Clowhom Project Water Use Plan

Role of Littoral Zone in Governing Clowhom Reservoir Productivity Capacity

Implementation Year 6

Reference: COMMON-2

Fish Productivity Monitoring Summary Report (2006, 2008-2011, 2016)

Study Period (Year 6): August – September, 2016

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Executive Summary

The Clowhom Lake Fish productivity monitoring study was developed and initiated in 2006 to assess changes in fish productivity. This planned monitoring program was in response to identified data gaps and knowledge of the reservoir ecology that may limit decision-making processes under the WUP.

It is speculated that fish productivity had decreased following the impoundment of the two Clowhom Lakes in 1956 and that this decrease may be a result of loss in productive littoral habitat. Little data existed to support this hypothesis prior to the WUP. As a result of concerns regarding the long-term productivity of the reservoir and recommended operational changes implemented following the WUP, a 20-year fish productivity monitoring plan was implemented. The first year of sampling occurred in 2006 with sampling to occur every 2 years (year 1, year 3 and year 5) and then at five-year intervals throughout the remainder of the 20-year period (year 10, 15 and 20). Additional funding in 2012 and 2014 allowed the addition of these sample periods, effectively increasing the data set required to review operational impacts.

In 2016, the first 10-year period was completed. Results for each sample period have been presented in earlier documents (Bates, 2007 and 2009, Bates and Coombes, 2012; Bates and Paul, 2011). This document summarizes earlier data into a 10-year summary.

Results of the surveys along with juvenile fish habitat survey data on Clowhom River (2009) have not adequately addressed the management questions identified in the Clowhom Water Use Plan (WUP). Additional data analysis, in particular the ELZ coupled with the managed drawdown schedules will allow a better understanding of the results (Bruce 2018).

The following recommendations for the next phase of sampling are proposed in response to the low catch data and continued un-answered management questions. In particular three key recommendations are presented.

1. Increase fish sampling both spatially and temporally. Sample numbers in the last phase is low and key species and age class data are missing. Presently the limited sampling will result in low power, but given the project length will result in a long data set. It is suggested that increasing sample size would improve the expected low power, improving the end result.

2. Qualify and quantify key habitats for salmonid life history in tributaries to Clowhom Lake and lower Clowhom River. Young-of-the-Year salmonids are noticeably absent in lake capture data. As a result, salmonid use of habitats by age class and the importance of these habitats for reservoir recruitment is poorly understood.

3. Include sampling of water chemistry and water quality parameters into bi-annual sampling protocols in order to better understand potential nutrient limiting factors and possible influence on fish productivity in the Clowhom Reservoir.

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Introduction

In 2005, BC Hydro concluded the water use planning (WUP) process for the Clowhom hydroelectric facility (BC Hydro, 2005). This planning process, designed to identify potential operating strategies for the Clowhom facility identified key knowledge gaps and understanding of the environmental impacts of the operational model on area fish and wildlife.

At its conclusion, the planning process recommended three operational changes for the Clowhom facility that would potentially have an impact on fish and wildlife success in and near the reservoir. These changes included:

- Raising the minimum reservoir operating levels from 47m to 49m
- Limiting annual maintenance-related drawdowns to the late winter period (March) when seasonal lows are expected, and;
- Increase the diversion license from 82cms to 100cms.

In 2006, the Sechelt First Nation and BC Hydro began the first year of a 20-year monitoring program documenting fish productivity in the Clowhom Lake Reservoir (COMMON-2). The monitoring program was implemented following recommendations made during WUP process and addresses a key data/knowledge gap required for support of the recommended operational changes. In the initial baseline study by *Bruce* (2003) a decrease in reservoir productivity was reported following the impoundment and creation of Clowhom Lake Reservoir in 1956. As a result, and following the WUP CC recommendations, BC Hydro developed the fish productivity-monitoring program in an attempt to address concerns and bottlenecks to salmonid production and potential means of improving fish populations following operational changes.

The monitoring program addresses specific management questions, that include:

- Does fish productivity change through time following the WUP implementation?
- Is any observed change correlated with changes in effective littoral zone changes?
- Is the population of salmonids in Clowhom lake recruitment limited and what role does the river play?
- If no change is observed what is the reason for the decline initially?
- Do operation-based solutions exist for the reservoir that would benefit fish productivity?

The purpose of this report is to collate and present data collected from the first 6 sample periods, encompassing a 10-year period, of the fish productivity monitoring program. The results allow general inferences and provide recommendations for changes to the second phase of the monitoring study.

1.0 Study Area

The Clowhom Lake is a 745ha reservoir located at the head of Salmon Inlet northeast of Sechelt BC. The creation of the reservoir occurred in the 1950’s with the construction of the

Clowhom Falls dam and the flooding of two smaller lakes resulting in the present-day impoundment. **Figure 1** shows the location of Clowhom Lake in relation to Sechelt BC.

The study area for this project includes the entire reservoir with 9 pre-selected sampling locations. These locations correspond to sites reported by *Bruce* (2003) and *Bates* (2007, 2009) and represent both the upper and lower portion of the reservoir. **Figure 2** shows the fish sampling locations in the Clowhom Reservoir.

2.0 Methods

3.1 Fish Sampling

Fish collection was completed in the years 2006, 2008, 2010, 2012, 2014 and 2016, by a two-person field crew. Sampling occurred in late summer between the end of August and the end of September using floating and sinking gill nets and baited "Gee" minnow traps. Gill net configurations were consistent with the mesh sizes recommended for lake inventory by the B.C. Resource Inventory Committee (*RIC*, 1998) and *Bruce* (2003).

The terms of reference (TOR) did not require sampling in 2012 and 2014. Additional funding opportunities provided the opportunity to include the additional sampling seasons and inclusion in this summary report.

