Pelagic Fish Surveys of 23 Sockeye Rearing Lakes in the Skeena River System and in Northern British Columbia Coastal Watersheds From 1997 to 2005

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PELAGIC FISH SURVEYS OF 23 SOCKEYE REARING LAKES IN THE SKEENA RIVER SYSTEM AND IN NORTHERN BRITISH COLUMBIA COASTAL WATERSHEDS FROM 1997 TO 2005

by

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ABSTRACT

Hume, J.M.B. and MacLellan, S.G. 2008. Pelagic fish surveys of 23 sockeye rearing lakes in the Skeena River system and in northern British Columbia coastal watersheds from 1997 to 2005. Can. Tech. Rep. Fish. Aquat. Sci. 2812: vi + 99 p.

We conducted pelagic fish surveys using hydroacoustics, midwater trawls and small mesh gillnets in 23 sockeye (*Oncorhynchus nerka*) rearing lakes in the Skeena River and north and central coast regions of British Columbia. We present the results in relation to lake water type and provide detailed results for each lake. Clear lakes had the most diverse pelagic fish community but age-0 *O. nerka* (mostly sockeye) were the most common species found. Glacially turbid lakes had far fewer species and age-0 *O. nerka* were the most common. Threespine stickleback (*Gasterosteus aculeatus*) were the dominant species in the stained lakes and age-0 *O. nerka* were the only other abundant taxa. *Daphnia* were the dominant prey item of age-0 *O. nerka* in clear lakes while *Bosmina* dominated in the diets in stained lakes. Copepods and terrestrial insects were the most common prey items in glacially turbid lakes. The potential competitor, threespine stickleback, comprised the majority of the planktivorous biomass in stained lakes but age-0 *O. nerka* had the largest biomass in clear and glacial lakes.

RÉSUMÉ

Hume, J.M.B. and MacLellan, S.G. 2008. Pelagic fish surveys of 23 sockeye rearing lakes in the Skeena River system and in northern British Columbia coastal watersheds from 1997 to 2005. Can. Tech. Rep. Fish. Aquat. Sci. 2812: vi + 99 p.

Nous avons effectué des relevés des poissons pélagiques au moyen de techniques hydroacoustiques, de chaluts pélagiques et de filets maillants à petites mailles dans 23 lacs servant d’habitat de grossissement pour le saumon rouge (*Oncorhynchus nerka*) dans les régions de la Skeena et du nord et du centre de la côte de la Colombie-Britannique. Nous présentons les résultats en fonction des types d’eaux des lacs, et fournissons des résultats détaillés pour chaque lac. Les lacs aux eaux claires présentaient la communauté de poissons pélagiques la plus diversifiée, les *O. nerka* (anadromes pour la plupart) d’âge 0 y étant les poissons les plus communs. Les lacs glaciaires turbides renfermaient beaucoup moins d’espèces, et les *O. nerka* d’âge 0 y étaient aussi les poissons les plus communs. L’épinoche à trois épines (*Gasterosteus aculeatus*) était l’espèce dominante dans les lacs aux eaux sombres, et les *O. nerka* d’âge 0 constituaient le seul autre taxon abondant. Les *Daphnia* constituaient les principales proies des *O. nerka* d’âge 0 dans les lacs aux eaux claires, tandis que les *Bosmina* dominaient dans les régimes alimentaires dans les lacs aux eaux sombres. Les copépodes et les insectes terrestres constituaient les proies les plus communes dans les lacs glaciaires turbides. Le compétiteur potentiel, l’épinoche à trois épines, représentait la plus grande grande partie de la biomasse planctophage dans les lacs aux eaux sombres, mais les *O. nerka* d’âge 0 constituaient la biomasse la plus importante dans les lacs aux eaux claires et les lacs glaciaires.

INTRODUCTION

To effectively manage Pacific salmon stocks, it is necessary to have reliable estimates of stock abundance and habitat capacity. The North and Central Coast Management area of Fisheries and Oceans Canada (DFO) has more than 145 sockeye salmon (*Oncorhynchus nerka*) stocks, most of which rear for the first year of their life in lakes downstream of the spawning streams (Riddell 2004). Many of these stocks are small, but represent a wide range of genetic diversity with stocks adapted to many varying habitats at all life history stages (DFO 2005). This large number of stocks, many in very remote locations with difficult access, makes traditional stock assessment and management procedures based on adult spawners difficult and often very expensive.

Stock abundance of Pacific salmon spawning populations is typically estimated by enumerating the spawning escapement in natal streams (Roos 1989, Schubert 1998), but as spawning often occurs over large areas and extended periods of time, great effort is required for accurate assessments. Unfortunately, various levels of effort have been used in enumerating adult spawners and the effort expended varied depending on the perceived importance of the stock and the difficulty of performing the assessment. Effort has varied from one-time qualitative stream walks or fly-overs to long-term fences that enumerate every fish returning to spawn (Cox-Rogers et al. 2004).

Sockeye salmon stocks are no exception, with many spawning streams and lakes in northern and coastal British Columbia in remote locations, having only airborne access (Shortreed et al. 1998; Cox-Rogers et al. 2004). In the past, spawning adults to these streams have been inconsistently enumerated, usually using techniques that only provided rough estimates of stock abundance. The utility of these estimates for stock assessment and determining current stock status is low, as the data quality is poor and there are often many annual data gaps (McKinnell and Rutherford 1994; Shortreed et al. 1998).

Stock assessment is best done when fish are congregated in a relatively small and accessible area. One such period for sockeye salmon is during the first year of their life when most stocks are rearing in nursery lakes. Hydroacoustic and midwater trawling techniques to assess lake rearing populations of juvenile sockeye have been developed over the last 35 years (Nunnallee and Mathisen 1972; Mathisen and Smith 1982; Hyatt et al. 1984; McDonald and Hume 1984; Burczynski and Johnson 1986; Enzenhofer and Hume 1989; Parkinson et al. 1994; Hume et al. 1996; Shortreed et al. 1998; Hume and MacLellan 2000; Hyatt et al. 2000). Under appropriate circumstances, these estimates provide an accurate estimate of juvenile sockeye salmon and are a cost effective means of obtaining stock status information for smaller sockeye salmon stocks (Cox-Rogers et al. 2004). Once estimates of juvenile abundance have been made they can then be compared against predictions of maximum juvenile biomass to determine stock status and appropriate management plans can be made (Cox-Rogers et al. 2004; Shortreed et al. 2007).

In this paper we report on surveys conducted between 1997 and 2005 in lakes of the Skeena River system and in lakes of smaller watersheds that drain into north and central coast waters. Hume et al. (1996), Shortreed et al. (1998), and Cox-Rogers et al. (2004) have developed and modified a habitat based model that utilizes known relationships between photosynthesis rate (PR) and maximum smolt biomass to estimate maximum juvenile biomass and optimum escapement (the PR model). The results from this paper and earlier studies are compared in Shortreed et al. (2007) to PR model based estimates of maximum juvenile biomass to determine the stock status of these sockeye populations at the time of the surveys.

THE STUDY LAKES

The 23 study lakes are in three broad regions of west central British Columbia; the Skeena River watershed, many smaller north coast watersheds and a single central coast watershed (Fig. 1). Seventeen of the lakes were within the Skeena River drainage basin including; Aldrich, McDonell, Swan, Club, Stephens, Azuklotz, Bear, Motase, Sustut, Johanson, Slamgeesh, Morice, Kitwanga, Kitsumkalum, and Lakelse lakes. Ecstall and Johnston lakes are also part of the Skeena River drainage but are located near enough to the coast to be considered part of the north coast region. Five of the study lakes, Evelyn, Banks East, Banks West, Kitkiata, and Hartley Bay Lower Lakes are located on the islands and peninsulas of British Columbia's north coast. Charlotte Lake is the lone study lake in the central coast area (Cariboo-Chilcotin) and drains to the Pacific Ocean via the Atnarko and Bella Coola rivers.

Elevations range from near sea level (18 m) to 1 444 m (Table 1). All of the lakes except Charlotte Lake are accessible to anadromous sockeye salmon. Climatic conditions vary considerably between the regions. Lakes near the coast are within the coastal western hemlock biogeoclimatic zone with a maritime temperate climate (cool summers and mild winters, Farley 1979). Most of the interior lakes are in the sub-boreal spruce biogeoclimatic zone and have a warm summer continental climate (warm summers, cold winters).

The study lakes range from small productive lakes like Slamgeesh, Johanson, Sustut and McDonell to large, relatively unproductive lakes such as Morice and Charlotte. The smallest and shallowest lake was Club Lake with surface area of 39 ha and mean depth of 3.7 m. The largest was Morice Lake, with a surface area of 9 739 ha and a mean depth of 100 m. With a maximum depth of 236 m, Morice Lake was also the deepest lake sampled. Detailed morphological and limnological descriptions of the lakes can be found in Shortreed et al. (1998, 2007).

Shortreed et al. (2007) found that differences in chemical, biological and primary productivity of sockeye rearing lakes were more related to water clarity than to physical location. They found significant differences between clear, glacially turbid and organically stained lakes, including all of the lakes in this study. Thirteen of the lakes in this study were clear (Aldrich, Azuklotz Bear, Charlotte, Club, Johanson, Kitwanga, Lakelse, McDonell, Slamgeesh, Stephens, Sustut, and Swan), four were glacially turbid (Johnston, Kitsumkalum, Morice, and Motase) and six were organically stained (Banks East, Banks West, Ecstall, Evelyn, Hartley Bay Lower and Kitkiata). We present our results in the context of water clarity and other factors that may affect sockeye growth, survival, and production.

METHODS

FIELD DATA COLLECTION

We enumerated and sampled populations of pelagic fish using hydroacoustic and midwater trawling techniques developed for juvenile sockeye salmon (Burczynski and Johnson 1986: Hume et al. 1996; Hyatt et al. 1984, MacLellan and Hume 2008). We collected additional fish samples with gillnets and occasionally with minnow traps. Surveys were conducted in late summer and early fall between August 25 and September 30. Most lakes were only surveyed once, but a few lakes were surveyed for two (Kitwanga, McDonell lakes) or three (Lakelse Lake) years. In addition, we also conducted early summer surveys on Kitwanga and Lakelse lakes in 2003.

Prior to the survey we divided each lake into one to four sections for population analysis and fish collection (Table 1, Fig. 2). Within each section we normally established a minimum of three hydroacoustic transects (MacLellan and Hume 2008). All lakes had a minimum of five transects except the smallest, Club Lake, which had three transects. One or more trawls were conducted in each section depending on fish abundance and vertical distribution. Ancillary information was also collected in each lake using gillnets and sometimes minnow traps. All sampling (hydroacoustics and trawling) was done at night when the fish tended to be closer to the surface and more accessible to both hydroacoustics and trawling (Burczynski and Johnson 1986, Narver 1970).

The sampling equipment was deployed from one of two boats; either an aluminum 7.3 m inboard/outboard cabin cruiser; or on lakes without road access, a 4.3 m inflatable boat powered by an outboard engine. On the cabin cruiser, we deployed the transducer from a towed body and used a closing 18-m long trawl with a 3-m wide by 7-m deep mouth opening (Enzenhofer and Hume 1989). On the inflatable, we used a pole mounted transducer and a 7.5 m long trawl with a 2x2-m mouth opening (Gjernes 1979, MacLellan and Hume 2008). The 2x2-m trawl is increasingly biased when fish size increases above 40 mm (Hyatt et al. 2004, McQueen et al. 2007). In this study, we did not use any corrections for bias since it was uncertain whether published values were applicable to our lakes, but see MacLellan and Hume (2008) for possible bias correction formulae.

One to four midwater tows of 3 to 50 minutes duration were conducted in each lake section, mainly targeting observed layers of fish-sized acoustic targets at depths ranging from the surface to 28 m (Table 2). After capture, most fish were anaesthetized with a lethal dose of clove oil solution (Anderson et al. 1997) to prevent regurgitation of stomach contents prior to preserving them in either 10% formalin or 85% ethanol. Fish too large for easy storage were identified, measured, and released alive without anaesthetizing. After 30 days or more, preserved fish were identified, measured, and weighed. Total length of sculpins and fork length of other fish was measured.

In most lakes we also sampled fish using modified "Swedish" style gillnets, consisting of four 4-m long panels with stretched mesh sizes of 12.5, 16, 20, and 25 mm (Appleberg 2000, MacLellan and Hume 2008). Gillnets were set in deep water, but near shore, for ease of deployment and retrieval. We usually used an overnight set of 1 or 2 nets in each lake for about 14 hrs on average (Table 2).

Before 2004, we also occasionally sampled with “Gee” minnow traps. These traps had a mesh size of 6 mm and had 2-cm mouth openings and were baited with canned cat food. They were used for collecting samples of small near shore fish.

Hydroacoustic Sampling

We used four models of Biosonics scientific echosounders for this study. In 1997, Charlotte Lake was surveyed with a Biosonics 105 echosounder using a 420-kHz dual beam (6°/15°) transducer. In 2001, Evelyn, Slamgeesh, McDonell and Aldrich lakes were surveyed with a DT6000 echosounder using a 208 kHz 6.6 degree split beam transducer. From 2002 to 2003, all lakes were surveyed with a DE6000 echosounder using a 201 kHz, 6.4 by 6.4 degree split beam transducer. In the spring of 2004 the DE6000 was upgraded to the Biosonics DEX model and this was used for all surveys in 2004 and 2005. The DT and DE sounders are similar in design and there is no significant difference in the data collected by these systems. There were very few targets detected in the hydroacoustic data from Charlotte Lake and although a subjective estimate was made from a visual inspection of the echograms, it was not post-processed. Thus, comparability between the Biosonics 105 and the DT/E systems was not relevant to this study.

The sounders transmitted at a pulse width of 0.4 ms and collected data above a lower threshold of -70 dB. Range was set to a maximum of 80 m in deep lakes and just beyond the maximum depth of shallower lakes. Pulse rate was optimized for maximum hits per target and the least interference from false bottom echoes and normally ranged from 3 to 10 pings/s. We conducted all surveys at night between the hours of civil sunset and sunrise (National Research Council Canada sunrise/sunset calculator, www.hia-iha.nrc-cnrc.gc.ca/sunrise_e.html).

We transected at 2.3 m/s when using the towed transducer and at 1.5 m/s or slower when using the pole mounted transducer (MacLellan and Hume 2008). Slower speeds will increase the number of ensonifications per fish.

Shallow water is not suitable for the enumeration of fish using a downward facing transducer for a combination of reasons (MacLellan and Hume 2008). Five lakes (Aldrich, Azuklotz, Club, Hartley Bay, and Slamgeesh) in this study were poor candidates for hydroacoustic surveys as they had mean depths of 5 m or less and maximum depths of less than 10 m.

Bathymetric charts were required for navigation, determination of the survey design, and for determining transect layer volumes in the post-survey hydroacoustic analysis. Charts were available for many of the lakes on the British Columbia Ministry of Environment’s “Fisheries inventory data queries” website: (http://a100.gov.bc.ca/pub/fidq/main.do). For eight of the lakes (Banks East, Banks West, Club, Evelyn, Hartley Bay Lower, Kitkiata, Stephens, and Swan lakes), we constructed new bathymetric charts from hydroacoustic data collected during the surveys (MacLellan and Hume 2008; Fig. 3).

SAMPLE AND DATA PROCESSING

<u>Hydroacoustic Methods</u>

We used four techniques to process our hydroacoustic data, echo integration, single target analysis (ST), track target analysis (TT) and a variation on tracked target analysis we call *modified* TT (MacLellan and Hume 2008). In this study, we used Biosonics' Visual Analyzer (www.biosonicsinc.com) for data collected in 2001 and Sonardata's Echoview (www.sonardata.com) since 2002.

In echo integration analysis, backscatter energy from targets at the depths of interest was integrated by the software over discrete distance and depth intervals to provide relative estimates of fish density (S_V). These relative estimates were then scaled with the average target strength (TS) for that transect layer to produce an absolute estimate of fish density (Burczynski and Johnson 1986). In single target echo counting analysis, the water column was sampled ping by ping and the software counted the number of single acceptable targets detected (MacLennan and Simmonds 1992; www.echoview.com/WebHelp/Echoview.htm). For each transect interval, the number of single target detections was divided by the sum of the volumes sampled by the sound beam of each ping to produce an absolute fish density for the interval (MacLellan and Hume 2008). In tracked target analysis fish counts were based on fish tracks, which were made up of a series of single targets grouped together to form a track of a single fish (Keiser and Mulligan 1984; www.echoview.com/webhelp/echoview.htm). Tracked target analysis used the volume of water in an interval-layer (cell) for sample volume (MacLellan and Hume 2008).

The larval form of the phantom midge (*Chaoborus* spp.) was present in the midwater in six study lakes, including high densities in Evelyn, Hartley Bay, and Kitwanga lakes, moderate densities in East and West Banks lakes and low densities in Aldrich Lake (Shortreed et al. 2007). Their diel behaviour, their acoustic signature due to the presence of two air sacs, and their potentially high density can create considerable interference with the acoustic enumeration of juvenile sockeye salmon (Teraguchi 1975; Jones and Xie 1994; Knudsen et al. 2006).

MacLellan and Hume (2008) report a method of separating the fish and *Chaoborus* signal through a combination of changes in data collection and in signal processing. Individual *Chaoborus* reflect acoustic energy differently than do fish and they rarely meet the criteria for tracked targets when using the minimum threshold settings typically used to assess fish populations. This method attempts to maximize the differences in the acoustic reflection of *Chaoborus* and fish with swim bladders. While we did not use the field modifications recommended by MacLellan and Hume (2008) we did follow their modified analysis techniques in lakes with *Chaoborus;* by narrowing the echo and tracked target acceptance parameters; and by increasing the minimum threshold setting to filter out the *Chaoborus* echoes (MacLellan and Hume 2008). We have termed this variation "modified TT".

Regardless of the analysis method used, results were analyzed by depth layer within each transect and expanded to whole lake estimates as described in MacLellan and Hume (2008). Following the general guidelines of MacLellan and Hume (2008) we report the integrated results when total fish densities are >500 fish/ha and tracked target results at lower densities or if *Chaoborus* is present. Results of all analyses are available for comparison in Appendix 3.

Fish Samples

Trawl and gillnet catches were used to determine species composition, size and age structure, and diet. We preserved most fish in formalin, but a small proportion of *O. nerka* from some surveys were preserved in 85% ethanol. These alcohol preserved fish were processed in a similar manner to the formalin preserved fish and then archived for possible otolith or DNA analysis. After a minimum of 30 days, we identified, weighed and measured all fish in each sample. A random subsample of 20 *O. nerka* juveniles was selected for diet and scale age analysis. Up to 30 more juveniles were sampled for scales, if needed, to clarify the age and size structure found in the trawl/gillnet sample. Scales were removed and sent to the Scale Ageing Lab at the Pacific Biological Station in Nanaimo, B.C. for aging.

Diet Samples

We took stomachs from up to 20 fish/trawl of each captured species that were present in significant numbers. To minimize bias caused by different digestion rates of prey, we attempted to only sample fish collected within three hours of the onset of civil dusk. Samples consisting of the contents of 10 pooled stomachs (2 samples/tow) were subsampled with a Folsom plankton splitter and enumerated with a computerized video measuring system (MacLellan et al. 1993). Diet analysis included a visual estimate of stomach fullness, identification and counts and biomass to genus or species, (MacLellan and Hume 2008). Zooplankton were accurately counted and measured but, biomass estimates for insects, due to difficulties in identification and measurement of heavily digested body parts meant that estimates of insect biomass were unreliable and most likely low (MacLellan and Hume 2008).

RESULTS AND DISCUSSION

SAMPLING EQUIPMENT

Midwater Trawls

Studies done by Hyatt et al. (2004) and McQueen et al. (2007) suggest that the 2x2 m midwater trawl is size selective. In comparisons of sockeye smolts caught in the small trawl with those captured in downstream traps at the same time, they found that with an increase in length over 40 mm there was an increased chance of individuals avoiding capture. Hyatt et al. (2004) attributed this to increased swimming speeds. Hyatt et al. (2004) and McQueen et al. (2007) found that the relationship between the length of smolts caught in the trap were 1.1 to 1.2 times larger than those caught in the trawls, depending on the group of lakes in each study. Other, indirect comparisons are indicative that the large trawl has less sampling bias for fish <150 mm than does the small trawl (MacLellan and Hume 2008). MacLellan and Hume (2008) found a similar relationship between the modal size of the catch in the large trawl vs. the small trawl (66 to 54 mm). Hume et al. (1996) in an analysis of Parkinson et al. (1994), which compared the catch of kokanee from fast Otter trawls to a beam trawl similar to our 3x7 m trawl, concluded there was little difference between the trawls in length-frequency histograms of the catch of age-0 and -1 kokanee up to 155 mm in length, but the beam trawl caught fewer larger fish (age-2 and -3 kokanee) than the two fast otter trawls. They concluded that the bias in their trawl data was restricted to underestimates of proportions of older kokanee (age-2 and -3) but that estimates of mean size of each age-class appeared to be unbiased. Similarly, a recent comparison of size of fish in trawl catches of Cultus Lake pre-smolts (range = 25-110 mm) and stickleback (range = 25-52 mm) found that there were no significant differences in fish length or weight between the large or small trawls (sockeye, n= 135, $P>0.05$; 3ss, n= 127, $P>0.05$). Currently the information supporting differences in size selectivity between small and large trawls is ambiguous but studies indicate they may be both biased when compared to the true population.

Gillnets

The small mesh gillnets we used were selected to specifically sample smaller fish (age-0 and -1 *O. nerka* and other similar sized fish) and were utilized to supplement trawl catch information and to expose any bias in the small trawl catch. These nets were mostly set in the epilimnetic pelagic zone but tended to be fished closer to shore and at shallower depths than were the trawls.

We conducted 137 overnight sets for a total of 668 hrs of fishing and caught a total of 595 fish of all species for a mean catch rate of 0.89 fish/hr or about 25 fish/survey. As the nets were only 1.5 m deep, they only sampled the near surface waters. Deeper nets would likely have higher catch rates and would be more representative of the full epilimnion. In spite of low catches, these nets were useful in sampling small shallow lakes (e.g. Azuklotz Lake), where trawling was difficult and often ineffective. They were also useful in glacial lakes (e.g. Motase Lake) where *O. nerka* were located within a few meters of the water surface.

The Swedish gillnets caught fish considerably larger than those caught in the trawls. *O. nerka* caught in the gillnets ranged from 51 to 180 mm with two modes at 75 mm and 85 mm, at least 25 mm larger than the modal size in the trawls (Fig. 4, 5). A large proportion of the catch in the trawls was of small fish between 24 and 50 mm, a size range almost nonexistent in the gillnet catches. The larger modal size in the gillnets is possibly due to the different net types being fished in somewhat different habitats and thus different encounter rates for the gillnets and trawls, or due to poor retention of the smaller fish in the gillnet after being caught (Appleberg 2000).

The close spacing and geometric sizing of the mesh openings in the Swedish gillnets was designed to sample all target fish sizes equally (Appleberg 2000). The multiple peaks in our gillnet data indicates that this may not be the case in the lakes sampled in this study (Fig. 5).

FISH SPECIES COMPOSITION AND SIZE

Pelagic Fish Composition - Trawl Samples

The midwater trawl data showed distinct differences in the pelagic species composition and catch rate between lake types (Table 3). As expected, age-0 *O. nerka* was the most ubiquitous fish species, occurring in 18 of 22 lakes. In a number of the lakes, we captured older age classes of *O. nerka*, indicating either the presence of kokanee or of sockeye spending more than one year in the lake. *O. nerka* had the highest overall catch rate of any fish species and clear lakes had the highest catch rates of *O. nerka.* We caught *O. nerka* in 9 of 12 clear lakes, 2 of 4 glacial lakes, and 3 of 6 stained lakes. Clear lakes had the highest species diversity in the midwater region (Table 3). In total, there were 11 other identified fish species captured in the midwater region of the lakes. Of these species, sculpins (prickly sculpin, *Cottus asper* when positively identified) were the most common, occurring in 6 of 12 clear lakes. They did not occur in glacial lakes and occurred in 2 of 4 stained lakes. Unidentified whitefish (*Prosopium* or *Coregonus spp.*) occurred only in 2 clear lakes, while pigmy whitefish (*P. coulteri*) occurred in 1 clear and 2 stained lakes. Unidentified larval suckers (*Catostomus spp.*), Pacific lamprey (*Lampetra tridentata*), river lamprey (*L. ayresi*), threespine stickleback (*Gasterosteus aculeatus*), bull trout (*Salvelinus confluentus*), cutthroat trout (*O. clarki*), lake trout (*S. namaycush*), mountain whitefish (*P. williamsoni*), and redside shiners (*Richardsonius balteatus*) each occurred in only one clear lake. We found longnose suckers (*C. catostomus*) in the pelagic zone of only 1 glacial lake (Table 3). Threespine stickleback were captured in all 6 stained lakes but in only 1 of 12 clear lakes and 1 of 4 glacial lakes. In the clear lakes, pygmy whitefish, Pacific lamprey, river lamprey, and lake trout were caught only in the trawls and not in the nearshore gillnets. Our trawl caught no fish in Charlotte Lake.

<u>Near Shore Fish Composition - Gillnet Samples</u>

Although the Swedish gillnets were fished in the nearshore pelagic waters and were biased towards larger fish, they did capture a similar mix of fish taxa as did the trawls (Table 3). As with the trawl catch, clear lakes had the highest species diversity, with 14 species captured. Threespine stickleback were the only lake resident fish not captured in gillnets set in the clear lakes. *O. nerka* were the most common fish in the clear lakes, but the gillnets caught a higher proportion of age-1 and age-2's than the trawls, most likely because of the sampling bias towards larger fish. Juvenile coho salmon (*O. kisutch*), prickly sculpin, rainbow trout (*O. mykiss*), redside shiner, and whitefish (*P. williamsoni* when identified) were also frequently caught. A number of species were only caught in gillnets, including; white sucker (*C. commersoni*), largescale sucker (*C. macrocheilus*), lake chub (*Couesius plumbeus*), peamouth (*Mylocheilus caurinus*), coho salmon, rainbow trout, and northern pikeminnow (*Ptychocheilus oregonensis*). In addition, adult sockeye and pink salmon (*O. gorbuscha*) migrating to spawning grounds were also caught.

Again, far fewer species were captured in gillnets in the glacial and stained lakes (Table 3). In glacial lakes, age-0 and older O. nerka, juvenile coho salmon, bull trout, and threespine stickleback were the most common taxa. Threespine stickleback occurred in 4 of 6 stained lakes sampled. Other common species included age-0 and older O. nerka, coho salmon, and cutthroat trout.

<u>Fish Size from Net Catch</u>

Mean size of age-0 *O. nerka* ranged widely. *O. nerka* grow rapidly in the late summer and early fall and differences in sampling dates (as much as 30 days) may mask differences in growth and final fall sizes between lakes. As well, the number of stained and glacial lakes with an adequate sample of age-0 *O. nerka* was small (≤ 5), limiting the utility of any comparison (Table 4). While clear lakes did tend to have larger age-0 *O. nerka* than did the other two lake types in both the trawl and gillnet catches, results from more lakes are needed for a truly valid comparison. Sample sizes of other taxa were too small for comparisons between lakes and water clarity types. Details of size and biomass by lake and by species are discussed in the individual lake reports in Appendices 1 and 2.

HYDROACOUSTICS

Fish Size from Acoustic Target Strength

While experimental evidence shows that information on midwater fish size can be obtained from acoustic target strength, a fish's acoustic reflectivity pattern is not uniform and is dependent on a number of factors other than size (Love 1971; Burczynski and Johnson 1986). So although fish length can be estimated from TS using Love's (1977) equation, correspondence to sampled fish size is often poor (MacLellan and Hume 2008).

We calculated TS from our trawl data using Love's formula, and compared it to the TS measured by the acoustic system in the surveys (Fig. 6). The distribution of TS from the acoustic surveys peaked at around -54 to -52 dB for fish in the clear and glacial lakes, but peaked at a much lower -58 dB in the stained lakes. Sample size of the trawl caught fish was considerably smaller and consequently the shape of the trawl TS distribution was not as obvious, though it does appear that the trawl TS for clear and glacial lakes was similar to the acoustic TS peaking at -54 to -50 dB. In the stained lakes there was a very poor match between acoustic TS and trawl TS, with the trawl TS being almost non-existent at -58 dB. The discrepancies between the two data sets may be explained by the species diversity found in the study lakes. Only similar sized age-0 sockeye were found during a survey of sockeye fry in Cultus Lake resulting in a relatively narrow TS range (Burczynski and Johnson 1986). The vast majority of the midwater fish in the clear and glacial lakes was also age-0 *O. nerka* while in the stained lakes it was approximately evenly split between age-0 *O. nerka* and threespine stickleback (Table 3). Although both *O. nerka* and threespine stickleback have a swim bladder, the body shapes, skin coverings (scales vs. plates) are quite different, possibly resulting in a very different directivity patterns and TS responses. The differences in TS response for common fish in the pelagic zone of the study lakes (*O. nerka*, threespine stickleback, sculpins) should be further investigated as differences in TS between species will have implications on sounder settings during data collection, and on analysis, interpretation, and abundance estimation.

Hydroacoustic Abundance Estimates

Chaoborus occurred in four stained lakes (Banks East, Banks West, Evelyn, and Hartley Bay Lower) and in one clear lake (Kitwanga), adversely affecting the acoustic estimates of pelagic fish. The use of the modified TT analysis enables reliable estimates to be made if the densities of *Chaoborus* were not extremely high (MacLellan and Hume 2008). When *Chaoborus* were very abundant or the fish were scarce, the distinction between the fish and the *Chaoborus* signal became less clear and our confidence in the fish estimate dropped below acceptable levels. In this study, the fish/*Chaoborus* ratio was sufficiently high in Banks East, Banks West, Evelyn, and Kitwanga (on one survey) lakes to successfully estimate fish abundance.

Hartley Bay Lower Lake had considerable interference from a very dense *Chaoborus* population. Its apparently low pelagic fish density resulted in a very low fish/*Chaoborus* ratio. Combined with its shallow depth and extensive macrophyte population, conditions for estimating the pelagic fish population did not warrant further processing using any analysis method.

Charlotte Lake is not accessible to anadromous sockeye and the pelagic environment does not appear to be occupied by another fish species. The acoustic fish estimate in Charlotte Lake was subjectively determined from the very low count of targets observed on the echogram (19 in total or 1 fish/km of transecting). This is equivalent to an estimate of close to 0 fish/ha, a result supported by the lack of catch in the trawl net. The moderate densities and large size of *Daphnia*, a favorite food source of pelagic planktivores such as sockeye and some rainbow trout populations, also support the near zero fish density estimate (Shortreed et al. 2007).

In the other lakes (all were accessible to anadromous fish) the estimated density of age-0 *O. nerka* ranged from 0 fish/ha in Aldrich Lake to 6 100/ha in Johnston Lake, while the density of other small fish ranged from 0/ha in 5 lakes to 4 800/ha in Aldrich Lake (Table 5). Pelagic fish populations in the stained lakes consistently had the highest density of other small fish (exclusively three spine stickleback) and the lowest proportion of age-0 *O. nerka* (43%) than did the other lake types. Pelagic fish populations in the glacial lakes were mostly age-0 *O. nerka* (≥90%). These lakes had very low densities of other small fish, usually a mixture of threespine stickleback, longnose sucker, and pygmy whitefish. The clear lakes also had a mixture of other small fish species with prickly sculpin being the most abundant in most. Details of the population estimates are presented in Appendices 1 and 3.

DIET

Zooplankton were the most common dietary component of age-0 sockeye in all three lake types and also usually contributed the most biomass (Fig. 7). In clear and stained lakes age-0 sockeye had similar numbers of zooplankton in their diet but clear lakes had considerably more biomass from zooplankton than did stained lakes, due to a greater proportion of larger bodied *Daphnia* in the diet of sockeye in clear lakes (Fig. 8). Age-0 sockeye in glacial lakes had many fewer zooplankton and lower biomass than in either of the other lake types (Fig. 7). Macro invertebrates (*Chaoborus* and mysids) were found only rarely in the diet of clear and stained lakes and contributed only slightly more in terms of biomass (Fig. 7). Terrestrial insects were also uncommon but did represent a higher proportion of the diet in glacial lakes. Their biomass contribution to the diet was considerably higher and may even be underestimated (MacLellan and Hume 2008). Details of the stomach contents are presented in Appendix 4.

Cladocerans, especially *Daphnia*, and sometimes the smaller Bosminids are the preferred prey of juvenile sockeye (Eggers 1982, Shortreed et al. 1998, Morton and Williams 1990). Either *Daphnia* or Bosminids were generally abundant in the clear lakes in this study (Shortreed et al. 1998, Shortreed et al. 2007) and were often the dominant prey type in the diet of age-0 sockeye (Fig. 8, 9). Notable exceptions were Bear Lake, where insects formed a significant portion of the diet and Stephens Lake where calanoid copepods were important. As well, Lakelse Lake sockeye stomach contents consisted mostly of the calanoid copepod *Epischura* in September 2004 but contained mostly *Daphnia* on the other sample dates (Appendix 4). In the stained lakes *Daphnia* only formed a major portion of the age-0 *O. nerka* diet in Evelyn Lake. Bosminids dominated in the other stained lakes.

In contrast to clear water and stained lakes, *O. nerka* diets in glacially turbid lakes rarely contained significant numbers of *Daphnia* or *Bosmina* (Fig. 8, 9). The one exception occurred in the Atna Bay area of Morice Lake, where *Bosmina* made up about one third of the diet items consumed by juvenile sockeye. The main diet items in glacial lakes tended to be calanoid and cyclopoid copepods, and terrestrial insects. Shortreed et al. (2007) reported that cladocerans were very sparse in glacial lakes and the zooplankton community was dominated by *Diacyclops*. In addition to copepods, Morice Lake sockeye diet also included *Holopedium*, a cladoceran known to favour cold oligotrophic lakes (Balcer et al. 1984). Although the biomass of terrestrial insects was not accurately determined, they likely contribute a significant biomass to the diets of *O. nerka* in most of the glacially turbid lakes (Fig. 10).

Limited observations in this study and observations from other studies indicate that other pelagic fish eat a wide variety of other food items but some may be significant competitors for the zooplankton resource (McPhail 2007). Threespine sticklebacks were the most common potential competitor, occurring in all lake types. In the six stained lakes for which we have samples, they appear to be significant competitors of age-0 sockeye with *Daphnia* and Bosminids dominating their diet (Fig. 9). In other small lakes they may be mostly benthic feeders but in some there are two foraging forms, pelagic planktivores and demersal benthivores (McPhail 1994, 2007). In large lakes they are often primarily planktivores. Pygmy and mountain whitefish, occurred occasionally in clear and glacial lakes and in Bear Lake, pygmy whitefish fed mainly on chironomids and terrestrial insects (Appendix 4, Fig. 9). However, they are known to feed on a variety of prey items including zooplankton (McPhail 2007).

Other fish captured in the pelagic region were less likely to compete with age-0 sockeye and were less common. In Bear Lake, redside shiners fed on chironomids and terrestrial insects (Appendix 4, Fig. 9) but are known to take a large variety of prey including organisms from throughout the water column (McPhail 2007). Pelagic bull trout, lake trout, and cutthroat trout were all found in the pelagic zone of some of the clear lakes and may be competitors when small as they feed on zooplankton and benthos when smaller but often become piscivores when larger (McPhail 2007). Prickly sculpin, found in clear and stained lakes are unlikely to compete with sockeye as they feed on microplankton as larvae, switch to benthic prey as they grow, and eventually include fish in their diet (McPhail 2007). Other fish species found in the pelagic zone are either parasitic on other fish (Pacific and river lamprey) or are only benthivores (longnose suckers, McPhail 2007).

PLANKTIVORE BIOMASS AND PREDICTED PRODUCTION

A useful tool for categorizing the current status of a particular sockeye stock is to compare the observed biomass of the age-0 population with predicted lake capacity. The PR model predicts maximum juvenile biomass from the known relationships between photosynthetic rate (PR) and maximum smolt biomass (Hume et al. 1996; Shortreed et al. 2000; Cox-Rogers et al. 2004). Smolt biomass can be estimated from late summer fry biomass by assuming that the loss in numbers due to mortality is compensated by the increase in biomass due to growth (Cox-Rogers et al. 2004; Shortreed et al. 2007).

PR model predictions must be revised downwards if planktivorous fish species other than age-0 sockeye are present in the pelagic zone and compete for the same prey items (Fig. 9) (Cox-Rogers et al. 2004). Age-0 sockeye in both clear and stained lakes fed mostly on zooplankton, while other fish species found in the pelagic zone had a more varied diet. Few, if any, are obligate planktivores, but some are known to feed extensively on zooplankton when in the pelagic zone and/or at a certain size. Based on the limited diet results from this study and on the species summaries in McPhail (2007), potential competitors for the zooplankton resources in these lakes include pelagic forms of threespine stickleback, redside shiner, pygmy and mountain whitefish, bull trout, lake trout and cutthroat trout as well as older age classes of *O. nerka*. We used these species in the calculation of potential competitor biomass. The other fish species caught in the pelagic zone (Pacific and river lampreys, prickly sculpin, and longnose suckers) are not known to feed on zooplankton and are thus unlikely to be competitors.

Biomass of age-0 sockeye and their fish competitors was determined from the hydroacoustic estimates and the mean size of the fish in the trawl catch. If trawl catch data was inadequate then information from gillnets was used.

Average age-0 biomass was 0.8 kg/ha in stained lakes, to 0.9 kg/ha in glacial lakes, and 1.3kg/ha in clear lakes (Table 6). Biomass of competitor species averaged 31% of total planktivorous biomass in clear lakes but only 13% in glacial lakes. On the other hand, competitor species (mainly threespine stickleback and some kokanee) comprised the majority of the planktivorous biomass in stained lakes, averaging 3.2 kg/ha or 80% of total biomass. Shortreed et al. (2007) have used these data and data reported in Shortreed et al. (1998) to estimate stock status of these and other lakes through comparisons to PR model predictions of rearing capacity.

