July 1985

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

Annual Report 1985

DOE/BP-22493-1

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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do r necessarily represent the views of BPA.

This document should be cited as follows:

Boules,Edward C. Project Leader, Vern L. Ellis, Fisheries Technician, Denlse Washick, Fisheries Technician, Flsherles Research Sectlon Idaho Department of Fish and Game, Fred Holm Divlslon of Fish and WildlIfe Bonneville Power Administration, U.S. Department of Energy, Agreement No. DE-A I79-1985BP22493, Project 1985-339, 47 electronic pages (BPA Report DOE/BP-22493-1)

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

ANNUAL PROGRESS REPORT FY 1985

BY

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Agreement No. DE-AI79-85BP22493

Project 85-339

July 1986

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ABSTRACT

Mid-water trawling techniques were used during September to estimate kokanee population abundance, structure and survival. Abundance in 1985 was estimated at 4.5 mll l ion f lsh (198 per hectare), down from over 12 mil l lon kokanee in 1974 when the population was first monitored. Hatchery fry production (<6 million annually) has stabilized kokanee abundance since its initial decline in the late 1960s. Wild fry recruitment has remalned relative1 y stable at 1.8 million since 1978; whereas recru 1 tment of hatchery-reared fry has ranged from 0.09 to 1.98 mill lon.

The 1985 creel survey indicated that kokanee harvest rates rema in l ow, with approximately one kokanee harvested per hour of effort from April to August. Catch rates were as high as 3.5 fish per hour during the mld-1960s.

The zoopl ankton community was monitored with periodic plankton tows. Zooplankton composition in 1985 was similar to previous years and appears to have stabilized following the introduction of myslds, wlth peak cladoceran production occurring several weeks after peak kokanee emergence. De l ayed release of hatchery fry resulted in higher survival of hatchery (7.3%) than w l ld (0.43%) kokanee fry. Other release strategies w 1 l l be tested as more fry become available.

The 1985 egg take was 10.6 mll l ion, down 29% from the 1984 take and less than 40% of the projected egg take necessary to f l l l Cab inet Gorge Hatchery. Low egg collectlon in 1985 was more a result of reduced spawner migration due to low water temperature than reduced spawner abundance. Length of kokanee spawners has been increasing since 1975, probably the result of low population density and utilization of mysids by older age-classes.

INTRODUCTION

Lake Pend Orellle supported the most popular kokanee salmon (Oncorhynchus nerka) fishery in Idaho from the 1940s until the early 1970s. The sport and commercial fishery produced an average annual yield of 1 mll l ion kokanee for 360,000 hours of angl lng effort from 1951 to 1965 (Ell is and Bowler 1979). Sport anglers enjoyed catch rates as high as 3.5 fish per hour during the mid-1960s. Annua l kokanee harvest has declined steadly since 1965 to present levels of less than 200,000 fish, supporting mean catch rates of approxlmately 1 kokanee per hour. in addition to provlding an important fishery, kokanee are the primary forage for trophy Kamloops rainbow trout (Salmo gairdneri) and bull trout (Salvelinus confluentus) in Lake Pend Orei l le. - - -

Several factors contributed to the Initial decl l ne of kokanee. Hydropower development adversely impacted spawnlng success of kokanee salmon. Aibeni Fails Dam was completed in 1952 by the Army Corps of Eng l neers as part of the Bonnev i l ie Power Administratlon (BPA) network. Located on the Pend Oreille River approximately 35 km downstream of Lake Pend Orei l le, Aibeni Fails Dam raised lake levels 4 m. Annual winter drawdown averaging 1.3 m from 1951 to 1968 increased embryo mortal ity by exposing redds of lakeshore spawning kokanee (Bowler et al. 1979). Cab i net Gorge Dam was constructed on the Clark Fork River (rkm 19) for power generation by Washington Water Power Company (WWP). Completlon of this dam in 1952 blocked an important kokanee spawning run into the Clark Fork River and its tr ibutar ies. Decl in 1 ng kokanee abundance may have been accelerated by commercial and sport fishing overharvest. The estab l ishment of opossum shrimp (Mysis rel_icta) in Lake Pend Oreil ie 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 juveni l e growth and surv ival 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) which are essential juvenlle kokanee forage during the first few weeks of feedlng (Rieman and Bowler 1980). increased growth of older kokanee was also not as great as anticipated due to spatial segregation between Mysis and feeding kokanee. Myslds 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 with its initial decline. The Army Corps of Engineers adopted a policy for Aibenl Fal is Dam in 1967 to minimize water level fluctuations during kokanee spawn i ng and incubation. IDFG enacted special sport harvest regulations for kokanee In 1973 and terminated the commercial fishery. Hatchery product ion of kokanee for Lake Pend Oreil le was establ lshed by 1974 and helped stabilize population numbers. Delayed planting of hatchery fry until mid-summer to avoid early season forage deficiencies increased hatchery fry survival up to 13 times that 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 flshery. Prlor to 1985, hatcheries could provide only 6 to 8 million kokanee fry annually for Lake Pend Orellle. Research indicated that releases of up to 20 ml I I ion fry annual I y may be necessary to restore the fishery to historic levels (Rieman 1981).

In an effort to enhance Lake Pend Orellle kokanee production, the Cabinet Gorge Hatchery was built on the 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 mitigatlon funds mandated by the Northwest Power Act of 1980. Construction and evaluation of the Cabinet Gorge Hatchery is specified by measure 804(e)(5) of the Columbia River Basin Fish and Wildl ife Program (NWPPC 1984). Cabinet Gorge Hatchery was operational by November 1985, in time to receive kokanee eggs from Granite Creek. At ful I capacity the hatchery wil I provide up to 20 ml I I ion kokanee fry for release Into the Pend Oreille system. Rebuilding the kokanee population to attain a goal of over 0.75 million kokanee harvested annually in 300,000 hours of effort will be dependent on productlon from this hatchery.

This research project was developed by IDFG in cooperation with BPA to eval uate the contr Ibut ion of Cabinet Gorge Hatchery to the Lake Pend Orei I le kokanee stock and f ishery and to provide recommendations for optimizing kokanee production and survival . Pre-project data col lected during 1985 and included in this report will be used with other data to measure the effectiveness of kokanee releases from Cabinet Gorge Hatchery beginning in 1986.

OBJECTIVES

1. To assess the status of kokanee In Lake Pend Oreille before the 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 Orellle.

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

4. To obtain index information on natural spawning kokanee.

5. To monitor the Lake Pend Orellle zooplankton community and relate to changes in kokanee abundance.

6. To obtain pre-hatchery harvest data for the Lake Pend Oreille fishery for comparison with slmliar data after hatchery product Ion inf I uences the f Ishery.

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 Oreil le is 629 msl. The Clark Fork River is the largest tributary to Lake Pend Oreil le. Outflow from the lake forms the Pend Oreille River.

Lake Pend Orei l e is a temperate, oligotrophic lake with minimal evidence of cultural or natural eutrophication (Rieman 1977). Summer temperatures average approximately 9 C in the upper 45 m of water. The N:P ratio is typical ly high (>11) and indicates primary production may be P I imited (Rieman and Bowler 1980). Mean chlorophyl l "a" concentration dur I ng summer is approximately 2 ug/l. Summer mean water transparency (secchi disk) ranges from 5 to 8 m.

A wide diversity of fish species are present in Lake Pend Orei l e. Kokanee entered the l ake in the ear l y 1930s, presumably from Flathead Lake and were wel l estabi lshed by the 1940s. Other game fish include: Kam loops rainbow trout, bull trout, rainbow trout (Salmo gairdneri), cutthroat trout (Salmo clarki), lake whitefish (Coregonus clupeaformis), 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 with a 140 hp diesel engine. The trawl net was 13.7 m long with a 3x3 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 col lected. Traw I ing was done at night dur ing the dark phase of the moon to optimize capture efficiency (Bowler 1979). The trawl was towed at 1.5 m/s at depths estimated from cable angle-length relationships and verified with a time-depth recorder. Each obl ique haul sampled the entire vertical distribution of kokanee, as determined from echograms produced by a 200 A depth sounder with two hull mounted transducers (22^o and 8^o beam angles). The vertical distribution of kokanee was divided into 13.7 m layers; usually 3 to 5 I ayers encompassed the vertical distribution of kokanee. A standard 3.5 minute tow was made in each layer, sampl ing 2,832 m^3 of water over a d istance of 305 m. Total vol ume of water sampled for each traw I hau I var led from 8,496 to 14,160 m^3 depending on the vertical distribution of kokanee.

A stratified random sampling scheme was used to estimate kokanee abundance and dens I ty. Lake Pend Oreil le was divided into seven sections or strata (Fig. 2). Area of each section was calculated within the 91.5 m depth contour, except section 7, which was calculated from the 36.6 m contour 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

