EA3619

ASSESSMENT OF KOKANEE MOVEMENT AND ABUNDANCE IN COQUITLAM RESERVOIR, SPRING 2015

This project was carried out with the financial support of the Fish and Wildlife Compensation Program (Project #16.COQ.02)

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March 2016

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FWCP Fish & Wildlife COMPENSATION PROGRAM

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ACKNOWLEDGEMENTS

We gratefully acknowledge the funding for this project by the Fish and Wildlife Compensation Program and we were supported administratively by Trevor Oussoren and Lorraine Enns (Fish and Wildlife Compensation Program) and by Trish Hall and Craig Orr (Watershed Watch Salmon Society).

Without the generous in-kind contribution of Metro Vancouver this project could have not been carried out. Managed by Heidi Walsh and Jeremy Appleton, the field team that also operated the in-kind project boat was composed of Scott Stuart, Judith Wheeler, Thomas Jackman, Matt Hamerson and Erica Forssman.

Shane Johnson and Ian Beveridge of LGL Limited were also essential in carrying out the field work.

Julio Novoa of LGL Limited provided GIS support and produced all maps of the reservoir.

EXECUTIVE SUMMARY

Coquitlam Reservoir does not have a spill way that would allow salmon smolts to leave the reservoir at the surface, migrate to the ocean and return as adult and anadromous Sockeye Salmon. The only way to leave Coquitlam Reservoir by passing the dam is by way of small diameter water release pipes with a deepwater intake that has had limited success to date (Plate et al. 2014). While it was hypothesized that the water intake to these pipes would be hard to find by smolts and thus outmigration would always be limited to very few fish (Plate et al. 2014), an alternate hypothesis was that smolts had lost their genetic drive to migrate towards the dam and leave the reservoir. In this context, the construction of a surface spillway would only lead to more smolts leaving the reservoir, if it could first be proven that smolts were migrating towards the dam. Therefore migratory behaviour of Kokanee smolts was investigated in the spring of 2015.

The 2015 study was carried out between 24-Mar and 14-May by comparing the distribution of fish in the Kokanee smolt (60-90 mm) and the smolt predator (>270 mm) length classes during six hydroacoustic surveys at night. Every hydroacoustic survey was supported by gillnet sets to verify species composition of hydroacoustic targets. During the first survey on 24-Mar, the majority of fish in the smolt and predator lengths classes, were observed in the north and central basins of the reservoir while very few fish (<2%) were observed in the south basin closest to the dam. This picture changed in the beginning of April when >20% of the smolt and predator sized fish were found in the south basin closest to the dam. A second increase of smolt sized fish at the beginning of May in the south basin again coincided with an increase in predator sized fish. Net catches of the typical Coquitlam predators, Northern Pikeminnow and Cutthroat Trout, also increased at the log boom close to the dam in the middle of April.

In general, the average abundance of all fish targets in 2015 was slightly lower than in 2011, 2010 and 2005 (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012). Kokanee depth distribution changed considerably over the six surveys between 24-March and 14-May. While the majority of fish targets detected in the pelagic zone of Coquitlam Reservoir was observed in the top 2 m of the water column on 24-March and 1-Apr this pattern changed for the last four surveys until 14-May when the majority of the fish targets were detected between depths of 5-25 m.

The 2015 gillnet catch was mainly composed of Peamouth Chub (33%), Largescale Sucker (30%), Northern Pikeminnow (24%) and few (7%) Kokanee and therefore different from previous years when the majority of the catch represented Kokanee (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012). This difference is likely based on the differences in net set locations. For all previous hydroacoustic studies in Coquitlam Reservoir the nets were set in the pelagic zone targeting Kokanee. In 2015, the majority of nets was set in the shallower and littoral zone of Coquitlam Reservoir close to the log boom that is blocking access to the dam forebay.

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INTRODUCTION

The restoration of anadromous fish runs, where practical, was given the highest possible priority ranking in the "2011 Coquitlam/Buntzen Watershed Salmonid Action Plan" (Fish and Wildlife Compensation Program 2011).

In the Coquitlam-Buntzen BC Hydro system, numerous interested parties including government agencies, the Kwikwetlem First Nation, stewardship groups, environmental Non-Government Organizations (NGOs), and concerned citizens have an interest in restoring anadromous salmon runs in the Coquitlam Reservoir while maintaining Coquitlam Reservoir's important role as a major source of high quality drinking water for Metro Vancouver.

In 2002, LGL Limited developed a framework for evaluating fish passage issues in the Bridge-Coastal hydro operating area (Bocking and Gaboury 2002) that was followed by an evaluation of the feasibility of restoring anadromous fish stocks into the Coquitlam Reservoir (Bocking and Gaboury 2003). Bocking and Gaboury (2003) estimated the rearing capacity for Sockeye salmon of Coquitlam Reservoir using two models; the Euphotic Volume (EV) model of Koenings and Burkett (1987) and the Photosynthetic Rate (PR) model of Shortreed et al. (2000). Both of these models estimate Sockeye biomass during the primary growing season from May to October in the oligotrophic (low productivity) conditions of Coquitlam Reservoir.

An assessment of fish abundance as well as biomass, and limnological characteristics in Coquitlam Reservoir was carried out in 2004 and 2005, to determine whether reintroducing anadromous Sockeye salmon to Coquitlam would be rearing-limited (Bussanich et al. 2006). The limnological characteristics of the reservoir were similar during 2004 and 2005 and showed that the reservoir is characterized by low nutrient concentrations (is phosphorous limited), low phytoplankton biomass, and good water clarity. Its relatively cool water temperature regime, high dissolved oxygen levels, and favourable water quality conditions make it suitable for resident coldwater fishes. It also has low zooplankton stocks (1.2 ug/L) compared with other west coast oligotrophic lakes, which may be limiting fish production (Bussanich et al. 2005).

In November 2002, a preliminary assessment of the fish population in the reservoir and potential salmonid spawning habitat in the upper Coquitlam watershed was conducted by LGL Limited (Bocking and Gaboury 2003). The Coquitlam Reservoir system supports several species of salmonids including Kokanee (*Oncorhynchus nerka*) and Cutthroat Trout (*Salmo clarki*), and a number of coarse fishes including Redside Shiner (*Richardsonius balteatus*), Peamouth Chub (*Mylocheilus caurinus*), Northern Pikeminnow (*Ptychocheilus oregonensis*), and Largescale Sucker (*Catostomus macrocheilus*).

Gaboury and Murray (2006) estimated that there is sufficient spawning habitat in the lake (1,500 m^2) below the 140 m contour and also in Cedar and Beaver creeks (1,000 m^2) to support a Kokanee population of 4,500 females or a Sockeye salmon population of 1,500 females. Additional spawning habitat (25,000 m^2) has also been identified in the Upper Coquitlam River and could support another 40,000 female spawners.

As part of the 2004-2005 study (Bussanich et al. 2005, Bussanich et al. 2006), analyses of fish stomach contents were conducted, and stable isotope levels in fish tissue indicated low pelagic (open water) productivity and the importance of nutrients and foods from nearshore and terrestrial areas in fish foraging. Results from the same study also showed that different fish species rely on different food sources. Only Kokanee and Threespine Stickleback forage in the pelagic habitat and obtain their carbon inputs essentially from pelagic food sources. To compare the 2005 (Bussanich et al. 2006), 2010 (Plate et al. 2011) and 2011 (Plate et al. 2012) hydroacoustic estimates of the total fish population, adjustments needed to be made to the 2005 data resulting in fall estimates of 124,988 (± 113,767 STDEV) fish in 2005 versus 72,511 (± 37,256 STDEV) in 2010 and 100,812 fish ± 54,909 in 201. The total Kokanee abundance in 2011 was estimated to be 58,470 (2010 study: 42,056; 2005 study: 97,491).

The results from the 2004 and 2005 studies (Bussanich et al. 2005, 2006) and the 2010 and 2011 studies (Plate et al. 2011, 2012) indicate that Coquitlam Reservoir is likely to support a relatively small Sockeye smolt population (i.e., less than 1 million smolts) while available lake shore spawning habitat could potentially support between 1,500 and 3,000 female Sockeye spawners. The total of 3,000 female Sockeye could produce a smolt population of approximately 300,000 4.5 g smolts.

Based on the combined results from the 2004, 2005, 2010 and the 2010 studies, a reasonable interim production target would be 300,000 4.5 g Sockeye smolts derived from a spawning population of 6,000 Sockeye adults. This would balance with the presumed available spawning habitat within the reservoir and would account for 1,350 kg of Sockeye/Kokanee smolt biomass.

Perrin et al. (2007) assumed that a Sockeye population that would completely replace the existing Kokanee population in Coquitlam Lake would be composed of 1,533 Sockeye and that a Sockeye population that would use all available spawning habitat without any enhancement would be composed of approximately 11,000 Sockeye. With enhancement of the spawning lake shore habitat and the re-introduction of a stream-spawning Sockeye stock to the Upper Coquitlam River Perrin et al. (2007) suggest approximately 31,200 Sockeye could spawn in the Coquitlam Reservoir and its tributaries.

In 2007, 2 adult Sockeye salmon returned to the Coquitlam Reservoir Dam following the release of 620 Kokanee/Sockeye smolts in 2005 (unpublished data from BC Hydro, James Bruce). These 2 fish died, but fish returning in 2008 were transported over the dam and released into the reservoir in a historical ceremony led by the Kwikwetlem First Nation. While the project has been successful in seeing these initial returns of Sockeye salmon to the Coquitlam River, fewer Sockeye/Kokanee smolts have emigrated from the reservoir in each successive year (only a handful emigrated in 2007 and 2008) and only one adult returned in 2009, three adults returned in 2010 (a banner year for many Fraser River Sockeye salmon stocks) and no adults returned in 2015; the reason for the low level of emigration and resulting low numbers of adult Sockeye salmon spawners returning is unknown. Clearly, something is constraining the Sockeye salmon production potential and an important remaining information gap is the current nerkid abundance and behaviour especially of smolts in the reservoir. The potential hypotheses that may explain the low number of Sockeye salmon smolts are:

<u>Hypothesis 1.</u> Sockeye salmon/Kokanee smolts are unable to find or do not have the genetic predisposition to find the outlets to the reservoir to migrate to sea or perish during migration before reaching the downstream trap; or

Hypothesis 2. The standing crop of Sockeye salmon/Kokanee in the reservoir is too small to enable a significant outmigration of smolts.

The intent of this project was to investigate smolt and predator behaviour in the reservoir from end of March to middle of May, the typical smolt outmigration period and thus the evaluation of Hypothesis 1.

GOALS AND OBJECTIVES

The primary goal of this project was to describe the migratory behaviour of Kokanee smolts (60-90 mm in length) and their predators (Cutthroat Trout and Northern Pikeminnow >270 mm in length) from March to May 2015 and assess the hypothesis that smolts are migrating towards the dam in bigger numbers.

The 2015 study had the following specific objectives:

1. Estimate fish distribution carrying out six hydroacoustic surveys from March to May;
2. Determine pelagic fish size and species composition close to the forebay area to calibrate the hydroacoustic estimates; and
3. Collect pelagic fish biological data close to the forebay area.

MATERIALS AND METHODS

Study Area

The Coquitlam Reservoir, located in southwest British Columbia and comprising an area of approximately 1,200 ha (Figure 1), is a major source of domestic water for Metro Vancouver. The area is characterized by west coast maritime air with cool wet winters and warm dry summers. The reservoir has mean and maximum depths of approximately 87 and 187 m, respectively, at a pool elevation of 152 m, with complete mixing occurring between November and March. It is approximately 12 km long with an average width of roughly 1 km, and is classified as a monomictic body of water with an ultra-oligotrophic status (Wetzel 2001). Some physical details of the reservoir are presented in Table 1.

