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SYSTEMS MODELING OF SOCKEYE SALMON IN THE WOOD RIVER LAKES

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SYSTEMS MODELING OF SOCKEYE SALMON IN THE WOOD RIVER LAKES

(Annual Report for the Period July 1, 1973 through June 30, 1974)

INTRODUCTION

Three components of the systems model limit or control under certain conditions the production of sockeye salmon in the Wood River lakes: (1) the amount of spawning area available, (2) the food-producing capacity of the lakes, and (3) predation, especially by arctic char and humans. The purpose of this study is to define the components and their interrelationships within the limits of existing data so that the annual variation and long-term trends in abundance of sockeye salmon can be explained and management alternatives provided thereby to achieve maximum sustainable yield to the presently depressed commercial fishery.

The first six months of this study (February 1, 1973 to June 30, 1973) were spent in theoretical development of the model, construction of a data bank, and compilation of reports and publications on studies in the Wood River lakes from 1946 to the present. A list of the reports is appended. The objectives of the second year of the study were to (1) model the feeding behavior and growth of juvenile sockeye salmon, (2) determine spawner-return relationships for the major spawning colonies (races) within the lake system, (3) determine the environmental influences on survival from eggs to juvenile, and (4) develop models for predation and the commercial fishery. Mr. Eggers, a graduate student, has concentrated his efforts on the first objective; however, he has enlarged the scope of his studies to include other sockeye salmon populations in addition to those in the Wood River lakes. His work is still in progress. My major effort was directed to the second and part of the fourth objective. The results of this work are reported here.

The relationship between the abundance of spawners (escapement) and that of their returning progeny has formed the basis for management (regulation of commercial fishing) of all major stocks of sockeye salmon in Bristol Bay since the mid-1960's. The optimum escapement calculated to produce, on the average, the maximum number of fish in the catches of future years is estimated for each lake system, and the commercial fishery on the annual run is regulated so that this optimum escapement can be achieved. The Wood River stock is intermixed with the stocks bound for the other three lake systems in the Nushagak district in Nushagak Bay, where the commercial fishery operated (Fig. 1). The Nushagak fishery is regulated largely for the protection of the most abundant stock, which in recent years has been the Wood River stock. This stock is composed of races bound for spawning grounds (creeks, rivers, and beaches) of the lakes in the Wood River system. Thus, the regulation of the fishery and the condition of the Nushagak stock are ultimately determined by the abundance of the numerous races and the capacity of the spawning areas. This, in turn, is partially controlled or limited by density-dependent factors.

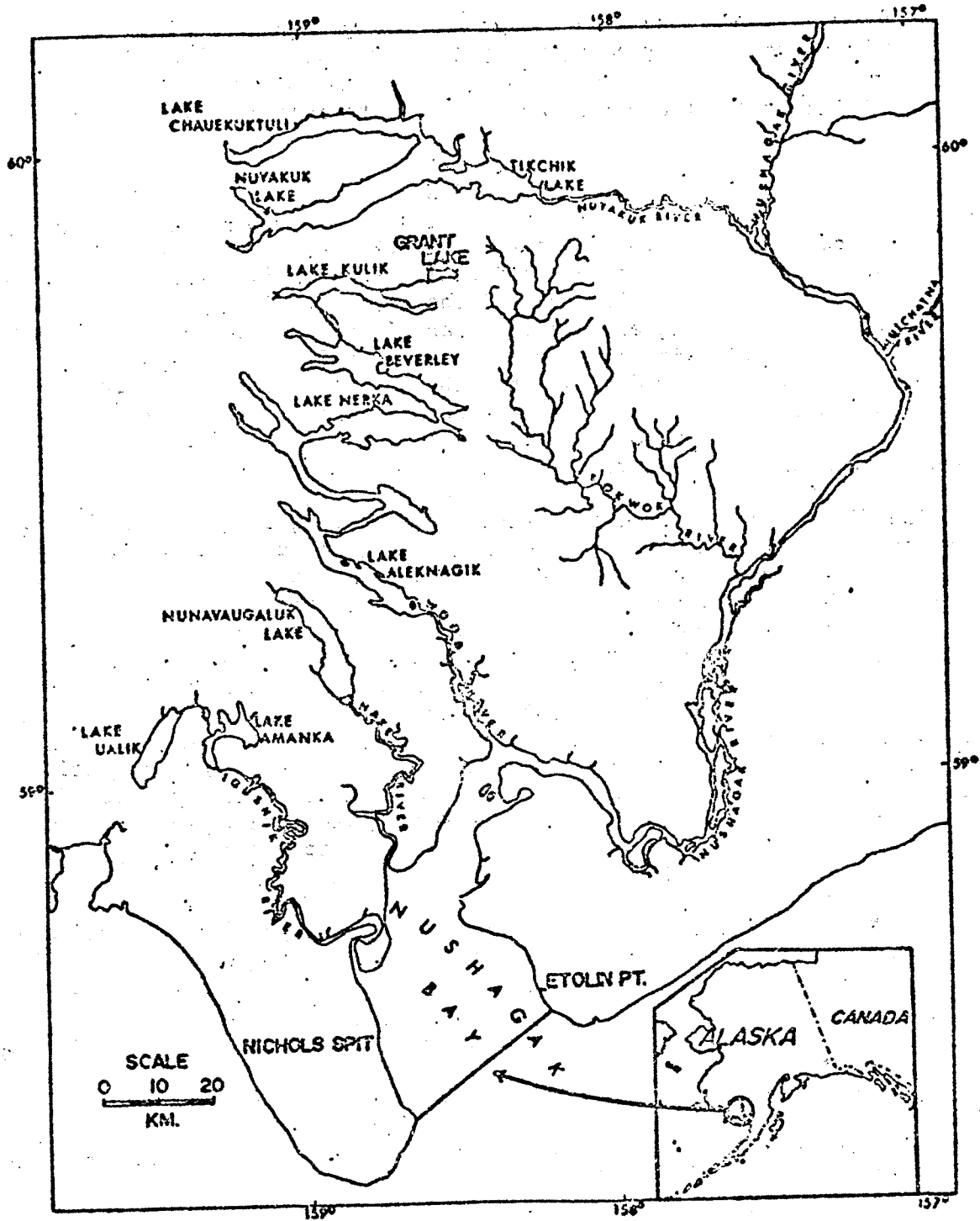


Fig. 1. The Nushagak District of Alaska showing (from north to south) the Tikchik, Wood River, Snake River, and Igushik River lake systems.

The accuracy and detail of the statistics¹ on the adult sockeye salmon vary according to the measurement and the complexity of the population sampled; e.g., sex ratios are available for the Nushagak District and the lake systems but not for individual spawning grounds, and rates of exploitation are of greatest accuracy for the Nushagak District and least for individual spawning grounds. The emphasis in this report is on the presentation of pertinent statistics on the adult sockeye salmon with discussion of those statistics that relate to (1) the probable effect of the fishery on the productive potential of the several races and lake stocks, and (2) management for the achievement of optimum escapement.

NUSHAGAK DISTRICT

Annual catches in the Nushagak District are available from the beginning of the fishery, about 1893, to the present, and direct estimates of annual escapements (hence, total runs) from 1946. The escapements prior to 1946 were estimated from fishing effort and catches by age and sex by Mathisen (1971). He demonstrated from all the aforementioned statistics that the rate of return per spawner declined during the history of the fishery and hypothesized that this decline proceeded from a diminishing productivity in the freshwater nursery areas. He did not believe that the decline in abundance of the stocks was caused by either overfishing or selectivity of the gear (primarily gill nets) because the reproductive potential of the stocks did not change significantly.

The history of the Nushagak fishery (after the initial buildup) is divided into three periods according to the abundance of annual catches (Fig. 2). In the first period (1900-1918) the average catch was 5.1 million, in the second period (1919-1946) 2.8 million, and the recent period (1949-1973) 0.9 million. A comparable decline in average catch was not evident for the other fishing districts in Bristol Bay. Although there was a decline in catches in the low cycle years of the Naknek-Kvichak stock, this decline corresponded somewhat with the inception of high seas fishing. Pink salmon catches in Bristol Bay (predominantly from the Nushagak) declined during the 1920's but then increased in the late 1950's (Fig. 3).

Detailed statistics on the annual runs of sockeye salmon to the Nushagak are available since 1925, so the decline from the second to the third period can be examined with more completeness than the first decline. The annual weight of fish in the run exhibited less variation than the number of fish in the run; however, the decline of 1949 was still obvious (Fig. 4). The average

¹Observations on the runs prior to 1946 were collected by the Bureau of Commercial Fisheries, those from 1946 to 1959 by the Fisheries Research Institute, and those from 1960 to the present by the Fisheries Research Institute and the Alaska Department of Fish and Game.

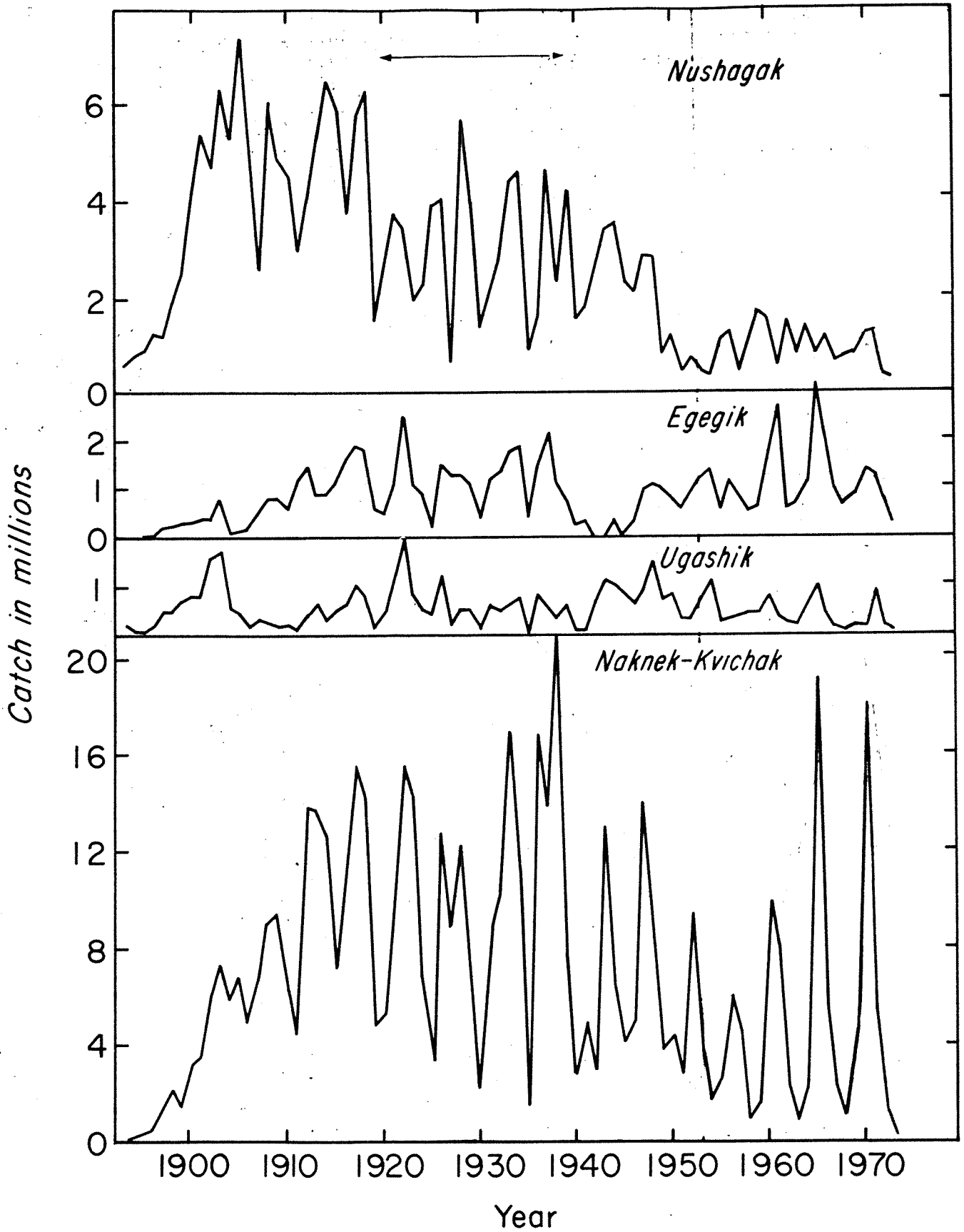


Fig. 2. Annual catches of sockeye salmon in the major fishing districts of Bristol Bay. Horizontal line at 1953 marks beginning of high seas fishery. Arrows indicate period of predator control in Bristol Bay.

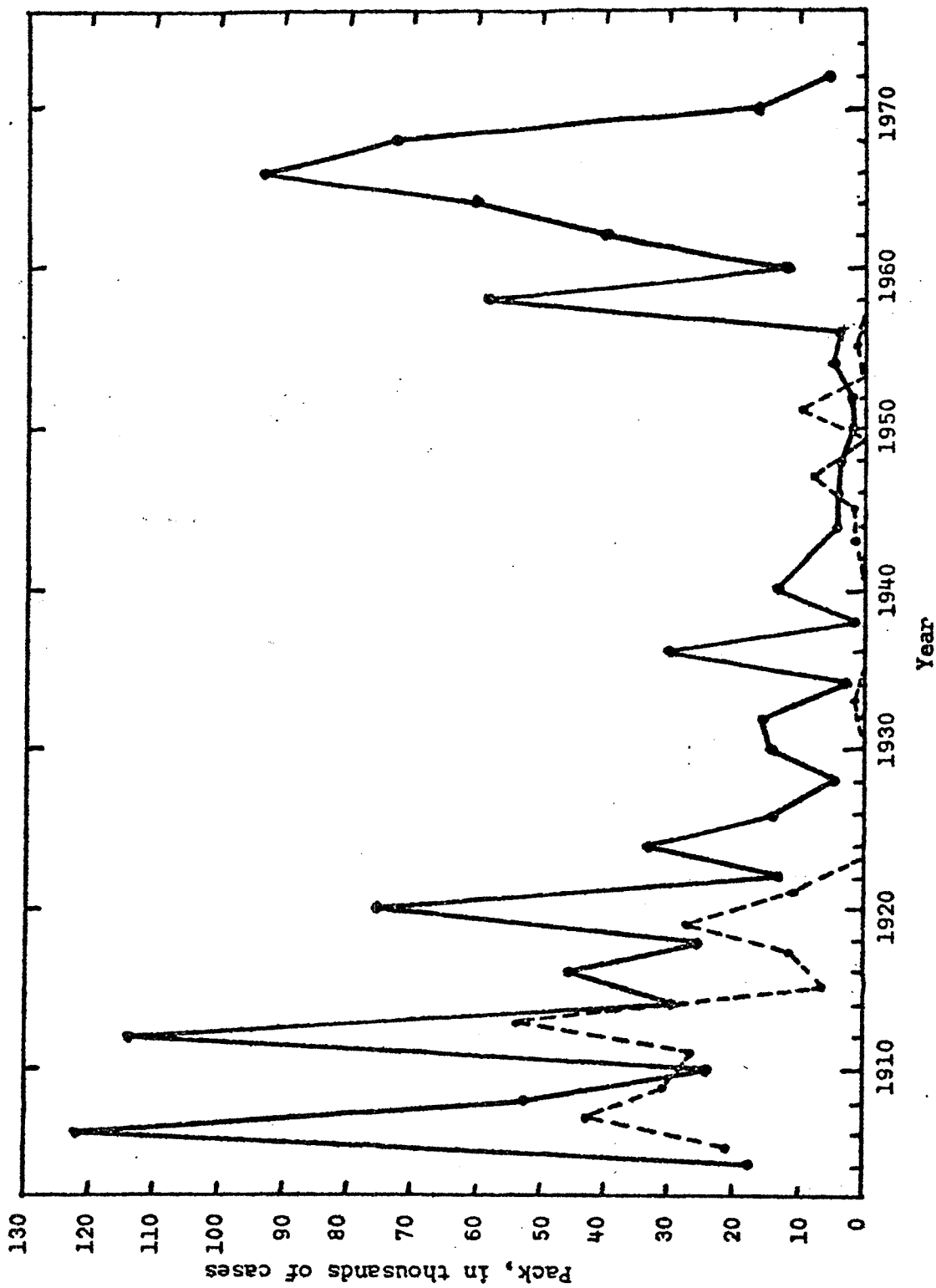


Fig. 3. Annual Bristol Bay pink salmon pack (thousands of cases) in even years (solid lines) and odd years (dashed lines), 1904-72.

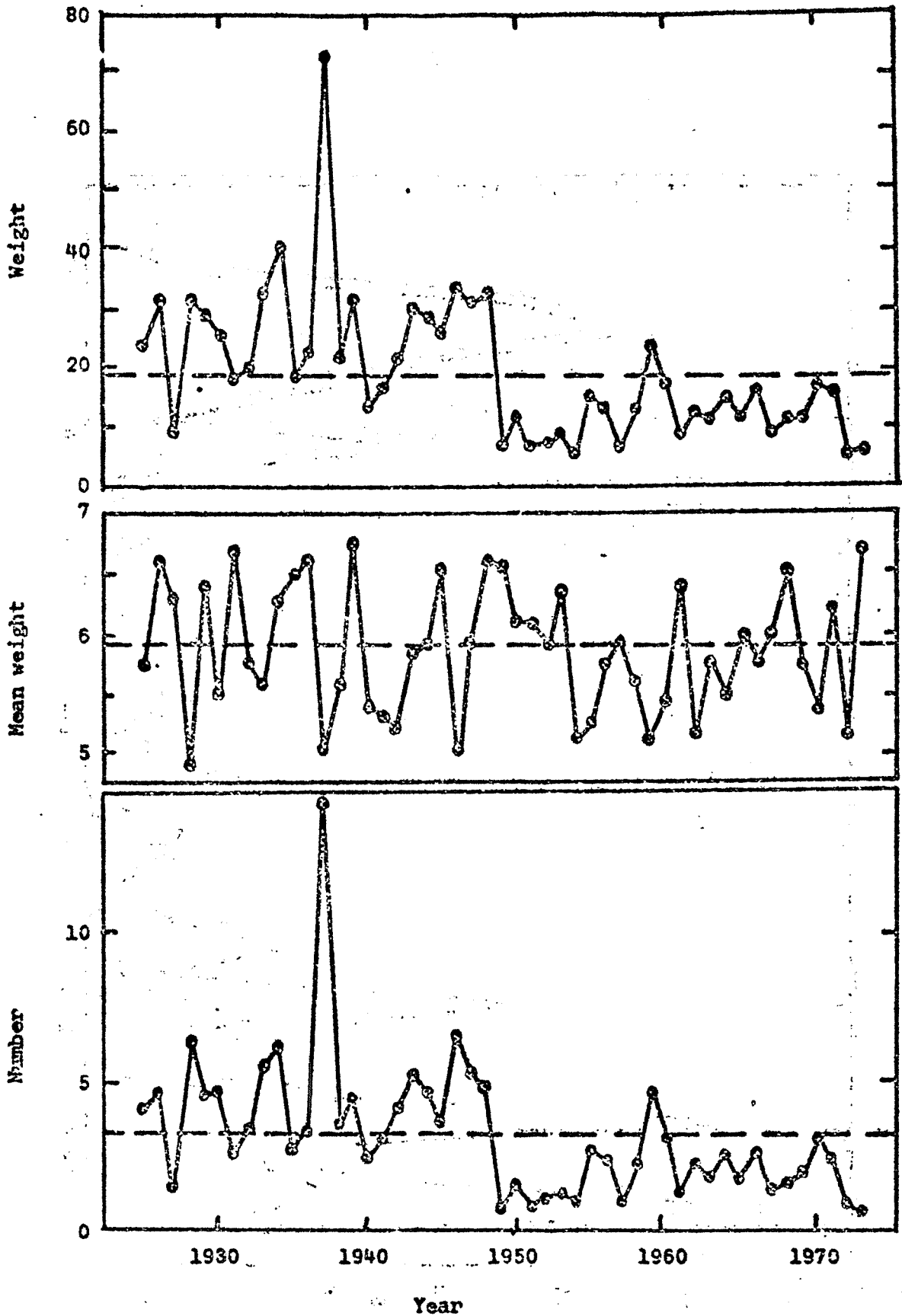


Fig. 4. Annual runs in weight (millions of lbs) and number (millions) and the mean weight (lbs) of sockeye salmon in the Nushagak District, 1925-73 (dashed lines are 49-year means).

weight of fish in the runs was slightly lower in the recent period. Weights by age and sex are available since 1959, and for earlier years the mean weights from Table 1 were applied to the runs by age group. The average size of the fish (by age and sex) tended to be smaller in the peak cycle runs in the Naknek-Kvichak; thus, two sets of means were used for years prior to 1959.

Most sockeye salmon of the Nushagak spend 1+ year in freshwater and either 2+ or 3+ years at sea and are 4 or 5 years old at maturity. If it is assumed that 4-year-old fish (age 1.2) tend to produce 4-year-olds and 5-year-olds (age 1.3) tend to produce 5-year-olds, the runs of 4-year olds can be arranged by 4-year lines and the runs of 5-year-olds by 5-year lines (Figs. 5 and 6). From these data, the declines in the age groups occurred at different times. The declines for the 4-year-olds tended to follow years with large escapements (i.e., 1946, 1959, 1928, 1937). In the recent period the Nushagak runs have been partly cyclic; a small run has occurred every four years (1949, 1953, 1957, etc). This phenomenon has been caused by the low runs of 2-ocean fish in the 1949 line and has been maintained even though escapements have been reasonably high (Fig. 7).

An examination of the spawner-return relationships for the middle and recent periods (Fig. 8) shows that large escapements (greater than 2 million) produced average to below-average returns in both periods, but small to medium-sized escapements produced greater returns in the earlier period. The ocean and freshwater age compositions of the returns did not change significantly between the two periods although a slightly higher percentage of age .2 fish returned in the recent period (Fig. 9).

The statistics on age compositions of the returns are summarized in Table 2. Ocean age at return (maturity) was partly dependent on freshwater age and sex. Fish that spent two years in freshwater tended to return earlier than those that spent one year, and males tended to return earlier than females. Age at return also differed by line, but line was somewhat correlated with abundance.

The sex ratios of the returns by age group did not differ significantly among the 4-year lines for the brood years from 1942 to 1965 (Table 3). The average ratios of females to males were about equal for 2-ocean fish (50.2:49.8, age 1.2), but in favor of females for 3-ocean fish (60.8:39.2), age 1.3) and for all ages combined (55.6:44.4). The mean percentages of females in the catch, escapement, and run are given in Table 4 by 4-year periods. The percentage of females in the catches of age 1.2 fish has declined since the early 1900's, whereas the percentage of females in the catches of age 1.3 fish has increased. In the latter case the trend is compatible with the decrease in mesh size during the history of the fishery (mesh size was 6-1/8 to 6-1/4 inches prior to 1908), since nets of smaller mesh size tend to catch a higher proportion of 3-ocean females than 3-ocean males. Nets of this mesh size should have also caught a larger proportion of 2-ocean females than males if the sex ratio in the run were constant.

Table 1. Mean weight (lb) by age group for sockeye salmon
in Nushagak runs, 1959-72

Year	Age group			
	1.2	2.2	1.3	2.3
1959	4.75	5.04	6.89	6.63
1960	4.13	4.46	6.57	6.51
1961	5.03	5.31	6.65	6.66
1962	4.90	5.24	7.01	7.18
1963	4.96	5.43	7.21	7.11
1964	4.96	5.47	7.08	7.11
1965	4.78	4.93	6.38	6.57
1966	4.33	4.78	6.56	6.73
1967	4.72	5.05	6.87	6.84
1968	4.87	5.32	7.30	7.69
1969	4.97	5.04	7.25	7.10
1970	4.29	4.67	6.31	6.41
1971	4.72	4.66	6.75	6.91
1972	4.30	4.47	6.50	6.10
Mean 1960, 1965, 1970	4.40	4.69	6.42	6.50
Mean other years (n=11)	4.77	5.07	6.92	6.92
All years	4.7	5.0	6.8	6.8

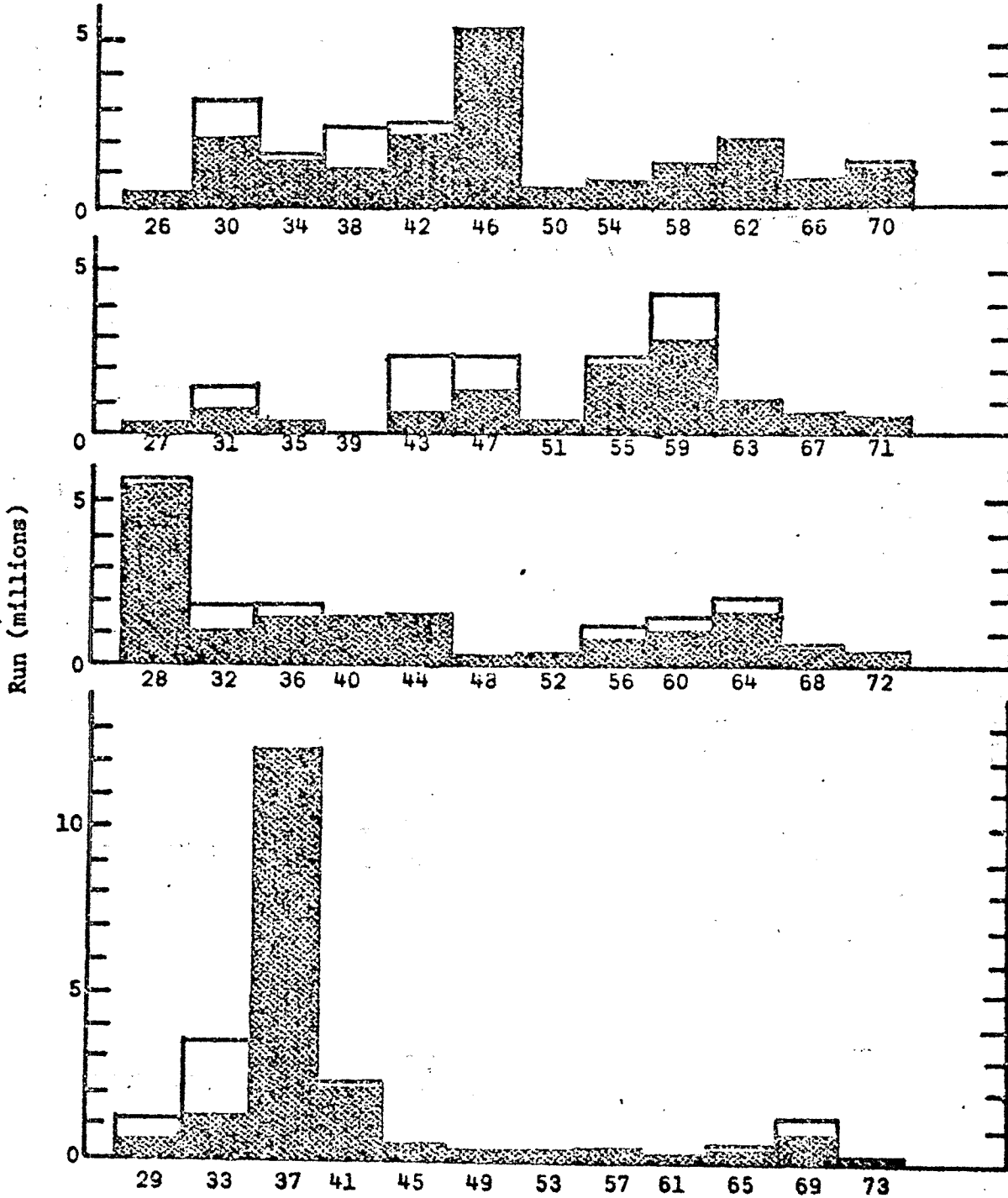


Fig. 5. Annual runs of 2-ocean sockeye salmon to the Nushagak District by four-year lines (solid bars are age 1.2, open bars are age 2.2 in following year).

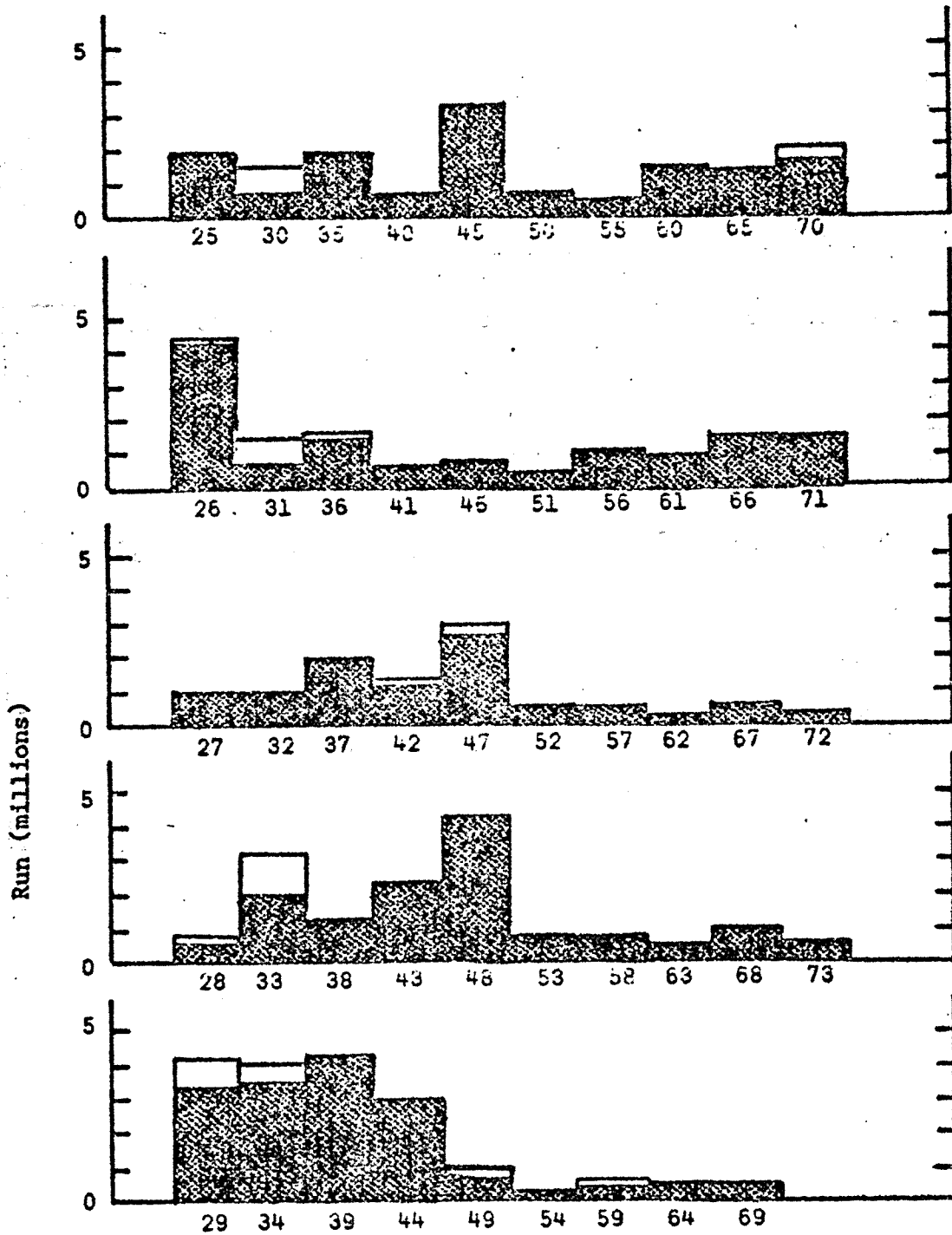


Fig. 6. Annual runs of 3-ocean sockeye salmon to the Nushagak District by five-year lines (solid bars are age 1.3, open bars are age 2.3 in following year).

