A REVIEW OF KOKANEE MANAGEMENT ON THE OREGON COAST

by

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I INTRODUCTION

Kokanee salmon, Oncorhynchus nerka (Walbaum), are well distributed over much of central and eastern Oregon but are relative newcomers to lakes along the Oregon coast. Kokanee were first introduced into coastal waters in 1952 when 51,802 fry were planted in Woahink Lake, a few miles south of Florence. Since that time, releases have been made in other coastal waters including Munsel, Mercer, Clear, Devils, and Eel Lakes. Presumably, the species did not become established in Devils Lake, and releases are no longer being made in that water. Eel Lake, on the south-central coast, is within another administrative region, and data from that water are not presented. So far as is known, the species shows promise of becoming established.

The purpose of this report is to bring together existing records and observations of kokanee from lakes along the mid-coast. Nearly all the available information is from Woahink and Munsel Lakes. Mercer Lake data is very meager at the present time. Clear Lake received an initial stocking of kokanee in 1965. It is hoped that this report will serve as a guide to identify problem areas and to stimulate further investigations of these fine fish.

Nearly all the Munsel Lake biological data were provided by Mr. Del Skeesick of the Research Division. Mr. Chris Jensen supplied life history information relative to the brood fish utilized to provide fry for the various lakes. Fishery agencies of Montana,

Washington, and British Columbia provided additional life history information upon request. Data from the Odell Lake stocks were provided by Mr. Homer Campbell, and similar data from Detroit Reservoir by Mr. Joe Weatherbee.

II CHARACTERISTICS OF KOKANEE LAKES

A. Size

Woahink, Munsel, Mercer, and Clear Lakes differ in physical characteristics. The size of the lakes varies from about 90 to nearly 800 surface acres. Table 1 presents a size and depth comparison of these waters. Figures 1 through 4 present contour maps of the lakes. Additional information on the morphometry of these waters may be found in the 1962 reports of the Fish Commission of Oregon. All four lakes have outlets to the ocean.

Table 1

Size and Depth of Four Kokanee Lakes

Lake	Surface Acres	Maximum Depth (ft.)	Average Depth
Woahink	787	85	41
Munsel	93	74	20
Mercer	341	41	25
Clear	140	82	39