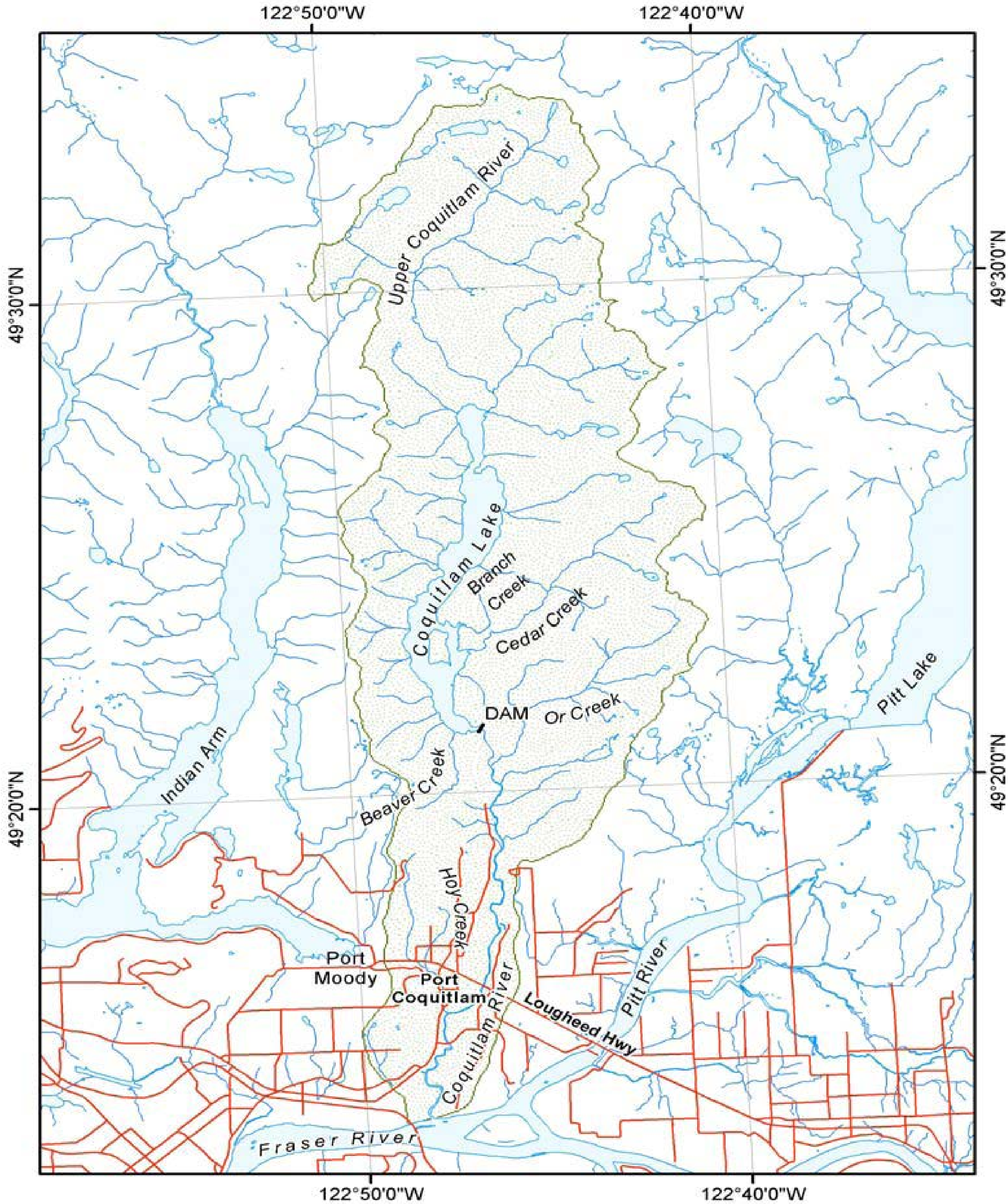

Figure 1 Overview map of the Coquitlam Reservoir (called Coquitlam Lake on the map) and Watershed showing local communities and features.

Table 1 Morphological characteristics of Coquitlam Reservoir (Nordin and Mazumder 2005; James 2000).

Attribute	Measure
Lake Volume (m^3)	1,044,000,000
Mean depth (m)	87
Surface area (km^2), (ha)	12 (1200)
Watershed area (km^2)	212
Watershed area contributing to reservoir (km^2)	191
Watershed to Reservoir area ratio [a]	15.9:1
Normal operating elevation (m)	137.48 - 154.86
Normal operating elevation range (m)	17.4
Average annual precipitation (rain) (mm)	3576.8
Average annual precipitation (snow) (mm)	158.2
Inflow (m^3/yr)	725,000
Mean inflow (m^3/s)	23
Water Residence time (yr)	1.44
Sedimentation rates - 1967-1997 (g/m^2/yr), (t/km^2/yr)	192 (1.92x10^2)
Sedimentation rates - 1990-2002 (g/m^2/yr)	267
Sedimentation rates - 1905-2002 (mm/year) [b]	1.8mm /year

[a] to the mouth of lower Coquitlam

[b] over the period

Hydroacoustic Surveys

In 2015, we conducted a total of six night-time hydroacoustic surveys on Coquitlam Reservoir at the dates and times shown in Table 2.

Table 2 Start and end dates and times for all hydroacoustic surveys carried out in the spring of 2015.

Start Date + End Date	Start Time	End Time	# of Transects	Side-Looker	Down-Looker
24-Mar to 25-Mar	20:30	0:33	21	Yes	Yes
01-Apr	20:04	23.34	21	Yes	Yes
14-Apr	20:01	23:30	21	Yes	Yes
23-Apr to 24-Apr	20:33	0:35	21	Yes	Yes
4-May	20:23	23:53	21	Yes	Yes
14-May to 15-May	21:22	1:12	21	Yes	Yes

For all surveys we used two 200-kHz frequency BioSonics DTX echo sounders (Figure 2) with one 6.6° circular transducer each (Figure 3). Transducer 1 was positioned 1 m below the water surface and aimed vertically to sample from 1.5 m below the surface to 50 m depth. Transducer 2 was positioned 0.9 m below the surface but was aimed horizontally to sample the top 2 m of the water column from 1.5 m to 20 m distance from the boat. During all six nighttime surveys the same 21 transects were sampled (Figure 4).

Figure 2 Echoprocessor used for hydroacoustic sampling on Coquitlam Reservoir, 2015.

Figure 3 Set-up for the down-looking and the side-looking circular transducers used for the 2015 hydroacoustic surveys.

The threshold for the system was set to -75 dB with a 0 dB power level. The sample rate for the transducer was set to 12 pings per second, and pulse duration was 0.1-0.2 msec. Data were automatically geo-referenced through a handheld GPS connected to the BioSonics DTX system. The acoustic system was calibrated after the data were collected using a standard (36 mm diameter) tungsten carbide calibration sphere. The calibration sphere was positioned at a distance of 3-5 m from in the beam of each transducer and several thousand pings were recorded to estimate target strength of the sphere. The post calibration indicated that no offset needed to be applied.

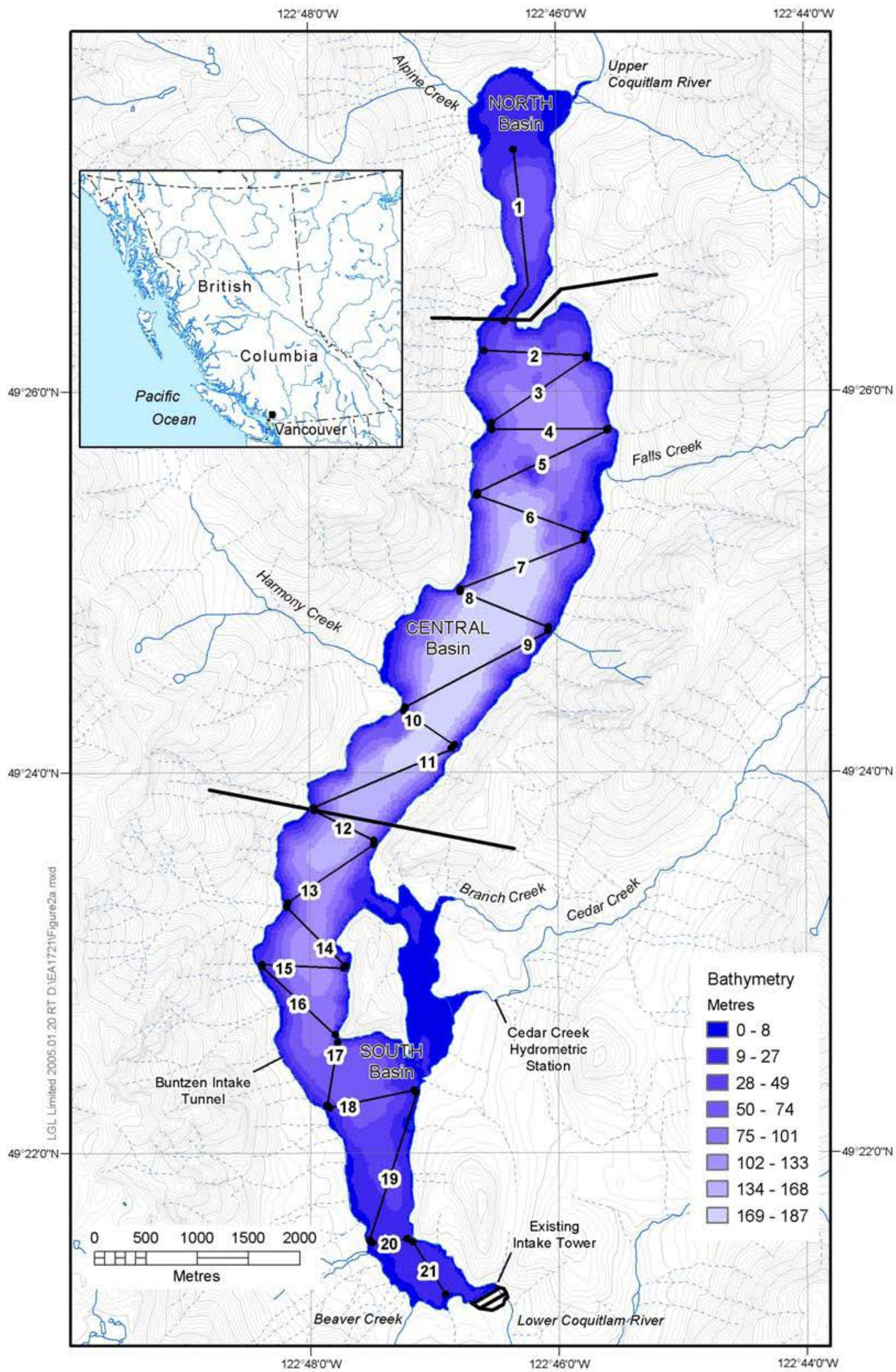

Figure 4 Map of Coquitlam Reservoir showing basin boundaries and hydroacoustic survey transects based on Bussanich et al. (2006).

Acoustic data were processed using Echoview V4.90 by echo tracking to combine individual echoes into fish tracks. The tracks were filtered by off axis angle to include only those tracks within five degrees of the center of the 6.6 degree beam. The effective beam width then varied by fish depending on the fish size relative to the analysis threshold of -60 dB.

For each transect fish density values were estimated as follows: each observed fish was weighted by the effective width of the beam at the range of the fish. The weighted fish count was then summed over each transect and divided by the transect length using the formula:

$$D_i = \frac{\sum_j \frac{1}{b_j}}{l_i}$$

Where D_i is the fish density (fish/m^2) of transect i, the summation is over all fish j observed in transect i, b_j is the beam diameter (m) at range of fish j, and l_i is the length (m) of transect i.

We assumed Love’s (1977) equation for all aspects was representative of the target strength distribution:

TS = 20 log L – 69.23 (all aspects);

where,
TS = target strength in decibels; and
L = fork length in centimeters.

Fish Sampling Operations

A three-person crew conducted gill netting for species identification parallel to each of the six hydroacoustic surveys from 24 Mar to 14 May, 2015. Gill netting sites were located throughout the reservoir and a site was deemed suitable for sampling if it met one of the following criteria:

1. Vicinity to the log boom that marks the entrance to the dam forebay (this location was chosen to ensure that changes in catch of Kokanee migrating to the dam would be identified);
2. A historical catch site based on studies carried out by Bocking and Gaboury (2003), Bussanich et al. (2006); Plate et al. (2011); Plate et al. (2012);
3. Relatively high densities of fish identified in hydroacoustic surveys; or
4. Bottom free of rocks, logs and other debris that might damage the nets or jeopardize crew safety.

<u>*Gillnets*</u>

We used gill netting in this study to develop an inventory of the fish stocks present in accordance with Resource Inventory Committee (RIC) standards (Anon. 2001). We chose to focus our sampling efforts on the pelagic zone throughout the lake and especially in the vicinity of the log boom that marks the entrance to the Coquitlam Dam forebay since the scope of this project was the detection of Kokanee smolts heading to the dam to leave the reservoir.

To hold the nets in place, we either used anchors and buoys on both sides or we used the Metro Vancouver water parameter floating platforms on one side and attached the other side with a long line to shore. If not attached to shore or an anchored floating structure, gillnets were kept in place by one anchor on each end connected via lines that were longer than the water depth to buoys that were suspending the nets at desired depths. All nets were set perpendicular to shore and with soak times greater than 1 h. Most nets were set over night. Sinking nets were set in pelagic areas only and in depths ranging from the surface to 10 m to focus on Kokanee smolts and their predators that are generally believed to migrate in the top 10 m of the water column.

Multi-panel gillnets were designed and set to mainly sample juvenile and adult Kokanee while trying to avoid by-catch of trout and coarse fish (e.g., Redside Shiners, Peamouth Chub, Sculpins, Suckers). All nets were constructed of double knotted, light green or transparent monofilament nylon mesh.

We used two different multi-panel and multi-mesh gill net types. Net type one consisted of five panels, four of which were 15 m long while the fifth one was 25 m long (thread diameter 0.2-0.25 mm), with mesh sizes of 12, 88, 50, 25 and 18 mm, strung together in a “gang” to form a net 96 m long and 3.6 m deep (Figure 5). Data from previous studies in British Columbia (Hamley 1972; Plate 2007) indicated a relationship between mesh sizes and the lengths of fish that are expected to be caught (Figure 6) and based on this relationship, we selected the mesh sizes. A 12 mm minimum mesh size should catch fish with a minimum fork length of 60 mm and thus be able to catch Age-1 Kokanee in the spring. For net type two, we used a smaller multi-mesh net with three 15 m by 2.4 m panels with mesh sizes of 19, 25 and 50 mm composed out of the same materials.