Table 1 provides the dates and reservoir water elevation for each sample year.

Table 1: The dates and surface water elevation on each sample year for the Clowhom Lake Reservoir. Dates varied depending on weather and lake working conditions.

Sample	Field Dates	Reservoir Elevation (masl)
1	September 13, 18 and 19, 2006	52.05
2	August 25 and 26, 2008	52.59
3	Sept 16 and 17, 2010	46.38
4	September 12 and 13, 2012	51.98
5	September 3 and 4, 2014	52.54
6	September 22 and 23, 2016	51.57

Three netting strategies were employed; floating; sinking and drift sets. The floating and sinking sets were anchored near the shoreline and oriented perpendicular to the lake edge. The drift net was released perpendicular to the lake mid-line or e-line and allowed to move with the wind and lake current(s). All net sampling was restricted to 3-hour soak times to minimize salmonid mortality. All captured salmonids were retained for detailed biometric data collection.

In addition to gill net sets, minnow traps were used to sample near shore habitats. Minnow traps were set in groups of 5 and baited with preserved chum salmon roe. The trap bait was contained in small "perforated" containers in order to prevent consumption by captured fish.

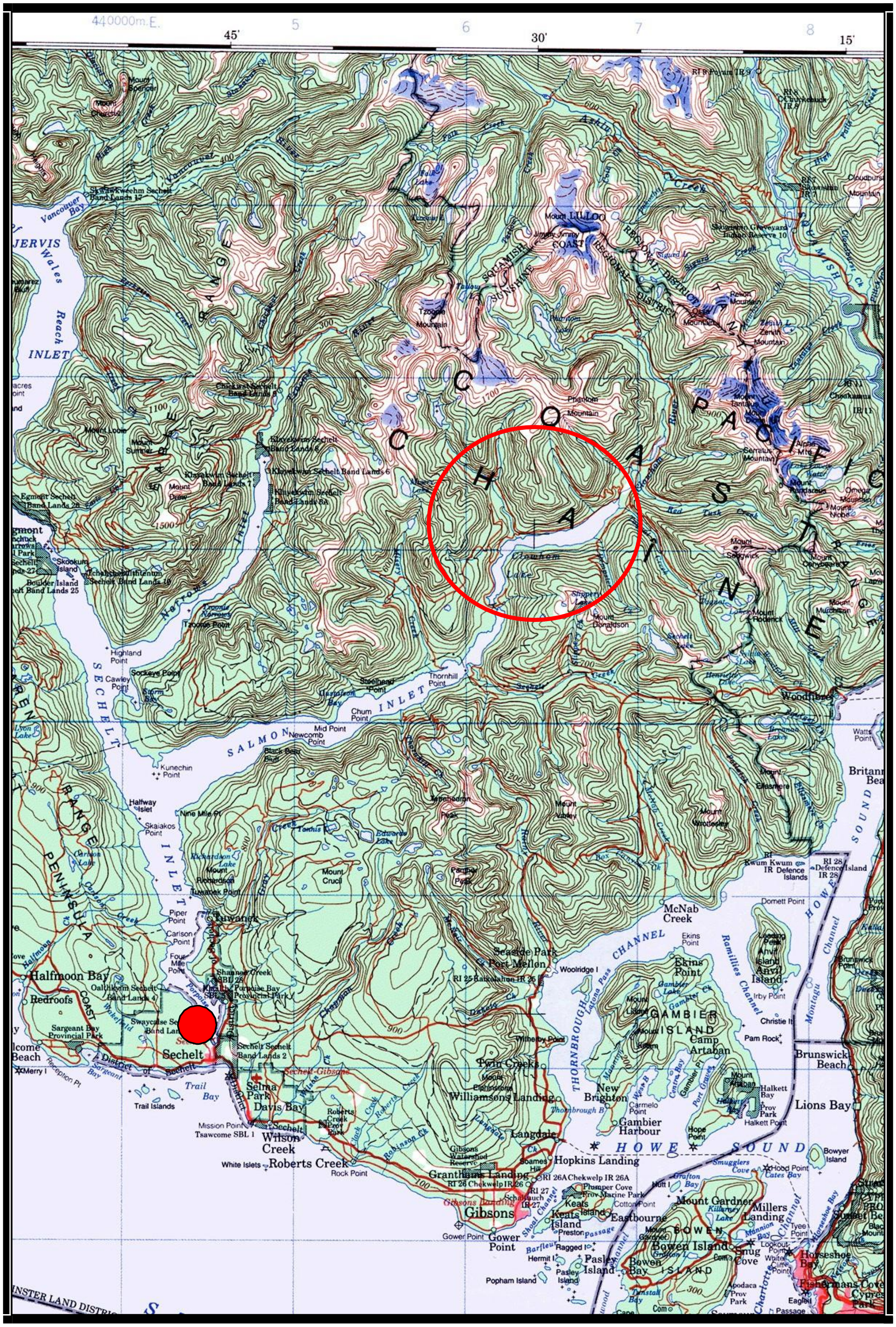

Figure 1: Location of Clowhom Lake (red circle) in relation to Sechelt (red dot), BC

