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KOKANEE STOCK STATUS AND CONTRIBUTION OF CABINET
GORGE HATCHERY, LAKE PEND ORE I LLE, IDAHO

Annual Report 1986

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KOKANEE STOCK STATUS AND CONTRIBUTION OF CABINET GORGE HATCHERY, LAKE PEND OREILLE, IDAHO

ANNUAL PROGRESS REPORT FY 1986

BY

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ABSTRACT

Estimated kokanee (Oncorhynchus nerka) abundance in Lake Pend Oreille was 4.3 Million during September 1996. This estimate was similar to 1985 and indicates continued suppression of the kokanee population since initial decline in the late 1960s. Atypically high survival of wild fry resulted in similar fry recruitment in 1986 as 1985, whereas hatchery-reared fry contributed only 8% to total fry recruitment as a result of low post-release survival (3%). Fry released into the Clark Fork River from Cabinet Gorge Hatchery had very low survival during emigration to Lake Pend Oreille, Resulting from poor flow conditions and potentialy high y predation. Fry survival during emigration was twice as high during nighttime flows of 16,000 cfs than 7,800 cfs. Emigration also was faster during higher flows.

Several marks were tested to differentially mark fry release groups to help determine impacts of flow and other factors on fry survival. Survival of fry marked with tetracycline a fluorescent dye was high (>99%) during the lo-week study. In contrast, survival of fry marked with fluorescent grit marks ranged from 5 to 93%, depending on application pressure and distance from the fry. Retention was high (>96%) for tetracycline and grit marks during the study, whereas dye marks were discernible (100%) for only one week.

Total egg take in 1986 was 9.1 million, with 7.3 million collected at Sullivan Sprlngs. This low take represented 32% of the eggs necessary to fill Cabinet Gorge Hatchery and reflected the lowest fry-to-adult return rate to Sullivan Sprlngs since initiation of enhancement efforts in the mid-1970s. Low escapement to Sullivan Springs may have been the result of a major freshet in Granite Creek that flushed spawners out of the system during the peak of the run and/or straying.

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INTRODUCTION

Lake Pend Oreille supported the most popular kokanee salmon (Oncorhynchus nerka) fishery in Idaho from the 1940s until the early 1970s. The sport and commercial fishery yielded an average annual harvest of one million kokanee for 360,000 hours of angling effort from 1951 to 1965 (Ellis and Bowler 1979). Sport anglers enjoyed catch rates as high as 3.5 fish/hr during the mid-1960s. Annual kokanee harvest has declined steadily since 1965 to present levels of less than 100,000 fish, with a mean catch rate of approximately one kokanee/hr. In addition to providing an important fishery, kokanee are the primary forage for trophy Kamloops (Gerrard) rainbow trout (Salmo gairdneri) and bull trout (Salvelinus confluentus) in Lake Pend Oreille.

Several factors contributed to the initial decline of kokanee abundance. Hydropower development adversely impacted spawning success of kokanee salmon. Albeni Falls Dam was completed in 1952 by the Army Corps of Engineers as part of the Bonneville Power Administration (BPA) network. Located on the Pend Oreille River approximately 35 km downstream of Lake Pend Oreille, Albeni Falls Dam raised lake levels by 4 m. Annual winter drawdown, averaging 1.3 m from 1951 to 1968, increased embryo mortality by exposing redds of lakeshore spawning kokanee (Bowler et al. 1979). Cabinet Gorge Dam was constructed on the Clark Fork River (rkm 24) for power generation by Washington Water Power Company (WWP). Completion of this dam in 1952 blocked an important kokanee spawning run into the Clark Fork River and tributaries. Declining kokanee abundance may have been accelerated by commercial and sport fishing. The establishment of opossum shrimp (Mysis relicta) in Lake Pend Oreille during the mid-1970s adversely impacted kokanee recruitment. Idaho Department of Fish and Game (IDFG) introduced Mysis in 1968 to enhance the kokanee forage base. The expected response of increased juvenile growth and survival did not occur because mysids competed with post-emergent kokanee fry for cladoceran zooplankton. Competition with and predation on zooplankton by mysids delayed production of two cladocerans (Daphnia and Bosmina) that are essential juvenile kokanee forage during the first few weeks of feeding (Rieman and Bowler 1980). Increased growth of older kokanee did not occur because of spatial segregation between Mysis and feeding kokanee. Mysids remain in deep water during daylight hours and migrate to surface waters at night. Kokanee are visual feeders and are thus able to feed on the shrimp for short periods during dawn and dusk only (Rieman 1977).

Interagency efforts to rehabilitate the kokanee fishery began during its initial decline. In 1967, the Army Corps of Engineers adopted a policy for operation of Albeni Falls Dam to minimize water level fluctuations during kokanee spawning and incubation. IDFG restricted kokanee sport harvest and terminated the commercial fishery in 1973. Hatchery production of kokanee for Lake Pend Oreille was established by 1974 and helped stabilize population numbers. Delayed planting of hatchery fry until midsummer to avoid early season forage deficiencies increased hatchery fry survival up to 13 times what is found in the wild (Bowler 1981). Hatchery production kept the fishery from total collapse, but rearing capacity of existing hatcheries was inadequate to rebuild the fishery. Prior to 1985, hatcheries could provide only six to eight million kokanee fry annually for Lake Pend Oreille. Research indicated that releases of up to 20 million fry annually may be necessary to restore the fishery to historic levels (Rieman 1981).

In an effort to enhance Lake Pend Oreille kokanee production, Cabinet Gorge Hatchery was built on Clark Fork River 4 km below Cabinet Gorge Dam. Cost of the hatchery was approximately $2.2 million and represented a cooperative effort among BPA, WWP and IDFG. BPA funding was from on-site resident fish mitigation funds mandated by the Northwest Power Act of 1980. Construction and evaluation of Cabinet Gorge Hatchery is specified by Measure 804(e)(5) of the Columbia River Basin Fish and Wildlife Program (NWPPC 1984). Cabinet Gorge Hatchery was operational by November 1985 and at full capacity will provide up to 20 million kokanee fry for release into the Pend Oreiile system. Rebuilding the kokanee population to attain the goal of over 0.75 million kokanee harvested annually and 300,000 hours of effort will depend on production from this hatchery.

This research project was developed by IDFG in cooperation with BPA and WWP to evaluate the contribution of Cabinet Gorge Hatchery to the Lake Pend Oreille kokanee stock and fishery and to provide recommendations for optimizing kokanee production and survival. BPA provided the majority (>90%) of funding for this project. Funds from WWP were used for the fry marking study that examined the feasibility of differentially marking kokanee release groups. WWP also provided funding assistance for evaluating kokanee fry release strategies, which included providing requested discharge rates from Cabinet Gorge Dam.

OBJECTIVES

1. To assess the status of kokanee in Lake Pend Oreille during the first year of influence of Cabinet Gorge Hatchery, including population size, age composition and hatchery-wild composition.

2. To determine kokanee age composition, growth and survival in relation to population density and carrying capacity of Lake Pend Oreille.

3. To evaluate size, timing and locations for release of hatchery-reared kokanee.

4. To determine feasibility of differentially marking fry release groups by evaluating retention and mortality associated with various marks.

5. To obtain index information on natural spawning kokanee.

6. To monitor the Lake Pend Oreille zooplankton community and relate to changes in kokanee abundances.

7. To obtain pre-hatchery harvest data for the Lake Pend Oreille fishery for comparison with similar data after hatchery production influences the fishery.

STUDY AREA

Lake Pend Oreille is located in the panhandle of Idaho (Fig. 1). It is the largest lake in Idaho, with a surface area of 383 km^2, mean depth of 164 m and maximum depth of 351 m. Mean surface elevation of Lake Pend Oreille is 629 msl. The Clark Fork River is the largest tributary to Lake Pend Oreille. Outflow from the lake forms the Pend Oreilie River.

Lake Pend Oreille is a temperate, oligotrophic lake. Summer temperatures average approximately 9 C in the upper 45 m of water (Rieman 1977). Thermal stratification typically occurs from late June to September. The N:P ratio is typically high (>11) and indicates primary production may be P limited (Rieman and Bowler 1980). Mean chlorophyll "a" concentration during summer is approximately 2 µg/l. Summer mean water transparency (Secchi disk) ranges from 5 to 8 m.

A wide diversity of fish species are present in Lake Pend Oreille. Kokanee entered the lake in the early 1930s, presumably from Flathead Lake, and were well established by the 1940s. Other game fish include: Kamloops (Gerrard) rainbow trout, bull trout, rainbow trout (*Salmo gairdneri*), cutthroat trout (*Salmo clarki*), lake whitefish (*Coregonus culpeaformis*), mountain whitefish (*Prosopium williamsoni*) and several spiny ray species.

METHODS

Kokanee Abundance

Kokanee were sampled in September with a mid-water trawl towed by a 8.5 m boat powered by a 140 hp diesel engine. The trawl net was 13.7 m long with a 3 x 3 m mouth. Mesh sizes (stretch measure) graduated from 32, 25, 19 and 13 mm in the body of the net to 6 mm in the cod end. All age classes of kokanee were collected. Trawling was done at night during the dark phase of the moon to optimize capture efficiency (Bowler 1979). The trawl was towed at 1.5 m/second at depths calibrated with sonar. Each oblique haul sampled the entire vertical distribution of kokanee, as determined from echograms produced by a Ross 200 A depth sounder with two hull-mounted transducers (22° and 8° beam angles). The vertical distribution of kokanee was divided into 3.5 m layers; usually 3 to 5 layers encompassed the vertical distribution of kokanee. A standard 3.5 minute tow was made in each layer, sampling 2,832 m^3 of water over a distance of 305 m. Total volume of water sampled for each trawl haul varied from 8,496 to 14,160 m^3, depending on the vertical distribution of kokanee.

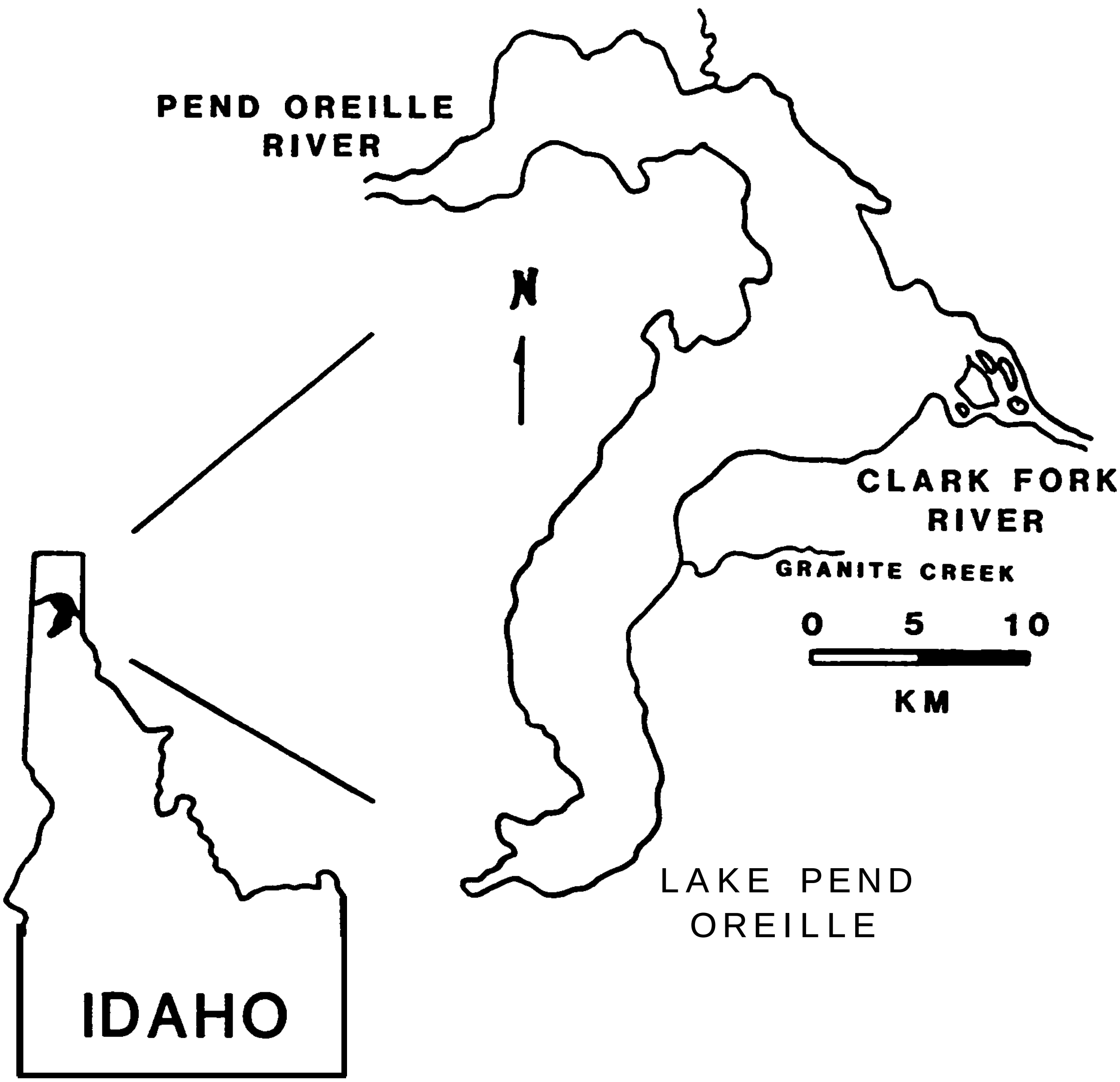


Figure 1. Lake Pend Oreille, Idaho.

A stratified systematic sampling scheme was used to estimate kokanee abundance and density. Lake Pend Oreille was divided into six sections or strata (Fig. 2). The area of each section was calculated for the 91.5 m contour; however, Section 6 was calculated from the 36.6 m contour in the northern end because of shallower water (Fig. 2). The 91.5 m contour was used because it represents the pelagic area of the lake where kokanee are found in September (Bowler 1978). Six transects were systematically selected within each section and one haul (sample) was made along each transect. Total sample size in 1986 was 36 hauls.

Fish numbers/transect (haul) were weighted by transect volume and the age-specific number of kokanee for each stratum was calculated with the formula (Scheaffer et al. 1979):

$$T_i = N_i \bar{y}_i$$

where: N_i = total possible standard transects for stratum_i

$\bar{y}_i$ = total fish collected weighted by standard transect/number of transects.

The variance associated with this estimate was calculated as:

$$\hat{V}(T_i) = N^2_i (s^2_i/n_i)((N_i - n_i)/N_i)$$

where: $s^2_i = \sum_{i=1} (y_i - \bar{y}_i)^2/(n_i - 1)$

n_i = number of samples (hauls) taken in stratum_i.

A 90% bound (B) ($\alpha = 0.10$) was placed on this estimate by:

$$B = 1.6\sqrt{\hat{V}(T_i)}$$

Total kokanee in Lake Pend Oreille for each age class was calculated as:

$$T_{total} = \sum_{i=1}^{L} N_i \bar{y}_i$$

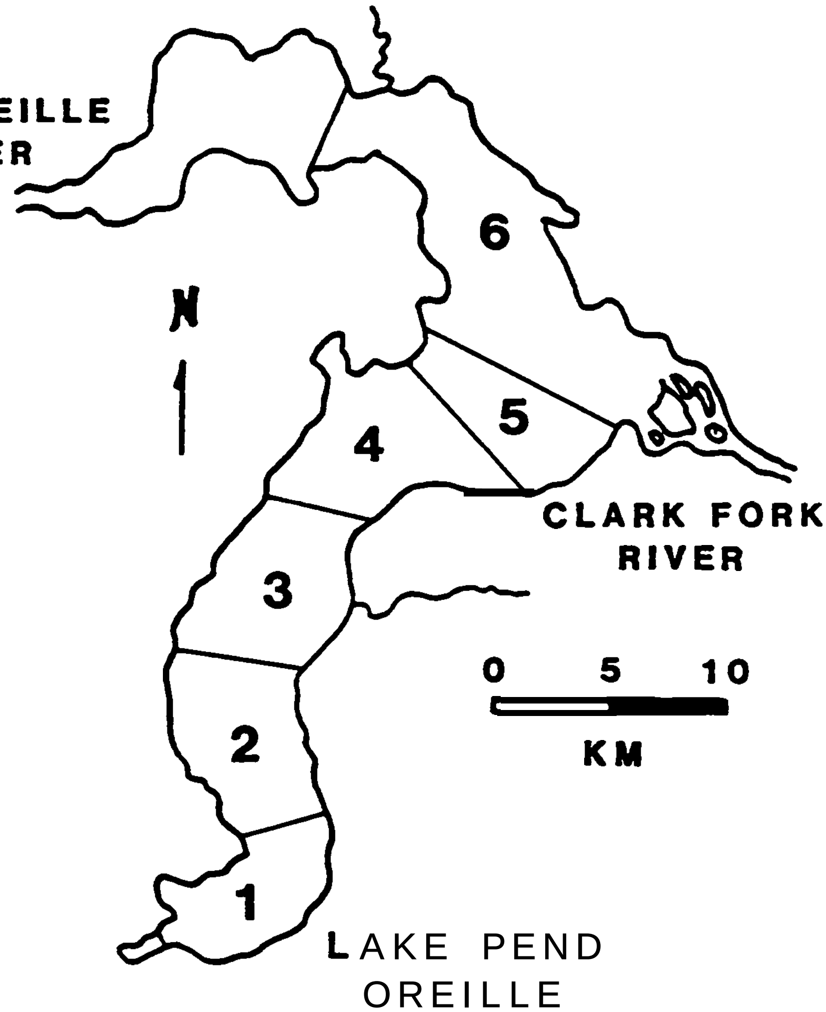
where: $N_i \bar{y}_i$ = population estimate for each stratum(i) for L total strata.

