exist in the 1948 sample, one at 200 mm and another 275 mm indicating two age classes. In 1948, the highest percentage (30%) of fish captured were 276 – 300 mm, while in 1993 the highest percentage of fish were 251 – 275 mm indicating better survival of older fish in 1948. In 1993, a widening of the distribution occurred where fish <200 mm and >400 mm were present, however, there were fewer numbers of larger cutthroat trout in that sample. In 2009, the highest percent of cutthroat captured were 176 – 200 while in 2010 the highest percent captured (40%) were 251-275 mm.

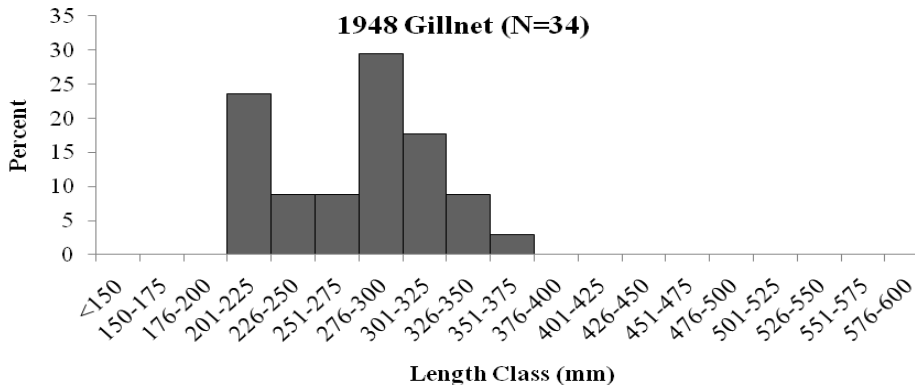

FIGURE 10. Length frequency of cutthroat trout captured in gillnets in Comox Lake, 1948 (N=34). (Source: Province of BC files, Nanaimo).

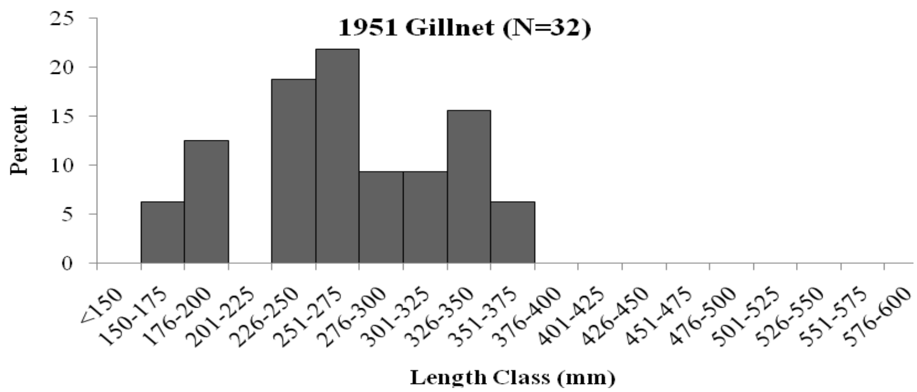

FIGURE 11. Length frequency of cutthroat trout captured in gillnets in Comox Lake, 1951 (N=32). (Source: Province of BC files, Nanaimo).

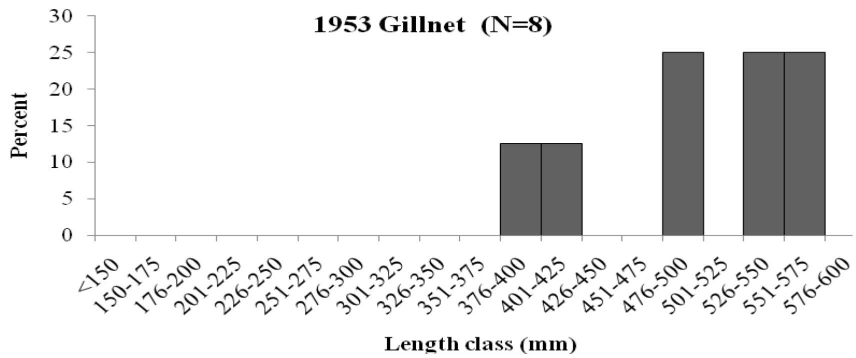

FIGURE 12. Length frequency of cutthroat trout captured in gillnets in Comox Lake, 1953 (N=8). (Source: Province of BC files, Nanaimo).

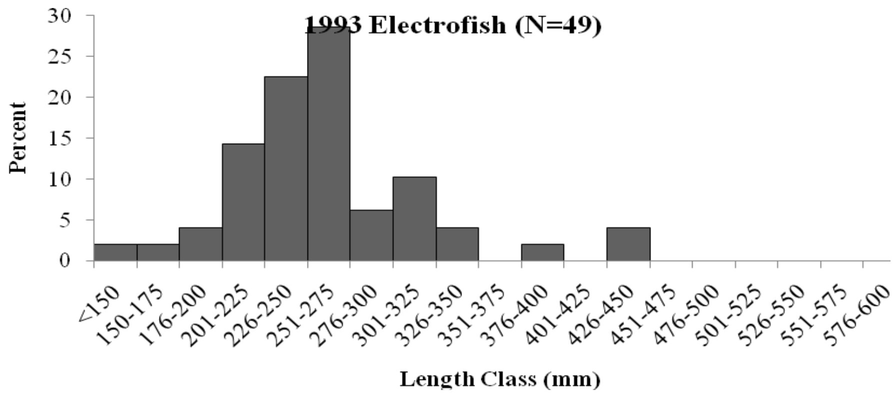

FIGURE 13. Length frequency of cutthroat trout captured in the Cruikshank and Upper Puntledge Rivers by electrofishing in November 1993 (N=49). (Source: Province of BC files, Nanaimo).

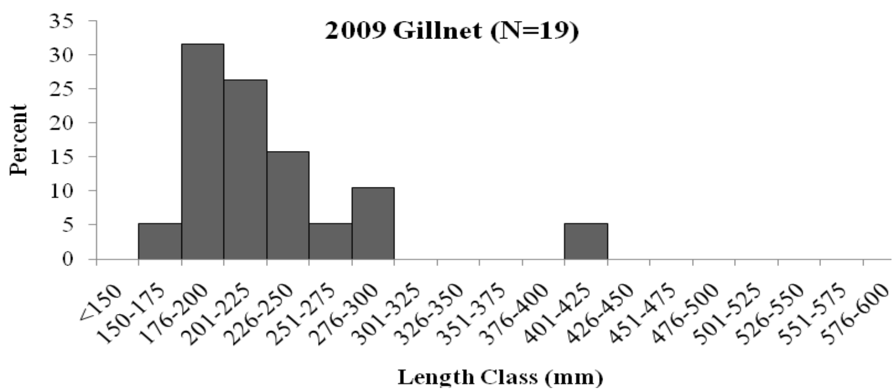

FIGURE 14. Length frequency of cutthroat trout captured in gillnets in Comox Lake, 2009 (N=19). (Source: Courtenay Fish and Game Protective Association, 2011).

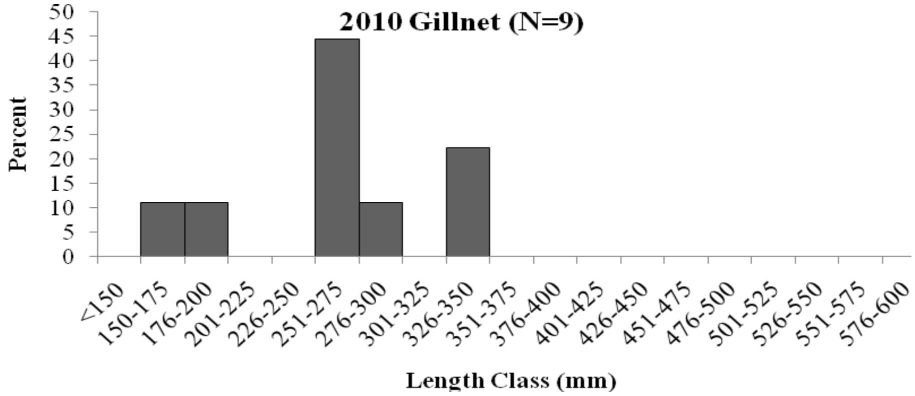

FIGURE 15. Length frequency of cutthroat trout captured in gillnets in Comox Lake, 2010 (N=9). (Source: Courtenay Fish and Game Protective Association, 2011).

Almost 90% of the 28 cutthroat trout captured in gillnets in August 2009 and August 2010 were <300mm (Figure 16). Cutthroat between 200 – 300 mm accounted for 57% of the catch.

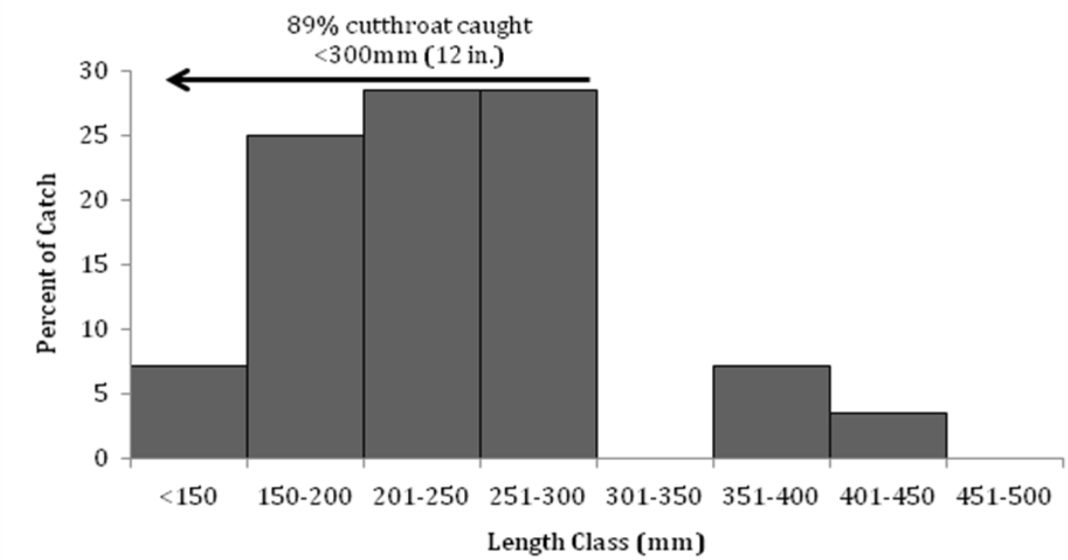

FIGURE 16. Length frequency diagram for cutthroat trout captured in gillnets at Comox Lake August, 2009 and August 2010 (N=28).

Modal Lengths

The modal length of cutthroat trout captured in gillnets in Comox Lake has varied from 300 mm in 1948, to 210 mm in 2009, and 265 mm in 2010 (Table 12). Although modal lengths were greater in 1951 and 1953, only 6 and 8 fish were captured in those years respectively.

TABLE 12. Total number, and modal fork length (mm) of cutthroat trout captured in gillnets in Comox Lake in 1948, 1951, 1953, 2009 and 2010 and by electrofishing in the Upper Puntledge and Cruikshank Rivers in 1993. (Source: FISS, Province of BC files, Nanaimo, Courtenay Fish and Game Protective Association).

Year	N	Modal Fork Length (mm)
1948	34	280
1951	32	255
1953	8	500
1993	49	244
2009	19	210
2010	9	265

Length-Weight Relationship

I've presented a length-weight relationship for cutthroat trout captured in gillnets in Comox Lake and by electrofishing Comox Lake tributaries in Figure 17. Although some cutthroat sampled have been >500 mm and >1400 g, most cutthroat have been ~300 mm and 300 g.

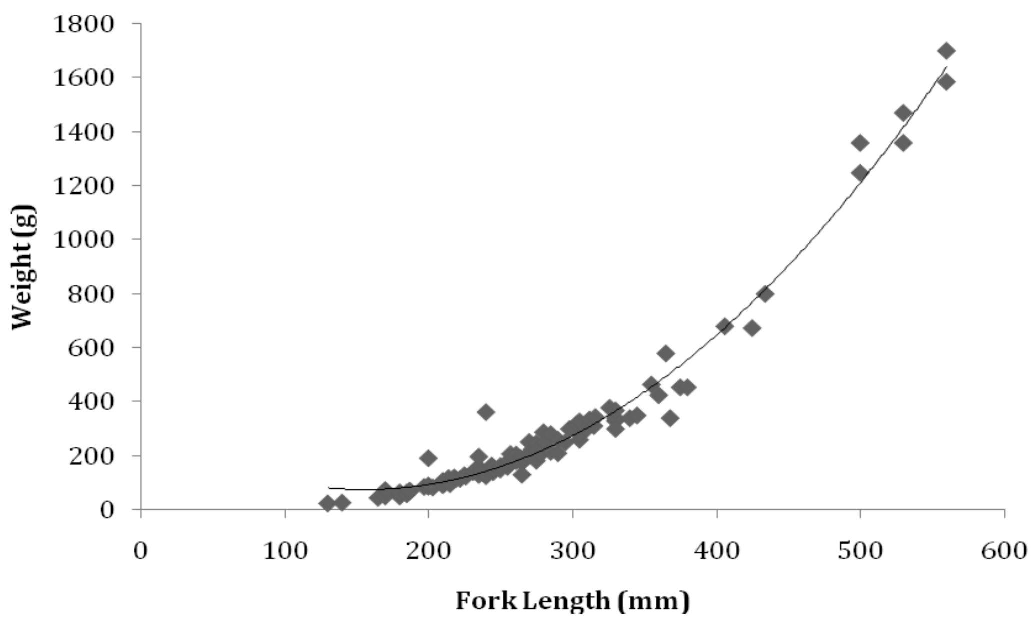

FIGURE 17. Length-weight relationship for cutthroat trout captured in gillnets in Comox Lake and by electrofishing in Comox Lake tributaries 1951- 2010 (N=116).