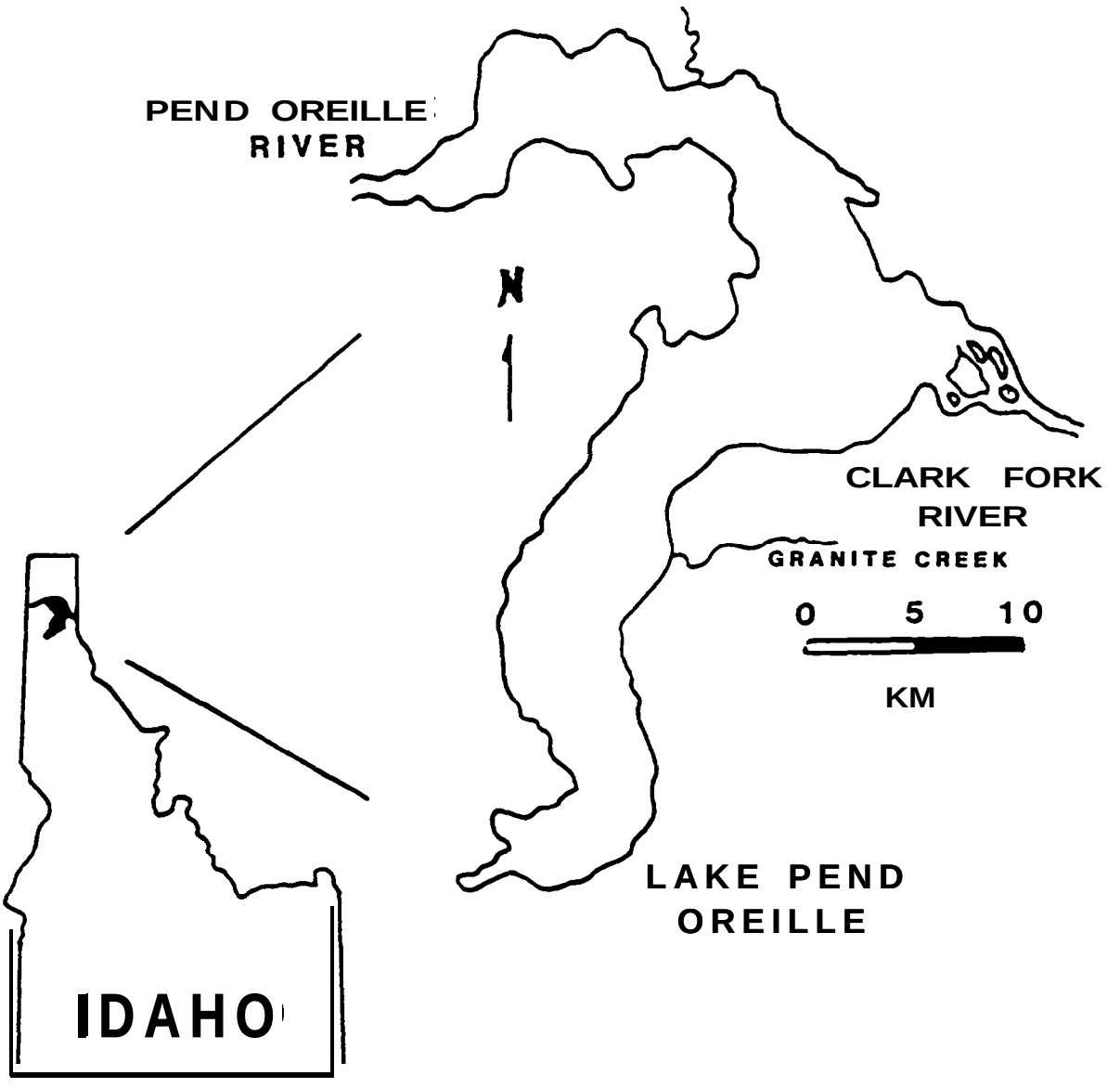

Figure 1. Lake Pend Oreille, Idaho.

Section	Area (ha)
1	3166.22
2	3220.15
3	3739.49
4	4036.73
5	3373.23
6	2298.39
7	2712.39

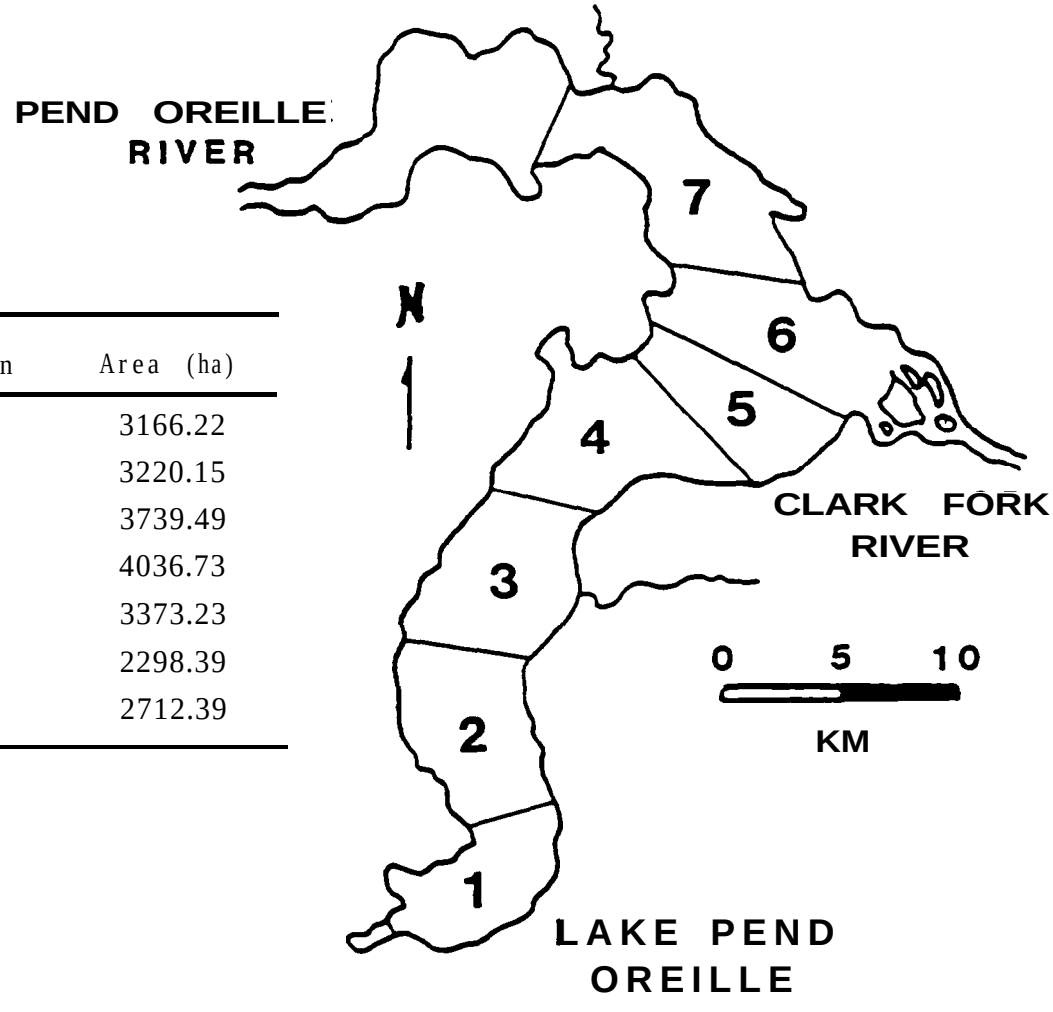

Figure 2. Stratified sampling sections and respective areas (hectares) used during 1985 for trawling and kokanee abundance estimation on Lake Pend Oreille, Idaho.

(Bowler 1978). Two to six transects were selected at random within each section and one haul (sample) was made along each transect. Total sample size in 1985 was 30 hauls.

Fish numbers per transect (haul) were weighted by transect volume and the age-specific number of kokanee for each stratum calcuated with the formula (Scheaffer et al. 19791:

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

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) (α =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 vat-lance 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) (α =0.10) was placed on this estimate by:

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

Kokanee population estimates (total and by section) were divided by respective lake surface areas to calculate kokanee densities (no./ha) 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 hatchery fry released In Lake Pend Orellle tributarles were marked with tetracycline. Tetracycl Ine (TM-501 was mlxed with fish feed at the rate of 11% by weight and fed to kokanee fry for 10 days prlor to release. Kokanee fry captured In the trawl during September were examlned for tetracycline marks uslng an ultraviolet I ght. The external mark was vlslble for several months after fry were released. When the external mark faded on older kokanee, the fluorescence was evldent In vertebrae. Survival of hatchery-reared kokanee fry was measured by comparing estimates of tetracycline-marked fry In the I ake dur I ng September to known numbers of marked fry released earl ler In the year.

Tetracyc I I ne-marked fry have been released I n Lake Pend Orel I I e and Its tributaries since 1978 (Table 1). Al I fry marked during 1985 were released In the Clark Fork RIver near Cabinet Gorge Hatchery and comprised 22.2% of the total fry released In the Clark Fork River, Granlte and Sullivan Sprlngs creeks.

Wild fry survival from potentlal egg deposltion (PED) to September abundance was estlmated from trawl catches. PED was calculated by multiplying average fecundity by estlmated mature female kokanee abundance.

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

Egg Take

Since 1974, Idaho Department of F Ish and Game has ma Inta Ined a permanent welr station at the mouth of Sullivan Springs Creek (tributary to Granlte Creek), a major kokanee spawning tributary to Lake Pend Orelll e (Flg. 1). I t has prov Ided kokanee eggs for Lake Pend Orel I I e as we I I as other enhancement actlvlties.

Naturally Kokanee

Adu I t kokanee were enumerated along I akeshore and tributary spawn Ing areas to provide an Index of naturally spawnlng kokanee abundance. Counts were made by walk I ng each area once dur Ing the f Irst week of December, the estimated peak of spawnlng activity. Only pre-determlned portlons of lakeshore spawning areas were surveyed, whereas entlre spawning areas were censused In trlbutary streams.

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

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
Prlest 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
Prlest 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
Granlte 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

Age and Length at Maturity

Total length was measured and otol iths extracted from mature kokanee collected during the late fall spawning season for spawner age and length frequency. Spawners were col lected at Scenic Bay with a gill net and from the weir on Sul I Ivan Springs Creek. Age of maturlty was also estlmated for kokanee collected during September trawling.

Zooplankton

The zoop I ankton community was sampled in three sect Ions of Lake Pend Orel I le selected to represent the southern, middle and northern portions of the lake (Fig. 3). Three random samples were col I ected from each sect Ion monthly from May to October. Samples were collected with a 1/2 m ring plankton sampler calibrated by a General Oceanlcs flow meter and equlpped with a 130 µm net and bucket. Vertical hauls were made by towlng the sampler a t approximately 0.15 m/s wlth an electric winch. Zooplankters were enumerated by genera using standard dllution and subsampling methods (Edmondson and Winberg 1971). Enumeration data were expanded to estlmate the temporal distribution of zooplankton densltles from May through October.

Angler Effort and Harvest

A creel survey was conducted to provlde minlmum estimates of angling effort, catch and harvest of sport flshes. 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 col lected creel data from Apr i l 15 to November 30, 1985. The census season was stratlfled into f lve 1.5-month periods to correspond with per lods used In surveys prior to 1980. Each period was further stratlfled Into three 2-week intervals. Sampl ing dates during the 2-week intervals were established to correspond wlth the 46-day (1.5-month) perlods used In surveys prior to 1980.