The variance associated with this estimate was calculated as:

$$\hat{V}(T_{total}) = \sum_{i=1}^{L} N^2_i ((N_i - n_i)/N_i)(s^2_i/n_i)$$

A 90% bound (B) ($\alpha = 0.10$) was placed on this estimate by:

$$B = 1.6\sqrt{\hat{V}(T_{total})}$$



Section	Area (ha)
1	
2	3220.15
4	3739.49
5	4036.73
6	5010.78

Figure 2. Stratified sampling sections and respective areas (hectares) used during 1986 for trawling and kokanee abundance estimation on Lake Pend Oreille, Idaho.

Kokanee population estimates (total and by section) were divided by respective lake surface areas to calculate kokanee densities (number/hectare) for each age class.

Survival

Relative recruitment and survival of hatchery-reared fry were determined from trawl catches of marked hatchery-reared fry. A portion of the total hatchery fry were marked with tetracycline prior to release into Lake Pend Oreille tributaries. Tetracycline (TM-501 was mixed with fish feed at the rate of 11% by weight and fed to kokanee fry for 10 days prior to release. Kokanee fry captured in the trawl during September were examined for tetracycline marks with a long wave (3,600 Å) ultraviolet light. When exposed to ultraviolet light, a yellow sheen is observed around the mandibles, opercles and bases of pelvic and pectoral fins. This mark is visible for several months after release. Survival of hatchery-reared kokanee fry was determined by comparing estimates of tetracycline-marked fry in the lake during September to known numbers of marked fry released earlier in the year.

Tetracycline-marked fry have been released in Lake Pend Oreille and its tributaries since 1978 (Table 1). During 1986, fry released into the Clark Fork River from Cabinet Gorge Hatchery were marked with tetracycline and comprised 68% of the total fry released into the Pend Oreille system. All additional fry were released into Sullivan Springs Creek, of which 71% were marked with tetracycline.

Wild fry survival from potential egg deposition (PED) to September abundance was estimated from trawl catches. PED was calculated by multiplying average fecundity by estimated mature female kokanee abundance.

Annual survival was estimated for age 1+ and older kokanee by comparing trawl-estimated abundance for each year class between years. Relative distribution by section of kokanee age classes was determined from abundance estimates for trawl catches within each section.

Emigration rate and relative survival of kokanee fry emigrating from Cabinet Gorge Hatchery to Lake Pend Oreille (22 km) were estimated during various discharge rates. Fry were released from the hatchery at dusk and allowed one hour acclimation prior to flow manipulation by WWP. Approximately 1.1 million fry were released into the Clark Fork River on July 30. An additional 1.5 million fry were released on August 4 and 0.77 million on August 12. WWP provided approximately 16,000 cfs flows for two nights (4 hour pulse/night) following the first release. Flows were maintained at 7,800 cfs for two nights following the second release and 7,800 cfs for one night following the third release. Dam discharge records were provided by WWP (Fig. 3). We verified and calibrated these flows on site with a General Oceanics velocity meter.

Table 1. Location and marking of hatchery-reared kokanee fry released in Lake Pend Oreille and its tributaries.

Location	Date	Number of kokanee fry	Tetracycline-marked
Sullivan Springs	7/78	1,600,000	Yes
Sullivan Springs	7/79	1,745,730	Yes
Sullivan Springs	7/80	1,081,400	Yes
Sullivan Springs	7/81	2,219,800	Yes
Clark Fork River	7/81	1,933,600	Yes
Sullivan Springs	7/82	2,487,800	No
Clark Fork River	7/82	1,200,500	Yes
Clark Fork River	7/82	653,000	No
Scenic Bay	7/82	1,480,600	No
Pack River	7/82	21,300	No
Spring Creek	7/82	100,500	Yes
Gamblin Creek	7/82	8,400	No
Sand Creek	7/82	8,400	No
Strong Creek	7/82	8,400	No
Schweitzer Creek	7/82	8,400	No
Grouse Creek	7/82	7,700	No
East River	7/82	10,700	No
Hoodoo Creek	7/82	25,100	No
Priest River	7/82	22,500	No
Sullivan Springs	7/83	2,875,600	No
Clark Fork River	7/83	1,883,300	Yes
Clark Fork River	7/83	607,100	No
Strong Creek	7/83	12,000	No
Sand Creek	7/83	10,200	No
Schweitzer Creek	7/83	10,200	No
Pack River	7/83	25,500	No
Priest River	7/83	20,400	No
Grouse Creek	7/83	10,200	No
East River	8/83	20,400	No
Hoodoo Creek	7/83	25,400	No
Murphy Creek	8/83	17,000	No
Clark Fork River	7/84	645,034	No
Clark Fork River	8/84	1,011,594	No
Granite Creek	7/84	1,388,638	Yes
Granite Creek	7/84	1,204,886	No
Granite Creek	8/84	571,900	Yes
Granite Creek	8/84	49,088	No
Clark Fork River	7/85	1,209,128	No
Clark Fork River	8/85	1,325,095	Yes
Granite Creek	8/85	489,888	No
Sullivan Springs	8/85	2,938,391	No
Clark Fork River	7/86	10,014	No
Clark Fork River	8/86	3,392,882	Yes
Clark Fork River	9/86	12,621	No
Sullivan Springs	8/86	466,176	No
Sullivan Springs	8/86	1,128,555	Yes

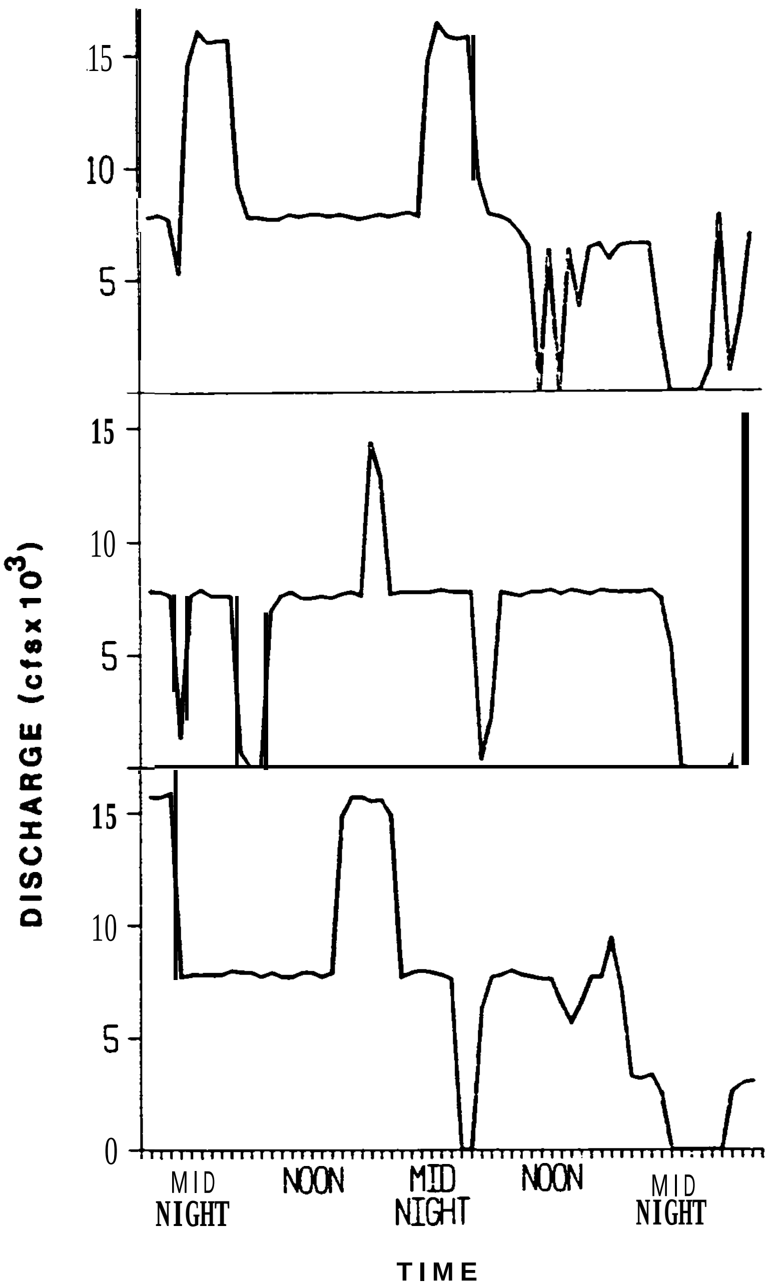


Figure 3. Rate of discharge from Cabinet Gorge Dam into the Clark Fork River for three nights following each fry release (at 2100 hours the first night) from Cabinet Gorge Hatchery.

Fry were sampled with a series of 5 to 10 drift nets suspended from a bridge near Clark Fork, Idaho, approximately 20 km below the hatchery as they immigrated to Lake Pend Oreille. The nets were 3 m long with a round 1 m diameter mouth tapering to a 102 mm diameter detachable bucket (PVC). Mesh sizes (stretch measure) graduated from 6.4 mm near the hoop to 3.2 mm in the cod end.

Nets were suspended from the bridge with a cable and pulley system and held in position with a 32 kg section of iron rail. Nets were set and pulled, using a truck-mounted pivoting boom and a 66 cc gas-powered chain saw winch. The cable and pulley system was designed to allow nets to be positioned differently in the water column and to allow the weight to remain stationary on the river bottom during retrieval of the nets.

We used a systematic sampling scheme stratified by time to collect kokanee fry and estimate relative survival and emigration rates. Nets were evenly spaced across the river channel (262 m wide) and checked every two to four hours day and night until fry were no longer collected. Mean depth of the channel at the sampling station was approximately two meters. Emigration rates were calculated by dividing the distance traveled (20 km) by the time required to travel. Survival was measured by comparing estimated abundance of emigrating fry near the mouth of Clark Fork River to known numbers of fry released at Cabinet Gorge Hatchery. Fry abundance was estimated by calculating the mean total catch/net/night and expanding the estimate to represent the entire river cross section. Estimates of survival and emigration rates were compared as a function of Clark Fork River flows for three release groups.

Fry Marking

Several marks were tested for retention and associated fry survival to determine the feasibiiity of differentially marking kokanee fry to test success of various release strategies once fish had entered Lake Pend Oreille. Five treatments were tested and included: tetracycline, fluorescent dye (Bismark Brown) and three different applications of fluorescent grit. The tetracycline mark was administered in the feed (as discussed in the previous section). The fluorescent dye mark was applied by immersing fry for 1 hr in a solution of 1 part dye to 30,000 parts water by weight. The fluorescent grit mark was applied by spraying the granular (30 to 350 microns) pigment into the dermis layer of fry with compressed air. The pigment was applied using three procedures: 50 psi from 15 cm to the fry, 80 psi from 30 cm and 80 psi from 15 cm. Each treatment (mark application) was replicated four times, resulting in 20 independent lots of marked fry (5 treatments with 4 replicates each). Marked lots were held in separate net pens constructed of 3 mm hardware cloth in raceways at the Mullan Hatchery.

Mark retention and related fry survival were monitored weekly for 10 weeks following application of the marks. A black light (ultraviolet) was used to determine mark retention from a weekly subsample of at least 10 fry from each lot. Fry marked only with tetracycline were used as a

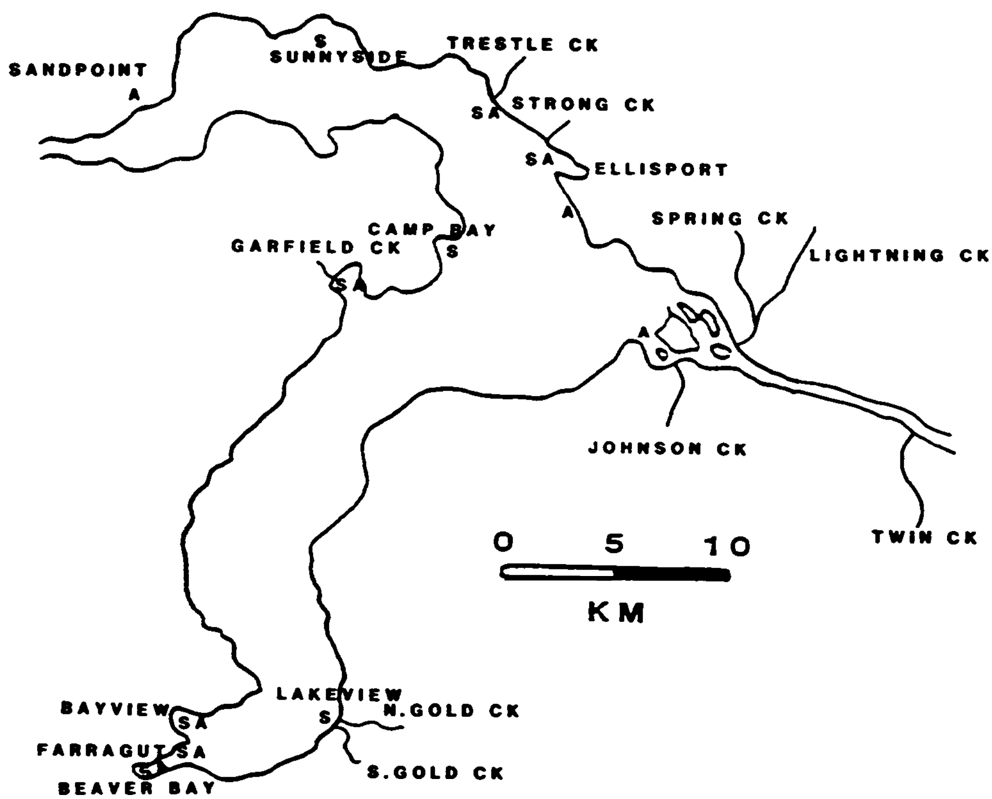


Figure 4. Angler access sites (A) used during the 1985 creel survey and locations of spawning ground surveys on lake shoals (S) and tributary streams, Lake Pend Oreille, Idaho.

control group when analyzing survival. Mark retention and survival were compared over time within and among treatments to determine the feasibility of using these marks for long-term (>4 weeks) and short-term (1 week) fry release studies.

Egg Take

Since 1974, IDFG has maintained a permanent weir at the mouth of Sullivan Springs Creek (tributary to Granite Creek), a major kokanee spawning tributary to Lake Pend Oreille (Fig. 1). This egg take station has provided kokanee eggs for Lake Pend Oreille, as well as enhancement activities for other lakes.

Naturally Spawning Kokanee

Adult kokanee were enumerated along lakeshore and tributary stream spawning areas to provide an index of naturally spawning kokanee abundance (Fig. 4). Counts were made by walking each area once during the first week of December, the estimated peak of spawning activity. Only predetermined portions of lakeshore spawning areas were surveyed, whereas entire spawning areas were censused in tributary streams. Trestle Creek was also censused in September to determine use by early run kokanee spawners.

Age and Length at Maturity

Total length was measured and otoliths extracted from mature kokanee collected during the late fall spawning season for spawner age and length distributions. Spawners were collected at Scenic Bay with a gill net and from the weir on Sullivan Springs Creek. Additional carcasses were collected from other tributary streams. Age of maturity was also estimated for kokanee collected during September trawling.