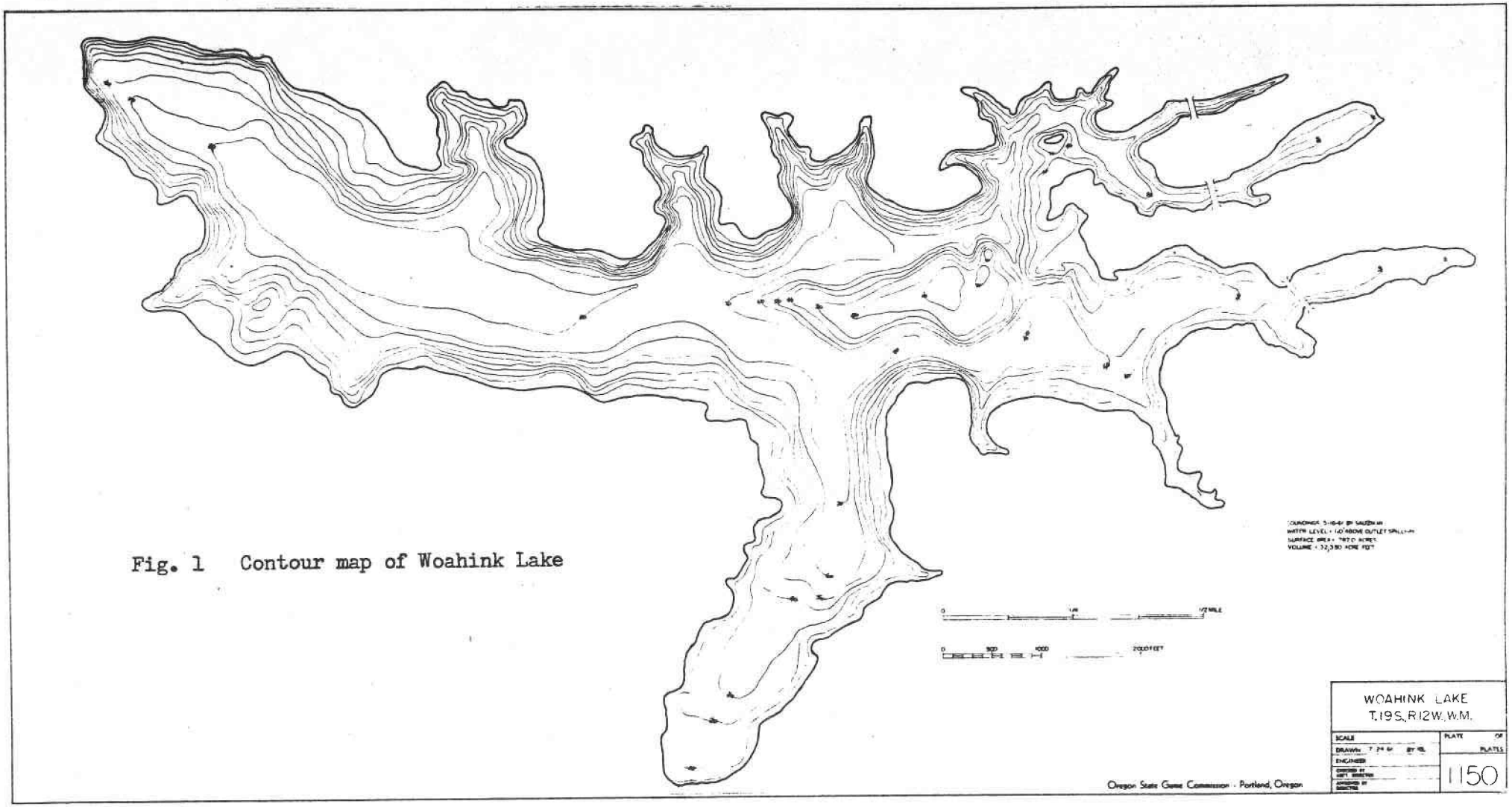

Fig. 1 Contour map of Woahink Lake

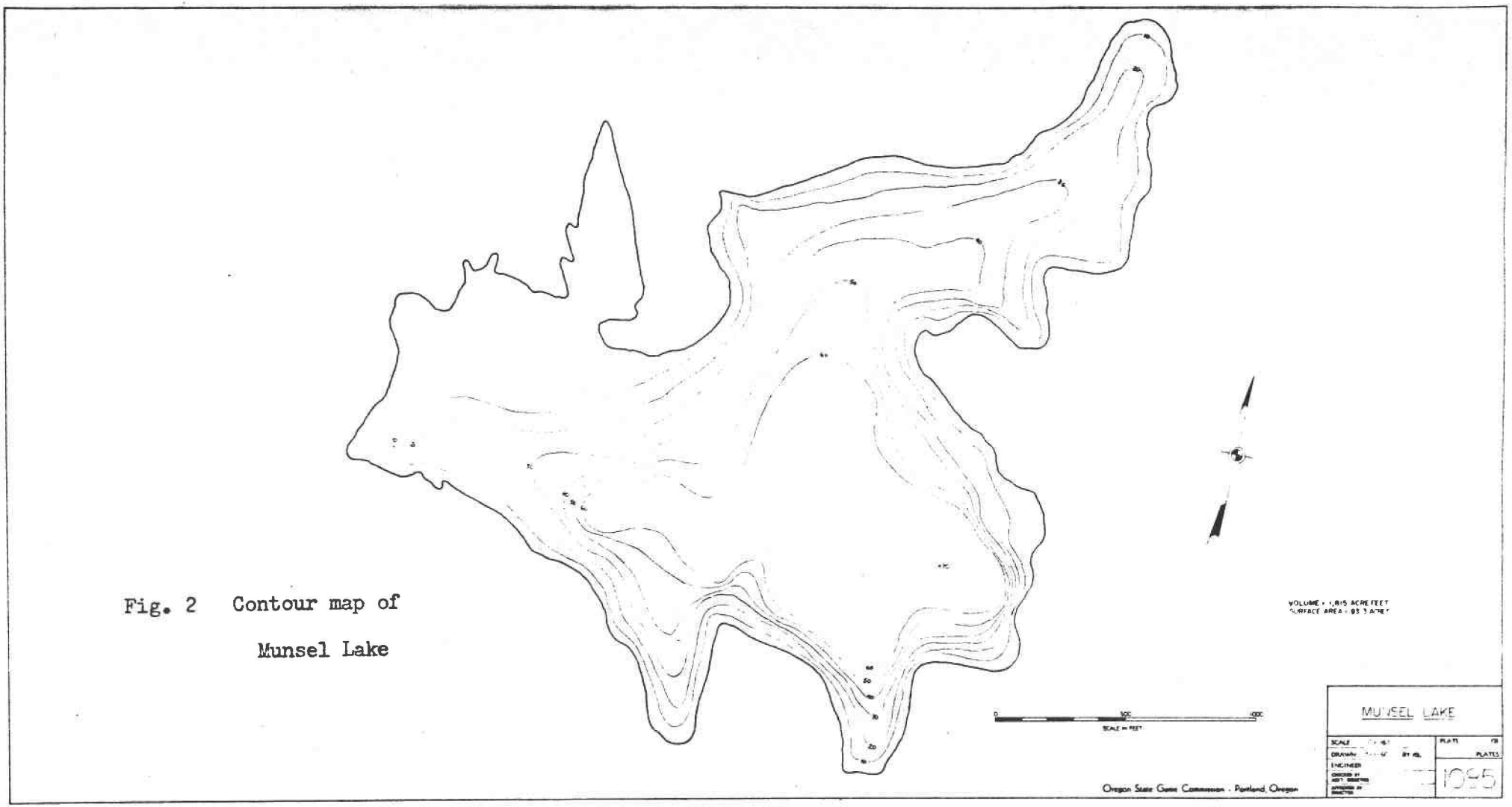

Fig. 2 Contour map of Munsel Lake

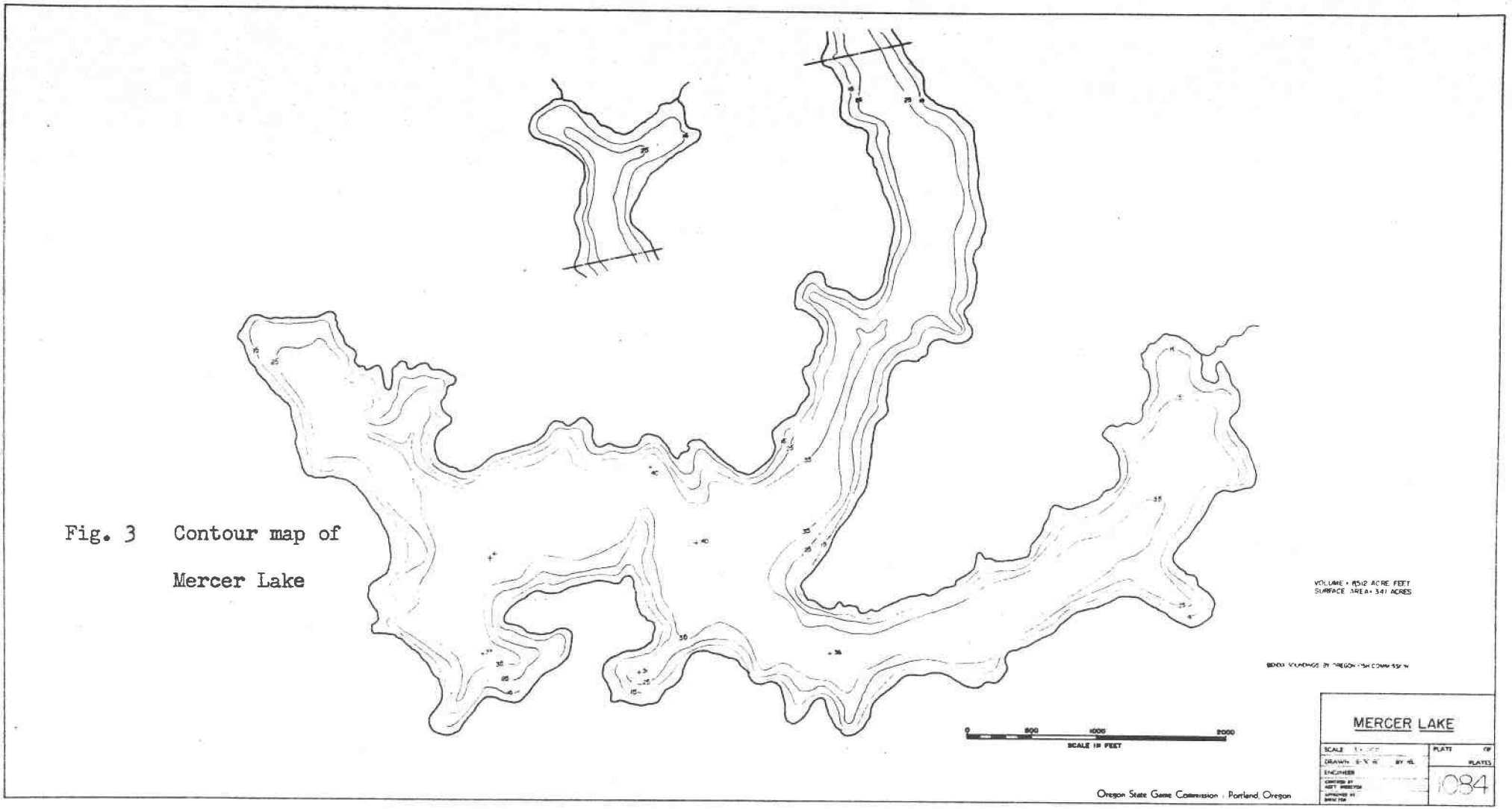

Fig. 3 Contour map of Mercer Lake

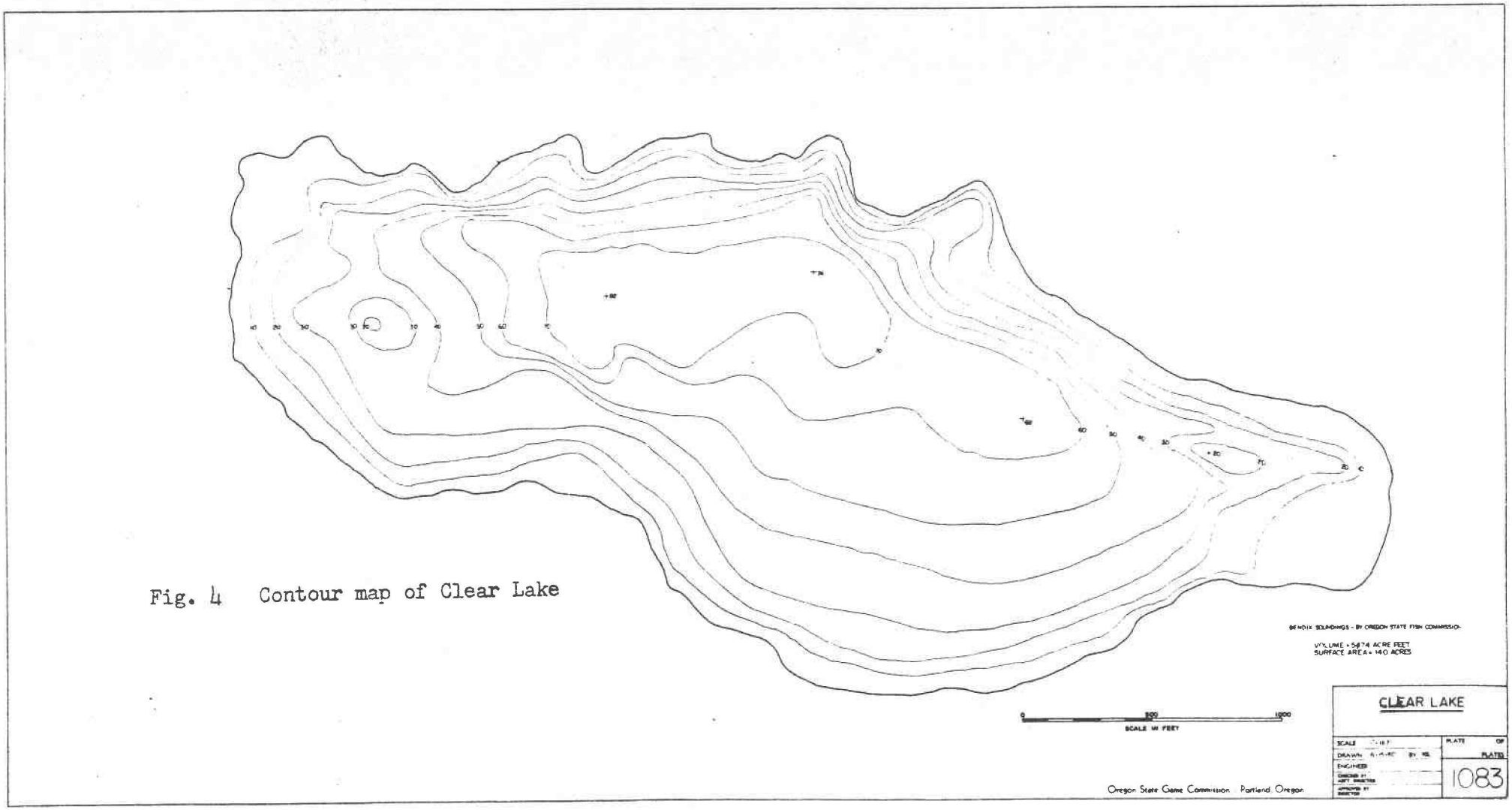

Fig. 4 Contour map of Clear Lake

B. Water Quality

Series of dissolved oxygen and temperature measurements were taken at the four lakes in August of 1964. Samples were collected from the deepest portion of each water. Tables 2 through 5 present the data obtained, together with similar measurements taken previously about this same time of year. Data for the year 1938 in Tables 2 and 4 were obtained from the report by Griffiths and Yeoman (1938). Data for the year 1960 in Tables 2, 3, and 4 were obtained from the reports of the Fish Commission of Oregon (op. cit.) for the various lakes. Dissolved oxygen values reported in the tables are expressed in parts per million and temperature in degrees Fahrenheit.

Table 2 for Woahink Lake depicts a deep thermocline in the midsummer period. The thermocline was located generally between 45 and 55 feet. Ample oxygen, 4 or 5 parts per million or more, extended through the thermocline and even well below in the August 5, 1964 sample. An abundance of deep, cold, well-oxygenated water is believed to be one important ecological requirement of kokanee. These water quality criteria are being met at Woahink Lake where a well-established population of kokanee exists.

Table 3 for Munsel Lake also depicts a midsummer thermocline, but at a lesser depth than at Woahink. The thermocline at Munsel is within the 20- to 40-foot strata and probably about 25 to 30 feet. Ample dissolved oxygen to a depth of at least 40 feet was found. Kokanee are well adapted to Munsel Lake.

Table 4 for Mercer Lake presents available data. Dissolved oxygen measurements taken in 1964 were later found to be questionable and are not included in Table 4. Additional temperature and

dissolved oxygen measurements are needed to demonstrate the suitability of this lake for kokanee. Kokanee were first planted in Mercer Lake in 1963, and it is not known at this time whether or not the species has become established.

Table 5 for Clear Lake indicates thermal stratification within the 30- to 40-foot level. An abundance of oxygen to a depth of at least 50 feet is indicated. Kokanee were planted in Clear Lake for the first time in 1965, so it is too early to assess results. Using the criteria of an abundance of deep, cold, well-oxygenated water, Clear Lake seems equally well suited for kokanee as either Woahink or Munsel Lakes.

More detailed water chemistry data on each lake may be found in the reports of the Fish Commission of Oregon (op. cit.). The reports by Saltzman on Woahink Lake (1962) and on Mercer Lake (1961) contain additional data on water quality. An extensive water quality study of Munsel Lake is being conducted as a part of the cutthroat study being done by the Research Division. These data are not yet available. The report of Griffiths and Yeoman (op. cit.) contains some additional information on water chemistry.

