September 1998

KOKANEE IMPACTS ASSESSMENT AND MONITORING ON LAKE PEND OREILLE, IDAHO

Annual Progress Report for October 1995 - September 1996

DOE/BP-98065-1

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 not necessarily represent the views of BPA.

This document should be cited as follows:

Maiolie, Melo A., William J. Ament, Bill Harryman, Bill Ament - Idaho Department of Fish and Game, Kokanee Impacts Assessment And Monitoring On Lake Pend Oreille, Idaho Annual Progress Report for October 95-September 96, Report to Bonneville Power Administration, Contract No. 1997BI98065, Project No. 199404700, 33 electronic pages (BPA Report DOE/BP-98065-1)

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KOKANEE IMPACTS ASSESSMENT AND MONITORING ON LAKE PEND OREILLE, IDAHO

Annual Progress Report for October 95–September 96

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IDFG 98-30
Project Number 1994-047-00
Contract Number 1997BI98065

SEPTEMBER 1998

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ABSTRACT

The purpose of this project was to Monitor Lake Pend Oreille's kokanee *Oncorhynchus nerka kennerlyi* population. Data will serve as a baseline for evaluating the benefits of a higher winter lake level beginning in 1996. We estimated the kokanee population in Lake Pend Oreille using a Hauser-type midwater trawl during August 1995 and September 1996. Population estimates in 1995 were 4.55 million age-0 kokanee, 2.87 million age-1 kokanee, 1.52 million age-2 kokanee, 0.74 million age-3 kokanee, 0.15 million age-4 kokanee, and 42,000 age-5 kokanee.

Population estimates in 1996 were 5.42 million age-0 kokanee, 3.57 million age-1 kokanee, 3.17 million age-2 kokanee, 0.67 million age-3 kokanee, 0.44 million age-4 kokanee, and no age-5 kokanee. These were two of the highest total populations of kokanee since trawling began in 1977; largely due to high numbers of young kokanee. The densities of age-4 and 5 kokanee (which make up the bulk of the fishery), however, were the lowest on record in 1995 and average in 1996.

We also surveyed traditional shoreline and tributary spawning areas. Counts of kokanee spawning in tributaries during 1995 were relatively consistent with previous years (6,261 kokanee). Counts of spawners along the shorelines reached a new record low of only 74 kokanee; a 93 percent decline from 1994. During December 1996, both counts dropped to their lowest point on record. Only 49 fish were seen spawning along the shorelines, and only 819 fish were seen in tributary streams. These low counts may have been partially due to higher lake levels during the spawning seasons. Higher than normal lake levels made additional gravel available for kokanee spawning in many areas of the lake. Possibly this caused kokanee to spread along the shorelines and reduced the spawner counts.

Kokanee fry that had been fin clipped and stocked at the Cabinet Gorge Fish Hatchery Ladder in 1991 and 1992 returned at a rate of 0.27% and 0.14% once they matured. This return rate was much lower than the rate measured for kokanee released at Sullivan Springs. Different size groups of fry were stocked at Sullivan Springs in 1991 and 1992. The largest size group (60 mm total length) returned at the highest rate of 2.1% when they matured. Smaller fry (37 mm and 50 mm total length) returned at a rate of about 1.5%.

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INTRODUCTION

The decline of the kokanee *Oncorhynchus nerka kennerlyi* population in Lake Pend Oreille has been largely attributed to the current operation of Albeni Falls Dam (Maiolie and Elam 1993; Paragamian and Ellis 1994). Historical population trends and harvest data indicated winter pool elevation affected kokanee abundance and harvest, and that winter drawdowns resulted in the loss of potential spawning areas. In an attempt to recover the kokanee population, the Idaho Department of Fish and Game proposed raising the minimum winter lake level to 626.3 m above mean sea level (amsl), approximately 1.2 m above the current level. Gravel surveys conducted in 1994 determined this would increase the amount of suitable kokanee spawning gravel by 560 percent (Fredericks et al. 1995). This project was designed to monitor Lake Pend Oreille's kokanee population as baseline data for future comparisons. Also included in this report are the result of an experiment to stock kokanee fry at two locations and two sizes to determine the best release strategy.

OBJECTIVE

To return kokanee harvest to 750,000 fish annually with a mean length of 250 mm. This will be possible on the adult kokanee population reaches 3.75 million fish.

STUDY AREA

Lake Pend Oreille is located in the northern panhandle of Idaho (Figure 1). It is the state's largest lake and has a surface area of 38,300 ha, a mean depth of 164 m and a maximum depth of 351 m. Summer pool elevation of Lake Pend Oreille is 628.7 m amsl. Deep-water habitat used by kokanee is considered to be 22,546 ha (Figure 2). The Clark Fork River is the largest tributary to the lake. Outflow from the lake forms the Pend Oreille River.

Lake Pend Oreille is a temperate, oligotrophic lake. Summer temperatures (May to October) average approximately 9^{o} C in the upper 45 m (Rieman 1977; Bowles et al. 1987, 1988, 1989). Thermal stratification typically occurs from late June to September. Operation of Albeni Falls Dam on the Pend Oreille River keeps the lake level stable at 628.7 m amsl during summer (July-September) then reduces lake level to 625.1 m amsl during fall and winter.

A wide diversity of fish species are present in Lake Pend Oreille. Kokanee entered the lake in the early 1930's from Flathead Lake, and were well established by the 1940's. Other game fish include: Gerrard rainbow trout *Oncorhynchus mykiss,* bull trout *Salvelinus confluentus*, westslope cutthroat trout *Oncorhynchus clarki*, lake whitefish *Coregonus clupeaformis*, and mountain whitefish *Prosopium williamsoni*, in addition to several other cool and warm water species.

Figure 1. Map of Lake Pend Oreille, Idaho, showing prominent landmarks. Stars indicate the locations of surveys for kokanee spawning on the shorelines.