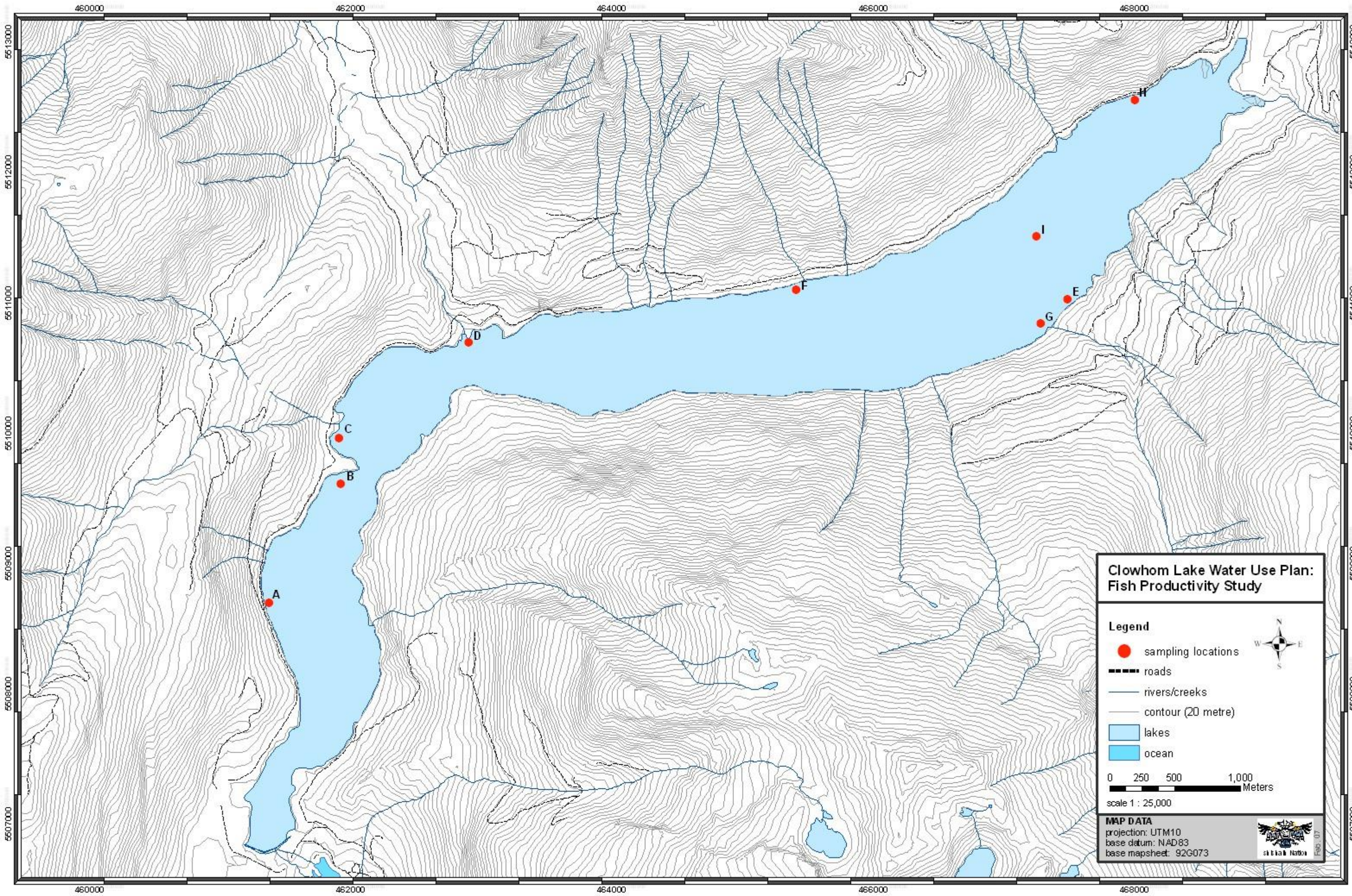

Figure 2: Sample locations selected for the gill net and minnow trapping of fish within Clowhom Reservoir. Each location is identified along the shoreline with flagging tape (Bates, 2007).

Traps were then set at mid-day and allowed to fish over night for a 24- hour period.

All sample locations are flagged along the lake shoreline and georeferenced using a Garmin handheld GPS receiver (60CSx). Sample locations remain the same in each sample year. Locations are highlighted on **Figure 2** and **Table 2** reports the targeted set times, spatial coordinates and gear used at each location.

Table 2: Type and set times for the sampling gear used to collect fish samples in the Clowhom Lake Reservoir for each sample year of the fish productivity study.

Site ID	UTM		Gear	Duration	Soak Time
	Northing	Easting			
A	5508579	461286	Float GN	Day	3:00
B	5509613	461887	Sink GN	Day	3:00
C	5509915	461774	MT	Night	24:00
D	5510722	462958	MT	Night	24:00
E	5510961	464552	Float GN	Day	3:00
F	5511065	467434	Sink GN	Day	3:00
G	5510897	467399	MT	Night	24:00
H	5512518	467991	MT	Night	24:00
I	-	-	Drift GN	Day	3:00

Note: GN = gillnet and MT minnow traps (5)

3.2 Fish Biometrics

All captured fish were enumerated and recorded by collection method. Captured salmonids were identified to species; the fork length measured to the nearest millimeter (mm) and wet weight nearest 0.1 grams were measured (*Bates*, 2007). Scale samples were collected from representative size ranges of each species following standard scale collection methodology and placed on glass microscope slides. The scales were then compressed with another slide, labeled and stored for future reading. Live fish (those in the Gee traps), were also identified and enumerated then released unharmed. All dead fish collected in gill nets were retained and returned to the lab. Dead fish (gill net captures) were dissected and stomachs of each fish removed and opened for examination of the contents

3.3 Scale Analysis

Scales from each captured salmonid (older than young-of-the-year) were reviewed under a dissecting microscope and a scale selected for clarity. The representative scale(s) was photographed using a digital camera mounted on the microscope and the image stored as a JPEG file. Images were later read using image preview software on a desktop computer.

Scale analysis was consistent with the iterative fashion reported by Bruce (2003) and the age is reported using the convention n+ values where the 'n' denotes the age as a full year and the '+' a partial year.