Creel data were collected from 13 major access areas (north end of lake: Garf leld Bay, Trestle Creek, Johnson Creek, Sandpoint, Island View, Kamloops Resort, Elllsport Bay; south end of lake: Farragut, MacDonalds, Boileaus, JD's, Vista Bay, Scenic Bay). These areas were sampled two weekend days and one weekday during each 46-day perlod. Several access areas (Trestle Creek, Johnson Creek, Sandpolnt, Island View, Kamloops Resort) were not sampled during extreme low use perlods.

Survey data were expanded by day type (weekends or weekdays) to estimate harvest, catch and effort (hours and angler-days) for each interval, perlod and entire census survey. For example, an angler-day was deflned as one angler's flshing trip regardless of actual fishing time. The number of anglers Interviewed on a glven day was multipl led by the number of similar day types within a 2-week interval to estimate minimum number of angler-days

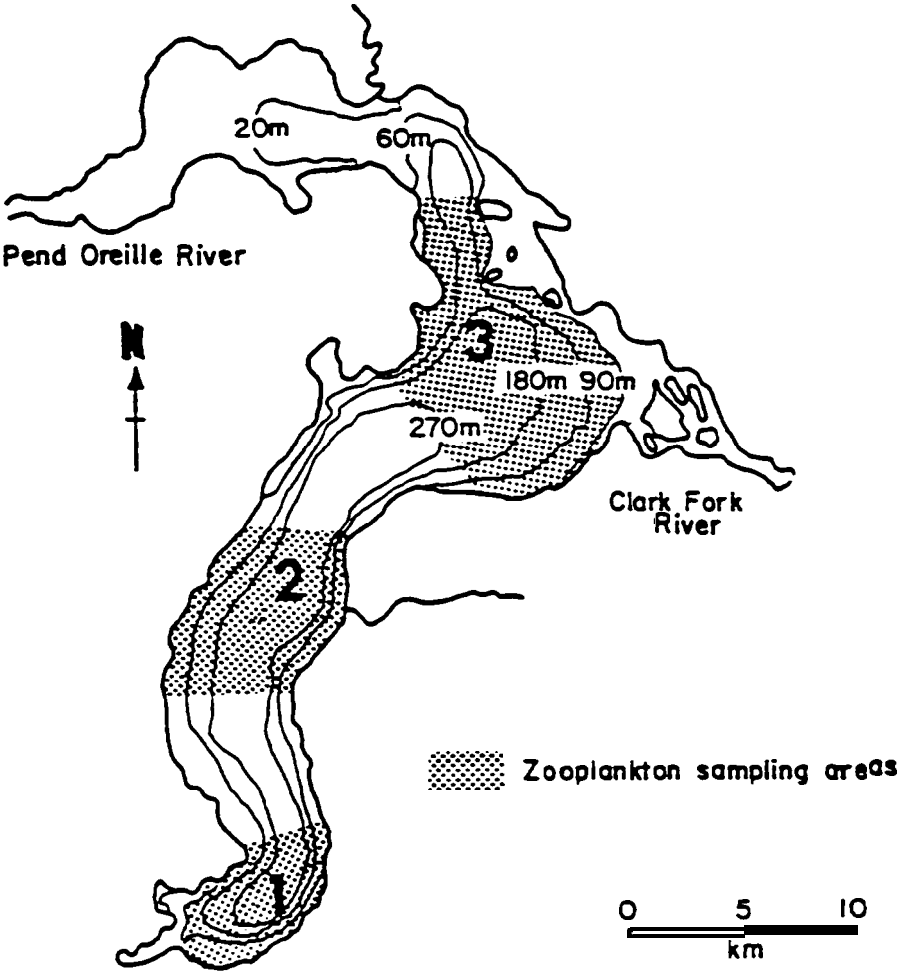

Figure 3. Zooplankton sampling areas used during 1985 on Lake Pend Oreille, Idaho.

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 data were classified as "estimated minimum" because some anglers exited the lake through unsurveyed landings.

RESULTS

Kokanee Abundance, Distribution and Biomass

Total kokanee abundance estimated during September 1985 was 4.47 million fish (Fig. 4). Contribution of individual year classes (YC) was 1.79 million for the 1984 YC (age 0+), 1.03 million for the 1983 YC (age 1+), 1.24 million for the 1982 YC (age 2+) and 0.37 million for the 1980-1981 YCs (age 3+ and 4+).

Average kokanee density estimated for the entire lake (combined age-classes) was 198 fish per hectare (Fig. 5). Densities ranged from a high of 315 kokanee/ha in section 2 to a low of 55 kokanee/ha in section 6. Age 0+ and age 2+ and older kokanee densities were significantly higher ($P<0.10$) in southern than northern sections of Lake Pend Oreille. Age 1+ kokanee densities were significantly higher in mid-lake than southern sections of Lake Pend Oreille.

Estimated biomass of age 1+ and older kokanee in Lake Pend Oreille during September was 201,803 kg. Mean kokanee lengths and weights from the September trawl catch were 153 mm and 29 g for the 1983 YC (age 1+), 221 mm and 92 g for the 1982 YC (age 2+), and 262 mm and 160 g for the 1980-81 YCs (age 3+ and 4+).

Age and Length at Maturity

Mature kokanee, determined from the September trawl catch, were found in the 2+ and older age classes only. Mature kokanee comprised 4.17% of age 2+ kokanee with 14% males and 86% females. An estimated 85.3% of age 3+ and 4+ kokanee were mature and comprised of 39% males and 61% females. Age composition of kokanee spawners in Sullivan Springs was 37% age 3+ (1981 YC) and 62% age 4+ (1980 YC).

Mean lengths of kokanee spawned from Sullivan Springs Creek were 283 $\pm$ 4.1 mm and 274 $\pm$ 3.4 mm ($\alpha = 0.05$) for male (n=54) and female (n=47) fish, respectively (Fig. 6). Mean lengths of kokanee spawners collected from Scenic Bay (Navy yard) in the southern end of Lake Pend Oreille were 283 $\pm$ 6.2 mm and 256 $\pm$ 3.0 mm ($\alpha = 0.05$) for males (n=30) and females (n=24), respectively. Males were significantly ($P<0.05$) larger than females at both locations. Male lengths did not differ significantly between locations, whereas females from Sullivan Springs were significantly longer than from Scenic Bay.

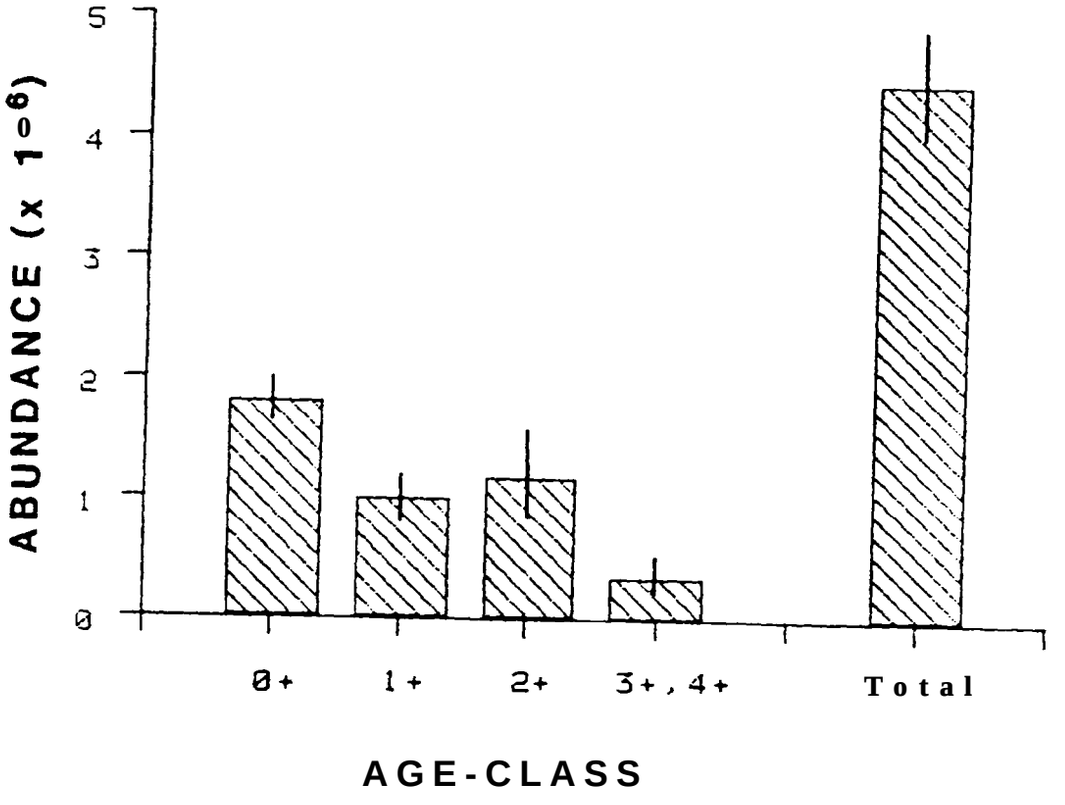

Figure 4. Kokanee abundance with 90% confidence intervals estimated in September 1985, Lake Pend Oreille, Idaho.