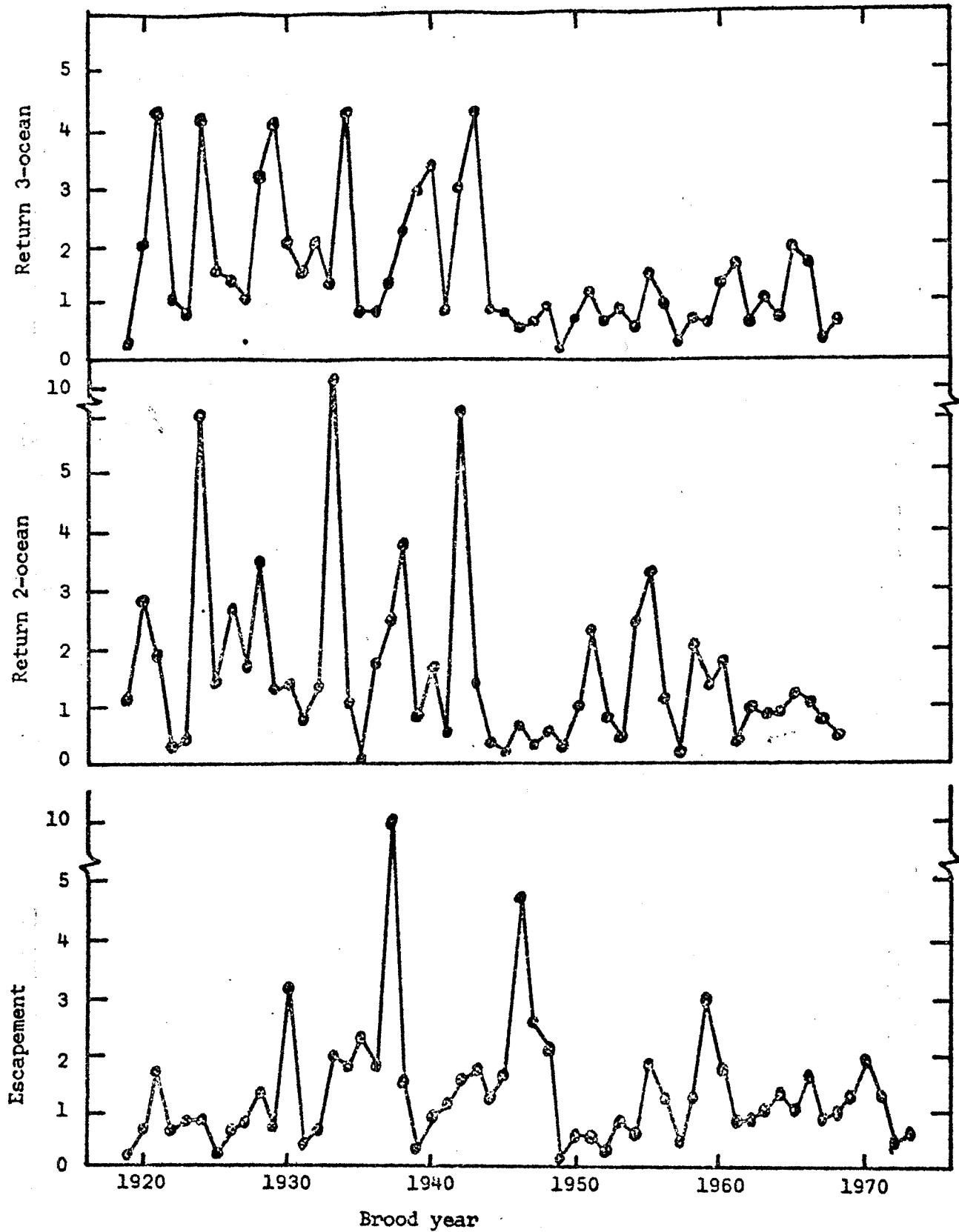


Fig. 7. Annual escapements of sockeye salmon to the Nushagak District and the returns by ocean age, 1919-1973. Number of fish in millions.

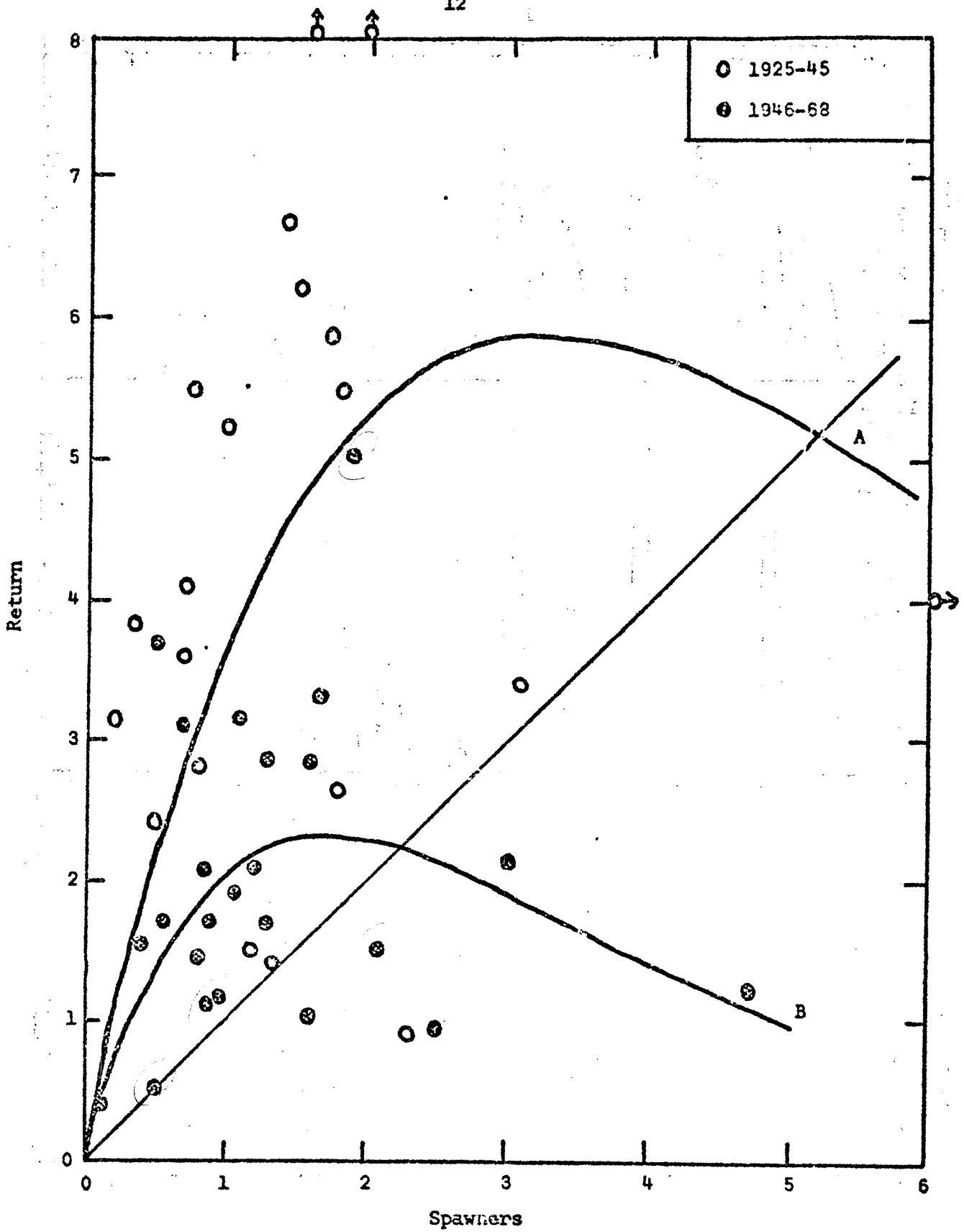


Fig. 8. Spawner return relationships for sockeye salmon in the Nushagak District.
A = 1925-45 brood years; B = 1946-68 brood years. Number of fish in millions.

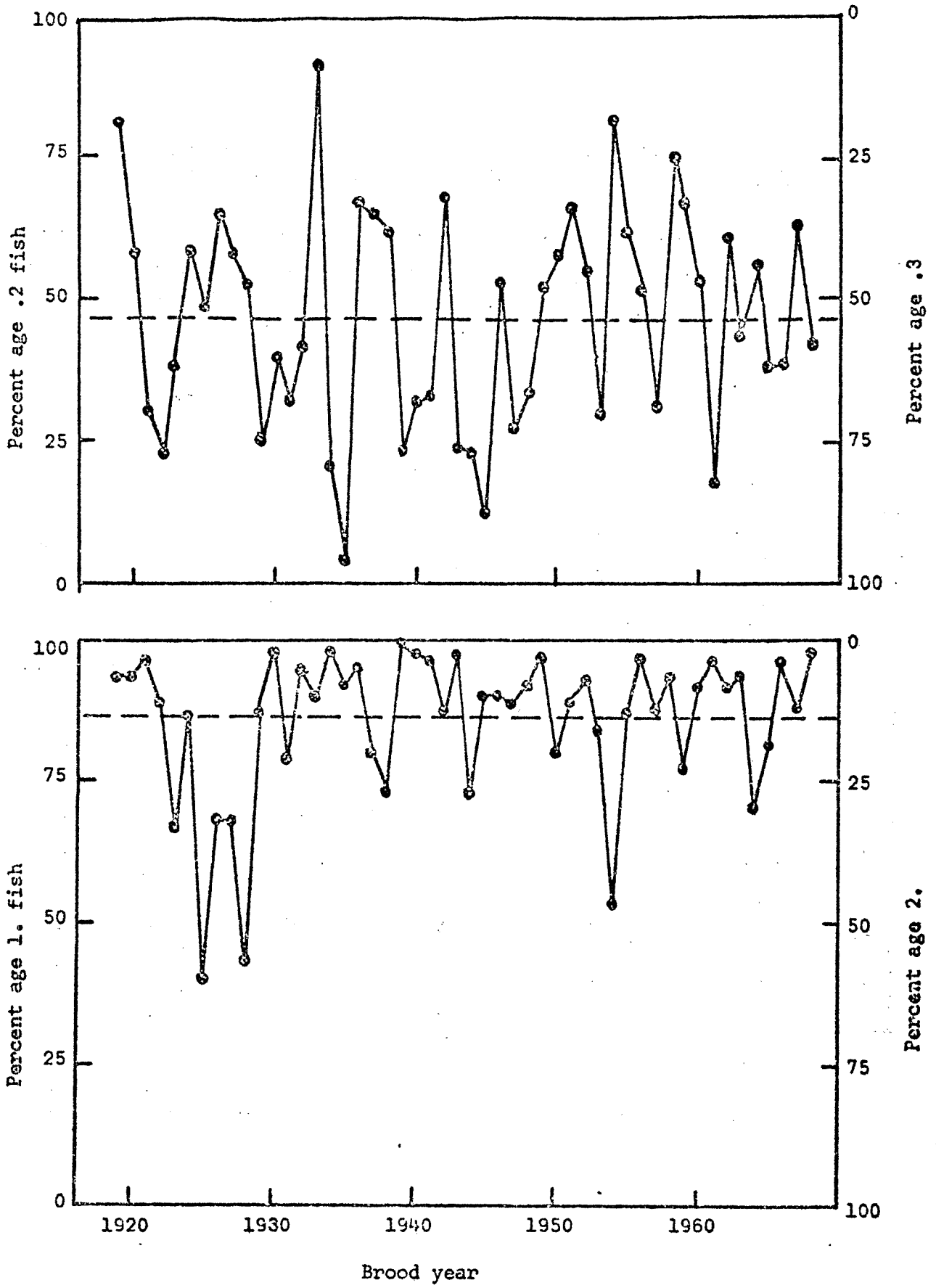


Fig. 9. Ocean age composition (top) and freshwater age composition (bottom) of the returns from the 1919-68 brood years in the Nushagak District (dashed lines are 50-year means).

Table 2. Age composition of sockeye salmon returns to the Nushagak by freshwater age and sex, 1942-65 brood years, arranged by 4-year lines

Brood year	Percent age 1.2 (1.2+1.3)		Percent age 2.2 (2.2+2.3)		Mean age (years)	
	M	F	M	F	M	F
1942	70	64	82	81	4.4	4.5
1946	59	41	94	90	4.5	4.6
1950	65	54	65	57	4.6	4.7
1954	81	72	92	87	4.6	4.7
1958	81	72	72	50	4.3	4.3
1962	<u>66</u>	<u>54</u>	<u>67</u>	<u>75</u>	<u>4.4</u>	<u>4.5</u>
Mean	70.3	59.5	78.7	73.7	4.47	4.55
1943	25	24	42	25	4.8	4.8
1947	33	23	39	26	4.8	4.9
1951	70	62	89	83	4.4	4.5
1955	72	63	81	66	4.4	4.5
1959	70	59	90	84	4.5	4.6
1963	<u>44</u>	<u>40</u>	<u>61</u>	<u>63</u>	<u>4.6</u>	<u>4.7</u>
Mean	52.3	45.2	67.0	57.8	4.58	4.67
1944	38	22	25	12	5.0	5.1
1948	38	25	94	90	4.7	4.8
1952	64	53	25	21	4.4	4.6
1956	57	48	45	47	4.5	4.5
1960	61	50	51	50	4.5	4.6
1964	<u>52</u>	<u>42</u>	<u>84</u>	<u>81</u>	<u>4.7</u>	<u>4.8</u>
Mean	51.7	40.0	54.3	50.2	4.63	4.73
1945	13	6	50	33	4.9	5.0
1949	62	49	100	100	4.4	4.5
1953	27	23	67	54	4.8	4.9
1957	34	26	78	71	4.8	4.8
1961	17	14	69	45	4.9	4.9
1965	<u>38</u>	<u>30</u>	<u>50</u>	<u>51</u>	<u>4.8</u>	<u>4.8</u>
Mean	31.8	24.7	69.0	59.0	4.77	4.82

Table 3. Percentages of females in the returns to the Kushagak by age, 1942-65 brood years, arranged by 4-year lines

Brood year	Age				All ages
	1.2	2.2	1.3	2.3	
1942	54	53	61	54	56
1946	43	46	60	60	51
1950	50	53	61	61	55
1954	51	53	64	67	54
1958	53	36	64	59	55
1962	<u>49</u>	<u>57</u>	<u>62</u>	<u>48</u>	<u>54</u>
Mean	50.0	49.7	62.0	58.2	54.2
1943	53	47	54	66	54
1947	47	44	59	59	55
1951	53	47	61	58	55
1955	53	46	64	66	56
1959	54	52	66	65	57
1963	<u>51</u>	<u>53</u>	<u>55</u>	<u>51</u>	<u>53</u>
Mean	51.8	48.2	59.8	60.8	55.0
1944	47	37	66	59	59
1948	43	53	58	67	54
1952	47	56	58	61	53
1956	53	56	62	55	57
1960	53	49	63	49	56
1964	<u>46</u>	<u>56</u>	<u>56</u>	<u>62</u>	<u>53</u>
Mean	48.2	51.2	60.5	58.8	55.3
1945	37	43	59	61	57
1949	54	50	66	--	59
1953	56	51	61	64	59
1957	56	58	65	67	62
1961	51	42	56	67	55
1965	<u>50</u>	<u>54</u>	<u>59</u>	<u>53</u>	<u>56</u>
Mean	50.7	49.7	61.0	62.4	58.0

Table 4. Mean sex ratio (percent females) in the Nushagak catches, escapements, and runs, 1910-72, by 4-year periods for ages 1.2 and 1.3

Years	Age 1.2			Age 1.3			Mesh size (inches)
	Catch	Escapement	Run	Catch	Escapement	Run	
1910-13	42	--	--	53	--	--	6
1914-17	64	--	--	44	--	--	5-3/4
1918-21	83	--	--	56	--	--	"
1922-25	43	--	--	53	--	--	"
1926-29	50	--	--	50	--	--	5-1/2
1930-33	42	--	--	54	--	--	"
1934-37	37	--	--	59	--	--	"
1938-41	41	--	--	61	--	--	"
1942-45	40	--	--	61	--	--	"
1946-49	32	58	48	59	60	60	"
1950-53	32	59	47	63	53	59	"
1954-57	44	56	52	66	56	62	"
1958-61	41	58	53	61	64	63	"
1962-65	47	59	53	66	62	64	5-3/8
1966-69	36	56	49	59	56	57	"
1970-72	42	56	53	57	52	55	"
MEANS							
1914-25	63	--	--	51	--	--	5-3/4
1926-45	42	--	--	57	--	--	5-1/2
1946-61	37	58	50	62	58	61	5-1/2
1962-72	42	57	52	61	57	59	5-3/8

These data suggest a higher proportion of females in the runs of age 1.2 during the first period of the fishery (prior to 1919) than the later periods.

1.4 The selectivity of the gill net fishery with respect to the size of the fish (hence age and sex) is of particular importance as it relates to the reproductive potential of escapements (larger females contain more and larger eggs than small ones) and the selectivity of races within the district (some races tend to be of 3-ocean age and others of 2-ocean age). Rates of exploitation by ocean age and sex are given in Table 5 in numbers and weights of fish for the Nushagak runs from 1959 to 1972. Rates are highest for 3-ocean females and lowest for 2-ocean females. The average rates by ocean age (sexes combined) for this period were: 0.367 (age .2) and 0.511 (age .3) in weight of fish. The average rates by sex (ages combined) were: 0.469 (males) and 0.414 (females) in numbers of fish, and 0.479 (males) and 0.446 (females) in weight of fish. For a given rate of exploitation on a run, the rate for 2-ocean females in the run was about 33 percent lower than for the total rate, whereas the rate for 2-ocean males was nearly the same as it (Table 6).

3 The size selectivity of the fishery in relation to the age and sex of fish is shown in Fig. 10. The greatest degree of size selection occurred for 2-ocean females where the average fish in the catch was 12 percent heavier than in the escapement, whereas the least degree of size selection occurred for 3-ocean males where the average fish in the catch was 3 percent smaller than in the escapement. Annual variation in size and rate of exploitation affected the degree of size selection, and the average weight of an age-sex group in the run (particularly 2-ocean females) affected the relative rate of exploitation among the age-sex groups (Fig. 11).

LAKE SYSTEMS OF THE NUSHAGAK

The annual runs of sockeye salmon to the major lake systems of the Nushagak are shown in Fig. 12. During the recent period of the Nushagak fishery (since 1943), the Wood River system has been the major producer, contributing 65 percent of the run, 68 percent of the escapement, and 67 percent of the catch. The system contains about 49 percent of the total lake surface area in the district. The Igushik lakes have contributed 20 percent of the runs, and contain 9 percent of the total surface area. These lakes have been the highest producers of sockeye salmon per unit of surface area in Bristol Bay. The Nuyakuk (Tikchik) lakes contain 32 percent of the lake surface area in the district but have produced only 10 percent of the runs in the recent period. This lake system has been about the lowest producer of sockeye salmon per unit of surface area in Bristol Bay.

The geometric means of the return per spawner for the three lake systems (1952-68 brood years) were: Wood River, 1.74; Igushik, 1.92; and Nuyakuk, 2.10. The mean for the entire district was 1.83. The relative survival from spawners

Table 5. Rates of exploitation (proportion caught) for number and weight of sockeye salmon in Nushagak runs by sex and ocean age, 1959-72

Year	Number					Weight				
	Male		Female		Combined	Male		Female		Combined
	.2	.3	.2	.3		.2	.3	.2	.3	
1959	.41	.43	.30	.37	.36	.43	.42	.32	.37	.38
1960	.46	.62	.25	.55	.48	.47	.61	.28	.57	.51
1961	.39	.41	.20	.37	.37	.40	.40	.20	.37	.37
1962	.66	.74	.51	.80	.61	.69	.71	.56	.81	.65
1963	.43	.46	.35	.56	.44	.44	.45	.37	.56	.46
1964	.55	.68	.39	.65	.51	.58	.69	.44	.67	.57
1965	.49	.41	.23	.45	.42	.52	.44	.26	.47	.45
1966	.51	.48	.11	.46	.42	.52	.50	.13	.48	.45
1967	.45	.38	.32	.54	.43	.45	.37	.33	.54	.43
1968	.36	.50	.34	.48	.42	.38	.49	.37	.48	.45
1969	.46	.37	.33	.40	.39	.46	.34	.34	.38	.38
1970	.32	.42	.22	.48	.38	.34	.42	.24	.48	.40
1971	.40	.51	.29	.55	.43	.41	.52	.28	.55	.50
1972	.37	.55	.24	.61	.42	.39	.56	.26	.64	.47
Means	.447	.497	.291	.519	.438	.463	.494	.313	.526	.462
Percent deviation from combined:										
	+2	+13	-34	+18		0	+7	-32	+14	

Table 6. Deviations from combined rates of exploitation in weight
(sex-age rate minus combined rates)

Year	Absolute				Percentage			
	Male		Female		Male		Female	
	.2	.3	.2	.3	.2	.3	.2	.3
1959	+0.05	+0.04	-0.06	-0.01	+13	+11	-16	- 3
1960	-0.05	+0.10	-0.23	+0.06	-10	+20	-45	+12
1961	+0.03	+0.03	-0.17	0	+ 8	+ 8	-46	0
1962	+0.04	+0.06	-0.09	+0.16	+ 6	+ 9	-14	+24
1963	-0.02	-0.01	-0.09	+0.10	- 4	- 2	-20	+22
1964	+0.01	+0.12	-0.13	+0.10	+ 2	+21	-23	+18
1965	+0.07	-0.01	-0.19	+0.02	+16	- 2	-42	+ 4
1966	+0.07	+0.05	-0.32	+0.03	+16	+11	-71	+ 7
1967	+0.02	-0.06	-0.10	+0.11	+ 5	-14	-23	+26
1968	-0.07	+0.04	-0.08	+0.03	-16	+ 9	-18	+ 7
1969	+0.08	-0.04	-0.04	0	+21	-11	-11	0
1970	-0.06	+0.02	-0.15	+0.08	-15	+ 5	-40	+20
1971	-0.09	+0.02	-0.22	+0.05	-18	+ 4	-44	+10
1972	-0.08	+0.09	-0.21	+0.17	-17	+19	-45	+36
Means	.00	+0.03	-0.15	+0.06	+ 3	+ 6	-33	+13

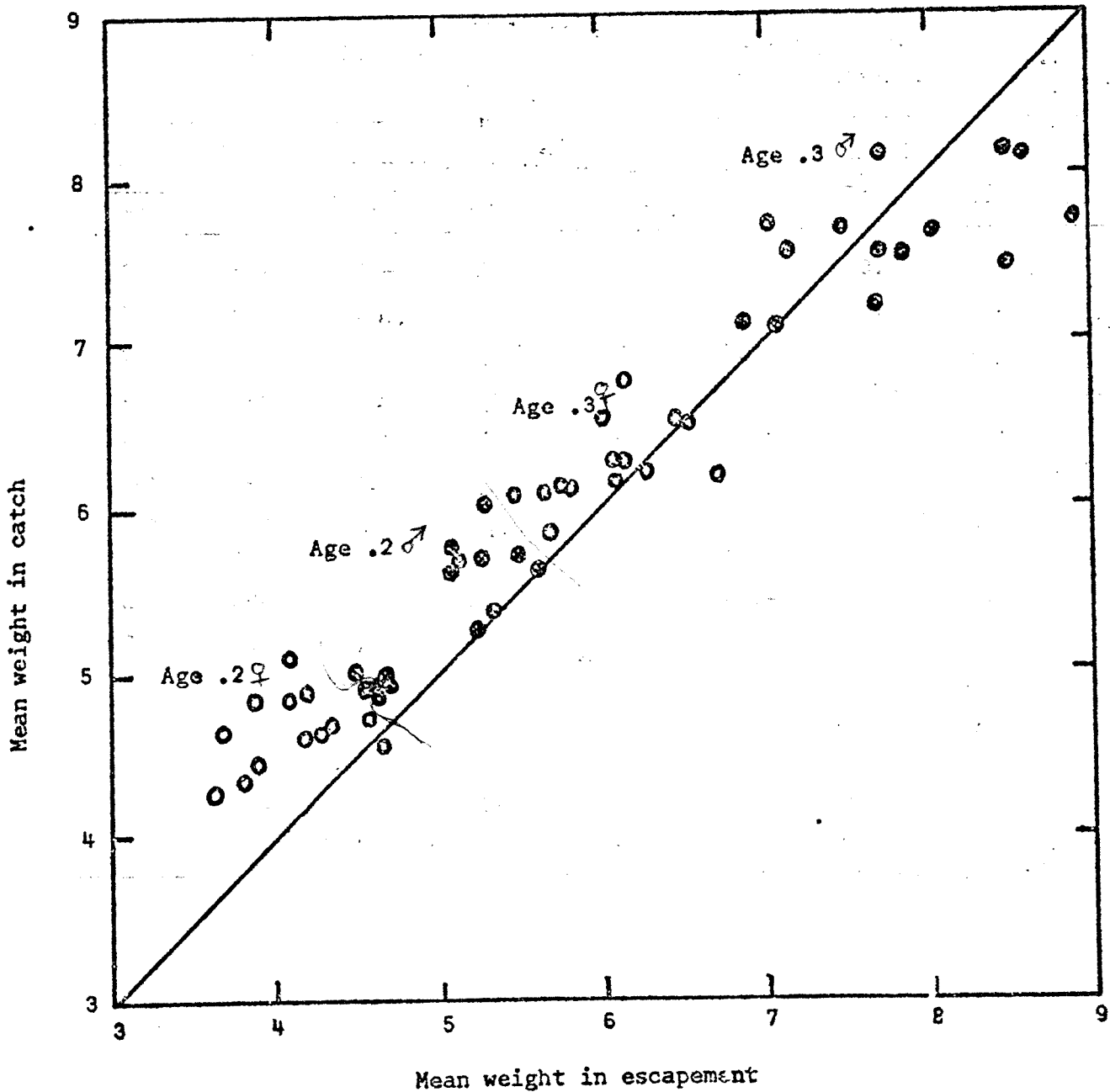


Fig. 10. Relationship between the mean weight (lbs) of sockeye salmon in the catch and the mean weight in the escapement for the Nushagak District, 1959-72 (open circles for females, solid circles for males).

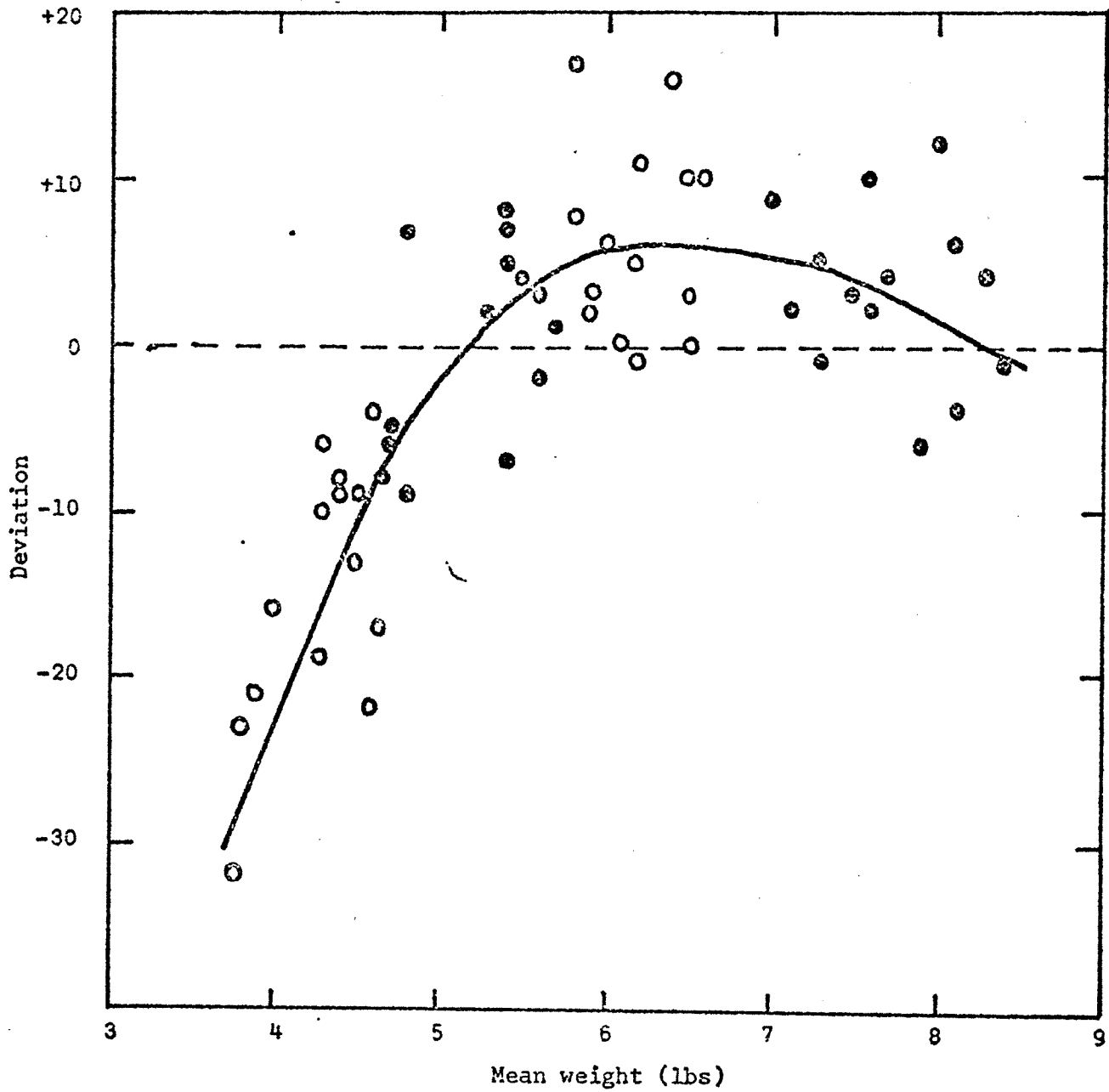


Fig. 11. Relationship between the deviation from the combined rate of exploitation and mean weight in the runs of sex-age groups. Open circles for females and solid circles for males (freehand curve).

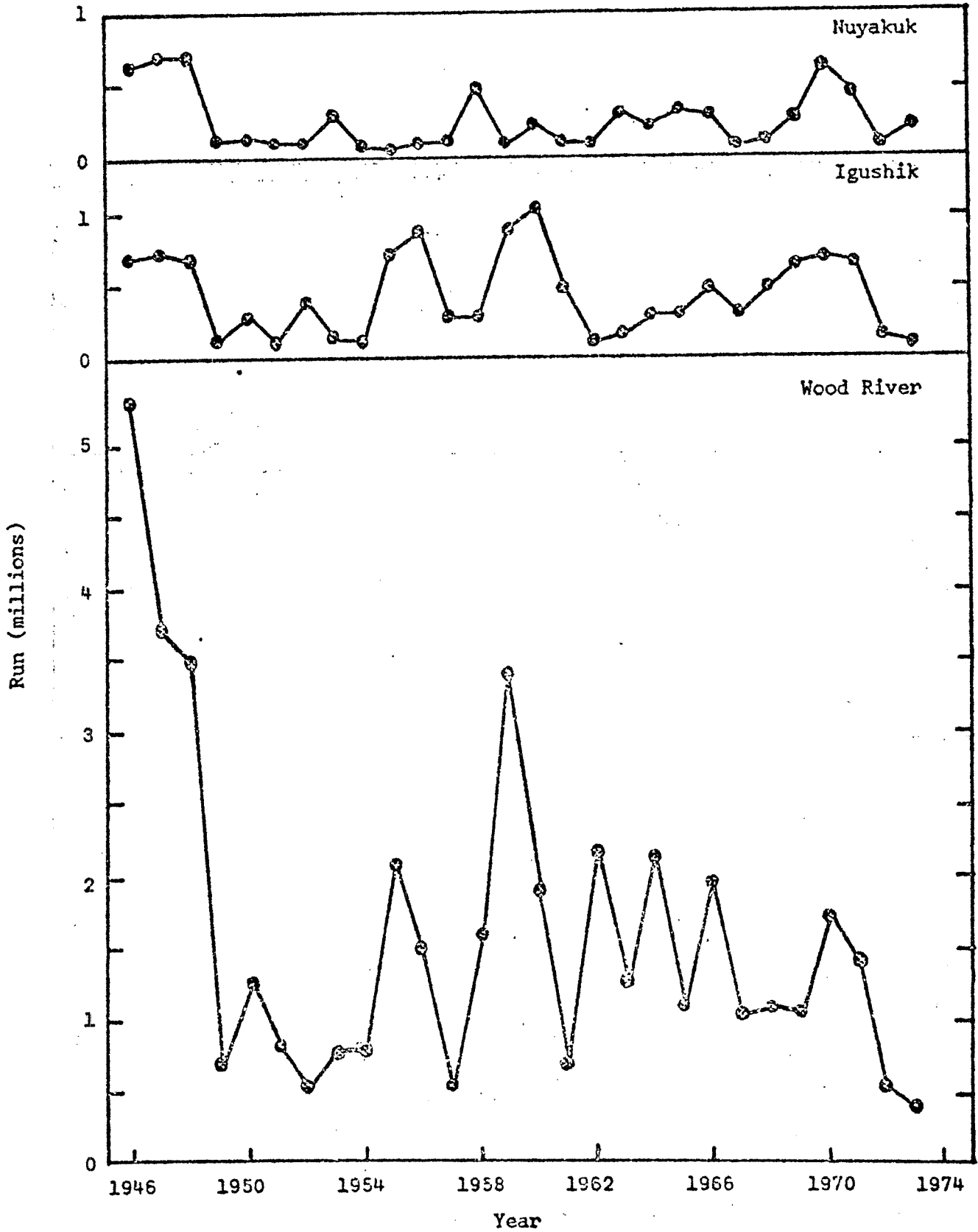


Fig. 12. Annual runs of sockeye salmon to the major lake systems of the Nushagak District, 1946-73.

to returning adults has been lowest for the Wood River sockeye salmon during the recent period, and likewise the average rate of exploitation has been lowest: 0.41 compared to 0.48 for Igushik and Nuyakuk sockeye salmon. The differences in rates of exploitation among the stocks of the three lake systems are due largely to differences in age composition. Stocks from the Igushik and Nuyakuk systems consisted predominantly of 3-ocean fish, but those from the Wood River system of 2-ocean fish (Figs. 13 and 14). All three stocks were primarily of freshwater age 1. The Igushik stock had a higher percentage of age 2. fish than the other stocks, probably as a result of a generally higher density of spawners (hence juveniles) in the Igushik lakes, which tend to cause slower growth and delay in smoltification.