Age

Carswell and MJ Lough aged 146 cutthroat captured in gillnets and by anglers in 2009 and 2010 (Table 13). Fish up to age 7+ years old were captured and these ranged from 300 mm to 356 mm and averaged 330 mm. Most (40%) of the fish captured were 3+ years old and ranged in size from ~200 mm to 350 mm and averaged 280 mm. Fish older than 3+

years and >300 mm accounted for 40 % of the fish sampled, however, this group included age classes from 4+ to 7+ years.

TABLE 13. Total number, average age and minimum, maximum and average fork length (cm) of each age class of cutthroat trout sampled in gillnets and by anglers in 2009 and 2010 in Comox Lake (Source: Province of BC, 2009, Nanaimo, Lough, 2009; Lough, 2010).

Age	N	Percent	Length (mm)		
			Minimum	Maximum	Average
1+	5	3	130	187	164
2+	24	16	180	300	215
3+	59	40	203	356	280
4+	32	22	240	380	320
5+	15	10	229	406	338
6+	7	5	285	445	348
7+	4	3	300	356	328
Summary	146		130	445	285
Average Age	3.4				

The average age of fish sampled in 2009 was 3.5 years and in 2010 was 3.2 years (Table 14). In 2009, age 3+ fish accounted for most of sample and that few fish outside of the 200 mm – 400 mm fork length range were sampled (Lough, 2010). Lough (2010) pointed out that age 3+ fish were vulnerable to capture by angling but the lack of fish > 440 mm suggested a low abundance of large fish in the Comox Lake population.

Lough found similar results in 2010 when the mean fork length of angler-caught cutthroat trout caught was 308 mm and no cutthroat >400 mm were sampled by anglers (Lough, 2010). That year, age 3+ fish accounted for almost 70% of the sample. Lough compared his Comox Lake results to results from a similar, currently running study at Cowichan Lake where the average size of angler-caught cutthroat trout was 421 mm and suggested that a possible explanation for the smaller average size of Comox Lake cutthroat trout was that angling pressure may be harvesting these fish at a rate that exceeds the recruitment rate to the older age groups (Lough, 2010).

TABLE 14. Total number, percent and average fork length (cm) of each age class of cutthroat trout sampled in gillnets and by anglers in 2009 and 2010 in Comox Lake. (Source: Province of BC, 2009, Nanaimo, Lough, 2009; Lough, 2010).

Age	2009			2010		
	N	Percent	Average Fork Length (mm)	N	Percent	Average Fork Length (mm)
1+	3	3	167	2	5	160
2+	24	22	215	-----	-----	-----
3+	33	31	264	26	68	300
4+	23	21	307	9	24	352
5+	14	13	334	1	3	400
6+	7	6	348	-----	-----	-----
7+	4	4	328	-----	-----	-----
Grand Total	108		277	38		308
Average Age	3.5			3.2		

Maturity

I assessed age-at-maturity for 23 cutthroat sampled in 2009 and 2010 and all but one fish was immature (Table 15). The 22 immature cutthroat trout sampled were, on average ~2 years of age while the only maturing cutthroat sampled was 4.0 years.

TABLE 15. Total number, average age and minimum, maximum and average fork length (cm) of cutthroat trout sampled in gillnets and by anglers in 2009 and 2010 in Comox Lake. (Source: Province of BC, 2009, Nanaimo, Lough, 2010; Lough, 2011).

Maturity	N	Average Age
Immature	22	2.1
Maturing	1	4.0

I assessed size-at-maturity for 25 cutthroat sampled in 2009 and 2010 and found the average size of maturing cutthroat was 395 mm, while the average size of immature fish was 225 mm (Figure 18).

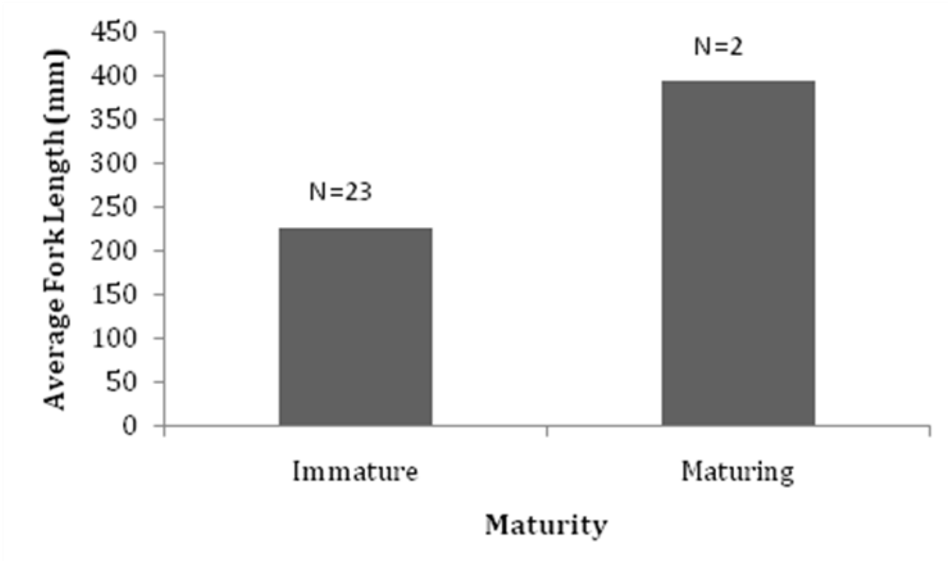

FIGURE 18. Average length of immature and mature cutthroat trout captured in gillnets in Comox Lake August, 2009 and August 2010 (N=25).

The average size of immature cutthroat trout has ranged from ~258 mm to 261 mm in 1948 and 1951, to 225 mm in 2009/10 (Table 16). Mature cutthroat were only recorded in the 1948 samples and these fish averaged 300 mm in length. On average, on Vancouver Island, cutthroat trout are ~ 340 mm when they reach maturity (Figure 19).

TABLE 16. Average lengths (mm) of immature and mature cutthroat trout captured in gillnets at Comox Lake, 1948, 1951 and 2009 2010. (Source 1948, 1951: Ministry of Forests, Lands and Natural Resource Operation, Nanaimo).

1948 (N=20)		1951 (N=30)	2009 and 2010 (N=23)
Immature (n=9)	Mature (n=11)	Immature	Immature
257.8	300.5	261.0	225.3

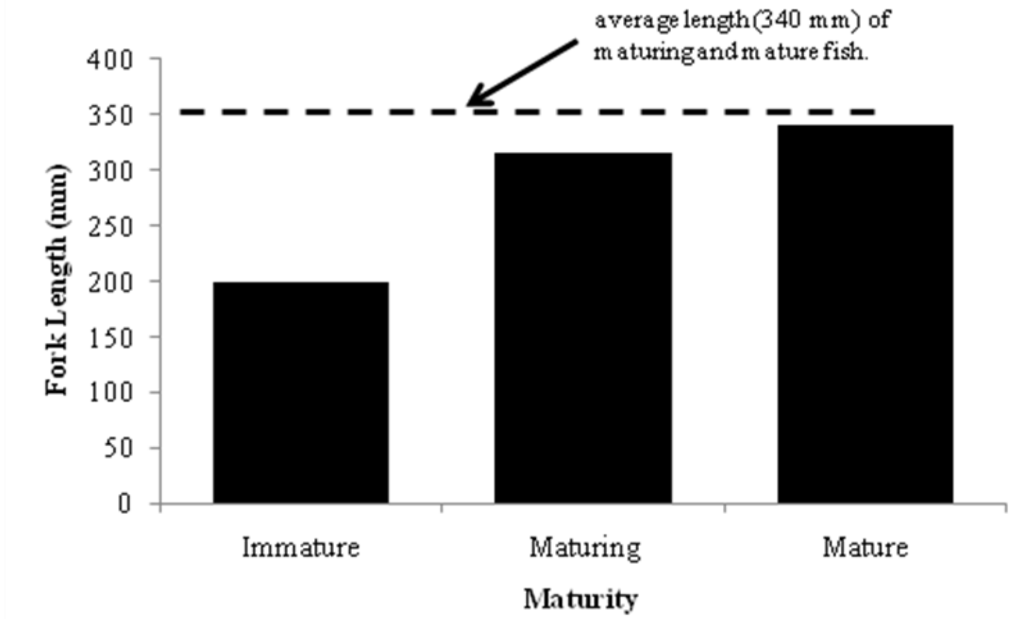

FIGURE 19. Average length of immature, maturing and mature cutthroat trout sampled in Vancouver Island large lakes (Alice, Buttle, Comox, Cowichan, Great Central, Elsie, Henderson, Huaskin, Kennedy, Lower Campbell, Nimpkish, Nitinat, Sproat, Upper Campbell, Victoria and Woss) (N=545). (Source: FISS/MELP Files, Narver, 1975,Hatfield Consultants, 1982, Rutherford, 1987, Stewart, 1990, Tilly, J. 1992, Hansen, D. 1993, Hallam Knight Piesold Ltd., 2000, Burt, 2002Michalski et al. 2004 Griffith, 1989 Michalski, 2006).

Spawning Behaviour and Timing

MJL Environmental Consultants conducted snorkel surveys to assess cutthroat trout spawning in Comox and Rees Creeks and the Upper Puntledge River between March and June, 2010 (Lough, 2011). Based on redd counts, Lough estimated a spawning escapement of ~1,700 cutthroat trout in these tributaries. Fish size, as determined by visual estimates, ranged from 300 mm to 550 mm while the mean fork length of the spawning population was 390 mm (Lough, 2011).

In addition to estimating size and numbers of spawning cutthroat in Comox Lake tributaries, Lough also determined that peak spawning occurred between March 18 – March 26 in the Upper Puntledge River, and April 2 – April 9 in Comox Creek in 2011. Although spawning declined in the Upper Puntledge after mid-April, Comox Creek showed a sustained flat peak that continued into May (Lough, 2011). Based on a combination of empirical and estimated water temperatures, Lough estimated that fry emergence ranges from early June to early July in the Upper Puntledge River, late June to late July in Comox Creek, and mid-July to early August in Rees Creek (Lough, 2011).

Juvenile Abundance

Russell et al (1990) conducted a two-pass removal electrofishing assessment to determine juvenile abundance in the Cruikshank and Upper Puntledge Rivers, and Comox Creek.

Russell et al chose their sites based on cutthroat distribution identified in a 1977 survey by Caw, as well as on access, fish usability, stream order and the ability to sample effectively. I've provided summary tables of Russell's results in Appendix 4.

We repeated Russell's electrofishing survey at Comox Creek in 2011 and I've compared the results of our study with those of Russell et al (1990) in Table 17. In contrast to Russell who found 2 age classes of cutthroat trout, we found only 0+ aged fish. Although average lengths and weights of 0+ fish were similar for both studies, fish densities were more than double when Russell sampled ~20 years ago.

TABLE 17. Total number and estimated number sampled, fish/m, density (fish/m2), sampled Fish per Unit (number of fry/100m2), biomass (g), average length (mm), and average weight (g) of 0+ and 1+ aged cutthroat trout sampled by electrofishing in Comox Creek in 1989 and 2010 (Source: Russell et al, 1990; Ministry of Forests, Lands and Natural Resource Operation, Nanaimo).

Year	Year Class	Number Sampled	Fish/m	Estimated Number	Density (fish/m2)	Sampled FPU (fry/100 m2)	Biomass (g)	Average Length (mm)	Average Weight (g)	Site Area (m2)
1989	0+	17	1.53	21	0.24	24	10.54	39.5	0.62	85.76
	1+	9	0.89	12	0.14	14	67.68	89.8	7.52	
2010	0+	31	0.77	45	0.10	10	18.8	34.3	0.60	435.75

In addition to sampling at Comox Creek, we also conducted an electrofishing assessment at Rees Creek (Table 18). Unfortunately, we sampled more fish on our second pass so I was unable to calculate densities. I believe our sampling was compromised because water levels were high. Of note, however, is that we sampled numerous coho salmon at this site.

TABLE 18. Total number, biomass (g), average length (mm), and average weight (g) of 0+ cutthroat trout, coho salmon and Dolly Varden sampled by electrofishing in Rees Creek 2010 (Source: Ministry of Forests, Lands and Natural Resource Operation, Nanaimo).

Species	Year Class	Number Sampled	Biomass	Average Length (mm)	Average Weight (g)	Site Area (m2)
Cutthroat	0+	24	34.9	43.0	1.5	331.15
Coho	0+	10	43.3	72.0	4.3	
Dolly Varden		1	23.5	130.0	23.5	

Water levels were too high to electrofish the Upper Puntledge River so we conducted a snorkel survey and set minnow traps to document fish presence in that system (Table 19). We observed almost 200 cutthroat trout ranging from 100 mm to >400 mm. Unlike Russell et al (1990), who found no evidence of coho in this system, we found numerous coho distributed the entire 3 km length from Willimar Lake to the bridge close to the mouth of the Upper Puntledge River at Comox Lake.