Zooplankton

The zooplankton community was sampled in three sections of Lake Pend Oreille selected to represent the southern, middle and northern portions of the lake (Fig. 5). Five random samples were collected from each section once a month from May through October. Samples were collected with a 0.5 m ring plankton sampler calibrated by a general Oceanics flow meter and equipped with a 130 µm net and bucket. Vertical hauls from 27.4 m depths to the surface were made by raising the sampler approximately 0.15 m/second with an electric winch. Zooplankters were enumerated by genus using standard dilution and subsampling methods (Edmondson and Winberg 1971). Enumeration data were standardized by volume of water filtered to determine zooplankton densities. Up to 50 organisms/sample were measured for each genus by projecting their image on a calibrated screen. Mean lengths were

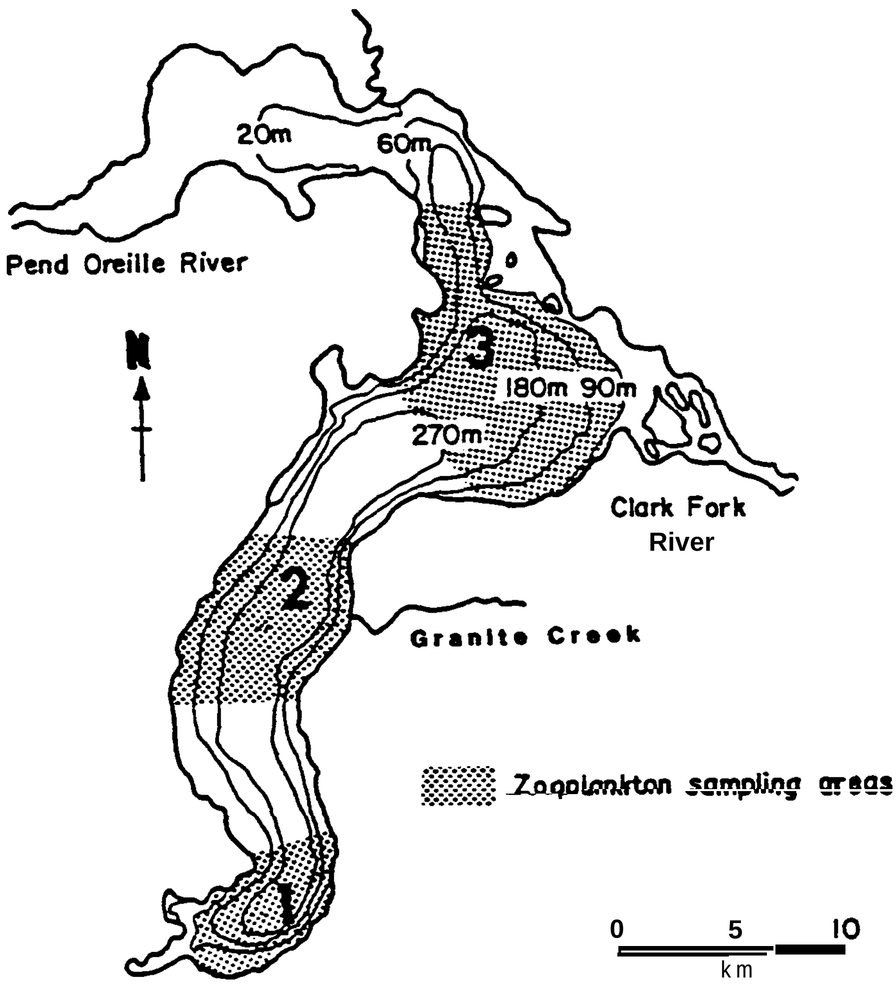


Figure 5. Zooplankton sampling areas used during 1985 and 1986 on Lake Pend Oreille, Idaho.

calculated for each month and lake section. Analysis of variance, utilizing a stratified random sampling scheme, was used to compare zooplankton densities and lengths both spatially and temporally.

Mysid Shrimp

Mysis were sampled at night during the moon's dark phase in early June. Five samples were randomly collected in each of three lake sections designated for zooplankton sampling (Fig. 5). Samples were collected with a Miller high-speed sampler equipped with a General Oceanics flow meter and a 130 µm plankton net and bucket. Stepped oblique tows were made from 46 m to the surface, sampling for 10 seconds at each 3 m interval. The sampler was towed approximately 1.5 m/second and raised 0.15 m/second with an electric winch. All Mysis were counted and differentiated by age class (juvenile or adult) for each sample. Estimated densities were based on volume of water filtered and comparisons made between age classes and among lake sections.

Angler Effort and Harvest

A creel survey was conducted during 1985 to provide minimum estimates of angling effort, catch and harvest of sport fishes. The 1985 survey incorporated a sampling scheme similar to that used in 1980 (Ellis and Bowler 1981).

The creel survey was temporally stratified to reduce variability and provide seasonal catch comparisons. Project personnel collected creel data from April 15 to November 30, 1985. The survey was stratified into five 1.5-month periods to correspond with periods used in surveys prior to 1980. Each period was further stratified into three two-week intervals.

Creel data were collected from 13 major access areas throughout the survey (north end of lake: Garfield Bay, Trestle Creek, Johnson Creek, Sandpoint, Island View, Kamloops Resort and Ellisport Bay; south end of lake: Farragut, MacDonalds, Boileaus, JD's, Vista Bay and Scenic Bay) (Fig. 4). These areas were sampled two weekend days and one weekday during each two-week interval. Several access areas (Trestle Creek, Johnson Creek, Sandpoint, Island View, Kamioops Resort) were not sampled during extreme low-use periods.

Survey data were expanded by day type (weekends or weekdays) to estimate harvest, catch and effort (hours and angler-days) for each interval, period and entire season. An angler-day was defined as one angler's fishing trip, regardless of actual fishing time. The number of anglers interviewed on a given day was multiplied by the number of similar day types within a two-week interval to estimate the minimum number of angler-days for each interval. Similar expansions were used to estimate harvest, catch and hours of effort. Interval estimates were summed for each period and period estimates were summed to represent the entire season. Expanded estimates were classified as "estimated minimum" because some anglers exited the lake through unsurveyed landings.

RESULTS

Kokanee Abundance, Distribution and Biomass

Estimated total kokanee abundance during September of 1986 was 4.27 million fish (Fig. 6). Contribution of Individual year classes was 1.66 million for the 1985 year class (age 0+), 1.15 million for the 1984 year class (age 1+), 0.68 million for the 1983 year class (age 2+) and 0.78 miilion for the 1981 and 1982 year classes (age 3+ and age 4+).

Estimated average kokanee density for the entire lake (all age classes combined) was 189 fish/hectare (Fig. 7). Densities ranged from a high of 274 kokanee/hectare in Section 1 to a low of 81 kokanee/hectare in Section 5. Age 0+ wild kokanee densities were highest in southern sections of Lake Pend Oreille, whereas hatchery fry densities were slightly higher in the north end of the lake. Densities of age 1+ kokanee were significantly ($P<0.10$) higher in the north end of Lake Pend Oreille than other sections. Age 2+ and older kokanee densities were higher in southern than northern sections and similar in midlake sections.

Estimated biomass of age 1+ and older kokanee in Lake Pend Oreille during September was 184,074 kg. Mean kokanee lengths and weights from the September trawl catch were 147 mm and 24 g for the 1984 year class (age 1+), 214 mm and 83 g for the 1983 year class (age 2+), 233 mm and 109 g for the 1982 year class (age 3+) and 259 mm and 150 g for 1981 year class (age 4+). Length frequencies of kokanee caught in the trawl are shown in Figure 8.

Age and Length at Maturity

Mature kokanee, determined from the September trawl catch, were age 3+ and older. An estimated 41% of age 3+ and age 4+ kokanee were mature and consisted of 48% males and 52% females.

Mean lengths of the kokanee spawned from Sullivan Springs Creek (predominantly hatchery origin) were 281 $\pm$ 4.5 mm and 273 $\pm$ 3.7 mm ($P<0.05$) for males ($n = 21$) and females ($n = 19$), respectively. Mean lengths of wild lakeshore kokanee spawners collected from Scenic Bay in the southern end of Lake Pend Oreille were 277 $\pm$ 3.6 mm and 267 $\pm$ 6.7 mm ($P<0.05$) for males ($n = 21$) and females ($n = 3$), respectively. Mean lengths of wild kokanee spawning in North and South Gold creeks (southern tributaries) were 273 $\pm$ 5.9 mm and 265 $\pm$ 5.0 mm ($P<0.05$) for males ($n = 17$) and females ($n = 14$), respectively. Male and female lengths did not differ significantly ($P>0.05$) between locations.

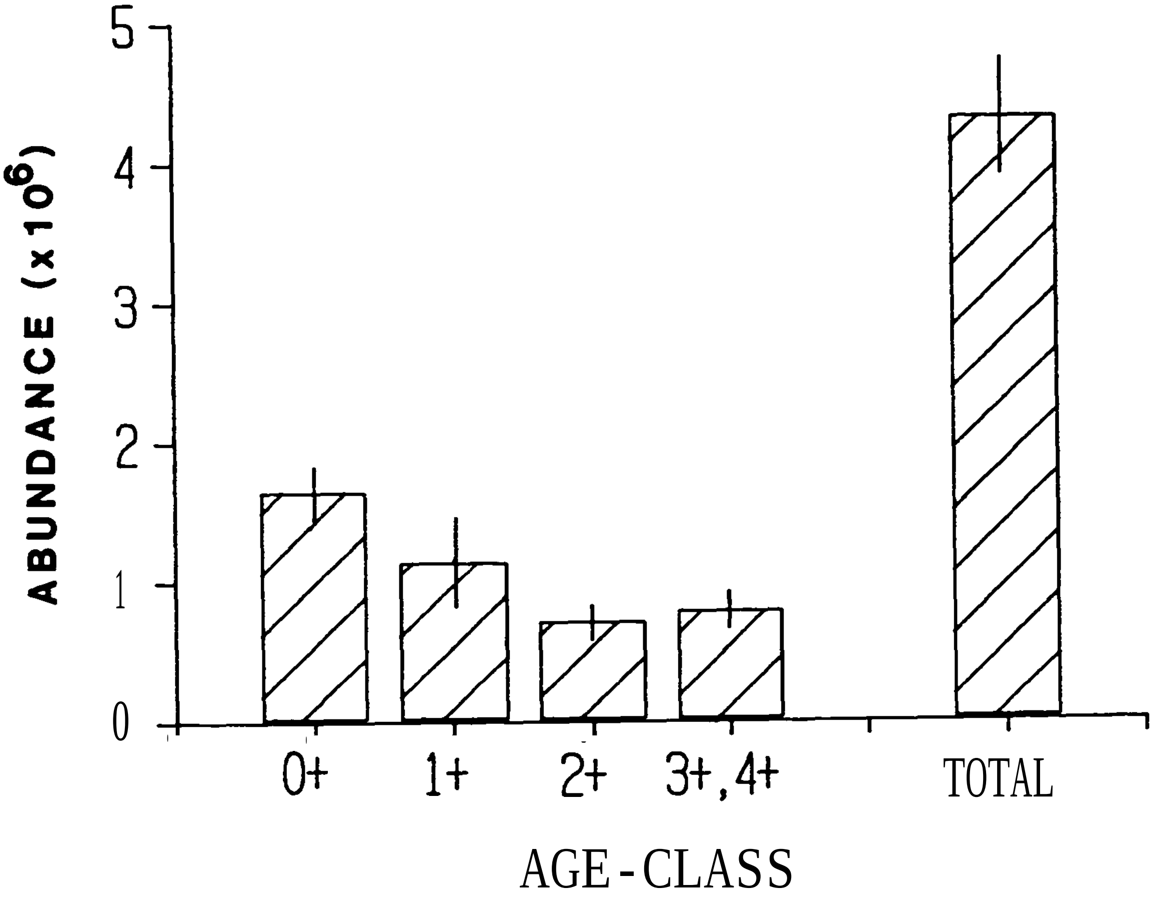


Figure 6. Estimated kokanee abundance with 90% confidence intervals for September 1986, Lake Pend Oreille, Idaho.

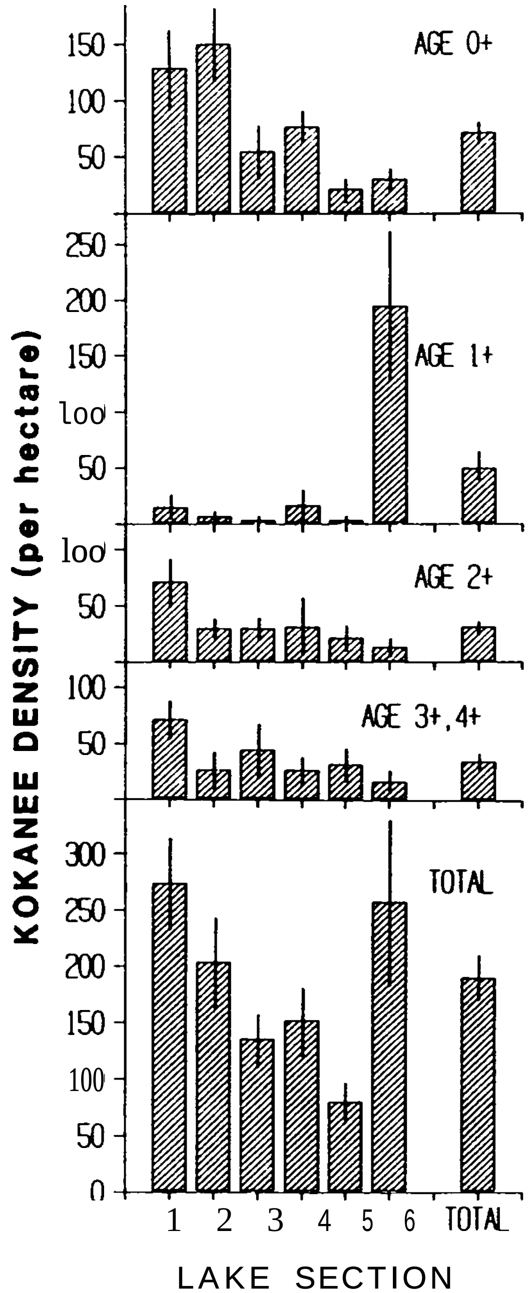


Figure 7. Kokanee density in Lake Pend Oreille, Idaho, by age group and lake section during September 1986. Vertical bars represent 90% confidence intervals.

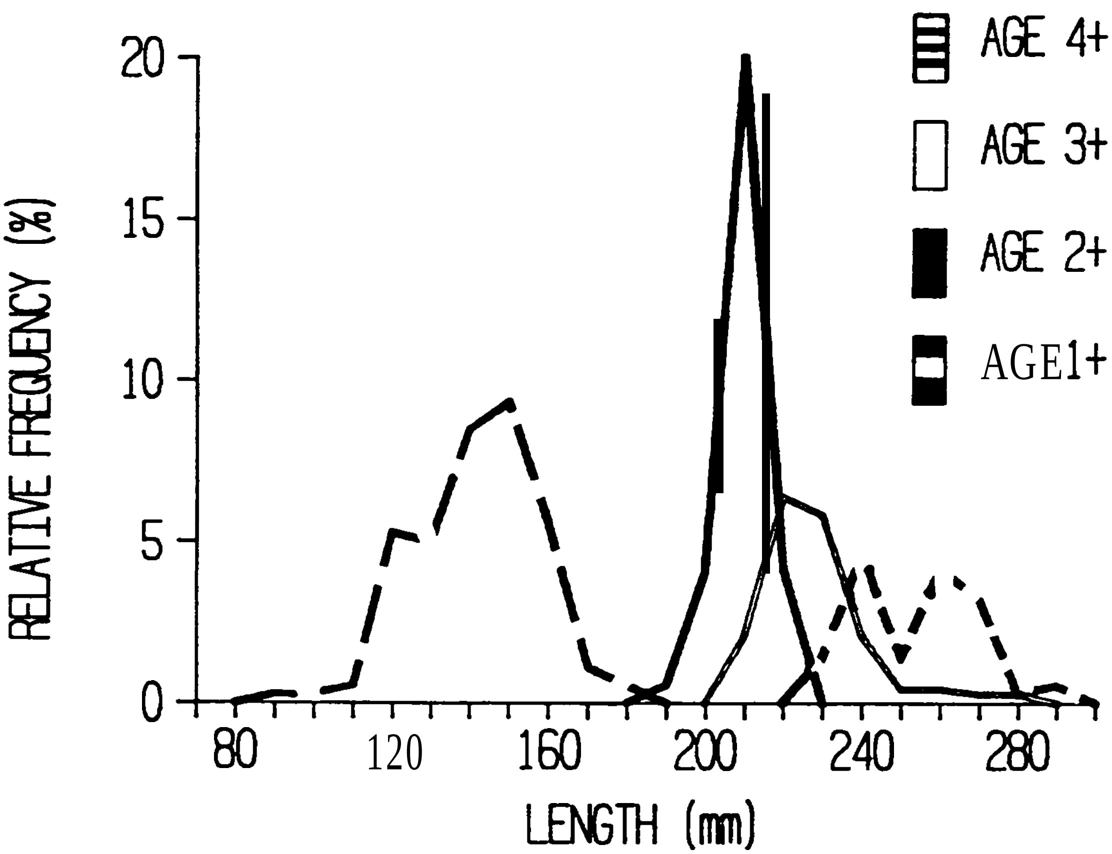


Figure 8. Length frequencies, by age class, of trawl-caught kokanee from Lake Pend Oreille, Idaho, during September 1986.

Spawning Escapement

An estimated 321,833 mature kokanee comprised the Lake Pend Oreille spawning population In 1986. The spawnlng run to Sullivan Springs Creek was approxlmately 42,230 kokanee (13% of the total escapement) and extended from the first week in November to early January. The estimated return of hatchery-reared fry as adults in 1986 was 1.9%. One-time late spawning kokanee counts (December) in other tributaries ranged from 14,000 in Spring Creek to none In Trestle, Twin, Hoodoo, Sand and Grouse creeks. Lakeshore spawner counts ranged from 1,857 kokanee on southern lakeshore areas to 41 on northern lakeshore beaches (Table 2). A count of 1,034 early run kokanee spawners was made in Trestle Creek during September.

Potential Egg Deposition and Egg Take

Estimated tota I potential egg deposition was 68.6 miilion with 59.6 million eggs attributed to natural spawning and a potential of 9.0 million eggs available from artificially spawned kokanee at Sullivan Sprlngs. Estimated abundance of mature female kokanee was 167,350 from September traw I i ng. Approximately 21,960 female kokanee were spawned at the Sul I Ivan Springs trap, which left an estlmated 145,390 female kokanee to spawn naturally throughout Lake Pend Oreille and its tributaries. Fecundity averaged 410 viable eggs/female (Gene McPherson, IDFG, unpublished data). Actual egg take at Sullivan Sprlngs was 7.3 miliion eggs (350 eggs/female), which was 85% of the total est i mated egg potential. An additional 1.4 ml I I ion eggs were taken at Clark Fork Hatchery from Spring Creek kokanee and 0.4 million eggs at Cabinet Gorge Hatchery from Clark Fork River kokanee for a total egg take of 9.1 million.

Fry Emigration

Hatchery-reared kokanee fry emigrating from Cabinet Gorge Hatchery to Lake Pend Oreille had the highest relative survival when nighttime flows were high. Survival was twice as high at nighttime flows of 16,000 cfs (one replicate) than 7,800 cfs (two replicates). Estimated total kokanee fry survival from Cabinet Gorge Hatchery to the Clark Fork River delta was 11%.

Emigration rates were also higher during flows of 16,000 cfs than 7,800 cfs. During the higher nighttime flows, the majority of kokanee emigrated at 3.7 km/hr and 95% of the surviving kokanee reached the Cl ark Fork River delta (21.9 km from hatchery) during the first night after release. During the lower nighttime flows, the majority of kokanee emigrated at 2.6 km/hr and 84% of the surv iv i ng kokanee reached the river delta during the first night after release. Although daytime flows were approximately 8,000 cfs, kokanee fry emigrated only at night, beginning Just after dark and continuing until dawn. During both flow conditions, nearly al I (>99%) of the survlving fry had reached the river delta by two hours before dawn on the second night after release.

Table 2. Late run kokanaa spawning Qround counts (early run count included for Trestle Creek] made In December during tha 1986 spawning aaaaon on Laka Pend Oreille and Its tributaries, excluding tha Grant to Creek drainage.

Lakaahoraa				Tributaries			
Southern		Northarn		Southarn		Northarn	
Sita	Count	Site	Count	Site	Count	Site	Count
Bayviaw areas		Garfield Bay	6	North Gold Creek	1,200	Traatla Creek[a]	0
		Camp Bay	0	South Gold Creek	1,550	Waat Traatla Creek	0
Bubb's	3	Sunny sida	0			Johnson Creek	182
Wheel Inn	7	Traatla Creek Rasorts	35			Garfield Creek	1
J.D.'s	0	Ellisport	0			Twln Creek	0
Boilleaus	65					Lighting Creek	165
Bayvlew Resort	225					Spring Creek	14,000
Navy Yard	407					Hoodoo Creek	0
Private Docks	569					Sand Creek	0
MacDonald's Resort	359					Grouse Creek	0
Vista Bey	5					Strong Creek	20
						Schweitzer Creak	1
Subtotal	1,720						
Farragut	10						
Lakeview	I27						
Total	1,857		41		2,750		15,403
Grand Total	18,996						

[a]Single early run count of kokanaa spawners during Saptambar was 1,034.

Survival and Recruitment

Estimated survival of kokanee fry from potential egg deposition to September trawl sampling was 1.36% for the 1985 year class. Survival estimates for hatchery and wild fry were 0.74% and 1.46%, respectively. A survival rate of 2.7% was estimated for 1985 year class hatchery-reared fry from time of release in late July to fall sampling in early September. Hatchery fry provided an estimated 8.3% of the total kokanee fry recruitment in 1986. These estimates are based in part on the release of 5.01 million hatchery-reared fry (90% marked with tetracycline) during late July and early August and the subsequent capture of 16 marked fry out of 246 total fry in the trawl catch. Annual survival (September to September for wild and hatchery fish combined) of other immature kokanee was estimated at 64% for the 1984 year class (age I+), 70% for the 1983 year class (age 2+) and 46% for the 1981 and 1982 year classes (age 3+ and age 4+).

Fry Marking Study

Survival

Fry survival associated with four exterior mark applications were compared to a control group marked with tetracycline to discern differences in initial (one week) and long-term (8 to 10 weeks) survival (Fig. 9). Fry averaged 2,324/kg and 33 mm total length when marked.

Initial survival of fry marked with fluorescent dye averaged 99.5% and total survival (10 weeks) averaged 99.3%. Neither initial ($P = 0.841$) or total ($P = 0.818$) survival varied significantly from the control group.

Initial survival of fry marked with fluorescent grit applied at 50 psi from 15 cm averaged 92.6%. Total survival for 10 weeks averaged 88.8%. Both initial ($P = 0.013$) and total ($P = 0.005$) survival were significantly lower than the control group. Cumulative fry survival, excluding initial marking mortalities, averaged 98.2% and did not differ significantly ($P = 0.051$) from the control group.

Initial and total fry survival following application of grit at 80 psi from 30 cm was 86.2% and 85.3%, respectively. Both initial ($P = 0.000$) and total ($P = 0.000$) survival were significantly lower than the control group. Total survival, excluding initial marking mortalities, averaged 99.1% and was not significantly ($P = 0.287$) lower than the control group.

Initial and total survival of fry marked with grit at 80 psi from 15 cm averaged 4.9% each and were significantly ($P = 0.000$) lower than the control group. Total survival excluding the high initial marking mortality averaged 99.7% and was not significantly different ($P = 0.074$) from the control group.

Fry growth was also monitored during the 10 weeks following mark applications. There were no significant ($P = 0.857$) differences in growth among the marked fry treatments.

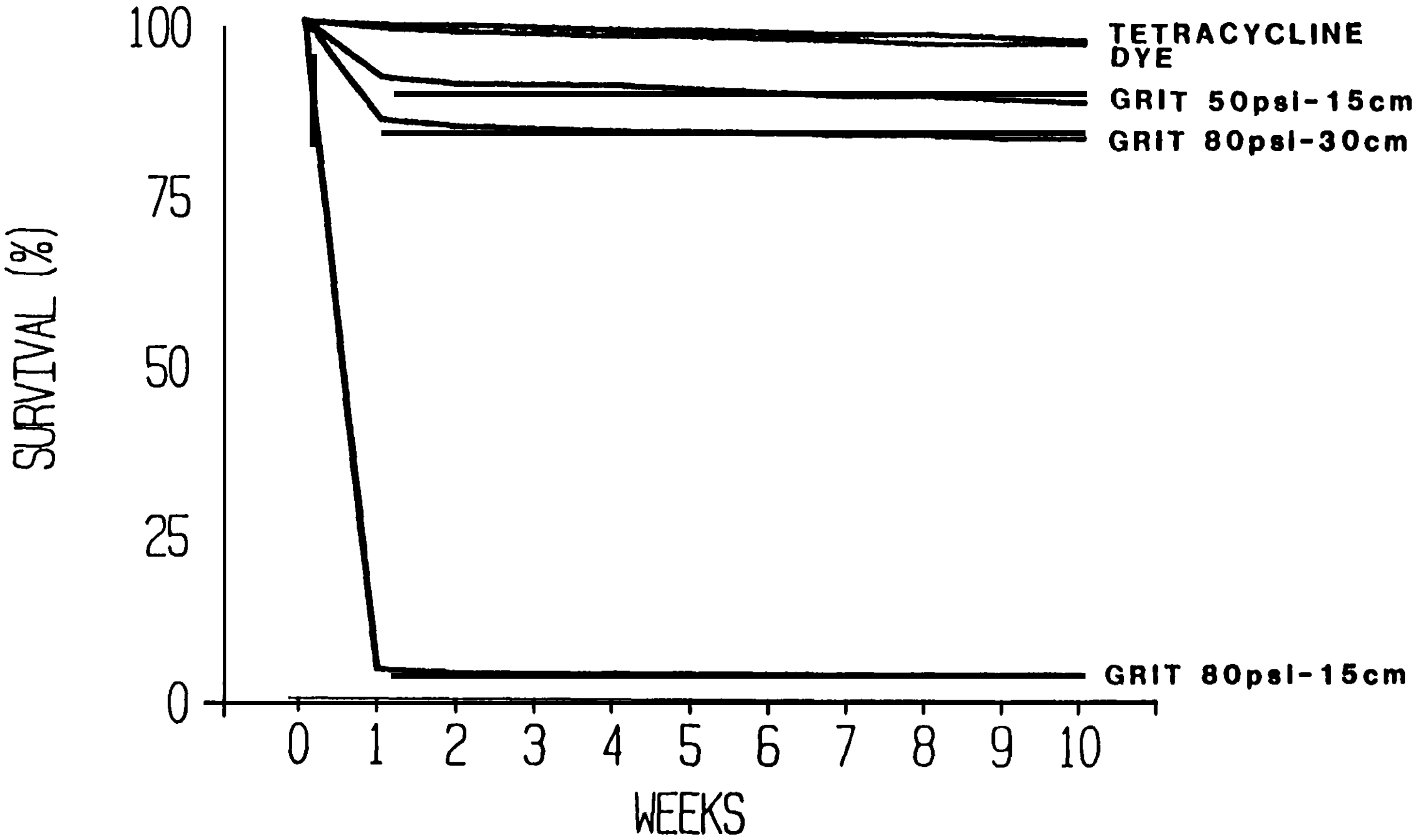


Figure 9. Average cumulat ve survival of kokanee fry marked w'"h tetracycline (control group), fluorescent dye and three d fferent apalications of uorescent grit. Fry were marked at 33 mm total length.

Mark Retention

Retention of marks on kokanee fry during 10 weeks following application averaged 100% for tetracycline, 96.4% for grit applied at 50 psi from 15 cm, 99.4% for grit applied at 80 psi from 30 cm and 99.3% for grit applied at 80 psi from 15 cm (Fig. 10). Average retention of tetracycline and grit marks did not differ significantly ($P>0.340$) from 100%. Retention of the fluorescent dye mark was 100% the first week and averaged 92.7% for two weeks following application. The dye was not recognizable during the remainder of the study.

Mysid Shrimp

Average Mysis shrimp density in Lake Pend Oreille during June 1986 was 0.039 organisms/liter. Total densities ranged from 0.011 organisms/liter in northern Lake Pend Oreille to 0.057 organisms/liter in the midsection (Fig. 11). Density in the southern section was 0.047 organisms/liter and did not differ significantly ($P = 0.275$) from the mean density in the midsection. Mysis density in northern Lake Pend Oreille was significantly lower ($P<0.002$) than in the midsection or southern section of the lake.

Juveniles comprised 72% of the total average Mysis density in Lake Pend Oreille, ranging from 65% in the northern end of the lake to 81% in the midsection. Mean density of juvenile Mysis for the entire lake was 0.029 organisms/liter, ranging from 0.007 organisms/liter in the northern section to 0.046 organisms/liter in the midsection (Fig. 11). Juvenile density in the southern section was 0.033 organisms/liter and did not differ significantly ($P = 0.383$) from the midsection. Density of juvenile mysids in the northern section of Lake Pend Oreille were significantly lower ($P = 0.000$) than other sections.

Adults comprised 28% of the total average Mysis density in Lake Pend Oreille, ranging from 19% in the midsection of the lake to 35% in the northern section. Adult Mysis averaged 0.008 organisms/liter for the entire lake. Densities ranged from 0.004 organisms/liter in the northern section to 0.011 organisms/liter in the midsection of Lake Pend Oreille (Fig. 11). Adult density in the southern section was 0.008 organisms/liter and did not vary significantly from the midsection ($P = 0.1301$, but was slightly higher than the northern section ($P = 0.057$). Adult mysid density in the midsection was significantly higher ($P = 0.002$) than in the northern section of Lake Pend Oreille.

Zooplankton Community

Macrozooplankton in Lake Pend Oreille were sampled from May through October during 1985 and 1986. Generic composition included Daphnia, Bosmina, Diaphanosoma, Cyclops, Diaptomus and Epischura. Copepod densities were higher than cladoceran densities throughout the sampling period (Fig. 12). Cladoceran production peaked in August and was approximately 20% of copepod production. Total zooplankton density ranged from approximately 5 organisms/liter in May to approximately 30/liter in August

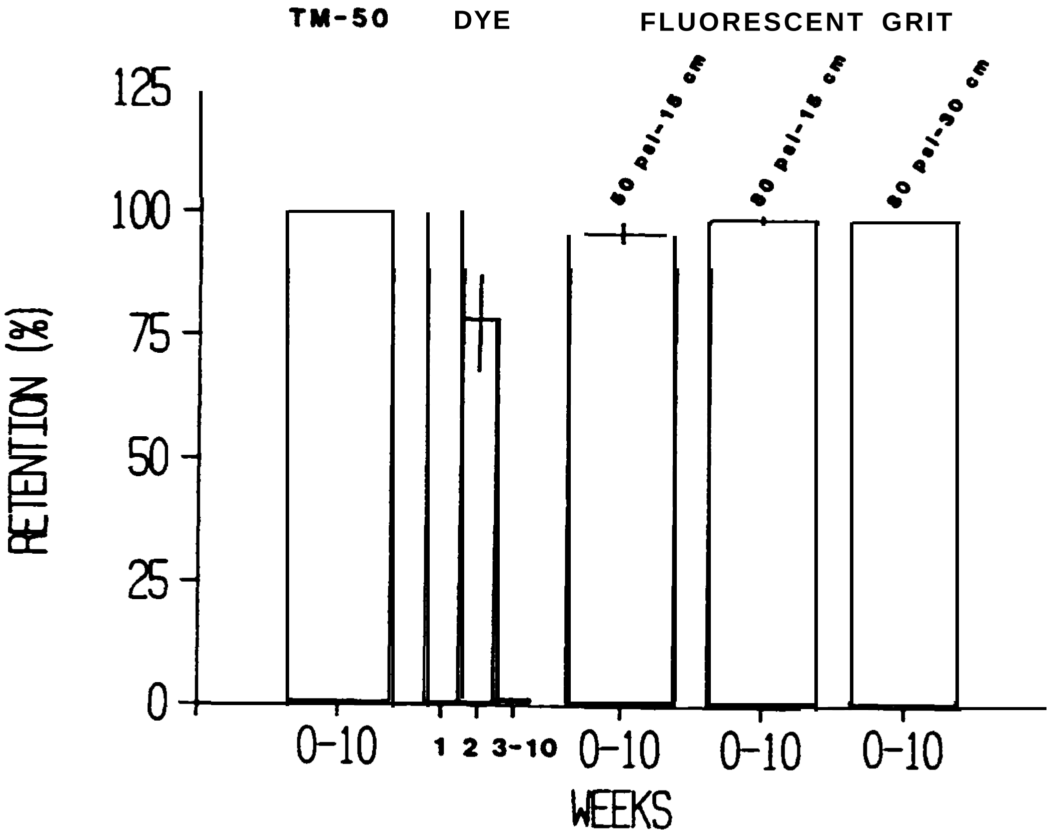


Figure 10. Average retention of tetracycline, fluorescent dye and fluorescent grit marks applied to kokanee fry. Vertical bars represent 95% confidence Intervals.

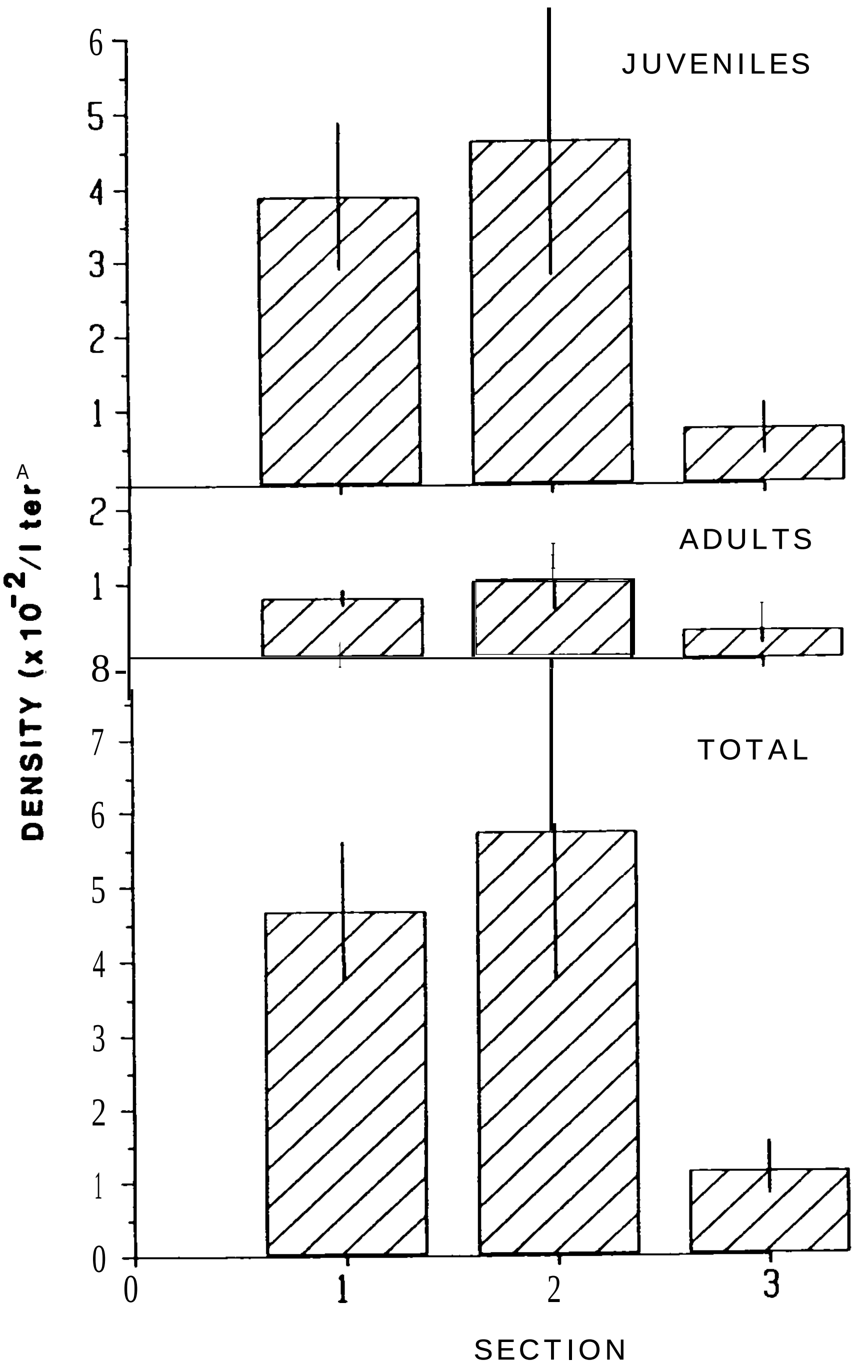


Figure 11. Average juvenile, adult and total densities of *Mysis* in Lake Pend Oreille, Idaho, sampled during June 1986. Vertical bars represent 90% confidence intervals.

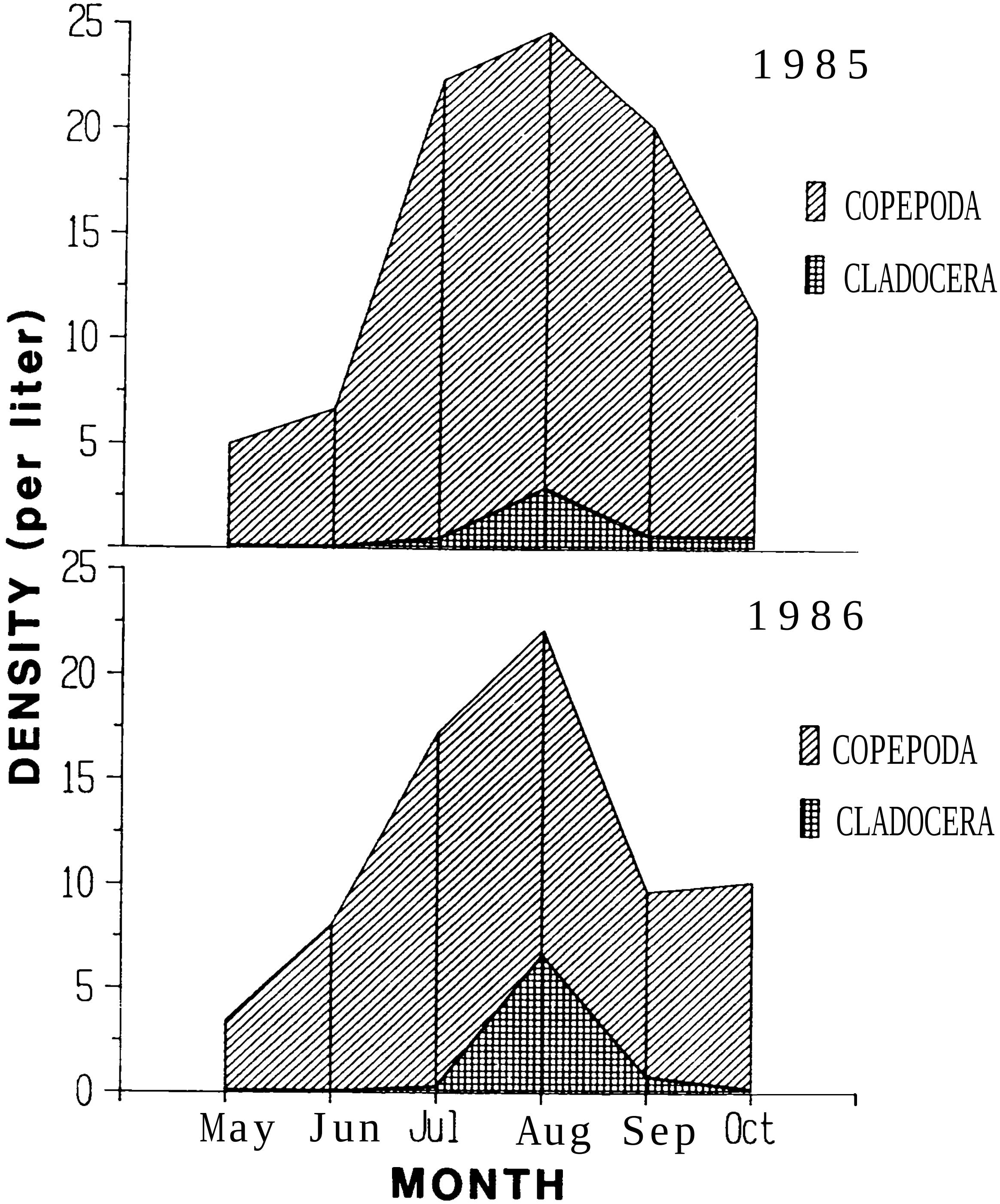


Figure 12. **Temporal distribution of Copepoda and Cladocera zooplankton in Lake Pend Oreille, Idaho, May to October 1985 and 1986.**

during both years (Fig. 13). The copepods Cyclops and Diaptomus were the most abundant zooplankters during 1985 and 1986, with combined densities ranging from approximately 4 organisms/liter in May to approximately 23 organisms/liter in August. Densities did not vary significantly between years (P>0.10). The cladocerans Daphnia and Bosmina were rarely collected until July. Bosmina densities in 1985 increased from 0.5 organisms/liter in July to 1.5 organisms/liter in August, whereas Bosmina densities during 1986 remained below 0.07 organisms/liter and were significantly (P<0.10) lower than 1985. Densities of Daphnia during 1985 were negligible during May, June and July, but increased to 1.4 organisms/liter by August. Daphnia densities during 1986 increased from 0 organisms/liter in May and June to 6.5 organisms/liter in August and were significantly (P<0.10) higher than 1985. Epischura and Diaphanosoma were rarely found in Lake Pend Oreille until August, when densities were approximately 0.1 and 0.05 organisms/liter, respectively. In general, zooplankton densities were similar (P>0.10) among northern, southern and midsections of Lake Pend Oreille (Fig. 13).

The largest zooplankter in Lake Pend Oreille during 1985 and 1986 was Epischura, which averaged 1.8 mm long, followed by Daphnia galeata and D. thorata, which averaged 1.1 mm each. Diaphanosana and Diaptanus had similar lengths at 0.91 and 0.90 mm, respectively. Length of Cyclops averaged 0.71 mm, followed by Bosmina, the smallest zooplankter, at 0.38 mm. In general, zooplankton lengths for each genus did not vary significantly (P>0.10) between years or among months and lake sections (Fig. 14).

Fishery

Total Catch and Effort

Lake Pend Oreille sport anglers fished an estimated 179,229 hours during 36,446 angler-days to catch 81,546 fish from April 15 to November 30, 1985 (Table 3). Game fish harvested includes: kokanee, Kamloops-rainbow trout, cutthroat trout, bull trout, lake whitefish, mountain whitefish and various spiny ray species. Approximately 45% of the anglers fished for kokanee, which made up 89% of the estimated catch and 51% of the anglers fished for trout (including bull trout), which comprised 9% of the estimated catch.

Kokanee Catch, Harvest and Exploitation

Anglers seeking kokanee caught an estimated 71,275 kokanee from April 15 to November 30, of which 71,208 (99.9% of total catch) were harvested (Table 4). Average catch rate for anglers seeking kokanee was approximately 1 fish/hr for 64,672 hours of effort. An additional 1,150 kokanee were harvested by anglers seeking other species. Mean total length of kokanee sampled from the creel during September was 254 mm. Kokanee sampled from the northern section of the lake (Johnson Creek access) averaged 242 mm, whereas kokanee from the southern portion of the lake (Bayview access) averaged 265 mm. Age structure of the kokanee catch throughout Lake Pend Oreille was 12% age 2+ and 88% age 3+ and age 4+ fish.

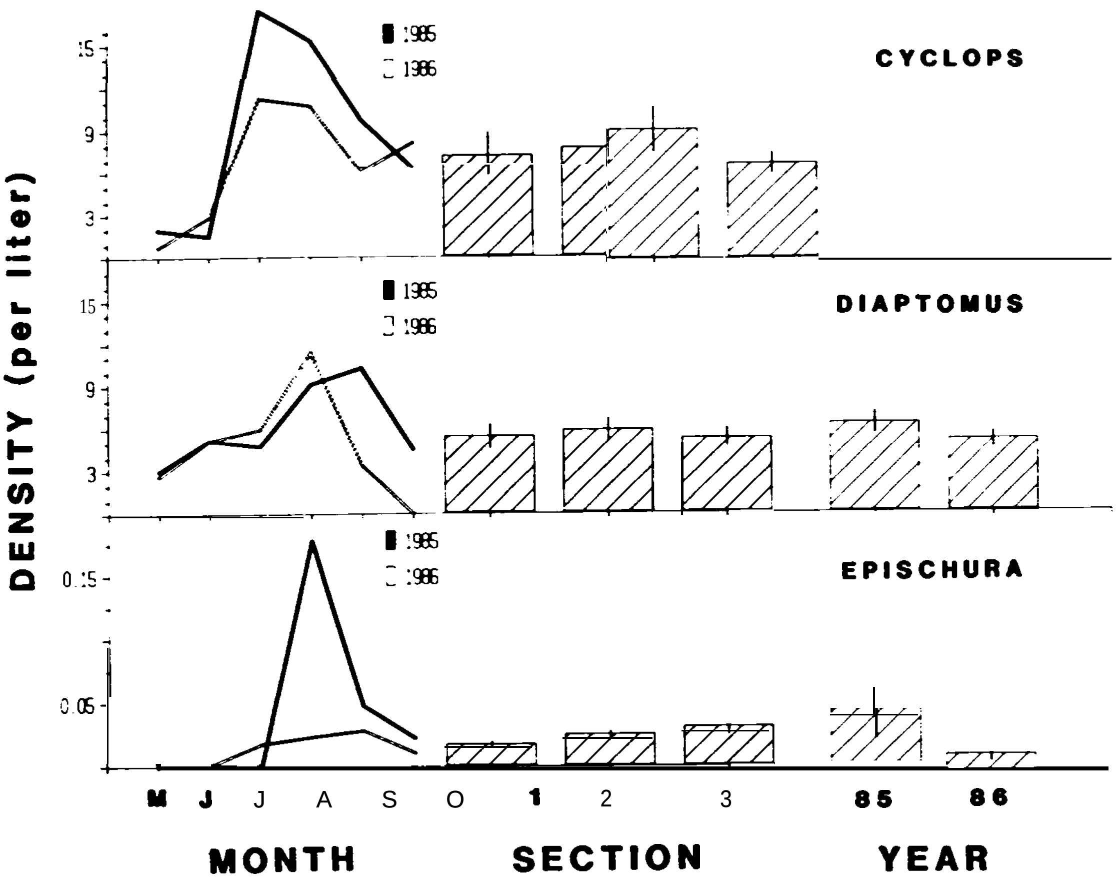


Figure 13. Temporal and spatial distribution of mean zooplankton densities in Lake Pend Oreille, Idaho, May to October 1985 and 1986. Vertical bars represent 90% confidence intervals.

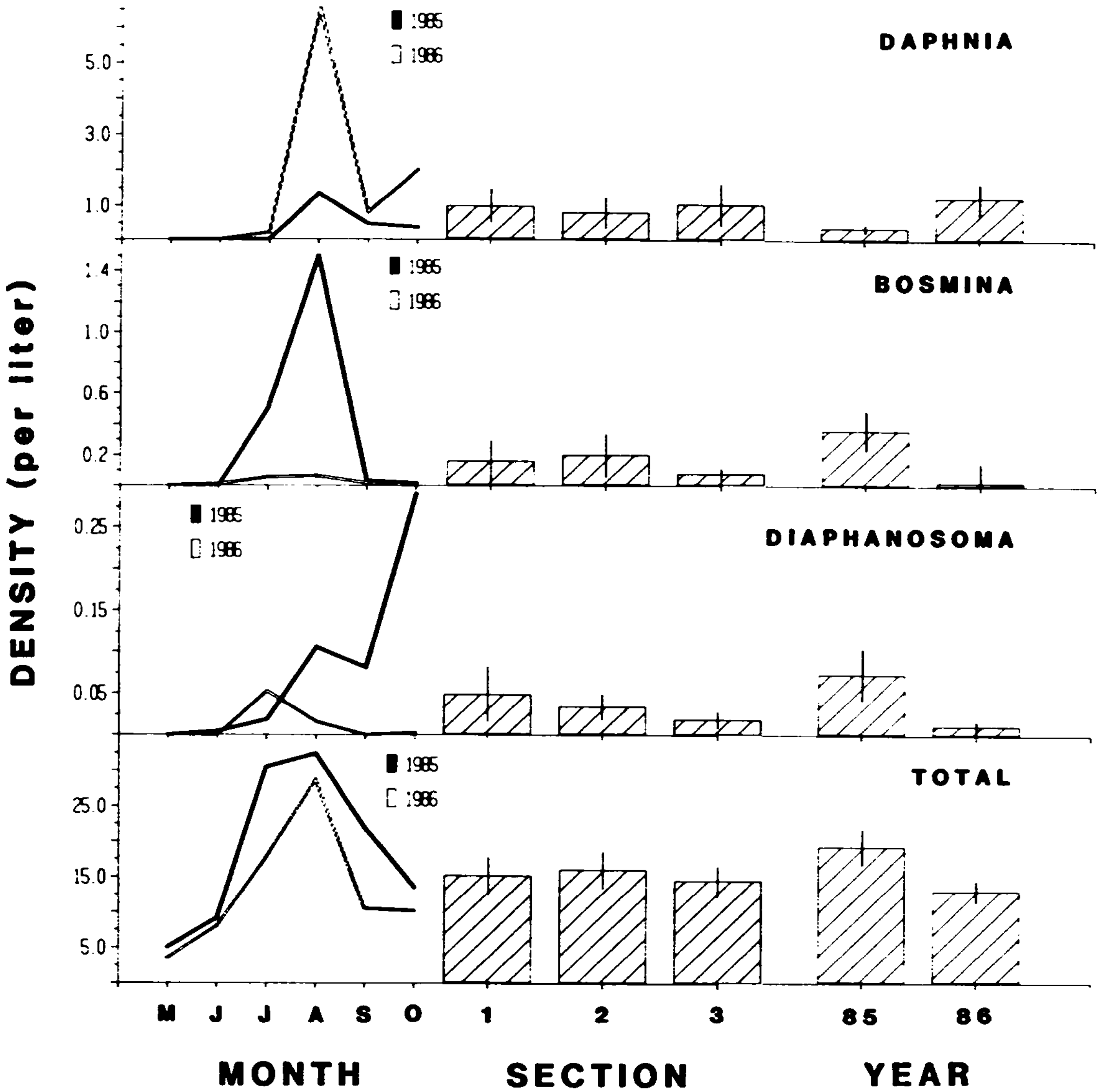


Figure 13. Continued.

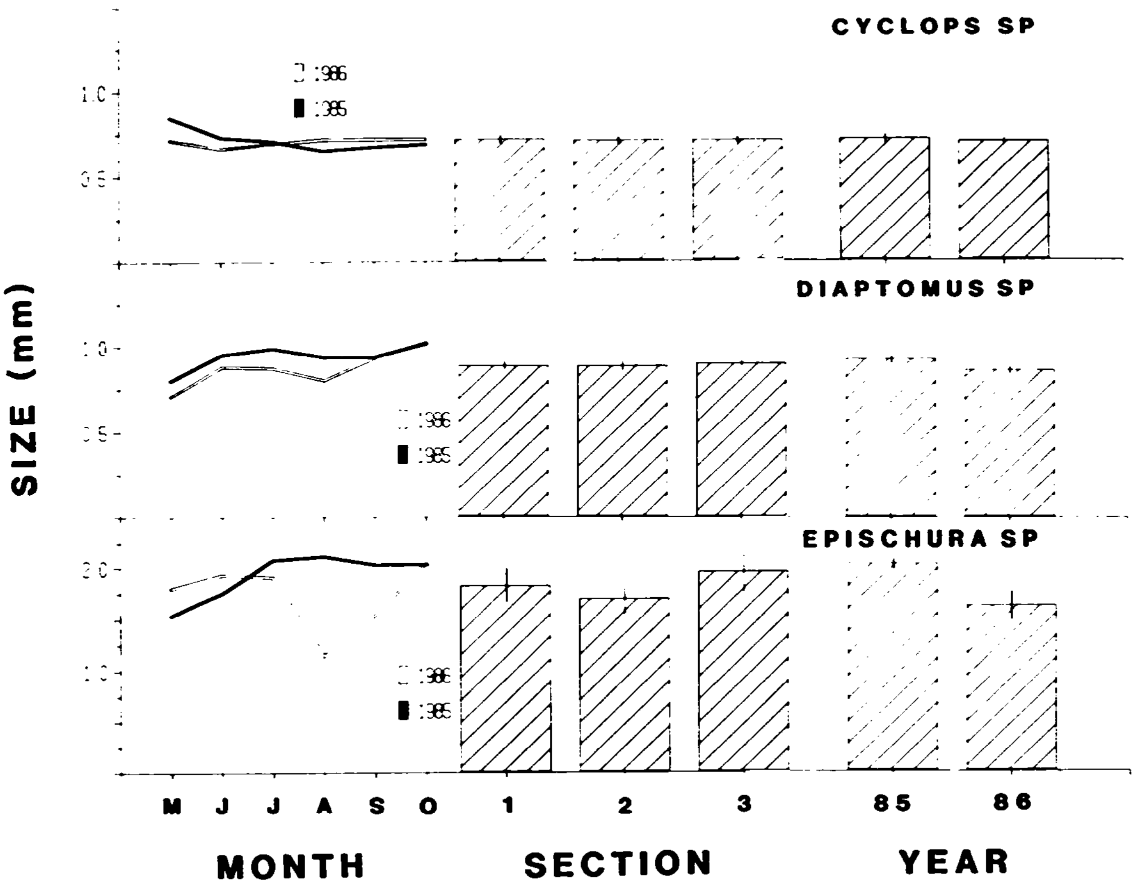


Figure 14. Temporal and spatial distribution of mean zooplankton lengths in Lake Pend Oreille, Idaho, May to October 1985 and 1986. Vertical bars represent 90% confidence intervals.

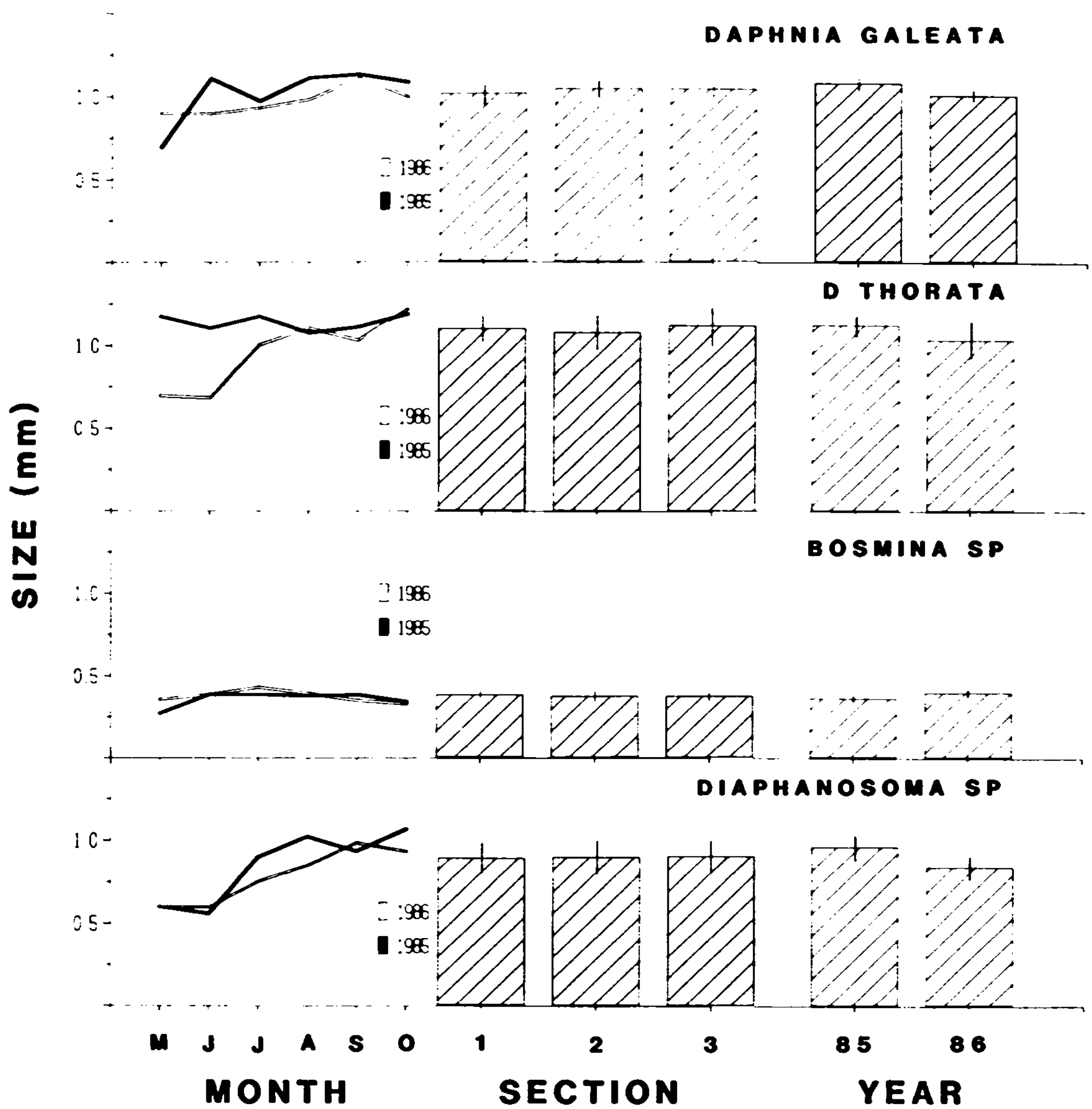


Figure 14. Continued.

Table 3. Estimated number of anglers, effort and harvest by survey perlod, Lake Pend Orellle, Idaho, 1985.

Period	Anglers	Hours	Creel compositlon									
			Kokanee	Small[a] rainbow	Large[b] ralnbow	Cut-throat	Bull trout	Lake white-fish	Spiny rays	Other trout	Non-game	Totals
Apr 15-May 30	11,391	70,205	1,942	1,552	911	203	621	606	62	138	74	6,109
May 31-July 15	9,120	41,667	24,580	1,147	372	267	149	0	139	215	19	26,896
July 16-Aug 30	9,367	37,587	26,628	985	144	125	60	22	200	42	2	20,208
Aug 31-Oct 15	5,082	22,351	18,819	516	158	50	79	0	0	40	0	19,662
Oct 16-Nov 30	1,486	7,419	381	151	112	19	6	0	0	2	0	671
Totals	36,446	179,229	72,358	4,351	1,697	664	915	628	401	437	95	81,546

[a] <43.2 cm
[b] ≥ 43.2 cm

Table 4. Estlmated catch and harvest for anglers seeking kokanee from April 15 to November 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours Fished	Kokanee caught	Kokanee harvested	Other game fish caught	Kokanee caught/ hour	Kokanee harvested/ hour	All game fish caught/ hour
Apr 15-May 30	934	4,068	1,550	1,550	208	0.28	0.28	0.32
May 31-July 15	4,659	18,999	24,196	24,170	652	1.13	1.13	1.17
July 16-Aug 30	7,343	27,930	26,589	26,548	1,053	0.92	0.92	0.95
Aug 31-Oct 15	3,137	12,798	18,583	18,583	123	1.34	1.34	1.35
Oct 16-Nov 30	226	877	357	357	2	0.46	0.47	0.47
Totals	16,299	64,672	71,275	71,208	2,038	1.03	1.03	1.06

Age structure of the catch from the northern end of the lake was 23% age 2+ and 77% age 3+ and age 4+ fish, whereas age structure of kokanee caught in the southern end of the lake was 2% age 2+ and 98% age 3+ and age 4+ fish. Exploitation of age 2+ (1982 year class) and age 3+ and age 4+ (1980 and 1981 year classes) kokanee were 0.7% and 15.25 respectively.

Rainbow Trout Catch and Harvest

Based on angler Interviews, the average catch rate for anglers seeking trophy (>43.2 cm total length) Kamloops (Gerrard rainbow) from April 15 to November 30 was approximately 61 hours/fish. An estimated 1,754 trophy Kamloops were caught and 1,363 (78%) were harvested In 99,296 hours of effort (Table 5). An additional 334 trophy Kamloops were harvested by anglers seeking other salmonids. Mean total length and weight of trophy Kamloops sampled from the creel were 566 mm and 2.3 kg, respectively.

Average catch rate for anglers seeking subtrophy (<43.2 cm) rainbow trout was approximately 0.11 fish/hour. Total estimated catch was 948 rainbow trout in 7,991 hours of effort (Table 6). Approximately 895 of these rainbow (94%) were harvested. An additional 3,456 subtrophy rainbow trout were harvested by anglers seeking other species. Mean total length of subtrophy Kamloops sampled from creels was 340 mm.

Cutthroat Trout Catch and Harvest

Average catch rate for anglers seeking cutthroat trout was approximately 0.04 fish/hr. Total estimated catch was 49 cutthroat, of which 43 (88%) were harvested in 1,406 hours of effort (Table 7). An additional 621 cutthroat were harvested by anglers seeking other species. Mean total length of cutthroat trout sampled from creels was 345 mm.

Bull Trout Catch and Harvest

Estimated catch rate for anglers seeking bull trout was 0.08 fish/hr. The estimated total catch of bull trout was 423, of which 405 (96%) were harvested in 5,275 hours of effort (Table 8). An additional 510 bull trout were harvested by anglers seeking other species. Mean total length of bull trout sampled from the creel was 496 mm.

Additional Harvest

Total lake whitefish harvested during the survey was estimated at 628, comprising 0.8% of the total harvest. An estimated 401 spiny ray and 437 miscellaneous other trout were harvested, each comprising approximately 0.5% of the total harvest. Estimated harvest of nongame fish was 95 for the reporting periods comprising 0.1% of the total harvest.

Table 5. Estimated catch and harvest for anglers seeking largr ralnbow trout[a] from April 15 to November 30, Lake Pond Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Large ralnbow caught	Large rainbow harvested	Other trout species caught	Other game fish caught	Large ralnbow caught (fish/hr)	Large ralnbow harvested (fish/hr)	All trout caught (fish/hr)	All game fish caught (fish/hr)
Apr 15-Msy 30	7.435	57,311	999	778	1,375	316	74	91	30	26
May 31-July 15	3,549	18,100	335	240	734	136	48	65	17	15
July 16-Aug 30	1,199	8,787	110	93	277	48	79	91	22	19
Aug 31-oct 15	1,681	0,340	157	140	343	121	49	61	18	15
Oct 16-Nov 30	1,165	6,158	153	112	137	28	39	55	19	17
Totals	15,629	99,296	1,754	1,363	2,866	649	61	70	23	20

[a] >43.2 cm total length

Table 6. Estimated catch and harvest for anglers seeking small ralnbow trout[a] from April 15 to November 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Small rainbow caught	Small rainbow harvested	Other trout species caught	Other game fish caught	Small ralnbow caught/ hour	Small ralnbow harvested/ hour	All trout caught/ hour	All game fish caught/ hour
Apr 15-May 30	731	3,610	320	290	137	242	0.09	0.09	0.12	0.17
May 31-July 15	681	2,785	331	318	241	318	0.10	0.10	0.18	0.28
July 16-Aug 30	99	380	97	87	27	34	0.20	0.17	0.25	0.35
Aug 31-Oct 15	201	1,000	154	154	49	86	0.17	0.17	0.23	0.30
Oct 16-Nov 30	64	216	46	46	2	0	0.08	0.08	0.10	0.10
Totals	1,776	7,991	948	895	456	680	0.11	0.11	0.17	0.24

[a] <43.2 cm total length

Table 7. Estimated catch and harvest for anglers seeking cutthroat trout from April 15 to November 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Cutthroat trout caught	Cuttthroat trout harvested	Other trout species caught	Other game fish caught	Cutthroat trout caught/ hour	Cutthroat trout harvested/ hour	All trout caught/ hour	All game fish caught/ hour
Apr 15-May 30	154	580	14	12	122	40	0.02	0.01	0.11	0.15
May 31-July 15	102	453	17	13	55	14	0.04	0.03	0.19	0.22
July 16-Aug 30	46	127	6	6	4	16	0.07	0.07	0.11	0.29
Aug 31-Oct 15	47	133	12	12	40	51	0.06	0.06	0.29	0.65
oct 16-Nov 30	21	113	0	0	13	0	0	0	0.07	0.07
Totals	370	1,406	49	43	234	121	0.04	0.03	0.16	0.23

Table 8. Estimated catch and harvest for anglers seeking bull trout from April 15 to November 30, 1985, Lake Pend Oreille, Idaho.

Period	Anglers	Hours fished	Bull trout caught	Bull trout harvested	Other trout species caught	Other game fish caught	Bull trout caught/hour	Bull trout harvested/hour	All trout caught/hour	All game fish caught/hour
Apr 15-May 30	835	4,452	365	353	439	452	0.08	0.08	0.15	0.22
May 31-July 15	90	565	42	36	18	6	0.11	0.09	0.15	0.17
July 16-Aug 30	34	122	14	14	0	0	0.10	0.10	0.10	0.10
Aug 31-Oct 15	16	80	2	2	2	0	0.02	0.02	0.05	0.05
Oct 15-Nov 30	10	56	0	0	2	2	0	0	0.04	0.07
Totals	985	5,275	423	405	461	460	0.08	0.08	0.14	0.20

Angler Residency

Idaho residents comprised 56% of the total anglers fishing Lake Pend Oreille and they expended 58% of the total fishing effort (Table 9). During the summer months (June through August), nonresidents maintained a slight majority of the total anglers (55%) and angling effort (53%) on Lake Pend Oreille.

Angler Attitudes

A majority (54%) of anglers (n = 4,876) fishing Lake Pend Oreille would prefer the fishery more restrictively managed to provide occasional catches of large rainbow than less restrictively managed to provide more consistent catches of smaller rainbow (Table 10).

When 3,742 anglers were asked which restrictive regulations would be acceptable, 77% favored some type of size limit, whereas 92% opposed a shortened season (Table 11). Implementation of a season bag limit was opposed by 52% of the anglers interviewed.

DISCUSSION

Population Status

Kokanee abundance in 1986 was similar to 1985 and indicated continued suppression of kokanee production since its initial decline in the 1960s (Fig. 15). Dramatic decline during the late 1960s and 1970s reduced kokanee abundance by over 60% of predecline levels. Although current levels remain low, abundance has not declined substantially since 1978--a result of both hatchery supplementation and relatively stable wild fry survival (Bowles et al. 1986). While total kokanee abundance has somewhat stabilized, age class structure continues to vary (Fig. 16). It is encouraging that relative abundance of age 3+ and age 4+ kokanee increased during the last two years following four years of decline, although the increase is more the result of relatively strong year classes moving through the population than a permanent shift in age structure. These older kokanee make up the majority of spawners and the fishery.

Annual survival was similar for age 1+ and age 2+ kokanee in 1986, but survival of age 1+ kokanee was nearly twice as high in 1986 than 1985. This indicates a potentially weak 1983 year class (age 2+ in 1986) that will enter the fishery and mature in 1987 and 1988. Annual survival of age 3+ and age 4+ immature kokanee in 1986 was nearly 20% lower than survival of age 1+ and age 2+ kokanee. Creel data from 1985 indicates that most of this difference can be attributed to harvest.

Table 9. Estimated number of resident and nonresident anglers and effort by survey period, Lake Pend Oreille, Idaho, 1985.

Period	Resident		Nonresident		Totals	
	Anglers	Hours	Anglers	Hours	Anglers	Hours
Apr 15-May 30	7,862	48,880	3,529	21,325	11,391	70,205
May 31-July 15	4,285	19,770	4,835	21,897	9,120	41,667
July 16-Aug 30	4,074	17,454	5,293	20,133	9,367	37,587
Aug 31-Oct 15	2,961	13,223	2,121	9,128	5,082	22,351
Oct 16-Nov 30	1,120	5,563	366	1,856	1,486	7,419
Totals	20,302	104,890	16,144	74,339	36,446	179,229
Percent of Total	56%	58%	44%	42%		

Table 10. Angler response by survey period to the question: "Would you prefer Lake Pend Oreille managed more restrictively to provide occasional catches of large rainbow (5-25 lbs) <u>or</u> less restrictively to provide more consistent catches of fish up to 5 lbs?"

Period	Sample size	Regulations: More restrictive (favored large fish size)	Regulations: Less restrictive (favored large fish numbers)
Apr 15-May 30	2,342	62%	38%
May 31-July 15	1,121	50%	50%
July 16-Aug 30	927	34%	665
Aug 31-Oct 15	319	51%	49%
Oct 16-Nov 30	167	81%	19%
Totals	4,876	54%	46%

Table 11. Angler response by survey period to the question: "If more restrictive regulations are required to maintaln or improve the trout fishery on Lake Pend Oreille which of the following regulations would you accept?"

	Regulations								
	Some type of size limit			Shortened season			Season bag limit		
Period	Sample size	Favored	Opposed	Sample size	Favored	Opposed	Sample size	Favored	Opposed
Apr 15-May 30	1,708	67%	33%	1,706	28%	72%	1,702	48%	52%
May 31-July 15	1,115	83%	17%	1,115	42%	58%	1,115	53%	47%
July 16 Aug 30	925	82%	18%	925	40%	60%	925	60%	40%
Aug 31-Oct 15	319	87%	13%	319	27%	73%	319	80%	20%
Oct 16 Nov 30	153	77%	23%	153	8%	92%	153	48%	52%
Totals	4,220	76%	24%	4,218	34%	66%	4,214	54%	46%

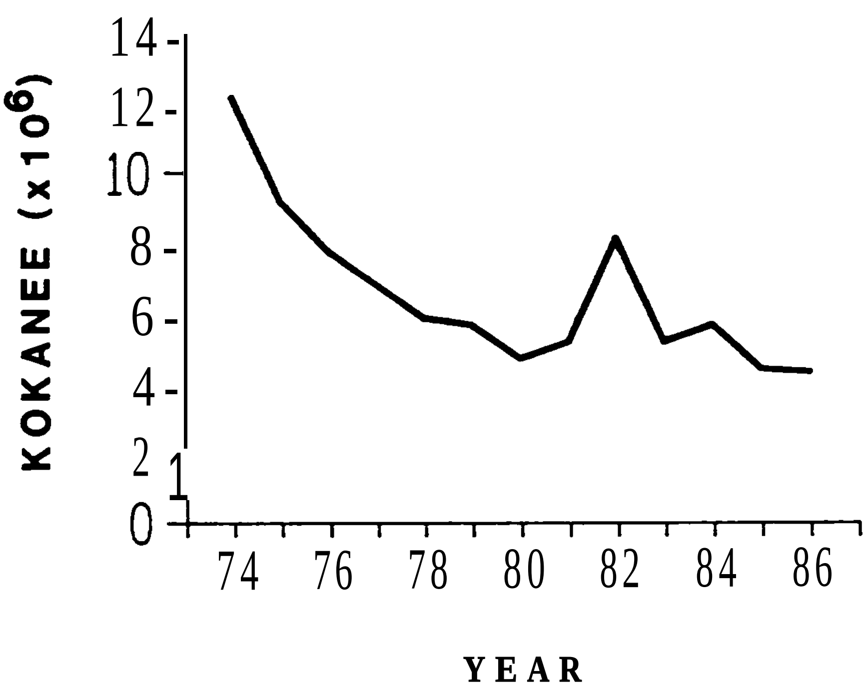


Figure 15. Estimated total kokanee abundance durlng September In Lake Pend Orei l le, Idaho, 1974-1986.

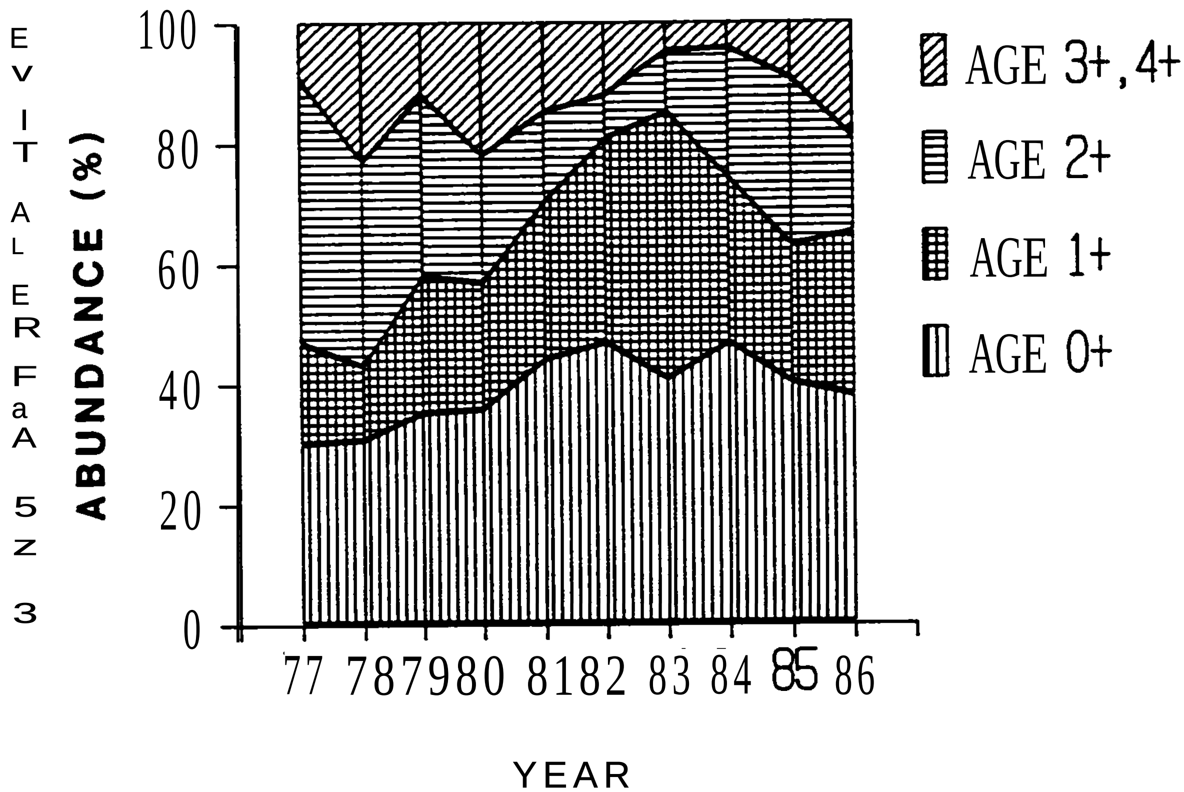


Figure 16. Relative abundance of four age groups of kokanee estimated during September from Lake Pend Oreille, Idaho, 1977-1986.

Fishery

Catch statistics indicate the quality of kokanee fishing continues to decline from the fishery enjoyed in the mid-1960s. Kokanee catch in 1985 represented a 61% reduction from the catch in 1980 and follows a downward trend evident since 1964 (Fig. 17). Fishing pressure for kokanee has also declined, with a 46% reduction from 1980 to 1985. This reduction in effort is evident in the percentage of total anglers seeking kokanee, which declined from 54% in 1980 to 36% in 1985. Concurrent decline of catch and effort has resulted in similar catch rates (approximately 1 fish/hr) for sport anglers seeking kokanee over the last seven survey years (1975-1980 and 1985), compared to catch rates in excess of 3 kokanee/hr for sport anglers during the mid-1960s (Ellis and Bowler 1981).

Mean total length of the kokanee catch in 1985 averaged just over 250 mm and was predominantly (88%) age 3+ and older fish. This compares to a mean kokanee length of 256 mm in the 1980 catch (Ellis and Bowler 1981). Age class structure of the catch varied between lake sections, with anglers harvesting a higher percentage of age 2+ kokanee in the northern (23%) than southern (2%) end of the lake. The fact that nearly all (99.9%) kokanee caught in Lake Pend Oreille are harvested indicates that this discrepancy is probably more the result of different age class distributions throughout the lake than different angler attitudes toward harvest. Exploitation of age 2+ kokanee was negligible (<1%) in 1985 and did not have much influence on annual survival. In contrast, exploitation of age 3+ and age 4+ kokanee was over 15%, resulting in a corresponding reduction in annual survival for immature age 3+ and age 4+ kokanee.

The 1985 trout and char fisheries on Lake Pend Oreille failed to show improvement over previous years. Quality of the trophy Kamloops (Gerrard) rainbow fishery has varied over the years. Although catch and catch rates had improved from the mid-1970s to 1980, both statistics declined in 1985 (Fig. 18). Effort, which had been increasing during this period, also declined in 1985. Average length of Kamloops in the catch has declined gradually since the early 1970s, which also indicates a deteriorating fishery. Recruitment of Kamloops to the trophy fishery may be influenced by incidental exploitation of younger (<43.2 cm total length) Kamloops by anglers seeking kokanee or large Kamloops. Incidental harvest of these smaller rainbow represented over 50% of the total Kamloops harvest in 1985. Catch of bull trout increased slightly from 1980 to 1985, but harvest remains low compared to other species. The fishery is mainly incidental, with approximately 56% of the harvest taken by anglers seeking other species. The cutthroat trout fishery has declined more dramatically than any other Lake Pend Oreille fishery; harvest has decreased over 90% from the early 1950s to 1985 (Fig. 19). Although a remnant cutthroat population remains in the system, approximately 94% of the current harvest is incidental, indicating the fishery is functionally extinct. The dramatic decline of cutthroat trout in Lake Pend Oreille has been attributed to both the loss and degradation of spawning and rearing habitat and excessive exploitation.

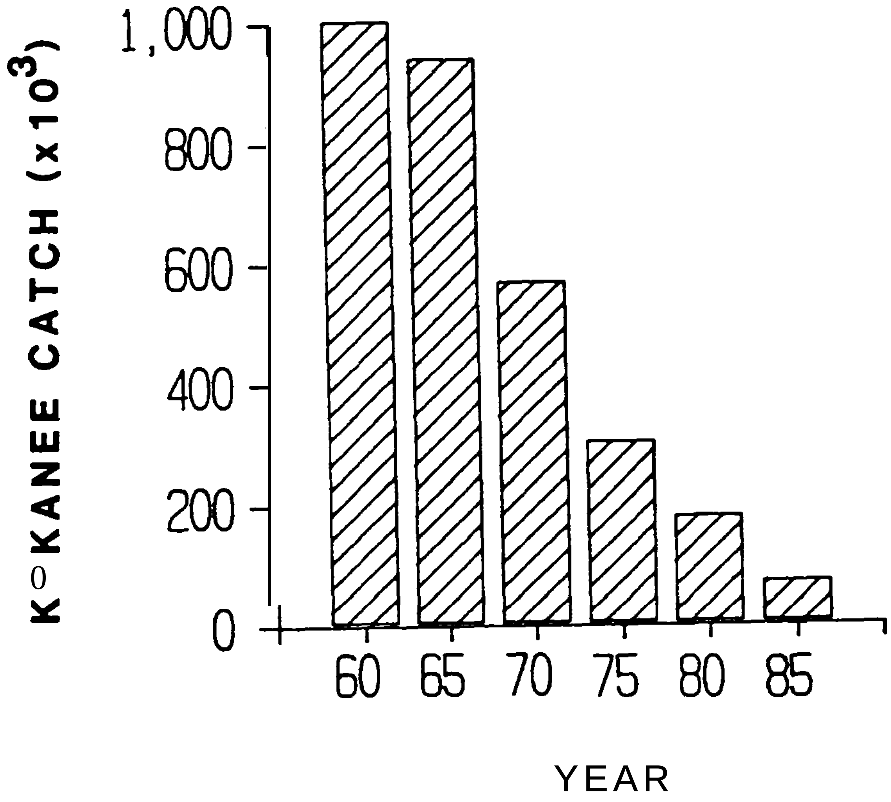


Figure 17. Mean (3 to 5 year) annual kokanee catch from Lake Pend Oreille, Idaho, April 15 to November 30, 1960-1980 and point estimate for 1985.

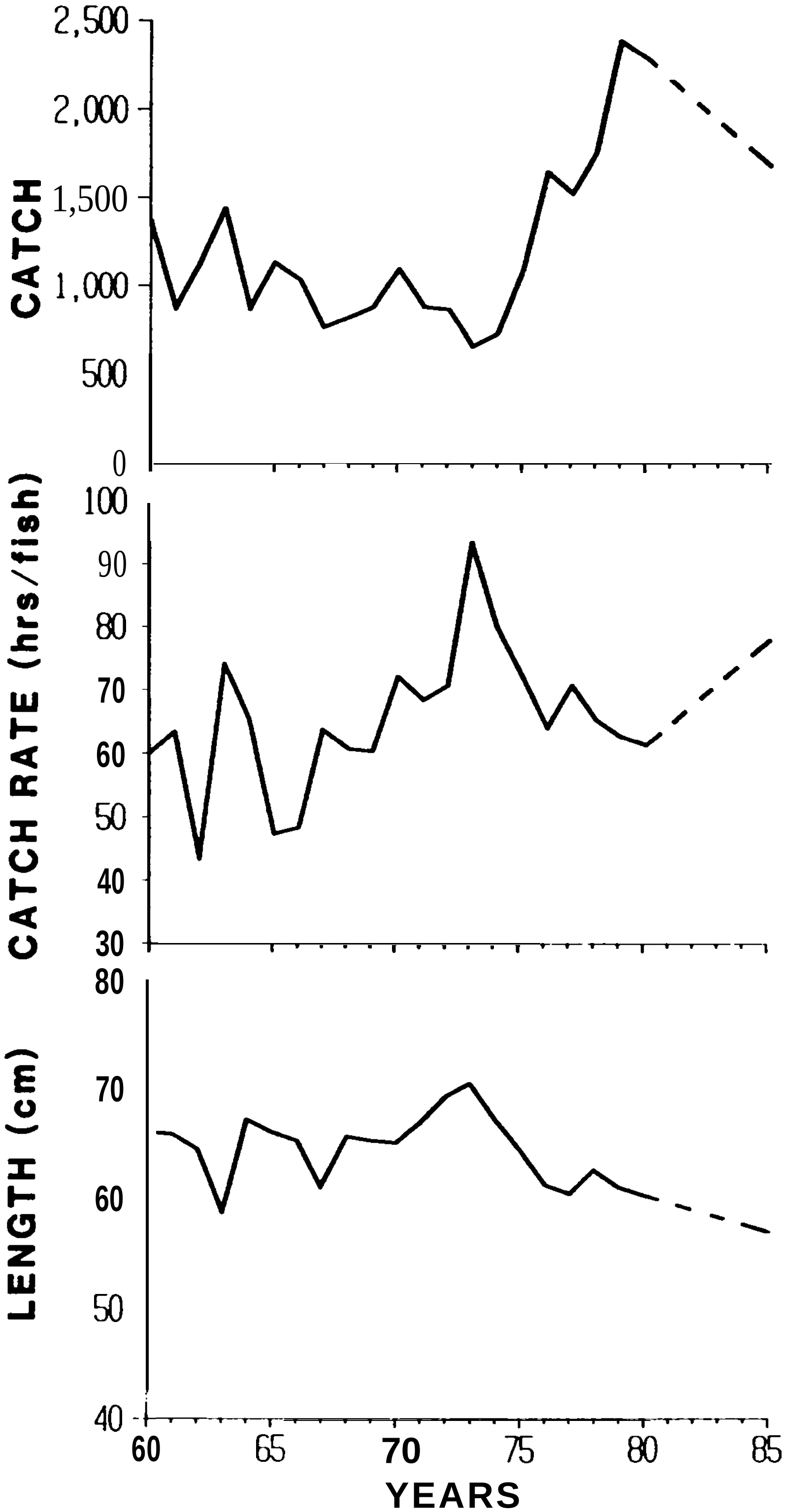


Figure 18. Catch, catch rate and length of Kamloops (≥ 43.2 cm TL) caught from Apri l 15-November 30 in Lake Pend Orel l le, Idaho, 1960-1980 and 1985.

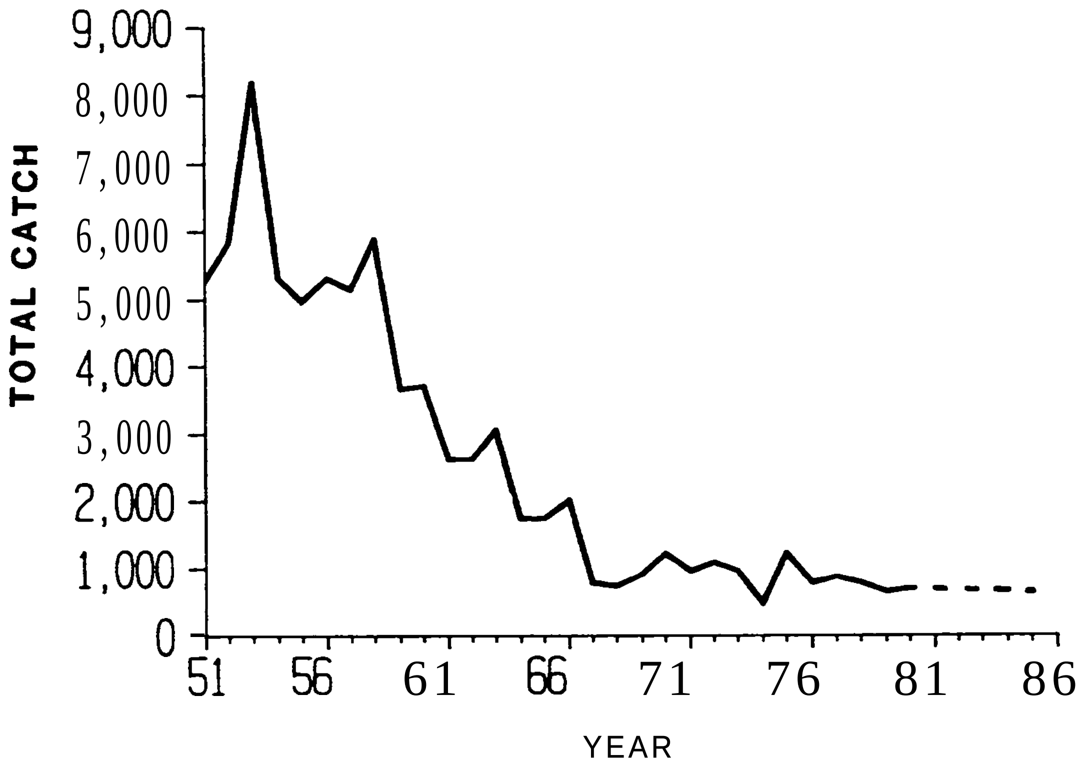


Figure 19. Estimated catch of cutthroat trout In Lake Pend Oreille, Idaho, 1951-1980 and 1985.

The potential for alternative species to contribute substantially to the fishery is questionable. Warmwater species are predominantly limited to the northern end of Lake Pend Oreille and constitute a very small portion (<1%) of the fishery. Lake whitefish up to 2 kg are abundant in Lake Pend Oreille, probably the result of effective utilization of *Mysis* shrimp for forage. Currently, lake whitefish constitute less than 1% of the total harvest, but their contribution could be greatly increased through an assertive angler education program. Emphasis toward less desirable species in other states has often increased their utilization (Bennett 1970).

Anglers polled in 1985 to determine attitudes toward potential regulation changes indicated a slight preference (54%) for a trophy rather than a yield rainbow trout fishery. The interest in a trophy fishery will probably increase as kokanee--the traditional yield fish of Lake Pend Oreille--abundance increases. Anglers favored a size limit (77%) and opposed a shortened season (92%) if restrictive regulations for Kamloops were implemented. Attitudes were evenly split concerning implementation of seasonal bag limits. Preference of a more restrictive size limit is encouraging because this regulation would best control the excessive exploitation of small Kamloops caught incidentally by kokanee anglers.

Fry Survival and Recruitment

Increased fry recruitment from hatchery and/or wild production is prerequisite to rebuilding the kokanee population in Lake Pend Oreille. Since 1978, annual recruitment of hatchery fry has typically been less than 0.5 million (22% of total), but has ranged from 0.09 to 1.98 million as a result of variable survival and number released (Fig. 20). Although severely depressed, annual recruitment of wild fry since 1978 has been relatively stable at approximately 1.8 million (range 1.5 to 2.1 million). Wild fry recruitment in 1986 was lower than typical, but still followed this relatively stable trend. The 1985 estimate was a definite exception to this trend, but may be inaccurate due to the small sample size (Bowles et al. 1986). Relatively stable wild recruitment indicates that fluctuations in total recruitment are primarily a function of hatchery fry production and survival. Although hatchery production has helped keep kokanee recruitment from further decline, both survival and the number released must increase dramatically to begin rebuilding the population.

Prior to 1986, hatchery fry survived 6 to 10 times better than wild fry, partially a result of midsummer fry releases to avoid early season forage deficiencies resulting from mysid-zooplankton interactions. Although our results indicate an abundant *Mysis* population and continued suppression of cladoceran zooplankton production, the typical survival advantage of hatchery fry over wild fry was not evident in 1986. In fact, survival to fall sampling was nearly twice as high for wild fry than hatchery fry. Although highly variable from year to year, survival during 1986 was at the lower end of the range (3.2 to 33%) reported in the literature for Lake Pend Oreille (Cochnauer 1984). Low post-release survival in 1986 was predominantly a result of high mortality during emigration down the Clark Fork River from Cabinet Gorge Hatchery to Lake

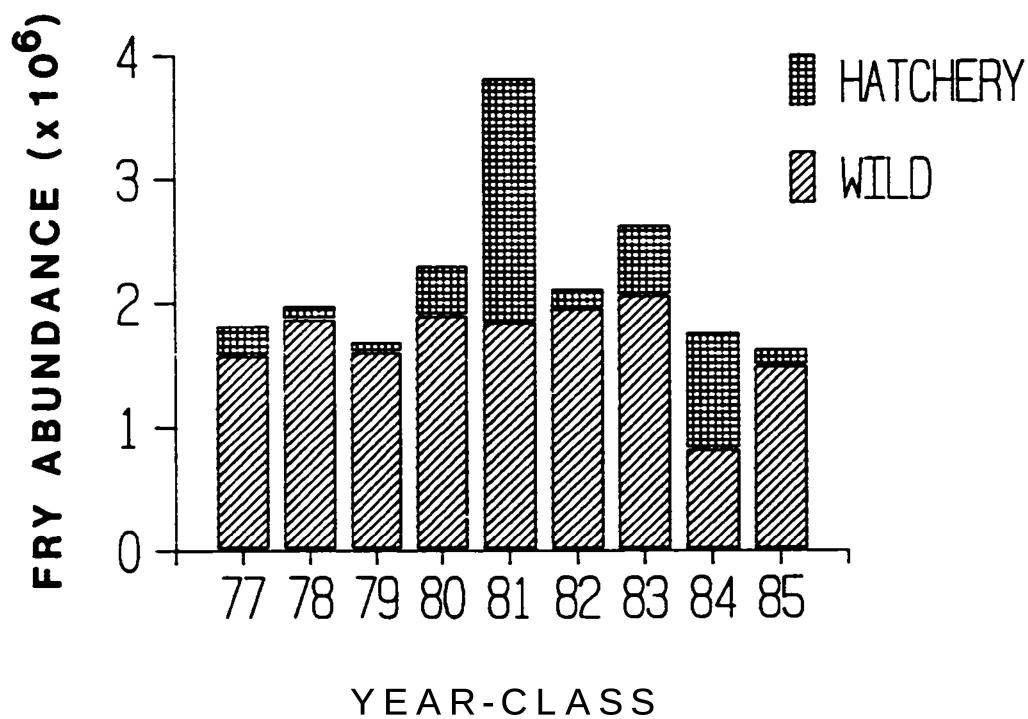


Figure 20. Relative contribution of wild and hatchery production to total kokanee fry recruitment (in September) in Lake Pend Oreille, Idaho, 1977-1985 year-classes.

Pend Oreille. Our sampling of fry during emigration indicated total survival may have been as low as 11%. This estimate is near the lower end of the range (9 to 68%) reported in the literature for emigrating sockeye salmon (Oncorhynchus nerka) fry (Foerster 1968).

One factor contributing to low survival during emigration in 1986 was extremely poor flow conditions in Clark Fork River during fry releases, resulting from a low water year (52% of normal) and mechanical problems at upriver dams. In spite of these difficulties, Washington Water Power Company (WWP) manipulated discharge to provide a 4-hour surge of 16,000 or 7,800 cfs flows for one or two nights after each fry release. Flows during the remainder of the night ranged from 0 to 8,000 cfs. Under a typical midsummer power production scenerio, WWP would maintain minimum flows (3,000 cfs) during nighttime hours (low power demand) and increase flows up to 20,000 cfs during daytime (high power demand) hours (Hank LuBean, WWP, personal communication). Our sampling near the mouth of Clark Fork River indicated survival of emigrating fry was twice as high during the higher flows, which may have increased survival by reducing exposure to predators. Northern squawfish (Ptychocheilus oregonensis) are abundant in lower Clark Fork River (Jeppson and Platts 1959) and are effective predators of salmon emigrants (Brett and McConnell 1950; Foerster 1968). We will continue to examine the relationship between river flows and fry emigration in order to balance acceptable fry survival with power production. We will also study the influence of other factors on fry survival, inclluding: size, release site, numbers, time of release and predation.

To effectively test more than one factor each year, it is necessary to differentially mark large groups of fry released under different conditions. Results of our multiple-marking study indicated that tetracycline is the best mark for ease of application (administered in feed), retention time (>10 weeks) and survival (100%). Fluorescent dye (Bismark Brown) appears to be an excellent short-term mark, with relative ease of application (immersion), high survival (99%) and good retention (100%) for one week. Mark loss after two weeks makes fluorescent dyes impractical for long-term experiments. Fraley and McMullin (1983) had similar results for kokanee fry marked with dye in the Flathead system. Fluorescent grit is a potentially good long-term mark and the option of different colors allows up to four separate marks. Mark retention was high (>96%) for the 10-week period. Application is more difficult than other marks, but experienced applicators have marked over 8,000 fry/man-hour (Phinney et al. 1967). Fry survival was excellent following initial mortalities incurred during application. These initial mortalities were probably the result of small fish (33 mm total length) and inexperienced applicators. In future years, fry produced at Cabinet Gorge Hatchery will be substantially larger (40 to 50 mm) than in 1986 (Ed Schriever, IDFG, personal communication). Kokanee fry typically do not form scales until 40 mm total length. Grit marking fry that have not yet formed scales often results in high mortality and low mark retention (Narver and Anderson 1969; Hennick and Tyler 1970). Fluorescent grit will be a practical and useful long-term mark if initial marking mortality can be kept under 5%. None of the external marks we tested appear to have adverse chronic effects on fry, as indicated by similar growth between marked and unmarked fry.

Spawning

Success of kokanee enhancement efforts depends on adequate spawning escapement and egg take. Although abundance of age 3+ and older kokanee was higher in 1986 than 1985, total spawning escapement was slightly lower. This discrepancy was the result of a much smaller proportion of mature fish in these older age classes in 1986 (41%) than 1985 (85%). The predominance of immature age 3+ kokanee in the 1986 population accounts for the lower percentage of mature fish in the 3+ and 4+ age classes. The proportion of mature fish in these older age classes should increase again next year as the remainder of this strong 1982 year class matures at age 4+ and the relatively weak 1983 year class contributes few mature kokanee at age 3+.

Spawning escapement to the Sullivan Springs weir represented a much smaller proportion of total spawners in 1986 (13%) than 1985 (21%). Total escapement to Sullivan Springs in 1986 declined 44% from 1985 and was the lowest escapement since 1979 (Table 12). Low adult returns resulted in the worst fry-to-adult return rate (2%) since initiation of the hatchery program in the mid-1970s. As in 1985, low escapement and return rate to Sullivan Springs in 1986 apparently were not the result of inadequate total spawner abundance in Lake Pend Oreille. Although we do not know exactly what caused the decline, weather-related factors and perhaps straying of adults were probably important factors. In 1985, extremely cold water temperature during the spawning period impeded migration up Granite Creek to the weir. In 1986, weather conditions once again reduced escapement to Sullivan Springs. A large freshet, produced by a rain-on-snow event just prior to the anticipated peak in spawning activity (late November), flushed spawners from Granite Creek and impeded migration for over a week. Although these fish may have successfully spawned on lake shoals, they were precluded from egg-taking efforts. In addition, large numbers of spawners destined for Sullivan Springs may stray and spawn elsewhere. Based on tetracycline marks, it has been estimated that up to 30% of lakeshore spawners in southern Lake Pend Oreille are hatchery origin (LaBolle 1986; Bowles et al. 1986).

Total egg take in 1986 (9.1 million) was bolstered by the spawn collected from Spring Creek and Clark Fork River spawners. The total take is adequate to maintain current enhancement levels, but will not increase hatchery production. Egg take for 1987 is difficult to project because fry-to-adult returns have varied from 2 to 13% over the last 6 years, with a marked decline the last 2 years. Based on average fry-to-adult return rates prior to 1985 (6.6% for age 3+ and 4.4% for age 4+), kokanee escapement to Sullivan Springs in 1987 may be as high as 340,000 adults. Although it is doubtful that Granite Creek could hold such a run, the escapement would yield more than enough eggs to fill Cabinet Gorge Hatchery (30 million eggs). Based on more recent returns (1% for age 3+ and 0.8% for age 4+), escapement to Sullivan Springs in 1987 may be as low as 55,000 adults. This escapement would yield less than 9 million eggs, far below the hatchery's capacity. Contingency plans are currently being developed to help offset potentially low escapement to Sullivan Springs in 1987 and reverse the apparent downward trend. These include increased egg take at other locations, releasing larger fry at Sullivan Springs and imprinting these fry with morpholine to reduce straying.

Table 12. Weir counts of kokanee entering Sullivan Springs from 1974 through 1986, number of eggs collected, subsequent fry released into Sullivan Springs and adult return rate.

Year	Kokanee spawned	Eggs collected	Fry released following year[a]	Estimated returning adults from hatchery releases and year returned		% hatchery fry returning as adults
1974	13,549	985,000	629,200	NA		NA
1975	14,200	NA	NA	NA		NA
1976	10,200	913,000	757,700	55,500 42,200	(1980) (1981)	12.96%
1977	17,560	2,040,000	1,598,800	135,300 29,000	(1981) (1982)	10.28%
1978	16,875	1,400,000	1,745,700	118,000 58,000	(1982) (1983)	10.08%
1979	12,005	1,451,400	1,081,400	42,000 75,660	(1983) (1984)	10.88%
1980	48,760	4,186,700	2,219,800	54,340 46,810	(1984) (1985)	4.56%
1981	112,820	11,653,000	2,487,800	27,935 20,060	(1985) (1986)	1.93%
1982	115,850	11,432,900	2,875,589	22,170		
1983	79,850	6,320,000	3,214,512			
1984	122,000	15,000,000	2,938,391			
1985	75,500	10,600,000	1,594,731			
1986	42,230	7,337,000[c]				

Additional fry were released in other areas.
this number reflects only those tetracycline-marked adults entering Sullivan Springs. Unknown numbers of marked adults have been documented spawning with wild kokanee in the Bayview area.
An additional 1.76 million eggs were collected from Spring Creek and the Clark Fork River, bringing the total egg take to 9.1 million.

Our spawning ground surveys indicate naturally spawning kokanee utilize various tributary streams (highest number In Spring Creek) and lakeshore (highest number on southern shoals) spawning areas. Al though lakeshore spawner counts were somewhat lower than last year, kokanee numbers in most spawning tributaries were substantially higher than last year (Table 13). Thls was particularly evident in Spring Creek where adult spawners were three times more abundant than last year. This increase was probably the result of outplanting kokanee fry into Spring Creek four years ago and straylng from Clark Fork River releases.

Adult returns to other tributaries outplanted in 1982 were negligible. Higher counts of kokanee spawners in other tributaries may have been the result of minimal icing problems and higher flows in 1986. Many tributary streams in 1985 had submergent flows and/or were partly iced over by the time counts were made. Trest I e Creek is the only known tributary on Lake Pend Oreille to maintain a remnant run of early spawnlng kokanee (September spawners). The run thls year was approximately five times higher than last year and the first reported increase since 1978. This probably is more the result of high parental escapement than Increased survival. If true, we can anticipate an even larger run of early spawning kokanee next year.

Table 13. Muxlmum single late run (early run Included for Trestle Creek) kokanee counts made during 1972-1978 and 1985-1986 spawnlng seasons on Lake Pond Orellle and Its trlbutarlcs, excluding Granlte Crook dralnage.

Area	maxImum single counts								
	1972	1973	1974	1975	1976	1977	1978	1985	1986
LAKESHORE									
Bayview	2,626	17,156	3,588	9,231	1,525	3,390	790	2,915	1,720
Farragut	25	0	0	0	0	0	0	--	10
Idlewlld Bay	13	0	25	0	0	0	0	-s	--
Lakeview	4	200	18	0	0	25	0	4	127
Elllsport Bay and Hope	1	436	975	0	0	0	0	0	0
Trestle Creek Resorts	0	1,000	2,250	0	115	75	138	2	35
Sunnyslde	0	25	0	0	0	0	0	0	0
Flsherman Island	0	0	75	0	0	0	0	--	--
Anderson Polnt	0	0	50	0	0	0	0	--	--
Camp Bay	0	617	0	0	0	0	0	0	0
Garfleld Bay	0	400	20	0	0	0	0	0	6
Subtotal	2,669	19,834	7,001	9,231	1,640	3,490	936	2,921	1,898
Percent of Total	29%	62s	25%	64s	33%	40%	19%	32%	10%
TRIBUTARIES									
South Gold Creek	1,030	1,875	1,050	440	0	30	--	235	1,550
North Gold Creek	744	1,303	1,068	663	130	426	--	696	1,200
Cedar Creek	0	267	44	16	11	0	0	--	--
Johnson Creek			1	0	0	0	0	--	182
Twln Creek	0	0	135	1	0	0	0	5	0
Mosqulto Creek	0	503	0	0	0	0	0	--	--
Clark Fork Rlver	539	3,520	6,180	0	--	--	--	--	--
Llghtnlng Creek (Lower)	350	500	2,350	995	2,240	1,300	44	127	165
Spring Creek	2,610	4,025	9,450	3,055	910	3,390	4,020	5,204	14,000
Trestle Creek	1,293	18	1,210	15	0	40	0	0	0
Trestle0	--	1,100	217	14,555	1,486	865	1,509	208	1,034
Garfleld Creek		0					0	--	1
Subtotal	6,568	12,091	21,513	5,185	3,291	5,188	4,046	6,347	17,098
Percent of Total	71	38%	75%	36%	67%	60%	81	68%	90%
Total	9,235	31,925	28,514	14,416	4,931	8,676	5,000	9,268	18,996

aMaxImum single early run count of kokanee spawners.
Excluding early run kokanee spawners In Trestle Creek.

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