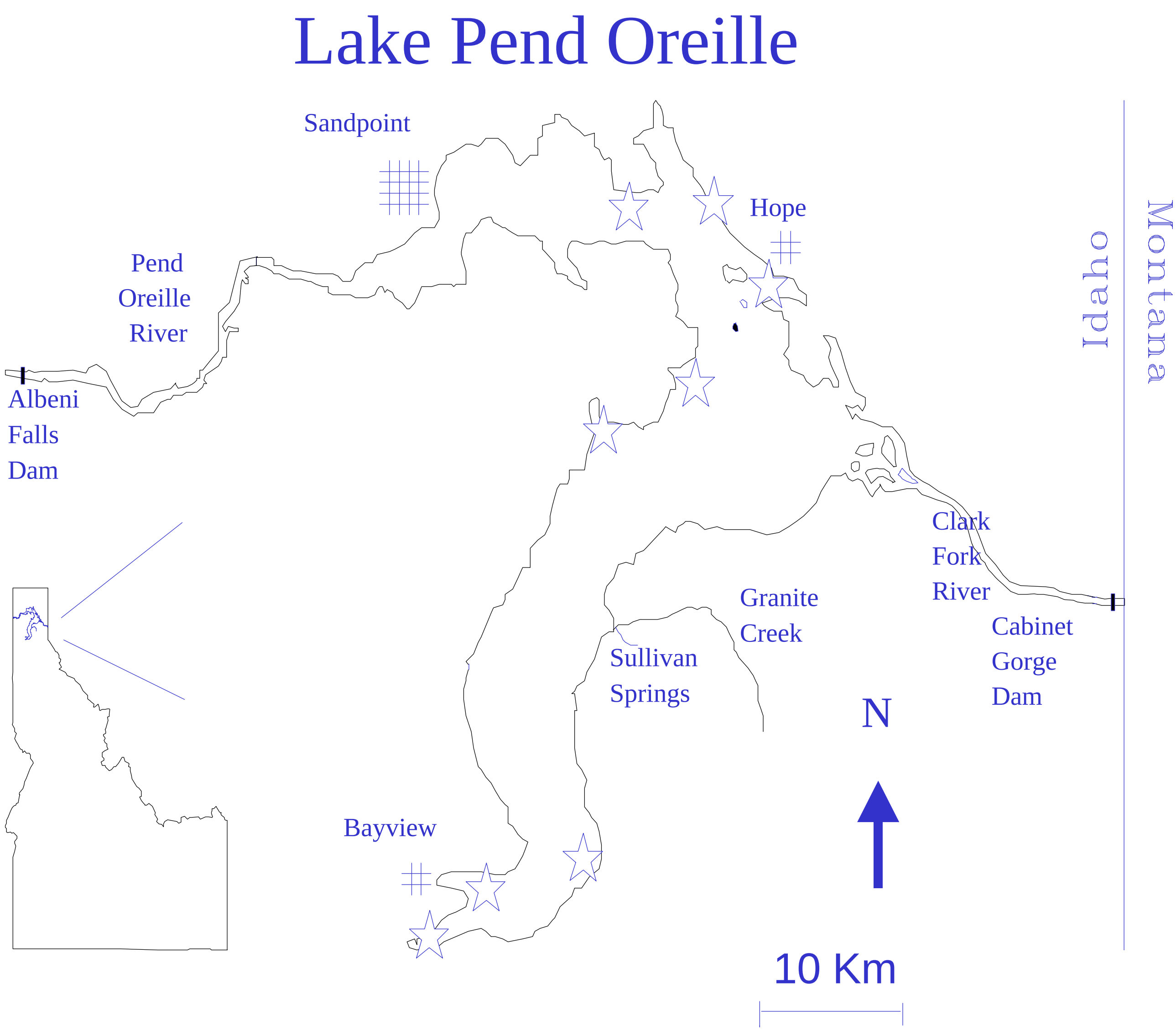
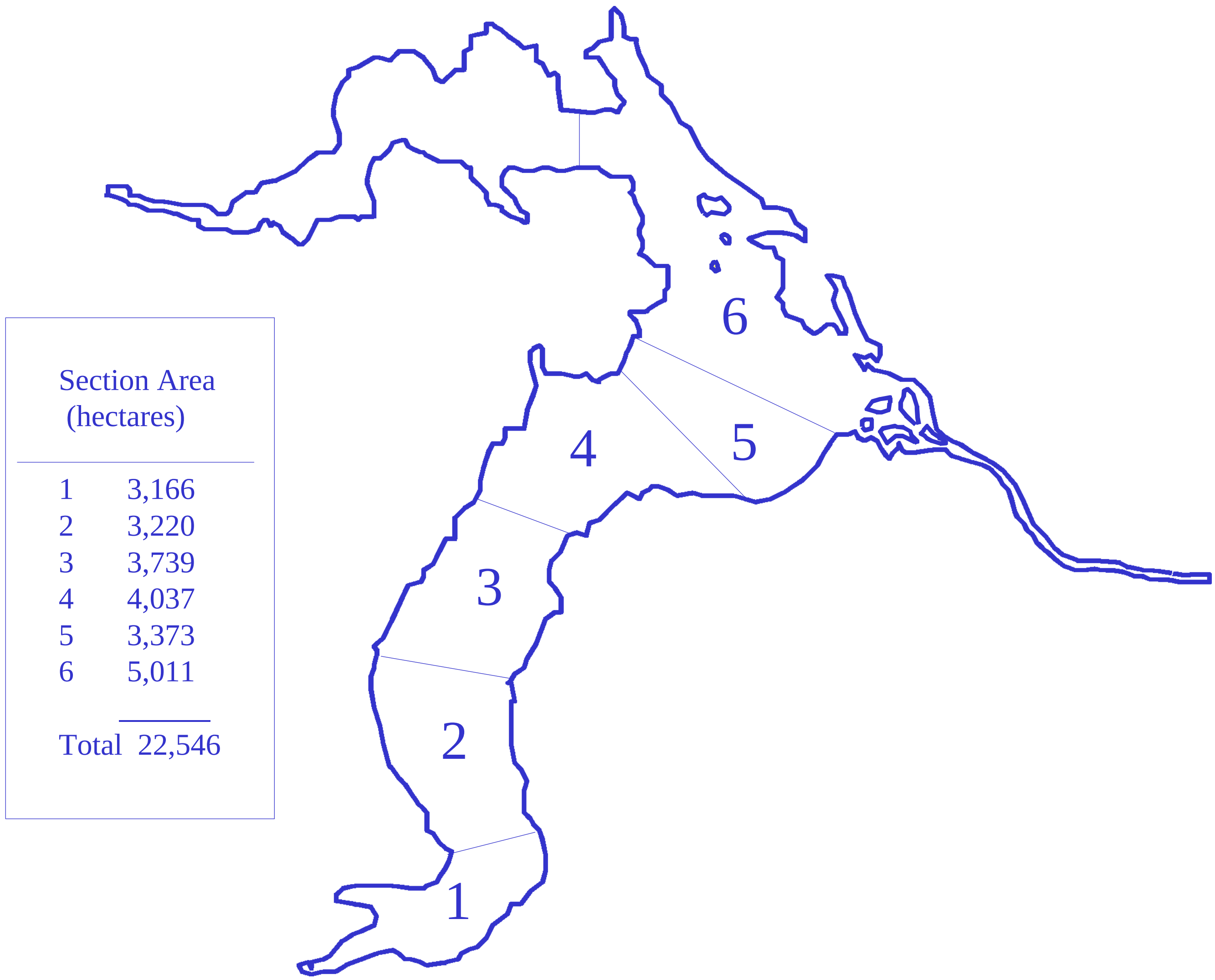


Figure 2. Six sections of Lake Pend Oreille used for estimating kokanee abundance by midwater trawling. Insert depicts the amount of kokanee habitat in each section.



METHODS

Midwater Trawling

We conducted standardized midwater trawling in Lake Pend Oreille on August 22-29, 1995 and September 8-12, 1996. These dates were during the dark phase of the moon, which optimized the trawl's capture efficiency (Bowler et al. 1979).

In 1995, the lake was divided into six sections or strata (Figure 2), and a stratified systematic sampling scheme was used to estimate kokanee abundance and density. Six transects were systematically selected within each section and one haul was made along each transect. The same transects were used in kokanee population monitoring on Lake Pend Oreille since 1977 (Bowler et al. 1979; Bowles et al. 1988, 1989; Paragamian and Ellis 1994). During 1996, sections 1 and 2, 3 and 4, and 5 and 6 were combined to stratify the lake into three sections. Twelve randomly selected locations were chosen within each section for trawling. We reduced the number of lake sections in 1996 to improve statistical precision. This change was based on consultations with a statistician and reanalyzing previously collected data.

Rieman (1992) described the midwater trawl and sampling procedures in detail. The net was 13.7 m long with a 3 m 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. The trawl net was towed at a speed of 1.5 m/s by a 8.5 m boat. We determined the vertical distribution of kokanee by using a Raytheon Model V850 depth sounder with a 20^o hull mounted transducer. A step-wise oblique tow was conducted along each transect which sampled the entire vertical distribution of kokanee.

Fish from each trawl sample were counted and measured. Approximately 10 individuals from each 10 mm length group were weighed, checked for maturity, and scales were removed for aging. We estimated the density (fish/m^3) of kokanee for each transect by dividing the number of fish caught by the amount of water that the net filtered. We then estimated the age-specific and total number of kokanee for each section, and lake total, using standard expansion formulas for stratified sampling designs (Scheaffer et al. 1979). The area of each section was calculated for the 91.5 m contour; however, Section 6 (the northern end) was calculated from the 36.6 m contour because of shallower water. The 91.5 m contour was used because it represents the pelagic area of the lake where kokanee are found during late summer (Bowler 1978). Ninety percent confidence intervals were calculated on the kokanee abundance estimates (Scheaffer et al. 1979).

To estimate the egg-to-fry survival, the estimated number of fry in the lake was divided by the potential number of eggs spawned naturally in the lake the previous year, the wild potential egg deposition (wild PED). Wild PED was calculated by estimating the number of mature, female kokanee of age-3, 4, and 5 in the lake during trawl sampling and multiplying it by the mean fecundity of females seen at the Granite Creek spawning station. We then subtracted the number of eggs collected by hatchery personnel at both egg take stations to determine the number of eggs spawned by wild fish in the lake.

Spawner Counts

Spawning populations of kokanee were estimated in tributary and shoreline areas. Detailed descriptions of each survey area are provided in Appendix A. All areas surveyed have been documented as historical spawning sites (Jeppson 1960). Areas were surveyed once a week for four straight weeks starting with the third week in November 1995. All kokanee, either alive or dead, were counted.

Tributary streams were surveyed by walking upstream from the mouth to the highest point utilized by kokanee. Trestle Creek, which supports a run of early spawning kokanee, was also surveyed in September for spawners.

Kokanee Abundance and Stock-Recruitment Curves

In 1994, a stock-recruitment model (Ricker 1958) was fitted to data on kokanee abundance in Lake Pend Oreille (Fredericks et al. 1995). The model assumed a five-year life cycle for kokanee. Abundance of each kokanee age class was plotted as a function of the 'stock' age class five years earlier. The age-3 and age-4 year classes were combined into a single class since they were not differentiated prior to 1986. The Ricker equation $R=(aP)e^{(-bP)}$ was used where:

R = # of recruits
P = # of parental stock
a = constant representing density independent mortality
b = constant representing density dependent mortality

We added the population data points for 1995 and 1996 to these stock-recruitment curves that were developed in 1994. Our intent was to determine whether changes in natural mortality were occurring.

Hatchery Fry

Fin-clipped fry were released at Sullivan Springs and the Cabinet Gorge Hatchery fish ladder between 1988 and 1993 in order to evaluate the survival rate of different groups of fish. Adipose and ventral fin clips were used to separate two length groups of fry released at Sullivan Springs and to distinguish the fry released at the ladder of the Cabinet Gorge Fish Hatchery. The intent of the study was to determine the best size and location for releasing hatchery fish.

In 1991, 30,000 kokanee with an adipose fin clip (AD) were released at Sullivan Springs, which averaged 50 mm in total length. An additional 30,000 kokanee were released which had an adipose and right ventral fin clip (AD/RV). These fry had a mean total length of 37 mm. Hatchery workers also released 60,000 fry at the Cabinet Gorge Hatchery ladder during 1991 which had been marked with a left ventral fin clip (LV), and averaged 50 mm in total length.

During 1992, 30,000 adipose fin-clipped fry were released at Sullivan Springs, which averaged 60 mm in total length. For comparison, 30,000 smaller fry that averaged 30 mm in length were given a right ventral clip and released at the same location.

All marked fry were clipped at least one week prior to release. They were anesthetized in 0.04 g MS-222/L water prior to clipping.

RESULTS

Midwater Trawling Estimates

Population estimates of kokanee during 1995 and 1996 are presented in Table 1. Also included in Table 1 are the 90% confidence interval (CI), density, mean weight, standing stock, mean length, and length range of each age group of fish. Total population in 1995 was 10 million kokanee and in 1996 this increased to 13 million kokanee. These relatively high numbers of kokanee were due to strong year classes of age-0 and age-1 fish in 1995, and age-0, age-1, and age-2 kokanee in 1996 (Table 2).

Survival rates of each age class ranged from 1.0% for eggs to fry, to 400% for age-1 kokanee to age-2 kokanee (Table 3). The erroneously high survival rate from age-1 to 2 stems from underestimating the abundance of age-1 in 1994.

Fry caught in the midwater trawl could not be separated into wild and hatchery fish since all of the hatchery fish were not marked. Survival from wild PED to fry (wild and hatchery) in 1995 was 1.85 % and reached 7.29% in 1996 (Table 4).

Potential Egg Deposition

Based on trawling in 1995, we estimated that the lake contained 334,938 mature kokanee. The sex ratio was 1:1 (n=28) based on the necropsy of kokanee in the trawl catch. This ratio was consistent with past estimates. Therefore 167,469 mature females were in the lake. Fish culturists collected 30,800 female kokanee from the lake, which left 136,694 to spawn naturally in the lake and its tributaries. Mean fecundity of 444 eggs/female (n=65) was determined at the Sullivan Springs egg take stations by examining kokanee throughout the run. Potential egg deposition for 1995 was therefore 74.4 million, of which 60.7 million were spawned in the lake and tributaries (Table 1). An additional 12.8 million eggs were taken into the hatcheries and 0.9 million eggs were left in females unstripped.

In 1996, we estimated PED at 138.8 million eggs (Table 2). Sex ratio from fish sampled by trawling was again 1:1. Mean fecundity was 353 eggs/female. All age-4 kokanee were found to be mature and 52% of the age-3 kokanee were mature. This gave a total of 393,200 mature females in the lake in 1996. Hatchery personnel spawned 13,199 females at the two spawning stations and collected 4.05 million eggs. This left 134.1 million eggs to be deposited naturally in and around the lake.

Spawner Counts

Counts of kokanee spawning along the shoreline in 1995 and 1996 were the lowest on record. Only 49 fish were counted in 1996 which was a 97% decline over the previous five year

Table 1. Kokanee population estimates (in millions; with 90% confidence intervals [CI]), density (fish/ha), mean weight (g), standing stock (kg/ha), mean length and length range (mm) of all age classes of kokanee in Lake Pend Oreille, Idaho, August 1995 and September 1996.

	Age					
	0	**1**	**2**	**3**	**4&5**	**Total**
1995						
Population (+/- 90% CI)	4.55 13%	2.87 27%	1.52 20%	0.74 25%	0.19 22%	9.87
Density	201	127	67	33	8	436
Mean weight	1	27	46	90	154	
Standing stock	0.29	3.41	3.08	2.96	1.23	10.97
Mean length	56	138	193	220	259	
Length range	20-99	90-190	130-220	200-270	230-28	
1996						
Population (+/- 90% CI)	5.42 12%	3.57 34%	3.17 23%	0.67 24%	0.44 27%	13.27
Density	240	158	141	30	20	588
Mean weight	2	26	49	77	121	
Standing stock	0.5	4.1	6.9	2.3	2.4	16.2
Mean length	63	151	188	212	242	
Length range	20-100	100-170	160-210	190-220	210-278	

Table 2. Estimated potential egg deposition (PED) (millions), hatchery egg take (included in PED) (millions), and estimated abundance (millions) of kokanee made by midwater trawl in Lake Pend Oreille, Idaho, for 1977-1996. To follow a particular year class, read up one row and right one column.

Sample Year	PED[a]	Hatchery Eggs	Age Class 0	1	2	3	4	5	Total	Age 4&5 Density (n/ha)
1996	138.8	4.1	5.42	3.57	3.17	0.67	0.44		13.27	19.52
1995	74.4	12.8	4.55	2.87	1.52	0.74	0.15	0.04	9.87	8.45
1994	246.0	16.6	6.76	0.38	0.70	0.99	0.76	0.07	9.66	36.90
1993	218.5	11.1	3.17	1.48	1.30	2.00	1.02		8.97	45.10
1992	169.0	7.5	4.55	1.33	0.78	1.11	0.64		8.41	28.30
1991	92.9	6.6	1.98	0.83	1.77	0.77	0.27		5.62	11.90
1990	63.9	6.0	3.35	1.59	1.45	0.33	0.20		6.93	8.80
1989	117.6	9.6	4.48	1.17	1.20	0.45	0.37	0.04	7.71	18.10
1988	118.3	14.0	7.31	1.66	0.51	0.38	0.35		10.21	15.50
1987	116.3	17.2	3.55	0.78	0.84	0.43	0.42		6.02	18.60
1986	68.6	9.1	1.66	1.15	0.68	0.54	0.24		4.26	10.60
1985	122.5	10.7	1.79	1.03	1.24	0.37[b]			4.47	[b]
1984	88.4	15.0	2.63	1.51	1.21	0.28[b]			5.62	[b]
1983	35.8	6.3	2.14	2.28	0.50	0.29[b]			5.21	[b]
1982	-	11.4	3.84	2.77	0.64	0.87[b]			8.12	[b]
1981	161.7	11.6	2.31	1.36	0.79	0.74[b]			5.20	[b]
1980	181.1	4.2	1.69	1.00	0.96	1.03[b]			4.68	[b]
1979	119.4	1.5	2.01	1.31	1.70	0.67[b]			5.69	[b]
1978	197.7	1.4	1.82	0.71	2.00	1.29[b]			5.82	[b]
1977	117.1	2.0	2.01	1.17	2.95	0.65[b]			6.78	[b]

([a]) PED is total eggs available in lake during midwater trawl.

([b]) Age 3 and 4 kokanee were not separated by age prior to 1986.

Table 3. Survival rates (%) for kokanee year classes (by age), in Lake Pend Oreille, Idaho, 1977-1995. Year class is the year eggs were deposited.

Year	Age Class					
Class	Eggs to 0[a]	0 to 1	1 to 2	2 to 3	3 to 4	Eggs to 3
1995	7.3	---	---	---	---	---
1994	1.9	78	---	---	---	---
1993	3.1	42	110	---	---	---
1992	1.8	12	400	44	---	0.40
1991	4.9	32	47	106	59	0.80
1990	3.1	67	98	76	15	1.55
1989	2.8	25	94	256	38	1.70
1988	3.8	35	111	63	92	0.94
1987	6.3	16	124	53	83	0.66
1986	5.2	47	72	27	82	0.48
1985	1.4	47	65	88	44	0.37
1984	2.0	64	73	45	97	0.43
1983	7.3	39	66	63	81	1.26
1982	---	70	82	43	77	2.49
1981	2.4	59	53	[b]		
1980	1.3	119	18	[b]		
1979	1.4	80	47	[b]		
1978	1.0	50	79	[b]		
1977	1.6	72	73	[b]		

[a] Eggs include both wild and hatchery

[b] Unable to calculate survival rate since age 3 and 4 kokanee were not separated prior to 1986.

Table 4. Wild and hatchery fry abundance (millions) based on late summer trawling, potential egg deposition (PED) minus hatchery eggs, PED to wild fry survival (%), and the amount of lake draw-down after November 15 of each year.

Sample Year	**Wild**	**Hatchery**	**Previous Year PED minus Hatchery Eggs**	**PED to Wild Fry Survival**	**Draw-down After 11/15 (m)**
1977	1.80	0.04	---	---	---
1978	1.57	0.22	115.1	1.36	0.40
1979	1.88	0.11	196.3	0.96	0.38
1980	1.60	0.09	117.9	1.36	0.38
1981	1.90	0.41	176.9	1.07	0.32
1982[a]	1.66	1.90	150.1	1.10	0.14
1983[a]	1.97	0.17	---	---	0.48
1984[a]	2.10	0.53	29.5	7.50	0.66
1985	1.00	---	73.4	1.36	0.31
1986	1.65	0.01	111.8	1.48	0.71
1987	2.75	0.08	59.5	4.62	0.17
1988	3.63	3.63	99.1	3.66	0.27
1989	2.23	2.25	104.3	2.14	0.18
1990	1.79	1.56	108.0	1.66	0.54
1991	0.93	1.05	57.9	1.61	0.44
1992	2.42	2.13	86.3	2.80	0.23
1993	2.97	0.20	161.5	1.84	0.00
1994	5.00	1.62	207.4	2.41	0.04
1995	---	4.55[b]	246.0[c]	1.85[d]	0.03
1996	---	5.42[b]	74.4[c]	7.29[d]	0.14

([a]) - Unable to verify PED numbers for these years.

([b]) - Hatchery and wild fry were not separated in 1995 and 1996.

([c]) - Hatchery eggs have not been excluded.

([d]) - Survival for both hatchery and wild fry combined.

average (Table 5). Bayview has consistently been the most productive shoreline spawning area with counts over 1,000 fish in all but three years. In 1995 and 1996 only 51 and 42 kokanee spawners were counted, respectively. Of the nine shoreline spawning areas we surveyed, only three had kokanee visible.

Tributary spawner counts were consistent with previous years in 1995 with 6,261 fish seen (Table 6). These counts dropped 87% in 1996 to 819 fish; the lowest number ever recorded.

Returns of Hatchery Kokanee

Of the 60,000 fin clipped fry released in 1991 at Sullivan Springs, 886 returned to spawn for an overall return rate of 1.48 percent (Table 7). The larger size group (50 mm in total length) returned at a rate of 1.47% and the smaller group (37 mm) returned at a rate of 1.51%. It is doubtful there was a significant difference between these size groups. Statistical significance, however, could not be tested on this one year's data since there was only one test group and 0 degrees of freedom.

Markedly different results were gathered from the test that began in 1992 (Table 7). The 60 mm test group returned at a rate of 2.067%, to date. Smaller fry (30 mm) returned at a rate of 0.44%. This test was not yet finished since some age-5 kokanee may return in 1997. However, to date nearly five times as many fish returned from the larger size group.

Of the fry stocked at the Cabinet Gorge fish ladder, only 0.267% of the 1991 fish, and only 0.136 % of the 1992 fish, have returned. The ratio of females to males has varied from 1:2 to 1:3 regardless of release site (Table 7). Thus these hatchery stocks of kokanee appeared to have a different sex ratio than kokanee sampled by trawling.

DISCUSSION

Kokanee Abundance

Data within this report were meant to serve as a baseline for future comparisons. It will provide up-to-date information to compare to year classes of kokanee produced after the lake level changes during the winter of 1996-97.

Stock recruitment curves depict the state of the kokanee population (Figures 3 - 7). Based on these curves, the kokanee population in 1995 and 1996 was stable with most year classes at or above the abundance of the previous generation. The exception to this were the curves for age-1 and age-2 fish (Figures 5 and 6). Abundance of age-1 kokanee in 1995 and age-1 and age-2 kokanee in 1996 were well above the predictions of the stock-recruitment model. These strong year classes of kokanee were produced in the two years, which had the highest PED on record; 218 million in 1993 and 246 million in 1994 (Table 2). The high number of eggs laid in 1993 became the record high number of wild fry seen in 1994; 5 million fry (Table 4). This strong year class, therefore, was originated by wild fish and not hatchery releases. The strong 1993 year classes of kokanee will begin spawning in 1998 during the last year of the scheduled lake level

Table 5. Counts of kokanee spawning along the shorelines of Lake Pend Oreille, 1972 - 1996. The numbers shown indicate the highest weekly count.

Year	Bayview	Farragut Ramp	Idlewild Bay	Lakeview	Hope	Trestle Cr. Area	Sunnyside	Garfield Bay	Camp Bay	Anderson Point	Total
1996	42	0	0	4	0	0	0	3	0	-	49
1995	51	0	0	0	0	10	0	13	0	-	74
1994	911	2	0	1	0	114	0	0	0	-	1,028
1993											
1992	1,825	0	0	0	0	0	0	34	0	-	1,859
1991	1,530	0	-	0	100	90	0	12	0	-	1,732
1990	2,036	0	-	75	0	80	0	0	0	-	2,191
1989	875	0	-	0	0	0	0	0	0	-	875
1988	2,100	4	-	0	0	2	0	35	0	-	2,141
1987	1,377	0	-	59	0	2	0	0	0	-	1,438
1986	1,720	10	-	127	0	350	0	6	0	-	2,213
1985	2,915	0	-	4	0	2	0	0	0	-	2,921
1978	798	0	0	0	0	138	0	0	0	0	936
1977	3,390	0	0	25	0	75	0	0	0	0	3,490
1976	1,525	0	0	0	0	115	0	0	0	0	1,640
1975	9,231	0	0	0	0	0	0	0	0	0	9,231
1974	3,588	0	25	18	975	2,250	0	20	0	50	6,926
1973	17,156	0	0	200	436	1,000	25	400	617	0	19,834
1972	2,626	25	13	4	1	0	0	0	0	0	2,669

Table 6. Counts of late-run kokanee spawning in tributaries of Lake Pend Oreille, 1972 - 1996. Trestle Creek was also walked in September to count early-run kokanee. The numbers shown indicate the highest weekly counts at each site.

Year	S. Gold	N. Gold	Cedar	Johnson	Twin	Mosquito	Lightning	Spring	Cascade	Trestle[a]	Trestle	Total
1996	0	42	7	0	0	--	--	17	--	753	0	819
1995	166	154	350	66	61	--	0	4,720	108	615	21	6,261
1994	569	471	12	2	0	--	0	4,124	72	170	0	5,420
1992	479	559	--	0	20	--	200	4,343	600	660	17	6,878
1991	120	550	--	0	0	--	0	2,710	0	995	62	4,437
1990	834	458	--	0	0	--	0	4,400	45	525	0	6,262
1989	830	448	--	0	0	--	0	2,400	48	466	0	4,192
1988	2,390	880	--	0	0	--	6	9,000	119	422	0	12,817
1987	2,761	2,750	--	0	0	--	75	1,500	0	410	0	7,496
1986	1,550	1,200	--	182	0	--	165	14,000	0	1,034	0	18,131
1985	235	696	--	0	5	--	127	5,284	0	208	0	6,555
1978	0	0	0	0	0	0	44	4,020	0	1,589	0	5,653
1977	30	426	0	0	0	0	1,300	3,390	0	865	40	6,051
1976	0	130	11	0	0	0	2,240	910	0	1,486	0	4,777
1975	440	668	16	0	1	0	995	3,055	0	14,555	15	19,740
1974	1,050	1,068	44	1	135	0	2,350	9,450	0	217	1,210	15,525
1973	1,875	1,383	267	0	0	503	500	4,025	0	1,100	18	9,671
1972	1,030	744	0	0	0	0	350	2,610	0	0	1,293	6,027

([a]) - Early-run kokanee

Table 7. Number of kokanee released into the Clark Fork River (ECF= early spring release, LCF= summer release) and into Sullivan Springs (SS) along with their subsequent rate of return as adults. Parentheses ( ) indicate kokanee straying to collection sites other than where they were released. Brackets [ ] indicate size in mm at release.

Year of Release	Release group	Number Released	Year of Release	Mark	% returning at age: 2	3	4	5	Fry adult return rate %	% strays	Percent Females	Males	Number returned from total Released
1988	ECF	3,414,000	50,000	LV		0 (0.008)	0.108	0	0.108	0.008			3,687
	LCF	1,297,000	40,000	RV		0.005 (0.003)	0.080	0	0.085	0.003			1,102
	SS	5,138,800	40,000	AD		0.395 (0.008)	0.573 (0.02)	0.03	0.998	0.038			51,259
1989	ECF	3,513,000	40,000	LV		0.040	0.03 (0.02)	0	0.070	0.002			2,459
	LCF	984,000	40,000	RV		0.018	0.020 (0.013)	0	0.038	0.013			369
	SS	3,538,000	40,000	AD		0.17 (0.008)	1.2 (0.043)	0	1.220	0.051			42,987
1990	ECF	3,429,700	60,000	LV		0.035 (0.002)	0.023	0	0.058	0.002			2,001
	SS	3,190,700	60,000	AD		0.480 (0.008)	0.267 (0.002)	0	0.747	0.010			23,930
1991	ECF	2,610,000	60,000	LV		0.255 (0.008)	0.0116(0.006)	0(0.002)	0.267	0.016	31	69	6,969
	SS [54]	2,540,000	30,000	AD		0.857 (0.047)	0.593(0.003)	0.023	1.473	0.050	38	62	37,414
	SS [43]	30,000	30,000	AD/RV		0.910 (0.017)	0.593	0.003	1.506	0.017	26	74	452
1992	LCF	1,123,600	60,000	LV	0.003	0.133(0.005)	0(0.003)		0.136	0.008	22	78	
	SS [58]	3,410,000	30,000	AD		1.370(0.003)	0.697		2.067	0.003	24	76	
	SS [50]	30,000	30,000	RV		0.340	0.100		0.440	0.000			
1993	CF	None	None										
	SS	561,000	70,000	AD		0.106							

experiment. During this experiment the winter lake levels will be held higher to provide addition-spawning areas for kokanee. A strong year class in 1998 should help to fully utilize the newly available gravel.

These stock-recruitment curves illustrate a population that is limited by its habitat. The equilibrium point is at 1 million age-3 and age-4 kokanee (Figure 7). Whenever strong year classes are produced which exceed the equilibrium points in Figures 3 to 7, the next generation of fish has poorer survival, which lowers abundance back towards equilibrium. Earlier reports demonstrated that the limiting habitat factor was shoreline spawning gravels. High numbers of kokanee adults that spawn in limited amounts of habitat would superimpose their redds thereby dislodging each others eggs and reducing overall survival. For example in 1978, an exceptionally high number of adult kokanee produced 198 million eggs. However, instead of producing a good year class of offspring, they had only 1.0% survival to fry which grew up to an adult generation that produced only 34 million eggs (Figure 3). This ended any expansion of the population.

Potential Egg Deposition and Spawner Counts

Egg production in 1995 dropped to its lowest point since 1990 (Table 2). A weak maturing year class and a 15 percent survival rate of the 1994 age-3 fish contributed to this decrease. High mortality between age-3 and 4 was a new development. In the past, survival rates were typically 80 - 90% (Table 3). One possible cause could be an increased percentage of hatchery kokanee in the population, which tend to mature, and die, at age-3. The survival rate from age-3 to age-4 returned to a more normal 59% in 1996. These mortality rates should be closely monitored in the future.

Counts of kokanee spawning along the shoreline in 1995 and 1996 showed a sharp decline (Table 5). Counts were more than an order of magnitude below the lowest count previously recorded. A possible explanation for this finding was that the raising of the lake level during the spawning season caused kokanee to move to new spawning areas around the lake which were not surveyed. These low spawner counts do not appear to reflect a low adult population. The adult population in 1996, as estimated by trawling, was near average and yet the spawner counts were very low.

Counts of kokanee spawning in tributary streams also dropped substantially in 1996 (Table 6). Lake Pend Oreille was held at an elevation of 626.4 m above msl during the winter of 1996-97 as the start of an experiment to test higher winter water levels. This possibly could have induced kokanee to spawn on the shorelines and not migrate up tributary streams. This trend should be monitored throughout the next two winters of this experiment.

Returns of Hatchery Kokanee

The return rate of fin-clipped kokanee that had been released into Sullivan Springs in 1991 was higher than any previous year (Table 7). Both the smaller fry and the larger fry returned at nearly the same rate; 1.50 and 1.45%, respectively. This finding would tend to down play the importance of size, but the size difference between the two groups was small, only 13 mm. Our

Figure 3. The number of kokanee eggs in Lake Pend Oreille (PED recruits) as a function of kokanee eggs 5 years earlier (PED stock). The data points for 1995 and 1996 are labeled for clarity

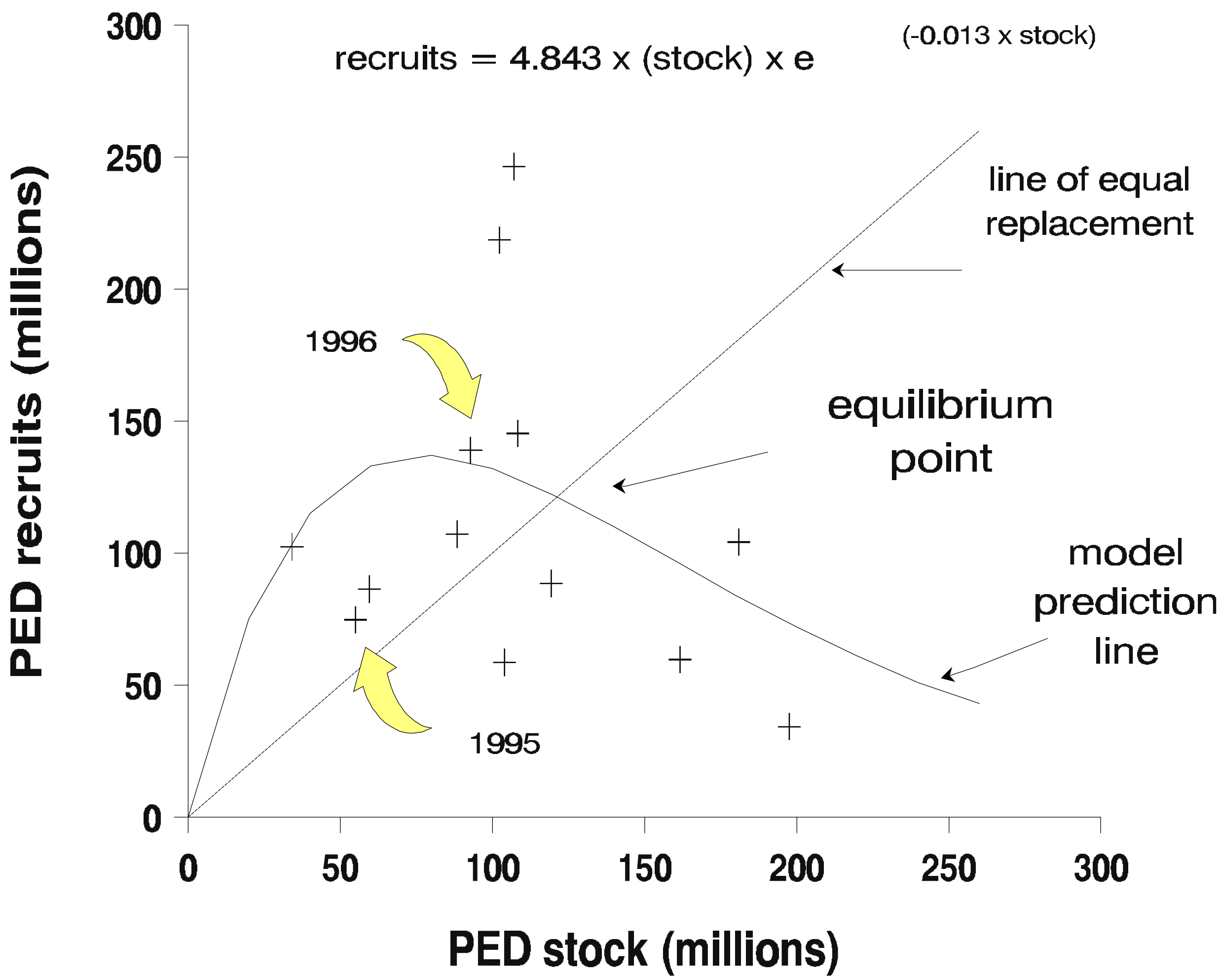


Figure 4. Abundance of kokanee fry (recruits) as a function of the number of kokanee fry 5 years earlier (stock). Data points for 1995 and 1996 are labeled for clarity.