Table 2

Temperature and Dissolved Oxygen Data

Obtained from Woahink Lake

Depth	Sept 3, 1938		Aug 27, 1949		Aug 16, 1960 (2 sites)				Aug 5, 1964	
	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.
Surface	-	10.4	71°	8.6					68°	9.8
5					69°	8.8	69°	8.8		
10			69°							
15										
20			69°		69°		69°		68°	
25										
30			69°							
35					68°		68°	8.5	67°	9.0
40	-	9.9	67°	7.9					67°	
45					67°	7.4	67°	8.3	64°	8.3
50		8.8	56°	5.0	66°		64°	6.2	57°	9.1
55					62°	5.3	62°	4.1	55°	
60			52°		60°	4.5			54°	5.9
65	-	3.8			60°	4.0			53°	
70	-	2.0	51°	0.4					53°	4.4
75										
80										

Table 3

Temperature and Dissolved Oxygen Data

Obtained from Munsel Lake

Depth (ft.)	August 9, 1960		August 8, 1964	
	Temp.	D.O.	Temp.	D.O.
Surface			71	9.2
5	71	8.8		
10				
15				
20	70		68	9.0
25	65	11.0	64	11.3
30	59	11.3	54	12.7
35	56		51	9.9
40	54	5.1	49	5.2
45			48	3.7
50	52			
55			47	2.3
60	52	1.0	47	1.2
65			47	
70			47	
74			47	0.1

Table 4

Temperature and Dissolved Oxygen Data

Obtained from Mercer Lake

Depth (ft.)	Oct 11, 1938	Oct 19, 1938	Aug 15, 1960 (2 sites)				Aug 6, 1964
	D.O.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp. °F.
Surface	11.2	9.5					70
5			71°	8.5	70°	8.6	69
10							68
15							68
20			70°	7.4	67°	6.1	67
22							
23							65
24							
25			61°	1.5	59°	0.5	62
26							
27							
28	11.1						59
29							
30							
31							
32							57
33	0.0	8.4					
34							
35			59°	0.0	59°	0.0	57
36		4.1					
37							
38							57
39							

Table 5

Temperature and Dissolved Oxygen Data

Obtained from Clear Lake

Depth (ft.)	August 10, 1960		August 31, 1964	
	Temp.	D.O.	Temp.	D.O.
Surface			69	9.0
5	71	8.1		
10				
15			69	
20	71			
25				
30	70	8.6	69	9.1
35	64	10.4	61	9.8
40	61		55	
45			52	7.9
50	59	5.0	50	
55			49	3.2
60	56		48	
65	56	1.3	48	1.3
70			48	

III ORIGIN AND STOCKING HISTORY

Kokanee eggs from a number of sources and with varied life history patterns have been obtained for incubation in Game Commission hatcheries. These sources have included the fishery agencies of British Columbia, Washington, and Montana. Odell Lake in Oregon provided the source of eggs for use in 1955. In 1965, brood fish from Detroit Reservoir provided the progeny for stocking coastal lakes. A record of the number and size of kokanee liberated in local waters is presented in Table 6. Kokanee have usually been planted as fry, although at times the fish are retained for a longer period and released as fingerlings.

Table 6

Records of Kokanee Liberations

in Lakes on the Central Coast

	Woahink		Munsel		Mercer		Clear	
Year	No.	No./lb.	No.	No./lb.	No.	No./lb.	No.	No./lb.
1952	51,802	4,016						
1953	47,792	3,688						
1954	49,950	4,163						
1955	49,894	4,264						
1956	15,126	176						
1957	0	-						
	49,925	434						
1958	170,998	3,717						
1959	0	-						
1960	100,030	5,527	39,960	4,078				
1961	119,559	3,105	30,252	3,119				
1962	25,120	670	10,148	700				
1963	54,008	314	15,700	314	40,077	472		
1964	200,400	5,010	15,030	5,010	80,160	5,010		
1965	199,260	3,560	25,675	3,950	86,800	3,950	46,230	3,560

Considerable effort has been directed to the determination and compilation of life history data for each kokanee planting. These data are appended to the report.

IV DISTRIBUTION

A. Vertical Distribution

The distribution of kokanee in space and time has not been explored in coastal lakes. The depth distribution of kokanee in Elk and Odell Lakes in central Oregon has received considerable attention by the Oregon Game Commission and is reported by Chapman and Fortune (1963). They found that all-year classes were present in surface waters in June, moved to deeper strata in midsummer, and returned to the surface waters again in the fall. A similar movement or occupancy of the deeper water strata in the summer months by kokanee is reported by Horal and Tanner (1964) for a reservoir in Colorado. They stated that kokanee were captured generally within a broad temperature range of from 46 - 65°F., with the mode occurring from 51 - 55°F. They found that of some 119 kokanee captured, 45.6 percent were taken within, 36.6 were above, and 17.8 percent were taken below the thermocline. The limited observations made at Woahink and Munsel Lakes appear to be in agreement with these findings. The movement of kokanee to a greater depth as the summer progresses is related to water temperature, although other factors may be important. Kokanee fry liberated at Woahink Lake hover close to the lake bottom in shallow areas shortly after release. At Woahink Lake kokanee angling success may become poorer as the summer progresses for those anglers fishing just off the bottom. This could be explained by fish leaving the deeper water strata, low in dissolved oxygen, in favor of more suitable waters nearer to or within the thermocline. Some movement from deeper water in late summer could also be associated with prespawning activities.

B. Migrations

Migration of adult kokanee to shoreline areas, tributaries, and outlets is usually associated with spawning activity. This activity results in kokanee being distributed around most shoreline areas of Woahink Lake by early fall. Some movement of mature kokanee has been observed down Woahink Creek, the outlet from Woahink Lake, for a distance of at least 0.5 mile. Movement of kokanee into the tributary waters of Woahink Lake has not been noted. Ripe kokanee have been observed in late summer and fall months in both Munsel and Ackerley Creeks, outlet and inlet streams, respectively, of Munsel Lake.

The trapping facility maintained by the Research Division monitors all fish migrations in Munsel Creek and has provided an opportunity to assess the migration of kokanee from Munsel Lake. Records of kokanee taken at the trap were supplied by Mr. Del Skeesick and are presented in Table 7. A number of downstream migrants, tentatively identified as kokanee, were taken in the trap in the spring of 1962. It is suspected that these fish were coho and not kokanee, and these records are therefore not included in Table 7. The record of upstream migration was not maintained at the weir in 1962. The period of operation of the trap in 1962 was from April 1 through November 26. The facility was reactivated on March 11, 1963 and was operated until high water forced a closure on February 2, 1964. Operation was resumed on March 21, 1964 and continued until June 30, 1964. The facility has been in continuous operation from November 4, 1964 into June of 1965. No kokanee are recorded from the trap in 1964 through the winter of 1964-65. An unexpected migration of kokanee occurred in the late spring of 1965. From May 14 through June 12, some 164 fry or zero-age class moved downstream through the

trap. These fish had a range in fork length from 2.5 to 4.1 inches. With this exception, the migration of kokanee of all age classes both up and down Munsel Creek has been nil, considering the period within which the trap has been operative.

The migration of kokanee from Woahink Lake in the spring appears to be of minor importance. The outlet of Woahink Lake was blocked from April 18 through June 2, 1965. A V-notch or an inclined-plane trap was fished continuously throughout this period. Some 652 fish of various species were taken. Of this number, only two kokanee of age class II+ were noted. The fish measured 6.3 and 6.6 inches in length. Twelve kokanee fry were collected. The fry appeared to be increasing in numbers when the facility had to be dismantled in early June.

Table 7

A Record of Kokanee Captured at the
Munsel Creek Trapping Facility in 1963

Date	Trap	Length (inches)	Sex	Maturity	Comments
March 29	Downstream	-	Male	Maturing	Spawned out
April 13	"	8.9	-	-	
" "	"	11.1	-	-	
" 30	"	5.0	-	-	
Nov. 8	Upstream	14.6	Female	Maturing	
" 17	Downstream	-	Male	Maturing	Dead in trap
" 25	Upstream	14.1	Female	Maturing	

V FOOD OF KOKANEE

It has been well established that kokanee feed primarily on zooplankton throughout most of their lives. In the final year of life, larger forms such as insect larvae may become important in the diet. Stomachs from a number of kokanee taken from both Woahink and Munsel Lakes in 1963 were examined and a gross determination of the stomach contents made. Findings were consistent with food habits of kokanee from other waters. These data together with limited studies made earlier are summarized in the following paragraphs. Stomachs from fish of zero-age class were not available for examination.

Woahink Lake

Stomachs from seven kokanee of age class I plus[1] (7.0 - 7.7 inches in fork length) taken June 15, 1963 were examined. Five of the stomachs were empty, one contained approximately 150 Cladocera, and the remaining stomach contained the remains of six mayfly larvae. The presence of food items, the size of mayfly larvae, in these immature fish was unusual.

Stomach analyses were made of some 31 kokanee of age class I+ (7.4 to 8.2 inches in fork length) taken July 11, 1963. Stomachs of five of the fish were empty. Cladocera were found in all the remaining stomachs, the estimated numbers ranging from 25 to 1,200 per stomach. No other food items were noted.

Stomachs from nine kokanee taken on November 20, 1963 were examined. These fish were of age class I+, but were approaching the designation of II when taken. The fish measured from 8.2 to

[1] Age determinations and definitions are discussed in detail in the next section.

8.8 inches in fork length. Cladocera were found in all stomachs, with estimated numbers per stomach ranging from 300 to over 4,000. No other food items were noted.

Stomach contents of adult kokanee were first reported by the Fish Commission of Oregon in 1962 (op. cit.). These fish were of age class II + (8.4 to 10.5 inches in fork length) taken July 12, 1960. Cladocera were by far the most numerous food items, being found in nine of the ten stomachs examined. Also noted were oppossum shrimp, Mysis sp., mayfly larvae, Tipulidae larvae, and unidentified insect parts.

Stomachs from four maturing kokanee of age class II + (9.2 to 10.4 inches in fork length) taken May 28, 1963 were checked. Two of the stomachs were empty and the remaining two stomachs each contained from 200 to 400 Cladocera.

Stomachs from 14 kokanee of age class II + (9.2 to 10.2 inches in fork length) taken on June 2, 1963 were examined. Two of the stomachs were empty, but Cladocera ranging in numbers from 40 to approximately 1,000 were found in the remaining 12 stomachs. In addition to the Cladocera, two stomachs each contained a single small beetle larvae, one stomach had six Tendipididae larvae, and one stomach had a number of unidentified insect parts.

Munsel Lake

Stomachs from 43 kokanee of age class I + (7.8 to 9.7 inches in fork length) taken from July 1 to 21, 1963 were examined. Stomachs of 22 of the kokanee were empty. Cladocera ranging in numbers from 15 to approximately 5,000 were found in the remaining stomachs.

Stomach contents noted in seven samples of age class I + fish (length data not available) taken August 24 to 28, 1963 were of interest. All seven stomachs contained food items but Cladocera were found in only four stomachs. The greatest number of Cladocera found in any one stomach was about 400. Oppossum shrimp numbering from 5 to 20 were found in five stomachs. Four stomachs contained from one to four Tendipididae larvae.

Stomachs from 13 kokanee presumably of age class II + (12.9 to 14.6 inches in fork length) taken from June 15 through August 25, 1963 were examined. Three of the stomachs were empty. Eight stomachs contained from 75 to about 800 Cladocera per stomach. From 18 to 35 oppossum shrimp were noted in two stomachs. Four stomachs each had from one to four Tendipididae larvae.

No attempt was made to classify the various planktons found in the stomachs to genera or species. Plankton samples taken at both Woahink and Munsel Lakes in 1962 were forwarded to the Research Division for identification. The results are reported by Chapman and Fortune (op. cit.). These authors also compare the composition of the plankton fauna in the stomach contents with that observed in plankton hauls at Odell Lake in central Oregon. Diaptomus was a minor component of the plankton fauna but was found to be an important item of food of the kokanee examined. This same report lists the following plankters common to both Woahink and Munsel Lakes: Cyclops bicuspidatus thomasi, Daphnia longispina, and Epischura nevadensis. Also taken from Woahink Lake were Diaptomus sp. and Diaphanosoma brachyurum. Diaptomus novamexicanus was identified from Munsel Lake.