TABLE 19. Results of a snorkel survey conducted August 23, 2011 from Willimar Lake to the bridge upstream of Comox Lake (~3 km) of the Upper Puntledge River (Source: Ministry of Forests, Lands and Natural Resource Operation, Nanaimo).

Location	Size (cm)					Comments
	10-20	20-30	30-40	>40	Total	
Willimar Lake outlet to log jam (~0.5 km)	4	9	6	0	19	numerous coho fry (0+ /variety of sizes ~8 gm); 1 sculpin
Log jam to log jam (~1 km)	38	29	21	5	93	abundant coho fry; 1 sculpin
Log jam to unnamed right bank tributary (~1 km)	23	17	7	2	49	1 rainbow > 30 cm; 1 chinook >60 cm; 1 Dolly Varden 20-30 cm; numerous coho fry
Unnamed tributary to bridge u/s of Comox Lake (~0.5 km)	16	16	6	0	38	possible rainbow/steelhead juvenile ~12-15 cm; numerous coho fry
Total	81	71	40	7	199	

Juvenile Recruitment

Lough (2011) estimated juvenile recruitment to the Upper Puntledge River and Comox and Rees Creeks using redd counts from their snorkel surveys and life-stage survival estimates provided by Slaney and Roberts (2005). Based on this analysis, Lough estimated fry recruitment in the study streams could be expected to range to 10,200 fry per km of stream in the Upper Puntledge River, 4,500 fry per km of stream in Comox Creek, and 2,200 fry per km of stream in Rees Creek (Lough, 2011).

Lough (2011) noted that since they found no obvious problems with the habitat during the egg-fry state, the spawning escapement in 2011 should have been adequate to saturate the fry rearing habitat in the study streams in 2011 with the possible exception of Rees creek. Citing the work by Russell et al (1990), Lough also pointed out, however, that there are some indications that juvenile densities are far below saturation levels, and that Russell's comparisons of sampled fry densities with theoretical capability levels found fry densities at only 21% of the predicted capability of the habitat (Appendix 2). Our own results suggest densities of cutthroat fry in Comox Creek at less than half that estimated by Russell et al (1990). Moreover, both Russell (1990) and Lough (2011) found few cutthroat trout parr, and we found none during our assessment of Comox Creek. Lough (2011) points out that the low juvenile abundance in the study streams are inconsistent with the relatively high levels expected from the redd counts and he outlines possible explanations for the inconsistency including:

- Low survival during the egg-fry state.
- Influences in the juvenile rearing habitat that restrict actual rearing capability such as low stream temperatures limiting the growth period (in Comox and Rees creeks).
- Fry out-migration to Comox Lake immediately following emergence.

Clearly, the rearing phase of Comox Lake cutthroat trout is poorly understood. It may be that cutthroat fry recruit to the lake during winter/spring freshets when high water would help fry move downstream and provide some protection from predators. Regardless, lower than predicted fry and parr abundance levels should be considered in light of the declines in angler success and size of angler-caught cutthroat in the Comox Lake fishery, and the size of cutthroat sampled recently vs. during historic gillnetting assessments.

Diet of Adult Cutthroat Trout in Comox Lake

We analyzed the stomach contents of 19 cutthroat trout sampled in 2009 and 2010 and found that almost half of the fish sampled contained only fish (stickleback and bullheads) in their stomach while a further 21% contained both insects and fish (Figure 20). Just over a quarter of the fish contained only insects, and 5% contained both insects and invertebrates (worms).

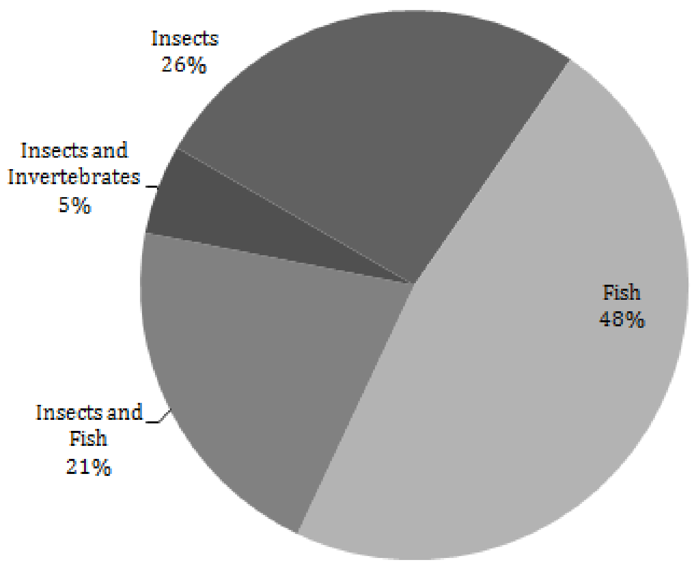

FIGURE 20. Percent of fish (stickleback, bullheads), insects, insects and invertebrates and insects and fish found in the stomachs of cutthroat trout captured in gillnets in Comox Lake August, 2009 and August 2010 (N=19).

5.2.2 Rainbow Trout

Gillnet Catch

Recent gillnet assessments have found more rainbow trout than historic studies and between 2009 and 2010 the catch per hour of this species almost doubled (Table 20).

TABLE 20. Catch per net of rainbow trout captured in gillnets in Comox Lake in 1948, 1951, 1953, 2009 and 2010 (Source: FISS, Courtenay Fish and Game Club). (Note: no information on sampling methods was provided in FISS for 1948, 1951, and 1953 sampling so we assumed one net was used in each of these years; no assumptions regarding net soak time was made for these years so no calculation of catch/hour was possible.

Year	Total Catch	Catch/Net	Soak Time (hours)	Catch/Hour
1948	3	3	-----	-----
1951	3	3	-----	-----
1953	2	2	-----	-----
2009	10	5	25	0.40
2010	19	10	26	0.73

Fish Length

Three rainbow trout ranging in length from 230 mm – 250 mm were sampled by gillnet in Comox Lake in 1948 (Table 21). Three rainbow were sampled in 1951 and these ranged from 155 mm to 267 mm. The fork length of the two rainbow sampled in 1953 ranged from 290 mm to 330 mm. In 2009, a total of 10 rainbow trout were sampled by gillnet ranging in length from 127 mm to 300 mm, while in 2010, 19 rainbow trout were sampled ranging in length from 110 mm to 375 mm.

TABLE 21. Total number, and minimum, maximum and average fork length of rainbow trout captured by gillnet in Comox Lake in 1948, 1951, 1953, 2009 and 2010. (Source: Province of BC files, Nanaimo).

	1948-Oct Gillnet	1951-Aug Gillnet	1953-Jun Gillnet	2009-Aug Gillnet	2010-Aug Gillnet
Minimum Fork Length	230	155	290	127	110
Maximum Fork Length	250	267	330	300	375
Average Fork Length	243	219	310	196	202
Number	3	3	2	10	19

Length Frequency

I've presented the percent length frequency of rainbow trout sampled in 2009 and 2010 in Figures 21 and 22. In both years, the highest percentage of rainbow captured (~60%) was <200 mm.

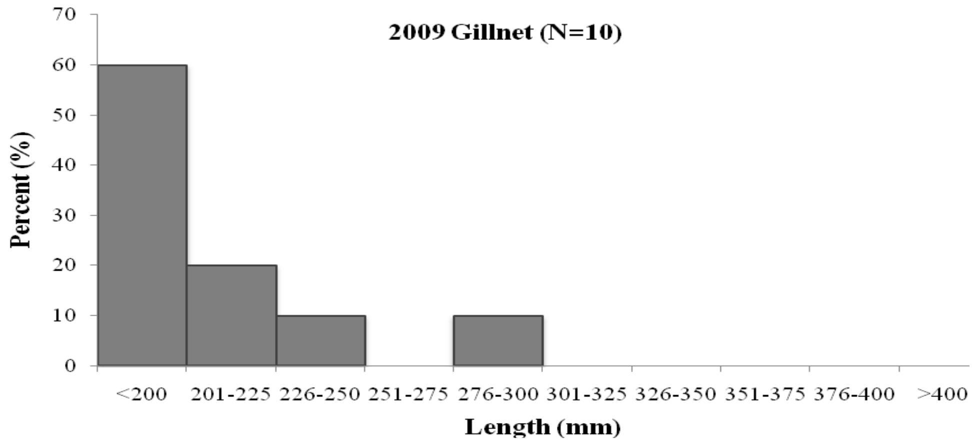

FIGURE 21. Length frequency of rainbow trout captured in gillnets in Comox Lake, 2009 (N=10). (Source: Courtenay Fish and Game Protective Association, 2011).

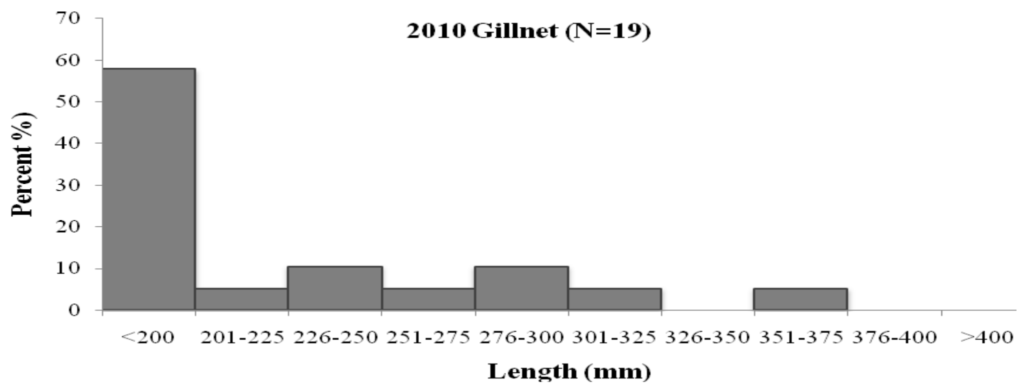

FIGURE 22. Length frequency of rainbow trout captured in gillnets in Comox Lake, 2010 (N=19). (Source: Courtenay Fish and Game Protective Association, 2011).

Modal Lengths

The modal length of rainbow trout captured in 1948 was 250 mm, while the modal length in 2010 was 130 mm (Table 22).

TABLE 22. Total number, and modal fork length (mm) of rainbow trout captured in gillnets in Comox Lake in 1948 and 2010. (Source: FISS, Province of BC files, Nanaimo, Courtenay Fish and Game Protective Association).

Year	N	Modal Fork Length (mm)
1948	3	250
2010	19	130

Length-Weight Relationship

I've presented a length-weight relationship for rainbow trout captured in gillnets in Comox Lake and by electrofishing in lake tributaries from 1951 – 2010 in Figure 23. Rainbow trout range from ~100 mm and <100 g, to 400 mm and ~600 gm. Most individuals of this species are less than that, however (i.e. ~200 mm and ~100 g).

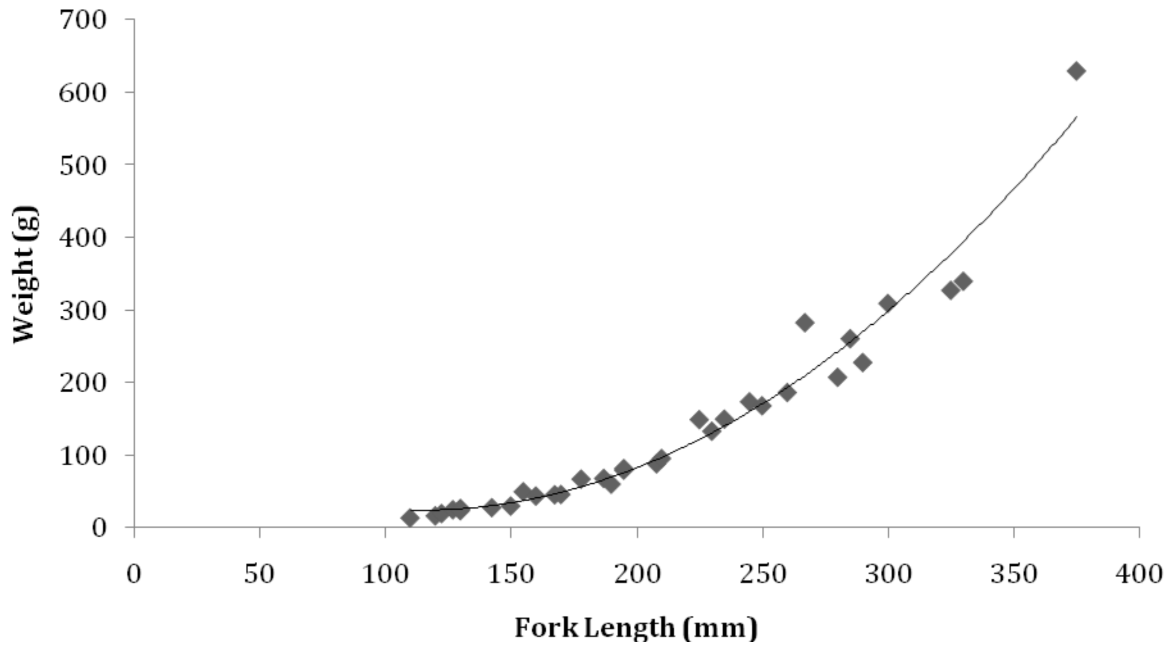

FIGURE 23. Length-weight relationship for rainbow trout captured in gillnets in Comox Lake and by electrofishing in Comox Lake tributaries 1951- 2010 (N=34).