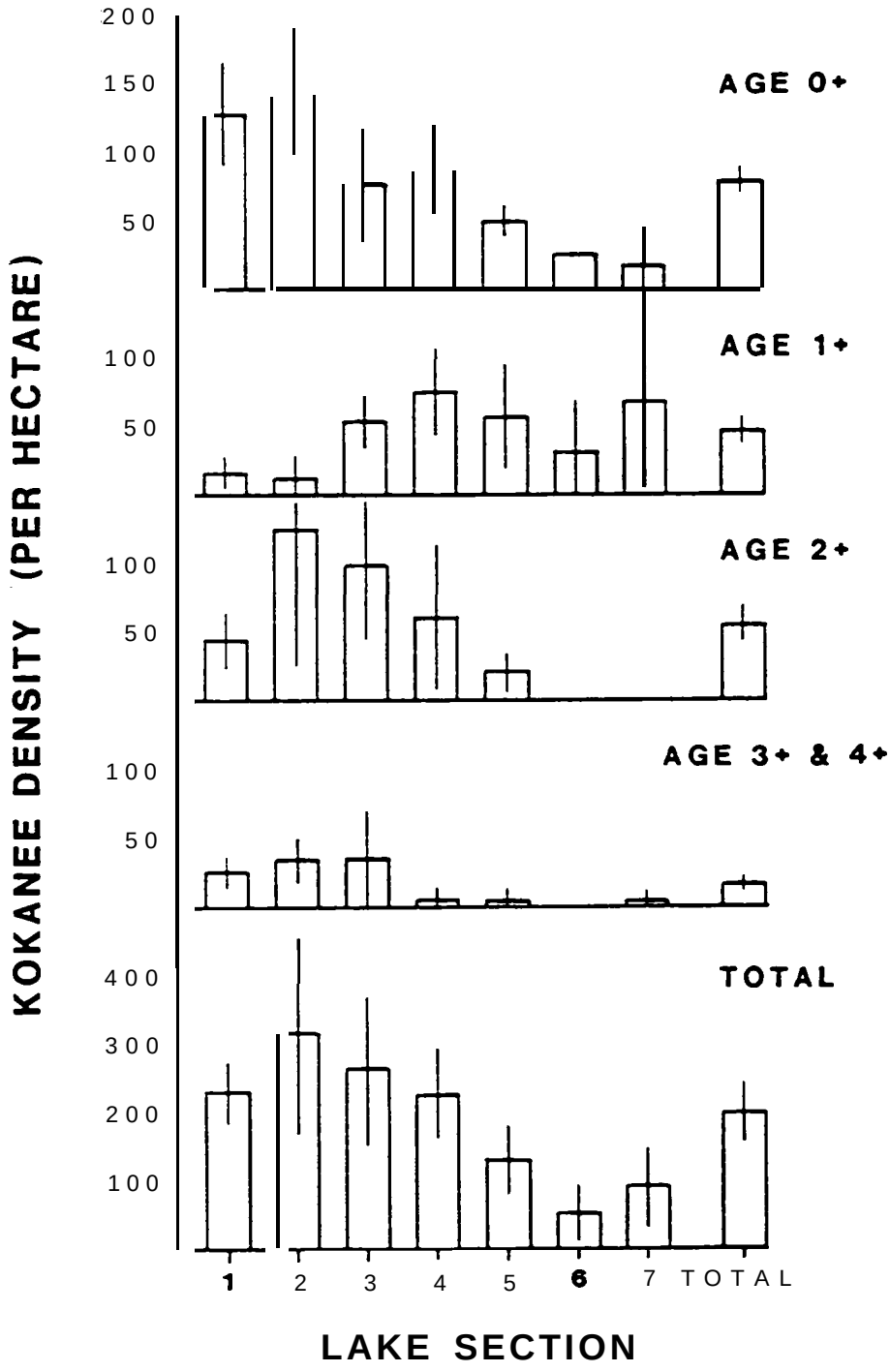

Figure 5. Kokanee density in Lake Pend Oreille by age group and lake section during September, 1985. Vertical bars represent 90% confidence intervals.

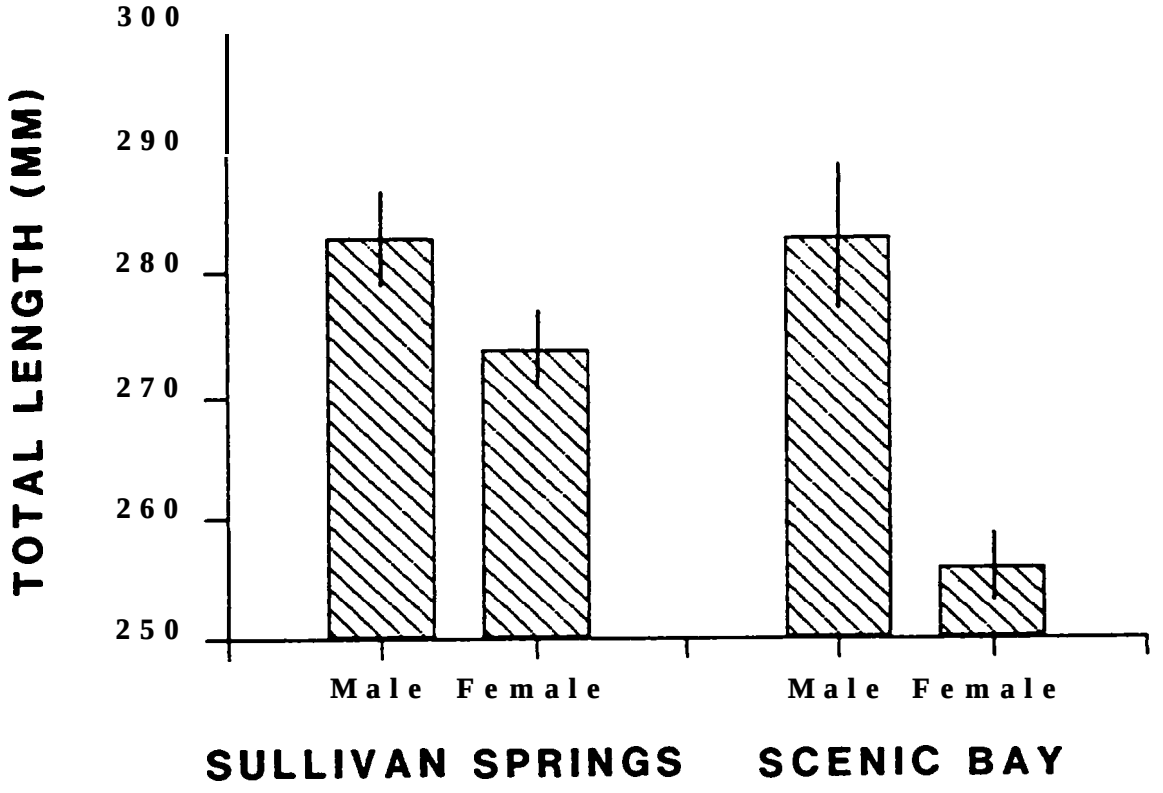

Figure 6. Mean lengths and 95% confidence limits for adult kokanee collected from Sullivan Springs Creek (weir) and Scenic Bay (gill net) during the 1985 spawning season.

Spawning Escapement

An estimated 366,426 mature kokanee comprised the 1985 spawning escapement in Lake Pend Oreille and its tributaries. Approximately 75,500 kokanee (53% males, 47% females) migrated to Sullivan Springs Creek from the first week in November to mid-January. The proportion of hatchery-reared fry returning as adults in 1985 was an estimated 4.6%. The Sullivan Springs run represented approximately 21% of the total Lake Pend Oreille spawning escapement. Spawner counts in other tributaries and lakeshore spawning areas ranged from 5,284 kokanee in Spring Creek to 0 kokanee in Trestle Creek, and 2,912 kokanee on southern lakeshore areas to 2 kokanee counted on northern lakeshore beaches (Table 2).

Based on tetracycline mark recoveries, an estimated 34% of the kokanee spawners collected by gill net in Scenic Bay were of hatchery origin.

Potential Egg Deposition and Egg Take

Total potential egg deposition was an estimated 122.5 million with 104.1 million eggs attributed to natural spawning and 18.4 million eggs available from Sullivan Springs kokanee. Mature female kokanee abundance, estimated from September trawling, was 234,620 fish. Approximately 35,300 female kokanee (15% of the total estimate) were spawned at the Sullivan Springs weir with 199,320 female kokanee left to spawn naturally throughout Lake Pend Oreille and its tributaries. Fecundity was assumed to be 522 viable eggs per female (Bowler 1979). Actual egg take at Sullivan Springs was 10.6 million eggs (300 eggs/female) which represents 58% of the estimated egg potential of artificially spawned females.

Survival and Recruitment

Estimated kokanee fry survival from potentfat egg deposition to September trawl sampling was at 1.46% for the 1984 YC. Survival estimates for hatchery and wild fry were 5.3 and 0.79%, respectively. A survival rate of 16.2% was estimated for 1984 YC hatchery-reared fry from time of release in late July to fall sampling in early September. Hatchery fry provided an estimated 54% of the total kokanee fry recruitment in 1985. These estimates are partially based on the release of 5.96 million hatchery-reared fry (22% marked with tetracycline) during late July and early August and the subsequent trawl catch of 3 marked fry out of 25 total fry. Estimated annual survival (September to September; combined wild and hatchery fish) of other kokanee was 39% for the 1983 YC (age 1+) and 82% for the 1982 YC (age 2+).

Table 2. Spawning ground survey sites and adult kokanee counts made during the 1985 spawning season on Lake Pend Oreille and its tributaries, excluding the Granite Creek drainage.

Lakeshore				Tributaries			
Southern		Northern		Southern		Northern	
Site	Count	Site	Count	Site	Count	Site	Count
Bayview areas		Garfield Bay	0	North Gold Creek	696	Trestle Creek	0
		Camp Bay	0	South Gold Creek	235	West Trestle Creek	0
Bubb's	2	Sunnyside	0			Johnson Creek	—
Wheel Inn	347	Trestle Creek Resorts	2			Garfield Creek	—
J.D.'s	6	Ellisport	0			Twin Creek	5
Boileaus	11					Lightning Creek	127
Bayview Resort	057					Spring Creek	5,234
Navy Yard	1,288						
Private Docks	165						
MacDonald's Resort	438						
Vista Bay	3						
Subtotal	2,915						
Farragut	—						
Lakeview	4						
Beaver Bay	—						
Total	2,919		2		931		5,416
Grand Total	9,268						

Zooplankton Community

Macro-zooplankton in Lake Pend Oreille were sampled from May to November in 1985. Zooplankton densities were estimated from May through July. Generic composition included Daphnia, Bosmina, Cyclops, Diaptomus, Diaphanosoma, and Epichura. Mysis density was not determined in 1985. Total zooplankton density was less than 10 organisms per liter at the end of June and increased to over 30 per liter during July (Fig. 7). The copepods Cyclops and Diaptomus were the most abundant zooplankters, with combined densities ranging from 7.3 per liter at the end of May to 24.5 per liter at the end of July. The cladocerans Daphnia and Bosmina were rarely collected until the end of July. Bosmina densities increased from 0.5 per liter at the end of June to 1.5 per liter by the end of July. Densities of Daphnia were negligible during May and June but increased to 1.4 per liter by the end of July. Epichura and Diaphanosoma were rarely found in Lake Pend Oreille until the end of July, when densities were 0.2 and 0.1 per liter, respectively. In general, zooplankton densities were lower in the northern portion (section 3) of Lake Pend Oreille than southern portions (sections 1 and 2). Statistical comparisons between months and between lake sections for each zooplankton group are shown in Figure 7 and Table 3.