VI AGE AND GROWTH

Kokanee have been collected in quantity from both Woahink and Munsel Lakes in recent years for age, growth, and survival studies. The records of all collections made from 1960 through March 1, 1965 have been prepared in tables which are on file in the Florence office.

Scale samples were taken from a large number of kokanee collected at the two lakes. The matter of age determination was discussed with Mr. Fran Sumner with the result that a carefully selected subsample of scales from this larger group was selected. These scales were subsequently mounted between glass microscope slides. Age assessments were then made by Mr. Fran Sumner. An explanation of the age class designations used is necessary. The time of annulus formation is believed to start about January 1 and to extend into April. A Roman numeral, such as "I" is used to indicate each completed annulus. A fish so designated has no new growth beyond the annulus and was captured within the period of annulus formation, January - April. Fish taken when new growth is in evidence on the scale beyond the annulus are designated with a "+" following the numeral. These specimens were captured sometime within the period from April through December.

Table 8 presents data obtained from the Woahink Lake fish, and Table 9 from the Munsel Lake specimens. Scale samples from only two fish were available from Siltcoos Lake, and the data from these appear in Table 10. A comparison of the age and growth of kokanee from Woahink, Munsel, and Siltcoos Lakes is presented in Table 11. It is interesting to note in the table that most of the collections of fish from Woahink Lake exhibit a greater length at annulus I than do fish from Munsel Lake. However, a rapid rate

of growth beyond annulus I is indicated for the Munsel Lake fish; and when annulus II is reached, they are nearly three inches longer than their counterparts at Woahink Lake. The single specimen from Siltcoos Lake of age class II + showed growth at annulus II intermediate between that of comparative samples from Woahink and Munsel Lakes.

Figures 5 and 6 present photographs of scales taken by Mr. Fran Sumner. The method[1] used to photograph the scales was "... made by setting a Ciroflex camera on a tripod so that the lens of the camera was against the microscope lens. Illumination was by a fluorescent desk lamp. Exposure was at f 3.5 and 2-8 seconds."

[1] Reported by Mr. Fran Sumner in a letter to William Saltzman dated May 24, 1965.

Table 8

Age of Kokanee from Woahink Lake

Age Class	Length (in.)	Date Taken	Year Liberated	Slide (No.)	Comments
I	4.6	April 10, 1963	1962	W8	
I+	6.3	May 28, 1963	1962	W9	
	6.8	" " "	"	W10	
	7.5	" " "	"	W11	
	7.6	July 11, 1963	"	W17	
	8.0	" " "	"	W18	
	8.3	Aug. 30, 1963	"	W19	
	9.6	" " "	"	W20	
	8.7	Nov. 20, 1963	"	W24	
	8.8	" " "	"	W25	
	9.0	" " "	"	W26	

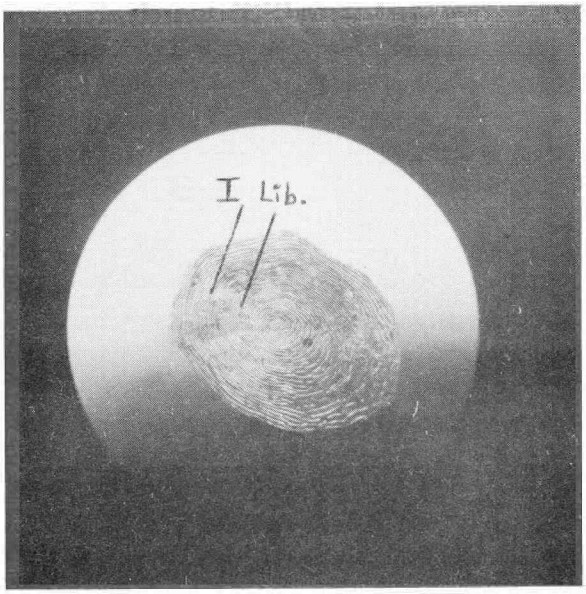

Fig. 5 Photograph of a kokanee scale of age class I+ from Woahink Lake. Fish was an immature female 6.3 inches in length taken May 28, 1963.

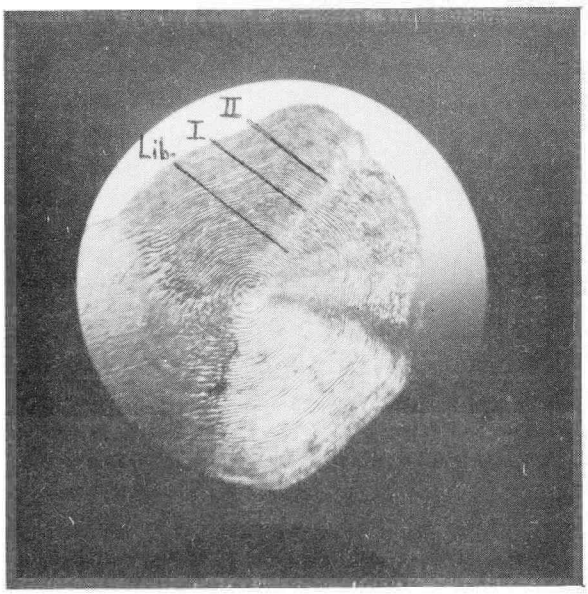

Fig. 6 Photograph of a kokanee scale of age class II+ from Woahink Lake. Sex and maturity unknown. Fish was 10.2 inches in length taken June 2, 1963.

Table 8 (cont.)

Age of Kokanee from Woahink Lake

Age Class	Length (in.)	Date Taken	Year Liberated	Slide (No.)	Comments
II	9.3	April 20, 1960	1958	W1	
II+	8.4	July 12, 1960	1958	W4	
	9.1	" " "	"	W6	
	9.9	" " "	"	W5	
	10.5	" " "	"	W7	
	9.2	May 28, 1963	1961	W12	
	9.8	" " "	"	W13	
	10.4	" " "	"	W14	
	9.2	June 2, 1963	"	W15	
	10.2	" " "	"	W16	
	10.3	Aug. 30, 1963	"	W21	
	10.6	" " "	"	W22	
	10.9	" " "	"	W23	
III	9.8	March 14, 1964	1961	W27	Age designation of III and IV questionable, scale patterns obscure. Specimens may not be this old.
IV	11.0	April 20, 1960	1956	W2	
	11.5	" " "	"	W3	

Table 9

Age of Kokanee from Munsel Lake

Age Class	Length (in.)	Date Taken	Year Liberated	Slide (No.)	Comments
I	9.3	Feb. 1, 1964	1963	M27	Scale patterns indicate I, but size of fish make II more likely
	9.6	March 23, 1964	"	M30	
	10.2	" " "	"	M31	
I+	4.9	April 17, 1963	1962	M2	
	5.3	" " "	"	M3	
	7.8	July 4, 1963	"	M9	
	8.1	" " "	"	M10	
	8.3	" " "	"	M11	
	8.7	" " "	"	M12	
	9.4	" " "	"	M7	
	9.5	July 1, 1963	"	M6	
	10.0	July 24, 1963	"	M19	
	10.2	July 16, 1963	"	M17	
	10.5	Aug. 24, 1963	"	M23	
	11.1	" " "	"	M24	
	10.0	Aug. 28, 1963	"	M22	
	10.4	Nov. 18, 1963	"	M25	
II	10.3	Feb. 1, 1964	1962	M28	
II+	8.9	April 13, 1963	1961	M1	Scale pattern indicates II, Size would indicate I.
	11.4	April 16, 1963	"	M5	
	11.4	April 21, 1963	"	M4	
	12.5	July 4, 1963	"	M15	
	12.9	" " "	"	M8	
	13.0	" " "	"	M16	

Table 9 (cont.)

Age of Kokanee from Munsel Lake

Age Class	Length (in.)	Date Taken	Year Liberated	Slide No.	Comments
II+ (cont.)	13.2	July 17, 1963	1961	M18	
	13.0	July 27, 1963	"	M20	
	13.9	" " "	"	M21	
	12.1	Nov. 18, 1963	"	M26	
	10.4	April 25, 1964	1962	M32	
	10.7	April 26, 1964	"	M33	
III	12.6	Feb. 2, 1964	1961	M29	
III+	13.0	May 9, 1964	1961	M34	

Table 10

Age of Kokanee from Siltcoos Lake

Age Class	Length (in.)	Date Taken	Year Liberated	Slide No.	Comments
II+	12.5	July 25, 1963	1961	S2	
III	11.3	April 20, 1963	1960	S1	

Table 11

Age and Growth Comparisons of Kokanee

from Three Lakes

Age Class	Lake	Average Calculated Length at Annulus (inches) I	Average Calculated Length at Annulus (inches) II	Length When Taken (inches)	Year Taken	Number in Sample
I+	Woahink	5.4 (4.4-6.6)		8.1 (6.3-9.6)	1963	11
	Munsel	4.8 (4.1-5.6)		8.9 (4.9-11.1)	1963	14
II+	Woahink	5.5 (5.2-5.8)	7.5 (7.0-7.7)	9.2 (8.4-10.5)	1960	5
		5.6 (4.7-6.3)	7.8 (6.2-9.0)	10.1 (9.2-10.9)	1963	8
	Munsel	5.9 (3.9-6.7)	10.8 (8.4-12.3)	12.2 (8.9-13.9)	1963	10
		4.2 (3.8-4.5)	10.2 (10.1-10.3)	10.5 (10.4-10.7)	1964	3
	Siltcoos	5.1	9.6	12.5	1963	1

VII REPRODUCTION

A. Spawning Characteristics

The spawning activities of kokanee have been observed or reported at Woahink Lake for about ten years and at Munsel Lake for the past three years. The observations and data relating to spawning activities at the two lakes are reported in this section.

The report by Seeley and McCammon (op. cit.) aptly summarizes the variations in age and size of maturing kokanee from a variety of waters. They point out that the life cycle of kokanee may vary from two to seven years, but that in their original range in North America, kokanee predominantly follow a four-year cycle. The bulk of the egg supply for the Woahink and Munsel Lake plants came from Washington and Montana. The brood fish from Montana are reported[1] to spawn at four years, while those from Washington are reported[1] to spawn at three and four years. A deviation from the four-year cycle exists at both Woahink and Munsel Lakes. Scale analyses by various Game Commission personnel in recent years, notably Messrs. Robert Phillips, Don Chapman, and William Saltzman, have disclosed maturing fish to be approaching their third complete year or age class II+. These findings are in agreement with the more intensive age analysis work conducted by Mr. Fran Sumner and reported in the preceding section.

Spawning may take place at the two lakes from August through December with the history of the parent stocks undoubtedly exerting its influence on the time of such activity. Water temperature and weather conditions at the approach of the spawning season may influence spawning activities.

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[1] Information obtained from fishery departments of the two states by Mr. Chris Jensen in March of 1964.