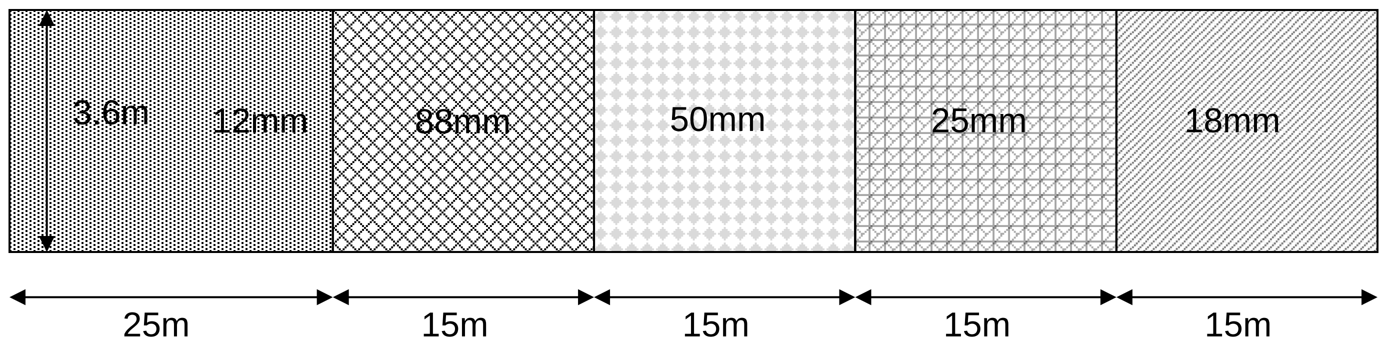

Figure 5 Conceptual depiction of the multi-panel and multi-mesh size net used in 2015 to focus on the catch of smaller especially Age-1 and Age-2 Kokanee.

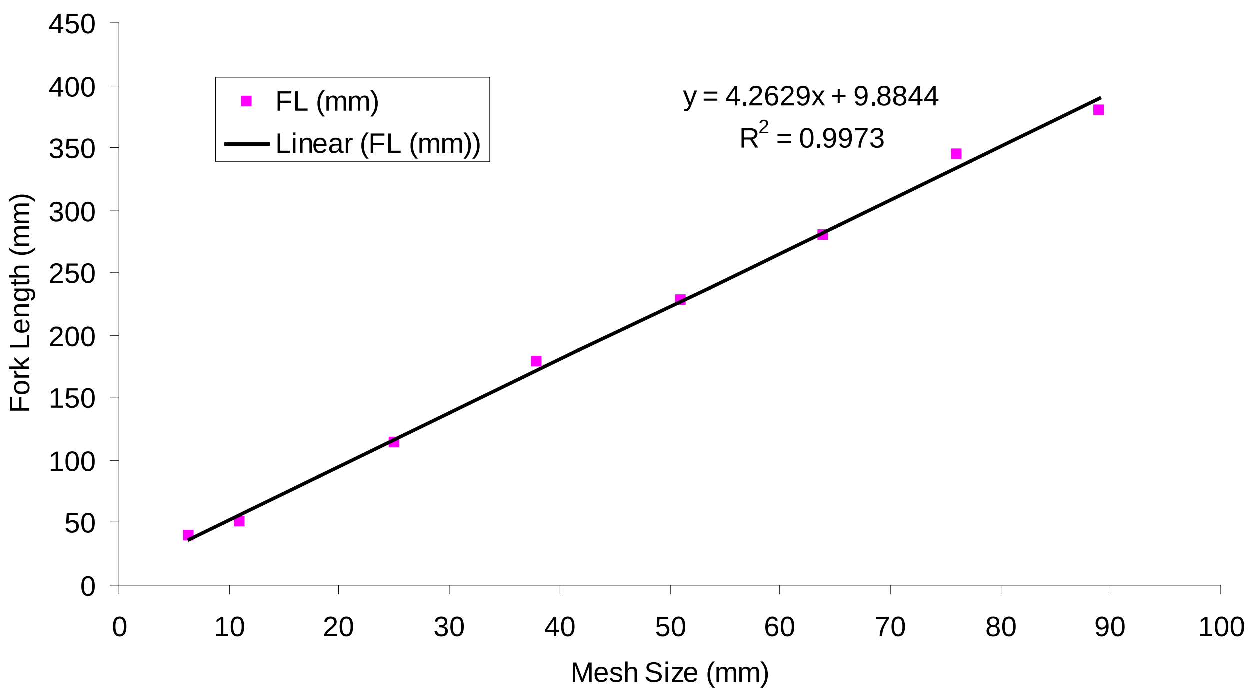

Figure 6 Graph showing fork lengths versus net mesh size for fish caught in freshwater lakes in British Columbia (Hamley 1972; Plate 2007).

Gillnets were deployed in 4 gillnet areas throughout the reservoir (Figure 7) and the total of 24 net sets were mainly focused on the southern basin close to the dam (Table 3).

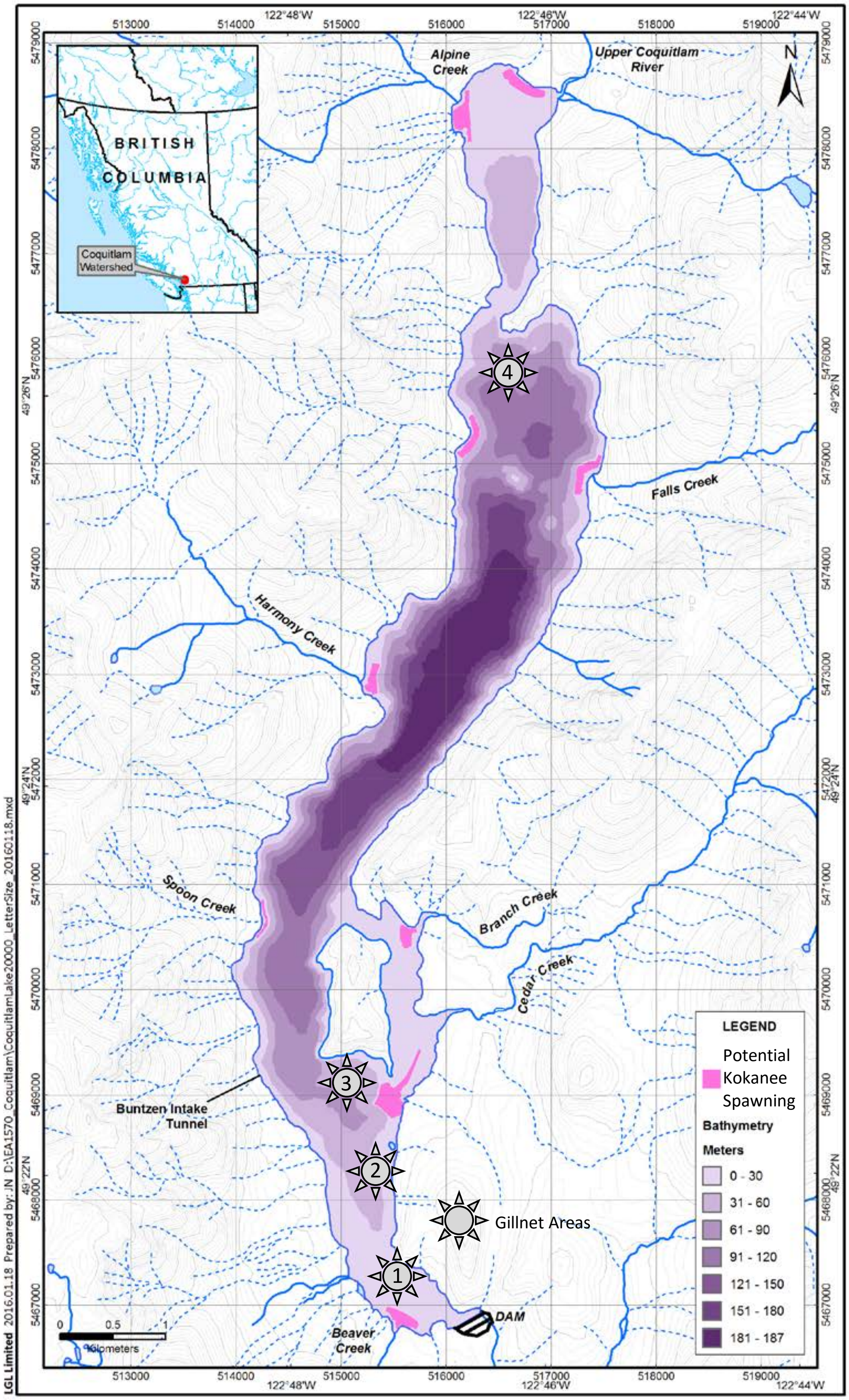

Figure 7 Coquitlam Reservoir gillnetting locations for spring of 2015.

Table 3 Gillnet set locations and set numbers in Coquitlam Reservoir for the spring 2015 hydroacoustic study.

Area on Map	Set Number	Description
1	1, 2, 5, 8, 12, 13, 14, 17, 18, 20, 21, 22, 23, 24 (14 of 24 sets)	South end of Coquitlam Reservoir, close to the boom and the dam
2	3, 4, 6, 7, 15, 19 (6 of 24 sets)	East shore in the centre of the south basin
3	11 (1 of 24 sets)	North shore (on the south shore of Cedar Island) of south basin
4	9, 10, 16 (3 of 24 sets)	Northern area of central basin

Effort and CPUE

Gillnetting effort for each set was measured as fishing time in hours, and was calculated in MS Excel as follows:

$$E = (HOUR(TR-TD)*60+MINUTE(TR-TD))/60$$

where,
E = effort in minutes;
TD = time of net deployment in 24 hour format;
TR = time of net retrieval in 24 hour format

Catch-per-unit-effort (CPUE) standardized to a fishing area of 90 m^2 and one hour was calculated as:

$$CPUEj = Nj/(Aj/90)/TFj$$

where,
Nj= catch in set j;
Aj= total area (gillnets) used in m^2 in set j;
TFj= total time fished in hours for set j.

Fish Handling

All crew members were experienced with the handling techniques necessary to minimize stress on captured fish. The standard procedure following capture was to assess fish condition. Only fish deemed to be in good condition were released. The remaining fish were immediately sacrificed by a blow to the head, placed in individually numbered plastic bags, stored in a cooler, and processed within 3 h.

Biological Sampling
All fish captured were identified to species, classified as adult or juvenile using RIC standards (Anon. 2001), and enumerated. For each individual fish caught, the following data were recorded: date, time, gear type, set number, fishing depth, fishing location coordinates, fish species and life stage. The samples were processed by measuring fork length (FL, mm) and wet weight (g) for each fish. Occasionally, stomach contents composition and fullness were recorded for Cutthroat Trout and Northern Pikeminnow to assess whether these two species were preying on juvenile Kokanee.

RESULTS

Fish Abundance and Depth Distribution Using Hydroacoustics

The total 2015 mean fish target strength over all six survey dates in Coquitlam Reservoir was -43.68 dB (2011: -40.23 dB). Mean length for all fish detected was 173 mm ± 132 mm STDEV (2011: 265 mm ± 226 mm STDEV) estimated using Love's equation (1977), while fish target size ranged from 21-501 mm (2011: 24 mm-2,885 mm). Of the 2015 average of 1267 fish targets detected per survey (2011: 1,560 per survey), 1146 or 90% of all fish targets (2011: 903 or 58%) fell into the Kokanee size category between 20 mm and 270 mm (Figure 8, Table 4). The total number of targets above 270 mm was 115 fish (2011: 657 fish) (Figure 8, Table 4).

Figure 8 (top panel) and Table 4 show a comparison for the summary data of the four years of hydroacoustic surveys carried out with a down-looking transducer in 2005, 2010, 2011 and 2015. Overall, the effect of year was statistically significant (Dev = 12.9, df = 3, $P = 0.0016$). Post-hoc tests showed that there were significantly fewer targets in 2015 and in 2010 than in 2005 and 2011 when comparing the number of fish targets detected by the down-looking transducer. The difference in target counts between 2005 and 2011 was not statistically significant and the same was true for the difference in target counts in 2015 and 2010.

Statistical analysis within size classes between the three years revealed the following results (Figure 8). For fish targets with a length between 60-90 mm (Kokanee smolt length category), numbers varied significantly with 'year' (Dev = 9.5, df = 2, $P = 0.009$). Post-hoc tests showed that there was a significantly lower number of targets in 2015 and 2010 than in 2011 and 2005.

Additional results obtained from the analysis of the side-looking transducer used in addition to the down-looking transducer in 2015 are shown in Figure 8 (bottom panel) and Table 4 and cannot be compared statistically to results from the side-lookers used throughout all four survey years. Nevertheless, approximately 10 times more fish targets were detected by the side-looker than by the down-looker. This means that at least in the spring time, a much greater portion of the fish in Coquitlam Reservoir can be found in the top 2 m of the water column when compared to the depths from 2-50 m. The 2015 result was based on a spring time survey while all previous surveys were carried out in the fall of the prevailing year.