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Table 1. Location and morphological data for each of the study lakes.

Lake	Region	Water type	Date surveyed	Lat. (°N)	Long. (°W)	Elevation (m)	Surface area (ha)	Mean depth (m)	Max. depth (m)	# of sections	# of transects
Aldrich	Interior Skeena	Clear	09-Sep-01	54º45'	127º22'	876	64	4.4	5.6	1	5
Azuklotz	Interior Skeena	Clear	27-Aug-03	56º05'	126º44'	783	165	4.1	9.5	1	5
Banks E.	North coast	Stained	16-Sep-04	53º23'	130º08'	18	204	22	65	2	8
Banks W.	North coast	Stained	17-Sep-04	53º23'	130º12'	21	160	13	45	2	6
Bear	North coast	Clear	26-Aug-03	56º07'	126º50'	780	1,884	14	75	3	14
Charlotte	Interior Bella Coola	Clear	04-Sep-97	52°11'	125°20'	1,169	6,597	41	101	1	7
Club	North coast	Clear	07-Sep-02	55º47'	128º34'	522	39	3.7	9.8	1	3
Ecstall	Interior Skeena	Stained	25-Aug-05	53º45'	129º24'	35	90	7	20	1	7
Evelyn	Interior Skeena	Stained	04-Sep-01	53º36'	128º56'	33	59	15	23	1	7
Hartley Bay (L)	Interior Skeena	Stained	30-Aug-05	53º26'	129º17'	18	93	3.5	9.5	1	5
Johanson	Interior Skeena	Clear	12-Sep-04	56º35'	126º11'	1,444	140	16	53	2	7
Johnston	North coast	Glacial	01-Sep-05	53º53'	129º27'	25	187	47	80	1	7
Kitkiata	North coast	Stained	27-Aug-05	53º43'	129º17'	31	270	26	59	2	8
Kitsumkalum	Interior Skeena	Glacial	04-Sep-05	54º74'	128º47'	122	1,800	81	139	2	7
Kitwanga	Interior Skeena	Clear	11-Jul-03	55º22'	128º07'	376	774	7	14.6	2	6
			01-Sep-03								
			22-Sep-04								
Lakelse	Interior Skeena	Clear	14-Jul-03	54º23'	128º33'	77	1,372	8.5	32	2	7
			30-Sep-03								
			25-Sep-04								
			05-Sep-05								
McDonell	Interior Skeena	Clear	10-Sep-01	54º47'	127º36'	827	227	8.2	14.6	2	8
			13-Sep-02								

Table 1. Location and morphological data for each of the study lakes (continued).

Lake	Region	Water type	Date surveyed	Lat. (°N)	Long. (°W)	Elevation (m)	Surface area (ha)	Mean depth (m)	Max. depth (m)	# of sections	# of transects
Morice	Interior Skeena	Glacial	15-Sep-02	54º00'	127º40'	764	9,739	100	236	4	10
Motase	Interior Skeena	Glacial	29-Aug-03	56º02'	127º03'	1,021	397	13.4	31	2	6
Slamgeesh	Interior Skeena	Clear	07-Sep-01	55º46'	128º26'	630	45	3.9	7.5	1	7
Stephens	Interior Skeena	Clear	10-Sep-02	55º45'	128º37'	518	188	11	27	1	5
Sustut	Interior Skeena	Clear	10-Sep-04	56º35'	126º27'	1,301	250	6	20	1	5
Swan	Interior Skeena	Clear	06-Sep-02	55º46'	128º39'	525	1,736	36	68	2	8

Table 2. Record of trawls and sets completed during surveys of the study lakes.

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
Aldrich	09-Sep-01	Trawl (2mx2m)	1	23:14	2	2	6	>50% cloud	Light air	Sculpin	1
	09-Sep-01	Trawl (2mx2m)	1	23:33	1	1	6	>50% cloud	Light air	No catch	0
	09-Sep-01	Gillnet (sinking)	1	19:00	0	3	310	>50% cloud	Light air	Coho salmon	2
										Prickly sculpin	4
										Mountain whitefish	6
										Cutthroat trout	4
										Largescale sucker	2
										Lake chub	24
	09-Sep-01	Gillnet (floating)	1	19:00	0	3	310	>50% cloud	Light air	Coho salmon	1
										Cutthroat trout	3
										Lake chub	1
Azuklotz	27-Aug-03	Gillnet (floating)	1	20:00	0	2	95	<10% cloud	Calm	Age-0 O. nerka	13
										Redside shiner	18
	27-Aug-03	Trawl (2mx2m)	1	22:37	3	3	15	<10% cloud	Calm	Prickly sculpin	3
Banks East	17-Sep-04	Trawl (2mx2m)	2	23:35	15	15	20			Age-0 O. nerka	7
										Age-1 O. nerka	1
										Threespine stickleback	10
	18-Sep-04	Trawl (2mx2m)	2	0:11	10	10	20			Age-0 O. nerka	5
										Threespine stickleback	27
	17-Sep-04	Gillnet (floating)	2	15:30	0	2	900			Age-0 O. nerka	10
Banks West	17-Sep-04	Trawl (2mx2m)	2	20:51	15	15	20			Age-0 O. nerka	14
										Age-1 O. nerka	1
										Threespine stickleback	13
										Prickly sculpin	1
	17-Sep-04	Trawl (2mx2m)	2	21:34	17	17	20			Age-0 O. nerka	16
										Threespine stickleback	5

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
	17-Sep-04	Gillnet (floating)	1	4:00	0	2	1260			Age-1 O. nerka	1
										Pink salmon	1
										Adult/jack sockeye	3
Bear	26-Aug-03	Gillnet (floating)	1	19:20	0	2	345	>50% cloud	Calm	Redside shiner	51
	26-Aug-03	Vertical Gillnet	2	19:50	5	13	235	>50% cloud	Calm	No catch	0
	26-Aug-03	Trawl (2mx2m)	2	22:17	10	19	30	>50% cloud	Calm	Age-0 O. nerka	2
										Whitefish	1
										Pygmy whitefish	12
	28-Aug-03	Trawl (2mx2m)	1	2:06	8	19	30	<10% cloud	Calm	Lake trout	1
	28-Aug-03	Trawl (2mx2m)	1	21:12	10	10	13	<10% cloud	Calm	Age-0 O. nerka	3
	28-Aug-03	Trawl (2mx2m)	1	22:12	19	27	28	<10% cloud	Calm	Pygmy whitefish	10
Club	07-Sep-02	Gillnet (floating)	1	20:00	0	2	120			Age-0 O. nerka	1
	07-Sep-02	Gillnet (floating)	1	21:00	0	2	60			Age-0 O. nerka	1
Ecstall	25-Aug-05	Trawl (2mx2m)	1	22:00	5	5	3	Contin. rain	Gentle breeze	Threespine stickleback	12
	25-Aug-05	Trawl (2mx2m)	1	23:00	5	12	10	Contin. rain	Gentle breeze	Age-0 O. nerka	1
										Threespine stickleback	7
	25-Aug-05	Trawl (2mx2m)	1	23:30	10	12	10	Contin. rain	Gentle breeze	Age-0 O. nerka	3
										Threespine stickleback	30
	25-Aug-05	Gillnet (floating)	1	13:30	3	3	1260			Threespine stickleback	3
	25-Aug-05	Gillnet (floating)	1	14:10	5	5	1235			Cutthroat trout	1
										Pink salmon	1

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
Evelyn	04-Sep-01	Trawl (2mx2m)	1	23:20	5	5	8	>50% cloud	Light air	Threespine stickleback	9
	04-Sep-01	Trawl (2mx2m)	1	23:49	9	9	8	>50% cloud	Light air	Age-0 O. nerka	44
										Age-1 O. nerka	7
										Threespine stickleback	6
	05-Sep-01	Trawl (2mx2m)	1	0:10	1	1	8	>50% cloud	Light air	No catch	0
	03-Sep-01	Gillnet (sinking)	1	20:00	2	14	840	>50% cloud	Light air	Age-0 O. nerka	1
										Age-1 O. nerka	8
										Age-2 O. nerka	1
										Threespine stickleback	6
										Bull trout	2
										Coho salmon	14
										Prickly sculpin	3
										Cutthroat trout	4
	03-Sep-01	Minnow traps	1	20:00	2	14	840	>50% cloud	Light air	Prickly sculpin	3
Hartley Bay	30-Aug-05	Gillnet (floating)	1	18:50	5	7	890			Threespine stickleback	1
(lower)	30-Aug-05	Gillnet (floating)	1	19:05	3	5	851			Threespine stickleback	1
	30-Aug-05	Trawl (2mx2m)	1	20:47	4	4	10	>50% cloud	Calm	Threespine stickleback	18
										Prickly sculpin	2
	30-Aug-05	Trawl (2mx2m)	1	22:22	4	4	10	Contin. rain	Calm	Threespine stickleback	11
										Prickly sculpin	1
Johanson	12-Sep-04	Trawl (2mx2m)	1	20:21	12	12	30			Age-0 O. nerka	240
										Bull trout	3
	11-Sep-04	Gillnet (floating)	1	19:30	0	2	840			Age-1 O. nerka	1

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
Johnston	01-Sep-05	Gillnet (floating)	1	20:00	15	17	720			No catch	0
	01-Sep-05	Gillnet (floating)	1	8:52	15	17	643			Threespine stickleback	2
										Adult/jack sockeye	1
	01-Sep-05	Trawl (2mx2m)	1	22:10	12	12	20	Contin. rain	Calm	Age-0 O. nerka	128
										Threespine stickleback	5
Kitkiata	27-Aug-05	Trawl (2mx2m)	2	21:00	10	10	20	Contin. rain	Light air	Age-0 O. nerka	1
										Threespine stickleback	1
	27-Aug-05	Trawl (2mx2m)	1	23:38	12	12	20	Contin. rain	Light air	Age-0 O. nerka	49
										Threespine stickleback	41
	27-Aug-05	Trawl (2mx2m)	2		27	27	20	Contin. rain	Light air	Age-0 O. nerka	21
										Threespine stickleback	5
	27-Aug-05	Gillnet (floating)	1	16:00	10	10	1140			No catch	0
	27-Aug-05	Gillnet (floating)	2	16:15	20	20	1140			Threespine stickleback	1
Kitsumkalum	04-Sep-05	Gillnet (floating)	1	19:30	5	7	400			Age-0 O. nerka	1
										Prickly sculpin	1
	04-Sep-05	Trawl (2mx2m)	2	20:30	27	27	30	>50% cloud	Calm	No catch	0
	05-Sep-05	Trawl (2mx2m)	1	0:40	25	25	30	>50% cloud	Calm	Age-0 O. nerka	36
	05-Sep-05	Trawl (2mx2m)	1	1:30	2	2	30	>50% cloud	Calm	Age-0 O. nerka	6
Kitwanga	11-Jul-03	Vertical gillnet	2	19:00	1	9	780	>50% cloud	Calm	Redside shiner	1
										Rainbow trout	2
	11-Jul-03	Trawl (3mx3m)	2	11:25	7	7	15	>50% cloud	Calm	No catch	0
	11-Jul-03	Trawl (3mx3m)	2	11:55	10	10	15	>50% cloud	Calm	Age-0 O. nerka	2
	12-Jul-03	Minnow traps	2	12:00	1	2	1200			Northern pikeminnow	1
										Prickly sculpin	5
	12-Jul-03	Gillnet (floating)	1	8:30	0	2	840			Peamouth	3
										Redside shiner	13

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
										Rainbow trout	5
										Coho salmon	2
	12-Jul-03	Gillnet (floating)	2	9:00	0	2	840			Northern pikeminnow	1
										Peamouth	7
										Redside shiner	48
										Rainbow trout	2
										Coho salmon	1
	12-Jul-03	Trawl (3mx3m)	1	13:58	6	6	30	>50% cloud	Calm	No catch	0
	12-Jul-03	Trawl (3mx3m)	1	23:47	2	2	30	>50% cloud	Calm	No catch	0
Kitwanga	01-Sep-03	Gillnet (floating)	1	19:00	0	2	900			Age-0 O. nerka	3
										Redside shiner	1
										Rainbow trout	3
	01-Sep-03	Gillnet (floating)	2	19:45	0	2	840			Redside shiner	2
										Rainbow trout	1
	01-Sep-03	Trawl (2mx2m)	2	21:03	10	10	15	>50% cloud	Light air	No catch	0
	01-Sep-03	Trawl (2mx2m)	2	21:33	10	7	25	>50% cloud	Light air	Age-0 O. nerka	10
										Redside shiner	1
	01-Sep-03	Trawl (2mx2m)	2	22:15	8	8	25	>50% cloud	Light air	Age-0 O. nerka	2
	01-Sep-03	Trawl (2mx2m)	1	23:52	6	7	30	10-50% cloud	Light air	Age-0 O. nerka	1
Kitwanga	22-Sep-04	Trawl (3mx7m)	2	21:22	7	7	20	Intermit. rain	Calm	Redside shiner	1
	22-Sep-04	Trawl (3mx7m)	2	22:10	7	7	20	Intermit. rain	Calm	Whitefish	1
										Cutthroat trout	1

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
	23-Sep-04	Trawl (3mx7m)	1	1:39	4	4	30	Intermit. rain	Gentle breeze	Age-0 O. nerka	2
										Prickly sculpin	1
	22-Sep-04	Gillnet (floating)	2	17:30	1	1	960			Redside shiner	2
										Cutthroat trout	1
	22-Sep-04	Gillnet (sinking)	2	17:30	11	11	960			No catch	0
	22-Sep-04	Gillnet (floating)	1	17:00	1	1	1020			Age-0 O. nerka	3
										Peamouth	1
										Cutthroat trout	2
	22-Sep-04	Gillnet (sinking)	1	17:00	7	7	1020			Bull trout	1
										Peamouth	23
										Redside shiner	3
										Prickly sculpin	6
										Cutthroat trout	1
Lakelse	29-Sep-03	Trawl (3mx7m)	1	22:20	7	18	43	<10% cloud	Light air	No catch	0
	14-Jul-03	Vertical gillnet	1	0:05	14	22	200	<10% cloud	Light air	Age-1 O. nerka	1
	14-Jul-03	Trawl (2mx2m)	1	0:53	15	22	25	<10% cloud	Calm	Age-0 O. nerka	19
										river lamprey	1
	14-Jul-03	Gillnet (floating)	1	21:45	0	2	373	>50% cloud	Gentle breeze	Northern pikeminnow	1
										Redside shiner	5
	14-Jul-03	Vertical gillnet	1	21:30	8	16	305	>50% cloud	Gentle breeze	Age-0 O. nerka	1
	14-Jul-03	Trawl (2mx2m)	2	23:22	8	12	30	>50% cloud	Gentle breeze	Age-0 O. nerka	6
										Sculpin	14
										pacific lamprey	5

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
Lakelse	25-Sep-04	Trawl (3mx7m)	1	20:43	13	17	20	10-50% cloud	Calm	Age-0 O. nerka	88
										Threespine stickleback	3
										Prickly sculpin	4
	25-Sep-04	Trawl (3mx7m)	1	22:37	11	14	15	10-50% cloud	Calm	Age-0 O. nerka	12
										Threespine stickleback	1
Lakelse	05-Sep-05	Trawl (2mx2m)	1	21:58	24	24	19	10-50% cloud	Light breeze	Age-0 O. nerka	172
										River lamprey	1
McDonell	10-Sep-01	Trawl (2mx2m)	1		9	9	8	>50% cloud	Gentle breeze	No catch	0
McDonell	13-Sep-02	Trawl (2mx2m)	1	22:39	10	10	16	Contin. rain	Calm	Age-0 O. nerka	20
	13-Sep-02	Gillnet (floating)	1	15:50	0	2	1044			Coho salmon	6
										Cutthroat trout	1
	13-Sep-02	Gillnet (floating)	2	16:00	0	2	1020			Age-1 O. nerka	1
										Rainbow trout	2
										Coho salmon	3
										Cutthroat trout	3
	13-Sep-02	Gillnet (sinking)	2	16:45	10	12	959			Bull trout	1
										Lake chub	1
Morice	15-Sep-02	Trawl (3mx7m)	4	23:34	15	15	33	Contin. rain	Calm	Age-0 O. nerka	32
										Age-1 O. nerka	3
										Pygmy whitefish	2
	16-Sep-02	Trawl (3mx7m)	1	1:20	10	10	30	Fog/haze	Gentle breeze	Age-0 O. nerka	3
Motase	29-Aug-03	Gillnet (floating)	2	19:50	0	2	902	10-50%	Calm	Age-0 O. nerka	2

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

Lake	Date	Gear	Sect.	Time (PST)	Depth (m) Start	Depth (m) End	Dura. (min)	Conditions Sky	Conditions Wind	Catch Taxa	Catch N
								cloud			
										Age-1 O. nerka	4
										Coho salmon	1
	29-Aug-03	Trawl (2mx2m)	1	21:10	8	12	12	<10% cloud	Calm	No catch	0
	29-Aug-03	Trawl (2mx2m)	2	22:32	28	12	15	<10% cloud	Calm	Age-1 O. nerka	2
	30-Aug-03	Gillnet (floating)	2	19:45	0	2	706			Age-0 O. nerka	2
										Age-1 O. nerka	3
										Bull trout	2
										Coho salmon	1
	30-Aug-03	Gillnet (floating)	2	20:00	0	2	671			Age-1 O. nerka	3
										Bull trout	1
	30-Aug-03	Trawl (2mx2m)		20:13	3	13	50	10-50% cloud	Light air	Age-0 O. nerka	5
										Age-1 O. nerka	5
										Longnose sucker	1
										Pygmy whitefish	1
	29-Aug-03	Vertical gillnet	2	20:10	0	8	860	10-50% cloud	Calm	No catch	0
Slamgeesh	07-Sep-01	Trawl (2mx2m)	1	0:00	3	3	5	>50% cloud	Light air	Age-0 O. nerka	1
										Sculpin	1
										Sucker	1
	07-Sep-01	Trawl (2mx2m)	1	21:50	4	4	27	>50% cloud	Light air	Age-0 O. nerka	23
										Prickly sculpin	67
										Mountain whitefish	1
	07-Sep-01	Gillnet (sinking)	1	14:00	0	4	1140	>50% cloud	Light air	Age-0 O. nerka	16
										Bull trout	3
										Coho salmon	3
										Prickly sculpin	10
										Mountain whitefish	19
										Longnose sucker	10

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
	07-Sep-01	Gillnet (floating)	1	14:00	0	4	1140	>50% cloud	Light air	Age-0 O. nerka	31
										Age-1 O. nerka	3
										Whitefish	2
										Bull trout	5
										Coho salmon	4
										Mountain whitefish	2
										Adult/jack sockeye	1
	07-Sep-01	Minnow traps	1	14:00	2	4	1150	>50% cloud	Light air	Prickly sculpin	3
Stephens	10-Sep-02	Trawl (2mx2m)	1	21:17	8	8	30	<10% cloud	Calm	No catch	0
	10-Sep-02	Trawl (2mx2m)	1	22:25	8	8	30	<10% cloud	Calm	Age-0 O. nerka	21
										Prickly sculpin	1
	10-Sep-02	Gillnet (floating)	1	15:00	0	2	1065			Age-0 O. nerka	1
										Age-1 O. nerka	1
										Rainbow trout	2
										Coho salmon	4
	10-Sep-02	Gillnet (sinking)	1	15:10	1	2	1044			Whitefish	1
										Coho salmon	17
										White sucker	9
	10-Sep-02	Gillnet (floating)	1	15:20	0	2	1017			Coho salmon	13
	10-Sep-02	Gillnet (sinking)	1	15:25	1	2	1055			Whitefish	1
										Coho salmon	5
										White sucker	1
Sustut	10-Sep-04	Trawl (2mx2m)	1	19:22	5	12	25	Contin. rain	Light air	Age-0 O. nerka	204
	09-Sep-04	Gillnet (floating)	1	20:30	0	2	720			Age-0 O. nerka	5
										Age-1 O. nerka	2
										Age-2 O. nerka	1
										Whitefish	1

Table 2. Record of trawls and sets completed during surveys of the study lakes (continued).

				Time	Depth (m)		Dura.	Conditions		Catch	
Lake	Date	Gear	Sect.	(PST)	Start	End	(min)	Sky	Wind	Taxa	N
Swan	06-Sep-02	Trawl (2mx2m)	1	21:55	9	9	30	<10% cloud	Calm	Age-0 O. nerka	7
	07-Sep-02	Trawl (2mx2m)	2	0:27	10	10	30	<10% cloud	Calm	Age-0 O. nerka	22
										Age-1 O. nerka	15
										Age-2 O. nerka	4
	06-Sep-02	Gillnet (sinking)	2	16:00	1	4	1020			Whitefish	2
										Rainbow trout	1
										Coho salmon	1
	06-Sep-02	Gillnet (floating)	2	16:15	0	2	1020			Age-2 O. nerka	8
										Threespine stickleback	8
	06-Sep-02	Gillnet (sinking)	2	16:30	1	4	1020			Age-0 O. nerka	1
										Age-1 O. nerka	1
										Age-2 O. nerka	1
										Threespine stickleback	1
										Prickly sculpin	1
										White sucker	2
	06-Sep-02	Gillnet (floating)	2	16:45	0	2	1020			Age-2 O. nerka	5
										Threespine stickleback	6
										Rainbow trout	2
	06-Sep-02	Minnow traps	2	17:00	1	3	1020			Longnose sucker	1

Table 3. Fish caught by the midwater trawls and gillnets in lakes of different water clarity. CPUE determined by dividing total catch of each species for each water type by total trawling time for each water type.

	Mean CPUE (Catch/hr)			Number of lakes		
Taxa	Clear	Glacial	Stained	Clear	Glacial	Stained
a) Midwater trawls						
Age-0 *O. nerka*	41.3	25.9	20.9	9	4	5
Age-1 *O. nerka*	0.7	1.2	1.2	1	2	3
Age-2 *O. nerka*	0.2			1		
Prickly sculpin	3.7		0.5	5		2
Unid. larval sculpin	0.8			3		
Threespine stickleback	0.2	0.6	25.3	1	1	6
Unid. whitefish	0.1			2		
Pygmy whitefish	1.1	0.4		1	2	
Mountain whitefish	<0.1			1		
Pacific lamprey	0.2			1		
River lamprey	0.1			1		
Redside shiner	0.1			1		
Bull trout	0.1			1		
Cutthroat trout	<0.1			1		
Lake trout	<0.1			1		
Unid. larval sucker	<0.1			1		
Longnose sucker		0.1			1	
No catch				1		
			Total taxa captured	13	5	4
			Lakes trawled	12	4	6
b) Swedish gillnets						
Age-0 *O. nerka*	3.7	0.6	1.4	8	2	2
Age-1 *O. nerka*	0.5	1.2	1.2	7	1	2
Age-2 *O. nerka*	1.4		0.1	2		1
Coho salmon	3.0	0.2	1.8	6	1	1
Prickly sculpin	1.0	0.1	0.4	4	1	1
Rainbow trout	1.0			4		
Redside shiner	6.9			4		
Unid. whitefish	0.3			4		
Mountain whitefish	1.3			2		
Bull trout	0.5	0.4	0.3	3	1	1
Cutthroat trout	0.7		0.6	3		2
White sucker	0.6			2		
Northern pikeminnow	0.1			2		
Lake chub	1.3			2		
Peamouth	1.6			1		
Largescale sucker	0.1			1		
Longnose sucker	0.5			1		
Threespine stickleback		0.2	1.6		1	4
Adult/jack sockeye	0.0	0.1	0.4	1	1	1
Adult pink salmon			0.3			2
No catch				2	2	1
			Total taxa captured	18	7	10
			Lakes gillnetted	12	3	6

Table 4. Size of age-0 *O. nerka* caught by trawl and gillnet in the study lakes. Only fish preserved in formalin are presented here.

					Weight (g)		Fork Length (mm)	
Clarity	Lake/Date	Date		Catch (n)	Mean	95% CI	Mean	95% CI
a) Midwater trawl								
Clear	Bear	2003-Aug		5	2.1	1.38	54	12.2
	Johanson	2004-Sep		169	1.3	0.05	49	0.6
	Kitwanga	2004-Jul		2	0.4	0.39	33	12.5
		2003-Sep		10	1.5	0.25	49	2.1
		2004-Sep	a	2	4.6	0.38	73	12.7
	Lakelse	2003-Jul		6	1.8	0.77	54	8.0
		2004-Sep	a	67	3.4	0.45	65	2.6
		2005-Sep		153	4.0	0.30	66	1.7
	McDonell	2002-Sep		20	1.5	0.28	52	3.1
	Slamgeesh	2001-Sep		24	3.6	0.84	64	4.7
	Stephens	2002-Sep		21	2.1	0.25	58	2.5
	Sustut	2004-Sep		126	1.3	0.10	49	1.3
	Swan	2002-Sep		22	0.9	0.16	44	2.4
Glacial	Johnston	2005-Sep		69	0.5	0.07	35	1.2
	Kitsumkalum	2005-Sep		42	1.3	0.21	53	3.0
	Morice	2002-Sep	a	22	1.8	0.48	53	4.9
	Motase	2003-Aug		5	1.1	0.60	44	8.1
Stained	Banks East	2004-Sep		5	2.9	2.75	59	
	Banks West	2004-Sep		14	2.4	0.46	57	3.6
	Ecstall	2005-Aug		4	1.0	0.88	43	9.8
	Evelyn	2001-Sep		44	0.9	0.25	40	2.8
	Kitkiata	2005-Aug		71	0.8	0.09	40	1.5

a Large trawl used on these surveys, all others were small trawl catches.

					Weight (g)		Fork Length (mm)	
b) Swedish gillnet								
Clear	Azuklotz	2003-Aug		13	4.8	1.02	72	5.2
	Club	2002-Sep		2	6.3	9.08	82	25.4
	Kitwanga	2004-Sep		3	4.9	1.91	75	5.0
	Lakelse	2003-Jul		1	4.5		74	
	McDonell	2005-Sep		1	9.4		94	
	Slamgeesh	2001-Sep	b	16	7.4	1.06	85	3.3
	Slamgeesh	2001-Sep		31	6.8	0.78	82	2.8
	Stephens	2002-Sep		1	4.1		74	
	Stephens	2005-Oct		1	5.1		82	
	Swan	2002-Sep	b	1	0.9		51	
Glacial	Motase	2003-Aug		2	2.0	0.25	59	12.7
Stained	Banks East	2004-Sep		8	4.8	0.31	75	1.5
	Evelyn	2001-Sep	b	1	3.7		69	

b Sinking gillnets used on these surveys, all others were caught in floating gillnets.

Table 5. Estimated density of the limnetic fish population from hydroacoustic and trawl surveys of the study lakes. See Appendix Table 2 for details and abundance estimates.

				Age-0 *O. nerka*		Other small fish				
Clarity	Lake	Date	Analysis method	Density (n/ha)	Prop. age-0 (%)	Density (n/ha)	Dominant species	All small fish (n/ha)	Large fish (n/ha)	Reliability of estimate
Clear	Aldrich	2001-Sep	TT	a		a	No trawl catch	4,773	0	Very low
	Azuklotz	2003-Aug	Integration	383	42	531	Prickly sculpin	914	108	Very low
	Bear	2003-Aug	TT	135	59	94	Pygmy whitefish	229	71	Medium
	Charlotte	1997-Sep	Visual	~0	0	~0	No trawl catch	~0	~0	High
	Club	2002-Sep	TT	55	100	0	None	55	1	Very low
	Johanson	2004-Sep	Integration	1,195	99	15	Bull trout	1,210	26	High
	Kitwanga	2003-Sep	TT	247	80	62	Redside shiner	309	32	Low
	Lakelse	2003-Jul	TT	217	83	43	Sculpin, lamprey	260	12	Medium
		2003-Sep	TT	90	69	41	NS - used 2003-Jul for apportioning	131	13	Low
		2004-Sep	TT	175	84	33	Prickly sculpin, threespine stickleback	208	15	High
		2005-Sep	Integration	288	93	32	River lamprey	320	26	High
	McDonell	2001-Sep	TT	a	0	a	Not sampled	352	76	Medium
		2002-Sep	Integration	595	100	0	None	595	53	High
	Slamgeesh	2001-Sep	TT	541	25	1,582	Prickly sculpin	2,123	243	Medium
	Stephens	2002-Sep	Integration	897	96	40	Prickly sculpin	937	64	High
	Sustut	2004-Sep	Integration	3,007	100	0	None	3,007	53	High
	Swan	2002-Sep	TT	329	100	0	None	329	135	High
Clear Mean				516	60	376		860	44	
Glacial	Johnston	2005-Sep	Integration	6,084	96	240	Threespine stickleback	6,324	23	High
	Kitsumkalum	2005-Sep	TT	279	100	0	None	279	11	High
	Morice	2002-Sep	TT	132	99	1	Pygmy whitefish	133	6	Low
	Motase	2003-Aug	TT	52	90	6	Longnose sucker, pygmy whitefish	58	3	Very low
Glacial Mean				1,637	96	62		1,699	11	

Table 5. Estimated density of the limnetic fish population from hydroacoustic and trawl surveys of the study lakes. See appendix table 2 for details and abundance estimates.

				Age-0 *O. nerka*		Other small fish				
Clarity	Lake	Date	Analysis method	Density (n/ha)	Prop. age-0 (%)	Density (n/ha)	Dominant species	All small fish (n/ha)	Large fish (n/ha)	Reliability of estimate
Stained	Banks E.	2004-Sep	TT	182	26	517	Threespine stickleback	699	25	Medium
	Banks W.	2004-Sep	TT	281	63	167	Threespine stickleback	448	60	Medium
	Ecstall	2005-Aug	Integration	71	4	1,587	Threespine stickleback	1,658	0	Medium
	Evelyn	2001-Sep	TT	847	49	895	Threespine stickleback	1,742	106	Medium
	Hartley Bay L.	2005-Aug	not done	na	na	na	Threespine stickleback	na	na	
	Kitkiata	2005-Aug	Integration	2,356	57	1,749	Threespine stickleback	4,105	15	High
Stained Mean				747	43	983		1,730	41	

a Trawling was limited on these surveys resulting in no catch, therefore the acoustic fish estimate was not attributed to any species.

Table 6. Estimated biomass of age-0 *O. nerka* and dominant competitor fish species in the study lakes based on data in tables 4, 5 and appendix 2. Information from gillnet catches was used when no competitor species were captured in the trawl.

			Age-0 sockeye			Competitor species					Prop. Age-0 (%)	
Type	Lake	Sample Date	Density (N/ha)	Size (g)	Biomass (kg/ha)	Main competitor	Density (N/ha)	Prop.b (%)	Size (g)	Biomass (kg/ha)	Density	Biomass
Clear	Aldrich	2001-Sep	a			Lake chub, mountain whitefish, trout	a					
	Azuklotz	2003-Aug	383	4.8	1.8	Redside shiner	531	50	7.5	2.0	41.9	48.0
	Bear	2003-Aug	135	2.1	0.3	Pygmy whitefish, redside shiner	94	100	4.5	0.4	59.0	40.1
	Charlotte	1997-Sep	0			None	0					
	Club	2002-Sep	55	1.0	0.1	None	0				100	100
	Johanson	2004-Sep	1195	1.3	1.5	Bull trout	15	100	6.4	0.1	99	94
	Kitwanga	2003-Sep	247	2.0	0.5	Redside shiner, whitefish, trout	62	100	10.0	0.6	80	45
	Lakelse	03,04,05-Sep	226	3.7	0.8	Stickleback, redside shiner	35	25	0.4	0.004	86	100
	McDonell	2002-Sep	595	1.5	0.9	Trout, coho	53	75	10.0	0.4	92	69
	Slamgeesh	2001-Sep	541	3.6	2.0	Mountain whitefish, bull trout	1582	25	2.5	1.0	25	67
	Stephens	2002-Sep	897	2.1	1.9	Kokanee	40	75	10.0	0.3	96	86
	Sustut	2004-Sep	3007	1.3	3.9	Kokanee	53	100	10.0	0.5	98	88
	Swan	2002-Sep	329	1.0	0.3	Kokanee	135	100	3.7	0.5	71	40
Glacial	Johnston	2005-Sep	6084	0.5	3.0	Stickleback	240	100	1.6	0.4	96	89
	Kitsumkalum	2005-Sep	279	1.3	0.4	None	0				100	100
	Morice	2002-Sep	132	1.8	0.2	Pygmy whitefish, kokanee	1	100	9.0	0.01	99	96

Table 6. Estimated biomass of age-0 *O. nerka* and dominant competitor fish species in the study lakes based on data in tables 4, 5 and appendix 2. Information from gillnet catches was used when no competitor species were captured in the trawl.

Type	Lake	Sample Date	Age-0 sockeye Density (N/ha)	Age-0 sockeye Size (g)	Age-0 sockeye Biomass (kg/ha)	Competitor species Main competitor	Competitor species Density (N/ha)	Competitor species Prop.b (%)	Competitor species Size (g)	Competitor species Biomass (kg/ha)	Prop. Age-0 (%) Density	Prop. Age-0 (%) Biomass
	Motase	2003-Aug	52	1.1	0.1	Pygmy whitefish, kokanee	6	50	4.5	0.01	90	81
Stained	Banks E.	2004-Sep	182	2.9	0.5	Stickleback, kokanee	517	100	3.3	1.7	26	24
	Banks W.	2004-Sep	281	2.4	0.7	Stickleback, kokanee	167	100	3.4	0.6	63	54
	Ecstall	2005-Aug	71	1.0	0.1	Stickleback	1587	100	1.3	2.1	4	3
	Evelyn	2001-Sep	847	0.9	0.8	Stickleback, kokanee	895	100	10.9	9.7	49	7
	Hartley Bay L.	2005-Aug	no est			Stickleback	no est					
	Kitkiata	2005-Aug	2356	0.8	1.9	Stickleback	1749	100	1.2	2.0	57	49

a No estimate made due to inadequate trawling and gillnetting.

b Proportion of the acoustic estimate of other small fish that comprise the competitor species (%).

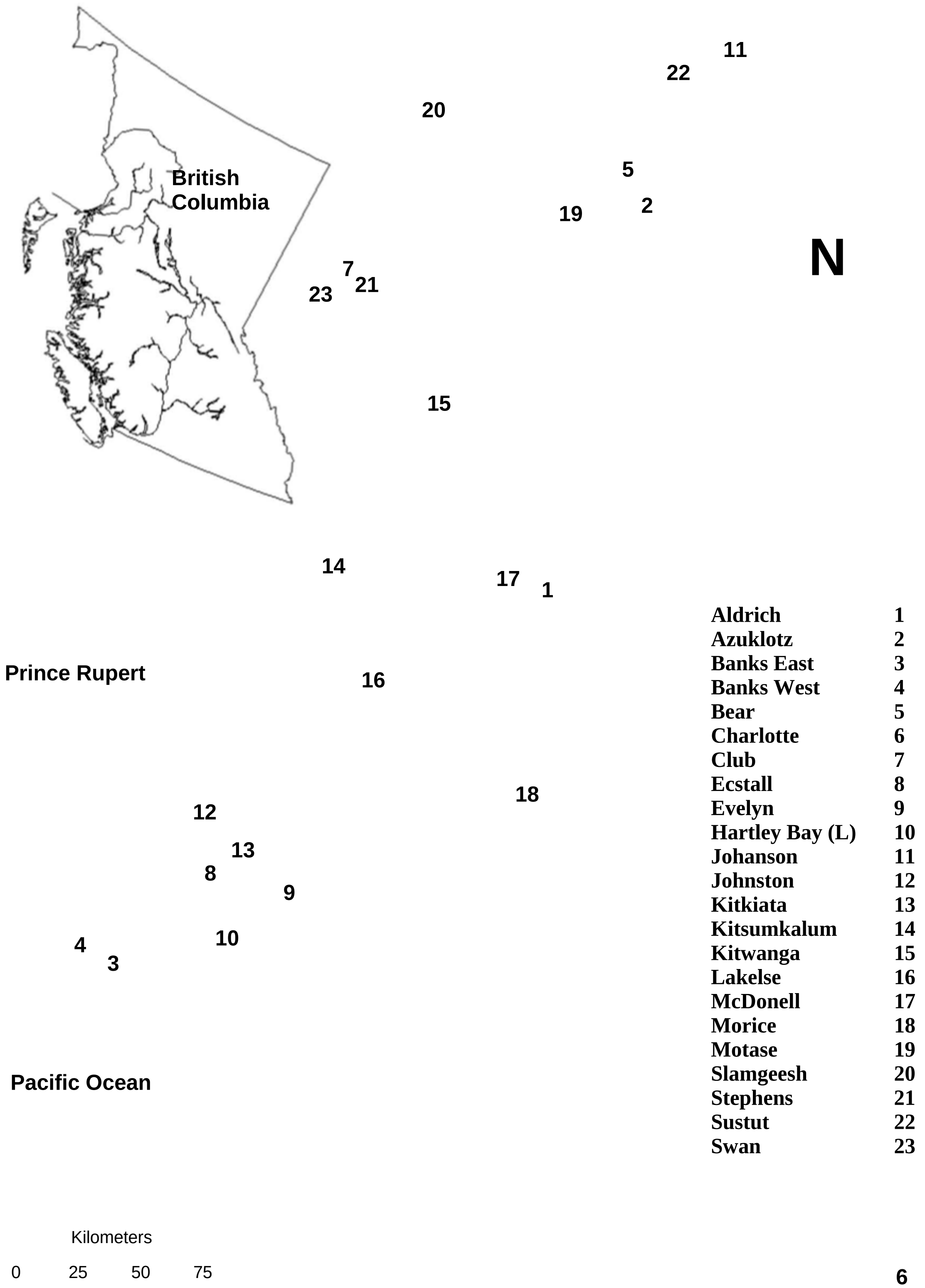


Figure 1. Overview map of study region showing the location of the surveyed lakes.