Observations of spawning kokanee at Woahink Lake are reported in the Annual Report of the Fishery Division (1959) on page 248 as follows:

"The shore of Woahink Lake was examined to determine the spawning activity of kokanee. On December 17, 1958, about 50 mature fish were seen spawning near the lake outlet. Another 25 were observed in the outlet at the North Beach Road bridge. The two larger inlets were spot checked, but no kokanee were found.

"The peak of spawning appeared to occur in mid-December. No dead fish could be found. The water temperature on December 17 was 52° F. All spawning activity had ceased when the outlet was visited on December 31."

An earlier spawning period is indicated from observations made in 1961. Ten dead kokanee were found on September 26, 1961 in a cove near the east side of the lake. Good spawning sites in the area were lacking, but two of the fish were examined and found to be spawned out. The owner of the Clearwater Marina at the southwest corner of the lake, Mr. John May, reported maturing kokanee just north of his establishment about September 25, 1961.

Some interesting observations of maturing fish were made in 1963. A stocking of 25,125 adipose-marked fingerling kokanee was made in Woahink Lake on June 14, 1962. The fish at this time were approximately 2.0 inches in length. A gill net set on July 11, 1963 took thirty of the marked fish. The fish measured from 7.4 to 8.2 inches in fork length and all were immature. On August 30, 1963, forty-nine of these marked fish were taken in gill nets. Of this number, all but six were approaching maturity. Maturing fish had a pink color and the scales were well set. Evidence of a kype was noted on most of the males. Egg development in the females

was well advanced and a few loose eggs were noted. These fish were obviously destined for early spawning, probably in September. Of the fish in the sample, thirty-two males and eleven females were in the group maturing. The six immature fish were all silvery in appearance and the scales were deciduous. The six fish were slightly smaller than their precocious kin, measuring from 8.3 to 8.7 inches in fork length; whereas the maturing fish measured from 8.9 to 10.2 inches in fork length. A check of the life history of the parent stock of these fish disclosed that they were taken from the Lake Whatcom Station in Washington. It is reported[1] that the brood fish were 10 to 11 inches in length and matured at 3 and 4 years. A rather severe departure from this pattern thus took place at Woahink Lake when some fish from this stock approached maturity at age class I+.

Further observations were made later in 1963. On November 20, 1963, nine adipose-marked fish were collected in gill nets. The fish measured from 8.2 to 9.0 inches in fork length and all were immature. It is thus evident that fish from a single plant, both males and females, comprised two distinct spawning groups. One group matured as I+ fish in the late summer or early fall following release. The other group spent an additional year in the lake before spawning as II+ fish. Size appears to be a factor associated with early maturity. The sample size of fish from which observations were made is small, but it did appear that those fish approaching 9.0 inches in fork length by September were slated for spawning that fall. Seeley and McCammon (op. cit.) point out that two distinct groups of kokanee exist based on their spawning time. The variation from this phenomenum as it occurred at Woahink Lake may be unique in that two age classes are represented by the spawning groups of fish.

[1] Personal communication from the Washington Department of Game to Mr. Chris Jensen dated March 30, 1964.

SCUBA diving activities were completed at various spawning sites along the shoreline of Woahink Lake on November 25, 1963. At the outlet of the lake eighty spawning kokanee were observed. Surface observations at this same site on October 2 disclosed only four fish, all males. These observations reflect the "typical" spawning behavior of kokanee at Woahink Lake. The peak of the spawning activity probably occurs in late November. The spawning population is composed of fish of age class II+ approaching three completed years of life.

On November 20, 1963, spawning kokanee, numbering 199, of age class II+ were taken in gill nets at Woahink Lake. The kype of the male fish precluded precise measurements in the usual manner. The range in length of the male fish measured was 10.5 to 12.5 inches fork length. The lengths of 80 female kokanee were determined. A range in fork length from 10.3 to 12.0 was determined with a mean length of 11.4 inches.

Spawning observations in 1964 were limited. Gill net collections and sport catch records disclosed a few adipose-marked fish, now of age class II+. A gill net collection of 23 fish taken July 31, 1964 disclosed that all were maturing and would soon spawn. Only three spawning kokanee were examined in October-November of 1964, and none of these were marked. Presumably, these were the survivors from natural reproduction spawning at the "normal" time, age class II+.

Spawning observations on Munsel Lake began in 1962. Some ten spawning kokanee were observed in the "late fall" (date unknown) of 1962 in Munsel Creek in the vicinity of the county road crossing. The fish were first planted in Munsel Lake in 1960. The spawning fish were 12 to 13 inches in length and of age class II+.

Fron November 5 to 20, 1963, kokanee were observed at the county road crossing on Munsel Creek and at a road crossing just below the head of Munsel Creek. The greatest number of fish observed at the two sites was 25. The early maturity of a group of kokanee in Munsel Lake similar to that reported for Woahink Lake is known to have occurred.

Spawning acitivites of the Munsel Lake fish in 1964 appeared to be concentrated in the lower 100 yards of Ackerley Creek, the major tributary of Munsel Lake. Information and comments on the spawning activities of kokanee at Munsel Lake in 1964 were taken from the notes of Mr. Del Skeesick. Kokanee were first reported spawning in Ackerley Creek on September 16, 1964. The water temperature at the time was 57° F. Active spawning at the site was noted on September 20. Spawning activity had apparently ceased by October 10 and no fish were observed in Ackerley Creek after that date. Only a single spawning kokanee was observed in the outlet of Munsel Lake in 1964 and that observation was made on October 16.

Scale examinations disclose that the usual age at maturity for Munsel Lake kokanee is II+ or the same as that noted for the Woahink Lake fish. The growth rate of the Munsel Lake fish is greater than that of the Woahink Lake specimens. The 6 mature female kokanee taken from Munsel Lake between November 8 and 25, 1963 had a range in fork length of 14.1 to 15.6 inches. The mean length of this group was 14.4 inches. The length at maturity of the Munsel Lake fish is approximately 3 inches greater than fish of the same age in Munsel Lake.

In summary, the spawning behavior of kokanee at the two lakes has shown variation in time and age composition of the spawning

fish. Behavior patterns are not well defined at this time. We need to know more about the role of the life history pattern of the parent stocks on the spawning behavior in the new environment. The effect of the size of fish at liberation and subsequent growth rate on the time of maturity are not fully understood.

B. Fecundity

Of interest was the spawning potential of those fish utilizing the limited spawning areas of both lakes. Eggs from a small number of maturing females were saved to determine the number per female. Egg count was made from the Munsel Lake fish. A subsample of the ova from each of the Woahink Lake fish was weighed and the figures expanded to arrive at the approximate total number of eggs per female. The data are presented in Table 12. The data presented in the table are in essential agreement with those reported elsewhere. Table 13 presents information available on the number of eggs per female kokanee from a number of sources. Information in the table was obtained from the report of Geeley and McCammon (op. cit.).

Table 12

Number of Eggs per Female Kokanee from Woahink and Munsel Lakes

Lake	Date	Length (inches)	Weight	Age	Number of Eggs		
					1st skein	2nd skein	Total
Woahink	Nov. 20, 1963	11.4	-	II+	-	-	583
	" " "	11.7	-	II+	-	-	733
	" " "	11.8	-		-	-	836
Munsel	July 18, 1963	9.4	174 gms.	I+	212	232	444
	Aug. 29, "	11.7	310 gms.	I+	292	245	537
	July 27, "	13.5	499 gms.	II+	484	514	998
	Aug. 25, "	14.6	578 gms.	II+	556	508	1,064

Table 13

Number of Eggs per Female Kokanee from Various Waters

(Modified from Seeley and McCammon - 1963)

Length of Fish	Mean No. Eggs/Female	Location
10.2"	395	Idaho (Lake Pend Oreille)
10.5 - 12"	400	Calif. (Twin Lakes)
11 - 12"	479	Calif. (Salt Springs Res.)
12.2"	534	Calif. (Lake Arrowhead)
15.0"	1,174	Calif. (Donner Lake)
15.3"	1,676	Colorado (Lake Granby)
16.0" (approx.)	1,764	Calif. (Bucks Lake)

VIII MANAGEMENT

A. Creation of Spawning Areas

The lack of suitable spawning areas at Woahink Lake is believed to be a factor limiting production. Spawning activities by kokanee have been noted at a number of sites along the shoreline of the lake. The substrate at most of the sites is either sand, sandstone bedrock, or silt. Effective spawning is precluded at these areas. Use of the limited tributary system by spawning kokanee has not been observed. A project was initiated in 1960 and continued in 1961 to create additional spawning areas. The project is the subject of this section.

It was believed that the placement of gravel of suitable size at selected sites would enhance the spawning success and, in turn, the production of kokanee in Woahink Lake. Information relative to the proper gravel size is provided in various reports. Dr. John Rayner[1] indicated that pea gravel was utilized by spawning kokanee at Wallowa Lake. The average size of these fish was 7.25 inches. In September of 1960, spawning kokanee were observed in the Deschutes River at Sheep Bridge Camp and in Odell Creek. The gravel size utilized by the Deschutes River spawners was from approximately 0.5 to 1.5 inches in diameter. The Odell Creek fish at the one site inspected appeared to be utilizing gravel from 0.25 to 1.5 inches in diameter. From these reports and observations, as well as the recommendations of Game Commission personnel, it was decided to experiment with gravel of two size ranges. The smaller size ranged from loose sand-grain size up to about 0.75 inch in diameter. A few pieces

[1] Personal communication from Dr. John Rayner to William Saltzman dated March 11, 1960.

ranged from 0.75 to 1.25 inches in diameter. This gravel was referred to by the gravel company where purchased as "reject." Gravel of a larger size termed "drainfield" was also utilized. It had a size range of from 0.75 to 2.0 inches in diameter. Figures 7 and 8 depict typical samples of the two size classifications. Some 79 yards of reject and 39 yards of drainfield gravel were distributed on Woahink Lake from September 17 through September 28, 1960.

The selection of sites for the construction of spawning areas was based on two criteria; those areas where prior spawning attempts had been noted, and the areas of the shore - line or shallows exposed to wave action. The location of the various sites is shown in Figure 9. Table 14 presents a description of each site.