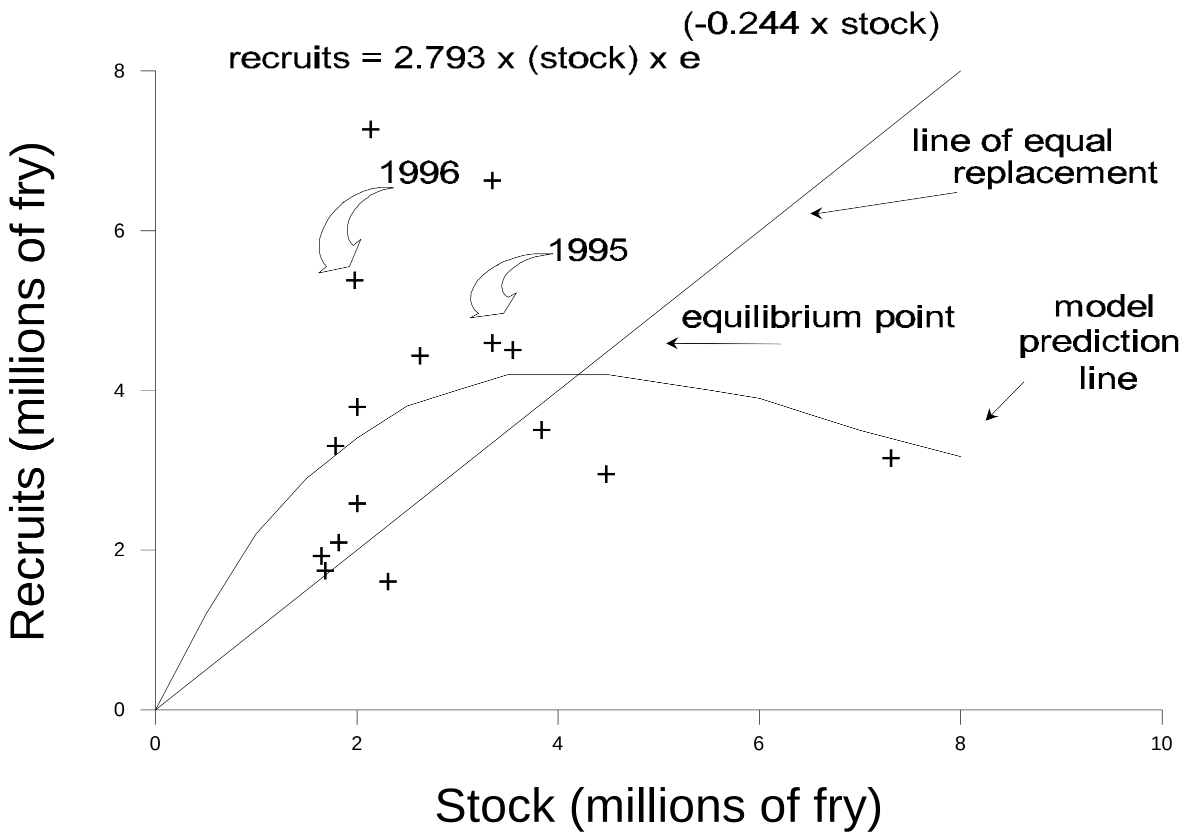


Figure 5. Abundance of age-1 kokanee (recruits) as a function of the number of age-1 kokanee 5 years earlier (stock). The data points for 1995 and 1996 are labeled for clarity.

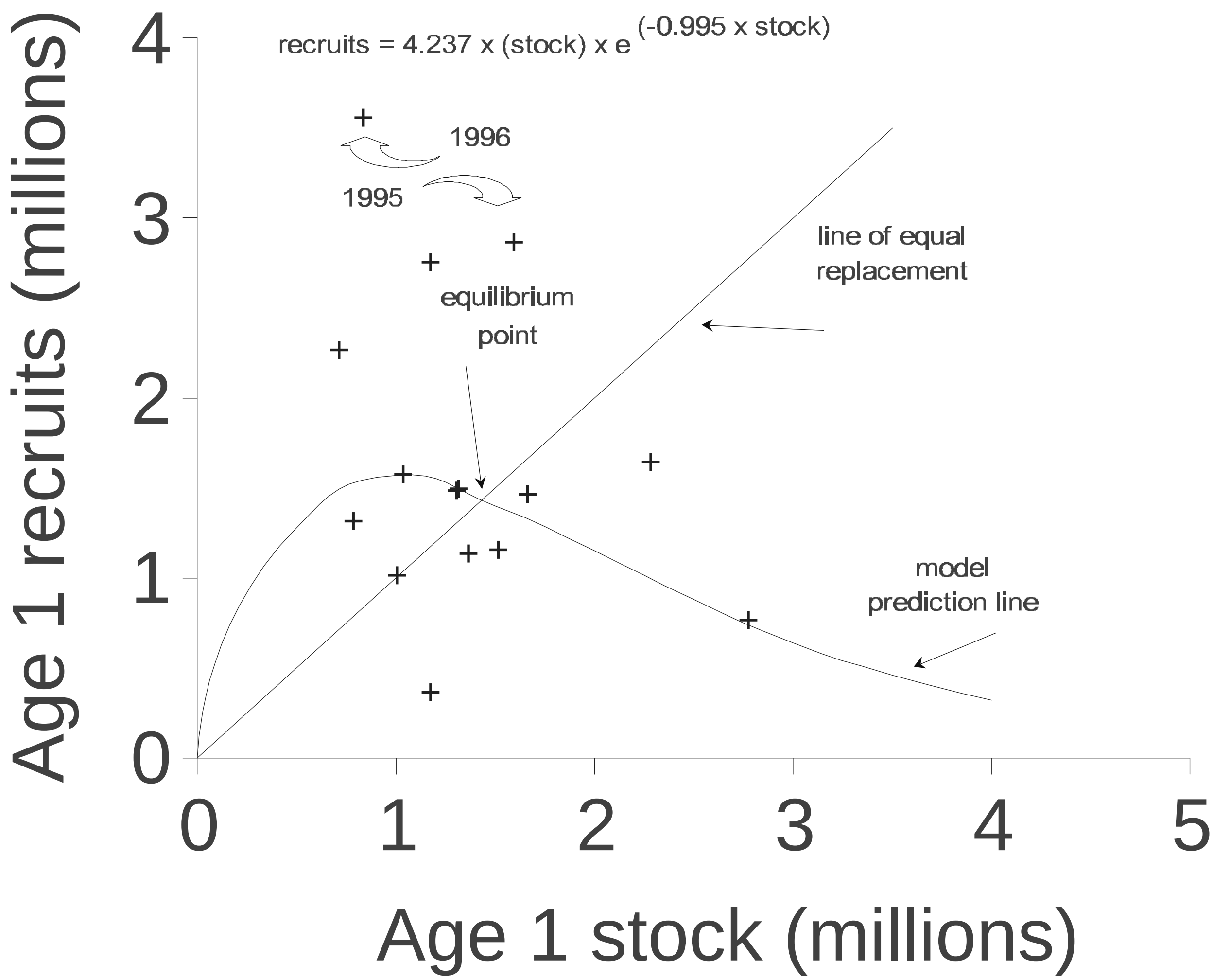


Figure 6. Abundance of age-2 kokanee (recruits) as a function of age-2 kokanee 5 years earlier (stock). The data points for 1995 and 1996 are labeled for clarity.