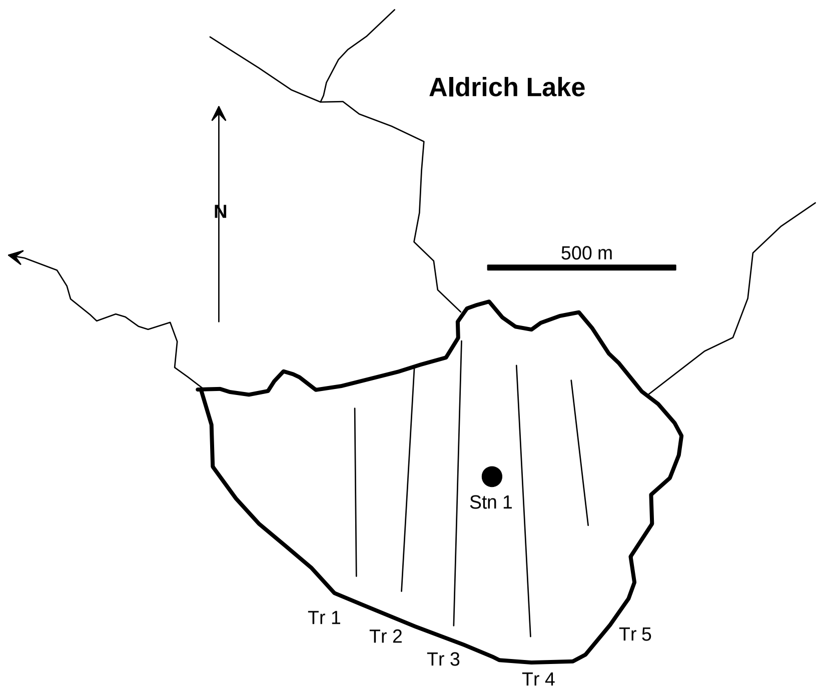


Figure 2a. Map of Aldrich Lake showing the location of transects and limnology stations. The lake is very shallow and transects do not reach shore.

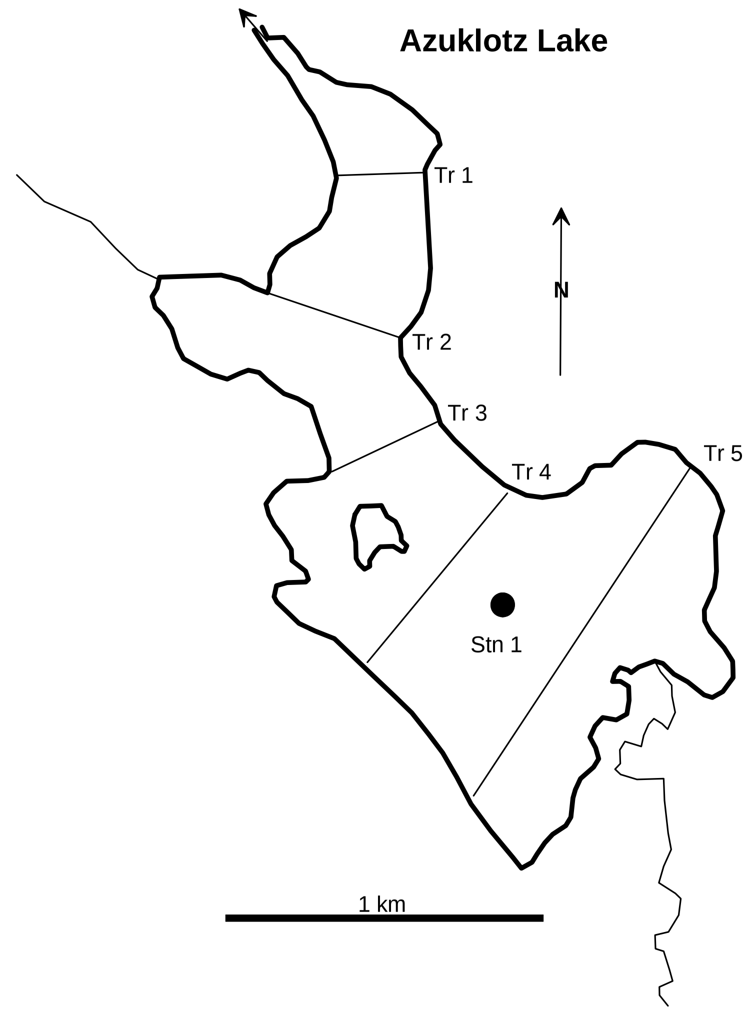


Figure 2b. Map of Azuklotz Lake showing the location of transects and limnology stations.

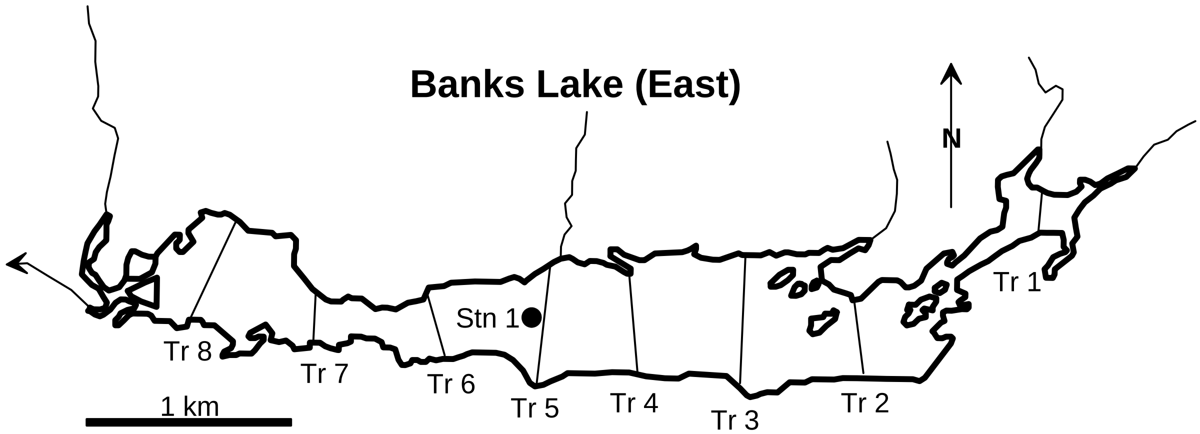


Figure 2c. Map of Banks East Lake showing the location of transects and limnology stations.

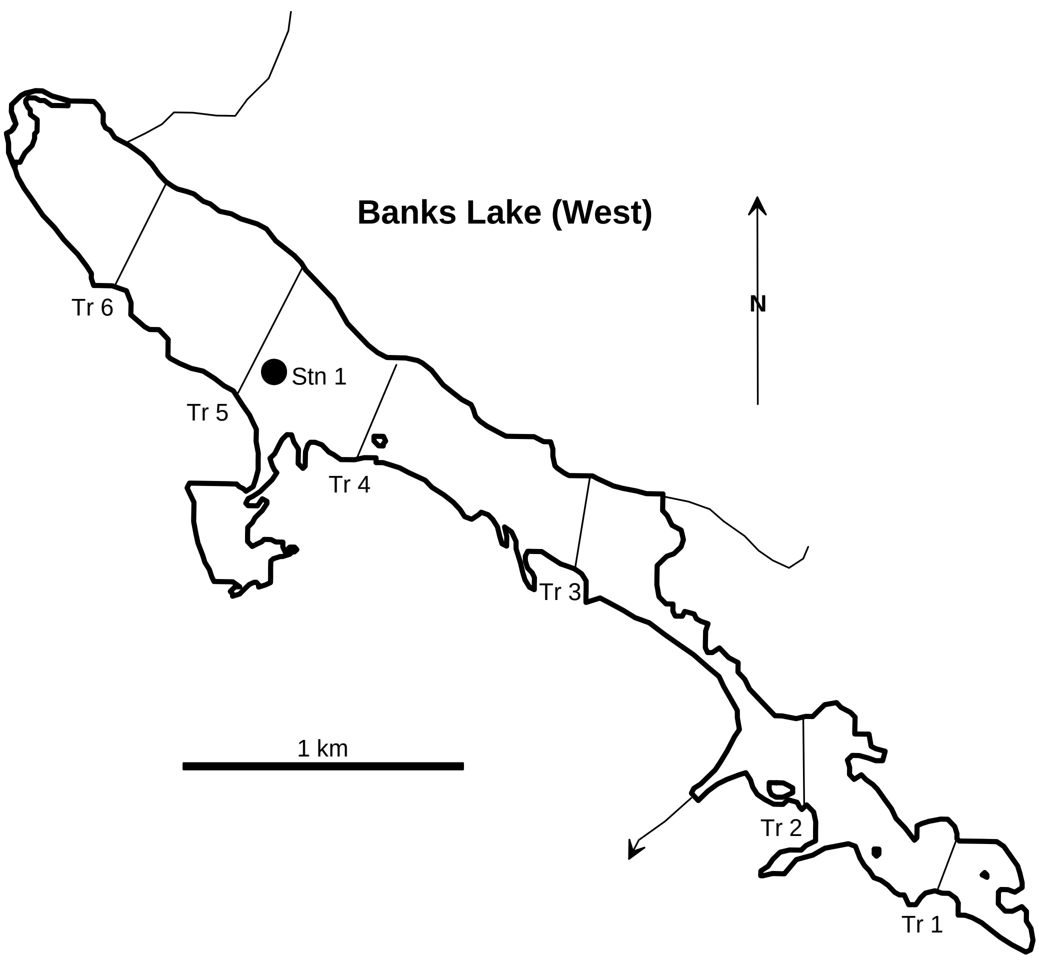


Figure 2d. Map of Banks West Lake showing the location of transects and limnology stations.

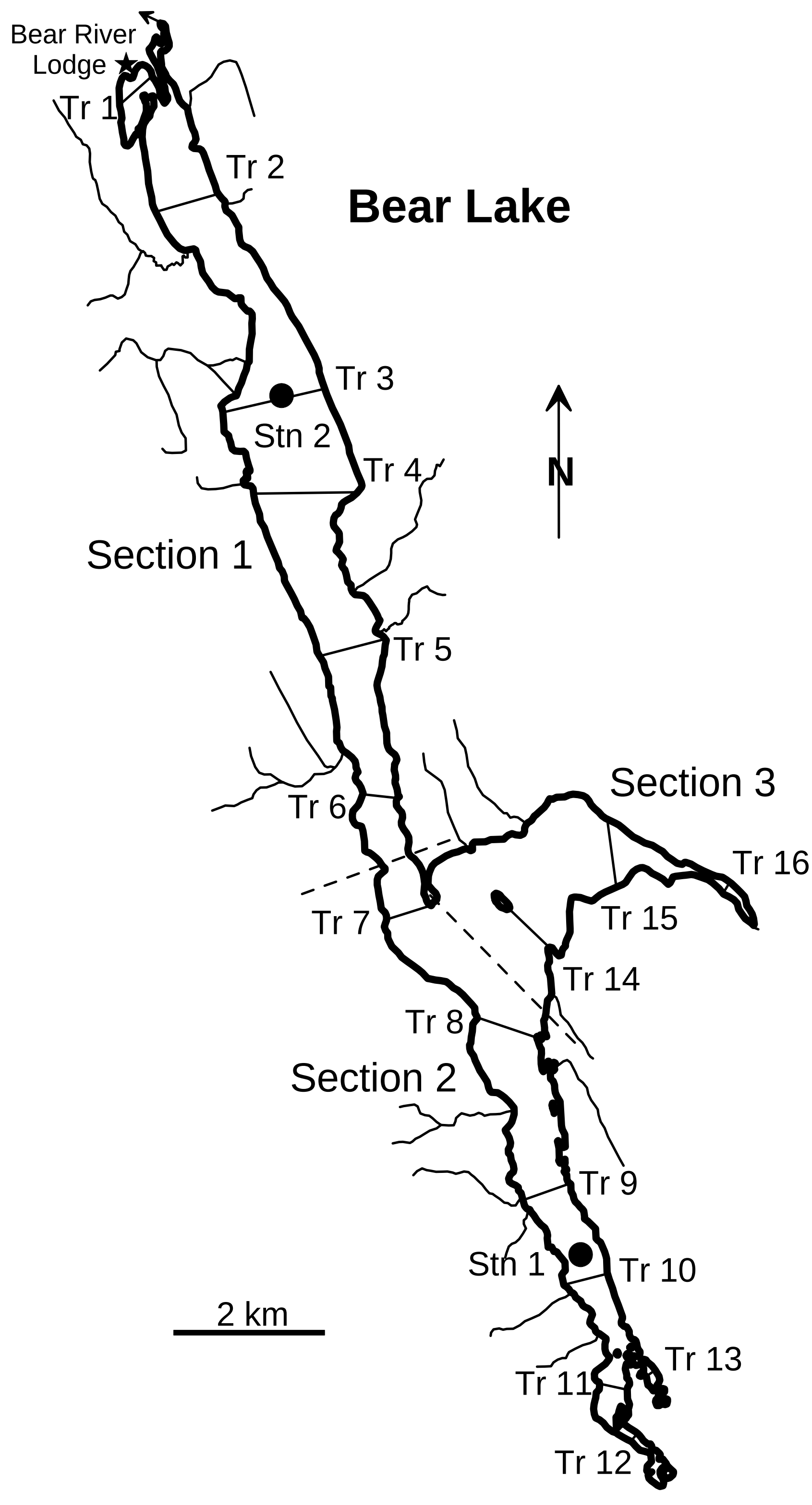


Figure 2e. Map of Bear Lake showing the location of transects and limnology stations.

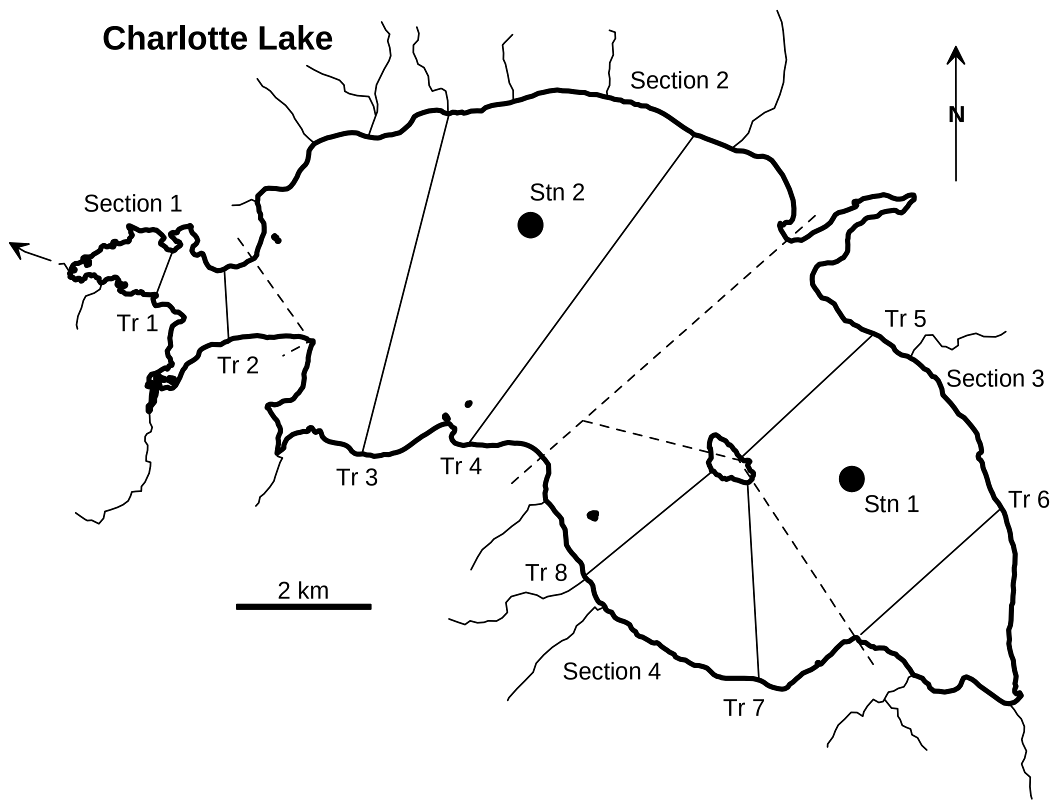


Figure 2f. Map of Charlotte Lake showing the location of transects and limnology stations.

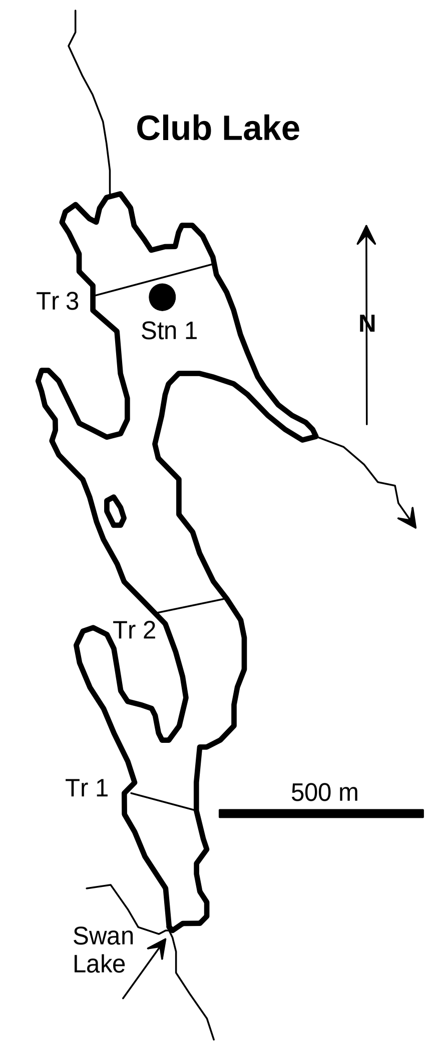


Figure 2g. Map of Club Lake showing the location of transects and limnology stations.

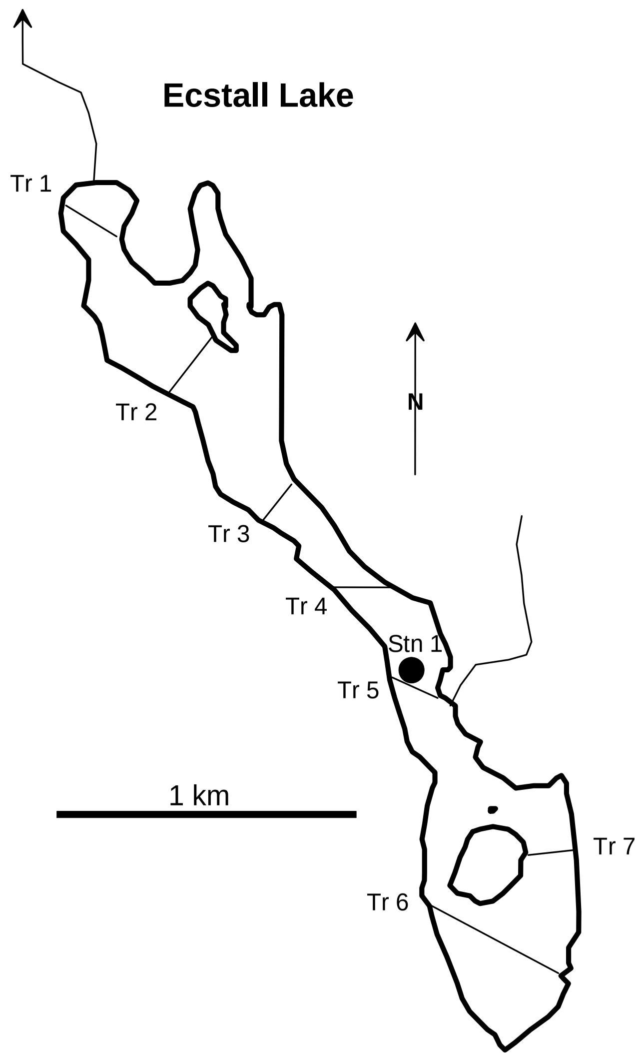


Figure 2h. Map of Ecstall Lake showing the location of transects and limnology stations.

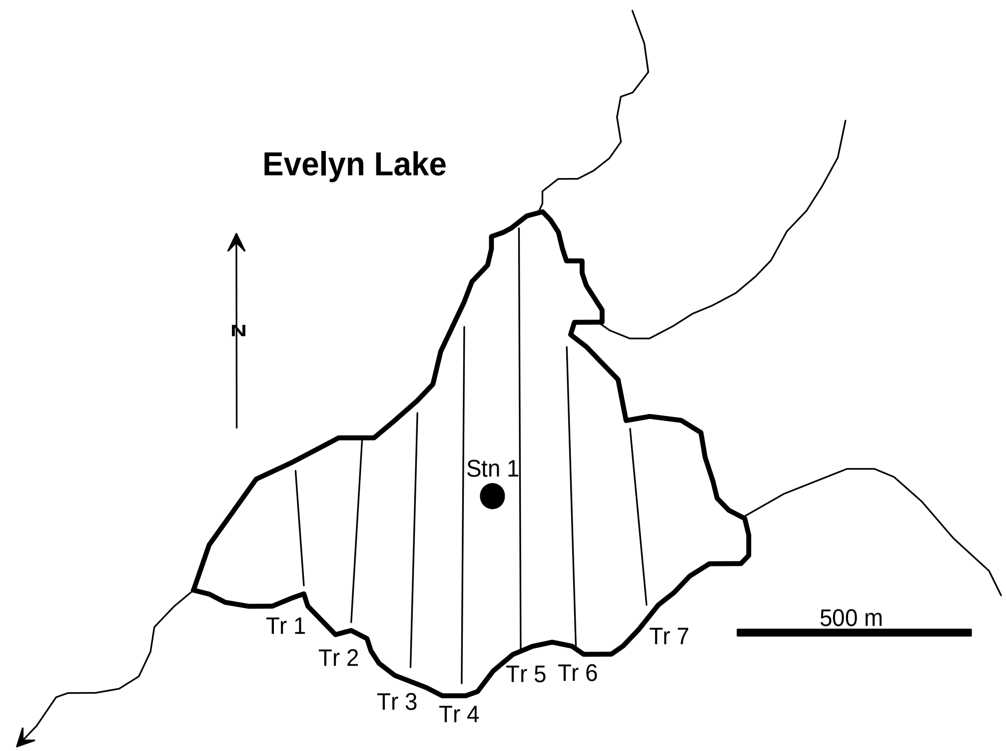


Figure 2i. Map of Evelyn Lake showing the location of transects and limnology stations.

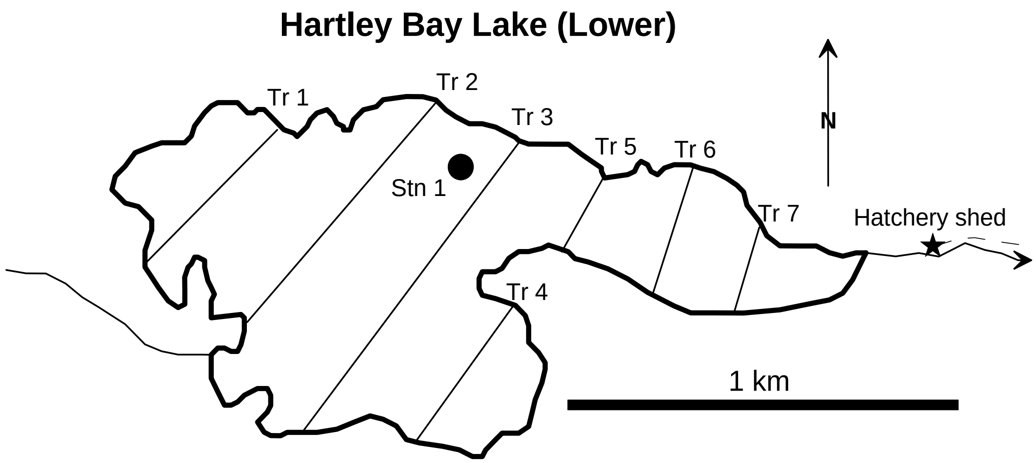


Figure 2j. Map of Hartley Bay Lower Lake showing the location of transects and limnology stations.

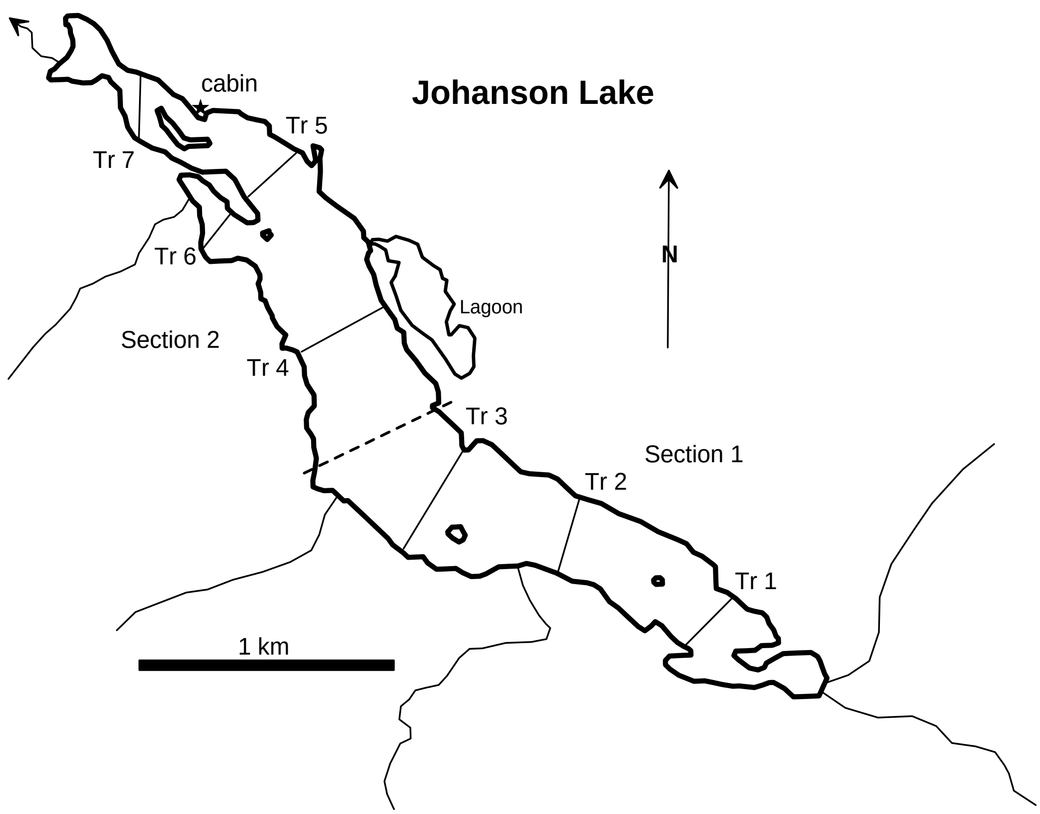


Figure 2k. Map of Johanson Lake showing the location of transects and limnology stations.

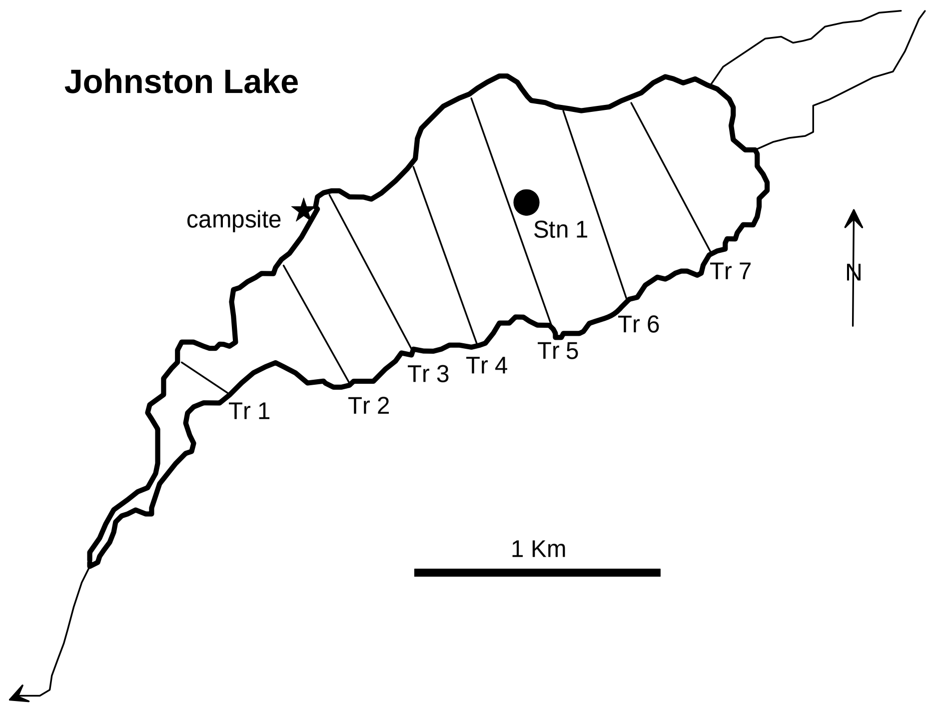


Figure 2l. Map of Johnston Lake showing the location of transects and limnology stations.

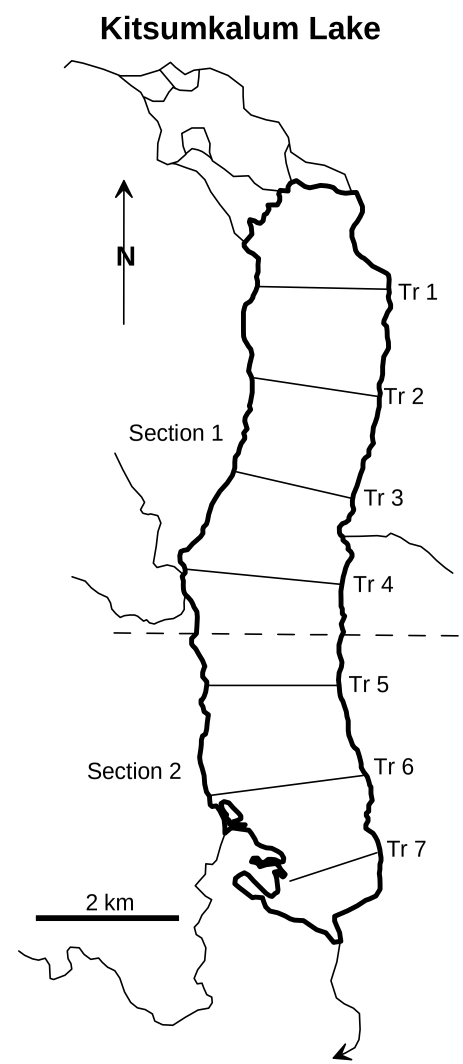


Figure 2m. Map of Kitsumkalum Lake showing the location of transects and limnology stations.

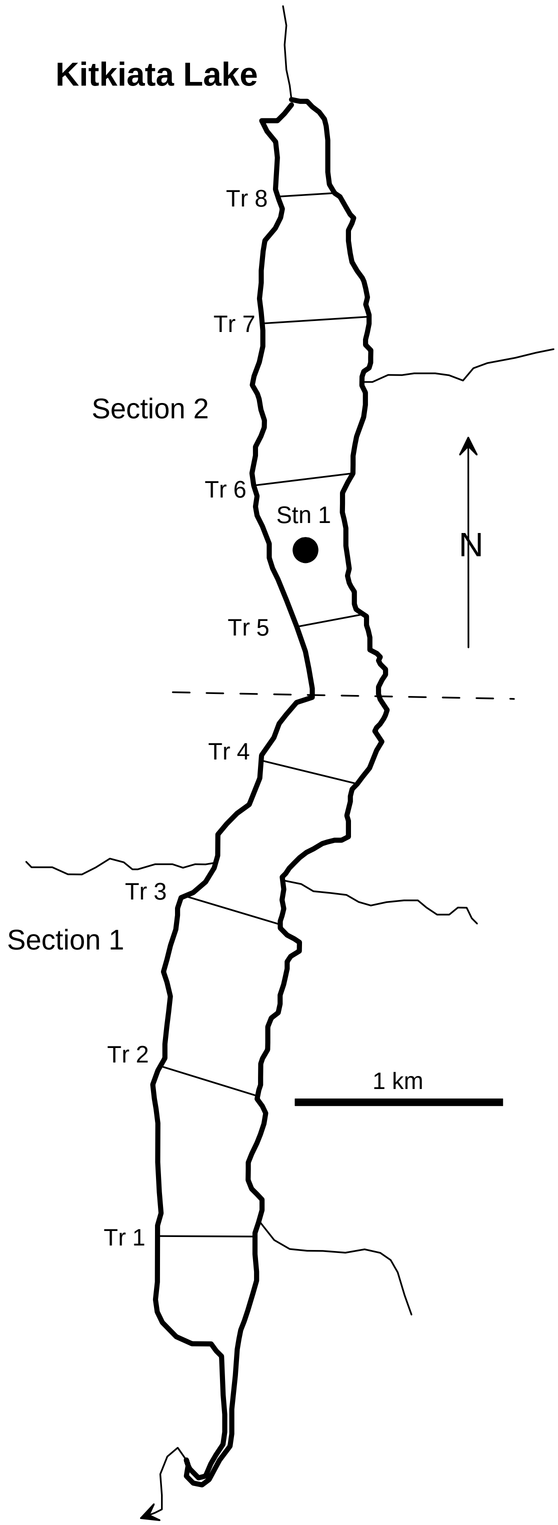


Figure 2n. Map of Kitkiata Lake showing the location of transects and limnology stations.

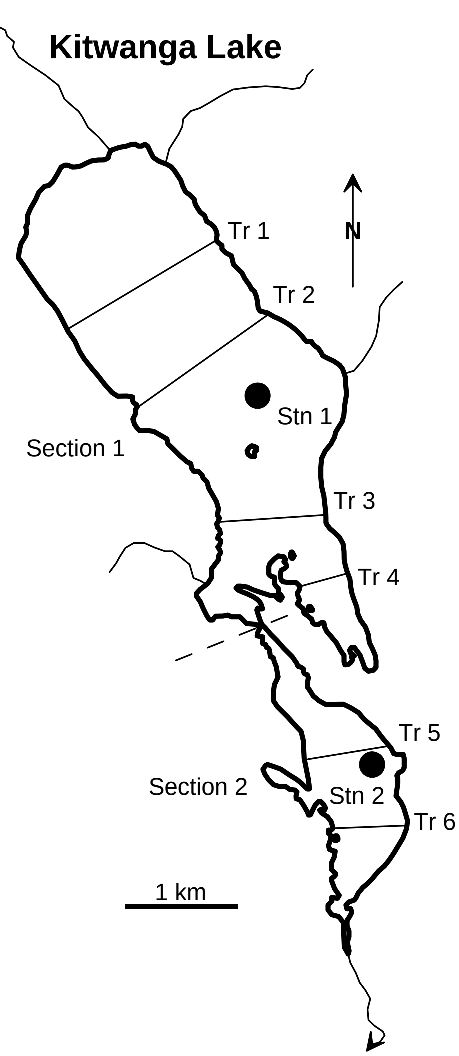


Figure 2o. Map of Kitwanga Lake showing the location of transects and limnology stations.

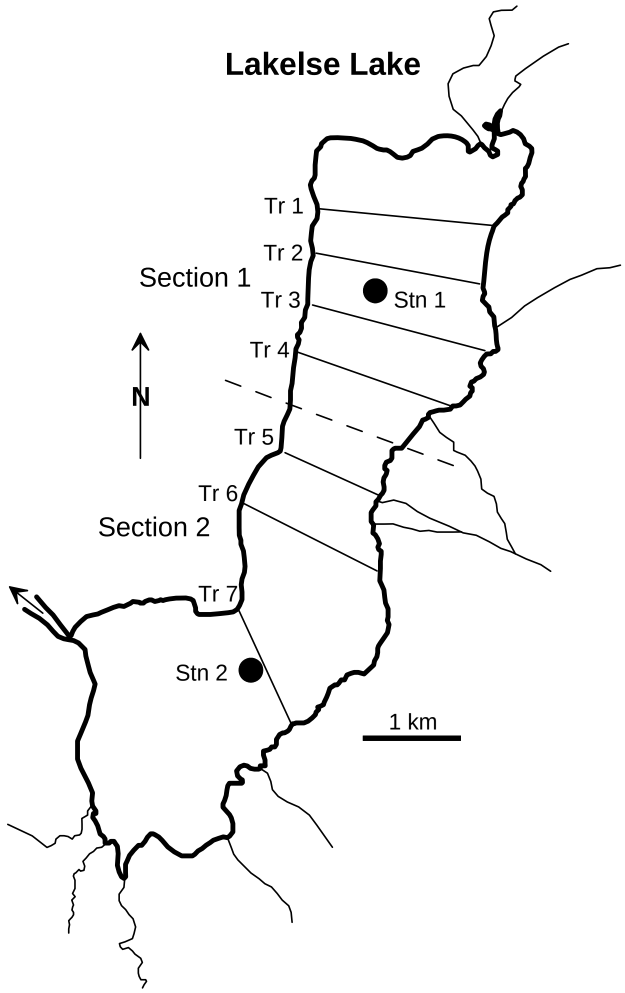


Figure 2p. Map of Lakelse Lake showing the location of transects and limnology stations.