Table 14

Characteristics of Spawning Sites Created at Woahink Lake in 1960

Number	Water Depth in Feet Range	Average	Gravel Size	Cubic Yards	Square Yards Covered
1	1 - 10	4	Reject	7	24
2	1 - 10	4	Reject	18	120
3	3 - 6	5	Reject	3	18
4	1 - 6	3	Reject	16	90
5	1 - 6	2	Reject	13	80
6	1 - 6	2	Drainfield	12	80
7	1 - 6	2	Reject	8	60
8	1 - 6	2	Drainfield	8	60
9	1 - 4	2	Reject	10	70
10	1 - 4	2	Drainfield	9	75
11	1 - 4	3	Reject	4	18
12	1 - 6	2	Drainfield	10	50

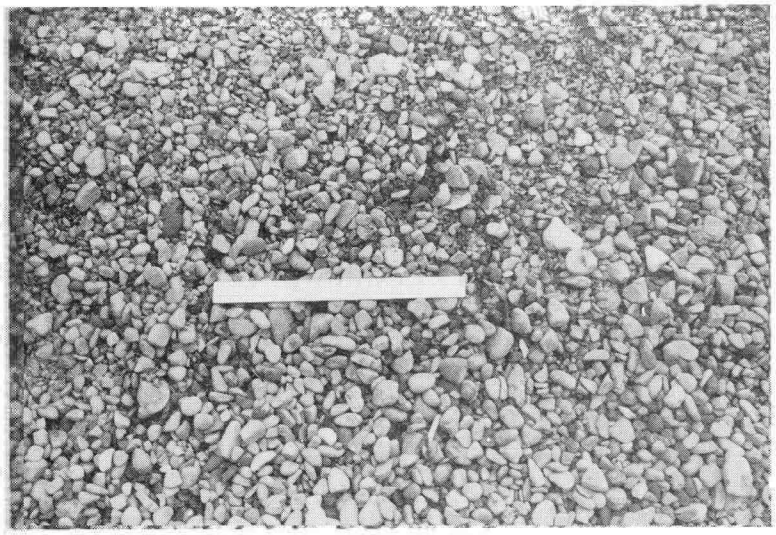

Fig. 7 Sample of the smaller size or "reject" gravel.

Fig. 8 Sample of the larger size or "drainfield" gravel.

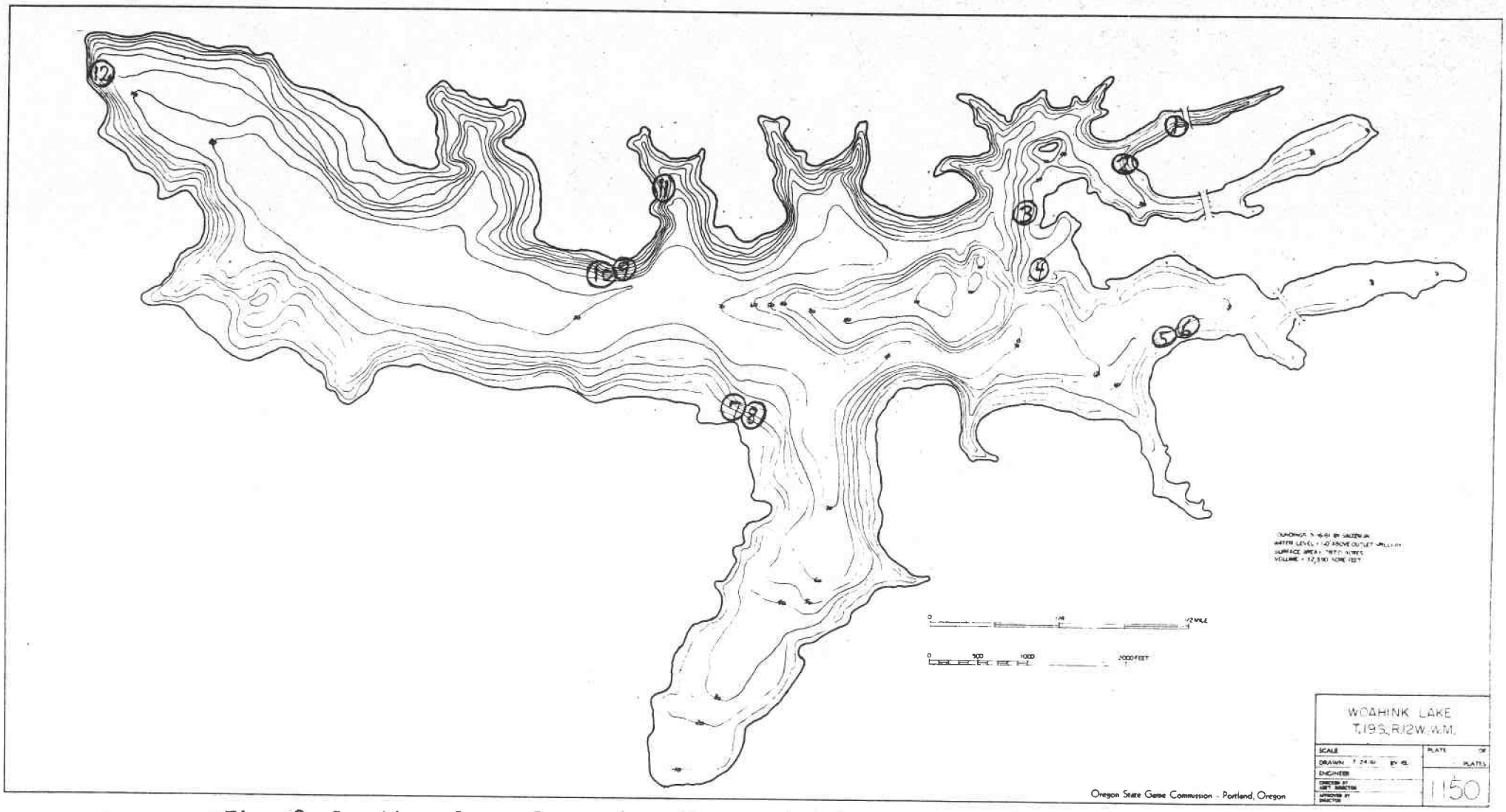

Fig. 9 Location of gravel spawning sites created for kokanee at Woahink Lake.

The gravel was first stockpiled and then loaded onto a barge by a "scoopmobile." The barge constructed for this project performed well. It was constructed with 2 x 12's on edge in the form of a square measuring 12 feet on a side. The barge was buoyed by 24 oil drums of 55-gallon capacity arranged in 4 rows of 6 drums each. A decking of 2 x 4's was placed across but not nailed to the frame. Unloading was accomplished by tipping one 2 x 4 at a time starting at one end. Gravel slid between the tipped 2 x 4's, and very little shovel work was required. Two men could easily unload a barge in a few minutes. Figure 10 is a view of the barge being unloaded. The barge was moved by a power boat. Towing was attempted but was soon abandoned. Much greater speed and maneuverability were realized when the barge was pushed. The barge was loaded down to within a few inches of the waterline. The capacity was believed to be about 4 cubic yards.

The spawning facilities were inspected a number of times in the late fall and winter of 1960-61. On December 16, 1960, SCUBA gear was employed by Messrs. Ralph Grenfell and William Saltzman to inspect the various sites. No evidence of utilization of sites 3, 5, 6, 7, 8, and 11 was observed. At site 1, egg deposition had been heavy. However, of some 200 eggs examined, only 12 were viable. No fish were observed at site 1. Approximately 35 kokanee were found at the outlet or site 12. Eggs (50) were excavated from redds here and all but 3 were viable. Complete utilization of this site appeared to have occurred. No fish were noted in sites 9 and 10 although some egg deposition had taken place. The greater utilization of the two sites occurred at site 10, which was composed of coarse gravel. Limited observation of the embryos of the two sites was made, but the loss appeared to be from 25 to 50 percent

Fig. 10 Gravel being unloaded from barge by tipping 2 x 4's.

of all eggs examined. Limited use was made of site 2. Many depressions which appeared to be redds were found to contain few if any eggs. A single clutch of 22 to 25 eggs was examined from site 2 and all were viable.

The observations made were not at all conclusive but did suggest that the larger-sized gravel had received greater use than the smaller material. Cottids were very common, especially in the coarse gravel. The role of cottids has not been determined, but they undoubtedly play a part in reducing the number of embryos in the gravel. The sites rejected by spawning fish or those from which poor survival was found are those heavily sanded or silted because of a lack of water movement through the gravel.

Plans were made to continue the gravel placement tests in 1961. The need in 1961 was for a gravel size range similar to the "drainfield" class used in 1960. It was also desirable to have a cleaner gravel than the unwashed material utilized in 1960. The gravel utilized in 1961 was washed at the gravel plant where purchased and measured from 0.75 to 1.5 inches in diameter. The gravel was uncrushed or "river run" as was all the material used in 1960.

Gravel in the amount of 200 yards was distributed in the fall of 1961 at sites 1, 2, 4, 10, and 12. No new sites were created in 1961. Approximate quantities of gravel utilized at the various sites include: site 1, 19 yards; site 2, 70 yards; site 4, 70 yards; site 10, 21 yards; and site 12, 20 yards.

Evaluation of the sites in 1961 became a part of the kokanee research program of the Research Division. Chapman and Fortune (op. cit.) report on the survival of kokanee embryos at Woahink Lake. Their study was more refined than that conducted in 1960. The results, however, are in substantial agreement with the findings

in 1960. Site 1 in 1961, as in 1960, had considerable use but low survival; whereas the outlet area or site 12 had the highest percentage survival of any of the sites examined.

The cost of materials used to construct the sites was not excessive. The same barge was utilized in 1960 and 1961. The total cost of the lumber and other material used to construct the barge was approximately $25. The cost was minimal because the drums furnishing the flotation were already on hand. The cost of the gravel in 1961 was $0.75 per yard for the "reject" and $1.50 per yard for the "drainfield" gravel. The washed gravel used in 1961 was available at a price of $2.50 per yard. The prices quoted for gravel represent cost at the gravel plant. All hauling was done with a Commission-owned dump truck. The total cost of all gravel distributed in both years was $610.25.

The lack of successful spawning at most of the sites is attributed to inadequate water movement through the gravel. Embryos were not adequately aerated and various degrees of silting took place. The placement of gravel over springs would be expected to provide good water mass movement; but unfortunately, sites meeting this criteria were not located for testing. Areas affected by inflowing streams would have provided water movement but were also ruled out. The lower portions of such streams were heavily silted and too soft to support gravel. A number of the sites were developed to take advantage of wave action. Gravel placement at all sites was completed in the fall months when the lake level was at lowest point. Under such conditions, it was not possible to get the loaded gravel barge as close to the beach as was desired. As a result, much of the gravel was deposited in water too deep to be affected by wave action. These shortcomings should be given serious consideration

if an attempt is made in the future to create additional spawning areas. Distribution of gravel along shore areas in late winter when the water level is higher would be desirable. Blocking the lake outlet to provide an additional height of water may be a possibility. Channel improvement to wash out silt and firm up the bottom could improve such sites for development of spawning a areas. A diligent search of the lake bottom for springs utilizing SCUBA gear could lead to the discovery of sites suitable for gravel deposition.

The development of spawning areas at other coastal lakes has not been attempted by the Game Commission. An interested resident of Munsel Lake purchased and dumped a load of gravel, presumably "0.75-inch minus" at the lower end of Ackerley Creek. The deposition was made in the fall of 1964 at the onset of the kokanee spawning period. Immediate and heavy use by kokanee of this very limited gravel area was noted.