3.4 Fish Data Analysis

Captured fish were recorded by catch type and catch-per-unit effort (CPUE). The CPUE for each sample year were then compared to one another along with the CPUE reported in Bruce (2003). Similarly, length, weight and condition coefficients were summarized and compared between sample years for each species and age class. Condition coefficient (CC) was calculated using:

Equation (1): $$CC = WT \times LT^{-3} \times 100$$

Where: CC = condition coefficient
WT LT = wet weight in grams
= nose to fork length in cm

3.0 Results

4.1 Fish Capture

A total of 161, 96, 120, 64, 43 and 67 fish were caught in 2006, 2008, 2010, 2012, 2014 and 2016 respectively. These catches broke down further with salmonids representing 11.8%, 22.0%, 25.0%, 25.0%, 20.9% and 19.4% of the total catch and the balance in each year consisting non-salmonid catches. **Table 3** provides the salmonid and non-salmonid species captured during the fish productivity monitoring study. All non-salmonids were caught along the shoreline in minnow traps.

Total catch during each sample years was also separated by capture method (net versus traps) and the catch reported by sample location used for each capture method (**Table 4**). All net caught fish were sacrificed and retained for dissection. Fish caught in the minnow traps were released unharmed. **Table 5** summarizes the spatial distribution of the minnow trap catches and the related reservoir tributaries.

Table 3: Species captured in Clowhom Lake reservoir between 2006 and 2016.

Salmonids		Non-salmonids	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Cutthroat Trout (CCT)	*Oncorhynchus clarkii*	Prickly sculpin (CAS)	*Cottus asper*
Rainbow Trout (RB)	*O. mykiss*	Three-spine stickleback (TSB)	*Gasterosteus spp.*
Kokanee (KO)	*O. nerka*		

Table 4: Summary of catch by sample location, gear type and sample year in Clowhom Lake Reservoir.

Site	Gear Type	Species	Number					
			2006	2008	2010	2012	2014	2016
A	Floating GN	Rainbow Trout	0	3	11	6	0	0
A	Floating GN	Cutthroat Trout	0	0	0	0	1	0
A	Floating GN	Kokanee	0	1	0	0	0	0
B	Sinking GN	Rainbow Trout	1	0	0	0	0	0
B	Sinking GN	Cutthroat Trout	2	3	3	1	4	5
B	Sinking GN	Kokanee	0	1	0	0	0	0
C	MT	Rainbow Trout	0	0	0	0	0	0
C	MT	Cutthroat Trout	0	0	0	0	0	0
C	MT	Prickly Sculpin	20	6	13	11	19	9
C	MT	Stickleback	1	5	14	0	6	4
D	MT	Rainbow Trout	0	0	0	0	0	0
D	MT	Cutthroat Trout	0	0	0	0	0	0
D	MT	Prickly Sculpin	30	4	3	11	9	3
D	MT	Stickleback	0	0	24	1	0	15
E	Floating GN	Rainbow Trout	2	9	9	0	0	2
E	Floating GN	Cutthroat Trout	0	2	0	0	0	0
E	Floating GN	Kokanee	0	0	3	0	0	1
F	Sinking GN	Rainbow Trout	0	0	0	2	4	0
F	Sinking GN	Cutthroat Trout	2	1	2	5	0	2
F	Sinking GN	Kokanee	0	0	0	0	0	1
G	MT	Rainbow Trout	6	2	1	0	0	0
G	MT	Cutthroat Trout	0	0	0	0	0	0
G	MT	Prickly Sculpin	17	7	0	17	0	3
G	MT	Stickleback	1	0	8	4	0	8
H	MT	Rainbow Trout	4	0	0	0	0	0
H	MT	Cutthroat Trout	0	0	0	2	0	0
H	MT	Prickly Sculpin	70	52	2	0	0	4
H	MT	Stickleback	3	0	26	4	0	8
I	Drift GN	Rainbow Trout	1	0	0	0	0	1
I	Drift GN	Cutthroat Trout	0	0	0	0	0	0
I	Drift GN	Kokanee	1	0	1	0	0	1

4.2 Fish Biometrics

Nose to fork length and wet weight data were compiled and applied to the appropriate age classes. **Tables 6**, **7** and **8** summarize the length-at-age, wet weights and condition coefficient data for the three species of salmonids captured.

The salmonid capture in 2010 was the largest number at 30 to a low of 9 in 2014. This compared to a capture of 23 in 2008 and 19 in 2006. Generally, increase in capture may reflect the increased soak times used in 2010. It should be noted that in 2010 the reservoir was drawn down for emergency repairs. This may have resulted in easier capture of salmonids if the fish were congregated at higher densities at the sample sites.

Table 5: Spatial distribution of minnow trap catch in the Clowhom Lake Reservoir for all sample years between 2006 and 2016 and the predetermined trapping location.

Species	Minnow Trap Location			
	Nagy Ck. (C)	**Bear Ck. (D)**	**Fisher Ck. (E)**	**Dempster Ck. (H)**
Prickly Sculpin	78	60	44	128
Threespine Stickleback	30	40	21	41
Rainbow Trout	0	0	9	4
Cutthroat Trout	0	0	0	2

Figure 3 shows the weight versus length relationship for each salmonid species caught and **Figure 4**, a comparison of the condition coefficients by species and year.

Catch per unit effort was calculated for each sample year. This varied from a low of zero to high of 6.42 in the gill net. Minnow trapping proved less successful with the majority of trapping efforts yielding no salmonid catches to a high of 0.25 in 2006. Catch per unit effort, expressed as fish caught per hour is presented in **Figure 5**. The top graph shows the gill net catch while the lower the minnow traps results. These CPUE are only for the salmonid species. Non-salmonids are not presented.

4.3 Scale Analysis

Representative scale samples collected from salmonids in each year photographed and archived as digital images. Age classes reported in **Tables 6, 7** and **8** below represent the results of examination of these scales.