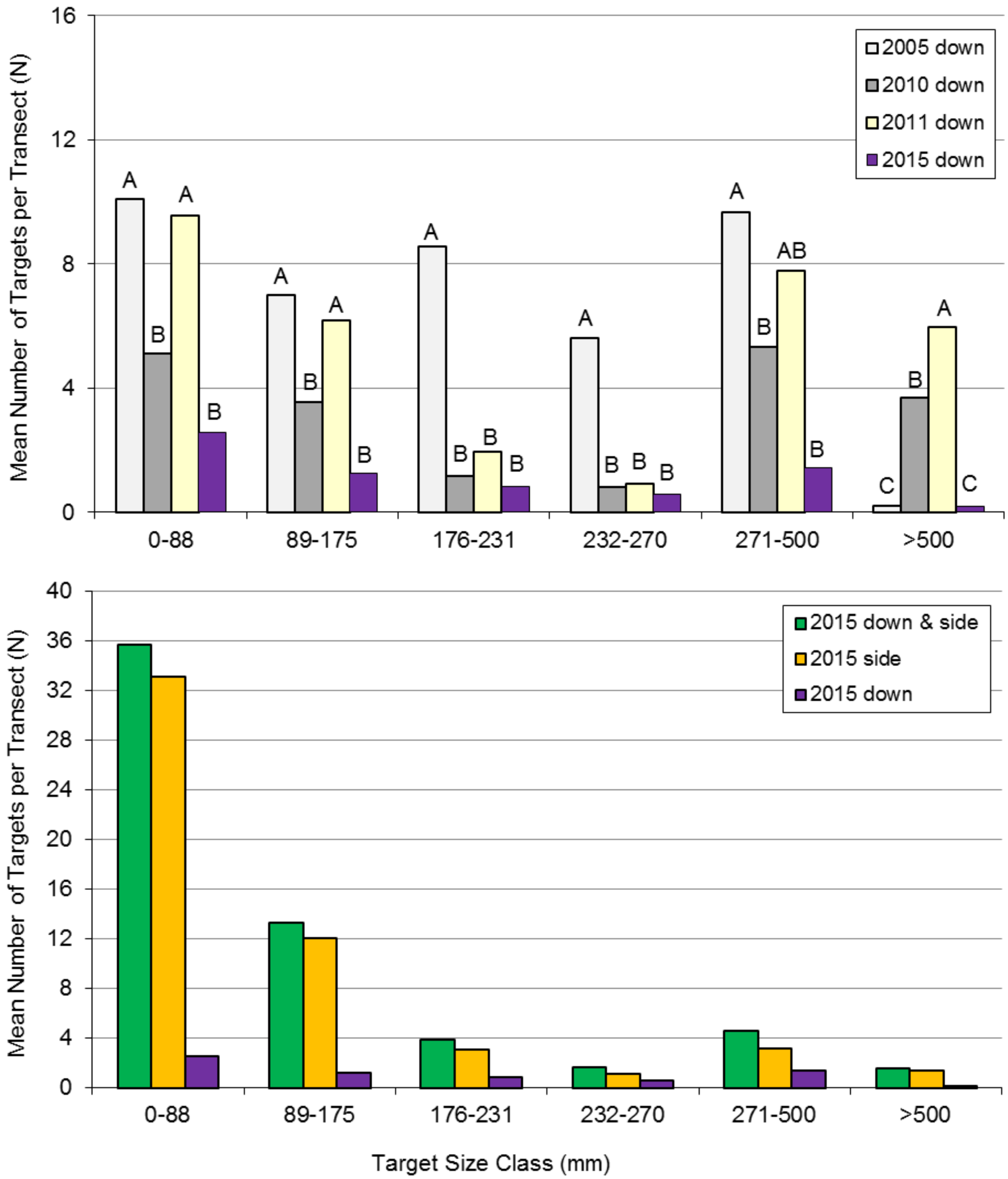

Figure 8 Mean number of targets per transects. Letters indicate statistical differences between years within a size category (top panel). Data for 2015 (purple bars, this study), 2011 (beige bars, Plate et al. 2012), 2010 (grey bars, Plate et al. 2011) and 2005 (white bars, Bussanich et al. 2006). The bottom panel shows data for 2015 only comparing, down- and side-looker (green bars) with side-looker (orange bars) and with down-looker (violet bars).

Table 4 Comparison of summary results of target parameters from 2005, 2010 and 2011 hydroacoustic surveys.

Year	Mean Fish Target Strength (dB)	Mean Length of Targets (mm)	Min Target Length (mm)	Max Target Length (mm)	Total Fish Targets (N)	Fish Targets in Kokanee Size Class (N)	Fish Targets > Kokanee Size Class (N)	Season and Trans. Direction
2005	-42.49	183	21	656	1,912	1,598	421	Fall, Down
2010	-40.45	266	23	1,004	915	564	385	Fall, Down
2011	-40.23	265	24	2,885	1,560	903	657	Fall, Down
2015	-43.68	173	21	501	428	430	48	Spring, Down
2015	-47.09	109	16	501	3,401	3,110	291	Spring, Side
2015	-45.39	141	16	501	3,829	3,437	392	Spring, Side + Down

In the 2015, 2011 and 2010 studies, fish targets in the Kokanee size classes from 0-270 mm showed the expected distribution of more younger and fewer older fish (Figure 8). For 2005, the number of targets in the younger Age-1+ and Age-2+ and Age-3+ and Age-4+ lengths bins were similar which is indicative of a lower recruitment from the 2003 and 2004 brood years.

Figure 9 shows the depths distribution of fish targets in the spring of 2015. The results show that:

- During the two early surveys (24-Mar and 1-Apr) >70 % of the fish were detected with the side-looking transducer in the top 2 m of the water column;
- For the next two sampling dates (14-Apr and 23-Apr) >70 % of the fish targets were detected with the down-looking transducer at depths between 5-25 m;
- For the next sampling date on 4-May >70 % of the fish targets were detected with the down-looking transducer found at depths between 5-15 m; and
- At the last sampling date on 14-May, >70 % of the fish targets were detected with down-looking transducer at depths from 5-25 m, similar to the typical depth distribution found in previous surveys carried out in the fall (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012).

The fish depth distribution shown in Figure 9 may be explained by the temperature distribution shown in Figure 10. The initial temperature of 7.6°C at 1 m depth on 24-Mar changed to 14.4 °C on 14-May, while the often preferred temperature range from 10-12 °C was found from 5-30 m later in the project. In addition, the depths distribution of Kokanee was surely affected by a likely increase in zooplankton or prey density typically starting in April.

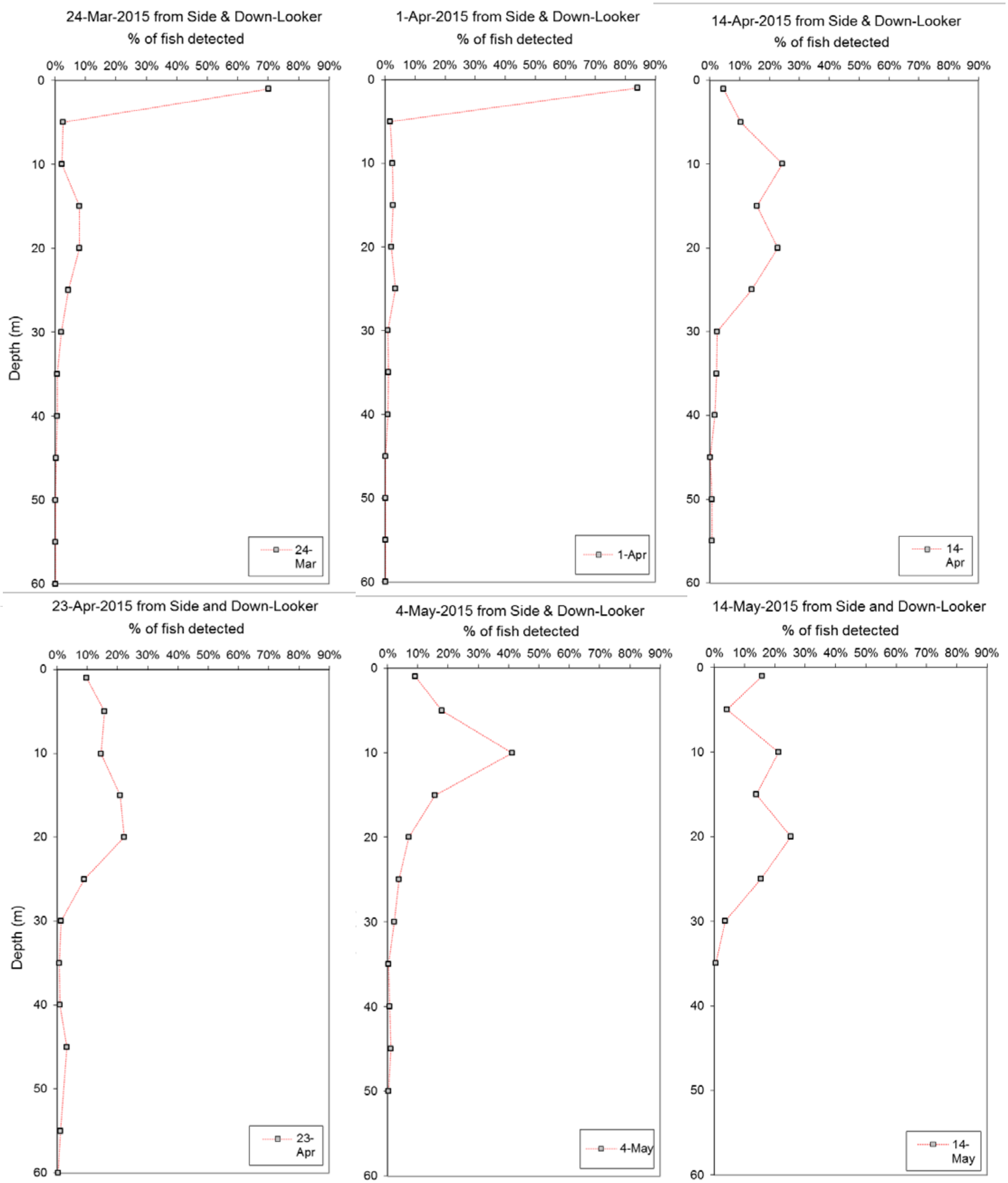

Figure 9 2015 fish target depths distributions for all six surveys dates between 24-Mar (top left panel) and 14-May (bottom right panel).

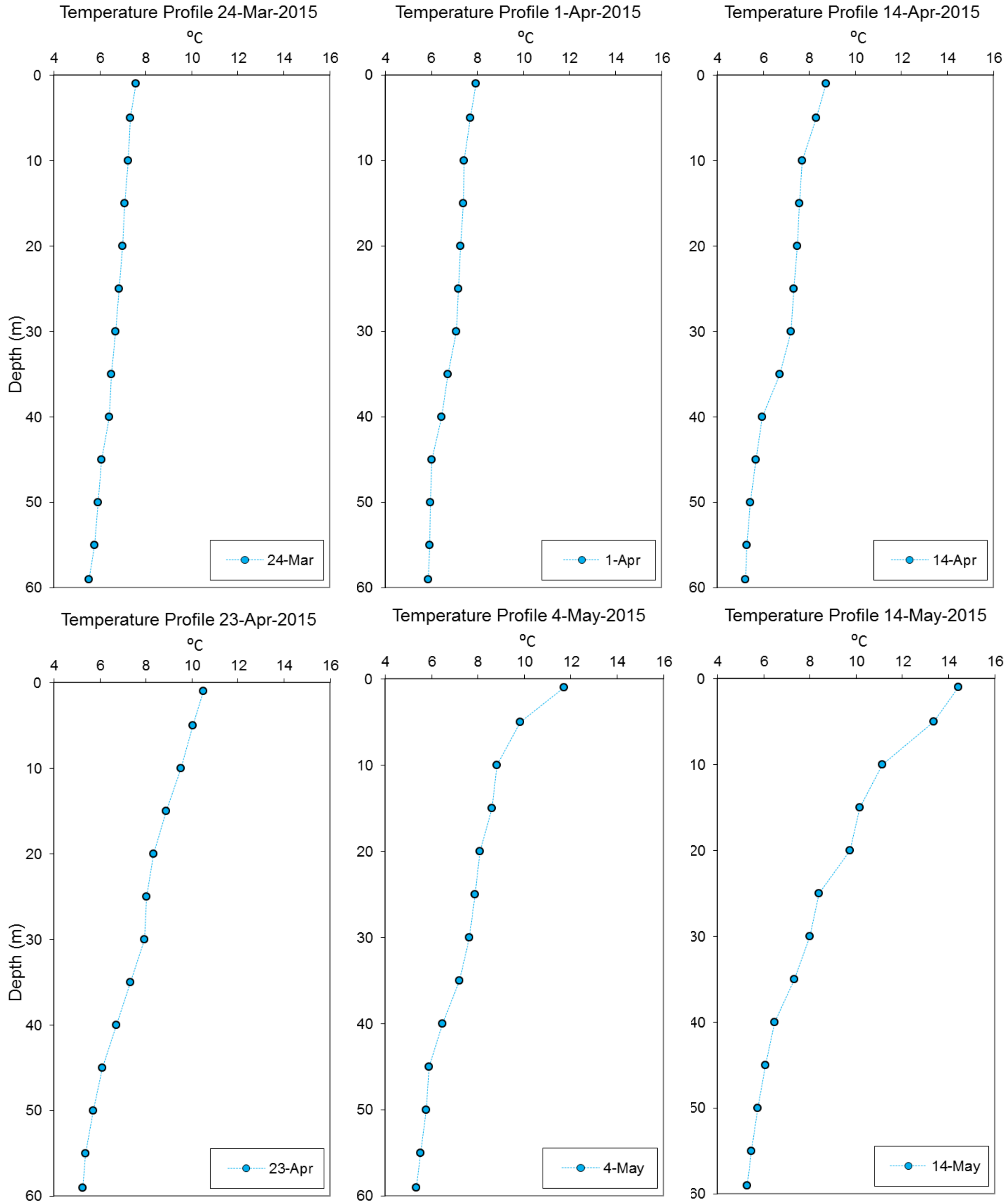

Figure 10 2015 fish target depths distributions for all six surveys dates between 24-Mar (top left panel) and 14-May (bottom right panel).