Maturity

No mature rainbow trout have been captured in Comox Lake, however, maturing rainbow have been caught in gillnets and these have averaged 320 mm (Table 23). Far more immature rainbow have been caught in gillnets and these have ranged from 110 mm to 280 mm and have averaged ~190 mm.

TABLE 23. Catch (n) and minimum, maximum and average lengths (mm) of immature rainbow trout captured in gillnets at Comox Lake 1951, 2009, 2010 (Source: Province of BC files, Nanaimo).

Immature				Maturing			
n	Minimum	Maximum	Average	n	Minimum	Maximum	Average
21	110	280	188.5	3	285	375	320

5.2.3 Dolly Varden

Fish Length

Forty-seven Dolly Varden ranging in length from 195 mm – 380 mm were captured in Comox Lake in 1948 and in 1993, 60 Dolly Varden were captured by electrofishing. These fish ranged in size from 112 mm to 392 mm (Table 24). In 2009, a single Dolly Varden measuring 187 mm was captured by gillnet and in 2010, eight Dolly Varden were captured by gillnet ranging between 150 mm and 340 mm. There was a decline in Dolly Varden mean length from 254 mm in 1948, to 246 mm in 1993. This observed difference may be the result of different sampling methodologies used between years. Also, sampling in both years was done in October/November so some mature fish would have been in the streams and missed in these assessments.

TABLE 24. Total number, and minimum, maximum and average fork length of Dolly Varden captured by gillnet in Comox Lake in 1948, 2009 and 2010, and by electrofishing in the Upper Puntledge and Cruikshank Rivers in 1993. (Source: Province of BC files, Nanaimo).

	1948-Oct Gillnet	1993-Nov Electrofish	2009-Aug Gillnet	2010-Aug Gillnet
Minimum Fork Length	195	112	187	150
Maximum Fork Length	380	392	187	340
Average Fork Length	254	248	187	246
Number	47	60	1	8

Length Frequency

I've presented the length frequency distributions of Dolly Varden sampled by gillnet in Comox Lake in 1948 and 2010, and by electrofishing in the Cruikshank and Upper Puntledge Rivers in 1993 in Figures 24, 25 and 26. Approximately 20% of Dolly Varden captured were in each length class between 201-225 mm and 251-275 mm in 1948. In 1993 and 2010 the highest percentage of Dolly Varden captured were in the 226 – 250 mm length class. Fish up to 400 mm were captured in 1948 and 1993, however, the largest Dolly Varden captured in 2010 was <350 mm (Figure 26).

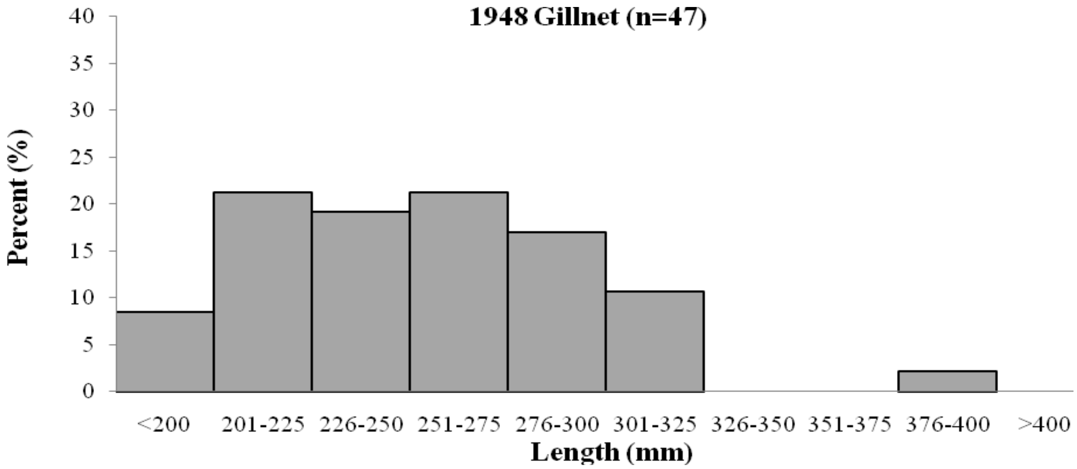

FIGURE 24. Percent length frequency analysis of Dolly Varden captured in gillnets in Comox Lake 1948 (N=47). (Source: Province of BC files, Nanaimo).

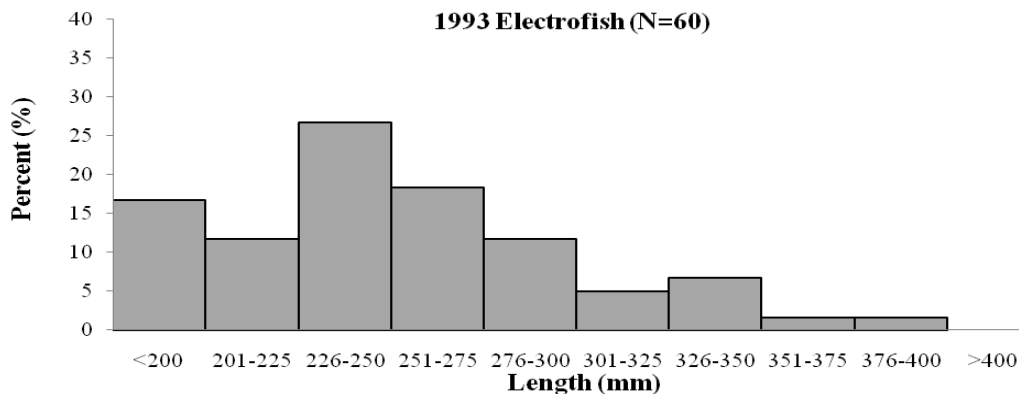

FIGURE 25. Percent length frequency analysis of Dolly Varden electrofished in the Cruikshank and Upper Puntledge Rivers in 1993 (N=60). (Source: Province of BC files, Nanaimo).

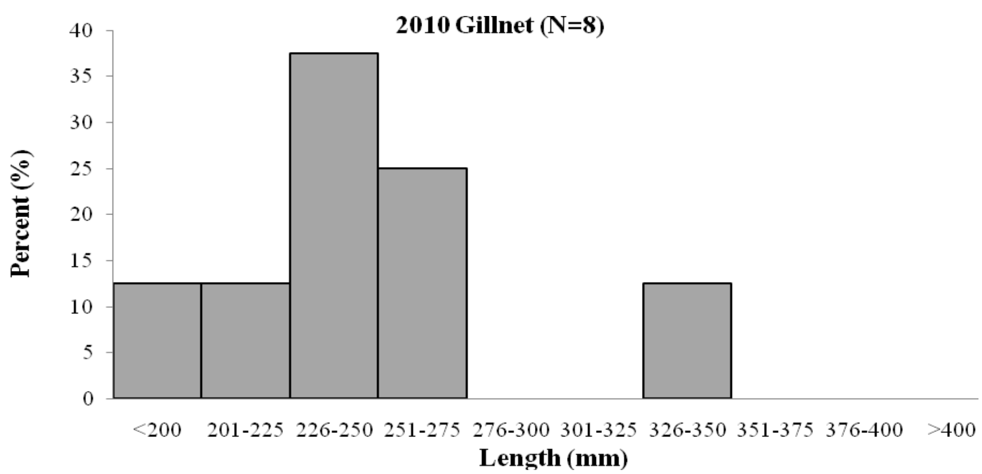

FIGURE 26. Percent length frequency analysis of Dolly Varden captured in gillnets in Comox Lake 2010 (N=8). (Source: Courtenay Fish and Game Protective Association, 2011).

Modal Lengths

The modal length of Dolly Varden captured in gillnets in Comox Lake in 1948 was 210 mm, while the modal length of this species captured in 2010 was 250 mm (Table 25). Note that in 1948, 47 fish were captured, while only 8 fish were captured in 2010.

TABLE 25. Total number, and modal length (mm) of Dolly Varden captured in gillnets in Comox Lake in 1948 and 2010. (Source: FISS, Province of BC files, Nanaimo, Courtenay Fish and Game Protective Association).

Year	N	Modal Fork Length (mm)
1948	47	210
2010	8	250

Length-Weight Relationship
Most Dolly Varden captured in Comox Lake and tributaries have been ~250 mm and <200 g although a small number of Dolly Varden have been ~400 mm and 400 g (Figure 27).

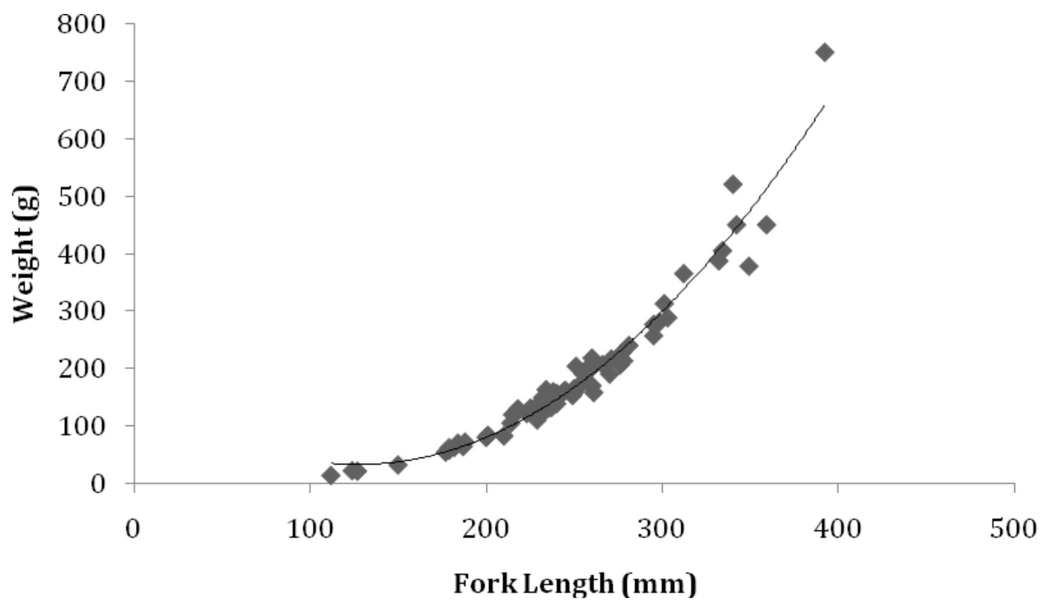

FIGURE 27. Length-weight relationship for Dolly Varden captured in gillnets in Comox Lake and by electrofishing in Comox Lake tributaries 1993, 2009, 2010 (N=69).

Maturity

Immature, maturing and mature Dolly Varden have been sampled in Comox Lake and I've presented the minimum, maximum and average fork lengths of these fish in Table 26. Immature fish have ranged from 187 mm to 308 mm and averaged 235 mm, while mature fish have ranged from 260 mm to 320 mm and averaged ~290 mm.

TABLE 26. Catch (n) and minimum, maximum and average lengths (mm) of immature, maturing and mature Dolly Varden captured in gillnets at Comox Lake, 1948, 2009, 2010. (Source Province of BC files, Nanaimo).

Immature				Maturing		Mature			
n	Min	Max	Ave	n	Length	N	Min	Max	Ave
31	187	308	235.1	1	340	11	260	320	287.7

6.0 Fisheries Management

6.1 Comox Lake Fishery and Stock Summary

- Angler effort at Comox Lake built through the 1980's and 1990's, approached the maximum in 1989 and 2002, and fell back in the mid-2000's (Aitzhanova, et al. 2003, Andrews, 2007) (Figure 5).
- Angler effort at Comox Lake has recently been <maximum, however, high angler catch and effort from the late 1980's until the early 2000's likely lead to declines in the fishery and stocks (Figure 3).
- Angler success (catch/angler day) currently averages 0.52 fish/angler day.
- Cutthroat trout comprise 86% of the catch.
- Ninety-four percent of the cutthroat trout caught are harvested.
- Almost 70% of cutthroat trout harvested at Comox Lake are <300 mm (12")
- On average, cutthroat trout mature at ~340 mm in Vancouver Island large lakes, therefore, most cutthroat harvested at Comox Lake are immature.
- Almost 90% of cutthroat trout captured in gillnets in 2009 and 2010 were <300mm and 96% were immature.
- Mature cutthroat have not been sampled in Comox Lake since 1948.
- The mean fork length of the spawning population is <400 mm (Lough, 2011).
- Maximum allowable harvest at large lakes in Region 1 is 30% of total catch (Andrusak and Brown in Reid, 1984).
- Current regulations at Comox Lake are 4 cutthroat per day; mandatory release of trout >50 cm; bait ban, single, barbless hook November 1-April 30.
- Cutthroat spawner surveys confirm the importance of the Upper Puntledge River, and Comox and Rees Creeks as critical spawning habitat for cutthroat trout.