4.4 Stomach Analysis

In each year (2006 through 2016) stomach samples from net mortalities were examined. Results were consistent with those reported by *Bruce* (2003). **Table 9** summarizes the identifiable principle food groups identified from stomachs of salmonids.

Table 6: Summary of nose to fork length, weight and condition coefficient at-age data for the Rainbow Trout (Oncorhynchus mykiss) caught in the Clowhom Lake reservoir from 2006 to 2016.

Nose to fork length (mm)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	7	112	6.6	3	127	12.0	2	108	2.1	3	123	14.8	3	117	2.9	2	132	9.9
2+	13	170	21.4	6	156	9.8	6	151	9.6	3	203	26.5	0	-	-	1	175	-
3+	10	202	25.3	4	197	15.3	8	191	32.8	7	248	16.4	0	-	-	0	-	-
4+	0	-	-	0	-	-	2	260	21.2	3	305	30.4	0	-	-	0	-	-
5+	0	-	-	0		-	0	-	-	0	-	-	0	-	-	0	-	-

Wet weight (gms)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	7	14.9	6.6	3	24.2	12.0	2	14.7	2.1	3	19.6	7.3	3	16.7	2.9	2	30.9	9.9
2+	13	54.1	21.4	6	42.3	9.8	6	37.8	9.6	3	86.1	28.2	0	-	-	1	51.3	-
3+	10	92.7	25.3	4	83.1	15.1	8	86.7	32.8	7	150.7	25.6	0	-	-	0	-	-
4+	0	-	-	0	-	-	2	179.6	21.2	3	301.1	82.7	0	-	-	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Condition coefficient

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**(SD)**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	7	1.05	0.12	3	1.16	0.05	2	1.09	0.08	3	1.01	0.05	3	1.04	0.18	2	1.34	0.08
2+	13	1.05	0.07	6	1.09	0.04	6	1.15	0.04	3	0.99	0.04	0	-	-	1	0.96	-
3+	10	1.08	0.06	4	1.07	0.08	8	1.07	0.06	7	0.98	0.04	0	-	-	0	-	-
4+	0	-	-	0	-	-	2	1.08	0.11	3	1.04	0.03	0	-	-	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Table 7: Summary of nose to fork length, weight and condition coefficient at-age data for the Coastal Cutthroat (Oncorhynchus clarkii) caught in the Clowhom Lake reservoir from 2006 to 2016.

Nose to fork length (mm)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	1	118	-	1	160	-	0	-	-	3	123	14.8	0	-	-	0	-	-
2+	6	184	50.0	3	166	22.5	0	-	-	0	-	-	2	155	14.1	4	256	19.6
3+	4	316	48.5	2	230	39.6	4	272	24.3	2	251	14.1	1	295	-	3	304	11.0
4+	6	356	26.1	2	358	46.0	1	305	-	3	305	30.4	2	312	3.5	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Wet weight (gms)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-		0	-	-	0	-	-
1+	1	17.2	-	1	42.3	10.9	0	-	-	3	19.6	7.3	0	-	-	0	-	-
2+	6	66.5	-	3	47.6	-	0	-	-	0	-	-	2	40.6	8.8	4	179.4	44.1
3+	4	331.1	-	2	127.0	79.7	4	208.5	6.59	2	154.6	24.0	1	273.5	-	3	291.1	20.4
4+	6	470.3	105.8	2	404.6	-	1	247.7	32.53	3	301.1	82.7	2	324.9	91.6	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Condition coefficient

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	1	1.05	-	1	1.03	-	0	-	-	3	1.01	0.05	0	-	-	0	-	-
2+	6	0.92	0.08	3	1.00	0.05	0	-	-	0	-	-	2	1.08	0.06	4	1.05	0.03
3+	4	1.01	0.15	2	1.06	0.22	4	1.02	0.06	2	0.98	0.01	1	1.07	-	3	1.03	0.04
4+	6	1.02	0.04	2	0.86	0.01	1	0.87	-	3	1.04	0.03	2	1.07	0.34	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Table 8: Summary of nose to fork length, wet weight and condition coefficient at-age data for the Kokanee (Oncorhynchus nerka) caught in the Clowhom Lake reservoir from 2006 to 2016.

Nose to fork Length (mm)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
2+	3	174	4.6	1	135	-	2	173	17.7	0	-	-	0	-	-	1	165	-
3+	1	187	-	1	325	-	2	195	7.1	0	-	-	0	-	-	2	248	2.8
4+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Wet weight (gms)

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
2+	3	57.1	-	1	28.3	-	2	56.30	14.85	0	-	-	0	-	-	1	52.0	-
3+	1	61.7	-	1	99.8	-	2	89.05	14.78	0	-	-	0	-	-	2	171.4	0.57
4+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

Condition coefficient

	2006			2008			2010			2012			2014			2016		
Age	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
0+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
1+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
2+	3	1.08	0.08	1	1.15	-	2	1.09	0.04	0	-	-	0	-	-	1	1.16	-
3+	1	0.94	-	1	0.85	-	2	1.20	0.06	0	-	-	0	-	-	2	1.12	0.04
4+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
5+	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-