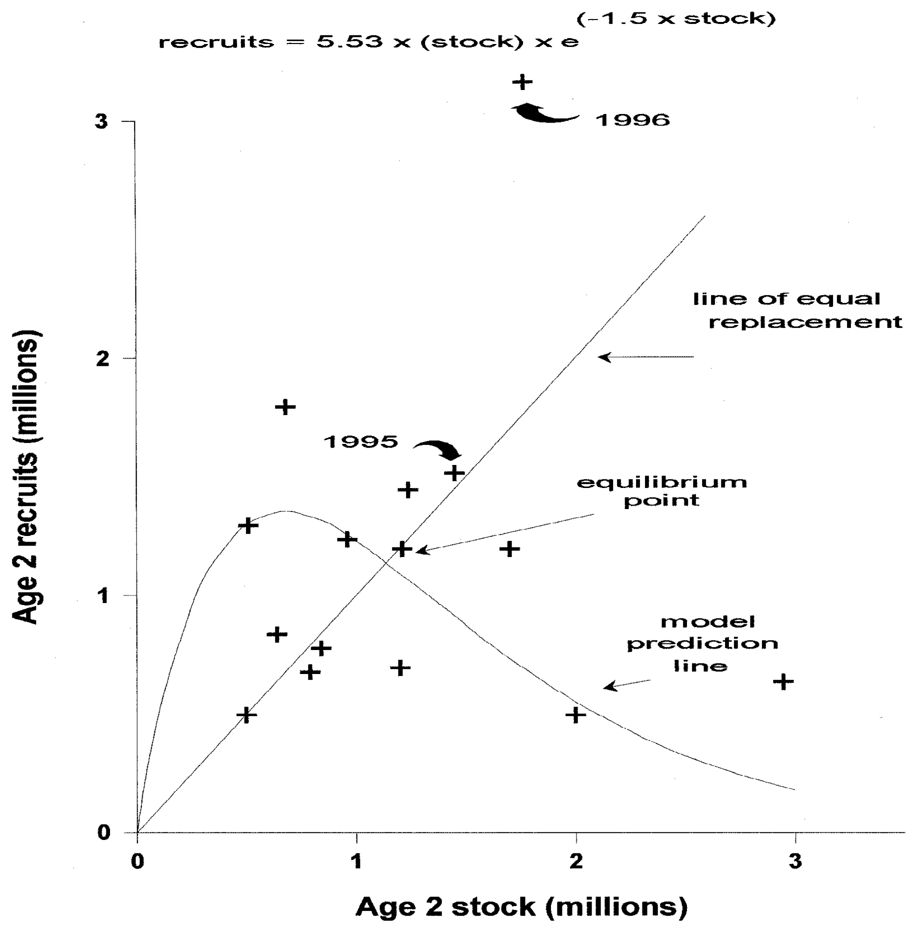
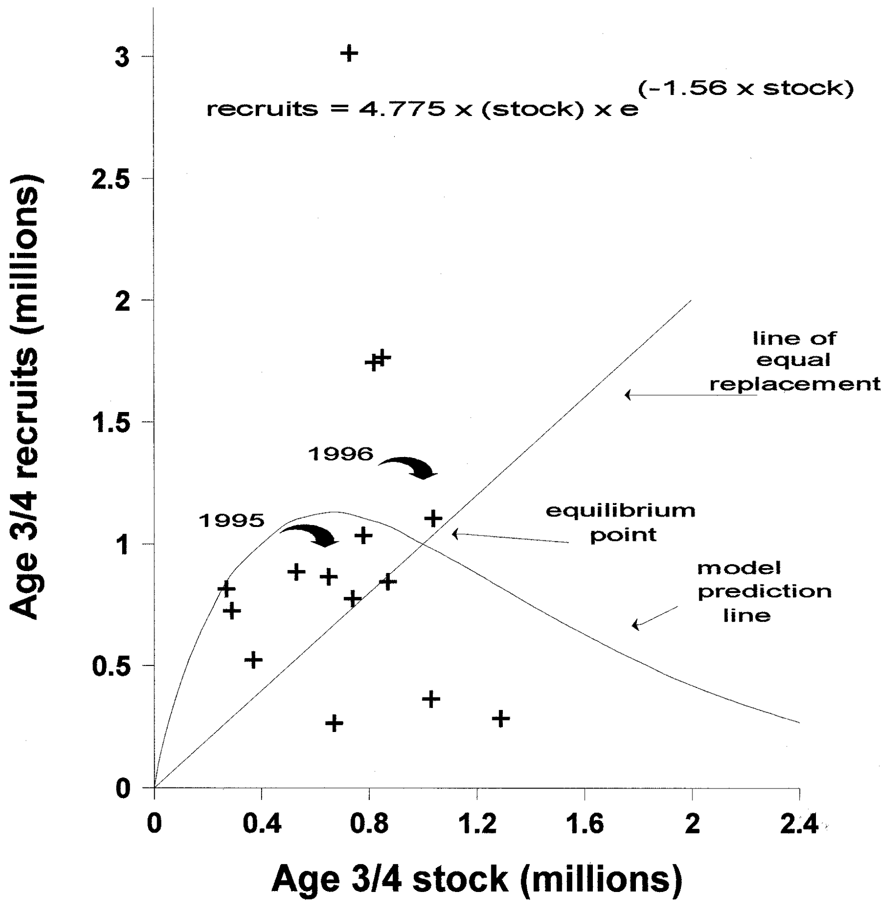


Figure 7. Abundance of age-3 and 4 kokanee (recruits) as a function of age-3 and 4 kokanee 5 years earlier (stock). The data points for 1995 and 1996 are labeled for clarity.



recommendation would be to test kokanee survival with larger size differences between test groups.

Results from the stocking that began in 1992 show a different result. In this test, the larger 60 mm fry returned at a much higher rate (2.1%) than the 30 mm fry (0.4%), indicating that larger fry are better (Table 7). These experiments are difficult to interpret since they contained no replication of test groups. However, they indicate that additional testing is warranted. Releasing larger fry means that the release date would need to be delayed until mid to late July. This adds an additional variable that needs to be tested before a large size at release can be recommended.

By multiplying the return rate of fin-clipped kokanee times the number of fry stocked, we estimated that 62,000 hatchery produced fish returned to Sullivan Springs in 1995. Thus 54% of the returning kokanee were hatchery fish and 46% were wild. This indicates that wild fish were a very large part of the run or that many fin clips regenerated so that these kokanee looked like wild fish. Until this is resolved, we stress the importance of continuing to release kokanee above the weir site for natural reproduction (10,000 kokanee are released above the weir to spawn naturally in an average year).

The return of kokanee to the Cabinet Gorge Hatchery ladder does not constitute a viable fish run at this time. Assuming a male to female sex ratio of 2:1 (a conservatively skewed ratio for the hatchery fish) and a fecundity of 444 eggs/female, we would need a return rate of 0.7% to just replace the parental generation. None of our releases at the fish ladder have come close to this return rate. The best we obtained was a return rate of 0.27% from the 1991 release group.

RECOMMENDATIONS

1. We recommend continued monitoring of the kokanee population using midwater trawling, hydroacoustics, and spawner counts during the experimental changes in lake levels.

2. All fry released from the hatchery should be marked to separate wild and hatchery stocks. This would greatly aid the monitoring of wild kokanee survival.

3. Kokanee should continue to be passed above the egg collection site at Granite Creek since many of the returning kokanee appear to have come from natural spawning. The current guideline of 10,000 fish or one half of the run is appropriate.

ACKNOWLEDGMENTS

Many people contributed to the 1995 and 1996 data collection. Ned Horner, Jim Davis, Lance Nelson, Gretchen Kruse, Mark Gilliland, Steve Hemstrom and Dmitri Vidergar all helped with midwater trawling on Lake Pend Oreille. Vern Ellis contributed to the shoreline and tributary kokanee spawner counts and data pertaining to the hatchery fry studies. Ned Horner, Dave Teuscher, and Jay Pravecek edited drafts of this report. The Bonneville Power Administration provided funding for this study. The help of these people and this agency were greatly appreciated.

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Appendix A. Definition of areas surveyed for shoreline spawning kokanee in Lake Pend Oreille, since 1972.

Bayview

- From MacDonald's Hudson Bay Resort to Bitter End Marina (the entire area within the confines of these two marinas).

Farragut State Park

- From state park boat ramp go both left and right approximately 1/3 km.
- Idlewild Bay - From Buttonhook Bay north to the north end of the swimming area parking lot.

Lakeview

- From mouth of North Gold Creek go north 100 meters and south 2 km.

Hope/East Hope

- Start at the east end of the boat launch overpass and go west 1/3 km.
- From Strong Creek go west and stop at Highway 200. Go east to Litehouse Restaurant.
- Start at East Hope Marina and go west stopping at Highway 200.

Trestle Creek Area

- From the Army Corps of Engineers recreational area boat ramp go west to mouth of Trestle Creek, including Jeb and Margarets RV boat launch area.

Sunnyside

- From Sunnyside Resort go east approximately 1/2 km.

Garfield Bay

- Along docks at Harbour Marina on east side of bay.
- From the Idaho Fish and Game managed boat ramp go toward Garfield Creek. Cross Garfield Creek and proceed 1/4 km.
- Survey Garfield Creek up to road culvert.

Camp Bay

- Entire area within confines of Camp Bay.

Fishermans Island

- Entire Island Shoreline - not surveyed since 1978.

Anderson Point

- Not surveyed since 1978.

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