6.2 Management Objectives and Strategies for Comox Lake

1. Fisheries management efforts should focus on cutthroat.
2. Implement mandatory release of cutthroat <300 mm (12") to protect first time spawners.
3. Monitor angler effort using the Vancouver Island Lakes Questionnaire and instant angler counts.
4. Implement conservation regulations if angler effort approaches the maximum (>9,000 angler days; Figure 5).
5. Mandatory release regulation will result in increased angler catch, success and average fish size; monitor angler catch, success, harvest and satisfaction beginning in 2012 to document the effect of the new regulation.
6. Extend mandatory release of all trout > 50 cm and bait ban, single, barbless hook all year.
7. Do not exceed the maximum allowable harvest of 30% of catch.
8. Develop further regulations if maximum allowable harvest is exceeded.
9. Erect signs outlining regulations at Cumberland and Courtenay Fish and Game Association boat launches to inform anglers of the new regulations.
10. Repeat spawner count on index streams spring 2014 (see Lough, 2011).
11. Repeat gillnetting assessment every 3 years beginning in 2013.
12. Request Fisheries and Oceans discontinue coho stocking in the Upper Puntledge River.

Part 2 - Comox Lake and Tributary Enhancement Plan

7.0 Comox Lake and Tributary Enhancement Plan

I've summarized the results of habitat assessments conducted in the Comox Lake watershed, provided a process for identifying habitat limiting factors, and outlined an enhancement plan for Comox Lake tributaries in the following section. I used the following guiding principles, identified by the subcommittee, to identify enhancement priorities:

- Enhancing wild stocks and their habitat is the primary focus.
- Limiting factors will be identified before developing habitat enhancement prescriptions.
- Limiting factors will be identified based on field assessments conducted according to established scientific standards.
- Habitat prescriptions will address limiting factors.
- Enhancement plans will identify projects in priority order according to factors limiting production for wild stocks.
- Under-seeded reaches are high priority areas for restoration.
- Tributaries and tributary reaches where hatchery fish have been introduced are a low priority.
- Reaches where an incomplete list of habitat parameters and limiting factors exists will be priority areas for habitat assessment.

7.1 Comox Lake Habitat Assessments and Identification of Enhancement Priorities

In 1976, Caw conducted an inventory of the tributaries to Comox Lake to document overall fisheries capability and productivity of the watershed, and record detailed physical habitat parameters of the tributaries and surrounding terrain (Figure 28) (Caw, et al. 1977). Caw found rearing cutthroat in Comox, Rees and Eric and of particular abundance in Comox and Rees Creeks, however, he noted that that major tributaries were all of considerable value to the Comox Lake system.

FIGURE 28. Location of Cruikshank River, Comox, Rees and Eric Creeks.

Identification of Enhancement Priorities Areas

Caw (1977) broke each tributary into homogeneous reaches then measured habitat parameters important for fish spawning, holding and rearing for each area. He provided measurements for many parameters and described physical descriptions for each habitat parameter as P (poor); L (low); F (fair); G (good); and E (excellent).

Caw did not assess the Upper Puntledge River, however, based on the identification of this system as critical cutthroat trout habitat by Russell et al (1990) and Lough (2011), Fisheries Section staff assessed Reach 1 of this system in 2011. Water levels were too high to walk the stream so we snorkelled from Willimar Lake to the bridge at the stream outlet stopping and assessing habitat characteristics each time we observed a gradient or habitat type change (i.e. from riffle to pool, etc.). I've summarized our results according to Caw's definitions (Table 27), and presented our detailed study results in Appendix 5. I assigned points to habitat descriptions and added the points so I could identify priority streams and reaches for enhancement (Table 27).

TABLE 27. Summary of classification of spawning, rearing and holding habitat for the Cruikshank River and Comox, Rees and Eric Creeks, Comox Lake (Data from Caw, 1977; Province of BC, 2011). Note: points assigned are as follows: E (excellent) =4 points, G (good) =3 points, F(fair)=2 points, L(low)=1 point P (poor)=0 points.

Stream	Reach	Spawning	Points	Rearing	Points	Holding	Points	Total
Cruikshank	1	E	4	E	4	E	4	12
	2	P	0	P	0	L	1	1
	3	E	4	E	4	G	3	11
	4	L	1	L	1	L	1	3
	5	P	0	P	0	P	0	0
Comox	1	E	4	E	4	G	3	11
	2	G	3	F	2	F	2	7
Comox Tributary (unnamed)	1	F	2	E	4	P	0	6
Comox Tributary (Kweishun creek)	1	G	3	G	3	G	3	9
	2	F	1	F	1	F	1	3
Rees	1	E	4	E	4	E	4	12
	2	F	2	E	4	E	4	10
	3	G	3	G	3	L	1	7
	4	L	1	L	1	L	1	3
	5	L	1	P	0	P	0	1
Eric creek	1	L	1	L	1	L	1	3
	2	G	3	G	3	G	3	9
	3	P	0	P	0	P	0	0
Upper Puntledge	1	G	3	G	3	G	3	9

After assigning points I refined rankings by assessing gradient and species presence for each reach. For this exercise, I referred to the subsequent habitat assessments conducted by Russell et al. (1990), and our own data collected in 2011.

Cutthroat trout prefer small streams (< 9m channel width), with gradients <3% (Appendix 6). Using this as a guideline, I ranked stream gradients between 0 and 1 as low priority areas for enhancement; gradients between 2% and 3% as high priorities; gradients between 3% and 4 % as medium priorities and rejected gradients >4%. I eliminated areas where gradients were too high for spawning and rearing.

I also assigned points for fish presences as follows: reaches where Caw (1977), Russell (1990) or we found cutthroat and Dolly Varden were ranked as high. Rainbow have been stocked into Comox Lake tributaries in the past, therefore, I gave reaches where this species has been found a medium ranking. Finally, since cutthroat trout are negatively impacted by the presence of hatchery coho (Appendix 6) I gave low rankings to reaches with hatchery coho. I've presented the final ratings in Table 28.

TABLE 28: Summary of stream gradient, and rearing species for the Cruikshank River and Comox, Rees and Eric Creeks, Comox Lake (Data from Caw, 1977; and Russell, 1990). Gradients rated 0-1% =low, 2-3=high, 3-4=Med, >4 = Reject. Cutthroat & Dolly Varden = high, Cutthroat, Dolly Varden & Rainbow = Medium, Coho present = low, Hatchery rainbow present = low.

Stream	Reach	Gradient %	Priority	Rearing species	Priority
Cruikshank	1	0.8	Low	cutthroat	High
	2	4.0	Reject	cutthroat	Low
	3	2.3	High	cutthroat, Dolly Varden,	High
	4	2.7	High	cutthroat, Dolly Varden, rainbow	Med
Comox	1	1.6	High	cutthroat,	High
	2	2.9	High	cutthroat, Dolly Varden	High
Comox Tributary (unnamed)	1	7.0	Reject	cutthroat	Low
Comox Tributary (Kweishun creek)	1 & 2	7.0	Reject	cutthroat	Low
Rees	1	1.0	High	cutthroat, coho,	Low
	2	3.0	Medium	cutthroat, coho, Dolly Varden	Low
	3	unknown; likely high	N/A	Unknown	Low
	4		N/A		
	5		N/A	no fish found	Reject
Eric	1	unknown; likely high	unknown; likely high	cutthroat, Dolly Varden	Possibly Med
	2			cutthroat	
	3			No fish found	Reject
U. Puntledge	1	1	Medium	cutthroat, Dolly Varden coho	Low; High if stocking discontinued
	2	0.4	Low	cutthroat	High
	4	1.6	High	cutthroat, rainbow	Low
	5	1.1	Medium	cutthroat, rainbow	Low

I combined the habitat and species factors to determine final rankings and priorities and present these in Table 29. Reaches 1 and 3 of the mainstem Cruikshank, and Reaches 1 and 2 of Comox Creek ranked as the highest priorities (Figures 29 and 30). Rees Creek and the Upper Puntledge are low priorities for enhancement because hatchery fish are present. Note, however, that Reach 1 of the Upper Puntledge would be a high priority if coho stocking were discontinued.

TABLE 29: Summary of classifications of stream habitat and species presence and final priority rankings for restoration of the Cruikshank River and Comox, Rees and Eric Creeks, Comox Lake (Data from Caw, 1977 and Russell, 1990). Note: results are listed in priority order; details regarding habitat classifications are in Table 1; details for species presence are presented in TABLE 2. Points are assigned as follows: habitat classification High =3; habitat classification Med=2; habitat classification Low=1; species rank High =4; species rank Med=3; species rank Low = 2).

Stream	Reach	Habitat Classification	Points	Species Presence	Points	Pts.	Rank
Cruikshank	1	High	3	High	4	7	1
	3	High	3	High	4	7	1
	4*	High	3	Low	2	5	2
Comox	1	High	3	High	4	7	1
	2	High	3	High	4	7	1
Rees	1	High	3	Low	2	5	2
	2	High	3	Low	2	5	2
U. Puntledge**	1	Low; would become high if stocking discontinued		High	4	4	3
	2			High	4	4	3
	4&5			Low	2	2	4

* Caw noted that Reach 4 of Cruikshank River is the mainstem of Erick Creek which is much larger than the Cruikshank at this point. The gradient of this creek is 3 – 3.5% with fast flowing water over coarse substrate; spawning and rearing capabilities are low and Caw did not attempt to sample (Caw, 1977).
**Habitat assessment for Reach 1 extending from Willimar Lake to Comox completed in 2011.

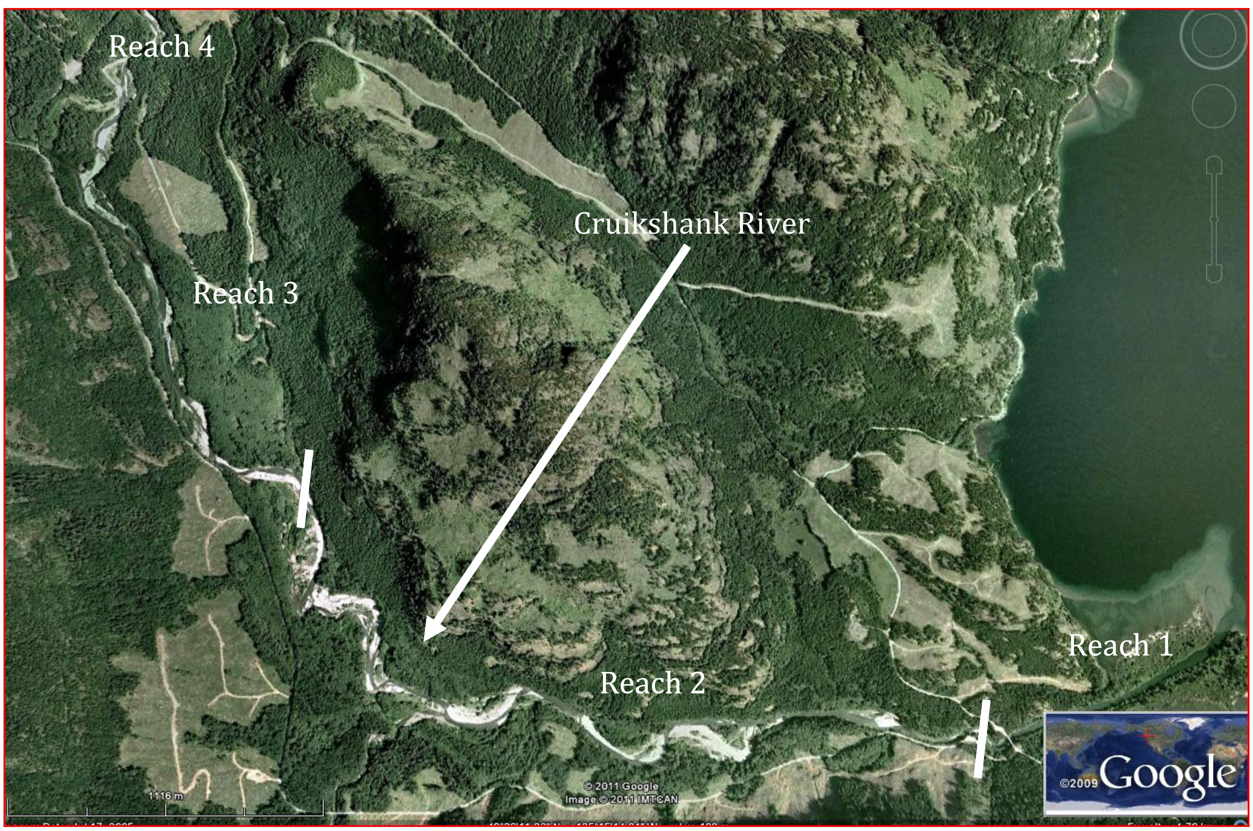

FIGURE 29. Reach locations on Cruikshank River, Comox Lake. (Source: Caw, 1977).