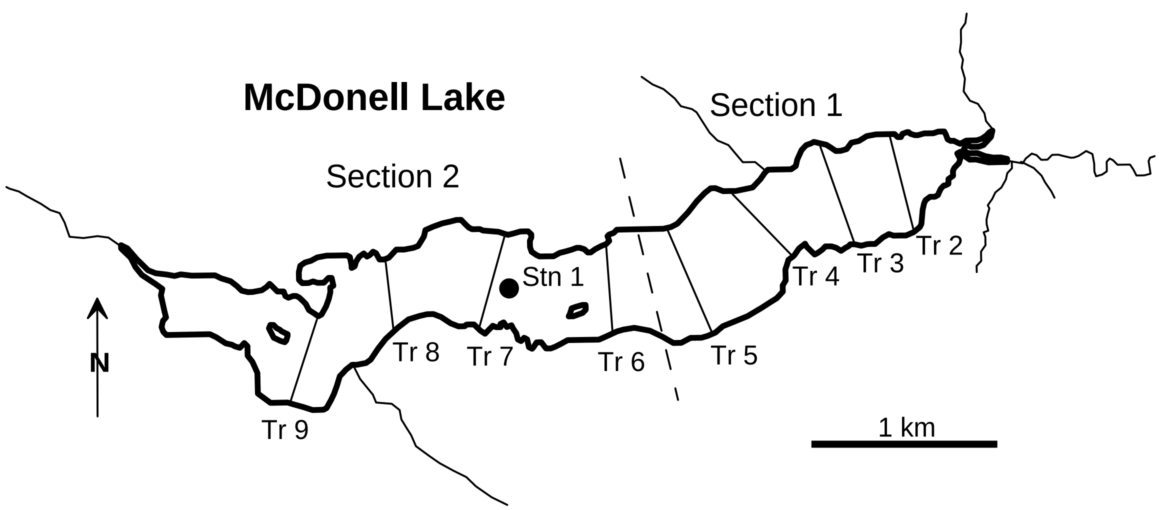


Figure 2q. Map of McDonell Lake showing the location of transects and limnology stations.

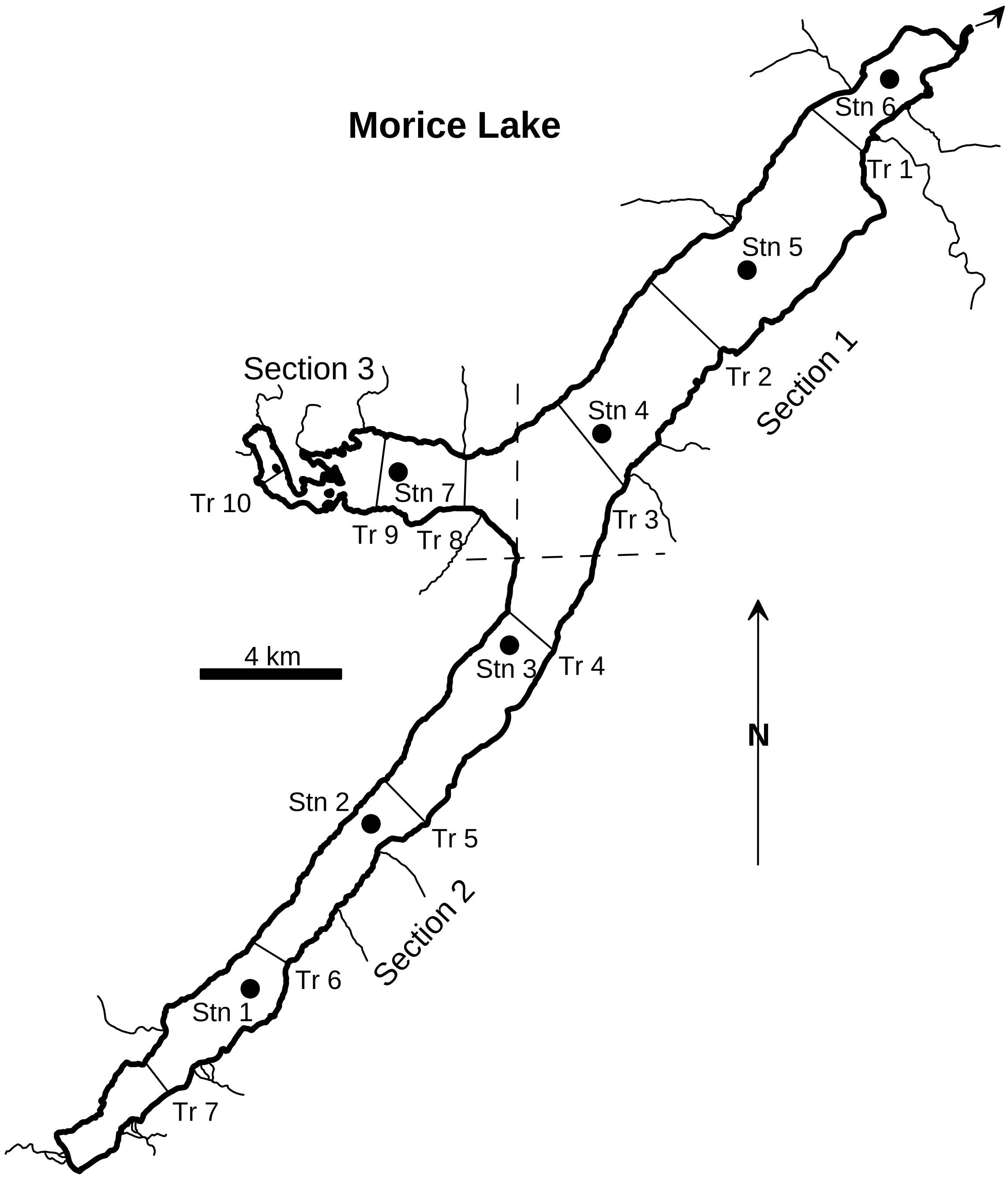


Figure 2r. Map of Morice Lake showing the location of transects and limnology stations.

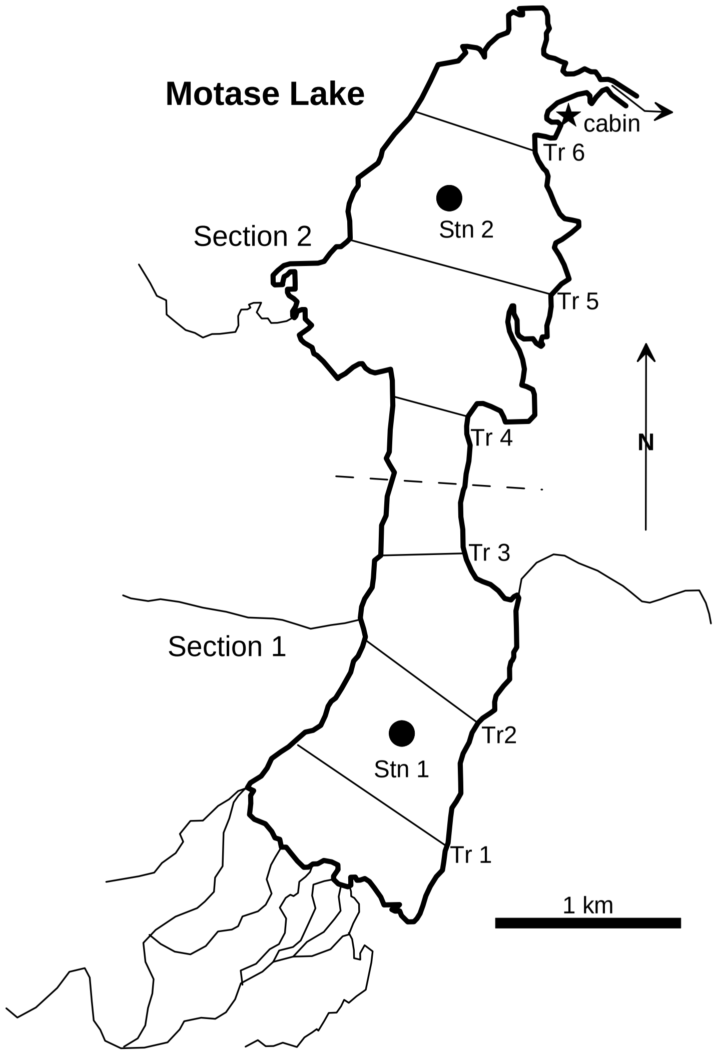


Figure 2s. Map of Motase Lake showing the location of transects and limnology stations.

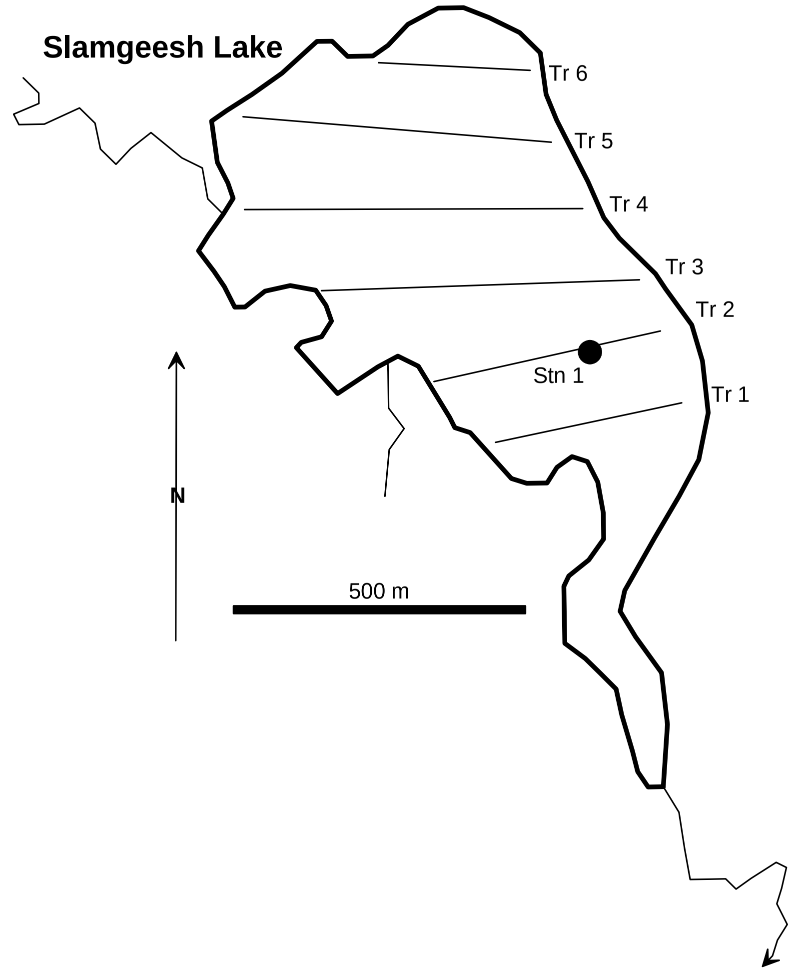


Figure 2t. Map of Slamgeesh Lake showing the location of transects and limnology stations.

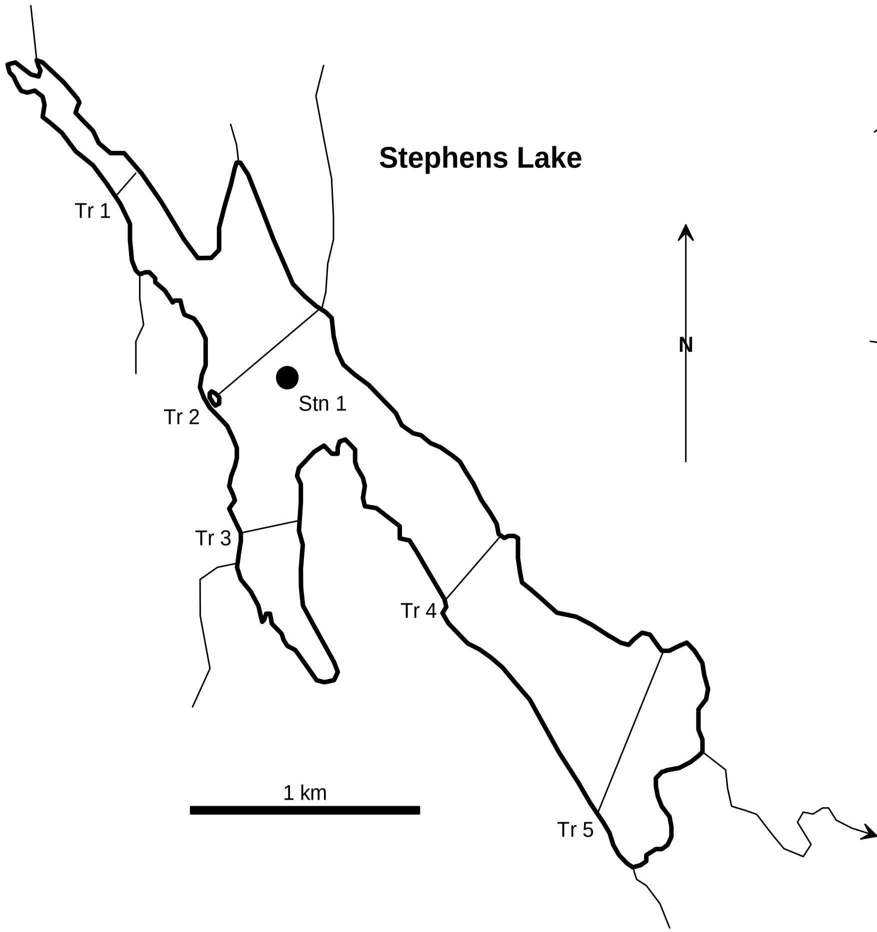


Figure 2u. Map of Stephens Lake showing the location of transects and limnology stations.

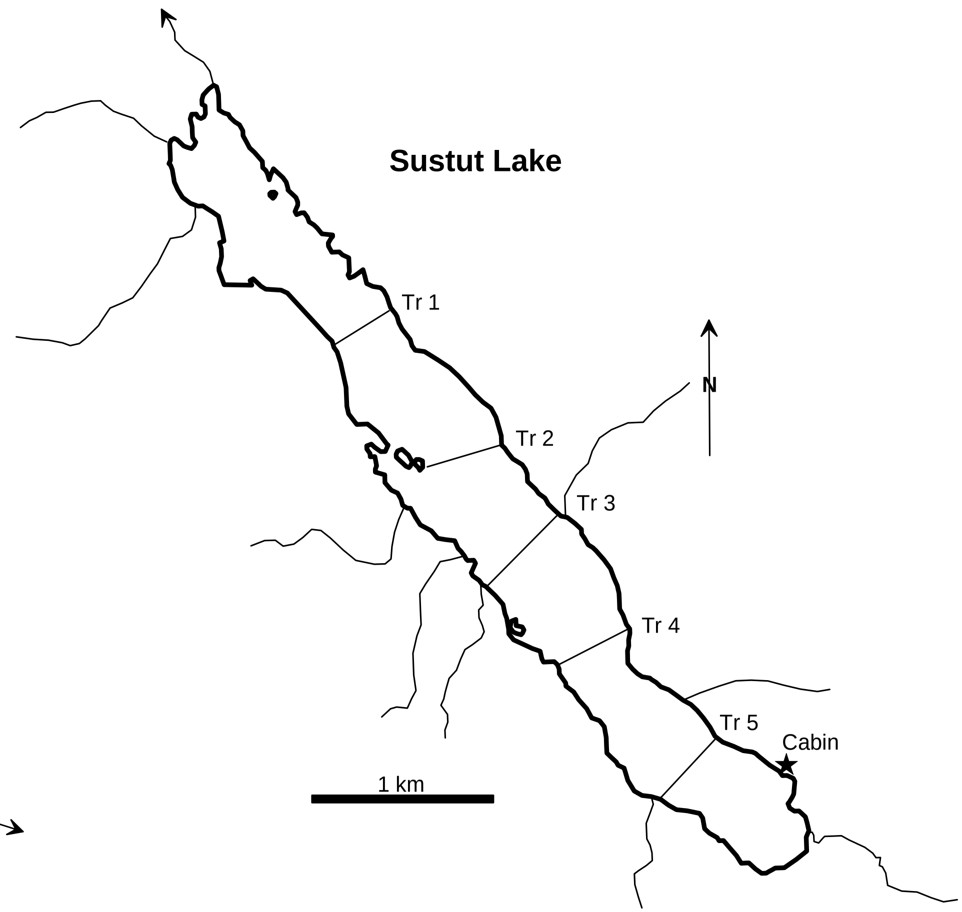


Figure 2v. Map of Sustut Lake showing the location of transects and limnology stations.

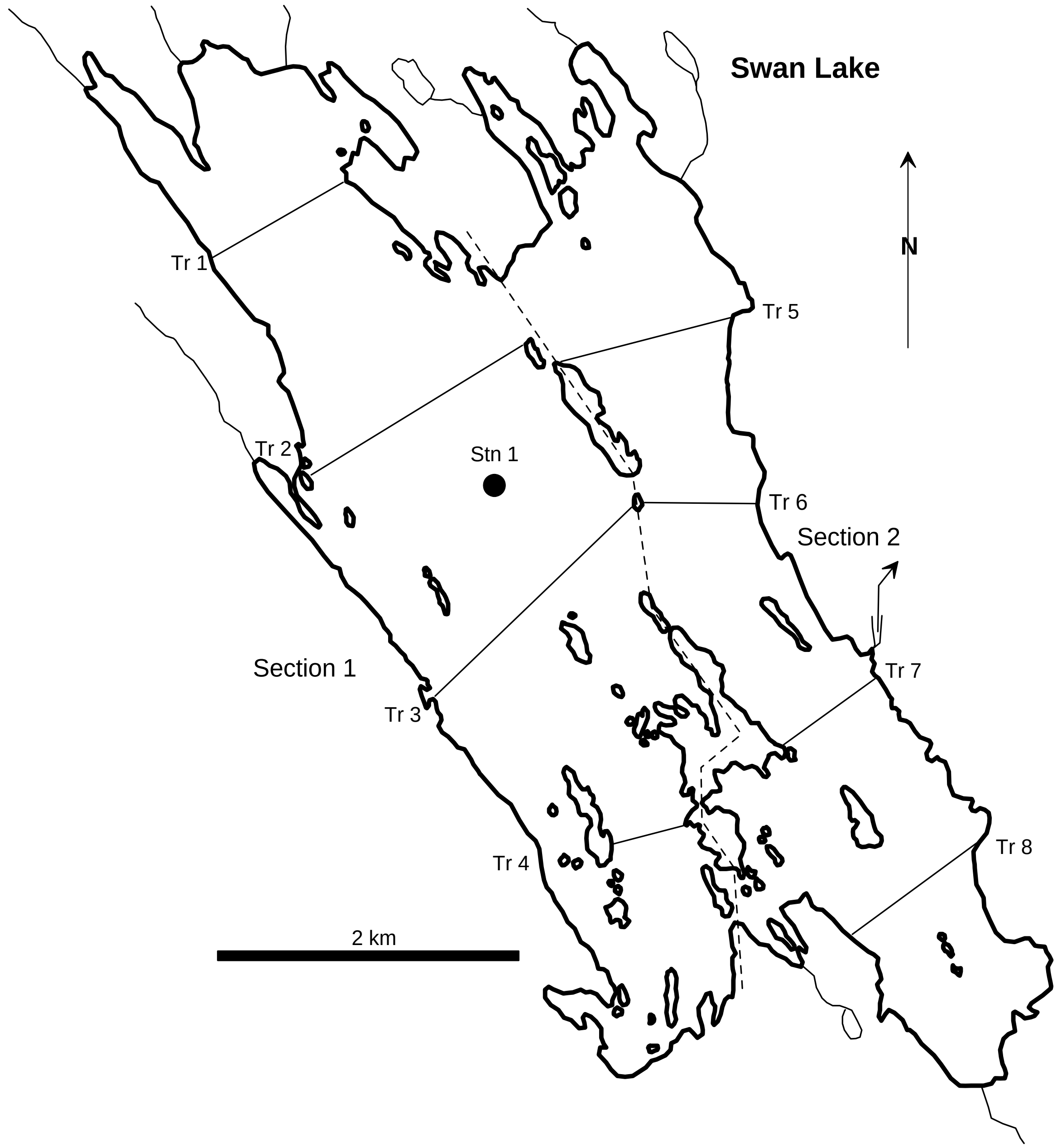
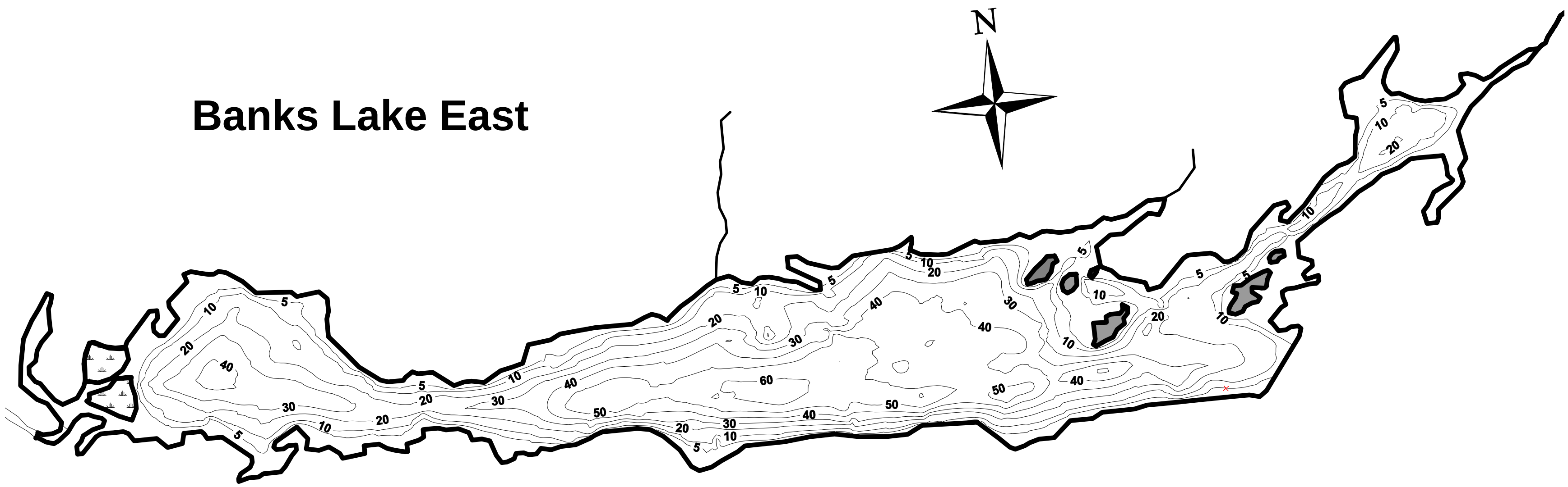


Figure 2w. Map of Swan Lake showing the location of transects and limnology stations.

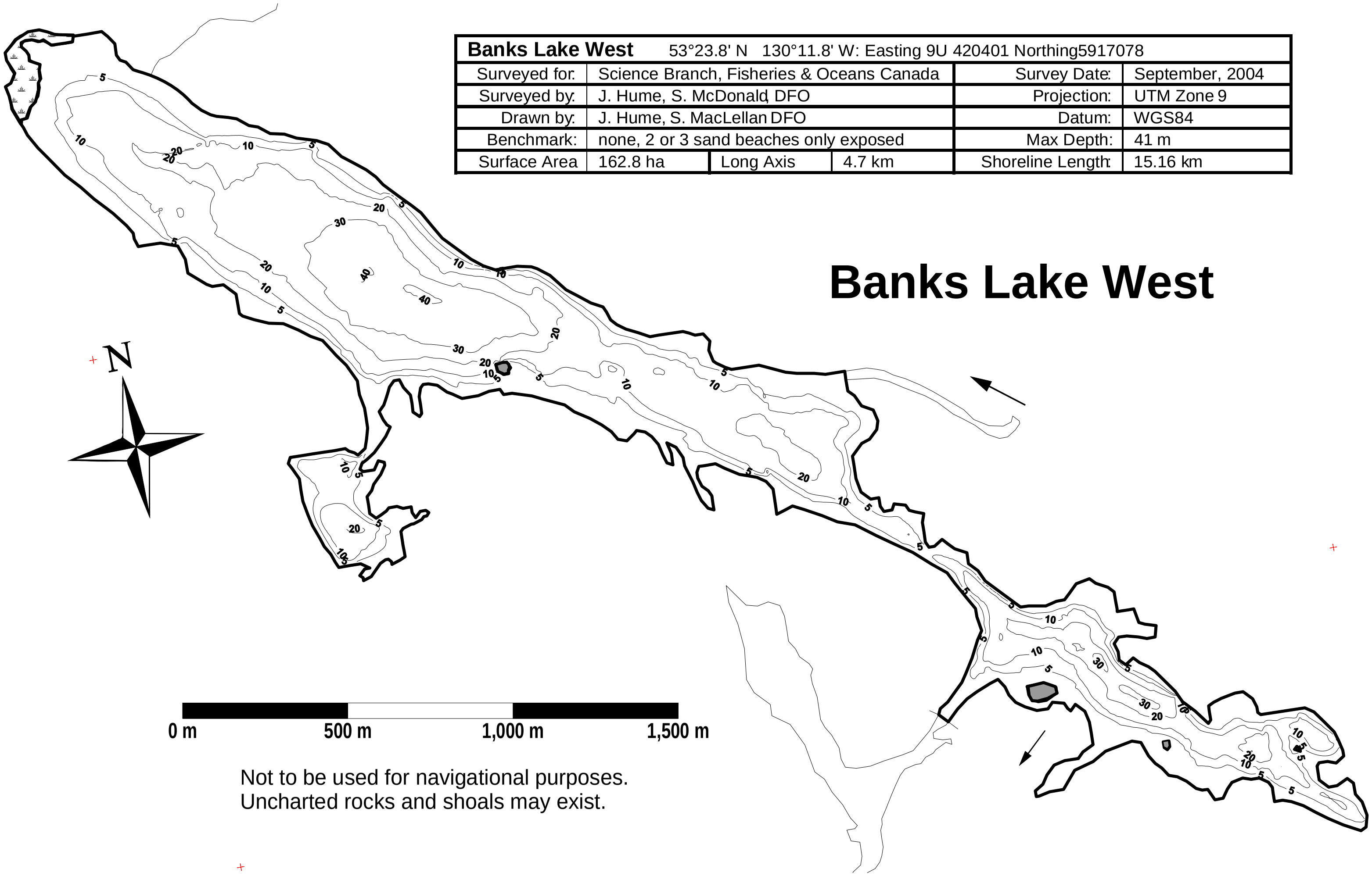


Banks Lake East	53°23.4' N 130°7.9' W : Easting 9U 424736 Northing 5916384				
Surveyed for:	Science Branch, Fisheries & Oceans Canada			Survey Date:	September, 2004
Surveyed by:	J. Hume, S. McDonald, DFO			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan DFO			Datum:	WGS84
Benchmark:	none, 2 or 3 sand beaches only exposed			Max Depth:	66 m
Surface Area	208.7 ha	Long Axis	4.8 km	Shoreline Length:	17.56 km

0 m 500 m 1000m

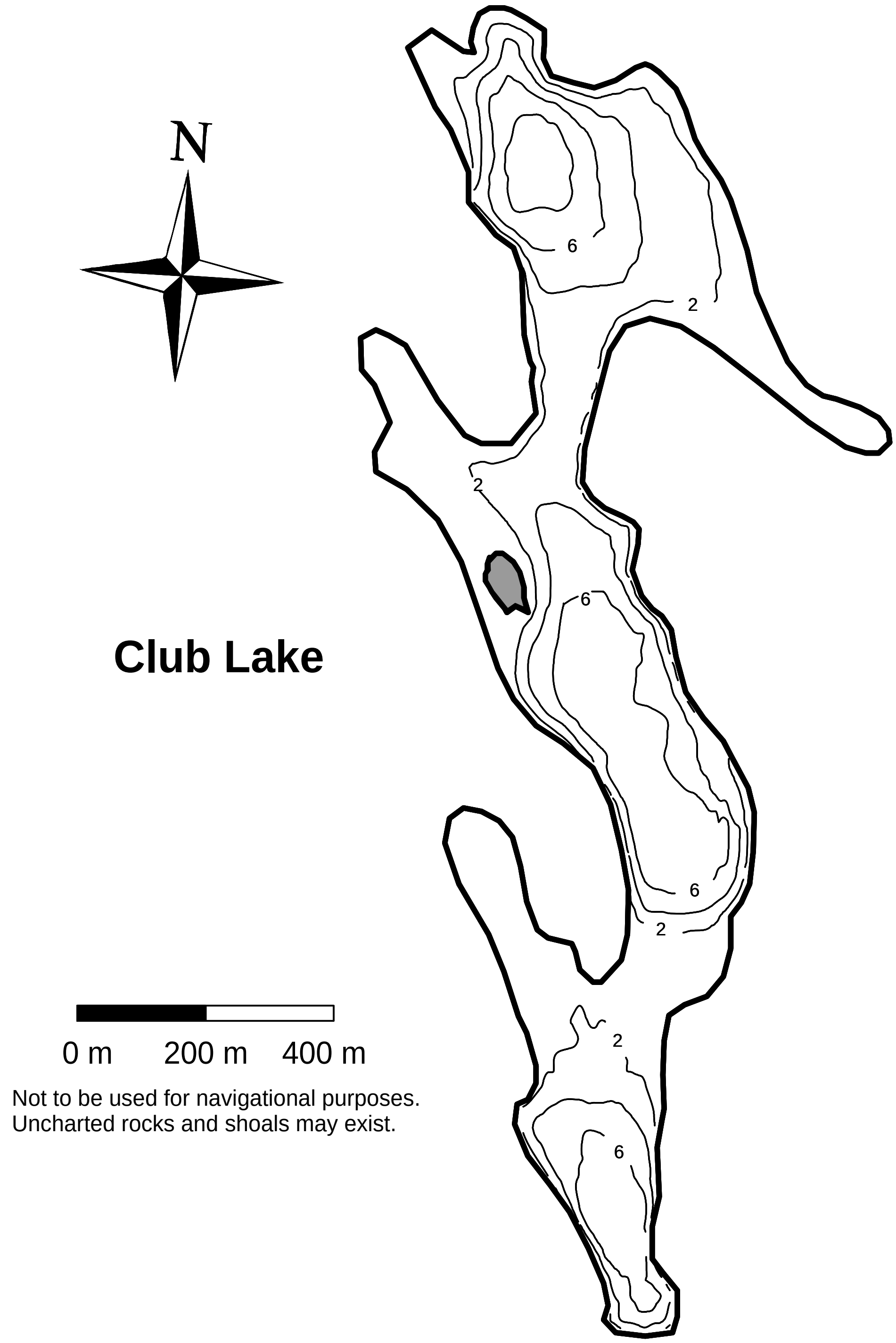
Not to be used for navigational purposes.
Uncharted rocks and shoals may exist.

Figure 3a. Bathymetric chart of Banks East Lake developed from survey soundings.



Banks Lake West	53°23.8' N 130°11.8' W: Easting 9U 420401 Northing5917078				
Surveyed for:	Science Branch, Fisheries & Oceans Canada			Survey Date:	September, 2004
Surveyed by:	J. Hume, S. McDonald, DFO			Projection:	UTM Zone 9
Drawn by:	J. Hume, S. MacLellan DFO			Datum:	WGS84
Benchmark:	none, 2 or 3 sand beaches only exposed			Max Depth:	41 m
Surface Area	162.8 ha	Long Axis	4.7 km	Shoreline Length:	15.16 km

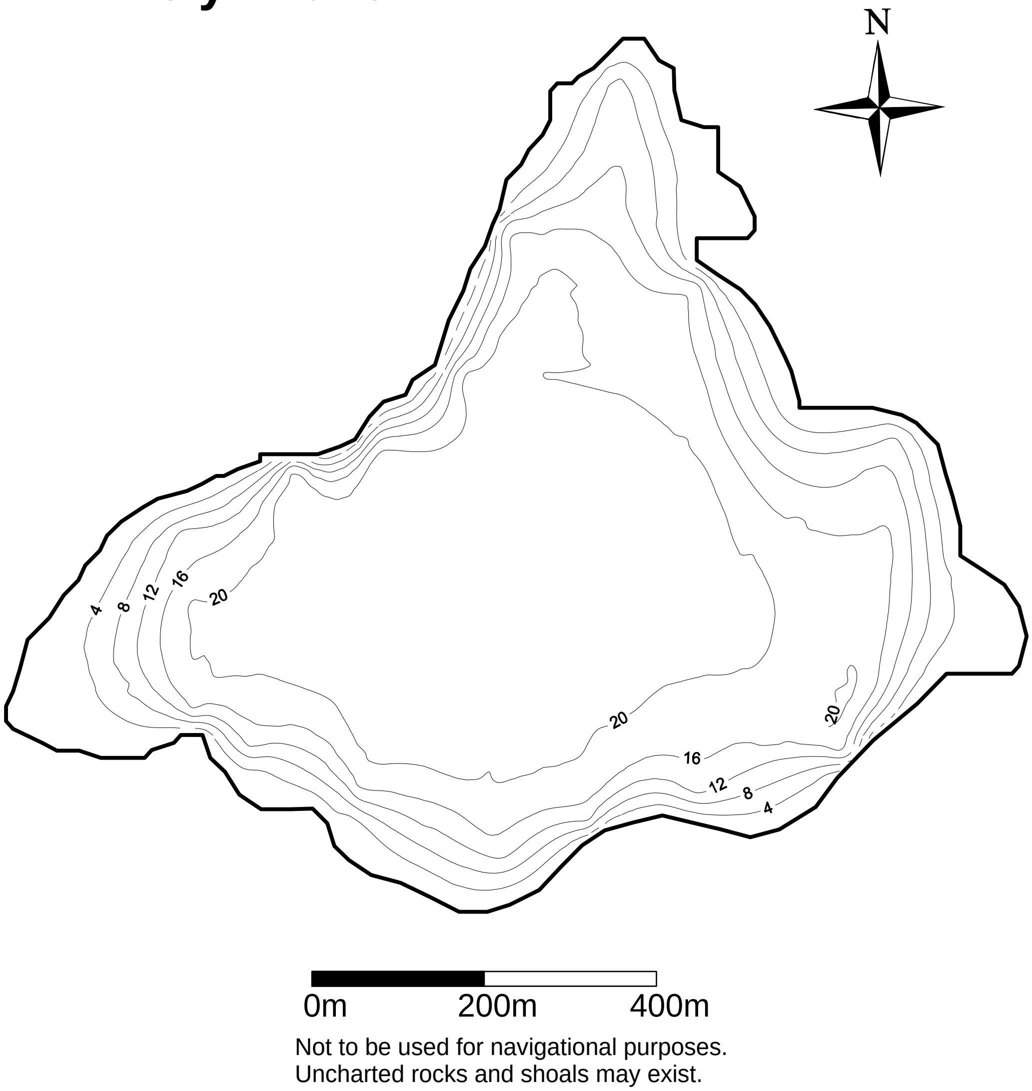
Figure 3b. Bathymetric chart of Banks Lake (West) developed from survey soundings.