Fishery

A creel survey was used to estimate catch, harvest and effort on Lake Pend Oreille from April 15 to November 30, 1985. At the time of this writing, creel survey information has been compiled only for the first three survey periods (through August 30).

Total Catch and Effort

Lake Pend Oreille sport anglers fished an estimated 149,459 hours during 29,878 angler days to catch 61,213 fish from April 15 to August 30, 1985 (Table 4). Creeled species include: kokanee, Kamloops, cutthroat, rainbow trout, bull trout, lake whitefish, mountain whitefish and various spiny rayed species. Approximately 43% of the anglers fished for kokanee which made up 87% of the estimated catch, and 52% of the anglers fished for trout (including bull trout) which comprised 11% of the estimated catch.

Kokanee Catch and Harvest

Anglers seeking kokanee caught an estimated 52,335 kokanee from April 15 to August 30 of which 52,268 (99.9%) were harvested (Table 5). Average catch rate for anglers seeking kokanee was approximately one fish per hour for 50,997 hours of effort. An additional 890 kokanee were harvested by anglers seeking other species.

Table 3. Statistical comparisons between months and between sections for zooplankton with significant [$P \leq 0.05$] interaction between sampling time [month] and location [section]. An S indicates significant difference between pairs, whereas NS indicates a non-significant difference. Comparisons for other zooplankton groups [with non-significant interaction terms] are listed in Figure 6.

Comparison	Cyclops			Bosmina			Epischura			Daphnia			Total		
	Section														
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
May vs June	S	S	S	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	S	S
May vs July	S	S	S	S	S	NS	NS	S	S	S	S	S	S	S	S
June vs July	S	NS	S	S	S	NS	NS	S	S	S	S	S	S	S	S
	Month														
	May	June	July	May	June	July	May	June	July	May	June	July	May	June	July
Sections 1 vs 2	NS	S	NS	NS	NS	S	NS	NS	S	NS	NS	NS	NS	S	NS
Sections 1 vs 3	NS	S	NS	NS	NS	S	NS	NS	S	NS	NS	S	NS	S	NS
Sections 2 vs 3	NS	S	NS	NS	NS	S	NS	NS	S	NS	NS	S	S	S	S

Table 4. Estimated number of anglers, effort and species harvested by survey period, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours	Kokanee	Small[a] rainbow	Large[b] rainbow	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	821	606	62	138	74	6,109
May 31-July 15	9,120	41,667	24,588	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	28,208
Totals	29,878	149,459	53,158	3,684	1,427	595	830	628	401	395	95	61,213

[a] < 43.2 cm
[b] ≥ 43.2 cm

Table 5. Estimated catch 8nd harvest data for anglers seeking kokanee from April 15 to August 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Kokanee caught	Kokanee harvested	Other game fi sh caught	kokanee caught per hour	kokanee harvested per hour	ALL game fish caught per hour
Apr 15-May 30	934	4,088	1,550	1,550	208	0.38	0.35	0.43
May 31-July I S	4,659	16,990	24,198	24,170	652	1.27	1.27	1.31
July 16-Aug 30	7,343	27,030	25,589	25,545	1,053	0.85	0.95	0.80
Totals	12,936	50,997	52,335	52,266	1,913	1.03	1.02	1.05

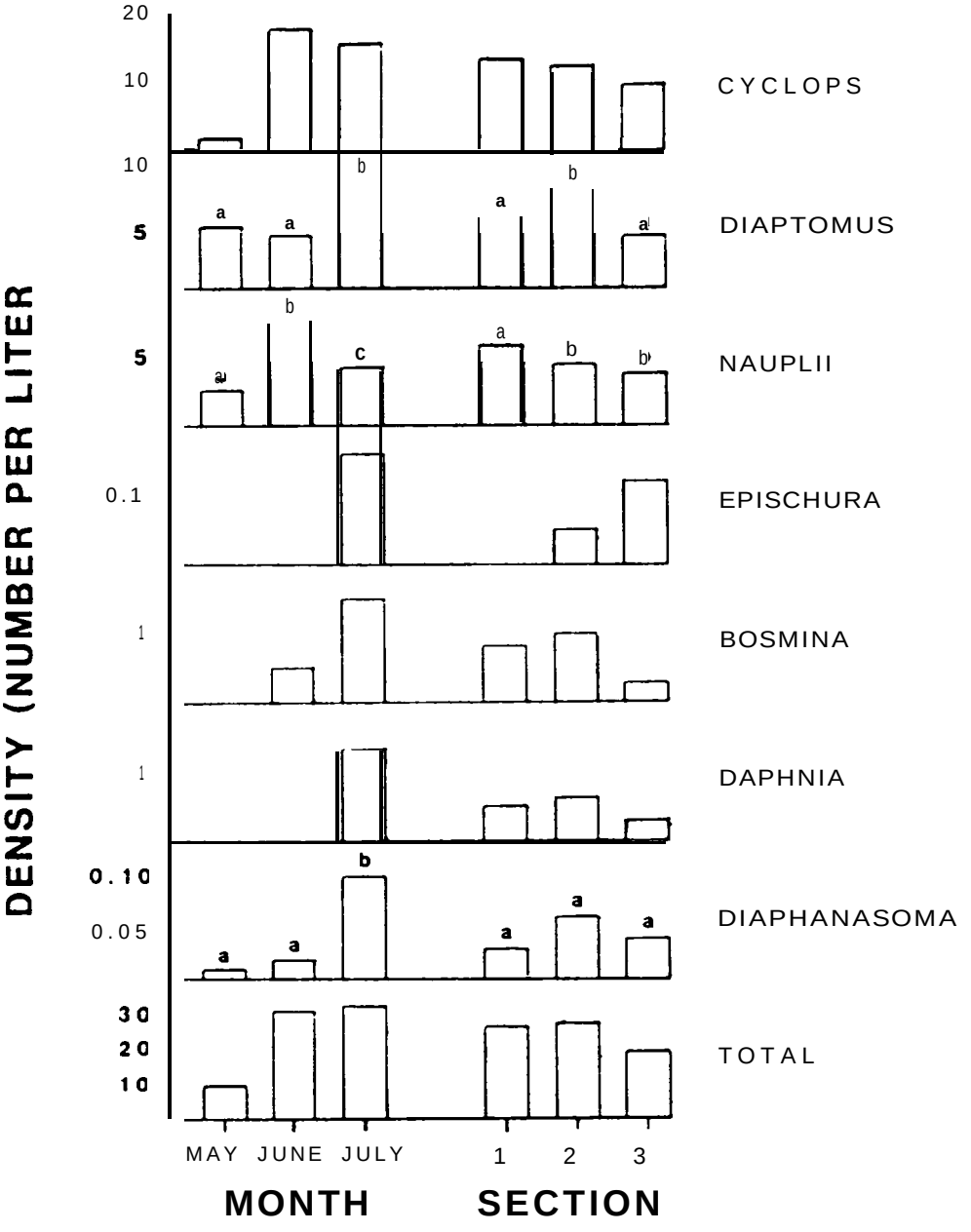

Figure 7. Tempora and spatial distribution of mean zooplankton densities in Lake Pend Oreille, Iidaho, May-July 1985. Identical letters above means indicate a non-significant (P>O. 05)difference between compared months or between compared lake sect ions for each zooplankton group (main effect pairwise comparison). Statistical comparisons for unlettered groups (signif icant interact ion between sampling time and locat ion) are 1isted in Table 3.

Kamloops/Rainbow Trout Catch and Harvest

Average catch rate for anglers seeking trophy (≥43.2 cm) Kamloops from April 15 to August 30 was approximately 59 hours per fish, calculated from a total catch of 1,444 trophy Kamloops in 84,798 hours of effort (Table 6). Of this catch 1,111 (77%) were harvested. An additional 316 trophy Kamloops were harvested by anglers seeking other salmonids.

Average catch rate for anglers seeking sub-trophy (<43.2 cm) rainbow trout was approximately 0.11 fish per hour, calculated from a total catch of 748 rainbow trout in 6,775 hours of effort (Table 7). Approximately 695 fish (93%) were harvested. An additional 2,989 sub-trophy rainbow trout were harvested by anglers seeking other species.

Cutthroat Trout Catch and Harvest

Average catch rate for anglers seeking cutthroat trout was approximately 0.03 fish per hour, calculated from a total catch of 37 cutthroat in 1,160 hours of effort (Table 8). Most of the fish caught (84%) were harvested. An additional 564 cutthroat were harvested by anglers seeking other species.

Bull Trout Catch and Harvest

Average catch rate for anglers seeking bull trout from April 15 to August 30 was estimated at 0.08 fish per hour, calculated from a total catch of 421 bull trout in 5,139 hours of effort (Table 9). Most of the bull trout catch (96%) was harvested. An additional 427 bull trout were harvested by anglers seeking other species.

Additional Harvest

Estimated whitefish harvest during the reported periods was 628 or 1.0% of the total harvest. An estimated 401 spiny ray and 395 miscellaneous salmonids were also caught, each comprising approximately 0.7% of the total harvest. Estimated harvest of nongame fish was 95 for the reporting periods which comprised 0.2% of the total harvest.

Angler Residency

Idaho residents comprised 54% of the total anglers fishing Lake Pend Oreille from April 15 to August 30 and expended 58% of the total fishing effort (Table 10).