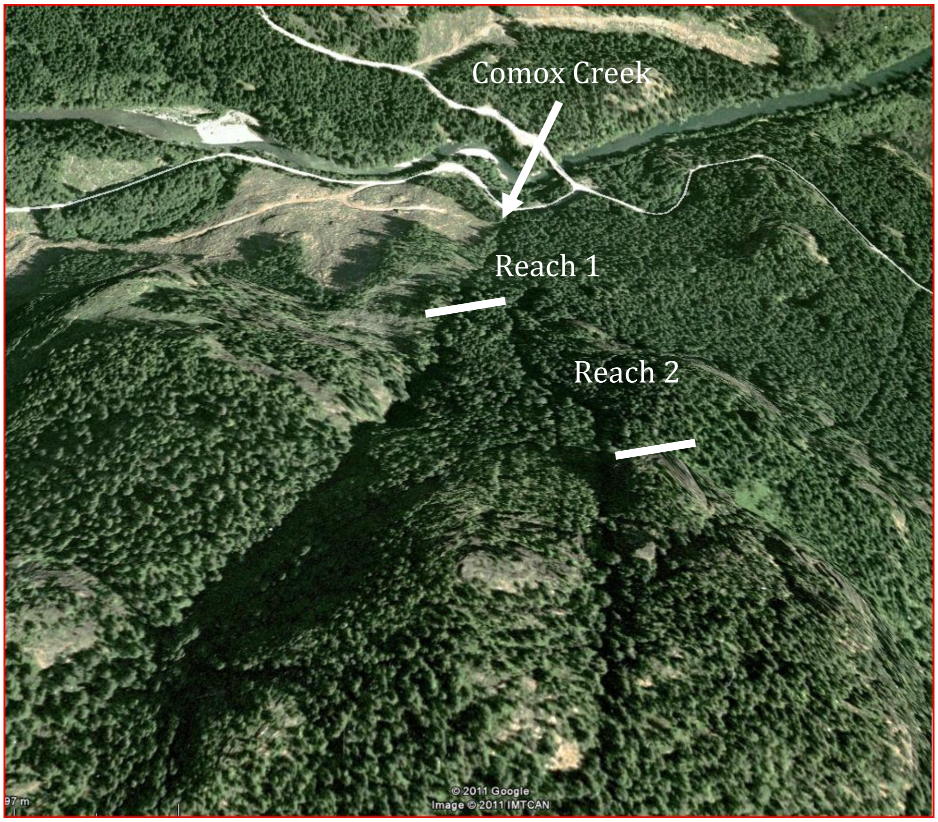

FIGURE 30. Reach locations on Comox Creek, Comox Lake. (Source: Caw, 1977).

Habitat Enhancement Prescriptions

I've presented the habitat indicators which make up good, fair, and poor salmonid habitat in Table 30 and my assessment of habitat indicators for the Comox Lake tributaries in Table 31. Two major things stand out. First in the high priority reaches in the Cruikshank mainstem and Comox Creeks lack pool area and have poor levels of Large Woody Debris (LWD) and work to improve these limiting factors should proceed. Second, more habitat sampling is required for pool, eroded and altered reaches, and identification of off- channel areas in each tributary.

TABLE 30: Habitat indicators of factors limiting fish production (Johnston et al. 1996, Michalski et al, 2001).

Indicator	Good	Fair	Poor
% Pool Area	>55 %	40-55%	<40%
LWD/Bankfull Channel Width	2	1-2	<1%
% Cover in Pools	>20	6-20%	<6%
Ave. % Boulder Cover	>30	10-30%	<10%
Ave. % Fines	<10	10-20%	>20%
% of reach eroded	<5	5-10%	>10%
% of Reach altered	<5	5-10%	>10
% Wetted Area	>90	70-90%	<70%
% off Channel Habitat	>30	15-30%	<15
Dissolved Oxygen	>7mg/l	5-7mg/l	<5mg/l
pH	6.5-8	5.5-6.5	<5.5 - >8

TABLE 31. Summary of habitat indicators or restoration of the Cruikshank River and Comox, Rees and Eric Creeks, Comox Lake. Note: tributaries and reaches are noted in priority order (Source: Caw, 1977; Russell et al, 1990; Province of BC, 2011).

Stream	Reach	% Pool Area	LWD/ Bankfull width	% Pool Cover	% Boulder Cover	% Fines	% Reach Eroded	% Reach Altered	% Wetted Area	% Off Channel
Cruikshank	1	P	P	RS	F	F	RS	RS	P	RS
	3	P	P	RS	F	F	RS	RS	P	RS
Comox	1	P	P	RS	F	F	G	RS	F	RS
	2	P	P	RS	F	F	RS	RS	F	RS
Rees	1	P	P	RS	F	F	RS	RS	G	RS
	2	G	RS	RS	P	P	G	RS	G	RS
	3	P	RS	RS	P	P	RS	RS	G	F
	4	P	RS	RS	G	G	RS	RS	G	F
U. Puntledge	1	G	F	F	F	F	G	F	G	P

G= Good F= Fair P= Poor RS = requires survey.

I’ve summarized the highest priority habitat restoration projects in the highest priority tributaries and reaches in Table 32. I recommend that work proceed in these tributaries and that a Watershed Restoration Program Level assessment be conducted to identify specific locations for restoration projects (Table 34). I’ve provided examples of restoration projects including LWD placement designs in Appendix 6.

TABLE 32. Priority streams and reaches, limiting factors and action for enhancement and habitat assessment for the Comox Lake watershed (Source: Caw, 1977; Russell et al, 1990; Province of BC, 2011).

Rank	Stream	Reach	Species Presence*	Primary Limiting Factors (Rated as Poor)**		
1	Cruikshank	1	High	% pool area	% wetted area	LWD/Bankfull width
		3	High	% pool area	% wetted area	LWD/Bankfull width
2	Comox	1	High	% pool area	LWD/Bankfull width	% boulder cover
		2	High	% pool area	LWD/Bankfull width	% boulder cover
3	U. Puntledge	1	High	Off-channel habitat		
		2	High	Requires Habitat Assessment		
4	U. Puntledge	4	Low	Requires Habitat Assessment		
		5	Low	Requires Habitat Assessment		
5	Rees	1	Low	% pool area	LWD/Bankfull width	
		2	Low	% boulder cover	% fines	

* see Table 3 for details.
** see Table 5 for details.

Nutrient Additions in the Comox Lake Watershed

Russell et al (1990) point out that streams flowing into Comox Lake are ultra-oligotrophic and this is a major factor in the amount of fish the watershed can produce. She determined cutthroat trout, Dolly Varden char and rainbow trout fry population estimates for the sampled reaches and used an alkalinity model to determine the theoretical and estimated capacity of the reaches she sampled (Appendix 4). I compared these two estimates and found a large difference between them in every case (Table 33).

TABLE 33. Comparison of estimated and theoretical fry capacity and the percent difference between the two estimates. The % difference represents the amount the reach is under capacity (data from Russell 1990).

Priority	Stream	Reach	Estimated Population	Theoretical Population	Difference	Action
1	U. Puntledge	5	2,310	19,022	88%	water quality monitoring & stream fertilization
2	Comox	1	3,388	16,444	80%	water quality monitoring & stream fertilization
		2	1,848	8,969		
	Cruikshank	1	9,504	13,200	28%	
		2	990	1,375		
		3	1,796	2,494		
		4	756	1,050		
N/A	U. Puntledge	1	1,782	4,050	56%	no action
		2	2,049	3,105	35%	
		3	1,485	2,250	33%	

Nutrient addition studies on Vancouver Island and the Lower Mainland have resulted in increases to juvenile steelhead production (Pellett, 2010) and stream fertilization may also stimulate the production of cutthroat trout juveniles in Comox Lake tributaries, and possibly the shoals of Comox Lake. I suggest that the feasibility and cost:benefit of nutrient enrichment in the Comox Lake watershed be investigated and, if the results are favourable, that nutrient addition proceed in tributaries where the difference between the theoretical and estimated capacity is greatest; i.e. Reach 5 of the Upper Puntledge River, and Comox Creek. I do not recommend fertilizing the Upper Puntledge because of the presence of hatchery coho in that system.

In addition to reviewing the feasibility and cost: benefit of nutrient addition, I recommend that future studies also test the efficacy of carcass analogs for nutrient restoration in Comox Lake tributaries. A 2007 study by Pearsons et al. found that carcass analogs have the potential to restore food pathways previously provided by salmon and have many desirable properties such as ease of distribution and potentially high ecological benefits relative to costs. As part of this evaluation it will also be important to determine if providing a food source such as a carcass will benefit the 0+ cutthroat trout in Comox Lake streams, or if nutrient addition that increases periphyton production would be more beneficial to these fish. Finally, I suggest that limestone, which has been used to increase nutrient levels in freshwater systems in Sweden, also be investigated as a potential nutrient source for the Comox Lake watershed.

8.0 Comox Lake Fish Stock and Fisheries Assessment, Monitoring and Enhancement Plan

I have presented a fish stock and fisheries assessments and habitat enhancement plan in Table 34. This plan lists projects focused on assessing the state of stocks and fisheries and implementing work to enhance the production of cutthroat in Comox Lake and tributaries. Suggested work can be implemented by the Courtenay and District Fish and Game Protective Association and/or Ministry staff. Results of the fisheries and stock assessments should be used not only for monitoring, but also for adjusting regulations and fisheries management objectives and targets outlined in Section 6.

TABLE 34. Comox Lake fish stock and fisheries assessment, monitoring and enhancement plan; 2012 and beyond.

Project	Date	Activities	Responsibility
		Comox Lake Fishery	
Angler Counts and Creel Surveys	2014	Fill data gaps identified in 2009 and provide additional data regarding fish size and angler preferences by: continuing angler counts and creel surveys; conducting angler preference survey during angler interviews. Monitor angler success rate to ensure fisheries management objectives are being met	Fieldwork Courtenay Fish and Game Association Volunteers Technical Support (field book templates and survey forms: Province of BC.
Courtenay Fish and Game Association Angler Record	ongoing	Fill data gaps including trip length and release rates.	Fieldwork Courtenay Fish and Game Association participants.
		Comox Lake Fish Stocks	
Gillnetting Assessment	August, 2013	Repeat the gillnetting assessment to confirm numbers, lengths and maturity of cutthroat stocks. Note consider re-locating gillnets to Section A based on local information:	Fieldwork Courtenay Fish and Game Association volunteers; Province of BC Data Analysis Contractor for scale reading.
Repeat Index Snorkel Survey	2014	Repeat Lough (2011); snorkel survey of Upper Puntledge, Rees and Comox creeks.	Technical Support Province of BC Fieldwork/Data Analysis: Consultant; Province of BC
Juvenile Assessment	2013	Water levels were too high in 2011 to complete these assessments effectively. Conduct electrofishing assessments at Rees and Erick creeks and Upper Puntledge River to determine juvenile trout presence and densities and compare to Russell et al (1990).	Technical Support Province of BC Fieldwork/Data Analysis: Consultant, Province of BC; Courtenay Fish and Game Association volunteers;
		Comox Lake Watershed Habitat Assessments	
Level 1 Watershed Restoration Program (WRP) Inventory	2013	Conduct habitat assessment to document rearing habitat available in the Comox Lake watershed. Also conduct assessments on Rees and Erick Creeks and Reaches 2-5 of Upper Puntledge River.	Technical Support Province of BC Fieldwork/Data Analysis: Consultant, Province of BC; Courtenay Fish and Game Association
	2012	Review habitat assessment, juvenile cutthroat abundance and coho stocking levels to ensure habitat is seeded at appropriate levels and stocking is consistent with stocking agreement between Fisheries and Oceans and Province of BC. Request no stocking in Upper Puntledge.	Data Analysis: Province of BC

Project	Date	Activities	Responsibility
		Comox Lake Watershed Habitat Restoration and Enhancement	
Habitat Enhancement –Comox Lake Tributaries	2012	Conduct a Level 2 WRP Assessment and develop restoration prescriptions for priority areas identified.	Province of BC in consultation with Courtenay Fish and Game Association
	2013	Implement habitat restoration projects identified in Level 2 WRP assessment.	Technical Support Province of BC Fieldwork/Data Analysis: Consultant, Courtenay Fish and Game Association
Habitat Enhancement – Comox Lake and Tributaries	2012	Conduct nutrient addition feasibility and cost: benefit analysis.	Technical Support Province of BC – Water Quality Branch; Fisheries Branch Assistance with Data Analysis and Planning: Consultant
	2013	Conduct preliminary water quality assessment to determine potential for lake fertilization projects	Technical Support Province of BC – Water Quality Branch; Fisheries Branch Assistance with Data Analysis and Planning: Consultant
	2013	Conduct bathymetric profile to determine potential for lakeshore enhancement with Large Woody Debris	Technical Support Province of BC – Water Quality Branch; Fisheries Branch Assistance with Data Analysis and Planning: Consultant
	2014	Develop and implement restoration monitoring program for restored streams (e.g. electrofishing); and lake (e.g. minnow trapping) to determine success of restoration projects.	Technical Support Consultant Fieldwork Courtenay Fish and Game Association volunteers

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Appendix 1.
Comox Lake creel calendar 2010

January '10

Su	M	Tu	W	Th	F	Sa
					1	9:00
3	4	5	12:00	7	8	9
10	11	8:00	13	14	15	16
10:00	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February '10

0.42	M	Tu	W	Th	F	Sa
	1	2	3	4	9:00	6
7	8	9	10	11	12	12:00
14	15	16	17	18	19	20
11:00	22	23	24	11:00	26	27
28						

March '10

0.42	M	Tu	W	Th	F	Sa
	1	2	3	4	5	6
10:00	13:00	9	10	11	12	13
11:00	15	16	9:00	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