Club Lake 55.79º N 128.62° W : Easting 9U 523711 Northing 6182438					
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September, 2002
Surveyed by:	J. Hume, S MacLellan			Projection:	UTM Zone 9
Drawn by:	B. Stables (Shsukan Fish. Con), J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map -Brown Bear Lake 103P/15				
Benchmark:	None, moderate water, some beach showing			Maximum depth:	9.7 m
Surface Area:	0.39 km²	Long Axis:	1.6 km	Shoreline length:	6.2 km

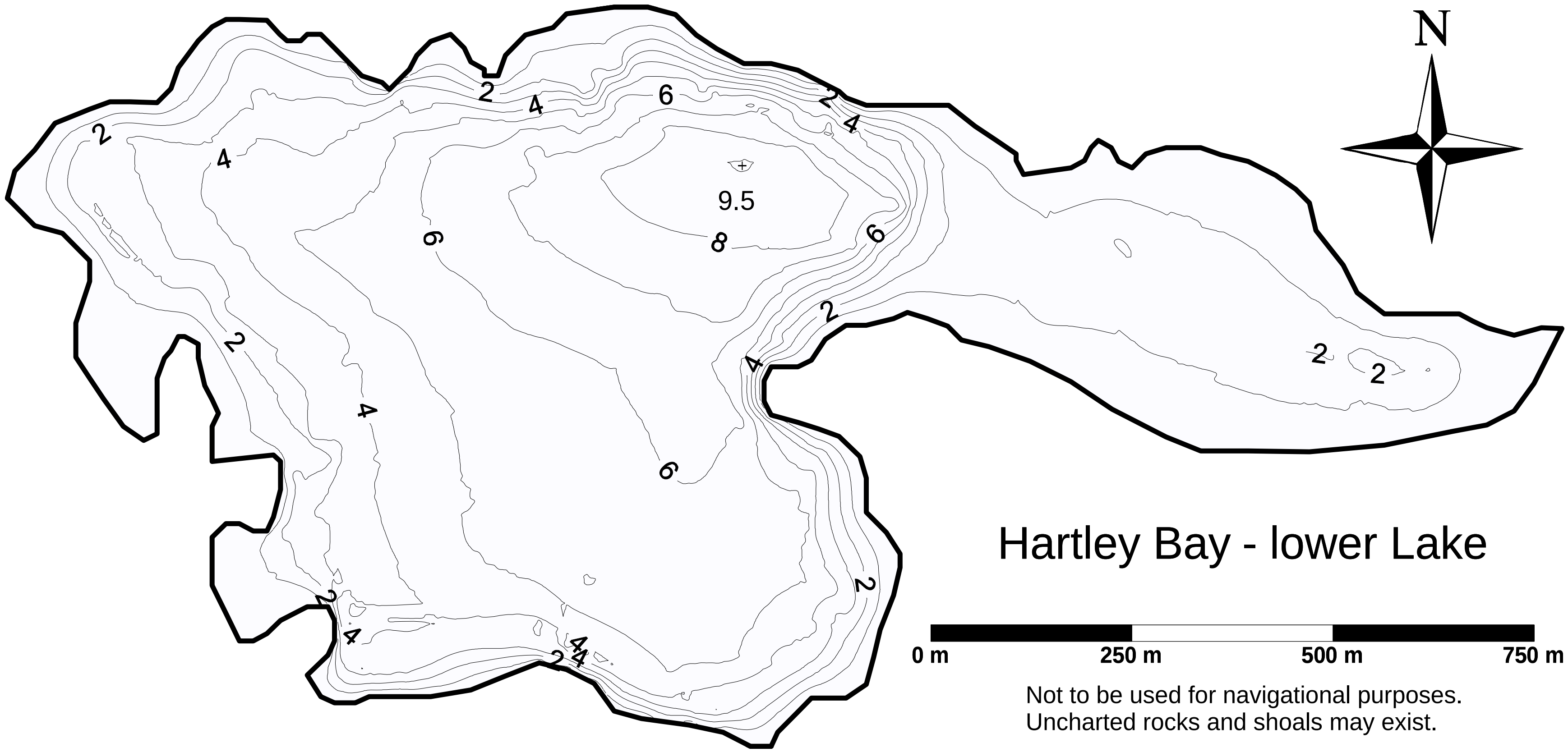
Figure 3c. Bathymetric chart of Club Lake developed from survey soundings

Evelyn Lake



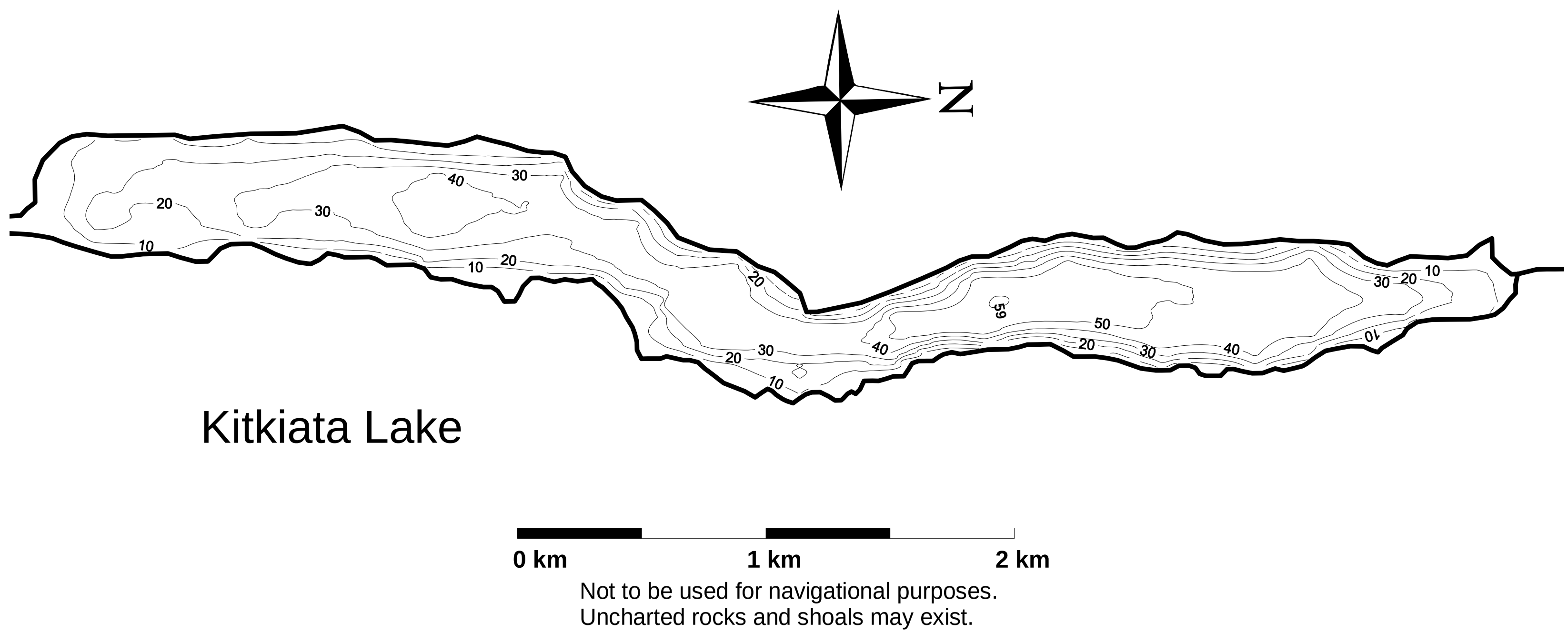
Evelyn Lake	53.60º N 128.93° W : Easting 9U 504757 Northing 5939036				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September, 2001
Surveyed by:	J. Hume, B. Stables (Shuksan Fisheries Consulting)			Projection:	UTM Zone 9
Drawn by:	B. Stables, J. Hume, S. MacLellan			Datum:	WGS84
Base map:	NTS 1:50000 map - Devastation Channel 103H/10				
Benchmark:	None, high water, no beach showing.			Maximum depth:	22 m
Surface Area:	0.58 km²	Long Axis:	1.1 km	Shoreline length:	3.6 km

Figure 3d. Bathymetric chart of Evelyn Lake developed from survey soundings.



Hartley Bay Lake Lower	53°25.6' N 130°17.3' W : Easting 9U 480793 Northing 5919838				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September, 2004
Surveyd by:	SG. Maclellan , S. McDonald, DFO			Projection:	UTM Zone 9
Drawn by:	JMB Hume, SG MacLellan, DFO			Datum:	WGS84
Benchmark:	none, moderate water ~60cm below dock			Maximum depth:	9.5 m
Surface Area:	0.90 km²	Long Axis:	1.91 km	Shoreline length:	6.09 km

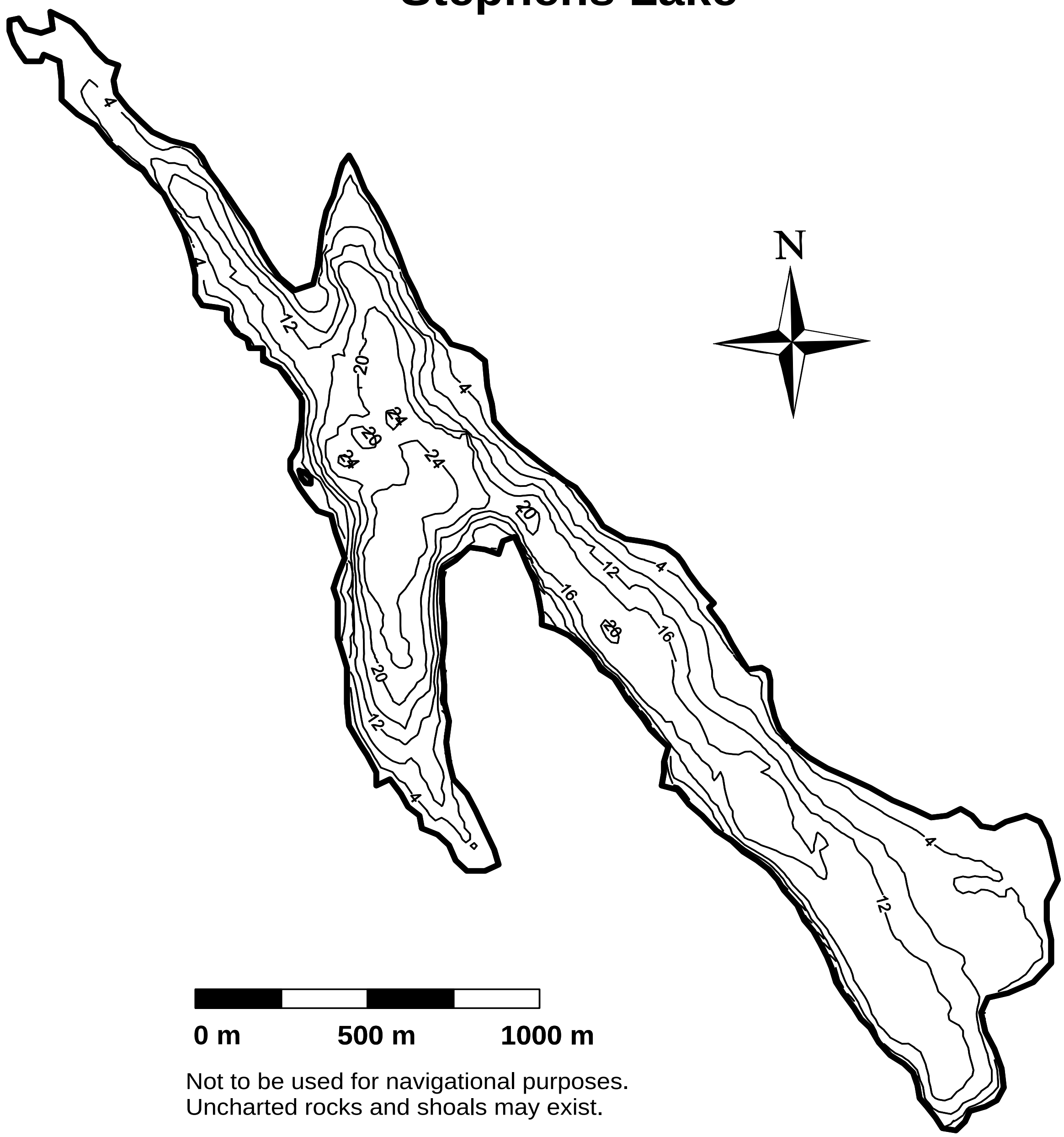
Figure 3e. Bathymetric chart of Hartley Bay (Lower) Lake developed from survey soundings.



Kitkiata Lake	53°43.3' N 130°17.1' W : Easting 9U 481157 Northing 5952596				
Surveyed for:	Fisheries and Oceans, Canada			Survey Date:	September, 2005
Surveyd by:	JMB Hume, S. McDonald, DFO			Projection:	UTM Zone 9
Drawn by:	JMB Hume, SG MacLellan, DFO			Datum:	WGS84
Benchmark:	none, moderately high water, no gravel beaches showing			Maximum depth:	58.6 m
Surface Area:	2.75 km²	Long Axis:	6.0 km	Shoreline length:	16.06 km

Figure 3f. Bathymetric chart of Kitkiata Lake developed from survey soundings.

Stephens Lake



Stephens Lake	55.78º N 128.59° W : Easting 9U 525841 Northing 6181422			
Surveyed for:	Fisheries and Oceans, Canada		Survey Date:	September, 2002
Surveyed by:	J. Hume, S MacLellan		Projection:	UTM Zone 9
Drawn by:	B. Stables (Shsukan Fish. Con), J. Hume, S. MacLellan		Datum:	WGS84
Base map:	NTS 1:50000 map -Brown Bear Lake 103P/15			
Benchmark:	None, moderate water, some beach showing		Maximum depth:	24 m
Surface Area:	1.88 km²	Long Axis: 4.4 km	Shoreline length:	13.3 km

Figure 3g. Bathymetric chart of Stephens Lake developed from survey soundings

Swan Lake

0 km 1 km 2 km

Not to be used for navigational purposes.
Uncharted rocks and shoals may exist.

Swan Lake 55.79º N 128.65° W : Easting 9U521847 Northing 6182066

Surveyed for:	**Fisheries and Oceans, Canada**	**Survey Date:**	**September, 2002**
Surveyed by:	**J. Hume, S MacLellan**	**Projection:**	**UTM Zone 9**
Drawn by:	**B. Stables (Shsukan Fish. Con), J. Hume, S. MacLellan**	**Datum:**	**WGS84**
Base map:	**NTS 1:50000 map -Brown Bear Lake 103P/15**		
Benchmark:	**None, moderate water, some beach showing**	**Maximum depth:**	**>60 m**
Surface Area:	**17.4 km² without islands Long axis: 7.6 km**	**Shoreline length:**	**39.7 km**

Figure 3h. Bathymetric chart of Swan Lake developed from survey soundings.

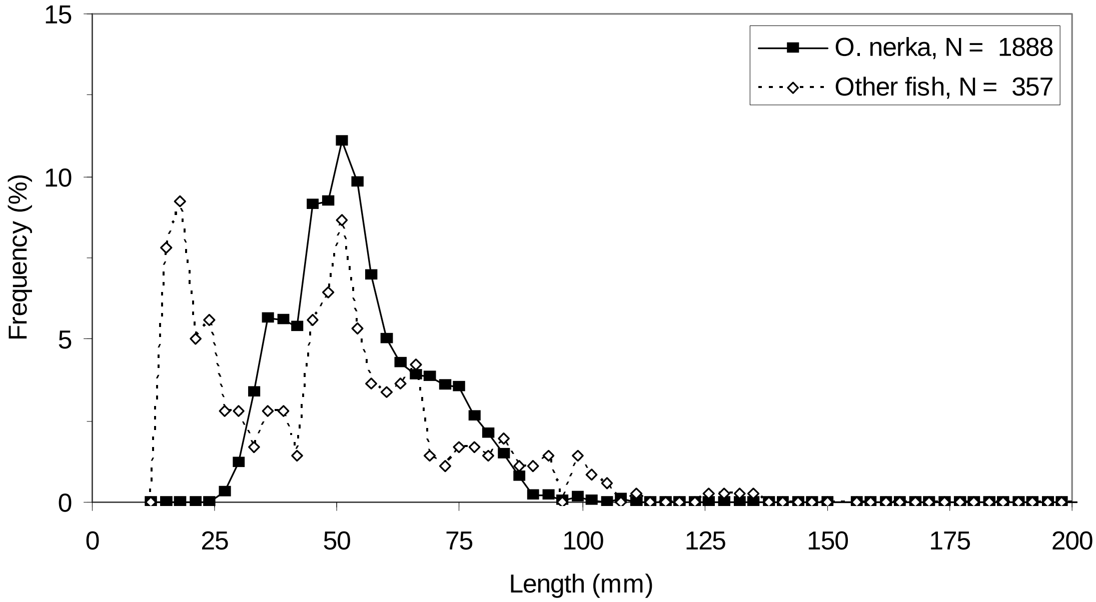


Fig. 4. Length frequency of all *O. nerka* and other fish caught in the midwater trawls. Data was grouped into 3-mm length bins for plotting.

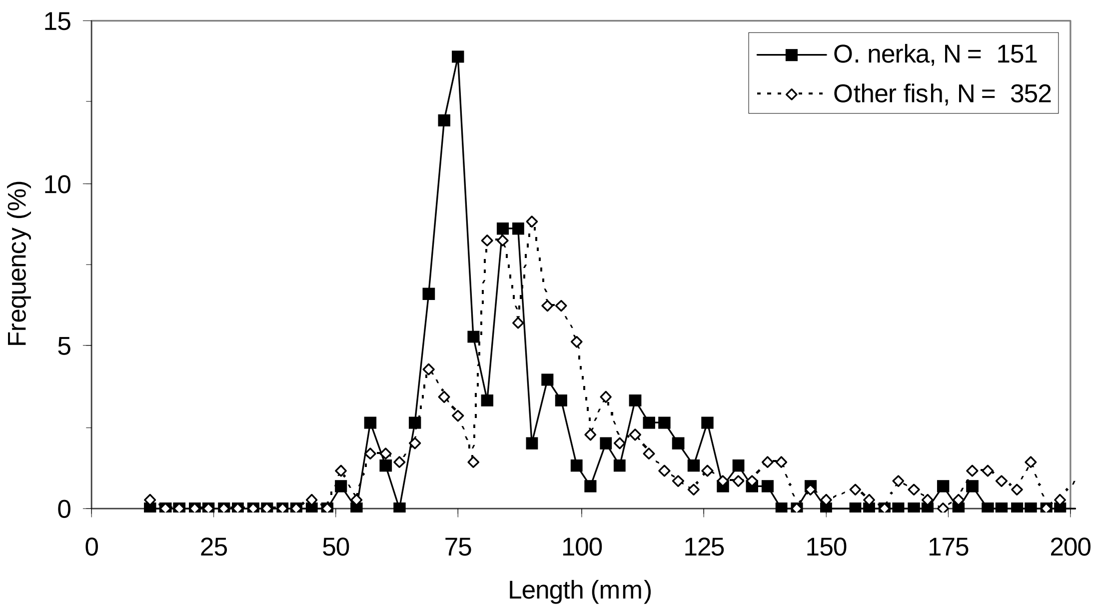
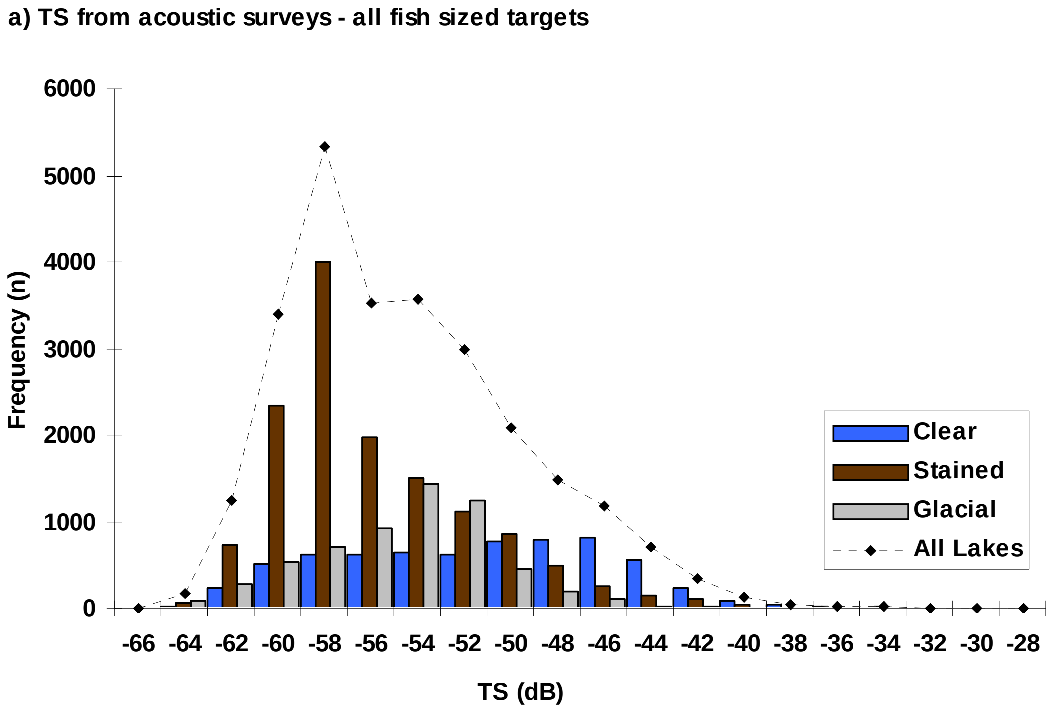


Figure 5. Length frequency of all *O. nerka* and other fish caught in the Swedish gillnets. Data was grouped into 3-mm length bins for plotting and does not include 82 other fish >201 mm.



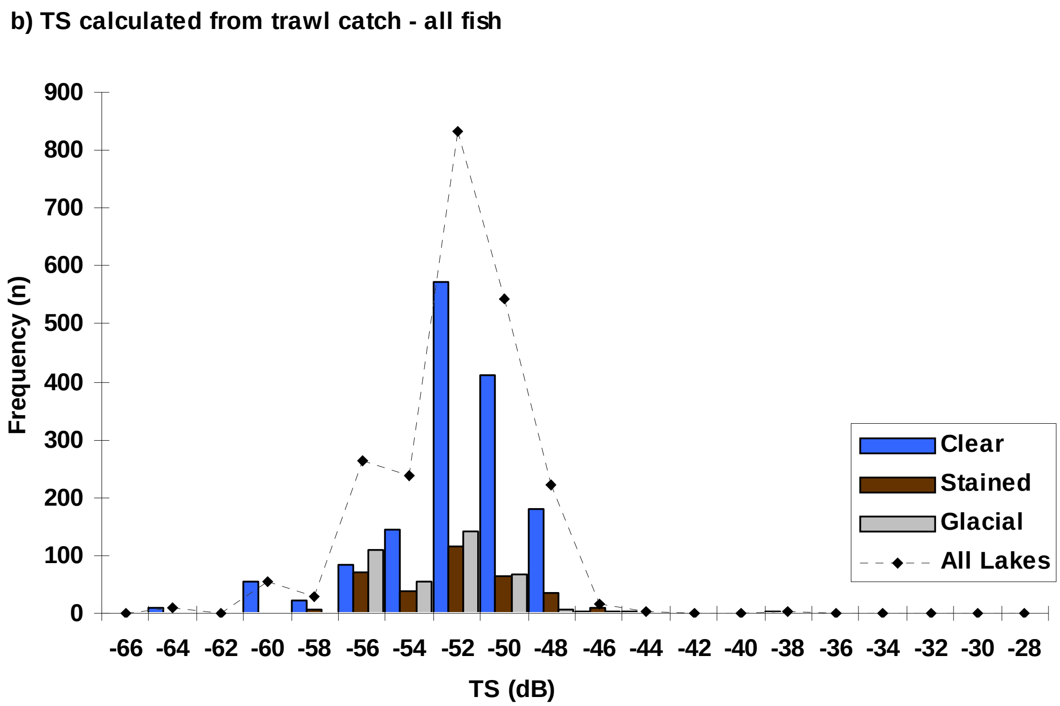


Figure 6. Comparison of target strength estimates from the hydroacoustic surveys and median TS calculated from the trawl catch using Love's (1977) ±45° conversion formula, for all fish categorized by lake type.

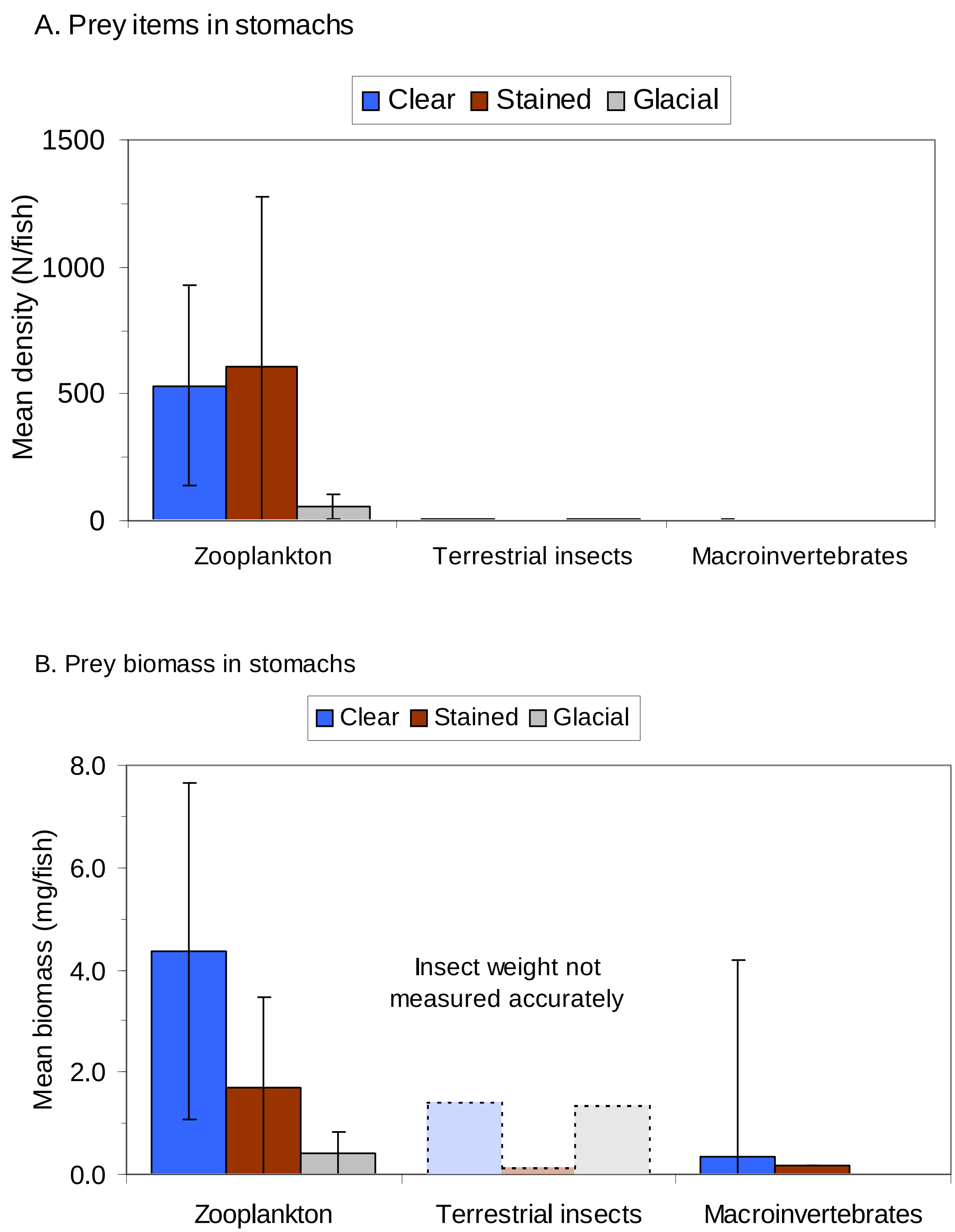


Figure 7. General components of the diet of age-0 sockeye in the 3 lake types by abundance and by biomass. The vertical lines indicate 95% confidence intervals. The biomass of terrestrial insects is not reliably measured. Macro-invertebrates includes *Chaoborus*, Chironomid*, and* Ceratopogonid larvae, *Neomysis*, and amphipods.

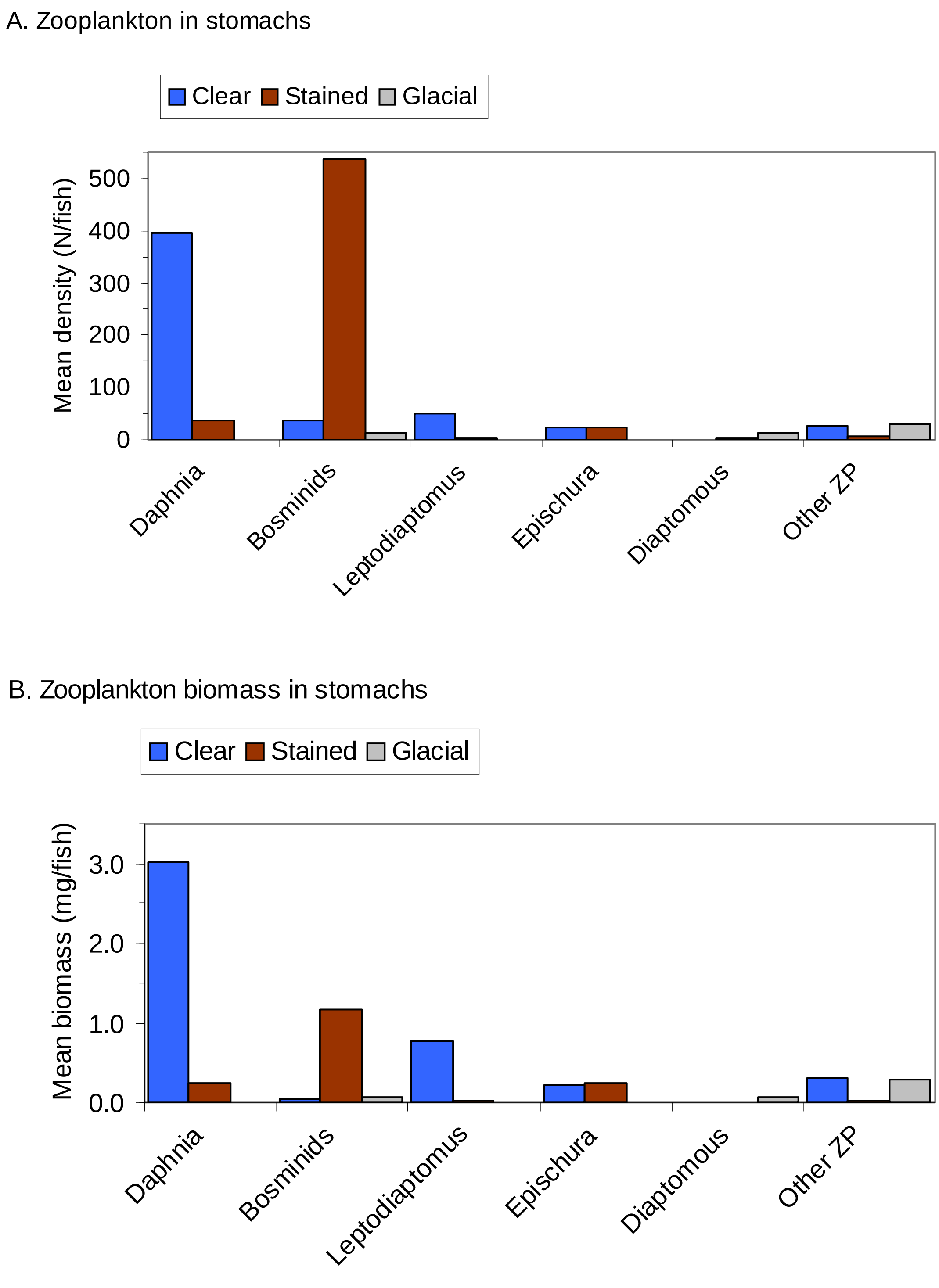


Figure 8. Major components of the zooplankton portion of the diet of age-0 *O. nerka* in the 3 lake types by abundance and by biomass. Means only include stomachs with zooplankton (ZP). The other ZP category includes 9 other genera of zooplankton.

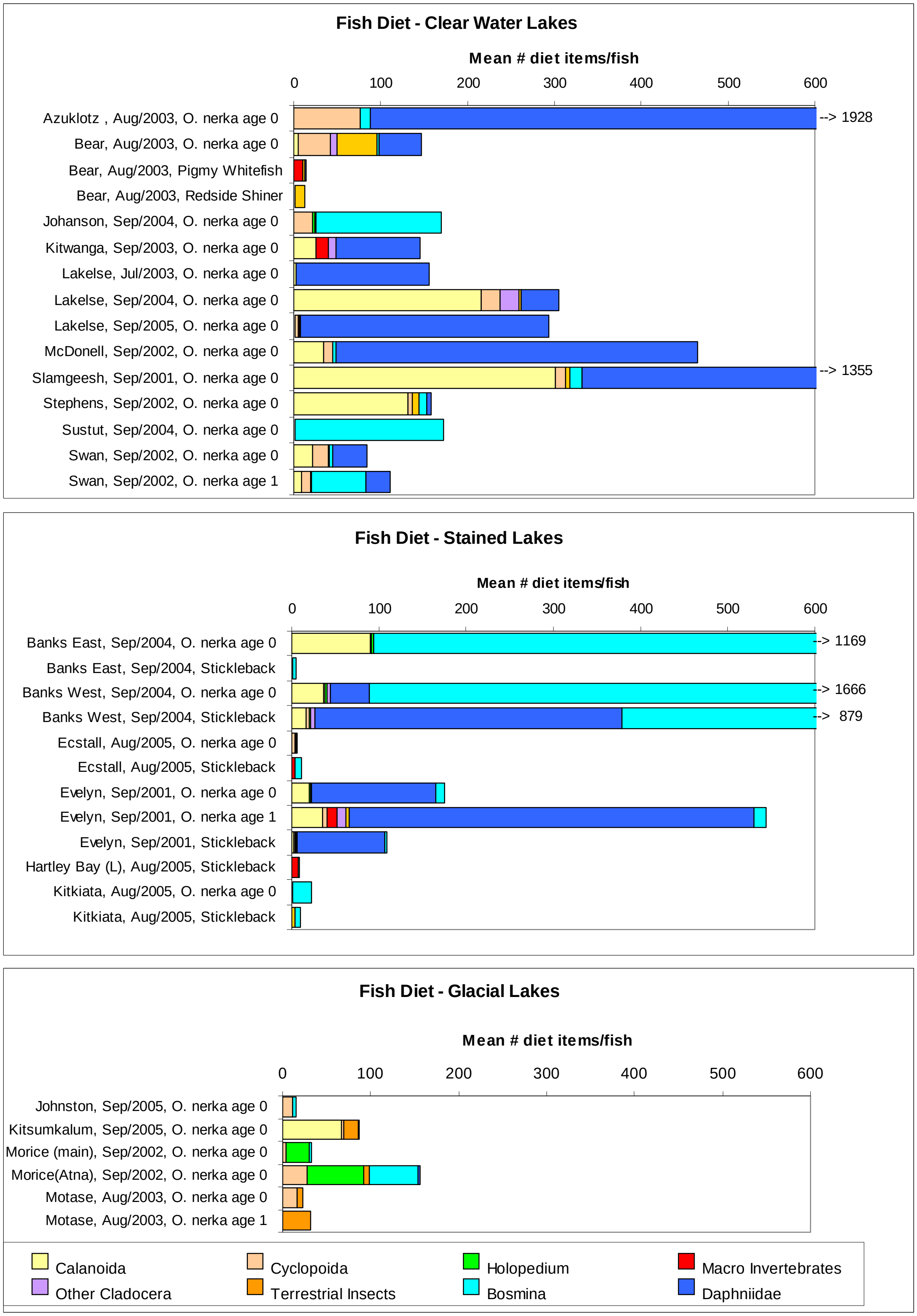


Figure 9. Estimated abundance of food items in the diet of fish from the lake surveys.

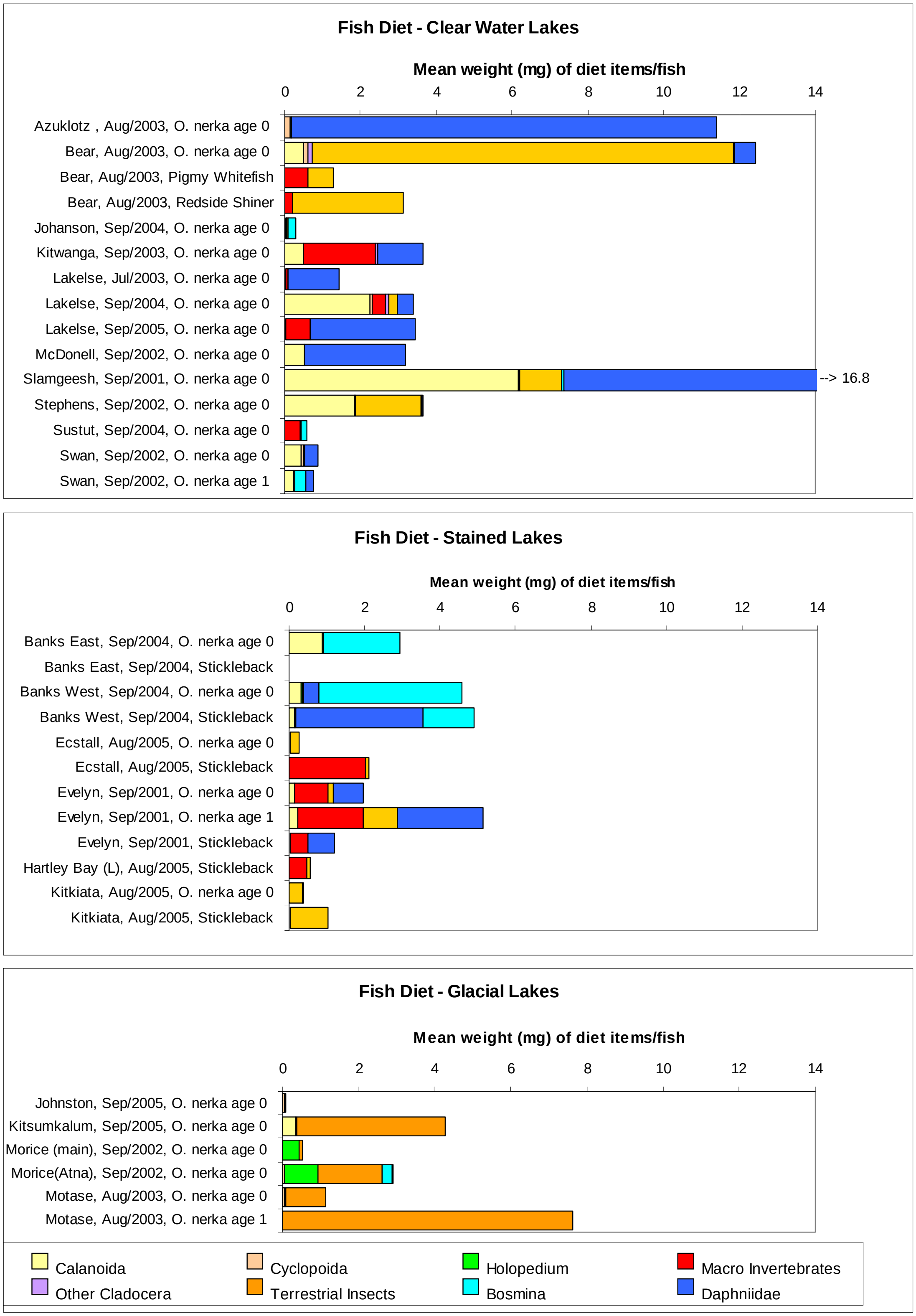


Figure 10. Estimated biomass of food items in the diet of fish from the lake surveys.

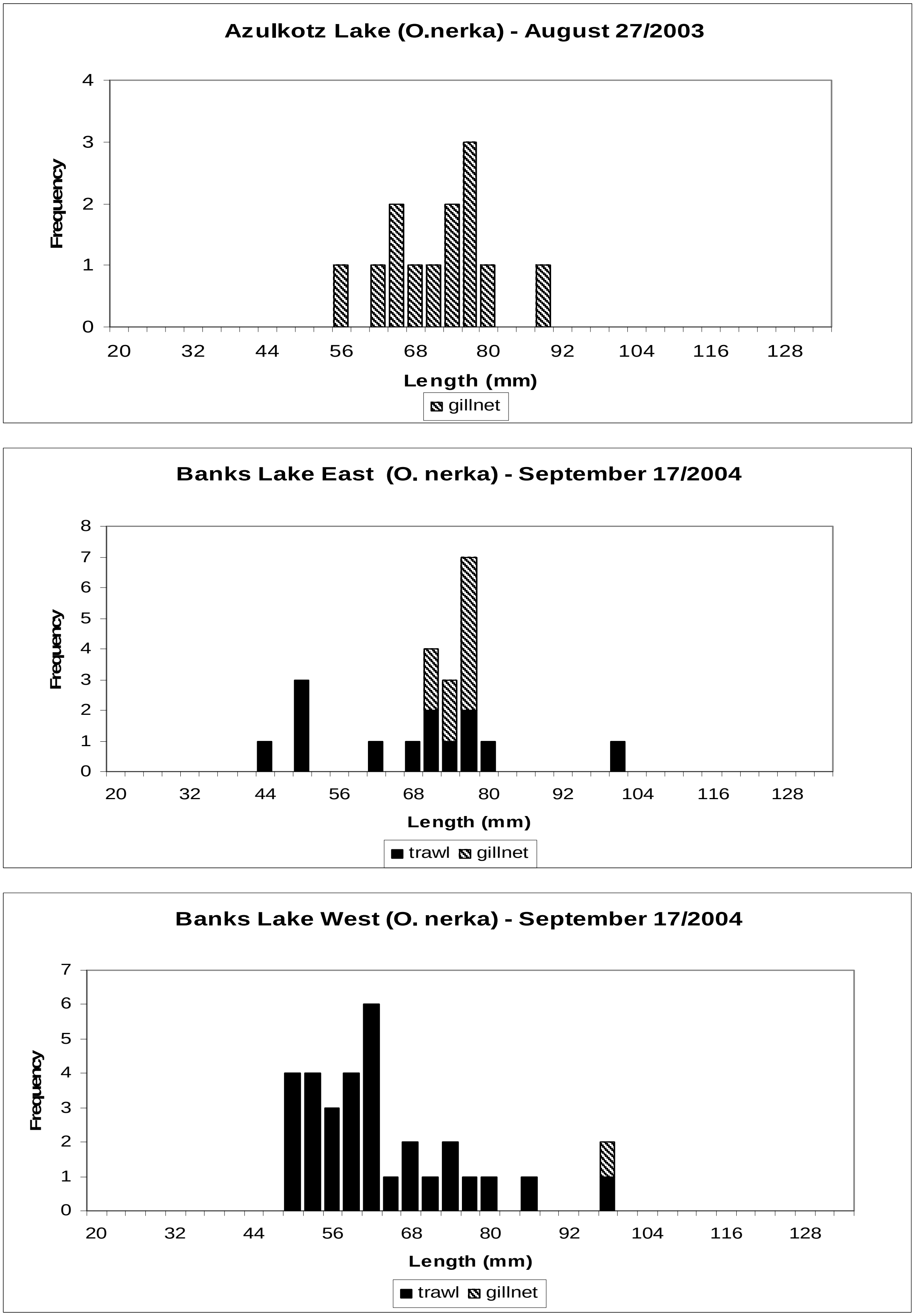


Figure 11. Length frequency histograms of *O. nerka* from each survey.

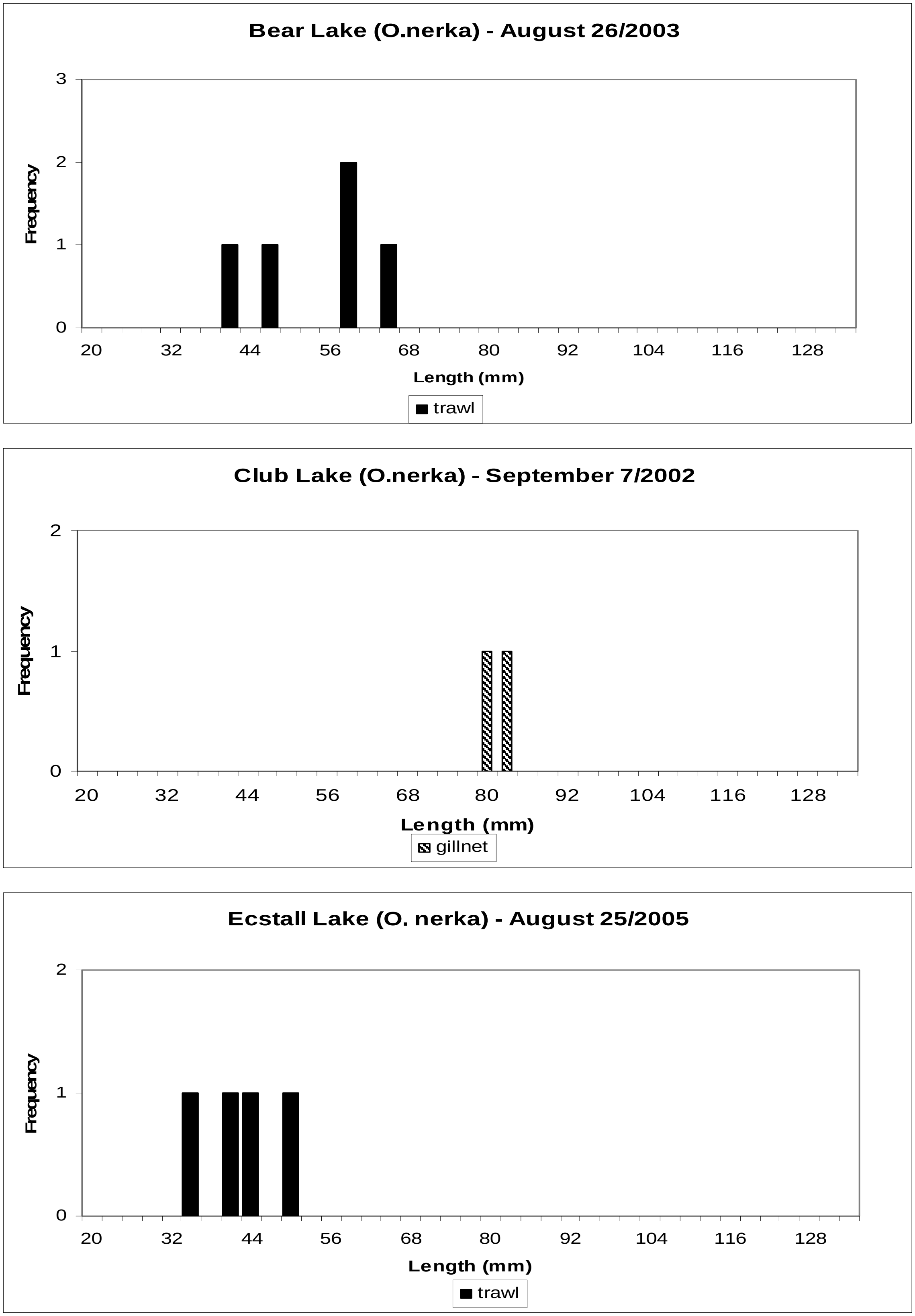
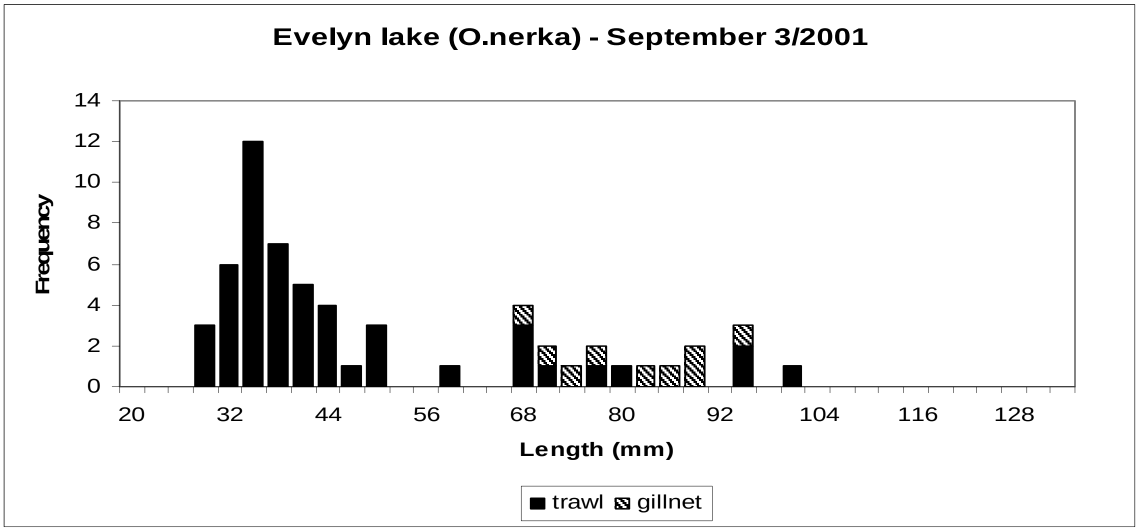
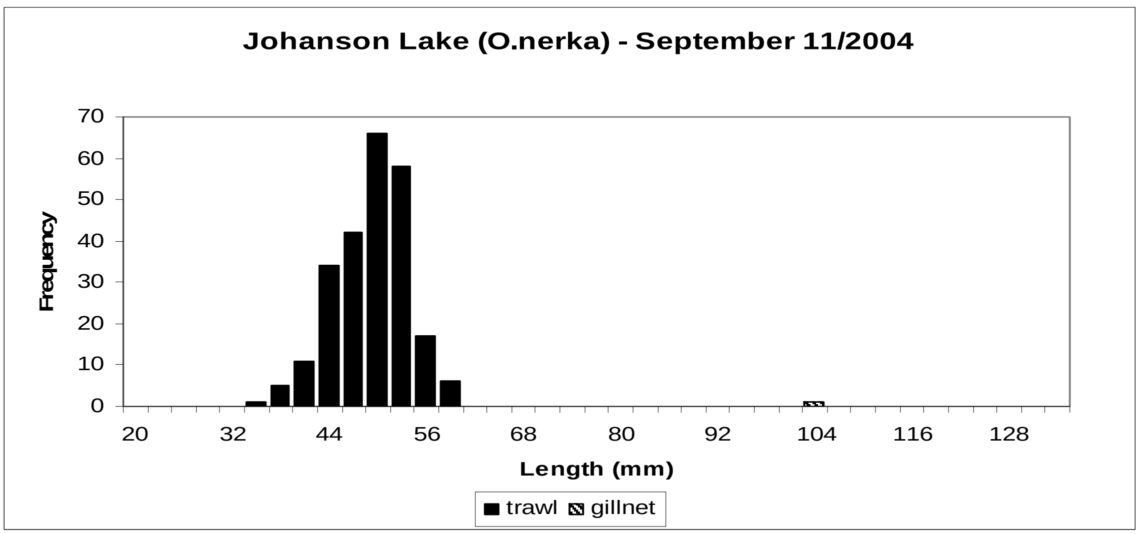


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).





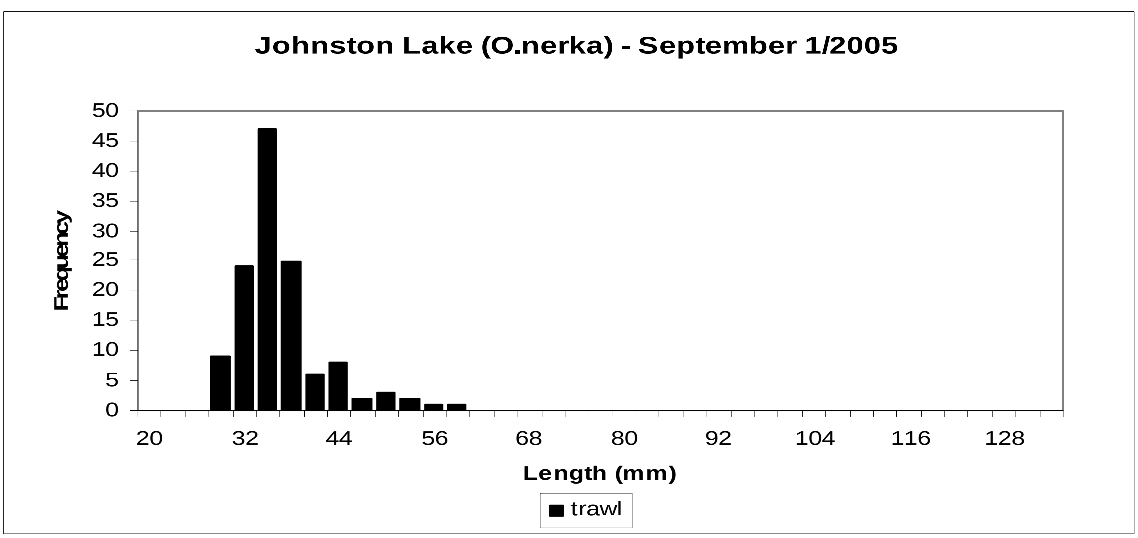
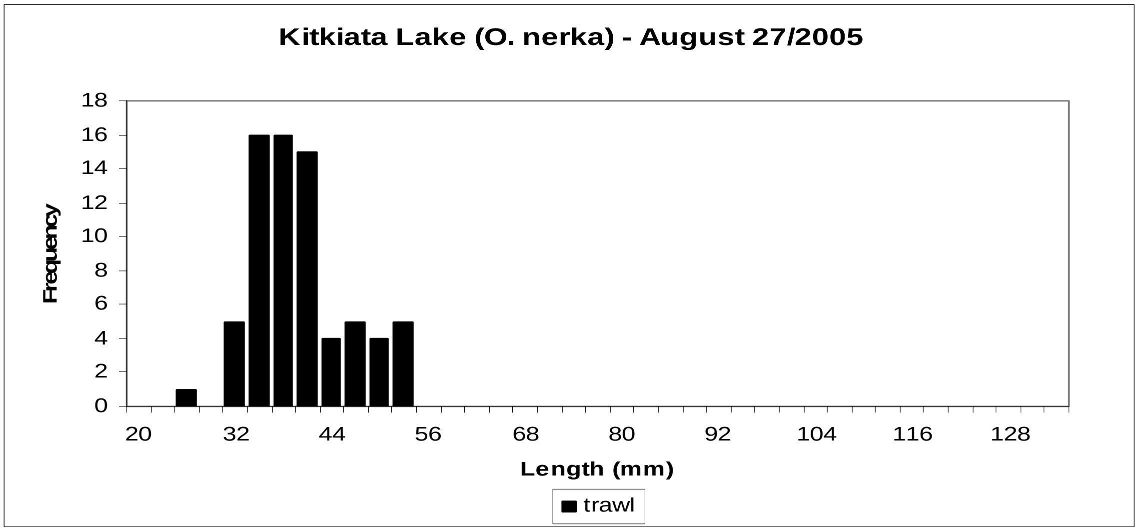
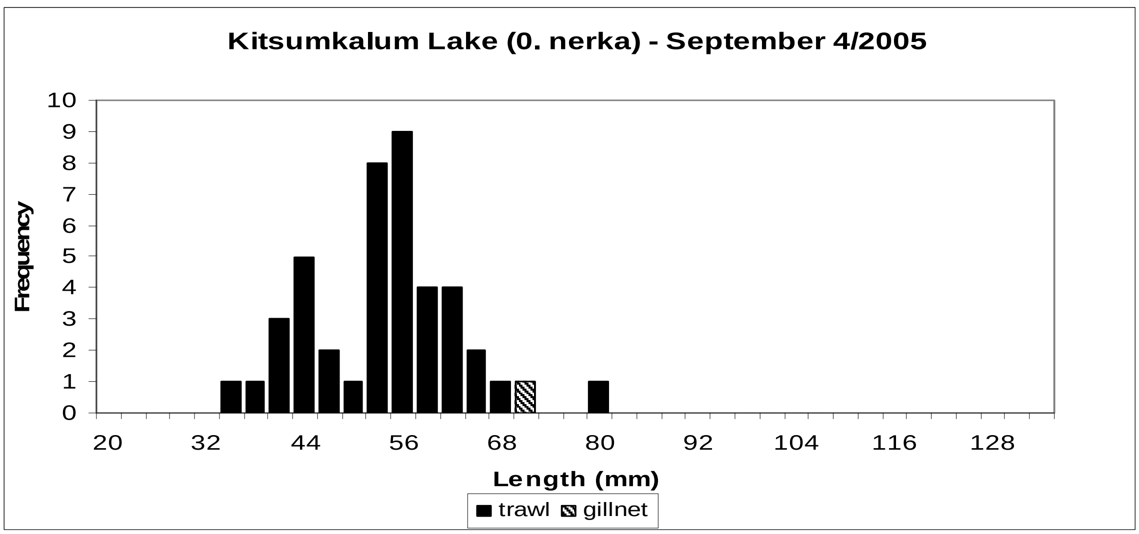


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).





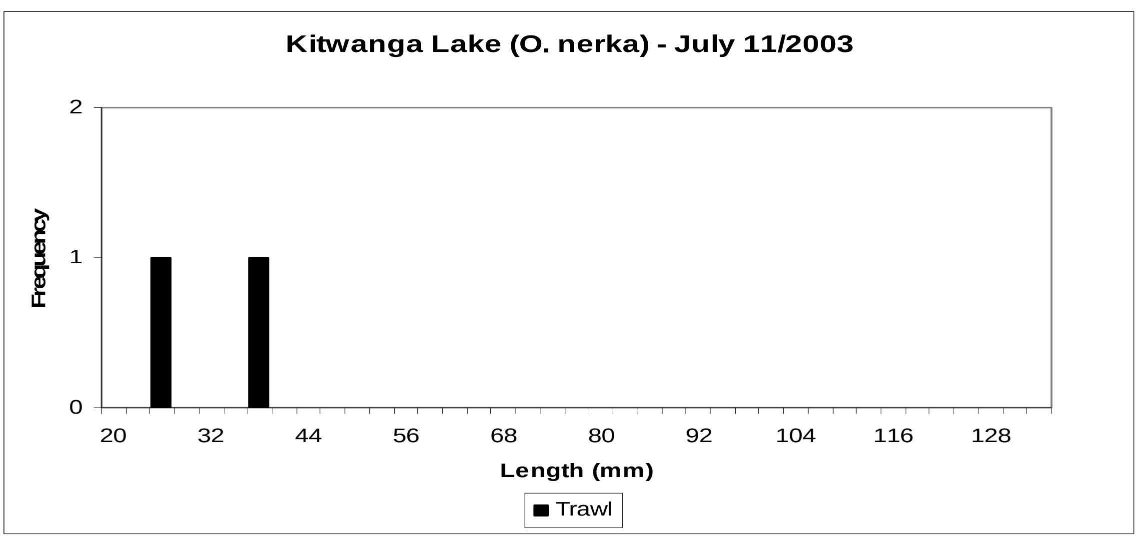
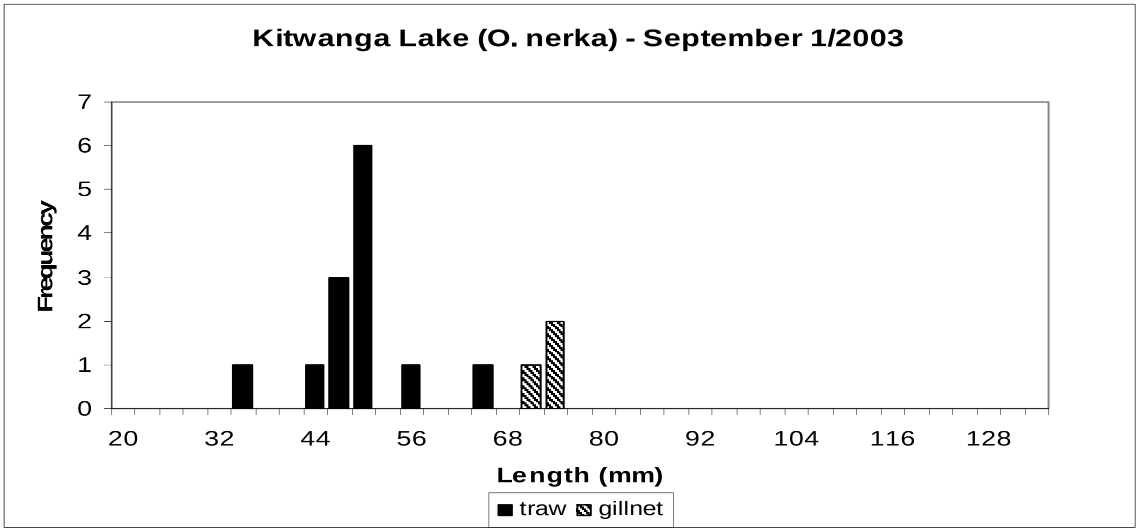
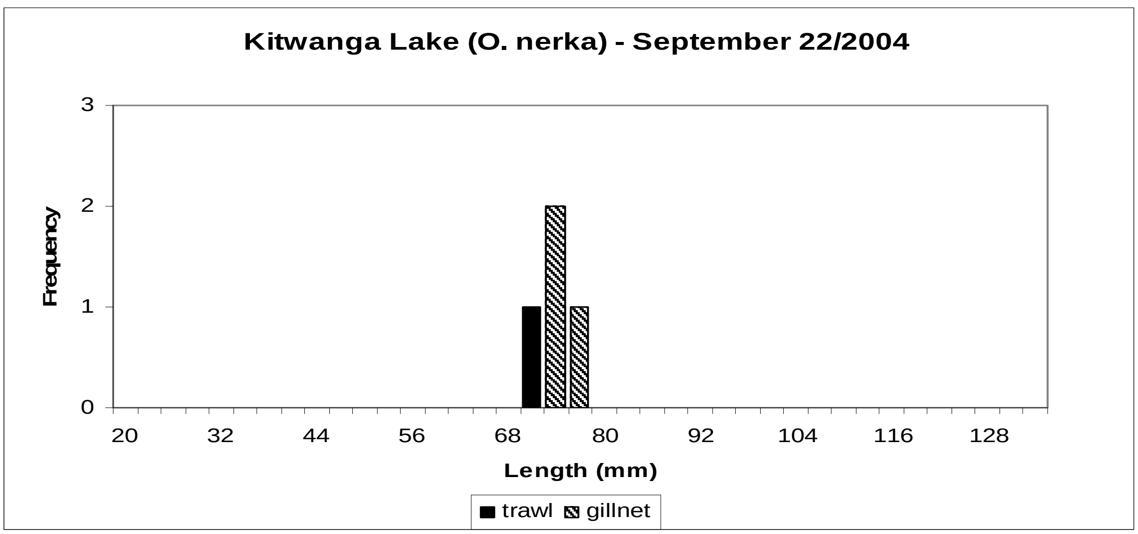


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).





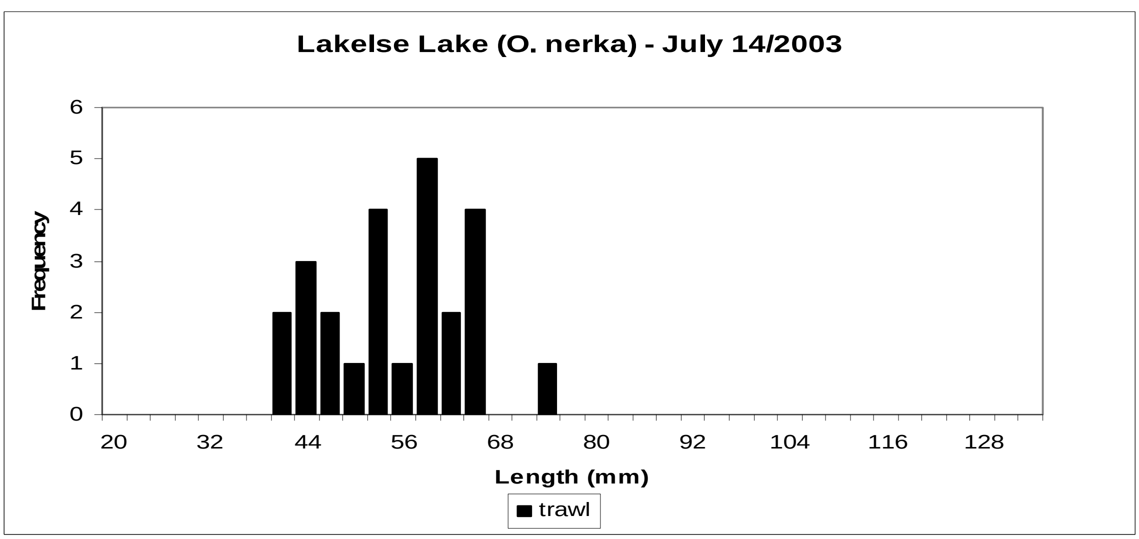
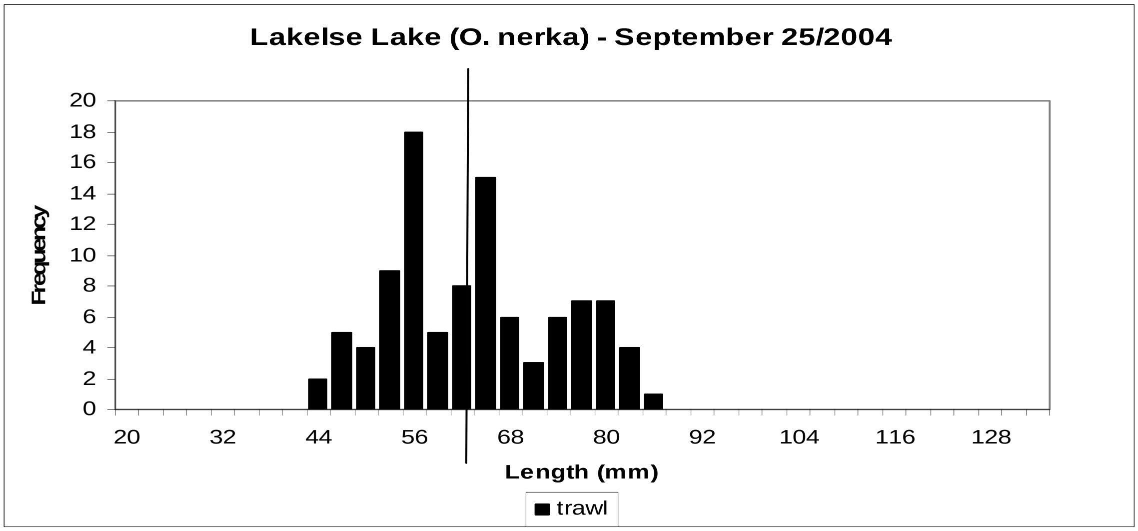
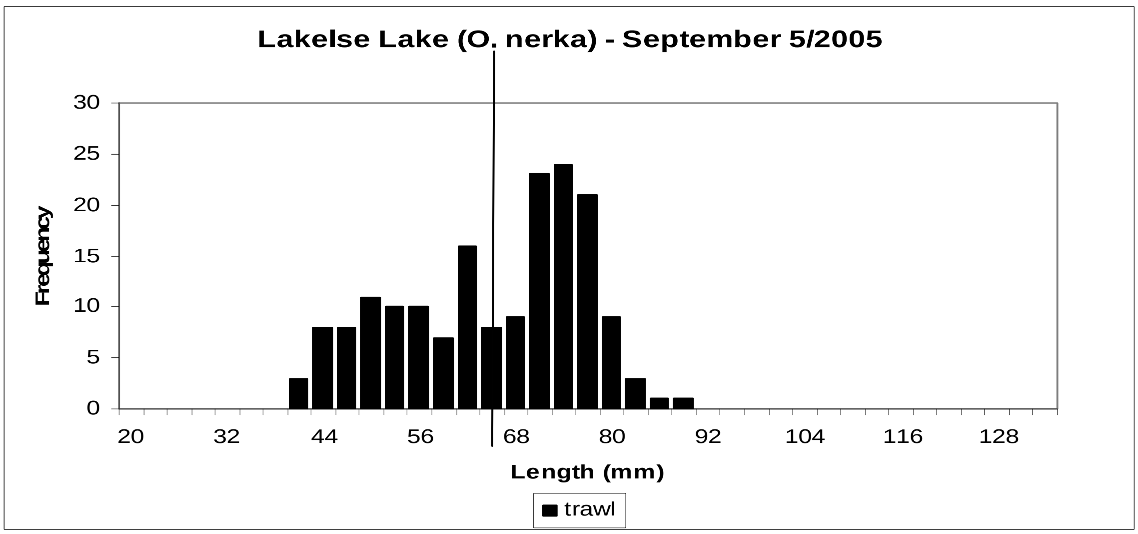


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).





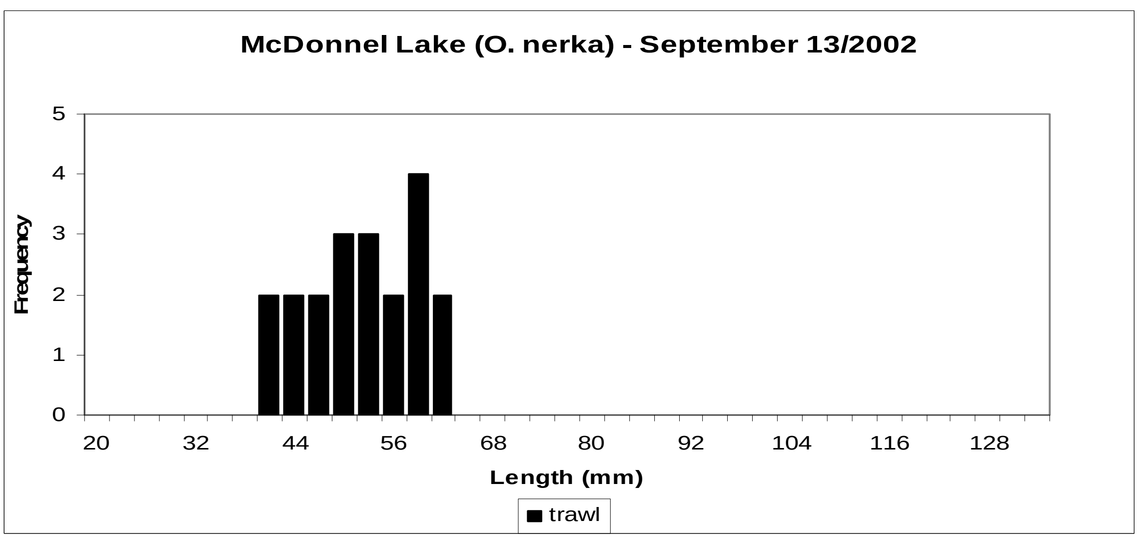


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).

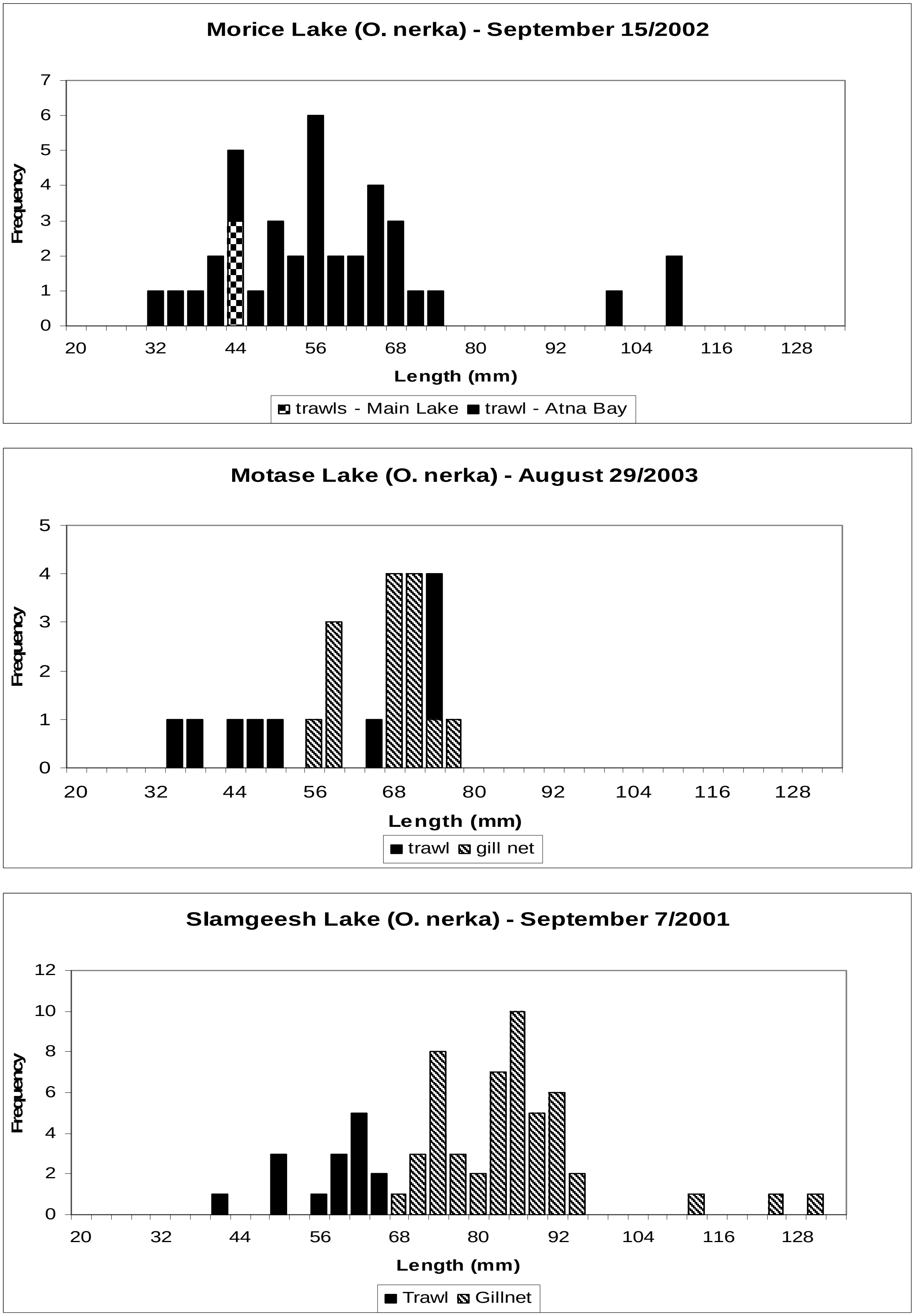
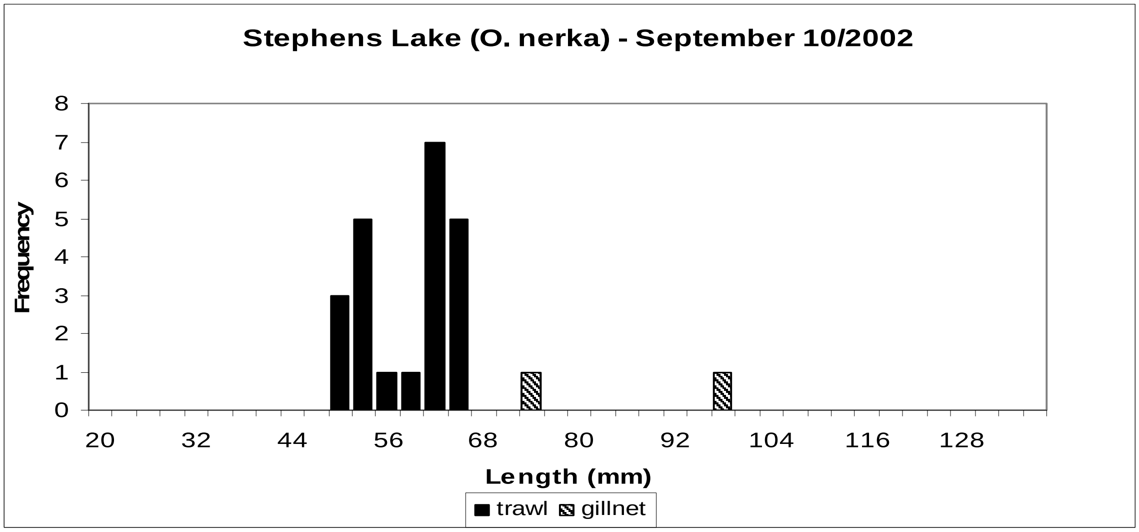
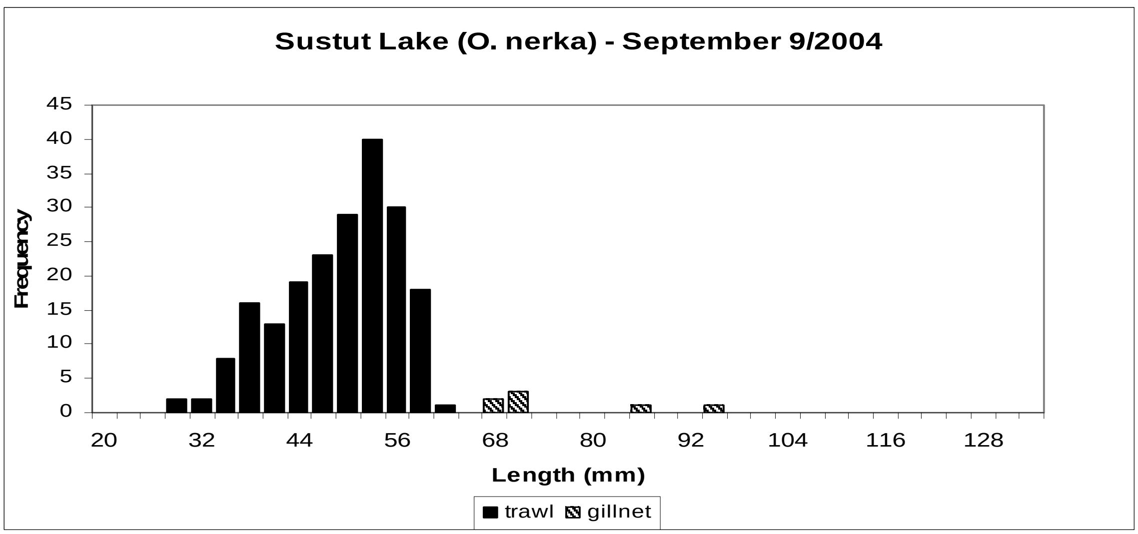


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).





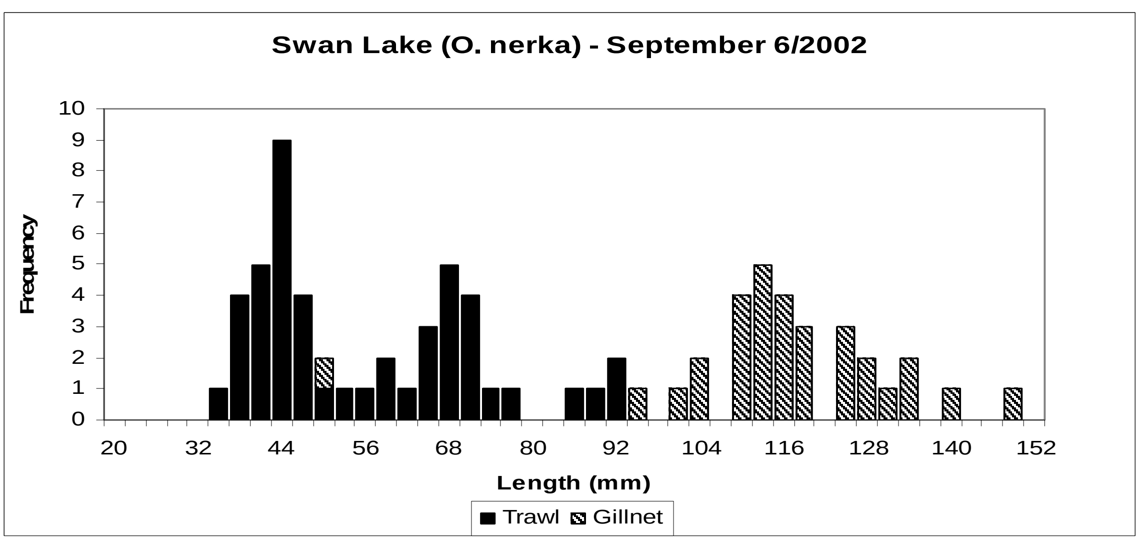


Figure 11. Length frequency histograms of *O. nerka* from each survey (continued).