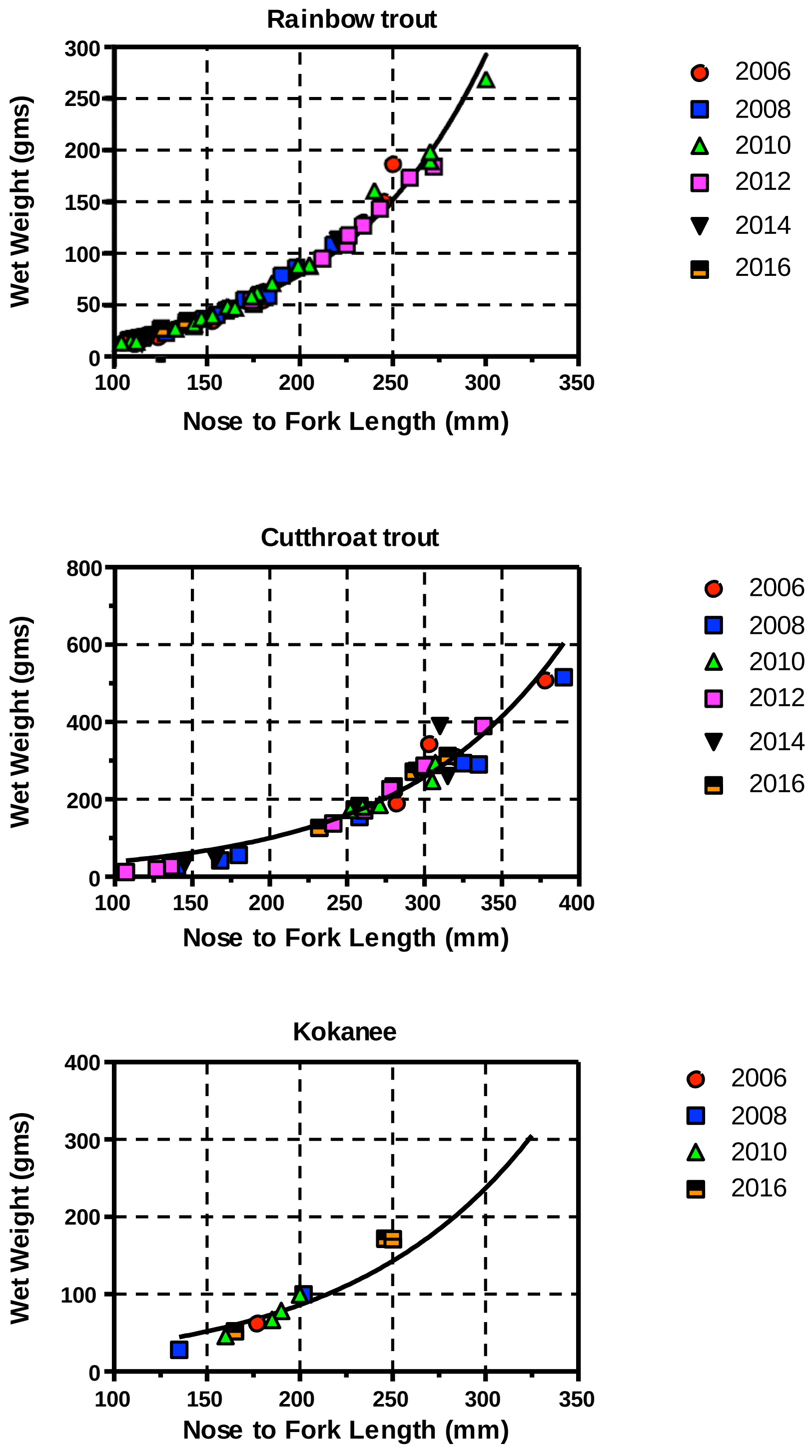

Figure 3: Length versus weight relationships for salmonids captured in Clowhom Reservoir in 2006 through 2016.

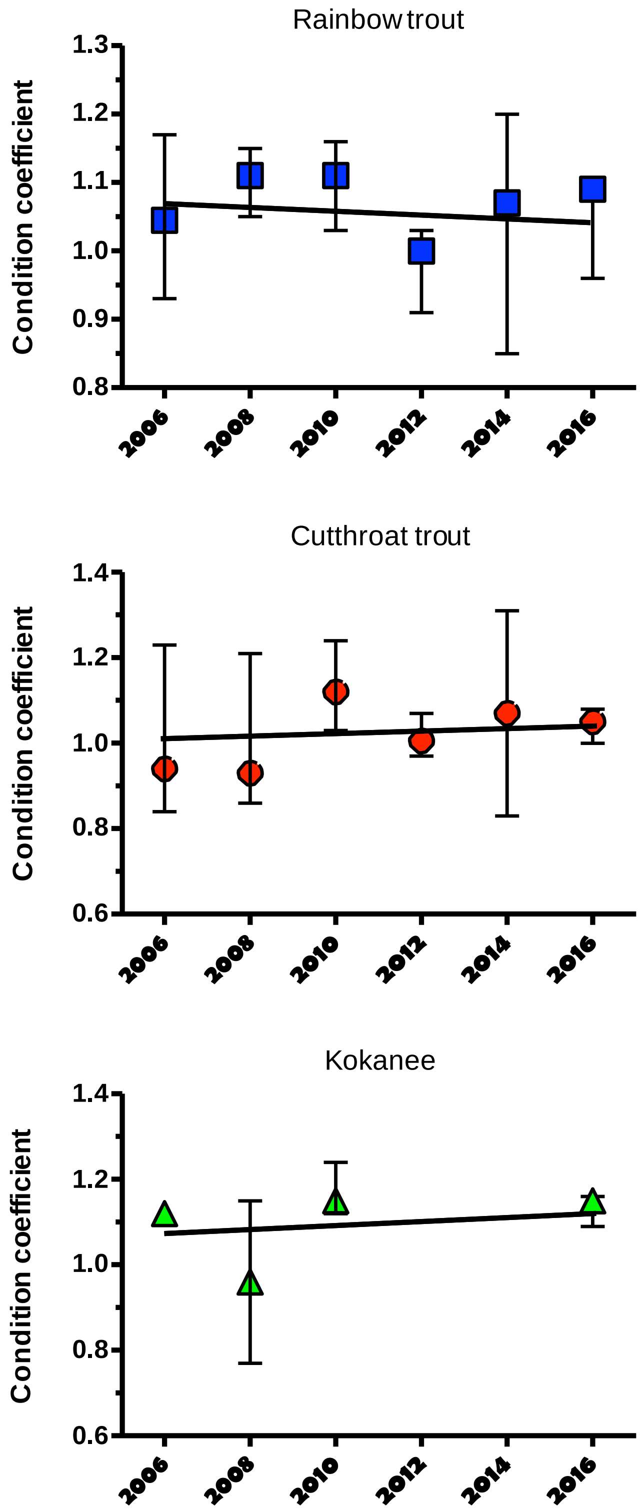

Figure 4: The condition coefficient for salmonids captured in Clowhom Reservoir over the period 2006 to 2016. Values shown are the median and 95% CI for the calculated condition of coefficient. The solid line represents the trend line and are not significantly different than zero.