In summary, the creation of additional spawning facilities for kokanee, either in tributary waters, shoreline sites, spring areas, and possibly other sites has merit. Water mass movement through the gravel appears to be a necessity if successful spawning and survival of the embryos is to be realized. No plans have been made for continued investigation of this management procedure. A dependable source of kokanee eggs has been developed since the experiments began, and an abundance of fry is now available for stocking local lakes on an annual basis. Interest in supplementing fry releases by the improvement of spawning facilities as a management tool appears to have diminished.

B. The Cost of Kokanee

The cost of stocking kokanee fry in California has been given as $0.005 each by Seeley and McCammon (op. cit.). Information provided by Mr. Reino Koski[1] on one lot of fish which weighed 500 per pound showed that the cost to produce 50,000 fish was $225. At this rate, a single fish would cost $0.0045 or almost exactly the cost of the California fish. The cost per adult fish would thus be about $0.25 if a 2 percent return was realized. The cost to the creel may be substantially less with kokanee than with trout planted as fingerling or "legal" fish over 8 inches in length.

C. The Size of Kokanee Stocked

It was shown in the section on "ORIGIN AND STOCKING HISTORY" that fry and fingerlings of various sizes have been planted. A comparison of the survival and return to the angler from the various plants has not been made except in a cursory manner as presented in the following section on "The Sport Fishery." Most of the stocking of coastal lakes has been with fry. This is true of most of the kokanee stocked in California and presumably in other states. Recent investigations at Odell Lake in central Oregon by the Research Division have disclosed[2] a four-fold increase in survival of kokanee planted in June 1963 at 114 per pound over those planted in May of that year at 240 per pound. The size and time of planting kokanee is a subject in need of much greater attention.

[1] Personal communication from Reino Koski to William Saltzman dated April 2, 1965.

[2] Personal communication from Homer Campbell dated April 19, 1965.

D. The Sport Fishery

Kokanee are taken by anglers from the onset of the trout season in late April through the summer months. The best angling usually occurs in the early part of the summer. Kokanee are taken by trolling using a flasher ahead of a small lure or bait. Kokanee are taken incidentally by anglers fishing for trout. Limited and sporadic fisheries have developed at Munsel and Woahink Lakes. Creel census data are limited but records and observations do exist. Available data are presented in chronological order beginning with Woahink Lake.

Woahink Lake

Kokanee were first introduced into Woahink Lake in 1952, although the first reports of fish caught by anglers were in 1954. The Annual Report of the Fishery Division (1956) states on page 221, "The kokanee fishery on Woahink Lake was watched closely in 1956 since adult fish were available for the first time. The lake was stocked annually with 50,000 kokanee 0 - 2 inches in length since 1952; and in 1955, residents along the lake observed kokanee swimming in schools near the shoreline in November. The first of the species to be caught by anglers was reported by the lodge owner on Woahink Lake on May 31, 1956. The fish were 9 to 10 inches in length and in excellent condition. From all reports received concerning the success of anglers during the season, the catch was sporadic since it appeared that the fish stayed in large schools and could be found only by considerable searching."

No records are available for the kokanee fishery in 1957. Presumably, it was of minor importance. The fishery would have been on the survivors of a plant of 49,894 fry made in 1955.

Angling for kokanee in 1958 was excellent according to the Annual Report of the Fishery Division (1958). It states on page 232, "A kokanee fishery has blossomed at Woahink Lake. It is the first season they have been taken in any number.... The fish were 9 to 11 inches in length and in prime condition." Creel census records for 1958 indicate a take of 504 kokanee by the 162 anglers checked. The anglers were catching the survivors of a plant of 15,126 two-to four-inch fish released in 1956.

The catch success was greatly reduced in 1959 over that experienced in 1958, and for good reasons. No kokanee were planted in 1957 and natural reproduction was very minor.

Angling for kokanee was again good in 1960. The Annual Report of the Fishery Division (1960), page 298, indicates that in the period of April 23 - 30, 19 anglers took 22 kokanee as well as 15 trout. The catch of kokanee later in the season is reported as greatly improved over the April period. Anglers in 1960 were taking the survivors of the 1958 releases of 170,998 fry and 49,925 two-to four-inch fingerlings.

Catch records are sparse in 1961. Presumably, the catch was small. The 65 anglers fishing from April 22 through May 15 had taken 8 kokanee plus 271 cutthroat and 8 rainbow trout. Angling was expected to be poor in 1961 since no kokanee were planted in 1959.

Limited catch records are available for 1962. On the opening weekend of the trout season in April, 27 anglers had taken a single kokanee plus 66 cutthroat and 4 rainbow. Angling for kokanee improved by early summer, but success was considered as fair for the season. Anglers were catching the survivors of a plant of 100,050 fry released in 1960.

Angling was generally very good in 1963 according to reports from anglers. The catch was composed of the survivors of a fry release made in 1961 of 119,659 fish.

Kokanee angling in 1964 was poor. The release of 25,120 two-inch fish made in 1962 should have contributed more to the catch. One reason for the lack of success was the precocious development of some fish from the 1963 release as was discussed in section VII A, "Spawning Characteristics." Such fish would not be available to the fishery in 1964.

Munsel Lake

Kokanee were first planted in Munsel Lake in 1960. Adult fish should have been available to anglers in 1962. No fish were known to have been taken by anglers in 1962, although spawning fish were noted later that year.

Angling in 1963 is believed to have been fair to good for the small number of local anglers who fished for kokanee. Fish 12 to 14 inches in length were caught. These fish were the survivors of a plant of 30,264 fry made in 1961.

Angling in 1964 was at least fair for the limited number of anglers in pursuit of these fish. Records kept by Mr. Del Skeesick disclose that at least 92 kokanee were taken by anglers. The fish were the survivors of 10,148 fish released at 1.5 inches in 1962.

IX SUGGESTIONS FOR THE FUTURE MANAGEMENT OF KOKANEE

The material presented in this report should make it clear that the knowledge needed for the effective management of kokanee greatly outweighs what is already known. The following suggested needs are presented as a guide for future work with these fine fish. The solution to some of the problems may be realized from kokanee investigations under way or planned by the Research Division.

1. Determination of the optimum stocking requirements for each kokanee lake.

This is probably the most important and most complex problem facing the kokanee manager. Attention should be directed to the size, time, density, sites, and methods of stocking. The measure of the survival to the fishery or spawning areas from the various releases is essential. The development of criteria for the selection of parent stocks which will produce the best offspring is needed.

2. Development of criteria for kokanee lakes.

What distinguishes a potential kokanee lake from a non-kokanee lake What minimum ecological requirements must be met for kokanee to survive? Answers to these questions are needed before kokanee are introduced into new waters. Such knowledge will prevent wasteful and fruitless releases of these fish in unsuitable waters.

3. Enhancement of spawning areas.

Consideration should be given to the merits of improving or developing spawning facilities for kokanee along shorelines, at springs, inlets, and outlets.

4. Life history data.

More precise knowledge of the spawning characteristics in numbers, time, and location is needed. All other phases of the life history of the fish merit further inquiry.

5. Creel census.

Adequate creel census records are lacking. Total catch figures for the various kokanee lakes are desirable. Mercer Lake, which is now open to year-round angling, presents a unique opportunity to measure the success of kokanee angling in the late fall, winter, and early spring periods when angling is prohibited at the other lakes.

6. The role of predators on kokanee.

Kokanee lakes in the area support populations of cutthroat and rainbow trout, largemouth bass and other warm-water species, squawfish and other nongame fish. Cottids are abundant. Loons, ospreys, grebes, and other water birds are not uncommon. The role of these forms as predators of alevins and fish of the various age classes has not been investigated.

7. The role of parasites and disease.

Little is known concerning the extent and the effect of parasites and disease organisms on the kokanee populations in local waters. All kokanee taken by nets or other means and available for examination should be inspected for parasites or disease organisms. Only healthy fish should be stocked. Unfortunately, these two obvious precautions have not always been observed. Identification of any parasites or disease organisms should be made. The role of the various water birds as possible carriers of diseases or parasites may warrant study.

8. Possibilities for an egg-take at Woahink Lake.

The possibility exists for the establishment of an egg-take at Woahink Lake. The number of eggs which could be obtained is not known but would probably be less than the annual number of fry stocked in the lake (200,000 in 1965). At Woahink Lake, a large percentage of the kokanee eggs deposited naturally fail to develop and are lost. Some attempt to offset this loss by hatchery methods may be justified.

9. Promotion of the sport fishery.

Undercropping of kokanee is well known from many waters. Anglers need to be alerted to the opportunities afforded by kokanee. Demonstrations, newspaper publicity, and various other means should be employed to focus attention on these fish.

10. Migration of kokanee.

Our knowledge of the migration of kokanee is meager. The occasional kokanee seen in Siltcoos Lake undoubtedly entered from Woahink Lake through Woahink Creek. The weir at Munsel Lake is ideally suited to monitor outmigrants and returning adults. Similar facilities could be installed at the outlet of Woahink Lake and at the inlet and outlet of Clear Lake. Careful consideration should be given to the role of migration in the management of kokanee populations.

11. Continuation of fish population studies.

Routine fish population studies should be continued on all waters, with special attention directed to Mercer and Clear Lakes. The various year classes should be followed closely in these two waters to determine their adaptability to these environments.

X SUMMARY

The report presents a compilation of existing kokanee records from lakes on the central coast of Oregon. Kokanee are not native to the area, but successful introductions have been made in some waters and popularity for the species is increasing. The characteristics of kokanee lakes, origin and stocking history, biology, and management are key topics considered. Suggestions for future investigations and management of kokanee are presented as a final portion of the report.

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APPENDIX

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: January 22, 1965

Planting method and sites: Airplane plant of about 30,000 made at south end of lake, remainder hosed out at public boat ramp.

Number: 199,260 Length: 0.75 inch

Total weight: 56.0 lbs. No./Lb.: 3,560

Hatchery: Willamette

Original source of fish

State: Oregon Water: Breitenbush River (Detroit Reservoir)

Brood fish:

Size: ♂ 13.0" ♀ 12.7" Age: III

Period of egg-take: Sept. 10 through Oct. 5

Time of egg shipment to Oregon: --

Comments: Original source of these fish was from British Columbia.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: April 17, 1964

Planting method and sites: Boat plant in south end of lake.

Number: 200,400 Length: 1.0 inch

Total weight: 40.0 lbs. No./Lb.: 5,010

Hatchery: Hood River

Original source of fish

State: British Columbia Water: Kootenay Lake

Brood fish:

Size: 8 to 12 inches Age: III

Period of egg-take: September

Time of egg shipment to Oregon: December 16, 1963.

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: July 23, 1963

Planting method and sites: Boat plant in south end of lake.

Number: 54,008 Length: 2.0 inches

Total Weight: 172.0 lbs. No./Lb.: 314

Hatchery: Alsea

Original source of fish

State: Washington Water: Lake Whatcom

Brood fish:

Size: 9 to 10 inches Age: III and IV

Period of egg-take: Late October through Dec. Most in November.

Time of egg shipment to Oregon: January 23, 1963

Comments: Fish had heavy loss in Alsea Hatchery. Disease tentatively diagnosed as kidney disease.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: June 14, 1962

Planting method and sites: Boat plant at north end of lake.

Number: 25,120 Length: 2.0 inches

Total weight: 37.5 lbs. No./Lb.: 670

Hatchery: Rock Creek

Original source of fish

State: Washington Water: Lake Whatcom

Brood fish:

Size: 9 to 10 inches Age: III and IV

Period of egg-take: Late Oct. through Nov. Most in Nov.

Time of egg shipment to Oregon: January 23, 1962

Comments: All fish marked by removal of adipose fin.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: March 8, 1961

Planting method and sites: 20,000 planted 2.0 miles up main tributary; remainder boat planted in north end of lake.

Number: 119,559 Length: 1.0 inch

Total weight: 38.5 lbs. No./Lb.: 3,105

Hatchery: Rock Creek

Original source of fish

State: Montana Water: Flathead Lake

Brood fish:

Size: ♂ 13.8" ♀ 13.3" Age: IV

Period of egg-take: Late October through December.

Time of egg shipment to Oregon: January 3 - 17, 1961

Comments: Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: March 9, 1960

Planting method and sites: Dipped out at public boat ramp.

Number: 100,030 Length: 1.0 inch

Total weight: 18.1 lbs. No./Lb.: 5,527

Hatchery: Rock Creek

Original source of fish

State: Montana Water: Flathead Lake

Brood fish:

Size: ♂ 13.9" ♀ 13.3" Age: IV

Period of egg-take: Late October through December.

Time of egg shipment to Oregon: January 6, February 1 - 3, 1960

Comments: Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: 1959

Planting method and sites:

Number: 0 Length:

Total weight: No./Lb.:

Hatchery:

Original source of fish

State: Water:

Brood fish:

Size: Age:

Period of egg-take:

Time of egg shipment to Oregon:

Comments: No kokanee planted in 1959, but plant made in December of 1958.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: December 30, 1958

Planting method and sites: Hosed out at public boat ramp.

Number: 170,998 Length: 1.0 inch

Total weight: 46.0 lbs. No./Lb.: 3,717

Hatchery: Willamette

Original source of fish

State: British Columbia Water: Meadow Creek

Brood fish:

Size: 10 inches + Age: III

Period of egg-take: September

Time of egg shipment to Oregon: September

Comments: Another plant of kokanee made in 1958. See other sheet.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: August 21, 1958

Planting method and sites: Hosed out at public boat ramp.

Number: 49,925 Length: 2.0 inches

Total weight: 115.0 lbs. No./Lb.: 434

Hatchery: Fall River

Original source of fish

State: Montana Water: Flathead Lake

Brood fish: ♂ ♀

1957 11.8" 11.4"

Size: (?) 1959 12.6" 12.2" Age: IV

Period of egg-take: Late October through December

Time of egg shipment to Oregon: --

Comments: Another plant of kokanee made in 1958. See other sheet.

Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: 1957

Planting method and sites:

Number: 0 Length:

Total weight: No./Lb.:

Hatchery:

Original source of fish

State: Water

Brood fish:

Size: Age:

Period of egg-take:

Time of egg shipment to Oregon:

Comments: No kokanee planted in 1957.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: June 6, 1956

Planting method and sites: Hosed out at public boat ramp.

Number: 15,126 Length: 3.0 inches

Total weight: 86.0 lbs. No./Lb.: 176

Hatchery: Fall River

Original source of fish

State: Montana Water: Flathead Lake

Brood fish:

Size: ♂ 12.3" ♀ 12.2" Age: IV

Period of egg-take: December 1955 to January 1956.

Time of egg shipment to Oregon: February 7, 1956.

Comments: Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: May 2, 1955

Planting method and sites: At public boat ramp.

Number: 49,894 Length: 1.0 inch

Total weight: 11.7 lbs. No./Lb.: 4,264

Hatchery: Willamette

Original source of fish

State: Oregon Water: Odell Lake

Brood fish:

Size: 10 to 11 inches Age: III, a few II

Period of egg-take: October 10 to 30.

Time of egg shipment to Oregon: --

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: April 4, 1954

Planting method and sites: At public boat ramp.

Number: 49,950 Length: 1.0 inch

Total weight: 12.0 lbs. No./Lb.: 4,163

Hatchery: Willamette

Original source of fish

State Montana Water: Flathead Lake

Brood fish:

Size: ♂ 12.9" ♀ 12.5" Age: IV

Period of egg-take: November to December, 1953.

Time of egg shipment to Oregon: December 24, 1953 and January 23, ~~1954~~.

Comments: Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: 1953

Planting method and sites: At public boat ramp.

Number: 49,792 Length: 1.0 inch

Total weight: 13.5 lbs. No./Lb.: 3,688

Hatchery: Willamette

Original source of fish

State: Montana Water: --

Brood fish:

Size: -- Age: --

Period of egg-take: November to December, 1952.

Time of egg shipment to Oregon: January 1953.

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Woahink Lake Date: 1952

Planting method and sites: At public boat ramp.

Number: 51,802 Length: 1.0 inch

Total Weight: 12.9 lbs. No./Lb.: 4,016

Hatchery: Willamette

Original source of fish

State: Montana Water: --

Brood fish:

Size: -- Age: --

Period of egg-take: December to January 1951

Time of egg shipment to Oregon: February 1952

Comments: This was the first plant made in Woahink Lake.

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: February 2, 1965

Planting method and sites: At bridge over inlet creek.

Number: 25,675 Length: 0.75 inch

Total weight: 6.5 lbs. No./Lb.: 3,950

Hatchery: Roaring River (Lot no. 83.01)

Original source of fish

State: Oregon Water: Breitenbush River (Detroit Reservoir)

Brood fish:

Size: ♂ 13.0" ♀ 12.7" Age: III

Period of egg-take: September 10 through October 5.

Time of egg shipment to Oregon: --

Comments: Fed 14 to 20 days. Length range of spawners was:

♂ 12.4 - 13.6"

♀ 10.4 - 13.6"

Original source of fish was from British Columbia.

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: April 17, 1964

Planting method and sites: At bridge over inlet creek.

Number: 15,030 Length: 1.0 inch

Total weight: 3.0 lbs. No./Lb.: 5,010

Hatchery: Hood River

Original source of fish

State: British Columbia Water: Kootenay Lake

Brood fish:

Size: 8 to 12 inches Age: III

Period of egg-take: September

Time of egg shipment to Oregon: December 16, 1963

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: July 22, 1963

Planting method and sites: At public boat ramp.

Number: 15,700 Length: 2.0 inches

Total weight: 50.0 No./Lb.: 314

Hatchery: Alsea

Original source of fish

State: Washington Water: Lake Whatcom

Brood fish:

Size: 9 to 10 inches Age: III and IV

Period of egg-take: Late October through December. Most taken in November.

Time of egg shipment to Oregon: January 23, 1963

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: June 13, 1962

Planting method and sites: At bridge over inlet creek.

Number: 10,148 Length: 1.5 inches

Total weight: 14.5 lbs. No./Lb.: 700

Hatchery: Rock Creek

Original source of fish

State: Washington Water: Lake Whatcom

Brood fish:

Size: 9 to 10 inches Age: III and IV

Period of egg-take: Late October through December. Most in November

Time of egg shipment to Oregon: January 23, 1962

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: 1961

Planting method and sites: At public boat ramp.

Number: 30,252 Length: 1.0 inch

Total weight: 9.7 lbs. No./Lb.: 3,119

Hatchery: Rock Creek

Original source of fish

State: Montana Water: Flathead Lake

Brood fish:

Size ♂ 13.8" ♀ 13.3" Age: IV

Period of egg-take: Late October through December.

Time of egg shipment to Oregon: --

Comments: Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Munsel Lake Date: 1960

Planting method and sites: At public boat ramp and at bridge over inlet creek.

Number: 39,960 Length: 1.0 inch

Total Weight: 9.8 lbs. No./Lb.: 4,078

Hatchery: Rock Creek

Original source of fish

State: Montana Water: Flathead Lake

Brood fish:

	♂	♀
Size	13.9"	13.3"

Age: IV

Period of egg-take: Late October through December.

Time of egg shipment to Oregon: --

Comments: This was the first plant in Munsel Lake. Size range of spawners at Flathead Lake reported as plus or minus one or two inches of averages listed above.

KOKANEE STOCKING RECORD FORM

Lake planted: Clear Lake Date: January 22, 1965

Planting method and sites: Airplane plant throughout lake.

Number: 46,230 Length: 0.75 inch

Total weight: 13 lbs. No./Lb.: 3,560

Hatchery: Willamette (Lot No. 83.01)

Original source of fish

State: Oregon Water: Detroit Reservoir

Brood fish:

Size: ♂ 13.0" ♀ 12.7" Age: III

Period of egg-take: September 10 through October 5.

Time of egg shipment to Oregon: --

Comments: This was the first plant made in Clear Lake. Length range of spawners was: ♂ 12.4 to 13.6" ♀ 10.4 to 13.6"

Original source of these fish was from British Columbia.

KOKANEE STOCKING RECORD FORM

Lake planted: Mercer Lake Date: February 2, 1965

Planting method and sites: Old landing west of Dowell Peninsula.

Number: 86,800 Length: 0.75 inch

Total weight: 22 lbs. No./Lb.: 3,950

Hatchery: Roaring River (Lot No. 83.01)

Original source of fish

State: Oregon Water: Detroit Lake

Brood fish:

Size: ♂ 13.0" ♀ 12.7" Age: III

Period of egg-take: September 10 through October 5.

Time of egg shipment to Oregon: --

Comments: Fed 14 to 20 days. Length range of spawners was:

♂ 12.4 to 13.6"

♀ 10.4 to 13.6"

KOKANEE STOCKING RECORD FORM

Lake planted: Mercer Lake Date: April 19, 1964

Planting method and sites: Boat plant throughout open water.

Number: 80,160 Length: 1.0 inch

Total weight: 16 lbs. No./Lb.: 5,010

Hatchery: Hood River

Original source of fish

State: British Columbia Water: Kootenay Lake

Brood fish:

Size: 8 to 12 inches Age: III

Period of egg-take: September

Time of egg shipment to Oregon: December 16, 1963

Comments:

KOKANEE STOCKING RECORD FORM

Lake planted: Mercer Lake Date: July 23, 1963

Planting method and sites: Boat plant throughout open water of lake.

Number: 40,077 Length: 2.1 inches

Total weight: 84.9 No./Lb.: 472

Hatchery: Fall River

Original source of fish

State: Montana Water: Lake Mary Ronan

Brood fish:

Size: ♂ 14.7" ♀ 13.8" Age: IV

Period of egg-take: About October 20 through November 10.

Time of egg shipment to Oregon: December 20, 1962

Comments: This was the first plant made in Mercer Lake. Size range of spawners at Lake Mary Ronan reported as plus or minus one or two inches of averages listed above.