APPENDICES

APPENDIX 1. INDIVIDUAL LAKE REPORTS

Aldrich Lake

We surveyed Aldrich on September 9, 2001 with the Little Echo and the 2 x 2 m trawl. Aldrich is a shallow 5.6 m deep lake and therefore was not well suited to an acoustic survey. We estimated a total fish abundance of 307 000 or 4 773/ha based on tracked target counting (Appendix 3). No sockeye were caught, so no portion of the fish population was assigned to that species. Nearly all targets detected by the sounder had low target strength, most in the -58 dB to -62 dB range, indicating a population of either very small fish (1 larval sculpin was caught in the trawl) or the presence of a large invertebrate such as *Chaoborus.* One *Chaoborus* was caught in a Wisconsin net by Shortreed et al. (2007) but the echograms did not indicate a significant *Chaoborus* population. No large fish were detected by the sounder, despite larger fish being caught in gill nets. In such shallow lakes, boat avoidance by larger fish is likely, and probably is responsible for the lack of larger targets on this survey. Gillnet catches included mountain whitefish, coho salmon, lake chub, prickly sculpin, largescale sucker and cutthroat trout.

Azuklotz Lake

We surveyed Azuklotz on August 27, 2003 with the Little Echo and the 2 x 2 m trawl. This lake has extensive shallows and weedy sections which could not be surveyed with the echo sounder. With a mean depth of 4.1 m and a maximum of 9.5 m, the remainder of the lake is only marginally deep enough for the sounder to be effective. It is likely that sockeye were only in the midwater column at dawn and dusk and spent the night on or near the bottom. Thus they would only be available to the sounder for short period of time. In addition, the few sockeye caught were in gillnets set near shore, indicating sockeye were utilizing the shallows for at least a portion of the time through the evening and early night.

Our trawl catch included only prickly sculpin while the gillnets caught age-0 *O. nerka* and redside shiner (Appendix 2). As we caught no sockeye in the trawl we used catch ratios from gillnets to apportion the estimate to sockeye and other fish. We estimated the juvenile sockeye population 63 000 (380/ha) using integration techniques but we have very little confidence in this estimate (Appendix 3).

Age-0 *O. nerka* in Azuklotz Lake were relatively large; 72 mm and 4.8 g on average from our gillnet catch (Fig.11, Appendix 2). The gillnet was set on the surface and in relatively shallow water before dusk and retrieved a couple of hours into the night, so it was apparent these sockeye were feeding in these areas of the lake. By far, the main diet item selected by juvenile sockeye was *Daphnia* (Fig. 9, Appendix 4). Redside shiners were also caught in good numbers by the gillnet and are possible competitors for food.

Banks East Lake

Banks East Lake was surveyed on September 16, 2004 with the Little Echo and the 2x2m trawl. The lake's bathymetry (22 m mean depth) was suited to a hydroacoustic survey, but the presence of numerous *Chaoborus* in the midst of the fish layer made hydroacoustic enumeration of the fish difficult. However, using the modified *TT* method, we produced an estimate of 36 000 *O. nerka* or 517 fish/ha (Appendix 3).

Our trawl catch included *O. nerka* and a large component of threespine stickleback. Since no bathymetric chart was available for this lake we developed one based on our transect soundings plus additional soundings specifically for this purpose (Fig. 3a).

Age-0 *O. nerka* in Banks East Lake were a good size for a coastal lake, with an average length of 59 mm (Table 4). *Bosmina* were clearly the most important diet item for these fish along with a small component of *Epischura* (Fig. 9, Appendix 4). The other main component of the pelagic fish population in this lake is the threespine stickleback which is roughly 3 times the *O. nerka* population (Appendix 3). Stomach samples from these fish contained very few food items, but did contain some *Bosmina.* Stickleback stomachs in the downstream Banks West Lake contained large numbers of *Bosmina* and some *Daphnia,* indicating stickleback were in direct competition for food with *O. nerka*.

<u>Banks West Lake</u>

We surveyed Banks West Lake on September 17, 2004 with the Little Echo and the 2 x 2 m trawl. This lake had similar characteristics and fish assemblages to Banks East Lake. *Chaoborus* was also present, but at much lower densities and posed less of a problem than in Banks East. While *Chaoborus* was less of a problem the modified TT method still produced the best acoustic fish estimate. The *O. nerka* estimate was 44 000 or 280/ha (Appendix 3). The catch included *O. nerka*, a large component of threespine stickleback, prickly sculpin and a few pink salmon and sockeye adults in gillnets (Appendix 2). Over 85% of the fish were found in section 2, the western most basin.

The *O. nerka* in Banks West Lake were similar in size although at a slightly higher density to those in Banks East Lake. Their diet was also similar except for the addition of a small *Daphnia* component. The threespine stickleback population, while smaller than seen in Banks East Lake, appears to be in direct competition for food with the *O. nerka* population (Fig. 9).

We generated a bathymetric map for this lake from soundings taken during the survey (Fig. 3b).

<u>Bear Lake</u>

Bear Lake was surveyed on August 26-27, 2003 with the Little Echo and the 2 x 2 m trawl. We stayed at the Bear River Lodge near the outlet. The three nights work to complete both Azuklotz and Bear Lake surveys was barely adequate and one more night would have been useful to thoroughly investigate this relatively large lake complex. The juvenile sockeye estimate was 258 000 or 135 age-0 *O. nerka*/ha (Appendix 3). Section 3, Tsaytut Bay, is a broad, mostly shallow bay and it showed few fish targets, making up only 5% of the total *O. nerka* population. The bulk of the population is distributed fairly evenly between the northern and southern sections of the main lake.

The near shore gillnet catch was largely redside shiners while trawls in the pelagic zone produced mainly pygmy whitefish with the odd *O. nerka* present (Appendix 2). The *O. nerka* catches in the various tows suggest there might be some night time vertical segregation of the two species. Shallower tows at 10-12 meters deep captured mainly *O. nerka*, whereas deeper tows captured predominately whitefish. We found several discrepancies with lake depths while surveying the lake, compared to those on the chart. Section 1 of the lake, in particular, appears to have a complicated bathymetry which makes trawling difficult at times. Future surveys on this lake would benefit from a more intense sounding of the lake for bathymetric purposes and a new chart drawn up. With new bathymetry, some transects may need to be moved to ensonify deeper waters.

Bear Lake trawls produced only 5 *O. nerka* of moderate size. Mean length was 54 mm and average formalin preserved weight was 2.1 g (Appendix 2). Diet items for these fish were an even mix of copepods, *Daphnia* and terrestrial insects, however, the insects provided the bulk of biomass to diet. Pygmy whitefish in the pelagic zone and possibly redside shiners near the littoral zone appear to be competing with *O. nerka* for insects (Fig. 9).

Charlotte Lake

On September 4 and 5, 1997, we carried out an acoustic and trawl survey of Charlotte Lake using the Night Echo and the 3 x 7 m trawl. Our acoustic survey found almost no pelagic fish, with only 19 individual targets detected over the course of 7 transects, a total of 19.8 km of transecting. This would indicate that the pelagic zone was virtually fishless at the time of the survey. As the 30 minute trawl caught no fish and the echograms where essentially barren of fish targets, we estimated that the density of midwater fish was close to zero.

Club Lake

We surveyed Club Lake on September 7, 2002 with the Little Echo. Access was somewhat difficult downstream from Swan Lake, due to a shallow sill and rapids. This very small lake lies between Swan and Stephens Lakes and consists of a series of 3 shallow basins, 6-8 m deep separated by extremely shallow and weedy shoals (Fig. 3c). Thus, much of the lake was not suited to a hydroacoustic survey and those areas that were marginally suitable (transects 1-3) had very few fish detections. None of the basins were sufficiently large enough to permit effective trawling, so only gillnets were used and only 2 juvenile *O. nerka* were caught. With so few fish caught and no trawl data it is difficult to apply any species ratio to the population estimate. The analysis indicates a total midwater fish population of 2 175sockeye sized fish (55/ha, Appendix 3) with sockeye/kokanee comprising an unknown proportion of that total. Given the small numbers of *O. nerka* present, the poor acoustic environment and the difficulty of access, future acoustic surveys would not be useful.

We completed some additional soundings and along with our survey transects, we were able to generate a bathymetric chart for this lake (Fig. 3c).

The two *O. nerka* captured in the gillnets were fairly large at 80 and 84 mm weighing an average of 6.3 g (Appendix 2).

Ecstall Lake

Ecstall was surveyed August 25, 2005 with the Little Echo and the 2 x 2 m trawl. This small lake consists of three basins separated by shallows, each basin deep enough to allow for an effective hydroacoustic survey. Two of the basins are large enough to permit effective trawling. Like many of the coastal lakes, the pelagic fish population is dominated by threespine stickleback with only a few sockeye. Trawls suggest no sockeye in the surface layers (0-6 m), but a small *O. nerka* component in deeper layers. Other species caught were a cutthroat trout and an adult pink salmon in gillnets.

Using integration we estimated 5 800 age-0 *O. nerka* (71/ha, Appendix 3). Only four *O. nerka* were picked up by the trawl and average size was relatively small at 43 mm and 1.03 g, preserved in formalin. The threespine stickleback population of 130 000 fish (1 600 fish/ha) dominated this small lake, and although stomachs from either of these species were not particularly full, they appear to be feeding on the same organisms (Appendix 4).

Evelyn Lake

Evelyn Lake was surveyed September 9, 2001 with the Little Echo and the 2 x 2 m trawl. There was a very dense *Chaoborus* population in the lake making the estimation of the fish population difficult (Shortreed et al. 2007). The survey date was prior to our development of the *Chaoborus* TT methodology so we did not apply the appropriate collection protocols. However, we reanalyzed the data for this report using the modified TT post processing protocols. This analysis appears to have reliably separated the fish targets from the *Chaoborus.* Particularly in the deeper depths below 6 m where fish tend to remain in the acoustic beam longer. We estimated a total small fish population of 102 000 fish (1742/ha) and 50 000 age-0 *O. nerka* (847fish/ha, Appendix 3). As the trawl catch indicated the juvenile sockeye portion of the population was mainly below 6 meters, we are reasonably confident in the sockeye portion of the estimate. Most of the uncertainty in this estimate concerns the identification of fish tracks in the upper layers (2-6 m), where single ping detections of fish are most frequent and the decision to include a single target detection as fish or reject it as *Chaoborus* becomes more subjective. The trawl results indicate that these layers consist mainly of threespine stickleback, so most of the uncertainty lies in the “other small fish” category.

Trawls suggest that the top layers (0-6 m) were predominately threespine stickleback while sockeye dominated the deeper layers with a few threespine stickleback. Many of the threespine stickleback were quite large (>90 mm) and may be an anadromous form. Other species caught in gillnets were coho salmon, bull trout, prickly sculpin, and cutthroat trout.

The *O. nerka* population of Evelyn lake is made up of at least two size classes, age-0 *O. nerka* that range from 29 to 70 mm in length and age-1 *O. nerka* ranging from 67 to 101 mm (Appendix 2). As well, a single age-2+ *O. nerka* with a fork length of 179 mm was captured in a gillnet, indicating the possibility of a kokanee component. The primary diet item for juvenile *O. nerka* in Evelyn was *Daphnia* , as it was for threespine stickleback (Fig. 9). However, both species also fed on larger food items including terrestrial insects and other macro invertebrates, which included Chironomids and *Chaoborus* (Appendix 4). These items contributed significantly to diet biomass (Fig. 10).

We generated a bathymetric map for this lake from our soundings of the lake (Fig. 3d).

Hartley Bay (lower) Lake

There are two lakes in the Gabion River (Hartley Bay River) drainage. The upper lake was reported as inaccessible to anadromous fish and was not surveyed (Chris Piccard, Gitga'at First Nation, Hartley Bay, personal communications,). The lower lake, Hartley Bay Lower Lake was surveyed on August 30, 2005 with the Little Echo using the 2 x 2 m trawl. We were unable to find a suitable base camp on the lake, and instead used the dock and accommodation in the Hartley Bay town site. Gear was transported to the lake by trailer and ATV via a boardwalk.

The lake is relatively shallow, with most of its area having depths of ≤ 5 m except for one small area along the northern shore where it drops to 9.5 m (Fig. 3e). Much of the lake was covered with dense aquatic macrophytes. We also found a very dense population of *Chaoborus* larvae. We found that the *Chaoborus* densities were too high to produce a reliable fish estimate even using the modified TT method. As well the shallow depths and the abundant aquatic vegetation would make a reliable estimate unlikely, consequently none was attempted.

In any case, no sockeye were caught in the trawls or gillnets. The catch consisted mainly of threespine stickleback with a few prickly sculpin (Appendix 2). Stickleback ranged in length from 15 to 65 mm and their diet was made up of small numbers of various organisms including Acari, *Chaoborus* , Chironomids, and terrestrial insects. Zooplankton where present in only small amounts (Appendix 4). Terrestrial insects and *Chaoborus* were the main contributors to diet biomass (Fig. 10).

From survey transects and some additional soundings we generated a bathymetric map for this lake (Fig. 3e).

Johanson Lake

Johanson was surveyed September 12, 2004 with the Little Echo and the 2 x 2 m trawl. The mean depth (16m) of Johanson Lake was sufficient to enable a good hydroacoustic survey (Table 1). *O. nerka* were by far the dominant fish in the trawl and gillnet catches, with only a few bull trout also being caught (Table 2). Most *O. nerka* were found in the northern half of the lake, that portion of the lake accounting for roughly 80% of the estimated *O. nerka* population. The *O. nerka* estimate using integration was 170 000 or 1 200 fish/ha (Appendix 3). Accommodation was found in a comfortable cabin at the west end of the lake maintained by the Fort St James snowmobile club.

Johanson *O. nerka* were relatively small for interior lakes, at an average of 49 mm length and 1.28 g weight. However, as Johanson Lake is the most northerly and highest (1 444 m, Table 1) lake in our study the small size is likely, at least partly, due to the short growing season at this location. These fish are mainly feeding on *Bosmina* with a small cyclopoid component (Fig. 9).

Johnston Lake

We surveyed Johnston Lake September 1, 2005 with the Little Echo and the 2 x 2 m trawl. Johnston Lake is a deep single basin lake which was full of small fish, most of which were *O. nerka* (96%). Fish distribution was unusual, with the fish layer extending from the surface to 60 m on most transects. Most of the age-0 sockeye were smaller than in all other lakes in this study, ranging from 29-44 mm with an average length of 35 mm (Appendix 2), with a very few ranging up to 60 mm in length (Fig. 11). The trawl catch was predominately *O. nerka* with only a few threespine stickleback present. Gillnets caught a few threespine stickleback and one adult/jack sockeye (380 mm). Using integration, we estimated 1 137 000 age-0 sockeye or 6 084 fish/ha, the highest density in the study (Appendix 3).

Mean stomach fullness of *O. nerka* in this lake was very low at 7%. Food items that were found in the stomachs were mainly cyclopoids and *Bosmina* (Appendix 4). This is the one lake in this study that exceeds the estimated rearing capacity as determined by the PR model (Shortreed, 2007). The extreme density, small size and near empty stomachs of the age-0 *O. nerka* clearly indicate that this population of juvenile *O. nerka* is overcrowded, perhaps due to over escapement.

Kitkiata Lake

Kitkiata was surveyed August 27, 2005 with the Little Echo and the 2 x 2 m trawl. This lake is a long narrow, fjord style lake with dense populations of *O. nerka* (60%) and threespine stickleback (40%). No other species were caught in either the trawl or gillnets. Sockeye densities were evenly distributed throughout the lake. We estimated 635 000 age-0 *O. nerka* or 2 356 fish/ha and 471 702 threespine stickleback or 1 749 fish/ha (Appendix 3).

The size of juvenile sockeye, as in Johnston Lake, was generally on the small side (32-44 mm) with smaller numbers of sockeye ranging up to 54 mm (Fig. 11). Also, as in Johnston Lake, *O. nerka* stomach fullness was low at 8% and zooplankton food items were for the most part, *Bosmina* and Cyclopoids. However, Kitkiata *O. nerka* appear to be utilizing terrestrial insects to a greater extent and they make up the bulk of the biomass found in stomachs (Fig. 10). Threespine stickleback were feeding on the same organisms, apparently in direct competition with age-0 sockeye (Fig. 9, 10).

We generated a bathymetric chart of Kitkiata Lake from the acoustic soundings, (Fig. 3f).

Kitsumkalum Lake

We surveyed Kitsumkalum Lake on August 27, 2005 with the Little Echo and the 2 x 2 m trawl. Weather conditions were ideal, with flat calm waters and the Little Echo navigated this relatively large lake with no difficulties. Over most of the lake, *O. nerka* densities were very low and fish were scattered between 10 to 35 m. Transect 1, at the northern end of the lake, showed moderate densities of fish in a layer from 10 to 30 m. The midwater trawl only caught age-0 *O. nerka* and as expected from the acoustics, all were caught in the northern end of the lake.

Using tracked targets, we estimated 516 000 age-0 *O. nerka* or 279 fish/ha (Appendix 3). Data analysis was impeded by no trawl catch in the southern end of the lake. In spite of low densities, approximately 30% of the estimated fish population or 155 000 fish were from this section. With no catch from the 30 minute trawl in the southern end, we assumed the species distribution was the same as in the northern end of the lake (100% age-0 *O. nerka*).

Kitsumkalum *O. nerka* ranged from 35 to 79 mm, with an average length of 53 mm (Fig. 11, Appendix 2). Their diet was mainly *Diaptomus sp*. and terrestrial insects and the insects must have dominated in terms of biomass (Fig. 10). No other species were detected in the pelagic zone of the lake.

Kitwanga Lake

Kitwanga Lake was surveyed on three occasions, on July 12 and September 1, 2003 with the Little Echo and the 2 x 2 m trawl and on September 22, 2004 with the Night Echo and the 3 x 7 m trawl.

Kitwanga Lake supports a dense population of *Chaoborus* which makes the estimation of the fish population very difficult and we only attempted further analysis on the September 2003 survey, using the modified TT method. We judged that *Chaoborus* densities and survey conditions and methodology were not suitable on the July 2003 and September 2004 surveys to complete the analysis. We estimated 193 000 age-0 *O. nerka* or 247 fish/ha in September 2003 (Appendix 3). However, our confidence in this estimate is also low for several reasons. Firstly, wind and transecting speeds were higher than ideal. Secondly, interpreting fish tracks was still difficult due to the high densities of *Chaoborus* present. Lastly, age-0 *O. nerka,* if present were likely closely associated with the bottom, and therefore not readily detectable by the sounder. This bottom association was due to the relatively shallow lake depth (mean = 7 m) and the warm epilimnion waters extending down to, or near the bottom, possibly excluding the *O. nerka* from surface and mid waters. Escapements of adult sockeye ranged from 230 to 3 400 over the course of our surveys (Mark Cleveland, Gitanyow Fisheries Authority, personal communications). However, with only 2 to 10 age-0 *O. nerka* captured per trawl, catches were considerably smaller than expected and were not any better using the large trawl than with the small trawl. September age-0 size however was larger in the big trawl than in the small trawl (4.8 g vs. 1.5g mean size). It is unclear whether this is due to gear bias as discussed in the results section or to year to year variation, possibly due to density effects on growth.

Only one survey date was sampled for diet, September 2003. At this time, Kitwanga juvenile sockeye fed mainly on *Daphnia* along with some *Leptodiaptomus* and *Chaoborus,* however *Chaoborus* contributed about 50% of the biomass in the diet. (Appendix 4).

Lakelse Lake

Four surveys were completed on Lakelse Lake. The Night Echo with the 3 x 7 m trawl was used on September 30, 2003 and September 25, 2004. On July 13, 2003 and September 5, 2005 we used the Little Echo and 2 x 2 m trawl.

Lakelse Lake has two distinct basins, a shallow southern half that was rarely deeper than 8 m and a deeper northern basin which reached a depth of approximately 30 m. *O. nerka* did not use the shallow southern basin, at least during the summer and early fall months during our study. There were several factors that complicated estimating *O. nerka* abundance on this lake. A large portion of the lake bottom at the north end was covered with debris and trees from a land slide with some trees extending from the bottom to the surface. These trees were responsible for the loss of one trawl net (September 2003) and required extensive editing and bottom adjustments on the echograms to separate fish echoes from woody debris. *Neomysis mercedis* also inhabited the pelagic zone of the lake but was eliminated from acoustic processing by using an appropriate threshold value and some editing of the echogram. Although making processing more difficult, none of these complicating factors precluded the possibility of arriving at a *O. nerka* population estimate.

Catches of age-0 *O. nerka* in the fall of 2004 and 2005 had a bimodal length distribution (Fig. 11). Since scale ages indicate all of these fish were young of the year, this may suggest a mix of sockeye and smaller kokanee were present. MacLellan and Hume (2002) were able to use Sr/Ca ratios in the otolith to identify life history origin and found that age-0 kokanee tended to be smaller than sockeye in Stuart Lake, but that there was considerable overlap. If we assume that the length frequencies of the two groups are roughly divided at the 62 to 65 mm range then about 60% of the 2004 fall fry population and 40% of the 2005 fall fry population were kokanee. In sampling so far, no older age classes of *O. nerka* have been captured in either trawls or gillnets.

O. nerka diet in Lakelse Lake varied over the three years we surveyed the lake (Fig. 9). Stomach samples from the July survey in 2003 showed *O. nerka* were feeding almost exclusively on *Daphnia* as did the fall survey in 2005. However in 2005, mysids were found in the diet, contributing heavily to diet biomass (Appendix 4, Fig. 10). In 2004, *Daphnia* was a relatively minor component in *O. nerka* diet. Instead, *O. nerka* were feeding heavily on calanoid copepods, specifically *Epischura,* along with minor amounts of Cyclopoids, the cladoceran *Diaphanosoma,* and chironomids (Fig. 9, 10, Appendix 4).

Given the lack of use of the shallow southern portion of the lake by juvenile *O. nerka*, for future surveys, it would be beneficial to add more transects in the deeper portion of the lake and perhaps decrease the coverage in the shallow portion.

McDonell Lake

McDonell Lake was surveyed on September 10, 2001 and September 13, 2002 with the Little Echo and the 2 x 2 m trawl system. This lake is just deep enough at 13-14 m for an effective downward looking hydroacoustic survey. In 2001, we estimated 75 500 small fish (352 fish/ha) in the pelagic zone. We had no trawl catch that year but caught only age-0 sockeye in 2002 (n=20). The Skeena Fisheries Commission has subsequently conducted 3 fall surveys and found 98 -100% of the pelagic fish were *O. nerka* (Peter Hall, DFO, Prince Rupert, personal communications). It is therefore likely that 2001 fish were *O. nerka* as well. In 2002, we estimated 127 500 sockeye using integration (Appendix 3). Swedish gillnets were also fished in 2002. Floating nets were used in the littoral zone and captured juvenile coho, cutthroat trout, rainbow trout and a single age-1 *O. nerka*. A sinking net was deployed mid lake on the bottom and caught a bull trout and a lake chub (Appendix 2).

Trawl caught *O. nerka* ranged from 40 to 62 mm in length with a mean of 52 mm. Average weight of formalin preserved fish was 1.5 g (Appendix 2). Their diet consisted mainly of *Daphnia* with a small component of copepods, in particular Leptodiaptomus (Fig. 9, Appendix 4).

Transect 1 on this lake was found to be shallow and weedy and therefore not used in the survey design for population estimates.

Morice Lake

We surveyed Morice Lake on September 15, 2002 with Night Echo and the 3 x 7 m trawl. This lake is large, deep, and has several arms and basins. Fish densities in the main lake (South, Main and Atna Arms) were low and often influenced by fish congregations showing shore and bottom orientation, bringing their species identity into question. Mid water, the juvenile sockeye population was only 132 fish/ha (1 270 000 fish). The trawl catch was also low with only 3 age-0 *O. nerka* captured. With so few *O. nerka* captured in the trawl, its difficult to have a lot of confidence in portioning 100% of the fish population estimate to *O. nerka* for the main body of the lake. However, in Atna Bay, a relatively small bay off the end of Atna Arm, we found a layer of midwater fish more typical of juvenile sockeye, and did catch a good number *O. nerka* (35), along with 2 pygmy whitefish, in our trawl (Appendix 2). As in previous years, age-0 *O. nerka* caught in the main lake were <1.0 g (Shortreed et al. 1998). Age-0 sockeye caught in Atna Bay were somewhat larger with a mean size of 1.8 g.

Diet in the main lake consisted almost entirely of Holopedium (Fig. 9). In Atna Bay, however, diet was much more diversified and included a mix of Holopedium, *Bosmina*, cyclopoids and terrestrial insects (Fig. 9.) The insects contributed to a significant proportion of the diet biomass (Fig. 10).

Motase Lake

Using the 2 x 2 m trawl and the Little Echo, we surveyed Motase on August 29, 2003. Motase Lake is a relatively deep, cold, and glacially turbid lake with a Secchi depth of only 0.2 m (Shortreed et al. 2007). Very few fish were detected by the sounder either at night or during the day. Trawl catches indicated that most fish were in the upper water column (<13 m), while the floating gillnets caught most fish in the upper 1 m of the nets. This indicates that most fish were near the surface and not available for ensonification by the echosounder. As this surface orientation effectively makes the majority of fish unavailable to our sounder system, we have very low confidence in the acoustic estimate of 52 age-0 *O. nerka*/ha (20 600 age-0 *O. nerka*; Appendix 3). Future acoustic estimates of fish in Motase Lake may benefit from the use of side scanning sonar to better detect and enumerate surface oriented sockeye (Yule 2000).

Two age classes of Motase *O. nerka* were caught with a combination of trawling and gillnets. Trawl caught Age-0 *O. nerka* averaged 1.1 g and ranged from 35 to 51 mm and Age-1 *O. nerka* averaged 3.3 g and ranged from 65 to 75 mm (Appendix 2). The Motase Lake juvenile *O. nerka* had an unusually milky white back with no parr marks or spots, possibly an adaptive colouration response to the glacially turbid water. The bull trout caught in gillnets were similarly coloured. Diet for age-0 *O. nerka* was composed of Cyclopoids, supplemented with a few terrestrial insects, however the bulk of diet biomass was contributed by insects. Age-1 *O. nerka* fed almost exclusively on insects (Appendix 4, Fig. 9, 10).

Slamgeesh Lake

We surveyed Slamgeesh Lake on September 7, 2001 with the Little Echo and the 2 x 2 m trawl. Slamgeesh is a shallow, productive lake with a mix of fish species and sizes in the midwater zone. Although it is shallow, fish targets appeared to be mostly in the water column and therefore were accessible to the hydroacoustic system. The major complicating factor on this survey was the presence of a large population of small larval sculpin in the midwater zone which could be seen on the sounder, but not reliably caught in the trawl due to their small size. We assumed these larval sculpins would have very low TS and we therefore eliminated the smaller ones from the analysis by increasing the processing threshold to -61 dB. and used tracked target analysis to estimate the population. When apportioning the hydroacoustic estimate with the trawl catch, we made the assumption that a sculpin large enough to be retained by the trawl net would exceed the analysis threshold and would be included in the estimate. The resulting age-0 *O. nerka* estimate was 541/ha or 20 000 fish (Appendix 3). If the TS of these larval sculpins is lower than expected and they did not form part of the acoustic estimate, then the true age-0 *O. nerka* density will be underestimated. Trawl caught age-0 *O. nerka* averaged 3.6 g and ranged in size from 41 to 85 mm. The subsequent smolt run in 2002 was 17 842 with an average size of 91 mm, indicating good survival and growth (Hall and Gottesfeld 2003). Age-0 *O. nerka* diet in Slamgeesh was predominately *Daphnia*, but these fish also fed significantly on *Leptodiaptomus*.

Stephens Lake

Stephens Lake was surveyed on September 10, 2002 with Little Echo and the 2 x 2 m trawl. The main part of Stephens Lake is moderately deep (maximum depth = 27 m) and was well suited to hydroacoustic surveying. The north west arm was considerably shallower and contained few pelagic fish. We estimated 897 age-0 *O. nerka*/ha (176 000 fish) using echo integration. Very few other pelagic species were found (Appendix 3).

Trawl caught age-0 *O. nerka* averaged 2.1 g and ranged from 51 to 66 mm.. Gillnets caught 2 additional *O. nerka*, an age-0 measuring 74 mm and an age-1 at 98 mm (Appendix 2). *O. nerka* diet consisted mainly of the Calanoid copepods *Heterocope* and *Leptodiaptomus* (Fig. 9, Appendix 4). Terrestrial insects, although relatively low in numbers, contributed significantly to diet biomass (Fig. 10).

We generated a bathymetric map from survey transects and some additional soundings for this lake (Fig. 3g). Transect design should be reconsidered to increase the number of transects in the main body of the lake.

Sustut Lake

We surveyed Sustut on September 10, 2004 with the Little Echo and the 2 x 2 m trawl. With an average depth of 20 m, Sustut Lake is well suited to hydroacoustic assessment. Age-0 *O. nerka* densities were high at 3 007 fish/ha (663 000 fish), estimated using integration (Appendix 3). This was somewhat higher than the density of age-0 *O. nerka* found in 1993 (Shortreed et al. 1998). No other pelagic fish were caught in 2004 while a single whitefish and a few larval cyprinids were caught in 1993 (Appendix 2). Poor accommodation was found in an old cabin at the SE end of the lake.

We caught a total of 204 *O. nerka* in our trawl which averaged 1.3 g and ranged from 28 to 76 mm. Gillnets also caught age-0 fish, age-1 and age-2+ *O. nerka* suggesting a kokanee population also occupies the lake. As with Johanson Lake, these fall fry are fairly small for an interior lake, but like Johanson Lake, Sustut Lake is at the northern edge of our study region and at a fairly high altitude of 1 301 m (Table 1), resulting in a shorter growing season than most of our study lakes.

O. nerka in Sustut Lake fed mainly on *Bosmina*, but supplemented their diet with Amphipods, which contributed greatly to diet biomass (Fig. 9 & 11, Appendix 4).

Swan Lake

The Little Echo and the 2 x 2 m trawl were used to survey Swan Lake on September 6, 2002. Swan is a deep multibasin lake with a complex bathymetry, having many shoal areas and islands. Juvenile *O. nerka* residing in the lake display typical deep lake behavior, schooling deep, 40-60 m during the day, and spreading out near or just below the thermocline (5-15 m) at night and are readily enumerated using hydroacoustic methods. Length frequency analysis of the trawl and gill net catch along with scale aging indicates a considerable population of kokanee in Swan Lake ranging from age-0 to age-3 (Fig. 11). Analysis of the Sr content of a small sample of otoliths from the age-0 fish indicated 9 of 11 juveniles were kokanee, while 2 were uncertain (data on file). Although most spawning in this system occurs downstream of Swan Lake in the stream sections above and below Club Lake, some adult sockeye spawn in smaller streams flowing into the lake, so some portion of the population must be anadromous (Peter Hall, DFO, Prince Rupert, personal communications).

Overall the juvenile *O. nerka* in the lake were very small and many of the older age classes were smaller than our normal acoustic TS cut off for age-0 fish in most other sockeye lakes (TS =- 45 dB, aprox. length = 135 mm). Age-0 fish ranged in length from 36-65 mm, age-1 from 59-95 mm and age-2+, which includes both 2 and 3 year olds, from 87-148 mm (Appendix 2, Fig. 11). As a result, the population estimate included the first three age classes and much, if not all, of an age 3 year class. In total then there were around 329 *O. nerka/ha* (576 000 fish) of all ages. In addition to *O. nerka*, our gillnets caught whitefish, rainbow trout, coho salmon, prickly sculpin, white suckers and a longnose sucker.

O. nerka diet in Swan Lake was varied, consisting of a mix of *Daphnia* , *Bosmina*, and Calanoid/Cyclopoid copepods (Fig. 9, 10). *Heterocope* was among the Calanoid component and being a large zooplankter, contributed significantly to diet biomass (Appendix 4).

We developed a bathymetric chart for this lake based on our soundings (Fig. 3h). However, weather prevented us from completing additional soundings specifically for the purpose of developing the chart. Given the complex nature of Swan Lake's bathymetry, future surveys should plan for additional bathymetric soundings between transects and in shoal areas to update the current bathymetric chart.

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa.

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
Aldrich	Trawl (2mx2m)	Formalin	Sculpin	1	0.0			0.0	0.0	15			15	15
09/09/2001	Swed gillnet (f)	Formalin	Coho salmon	1	17.6			17.6	17.6	113			113	113
		Live	Cutthroat trout	3						244	37.0	15.0	227	253
			Lake chub	1						160			160	160
	Swed gillnet (s)	Formalin	Coho salmon	2	11.0	35.0	3.9	8.2	13.7	93	108.0	12.0	84	101
			Lake chub	7	21.6	15.7	16.9	7.4	54.8	118	28.0	30.0	87	170
			Largescale sucker	1	18.3			18.3	18.3	100			100	100
			Mountain whitefish	1	115.3			115.3	115.3	208			208	208
			Prickly sculpin	4	8.2	6.3	4.0	5.0	13.8	90	19.0	12.0	78	106
		Live	Cutthroat trout	4						222	35.0	22.0	190	238
			Lake chub	17						164	17.0	33.0	113	208
			Largescale sucker	1						138			138	138
			Mountain whitefish	5						227	19.0	15.0	210	247
Azuklotz	Trawl (2mx2m)	Ethanol	Prickly sculpin	3	0.1	0.1	0.1	0.0	0.1	20	10.0	4.0	17	25
27/08/2003	Swed gillnet (f)	Formalin	Age 0 nerka	13	4.8	1.0	1.7	2.1	8.9	72	5.0	9.0	57	90
			Redside shiner	6	7.5	3.8	3.6	2.7	10.4	79	16.0	15.0	58	91
		Live	Redside shiner	12						95	5.0	7.0	85	110
Banks East	Trawl (2mx2m)	Ethanol	Stickleback	10	3.6	1.5	2.1	0.5	6.1	68	13.0	18.0	39	87
17/09/2004			Age 0 nerka	7	3.6	1.3	1.4	1.2	5.2	69	10.0	10.0	49	79
			Age 1 nerka	1	10.3			10.3	10.3	100			100	100
		Formalin	Stickleback	27	3.3	0.6	1.6	0.3	6.6	67	5.0	12.0	31	87
			Age 0 nerka	5	2.9	2.8	2.2	1.0	5.8	59	18.0	14.0	45	77
	Swed gillnet (f)	Formalin	Age 0 nerka	10a	4.8	0.3	0.4	4.2	5.4	75	2.0	2.0	72	78
Banks West	Trawl (2mx2m)	Ethanol	Age 0 nerka	16	3.0	0.8	1.5	1.3	6.0	65	5.0	10.0	53	85
17/09/2004		Formalin	Stickleback	18	3.4	1.2	2.4	0.5	8.9	65	7.0	15.0	40	93
			Age 0 nerka	14	2.4	0.5	0.8	1.4	4.2	57	4.0	6.0	49	68
			Age 1 nerka	1	12.4			12.4	12.4	99			99	99

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
			Prickly sculpin	1	1.1			1.1	1.1	48			48	48
	Swed gillnet (f)	Ethanol	Age 1 nerka	1	11.4			11.4	11.4	99			99	99
		Live	Adult/jack sockeye	3						800	0.0	0.0	800	800
			Pink salmon	1						600			600	600
Bear	Trawl (2mx2m)	Formalin	Age 0 nerka	5	2.1	1.4	1.1	0.7	3.2	54	12.0	10.0	41	64
26/08/2003			Lake trout	1	6.2			6.2	6.2	81			81	81
			Pygmy whitefish	22	2.3	1.2	2.8	0.1	10.5	52	10.0	23.0	26	101
		Live	Whitefish	1						360			360	360
	Swed gillnet (f)	Formalin	Redside shiner	12	8.9	1.6	2.5	5.7	13.0	85	5.0	7.0	72	95
		Live	Redside shiner	39						88	2.0	7.0	69	100
Club	Swed gillnet (f)	Formalin	Age 0 nerka	2	6.3	9.1	1.0	5.6	7.0	82	25.4	2.8	80	84
07/09/2002														
Ecstall	Trawl (2mx2m)	Formalin	Stickleback	49	1.3	0.2	0.7	0.1	3.1	49	3.0	11.0	24	70
25/08/2005			Age 0 nerka	4	1.0	0.9	0.6	0.6	1.8	43	10.0	6.0	36	51
	Swed gillnet (f)	Live	Stickleback	3						52	2.0	1.0	51	53
			Cutthroat trout	1						300			300	300
			Pink salmon	1						600			600	600
Evelyn	Trawl (2mx2m)	Formalin	Stickleback	15	10.9	1.8	3.3	0.1	13.9	92	11.0	20.0	23	104
03/09/2001			Age 0 nerka	44	0.9	0.3	0.8	0.3	4.3	40	3.0	9.0	29	70
			Age 1 nerka	7	7.8	3.8	4.1	3.6	12.8	83	13.0	14.0	67	101
	Minnow traps	Live	Prickly sculpin	3						112	36.0	14.0	95	121
	Swed gillnet (s)	Formalin	Stickleback	6	2.1	0.9	0.8	1.1	3.0	56	8.0	7.0	45	63
			Age 0 nerka	1	3.7			3.7	3.7	69			69	69
			Age 1 nerka	8	6.9	2.0	2.4	3.9	11.1	83	7.0	8.0	72	96
			Age 2+ nerka	1	72.0			72.0	72.0	179			179	179
			Coho salmon	14	14.5	3.6	6.3	3.8	26.4	101	10.0	17.0	68	128

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
			Cutthroat trout	1	43.0			43.0	43.0	157			157	157
			Prickly sculpin	3	6.2	10.0	4.0	2.5	10.5	79	46.0	19.0	59	96
		Live	Bull trout	2						325	318.0	35.0	300	350
			Cutthroat trout	3						283	72.0	29.0	250	300
Hartley Bay	Trawl (2mx2m)	Formalin	Stickleback	29	1.3	0.4	1.0	0.0	3.1	44	6.0	15.0	15	65
(Lower)			Prickly sculpin	3	0.1	0.1	0.0	0.1	0.2	24	4.0	2.0	22	25
30/08/2005	Swed gillnet (f)	Live	Stickleback	2						54	51.0	6.0	50	58
Johanson	Trawl (2mx2m)	Ethanol	Age 0 nerka	71	0.9	0.1	0.3	0.2	1.6	50	1.0	5.0	35	59
11/09/2004		Formalin	Age 0 nerka	169	1.3	0.1	0.3	0.5	2.3	49	1.0	4.0	37	60
			Bull trout	3	6.4	6.9	2.8	3.6	9.1	78	27.0	11.0	67	89
	Swed gillnet (f)	Live	Age 1 nerka	1						105			105	105
Johnston	Trawl (2mx2m)	Ethanol	Age 0 nerka	59	0.4	0.1	0.3	0.2	1.8	39	1.0	6.0	29	58
01/09/2005		Formalin	Stickleback	5	1.6	1.2	0.9	0.9	2.9	53	11.0	9.0	44	65
			Age 0 nerka	69	0.5	0.1	0.3	0.2	2.1	35	1.0	5.0	28	55
	Swed gillnet (f)	Ethanol	Stickleback	2	1.8	1.8	0.2	1.6	1.9	59	6.0	1.0	58	59
		Live	Adult/jack sockeye	1						380			380	380
Kitkiata	Trawl (2mx2m)	Formalin	Stickleback	47	1.2	0.1	0.4	0.5	3.4	48	1.0	5.0	37	68
27/08/2005			Age 0 nerka	71	0.8	0.1	0.4	0.2	1.9	40	1.0	6.0	26	54
	Swed gillnet (f)	Live	Stickleback	1						11			11	11
Kitsumkalum	Trawl (2mx2m)	Ethanol	Age 0 nerka	42	1.3	0.2	0.7	0.4	4.0	53	3.0	9.0	35	79
04/09/2005	Swed gillnet (f)	Ethanol	Age 0 nerka	1	4.4			4.4	4.4	72			72	72
			Prickly sculpin	1	7.7			7.7	7.7	86			86	86
Kitwanga	Trawl (3mx3m)	frozen	Age 0 nerka	2	0.4	2.5	0.3	0.2	0.6	83	12.5	9.0	26	39
11/07/2003	Minnow traps	Live	N. pikeminnow	1						84			84	84

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
			Prickly sculpin	5						61	23.0	18.0	45	82
	Swed gillnet (f)	Live	Coho salmon	3						69	5.0	2.0	67	71
			N. pikeminnow	1						139			139	139
			Peamouth	10						149	23.0	32.0	112	225
			Rainbow trout	7						260	33.0	36.0	193	300
			Redside shiner	61						89	2.0	10.0	56	107
	Swed gillnet (v)	Formalin	Redside shiner	1	11.4			11.4	11.4	91			91	91
		Live	Rainbow trout	2						295	64.0	7.0	290	300
Kitwanga	Trawl (2mx2m)	Ethanol	Age 0 nerka	3	1.2	2.6	1.1	0.3	2.4	49	39.0	16.0	34	65
01/09/2003		Formalin	Age 0 nerka	10	1.5	0.3	0.3	1.2	2.4	49	2.0	3.0	45	55
			Redside shiner	1	0.2			0.2	0.2	25			25	25
	Swed gillnet (f)	Ethanol	Age 0 nerka	3	3.7	1.3	0.5	3.2	4.2	73	7.0	3.0	70	75
		Formalin	Rainbow trout	1	157.1			157.1	157.1	230			230	230
			Redside shiner	3	10.6	4.5	1.8	8.9	12.5	92	21.0	9.0	83	100
		Live	Rainbow trout	3						287	100.0	40.0	250	330
Kitwanga	Trawl (3mx7m)	Formalin	Age 0 nerka	2	4.6	0.4	0.0	4.5	4.6	73	13.0	1.0	72	74
22/09/2004			Prickly sculpin	1	0.6			0.6	0.6	39			39	39
		Live	Cutthroat trout	1						280			280	280
			Redside shiner	1						25			25	25
			Whitefish	1						300			300	300
	Swed gillnet (f)	Formalin	Age 0 nerka	3	4.9	1.9	0.8	4.1	5.6	75	5.0	2.0	73	77
			Peamouth	1	27.9			27.9	27.9	128			128	128
		Live	Cutthroat trout	3						270	75.0	30.0	240	300
			Redside shiner	2						70	127.0	14.0	60	80
	Swed gillnet (s)	Formalin	Peamouth	6	18.1	16.1	15.4	3.4	40.3	103	34.0	32.0	65	147
		Formalin	Prickly sculpin	3	3.1	3.7	1.5	2.2	4.9	64	22.0	9.0	58	74
		Live	Bull trout	1						300			300	300

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

Lake/Date	Gear	Fish State	Catch Taxa	n	Weight (g) mean	95CI	SD	min	max	Fork Length (mm) mean	95CI	SD	min	max
			Cutthroat trout	1						240			240	240
			Peamouth	17b						96	17.0	30.0	64	139
			Prickly sculpin	3						67	7.0	3.0	64	69
			Redside shiner	3						101	46.0	18.0	85	121
Lakelse 14/07/2003	Trawl (2mx2m)	Ethanol	Age 0 nerka	14	1.4	0.4	0.7	0.5	2.3	54	5.0	8.0	41	64
			River lamprey	1	0.2			0.2	0.2	64			64	64
		Formalin	Age 0 nerka	6	1.8	0.8	0.7	0.9	3.1	54	8.0	8.0	42	65
			Pacific lamprey	5	2.7	1.4	1.2	0.8	3.7	116	26.0	21.0	80	131
			Sculpin	14	0.1	0.0	0.0	0.1	0.1	18	1.0	2.0	14	22
		frozen	Age 0 nerka	5	2.3	1.0	0.8	1.4	3.2	60	6.0	5.0	54	65
	Swed gillnet (f)	Live	N. pikeminnow	1						224			224	224
			Redside shiner	5						91	15.0	12.0	72	100
	Swed gillnet (v)	Formalin	Age 0 nerka	1	4.5			4.5	4.5	74			74	74
		Live	Age 1 nerka	1						143			143	143
Lakelse 25/09/2004	Trawl (3mx7m)	Ethanol	Stickleback	1										
			Age 0 nerka	33	2.3	0.5	1.5	0.6	5.7	62	4.0	11.0	45	82
		Formalin	Stickleback	3	0.4	0.2	0.1	0.3	0.5	34	4.0	2.0	32	35
			Age 0 nerka	67	3.4	0.5	1.9	1.0	8.2	65	3.0	11.0	45	86
			Prickly sculpin	4	1.7	3.6	2.3	0.2	5.1	48	34.0	21.0	29	78
Lakelse 05/09/2005	Trawl (2mx2m)	Ethanol	Age 0 nerka	19	2.5	0.9	1.9	0.7	6.8	60	7.0	15.0	42	88
		Formalin	Age 0 nerka	153	4.0	0.3	1.9	0.9	8.0	66	2.0	11.0	41	84
			River lamprey	1	0.5			0.5	0.5	59			59	59
McDonell 13/09/2002	Trawl (2mx2m)	Formalin	Age 0 nerka	20	1.5	0.3	0.6	0.6	2.6	52	3.0	7.0	40	62
	Swed gillnet (s)	Formalin	Bull trout	1	52.0			52.0	52.0	182			182	182
			Lake chub	1	27.4			27.4	27.4	131			131	131
	Swed gillnet (f)	Formalin	Age 1 nerka	1	16.9			16.9	16.9	115			115	115

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
		Formalin	Rainbow trout	2	43.3	2.2	0.3	43.1	43.5	167	6.4	0.7	166	167
		Formalin	Coho salmon	9	12.8	3.1	4.0	6.6	17.4	100	9.4	11.5	81	110
		Live	Cutthroat trout	4						242	117.0	73.5	180	345
Morice 15/09/2002	Trawl (3mx7m)	Ethanol	Age 0 nerka	13	1.7	0.5	0.8	0.6	3.0	57	6.0	10.0	41	70
			Age 1 nerka	2	11.2	18.8	2.1	9.7	12.7	105	57.0	6.0	100	109
		Formalin	Age 0 nerka	22	1.8	0.5	1.1	0.3	4.2	53	5.0	11.0	32	73
			Age 1 nerka	1	14.6			14.6	14.6	109			109	109
			Pygmy whitefish	2	3.9	23.6	2.6	2.1	5.8	72	172.0	19.0	58	85
Motase 29/08/2003	Trawl (2mx2m)	Ethanol	Age 1 nerka	2	4.1	3.9	0.4	3.8	4.4	75	6.0	1.0	74	75
		Formalin	Age 0 nerka	5	1.1	0.6	0.5	0.5	1.7	44	8.0	7.0	35	51
			Age 1 nerka	5	4.4	1.0	0.8	3.5	5.3	70	5.0	4.0	65	75
			Longnose sucker	1	161.0			161.0	161.0	235			235	235
			Pygmy whitefish	1	5.2			5.2	5.2	76			76	76
	Swed gillnet (f)	Ethanol	Age 0 nerka	2	1.6	0.8	0.1	1.5	1.6	57	13.0	1.0	56	58
			Age 1 nerka	6	3.4	0.3	0.3	3.0	3.7	70	2.0	2.0	68	72
			Coho salmon	1	5.2			5.2	5.2	80			80	80
		Formalin	Age 0 nerka	2	2.0	0.3	0.0	2.0	2.1	59	13.0	1.0	58	60
			Age 1 nerka	4	4.3	1.7	1.1	3.2	5.5	73	7.0	4.0	67	77
			Coho salmon	1	6.9			6.9	6.9	81			81	81
		Live	Bull trout	3						247	52.0	21.0	230	270
Slamgeesh 07/09/2001	Trawl (2mx2m)	Formalin	Age 0 nerka	24	3.6	0.8	2.0	1.0	8.5	64	5.0	11.0	41	85
			Mountain whitefish	1	2.4			2.4	2.4	58			58	58
			Prickly sculpin	67	0.1	0.0	0.1	0.0	0.2	18	1.0	3.0	14	26
			Sculpin	1	0.1			0.1	0.1	18			18	18
			Sucker	1	0.5			0.5	0.5	30			30	30
	Minnow traps	Live	Prickly sculpin	3						106	24.0	10.0	96	115
	Swed gillnet (f)	Formalin	Age 0 nerka	31	6.8	0.8	2.1	3.4	11.3	82	3.0	8.0	67	95

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
			Age 1 nerka	3	24.0	10.8	4.4	19.1	27.5	122	23.0	9.0	112	130
			Coho salmon	4	8.9	1.3	0.8	7.9	9.8	87	5.0	3.0	84	90
		Live	Adult/jack sockeye	1						380			380	380
			Bull trout	5						443	133.0	107.0	280	580
			Mountain whitefish	2						292	83.0	9.0	285	298
			Whitefish	2										
	Swed gillnet (s)	Formalin	Age 0 nerka	16	7.4	1.1	2.0	4.4	10.6	85	3.0	6.0	75	95
			Bull trout	3						317	275.0	111.0	200	420
			Coho salmon	3	13.4	21.5	8.7	7.1	23.2	98	46.0	18.0	82	118
			Longnose sucker	10c	31.4	13.9	10.6	19.8	40.5	158	35.0	49.0	89	230
			Mountain whitefish	19d	25.6	29.5	34.4	2.5	71.0	229	43.0	89.0	67	320
			Prickly sculpin	10e	12.8	2.3	1.5	11.8	13.9	100	6.0	9.0	81	111
Stephens 10/09/2002	Trawl (2mx2m)	Formalin	Age 0 nerka	21	2.1	0.3	0.5	1.4	2.9	58	2.0	5.0	51	66
			Prickly sculpin	1	2.6			2.6	2.6	61			61	61
	Swed gillnet (s)	Formalin	Coho salmon	22g	6.5	0.8	1.8	4.1	9.7	81	3.5	7.6	69	92
			White sucker	9	21.3	16.6	21.6	3.5	66.7	107	30.7	40.0	66	176
		Live	Whitefish	2						329	114.4	12.7	320	338
			White sucker	1						184			184	184
	Swed gillnet (f)	Formalin	Age 0 nerka	1	4.1			4.1	4.1	74			74	74
			Age 1 nerka	1	11.0			11.0	11.0	98			98	98
			Rainbow trout	2	66.6	183.0	20.4	52.2	81.0	178	114.4	12.7	169	187
			Coho salmon	17	9.1	2.2	4.3	3.5	16.6	88	7.5	14.2	67	111
Sustut 09/09/2004	Trawl (2mx2m)	Ethanol	Age 0 nerka	78	1.0	0.1	0.4	0.3	2.5	50	2.0	7.0	35	67
		Formalin	Age 0 nerka	126f	1.3	0.1	0.6	0.2	3.8	49	1.0	8.0	28	67
	Swed gillnet (f)	Ethanol	Age 0 nerka	5	3.2	0.3	0.2	3.0	3.5	70	2.0	2.0	68	72
			Age 1 nerka	2	7.2	12.6	1.4	6.2	8.2	92	57.0	6.0	87	96
		Live	Age 2+ nerka	1						174			174	174
			Whitefish	1						186			186	186

APPENDIX 2. Summary of captured fish for each survey by capture gear, preservative method, and taxa (continued).

		Fish	Catch		Weight (g)					Fork Length (mm)				
Lake/Date	Gear	State	Taxa	n	mean	95CI	SD	min	max	mean	95CI	SD	min	max
Swan 06/09/2002	Trawl (2mx2m)	Ethanol	Age 0 nerka	7	1.0	0.6	0.6	0.4	2.0	49	9.0	10.0	38	65
			Age 1 nerka	2	2.6	0.1	0.0	2.6	2.6	69	6.0	1.0	68	69
			Age 2+ nerka	3	6.0	1.3	0.5	5.4	6.4	91	8.0	3.0	87	93
		Formalin	Age 0 nerka	22	0.9	0.2	0.4	0.5	1.8	44	2.0	5.0	36	56
			Age 1 nerka	13	3.1	0.4	0.7	2.0	4.4	68	3.0	5.0	59	78
			Age 2+ nerka	1	6.7			6.7	6.7	89			89	89
	Minnow traps	Live	Longnose sucker	1						138			138	138
	Swed gillnet (s)	Formalin	Age 0 nerka	1	0.9			0.9	0.9	51			51	51
			Age 1 nerka	1	10.5			10.5	10.5	95			95	95
			Age 2+ nerka	2	17.8	26.1	2.9	15.7	19.8	121	82.6	9.2	114	127
			Prickly sculpin	1	3.5			3.5	3.5	69			69	69
			White sucker	2	7.9	5.1	0.6	7.5	8.3	90	25.4	2.8	88	92
		Live	Whitefish	2						368	203.3	22.6	352	384
			Rainbow trout	1						249			249	249
			Coho salmon	1						69			69	69
	Swed gillnet (f)	Formalin	Age 2+ nerka	25	18.5	2.1	5.1	9.8	34.3	118	4.6	11.1	102	148
		Live	Rainbow trout	2						303	984.7	109.6	225	380
		Ethanol	Age 2+ nerka	2	19.4	23.5	2.6	17.6	21.3	129	25.4	2.8	127	131

a N=8 for weight, N=9 for length
b N=14 for length
c N=3 for weight
d N=6 for weight
e N=2 for weight
f N=125 for length and weight
g N=20 for length

APPENDIX 3. Hydroacoustic estimates of pelagic fish populations.

				Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability of estimate
Lake	Date	Analysis		N/ha	N	95% CI	N/ha	N	95% CI	N/ha	N	95% CI	
Aldrich	09/09/2001	Tracked targets	a	0	0	-	4,773	306,809	105%	0	0	-	Very low
Azuklotz	27/08/2003	Integration	a	383	63,428	63%	531	87,951	63%	108	17,911	105%	Very low
		Single targets		252	41,729	59%	349	57,863	59%	91	15,014	122%	Very low
		Tracked targets		275	45,645	51%	382	63,293	51%	97	16,019	114%	Very low
Banks East	16/09/2004	Tracked targets	a	182	36,220	41%	517	103,089	34%	25	5,017	91%	Medium
Banks West	17/09/2004	Tracked targets	a	281	43,770	101%	167	26,039	101%	60	9,357	107%	Medium
Bear	26/08/2003	Integration		125	238,025	36%	88	168,758	79%	61	116,851	46%	Medium
		Single targets		116	221,462	36%	73	138,695	64%	60	114,977	34%	Medium
		Tracked targets	a	135	257,805	35%	94	179,642	62%	71	136,073	29%	Medium
Charlotte	04/09/1997	Visual	a	~0	very few targets detected in limnetic zone								High
Club [b]	07/09/2002	Integration		56	2,224	397%	0	0	-	2	97	299%	Very low
		Single targets		45	1,756	387%	0	0	-	1	30	430%	Very low
		Tracked targets	a	55	2,174	394%	0	0	-	1	31	430%	Very low
Ecstall	25/08/2005	Integration	a	71	5 798	59%	1,587	129,634	53%	0	0	-	Medium
		Single targets		77	6,310	56%	1,961	160,245	51%	0	0	-	Medium
		Tracked targets		85	6,920	52%	1,837	150,060	49%	0	0	-	Medium
Evelyn	03/09/2001	Tracked targets	a	847	49,798	32%	895	52,636	32%	106	6240	47%	Medium
Hartley Bay lower	30/08/2005	no estimate	a	-	-	-	-	-	-	-	-	-	-

APPENDIX 3. Hydroacoustic estimates of pelagic fish populations (continued).

Lake	Date	Analysis		Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability of estimate
				N/ha	N	95% CI	N/ha	N	95% CI	N/ha	N	95% CI	
Johanson	12/09/2004	Integration	a	1,195	169,684	27%	15	2,061	27%	26	3,722	48%	High
		Single targets		1,299	184,448	27%	16	2,240	27%	27	3,878	53%	High
		Tracked targets		1,525	216,462	25%	19	2,629	25%	33	4,666	48%	High
Johnston	01/09/2005	Integration	a	6,084	1,137,068	53%	240	44,915	53%	23	4,309	137%	High
		Single targets		6,081	1,136,422	37%	240	44,890	37%	22	4,196	118%	High
		Tracked targets		5,701	1,065,486	46%	225	42,088	46%	22	4,133	123%	High
Kitkiata	27/08/2005	Integration	a	2,356	635,336	14%	1,749	471,702	12%	15	3,946	110%	High
		Single targets		2,797	754,141	15%	2,091	563,944	15%	17	4,673	101%	High
		Tracked targets		2,742	739,278	15%	1,972	531,629	13%	14	3,855	86%	High
Kitsumkalum	04/09/2005	Integration		254	470,322	46%	0	0	-	11	19,510	47%	Medium
		Single targets		273	505,520	52%	0	0	-	11	20,228	24%	Medium
		Tracked targets	a	279	516,475	50%	0	0	-	11	19,987	25%	Medium
Kitwanga	11/07/2003	No estimate		-	-	-	-	-	-	-	-	-	-
	01/09/2003	Tracked targets	a	247	192,884	71%	62	48,221	71%	32	24,655	80%	Low
	22/09/2004	No estimate		-	-	-	-	-	-	-	-	-	-
Lakelse	13/07/2003	Integration		144	195,875	52%	27	36,883	108%	7	9,934	67%	Medium
		Single targets		147	200,059	55%	33	44,448	113%	8	10,793	64%	Medium
		Tracked targets	a	217	295,846	50%	43	58,050	101%	12	15,949	66%	Medium
	30/09/2003	Integration		80	108,837	52%	85	115,485	104%	10	13,213	50%	Low
		Single targets		78	106,749	58%	45	61,667	113%	12	15,656	69%	Low
		Tracked targets	a	90	123,036	61%	41	55,972	119%	13	17,294	71%	Low

APPENDIX 3. Hydroacoustic estimates of pelagic fish populations (continued).

Lake	Date	Analysis		Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability of estimate
				N/ha	N	95% CI	N/ha	N	95% CI	N/ha	N	95% CI	
	25/09/2004	Integration		158	215,365	59%	28	37,602	52%	15	20,987	37%	High
		Single targets		146	198,248	72%	29	39,540	70%	13	17,229	53%	High
		Tracked targets	a	175	238,429	74%	33	45,476	82%	15	20,627	56%	High
	05/09/2005	Integration	a	288	391,401	84%	32	43,647	81%	26	34,693	82%	High
		Single targets		290	394,844	81%	28	38,567	48%	26	35,911	76%	High
		Tracked targets		413	562,323	85%	32	44,156	121%	38	51,562	90%	Medium
McDonell	10/09/2001	Tracked targets	a	no fish caught in trawl			352	75,510	36%	76	16,237	27%	Medium
	13/09/2002	Integration	a	595	127,494	42%	0	0	-	53	11,298	42%	High
		Single targets		573	122,882	42%	0	0	-	50	10,668	50%	High
		Tracked targets		545	116,786	44%	0	0	-	47	10,040	55%	High
Morice	15/09/2002	Integration		160	1,530,203	47%	1	13,305	0%	5	50,893	68%	Low
		Single targets		256	2,454,237	80%	1	9,886	0%	10	92,670	116%	Low
		Tracked targets	a	132	1,266,848	81%	1	6,778	0%	6	58,779	101%	Low
Motase	29/08/2003	Integration		52	20,676	53%	6	2,374	53%	2	671	142%	Very low
		Single targets		31	12,235	33%	4	1,405	33%	2	789	145%	Very low
		Tracked targets	a	52	20,647	103%	6	2,371	103%	3	1,135	148%	Very low
Slamgeesh	07/09/2001	Tracked targets	a	541	20,382	79%	1582	59,549	79%	243	9,136	71%	Medium

APPENDIX 3. Hydroacoustic estimates of pelagic fish populations (continued).

Lake	Date	Analysis		Juvenile *O. nerka*			Other Small Fish			Large Fish			Reliability of estimate
				N/ha	N	95% CI	N/ha	N	95% CI	N/ha	N	95% CI	
Stephens	10/09/2002	Integration	a	897	176,326	55%	40	7,923	55%	64	12,651	81%	High
		Single targets		900	176,994	58%	40	7,953	58%	65	12,686	81%	High
		Tracked targets		798	156,796	59%	36	7,045	59%	58	11,337	79%	High
Sustut	10/09/2004	Integration	a	3,007	662,920	51%	0	0	-	53	11,696	90%	High
		Single targets		3,289	725,036	56%	0	0	-	58	12,870	95%	High
		Tracked targets		3,628	799,841	55%	0	0	-	62	13,699	92%	High
Swan	06/09/2002	Integration		386	676,015	48%	0	0	-	156	273,097	49%	High
		Single targets		372	651,076	45%	0	0	-	152	267,106	51%	High
		Tracked targets	a	329	576,082	45%	0	0	-	135	236,340	51%	High

[a] Preferred analysis method and data used in Table 5.

[b] Taxa of fish is unknown.

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes.

Lake	Date	Fish Taxa	Fish: #	Fish: Mean Length (mm)	Fish: Mean Weight (g)	Fish: Mean Fullness (%)	Diet Items	Mean Diet Items/Fish: N	Mean Diet Items/Fish: Weight (mg)	Mean Diet Items/Fish: N (%)	Mean Diet Items/Fish: Weight (%)
Azuklotz	27-Aug-03	*O. nerka*, age-0	13	72	4.77	86	Diacyclops	76.2	0.13248	4	1.2
							Daphnia	1840	11.2207	95.5	98.3
							Bosmina	11.5	0.057	0.6	0.5
Banks East	18-Sep-04	*O. nerka*, age-0	12	65	3.3	50	Diacyclops	0.9	0.00279	0.1	0.1
							Diaptomous	1.8	0.0059	0.2	0.2
							Epischura	88.4	0.87078	7.6	29.7
							Bosmina	1075	2.02099	91.9	68.9
							Holopedium	3.1	0.03245	0.3	1.1
Banks East	18-Sep-04	Stickleback	10	71	3.77	6	Amphipod	0.1	0.02739	1.9	67.4
							Diacyclops	0.1	0.00012	1.9	0.3
							Daphnia	0.1	0.00044	1.9	1.1
							Diaptomous	0.2	0.00097	3.9	2.4
							Epischura	0.2	0.00244	3.9	6
							Bosmina	4.5	0.00926	86.5	22.8
Banks West	17-Sep-04	*O. nerka*, age-0	20	65	3.27	48	Diacyclops	1.3	0.00391	0.1	0.1
							Daphnia	43.8	0.43626	2.6	9.5
							Diaptomous	7.5	0.02673	0.5	0.6
							Epischura	28.8	0.29349	1.7	6.4
							Bosmina	1577.5	3.78786	94.7	82.5
							Holopedium	3.8	0.03894	0.2	0.9
							Polyphemus	3.8	0.00515	0.2	0.1
Banks West	17-Sep-04	Stickleback	15	65	3.33	36	Ceriodaphnia	9.3	0.03725	1.1	0.8
							Diacyclops	3.3	0.00684	0.4	0.1
							Daphnia	342.3	3.34741	39	68.4
							Diaptomous	2.7	0.01297	0.3	0.3
							Epischura	14.3	0.12645	1.6	2.6
							Bosmina	500	1.34174	56.9	27.4
							Holopedium	1.3	0.01385	0.2	0.3
							Polyphemus	5.3	0.00806	0.6	0.2

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes (continued).

Lake	Date	Fish Taxa	Fish				Diet Items	Mean Diet Items/Fish			
			#	Mean Length (mm)	Mean Weight (g)	Mean Fullness (%)		N	Weight (mg)	N (%)	Weight (%)
Bear	28-Aug-03	*O. nerka*, age-0	3	49	1.57	63	Diacyclops	37	0.09836	25.2	0.8
							Daphnia	49	0.57435	33.3	4.6
							Bosmina	2	0.00818	1.4	0.1
							Heterocope	5.5	0.51079	3.7	4.1
							Insect	46	11.1118	31.3	89.4
							Leptodora	7.5	0.12488	5.1	1
Bear	26-Aug-03	Redside shiner	10	84	8.19	23	Chironomid	0.8	0.21576	6.2	6.9
							Insect	12.1	2.92289	93.8	93.1
Bear	28-Aug-03	Pygmy whitefish	10	62	3.31	30	Chironomid	10.4	0.60495	77	46.6
							Daphnia	0.1	0.00103	0.7	0.1
							Heterocope	0.1	0.0129	0.7	1
							Insect	2.8	0.67651	20.7	52.2
							Leptodora	0.1	0.00167	0.7	0.1
Ecstall	25-Aug-05	*O. nerka*, age-0	3	43	1.11	25	Alona	0.3	0.00295	5	1.1
							Cyclopoid	4.3	0.0212	65	8
							Bosmina	1	0.00101	15	0.4
							Insect	1	0.24154	15	90.6
Ecstall	25-Aug-05	Stickleback	20	53	1.48	12	Alona	0.1	0.00004	0.8	0
							Chironomid	3.1	2.0165	25.6	95.6
							Cyclopoid	0.1	0.00028	0.8	0
							Diacyclops	0.5	0.00134	3.8	0.1
							Bosmina	7.9	0.00767	66	0.4
							Insect	0.4	0.08455	2.9	4
Evelyn	04-Sep-01	*O. nerka*, age-0	10	43	1.04	55	Acanthocyclops	0.6	0.00116	0.3	0.1
							Bosmina	10.2	0.01829	5.8	0.9
							Chironomid	1.2	0.87515	0.7	44.2
							Daphnia	132.6	0.77914	75.4	39.4
							Holopedium	0.6	0.00623	0.3	0.3
							Insect	0.6	0.14494	0.3	7.3
							Leptodiaptomus	19.8	0.13321	11.3	6.7

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes (continued).

Lake	Date	Fish Taxa	Fish #	Fish Mean Length (mm)	Fish Mean Weight (g)	Fish Mean Fullness (%)	Diet Items	Mean Diet Items/Fish N	Mean Diet Items/Fish Weight (mg)	Mean Diet Items/Fish N (%)	Mean Diet Items/Fish Weight (%)
							Schapholoberis	10.2	0.02063	5.8	1
Evelyn	04-Sep-01	*O. nerka*, age-1	10	78	6.53	45	Acanthocyclops	5.6	0.01086	1	0.2
							Bosmina	13.1	0.02277	2.4	0.4
							Chironomid	11.3	1.71948	2.1	33.4
							Daphnia	453.8	2.22477	83.5	43.2
							Insect	3.8	0.90585	0.7	17.6
							Leptodiaptomus	35.6	0.22405	6.6	4.4
							Polyphemus	9.4	0.02291	1.7	0.5
							Schapholoberis	11.3	0.01564	2.1	0.3
Evelyn	04-Sep-01	Stickleback	8	97	11.59	4	Acanthocyclops	0.8	0.00145	0.7	0.1
							Bosmina	3	0.00497	2.7	0.4
							Chaoborus	0.8	0.11624	0.7	9.6
							Chironomid	0.8	0.3624	0.7	30
							Daphnia	98.3	0.69495	89.7	57.4
							Holopedium	0.8	0.00779	0.7	0.6
							Leptodiaptomus	3	0.01352	2.7	1.1
							Polyphemus	0.8	0.00221	0.7	0.2
							Schapholoberis	1.5	0.00637	1.4	0.5
Hartley Bay (Lower)	30-Aug-05	Stickleback	17	56	2.03	15	Acari	3.9	0.00799	45	1.4
							Chaoborus	2.9	0.45534	32.9	79.8
							Chironomid	0.2	0.00471	2	0.8
							Diaptomous	0.1	0.00018	0.7	0
							Bosmina	1.1	0.00155	12.1	0.3
							Insect	0.7	0.101	7.4	17.7
Johanson	12-Sep-04	*O. nerka*, age-0	30	49	1.34	22	Alona	1.4	0.00126	0.8	0.5
							Bosmina	144.1	0.20089	84.9	71.3
							Diacyclops	21.3	0.03617	12.5	12.8
							Holopedium	3	0.00977	1.7	3.5
							Insect	0.1	0.03355	0.1	11.9
Johnston	01-Sep-05	*O. nerka*, age-0	23	38	0.63	7	Cyclopoid	11	0.04397	75.8	55.1

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes (continued).

Lake	Date	Fish Taxa	Fish #	Fish Mean Length (mm)	Fish Mean Weight (g)	Fish Mean Fullness (%)	Diet Items	Mean Diet Items/Fish N	Mean Diet Items/Fish Weight (mg)	Mean Diet Items/Fish N (%)	Mean Diet Items/Fish Weight (%)
							Bosmina	3.4	0.00436	23.4	5.5
							Insect	0.1	0.0315	0.9	39.5
Kitkiata	27-Aug-05	*O. nerka*, age-0	20	43	1	8	Chironomid	0.1	0.00764	0.2	2.1
							Diacyclops	0.3	0.00076	1.1	0.2
							Bosmina	20.9	0.01736	92.3	4.7
							Insect	1.4	0.34758	6.4	93.1
Kitkiata	27-Aug-05	Stickleback	20	49	1.2	13	Chironomid	0.1	0.02642	0.5	2.6
							Chydorus	0.1	0.00007	0.5	0
							Bosmina	6.3	0.00916	60	0.9
							Insect	4.1	0.9904	39.1	96.5
Kitsumkalum	05-Sep-05	*O. nerka*, age-0	6	63	2.33	22	Chaoborus	0.3	0.04613	0.3	1.1
							Cyclopoid	2.1	0.00651	2.4	0.2
							Daphnia	1.2	0.00959	1.4	0.2
							Diaptomous	67.3	0.33624	77.4	7.9
							Insect	16.1	3.88199	18.5	90.7
Kitwanga	01-Sep-03	*O. nerka*, age-0	10	49	1.54	54	Chaoborus	14	1.90525	9.6	52
							Diaphanosoma	7	0.01468	4.8	0.4
							Daphnia	97.5	1.20571	66.8	32.9
							Leptodiaptomus	25.5	0.50398	17.5	13.8
							Leptodora	2	0.0333	1.4	0.9
Lakelse	14-Jul-03	*O. nerka*, age-0	16	56	1.7	35	Ceratopognid	0.4	0.05026	0.2	3.5
							Daphnia	152.8	1.3599	98.2	94.1
							Epischura	2.5	0.03471	1.6	2.4
Lakelse	25-Sep-04	*O. nerka*, age-0	20	70	4.38	29	Chironomid	0.6	0.34872	0.2	10.3
							Diacyclops	21.3	0.05234	7	1.5
							Diaphanosoma	21.5	0.08035	7	2.4
							Daphnia	43.8	0.41243	14.3	12.2
							Epischura	215.6	2.26294	70.7	66.7
							Insect	2.3	0.23685	0.8	7
Lakelse	05-Sep-05	*O. nerka*, age-0	20	64	3.81	39	Diacyclops	4.2	0.01014	1.4	0.3

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes (continued).

Lake	Date	Fish Taxa	Fish #	Fish Mean Length (mm)	Fish Mean Weight (g)	Fish Mean Fullness (%)	Diet Items	Mean Diet Items/Fish N	Weight (mg)	N (%)	Weight (%)
							Daphnia	286.2	2.76129	97.3	80.1
							Epischura	1	0.01221	0.3	0.4
							Bosmina	2	0.00925	0.7	0.3
							Neomysis	0.75	0.6535	0.3	19.0
McDonell	13-Sep-02	*O. nerka*, age-0	10	50	1.35	42	Acanthocyclops	10.5	0.02011	2.3	0.6
							Daphnia	417	2.63841	89.7	83
							Bosmina	3	0.00528	0.7	0.2
							Leptodiaptomus	34.5	0.51409	7.4	16.2
Morice (Atna)	15-Sep-02	*O. nerka*, age-0	10	57	2.13	44	Diacyclops	27.3	0.06772	17.5	2.3
							Daphnia	2.1	0.01073	1.4	0.4
							Bosmina	55.7	0.28078	35.6	9.7
							Holopedium	64.3	0.85606	41.1	29.5
							Insect	7	1.68226	4.5	58.1
Morice (main)	16-Sep-02	*O. nerka*, age-0	3	45	0.83	42	Diacyclops	3.7	0.00962	11.1	1.8
							Bosmina	3	0.01814	9.1	3.4
							Holopedium	26	0.41933	78.8	79.5
							Insect	0.3	0.08051	1	15.3
Motase	30-Aug-03	*O. nerka*, age-0	5	44	1.1	10	Chironomid	0.4	0.02526	1.8	2.2
							Diacyclops	16.4	0.06323	73.2	5.6
							Insect	5.6	1.03684	25	92.1
Motase	30-Aug-03	*O. nerka*, age-1	5	70	4.38	37	Diacyclops	0.2	0.00122	0.6	0
							Insect	31.6	7.63334	99.4	100
Slamgeesh	07-Sep-01	*O. nerka*, age-0	20	66	3.95	82	Acanthocyclops	12.3	0.01873	0.9	0.1
							Daphnia	1023	9.41261	75.5	56.1
							Bosmina	14	0.04768	1	0.3
							Insect	4.7	1.12728	0.3	6.7
							Leptodiaptomus	301	6.16614	22.2	36.8
Stephens	10-Sep-02	*O. nerka*, age-0	10	57	2	46	Diacyclops	6	0.01759	3.8	0.5
							Daphnia	4.9	0.02937	3.1	0.8
							Bosmina	9.3	0.02976	5.9	0.8

APPENDIX 4. Stomach contents of fish caught during surveys of the study lakes (continued).

Lake	Date	Fish Taxa	Fish #	Fish Mean Length (mm)	Fish Mean Weight (g)	Fish Mean Fullness (%)	Diet Items	Mean Diet Items/Fish N	Mean Diet Items/Fish Weight (mg)	Mean Diet Items/Fish N (%)	Mean Diet Items/Fish Weight (%)
							Heterocope	19.1	1.46054	12.1	40.1
							Insect	7.1	1.71303	4.5	47.1
							Leptodiaptomus	111.8	0.39017	70.7	10.7
Sustut	10-Sep-04	*O. nerka*, age-0	30	50	1.45	9	Alona	0.7	0.0186	0.4	3.2
							Amphipod	0.3	0.40742	0.2	69.7
							Bosmina	170.9	0.15454	99.1	26.4
							Diacyclops	0.7	0.0044	0.4	0.8
Swan	06-Sep-02	*O. nerka*, age-0	7	47	1.1	28	Diacyclops	18.3	0.0702	21.6	8
							Daphnia	39.4	0.35538	46.6	40.4
							Bosmina	4.6	0.02215	5.4	2.5
							Heterocope	6.3	0.33812	7.4	38.4
							Holopedium	0.6	0.00593	0.7	0.7
							Leptodiaptomus	15.4	0.08833	18.2	10
Swan	07-Sep-02	*O. nerka*, age-1	10	70	3.53	18	Diacyclops	9.8	0.03298	8.8	4.4
							Daphnia	27.8	0.20065	25.1	26.8
							Bosmina	63	0.28093	57	37.5
							Heterocope	1.5	0.19353	1.4	25.8
							Leptodiaptomus	7.9	0.02871	7.1	3.8
							Leptodora	0.8	0.01249	0.7	1.7