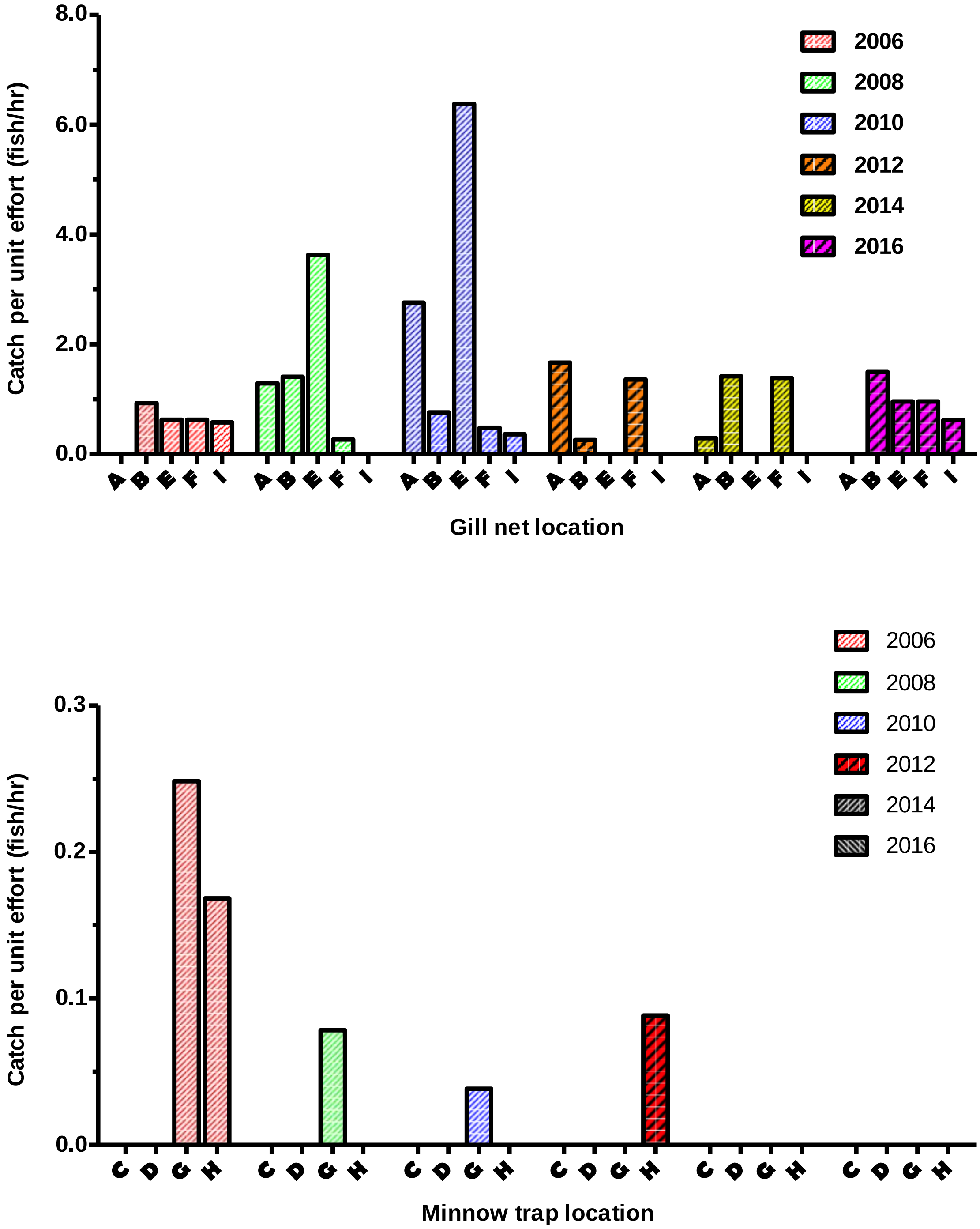

Figure 5: Catch per unit effort (CPUE) in each year of Clowhom Reservoir sampling. The top graph shows the CPUE for gill netting, while the lower the minnow trapping results (C=Nagy, D=Bear, G=Fisher, H=Dempster Creeks).

Table 9: Summary of prey items identified in the stomach of salmonids captured in Clowhom Reservoir.

Species	Type of Prey Reported				
	Empty	**Zooplankton**	**Insects**	**Fish**	**Other**
Rainbow Trout	2010	-	2006	-	2010
	-	-	2008	-	-
	-	-	2010	-	-
	-	-	2016	-	-
Cutthroat Trout	2008	-	2006	2006	
			-	2008	
			-	2010	
			-	2016	
Kokanee	2006	-	-	-	2008
	2008	-	-	-	-
	2010	-	-	-	-
	2016	-	-	-	-

4.0 Discussion

The completion of the 2016 sampling year closed the first half of the 20-year monitoring cycle. Results from the sampling period while variable, appear to not be significantly different. The CPUE shows an increase in catch around 2010 but results in the last year, 2016, are consistent with earlier results. Assuming the reservoir operations has a significant effect on lake productivity, it is hypothesized that the condition of fish would be the metric that would show operational influence. The plotted condition coefficients do not show any significant change in the condition of rearing salmonids over the first 10 years. While it appears no change has occurred, it may also be a result of the limited sampling undertaken and that increased sampling including greater samples through the growing season and more frequently (yearly) may have provided additional insight into the condition.