Table 6. Estimated catch and harvest data for interviewed anglers seeking large rainbow trout[a] from April 15 to August 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Large rainbow caught	Large rainbow harvested	Other trout species caught	Other game fish caught	Large rainbow caught (hrs/fish)	Large rainbow harvested (hrs/fish)	All trout caught (hrs/fish)	All game fish caught (hrs/fish)
Apr 15–May 30	7,435	57,311	999	778	1,375	316	57	74	24	21
May 31–July 15	3,549	18,700	335	240	734	136	56	78	17	15
July 16–Aug 30	1,799	8,787	110	93	277	48	80	94	23	20
Totals	12,783	84,798	1,444	1,111	2,386	500	59	76	22	20

[a] $\geq$ 43.2 cm

Table 7. Estimated catch and harvest data for interviewed anglers seeking small rainbow trout[a] from April 15 to August 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 rainbow caught per hour	Small rainbow harvested per hour	All trout caught per hour	All game fish caught per hour
Apr 15–May 30	731	3,[illegible]0	320	290	137	242	0.[illegible]0	0.08	0.13	0.19
May 31–July 15	681	2,786	331	318	241	318	0.12	0.11	0.21	0.32
July 16–Aug 30	99	380	97	87	27	34	0.26	0.23	0.33	0.42
Totals	1,511	6,775	748	695	405	594	0.11	0.10	0.17	0.26

Table 8. Estimated catch and harvest data for interviewed anglers seeking cutthroat trout from April 15 to August 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Cut-throat trout caught	Cut-throat trout harvested	Other trout species caught	Other game fish caught	Cutthroat trout caught per hour	Cutthroat trout harvested per hour	All trout caught per hour	All game fish caught per hour
Apr 15-May 30	154	580	14	12	122	40	0.02	0.02	0.23	0.30
May 31-July 15	102	453	17	13	55	14	0.04	0.03	0.16	0.19
July 16-Aug 30	46	127	6	6	4	16	0.05	0.05	0.08	0.20
Totals	302	1,160	37	31	181	70	0.03	0.03	0.19	0.25

Table 9. Estimated catch and harvest data for interviewed anglers seeking bull trout from April 15 to August 30, Lake Pend Oreille, Idaho, 1985.

Period	Anglers	Hours fished	Bull trout caught	Bull trout harvested	Other trout species caught	Other game fish caught	Bull trout caught per hour	Bull trout harvested per hour	All trout caught per hour	All game fish caught per hour
Apr 15–May 30	835	4,452	365	353	439	452	0.08	0.08	0.18	0.28
May 31–July 15	90	585	42	36	18	6	0.07	0.06	0.11	0.12
July 16–Aug 30	34	122	14	14	0	0	0.11	0.11	0.11	0.11
Totals	959	5,139	421	403	457	458	0.08	0.08	0.17	0.26

Table 10. Estimated number and effort of reslident and nonresident anglers by survey period, Lake Pend Oreille, Idaho, 1985.

Perlod	Resident		Nonresldent		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
Totals	16,221	86,104	13,657	63,355	29,878	149,459
Percent of Total	54%	58%	46%	42%		

DISCUSSION

Population Status and Fishery

Low kokanee abundance in 1985 indicated continued suppression of kokanee production since its initial decline in the 1960s (Fig. 8). Although low, population totals have been assisted by hatchery supplementation and have not declined substantially since 1978. While total kokanee abundance has stabilized somewhat during the past eight years, age-class structure has varied. Relative contribution of age 0+ kokanee has been increasing since 1977, whereas the proportion of age 3+ and older kokanee increased only in 1985 after declining the previous four years (Fig. 9). This latter age group makes up the majority of kokanee spawners and the kokanee fishery.

In general, catch statistics indicate that the quality of kokanee fishing continues to decline from the fishery of the mid-1960s. Kokanee catch from April to September in 1985 represented a 44% decline from estimated catch in 1980 for the same time period and follows a downward trend evident since 1964 (Fig. 10). Fishing pressure for kokanee has also declined, with a 34% 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 43% in 1985. Concurrent decline of catch and effort has resulted in similar catch rates (approximately 1 fish/hour) for anglers seeking kokanee over the last seven survey years (1975-1980 and 1985), compared to catch rates in excess of 3 kokanee per hour for sport anglers during the mid-1960s (Ellis and Bowler 1981).

Kokanee production at Cabinet Gorge Hatchery will help rebuild the kokanee population and fishery in Lake Pend Oreille and provide valuable economic benefits. Net economic worth of the kokanee fishery has reflected the decline in the kokanee population. Estimated annual economic worth (in 1984 dollars) was approximately $5 million in the early 1960s prior to the decline in kokanee catch (calculated from Gordon 1970). By 1984, the estimated economic worth of the kokanee fishery had declined by 40% to $3 million. Recognizing the importance of the Lake Pend Oreille kokanee fishery, Idaho Department of Fish and Game has made the restoration of this fishery one of its highest priorities in the panhandle region. Management goals include an annual harvest of 0.75 million kokanee supporting 330,000 hours of effort with catch rates over 2 fish per hour. These goals were designed to provide a fishery comparable to the kokanee fishery of the mid-1960s. Realization of these goals would be impossible without the additional hatchery space provided by Cabinet Gorge Hatchery. At full capacity, up to 20 million kokanee fry will be produced annually, whereas previous hatchery production was limited to 6-8 million kokanee fry. This increased production will provide the basis for rebuilding the kokanee population to historic levels (>12 million). In addition to improving the kokanee fishery, increased kokanee production will enhance the forage base for trophy Kamloops, bull trout and bald eagles.

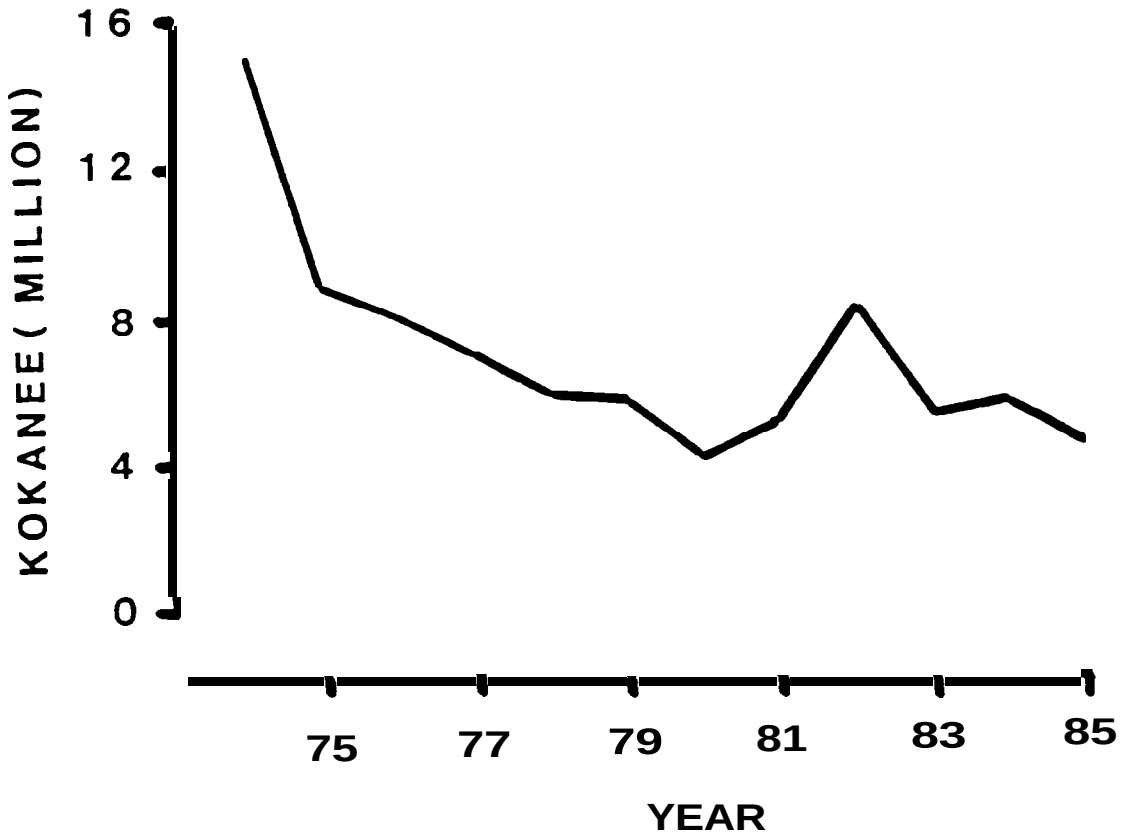

Figure 8. Total kokanee abundance estimated during September- in lake Pend Oreille, Idaho, 1974-1985.