→ 2a Sockeye salmon of a given ocean age and sex in the Wood River escapements were generally smaller than those in the Igushik and Nuyakuk escapements (Table 7). Although the differences were quite small, they would tend to result in relatively lower rates of exploitation for the Wood River stock. The average sizes of fish by age and sex in the Nushagak catches and Wood River escapements for 1959-1972 are given in Tables 8 and 9.

Considering the decline in abundance that occurred from 1946-1948 to the present among the three stocks, the present age composition of the stocks, and the present productivity (average run per unit of surface area and average return per spawner), one must conclude that the decline of the Nushagak fishery was due largely to a decline in abundance of the Wood River stock. It seems unlikely that the rather small Igushik lakes could have produced substantially larger runs than they presently do. The Nuyakuk lakes have the shortest ice-free period and about the lowest primary productivity of any of the Bristol Bay lakes and are thus relatively poor nursery areas for juvenile sockeye. It is also unlikely, then, that these lakes produced substantially larger runs than they presently do.

WOOD RIVER LAKES

The annual escapements and returns to the major Wood River lakes since 1946 are given in Appendix Table 1. The annual runs and escapements since 1958 are shown in Fig. 15. A low run every four years is evident in all lakes except Aleknagik and North Nerka. The stocks from these two lakes have a higher return per spawner (Table 10) and a higher proportion of 3-ocean fish than those from the other lakes. The mean escapements and returns by four-year lines are given in Table 11. The low abundance of the 1949 line is particularly evident for the stocks from the upper lakes of the system (Beverley and Kulik). This cyclic abundance can be seen in the Nushagak statistics since 1941, and is maintained partly by a combination of age composition of the returns. The 1949 line tends to produce a high proportion of 5-year-olds, whereas the preceding line (1948) tends to produce a high proportion of 4-year-olds.

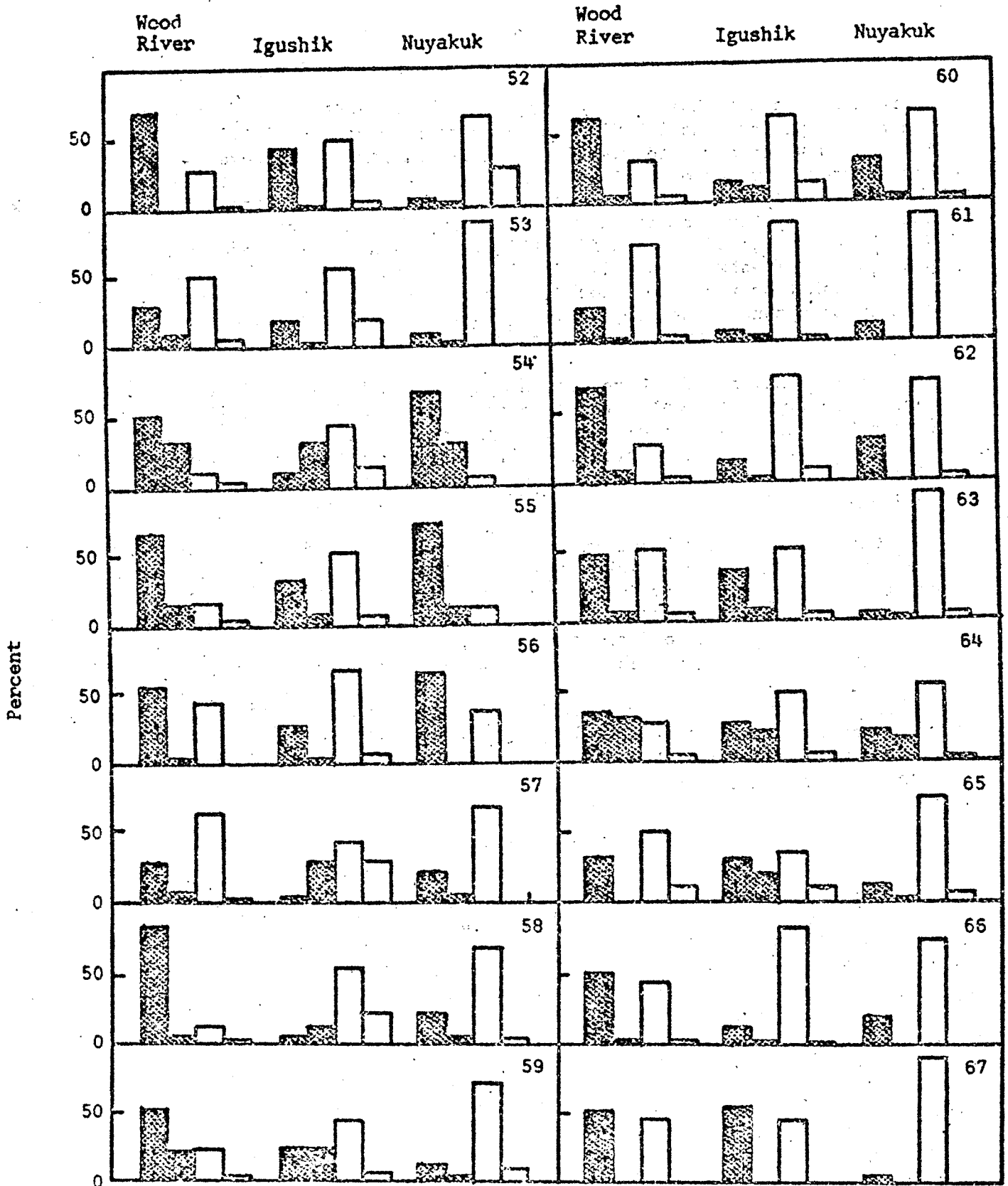
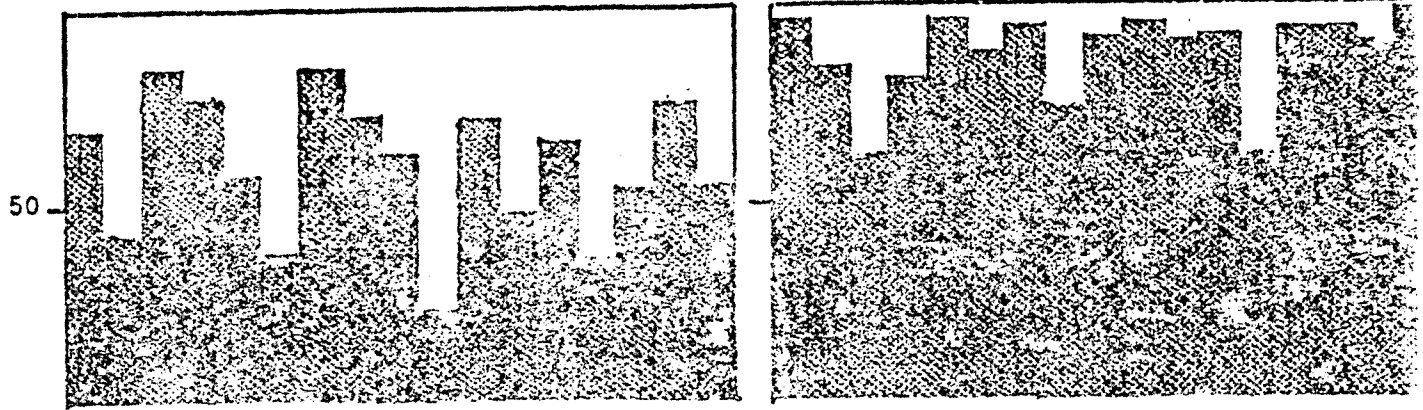
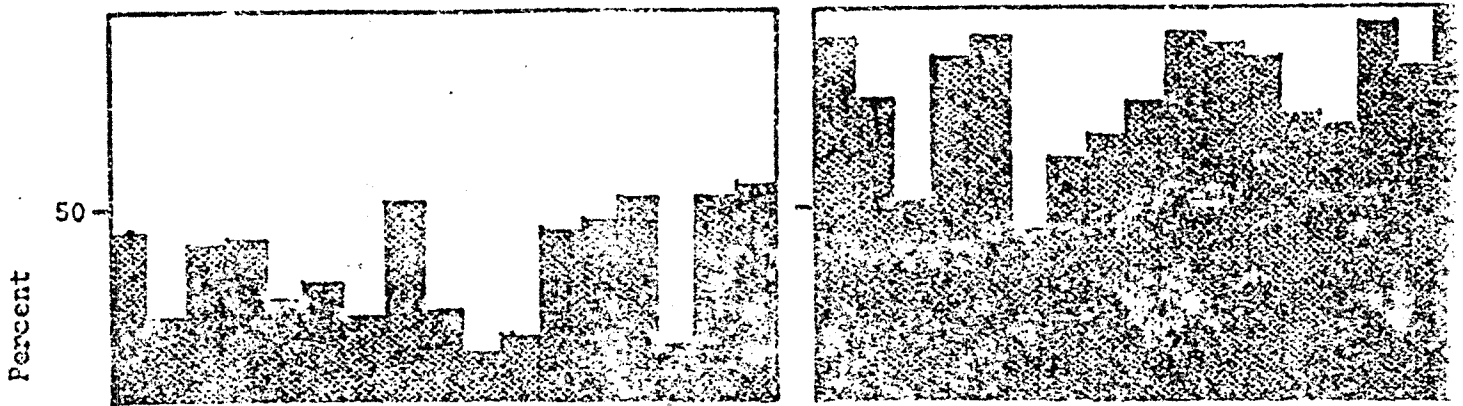


Fig. 13. Age compositions of the returns from the 1952-67 brood years for the Wood River, Igushik, and Nuyakuk stocks of sockeye salmon (ages 1.2, 2.2, 1.3, 2.3).

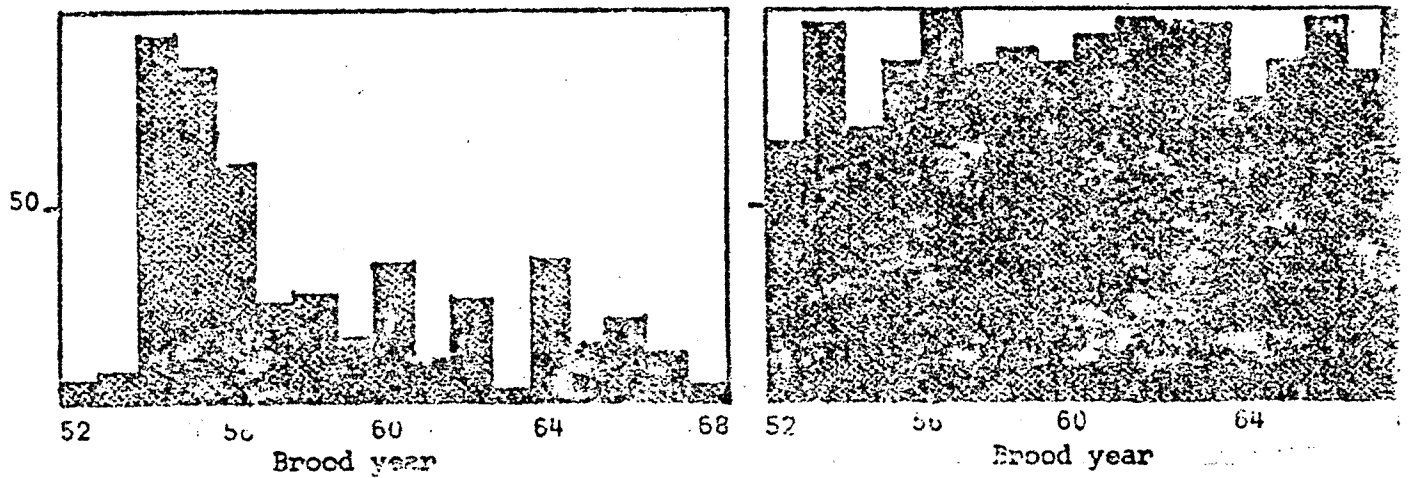
Wood River



Igushik



Nuyakuk



A. Ocean age (solid, age .2 and open, age.3)

B. Freshwater age (solid, age 1. a open, age 2.)

Fig. 14. Age compositions of the returns from the 1952-68 brood years for three major systems of the Nushagak District.

Table 7. Average weights (lb) of sockeye salmon in the Wood River, Igushik, and Nuyakuk escapements by ocean age and sex, 1963-72

Year	System	Males			Females		
		.2	.3	Comb.	.2	.3	Comb.
1963	Wood River	5.42	8.68	6.02	4.35	6.84	4.90
	Igushik	5.49	8.51	6.50	4.24	6.59	4.98
	Nuyakuk	5.12	8.55	7.73	4.94	6.27	6.22
1964	Wood River	5.25	7.65	5.49	4.05	6.15	4.35
	Igushik	5.85	7.97	6.82	4.45	6.32	5.28
	Nuyakuk	5.40	7.75	5.90	4.19	6.04	4.62
1965	Wood River	5.02	6.65	6.11	3.98	5.66	5.16
	Igushik	5.26	7.37	6.92	4.24	5.62	5.31
	Nuyakuk	5.56	7.70	7.39	4.54	5.62	5.42
1966	Wood River	4.75	6.91	5.89	3.69	5.78	4.62
	Igushik	5.02	7.31	7.14	4.06	5.54	5.38
	Nuyakuk	3.41	8.23	7.76	3.54	6.06	5.93
1967	Wood River	5.19	7.80	6.10	4.28	6.27	4.85
	Igushik	5.36	8.29	6.65	4.20	6.10	5.18
	Nuyakuk	3.85	8.55	7.96	4.50	6.23	6.09
1968	Wood River	5.12	8.29	6.79	4.13	6.43	5.44
	Igushik	5.59	9.01	6.77	4.50	6.59	5.62
	Nuyakuk	4.35	8.69	8.20	4.13	6.43	6.20
1969	Wood River	5.22	7.83	5.98	4.31	6.39	4.77
	Igushik	5.69	9.08	7.21	5.09	7.00	5.98
	Nuyakuk	4.92	8.03	5.96	4.31	6.15	4.81
1970	Wood River	4.49	6.58	5.33	3.76	5.58	4.49
	Igushik	5.42	7.90	6.82	4.35	5.94	5.24
	Nuyakuk	4.75	7.63	6.96	4.02	5.74	5.12
1971	Wood River	4.69	6.90	6.01	4.68	5.90	5.27
	Igushik	5.40	8.21	7.75	4.50	6.31	5.99
	Nuyakuk	3.80	8.35	8.13	4.84	6.22	6.18
1972	Wood River	4.57	6.73	5.15	3.85	5.29	4.16
	Igushik	3.89	6.97	5.69	3.62	5.70	4.40
	Nuyakuk	3.00	7.87	6.25	3.47	5.91	5.21
Mean	Wood River	4.97	7.40	5.89	4.11	6.03	4.80
	Igushik	5.30	8.06	6.83	4.33	6.17	5.34
	Nuyakuk	4.42	8.14	7.22	4.25	6.07	5.58

Table 8. Average weights (lb) and numbers of fish (thousands) in the Bushagak District catch, 1959-72

Year		Males				Females				Combined ¹
		1.2	2.2	1.3	2.3	1.2	2.2	1.3	2.3	
1959	No.	534	241	90	22	438	197	143	35	1700
	\bar{W}	5.58	5.77	7.42	7.81	4.60	4.64	6.15	6.30	5.43
1960	No.	202	151	320	41	116	79	509	55	1518
	\bar{W}	4.74	4.86	7.47	7.81	4.16	4.28	6.09	6.13	5.89
1961	No.	15	9	136	28	7	8	193	48	510
	\bar{W}	5.68	5.49	7.15	7.42	4.70	4.92	6.09	6.23	6.46
1962	No.	627	20	69	13	534	25	137	16	1448
	\bar{W}	5.72	6.06	7.69	8.00	4.79	4.92	6.52	6.54	5.57
1963	No.	195	31	144	6	179	28	246	9	843
	\bar{W}	5.67	5.64	8.08	8.25	4.61	4.88	6.36	6.46	6.04
1964	No.	407	133	132	20	302	119	246	27	1421
	\bar{W}	5.91	6.36	8.14	8.00	5.02	5.31	6.77	6.75	6.21
1965	No.	56	56	197	11	27	25	372	19	792
	\bar{W}	5.82	5.44	7.69	8.08	4.79	4.85	6.06	6.27	6.38
1966	No.	230	20	344	47	45	7	418	45	1157
	\bar{W}	4.88	5.27	7.50	7.38	4.56	4.88	6.09	6.09	6.25
1967	No.	157	28	84	6	106	34	200	14	653
	\bar{W}	5.19	5.55	7.59	8.05	4.33	4.57	6.25	6.30	5.76
1968	No.	96	23	230	13	77	25	258	14	748
	\bar{W}	5.54	5.93	8.13	8.33	4.77	5.15	6.48	6.69	6.67
1969	No.	190	96	94	14	139	87	126	17	779
	\bar{W}	5.31	5.49	7.38	6.97	4.70	4.73	6.15	6.10	5.63
1970	No.	156	52	280	19	103	47	459	34	1108
	\bar{W}	4.82	5.24	7.06	7.21	4.39	4.46	5.79	5.94	5.80
1971	No.	111	7	369	59	101	9	500	81	1253
	\bar{W}	4.92	5.30	7.55	8.15	4.48	5.03	6.21	6.25	6.44
1972	No.	78	22	83	21	49	12	90	17	393
	\bar{W}	5.00	4.92	7.29	6.26	4.27	4.52	6.00	5.95	5.79

¹Includes other minor age groups.

Table 9. Average weights (lb) and numbers of fish (thousands) in the Wood River escapements, 1959-72

Year		Males				Females				Combined
		1.2	2.2	1.3	2.3	1.2	2.2	1.3	2.3	
1959	No.	726	157	55	4	878	271	108	9	2208
	\bar{W}	5.05	5.39	7.83	7.83	4.06	4.46	6.31	5.58	4.77
1960	No.	194	77	86	1	295	109	230	22	1015
	\bar{W}	4.49	4.65	7.50	6.85	3.54	3.80	5.82	5.41	4.73
1961	No.	34	2	114	17	51	4	186	42	459
	\bar{W}	5.59	6.13	7.31	7.50	4.50	4.98	5.98	6.06	6.17
1962	No.	316	0	20	0	508	3	28	0	675
	\bar{W}	5.09	--	8.95	--	3.91	3.76	6.02	--	4.52
1963	No.	215	23	54	0	315	6	92	0	705
	\bar{W}	5.39	5.86	8.68	9.21	4.35	4.90	6.84	6.80	5.37
1964	No.	309	65	38	4	484	82	89	5	1076
	\bar{W}	5.17	5.65	7.63	7.80	4.01	4.29	6.17	5.75	4.79
1965	No.	70	15	165	8	92	30	277	14	673
	\bar{W}	5.02	5.06	6.58	6.78	3.94	4.20	5.66	5.94	5.53
1966	No.	225	2	238	18	396	5	306	17	1207
	\bar{W}	4.75	4.59	6.91	6.85	3.69	3.65	5.78	5.74	5.13
1967	No.	122	19	74	2	183	28	80	5	513
	\bar{W}	5.12	5.72	7.60	8.03	4.20	4.65	6.31	5.78	5.38
1968	No.	128	16	150	9	129	17	185	6	642
	\bar{W}	5.09	5.39	8.23	3.92	4.06	4.61	6.43	6.55	6.08
1969	No.	112	72	64	10	151	113	70	6	599
	\bar{W}	5.19	5.26	7.77	8.29	4.28	4.35	6.39	6.43	5.29
1970	No.	309	26	214	12	331	27	221	15	1159
	\bar{W}	4.49	4.55	6.58	6.71	3.76	3.87	5.58	5.78	4.90
1971	No.	140	13	172	53	224	17	189	37	851
	\bar{W}	4.71	4.48	6.87	6.99	4.71	4.24	5.90	5.91	5.60
1972	No.	134	17	46	9	162	15	37	10	431
	\bar{W}	4.60	4.29	6.83	6.21	3.83	4.03	5.26	5.39	4.63

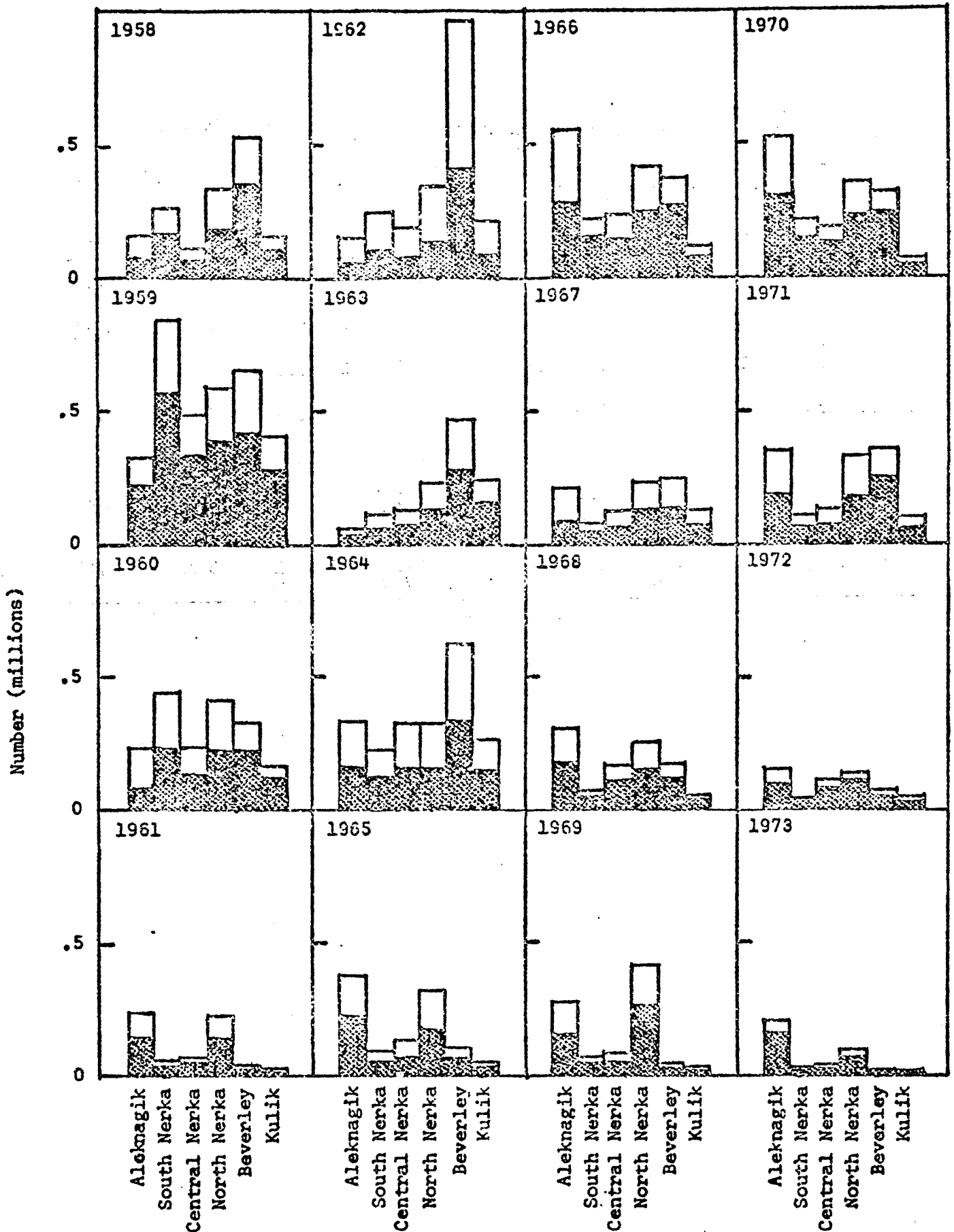


Fig. 15. Annual runs (open bars) and escapements (solid bars) to the major Wood River lakes, 1958-73.

Table 10. Summary of spawner-return data for the major Wood River lakes, 1946-68 brood years (number of fish in thousands)

Lake	Spawners			Returns			Geometric mean		
	Arithmetic Mean	S.D.	Range	Arithmetic Mean	S.D.	Range	S	R	R/S
Aleknagik	163	112	31- 493	300	195	97- 849	130	241	1.85
South Nerka	134	118	12- 564	192	199	30- 996	98	139	1.41
Central Nerka	144	228	15-1112	150	108	22- 555	83	124	1.51
North Nerka	185	151	26- 665	275	167	53- 807	138	229	1.67
Beverley	219	226	6-1013	281	286	22-1116	118	154	1.31
Kulik	81	76	4- 283	110	113	3- 434	46	63	1.36
Total lake system	962	788	101-3717	1355	790	275-3681	733	1146	1.57

Table 11. Mean escapements and returns (thousands) by 4-year lines for the Wood River lakes, 1949-68 brood years (five generations)

Lake	Line	Escapement		Mean returns						
		Mean	Percent age .2	4 years			5 years		6 years	
				1.2	2.2	1.3	Total	2.3	Total	
Aleknagik	1946	132	53	79	6	152	158	12	249	
	1947	183	47	148	23	172	195	15	358	
	1948	147	48	102	34	189	223	21	346	
	1949	149	13	38	11	201	212	31	281	
South Nerka	1946	129	84	168	23	30	63	5	236	
	1947	177	77	203	27	53	80	2	285	
	1948	126	82	138	5	29	34	2	174	
	1949	48	50	44	1	36	37	1	82	
Central Nerka	1946	71	69	105	5	37	42	2	149	
	1947	126	80	166	12	47	59	3	228	
	1948	89	74	126	5	41	46	1	173	
	1949	46	42	38	1	45	46	1	85	
North Nerka	1946	137	66	174	15	109	124	6	304	
	1947	182	70	219	26	107	133	17	369	
	1948	143	67	135	17	119	136	5	276	
	1949	111	26	85	8	132	140	3	228	
Little Togiak	1946	13	65	23	3	12	15	1	39	
	1947	19	72	23	6	11	17	1	41	
	1948	15	66	13	4	9	13	1	27	
	1949	11	44	10	4	10	14	0	24	
Beverley	1946	255	95	462	84	50	134	7	603	
	1947	230	77	271	88	44	132	1	404	
	1948	144	67	128	5	15	20	0	148	
	1949	27	64	22	7	11	18	3	43	
Kulik	1946	61	90	101	67	16	83	2	186	
	1947	136	81	134	49	17	66	1	201	
	1948	63	73	52	5	8	13	1	66	
	1949	13	47	9	5	8	13	0	22	

The escapements and returns to the lakes of the system were divided by the lake surface area for adjustment of differences in size of the nursery areas and, at least partly, the amount of spawning area. Lake Nerka was divided into three "lakes" that approximately correspond to the major basins in the lake. Spawner-return curves were fitted to the data from the 1949-1968 brood years (Table 12). Observations from the 1946-1948 brood years were omitted because they were less precise than more recent observations and less representative of present (hence, future) conditions. The Ricker-type curves were generally good fits to the observations; however, for Lake Aleknagik the variability about the curve was greater than the variability about the average return. Little Togiak Lake was the highest producer (per unit of surface area) in the system; however, this small lake (6 km²) contributed only about 2 percent of the total returns to the lake system. Lakes Aleknagik and North Nerka contained a higher proportion of 3-ocean fish than the other major lakes and their stocks had a higher average return per average density of spawners (Fig. 16).

The annual deviations from the spawner-return curves were significantly correlated between Aleknagik and North Nerka, South and Central Nerka, and the upper lakes (Beverley and Kulik). The mean annual deviations for the three pairs of lakes are shown in Fig. 17. The stocks that contained a high proportion of 2-ocean fish (South and Central Nerka, Beverley, and Kulik) exhibited a recent trend in low returns after adjustment for spawning density was made (1963-1968 brood years).

The average number of spawners for the 1949-1968 brood years was greater than the calculated optimum number in one-half of the major lakes and less than the optimum number in the other one-half (Table 13). The average number of spawners for the total lake system was close to the optimum and the average return was close to the expected return from the optimum escapement. If the lake nursery area affects the relative production or survival to adult, then the optimum escapement for the lake system is valid only if the distribution of a run corresponds approximately to the size and productivity of the individual lakes. The annual runs and escapements to the lakes vary somewhat independently; thus, in most years, the rate of exploitation required to obtain an optimum escapement for the lake system was too high for the stocks of one lake and too low for the stocks in another lake (Table 14).