The purpose of the monitoring study is to address a series of management questions. It was noted that operations of the reservoir have been modified to reduce the minimum drawdown. It was noted that the intent of this change was to reduce the impacts to littoral areas and by association, productivity impacting fish production in the reservoir.

While the annual maintenance drawdown has been scheduled to occur annually in March, it has been noted that additional emergency drawdowns have also occurred and likely exceeded this minimum value. As witnessed in 2010 the severe nature of the exposure of littoral areas (reservoir level was 46.38 masl during survey) likely has a detrimental effect on the function of these areas.

Whether this type of unplanned event occurs again in the future is unknown. What is relatively certain is that extreme drawdowns like those witnessed possibly negates the benefits of reducing the minimum drawdown listed under the WUP and that without a consistent level range, minimizing littoral exposure, changes attributed to "new" reservoir management may be difficult to ascertain.

The second management question, (observed change through time with changes in ELZ), regarding correlation to changes in fish production and littoral area performance is difficult given the limited data collected (see comment above).

Clowhom reservoir experiences multiple large fluctuations in stage that presumably influences littoral areas. While these may be outside the "normal" growth window it is expected to impact littoral area success. The sampling of salmonids has been a snap shot in time and may not provide a suitable sample size from which to extract meaningful information. Ideally sampling frequency would be increased both spatially and temporally. This would provide additional species and age class data. Expanding the study to include main tributaries would also help identify important habitat for spawning and provide a better understanding of spawner recruitment mechanisms. To date young-of-the year data is noticeably absent and reflects the sampling model and methodology. The consequence is a poor understanding of how the reservoir operation impacts tributary streams required for sustaining the salmonid populations in the reservoir.

Interestingly, absence of young-of-the-year was also highlighted in *Bruce* (2003). It was suggested that this age class might be using areas other than the lake for rearing. This question remains un-answered. *Bates and Paul* (2010) reported efforts to document salmonid use in the lower reaches of the Clowhom River. It was hypothesized that juvenile salmonids remain in these areas and that lake recruitment occurred from these upstream sources. This question remains, as efforts of swimming and electrofishing the lower Clowhom River resulted poor estimates of salmonid use and no identifiable YOY.

Perhaps more likely recruitment contributors to Clowhom Reservoir are the numerous tributaries to Clowhom Lake (*Bates and Coombs*, 2012). Many of these are small with short accessible reaches (*Bruce*, 2003). As previously reported (*Bates and Coombes*, 2012) no attempt has been made to determine the use for rearing or spawning. This information would be beneficial and must be considered in future sample years.

5.0 Conclusion/Recommendations

The completion of a sixth season (2016) of salmonid sampling in the Clowhom reservoir marked the end of the first 10-year rotation as defined under the Terms of Reference (TOR) for this project. This period included two additional years of sampling that was not initially included in the TOR. Given the long-term management objectives the following conclusion and recommendations are provided.

- Fish productivity, measured as relative abundance may not be appropriate without an increase in sampling effort that increases both spatially and temporally. The temporal change may help address questions of "unknown" age classes and scarce species.

The 2004 catch reported by *Bruce* (2003) and presumably prior to changes in the minimum drawdown under the WUP (49 versus 47) reported a total catch of 47 salmonids. This is compared to subsequent years where a low of 19 (2006) were captured to a high of 29 (2010). All lower than the pre-WUP change. The question of whether the effort of sampling is adequate remains and the degree of uncertainty regarding operational change success is high.

The likely metric that would show the benefits of operational change effects and presumably increased lake productivity is the condition of captured salmonids. The results from this data remains inconclusive and there was no significant change in trend over the 10-year period using the limited data set.

- Potentially complicating analysis is sudden "extreme" drawdowns that may have occurred for maintenance/repairs. Such as the witnessed "deep" drawdown in 2010. In this case sampling was adjusted to meet changes but extensive littoral areas were exposed for an extended period. What effect and how this may impede productivity remains un-answered and will be reviewed in the analysis of the ELZ sampling (*Bruce,* 2018).

- Is the population of salmonids in Clowhom Reservoir a reflection of operational management or a question of salmonid recruitment? This question remains unanswered. The results presented show limited YOY numbers (juveniles) and the lack of observed utilization of the Clowhom River suggest another factor, yet un-discovered, may be at play in the area. The obvious unknown is the contribution of all reservoir and lower Clowhom River tributaries on salmonid life history and whether reservoir operations has an effect on access and production form these tributaries.

  It is again recommended that an attempt be made to sample and quantify using electrofishing methods, summer standing stocks in the "key" tributaries on the reservoir and river. Particular emphasis should be placed on the small tributaries of the Clowhom River below the 17-km bridge and streams along the north shore of the lake. Question of use for initial rearing remain but so too does the question of spawning habitats and effects of reservoir "flooding" on potential critical habitats (*Bates and Coombes*, 2012).

- Efforts to date have focused on fish relative abundance and biometrics. In 2003, sampling included chemistry data. It appears this is the only year the data exists. It is possible, production, while influenced by the reservoir operations may have additional driving mechanisms such as changes in dissolved nutrients and/or water quality as critical times of the year (summer/fall).

  It is recommended that an effort to include water sampling in future monitoring. A poor understanding of the nutrient loading and dynamic exists for Clowhom

Reservoir. This is a critical omission and should be included in future sampling and analysis. It is recommended that in subsequent years nutrients and possibly plankton sampling be included during scheduled sampling periods.

6.0 References

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