Changes to Fish Distribution within Coquitlam Reservoir over the Six Spring Sampling Dates

The majority of the pelagic fish targets in Coquitlam Reservoir are Kokanee based on our net catches in this and three previous studies (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012). How Kokanee were distributed throughout Coquitlam Reservoir (Figure 4) during our six surveys from 24-Mar to 14-May is shown in Figure 11 for fish in the Kokanee smolt size range from 60-90 mm and is shown in Figure 12 for the fish that are larger than the maximum length of Kokanee (>270 mm) and are therefore likely Kokanee predators such as Cutthroat Trout and Northern Pikeminnow.

The distribution of fish targets in the Kokanee smolt length range (60-100 mm) changed over the six surveys dates. While >90 % of these targets were found in the northern half for the reservoir on 24-Mar (Figure 11, top panel), only 1% of these targets was detected on transects closest to the dam. The percentage of smolt-size fish in the northern half of the reservoir decreased to 62% on 1-Apr while the percentage of fish on the transects closest to the dam increased to 22% (Figure 11, second panel from top). For the next three surveys (14-Apr, 23-Apr, 4-May) the percentage of smolt-size fish detected on the transects closest to the dam stayed between 8-18% (Figure 11, third, fourth and fifth panel from top) before dropping back to 4% on 14-May (Figure 11, bottom panel).

A similar pattern of changes was observed for fish targets in the size range of Kokanee predators (>270 mm) (Figure 12). No predator-size fish were detected on the transects closest to the dam on 24-Mar, 14-Apr, 23-Apr and 14-May (Figure 12, first, third, fourth and sixth panel from the top). In between, on 1-Apr and on 4-May, 25% and 21% of all predator-size fish were detected on the transects closest to the dam (Figure 12, second and fifth panel from the top).

When compared to fish distribution throughout the reservoir observed in hydroacoustic surveys of the pelagic fish population in the fall of 2005 (Bussanich et al. 2006) shown in Figure 13, >20% of fish detected on the transects closest to the dam appears to be a very high value.

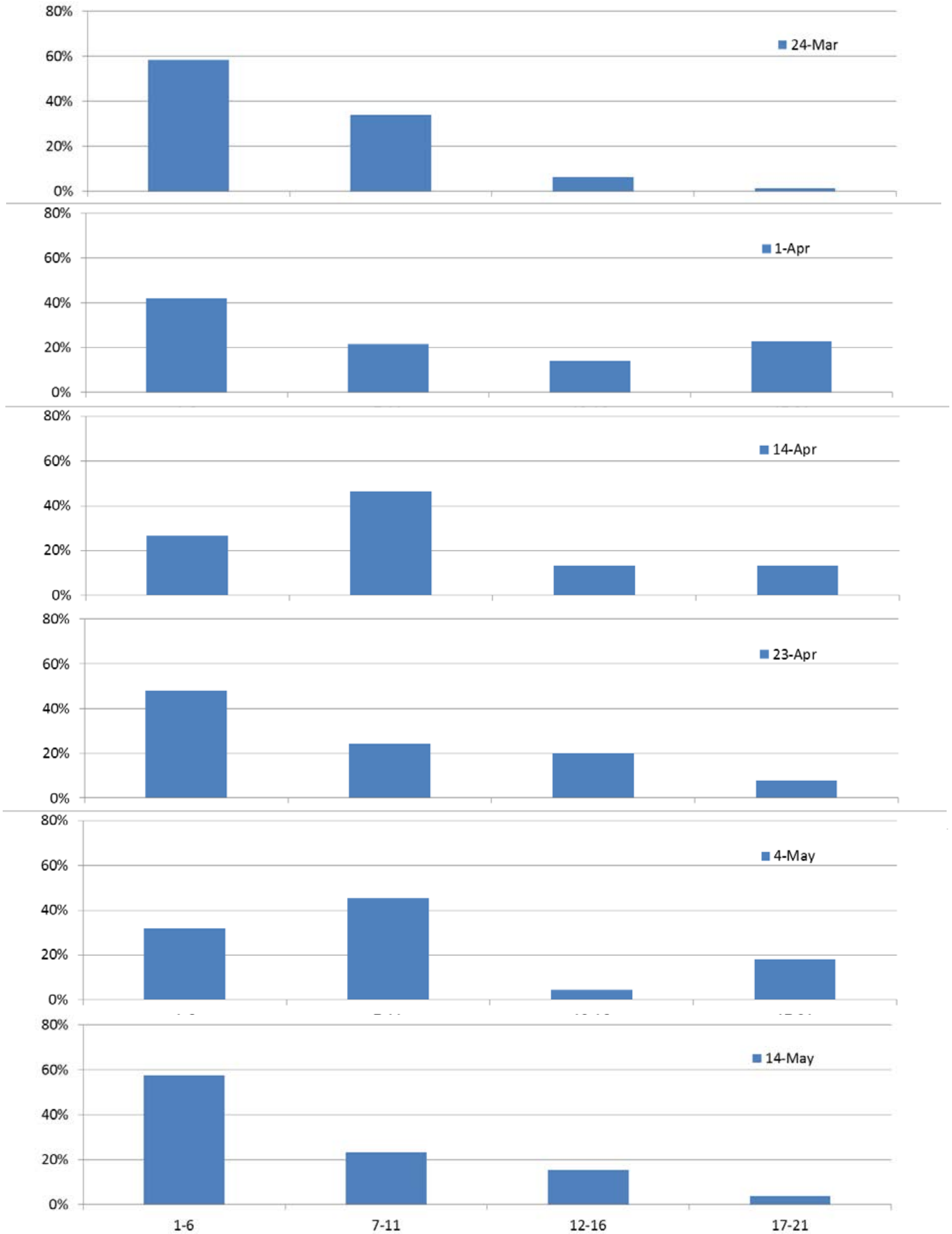

Figure 11 Distribution of Kokanee in the smolt size range (60-90 mm) over four regions of Coquitlam Reservoir from the north (Transects 1-6), to the south by the dam (Transects 17-21) over six survey dates from 24-Mar to 14-May.

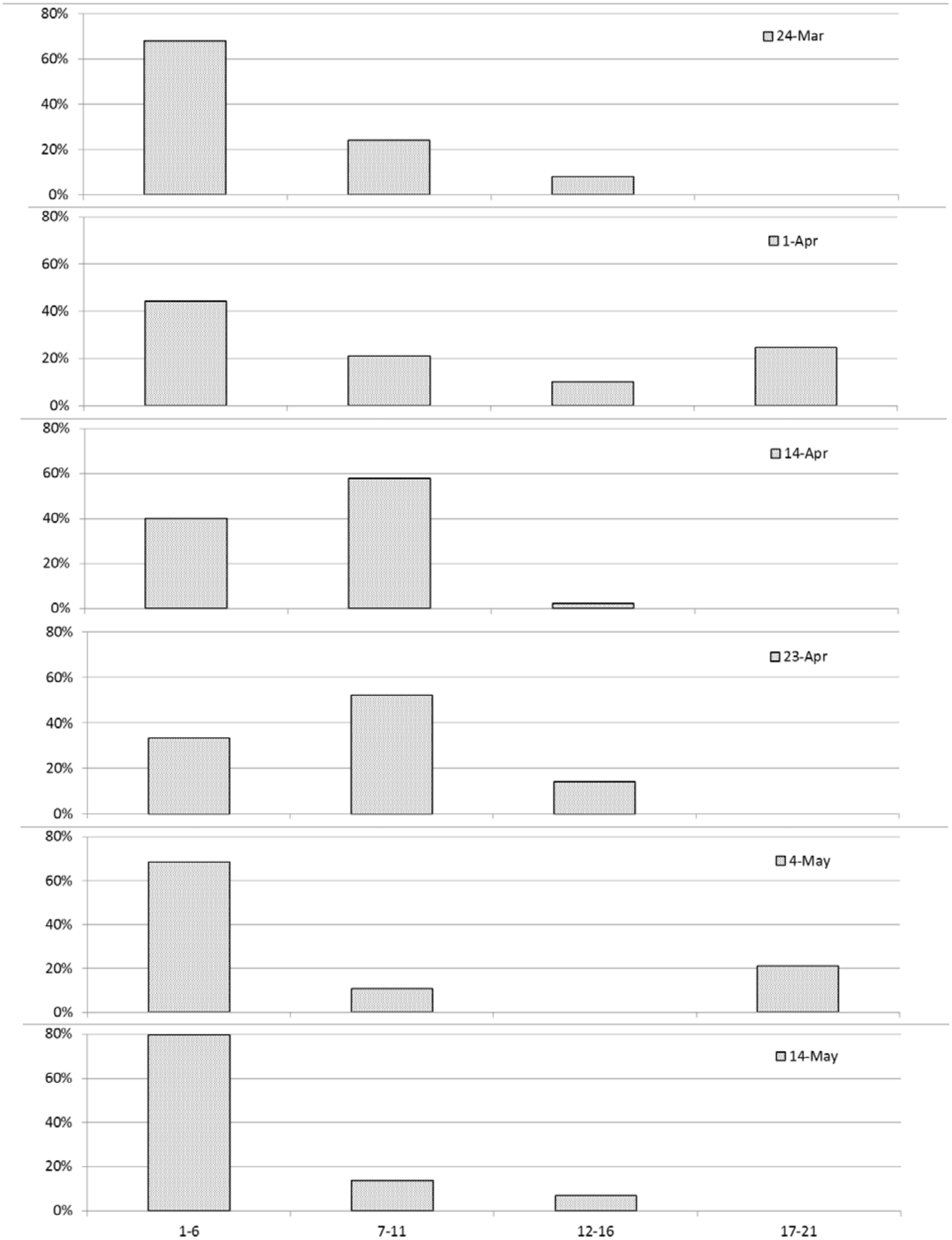

Figure 12 Distribution of likely Kokanee predators (<270 mm) over four regions of Coquitlam Reservoir from the north (Transects 1-6), to the south by the dam (Transects 17-21) over six survey dates from 24-Mar to 14-May.

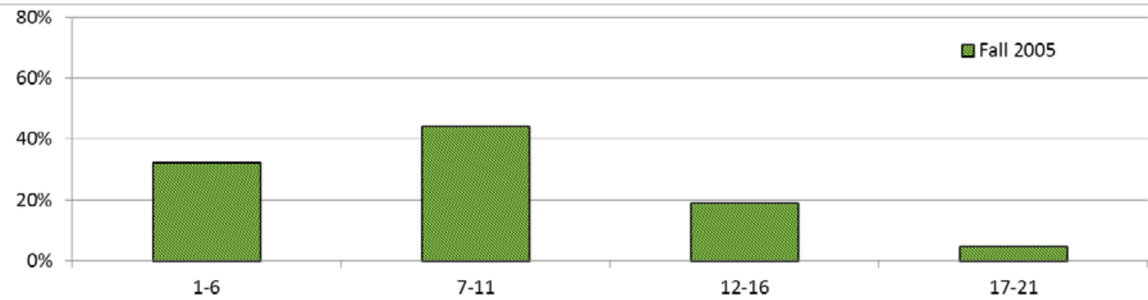

Figure 13 Distribution of all fish sizes over four regions of Coquitlam Reservoir from the north (Transects 1-6), to the south by the dam (Transects 17-21) for one hydroacoustic survey carried out in the fall of 2005 (Bussanich et al. 2006).

Gill-Netting Results

In 2015, an average Catch per Unit Effort or CPUE (catch per hour standardized for a 90 m^2 net area) of 0.07 fish was estimated for the combined gillnet effort. Average CPUE for Kokanee in 2015 was 0.01. In 2015, gillnets were mainly set close to the boom that is restricting access from the reservoir to the forebay and therefore areas that showed higher Kokanee abundance in previous studies were not used and comparisons to previous studies cannot be made. Nevertheless, the CPUE close to the dam changed considerably over the six survey dates as shown in Figure 14. The CPUE at the boom site went from 0 fish on 24-Mar to 0.17 on 15-Apr. The majority of the fish caught from 15-Apr to 15-May belonged to fish species in the predator group.