April '10

0.42	M	Tu	W	Th	F	Sa
				1	2	10:00
4	5	6	7	9:00	9	10
11	12	13	14	15	16	17
18	19	13:00	21	22	23	24
13:00	26	27	28	29	30	

May '10

0.42	M	Tu	W	Th	F	Sa
						13:00
2	3	4	5	12:00	7	8
14:00	10	11	13:00	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	10:00
30	31					

June '10

0.42	M	Tu	W	Th	F	Sa
		1	14:00	3	4	5
6	7	8	9	10	11	13:00
13	14	15	15:00	17	18	19
20	21	22	23	24	25	26
27	10:00	29	30			

July '10

0.42	M	Tu	W	Th	F	Sa
				1	2	16:00
4	5	12:00	7	8	9	10
11	12	13	14	15	16	13:00
18	13:00	20	21	22	23	24
25	26	27	28	29	30	31

August '10

0.42	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
10:00	8:00	17	18	19	20	21
14:00	23	24	25	26	27	28
29	16:00	31				

September '10

0.42	M	Tu	W	Th	F	Sa
			1	2	3	4
9:00	6	7	12:00	9	10	11
12	13	14	15	16	17	18
15:00	20	21	22	23	24	25
26	27	28	11:00	30		

October '10

0.42	M	Tu	W	Th	F	Sa
					1	2
10:00	4	5	6	7	8	9
11:00	11	12	13	14	15	12:00
17	13:00	19	20	21	22	23
24	25	26	27	28	29	30
31						

November '10

0.42	M	Tu	W	Th	F	Sa
	1	2	3	4	10:00	6
7	8	13:00	10	11	12	13
14	15	16	17	18	19	10:00
21	22	23	24	25	26	27
12:00	29	30				

December '10

0.42	M	Tu	W	Th	F	Sa
			1	2	3	11:00
5	6	7	8	9	10	11
13:00	13	14	15	16	12:00	18
19	20	21	9:00	23	24	25
26	27	28	29	30	31	

Appendix 2.
Instant angler count data and angler effort and catch information.

Expanded Effort	Observed Effort	Fishable Hours	Number of Days	Expanded effort	Instant Count	Expanded effort
09-Apr						
weekdays	1	14	20	280	4.67	60
weekends	0	14	10	0	4.67	0
total	1		30	280		60
09-May						
weekdays	7	15	20	2100	5.00	420
weekends	22	15	11	3630	5.00	726
total	29		31	5730		1146
09-Jun						
weekdays	8	16	22	2816	5.33	528
weekends	22	16	8	2816	5.33	528
total	30		30	5632		1056
Jul-09						
weekdays	9	16	22	3168	5.33	594
weekends	26	16	9	3744	5.33	702
total	35		31	6912		1296
09-Aug						
weekdays	10	14	20	2800	4.67	600
weekends	0	14	11	0	4.67	0
total	10		31	2800		600
09-Sep						
weekdays	4	12	21	1008	4.00	252
weekends	17	12	9	1836	4.00	459
total	21		30	2844		711
09-Oct						
weekdays	4	11	21	924	3.67	252
weekends	7	11	10	770	3.67	210
total	11		31	1694		462
09-Nov						
weekdays	5	9	20	900	3.00	300
weekends	0	9	10	0	3.00	0
total	5		30	900		300
09-Dec						
weekdays	0	8	22	0	2.67	0

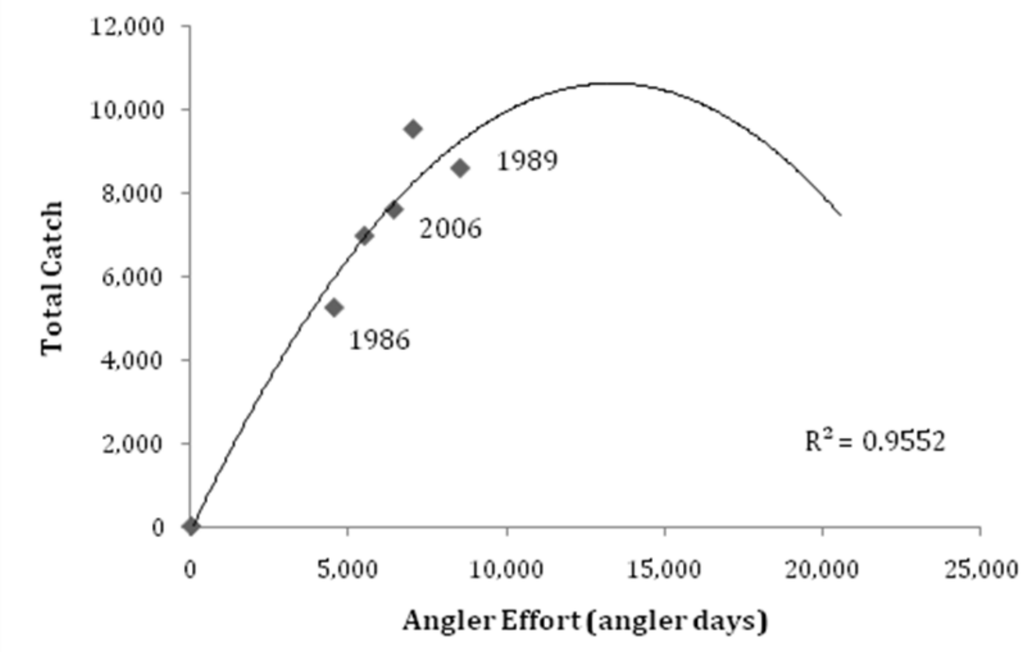
Expanded Effort	Observed Effort	Fishable Hours	Number of Days	Expanded effort	Instant Count	Expanded effort
weekends	0	8	9	0	2.67	0
total	0		31	0		0
10-Jan						
weekdays	0	8	20	0	2.67	0
weekends	3	8	11	264	2.67	99
total	3		31	264		99
10-Feb						
weekdays	3	10	20	600	3.33	180
weekends	2	10	8	160	3.33	48
total	5		28	760		228
10-Mar						
weekdays	0	12	23	0	4.00	0
weekends	0	12	8	0	4.00	0
total	0		31	0		0
10-Apr						
weekdays	2	14	21	588	4.67	126
weekends	0	14	10	0	4.67	0
total	2		31	588		126
10-May						
weekdays	1	15	20	300	5.00	60
weekends	0	15	11	0	5.00	0
total	1		31	300		60
10-Jun						
weekdays	21	16	22	7392	5.33	1386
weekends	11	16	8	1408	5.33	264
total	32		30	8800		1650
10-Jul						
weekdays	14	16	21	4704	5.33	882
weekends	7	16	10	1120	5.33	210
total	21		31	5824		1092
10-Aug						
weekdays	19	14	21	5586	4.67	1197
weekends	15	14	10	2100	4.67	450
total	34		31	7686		1647
10-Sep						
weekdays	2	12	21	504	4.00	126

Expanded Effort	Observed Effort	Fishable Hours	Number of Days	Expanded effort	Instant Count	Expanded effort
weekends	20	12	9	2160	4.00	540
total	22		30	2664		666
10-Oct						
weekdays	0	11	20	0	3.67	0
weekends	0	11	11	0	3.67	0
total	0		31	0		0

Appendix 3.
Summary of analyses of data from the Vancouver Island Lakes Questionnaire.

Angler Effort

Angler effort at Comox Lake was ~3,510 angler days in 1986 and reached its highest recorded level in 1989 exceeding 8,500 angler days(Aitzhanova, et al. 2003, Andrews, 2007). By 2006, angler effort had dropped by 25% to ~ 6,400 angler days.



Angler effort (angler days) and total catch at Comox Lake 1986 – 2006 (Source: Aitzhanova, et al. 2003, Andrews, 2007).

Angler Catch and Harvest

Between 1986 and 2002, total catch at Comox Lake increased by ~80% from 5,265 to 9,560 fish. Recent angler interviews conducted by the Courtenay Fish and Game show that in 2009 and 2010, ~80% of the catch at Comox Lake was cutthroat and the total harvest rate was 79%. If the same was true from 1986 – 2002 then almost ~6,000 cutthroat trout would have been caught and almost 5,000 of those harvested at the lake in 2006.

Total catch, and estimated catch and harvest of cutthroat trout at Comox Lake 1986 – 2006 (Source: Aitzhanova, et al. 2003, Andrews, 2007; angler interviews conducted by Courtenay Fish and Game Club April, 2009 – October, 2010).

Year	Total Catch	Estimated Catch of Cutthroat	Estimated Harvest of Cutthroat
1986	5,265	4,317	3,411
1989	8,623	7,071	5,586
1992	6,993	5,734	4,530
2002	9,563	7,842	6,195
2006	7,625	6,253	4,939

Appendix 4.
Summary of results of fish assessments by Russell et al, 1990.

1. Electrofishing Results

Habitat types, total number, age, mean size (mm) and estimated density (number/m2) of each species captured by electrofishing at Comox creek, the Cruikshank and Upper Puntledge Rivers in 1989 (Source: Russell, et al, 1990).

Stream	Site	Habitat Type	Species	Age	Number Captured*	Mean Size (mm)	Estimated Density (number/m^2)
Comox	20	Riffle/glide	cutthroat	0	17	39.5	0.24
			cutthroat	1+	9	89.8	0.14
			Dolly Varden	1+	1	75.0	0.01
Cruikshank	63	Riffle	cutthroat	0	31	38.4	2.15
			Dolly Varden	1+	1	76.0	0.07
U. Puntledge	330	Riffle/pool	cutthroat	0	3	58.0	0.15
			cutthroat	1+	2	128.0	0.10
			rainbow	0	11	56.5	0.57
			rainbow	1+	4	105.8	0.21
U. Puntledge	335	Riffle/glide	rainbow	0	9	39.3	0.67

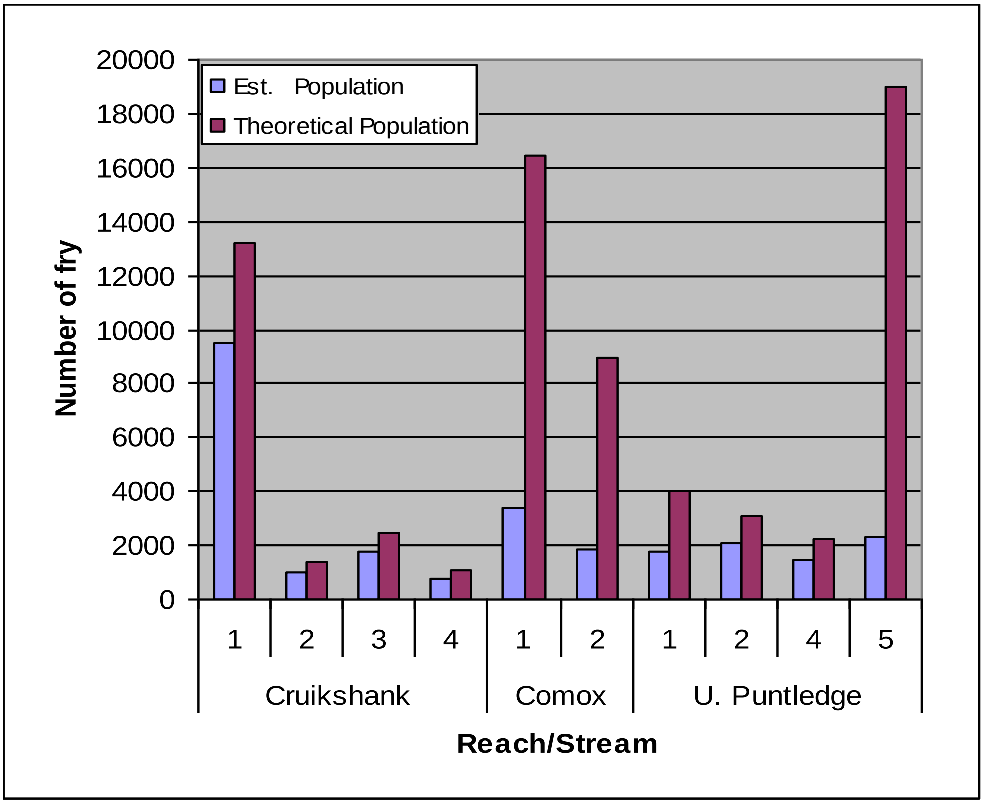
*total of both passes.

Russell et al (1990) used a preliminary Fisheries Assessment and Improvement Unit (FAIU) habitat capability model to estimate theoretical maximum density for cutthroat fry and parr. Trout fry abundance ranged from 9 – 24 fry/100m^2 at the four electroshocking sites (numbers of fry /100m^2 – fry per unit area or FPU). When adjusted for hydraulic usability, Russell et al (1990) calculated a maximum of 22.2 – 44.4 FPU. Note that no coho were captured at any sites indicating competition between these two species was not a factor in determining abundance. Densities in all sample sites were relatively low suggesting inadequate escapement to saturate available fry habitat (Russell, et al, 1990).

Summary of trout fry density information for four sample sites where hydraulic usability data was collected (Source: Russell, et al, 1990).