The problem of managing the runs to the Wood River lakes is greatest in the low years of the cycle, i.e., the 1949 line. For example, in 1965 and 1969 the runs to Lakes Aleknagik and North Nerka were well above average, whereas the runs to the other major lakes were quite low, generally less than the optimum escapement. Therefore, a rate of exploitation of 60-70 percent was required for two of the lakes so that optimum escapements could be obtained while no exploitation was allowable for most of the other lakes (Fig. 18). For the stocks from the upper lakes in the system, a rate of exploitation of 50 percent or no exploitation would make little difference; the resulting escapements would be too small to increase substantially the low cycle

Table 12. Parameters for spawner-return curves (thousands per km² of lake surface area):
 $R = aSe^{-bS}$ and associated statistics for the 1949-68 brood years

Lake (surface area)	Parameters		Means		Standard deviation		At optimum				
	a	b	Spawners (\bar{x})	Returns (\bar{y})	Spawners Sy	Returns Sy	Sy*x	Spawners	Returns	R/S	μ (%)
Aleknagik	4.342	-.405	1.84	3.72	2.43	2.43	2.61	1.35	3.39	2.51	60
South Nerka	2.860	-.307	1.90	3.08	3.33	3.33	3.29	1.45	2.63	1.81	45
Central Nerka	3.035	-.272	1.67	3.10	2.22	2.22	2.00	1.75	3.30	1.89	47
North Nerka	4.145	-.383	1.66	3.41	1.92	1.92	1.75	1.50	3.50	2.33	57
Beverley	2.513	-.190	1.82	3.34	3.31	3.31	2.70	2.10	3.54	1.69	41
Kulik	2.581	-.248	1.51	2.66	2.62	2.62	2.51	1.65	2.83	1.72	42
Little Togiak	5.204	-.295	2.47	5.54	2.94	2.94	2.76	2.15	5.93	2.76	64

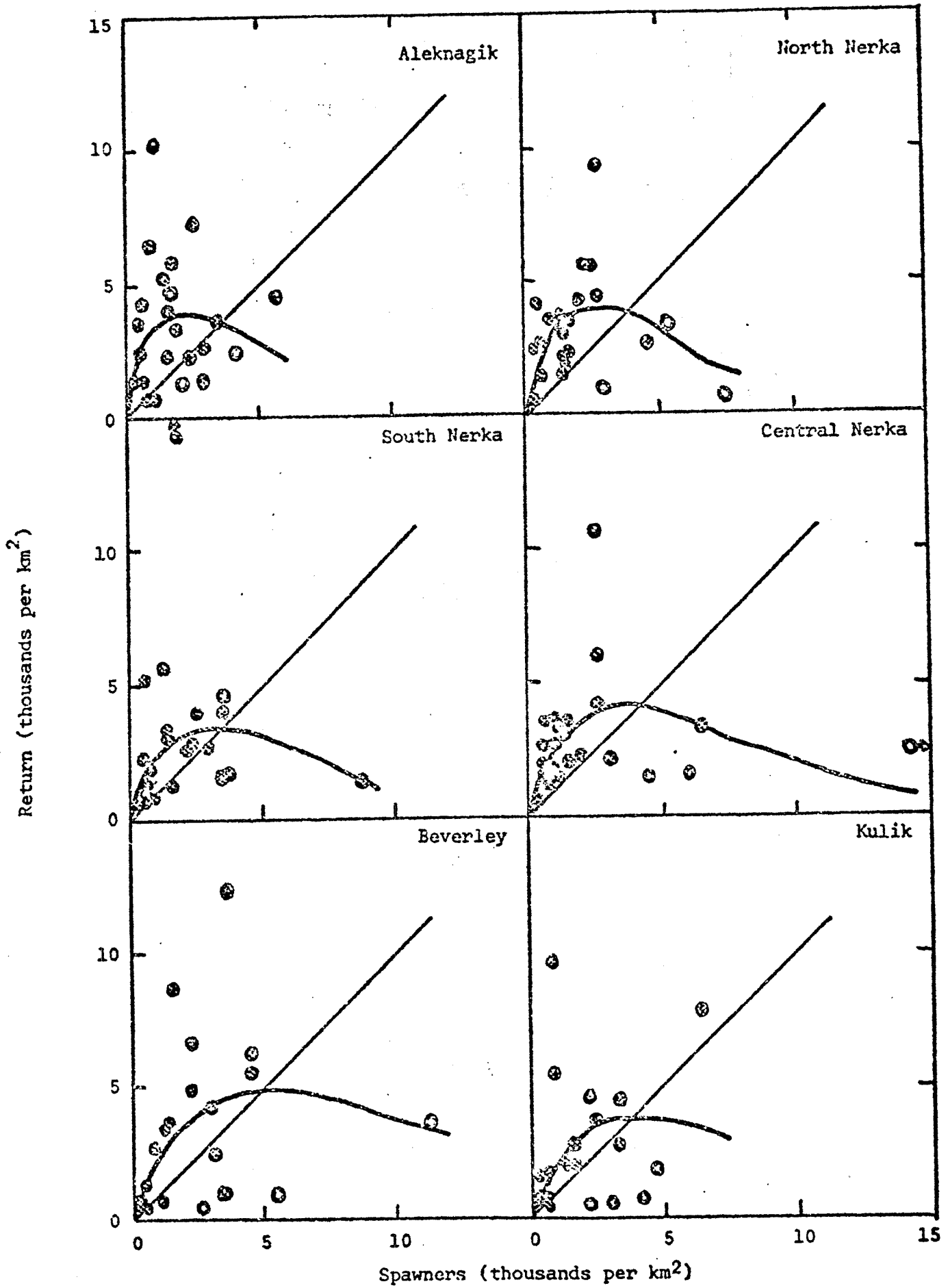


Fig. 16. Spawner-return curves for the major Wood River lakes, 1949-68 brood years (1946-48 are open circles).

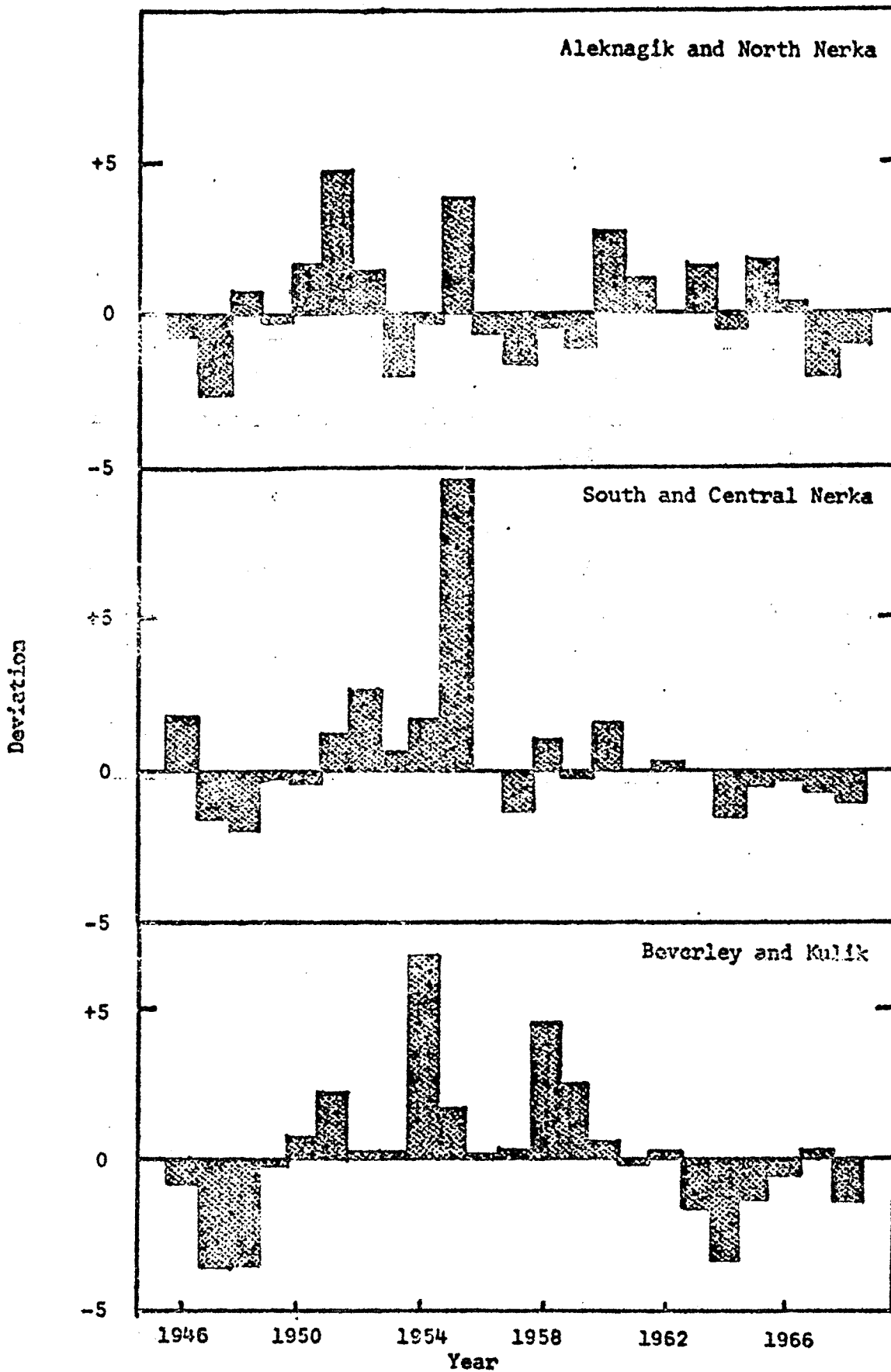


Fig. 17. Deviations from spawner-return curves, 1946-68 (thousands per km² of lake surface area).

Table 13. Optimum number of spawners and calculated returns
(in thousands) for the Wood River lakes from
1949-68 brood years

Lake	Optimum		Observed means	
	Spawners	Returns	Spawners	Returns
Aleknagik	112	281	153	309
South Nerka	92	166	120	195
Central Nerka	90	169	86	159
North Nerka	130	302	143	295
Beverley	189	319	164	301
Kulik	74	127	68	120
Little Togiak	13	36	15	33
Totals	700	1,400	749	1,412

Table 14. Observed rates of exploitation (%) and required rates for achievement of optimum number of spawners for the runs, 1950-73

Year	Aleknagik		South Nerka		Central Nerka		North Nerka		Beverley		Kulik		Little Togiak	
	Obs.	Opt.	Obs.	Opt.	Obs.	Opt.	Obs.	Opt.	Obs.	Opt.	Obs.	Opt.	Obs.	Opt.
1950	69	73	64	78	70	33	70	0	59	6	59	0	70	0
1951	47	36	44	47	40	0	48	0	46	22	46	0	45	0
1952	59	32	58	4	58	0	59	6	63	0	64	0	62	0
1953	35	71	34	0	36	0	35	45	28	0	30	0	29	7
1954	33	44	28	24	31	0	30	6	27	9	27	0	30	43
1955	34	85	38	53	33	52	34	65	33	39	33	68	35	58
1956	54	80	42	74	40	26	44	46	50	0	50	0	52	69
1957	54	41	46	32	45	13	50	0	45	0	50	0	50	0
1958	57	24	38	65	43	12	44	62	34	65	35	52	52	61
1959	36	65	34	89	32	62	34	78	38	71	30	82	34	79
1960	60	48	48	79	40	61	47	68	36	42	36	55	45	58
1961	36	53	29	0	33	0	34	40	26	0	34	0	35	24
1962	66	21	60	62	61	52	63	62	58	81	59	63	60	48
1963	49	0	43	7	45	24	48	39	40	60	39	69	46	67
1964	53	66	47	56	49	71	51	60	49	70	50	73	50	57
1965	43	71	37	4	38	28	42	59	36	0	38	0	36	69
1966	48	80	31	58	38	60	42	69	27	50	31	30	41	65
1967	54	44	48	0	48	26	50	43	51	21	50	39	50	35
1968	41	63	34	0	38	46	41	49	40	0	39	0	39	61
1969	44	61	35	0	38	0	37	69	36	0	45	0	35	58
1970	42	79	30	54	29	52	36	64	24	40	24	0	29	83
1971	40	68	37	15	41	27	46	60	31	47	32	24	43	69
1972	33	24	20	0	23	15	22	6	28	0	28	0	30	35
1973	20	45	21	0	19	0	19	0	14	0	9	0	22	28
Mean 1950-1961	48	54	42	45	42	23	44	35	40	21	42	21	45	33
Mean 1962-1973	45	52	37	21	39	33	41	46	36	31	37	25	40	56

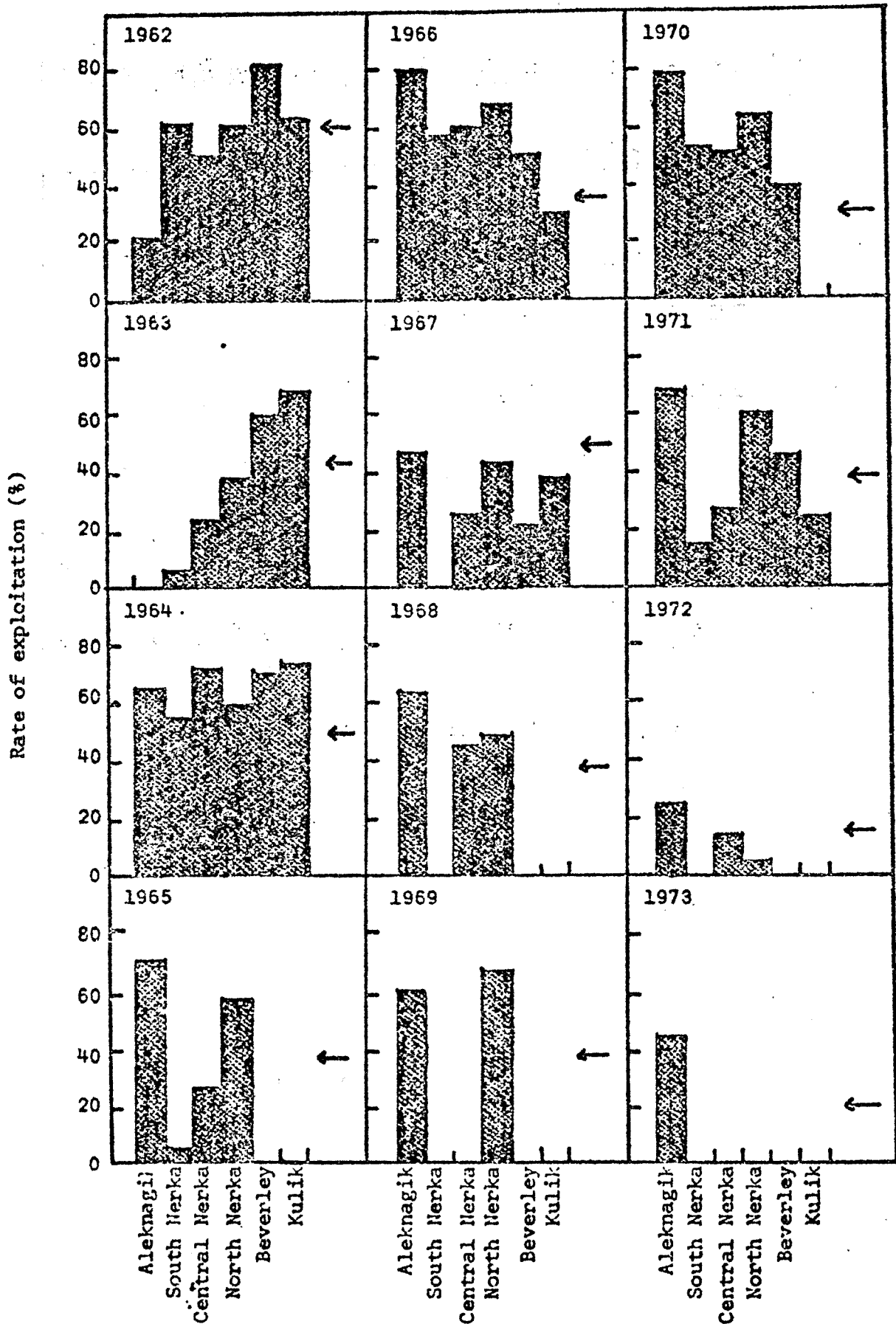


Fig. 18. Rates of exploitation required to obtain optimum numbers of spawners in each of the Wood River lakes from the runs 1962-73 (arrow indicates mean observed rate).

runs. The spawner-return statistics for the entire lake system indicate that the relative production from the 1949 line is less than that for the other lines (Fig. 19). Management of the runs in the low cycle years should be aimed at achieving optimum escapements to Lakes Aleknagik and North Nerka.

SPAWNING GROUNDS OF THE WOOD RIVER LAKES

The annual abundance of spawners in the major spawning grounds of the Wood River lakes (Fig. 20) was measured by (1) ground counts of live and dead fish in small creeks and rivers near the time of peak spawning, i.e., when about equal numbers of live and dead fish were present, and (2) aerial estimates of the number of fish on beaches and in large rivers (Gilbert, 1968). The age composition of the spawners was estimated from samples of about 100 fish of each sex. The combined age composition was obtained by weighting by the sex composition in the trunk stream (Wood River) escapement, since the sex ratios from spawning ground samples are unreliable. The number of spawners of a given age was obtained by multiplying the total number by the age composition. The run (catch and escapement) for each age group was calculated by multiplying the number of spawners (escapement) by the ratio of run to escapement as determined by age for the entire lake system in each year. The major assumption in these estimates was that the rate of exploitation for a given age group in a given year was the same for all spawning populations in the fishery. The annual runs by age were then arranged by brood year and the abundance of each age class was summed for procurement of the total return.

Variances of the numbers of spawners and numbers in the returns were not estimated; however, the precision of the estimates are probably in the range of ± 25 percent to ± 50 percent. The estimates for small creeks are undoubtedly more precise than the estimates for large rivers and beach areas. In either case the variance of an annual estimate of abundance is probably less than the variances in the annual escapements and returns.

The Ricker-type spawner-return relationship was fitted to each spawning group (race). The parameters were estimated from linear regression ($\ln R/S = \ln a - bS$), and the curve and observations were plotted on the original scale and examined. For several of the groups the fit of the model was very poor; however, it appeared that no other model (e.g., parabola, linear) would have been better. The serial correlation coefficient of the residuals was calculated as a measure of the randomness of the yearly fluctuations about each spawner-return curve, and the residuals about each curve were used to obtain correlation coefficients among groups for examination of the randomness of between-group fluctuations. The optimum escapement was estimated, and the annual rates of exploitation which would have been required to obtain optimum escapement to each spawning ground were examined.

The annual escapements, age compositions, and returns by age are given for 22 spawning populations in Appendix Table 2. For two locations, Lake

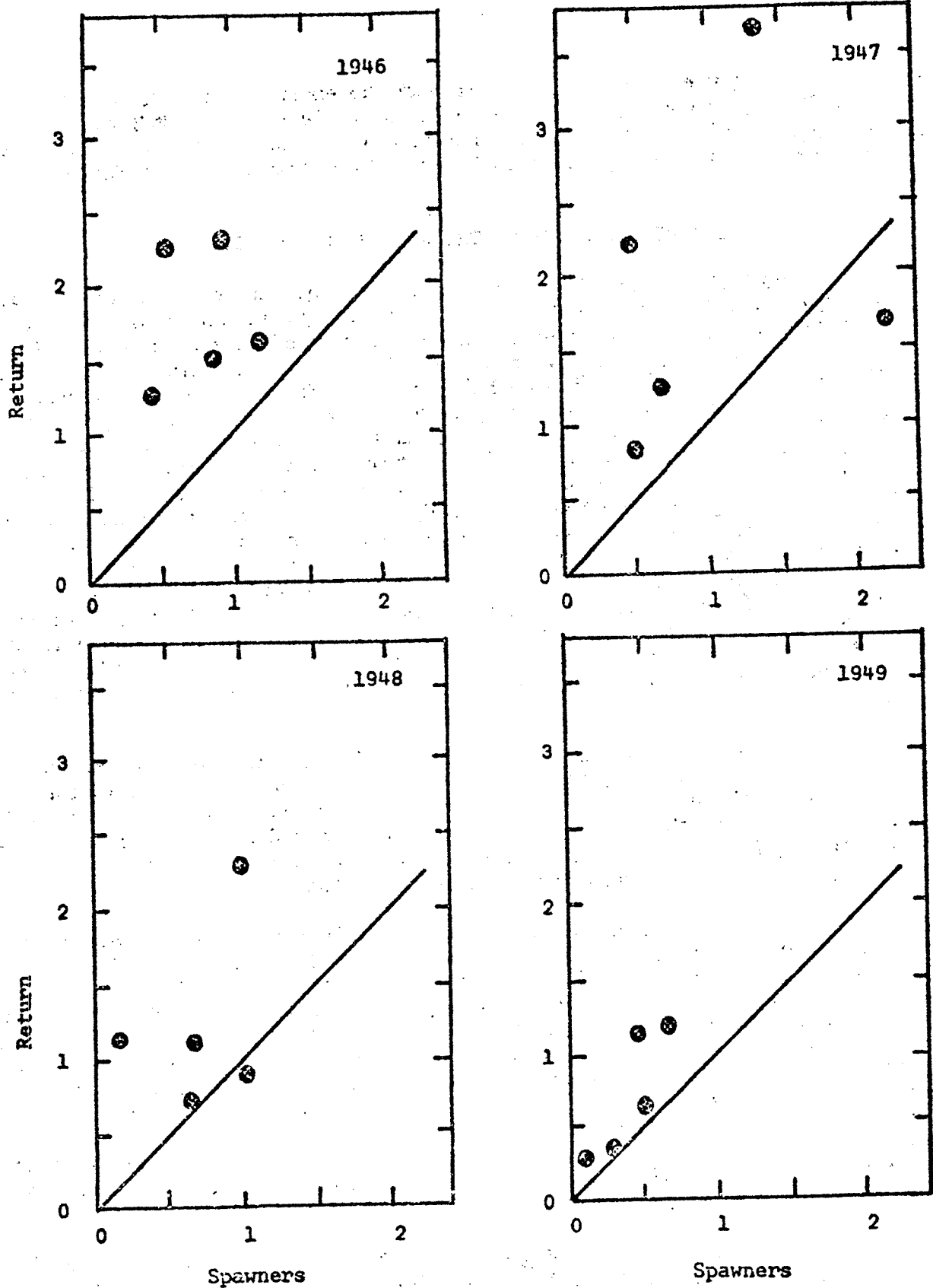


Fig. 19. Spawner-return plots by 4-year lines for the Wood River lake system, 1949-68 brood years (number of fish in millions).

Mulik beaches and Little Topiak beaches, the spawners are from geographically separated beaches; for the remaining locations the spawners are from a rather small definable area of spawning during a short (usually 1-2 weeks) period of time. Trends in the annual runs during the recent period of the fishery are indicated by the four-year averages in Table 15. Abundance was generally high during 1946-1949, low during 1950-1957, high during 1958-1965, and low during the past eight years. The trends in abundance for the two main rivers (Agulowak and Agulukpak) are distinctly different, however, as the abundance appears to have been increasing over the 28-year period.

Except for fish spawning in the two major rivers and in Ice Creek (predominantly 5-year-olds), the annual runs to the spawning grounds exhibited cyclic diminution in abundance every fourth year (the 1949 line). Particularly was this pronounced among beach-spawning populations (Table 15). Although rates of exploitation have generally been lower in the 1949 line than in others, the total run has been usually too small to increase adequately the abundance of spawners even if no fishing had occurred. Moreover, the abundance of the runs to the rivers has tended to be higher in this line, thus some harvesting of these fish (usually 3-ocean) is desirable.

The numbers of spawners and numbers of fish in the returns are summarized in Table 17. The geometric means are close to the medians and are probably better estimates of the averages than the arithmetic means. Estimates of potential spawning area in the creeks and rivers are available, and there has been at least one year when the density of spawners was excessive, i.e., less than 1 m² per spawner or 2 m² per female (Rogers and Hamalainen, 1972). Densities in excess of 1 m² per spawner have resulted generally in redd superimposition and loss of eggs (dead eggs were observed on the gravel).

The parameters for the spawner-return curves and some associated statistics are given in Table 18. Plots of the observations and the fitted curves are shown for selected spawning grounds in Figs 21-23. The Ricker-type model was a reasonably good fit for all groups except those for the two major rivers. For the populations spawning in these rivers, there was only a slight indication of a decrease in returns at the highest observed abundance of spawners. In general, the variability about the curves was as great as the variability about the means of the returns. Serial correlations were highly significant for all beach and creek populations except the latter in Lake Aleknagik. Thus, for most groups the annual deviations from the curves were not independent.

The annual deviations from the curves were significantly correlated among spawning populations within each lake except for the two major rivers (Table 19). Some correlation emerged between locations in Lake Nerka and those in the upper lakes of the system, but none between the creeks in Lake Aleknagik and any location in the other lakes. These results of the correlation analysis indicate that the same or similar environmental conditions influence the relative production of adults for a given year of spawning for creeks and beaches within a lake and to a lesser extent for creeks and beaches in all lakes except Aleknagik.

Fig. 20 legend

1. Hansen Creek
2. Happy Creek
3. Bear Creek
4. Ice Creek
5. Agulowak River
6. Fenno Creek
7. Stovall Creek
8. Lynx Creek
9. N4-N6 Beach
10. Pick Creek
11. Little Togiak River
12. Anvil Bay Beach
13. Hidden Lake Creek
14. Kema Creek
15. Agulukpak River
16. A and C Creeks
17. Little Togiak Beach
18. Moose Creek
19. B9-B12 Beach
20. Hardluck Bay Beach
21. Silver Horn Beach
22. N.W. Mikchalk Beach
23. Kulik Beaches
24. Grant River

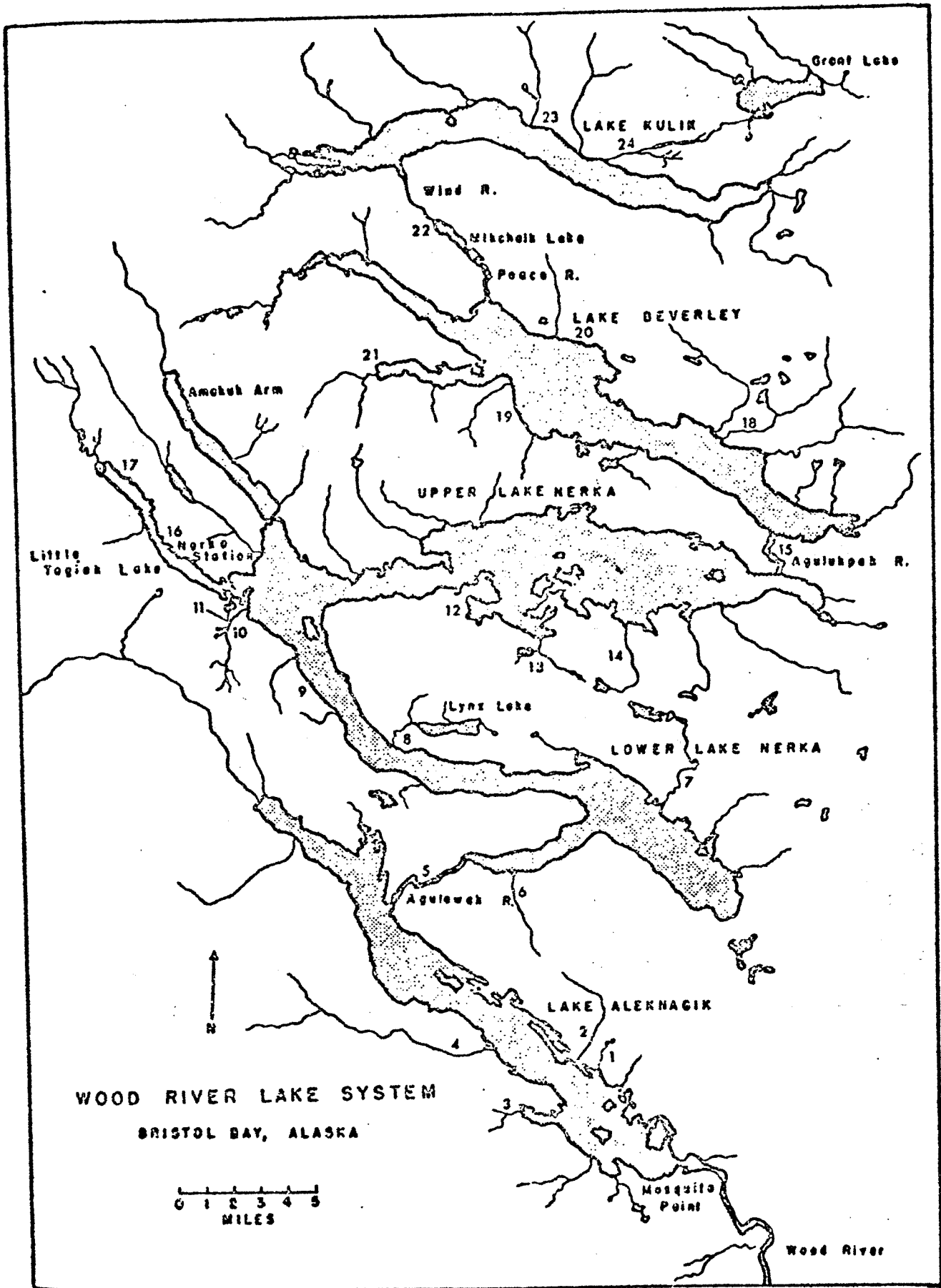


Fig. 20. Locations of spawning areas surveyed in the Wood River lakes. (see legend on following page).

Table 15. Average runs (thousands) to spawning areas in the Wood River lakes by 4-year periods

Location	1945- 1949	1950- 1953	1954- 1957	1958- 1961	1962- 1965	1966- 1969	1970- 1973
Aleknagik							
Hansen Cr.	3	4	11	7	7	9	2
Happy Cr.	7	4	9	2	3	3	1
Bear Cr.	8	5	9	4	5	6	5
Ice Cr.	9	12	14	8	11	14	10
Agulowak R.	134	78	164	147	136	235	240
Nerka							
Fenno Cr.	--	3	4	10	4	5	4
Lynx Cr.	14	2	2	7	2	3	3
Stovall Cr.	--	-	17	31	9	7	6
Pick Cr.	22	8	12	44	22	11	11
Little Togiak R.	5	2	3	15	17	11	12
N4-N6 B.	25	2	10	19	16	11	11
Hidden Lake Cr.	--	2	4	10	7	3	2
Kema Cr.	--	-	12	19	15	5	3
Anvil Bay B.	36	7	14	54	43	27	22
Agulukpuk R.	29	27	44	120	131	170	164
Beverley							
B9-B12 B.	21	3	2	22	27	10	3
Silver Horn B.	64	7	15	68	113	32	32
Hardluck Bay B.	42	4	8	49	52	25	23
Mikchalk							
Beaches	43	4	9	35	40	16	12
Kulik							
Beaches	157	9	45	142	153	64	48
Grant R.	26	5	13	26	28	6	7
Little Togiak							
Beaches	78	12	27	36	34	30	39

Table 16. Geometric means of the annual runs (thousands) and average rates of exploitation (percent) by 4-year lines, 1954-73, for spawning colonies, Wood River lakes

Location	Line							
	1946		1947		1948		1949	
	R	μ	R	μ	R	μ	R	μ
Aleknagik								
Hansen Cr.	9.6	36	7.4	41	4.3	45	1.4	36
Happy Cr.	3.1	47	2.7	44	3.0	47	2.1	40
Bear Cr.	4.6	46	5.7	42	5.5	46	3.9	39
Ice Cr. ¹	8.7	52	10.1	45	12.9	47	8.7	38
Agulowak R. ¹	110.9	54	152.4	46	158.2	52	174.8	36
Nerka								
Fenno Cr.	3.5	42	5.3	40	6.0	39	2.1	35
Lynx Cr.	1.7	35	5.4	39	3.7	39	0.7	31
Stovall Cr.	6.1	40	12.8	44	7.7	38	2.1	32
Pick Cr.	12.6	37	19.4	40	19.9	39	7.3	35
Little Togiak R.	6.7	43	11.9	42	12.6	43	5.2	35
N4-N6 B.	13.6	42	12.0	40	12.7	43	9.5	35
Hidden Lake Cr.	2.0	38	4.6	40	6.9	37	0.9	35
Kema Cr.	10.1	43	9.9	41	7.3	41	2.3	35
Anvil Bay B.	34.3	37	36.9	40	27.5	42	6.5	34
Agulukpak R. ¹	95.6	51	97.1	45	110.2	50	123.4	39
Beverley								
B9-B12 S.	16.7	34	11.6	39	4.5	43	0.4	33
Silver Horn B.	66.3	34	60.2	40	26.9	42	2.2	29
Hardluck Bay B.	29.9	34	41.7	40	22.5	42	3.9	30
Mikchik								
Beaches	24.3	33	27.0	39	15.9	43	5.5	34
Kulik								
Beaches	80.7	34	143.8	40	64.5	44	10.1	39
Grant R.	9.1	39	22.9	41	12.1	41	3.8	34
Little Togiak								
Beaches	35.2	42	36.2	42	30.4	43	21.7	36

¹Predominantly 5-year-old fish.