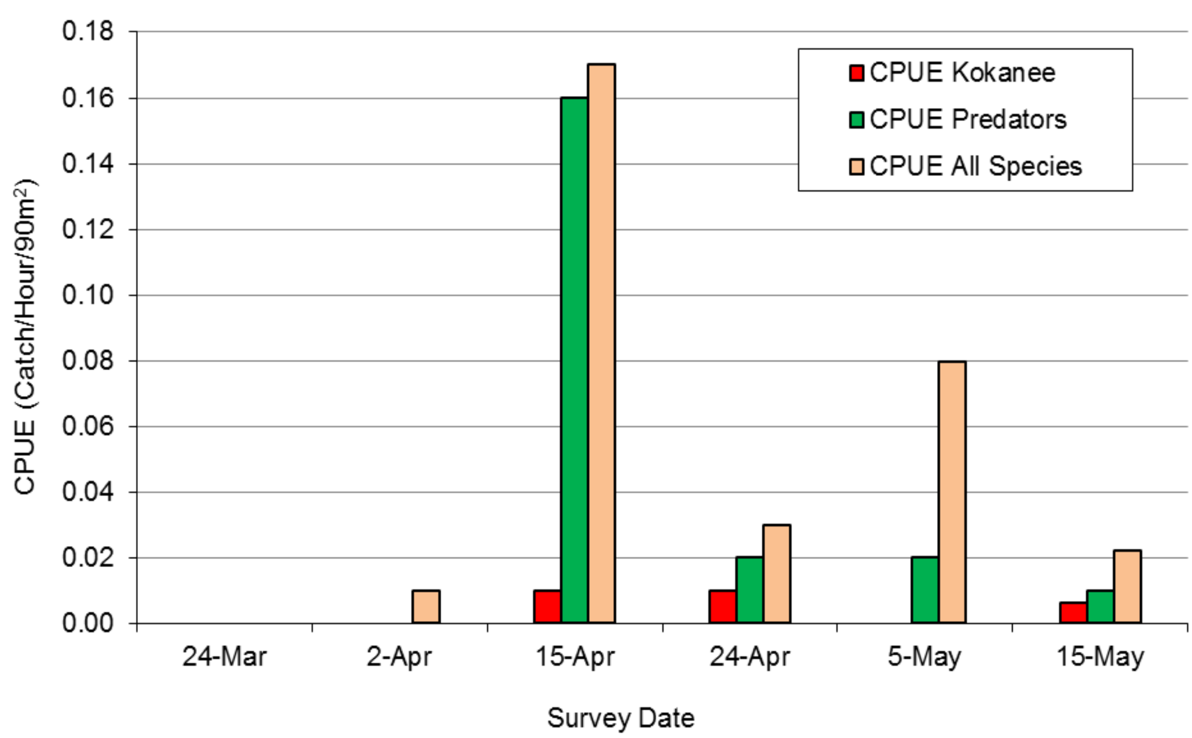

Figure 14 Percent of total fish numbers (upper panel) and fish biomass (lower panel) by species sampled in the fall of 2010 and 2011.

Gillnet Catch Species Composition

The total catch of 128 fish in the spring 2015 study was comprised of 6 Cutthroat Trout or 5% of the total catch, 9 Kokanee (7%), 38 Largescale Suckers (30%), 43 Peamouth Chub (34%), 31 Northern Pikeminnow (24%), no Redside Shiner (0%), 1 Sculpin (1%) and no Three-Spine Stickleback (Figure 15, top panel).

In comparison to the three previous fall studies (Bussanich et cal. 2006; Plate et al. 2011; Plate et al. 2012), where nets were set in the pelagic regions throughout the reservoir and Kokanee Salmon were the most caught fish species (Figure 15, bottom panel), the fish species most often caught in the spring of 2015 were Peamouth Chub, Largescale Sucker and Pikeminnow (Figure 15, top panel) (Table 5). Nets in 2015 were mainly set at the southern end of the reservoir in a mixed littoral and pelagic zone to intercept fish close to the dam.

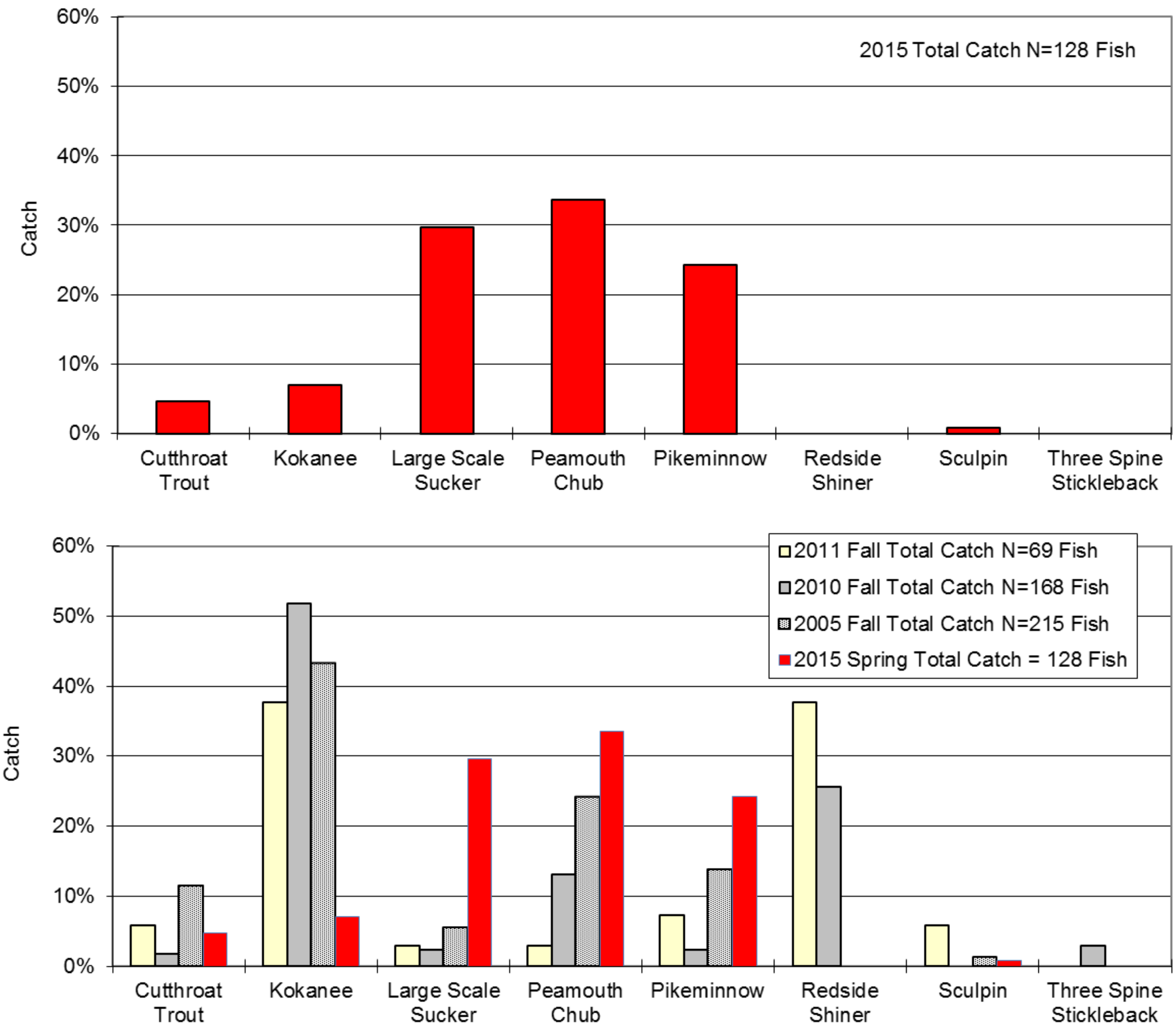

Figure 15 Percent of total catch in 2015 (upper panel) and compared to the three previous studies in (lower panel) by species.

Table 5 Comparison of fish catches by species to verify species composition in the 2005, 2010, 2011 and 2015 hydroacoustic surveys.

Catch by Species (N)									
Year	Total Catch	Cutthroat Trout	Kokanee	Largescale Sucker	Peamouth Chub	Northern Pikeminnow	Redside Shiner	Sculpin	Three-Spine Stickleback
2005	215	25	93	12	52	30	0	3	0
2010	168	3	87	4	22	4	43	0	3
2011	69	4	26	2	2	5	26	4	0
2015	128	6	9	38	43	31	0	1	0
Totals	**580**	**38**	**215**	**56**	**119**	**70**	**69**	**8**	**3**

DISCUSSION

Fish Abundance and Depth Distribution Using Hydroacoustics

Fish abundance in 2015 was slightly lower than in 2011, 2010 and 2005 (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012) with the typical very low average densities of 79 fish/ha (±67 STDEV). Based on the available data, we are assuming that the low Kokanee abundance may be the result of two effects: 1.) a bottom-up effect of low density of Kokanee prey organisms such as large Daphnia species and, 2.) a top-down effect of high densities of Kokanee predators such as Northern Pikeminnow. Low primary productivity, resulting in a lack of larger cladoceran zooplankton species such as *Daphnia pulex* was described for Coquitlam Reservoir by Bussanich et al. (2006). This lack of larger prey species may also contribute to the smaller average size of Coquitlam Reservoir Kokanee at spawning (245 mm) when compared with other Kokanee bearing lakes and reservoirs where Kokanee spawn at lengths between 300-450 mm (McGurk 2000). When compared to other lakes and reservoirs in similar latitudes and trophic classification without large Daphnia species, Coquitlam Reservoir Kokanee are in the middle of the observed lengths at spawning values (McGurk 2000). Nevertheless, the length and weight at spawning for Kokanee in Coquitlam Reservoir is comparable to many other oligotrophic systems (Rieman and Myers 1992).

In this study and an additional study carried out in the fall of 2015 (Roias and Plate, in preparation), high numbers of Northern Pikeminnow were caught in the littoral as well as the pelagic zones of Coquitlam Reservoir. Northern Pikeminnow were identified as a predator of juvenile Sockeye Salmon in other similar systems in the Lower Fraser Valley by Mossop et al. (2004).

Changes to the Vertical or Depth Distribution of Kokanee

Kokanee depth distribution changed considerably over the six surveys between 24-Mar and 14-May. While the majority of fish targets detected in the pelagic zone of Coquitlam Reservoir was observed in the top 2 m of the water column on 24-Mar and 1-Apr this pattern changed for the last four surveys until 14-May when the majority of the fish targets were detected between depths of 5-25 m. This change in depth distribution was likely influenced by changes in water temperature and highest density of prey abundance. The surface temperature, changed from a temperature of 7.5 C (24-Mar) which is within the optimal bioenergetic range for Kokanee to a temperature that was slightly above the optimal range on 14-May (14.4 °C) (Bevelhimer and Adams 1993). In addition, zooplankton abundance in deeper water typically increases in April to force Kokanee to switch from a mixed diet of terrestrial insects at the surface and low densities of zooplankton in deeper water typical before April to a diet mainly composed of high zooplankton densities in deeper water in May (Bevelhimer and Adams 1993).

Changes to the Horizontal or Geographical Distribution of Kokanee and Gill-Netting Results

The main hypothesis that we were trying to prove in this study was that Kokanee, especially in the smolt length range from 60-90 mm, are migrating towards the dam of Coquitlam Reservoir to leave for the ocean in April and May. In addition, and if Kokanee smolts are migrating towards the dam, predator species that are typically > 270 mm in Coquitlam Reservoir should follow the smolts. Both of these phenomena were observed in the spring of 2015. During the first survey on

24-Mar, the majority of fish in the smolt and predator lengths classes, were observed in the north and central basins of the reservoir while very few fish (<2%) were observed in the south basin closest to the dam. This picture changed in the beginning of April when >20% of the smolt and predator sized fish were found in the south basin closest to the dam. A second increase of smolt sized fish at the beginning of May in the south basin again coincided with an increase in predator sized fish. Net catches of the typical Coquitlam predators, Northern Pikeminnow and Cutthroat Trout, also increased at the log boom close to the dam in the middle of April. All but one of the predators were alive when caught in the net and therefore had to be released without an analysis of stomach content that could have proven them preying on Kokanee close to the dam. The movement of Kokanee in the smolt length class could represent the first step of the migration to the ocean or smolts following an accumulation of planktonic Kokanee prey into the forebay area. An investigation of changes in the distribution of zooplankton densities in the reservoir over the spring period would need to be carried out to identify whether migratory behaviour or prey abundance caused Kokanee smolts to seek out the forebay area.