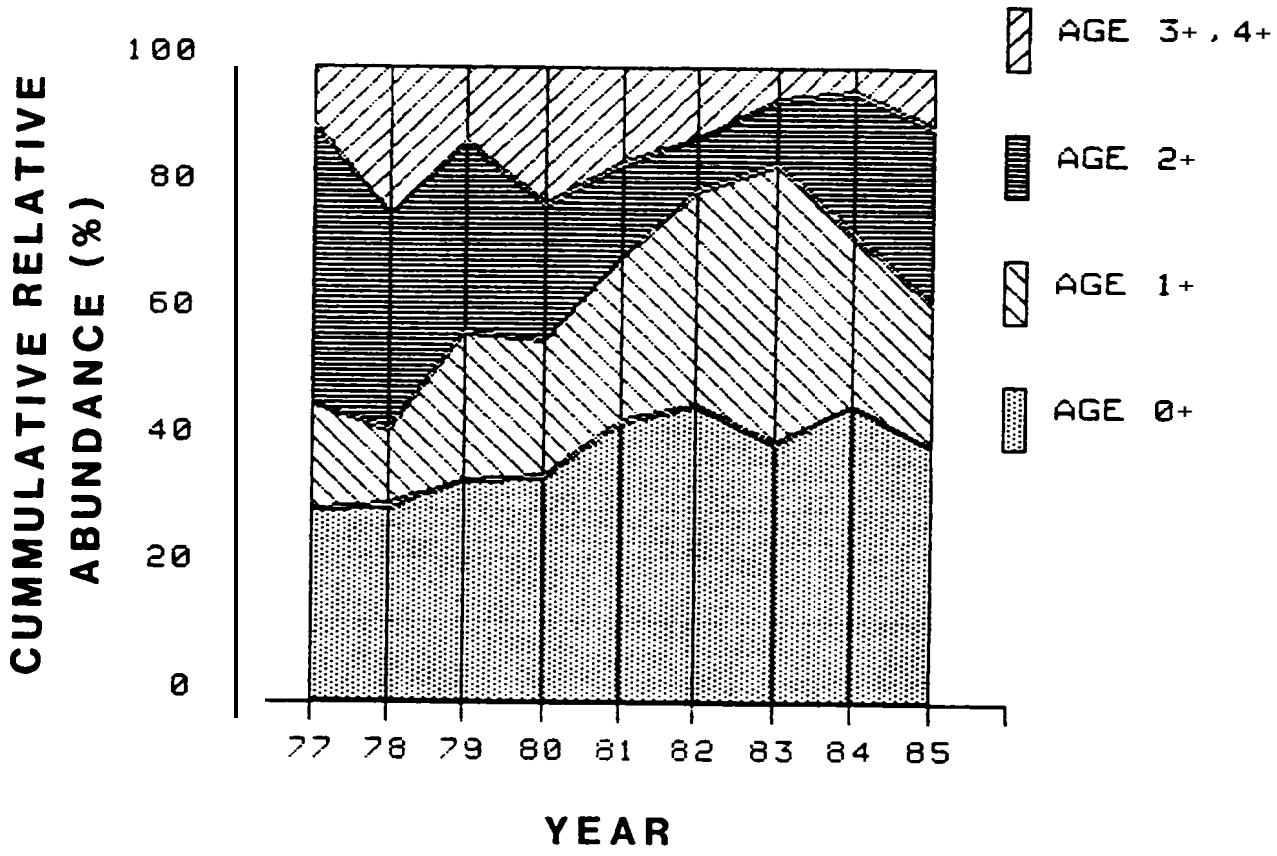

Figure 9. Relative abundance of four age groups of kokanee estimated during September from Lake Pend Oreille, Idaho, 1977-1985.

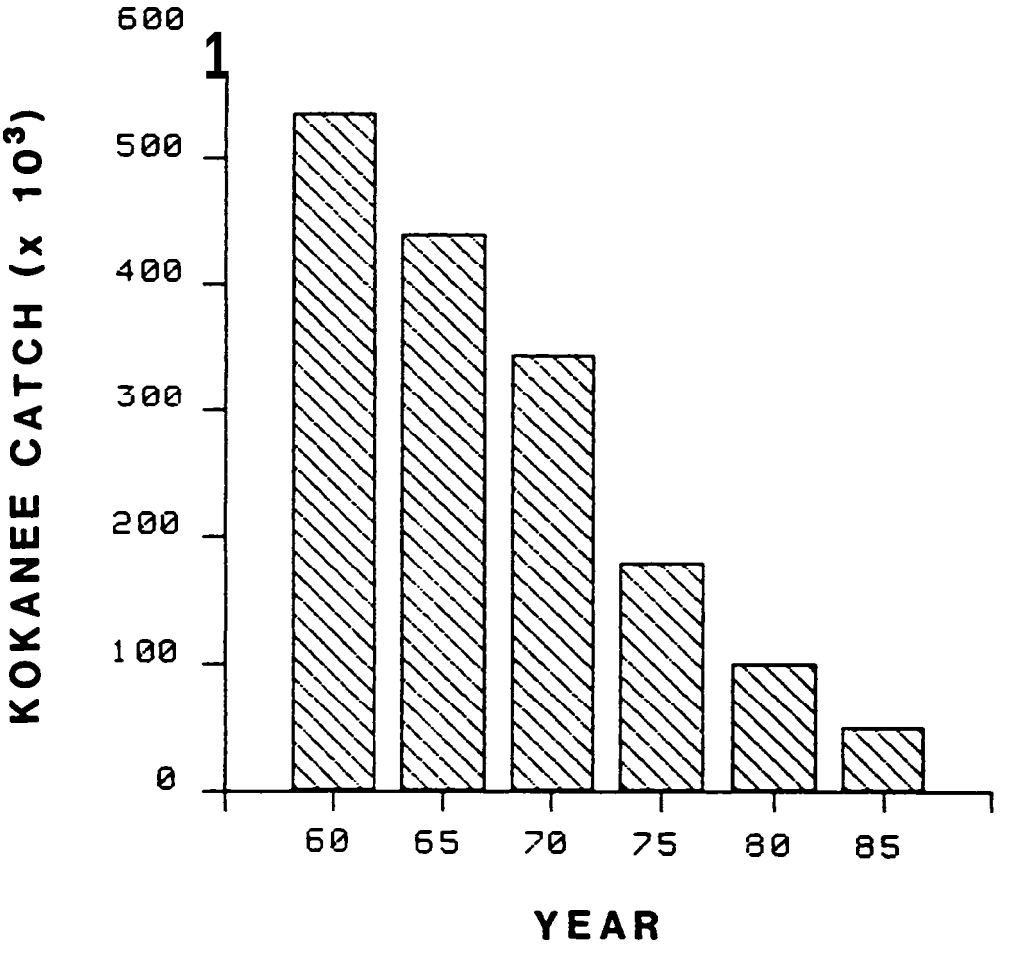

Figure 10. Mean (3 to 5 year) annual kokanee catch from Lake Pend Oreille, Idaho, April 15 – August 30, 1960-1980, and point estimate for 1985.

Spawning

Increased kokanee production is dependent on adequate spawning escapement and egg take. The kokanee run up Granite Creek to the Sullivan Springs weir and egg take station comprised approximately 21% of the total spawning escapement. Kokanee spawning escapement to Sullivan Springs in 1985 (75,500 adults) was substantially lower than in 1984 (130,000 adults). An estimated 4.6% of hatchery fry released in Sullivan Springs during 1980 returned as adults, compared to over 10% in previous years (Table 11). This 42% reduction in spawner numbers and estimated fry-to-adult survival is probably a result of extreme cold water conditions in November and December and not an indication of lower total spawner numbers. Abnormally low water temperatures reduced migration activity, resulting in a large portion of Sullivan Springs spawners using lower Granite Creek and lakeshore areas near the mouth of Granite Creek to spawn (Gene McPherson, IDFG, personal communication). Actual egg take at Sullivan Springs was 10.6 million which represents 58% of the estimated number of eggs available in the system (18.4 million). The 1985 egg take represents only 71% of the 1984 egg take (15 million) and 38% of the anticipated egg take necessary to fill Cabinet Gorge Hatchery (28 million). Kokanee escapement to Sullivan Springs in 1986 may be as high as 260,000 adults if northern Idaho has typical late fall and early winter weather. This escapement would yield over 38 million eggs and exceed the egg take necessary to fill Cabinet Gorge Hatchery. On the other hand, kokanee escapement to Sullivan Springs In 1986 may be less than 120,000 adults if weather during the spawning season (November-December) is simllar to 1985. This escapement would yield less than 18 million eggs for hatchery production. Contingency plans are being developed to optimize egg take if conditions unfavorable for kokanee migration occur.

In addition to Granite Creek, kokanee spawners utilized other tributary streams (highest number in Spring Creek) and lakeshore (highest number on southern lakeshore beaches) spawning areas. Although more adult kokanee were counted in 1985 than during the previous spawning ground survey (1978), no consistent trends have developed since counts began in 1972 (Table 12). Hatchery contribution to naturally spawning kokanee on lakeshore areas was approximately 34% In 1985, which corresponds closely to the estimates for 1983 (30%) and 1984 (32%) (LaBolle 1986). Hatchery contribution to naturally spawning kokanee abundance will be monitored closely as hatchery production increases.

Several undesirable responses In the spawning population may occur as kokanee abundance increases in Lake Pend Oreille. Declining kokanee abundance has resulted In increased spawner age and length. Age 4+ kokanee dominated the spawning run to Sullivan Springs Creek in 1984 and 1985, compared to a dominance of age 3t spawners In 1983 (Cochnauer 1984). Mean length of kokanee spawners has varied from 292 mm In 1951 to 245 mm in 1976 and has been Increasing since 1976 (Fig. 11). Increasing length may be the result of reduced competition for forage due to low population densities and increased foraging efficiency on mysids by larger size classes. Larger and older kokanee spawners Increase Individual fecundity, provide a more desirable sport harvest and allow the catchable population to be in the fishery for' an additional year. Age and length of kokanee spawners are typically density dependent and will decline somewhat as kokanee density

Table 11. Weir counts of kokanee entering Sullivan Springs from 1974 through 1985, number of eggs collected and subsequent fry released into Sullivan Springs.

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%[b]
1977	17,560	2,040,000	1,598,800	135,300 29,000	(1981) (1982)	10.28%[b]
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	(1985)	
1982	115,850	11,432,900	2,875,589			
1983	79,850	6,320,000	3,214,512			
1984	122,000	15,000,000	2,938,391			
1985	75,500	10,600,000				

[a] Additional fry were released in other areas.

[b] 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.

Table 12. Maximum single late-run kokanee counts made during the 1972-1978 and 1985 spawning seasons on Lake Pend Oreille and its tributaries, excluding the Granite Creek drainage.