Stream	Site	Sampled FPU	Mean Size (g)	Adjusted FPU	% Saturation
Comox	20	24.0	0.6	44.4	22
Cruikshank	63	9.2	0.5	35.6	16
U. Puntledge	330	8.9	1.9	22.2	33
U. Puntledge	335	10.8	0.8	32.7	18

2. Estimated vs. Theoretical Production



Estimated population and carrying capacity of trout fry in Comox Creek and the Cruikshank and Upper Puntledge Rivers (Data are from Russell et al, 1990).

Appendix 5.
Results of habitat assessment and minnow trapping conducted by Fisheries Section staff, August, 2011.

1. Habitat Assessment Results

Date	23-Aug-11		UTM Start	UTM Finish
Start Time	11:45		103423025487953	103419765489714
Finish Time	17:00		Stream Temp	16.1⁰
Location	Upper Puntledge Reach 1 - Willimar Lake to Comox Lake			
Crew	Brendan Anderson	Tracy Michalski	Weather	raining; warm

Site	1	2	3	4
Location	Lake Outlet	Log Jam to Log Jam	Log Jam to Dry Tributary	Dry Tributary to Bridge U/S Comox Lake
UTM	103423025487953	103422845487455	103422115488391	103419095489234
Habitat Type	glide	riffle; pool	glide; pool	riffle; pool
Channel Width (m)	30	15	22	18
Wetted Width (m)	30	15	19	18
Gradient (5)	0.5	1	0.5	1
Residual Pool Depth (m)	1 meter			
Stage	medium/high	medium/high	medium/high	medium/high
Cover	LWD; functional	LWD; functional; boulder	no significant cover	no significant cover
Instream Vegetation	aquatic vegetation		aquatic vegetation	
Substrate	<20% cobble; most of site is gravel covered with fines	boulder; gravel; some cobble	gravel; fines	gravel; cobble
Riparian Vegetation	mixed	mixed	mixed	mixed
Stage	mature forest			
Islands	none	instream	none	none
Bars	none	none	side	
Coupling	partial	partial		
Confinement	occasional confinement	defined channel		
Photos	1, 2, 3, 4	6-16	5 photos of log jam; 3 of site; 6 photos taken at downstream end near confluence.	

Site	1	2	3	4
Location	Lake Outlet	Log Jam to Log Jam	Log Jam to Dry Tributary	Dry Tributary to Bridge U/S Comox Lake
Notes	very "lake-like" site; low velocity flows; highly vegetated; some deep pools (~2 meters) for ~50 meters; another 2 pools (~20 m length) and 1.5-2 meters deep); lots of woody debris but little that is functional (i.e. creating scour); site is primarily glides; upper 50 meters of site is different from lower 450 m; at start habitat is deep pool with boulders with slightly more constrained channel and higher flow velocity; substrate then changes to cobble, gravel with many old redds extending for ~100 meters; then bottom substrate dominated by wood and bark chips and channel is more like a lake outlet with low flow; few fish relative to later reaches. Site end in large log/debris jam.	site 2 starts below log jam in large deep pool with large cutthroat; site then picks up gradient and flow; more frequent pools and riffles; substrate has some boulders at start and some large woody debris; many more fish in this site than previous; cutthroat primarily associated with LWD and boulders - some functional LWD present - could put more LWD in to enhance habitat more; site is characterized by several large pools (>2meters residual depth); lots of pools formed by boulders; numerous tertiary pools.	log jam at start of site is 143 meters long and has been at site for many years; site has more frequent gravel bars and side/secondary channels; slow moving water more like first site; fairly slack water; few fish and few areas of cover; substrate gravel and covered with algae (gonphonemia); and other instream vegetation and plants; freshwater mussels present.	

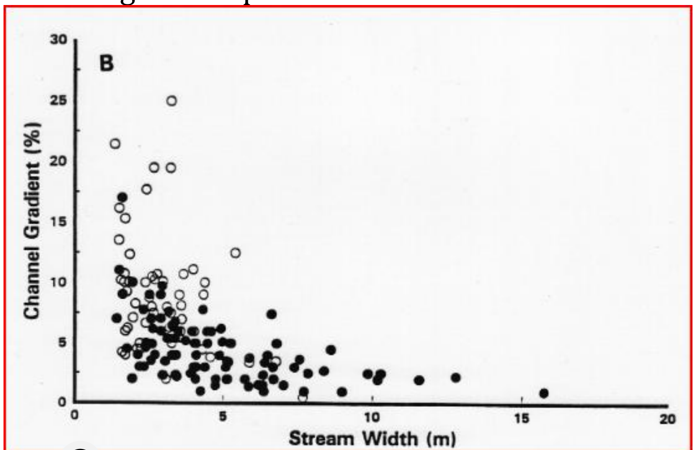
2. Minnow Trapping Results

	Coho				Other
Trap #	1	2	3	Total	
Site 1	20	30	2	52	3 sculpin
Site 4	26	17		43	120 mm Dolly Varden; 1 sculpin
Total	46	47	2	95	

*coho were various sizes - <10 gm

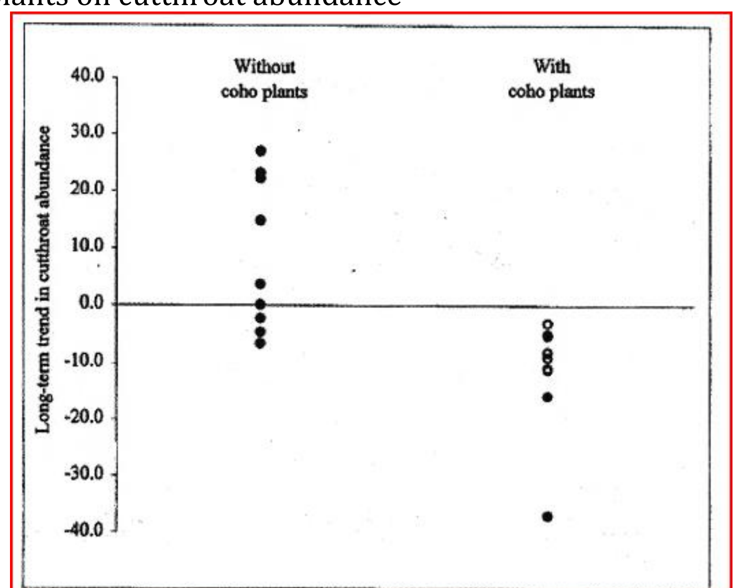
Appendix 6.
Summary of studies and information on cutthroat trout habitat and preferences

1. Stream width and channel gradient preferences



Presence ( ) and absence ( ) of cutthroat trout in relation to channel gradient and stream width (Reid, 2011; unpublished).

2. Effects of coho plants on cutthroat abundance



Long-term trend in abundance of coastal cutthroat trout in Washington streams with and without planted hatchery coho fry after 1985. Open circles indicate trends in coastal cutthroat trout adult numbers, closed circles indicate trends in coast cutthroat trout juveniles. Trends in adults were compared to coho fry plants 4 years before (Reid, 2011; unpublished).

Appendix 7. Examples of restoration projects including LWD placement designs.

Summary of Cruikshank River reach 1 and 2 gradient, bankfull width, discharge, substrate and channel type and associated proposed LWD design.

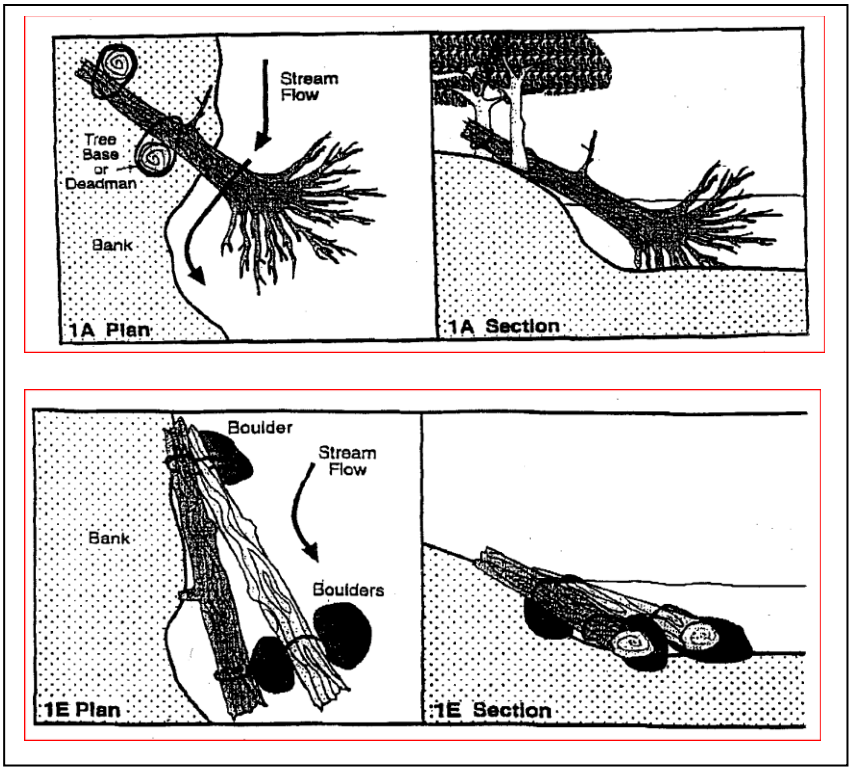
Stream	Reach	Gradient (%)	Average Bankfull Width (m)	Discharge (m^3/sec).	Substrate	Chanel Type	LWD Design Proposed*
Cruikshank River	1	0.8	30 m (varies from 25-60)	11.3	Fines: 10% Gravel: 50% Cobble: 30% Boulder: 10%	abundant exposed substrate bars; side and back waters; heavily rooted banks frequently undercut; many large, deep pools; 80% runs	1A. Anchored Rootwad; 1E. LWD/Boulder; 1H. Mini-log Jam
	3	2.3	18 (varies from 15-22)	5.1	Described as similar to Reach 1 but narrower bed; lower discharge and higher gradient	lack of large pools; spawning and rearing capabilities are high	

* Source: WRP Level II Template, Vancouver Island Region

Restoration Structure Specifications

Design 1A and 1 E. Anchored Rootwad and LWD/Boulders (Figure 8)

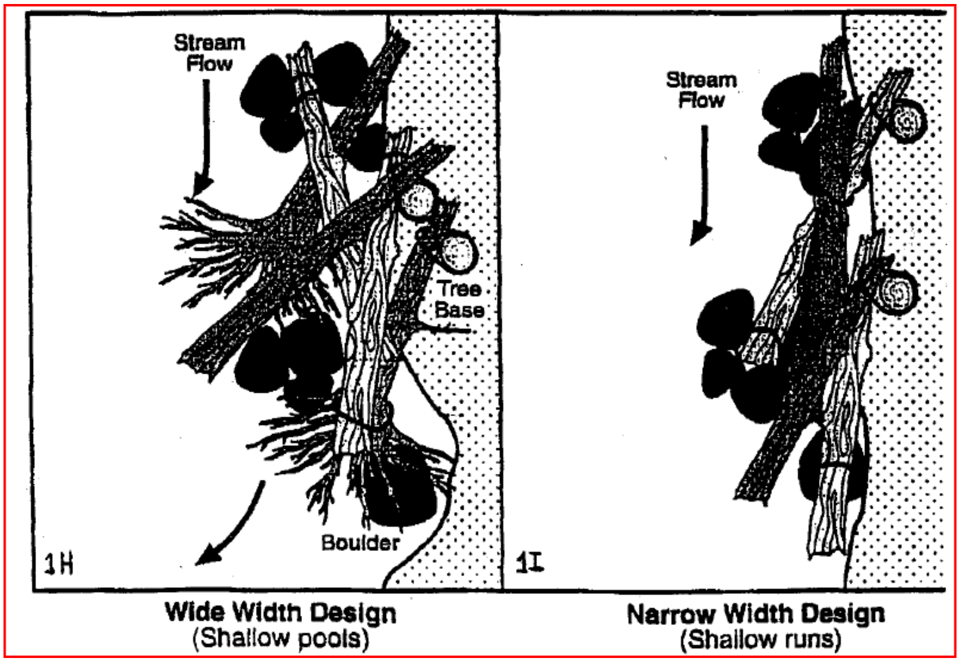
- Target on shallow pools, runs and riffle pockets lacking cover.
- Retain 2/3 of channel width.
- Angle logs or log-rootwads 30 – 450 downstream.
- Log size to increase with channel width (15 m > 50 cm; 20 m > 60cm).
- Target on 2 logs unless log-rootwad is used.
- Place rootwad into pools.
- Target frequency: 3-4 structures per channel width.
- Use cedar where possible.
- Attachments: galvanized cable, epoxy secured to boulders; duckbill anchors.



Plan and section view of anchored rootwad (1A) and LWD/boulders (1E) structure designs (Source: WRP Level II Template, Vancouver Island Region, 1997).

1H. Mini-Log Jam (Figure 9).

- Select locations in shallow pools and shallow runs.
- Target log-jam < 1/3 bankfull channel width.
- Locate on stream bends.
- 3-6 logs (5 target) or rootwads.
- Logs connected by galvanized cables.
- Use boulders as ballast.
- Cedar where possible, but mixed as needed (local materials).
- Pre-excavate under jam if coarse substrate.
- Attachments: ballast (galvanized cables), epoxy to boulders.



Plan and section view of anchored rootwad (1A) and LWD/boulders (1E) structure designs (Source: WRP Level II Template, Vancouver Island Region, 1997).