Gillnet Catch Species Composition

The 2105 gillnet catch was mainly composed of Peamouth Chub (33%), Largescale Sucker (30%), Northern Pikeminnow (24%) and few (7%) Kokanee (Figure 15, top panel). Catch composition is therefore quite different from previous years when the majority of the catch represented Kokanee (Bussanich et al. 2006; Plate et al. 2011; Plate et al. 2012). This difference is likely based on the differences in net set locations. For all previous hydroacoustic studies in Coquitlam Reservoir, the nets were set in the pelagic zone targeting Kokanee. In 2015, the majority of nets was set in the shallower and littoral zone of Coquitlam Reservoir close to the log boom that is blocking access to the dam forebay. Thus, it was tried to target Kokanee smolts and their predators when approaching the dam. Therefore, the 2015 catch composition represents the littoral zone while the catch composition of previous years represents the pelagic zone.

RECOMMENDATIONS

Based on the results of this study in Coquitlam Reservoir and the background literature reviews (Plate et al. 2014) and conversations with BC Hydro and Metro Vancouver representatives, the following recommendations with regards to potential next steps are made:

- Kokanee smolts appear to migrate to the Coquitlam Reservoir Dam in the spring to leave the reservoir but are not being caught in the Rotary Screw Traps (RSTs) in the Coquitlam River below the dam. Therefore, Kokanee either are not successful in leaving the reservoir through the deep water outflow or are in the forebay for other reasons and currently do not try to leave the reservoir. Regardless, Kokanee smolts can be found in the forebay area in the spring and a surface spillway would likely lead to the natural outmigration of Kokanee smolts in Coquitlam Reservoir just as it does successfully in the Alouette Reservoir and could thus help in building a self-sustaining Sockeye Salmon population.

With regards to additional studies that will add to the knowledge base on Kokanee smolt behaviour it is recommended to:

- Assess the potential entrainment of Kokanee into Buntzen Lake by:
    a. Investigating whether Kokanee are present in Buntzen Lake and whether they belong to the Coquitlam Reservoir stock; and
    b. If Kokanee are present, monitor the outflow of Buntzen Lake into the ocean in early fall for returning Sockeye and determine whether those fish belong to the Coquitlam Reservoir stock.

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APPENDIX A: RAW DATA

Table 6 Summary of all fish targets for all transects and survey dates in 2015

3/24/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	6.28	70.65	19.51	1.73	0.00	4.99	6.22	51.58	0.00	6.67	5.75	5.13	0.00	1.05	0.38	17.83	0.00	0.00	0.83	0.00	0.00
5	0.00	2.08	1.71	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	1.08	0.00	0.00
10	0.49	1.89	1.54	0.41	0.00	0.00	0.00	0.00	0.98	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	1.22	2.21	2.40	0.60	3.55	1.14	0.29	0.58	0.59	0.00	1.85	2.04	2.27	0.41	0.71	0.00	1.00	1.10	0.73	0.00	0.00
20	1.73	0.37	3.45	0.30	0.53	1.72	1.55	3.26	1.38	0.27	0.23	1.25	1.37	1.09	0.51	0.00	1.31	0.59	1.64	0.00	0.00
25	0.59	0.30	0.20	0.00	0.00	1.07	0.89	0.45	2.08	1.30	0.41	0.24	0.58	0.40	0.18	0.72	2.16	0.00	1.01	0.00	0.00
30	0.00	1.24	0.79	0.44	0.17	0.00	0.39	0.81	0.19	0.00	0.00	0.00	1.56	0.00	0.00	0.16	0.00	0.00	0.32	0.00	0.00
35	0.00	0.00	0.00	0.39	0.27	0.00	0.00	0.43	0.54	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00
40	0.00	0.12	0.14	0.28	0.19	0.41	0.00	0.00	0.00	0.00	0.52	0.23	0.00	0.00	0.00	0.00	0.19	0.28	0.00	0.00	0.00
45	0.00	0.15	0.13	0.22	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00
50	0.10	0.00	0.16	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/24/2015	10.40	79.01	30.04	4.37	6.53	9.55	9.35	57.11	5.92	9.07	10.07	8.89	5.78	3.87	1.79	18.71	4.89	2.23	5.61	0.00	0.00
%	3.674	27.9	10.61	1.545	2.31	3.37	3.3	20.17	2.09	3.202	3.555	3.14	2.04	1.367	0.63	6.608	1.73	0.787	1.98	0	0
4/1/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	63.55	31.31	25.10	10.61	2.38	1.44	2.41	20.06	25.59	20.93	6.04	6.50	11.40	8.17	6.57	13.58	3.95	16.81	33.47	3.50	15.14
5	0.00	0.77	2.04	0.78	0.00	0.71	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00
10	1.52	3.38	1.36	0.00	1.01	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.66
15	0.00	5.24	0.79	1.21	0.00	0.80	0.00	0.37	0.00	0.00	0.00	1.03	0.00	0.33	0.00	0.00	0.41	0.00	0.00	0.00	0.00
20	0.37	3.63	0.50	0.82	1.27	0.00	0.29	0.00	0.00	0.00	0.00	0.66	0.00	0.47	0.00	0.00	0.00	0.00	0.45	0.00	0.00
25	0.00	2.36	0.79	1.16	0.70	1.98	2.06	1.22	1.70	0.35	0.27	0.18	0.00	0.24	0.21	0.00	0.00	0.00	0.51	0.00	0.00
30	0.00	0.80	0.34	0.41	0.69	0.15	0.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.24	0.00	0.00	0.00
35	0.00	2.51	0.14	0.44	0.14	0.00	0.14	0.27	0.28	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	1.81	0.00	0.31	0.22	0.00	0.00	0.00	0.24	0.00	0.29	0.00	0.30	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00
45	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
55	0.00	0.46	0.15	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
65	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4/1/2015	65.44	53.18	31.35	15.73	6.50	5.07	5.07	25.07	27.81	21.28	7.10	8.37	11.71	9.22	7.08	14.03	4.90	17.05	35.70	3.50	15.80
	16.74	13.6	8.018	4.025	1.66	1.3	1.3	6.412	7.113	5.443	1.816	2.141	2.995	2.357	1.81	3.589	1.25	4.361	9.131	0.89	4.041

4/14/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.29	0.07	0.17	0.24	0.19	0.00	0.00	0.06	0.28	0.00	0.04	0.07	0.03	0.20	0.05	0.19	0.03	0.25	0.28	0.07	0.00
5	0.00	0.00	0.00	0.00	0.72	3.65	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	1.06	2.47	0.00	2.28	0.00	0.00	2.39	0.00	0.00	0.00	1.41	0.68	0.45	0.98	0.00	1.45	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	1.81	1.09	0.38	2.32	0.42	0.30	0.00	0.51	0.00	0.00	0.00	0.48	0.50	0.69	0.00	0.00
20	1.39	0.00	0.00	0.30	1.27	1.57	1.02	1.69	2.04	0.49	1.03	0.00	0.48	0.00	0.00	0.00	0.28	0.31	0.46	0.00	0.00
25	1.07	0.21	0.00	0.71	0.39	0.40	1.07	1.08	1.35	0.21	0.62	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00
30	0.00	0.00	0.17	0.22	0.33	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.15	0.00	0.00	0.25	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.17	0.00	0.00
40	0.00	0.00	0.00	0.21	0.12	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.24	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4/14/2015	2.74	0.51	1.54	4.29	3.02	10.07	3.19	3.38	8.72	1.13	3.18	1.36	2.82	1.20	0.50	1.17	0.78	2.51	1.82	0.07	0.00
	5.082	0.951	2.855	7.937	5.6	18.6	5.91	6.259	16.15	2.09	5.893	2.509	5.216	2.219	0.92	2.158	1.45	4.655	3.376	0.13	0
4/23/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.27	0.36	0.31	0.37	0.15	0.27	0.35	0.35	0.37	0.21	0.37	0.10	0.00	0.00	0.00	0.08	0.00	0.26	0.72	0.00	0.05
5	0.00	0.00	0.00	0.00	0.70	3.16	0.00	0.97	0.00	0.00	1.25	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00
10	0.00	0.46	1.06	0.69	0.91	0.70	0.87	0.00	1.18	0.00	0.00	0.47	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.32	1.16	0.30	1.75	1.45	0.71	1.01	0.00	0.36	0.68	0.00	0.49	0.34	0.32	0.00	0.00	0.94	0.00	0.00
20	0.00	0.00	1.73	1.54	0.77	0.25	1.27	0.48	1.10	0.26	0.65	0.51	0.27	0.00	0.00	0.32	0.00	0.70	0.63	0.00	0.00
25	0.00	0.00	1.25	0.90	0.00	0.25	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.43	0.00	0.00
30	0.00	0.24	0.22	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00
40	0.19	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.57	0.00	0.00	0.59	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4/23/2015	0.46	1.06	5.61	4.67	3.11	7.13	3.93	2.51	3.88	0.99	3.58	1.76	0.27	1.05	0.34	2.04	0.67	1.33	2.72	0.00	0.05
	0.984	2.241	11.9	9.904	6.6	15.1	8.35	5.326	8.227	2.102	7.587	3.729	0.565	2.221	0.72	4.321	1.43	2.818	5.763	0	0.098

5/4/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.05	0.03	0.37	0.35	0.12	0.21	0.20	0.24	0.37	0.25	0.73	0.08	0.11	0.05	0.04	0.24	0.00	0.05	0.27	0.04	0.31
5	0.00	0.00	0.76	4.45	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10
10	3.05	0.98	3.05	8.25	1.22	0.97	0.42	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	1.49	1.04	0.75	0.00	1.26	1.40	0.00	0.69	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.32	0.00	0.00	0.77	0.23	0.22	0.45	0.00	0.00	0.00	0.25	0.57	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
25	0.65	0.00	0.00	0.47	0.18	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.44	0.22	0.17	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00
45	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/4/2015	4.46	2.94	5.64	15.35	2.47	3.09	2.64	0.95	1.07	0.68	0.98	0.65	1.34	0.05	0.04	0.61	0.00	0.48	0.27	0.04	1.41
	9.884	6.52	12.49	33.98	5.47	6.84	5.85	2.103	2.359	1.511	2.175	1.432	2.976	0.119	0.08	1.341	0	1.052	0.607	0.09	3.121
5/14/2015	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.90	0.51	0.40	0.34	0.59	1.82	0.54	0.59	0.00	0.10	0.59	0.08	0.09	0.04	0.27	0.50	0.00	0.00	0.45	0.08	0.35
5	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	6.92	1.06	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.45	0.84	0.00	0.66	0.00	0.00	0.00	0.00	0.00
15	1.02	0.36	0.00	1.26	0.00	0.29	0.00	0.92	0.41	1.26	0.00	0.00	1.40	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.25	0.69	1.48	1.38	3.47	0.33	0.81	1.72	0.60	0.91	0.67	0.32	0.00	0.26	0.24	0.00	0.00	0.00	0.00	0.00
25	0.49	0.29	1.61	1.10	0.00	1.33	0.47	0.39	1.17	0.00	0.00	0.76	0.19	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00
30	0.00	0.00	0.30	0.18	0.37	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.33	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/14/2015	10.33	2.47	3.69	4.37	2.34	6.91	1.34	2.86	3.30	2.71	1.96	1.52	3.48	1.70	0.53	1.40	0.00	0.21	0.45	0.08	0.35
	19.87	4.749	7.097	8.406	4.49	13.3	2.57	5.508	6.353	5.217	3.765	2.917	6.684	3.277	1.03	2.69	0	0.404	0.858	0.15	0.674

Table 7 Summary of all fishing data for the 2015 study

Net Size (m²)	Net Top Depth	Depth Bottom Depth	Date & Time In (dd-mmm)	Date & Time Out (dd-mmm)	Time Fished (min)	Time Fished (h)	Total Catch	CPUE Total	CPUE Kokanee	Large Scale Sucker	Kokanee	Bull Trout	Peamouth Chub	Pikeminnow	Cutthroat Trout	Prickly Sculpin	Total Catch	Easting	Northing	Easting	Northing	Length Of Fishing Path (m)	Area Description (1 = close to boom, 2 = south, 3 = centre, 4 = north)
302	5	8.6	3/23/15 14:40	3/24/15 10:00	1160	19.3	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515625	5467360	515625	5467360	1	1.00
302	10	13.6	3/23/15 15:00	3/24/15 10:20	1160	19.3	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515619	5467225	515619	5467225	1	1.00
302	5	8.6	3/23/15 15:40	3/24/15 10:40	1140	19.0	2.0	0.03	0.02	0	1	0	1	0	0	0	2	514986	5469004	514986	5469004	1	2.00
302	10	13.6	3/23/15 16:40	3/24/15 11:20	1120	18.7	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515377	5468425	515377	5468425	1	2.00
302	5	8.6	4/1/15 11:33	4/2/15 10:35	1382	23.0	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515637	5467239	515637	5467239	1	1.00
302	5	8.6	4/1/15 12:05	4/2/15 11:31	1406	23.4	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515446	5468131	515446	5468131	1	2.00
302	10	13.6	4/1/15 12:55	4/2/15 12:15	1400	23.3	0.0	0.00	0.00	0	0	0	0	0	0	0	0	514871	5469140	514871	5469140	1	2.00
302	10	13.6	4/1/15 13:20	4/2/15 11:06	1306	21.8	1.0	0.01	0.00	1	0	0	0	0	0	0	1	515618	5467219	515618	5467219	1	1.00
302	20	23.6	4/14/15 12:00	4/15/15 10:34	1354	22.6	0.0	0.00	0.00	0	0	0	0	0	0	0	0	517159	5474715	517159	5474715	1	4.00
302	20	23.6	4/14/15 12:30	4/15/15 12:00	1410	23.5	0.0	0.00	0.00	0	0	0	0	0	0	0	0	516180	5475100	516180	5475100	1	4.00
302	10	13.6	4/14/15 13:00	4/15/15 11:09	1329	22.2	1.0	0.01	0.00	0	0	0	0	1	0	0	1	517101	5474313	517101	5474313	1	3.00
302	5	8.6	4/14/15 13:42	4/15/15 12:40	1378	23.0	13.0	0.17	0.01	1	1	0	0	8	3	0	13	515726	5467123	515726	5467123	1	1.00
302	1	4.6	4/23/15 10:30	4/24/15 11:07	1477	24.6	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515745	5467132	515745	5467132	1	1.00
302	6	9.6	4/23/15 10:50	4/24/15 11:20	1470	24.5	5.0	0.06	0.01	1	1	0	0	3	0	0	5	515806	5466982	515806	5466982	1	1.00
302	5	8.6	4/23/15 11:40	4/24/15 11:55	1455	24.3	75.0	0.92	0.01	20	1	0	41	11	1	1	75	515425	5469119	515425	5469119	1	2.00
302	10	13.6	4/23/15 12:20	4/24/15 12:50	1470	24.5	6.0	0.07	0.04	0	3	0	1	2	0	0	6	516431	5476443	516431	5476443	1	4.00
302	5	8.6	5/4/15 10:00	5/5/15 9:40	1420	23.7	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515580	5467271	515580	5467271	1	1.00
302	10	13.6	5/4/15 10:10	5/5/15 9:55	1425	23.8	16.0	0.20	0.00	13	0	0	0	1	2	0	16	515580	5467271	515580	5467271	1	1.00
302	10	13.6	5/4/15 10:40	5/5/15 10:35	1435	23.9	3.0	0.04	0.00	2	0	0	1	0	0	0	3	515409	5467724	515409	5467724	1	2.00
302	5	8.6	5/4/15 11:10	5/5/15 10:55	1425	23.7	3.0	0.04	0.00	2	0	0	0	1	0	0	3	515698	5467065	515698	5467065	1	1.00
302	5	8.6	5/14/15 11:45	5/15/15 11:45	1440	24.0	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515498	5467394	515498	5467394	1	1.00
302	10	13.6	5/14/15 12:10	5/15/15 12:10	1440	24.0	0.0	0.00	0.00	0	0	0	0	0	0	0	0	515504	5467391	515504	5467391	1	1.00
302	1	4.6	5/14/15 12:30	5/15/15 12:20	1430	23.8	1.0	0.01	0.00	0	0	0	0	1	0	0	1	515513	5467391	515513	5467391	1	1.00
302	1	4.6	5/14/15 13:20	5/15/15 12:50	1410	23.5	6.0	0.08	0.03	0	2	0	0	4	0	0	6	5155124	5467390	5155124	5467390	1	1.00
					32842	547.4	132.0	0.069	0.005	40	9	0	44	32	6	1	**132**					24	

Table 8 Summary of all biological data for the 2015 study

Location Code, 1=South End SB, 2=East Shore SB, 3=North Shore SB, 4=North End CB	Set #	Date (dd/mm)	Data Taker Initials	Depth Caught	Fish ID #	Species	Fish ID Code	Fork Length (mm)
1	12	15-Apr	IB	5	12	Cutthroat Trout		268
1	12	15-Apr	IB	5	16	Cutthroat Trout		285
1	12	15-Apr	IB	5	17	Cutthroat Trout		253
2	15	24-Apr	IB	5	42	Cutthroat Trout		290
1	18	5-May	SJ	10	110	Cutthroat Trout		250
1	18	5-May	SJ	10	112	Cutthroat Trout		290
2	3	23-Mar	EP	10	2	Kokanee		213
1	12	15-Apr	IB	5	13	Kokanee		187
1	14	24-Apr	IB	6	20	Kokanee		190
2	15	24-Apr	IB	5	63	Kokanee		210
4	16	24-Apr	IB	5	101	Kokanee		213
4	16	24-Apr	IB	5	102	Kokanee		205
4	16	24-Apr	IB	5	103	Kokanee		190
1	24	15-May	EP	1	130	Kokanee		205
1	24	15-May	EP	1	131	Kokanee		177
1	8	2-Apr	SJ	10	3	Large Scale Sucker		220
1	12	15-Apr	IB	5	7	Large Scale Sucker		204
1	14	24-Apr	IB	6	21	Large Scale Sucker		298
2	15	24-Apr	IB	5	28	Large Scale Sucker		310
2	15	24-Apr	IB	5	29	Large Scale Sucker		390
2	15	24-Apr	IB	5	32	Large Scale Sucker		215
2	15	24-Apr	IB	5	36	Large Scale Sucker		240
2	15	24-Apr	IB	5	38	Large Scale Sucker		210
2	15	24-Apr	IB	5	40	Large Scale Sucker		205
2	15	24-Apr	IB	5	44	Large Scale Sucker		198
2	15	24-Apr	IB	5	45	Large Scale Sucker		230
2	15	24-Apr	IB	5	47	Large Scale Sucker		208
2	15	24-Apr	IB	5	48	Large Scale Sucker		214
2	15	24-Apr	IB	5	50	Large Scale Sucker		210
2	15	24-Apr	IB	5	54	Large Scale Sucker		305
2	15	24-Apr	IB	5	67	Large Scale Sucker		231
2	15	24-Apr	IB	5	70	Large Scale Sucker		217
2	15	24-Apr	IB	5	89	Large Scale Sucker		345
2	15	24-Apr	IB	5	91	Large Scale Sucker		340
2	15	24-Apr	IB	5	92	Large Scale Sucker		207
2	15	24-Apr	IB	5	93	Large Scale Sucker		210
2	15	24-Apr	IB	5	94	Large Scale Sucker		204
2	15	24-Apr	IB	5	96	Large Scale Sucker		337
1	18	5-May	SJ	10	105	Large Scale Sucker		265
1	18	5-May	SJ	10	106	Large Scale Sucker		258

Location Code, 1=South End SB, 2=East Shore SB, 3=North Shore SB, 4=North End CB	Set #	Date (dd/mm)	Data Taker Initials	Depth Caught	Fish ID #	Species	Fish ID Code	Fork Length (mm)
1	18	5-May	SJ	10	107	Large Scale Sucker		355
1	18	5-May	SJ	10	108	Large Scale Sucker		355
1	18	5-May	SJ	10	109	Large Scale Sucker		345
1	18	5-May	SJ	10	111	Large Scale Sucker		380
1	18	5-May	SJ	10	113	Large Scale Sucker		350
1	18	5-May	SJ	10	114	Large Scale Sucker		215
1	18	5-May	SJ	10	115	Large Scale Sucker		225
1	18	5-May	SJ	10	116	Large Scale Sucker		205
1	18	5-May	SJ	10	117	Large Scale Sucker		215
1	18	5-May	SJ	10	118	Large Scale Sucker		220
1	18	5-May	SJ	10	119	Large Scale Sucker		235
2	19	5-May	SJ	10	120	Large Scale Sucker		245
1	20	5-May	SJ	10	122	Large Scale Sucker		275
1	20	5-May	SJ	10	123	Large Scale Sucker		280
2	3	23-Mar	EP	10	1	Peamouth Chub		131
2	15	24-Apr	IB	5	24	Peamouth Chub		223
2	15	24-Apr	IB	5	25	Peamouth Chub		207
2	15	24-Apr	IB	5	26	Peamouth Chub		220
2	15	24-Apr	IB	5	27	Peamouth Chub		215
2	15	24-Apr	IB	5	31	Peamouth Chub		217
2	15	24-Apr	IB	5	33	Peamouth Chub		210
2	15	24-Apr	IB	5	34	Peamouth Chub		210
2	15	24-Apr	IB	5	35	Peamouth Chub		210
2	15	24-Apr	IB	5	39	Peamouth Chub		204
2	15	24-Apr	IB	5	41	Peamouth Chub		200
2	15	24-Apr	IB	5	43	Peamouth Chub		220
2	15	24-Apr	IB	5	46	Peamouth Chub		
2	15	24-Apr	IB	5	49	Peamouth Chub		205
2	15	24-Apr	IB	5	51	Peamouth Chub		210
2	15	24-Apr	IB	5	52	Peamouth Chub		197
2	15	24-Apr	IB	5	53	Peamouth Chub		199
2	15	24-Apr	IB	5	55	Peamouth Chub		221
2	15	24-Apr	IB	5	56	Peamouth Chub		200
2	15	24-Apr	IB	5	57	Peamouth Chub		213
2	15	24-Apr	IB	5	58	Peamouth Chub		210
2	15	24-Apr	IB	5	59	Peamouth Chub		198
2	15	24-Apr	IB	5	60	Peamouth Chub		208
2	15	24-Apr	IB	5	61	Peamouth Chub		245
2	15	24-Apr	IB	5	62	Peamouth Chub		203
2	15	24-Apr	IB	5	64	Peamouth Chub		202
2	15	24-Apr	IB	5	65	Peamouth Chub		175

Location Code, 1=South End SB, 2=East Shore SB, 3=North Shore SB, 4=North End CB	Set #	Date (dd/mm)	Data Taker Initials	Depth Caught	Fish ID #	Species	Fish ID Code	Fork Length (mm)
2	15	24-Apr	IB	5	66	Peamouth Chub		200
2	15	24-Apr	IB	5	68	Peamouth Chub		180
2	15	24-Apr	IB	5	69	Peamouth Chub		210
2	15	24-Apr	IB	5	73	Peamouth Chub		209
2	15	24-Apr	IB	5	75	Peamouth Chub		250
2	15	24-Apr	IB	5	77	Peamouth Chub		209
2	15	24-Apr	IB	5	78	Peamouth Chub		240
2	15	24-Apr	IB	5	81	Peamouth Chub		215
2	15	24-Apr	IB	5	82	Peamouth Chub		218
2	15	24-Apr	IB	5	85	Peamouth Chub		220
2	15	24-Apr	IB	5	86	Peamouth Chub		215
2	15	24-Apr	IB	5	87	Peamouth Chub		215
2	15	24-Apr	IB	5	88	Peamouth Chub		203
2	15	24-Apr	IB	5	90	Peamouth Chub		249
2	15	24-Apr	IB	5	95	Peamouth Chub		218
4	16	24-Apr	IB	5	98	Peamouth Chub		63
2	19	5-May	SJ	10	121	Peamouth Chub		208
3	11	15-Apr	IB	10	4	Pikeminnow		365
1	12	15-Apr	IB	5	5	Pikeminnow		122
1	12	15-Apr	IB	5	6	Pikeminnow		160
1	12	15-Apr	IB	5	8	Pikeminnow		163
1	12	15-Apr	IB	5	9	Pikeminnow		117
1	12	15-Apr	IB	5	10	Pikeminnow		112
1	12	15-Apr	IB	5	11	Pikeminnow		124
1	12	15-Apr	IB	5	14	Pikeminnow		158
1	12	15-Apr	IB	5	15	Pikeminnow		147
1	14	24-Apr	IB	6	18	Pikeminnow		175
1	14	24-Apr	IB	6	19	Pikeminnow		173
1	14	24-Apr	IB	6	22	Pikeminnow		123
2	15	25-Apr	IB	6	23	Pikeminnow		400
2	15	24-Apr	IB	5	30	Pikeminnow		221
2	15	24-Apr	IB	5	37	Pikeminnow		258
2	15	24-Apr	IB	5	71	Pikeminnow		175
2	15	24-Apr	IB	5	72	Pikeminnow		210
2	15	24-Apr	IB	5	74	Pikeminnow		255
2	15	24-Apr	IB	5	76	Pikeminnow		273
2	15	24-Apr	IB	5	79	Pikeminnow		260
2	15	24-Apr	IB	5	80	Pikeminnow		255
2	15	24-Apr	IB	5	83	Pikeminnow		175
2	15	24-Apr	IB	5	84	Pikeminnow		255
4	16	24-Apr	IB	5	99	Pikeminnow		470
4	16	24-Apr	IB	5	100	Pikeminnow		420

Location Code, 1=South End SB, 2=East Shore SB, 3=North Shore SB, 4=North End CB	Set #	Date (dd/mm)	Data Taker Initials	Depth Caught	Fish ID #	Species	Fish ID Code	Fork Length (mm)
1	18	5-May	SJ	10	104	Pikeminnow		215
1	20	5-May	SJ	10	124	Pikeminnow		290
1	23	15-May	EP	5	125	Pikeminnow		340
1	24	15-May	EP	1	126	Pikeminnow		340
1	24	15-May	EP	1	127	Pikeminnow		280
1	24	15-May	EP	1	128	Pikeminnow		180
1	24	15-May	EP	1	129	Pikeminnow		120
2	15	24-Apr	IB	5	97	Sculpin		180