Area	Maximum single counts							
	1972	1973	1974	1975	1976	1977	1978	1985
Lakeshore								
Bayview	2,626	17,156	3,588	9,231	1,525	3,390	798	2,915
Farregut	25	0	0	0	0	0	0	—
Idlewild Bay	13	0	25	0	0	0	0	—
Lakeview	4	200	18	0	0	25	0	4
Ellisport Bay and Hope	1	436	975	0	0	0	0	0
Trestle Creek Resorts	0	1,000	2,250	0	115	75	138	2
Sunnyside	0	25	0	0	0	0	0	0
Fisherman Island	0	0	75	0	0	0	0	—
Anderson Point	0	0	50	0	0	0	0	—
Camp Bay	0	617	0	0	0	0	0	0
Garfield Bay	0	400	20	0	0	0	0	0
Subtotal	2,669	19,834	7,001	9,231	1,640	3,490	936	2,921
Percent of Total	29%	62%	25%	64%	33%	40%	19%	32%
Tributaries								
South Gold Creek	1,030	1,875	1,050	440	0	30	—	235
North Gold Creek	744	1,383	1,068	663	130	426	—	696
Cedar Creek	0	267	44	16	11	0	0	—
Johnson Creek	0	0	1	0	0	0	0	—
Twin Creek	0	0	135	1	0	0	0	5
Mosquito Creek	0	503	0	0	0	0	0	—
Clark Fork River	539	3,520	6,180	0	—	—	—	—
Lightning Creek (Lower)	350	500	2,350	995	2,240	1,300	44	127
Spring Creek	2,610	4,025	9,450	3,055	910	3,390	4,020	5,284
Trestle Creek	1,293	18	1,210	15	0	40	0	0
Garfield Creek	0	0	25	0	0	0	0	—
Subtotal	6,566	12,091	21,513	5,185	3,291	5,186	4,046	6,347
Percent of Total	71%	38%	75%	36%	67%	60%	21%	68%
Total	9,235	31,925	28,514	14,416	4,931	8,676	5,000	9,268

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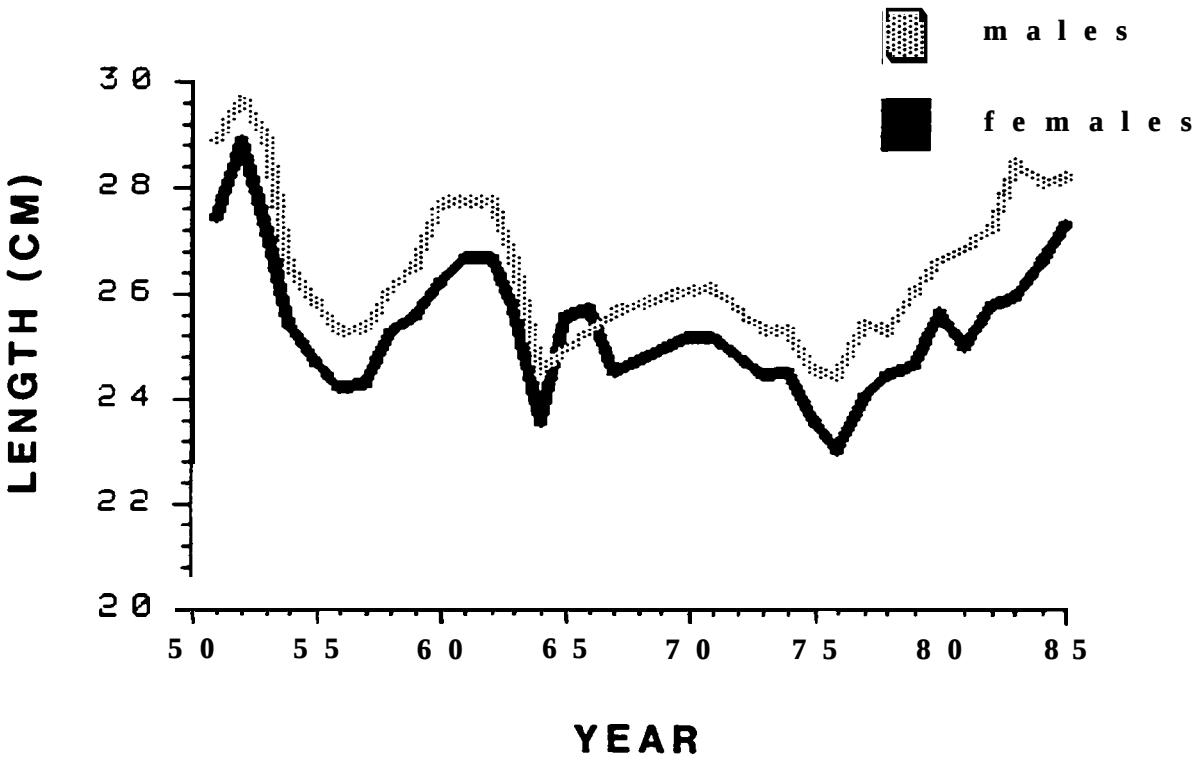

Figure 11. Mean total length of male and female kokanee spawners from Lake Pend Oreille, Idaho, 1951-1985.

Increases. Changes In length, age and fecundity will be monitored as the kokanee populatlon approaches carrying capacity In order to optimize catch, size and fecundity.

Recru I tment

Increased kokanee abundance in lake Pend Orellle will be dependent on fry recruitment from hatchery and w I ld stocks. Kokanee fry survival from PED to September trawl sampl Ing was 6.6 times higher for hatchery-reared fry (5.3%) than for wild fry (0.79%), partially a result of mld-summer fry releases to avoid early season forage deflclency. Kokanee forage exclusively on zooplankton and prefer cladocerans (Daphnia and Bosmina) when available. The zooplankton community during May, June and July 1985 was dominated by copepods, whereas cl adocerans were not evident unti l l ate June or Ju l y. Similar zooplankton community structures have been ev ldent in Lake Pend Orellle since mysids were wel l establ lshed in 1974 (Rieman 1981). The temporal displacement of cladoceran production (from late May prior to mysid influence to late July following mysld influence) Indicates the cont I nued need to delay hatchery fry releases until mid-summer to coincide with Increasing cladoceran production. Recrultment of wild kokanee fry (peak emergence in June) may continue at depressed levels as a result of this apparently permanent shift in cladoceran production. Atypically high mortality of emerging sockeye salmon (Oncorhynchus nerka) has been documented when essentlal food Items such as Bosmlna were not ava l lab le (Foerster 1968). Zooplankton densitles from May to July 1985 tended to be lower in northern than mld or southern sections of Lake Pend Orellle. Lower densltles In this area may be the result of lower lake productlvity as a result of the Clark Fork River Influence (Rieman 1976; 1978). Zooplankton composition and density in northern sections of Lake Pend Orellle will be monltored closely as kokanee fry releases from Cabinet Gorge Hatchery Increase In the Clark Fork River.

Since 1978, annual recru itment of hatchery fry has been typ lcal l y l ess than 0.5 mll l ion (22% of total), but has ranged from 0.09 to 1.98 mll l lon as a result of variable survival and number released (Fig. 12). Al though severely depressed, annual recrultment of wlld fry has been relatively stable at approximately 1.8 mllllon (range 1.6 to 2.1 mllllon) since 1978. The 1985 estimate (0.8 mi l l lon) was an exception to this trend but may be Inaccurate due to smal l sample size. Thus, the f luctuatlon In kokanee fry recrultment and relatlve year class strength are more a function of hatchery fry productlon and survival than production and survival of wlld fry. Fry surv l val wll l be monltored closely in future years to substantiate potential changes resulting from different release strategles and increased hatchery productlon.

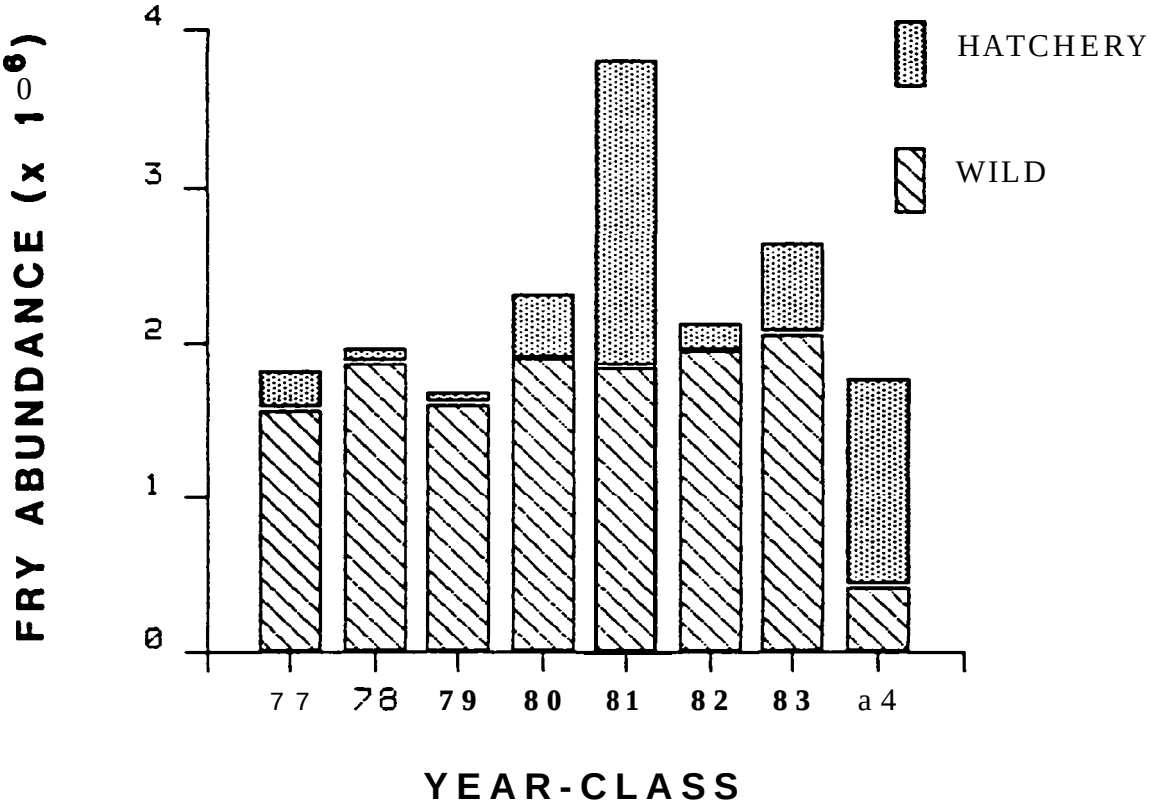

Figure 12. Relative contribution of wild and hatchery production to total kokanee fry recruitment (in September) in Lake Pend Oreille, Idaho, 1977-1984 year classes.

ACKNOWLEDGMENTS

Thanks are extended to Larry LaBolle, project leader during the first several months of th Is study, who continued to provide adv Ice and assistance after leaving the posltlon. Tom McArthur and Greg Jahn prov ided valuable assistance with statistical analyses and computer programming. Personne I from Clark Fork and Cablnet Gorge fish hatcheries were responsible for egg take and fry marking operations.

Funding for this study was provided by Bonnevllle Power Adminlstratlon.

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