Table 17. Summary of statistics on number of spawners and returning adults for individual spawning grounds in the Wood River lake system, 1946-68 (number of fish in thousands)

Location	Years n	Spawners			Returns			Geometric mean	
		Arithmetic mean	S.D.	Range	Arithmetic mean	S.D.	Range	$\frac{1}{3}$	R
Aleknagik									
Hansen Cr.	22	4.1	4.1	0.8-15.7	6.5	7.0	0.3-24.2	2.7	3.7
Happy Cr.	23	2.6	2.9	0.5-14.0	3.7	3.2	0.9-13.0	1.8	2.8
Bear Cr.	23	3.1	1.9	0.6- 9.0	5.5	3.7	0.9-16.3	2.7	4.5
Ice Cr.	23	5.9	4.6	0.2-18.0	11.2	8.1	3.0-33.3	4.3	8.8
Agulowak R.	23	76	60	5-210	161	123	21-498	49.9	126.6
Nerka									
Fenno Cr. (S)	18	3.1	3.7	0.9-17.0	5.7	6.5	1.4-23.7	2.2	4.1
Lynn Cr. (S)	23	2.9	3.8	0.1-15.0	3.5	4.5	0.3-23.2	1.6	2.4
Stovall Cr. (S)	13	10.7	20.2	0.9-75.0	7.0	6.2	1.1-22.3	4.3	4.9
Pick Cr. (C)	23	12.0	16.5	0.4-78.2	18.3	24.7	0.9-123.6	7.1	11.6
Little Togiak R. (C)	23	4.9	5.1	0.2-20.0	10.2	10.0	0.7-41.2	2.8	6.0
N4-N6 Beach (C)	23	8.3	11.1	0.1-55.0	12.1	8.3	1.1-37.1	4.1	8.9
Hidden Cr. (N)	18	3.2	4.0	0.6-16.3	5.4	6.3	0.7-25.2	1.9	3.2
Kema Cr. (N)	14	7.6	6.2	1.5-20.0	10.2	12.9	1.7-42.1	5.4	10.4
Anvil Bay Beach (N)	23	17.4	14.5	0.6-51.0	28.4	23.7	2.0-94.3	10.3	18.8
Agulupak R. (N)	23	42	38	3-130	100	88	7-351	26.2	78.5
Beverley									
B9-B12 Beach	23	8.3	8.5	0.1-24.0	11.7	17.1	0.1-62.9	2.9	3.3
Silver Horn Beach	23	29.9	34.2	0.4-125	46.0	59.3	1.2-236.5	11.5	19.3
Hardluck Bay Beach	23	17.5	15.4	0.4-56	27.8	30.8	0.7-111.4	8.6	13.3
Mikchalk									
Beaches	23	14.6	17.6	0.6-80	20.1	22.7	1.0-94.5	7.7	11.7
Kulik									
Beaches	23	55.4	53.3	1.0-179	79.6	92.1	1.0-338	24.2	35.3
Grant R.	23	10.2	9.7	0.5-32.0	14.5	14.7	0.5-50.2	5.7	8.6
Little Togiak									
Beaches	23	19.6	17.0	1.0-80	27.5	19.5	5-54	13.8	25.2

Table 18. Parameters for spawner-return curves: $R = aSe^{-bS}$ and associated statistics (number of fish in thousands)

Location	Parameters		Standard deviation			At optimum		
	a	b	From curve		Serial correlation	Spawners	Return	R/S (%)
			Percent	Absolute				
Aleknegik								
Hansen Cr.	2.165	-.106	5.7	7.1	7.0	3.5	5.2	1.49
Happy Cr.	2.789	-.222	3.5	3.6	3.2	2	3.6	1.80
Bear Cr.	4.285	-.297	3.8	3.9	3.7	2	4.7	2.35
Ice Cr.	3.977	-.113	6.9	8.3	8.1	5	11.3	2.26
Agulowak R.	5.234	-.011	120.4	113.2	123.4	60	162	2.70
Nerka								
Fenno Cr.	2.879	-.141	5.2	6.4	6.5	3	5.7	1.90
Lynx Cr.	2.848	-.210	3.1	4.4	4.5	2	3.7	1.85
Stovall Cr.	1.968	-.051	6.2	7.3	6.2	6	8.7	1.45
Pick Cr.	2.628	-.039	15.8	24.3	24.7	10	17.8	1.78
Little Togiak R.	3.429	-.096	7.8	9.8	10.0	5.5	11.1	2.02
N4-N6 Beach	5.192	-.106	5.5	8.4	8.3	6	10.5	1.75
Hidden Cr.	2.666	-.134	4.1	5.8	6.3	3	5.4	1.80
Kema Cr.	2.101	-.078	9.8	12.7	12.9	4.5	6.7	1.49
Anvil Bay Beach	5.133	-.059	20.1	24.8	23.7	10	28.5	2.85
Agulukpak R.	2.888	-.004	31.0	51.2	88.4	115	212	1.84
Beverley								
B9-B12 Beach	2.180	-.082	7.6	18.1	17.1	4	6.3	1.58
Silver Horn Beach	3.409	-.024	25.4	56.4	59.3	21	43.2	2.06
Hardluck Bay Beach	4.151	-.056	21.4	32.7	30.8	10	23.7	2.37
Mikchalk								
Beaches	2.787	-.041	14.3	21.9	22.8	11	19.5	1.77
Kulik								
Beaches	3.870	-.018	65.7	96.5	92.1	30	67.7	2.26
Grant R.	3.489	-.064	14.5	16.2	14.7	6.5	13.1	2.02
Little Togiak								
Beaches	3.359	-.042	7.6	17.2	19.5	11	23.3	2.12

¹From percentage variance = $\left[\frac{(R-P)^2}{P} \right]$, where P is predicted return.

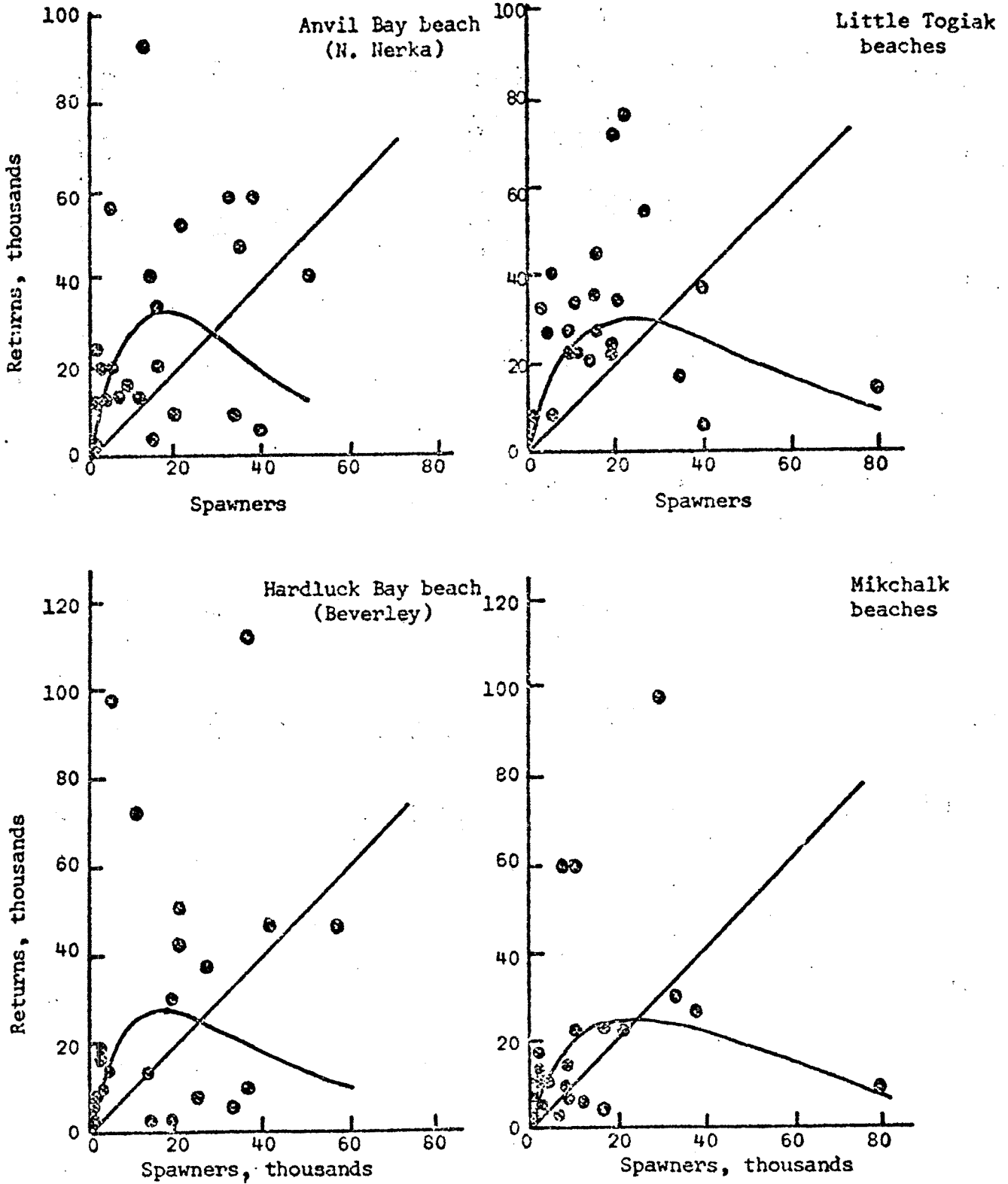


Fig. 21. Spawner-return relationships for four beach spawning areas of the Wood River lakes, 1946-68 brood years.

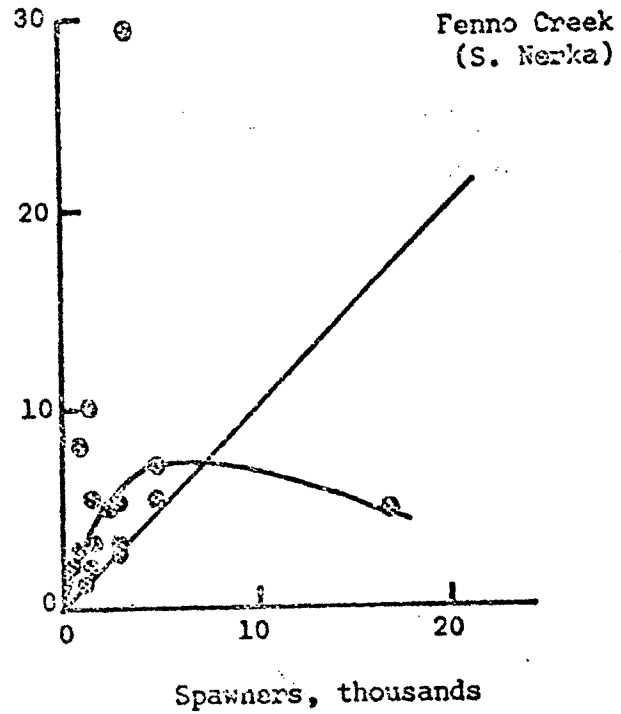
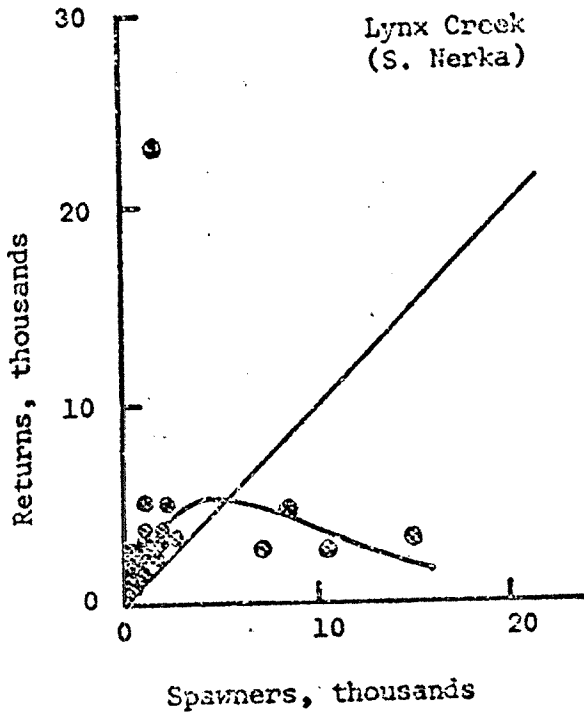
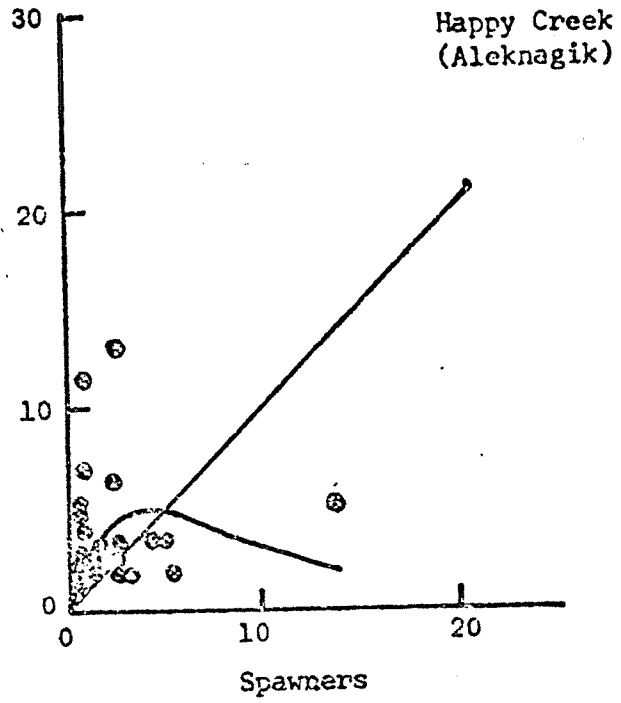
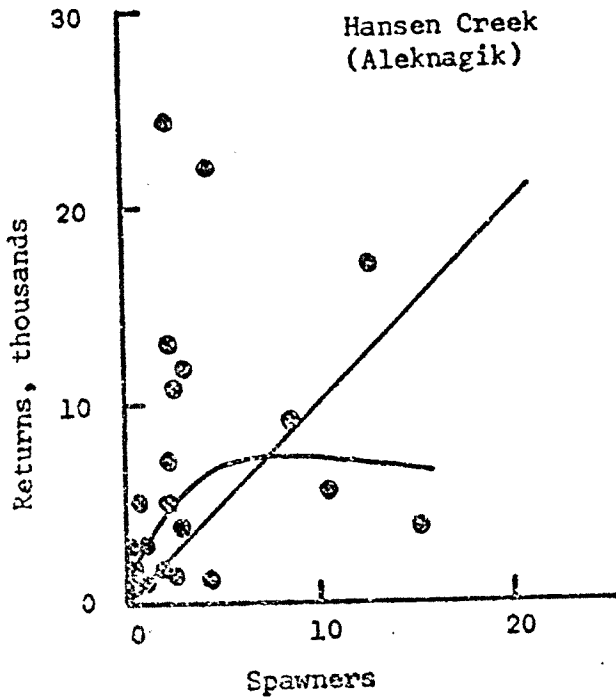


Fig. 22. Spawner-return relationships for four creeks in the Wood River lakes, 1946-68 brood years.

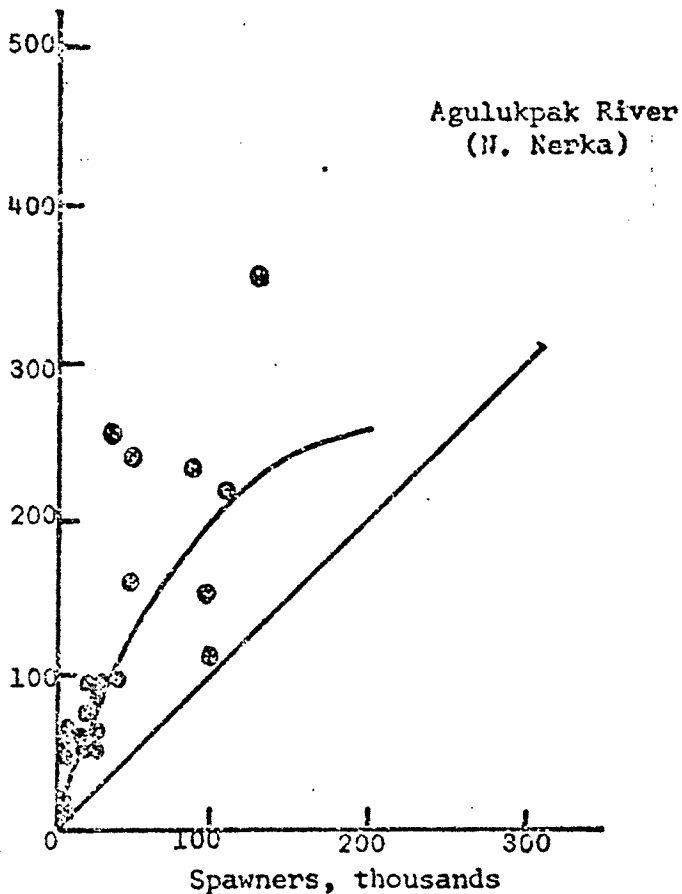
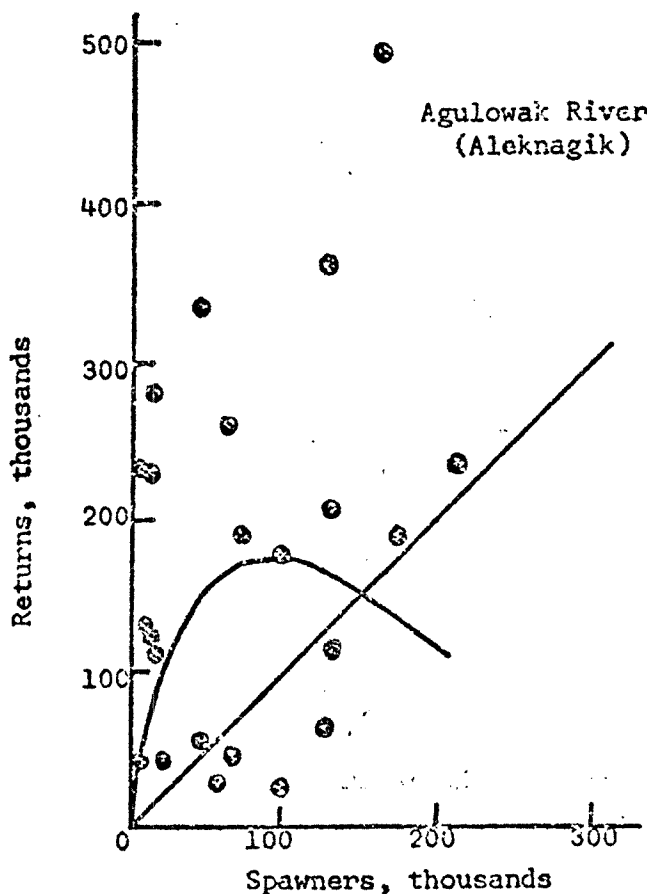
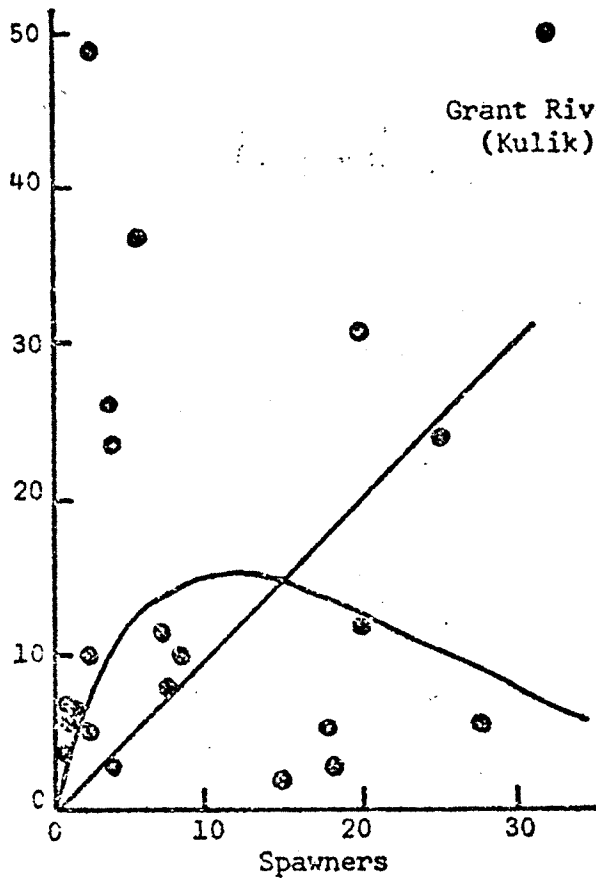
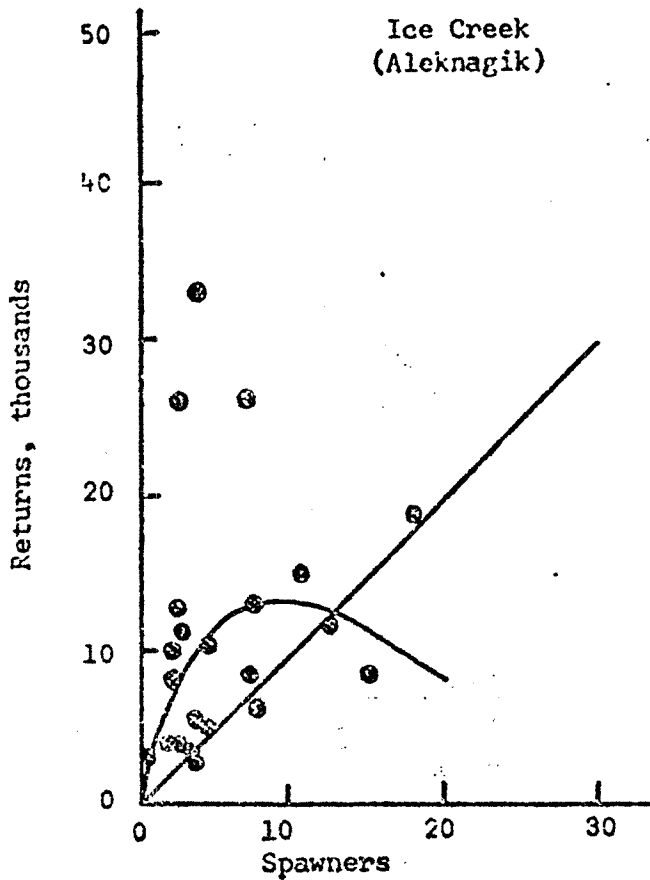


Fig. 23. Spawner-return relationships for one large creek and three inter-connecting rivers of the Wood River lakes, 1946-68 brood years.

Table 19. Linear correlation coefficients in the deviations from spawner-return curves, 1946-68, n = 23 ($r > .45$ significant at .05 level)

Aleknagik

	2	3	4
1. Hansen Cr.	.53	.56	.62
2. Happy Cr.		.79	.64
3. Bear Cr.			.81
4. Ice Cr.			

Nerka, Little Togiak

	6	7	8	9	10	11
5. Fenno Cr.	.89	.88	.74	.61	.50	.63
6. Lynx Cr.		.89	.79	.45	.56	.57
7. Pick Cr.			.89	.67	.70	.55
8. Little Togiak R.				.58	.80	.67
9. N4-N6 B.					.70	n.s.
10. Anvil Bay B.						.50
11. Little Togiak B.						

Beverley, Mikchalk, Kulik

	13	14	15	16	17
12. B9-B12 B.	.93	.93	.89	.72	.61
13. Silver Horn B.		.93	.91	.77	.69
14. Hardluck Bay B.			.89	.80	.69
15. Mikchalk Beaches				.66	.58
16. Kulik Beaches					.92
17. Grant R.					

Nerka

Beverley, Mikchalk, Kulik

	5	6	7	8	9	10	11
12. B9-B12 B.	n.s.	n.s.	n.s.	.48	n.s.	.74	n.s.
13. Silver Horn B.	n.s.	n.s.	n.s.	n.s.	n.s.	.72	n.s.
14. Hardluck Bay B.	n.s.	n.s.	n.s.	.48	.46	.77	n.s.
15. Mikchalk Beach	n.s.	n.s.	.54	.52	.63	.74	n.s.
16. Kulik Beaches	n.s.	n.s.	n.s.	n.s.	n.s.	.67	n.s.
17. Grant R.	n.s.	n.s.	n.s.	n.s.	n.s.	.68	n.s.

Agulupak R.

Agulowak R.

.48

The rates of exploitation that would have been required to obtain optimum number of spawners to individual spawning areas for the runs in 1964-1973 are given in Table 20. The difficulty, if not impossibility, of managing the annual runs to a lake system for achievement of optimum escapement is evident from these data. The best that can be done with the common fishery is to regulate fishing to achieve somewhat optimum escapements for the most abundant populations in the system. During the last ten years, the rate of exploitation on the Wood River run was too low in 1964, 1966, and 1970 for optimum escapements to be achieved on the major spawning grounds. In the other years it is difficult to see how any other rate of exploitation could have been better or worse because some populations had very low runs and others had high.

SUMMARY AND CONCLUSIONS

The catches of sockeye salmon in the Nushagak have declined significantly since the initial buildup of the fishery and this occurred primarily because of a decline in the abundance of the Wood River stock. The selectivity of the gill net fishery has altered the sex and age composition of the spawning stock through differential mortality on the spawning populations (races) in the lake system. Although the fishery undoubtedly affected the productive capacity of the stock, the major declines in abundance were not associated with changes in the quality of spawners but rather with the quantity of spawners. Major declines in the runs followed years of large escapements (descending limb of the spawner-return curve) so that under exploitation in some years probably contributed more to the decline in abundance than did over exploitation.

Because of frequent lack of correlation in the abundance of runs to the individual spawning grounds in the lake system, it is often impossible to achieve optimum escapements to the spawning grounds in a given year. Nevertheless, the average escapements to the spawning grounds have been close to the optimum number and still the returns have declined for the majority of the spawning populations. Presently, the most productive populations per unit size (river spawners) receive the highest rate of exploitation and the least productive per unit size (beach spawners) receive the lowest rate of exploitation. The beach spawning populations appear to offer the greatest potential for increasing the total abundance of the annual runs to the Nushagak fishery; however, such an increase cannot be achieved by regulation of fishing mortality alone.

Methods of management in the freshwater habitat of the sockeye salmon provide the most promising means of achieving an increase in their production. The methods should be developed from information on the early life history of the fish and their interactions with their environment.

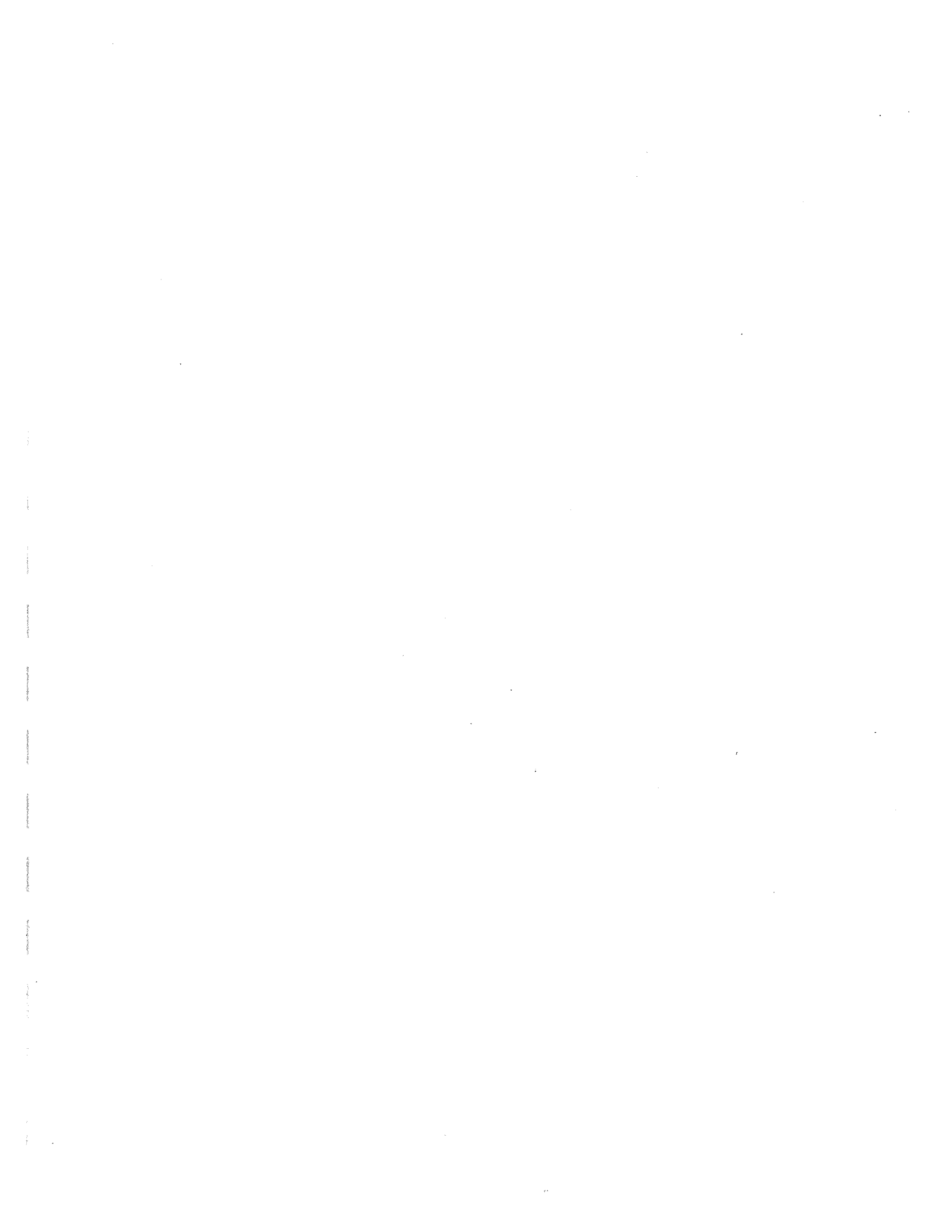
Table 20. Rates of exploitation (%) required to obtain optimum escapements from runs in 1964-73 to the Wood River lakes

Location	Year									
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Aleknagik										
Hansen Cr.	31	45	84	46	15	26	27	0	0	0
Happy Cr.	50	53	65	0	9	29	0	0	0	0
Bear Cr.	68	73	78	52	59	64	51	78	58	0
Ice Cr.	48	75	81	43	.62	49	62	54	50	38
Agulowak R.	60	80	83	61	73	72	86	78	45	62
Nerka										
Fenno Cr.	48	0	36	0	43	60	49	6	17	0
Lynx Cr.	33	0	9	56	43	0	29	63	41	0
Stovall Cr.	71	0	57	0	0	2	33	50	0	0
Pick Cr.	67	17	30	0	0	9	33	0	33	0
Little Togiak R.	82	61	66	60	38	0	71	50	52	0
N4-N6 Beach	70	44	64	14	42	42	66	48	49	0
Hidden Cr.	80	0	0	0	50	19	0	0	0	0
Kema Cr.	60	42	15	0	8	0	0	39	0	0
Anvil Bay Beach	84	53	80	70	22	7	68	74	24	0
Agulukpak R.	0	50	49	0	34	50	46	45	18	0
Beverley										
B9-B12 Beach	61	0	85	66	0	0	37	18	0	0
Silver Horn Beach	85	0	66	31	30	0	61	68	0	0
Hardluck Bay Beach	80	58	64	76	61	0	55	82	21	0
Mikchalk										
Beaches	58	31	25	55	37	0	15	54	0	0
Kulik										
Beaches	87	6	65	72	29	0	46	65	27	0
Grant R.	82	8	47	0	0	0	26	44	0	0
Little Togiak										
Beaches	63	74	70	45	67	65	86	74	45	39
Total run to lake system (1,000's)	2,151	1,143	1,964	1,046	1,010	1,036	1,745	1,438	585	413
Rate of exploitation	50	41	38	51	36	42	33	41	26	20

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APPENDICES



Appendix Table 1. Statistics on escapements and returns for the major Hood River lakes
1. Lake Aleknagik

Year	Escapement (thousands)	Percentage composition					Return (thousands)					Total	
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2		1.3
1946	350	-	-	-	-	-	-	-	76	2	131	0	209
1947	186	-	-	-	-	-	-	0	29	0	65	3	97
1948	155	-	-	-	-	-	-	#	99	1	305	0	405
1949	33	-	-	-	-	-	-	0	.81	0	51	0	132
1950	130	0	0	26.4	8.1	49.3	16.2	0	148	6	261	18	433
1951	92	0.3	0	20.6	0.6	71.1	7.4	0	483	75	269	22	849
1952	67	0.1	0	56.6	0	33.3	0	1	191	3	155	17	367
1953	252	0	0	24.1	0.3	74.7	0.9	0	11	21	64	16	112
1954	134	0	0	81.0	0	19.0	0	0	45	22	123	5	195
1955	493	0.1	0	66.0	0.7	33.2	0	1	160	17	166	43	387
1956	252	0	0	48.7	5.6	44.4	1.3	0	27	1	192	#	220
1957	88	0	0	7.7	0.5	82.4	9.4	0	3	0	61	#	64
1958	63	0.7	0.2	48.2	9.4	40.3	1.2	#	80	#	35	1	116
1959	205	0	0	52.7	6.2	38.2	2.9	#	26	18	136	11	191
1960	85	0	0	20.1	14.2	63.3	2.4	#	176	18	321	33	548
1961	153	0.2	0	1.5	0.1	80.4	17.8	0	36	3	434	24	497
1962	48	0.3	0	68.9	0	30.2	0.6	#	83	#	119	1	203
1963	31	0.1	0	53.0	0.3	46.4	0.2	#	57	2	252	1	312
1964	155	0	0	61.8	5.4	32.7	0.1	0	45	145	82	57	329
1965	220	0.2	0	12.3	4.4	80.9	2.2	0	58	31	395	117	601
1966	287	0.1	0	21.5	0.2	74.3	3.9	#	38	8	216	35	297
1967	92	0	0	32.5	0.1	57.4	9.9	0	14	2	40	0	56
1968	177	0	0	17.1	0.7	82.2	0.1	0	70	1	198	-	270
1969	160	0.1	0	24.4	42.7	32.7	0.1	0	3	-	-	-	-
1970	302	0	0	9.5	7.4	72.0	11.1	#	-	-	-	-	-
1971	182	0	0	5.6	1.7	59.1	33.6	-	-	-	-	-	-
1972	98	0	0	58.3	0.1	28.6	13.0	-	-	-	-	-	-
1973	162	0.1	0	1.7	0.7	97.5	0	-	-	-	-	-	-

Appendix Table 1. Statistics on escapements and returns for the major Wood River lakes - continued

2. South Nerka

Year	Escapement (thousands)	Percentage composition						Return (thousands)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1946	230	-	-	-	-	-	-	-	0	202	3	96	1	302
1947	223	-	-	-	-	-	-	3	0	67	2	27	#	99
1948	235	-	-	-	-	-	-	#	0	66	1	47	0	114
1949	12	-	-	-	-	-	-	#	0	19	0	10	1	30
1950	151	2.2	0	59.7	2.2	35.9	0	0	0	109	61	14	#	184
1951	97	0.1	0	45.8	1.8	49.1	3.2	2	0	121	24	62	1	210
1952	40	0.3	0	74.3	2.6	21.8	1.0	#	0	267	4	51	0	322
1953	44	0	0	30.6	2.2	66.8	0.4	0	0	80	1	53	4	138
1954	87	2.6	0	91.9	0	5.5	-	0	0	206	99	41	21	367
1955	123	0.1	0	66.5	25.0	7.3	1.1	3	#	704	108	172	9	996
1956	205	0	0	84.2	2.5	13.2	0.1	1	0	139	4	27	0	171
1957	73	0	0	65.8	1.0	32.9	0.3	0	0	28	4	19	0	51
1958	163	1.7	0	85.1	0.2	13.0	0.0	1	0	218	0	27	4	250
1959	564	0.2	#	84.8	10.1	4.6	0.3	#	0	72	1	14	1	88
1960	231	0	0	39.4	32.3	24.5	3.8	0	0	189	6	54	9	257
1961	49	1.5	0	47.5	3.0	35.9	12.1	0	0	35	1	34	0	70
1962	97	#	0	95.0	0.2	4.8	0	#	0	173	0	28	0	201
1963	56	0	0	80.3	0	19.7	0	0	0	57	1	15	1	74
1964	110	0	0	94.7	0.5	4.6	0.2	#	0	54	7	11	1	73
1965	60	0.1	0	44.6	4.7	49.9	0.7	#	0	59	1	62	0	122
1966	149	0	0	86.6	0.1	11.4	1.9	1	0	134	3	42	0	180
1967	44	0.6	0	70.7	0	28.7	0	3	0	63	0	5	0	71
1968	46	0.5	0	80.2	0.9	18.4	0	0	0	41	0	8	-	49
1969	51	1.0	0	79.9	6.1	12.8	0.2	0	0	16	-	-	-	-
1970	141	2.1	0	72.6	0.4	24.5	0.4	#	-	-	-	-	-	-
1971	68	0	0	67.6	1.2	31.2	0	-	-	-	-	-	-	-
1972	37	0	0	91.2	0	8.8	0	-	-	-	-	-	-	-
1973	19	1.7	0	65.2	0	33.1	0	-	-	-	-	-	-	-

Appendix Table 1. Statistics on escapements and returns for the major Wood River lakes - continued

3. Central Nerka

Year	Escapement (thousands)	Percentage composition						Return (thousands)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1946	1112	-	-	-	-	-	-	-	0	32	2	96	*	130
1947	318	-	-	-	-	-	-	0	0	45	2	27	*	75
1948	229	-	-	-	-	-	-	0	0	40	*	35	0	75
1949	15	-	-	-	-	-	-	*	0	12	*	10	0	22
1950	41	0	0	33.3	0.2	66.4	0.1	*	0	50	4	24	3	81
1951	45	0	0	66.6	1.4	31.5	0.5	1	0	161	2	16	1	181
1952	29	0.6	0	60.6	1.8	37.0	0.0	0	0	100	0	43	*	143
1953	30	0.2	0	28.1	0.3	71.0	0.4	0	0	60	*	39	3	102
1954	42	2.3	0	87.6	0.3	9.8	0	*	*	62	16	16	3	97
1955	125	0	0	86.4	1.7	11.9	0	2	0	456	28	61	8	555
1956	73	0	0	88.7	0.5	10.0	0.0	0	0	137	2	50	*	189
1957	57	0.1	0	63.4	0	35.9	0.6	0	0	15	*	34	0	49
1958	58	2.9	0.2	70.8	0.1	25.9	0.1	*	0	154	1	39	0	194
1959	332	0	0	93.5	2.9	3.2	0.4	0	0	78	19	65	3	165
1960	137	0	0	65.0	13.8	20.4	0.8	*	0	228	15	64	5	312
1961	50	0.4	0	24.4	1.2	64.3	9.7	*	0	43	2	100	1	146
1962	73	0	0	88.8	0.1	11.0	0.1	*	0	120	1	35	2	158
1963	65	*	0	74.9	0.5	24.6	0	0	0	85	6	80	5	176
1964	159	0.2	0	78.7	6.0	15.1	0	0	0	78	10	15	2	105
1965	77	*	0	43.2	9.4	45.7	1.7	*	0	60	4	43	1	109
1966	141	0	0	63.3	0.3	35.0	1.4	*	0	138	1	72	0	211
1967	64	0	0	73.5	1.0	24.9	0.6	0	0	50	6	14	0	70
1968	103	0.6	0	51.2	3.2	44.5	0.3	*	0	86	*	29	-	115
1969	56	0.4	0	73.0	8.7	16.8	1.1	0	0	7	-	-	-	-
1970	132	0	0	79.1	2.3	17.9	0.7	0	0	-	-	-	-	-
1971	73	0.1	0	49.8	0.2	49.4	0.5	-	-	-	-	-	-	-
1972	82	0	0	87.6	0.5	11.9	0	-	-	-	-	-	-	-
1973	29	0	0	19.0	1.2	79.8	0	-	-	-	-	-	-	-

Appendix Table 1. Statistics on escapements and returns for the major Wood River lakes - continued

4. North Nerka

Year	Escapement (thousands)	Percentage composition						Return (thousands)								
		1.1		2.1		1.2		1.3		2.2		1.3		2.3		Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3			
1946	665	-	-	-	-	-	-	-	0	20	1	40	3	64		
1947	266	-	-	-	-	-	-	0	0	33	*	50	3	86		
1948	466	-	-	-	-	-	-	*	0	86	*	201	0	287		
1949	26	-	-	-	-	-	-	*	0	33	0	20	0	53		
1950	28	0	0	32.6	1.1	58.3	8.0	*	0	116	10	76	9	213		
1951	45	0.3	0	49.1	1.3	43.9	5.4	1	0	285	10	57	2	355		
1952	57	0.3	0	68.8	0.1	29.4	1.4	1	0	165	1	65	1	233		
1953	151	0.1	0	16.3	0.2	82.2	1.2	0	0	35	15	119	2	171		
1954	97	1.3	0	89.3	0	9.4	0	0	*	201	56	39	8	304		
1955	246	0.3	0	78.0	2.0	19.7	0	2	0	497	64	163	61	807		
1956	135	0	0	79.0	1.3	18.6	1.1	0	0	152	5	127	*	284		
1957	52	0	0	40.3	0.4	57.7	1.6	0	0	25	12	88	*	125		
1958	188	1.2	*	71.4	2.4	24.9	0.1	*	0	244	3	103	5	355		
1959	395	0	0	85.6	7.8	6.4	0.2	0	0	106	33	81	13	233		
1960	214	0	0	47.1	26.2	25.1	1.6	1	0	209	25	222	23	480		
1961	143	0.3	0	14.3	1.2	57.0	27.2	0	0	60	5	231	4	300		
1962	126	0	0	81.1	1.9	16.7	0.3	*	0	164	3	85	6	258		
1963	110	0.5	0	60.0	1.6	37.8	0.1	0	0	135	4	180	9	328		
1964	161	0	0	71.1	9.8	18.8	0.3	0	0	63	55	92	3	203		
1965	184	0.1	0	24.1	6.3	66.6	3.0	*	0	273	6	206	11	496		
1966	246	0	0	50.0	0.5	46.2	3.3	1	0	145	1	244	1	392		
1967	114	0	0	64.2	1.3	33.0	1.5	*	0	71	0	52	*	123		
1968	150	0.1	0	28.5	1.7	68.9	0.8	*	0	86	*	97	-	183		
1969	266	0.3	0	69.8	9.8	19.7	0.4	0	0	6	-	-	-	-		
1970	229	0.2	0	47.8	2.0	49.4	0.6	0	-	-	-	-	-	-		
1971	178	*	0	28.7	0.2	68.0	3.1	-	-	-	-	-	-	-		
1972	109	0	0	66.2	0.0	33.5	0.3	-	-	-	-	-	-	-		
1973	83	0	0	5.9	0.2	93.8	0.1	-	-	-	-	-	-	-		

Appendix Table 1. Statistics on escapements and returns for the major Wood River lakes - continued

5. Lake Beverley

Year	Escapement (thousands)	Percentage composition						Return (thousands)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1946	1013	-	-	-	-	-	-	-	0	155	5	167	9	336
1947	496	-	-	-	-	-	-	0	0	64	2	21	#	87
1948	255	-	-	-	-	-	-	0	0	11	0	11	0	22
1949	10	-	-	-	-	-	-	0	0	17	0	6	#	23
1950	82	0	0	84.7	0.8	14.0	0.5	1	0	201	9	30	3	244
1951	131	0	0	32.1	2.0	63.5	2.4	1	0	273	11	50	#	335
1952	16	0	0	29.0	8.0	44.0	19.0	0	0	48	0	2	0	50
1953	21	2.7	0	62.8	0	32.1	2.4	0	0	8	9	19	9	45
1954	152	0.5	0	97.5	0	2.0	0	1	2	505	255	29	11	803
1955	203	0	0	88.7	2.2	9.0	0.1	3	0	370	209	25	1	608
1956	56	0	0	56.6	3.5	38.9	1.0	0	0	83	1	19	#	103
1957	6	8.6	0	79.0	0	11.4	1.0	0	0	20	19	10	3	52
1958	354	0.8	0.6	95.7	0.8	2.1	0	2	2	947	80	74	11	1116
1959	414	0	0	60.8	34.2	4.4	0.6	1	1	311	190	46	5	552
1960	211	0	0	26.1	68.0	3.7	2.2	1	0	389	8	46	0	444
1961	32	4.9	0	52.9	1.4	38.5	2.3	#	0	46	4	21	1	72
1962	411	0.2	0.2	97.2	1.8	0.6	0	0	0	352	73	63	9	497
1963	281	0.2	0.5	69.3	18.1	10.7	1.2	0	0	102	20	90	#	212
1964	324	#	0	66.7	28.0	5.1	0.2	0	0	67	11	10	1	89
1965	67	0	0	52.6	6.2	38.0	3.2	0	0	19	1	3	1	24
1966	276	0	0	96.0	0.3	3.7	0	2	1	307	1	56	0	367
1967	117	0	0	48.0	27.8	23.8	0.4	#	0	239	10	10	0	318
1968	112	0	0	40.9	10.4	46.3	2.4	0	0	54	#	5	-	59
1969	27	9.1	0	47.5	18.9	24.3	0.2	0	0	9	-	-	-	-
1970	238	0.2	0.3	98.4	0.3	0.6	0.2	1	-	-	-	-	-	-
1971	245	0	0	88.1	0.2	11.5	0.2	-	-	-	-	-	-	-
1972	53	0	0	88.7	0.4	10.9	0	-	-	-	-	-	-	-
1973	12	5.5	0	60.2	4.0	30.3	0	-	-	-	-	-	-	-

Appendix Table 1. Statistics on escapements and returns for the major Wood River lakes - continued

6. Lake Kulik

Year	Escapement (thousands)	Percentage composition						Return (thousands)							
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total	
1946	215	-	-	-	-	-	-	-	-	0	27	6	46	6	85
1947	195	-	-	-	-	-	-	0	0	0	15	2	18	*	35
1948	100	-	-	-	-	-	-	0	0	0	7	1	8	0	16
1949	4	-	-	-	-	-	-	0	0	0	1	0	2	0	3
1950	14	0	0	86.9	0.8	11.5	0.8	*	0	0	46	10	15	4	75
1951	40	0	0	23.9	10.9	57.5	7.7	*	0	0	203	20	21	1	245
1952	12	0	0	24.6	11.6	51.5	12.3	0	0	0	26	1	4	2	33
1953	7	1.4	0	18.3	5.0	73.2	2.1	0	0	0	4	11	16	0	31
1954	35	1.1	0	98.1	0	0.8	0	*	10	113	300	4	4	7	434
1955	153	0	0	89.5	4.3	6.2	0	3	1	102	86	8	8	1	201
1956	30	0	0	54.8	13.4	29.5	2.3	0	0	62	3	17	17	0	82
1957	5	2.2	0	52.4	3.9	38.0	3.5	0	0	8	2	10	10	0	20
1958	100	3.1	9.6	77.1	3.7	6.3	0.2	*	0	190	5	15	15	0	210
1959	283	0	0.5	29.0	69.4	1.1	0	0	1	214	103	35	35	1	354
1960	105	0	0	39.4	55.6	2.4	2.6	0	0	132	10	16	16	2	160
1961	19	2.2	0	36.0	4.8	54.8	2.2	0	0	18	2	19	19	0	39
1962	83	0	0	96.8	0.2	3.0	0	0	0	83	22	25	25	0	130
1963	144	0	0.5	93.0	2.4	4.1	0	0	*	75	29	14	14	3	121
1964	135	0	0	53.4	37.1	9.5	0	0	0	8	11	3	3	0	22
1965	28	0	0	49.2	17.2	32.2	1.4	0	0	13	1	*	*	0	14
1966	73	0	0	85.8	0.8	12.5	0.9	1	0	71	0	21	21	0	93
1967	61	0	*	66.2	15.6	18.2	0	*	0	76	6	8	8	0	90
1968	31	0	0	18.3	55.5	26.2	0	0	0	32	*	2	2	-	34
1969	17	6.1	0	50.4	31.1	10.8	1.6	0	0	8	-	-	-	-	-
1970	55	0.5	0	97.9	1.3	0.3	0	1	-	-	-	-	-	-	-
1971	66	0	0	83.9	0	16.1	0	-	-	-	-	-	-	-	-
1972	33	0	0	80.3	3.7	16.0	0	-	-	-	-	-	-	-	-
1973	10	5.6	0	70.8	4.1	19.5	0	-	-	-	-	-	-	-	-

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system

1. Hansen Creek (Aleknagik)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	
1947	14	0	0	36.2	0	63.8	0	0	0	14	0	10	0	24
1948	8	0	0	42.6	0	57.4	0	*	0	16	*	9	0	25
1949	8	2.0	0	62.5	0	37.5	0	*	0	11	0	6	0	17
1950	23	0	0	83.9	1.8	11.2	3.1	*	0	116	1	9	3	129
1951	25	0.9	0	37.3	2.0	56.5	3.3	0	0	179	28	35	*	242
1952	11	0.9	0	57.0	0	32.1	0	*	0	38	0	13	0	51
1953	14	0.9	0	60.7	0.6	37.8	0	0	0	1	4	*	1	7
1954	88	0	0	96.7	0	3.3	0	*	*	51	24	18	1	94
1955	128	0.4	0	94.5	0.5	4.6	0	1	0	117	29	21	3	171
1956	45	0	0	54.1	12.0	32.8	1.1	0	0	3	0	4	0	7
1957	7	0.4	0	9.5	0	87.3	2.8	0	*	*	0	2	0	3
1958	37	2.6	0.5	93.3	3.2	0.4	0	*	0	114	0	5	*	119
1959	105	0	0	75.8	12.8	11.0	0.4	*	0	39	5	9	1	54
1960	29	0	0	7.1	68.0	24.3	0.6	0	0	37	16	44	12	109
1961	5	3.0	1.2	6.0	0.2	53.0	36.6	0	0	3	4	10	0	17
1962	49	0.8	0	98.1	0	1.1	0	1	0	196	*	22	1	220
1963	26	0	0	92.8	0	7.2	0	*	0	43	4	27	*	74
1964	26	0	0	77.2	9.9	12.5	0.4	0	0	9	31	2	6	48
1965	36	4.2	0	5.7	22.0	67.5	0.6	0	0	14	10	9	6	39
1966	157	0.2	0	93.2	0.7	3.2	2.7	*	0	23	3	11	*	37
1967	33	0	0	70.5	0.4	29.1	0	0	0	5	0	2	0	7
1968	24	0	0	25.7	9.0	64.3	1.0	*	0	20	*	1	-	11
1969	29	0.4	0	29.9	64.1	5.0	0.6	0	0	1	-	-	-	-
1970	32	0	0	55.4	22.2	15.2	7.2	-	-	-	-	-	-	-
1971	13	0.4	0	23.3	17.2	37.6	21.5	-	-	-	-	-	-	-
1972	8	0	0	89.9	0	9.7	0.4	-	-	-	-	-	-	-
1973	2	0	0	49.7	0.7	49.6	0	-	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

2. Happy Creek (Aleknagik)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1946	140	-	-	-	-	-	-	0	0	16	0	34	0	50
1947	10	-	-	-	-	-	-	0	0	7	0	13	0	20
1948	5	-	-	-	-	-	-	0	0	12	0	8	0	20
1949	7	-	-	-	-	-	-	0	0	19	0	32	0	51
1950	24	0	0	29.6	19.8	16.9	33.7	0	0	39	5	16	2	62
1951	25	0	0	19.3	0	66.9	13.8	0	0	51	35	32	12	130
1952	10	0	0	55.3	0	44.7	0	0	0	56	1	57	*	114
1953	19	0	0	74.8	0	25.2	0	0	0	6	7	3	2	18
1954	44	0	0	64.5	0	35.5	0	0	*	10	5	16	*	31
1955	47	0	0	72.7	5.6	21.7	0	*	0	23	2	4	3	32
1956	57	0	0	63.5	11.8	24.0	0.7	0	0	6	*	11	0	17
1957	35	0	0	10.4	0.6	75.6	13.4	0	*	1	0	16	*	17
1958	10	0.6	1.3	63.5	20.6	11.7	2.3	0	0	8	0	12	0	20
1959	30	0	0	52.7	10.0	34.3	3.0	0	0	4	7	13	2	26
1960	7	0	0	57.7	21.4	19.7	1.2	0	0	20	10	18	0	49
1961	10	0	0.4	9.4	1.1	71.4	17.7	0	0	13	0	54	*	67
1962	7	0	0	45.8	0	54.2	0	0	0	3	*	7	1	11
1963	8	0	0	35.9	0	63.5	0.6	0	0	13	2	14	0	29
1964	19	0	0	58.7	16.4	24.9	0	0	0	5	18	7	*	30
1965	26	0	0	37.9	19.7	38.5	3.9	0	0	3	4	4	2	13
1966	29	0	0	9.2	0	90.8	0	0	0	5	*	10	2	17
1967	10	0	0	67.2	0.6	30.9	1.3	*	0	2	0	7	0	9
1968	13	0	0	25.9	9.3	63.8	1.0	0	0	9	0	2	-	11
1969	17	0	0	10.0	64.7	25.3	0	0	0	1	-	-	-	-
1970	10	0.9	0	41.1	25.5	21.1	11.4	*	-	-	-	-	-	-
1971	7	0	0	17.7	4.3	62.3	15.7	-	-	-	-	-	-	-
1972	10	0	0	64.6	0	26.9	8.5	-	-	-	-	-	-	-
1973	2	9.8	0	27.6	0	62.6	0	-	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

4. Ice Creek (Aleknagik)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)					Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3				
1946	153	-	-	-	-	-	-	0	0	0	0	22	0	66	0	88	
1947	25	-	-	-	-	-	-	0	0	0	0	6	0	35	0	41	
1948	-	-	-	-	-	-	-	0	0	0	0	36	0	64	0	100	
1949	2	-	-	-	-	-	-	0	0	0	0	7	0	25	0	32	
1950	77	0	0	12.9	7.2	67.4	12.5	0	0	0	0	20	0	66	0	86	
1951	40	0	0	9.0	0	82.2	8.8	0	0	0	0	206	0	118	9	333	
1952	28	0	0	57.6	0	42.4	0	0	0	0	0	46	1	62	2	111	
1953	45	0	0	12.4	0	87.6	0	0	0	0	0	4	4	34	3	45	
1954	27	0	0	54.6	0	45.4	0	0	0	0	0	10	4	14	4	32	
1955	180	0	0	77.1	0	22.9	0	0	0	0	0	44	11	127	5	187	
1956	80	0	0	37.0	0	63.0	0	0	0	0	0	29	*	35	*	64	
1957	35	0	0	7.7	0.5	82.4	9.4	0	0	0	0	2	0	28	*	30	
1958	22	0	0	29.4	5.1	61.3	4.2	0	0	0	0	36	0	47	18	101	
1959	42	0	0	70.5	5.5	21.6	2.4	0	0	0	0	17	*	9	4	31	
1960	70	0	0	27.0	11.2	59.5	2.3	0	0	0	0	63	14	153	24	260	
1961	27	0	0	5.3	0.5	82.3	11.9	0	0	0	0	29	0	223	9	261	
1962	22	0.3	0	68.8	0	30.3	0.6	0	0	0	0	12	*	74	0	86	
1963	30	0	0	35.9	0	63.5	0.6	0	0	0	0	14	1	111	1	127	
1964	48	0	0	78.4	0.4	7.2	14.0	0	0	0	0	21	28	38	15	102	
1965	115	0	0	18.9	6.2	73.5	1.4	0	0	0	0	31	12	97	13	153	
1966	127	0	0	7.0	0	86.6	6.4	0	0	0	0	7	1	92	23	123	
1967	44	0	0	17.4	0.5	74.6	7.5	0	0	0	0	2	0	52	0	54	
1968	79	0	0	17.9	1.0	81.1	0	0	0	0	0	48	0	79	-	127	
1969	61	0.5	0	31.4	27.4	39.6	1.1	0	0	0	0	2	-	-	-	-	
1970	71	0	0	7.5	11.4	73.1	8.0	*	-	-	-	-	-	-	-	-	
1971	51	0	0	2.5	1.1	83.2	13.2	-	-	-	-	-	-	-	-	-	
1972	66	0	0	52.3	0	31.2	16.5	-	-	-	-	-	-	-	-	-	
1973	66	0.3	0	2.1	0	97.6	0	-	-	-	-	-	-	-	-	-	

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

5. Agulowak River (Aleknagik)

Year	Escapement (thousands)	Percentage composition										Returns (thousands)					Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3				
1946	60	-	-	-	-	-	-	0	0	4	0	25	0	29			
1947	100	0	0	25.2	0	74.8	0	0	0	4	0	14	3	21			
1948	75	0	0	10.0	0	90.0	0	0	0	19	1	170	0	190			
1949	5	0	0	15.8	9.9	74.3	0	0	0	.28	0	15	0	43			
1950	13	0	0	11.9	0	67.6	20.5	0	0	12	2	198	15	227			
1951	16	0	0	14.9	0	77.1	6.0	0	0	125	13	127	15	280			
1952	13	0	0	64.8	0	35.2	0	0	0	64	1	63	*	128			
1953	129	0	0	16.5	0.6	81.3	1.6	0	0	4	13	36	15	68			
1954	16	0	0	54.1	0	45.9	0	0	0	10	7	103	3	123			
1955	210	0	0	40.2	0.6	59.2	0	0	0	80	3	111	36	230			
1956	100	0	0	41.0	2.5	54.0	2.5	0	0	10	0	162	*	172			
1957	48	0	0	5.5	0.5	82.4	11.6	0	0	1	0	52	0	53			
1958	25	0	0	27.8	15.6	56.2	0.4	0	0	17	*	23	0	40			
1959	129	0	0	42.3	2.9	50.7	4.1	0	0	8	6	94	9	117			
1960	46	0	0	13.6	3.8	79.6	3.0	0	0	50	5	257	21	333			
1961	127	0	0	0.4	0	81.7	17.9	0	0	22	0	320	21	363			
1962	20	0	0	35.9	0	61.7	1.4	0	0	15	0	93	0	108			
1963	14	0	0	23.6	0.6	65.8	0	0	0	38	0	194	0	232			
1964	65	0	0	41.8	4.2	54.0	0	0	0	26	93	70	71	260			
1965	165	0	0	9.9	1.6	86.1	2.4	0	0	49	12	330	107	498			
1966	176	0	0	6.5	0	69.5	4.0	0	0	10	1	158	18	187			
1967	70	0	0	29.4	0	58.9	11.7	0	0	3	0	44	0	47			
1968	180	0	0	13.9	0	86.1	0	0	0	47	1	156	-	204			
1969	130	0	0	23.2	42.7	34.1	0	0	0	2	-	-	-	-			
1970	220	0	0	3.3	3.8	80.6	12.3	0	-	-	-	-	-	-			
1971	130	0	0	1.4	0.6	56.0	42.0	-	-	-	-	-	-	-			
1972	60	0	0	56.4	0	29.3	14.3	-	-	-	-	-	-	-			
1973	130	0	0	1.0	0.4	98.6	0	-	-	-	-	-	-	-			

*Less than 500 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

6. Fenno Creek (South Nerka)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)					Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3				
1951	17	0.5	0	43.9	0	55.6	0	2	0	53	*	1	0	56			
1952	11	1.3	0	66.2	0	32.5	0	0	0	72	0	9	0	81			
1953	12	0	0	34.4	0	65.6	0	0	0	10	1	17	0	28			
1954	16	9.5	0	81.1	0	9.4	0	0	*	14	0	0	0	14			
1955	37	0	0	96.6	0	3.4	0	3	0	248	18	26	2	297			
1956	50	0	0	93.1	0.9	6.0	0	1	0	44	*	11	0	57			
1957	10	0	0	59.7	0	40.3	0	0	0	7	0	5	0	12			
1958	19	15.8	0.5	47.7	1.1	34.9	0	*	0	18	0	15	1	34			
1959	170	0.8	0	99.2	0	0	0	*	0	40	*	5	*	45			
1960	50	0	0	58.0	24.6	17.4	0	0	*	52	3	15	2	72			
1961	14	0.7	0	40.9	0.7	49.9	7.8	0	0	8	*	12	0	20			
1962	9	0.8	0	85.4	0	13.8	0	0	0	23	0	4	0	27			
1963	31	0	0	79.9	0	20.1	0	0	0	13	1	13	*	28			
1964	31	0	0.4	92.8	0.4	5.8	0.6	*	0	39	5	7	1	52			
1965	16	0	0	36.7	8.9	53.4	1.0	0	0	63	1	36	0	100			
1966	24	0	0	72.2	0.4	25.0	2.4	0	0	36	1	17	0	54			
1967	9	1.7	0	80.5	0	17.8	0	*	0	14	0	6	0	20			
1968	35	0	0	76.5	1.5	22.0	0	0	0	30	0	2	-	32			
1969	46	0	0	83.3	6.4	9.9	0.4	0	0	3	-	-	-	-			
1970	48	0.5	0	57.4	1.0	40.6	0.5	0	-	-	-	-	-	-			
1971	18	0	0	51.5	4.5	44.0	0	-	-	-	-	-	-	-			
1972	24	0	0	90.6	0	9.4	0	-	-	-	-	-	-	-			
1973	4	0	0	65.7	0	34.3	0	-	-	-	-	-	-	-			

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

7. Lynx Creek (South Nerka)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)					Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3				
1946	75	-	-	-	-	-	-	0	0	7	0	15	1	23			
1947	104	-	-	-	-	-	-	*	0	16	2	6	1	25			
1948	88	-	-	-	-	-	-	0	0	25	0	16	0	41			
1949	5	-	-	-	-	-	-	0	0	3	0	*	0	3			
1950	5	2.2	0	59.7	2.2	35.9	0	0	0	6	0	1	1	8			
1951	18	0	0	59.0	0	41.0	0	*	0	29	1	5	0	35			
1952	15	0	0	76.2	6.3	14.5	3.0	*	0	29	0	3	0	32			
1953	12	0	0	14.8	0	82.8	2.4	0	0	5	0	7	0	12			
1954	5	3.1	0	93.9	0	3.0	0	0	0	9	16	2	0	27			
1955	20	0.9	0	96.2	0	2.9	0	1	0	206	11	14	0	232			
1956	21	0	0	87.6	0.9	10.8	0.7	0	0	27	0	*	0	27			
1957	4	0	0	67.2	0	32.8	0	0	0	1	*	6	0	7			
1958	10	12.8	0	59.3	0	27.9	0	*	0	18	0	3	*	21			
1959	150	0	0	93.2	5.8	1.0	0	0	0	24	*	5	*	29			
1960	30	0	0	59.0	25.7	15.3	0	0	0	25	1	7	0	33			
1961	1	29.0	0	44.0	0	27.0	0	0	0	6	1	4	0	11			
1962	9	0	0	82.7	0.6	16.7	0	*	0	17	0	5	0	23			
1963	16	0	0	93.0	0	7.0	0	0	0	40	*	9	0	49			
1964	16	0	0	87.5	1.4	10.5	0.6	0	0	26	1	4	0	31			
1965	9	0.5	0	52.9	3.4	42.6	0.6	*	0	15	*	4	0	19			
1966	15	0	0	85.6	0.6	13.8	0	*	0	24	0	13	0	37			
1967	24	0	0	90.1	0	9.9	0	*	0	41	0	5	0	46			
1968	23	1.0	0	76.4	1.0	21.6	0	0	0	29	0	3	-	32			
1969	13	2.2	0	71.3	4.7	21.8	0	0	0	3	-	-	-	-			
1970	21	1.0	0	88.8	0.5	9.7	0	0	0	-	-	-	-	-			
1971	33	0	0	82.4	0	17.6	0	-	-	-	-	-	-	-			
1972	23	0	0	92.1	0	7.9	0	-	-	-	-	-	-	-			
1973	5	0	0	47.3	0	52.7	0	-	-	-	-	-	-	-			

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

8. Stovall Creek (South Merka)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	
1952	-	-	-	-	-	-	-	-	0	321	1	16	0	338
1953	-	-	-	-	-	-	-	0	0	12	0	4	0	16
1954	-	-	-	-	-	-	-	0	0	11	105	55	5	176
1955	-	-	-	-	-	-	-	*	0	965	35	32	4	1,036
1956	210	0	98.6	0	1.4	0	0	0	0	20	6	5	0	31
1957	15	0	47.9	1.7	50.4	0	0	0	0	12	0	5	0	17
1958	9	1.9	82.2	0	15.9	0	*	0	0	65	0	22	0	88
1959	750	0	87.5	7.8	4.7	0	0	0	0	45	1	10	*	56
1960	50	0	26.7	40.4	21.0	3.9	0	0	0	198	1	18	6	223
1961	20	2.1	51.2	10.2	24.8	11.7	0	0	0	12	0	13	0	25
1962	29	0	95.9	0	4.1	0	0	0	0	122	0	16	0	138
1963	37	0	75.6	0	24.4	0	0	0	0	13	0	4	0	17
1964	113	0	93.4	0.4	3.2	0	*	0	0	30	4	8	1	43
1965	20	0	46.6	2.5	50.3	0.6	*	0	0	48	0	24	0	72
1966	99	0	91.8	0	6.2	2.0	1	0	0	63	0	64	0	128
1967	14	0.5	49.3	0	50.2	0	2	0	0	57	0	2	0	61
1968	23	1.0	89.4	0	9.6	0	0	0	0	11	0	0	0	11
1969	37	1.7	78.8	6.3	13.2	0	0	0	0	3	-	-	-	-
1970	64	3.5	76.3	0	19.7	0.5	*	-	-	-	-	-	-	-
1971	67	0	56.1	0	43.9	0	-	-	-	-	-	-	-	-
1972	9	0	90.8	0	9.2	0	-	-	-	-	-	-	-	-
1973	3	7.0	93.0	0	0	0	-	-	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

9. Pick Creek (Central Nerka)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	
1946	358	-	-	-	-	-	-	0	0	30	1	23	0	54
1947	81	0	0	64.5	0	35.5	0	0	0	52	1	28	0	81
1948	77	0.5	0	16.4	0	83.1	0	0	0	31	*	31	0	62
1949	4	0	0	50.9	0	49.1	0	*	0	.7	*	1	0	9
1950	39	0	0	34.2	0	65.8	0	*	0	41	2	21	7	71
1951	47	0	0	73.0	1.9	24.5	0.6	1	0	176	0	4	1	182
1952	24	0.5	0	58.5	1.0	40.0	0	0	0	150	0	53	0	203
1953	25	0.4	0	23.3	0.7	75.6	0	0	0	33	1	20	11	65
1954	32	4.5	0	93.4	0.6	1.5	0	*	*	88	16	32	0	136
1955	133	0	0	89.2	0.9	9.9	0	3	0	1,101	24	104	4	1,236
1956	100	0	0	97.0	0	1.8	1.2	0	0	304	0	49	*	353
1957	45	0.4	0	44.3	0	54.6	0.7	0	0	7	1	43	0	51
1958	71	4.8	0.5	83.3	0.4	11.0	0	1	0	259	1	38	0	299
1959	782	0	0	95.0	1.1	2.6	0.5	0	0	129	7	42	*	179
1960	250	0	0	79.9	6.5	13.6	0	*	0	257	12	60	2	331
1961	40	1.5	0	13.8	0	76.0	6.7	0	0	48	*	47	1	96
1962	120	0	0	91.0	0.3	8.5	0.2	*	0	94	1	20	0	116
1963	97	0.1	0	83.4	0.5	16.0	0	0	0	53	3	30	*	86
1964	160	0	0	88.1	2.1	9.8	0	0	0	64	8	11	1	84
1965	76	0.5	0	47.5	7.8	44.0	0.2	1	0	91	2	20	*	114
1966	94	0	0	74.7	0.1	24.5	0.7	*	0	127	0	62	0	189
1967	39	0	0	74.4	1.6	22.6	1.4	0	0	33	0	23	0	56
1968	63	1.0	0	68.7	2.8	27.5	0	*	0	127	*	21	-	148
1969	68	0.2	0	81.6	7.2	10.7	0.3	0	0	9	-	-	-	-
1970	110	0	0	88.6	1.1	10.1	0.2	0	-	-	-	-	-	-
1971	51	0.4	0	43.0	0	56.3	0.3	-	-	-	-	-	-	-
1972	101	0	0	91.1	0	8.9	0	-	-	-	-	-	-	-
1973	25	0	0	28.1	1.5	70.4	0	-	-	-	-	-	-	-

*Less than 50 fish

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

10. Little Togiak River (Central Nerka)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1946	30	-	-	-	-	-	-	-	0	2	0	5	0	7
1947	30	-	-	-	-	-	-	0	0	7	#	2	#	9
1948	30	-	-	-	-	-	-	0	0	9	0	8	0	17
1949	2	-	-	-	-	-	-	#	0	4	0	6	0	10
1950	15	0	0	5.8	1.6	91.3	1.3	0	0	10	0	5	0	15
1951	7	0	0	62.8	0	37.2	0	0	0	25	5	5	0	35
1952	5	1.8	0	82.0	3.5	12.7	0	0	0	42	0	7	#	49
1953	8	0	0	37.4	0	60.0	2.6	0	0	11	0	12	0	23
1954	10	0	0	72.4	0	27.6	0	#	#	21	21	9	2	53
1955	20	0	0	84.8	0	15.2	0	1	0	268	24	110	9	412
1956	30	0	0	89.2	3.3	7.5	0	0	0	71	4	32	0	107
1957	10	0.9	0	66.4	0	32.7	0	0	0	6	0	27	0	33
1958	20	5.6	0.5	68.9	0	24.3	0.7	0	0	56	0	85	0	141
1959	200	0	0	91.3	5.8	2.9	0	0	0	89	23	71	1	184
1960	100	0	0	46.7	16.2	36.1	1.0	0	0	204	11	75	2	292
1961	33	0	0	16.0	3.7	62.4	17.9	1	0	54	3	116	0	174
1962	30	0	0	79.0	0	21.0	0	0	0	42	1	50	1	94
1963	90	0	0	61.6	0	38.4	0	0	0	87	1	45	0	133
1964	150	0.5	0	74.6	7.4	17.5	0	0	0	41	4	8	5	58
1965	89	0	0	46.2	6.4	46.8	0.6	0	0	43	6	60	2	111
1966	90	0	0	35.2	1.0	63.2	0.6	0	0	119	0	67	0	186
1967	70	0	0	68.2	0.4	31.4	0	0	0	42	0	24	0	66
1968	55	0	0	51.2	1.0	47.3	0.5	0	0	90	#	50	-	140
1969	33	0	0	78.7	6.9	14.4	0	0	0	5	-	-	-	-
1970	130	0	0	70.4	3.4	24.7	1.5	0	0	-	-	-	-	-
1971	60	0	0	46.2	0	51.8	2.0	0	0	-	-	-	-	-
1972	75	0	0	87.2	0	12.8	0	0	0	-	-	-	-	-
1973	45	0	0	8.9	0.4	90.7	0	0	0	-	-	-	-	-

#Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

11. Hidden Lake Creek (North Nerka)

Year	Escapement (hundreds)	Percentage composition									Return (hundreds)								
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3
1951	9	0.9	0	60.8	2.7	33.8	1.8	*	0	66	0	5	1	72					
1952	11	0	85.2	0	14.8	0	0	0	0	45	0	5	0	50					
1953	8	0	21.3	2.5	76.2	0	0	0	0	.4	0	3	0	8					
1954	7	2.3	0	92.6	0	5.1	0	*	12	3	2	0	17						
1955	45	0	99.0	0	1.0	0	1	0	235	8	8	0	252						
1956	32	0	91.5	0	6.7	1.8	0	0	109	0	6	0	115						
1957	5	0	51.8	0	44.4	3.8	0	0	3	0	4	0	7						
1958	10	5.7	0.5	80.7	0	13.1	0	0	46	0	11	0	59						
1959	163	0	98.3	1.1	0.6	0	0	0	31	0	2	0	33						
1960	20	0	89.9	6.8	3.3	0	*	0	148	3	5	*	156						
1961	6	0	39.5	0	60.5	0	0	0	8	0	3	0	11						
1962	21	0	95.7	0	4.3	0	0	0	11	*	4	0	15						
1963	24	1.7	0	79.2	0	19.1	0	0	21	*	6	0	27						
1964	82	0	99.0	0	1.0	0	0	0	54	6	3	1	64						
1965	10	0	60.4	12.9	26.3	0	*	0	28	1	9	0	38						
1966	10	0	83.0	0	15.5	1.5	0	0	14	0	4	0	18						
1967	13	0	86.5	0.6	12.9	0	*	0	8	0	2	0	10						
1968	40	0.5	0	90.9	0.5	8.1	0	*	23	0	0	-	23						
1969	23	0	74.1	16.3	9.6	0	0	0	1	-	-	-	-						
1970	17	1.0	0	62.9	4.1	29.6	2.4	0	-	-	-	-	-						
1971	7	3.7	0	70.3	0	26.0	0	-	-	-	-	-	-						
1972	17	0	95.4	0	3.6	0	-	-	-	-	-	-	-						
1973	1	0	-	-	-	-	-	-	-	-	-	-	-						

less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

12. Kema Creek (North Nerka)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)					Total			
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	1.2	2.2	1.3		2.3		
1952	-	-	-	-	-	-	-	-	-	-	-	-	-	0	69	1	17	0	0	87
1953	-	-	-	-	-	-	-	-	-	-	-	-	-	0	13	4	63	0	0	80
1954	-	-	-	-	-	-	-	-	-	-	-	-	-	0	106	54	3	3	3	167
1955	150	-	-	-	-	-	-	-	-	-	-	-	-	0	247	137	34	1	1	421
1956	53	0	0	83.7	4.8	10.6	0.9	0	0	0	0	0	0	0	70	0	11	0	0	81
1957	15	0	0	51.7	0.7	46.9	0.7	0	0	0	0	0	0	0	14	0	16	0	0	30
1958	100	2.4	0.5	71.2	1.2	24.7	0	1	0	0	0	0	0	0	346	1	25	0	0	373
1959	200	0	0	84.0	15.1	0.9	0	0	0	0	0	0	0	0	21	10	9	0	0	40
1960	152	0	0	30.2	61.7	7.3	0.8	0	0	0	0	0	0	0	94	13	24	1	1	132
1961	20	3.5	0	59.7	0	33.8	3.0	0	0	0	0	0	0	0	40	2	19	0	0	61
1962	150	0	0	97.4	0	2.6	0	0	0	0	0	0	0	0	31	1	2	0	0	34
1963	24	0	0	53.0	4.1	42.9	0	0	0	0	0	0	0	0	36	1	19	0	0	56
1964	60	0	0	86.0	8.3	5.7	0	0	0	0	0	0	0	0	29	1	5	0	0	35
1965	50	0	0	60.4	12.9	26.7	0	0	0	0	0	0	0	0	35	1	10	0	0	46
1966	33	0	0	69.6	1.6	27.8	1.0	0	0	0	0	0	0	0	20	0	22	0	0	42
1967	21	0	0	93.8	1.2	5.0	0	0	0	0	0	0	0	0	52	0	2	*	0	54
1968	31	0	0	63.2	1.5	35.3	0	0	0	0	0	0	0	0	14	0	3	-	-	17
1969	25	0	0	85.9	1.4	12.7	0	0	0	0	0	0	0	0	4	-	-	-	-	-
1970	21	0	0	73.0	2.0	25.0	0	0	0	0	0	0	0	0	-	-	-	-	-	-
1971	44	0	0	77.1	0	22.9	0	0	0	0	0	0	0	0	-	-	-	-	-	-
1972	11	0	0	92.7	0	7.3	0	0	0	0	0	0	0	0	-	-	-	-	-	-
1973	5	0	0	57.1	0	41.8	1.1	0	0	0	0	0	0	0	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued
 13. Agulukpak River (North Nerka)

Year	Escapement (thousands)	Percentage composition									Return (thousands)								
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total					
1946	7	-	-	-	-	-	-	0	0	1	#	5	#	7					
1947	7	-	-	-	-	-	-	0	0	4	#	13	#	17					
1948	30	-	-	-	-	-	-	0	0	4	0	47	0	51					
1949	3	-	-	-	-	-	-	0	0	4	0	9	0	13					
1950	8	0	0	7.8	0	69.0	23.2	#	0	16	#	29	3	49					
1951	6	0	0	41.8	1.8	39.9	17.5	0	0	24	2	24	1	51					
1952	6	0	0	31.4	0.6	67.4	0.6	0	0	29	0	35	#	64					
1953	32	0.1	0	9.0	0	90.1	0.8	0	0	6	2	49	2	58					
1954	16	0	0	72.5	0	27.5	0	0	#	15	19	25	5	64					
1955	35	0	0	46.5	1.1	52.4	0	0	0	107	18	87	52	264					
1956	30	0	0	62.7	1.3	34.2	1.8	0	0	12	2	81	0	95					
1957	20	0	0	17.5	0	81.0	1.5	0	0	5	0	69	#	74					
1958	30	0	0.1	33.4	1.8	64.2	0.5	0	0	32	1	60	#	93					
1959	100	0	0	73.0	10.7	15.6	0.7	0	#	36	18	42	12	107					
1960	51	0	0	15.8	24.2	56.2	3.8	#	0	34	12	179	19	244					
1961	90	0	0	4.8	0.8	57.8	35.5	0	0	28	3	197	4	232					
1962	30	0	0	45.1	0	54.9	0	0	0	7	2	36	5	50					
1963	48	0.2	0.2	46.7	1.2	51.4	0.3	0	0	10	3	142	2	157					
1964	43	0	0	43.5	19.6	36.6	0.2	0	0	23	19	49	4	95					
1965	131	0	0	16.4	4.2	75.5	3.9	0	0	159	6	177	9	351					
1966	110	0	0	5.0	0.6	69.4	6.0	0	0	25	0	192	1	218					
1967	25	0	0	22.0	3.0	63.7	5.3	0	0	10	0	82	0	92					
1968	100	0	0	15.3	1.5	82.2	1.0	0	0	58	0	92	-	150					
1969	140	0	0	69.2	8.1	22.1	0.6	0	0	0	-	-	-	-					
1970	120	0	0	16.0	3.4	79.5	1.1	0	-	-	-	-	-	-					
1971	100	0	0	6.5	0	83.7	4.8	-	-	-	-	-	-	-					
1972	75	0	0	56.1	0	43.4	0.5	-	-	-	-	-	-	-					
1973	70	0	0	0	0	100.0	0	-	-	-	-	-	-	-					

#Less than 500 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

14. Grant River (Kulik)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)									
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total	
1946	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	76	1	116	
1947	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	*	53	
1948	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	0	18	
1949	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	5	
1950	20	0	0	87.2	0	12.8	0	0	0	0	0	*	0	0	0	0	0	19	7	66	
1951	60	0	0	34.1	0	63.0	0	0	0	0	0	0	0	0	0	0	0	13	1	367	
1952	11	0	0	20.8	7.8	60.2	3.2	0	0	0	0	0	0	0	0	0	0	8	0	61	
1953	9	1.4	0	18.3	5.0	73.3	2.0	0	0	0	0	0	0	0	0	0	0	19	0	35	
1954	26	0	0	95.3	0	4.7	0	*	1	46	432	3	4	486	4	486	3	4	486		
1955	250	0	0	94.0	1.3	4.7	0	1	1	112	103	21	0	238	0	238	21	0	238		
1956	40	0	0	81.4	2.6	13.2	2.8	0	0	184	11	66	0	261	0	261	66	0	261		
1957	10	2.2	0	52.3	3.9	38.0	3.6	0	0	41	2	25	0	68	0	68	25	0	68		
1958	43	2.4	3.3	72.2	4.9	17.2	0	0	0	191	4	41	0	236	0	236	41	0	236		
1959	320	0	0.4	23.9	75.1	0.6	0	0	0	415	51	34	0	502	0	502	34	2	502		
1960	200	0	0	60.6	35.1	3.5	0.8	0	0	267	9	30	1	307	0	307	267	1	307		
1961	80	0	0	42.5	4.5	53.0	0	0	0	30	5	48	0	83	0	83	30	0	83		
1962	87	0	0	92.6	0.7	6.7	0	0	0	68	7	28	0	103	0	103	68	0	103		
1963	279	0	0	93.0	1.0	6.0	0	0	*	23	14	16	0	53	0	53	23	0	53		
1964	184	0	0	79.9	13.2	6.9	0	0	0	23	2	3	0	28	0	28	23	0	28		
1965	45	0	0	50.9	10.1	37.1	1.9	0	0	16	1	2	0	19	0	19	16	0	19		
1966	76	0	0	67.0	1.8	30.8	0.4	1	0	85	0	30	0	115	0	115	85	0	115		
1967	28	0	0.4	44.2	10.7	44.7	0	*	0	86	0	13	0	99	0	99	86	0	99		
1968	33	0	0	46.5	26.0	27.5	0	0	0	46	*	2	0	48	0	48	46	0	48		
1969	14	4.8	0	71.4	9.5	14.3	0	0	0	19	-	-	0	-	0	-	19	-	-		
1970	67	0.5	0	97.5	0.5	1.5	0	*	-	-	-	-	0	-	0	-	-	-	-		
1971	70	0	0	80.4	0	19.6	0	-	-	-	-	-	0	-	0	-	-	-	-		
1972	39	0	0	86.4	0	13.6	0	-	-	-	-	-	0	-	0	-	-	-	-		
1973	18	2.7	0	86.3	0.8	10.2	0	-	-	-	-	-	0	-	0	-	-	-	-		

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River Lake system - continued

15. N4-N6 Beach (Central Nerka)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	
1946	550	-	-	-	-	-	-	-	0	5	0	10	0	15
1947	60	-	-	-	-	-	-	0	0	3	7	0	11	
1948	30	-	-	-	-	-	-	0	0	6	20	0	26	
1949	1	-	-	-	-	-	-	0	0	7	6	0	13	
1950	3	0	0	67.0	0	33.0	0	0	0	25	21	0	52	
1951	7	0	0	29.0	0	71.0	0	0	0	116	30	1	147	
1952	5	0	0	49.8	4.6	45.6	0	0	0	41	55	0	96	
1953	18	0	0	30.8	0	69.2	0	0	0	114	92	0	206	
1954	21	0	0	86.0	0	14.0	0	0	0	91	17	0	131	
1955	95	0	0	82.6	3.4	14.0	0	9	0	234	76	10	371	
1956	39	0	0	67.0	0	33.0	0	0	0	75	70	0	147	
1957	95	0	0	72.3	0	27.1	0.6	0	0	32	47	0	79	
1958	98	0.9	0	62.1	0	37.0	0	0	0	213	18	0	232	
1959	183	0	0	86.9	7.1	6.0	0	0	0	61	49	5	133	
1960	163	0	0	47.9	27.7	24.4	0	0	0	134	52	9	212	
1961	78	0	0	34.1	0.9	57.2	7.8	0	0	33	50	3	86	
1962	101	0	0	88.9	0	11.1	0	0	0	109	18	2	129	
1963	46	0	0	83.0	1.6	15.4	0	0	0	49	60	2	115	
1964	100	0	0	73.4	8.5	18.1	0	0	0	33	12	3	71	
1965	64	0	0	39.6	13.5	44.7	3.2	0	0	71	5	0	127	
1966	169	0	0	74.6	0	22.6	2.8	0	0	118	60	0	178	
1967	35	0	0	74.9	0	22.4	2.7	0	0	55	29	0	86	
1968	64	0.5	0	40.7	4.0	54.3	0.5	0	0	86	1	0	116	
1969	64	0.4	0	67.7	11.6	18.3	2.0	0	0	7	-	-	-	
1970	123	0	0	73.5	3.1	22.4	0.6	0	-	-	-	-	-	
1971	64	0	0	56.6	0.5	43.0	0	-	-	-	-	-	-	
1972	75	0	0	83.0	1.5	15.5	0	-	-	-	-	-	-	
1973	30	0	0	19.7	1.8	78.5	0	-	-	-	-	-	-	

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

16. Anvil Bay Beach (North Nerka)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	
1946	400	-	-	-	-	-	-	-	0	37	0	13	1	51
1947	150	-	-	-	-	-	-	0	0	8	0	10	2	20
1948	200	-	-	-	-	-	-	0	0	27	0	60	0	87
1949	10	-	-	-	-	-	-	*	0	15	0	6	0	21
1950	40	0	0	41.5	1.5	54.5	2.5	0	0	75	9	23	5	112
1951	12	0	0	45.2	0	54.8	0	1	0	178	3	62	*	244
1952	16	0.5	0	75.9	0	21.1	2.5	1	0	197	*	4	0	202
1953	50	0	0	23.0	0	74.5	2.5	0	0	6	38	157	0	201
1954	60	1.4	0	93.5	0	5.1	0	0	0	467	50	32	9	558
1955	140	0.5	0	85.9	3.1	10.5	0	4	0	678	69	186	6	943
1956	155	0	0	82.1	0.4	16.9	0.6	0	0	301	8	93	1	403
1957	6	0	0	62.7	1.2	33.7	2.4	0	0	42	28	46	0	116
1958	390	0.9	0	80.4	2.9	15.8	0	0	0	464	5	116	4	589
1959	510	0	0	90.5	5.5	4.0	0	0	0	206	52	140	3	401
1960	315	0	0	63.8	15.3	19.7	1.2	1	0	439	24	114	10	588
1961	101	0.6	0	34.0	2.9	58.9	3.6	0	0	69	5	76	0	150
1962	216	0	0	90.7	3.6	5.1	0.6	1	0	415	3	100	2	521
1963	180	0.4	0	71.5	1.9	26.2	0	0	0	235	5	83	*	323
1964	328	0	0	75.4	7.8	16.3	0.4	0	0	38	17	20	0	75
1965	129	0.4	0	40.5	9.1	49.0	1.0	0	0	69	0	62	4	135
1966	352	0	0	88.0	0.4	10.6	1.0	1	0	254	2	211	0	468
1967	174	0	0	73.7	0.8	25.5	0	1	0	167	0	29	0	197
1968	77	0	0	33.5	3.5	62.5	0.5	0	0	102	1	21	-	124
1969	66	0.5	0	63.9	15.1	19.7	0.4	0	0	12	-	-	-	-
1970	230	0.5	0	84.9	0	14.6	0	0	-	-	-	-	-	-
1971	210	0	0	52.2	0.6	46.2	1.0	-	-	-	-	-	-	-
1972	85	0	0	86.6	0	13.4	0	-	-	-	-	-	-	-
1973	27	0	0	34.6	2.1	63.3	0	-	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued
 17. B9-B12 Beach (Beverley)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)						Total	
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2		1.3
1946	200	-	-	-	-	-	-	-	-	-	-	0	0	47	3	41	1	1	92
1947	150	-	-	-	-	-	-	-	-	-	-	0	0	11	*	1	*	*	12
1948	90	-	-	-	-	-	-	-	-	-	-	0	0	1	0	*	0	0	1
1949	3	-	-	-	-	-	-	-	-	-	-	0	0	*	0	0	*	*	1
1950 ¹	25	0	0	83.1	0.8	15.5	0.6	*	0	43	2	4	0	43	2	4	*	*	49
1951	30	0	0	23.9	6.6	67.4	2.1	*	0	34	*	3	0	34	*	3	0	0	37
1952	1	0	0	21.9	19.5	40.2	18.4	0	0	3	0	0	0	3	0	0	0	0	3
1953 ¹	1	2.4	0	64.1	0	31.5	2.0	0	0	0	0	0	0	0	0	4	6	10	10
1954	32	1.3	0	98.7	0	0	0	0	0	301	133	17	6	301	133	17	6	6	459
1955	27	0	0	85.8	3.3	9.7	1.2	0	0	193	132	10	0	193	132	10	0	0	335
1956 ¹	3	0	0	58.4	3.4	37.2	1.0	0	0	64	1	4	0	64	1	4	0	0	69
1957	1	-	-	-	-	-	-	-	-	4	14	5	0	4	14	5	0	0	23
1958	205	0	0.8	97.4	0	0.8	0	*	1	553	53	22	0	553	53	22	0	0	629
1959	218	0	0	60.1	34.0	4.9	1.0	1	5	179	106	4	1	179	106	4	1	1	296
1960	138	0	0	30.4	65.4	2.3	1.9	0	0	104	7	8	0	104	7	8	0	0	119
1961	6	4.2	0	50.3	6.5	39.0	0	0	0	6	3	15	1	6	3	15	1	1	25
1962 ¹	240	0.3	0.3	97.3	1.6	0.5	0	0	0	246	49	29	3	246	49	29	3	3	327
1963	160	0	3.4	70.0	21.0	5.6	0	0	0	39	7	15	0	39	7	15	0	0	61
1964	109	0	0	52.2	46.5	1.3	0	0	0	5	1	*	1	5	1	*	1	1	7
1965	13	0	0	35.2	26.4	34.1	4.3	0	0	1	0	0	0	1	0	0	0	0	1
1966	192	0	0	45.8	0.4	3.8	0	*	0	63	0	7	0	63	0	7	0	0	70
1967	56	0	0	38.5	38.4	22.7	0.4	*	0	42	*	5	0	42	*	5	0	0	47
1968	17	0	0	19.4	24.7	52.0	3.9	0	0	17	*	1	-	17	*	1	-	-	18
1969	2	17.2	0	43.6	29.9	9.3	0	0	0	1	-	-	-	1	-	-	-	-	-
1970	49	0.5	0	98.5	0	0	1.0	*	-	-	-	-	-	-	-	-	-	-	-
1971	31	0	0	90.2	0	9.8	0	-	-	-	-	-	-	-	-	-	-	-	-
1972	14	0	0	85.4	0.8	13.8	0	-	-	-	-	-	-	-	-	-	-	-	-
1973 ¹	2	6.2	0	58.4	4.6	30.8	0	-	-	-	-	-	-	-	-	-	-	-	-

¹Less than 50 fish.

¹Age composition estimated from adjacent spawning grounds.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued.

18. Silver Horn Beach (Beverley)

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)						Total		
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2		1.3	2.3
1946	1,250	-	-	-	-	-	-	-	-	-	-	0	0	0	64	3	71	0	0	138
1947	250	0	0	49.5	13.1	37.4	0	0	0	0	0	0	0	0	56	0	14	0	0	70
1948	100	0	0	21.1	0	78.9	0	0	0	0	0	0	0	0	7	0	5	0	0	12
1949	5	0	0	29.6	0	70.4	0	0	0	0	0	0	0	0	9	0	8	0	0	17
1950	40	0	0	71.3	1.8	25.6	1.3	0	0	0	0	*	0	0	197	9	32	4	4	242
1951	80	0	0	45.7	2.7	44.4	7.2	0	0	0	0	1	0	0	237	8	34	*	*	280
1952	8	0	0	41.5	0	58.5	0	0	0	0	0	0	0	0	62	0	1	0	0	63
1953	10	1.3	0	69.7	0	29.0	0	0	0	0	0	0	0	0	5	18	54	30	30	107
1954	150	0.9	0	96.6	0	2.5	0	0	0	0	0	*	2	0	935	501	70	3	3	1,511
1955	185	0	0	86.7	2.4	10.9	0	0	0	0	0	4	0	0	583	214	68	0	0	869
1956	57	0	0	70.3	2.7	25.7	1.3	0	0	0	0	0	0	0	182	*	15	0	0	197
1957	4	5.8	0	80.1	0	12.5	1.6	0	0	0	0	0	0	0	28	17	0	0	0	48
1958	660	0.6	0.3	95.1	0.8	3.2	0	0	0	0	0	1	5	1,841	276	223	19	19	2,365	
1959	731	0	0	54.3	38.1	6.1	1.5	0	0	0	0	5	3	695	431	196	4	4	1,334	
1960	290	0	0	41.3	50.6	7.7	0.4	0	0	0	0	6	0	739	4	28	0	0	777	
1961	34	2.7	0	68.2	0.4	28.7	0	0	0	0	0	3	0	33	0	42	2	2	80	
1962	790	0.6	0.6	98.2	0.6	0	0	0	0	0	0	0	0	574	76	54	17	17	721	
1963	713	0.9	0.4	60.9	24.7	12.7	0.4	0	0	0	0	0	0	172	41	178	1	1	392	
1964	695	0.4	0	58.4	29.7	10.5	1.0	0	0	0	0	0	0	65	11	5	5	5	86	
1965	44	0	0	56.8	4.2	34.8	4.2	0	0	0	0	0	0	29	0	0	0	0	33	
1966	449	0	0	95.4	0	4.6	0	0	0	0	0	3	0	525	3	90	0	0	621	
1967	152	0	0	61.7	22.1	15.8	0.4	0	0	0	0	2	0	559	*	11	0	0	572	
1968	175	0	0	25.4	14.0	58.7	1.9	0	0	0	0	0	0	56	*	2	-	-	58	
1969	31	11.2	0	58.0	20.4	9.4	1.0	0	0	0	0	0	0	4	-	-	-	-	-	
1970	408	0.5	0	99.0	0	0	0.5	0	0	0	0	*	-	-	-	-	-	-	-	-
1971	414	0	0	83.9	0.6	10.0	0.6	0	0	0	0	-	-	-	-	-	-	-	-	-
1972	45	0	0	52.1	0.5	9.4	0	0	0	0	0	-	-	-	-	-	-	-	-	-
1973 ¹	5	6.2	0	58.4	4.6	30.8	0	0	0	0	0	-	-	-	-	-	-	-	-	-

*Less than 50 fish.

¹Age composition estimated from adjacent spawning grounds.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

19. Hardluck Bay Beach (Beverley)

Year	Escapement (hundreds)	Percentage composition						Return (hundreds)						
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3	Total
1945	350	-	-	-	-	-	-	-	0	48	2	36	0	86
1947	320	-	-	-	-	-	-	0	0	28	0	7	0	35
1948	200	-	-	-	-	-	-	0	0	4	0	3	0	7
1949	5	-	-	-	-	-	-	0	0	6	0	3	0	9
1950	30	0	0	71.3	1.8	25.6	1.3	*	0	68	5	19	3	95
1951	40	0	0	45.6	2.7	44.3	4.4	*	0	141	6	25	*	172
1952	4	0	0	41.5	0	58.5	0	0	0	46	0	2	0	48
1953	6	1.3	0	69.7	0	29.0	0	0	0	8	10	30	23	71
1954	52	0.9	0	96.6	0	2.5	0	*	1	524	381	53	3	962
1955	110	0	0	86.7	2.4	10.9	0	2	0	443	199	63	0	707
1956	42	0	0	70.3	2.7	25.7	1.3	0	0	169	1	22	0	192
1957	6	5.8	0	80.1	0	12.5	1.6	0	0	41	9	0	1	51
1958	370	0.6	0.3	95.1	0.8	3.2	0	1	2	954	83	67	7	1,114
1959	555	0	0	54.3	38.1	6.1	1.5	2	1	210	158	72	15	458
1960	278	0	0	41.3	50.6	7.7	0.4	2	0	270	13	97	0	382
1961	50	2.7	0	68.2	0.4	28.7	0	1	0	115	0	19	3	138
1962	414	0.6	0.6	98.2	0.6	0	0	0	0	262	105	75	14	456
1963	215	0.9	0.4	61.0	24.7	12.6	0.4	0	0	238	35	152	*	425
1964	254	0.4	0	58.4	29.7	10.5	1.0	0	0	56	5	2	2	65
1965	154	0	0	58.8	4.2	34.8	4.2	0	0	15	0	0	4	19
1966	205	0	0	95.4	0	4.6	0	2	0	217	3	76	0	298
1967	211	0	0	61.7	22.1	15.7	0.5	1	0	472	1	20	0	494
1968	150	0	0	25.4	14.0	58.7	1.9	0	0	106	1	8	-	115
1969	16	11.2	0	58.0	20.4	9.4	1.0	0	0	14	-	-	-	-
1970	169	0.5	0	99.0	0	0	0.5	1	-	-	-	-	-	-
1971	350	0	0	68.8	0.6	10.0	0.6	-	-	-	-	-	-	-
1972	85	0	0	90.1	0.5	9.4	0	-	-	-	-	-	-	-
1973	20	6.2	0	58.4	4.6	30.8	0	-	-	-	-	-	-	-

*Less than 50 fish.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

20. Mikchalk Beaches

Year	Escapement (hundreds)	Percentage composition										Return (hundreds)					Total
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3				
1946	800	-	-	-	-	-	-	-	-	-	-	0	57	1	27	1	86
1947	160	-	-	-	-	-	-	-	-	-	-	0	10	1	22	1	34
1948	80	-	-	-	-	-	-	-	-	-	-	0	8	*	2	0	10
1949	6	-	-	-	-	-	-	-	-	-	-	0	10	0	0	0	10
1950 ¹	30	0	0	84.8	0.8	13.9	0.5	0	0	0	0	0	109	4	4	7	124
1951 ¹	21	0	0	32.1	2.0	63.5	2.4	0	0	0	0	0	141	12	17	*	170
1952	12	0	0	30.5	3.7	62.1	3.7	0	0	0	0	0	45	0	5	6	56
1953	10	0	0	75.4	3.3	12.1	9.2	0	0	0	0	0	25	16	49	10	100
1954	80	0	0	100.0	0	0	0	0	0	0	0	2	393	150	17	34	604
1955	100	0	0	95.5	2.3	2.3	0	0	0	0	0	2	343	210	36	12	603
1956	40	0	0	72.6	5.9	18.6	2.9	0	0	0	0	0	79	12	10	0	101
1957 ¹	19	6.7	0	79.0	0	11.4	0.9	0	0	0	0	0	17	23	9	3	52
1958	300	0.8	2.5	87.9	1.6	6.4	0.8	0	0	0	0	*	827	91	25	1	945
1959	331	0	0	70.5	25.2	3.2	1.1	0	0	0	0	1	197	60	46	0	304
1960	221	0	0	23.5	65.0	5.3	6.2	0	0	0	0	0	152	17	55	0	224
1961	32	1.3	0	43.2	13.0	19.2	23.3	0	0	0	0	1	87	0	37	0	125
1962 ¹	359	0.2	0.2	97.2	1.8	0.6	0	0	0	0	0	0	110	74	66	16	266
1963	194	0	0	63.5	29.8	5.2	1.5	0	0	0	0	0	107	26	92	0	225
1964	130	0.4	0	64.1	22.0	13.1	0.4	0	0	0	0	1	41	6	7	3	58
1965	105	0	0	62.9	8.0	29.1	0	0	0	0	0	0	68	5	12	0	85
1966	100	0	0	82.0	0	18.0	0	0	0	0	0	1	108	0	32	0	141
1967	120	0	0	43.5	27.2	24.3	0	0	0	0	0	1	205	1	15	0	222
1968	100	0	0.5	27.9	15.4	53.1	3.1	0	0	0	0	0	60	1	8	-	69
1969	50	1.7	0	82.6	6.7	9.0	0	0	0	0	0	0	14	-	-	-	-
1970	95	1.1	0	87.7	3.4	6.7	1.1	0	0	0	0	1	-	-	-	-	-
1971	150	0	0	90.1	0	9.9	0	0	0	0	0	-	-	-	-	-	-
1972	50	0	0	86.3	1.5	12.2	0	0	0	0	0	-	-	-	-	-	-
1973 ¹	20	6.2	0	58.4	4.6	30.8	0	0	0	0	0	-	-	-	-	-	-

*Less than 50 fish.

¹Age composition estimated from Lake Beverley.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

21. Lake Kulik Beaches

Year	Escapement (thousands)	Percentage composition										Return (thousands)					Total		
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.3						
1946	144	-	-	-	-	-	-	-	-	-	-	0	0	0	2	11	1	1	22
1947	138	-	-	-	-	-	-	-	-	-	-	0	0	0	3	4	*	*	8
1948	50	-	-	-	-	-	-	-	-	-	-	0	0	0	1	2	0	0	3
1949	2	-	-	-	-	-	-	-	-	-	-	0	0	0	*	0	0	0	1
1950	4	0	0	66.8	1.1	11.0	1.1	1.1	1.1	1.1	1.1	0	0	0	31	9	1	1	50
1951	10	0	0	19.7	15.5	55.0	9.8	9.8	9.8	9.8	9.8	0	0	0	104	8	*	*	119
1952	3	0	0	23.3	12.8	43.6	15.3	15.3	15.3	15.3	15.3	0	0	0	8	1	1	1	10
1953 ¹	1	1.4	0	18.3	5.0	73.3	2.0	2.0	2.0	2.0	2.0	0	0	0	1	4	0	0	15
1954	23	1.3	0	98.7	0	0	0	0	0	0	0	*	11	106	210	4	7	338	
1955	80	0	0	87.2	5.8	7.0	0	0	0	0	0	3	1	66	77	4	*	168	
1956	10	0	0	50.6	15.2	32.1	2.1	2.1	2.1	2.1	2.1	0	0	31	1	7	0	39	
1957 ¹	1	2.2	0	52.3	3.9	33.0	3.6	3.6	3.6	3.6	3.6	0	0	3	0	6	0	9	
1958	90	3.3	12.1	79.1	3.2	1.9	0.4	0.4	0.4	0.4	0.4	*	0	166	6	8	0	180	
1959	179	0	0.4	32.8	65.3	1.5	0	0	0	0	0	0	1	165	99	30	*	295	
1960	77	0	0	25.2	68.3	1.8	3.7	3.7	3.7	3.7	3.7	0	0	98	8	11	1	118	
1961	8	3.9	0	31.3	5.1	56.0	3.7	3.7	3.7	3.7	3.7	0	0	13	1	11	0	25	
1962	72	0	0	98.1	0	1.9	0	0	0	0	0	0	0	72	20	19	0	111	
1963	111	0	0.9	93.0	3.3	2.8	0	0	0	0	0	0	0	69	27	11	*	107	
1964	112	0	0	48.0	42.0	10.0	0	0	0	0	0	0	0	4	8	2	0	14	
1965	20	0	0	48.5	20.0	31.8	0.7	0.7	0.7	0.7	0.7	0	0	8	1	0	0	9	
1966	60	0	0	89.8	0.6	9.0	0.6	0.6	0.6	0.6	0.6	1	0	54	0	18	0	73	
1967	55	0	0	68.5	16.2	15.3	0	0	0	0	0	*	0	68	2	11	0	81	
1968	25	0	0	11.5	62.8	25.7	0	0	0	0	0	0	0	29	*	2	-	30	
1969	12	6.5	0	41.7	40.3	9.3	2.2	2.2	2.2	2.2	2.2	0	0	6	-	-	-	-	
1970	42	0.5	0	98.0	1.5	0	0	0	0	0	0	*	-	-	-	-	-	-	
1971	59	0	0	94.7	0	15.3	0	0	0	0	0	-	-	-	-	-	-	-	
1972	28	0	0	78.7	4.6	16.7	0	0	0	0	0	-	-	-	-	-	-	-	
1973	7	6.6	0	65.3	5.3	22.8	0	0	0	0	0	-	-	-	-	-	-	-	

¹ Less than 500 fish.

² Age composition estimated from Grant River.

Appendix Table 2. Statistics on escapements and returns for individual spawning grounds in the Wood River lake system - continued

22. Little Togiak Lake Beaches

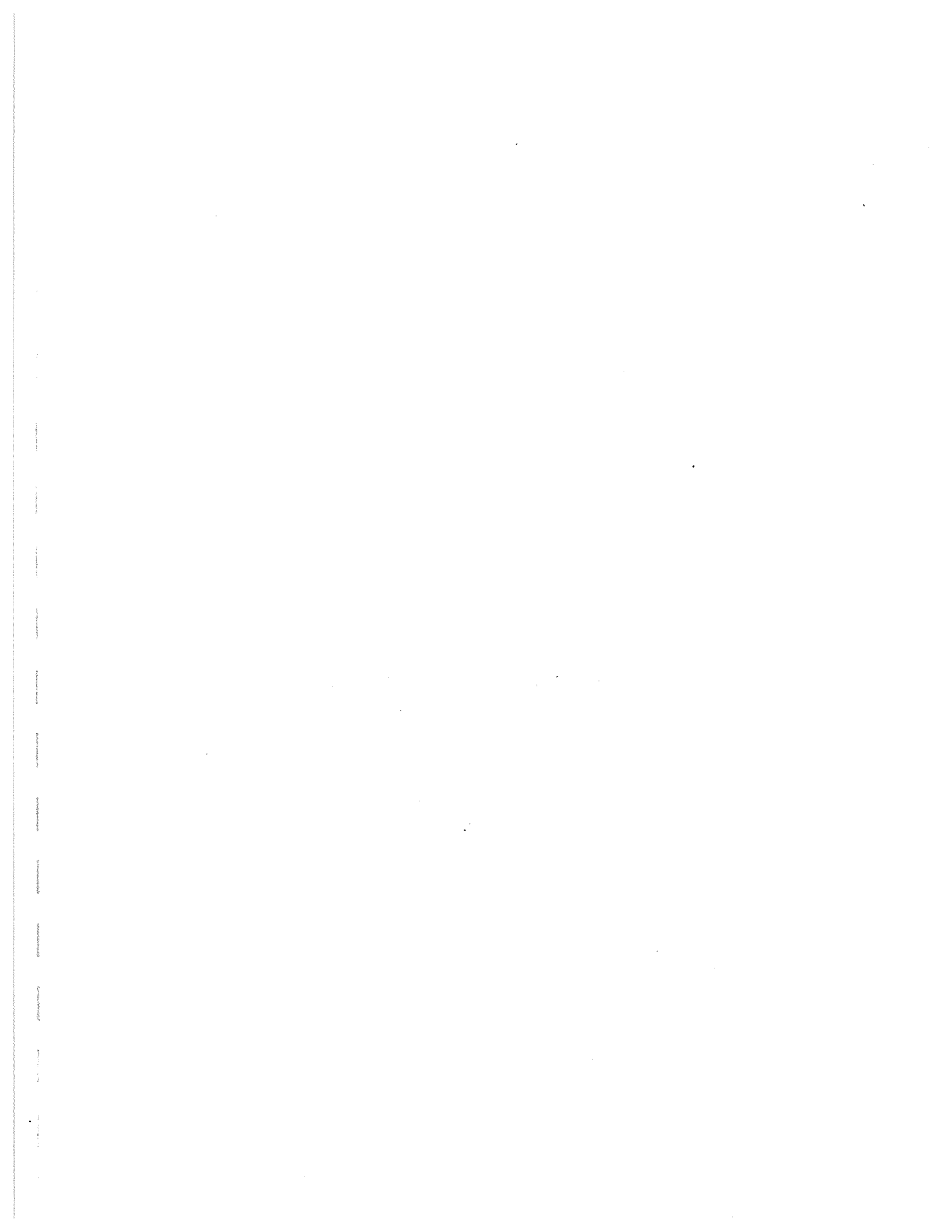
Year	Escapement (thousands)	Percentage composition										Return (thousands)					Total		
		1.1	2.1	1.2	2.2	1.3	2.3	1.1	2.1	1.2	2.2	1.3	2.2	1.2	1.3	2.3			
1946	40	-	-	-	-	-	-	-	-	-	-	-	0	*	5	0	5	0	5
1947	80	-	-	-	-	-	-	-	-	-	-	-	0	5	7	1	7	*	13
1948	35	-	-	-	-	-	-	-	-	-	-	-	0	5	10	1	10	*	16
1949	1	-	-	-	-	-	-	-	-	-	-	-	0	4	4	*	4	*	8
1950	3	0	0	2.7	19.7	45.1	32.7	0	0	19	3	8	0	19	3	3	8	3	33
1951	6	0	0	50.3	0	40.0	10.7	0	0	20	8	12	0	20	8	12	*	40	
1952	5	0	0	44.0	12.4	43.6	0	0	0	19	8	8	0	19	8	8	0	27	
1953	10	0	0	29.9	6.4	61.4	2.3	0	0	3	3	16	0	3	16	1	23	23	
1954	16	0	0	87.0	1.8	10.0	0.6	0	0	14	9	2	*	14	9	2	2	27	
1955	20	0	0	66.2	7.0	26.2	0.6	0	0	49	10	10	0	49	10	10	2	71	
1956	20	0	0	62.0	8.0	27.2	2.8	0	0	9	1	11	0	9	1	11	0	21	
1957	6	0	0	32.3	0.8	63.7	3.4	0	0	3	*	5	0	3	*	5	0	8	
1958	16	0.9	0.4	54.8	5.4	38.5	0	*	0	20	2	13	0	20	2	13	*	35	
1959	40	0	0	83.0	12.7	3.4	0.9	0	0	24	7	5	0	24	7	5	*	36	
1960	17	0	0	36.1	41.4	18.4	4.1	0	0	18	16	8	0	18	16	8	3	45	
1961	11	0.8	0	19.4	3.3	66.2	10.3	0	0	18	1	15	0	18	1	15	*	34	
1962	10	0	0	85.5	2.7	11.8	0	0	0	18	*	9	0	18	*	9	0	27	
1963	21	0	0	70.5	5.1	24.4	0	0	0	11	2	21	0	11	2	21	0	34	
1964	15	0	0	65.5	21.2	13.0	0.3	0	0	10	3	5	0	10	3	5	2	20	
1965	27	0	0	52.9	29.2	17.3	0.6	0	0	23	15	15	0	23	15	15	1	54	
1966	22	0	0	60.4	0.8	34.4	4.4	0	0	45	2	28	0	45	2	28	1	76	
1967	10	0	0	59.7	1.0	38.7	0.6	0	0	11	2	8	0	11	2	8	1	22	
1968	20	0	0	33.2	5.9	60.3	0	0	0	9	0	15	0	9	0	15	-	24	
1969	20	0	0	78.7	6.9	14.4	0	0	0	2	-	-	0	2	-	-	-	-	
1970	55	0	0	62.7	19.8	15.1	2.0	0	0	-	-	-	0	-	-	-	-	-	
1971	24	0	0	34.4	3.0	59.4	3.2	-	-	-	-	-	-	-	-	-	-	-	
1972	14	0	0	54.4	2.8	41.0	1.8	-	-	-	-	-	-	-	-	-	-	-	
1973	14	0	0	12.0	0	84.7	3.3	-	-	-	-	-	-	-	-	-	-	-	

*Less than 500 fish.

of

Addendum

LISTS OF PUBLICATIONS AND REPORTS
ON THE WOOD RIVER LAKES



ADDENDUM

LISTS OF PUBLICATIONS
AND REPORTS ON THE
WOOD RIVER LAKES

PUBLICATIONS (WOOD RIVER STUDIES)

<u>Date</u>	<u>Author(s)</u>	<u>Title</u>
1950	Anon.	The fruits of research. (About the Ekuk beach mesh experiments.) Pac. Fish., Apr. 1950. Pp. 17-19.
1959a	W. F. Royce and O. A. Mathisen	Optimum escapement of red salmon in the Nushagak area of Bristol Bay. Pac. Fish., Oct. 1959. 3 p.
1959b	W. F. Thompson and D. W. Clancy	Length measurement of migrating salmon by paired underwater cameras. Photogrammetric Engineering, June, 1959. Pp. 449-455.
1962a	R. L. Burgner	Sampling red salmon fry by lake trap in the Wood River lakes, Alaska. Univ. Washington, Publ. in Fish., New Ser. 3:317-348.
1962b	R. L. Burgner	Studies of red salmon smolts from the Wood River lakes, Alaska. Univ. Washington, Publ. in Fish., New Ser. 3:249-295.
1962c	O. A. Mathisen	Comparative characteristics of age and growth of red salmon in Lake Kuril, Kamchatka and in Bristol Bay, Alaska. Voprosy Ikh., Moscow 2(1): 42-54 (in Russian).
1962d	O. A. Mathisen	Photographic enumeration of red salmon escapement. Univ. Washington, Publ. in Fish., New Ser. 3:351-372.
1962e	O. A. Mathisen	The effect of altered sex ratios on the spawning of red salmon. Univ. Washington, Publ. in Fish., New Ser. 3:139-222.
1962f	W. S. Koo	Age and growth studies of red salmon scales by graphical means. Univ. Washington, Publ. in Fish., New Ser. 3:51-100.
1963	O. A. Mathisen, R. L. Burgner, and S. Y. Koo	Statistical records and computations on red salmon runs in the Nushagak District, Bristol Bay, Alaska, 1946-59. U.S. Fish. Wildl. Serv. Spec. Sci. Rep.--Fish. No. 458. 32 pp.

- 1964a R. L. Burgner Factors influencing production of sockeye salmon in lakes of western Alaska. Verh. Internat. Verein. Limnol. 15:504-513.
- 1964b R. L. Burgner, et al. Summary report of studies on the optimum escapement of sockeye salmon in southwestern Alaska, 1961 and 1962. U.S. Bur. Com. Fish., Manuscript Rep. 64-2. 119 p. Auke Bay, Alaska.
- 1964c R. A. Marriott, N. Aspinwall, S. Y. Koo Stream catalog of the Wood River Lake system, Bristol Bay, Alaska. U.S. Fish. Wildl. Serv., Spec. Sci. Rep. Fish. No. 494. 210 pp.
- 1966 R. L. Burgner Food production in two lake chains of southwestern Alaska. Verh. Internat. Verein. Limnol. 16:1036-1043.
- 1968a J. R. Gilbert Surveys of sockeye salmon spawning populations in the Nushagak District, Bristol Bay, Alaska, 1946-1958. Univ. Washington, Publ. in Fish., New Ser. 3:201-267.
- 1968b W. S. Kim and K. Roberson On the use of otoliths of sockeye salmon for age determination. Univ. Washington, Publ. in Fish., New Ser. 3:151-168.
- 1968c J. J. Pella Distribution and growth of sockeye salmon fry in Lake Aleknagik, Alaska during the summer of 1962. Univ. Washington, Publ. in Fish., New Ser. 3:47-111.
- 1968d D. E. Rogers A comparison of the food of red salmon fry and threespine sticklebacks in the Wood River lakes. Univ. Washington, Publ. in Fish., New Ser. 3:1-43.
- 1969 R. L. Burgner, et al. Biological studies and estimates of optimum escapements of sockeye salmon in the major river systems in southwestern Alaska. N.O.A.A. Fish. Bull. 67(2):405-459.
- 1971 O. A. Mathisen Escapement levels and productivity of the Nushagak sockeye salmon runs from 1903-1966. N.O.A.A. Fish. Bull. 69(4):747-763.
- 1972a W. L. Hartman and R. L. Burgner Limnology and fish ecology of sockeye salmon nursery lakes of the world. J. Fish. Res. Bd. Canada 29:699-715.

- 1972b O. A. Mathisen Biogenic enrichment of sockeye salmon lakes and stock productivity. Verh. Internat. Verein. Limnol. 18:1089-1095.
- 1973 D. E. Rogers Abundance and size of juvenile sockeye salmon and associated species in Lake Aleknagik, Alaska in relation to their physical environment. N.O.A.A. Fish. Bull. 71(4):1061-1075.

RESEARCH IN FISHERIES (WOOD RIVER STUDIES)

Year	Subject No.	Contents
1972	1	Discussion of systems modeling study in the Wood River Lakes - text only.
	2	Fertilization of Bear Bay. Discussion and table of the means of measurements by summer (1970, 71, 72) in Bear Bay and other locations (grouped) in the lower end of Lake Aleknagik.
1971	1	Sockeye salmon production in the Wood River Lakes from 1957-1970 brood years. Table: Lists adult escapements, no. of age 0 juveniles, percent survival from eggs to age 0, mean length at age 0, inshore returns, and percent survival from eggs to return. Discussion of effect of cold spring in 1970 on the survival of 1970 eggs and fry.
	2	Discussion of char study with an estimation of the number of smolts consumed in that year.
1970		No new data presented. Discusses history of the Nushagak catches and rationale for a fertilization study and a char study.
1969	1	Figure on the relationship of numbers of zooplankton per cubic meter versus the number of adult spawners. Table on average numbers of zooplankters per cubic meter in the Wood River lakes (by lake and species) in the summers of 1967 and 1968. Also lists spawner density and mean fry lengths. Table and figure with a discussion.
1968	1	Table as in 1971 subject 1 except for a column of percent survival age 0 to return and no column of numbers of age 0 juveniles.

- 2 Table of distribution of escapement and juveniles among the major Wood River Lakes (Aleknagik, Nerka, Beverley, Kulik) for the 1964-65 brood year. (Lake and year, escapement, eggs, numbers and mean lengths of age 0 and I smolts.)
- 3 Table of average and range in percentage returns for the major age classes in the Wood River lakes for brood years 1953-62. (All years and all lakes grouped.)
- 1967 1 Two page discussion on pink salmon in the Nushagak. History of the fishery. Distribution within the lake system. Behavior of fry in Lake Aleknagik. Growth rate in Lake Aleknagik. Feeding habits in the lake. Table: Catches and lengths of pink and sockeye fry from townet catches in Lake Aleknagik in odd years, 1959-1967. Includes number of sockeye spawners. Table: Percent composition of food in stomachs of pink fry and sockeye (age 0 and 1) and threespine sticklebacks.
- 2 Benthic studies discussion. Includes Table 4 of the second quarterly report, 1/1/68. Table of the densities of bottom fauna to 20 meters in the four major Nushagak lake systems. With estimated wet weight in kilograms per hectare. Compares these data to lakes in Europe and North America. Figure: Trends in benthic fauna, zooplankton, sockeye salmon spawners and whitefish densities among four lake systems in the Nushagak.
- 1966 Entire 3-1/2 pages on smolt/escapement studies. Discussion and figures.
- 1 Distribution of spawning density in Wood River lake system, 1956-1965 (by lake). Figure: (Potential egg deposition, by lake).
- 2 Figure: Potential egg deposition in 1965 and length of resulting fry on September 1, 1966.
- 3 Figure: Potential egg deposition and growth of fry to September 1 of the summer following spawning, 1957-1965 year classes, Lake Aleknagik.
- 4 Figure: Growth of sockeye fry in lower end of Lake Aleknagik, 1963-1966.
- 5 Figure: Average net plankton abundance, chlorophyll α , and rate of carbon fixation.

- 6 Comparison of parent egg deposition, fry indices; and smolt abundance and the resulting return of adults, parent years 1957-65.
- 1965 1 No data presented. Discussion of goals and methods of sockeye smolt studies.
- 2 Discussion of the comparative ecology and limnology of the Igushik, Snake River, Tikchik and Wood River lakes. No data.
- 3 Changes of the rank of abundance of zooplankters through the summer in the Wood River lakes. List of names only.
- 4 Progress of the echosounding study. No data.
- 1964 1 Limnology of the Tikchik lakes as compared with the Wood River lakes. Discussion and table comparing Lake Aleknagik to the Tikchiks (e.g., pH - Lake Aleknagik mean and range - Tikchiks, mean and range).
- 2 Abundance and distribution of fish in the Tikchik Lake system. Table: Percent composition of fish in catches (gill net and beach seine) and lake trout stomach contents.
- 3 Table: average weight (pounds) of fish (by species) caught by gill net (by Tikchik lake).
- 4 Food habits of the char from Lake Aleknagik. Stomach samples from 1,178 char were examined. Table and a one-page discussion.
- 1963 1 **Net selectivity in relation to spawning populations of Nushagak sockeye. A two-page discussion.**
- 2 Circulus height and related morphology of sockeye scales as determined from sections.
- 3 Some morphological and life history data on pygmy whitefish from Wood River. Table: Age, sex, and size from Wood River. Table: Food category, percent occurrence, and percent volume.
- 4 Artificial fertilization of the Alaskan blackfish. Table: Daily temperature units for incubating blackfish eggs from fertilization to hatching.

- 1962 1 Sockeye population studies, Wood River lakes. Figure: Average number of spawners per km² of lake area in each of the Wood River lakes, 1956 to 1962 (by year). Table: Mean lengths of young sockeye near end of first growing season in three areas of Lake Beverley. (Years 1959-1962.) Figure: Relationship between adult population size and growth of young.
- 2 Sockeye spawning areas in the Wood River lakes.
- 3 Relative abundance and distribution of fish species in Lake Aleknagik. Table: Species and percent composition of catches by gear. Figure: Average catches of sockeye fry, threespine stickleback and other fishes (grouped) by gear and date.
- 4 Analysis of Kushagak sockeye cannery records. Figure: Kushagak catch curve, 1893-1962.
- 5 The use of otoliths for age determination in sockeye.
- 1961 1 Studies of carrying capacity of sockeye nursery areas
 a. Description of basic productivity studies (no data).
 b. Table: The chemical analysis of lake water from each Wood River lake, Iliamna Lake, and the two Chignik lakes.
 c. Abundance and growth of sockeye and sticklebacks in Wood River lakes nursery areas (no data).
- 2 Sea-type red salmon in the 1961 Kushagak run. Table: Age compositions of 1961 catch and escapements.
- 3 Reproduction of the threespine stickleback.
 a. Age classes.
 b. Age at maturity, spawning time and spawning habitat.
 c. Fecundity versus size of fish.
- 1960 1 Unusual occurrences of smolt migration. Smolt indices from fykenetting, 1951-1960. Figure: Date versus number of migrating smolts and mean lengths.
- 2 Sex and age composition of adults in 1961.
- 3 Discussion of 1960 and 1961 forecasts.
- 4 Effect of heavy 1959 escapements on growth of 1960 fry. The number of spawners per square meter and growth (for each Wood River lake). Table: The

number of spawners per square km, and growth attained by fry on September 1, 1960. (For each Wood River lake.)

- 5 Food studies of red fry and sticklebacks. Table: Percent composition of each food item in the stomachs.
- 1959 1 Discussion of the 1959 run and forecast. Table: Predicted/actual returns by district.
- 2 Distribution of Nushagak escapement (by lake system), 1959.
- 3 Effect of over-escapement on survival and growth of fry. Table: Ratio of parent escapements 1958/1957, ratio of fry catch/tow 1959/1958 by lake. Table: Number of spawners per m² of rearing area and mean length of fry on September 1, 1959, by lake.
- 4 Discussion of 1960 forecast.
- 1958 1 Forecast for Nushagak run, 1959. With figures on the relationship between the smolt index and the run.
- 2 Escapement to five Nushagak lake systems, 1958. (Total run is noted.) Figures of number of fish in the catch and escapement by days (in Wood River lakes). Review of 1958 forecast.
- 3 Number of years spent in freshwater by Naknek-Kvichak smolts versus number of years spent in freshwater by Nushagak smolts. Data from eight fishing periods, June 23 - July 18, 1958 (lists percent one winter and percent two winters).
- 4 Escapements to areas within the Nushagak, 1946-58 with a discussion of trends and history. Return/spawner is given from the brood years 1946-1953.
- 5 Smolt indices 1951-1958 with a discussion of the quality of the 1958 smolts (from Mosquito Point fykenetting).
- 6 Variation in survival. Figure: Smolts produced versus escapement, 1949-1954 (Wood River system). Figure: Season composite length frequencies of sockeye smolts, Wood River, 1954-1958 (by year). Table: 1957 spawner density and numbers of resultant fry by lake.
- 7 The pink salmon run in the Nushagak. Figure: Case pack, 1900-1958.

THESES (WOOD RIVER STUDIES)

<u>Year</u>	<u>Author</u>	<u>Degree</u>	<u>Title</u>
1955	O. A. Mathisen	Ph.D.	Studies on the spawning biology of the red salmon, <i>Oncorhynchus nerka</i> (Walbaum) in Bristol Bay, Alaska with special reference to the effect of altered sex ratios. 285 pp.
1956	R. E. Duncan	M.S.	Two measures of the length of red salmon, <i>Oncorhynchus nerka</i> (Walbaum), their relation and application in the study of the catch and escapement in Bristol Bay, Alaska 92 pp.
1958	R. L. Burgner	Ph.D.	Fluctuations in abundance, growth and survival in the early life stages of red salmon of the Wood River lakes, Alaska. 200 pp.
1961	D. E. Rogers	M.S.	A comparison of the food of red salmon fry and threespine sticklebacks in the Wood River lakes. 60 pp.
1963	W. S. Kim	M.S.	On the use of otoliths of red salmon for age and racial studies. 63 pp.
1964	J. J. Pella	M.S.	Sockeye salmon fry distribution and growth in Lake Aleknagik, Alaska, during the summer of 1962. 132 pp.
1965	N. Aspinwall	M.S.	Spawning characteristics and early life history of the Alaskan blackfish, <i>Dallia pectoralis</i> Bean. 78 pp.
1966a	E. L. Gadau	M.S.	Mineral study of the four lake systems in the Nushagak District of Alaska. 299 pp.
1966b	M. O. Nelson	M.S.	Food and distribution of Arctic char in Lake Aleknagik, Alaska, during the summer of 1962. 164 pp.
1967	D. E. Rogers	Ph.D.	Estimation of pelagic fish populations in the Wood River lakes, Alaska, from tow net catches and echogram marks. 91 pp.
1968	B. Waters	M.S.	Variations in the abundance of young sockeye salmon and four associated species in the littoral zone of Lake Aleknagik, Alaska, as determined from beach seine catches. 85 pp.
1969	J. Reeves	Ph.D.	A comparative analysis of Arctic char populations in sockeye salmon lakes of the Nushagak district, Alaska. 218 pp.

CIRCULARS (WOOD RIVER STUDIES)

<u>Circular no.</u>	<u>Date</u>	<u>Author</u>	<u>Title and Contents</u>
35 Memo 3	1952	FRI Staff	Memorandum on the effect of net marks. Concerns the effect of gill net marks on migrating adult sockeye as observed on Wood River fish. Includes an excellent set of 17 photographs illustrating mark types.
50 Memo 9	1/-/55	W. F. Thompson	Red salmon of the Nushagak. Outlines program of study for the Nushagak sockeye.
62 Memo 5	3/23/54	R. L. Burgner and S. Y. Koo	Results of the red salmon seaward migrant enumeration, Wood River lakes, 1951-1953. Smolt indices 1951-53 from fykenetting. Little data.
63 Memo 6	4/6/54	FRI Staff	Observations of physical conditions and salmon survival in Bristol Bay. Lake Nerka water levels, 1952-54. Notes date of freeze-up and break-up. Mean air temperature and snow levels 1952-54 at Lake Nerka.
66 Memo 7	10/-/54	FRI Staff	Nushagak red salmon forecast for 1955. Length of fish in catch and escapement, 1953-54.
77	1/-/55	FRI Staff	Summary tables of morphometric material collected by FRI on Bristol Bay red salmon. Numbers of measurements taken 1948-54.
84 Memo 11	3/12/56	FRI Staff	Nushagak red salmon forecast for 1956.
95	10/25/57	W. F. Thompson	Text is a letter to the FRI Advisory Board about the Nushagak catch 1900-1957. Nushagak returns by ocean age. Concerns the Japanese fishery.
99	3/27/59	FRI Staff	The expected run of red salmon in 1959 and the optimum escapement.
103	5/13/59	S. Y. Koo	Red salmon smolt enumeration in the Wood River system. Report of field operations and results 1958. Smolt index 1951-58. Daily catch and smolt index, 1958 (Mosquito Point.) Hourly catches, 2100-0200 (by day, 1958).

- 113 1960 R. L. Burgner and W. A. Church Observations on mortality of red salmon eggs in the Wood River lakes, fall 1959.
Some data from redd studies (high escapement in 1959).
- 116 1960 R. A. Marriott Size, age, and sex composition of red salmon commercial catch in Kushagak, 1959.
Much data included.
- 118 1960 S. Y. Koo Abundance, size, and age of red salmon smolts from the Wood River system, 1959.
From fykenetting at Mosquito Point. Does not include data from earlier years.
- 119 1960 M. O. Nelson Red salmon spawning ground surveys in the Kushagak district, Bristol Bay, Alaska, 1959.
Primarily aerial surveys. Includes Wood River lakes, Tikchiks, Igushiks, and Lake Munavaugluk. Uses 1958 data for comparison.
- 121 1960 R. A. Marriott Size and age composition of red salmon escapement to the Wood River lakes in 1959.
Beach seining of adults in the Aleknagik lagoon.
Aging by scale samples.
- 141 1961 O. A. Kerns, S. Y. Koo, and C. O. Junge Summary report on photoelectric counting of red salmon smolts, 1960.
Techniques.
- 154 1962 R. A. Marriott Size and sex composition of red salmon escapement to the Wood River lakes in 1961.
Beach seining, scales, otoliths, ground tower and aerial surveys. Many tables.
- 156 1962 W. S. