KOKANEE STOCKING AND MONITORING

FLATHEAD LAKE - 1993 AND 1994

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EXECUTIVE SUMMARY

One mitigation goal of the Hungry Horse Dam fisheries mitigation program, funded by the Bonneville Power Administration, is to replace lost production of 100,000 adult kokanee in Flathead Lake. The mitigation program calls for a five-year test to determine if kokanee can be reestablished in Flathead Lake. The test consists. of annual stocking of one million hatchery-raised yearling kokanee. There are three benchmarks for judging the success of the kokanee reintroduction effort:

1. Post-stocking survival of 30 percent of planted kokanee one year after stocking;

2. Yearling to adult survival of 10 percent (100,000 adult salmon);

3. Annual kokanee harvest of 50,000 or more fish per year by 1998, with an average length of 11 inches or longer for harvested fish, and fishing pressure of 100,000 angler hours or more.

Kokanee were the primary sport fish species in the Flathead Lake fishery in the early 1900s, and up until the late 1980s when the population rapidly declined in numbers and then disappeared. Factors identified which influenced the decline of kokanee are the introduction of opossum shrimp ***(Mysis relicta)*****,** hydroelectric operations, overharvest through angling, and competition and/or predation by lake trout ***(Salvelinus namaycush)*** and lake whitefish ***(Coregonus clupeaformis)*****.** The purpose of this report was to summarize the stocking program and present monitoring results from the 1993 and 1994 field seasons.

In June 1993, roughly 210,000 yearling kokanee were stocked into two bays on the east shore of Flathead Lake. Following stocking, we observed a high incidence of stocked kokanee in stomach samples from lake trout captured in areas adjacent to the stocking sites and a high percentage of captured lake trout containing kokanee. Subsequent monitoring concluded that excessive lake trout predation precluded significant survival of kokanee stocked in 1993.

In June 1994, over 802,000 kokanee were stocked into Big Arm Bay. The combination of near optimum water temperatures, an upsurge in the abundance of ***Daphnia thorata*****,** and saturation planting in an area believed to have lower lake trout densities was expected to maximize short-term survival of stocked kokanee. A net-pen experiment demonstrated that yearling hatchery kokanee, in the absence of predation, adjusted to conditions in Flathead Lake and utilized available zooplankton during June and July without substantial post-stocking mortality. Kokanee captured after several months in the lake exhibited good growth and condition. We concluded that the food supply in Big Arm Bay was not limiting survival of stocked kokanee.

The 1994 monitoring objective was to quantify lake trout predation of kokanee in Big Arm Bay in the first eight weeks following stocking. There were three components needed to quantify predation; estimated number of lake trout in Big Arm Bay, average number of kokanee consumed by lake trout, and estimated time required for lake trout to digest kokanee.

As in the previous year, the monitoring results from the 1994 kokanee plant demonstrated that lake trout predation is the primary factor reducing survival of stocked kokanee. We estimated that lake trout consumed a minimum of 232,000 kokanee in Big Arm Bay during the first eight weeks following stocking. This represents 29 percent of kokanee planted. The consumption estimate was based on a hydroacoustic estimate for lake trout abundance (7,850 fish over 300 mm in total length), an incidence of kokanee per lake trout stomach sample which ranged from 2.99 to 0.22 fish, and a gastric evacuation rate of 47 hours for lake trout to digest consumed kokanee. Due to hydroacoustic limitations in identifying bottom-oriented lake trout, we underestimated the true abundance of lake trout, which led to an underestimate of kokanee mortality.

By fall of 1994, we estimated that an additional 12.7 percent of surviving kokanee matured, based on observations of similar-sized fish in the hatchery. Thus, up to 72,000 additional fish were removed from the population due to early maturation. Adding the loss due to predation in the first eight weeks (232,000) to the loss due to early maturation (72,000), we accounted for mortality of at least 304,000 (38 percent) of the original 802,000 fish planted. These estimates did not account for additional losses, including predation outside Big Arm Bay, predation in the months following July, and predation from species other than lake trout, such as bull trout and northern squawfish We documented lake trout predation of kokanee from June through October, and predation by fish species other than lake trout.

One of the program goals is to achieve post-stocking survival of 30 percent one year after planting. Based on observations of the 1994 program, it is unlikely we will achieve this level of survival from the 1994 plant. To attain this survival goal, in the 44 weeks following this study there would have to be a dramatically reduced level of predation than what we observed in the first 8 weeks following stocking.

The second benchmark of the program is survival of 10 percent of stocked fish to adulthood. Since the majority of the fish from the 1994 plant will reach sexual maturity in the fall of 1995, we were unable to evaluate this criterion. Intensive monitoring of spawning areas in fall of 1995 will determine if this objective is met. We did not observe large concentrations of spawning kokanee resulting from the 210,000 kokanee yearlings stocked in 1993.

Finally, the third benchmark is to achieve annual kokanee harvest of 50,000 or more fish. It is assumed that kokanee would be taken by anglers at sizes of eight inches or larger. Based on observations of growth rates of fish stocked in 1994, it is likely that faster growing members of the population would be vulnerable to the fishery shortly after stocking. If the fishery were open, it is probable that some of the larger fish would be harvested by anglers. We cannot evaluate the kokanee harvest without an open fishery, and recommend that the fishery be reopened to angling in subsequent years.

INTRODUCTION

History of Kokanee in Flathead Lake

Kokanee salmon ***(Oncorhynchus nerka)*** were introduced into Flathead Lake in 1916. Within 30 years of this single introduction, the species had become an integral self-sustaining part of the Flathead Lake ecosystem, sport fishery, and area economy. Kokanec were the primary sport species in the fishery through the second half of this century, until numbers rapidly declined in the mid-1980s. By the early 1990s kokanee had completely disappeared from Flathead Lake. Factors identified which influenced the decline in kokanee are the introduction of opossum shrimp ***(Mysis relicta)***, hydroelectric operations, overharvest through angling, and competition and/or predation by lake trout ***(Salvelinus namaycush)*** and lake whitefish ***(Coregonus clupeaformis)*** **(Beattie** and Clancey 1991).

The 40-year history of fisheries investigations in Flathead Lake provided considerable insight into movement patterns of wild kokanee. In particular, a 1982 report on Flathead Lake fish food habits contains information on kokanee diet, zooplankton populations, and fish distribution (Leathe and Graham 1982). It is assumed that kokanee movement patterns would be similar today if kokanee were reestablished.

Young-of-the-year salmon were historically distributed throughout the lake and separated from schools of two and three-year-old fish (Leathe and Graham 1982). During winter, schools of older kokanee typically migrated to areas along the east shore between Woods Bay and Skidoo Bay, with smaller accumulations at other sites such as near Wild Horse Island (Figure 1). It was presumed, but not conclusively demonstrated, that zooplankton bloomed earlier in the south end of the lake and salmon migrated there in the spring as a feeding response.(Leathe and Graham 1982). In summer, age three and four salmon formed large schools and migrated north to the mid-lake area. By September, adult fish moved north into the river system or to shoreline spawning areas to complete their life cycle, while sub-adults concentrated again in the deeper waters off the east lakeshore.

In the early 1980s, kokanee provided more than 90 percent of the sport fishery in Flathead Lake (Graham and Fredenberg 1983). At present, a kokanee fishery does not exist in Flathead Lake and about 80 percent of angler effort is directed at lake trout (Evarts et al. 1994). Montana Fish, Wildlife and Parks stocked over 11,250,000 young-of-year kokanee (roughly 50 mm in length) into Flathead Lake during the 1988-1991 period, after the collapse of kokanee populations, but the kokanee population did not reestablish.

The Mitigation Program

The mitigation goal, as stated in the Fisheries Mitigation Plan for Losses Attributed to the Construction and Operation of Hungry Horse Dam (Montana Fish Wildlife & Parks, and Confederated Salish and Kootenai Tribes 1991), is to: "Replace lost annual production of 100,000 kokanee adults, initially through hatchery production and pen rearing in Flathead

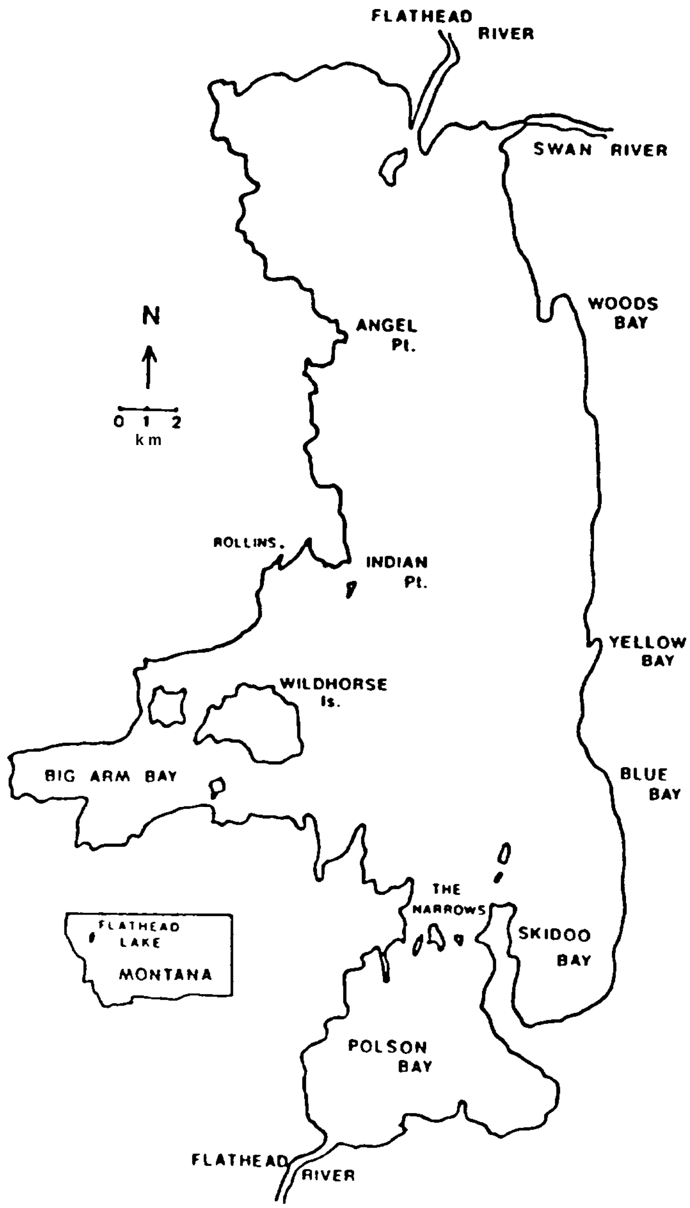

Figure 1. Map of Flathead Lake (Beattie et al. 1986).

Lake, partially replacing lost forage for lake trout in Flathead Lake." Montana Fish, Wildlife & Parks (FWP) and the Confederated Salish and Kootenai Tribes (CSKT) share authority and responsibility for administering the mitigation for impacts from construction and operation of Hungry Horse Dam on the fisheries of the Flathead system. An Implementation Group, consisting of representatives from both agencies, and from the U.S. Fish & Wildlife Service, is responsible for identifying and implementing mitigation projects, which are funded by the Bonneville Power Administration.

The Hungry Horse Dam Fisheries Mitigation Implementation Plan (Plan) (Montana Fish, Wildlife & Parks and Confederated Salish and Kootenai Tribe 1993), adopted by the Northwest Power Planning Council on March 10, 1993, and funded by the Bonneville Power Administration, identified the strategy for achieving the restoration goal. Because earlier fry plants were not successful in restoring the kokanee fishery, the Plan called for stocking yearling kokanee, assuming that larger kokanee would survive better than fry. The Plan calls for annual stocking of one million 6- to 8-inch yearling kokanee, reared at Creston National Fish Hatchery (Creston), for each of five years (1994-1998). This program is considered a "test" of the feasibility of reestablishing a kokanee fishery. According to the Plan, "During the five year test period, we will accumulate sufficient information to determine whether the plants were successful, thereby dictating future hatchery operations and facility upgrades."

The Implementation Plan established criteria for judging the success of the kokanee reintroduction effort. These included:

1. Post-stocking survival of 30 percent of planted kokanee one year after stocking;

2. Yearling to adult survival of 10 percent (100,000 adult salmon);

3. Annual kokanee harvest of 50,000 or more fish per year by 1998 with an average length of 11 inches or longer for harvested fish and fishing pressure of 100,000 angler hours or more.

Reestablishing a naturally reproducing kokanee population in Flathead Lake is not a primary mitigation goal. However, natural reproduction of kokanee would lead to modifications in stocking efforts that could eventually phase out the kokanee stocking program.

Fundamentals of the Stocking Program

Fundamental considerations of a stocking program include numbers, size and age of fish, timing of outplanting (which must take into consideration thermal conditions in the hatchery and the lake as well as food availability in the lake), location of stocking, method of stocking, and predation on stocked fish. These factors were analyzed in detail while developing a stocking strategy for 1994. Numerous authors have discussed the factors that must be taken into account when developing a supplementation program for stocking hatchery fish on top of wild populations (Smith et al. 1985, Steward and Bjomn 1990, Cuenco et al.

1993). When the objective is to maximize survival of stocked fish entering a fishery and a wild population doe-s not exist, as in the Flathead Lake kokanee program, it is not considered supplementation but rather put-grow-and-take stocking, and the complexity of concerns are reduced. Nonetheless, many of the same factors still apply for maximizing survival of stocked fish.

Successful stocking of hatchery-reared salmonids is complex. In a system as large as Flathead Lake it is very difficult to evaluate stocking success. It is critical to systematically evaluate this stocking program (RASP 1992). We focused on short-term post-stocking survival using net pen experiments, evaluation of lake trout food habits, and spawner escapement and long-term monitoring such as lake trout population estimates and hydroacoustic surveys. In 1994, we evaluated post-stocking survival of kokanee in a semi-isolated bay (Big Arm Bay), to assess the feasibility of stocking and to build a decision-making process that will enhance our ability to evaluate and conduct future stocking programs and possibly to improve kokanee survival.

Zooplankton Abundance and Utilization by Kokanee

The introduction of ***Mysis*** dramatically changed the food web in Flathead Lake (Beattie and Clancey 1991, Spencer et al. 1991). ***Mysis*,** first discovered in the lake in 1981, provided forage for deepwater benthic species, and apparently improved survival of juvenile lake trout and lake whitefish. ***Mysis*** numbers in Flathead Lake peaked in 1986 at 129 per square meter and have since declined to a range of 20-50 per square meter in the 1990s (Flathead Basin Commission, 1993). A similar temporal pattern of ***Mysis*** densities, peaking and then declining to a lower level, has been observed in other lakes and reservoirs throughout the western United States following introduction of ***Mysis*** (Nesler and Bergersen 1991).

The zooplankton community in Flathead Lake has been considerably altered by ***Mysis*,** which have markedly reduced populations of larger cladocerans and copepods Prior to the establishment of ***Mysis*,** the principle food of kokanee in Flathead Lake was the large cladoceran ***Daphnia thorata*** (Leathe and Graham 1982). This organism comprised 72 percent of the total food biomass eaten by kokanee age three and older from June through November of 1980 and 1981. Younger kokanee were even more dependent on this organism as a food source.

During Leathe and Graham's (1982) study, the mean density of ***D. thorata*** at a sampling station in Big Arm Bay, near the 1994 stocking site, was 1.2 organisms per liter (range 0. l-3.3) from June through December, 1980. During one and one-half years of investigation, there were no significant differences in the density of the four principal crustacean zooplankton species utilized by kokanee **(*D. thorata*, *Epischura*, *Leptodora*,** and ***Diaptomus*)** at seven sites sampled around the lake (Leathe and Graham 1982). Total zooplankton density peaked at approximately 30 organisms per liter in July and August of 1980, and in late June of 1981.

In 1986 and 1987, when ***Mysis*** levels peaked, the spring population bloom of ***D. thorata was*** delayed until July, and the maximum summer abundance was less than one-third of 1980-1982 levels (Beattie and Clancey 1991). These authors noted that smaller zooplanktors such ***as Cyclops*, *Diaptomus*, *Epischura*,** and ***Bosmina*,** as well as chironomids, constituted the bulk of the early summer diet of kokanee. The growth rates of age 0 and age 1 fish in 1986-1987 were not significantly different than they had been in 1980-1981.

Mechanisms which caused the collapse of kokanee in Flathead Lake have not been conclusively defined. Changes in zooplankton abundance were believed to be a likely cause of the kokanee collapse (Beattie et al. 1988, Spencer et al. 1991). This opinion is supported by the evidence from other western waters where ***Mysis*** have been introduced (Nesler and Bergersen 1991). However, Leathe and Graham (1982) calculated the total cropping rate of ***D. thorata*** in Flathead Lake (0.3 percent per day), and noted that this represented a lower rate in comparison to other studies. They concluded that kokanee in Flathead Lake were not food-limited during the pre-Mysis period. Similarly, Beattie et al. (1990) noted that data did not demonstrate that kokanee were food-limited and stated that kokanee captured in the late 1980s **(post-*Mysis*)** were always in excellent condition. These authors reported that "predation by other fish is more likely the dominant factor determining the fate of kokanee populations."

During recent summers (1988-1993), investigators at the University of Montana's Flathead Lake Biological Station have sampled zooplankton at a deep mid-lake site. Density of ***D. thorata*** has generally ranged from 0.0 to 1.0 organism per liter with peak densities occurring in late July (Chess 1995, unpublished data). Total crustacean zooplankton density peaked at about 6.0-8.0 organisms per liter.

Changes in zooplankton abundance documented in the **post-*Mysis*** period, including a delayed and reduced peak in the summer abundance of ***D. thorata*,** contributed to the decision to stock fingerling-sized kokanee in Flathead Lake. The relatively large size and good condition of stocked fingerling kokanee, provide fat reserves that should increase survival, even if immediate food availability is low.

Study Objectives

To determine if reintroducing kokanee into Flathead Lake is feasible, we developed a monitoring program to assess stocked kokanee survival. The purpose of this report is to summarize the stocking and monitoring results from the 1993 and 1994 field seasons. Monitoring programs will be modified in future years as data on the success of the program in 1994 and beyond become available. Recommendations for the 1995 stocking program are presented in Appendix B.

The 1994 monitoring objective was to quantify lake trout predation of kokanee in the eight weeks following stocking. Three components were needed to quantify predation. First, we attempted to estimate the number of lake trout in Big Arm Bay using hvo methods, a mark/recapture estimate and a hydroacoustic survey. Second, we determined the average number of kokanee consumed per lake trout. Gill net surveys provided weekly proportions of lake trout consuming kokanee and numbers of kokanee per lake trout. The third component, an estimate of the time required for a lake trout to digest kokanee, was obtained from existing literature.

DESCRIPTION OF STUDY AREA

Flathead Lake, located in northwestern Montana, is the largest natural freshwater lake west of the Mississippi River. It is roughly 510 km^2 in surface area, oligomesotrophic, and has a mean depth of 50.2 m and a maximum depth of 113.0 m (Zackheim 1983). The lake is noted for its high water quality, and most of the 18,400-km^2 drainage area is underlain by nutrient-poor Precambrian sedimentary rock (Leathe and Graham 1982). In recent years researchers have identified a deterioration in the quality of water in the Flathead Basin, due primarily to increased nutrients resulting from the rapidly increasing human population (Flathead Basin Commission 1993). Major tributaries to the lake are the Flathead River with three forks, and the Swan River.

There are at least 25 fish species presently found in Flathead Lake (Leathe and Graham 1982). Only ten are native. Major game fish species discussed in this report include introduced kokanee, lake trout, lake whitefish (*Coregonus clupeaformis*) and native bull trout (*Salvelinus confluentus*). Nongame species, all of which are native, include northern squawfish (*Ptychocheilus oregonensis*), peamouth (*Mylocheilus caurinus*), longnose and largescale suckers (*Catostomus catostomus* and C. *macrocheilus*), and redside shiner (*Richardsonius balteatus*). In addition, yellow perch (*Perca flavescens*) is an introduced species.

Big Arm Bay was chosen as the site for the 1994 kokanee stocking and subsequent monitoring program (Figure 1). The bay is relatively isolated from the main lake by Wild Horse, Cromwell and Melita islands, which form an island chain between the bay and the main body of the lake. The study area included all the water west of a north-south line extending from White Swan Point, along the east shore of Wild Horse Island, and then north to the most prominent point along the main lakeshore between Dayton and Rollins (Figure 2). The surface area of Big Arm Bay (study area), estimated by using a planimeter on a detailed bathymetric map, was 45.7-km^2 (17.6 square miles), roughly 10 percent of the surface area of Flathead Lake. The bay was partitioned into eight sample areas (Figure 2). Subdivisions were based on uniformity of depth and basin configuration. Maximum depth is about 35 m in all areas except Area D, where maximum depth is 60 m.

Fish that move out of the bay along either side of Wild Horse Island encounter water over 60 m deep in the mid-lake area. Big Arm Bay provided a stocking site close to the mid-lake area that we hoped, by its confined nature, would allow kokanee to acclimate to the lake before moving into deeper waters which contained higher lake trout densities, and thus more intense predatory pressures. We monitored kokanee survival only in Big Arm Bay and assumed the bay approximated a closed system conducive for enumerating fish populations.

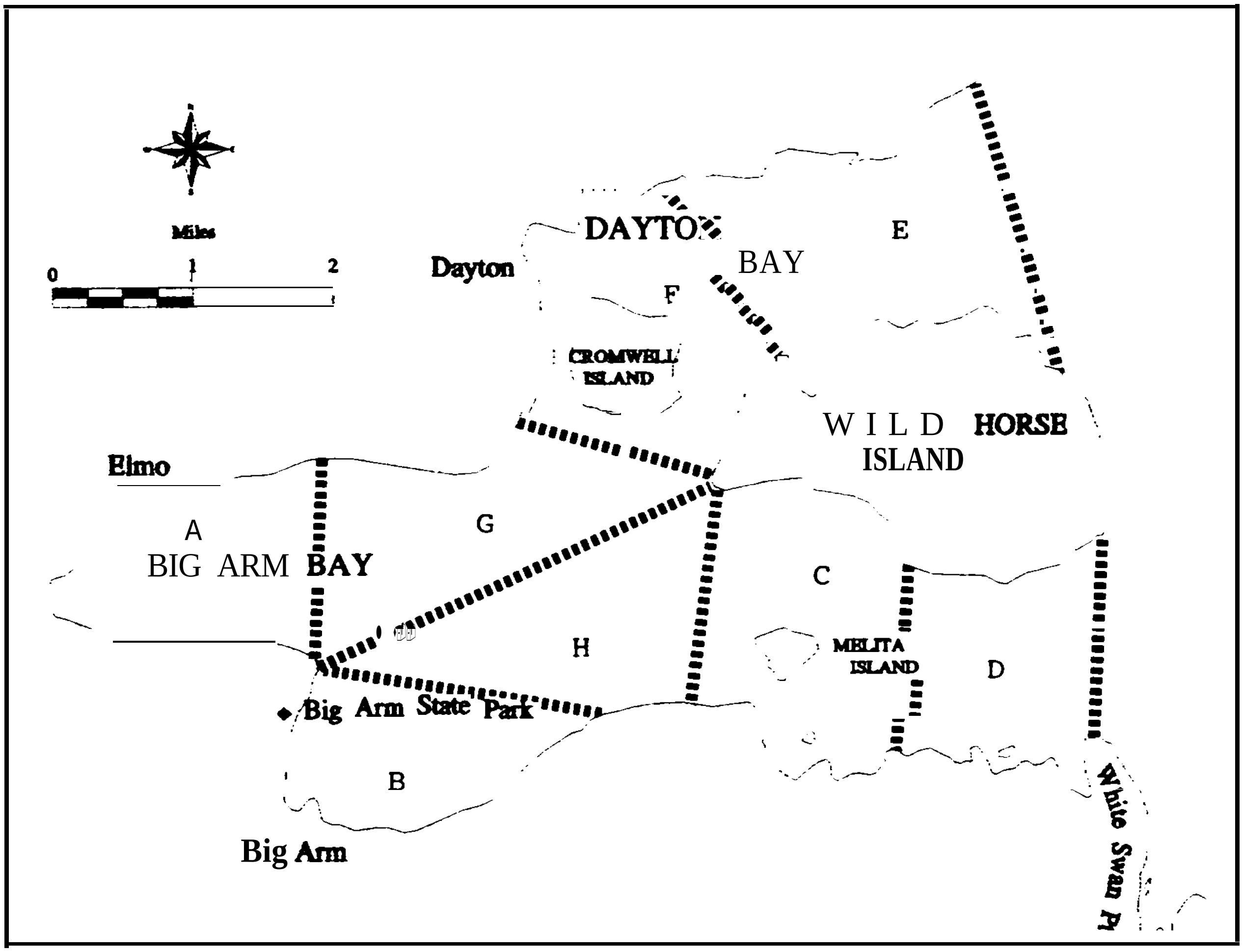

Figure 2. Eight sampling areas within the study site in Big Arm Bay, 1994.

METHODS

1993 Stocking and Monitoring

In early June, 1993, a total of 210,000 yearling kokanee were stocked into two bays (Woods and Blue) on the east shore of Flathead Lake. These fish averaged 170 mm (6.7 in) in length and ranged from 127 to 229 mm (5 to 9 in). Our strategy was to reintroduce kokanee into areas where they had naturally concentrated prior to the collapse, that also provided access to deep water. Based on these criteria, we believed the best introduction sites were along the east side of the lake in the deep sheltered bays.

Stocked fish were given an oxytetracycline mark. We monitored the areas adjacent to the stocking locations using sinking standard experimental gill nets. We examined lake trout stomach contents for consumed kokanee Nets fished overnight and were set weekly.

1994 Stocking and Net Pen Evaluation

A total of 802,174 kokanee, averaging 163 mm (6.4 in) in length and ranging from 102 to 229 mm (4 to 9 in), were stocked into Big Arm Bay from June 6 through June 10, 1994. Planting conditions at the lake were excellent, winds were calm, and observed predation by birds was minimal.

Kokanee were released at the public boat ramp at the west end of Big Arm Bay (Big Arm State Recreation Area). Fish were loaded at the Creston Hatchery using a pump system and hauled approximately 45 minutes to the stocking location. We planted fish directly from the truck, delivering them to the water by a flexible pipe, between the hours of 9 a.m. and 4 p.m. Water temperature in the truck was 9 to 10°C and lake water at the stocking site was 11 to 12°C.

Stocked fish were the progeny of kokanee in Granby Reservoir, Colorado. Eggs were shipped to Creston Hatchery in December 1992 from Glenwood Springs State Fish Hatchery in Colorado. Fish hatched in late January and early February of 1993, and were approximately 16 months old (post-hatch) at the time of stocking. The kokanec stock in Granby Reservoir was derived from the former Flathcad Lake stock.

For ten days, all stocked fish were fed a diet mixed with ten percent oxytetracycline, a common antibiotic, to develop a distinctive ring on their bones that fluoresces under black light. This enabled biologists to examine fish or fish parts to identify hatchery origin. The mark is carried throughout life. The methodology was tested in 1993 and proven successful. In 1994, a double tetracycline mark was applied to all fish, first at an average length of 102 and then at 119 mm (4.0 and 4.7 in). We marked fish in late August and again in early November.

We evaluated the short-term survival of stocked kokanee in the absence of predation using a low-density net pen experiment. Secondary goals of this experiment were to examine the ability of kokanee to convert from a hatchery diet to zooplankton and evaluate their survival until zooplankton abundance increased. On June 10, 1994, two sample lots of kokanec, averaging approximately 163 mm total length, were stocked into the net pen directly out of the hatchery truck. The fish were evenly divided into two compartments, each 2.4 m square by 3.0 m deep, enclosed by 0.6 mm nylon mesh netting. The net pen was towed to a site approximately 100 m offshore and anchored in 15 m of water. The water surface inside the pens was not covered. Surface temperature was 12.6°C (54.6°F). Fish in the net pens were evaluated on June 13 (3 days post-stocking), June 23 (13 days), and July 13 (33 days), after which time the experiment was terminated.

Temperature Monitoring

Temperature profiles were collected with a Yellow Springs Instrument Model 58 digital electronic temperature meter, by lowering the probe on a marked cord from the boat. Temperatures were recorded biweekly from May 23, 1994 through June 29, 1994, and monthly thereafter through September 13, 1994. Readings were obtained at the surface, at 1.0 m, every 2.0 m from 3.0 to 15.0 m depth, and then every 3.0 m to the bottom. Profiles were taken at two locations in the study area, determined by triangulation off landmarks on shore. One area was close to the geographic center of Big Arm Bay, at the midline of sampling sectors G and H, in about 30 m of water (Figure 2). The other monitoring area was along the north shore of Wild Horse Island, in the center of sampling sector E, in about 25 to 30 m of water. Water depths varied between some sampling dates because of the approximation of locations. Temperature profiles were taken during early to mid-afternoon (1200 to 1500 hours).

Estimation of Lake Trout Abundance

Mark/Recapture Method

We captured lake trout with horizontal sinking gill nets that were 38 m long and 2 m deep, consisting of five individual panels, each with a different mesh size ranging from 19 to 51 mm. Each gill net set consisted of two nets tied end to end. Netting began on May 16, 1994, and continued weekly through July, biweekly during August, and monthly in September and October. The last samples were collected on October 20, 1994. Duration of sets ranged from 1 to 27 hours, and averaged 18 hours. After initial short-duration sets proved ineffective, we set the nets overnight to capitalize on the higher capture efficiency during darkness. Lake trout were visually examined after removal from the nets, and only those considered to have a high likelihood of survival were marked and released. All released lake trout were marked with numbered floy tags and by removal of half of the right pelvic fin. All fish lengths were measured as total lengths (TL).

FWP crews netted the four sectors of the north half of the study area (Areas A, G, F and E) and CSKT crews netted the four sectors of the south half (Areas B, H, C and D) (Figure 2). We coordinated the time and place of gill netting to achieve uniform sampling between areas. We did not sample randomly within areas to minimize travel time between sites. Also, during some periods we avoided locations that were not considered to be representative of the whole area. We used the adjusted Petersen formula (Ricker 1975) to estimate lake trout abundance

Hydroacoustic Method

A hydroacoustic survey provided the primary means of estimating lake trout abundance in Big Arm Bay. We used a 25-foot boat equipped with dual-beam hydroacoustic sampling gear, radar, and global positioning systems. Hydroacoustic equipment consisted of BioSonics Model 105 echosounder equipped with dual-beam transducer and BioSonics 171 tape recorder interface. Surveys were recorded on digital audio tapes, which BioSonics summarized to target densities by transect and depth strata. We separated targets into three depth strata (2 to 12.2 m, 12.2 to 24.4 m and depths greater than 24.4 m).

On June 16, 1994, we followed a predetermined course along 15 transects. Transects included all available depths. We estimated fish numbers and densities for the entire bay using densities per surface area expansions. In conjunction with the hydroacoustic survey, we set horizontal and vertical gill nets in the three depth strata to determine fish species composition and sizes. Percent composition of species captured in the nets was combined with target numbers from hydroacoustics to estimate numbers of fish species by depth stratum.

Target strengths by size class for kokanee was developed from hydroacoustic work in Koocanusa Reservoir (Skaar, MFWP pers. comm. 1993) (Table 1). The average total length of kokanee in the 1994 Flathead Lake plant was 163 mm, which would produce a target strength between -57 and -47 db.

Table 1. Target strengths for size groups of kokanee salmon in Koocanusa Reservoir (Skaar, FWP, pers. comm. 1993).

Size Group (mm)	Modal Target Strength
65 mean 40-100 range	-59db
125 mean 110-140 range	-57db
199 mean 170-270 range	-47db
213 mean 200-240 range	-45 db

We estimated the surface area of Big Arm Bay and each depth stratum using a planimeter and the most detailed bathymetric map available for Flathead Lake (Mountain Press Publishing Co. 1990). Depth strata were separated at 12.2 meter (40 foot) intervals. Surface area was separated into depth strata to be compatible with fish density estimates produced through hydroacoustic analysis, and species composition determined through netting.

From the hydroacoustic survey, we produced a weighted mean fish density for each depth stratum. Density was modified by the nominal width of and sampled proportion along each transect by depth stratum. These modifications produced a mean estimate of fish numbers per square meter by stratum, which when multiplied by the surface area of each stratum, provided an estimate of total fish abundance for each depth stratum.

To separate fish numbers by length groups (less than 300 mm, 300 to 460 mm, and greater than 460 mm TL) we applied target strength distribution from the survey separated proportionally at length intervals. We used a relationship of target strength (dB) and fish length developed in previous studies (Hanzel, MFWP pers. comm. 1993, Love 1971). We used -38 dB and -35 dB to describe the lengths 300 mm and 460 mm, respectively. Proportions of targets in these length intervals were applied to fish abundance estimates by depth stratum to estimate the number of fish in each length group at each depth stratum. We separated our hydroacoustic estimate in this method to be compatible with gill netting data, also separated by fish length groups and depth strata.

Fish Species Composition

We combined hydroacoustic estimates and fish species composition from gill nets to estimate the number of lake trout in Big Arm Bay. We combined sinking gill net catch over a four week period (June 6 to July 1) to represent fish species composition in Big Arm Bay. We used two standard experimental sinking gill nets tied end to end at each location. We sampled all eight study areas in the bay and all three depth strata (0 to 12.2 m, 12.2 to 24.4 m, and over 24.4 m). We separated total catch by depth stratum and three fish length groups; less than 300 mm, 300 to 460 mm, and over 460 mm TL. We used vertical gill nets to distinguish the fish species which produced pelagic targets.

Lake Trout Food Habits

Stomach Sampling

In conjunction with kokanee stocking in Big Arm Bay, we collected lake trout in gill nets for food habit analyses. Kokanee stocking took place over a five-day period (June 6 through June 10). We began sampling lake trout stomachs on the second day of stocking.

There were two objectives for analyzing lake trout food habits. First, for each week, we estimated the percent of lake trout that had eaten kokanee The weekly proportion of lake trout containing kokanee was calculated as a percentage of the total capture. Second, we estimated the weekly average number of kokanee per captured lake trout. We defined the weekly incidence of kokanee per lake trout as the total number of kokanee observed in lake trout stomachs divided by the total number of captured lake trout. These values were used to estimate the number of kokanee consumed by lake trout.

Only lake trout over 300 mm TL were considered large enough to prey upon planted hatchery kokanee. Lake trout consumed fish less than 50 percent of their own lengths in Flaming Gorge Reservoir (Yule and Luecke 1993). We captured 16 lake trout less than 300 mm in the eight-week period following kokanee introduction, none contained kokanee. Therefore, we assumed planted kokanee would generally be larger than prey selected by lake trout less than 300 mm TL.

Stomach Lavage Test

Generally, fish under five pounds were sacrificed and stomach contents examined by direct observation. We pumped the stomachs of larger lake trout to reduce mortality of trophy sport fish. Captured lake trout were immediately removed from the nets and held in a live well until the entire net was retrieved. We anesthetized fish in Tricaine Methanesulfonate (MS-222) prior to evacuating stomach contents using the lavage method (Light et al. 1983, Yule and Luecke 1993). We modified the lavage design using a 1,500 gph bilge pump placed overboard to provide water pressure, and added a series of valves to control flow into fish stomachs. We quickly filled the gut cavity with water then inverted the fish over a U.S. standard sieve series #70, 12 inch diameter, with 210 micron (0.0083 in) openings. The sieve fit over a five gallon bucket. The lavage process was repeated, until contents flushed. The sieve was washed after each fish was sampled. Unidentified stomach contents were bagged, stored on ice and analyzed for oxytetracycline marks in the lab. We identified whole forage fish to species and measured total length. After flushing stomach contents, we revived, tagged and released the fish.

Determination of Gastric Evacuation Rates

Gastric evacuation rate is the time needed to digest a prey item and pass it out of the stomach. As stomach contents pass into the intestines, they become unavailable to sampling by lavage methods. The speed of digestion and evacuation from the stomach influences calculations of lake trout predation on kokanee. To account for prey eaten and digested during the sampling period, but not observed in stomach contents on a specific sampling date, an estimate of evacuation is necessary.

A number of variables affect gastric evacuation rates in fishes including water temperature, food particle size, prey type, predator size, multiple meals, and the number of food items in a predator's stomach (Durbin et al. 1983). Diet and feeding behavior, whether omnivorous or piscivorous, also influences evacuation rates (Borsclair and Marchand 1993). Water temperature and prey size were the most important factors influencing evacuation rates in piscivorous brown trout feeding on fingerling rainbow trout (He and Wurtsbaugh 1993). He and Wurtsbaugh (1993) formulated a model to describe instantaneous evacuation based on a laboratory analysis of brown trout and numerous previous studies (Equation 1).

Equation 1.

$$\text{Instantaneous gastric evacuation rate } (R_e) = 0.049 * e^{0.072 * T - 0.060 * \log_e (ps)}$$

Where,

T = water temperature (°C)

and

ps = particle size, wet weight (g)

He and Wurtsbaugh (1993) found this model explained most of the variance in evacuation rates in fishes from 191 published studies on 22 fish species. We used this equation to estimate instantaneous gastric evacuation for lake trout in Flathead Lake, assuming that evacuation rates were similar in lake trout and brown trout and that kokanee were digested similar to rainbow trout.

Calculating evacuation rates for lake trout feeding on kokanee fingerlings required values for prey size and water temperature in Flathead Lake. Water temperatures varied throughout the water column as the lake became thermally stratified. Lake trout were captured in gill nets at all depths prior to complete stratification. We used 9.0°C to represent water temperature occupied by lake trout, based on temperatures recorded in Big Arm Bay. During June and July 1994, temperatures ranged from 18.6°C at the water surface to 5.0°C at 30 m below the surface. At the Big Arm sampling location, mean water temperature of the water column on June 3 and June 16, was 8.7°C and 8.5°C, respectively. As surface temperatures warmed, we averaged the temperature measurements below 10 meters of depth, near the thermocline. On June 29 and July 19, mean water temperature below 10 meters was 9.1°C and 9.4°C, respectively. The value 9.0°C approximates the mean water temperature used by lake trout in Big Arm Bay in June and July. Lake trout using water warmer than 9.0°C will digest prey faster than our estimate, those using colder temperatures will digest prey slower. In Flaming Gorge Reservoir, the mean water temperature occupied by lake trout was 9.3°C ± 4.3°C and 8.9°C ± 1.0°C during two summer surveys (Yule and Luecke 1993).

At the time of stocking, mean wet weight of kokanee, estimated from a sample of 150 fish, averaged 40.5 g We used this weight as the prey particle size in calculations of instantaneous gastric evacuation rates.

Using the values 9.0°C and 40.5g, the instantaneous gastric evacuation rate for lake trout digesting kokanee in Flathead Lake was $R_e = 0.075\ h^{-1}$, or 7.5 percent per hour. However, digestion does not occur at a constant rate. He and Wurtsbaugh (1993) found an exponential equation best described evacuation rate for piscivorous brown trout (Equation 2).

Equation 2.

$$\mathbf{Log\ e\ (W_t/W_o) = b - R_e\ t}$$

Where,

$\mathbf{W_t/W_o}$ = final dry weight of prey to initial dry weight of prey

b = y-axis intercept of 0

$\mathbf{R_e}$ = instantaneous gastric evacuation rate (Equation 1)

and

t = time (h)

For only the vertebral column present, no flesh or other bones remaining, they found $\mathbf{W_t/W_o}$ to equal three percent (Table 2). This is the final stage in the digestive process at which we were able to identify kokanee in lake trout stomachs. Using 0.03 for $\mathbf{W_t/W_o}$ and the previously computed $\mathbf{R_e}$ = 0.075 $\mathbf{h^{-1}}$, we calculated the time for which a kokanee is identifiable in a lake trout stomach (t) to be 47 h for lake trout in Flathead Lake (Equation 2). This was factored into the weekly consumption rate (Equation 3), since kokanee found in stomach samples were consumed within the previous 47 hour period.

Table 2. Qualitative measures of digestive states of fingerling rainbow trout in the stomachs of predatory brown trout. Numbers in parentheses show the mean percentage of prey dry weight remaining at each digestive state (He and Wurtsbaugh 1993).

Digestive State	Description
1	Fingerlings intact (88 %)
2	Fingerlings intact but skinless (65%)
3	Fingerlings identifiable as salmonids by shape (50%)
4	Skeleton intact; more than 50% of flesh remaining; all bones present (35%)
5	Vertebral column and most bones present; some flesh left (15%)
6	Vertebral column and some bones present; very little flesh left (5%)
7	Only vertebral column present; no flesh or other bones present (3%)

Estimated Lake Trout Predation

A number of recent studies have investigated predation levels on smolting salmonids in the Columbia River System (Beamesderfer and Rieman 1991, Poe et al. 1991, Rieman et al. 1991, and Vigg et al. 1991). Investigators took a similar approach in estimating predation as we attempted in this study. Two main factors were involved, estimated consumption rates per predator and the estimated number of predators. Combining three components, abundance of lake trout, average number of kokanee consumed per lake trout, and prey digestion rate, we estimated weekly consumption of kokanee using Equation 3.

Equation 3. Weekly lake trout consumption of kokanee in Big Arm Bay.

$$K_x = L_x * A_x * \frac{168}{\hat{t}}$$

Where,

K_x = number of kokanee consumed by lake trout in week x.

L_x = number of lake trout in Big Arm Bay in week x.

A, = average number of kokanee per lake trout in week x.

and

t = time period (h) kokanee are identifiable in stomach samples after consumption.

Summer/Fall Kokanee Distribution

FWP conducted a survey in 1994 to estimate escapement of spawning kokanee in the Flathead River. On October 17 and November 15, we inspected 11 of 12 monitoring areas, as well as other historical spawning and staging sites below the confluence of the South Fork and the main stem Flathead River and above the Old Steel Bridge in Kalispell. We conducted visual observations from jet boat, following a proven methodology (Clancey and Fraley 1986). Hungry Horse Dam discharged minimal water to accommodate the survey.

On November 18, 1994, CSKT and FWP surveyed traditional kokanee spawning areas on the east shore of Flathead Lake. Crews checked 13 areas, following proven methodology (Beattie and Clancey 1987). Visual observations were conducted from boat during optimal conditions.

Using combinations of electrofishing, gill netting, and snorkeling we surveyed McDonald Creek (Glacier National Park), Mill Creek (Creston National Fish Hatchery), and the Swan River, downstream of Bigfork Dam. We collected kokanee, recorded lengths and weights, and analyzed vertebrae for oxytetracycline marks.

RESULTS AND DISCUSSION

1993 Monitoring

Monitoring the 1993 kokanee stocking revealed a high incidence of stocked kokanee in lake trout stomach samples. We concluded that stocked yearling kokanee were highly susceptible to lake trout predation in Flathead Lake. In areas adjacent to stocking locations, a high percentage of lake trout consumed stocked kokanee. One week after stocking, 62 percent of captured lake trout contained kokanee, averaging 2.3 kokanee per lake trout. After the second week, 46 percent of lake trout captured contained kokanee, averaging 1.7 kokanee per lake trout.

We concluded that lake trout predation was extremely high and believe it precluded significant survival of stocked kokanee. Based on monitoring results in 1993, we concluded that the primary source of mortality for stocked kokanee in Flathead Lake was lake trout predation. Therefore, the 1994 monitoring emphasized quantification of lake trout predation.

1994 Stocking and Net Pen Evaluation

Between June 6 and June 10, 1994, a total of 802,174 kokanee were stocked into Big Arm Bay. Observations of mortality at the ramp after stocking indicated that less than 1,000 fish (0.1 percent) died as a direct result of stress related to hauling and stocking. Many came from one truckload on the first day, which suffered stress-related losses due to overloading. Subsequent loads were carried at lower densities.

Prior to stocking, the average length of 150 fish was 162.8 mm (6.4 in), with a range of 102 to 221 mm (4.0 to 8.7 in). Average weight was 40.5 grams (0.09 lb), with a range of 12 to 106 grams. The average condition factor of the 150 sampled fish was K=87.7 (C=31.7). Examination of 17 marked fish prior to stocking indicated all had clearly identifiable double tetracycline marks.

After 72 hours, we counted all fish in the net pens and measured and weighed a random sample of 25 fish (Table 3). The two pens contained a total of 278 Jive fish and two dead ones. Because fish were not counted at the time they were placed in the pen, we could not directly assess post-planting mortality. However, all fish that died near the boat ramp at the time of planting were observed to sink to the bottom and it is believed that mortalities in the net pen probably did likewise. The live fish tended to stay on the bottom of the pen as well, leading us to believe that mortality from gulls and other surface-feeding birds was minimal. Live fish appeared healthy. We believe that initial post-planting mortality was probably less than 1 percent (2/280 = 0.7 percent). Several live fish were necropsied and their stomachs contained small quantities of zooplankton. A total of 100 fish were returned to each pen for further evaluation of survival.

Fish were again sampled after 13 days in the net pens. Surface water temperature was **16.6°C.** A total of 208 live fish and 4 dead ones were removed; apparently the original counts of 200 fish were in error. Mortality in the 10-day period was 1.9 percent (4/2 12). The average condition factor of a 50 fish subsample was nearly identical to that of the initial pre-planting inventory (Table 3). Fish in the pens were observed to be actively schooling, with occasional surface activity that simulated feeding behavior.

Table 3. Average length (mm), weight (g), and condition factor (K) of kokanee held in Flathead Lake net pens during June and July, 1994.

Date	Sample Size	Mean Length (mm)	Mean Weight (g)	Mean Condition (K)
6/10	150	162.8	40.5	87.7
6/13	25	176.8	49.6	86.4
6/23	50	166.0	42.2	87.6
7/13	93	175.8	48.8	87.6

On June 29 or 30, a strong wind dislodged the net pen and caused it to drift approximately five km east, where it was located and re-anchored in the trough between Wild Horse and Melita islands (Figure 2). On July 1, the fish appeared healthy and no mortalities were found in the bottom of the pen.

On July 13, after 33 days, the net pen experiment was concluded. The surface temperature had reached **(63.5°F)** at the site. A full inventory was conducted and 187 Jive fish were examined. With the exception of some descaling, all fish appeared healthy. There were no dead fish in the net and marks consistent with merganser attacks on some of the live fish led us to conclude that the 21 fish removed from the net since June 23 (a 20day period) were probably removed by mergansers, or perhaps had jumped out of the pen, but were probably not natural mortalities due to conditions in the pen. A total of 93 fish inventoried on July 13, had an average length of 175.8 mm, average weight of 48.8 g, and average condition factor (K) of 87.6, which was identical to the prestocking condition factor (Table 3). Fish were observed to be in excellent health with ample body fat. Stomachs of five fish examined contained substantial amounts of zooplankton. The flesh of the net-penned fish remained white, with little evidence of conversion to the pink or orange coloration typical of natural lake kokanee populations.

Growth Rate and Early Maturation

On August 10, 1994 a sample of 37 kokanee captured in gill nets in Big Arm Bay averaged 216 mm (8.5 in) in length with a range of 183 to 264 mm. The four largest fish were maturing "jack" males. Average weight was 93.5 g (0.21 lb) with a range of 50 to 177 g. The average condition factor (K) was 90.1 (C=32.6). Two months post-stocking, the average length of these fish was 53 mm greater than the average at stocking, average weight was double that at stocking, and condition factor was slightly higher. The flesh of these fish had turned pink, an indication of conversion to a zooplankton diet.

The development of early-maturing "jack" males in the population is a common occurrence in both hatchery and wild stocks of salmonids. In 1993, the captive kokanee brood population held at Creston Hatchery produced about 12.7 percent jack males. These fish showed strong external secondary sex differentiation by early September. Less than 0.5 percent of the females matured early. These males underwent normal sexual maturation, producing milt by late November, and died in late December and early January. The "jacks" were typically the largest fish in the population, averaging 281 mm in length on September 3, 1993, as compared to 210 mm average length in the non-maturing fish. This pattern of early maturation in kokanee, related to size, has been noted by others conducting experimental work with hatchery kokanee (Martinez and Wiltzius 1991). The percentage of "jack" males was 12.7 in the 1994 broodstock held at Creston Hatchery, the same lot of fish as those stocked into Big Arm Bay. Since maturity is believed to be determined in spring of the year in which maturation occurs (Scott Patterson, Idaho Fish and Game, pers. comm. 1993), we can assume that about 12.7 percent of the stocked fish would be "jacks" in the fall of 1994.

Average lengths of kokanee captured in gill nets increased from 185 mm at time of release, to 229 mm 14 weeks after release (Figure 3). Two mature males were caught in October that averaged 3 10 mm. This change in average length can be assumed to equate to growth; however, smaller kokanee may be more vulnerable to predation and less vulnerable to capture in gill nets.

Zooplankton Abundance

Zooplankton abundance was monitored bimonthly or monthly during 1994, at the mid-lake deep water sampling station from mid-May through late October (D. Chess, pers. comm. 1995). Density of ***Daphnia thorata*** peaked in a June 29 sample at 2.33 organisms per liter. Samples collected from June 6 through September 22 were consistently in the range of 0.5 ***D. thorata*** per liter or higher. In general, these levels are higher than they have been in recent years, reflecting a better than average food supply for kokanee stocked in 1994.

The total adult crustacean zooplankton density (consisting of aggregate values for the most common species) peaked at 16 organisms per liter on May 16, and ranged as low as 4 organisms per liter; again generally higher than in recent years. ***Mysis*** densities averaged 26.3 per square meter in 1994, midway in the range of 16.1 to 37.4 ***Mysis*** per square meter found in 1989-1993 (D. Chess, pers. comm. 1995).

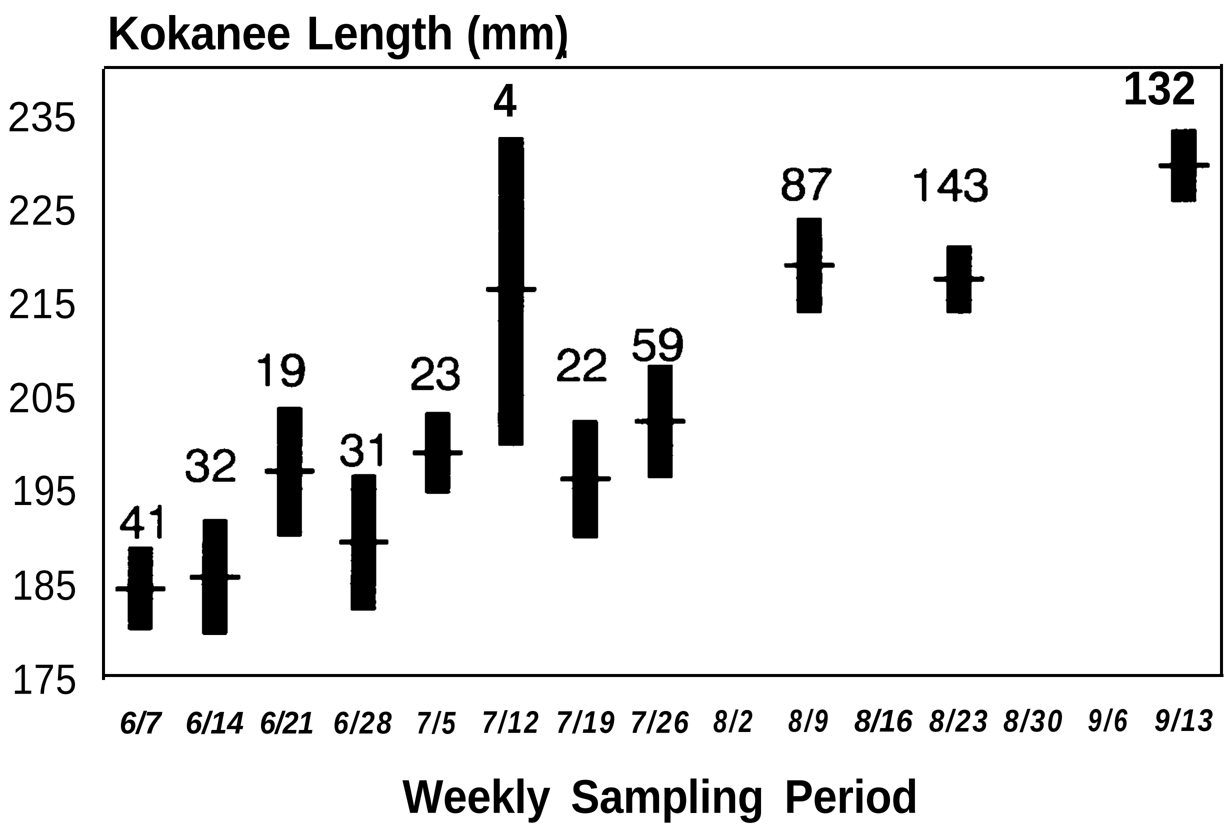

Figure 3. Average and range of lengths of kokanee captured in gill nets in Big Arm Bay, 1994. The bars represent 95 percent confidence intervals and the superscripts represent sample sizes. No samples were collected in those weeks for which no data is presented.

Temperature Monitoring

Water temperatures fluctuated very little in Big Arm Bay during the period May 23 through June 16, the immediate pre- and post-stocking period (Table 4). Surface waters were 11.3 to 11.9°C and temperature declined very gradually to the bottom, with a minimum of 5.2 to 5.6°C at depths of 30 to 33 m By the end of June, weak stratification had begun and the epilimnion had warmed to 11 m of depth. The thermocline, at 11 to 13 m depth, strengthened during July and August with mid-August water temperature exceeding 20°C in the upper 10 m of surface water. By early to mid-September surface waters had cooled to about 17°C and water in the upper 15 meters was nearly isothermal. Bottom temperatures increased gradually throughout the season, peaking during the last reading in September at nearly 8°C.

At the Wild Horse Island station (Table 4), thermal conditions were similar to those further west in the bay, but profiles were more erratic (both temperatures and depth); probably a result of less uniform bottom topography and/or less precise location of the sampling site. A strong thermocline formed earlier, by June 16 at this location at about 15 meters depth, and remained through early September. Surface temperatures peaked at 2 1.4°C with bottom readings as high as 10.4°C.

Kokanee, lake trout, and lake whitefish all exhibit strong preferences for cold waters. In most lakes, including Flathead Lake historically, kokanee spent summer months suspended at or below the thermocline. Based on the 1994 thermal monitoring results, it is likely kokanee would have been distributed at a depth of 10 meters or deeper in this portion of the lake from late June through early September.

Estimation of Lake Trout Abundance

Mark/Recapture Method

A total of 1,124 lake trout were captured in 442 gill net sets (Figures 4 and 5). We marked 352 lake trout prior to the release of the kokanee on June 6, 1994, and recaptured 15 of them during the entire period of monitoring (June 8-October 21) (Table 5). We were not able to estimate the total lake trout abundance in Big Arm Bay using the mark/recapture technique. Unquantified violations of the underlying assumptions of the mark/recapture precluded its use for estimating lake trout abundance. For example, marked fish and recaptured fish had dissimilar length-frequency distributions. Of the 15 recaptured fish, the smallest was 685 mm in length, which was longer than 67 percent of the fish that were marked. The assumption of a "closed population" was violated by emigration out of the study area, as indicated by recapture of marked fish by anglers outside of the study area. Such movement was illustrated by one lake trout (774 mm) tagged in Area B on June 2, 1994, and recaptured in Woods Bay on July 25, 1994, and by another (580 mm) tagged in Area Eon May 17, 1994, and recaptured in the Swan River, near the town of Bigfork on June 15, 1994. Also, marked fish possibly suffered greater mortality than did the unmarked fish due to the trauma experienced in the gill nets. We attempted to minimize this bias by only marking and releasing those fish we thought had a high likelihood of survival.

Table 4. Thermal profiles in Big Arm Bay and at a site north of Wild Horse Island during the 1994 kokanee test monitoring period.

DEPTH (Meters)	DATE 5/23	6/3	6/16	6/29	7/19	8/10	9/13
BIG ARM BAY STATION							
0.0	11.9	11.5	11.3	16.7	18.6	22.0	17.4
1.0	11.8	11.4	11.2	16.5	18.5	22.0	17.4
3.0	11.5	10.7	10.7	16.4	18.5	22.0	17.4
5.0	11.1	10.4	10.5	15.7	17.8	22.0	17.4
7.0	10.5	9.9	10.4	15.1	17.5	22.0	17.4
9.0	10.0	9.7	9.7	14.1	14.9	21.3	17.3
11.0	9.6	9.4	8.8	12.6	13.6	19.1	17.3
13.0	9.2	9.2	8.4	11.6	12.6	15.0	17.3
15.0	8.6	8.4	7.3	10.6	10.5	11.8	17.3
18.0	7.5	7.4	6.9	8.6	9.1	10.6	13.3
21.0	6.7	6.4	6.6	7.2	7.9	8.5	10.7
24.0	6.1	6.1	6.3	6.9	7.5	7.9	9.1
27.0	5.3	5.9	5.8	6.0	7.3	7.7	8.6
29-33 BOTT.	5.2	5.6	5.5	NA	6.5	7.3	7.8
WILD HORSE ISLAND STATION							
0.0	11.6	12.0	12.4	16.3	18.5	21.2	17.3
1.0	11.4	12.0	12.4	16.2	18.4	21.4	17.3
3.0	11.0	11.7	12.4	15.9	18.1	21.3	17.3
5.0	9.1	11.5	12.3	15.1	17.9	21.1	17.3
7.0	8.9	10.5	12.3	14.8	17.5	21.1	17.3
9.0	8.9	10.2	12.3	13.7	17.2	21.0	17.3
11.0	8.9	9.8	12.3	12.6	16.4	20.5	17.2
13.0	8.2	8.8	12.2	11.9	14.4	19.3	17.2
15.0	6.5	7.4	12.2	11.5	12.8	15.9	17.2
18.0	6.0	6.6	12.0	10.9	12.4	11.0	16.8
21.0	5.3	6.2	11.1	9.7	11.8	8.5	10.1
24.0	5.0	5.7	9.9	8.7	10.4	7.8	9.3
27.0						6.5	7.3
30.0 BOTT.						6.6	6.1

Eight lake trout were recaptured between June 8 and July 31, but all were greater than 680 mm TL. The recapture success in the greater than 680 mm TL length group permitted us to apply the mark/recapture method, but only to the larger length group. Estimating only the larger lake trout did not meet the objective of quantifying lake trout abundance and mortality of kokanee, but provided a reference for judging the accuracy of the hydroacoustic-based estimate. We estimated that 2,238 (S.D. = 684) lake trout greater than 680 mm TL were present in Big Arm Bay on June 7, 1994. This estimate was not directly comparable to the estimate derived from the hydroacoustic survey since the length group separations were different, but the relative magnitude of the two estimates was similar.

Table 5. Lake trout tagged and recaptured in Big Arm Bay during the study period, May through October, 1994.

Date Marked	Area	Length (mm)	Date Recaptured	Area
5/18/94	G	807	6/08/94	B
5/18/94	G	685	6/14/94	G
5/19/94	F	955	6/16/94	G
5/23/94	E	967	6/30/94	A
5/24/94	C	836	6/29/94	D
5/25/94	E	735	9/16/94	B
5/26/94	E	690	6/01/94	G
5/26/94	B	791	6/28/94	G
5/26/94	B	845	10/20/94	C
5/31/94	G	920	7/07/94	F
6/01/94	H	749	6/04/94	C
6/07/94	G	885	6/23/94	B
6/08/94	B	837	9/16/94	C
6/16/94	B	840	7/12/94	B
6/21/94	G	925	9/16/94	B

<u>Information from Species Other than Lake</u> <u>Trout</u>

Other fish species collected during gill net sampling included lake and mountain whitefish ***(Prosopium williamsoni),*** bull and cutthroat trout, peamouth, northern squawfish, largescale and longnose suckers, kokanee, and yellow perch. Lake whitefish were the most abundant fish in the nets, with catch rates generally five times that of lake trout (Figure 6).

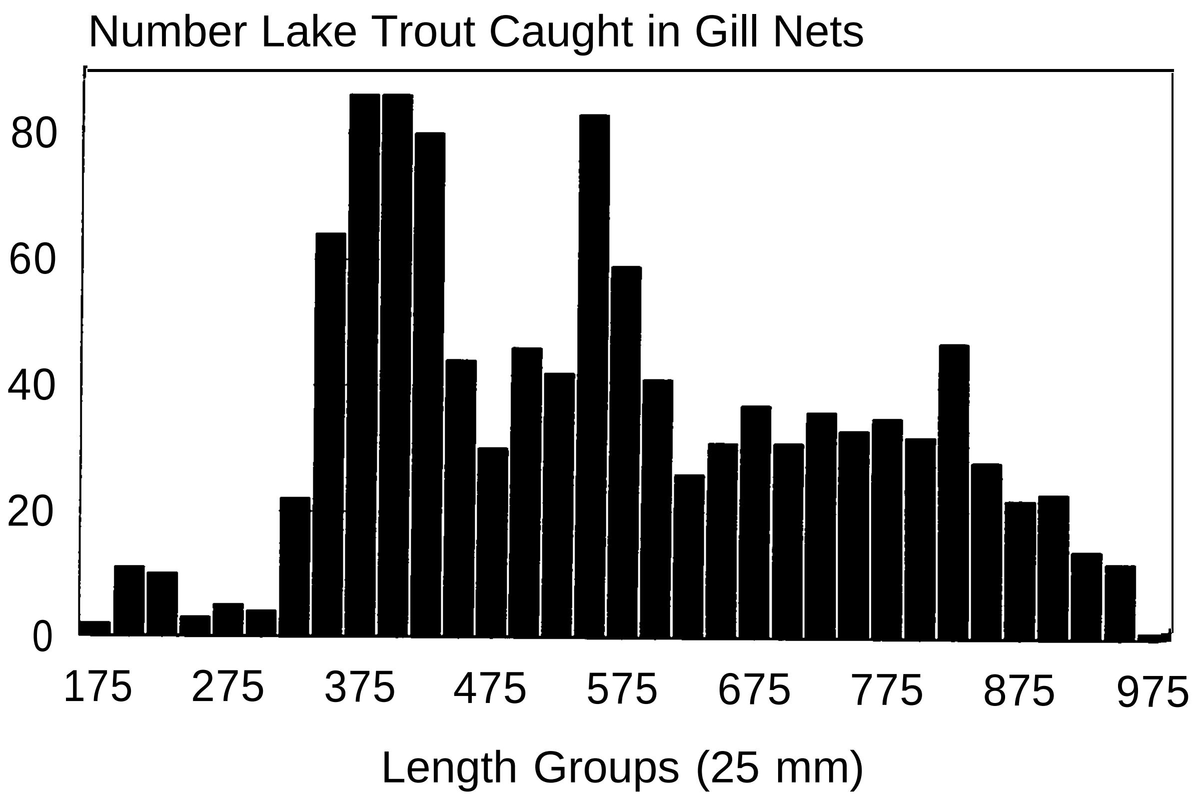

Figure 4. Length-frequency distribution of lake trout caught in gill nets in Big Arm Bay, Flathead Lake, 1994.

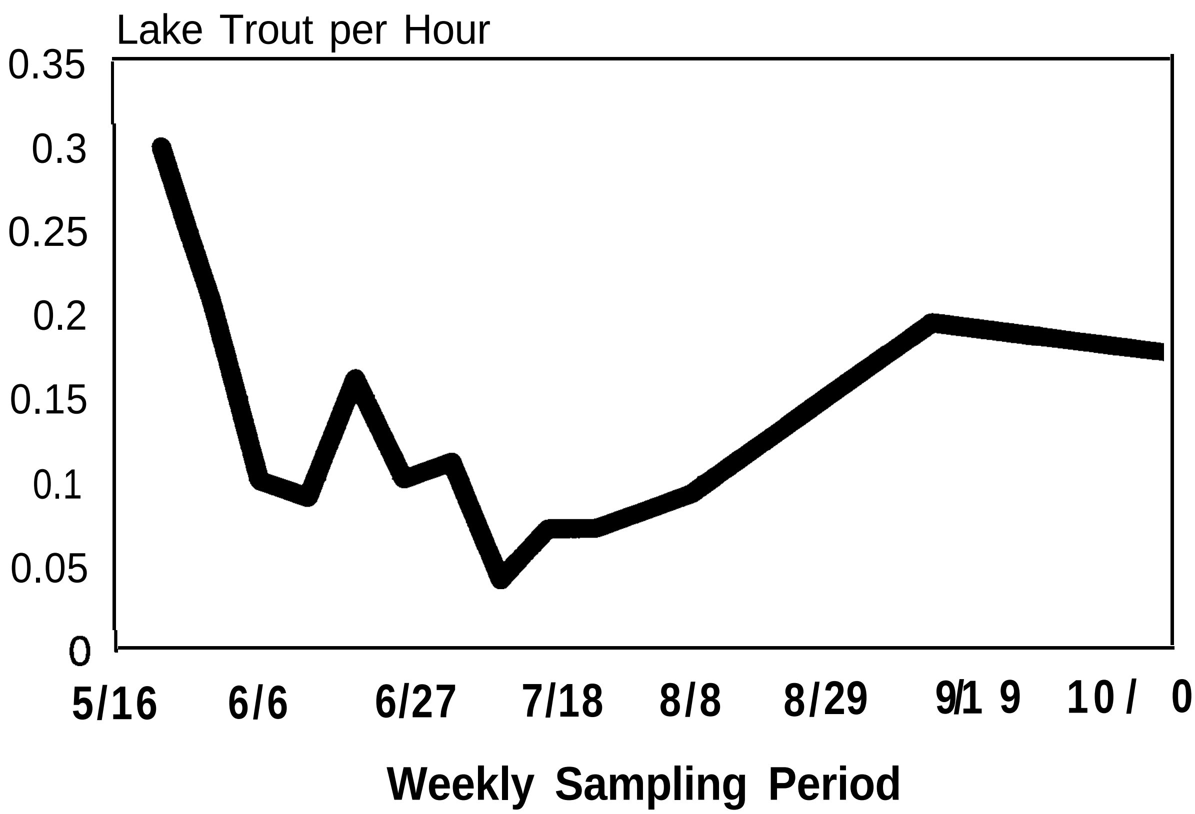

Figure 5. Average number of lake trout caught per hour (fish/net/hour) in gill nets in Big Arm Bay, May through October, 1994.

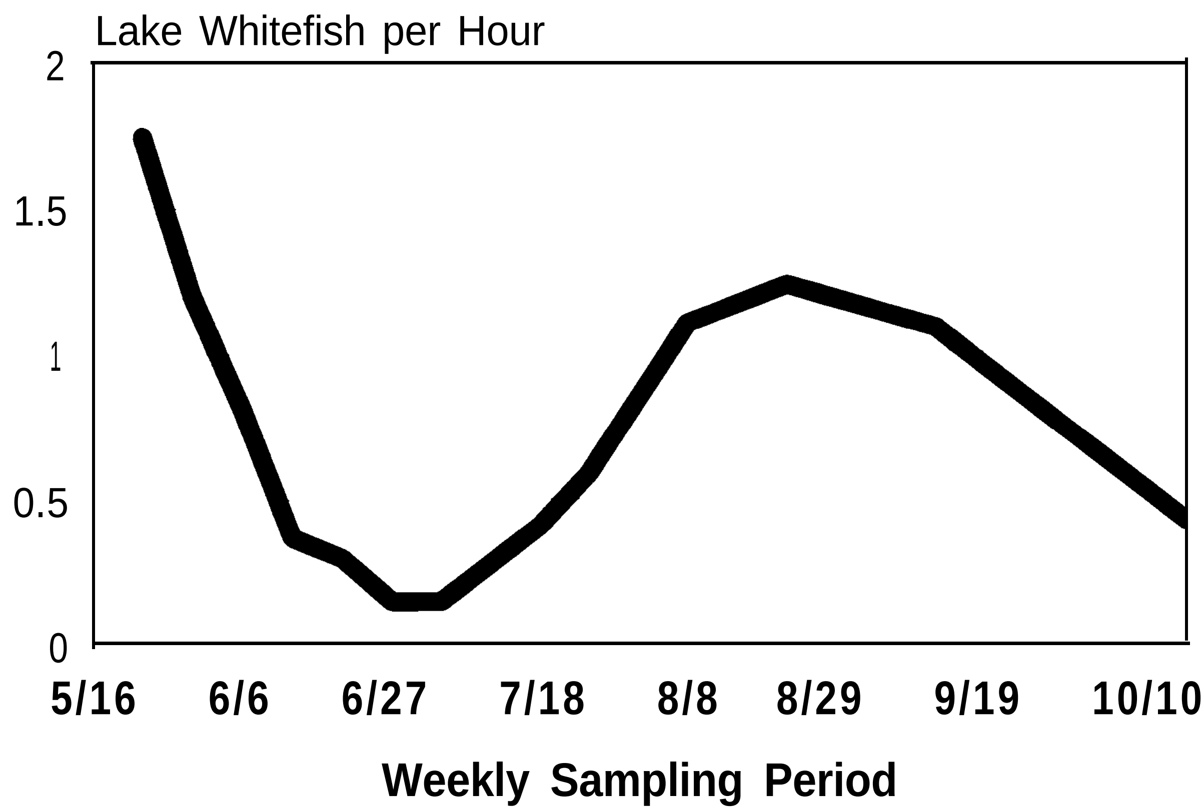

Figure 6. Average number of lake whitefish caught per hour (fish/net/hour) in gill nets in Big Arm Bay, 1994.

Kokanee were first caught in our gill nets on June 7, 1994, one day after the initial release of kokanee at the Big Arm boat ramp. Catch rates of kokanee were low through June and July, but increased through August and September (Figure 7) The variance in the number of kokanee caught per net was high, but an upward trend in the number caught occurred over the study period. This trend was obviously a result of increased vulnerability to capture by gill nets as kokanee increased in length, since we knew the kokanee numbers were declining due to predation and emigration during the study period.

Hydroacoustic Method

We estimated 594,901 fish in Big Arm Bay on June 16, 1994, six days following the completion of kokanee stocking. Over 507,000 fish were in the shallow depth stratum (Table 6). We estimated over 518,000 fish less than 300 mm TL, over 62,000 fish with total lengths between 300 and 460 mm TL and 13,000 fish greater than 460 mm TL. Thus, fish less than 300 mm TL comprised over 87 percent of targets. Because gill nets were less effective in sampling small fish (< 300 mm TL), we did not distinguish fish species for targets with estimated lengths less than 300 mm TL.

We estimated fish density by surface area in three depth strata, horizontal stacked layers, each 12.2 m in depth. The estimated surface area of Big Arm Bay was 4,569 hectares (17.6 square miles). The surface area with depth stratum of 12.2 to 24.4 m covered roughly 83 percent (3,784 hectares) of the bay. The stratum with depths over 24.4 m covered over 57 percent (2,618 hectares) of the total surface area.

Acoustic target density decreased with increasing fish size (Table 7). The smallest size group (less than 300 mm) comprised the greatest proportion of targets in all three depth strata, while the size group with the largest fish (greater than 460 mm) had the lowest proportions. Targets ranged from -64 to -24 dB in strength.

Highest fish densities were observed in transects located in the main body of the bay, east of Big Arm State Park, and one transect east of **Melita** Island. Along transects, densities in the shallow interval ranged from 1.2 to 29.3 fish per square meter surface area. Fish densities ranged from 0.1 to 3.3 and from 0 to 1.8 fish per square meter surface area in the intermediate and deep strata, respectively. Weighted mean fish densities were 11.11, 1.85, 0.65, and 0.06 fish per square meter for depth intervals, 0 to 12.2, 12.2 to 24.4, 24.4 to 36.6, and over 36.6 m, respectively. We combined the two deepest strata, 24.4 to 36.6 m and greater than 36.6 m, after estimating fish abundance.

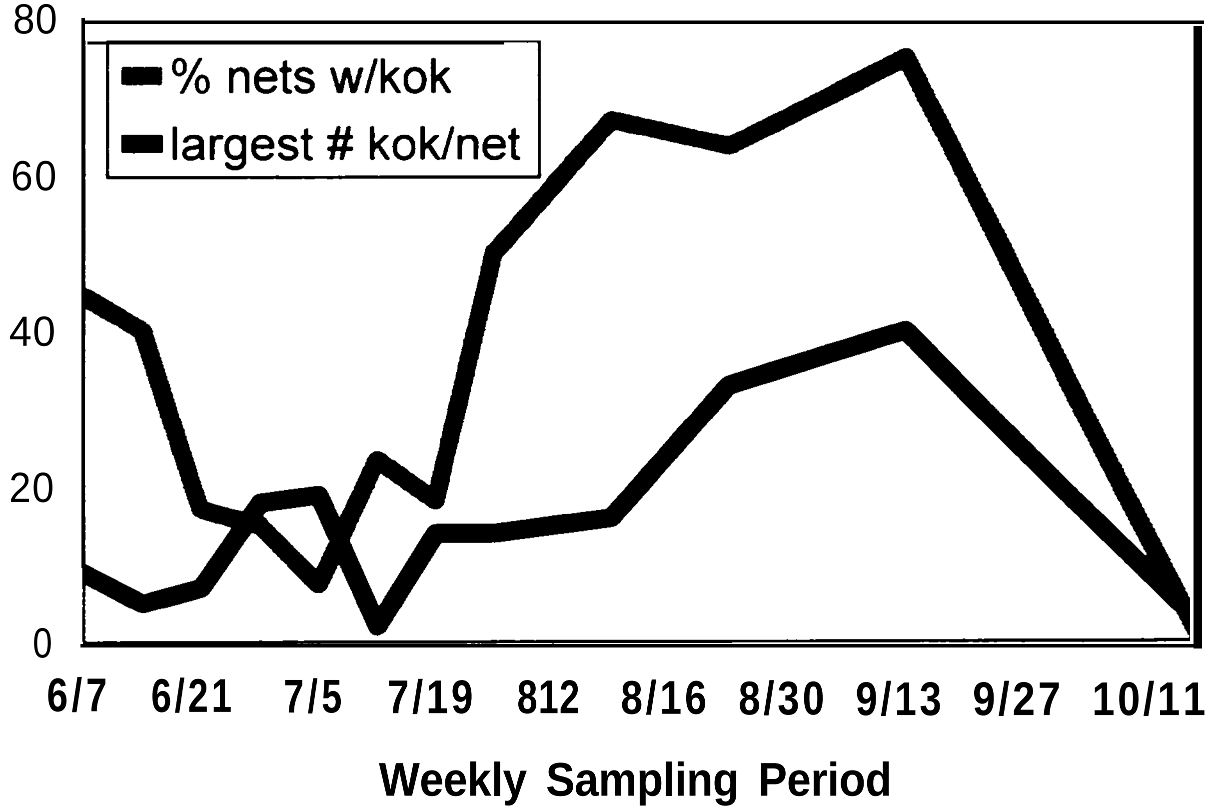

Figure 7. Kokanee captures in gill nets expressed as percent of nets with kokanee and as the largest number of kokanee per net per weekly sampling period in Big Arm Bay, 1994.

Table 6. Estimates of fish abundance in three depth strata and three length groups for Big Arm Bay, June 16, 1994.

Depth Stratum (m)	Estimated Fish Number			
	Total	<300 mm	300-460mm	>460 mm
0 - 12.2	507,622	455,509	50,183	1,930
12.2 - 24.4	70,080	46,720	12,102	11,258
24.4 - Bottom	17,199	16,506	555	139
Combined Total	594,901	518,734	62,840	13,326

Table 7. Target strength distribution by depth stratum and fish length group, Big Arm Bay, June 16, 1994.

Fish Length Group (mm)	Proportion of Targets by Depth Stratum (m)		
	0 - 12.2	12.2 - 24.4	24.4 - Bottom
<300	0.897	0.667	0.960
300-460	0.099	0.173	0.032
>460	0.004	0.161	0.008
Total	1.000	1.001	1.000

Fish Species Composition

There were dramatic differences in species composition in gill net catches between depth strata and fish length groups (Table 8). Lake trout comprised 1, 6, and 18 percent of intermediate-sized fish in the shallow, intermediate, and deep strata, respectively. The species composition of the intermediate length group (300 to 460 mm TL) was dominated by lake whitefish and northern squawfish in the 0 to 12.2 m and the 12.2 to 24.4 m depth strata (Figure 8). Lake whitefish dominated species composition in the deep stratum.

Lake trout made up large proportions of the catch of fish over 460 mm TL in each depth stratum (Figure 9). At shallow depths, lake whitefish, largescale sucker, and lake trout comprised 50.0, 16.7, and 16.7 percent of catch, respectively. At intermediate and deep strata, lake trout dominated the catch, 53.7 and 62.4 percent, respectively, followed by lake whitefish which comprised 37.4 and 36.8 percent of catch, respectively. We captured two bull trout over 460 mm TL, no bull trout in the 300 to 460 mm range, and four bull trout less than 300 mm TL during the four week sampling period.

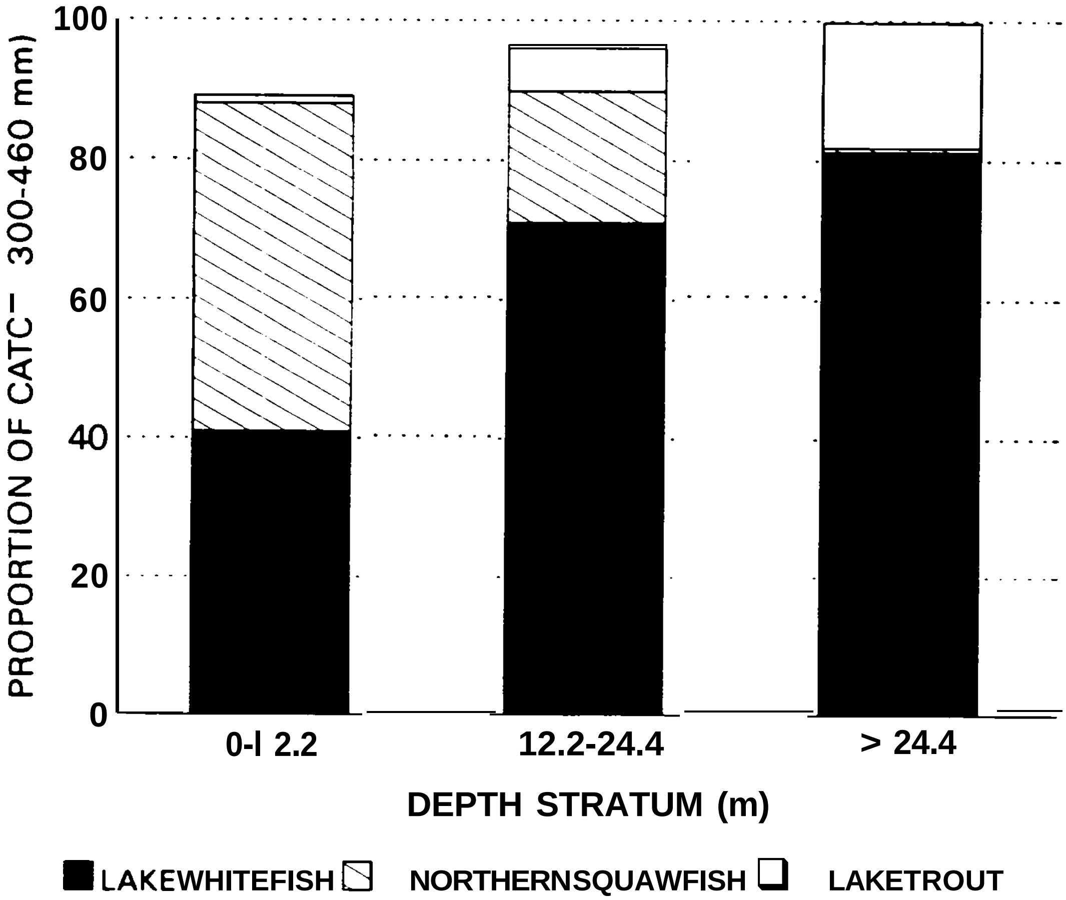

Figure 8. Proportions of fish species in intermediate size range (300 to 460 mm) captured in sinking gill nets, Big Arm Bay, June 1994.

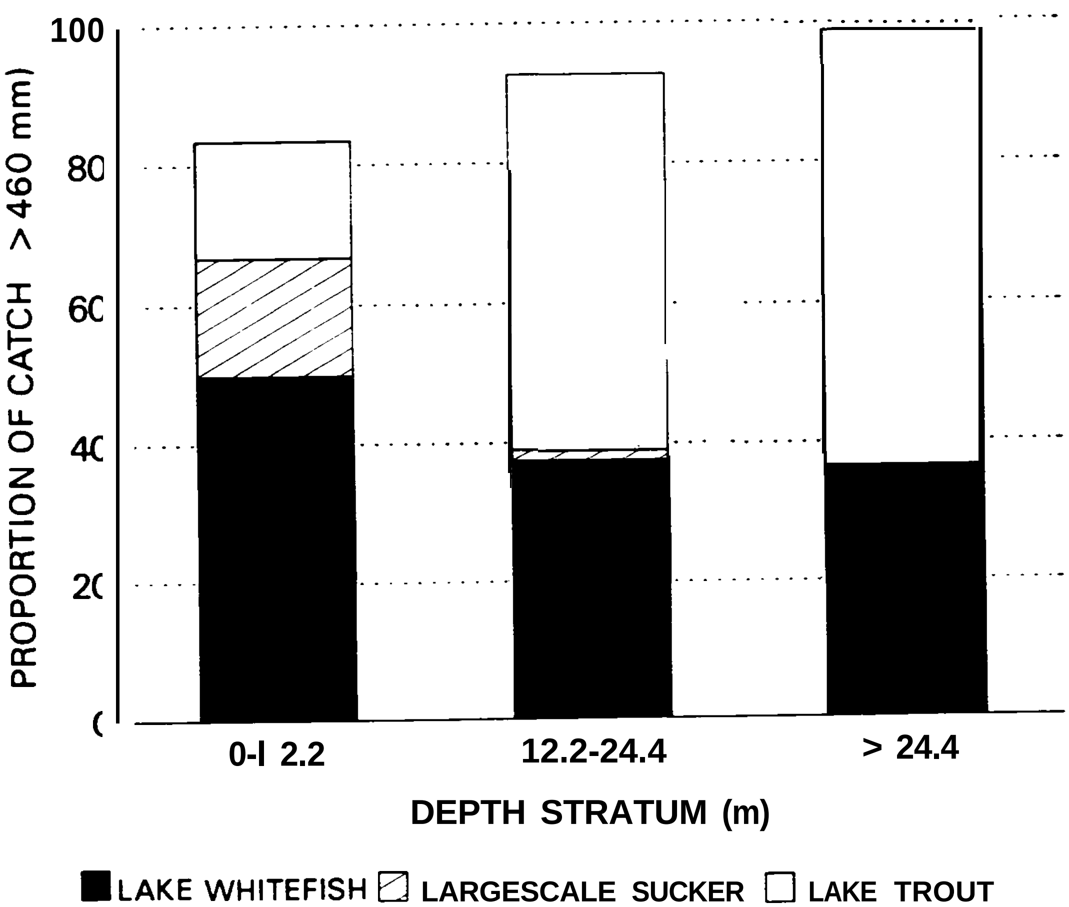

Figure 9. Proportions of fish species in large size range (> 460 mm) captured in sinking gill nets, Big Arm Bay, June 1994.

We used vertical gill nets to distinguish the fish species which produced pelagic targets. We set nets immediately following the hydroacoustic survey and captured few (17) fish in five days and nights of netting. Fish caught within two meters of the lake bottom were not included in numbers of fish captured in pelagic zones. Vertical nets captured ten kokanee and one pygmy whitefish that were all less than 300 mm TL, which was smaller than targets for which we estimated species composition and abundance. The remaining catch consisted of four lake whitefish and two lake trout, all over 300 mm TL. Lake trout were captured within four meters of the lake bottom. We did not include vertical netting results in our species composition estimates due to the limited catch. The species of the larger fish caught (lake trout and lake whitefish) were better represented by our sinking gill net catches.

Table 8. Fish species composition in sinking gill nets (n = 246) fished in Big Arm Bay, Flathead Lake in June 1994.

		Depth Strata (Meters)					
		0 - 12.2		12.2 - 24.4		over 24.4	
Fish Species	**Length Group (mm)**	**n**	**% Catch**	**n**	%Catch	**n**	% Catch
Bull Trout	300-460	0	0.0	0	0.0	0	0.0
	>460	0	0.0	1	0.53	1	0.85
Lake Trout	300-460	2	1.09	52	6.20	60	17.91
	>460	2	16.67	102	53.68	74	62.39
Lake Whitefish	300-460	75	40.98	595	70.92	272	81.19
	>460	6	50.0	71	37.37	43	36.44
Peamouth	300-460	7	3.83	13	1.55	0	0.0
	>460	0	0.0	0	0.0	0	0.0
N. Squawfish	300-460	86	47.00	158	18.83	2	0.58
	>460	1	8.33	12	6.32	0	0.0
Longnose sucker	300-460	11	6.01	16	1.91	1	0.30
	>460	1	8.33	1	0.53	0	0.0
Largescale Sucker	300-460	2	1.09	5	0.60	0	0.0
	>460	2	16.67	3	1.58	0	0.0

Estimated Fish Abundance

We estimated the number of fish in length groups 300 to 460 mm and over 460 mm for seven fish species by combining species composition from gill net surveys with fish abundance estimates from hydroacoustics (Table 9). Lake whitefish and northern squawfish dominated total fish number and numbers of fish in the 300 to 460 mm size range. Lake trout and lake whitefish dominated the over 460 mm length range.

In Big Arm Bay, we estimated a total of 7,850 lake trout greater than 300 mm TL, with 82 percent (6,452) over 460 mm TL The majority of the lake trout (6,794) were found in the 12.2 to 24.4 m depth stratum. In the longer length group (> 460 mm TL), we estimated 60 bull trout and 872 northern squawfish We estimated zero bull trout in the 300 to 460 mm range because gill netting produced no bull trout in this length range, over the four week sampling period.

Over 518,000 fish targets had strengths representing lengths less than 300 mm. During acoustic sampling, all kokanee captured in nets were smaller than 300 mm. We did not produce an estimate for kokanee remaining in Big Arm Bay.

Table 9. Estimated abundance of fish over 300 mm TL from gill netting and hydroacoustic surveys in Big Arm Bay, June 16, 1994.

Species	Total Estimate	300 to 460 mm Estimate	>460 mm Estimate
Lake Trout	7,850	1,398	6,452
Lake Whitefish	34,823	29,600	5,223
N. Squawfish	26,737	25,866	872
Peamouth	2,107	2,107	0
Bull Trout	60	0	60
Longnose Sucker	3,469	3,249	220
Largescale Sucker	1,120	621	499

Lake Trout Food Habits

Stomach Sampling

We sampled stomachs from 475 lake trout (> 300 mm TL) in June and July, and 673 stomachs over the entire five month sampling period (June-October). In June and July, 27 percent (129) of stomach samples were empty, with 32 percent (215) being empty over the five-month period.

We observed a high incidence of stocked kokanee in lake trout stomach samples. In the southern half of the bay (Areas B, H, C, and D on Figure 2), over 50 percent of lake trout captured in the first week contained kokanee. In the northern half (areas A, G, E, and F), roughly 29 percent of lake trout contained kokanee in the first week. Over the entire bay, roughly 40 percent of lake trout contained kokanee during the week following stocking (Table 10).

In the second week after stocking, the proportion of lake trout which contained kokanee and incidence of kokanee per lake trout peaked at 70.3 percent and 2.99, respectively (Table 10). These values declined during the following six weeks. Trends in kokanee per captured lake trout and proportion of lake trout containing kokanee were similar in both the northern and southern halves of the bay. Few individual lake trout contained more than ten kokanee. However, one lake trout (680 mm TL) consumed 21 kokanee, while other individuals contained 15, 13, and 11 kokanee. Of the lake trout containing kokanee, the mean and median number of kokanee per lake trout was three (S.D. = 1.5) over the eight-week sampling period. Four weeks after stocking, we found few lake trout which contained more than three kokanee per stomach sample. We completed netting in October, over four months after stocking kokanee. We captured lake trout which contained kokanee in stomach samples throughout the sample period.

Other investigators found that yearling kokanee were susceptible to predation by lake trout. In lakes in Idaho, lake trout selected kokanee 150 mm to 200 mm in length more often than larger or smaller fish (Rieman and Myers 1991). As kokanee attained these lengths, they became prey items preferred by lake trout. Lake trout in Flaming Gorge Reservoir selected forage fish (kokanee, rainbow trout, and utah chub) in a wide range of sixes. Lake trout less than 600 mm in length selected prey size with a mean length of **118 ± 59** mm and length range of 23 to 268 mm. Lake trout greater than 600 mm selected prey size which had a mean length of **263 ± 69** mm and length range of 198 to 425 mm TL (Yule and Luecke 1993).

Following stocking, kokanee were abundant in Big Arm Bay. Stocked kokanee made up over 81 percent, by number, of identifiable prey fish found in lake trout stomachs over the five-month sampling period (Figure 10). In the early 198Os, when kokanee were abundant in Flathead Lake, kokanee and whitefish dominated lake trout prey items (Leathe and Graham 1982). Other investigators have found that when available, kokanee accounted for the majority of large lake trout prey items (Yule and Luecke 1993, Rieman et. al 1979). In Big Arm Bay, lake whitefish were the second most numerous identifiable fish prey. Based on ratios of identified species (Figure **10),** it is likely that a proportion of unidentified fish were lake whitefish. However, few or none were believed to be kokanee, because we did not find oxytetracycline marks on vertebrae of unidentified fish. The mean total length of lake whitefish in stomach samples was 319 mm (SD. = 96.5 mm, n = 90). Lengths of lake whitefish prey ranged from 100 to 480 mm. Yellow perch, redside shiner, lake trout, sculpin, peamouth, sucker, and northern squawfish comprised the other identifiable prey fish species (Figure 10). Notable large prey were a 470 mm lake trout and a 480 mm sucker found in 878 mm and 901 mm lake trout, respectively. Large lake trout utilized prey fish with lengths up to and slightly over half their total length. Fish prey lengths ranged from 22 to 480 mm.

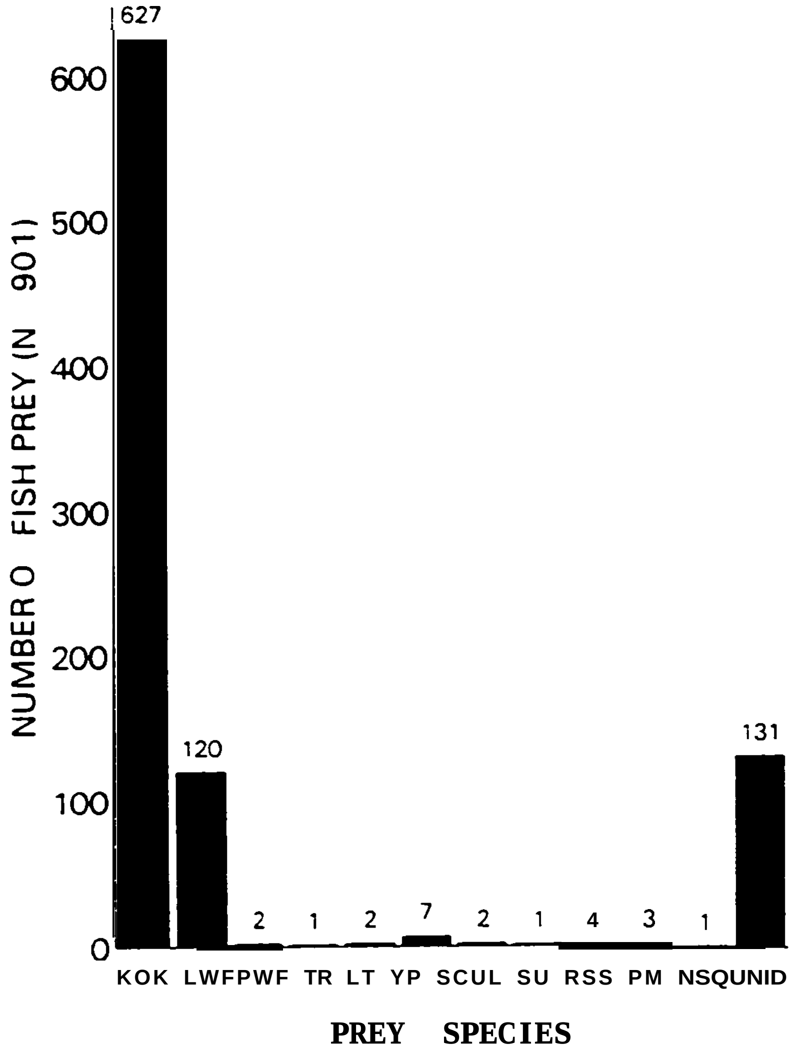

Figure 10. Number of fish prey items, **by** species, present in 685 lake trout captured in Big Arm Bay, Flathead Lake, summer 1994 (KOK = Kokanee, LWF = Lake Whitefish, PWF = Pygmy whitefish, TR = Unidentified Trout, LT = Lake Trout, YP = Yellow Perch, SCUL = Sculpin, SU = Longnose and Largescale Suckers, RSS = Redside Shiner, PM = Peamouth, NSQ = Northern Squawfish, UNID = Unidentified Fish Species).

Table 10. Weekly totals for number of kokanee observed in lake trout (>300 mm TL) stomach samples from Big Arm Bay, Flathead Lake, 1994.

Week	No. Lake Trout Captured	Lake Trout Containing Kokanee		Total No. Kokanee in Lake Trout	Avg. No. of Kokanee/ Lake Trout
		N			
6/6 - 6/12	73	29	39.7	77	1.06
6/13 - 6/19	74	52	70.3	221	2.99
6/20 - 6/26	97	37	38.1	106	1.09
6/27 - 7/3	87	52	59.8	130	1.49
7/4 - 7/10	59	17	28.8	35	0.59
7/11 - 7/17	22	5	22.7	9	0.41
7/18 - 7/24	36	10	27.8	15	0.42
7/25 - 7/31	27	3	11.1	6	0.22
8/8 - 8/14	31	5	16.1	6	0.19
8/22 - 8/28	59	5	8.5	7	0.12
9/12 - 9/18	56	7	12.5	11	0.20
l0/17 - l0/23	52	4	7.7	4	0.08

‘Reduced netting effort.

We also observed non-fish prey items in lake trout stomach samples. ***Mysis*** and dipteran pupae were found frequently and comprised the majority of non-fish items. We found crayfish, amphipods, ***Daphnia,*** and aquatic insects, including ***Coleoptera, Ephemoroptera, Odonara,*** and ***Homoptera.***

The incidence of stomach samples which did not contain fish prey and those which contained only kokanee varied inversely during the sampling period (Table 11). For the sampling period, over 44 percent of lake trout stomachs did not contain fish prey. In June, we observed the lowest percentage of stomachs without fish contents, and in October we saw the greatest percentage. This increasing trend may have been partially due to the decreasing availability of kokanee (Table 11). There was a decreasing trend in percentage of lake trout samples which contained only kokanee and no other fish prey (Table 11). This trend was also believed to be partially due to decreasing kokanee abundance in the bay.

Table 11. Lake trout (>300 mm TL) stomach samples which did not contain fish prey or contained only kokanee from Big Arm Bay, 1994.

Month	No. of Lake Trout Sampled	% Lake Trout Without Fish Prey	% Lake Trout With Only Kokanee as Fish Prey	Combined % Lake Trout Without Fish Frey or With Only Kokanee
June	325	31	40	71
July	150	45	19	64
August	90	53	14	68
September	56	71	9	80
October	52	77	6	83
Combined'	673	44	27	71

'Combined values influenced by greater sampling effort in June and July.

Combining the number of lake trout not containing prey fish items and those with only kokanee in stomach contents gave the portion of lake trout which may not have contained prey fish if kokanee were absent (Table 11). Over the June through October sampling period, there was an increase in percentage of lake trout without fish, excluding kokanee. As the bay became thermally stratified, non-kokanee forage fish probably became less available to lake trout in Big Arm Bay.

Stomach Lavage Test

To determine the effectiveness of lavage, we visually examined stomachs from 31 lake trout, over a wide range of sixes, following field application of lavage. Ninety-seven percent (30/31) of the stomachs were empty after the lavage process. We found two dipteran pupae in the stomach which was not completely flushed.

We lavaged lake trout ranging from 340 to 970 mm TL (13.4 to 38.2 in). We successfully removed small prey items such as ***Mysis*** shrimp, aquatic insect larvae, ***Gammarus*,** and larger prey items, including fish up to 480 mm TL. Regurgitated fish included lake whitefish, suckers, yellow perch, redside shiner, peamouth, kokanee, and trout.

Estimated Lake Trout Predation

Determining the number of kokanee consumed in Big Arm Bay required estimating unknown parameters in Equation 3 (page 15). These parameters were lake trout abundance, time for digestion of kokanee prey, and the average number of kokanee consumed per lake trout. We estimated lake trout abundance (fish over 300 mm TL) to be 7,850 using hydroacoustics. We assumed lake trout numbers remained constant in the bay during the eight-week sampling period. The hydroacoustic survey provided an estimate of fish abundance on one day in mid-June. Numbers may have varied from this estimate in following weeks. Estimated time for lake trout to digest kokanee prey to an unrecognizable state was 47 hours, as discussed in the report section concerning evacuation rates. We estimated kokanee mortality due to lake trout predation by weekly intervals. To include consumed kokanee, which were digested prior to or following our examination of stomach contents, we divided the number of hours in a week (168) by the evacuation rate of 47 hours and produced a factor of 3.58, which was incorporated into Equation 3. The third unknown in Equation 3 was the average number of kokanee found in lake trout stomachs each week. This was derived by examining stomach contents as discussed in the report section on lake trout stomach sampling.

Incorporating weekly averages into Equation 3 allowed us to estimate lake trout consumption of kokanee on a weekly basis (Table 12). Using the hydroacoustic abundance estimate of 7,850 lake trout, lake trout consumed 232,412 kokanee in the eight weeks following stocking.

Table 12. Estimated number of kokanee consumed weekly by lake trout in Big Arm Bay of Flathead Lake, June 6 to July 31, 1994. Lake trout abundance was estimated through a hydroacoustic survey.

Week	Date	Kokanee Per Lake Trout	No. of Lake Trout	No. of Kokanee Cod
1	6/6 - 6/12	1.06	7,850	29,789
2	6/13 - 6/19	2.99	7,850	84,028
3	6/20 - 6/26	1.09	7,850	30,632
4	6/27 - 7/3	1.49	7,850	41,873
5	7/4 - 7/10	0.59	7,850	16.581
6	7/11 - 7/17	0.41	7,850	11,522
7	7/18 - 7/24	0.42	7,850	11,803
8	7/25 - 7/31	0.22	7,850	6,183
Total				232,412

The estimated consumption of 232,000 fish in Big Arm Bay during June and July represents 29 percent of the total number of stocked kokanee (802,000). We estimated lake trout consumption of over 186,000 kokanee in the first four weeks following stocking. In week two, we estimated over 10 percent (84,000) of the total number of stocked kokanee were eaten by lake trout. We believe that 232,000 kokanee consumed by lake trout is a minimum value and underestimates kokanee mortality for the eight weeks following stocking. Barczynski and Johnson (1986) discuss several reasons acoustic estimates of fish abundance are biased towards underestimation. The hydroacoustic survey most likely under-estimates lake trout abundance due to the inability to detect targets in close proximity to the substrate The bottom echo obscures targets within one half meter of the bottom. AlI lake trout and whitefish captured in gill nets were within two meters of the bottom. Some lake trout certainly went undetected by the hydroacoustic equipment.

Another possible bias towards underestimation lies in regurgitation of stomach contents. As discussed in the previous section on stomach sampling, there were captured lake trout which had empty stomachs or did not contain fish prey items. It is possible, although unquantified, that a portion of these fish regurgitated stomach contents while trapped in gill nets. Regurgitation of kokanee would lead to a reduced occurrence of kokanee in lake trout stomachs, underestimating lake trout consumption of kokanee.

In addition, the estimate does not account for kokanee consumed in other areas of Flathead Lake, outside of Big Arm Bay. Three days after beginning stocking, we captured stocked kokanee in gill nets in the outside areas (D and E) of Big Arm Bay (Figure 2). It appears from netting results that some kokanee quickly dispersed into the main body of the lake, where we did not monitor predation. The study site in Big Arm Bay represents only ten percent of the surface area of Flathead Lake. Big Arm Bay, due to relatively shallow depths, has historically been considered to have lower lake trout abundance than other areas of the lake. Kokanee moving outside of Big Arm Bay, into deeper areas of the lake, likely came into contact with lake trout in greater densities than we estimated in Big Arm Bay.

The intensive monitoring in this study spanned the first two months following kokanee stocking. It will take an additional 14 months for stocked kokanee to reach maturity. During this time, kokanee will be subjected to predation by lake trout. We intensively monitored only 12 percent of the time period stocked kokanee will be in Flathead Lake.

Other Predators

In addition to lake trout, northern squawfish, and bull trout are two large piscivores in Big Arm Bay. We sub-sampled stomachs from northern squawfish over 300 mm TL In the first four weeks following kokanee stocking, we captured 204 large (300 to 595 mm TL) northern squawfish in gill nets. Seven (three percent) of these contained kokanee. One squawfish (595 mm TL) contained a large kokanee, which measured 250 mm TL. Squawfish stomachs contained other fish prey, including sculpin, lake trout, lake whitefish, redside shiners, yellow perch, and other unidentifiable fish. Squawfish comprised 18 percent of net-captured fish over 300 mm in total length. Through hydroacoustics, we estimated 26,737 squawfish greater than 300 mm TL in Big Arm Bay (Table 9).

We did not estimate bull trout consumption of stocked kokanee. In an effort to avoid killing bull trout, we immediately released live bull trout captured in nets. During the four month sampling period, we investigated stomach contents of five dead bull trout, all greater than 300 mm TL. One bull trout contained one kokanee and another contained two kokanee. We estimated few (60) bull trout in Big Arm Bay. Bull trout consumption of kokanee was relatively low compared to lake trout predation.

Predation by birds also was not quantified. Mergansers were the most likely avian predator, since they were the only diving piscivorous bird that occurred in appreciable numbers. Surface-feeding birds such as gulls, eagles and osprey and wading birds such as great blue herons did not occur in sufficient numbers or have opportunity to capture deep schooling kokanee. Cormorants and pelicans, which have been implicated in substantial predation of stocked fish (Huner 1993) were rare in Big Arm Bay. While mergansers were observed to eat many of the fish that died at the time of stocking, and may have preyed on some of the fish in the net pen, our observations indicated they did not substantially impact stocked kokanee.

Collectively, losses to these other predators, although unquantified, would raise the estimate of kokanee consumption by predators above the 232,000 we accounted for by lake trout. However, we speculate that these losses were minor in comparison to lake trout predation.

Summer/Fall Kokanee Distribution

One of the benchmarks for judging the success of kokanee reintroduction is yearling to adult survival of 10 percent (100,000 adult salmon if one million yearlings were stocked). Past investigators have estimated spawner escapement in the Flathead River system (Beattie et al. 1990). During 1979 to 1989, escapement ranged from 60 to over 150,000 spawners. Based on past successful methodology, we are confident that if adult salmon attempt to spawn in the Flathead Lake and River system, we will observe them through surveys of traditional spawning and staging areas.

Since 1974, FWP has surveyed kokanee spawning and staging habitat in the Flathead Lake and River system. Fifty kokanee spawning areas have been documented on the main stem Flathead River; twelve of these areas accounted for roughly 70 percent of redds (Clancey and Fraley 1986). Redd counts occurred from 1979 to 1993. We have not observed kokanee redds in the main stem Flathead River since 1989. Proven methodology was used in 1993 and 1994 surveys to monitor kokanee survival and determine if stocked kokanee survived to maturity and utilized traditional habitat. The habitat remains in suitable condition for successful spawning. McDonald Creek in Glacier National Park accounted for up to 77 percent of the kokanee spawning run from Flathead Lake (Clancey and Fraley 1986). Kokanee were last seen in McDonald Creek in 1990. There were no redds from 1991 to 1993. In addition to river spawning fish, populations of kokanee once spawned on shoreline areas in Flathead Lake (Beattie and Clancey 1987, Beattie et al. 1988). FWP conducted annual surveys in 15 documented shoreline spawning areas from 1981 through 1990. Kokanee were last observed in 1988. In 1994, we monitored these sites in an effort to locate mature stocked kokanee.

In 1994, we conducted two surveys of kokanee staging and spawning habitat in the Flathead River, one on October 17 and the other on November 14. We did not find redds or spawners on either survey. Conditions for visual surveys were good on both dates, flows were low and light was adequate. If 21,000 adult kokanee (10 percent of stocked yearlings) survived from the 1993 stocking, they would have been visible in spawning and staging habitat traditionally used by Flathead Lake kokanee. Also, precocious males from the annual stocking would increase the number of mature kokanee in that year's spawning run. We observed mountain and lake whitefish throughout the river corridor in deep pools and runs. We also did not find kokanee redds or spawning adults in 13 shoreline areas of Flathead Lake on November 18. Viewing conditions were good with clear skies.

In response to an angler report of kokanee in the "Salmon Hole" of the Flathead River, FWP set an experimental gill net on October 26. The net sampled water depths from three to ten feet. We caught nine lake whitefish (adults), two lake trout (395 and 454 mm), one juvenile bull trout (256 mm), two westslope cutthroat (253 and 237 mm), six northern squawfish, one peamouth, and one longnose sucker. No kokanee were captured.

We snorkeled McDonald Creek in Glacier National Park on November 16, 1994. McDonald Lake also has a population of kokanee which spawn in both the lake inlet and outlet. The majority of McDonald Lake kokanee use the inlet. We found five kokanee redds near the mouth of the outlet. These were in a stream section that McDonald Lake fish have traditionally used. We found two redds downstream within one-quarter mile of the confluence with the Middle Fork of the Flathead River. This is an area traditionally used by Flathead Lake spawners. We are unsure of the origin of these spawners. Snorkelers observed one westslope cutthroat, two adult and one juvenile rainbow trout, and four adult and numerous juvenile mountain whitefish. We did not see adult kokanee or carcasses.

We observed mature kokanee in Mill Creek, adjacent to the Creston National Fish Hatchery. Mill Creek is a tributary to the Flathead River and is the water source in which hatchery kokanee were reared and imprinted. USFWS personnel observed several kokanee spawning at the base of the dam on Jessup Mill Pond, in early November, 1994. We collected four of these fish, three of which appeared to be fish which had recently escaped from the hatchery, based on their white flesh and single oxytetracycline mark similar to the broodstock held at the hatchery. The fourth fish, a 376 mm male, had orange flesh, indicating a period of lake residency and a diet of zooplankton This fish had an oxytetracycline mark, indicating the stocking location of Woods Bay in 1993. In mid-November, several more kokanee appeared below the dam on Mill Creek. The external appearance of two of the kokanee observed indicated a period of lake residence, but they were not captured for verification. In summary, at least one, but probably three or more kokanee returned to the hatchery from the 1993 plant in Flathead Lake.

We snorkeled, electrofished, and netted the Swan River, below Bigfork Dam. The Swan River is a tributary to Flathead Lake, entering at the town of Bigfork. On September 23, 1994, snorkelers observed over 40 rainbow trout, five westslope cutthroat trout, one northern pike, numerous mountain whitefish and peamouth, and four largescale suckers. We did not find kokanee, lake trout, or bull trout below the Bigfork Dam and powerhouse during this survey.

In a second survey conducted on October 26, 1994, we observed 25 kokanee, 2 lake trout, and a number of other fish species below the dam. We seined nine of these maturing kokanee, eight males and one female. The female did not have an oxytetracycline mark, appearing to be a wild fish, possibly from Swan Lake. The eight males all had double marks. Seven of these fish originated from the stocking in Big Arm Bay in 1994 and ranged from 192 to 298 mm in length. The other male fish (390 mm) was from the 1993 stocking in Blue Bay. Of the 25 observed, 5 appeared to be larger, similar to the large male (390 mm) which we captured. A survey on November 15 found 12 kokanee and one kokanee carcass, none of which were collected.

CONCLUSIONS

By stocking kokanee in Big Arm Bay during the first week of June, 1994, we attempted to maximize kokanee survival. Water temperatures and stocking conditions were near optimum and the fish were planted on the leading edge of an upsurge in density of ***Daphnia thorata,*** important as a food source. Saturation planting was attempted at a site where predator densities were believed to be low, especially compared to deepwater locations. This combination of factors was expected to maximize short-term survival by allowing fish to acclimate to the lake environment.

The net pen experiment demonstrated that yearling hatchery kokanee, in the absence of predation, adjusted to the environmental conditions present in Flathead Lake during June and early July without substantial post-stocking mortality. Even if all fish unaccounted for in this experiment were considered to be natural mortalities, the cumulative mortality in the net pens over a 33day period was about 12 percent. Evidence strongly suggested that actual mortality was substantially lower than 12 percent. Hatchery kokanee were able to utilize available zooplankton without a noticeable loss of condition, even within the restrictive unnatural environment of the net pen. After several months in the lake the kokanee stocked in Big Arm Bay exhibited good growth and condition and their flesh color had turned orange, which was an indication that fish were utilizing zooplankton. Further monitoring will determine whether food abundance is limiting in winter or spring, but we conclude that food supply for kokanee was not limiting survival in Big Arm Bay during the summer of 1994.

Monitoring results from the 1994 kokanee plant in Flathead Lake demonstrated that a minimum of 232,000 yearling kokanee (29 percent of the plant) were eaten by lake trout in Big Arm Bay in the first eight weeks following stocking. Because we believe the hydroacoustic estimate of lake trout is low, for reasons discussed earlier, this estimate is very conservative. Stocking yearling kokanee has not precluded a high mortality rate incurred through lake trout predation.

By fall of 1994, about 12.7 percent of the planted kokanee population were likely to be maturing "jack" males, based on observations of similar-sized fish in the hatchery. Thus, by January 1, 1995, it is likely that these fish were removed from the lake kokanee population due to early maturation. Adding the estimated loss due to predation in the first eight weeks (232,000) to a 12.7 percent loss of the remaining fish due to maturation (72,000), we accounted for mortality of at least 304,000 (38 percent) of the original 802,000 fish planted.

These estimates did not account for all losses to predation. For example, Big Arm Bay is roughly 10 percent of the total surface area of Flathead Lake, and a portion of kokanee stocked into Big Arm Bay emigrated to the main body of the lake. We did not account for predation of kokanee outside of Big Arm Bay. We also did not estimate predation in Big Arm Bay after July, although we documented lake trout consumption of kokanee through October. In addition, we did not quantify predation by species other than lake trout, even though we documented bull trout and northern squawfish consumption of kokanee. This consumption, combined with avian predation, would further increase the estimate of kokanee mortality. Obviously, there was potential to substantially increase the total estimated loss in 1994. We can only speculate about these unquantified losses. It is our collective opinion that a substantial proportion of the remaining kokanee in the lake were eaten by lake trout in the months following the completion of initial monitoring.

As stated in the introduction, one program goal is to achieve post-stocking survival of 30 percent one year after planting. Based on our quantification of mortality in 1994, it is unlikely that 30 percent of the 1994 plant (240,000 fish) will survive to May, 1995.

The second benchmark of the program is survival to adulthood of 10 percent of stocked fish. Since the vast majority of the fish from the 1994 stocking will reach sexual maturity in the fall of 1995, we were not able to evaluate this criterion. Intensive monitoring of the spawning areas in the fall of 1995 will assess the success of meeting this objective. Predation loss in the 16 months following stocking must be dramatically lower than the level we observed in the first two months in order to achieve this benchmark. The 1994 results indicated that this benchmark was not met by the 1993 introduction. Although the number of kokanee stocked (210,000) in 1993 was substantially lower than the 1,000,000 called for in the experimental design, we did not observe kokanee concentrations which indicated 21,000 kokanee (10 percent) survived to adulthood.

Finally, the third benchmark is to achieve annual kokanee harvest of 50,000 or more fish. It is assumed that kokanee would be taken by anglers at sixes of eight inches or larger. Based on observations of growth rates of fish stocked in 1994, it is likely that the faster growing members of the population would be vulnerable to the fishery shortly after stocking. If the fishery were open, it is probable that some of the larger fish, in particular some of the early maturing "jack" males, would be harvested by anglers rather than eaten by lake trout. We cannot evaluate the kokanee harvest without an open fishery, and recommend that the fishery be reopened to angling in subsequent years so that this aspect of the program can be evaluated.

Data gathered in Big Arm Bay in 1994 indicated that growth and survival of stocked yearling kokanee would be good in the absence of predation. We continued to capture kokanee in gill nets at the conclusion of monitoring (October 21, 1994), indicating persistence of some kokanee. By monitoring the 1993 kokanee stocking, we concluded that predation by lake trout was the major obstacle to successful reintroduction. We intensified monitoring in 1994 to quantify lake trout predation of kokanee. The 1994 data showed a minimum loss of 29 percent of stocked kokanee in the first eight weeks following stocking. We conclude that lake trout predation is limiting successful reintroduction of kokanee into Flathead Lake.

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APPENDIX A

Summary of lake trout and lake whitefish catches in gill nets by Area in Big Arm Bay, May 16 through October 21, 1994.

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
5/16 -5/20	A	ss	----	----	----	6	26
	B	ss	----	----	----	1	2
	C	ss	----	----	----	1	10
	D	ss	----	----	----	2	7
	E	ss	----	----	----	41	116
	F	ss	----	----	----	24	130
	G	ss	----	----	----	36	56
	H	ss	----	----	----	6	36
5/23 -5/27	A	2	0.22 (0.01)	2.00 (0.00)	1.45 (0.09)	4	28
	B	6	0.25 (0.10)	3.00 (1.26)	1.61 (0.60)	18	116
	C	7	0.41 (0.24)	5.14 (2.67)	1.96 (1.19)	36	140
	D	5	1.19 (1.87)	5.00 (1.87)	2.01 (1.19)	25	115
	E	7	0.28 (0.12)	3.00 (1.41)	1.91 (1.49)	27	156
	F	10	0.31 (0.23)	3.78 (2.77)	2.60 (1.39)	38	178
	G	7	0.13 (0.14)	1.71 (1.98)	0.87 (0.64)	13	95
	H	3	0.36 (0.22)	4.33 (2.31)	1.59 (0.99)	13	57

"----" designates insufficient record for time fished.
"ss" designates net sets over a short time period.

Date	**Area**	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total **WF**
5/30 -6/6	A	4	**0.34** **(0.23)**	4.75 (1.71)	2.76 (1.71)	19	163
	B	3	0.13 **(0.04)**	1.67 (0.58)	1.10 0	5	43
	C	18	0.19 **(0.17)**	2.33 (1.88)	0.50 0	43	113
	D	5	0.22 (0.11)	**3.60** **(1.67)**	0.37 0	18	30
	E	1	0.11 - -	1.00 ---	0.84 - -	1	8
	F	0	- -	- -	- -	0	0
	G	10	0.26 (0.08)	**3.40** **(1.07)**	1.79 (0.68)	34	330
	H	8	0.21 (0.18)	2.88 (2.23)	1.01 (0)	23	100
6/7 -6/10	A	4	0.16 (0.11)	**3.00** **(1.41)**	3.02 (0.20)	12	248
	B	4	0.15 (0.07)	3.50 (1.29)	1.21 (0.54)	14	114
	C	4	**0.05** **(0.07)**	**1.00** **(1.41)**	0.18 (0.12)	4	15
	D	2	**0.09** **(0.00)**	**2.00** **(0.00)**	0.25 (0.16)	4	2
	E	6	**0.07** **(0.06)**	1.50 (1.38)	**0.44** **(0.22)**	9	57
	F	4	0.08 (0.05)	1.50 **(1.00)**	0.24 (0.21)	6	22
	G	6	0.18 (0.13)	**3.00** **(1.79)**	0.75 (0.25)	18	94
	H	8	0.05 **(0.04)**	1.13 **(0.99)**	0.42 (0.38)	9	77

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
6/13 -6/17	A	5	0.13 (0.10)	2.80 (2.05)	1.45 (0.87)	14	163
	B	4	0.20 (0.11)	4.50 (3.00)	0.23 (0.11)	18	20
	C	4	0.05 (0.07)	1.00 (1.41)	0.16 (0.27)	4	14
	D	5	0.08 (0.08)	2.00 (2.00)	0.14 (0.23)	10	16
	E	6	0.03 (0.04)	0.67 (0.82)	0.18 (0.29)	4	23
	F	4	0.07 (0.03)	1.50 (0.58)	0.14 (0.19)	6	12
	G	5	0.12 (0.08)	2.40 (1.34)	0.59 (0.42)	12	58
	H	8	0.05 (0.04)	1.00 (0.93)	0.10 (0.17)	8	17
6/20 -6/24	A	5	0.33 (0.38)	3.60 (3.65)	0.62 (0.84)	18	52
	B	6	0.08 (0.07)	1.67 (1.51)	0.06 (0.07)	10	8
	C	6	0.07 (0.06)	1.67 (1.37)	0.09 (0.04)	10	12
	D	4	0.26 (0.14)	6.25 (3.50)	0.64 (0.23)	25	60
	E	6	0.06 (0.08)	1.00 (1.55)	0.23 (0.14)	6	19
	F	4	0.19 (0.16)	2.00 (1.15)	0.22 (0.14)	8	10
	G	5	0.22 (0.21)	2.60 (2.41)	0.51 (0.91)	13	39
	H	5	0.08 (0.08)	1.60 (1.67)	0.04 (0.04)	8	5

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
6/27 -7/l	A	4	0.31 (0.25)	6.25 (5.06)	0.05 (0.10)	25	4
	B	6	0.14 (0.06)	3.00 (1.40)	0.04 (0.03)	18	5
	C	6	0.09 (0.06)	2.17 (1.33)	0.12 (0.12)	13	17
	D	3	0.05 (0.12)	3.33 (2.52)	0.28 (0.31)	10	18
	E	4	0.05 (0.01)	1.00 (0.00)	0.44 (0.48)	4	38
	F	5	0.04 (0.08)	1.00 (1.73)	0.17 (0.16)	5	19
	G	6	0.05 (0.03)	1.17 (0.75)	0.05 (0.06)	7	6
	H	6	0.05 (0.04)	1.00 (0.89)	0.06 (0.04)	6	8
7/5 -7/8	A	5	0.09 (0.04)	1.80 (0.84)	0.13 (0.17)	9	13
	B	4	0.07 (0.04)	1.75 (0.96)	0.06 (0.07)	7	5
	C	3	0.09 (0.06)	2.33 (1.53)	0.09 (0.08)	7	7
	D	3	0.11 (0.05)	2.67 (1.15)	0.13 (0.05)	8	10
	E	2	0.10 (0.06)	1.50 (0.71)	0.26 (0.24)	3	12
	F	2	0.19 (0.10)	4.50 (2.12)	0.19 (0.10)	9	9
	G	4	0.12 (0.12)	2.25 (2.63)	0.30 (0.29)	9	23
	H	4	0.10 (0.04)	2.25 (0.96)	0.06 (0.05)	9	6

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
7/ll-7/15	A	2	0.02 (0.03)	0.50 (0.71)	0.20 (0.28)	1	21
	B	3	0.04 (0.04)	1.00 (1.00)	0.15 (0.12)	3	11
	C	0	----	----	----	---	---
	D	0	----	----	----	---	---
	E	3	0.05 (0.03)	1.67 (1.15)	0.22 (0.25)	5	19
	F	2	0.00	0.00	0.06	0	2
	G	3	0.05 (0.05)	2.00 (2.00)	0.84 (0.41)	6	60
	H	4	0.07 (0.04)	2.00 (0.82)	0.20 (0.17)	8	21
7/18 -7/22	A	2	0.07 (0.09)	1.50 (2.12)	0.65 (0.54)	3	29
	B	3	0.08 (0.03)	1.67 (0.58)	0.46 (0.14)	5	28
	C	4	0.05 (0.05)	2.00 (1.15)	0.17 (0.11)	4	16
	D	3	0.08 (0.04)	1.67 (1.00)	0.28 (0.06)	6	22
	E	3	0.10 (0.05)	2.00 (1.00)	0.53 (0.24)	6	32
	F	1	0.00	0.00	0.15	0	3
	G	2	0.12 (0.04)	2.50 (0.71)	0.51 (0.06)	5	22
	H	4	0.09 (0.08)	**2.00 (1.83)**	0.49 (0.23)	8	54

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
7/25 -7/29	A	2	0.05	1.00 (0.00)	1.11 (0.87)	2	44
	B	3	0.03 (0.03)	0.67 (0.58)	0.99 (0.44)	2	57
	C	4	0.07 (0.06)	1.75 (1.50)	0.29 (0.21)	7	32
	D	3	0.11 (0.12)	2.67 (2.89)	0.79 (0.13)	8	62
	E	2	0.05 (0.06)	1.00 (1.41)	0.30 (0.36)	2	19
	F	2	0.11 (0.04)	2.50 (0.71)	0.23 (0.33)	5	11
	G	2	0.08 (0.04)	1.50 (0.71)	0.69 (0.08)	3	26
	H	4	0.05 (0.03)	0.75 (0.50)	0.33 (0.19)	3	23
8/8 -8/12	A	2	0.10 (0.05)	1.50 (0.71)	2.39 (1.30)	3	84
	B	3	0.03 (0.03)	0.67 (0.58)	1.26 (0.45)	2	77
	C	3	0.05 (0.05)	1.00 (1.00)	0.61 (0.66)	3	38
	D	3	0.09 (0.08)	2.00 (1.73)	0.62 (0.56)	6	43
	E	2	0.16 (0.18)	3.00 (2.83)	1.60 (0.61)	6	48
	F	2	0.13 (0.09)	2.00 (1.41)	0.51 (0.19)	4	16
	G	2	0.07 (0.00)	1.00 (0.00)	0.89 (0.67)	2	26
	H	4	0.07 (0.06)	1.50 (1.29)	0.90 (0.50)	6	84

Date	Area	#Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
8/22 -8/26	A	2	0.26 (0.10)	4.00 (1.41)	0.94 (1.03)	8	38
	B	3	0.03 (0.03)	1.33 (1.53)	1.53 (0.67)	4	93
	C	4	0.15 (0.08)	3.75 (1.71)	0.79 (0.46)	15	80
	D	3	0.19 (0.09)	4.67 (2.08)	0.84 (0.46)	14	61
	E	3	0.07 (0.07)	1.00 (1.00)	1.20 (0.79)	3	52
	F	1	0.13 ---	2.00 ---	2.36 ----	2	36
	G	2	0.14 (0.11)	2.00 (1.41)	1.24 (1.45)	4	39
	H	4	0.10 (0.05)	2.25 (1.26)	0.97 (0.73)	9	88
9/12 -9/16	A	2	0.16 (0.15)	3.00 (2.83)	0.96 (0.33)	6	37
	B	2	0.17 (0.03)	3.50 (0.71)	2.02 (0.67)	7	82
	C	2	0.17 (0.07)	3.00 (1.41)	1.11 (0.55)	6	38
	D	2	0.32 (0.04)	5.50 (0.71)	0.76 (0.91)	11	26
	E	2	0.28 (0.15)	5.00 (2.83)	0.92 (0.33)	10	33
	F	2	0.16 (0.07)	3.00 (1.41)	0.80 (0.24)	6	30
	G	2	0.11 (0.00)	2.00 (0.00)	0.88 (0.18)	4	32
	H	2	0.15 (0.06)	3.00 (1.41)	1.21 (0.54)	6	50

Date	Area	# Nets	#LT/HR (S.D.)	#LT/NT (S.D.)	#WF/HR (S.D.)	Total LT	Total WF
10/17-10/21	A	2	0.16 (0.10)	3.50 (2.12)	0.55 (0.01)	7	22
	B	1	0.04	1.00	0.74	1	17
	C	2	0.39 (0.18)	9.00 (4.24)	0.66 (0.27)	18	31
	D	1	0.40 ---	10.00 ---	0.52 ---	10	13
	E	2	0.19 (0.03)	3.50 (0.71)	0.33 (0.40)	7	12
	F	2	0.13 (0.17)	3.50 (2.12)	0.05 (0.07)	7	2
	G	2	0.05 (0.00)	3.00 (2.83)	0.28 (0.32)	2	11
	H	2	0.00 (0.00)	0.00 (0.00)	0.13 (0.06)	0	6

APPENDIX B

Recommendations for 1995

In preparation for the 1995 Flathead Lake planting program we are continuing to adapt our kokanee stocking strategy based on results achieved in 1993 and 1994. In 1995 we anticipate stocking about 500,000 yearling kokanee into Flathead Lake. In addition, we are attempting to rear another 500,000 fingerlings (approximate 3-inch) from relatively early 1994 Wyoming egg collections. Fingerlings could be available for stocking in June.

Alternative stocking sites that have not been tried exist on the north end of the lake (e.g. Somers Bay or Bigfork). These sites are further from the areas in which kokanee traditionally concentrated in early summer and are subject to the influence of turbid spring runoff from the river. The effects of this are uncertain, but could be postulated to have both positive and negative effects.

Another alternative introduction site is the lower Flathead River upstream from the lake. The logic in this type of introduction is to imprint the fish into the river system prior to their entry into the lake. However, scientific evidence on imprinting indicates that kokanee, like sockeye and chum salmon that emigrate from their natal tributary shortly after emergence, imprint primarily at the time of hatching and as swim-up fry (Scholz et al. 1993). Additional evidence has been developed that kokanee undergo a modified smolting period between 12- 18 months of age and imprinting may occur at this time as well (Tilson et al. 1994). We can not anticipate the homing response to the stocking site in these yearling kokanee. However, we are concerned about food availability for kokanee in the inflow waters and the high predator (lake trout and bull trout) concentrations around the river mouth.

In 1995, after considering these alternatives, we decided to further test the suitability of planting sites by releasing yearling kokanee into the South Bay of Flathead Lake. The uniqueness of South Bay provides a strong contrast to previous release sites.

South Bay, the southernmost lobe of Flathead Lake (Figure B1), is separated from the main lake by an island-dotted channel, the Narrows, and is bounded on the south by Polson Bridge which spans the outlet to the lake (Cross and Waite 1988). It is the most extensive shallow area of the lake, with a maximum depth of 10.6 m, an average depth of 4.6 m, and a surface area of 5,448 ha (13,460 acres) (Cross and Waite 1988). Comprising 11.8 percent of the surface area of Flathead Lake at full pool, South Bay is slightly larger than Big Arm Bay as defined in this report.

Within the South Bay perimeter, the East Bay is the shallowest portion of South Bay (Figure B1) Substrates are primarily mud and silt and a significant portion of the bay supports a dense growth of rooted aquatic vegetation ***(Potamogeton, Myriophyllum,*** and ***Chara)*** in the summer months (Cross and Waite 1988). Surface waters of South Bay typically freeze in the winter, warm steadily from March through the end of July, with peak temperatures in late July or August at about 22-23°C (Cross and Waite 1988)(Figure B2).

During 1984-1986 in South Bay, lake whitefish larvae were caught in abundance in late March through May and yellow perch in early May into June (Cross and Waite 1988). Yellow perch were by far the predominant catch in beach seining conducted in May, July, and September, with catch rates highest in September. Kokanee were captured sporadically in April through June.

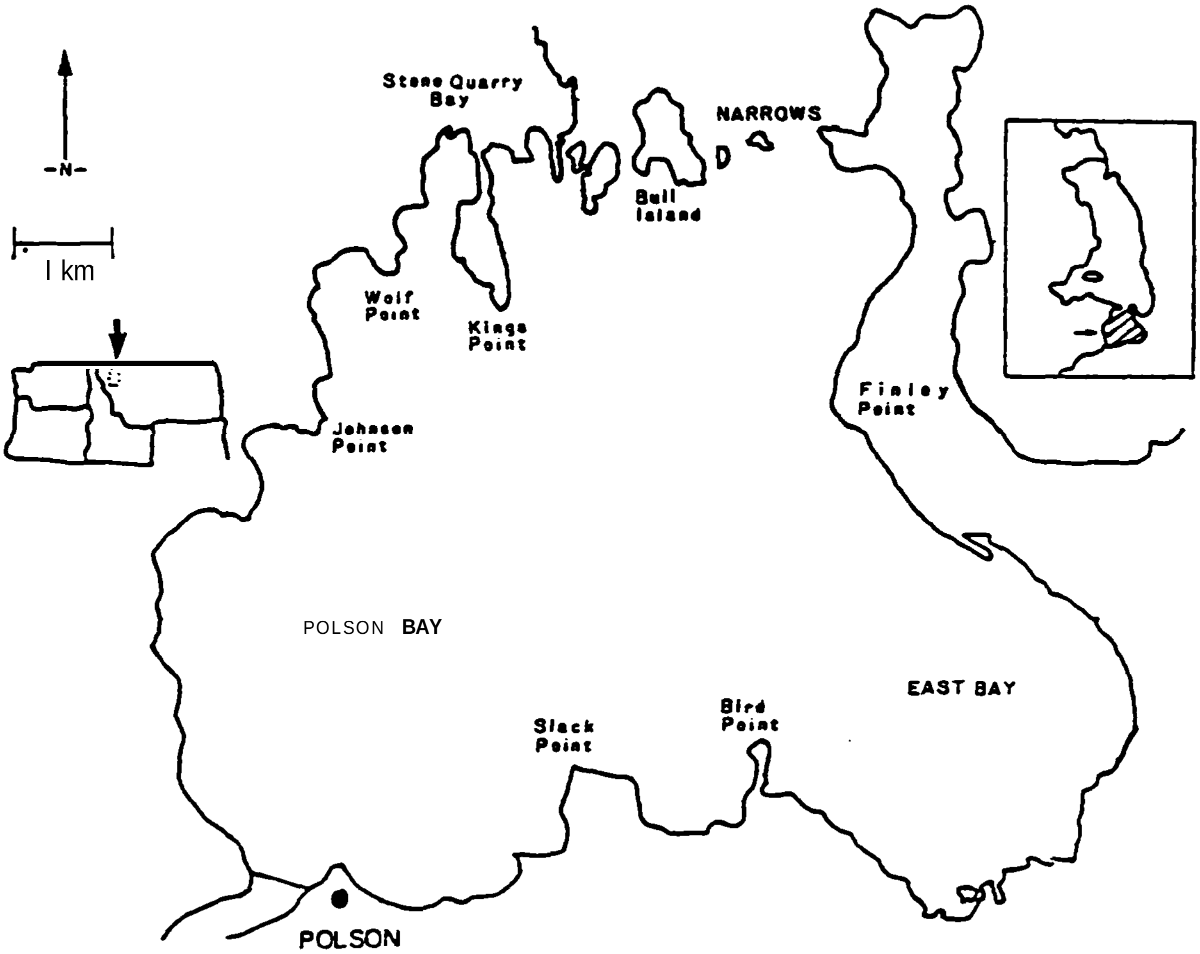

Figure Bl . Location and important features of South Bay, Flathead Lake, Montana (Cross and Waite **1988).**

Experimental gill net sampling, conducted April through October 1984-1986 (with the exception of August), captured 5,328 fish (Cross and Waite 1988). Yellow perch, northern squawfish, peamouth, and lake whitefish, in order of abundance, comprised over 98 percent of the catch. Catches of bull trout and rainbow/cutthroat trout occurred sporadically, but no lake trout were reported in 3 18 nets set in 1985 and 1986.

In recent years, fish species composition in South Bay has changed. Ten gill nets set in South Bay in May, 1991, captured eight lake trout. Similarly, while no lake trout were reported in a creel of South Bay conducted in the winter of 1985, in winter 1993 lake trout were caught by anglers at a rate of 0.28 fish per hour. Although the incidence of lake trout in South Bay has increased in recent years, it is believed that densities of lake trout in spring and summer months are lower than other areas of the lake.

In 1995, we propose stocking kokanee during the period when mean water temperature is in the range of **10-15°C,** allowing the fish to acclimate and school. As water temperatures continue to warm, the kokanee will likely encounter the colder plume flowing in through the narrows and emigrate to the main lake. If properly timed, we believe lake trout populations will have largely emigrated from the bay by the time of stocking. This window of opportunity for stocking should occur in mid-to late May based on 1984-1986 thermal data (Figure B2). There is no zooplankton monitoring data available from South Bay.

In Lake Pend Oreille, Idaho researchers experimented with a number of stocking techniques (Paragamian and Ellis 1994). Authors concluded that survival of stocked kokanee fry was due to a complex relationship, with variables including size of fry and zooplankton densities as well as water conditions. Kokanee survival was best in years of early and rapid thermal increase in the shallow areas of the lake and rapid lake stratification. In general, late release groups had higher survival than early groups (Paragamian and Ellis 1994).

The recommended stocking strategy for 1995 is an attempt to explore the outer bounds of usable kokanee habitat in Flathead Lake through adaptive management. With those factors in mind, and having considered the same stocking considerations discussed in this report, we have concluded that we should treat the 1995 plants as the final test of alternative sites, prior to stocking 1.0 million or more yearling fish in 1996.

The 1995 monitoring effort will consist of two parts. The first is follow-up evaluation of the continued survival of kokanee from the 1994 plant. This will involve the annual lake-wide spring and fall gill net and hydroacoustic surveys. In the fall, spawning surveys in Flathead Lake, the Flathead River, and tributaries to the lake and river system will be used to estimate abundance and distribution of surviving adults from the plant in Big Arm Bay. This effort will be primarily carried out by FWP and CSKT personnel. Secondly, we will track the fish stocked in 1995. This will include gill netting and visual observation (surface and diving) in South Bay, similar to the 1994 effort but at a lower intensity. The purpose of this effort is to assess whether or not kokanee plants in South Bay suffer high early mortality as a result of lake trout predation. Another concern is the potential for stocked fish to migrate along the shoreline to Polson Bridge

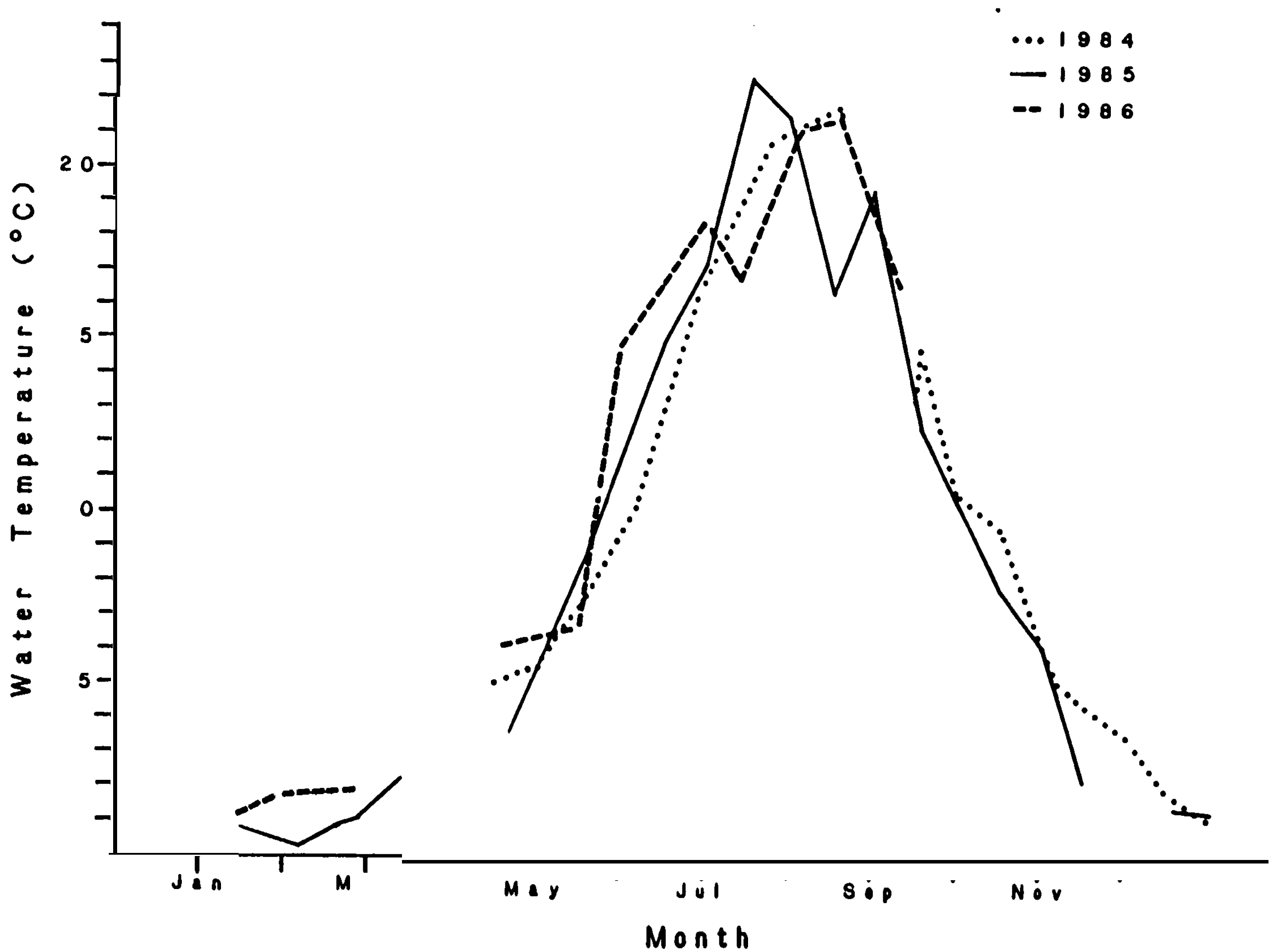

Figure B2. Mean monthly water column temperatures (°C) from South Bay of Flathead Lake, Montana, 1984-1986 (Cross and Waite 1988).

and be lost down the Lower Flathead River through Kerr Dam. In addition, we will attempt to track the movement of kokanee out of South Bay through the Narrows. This effort will be the primary responsibility of CSKT, with assistance from USFWS.

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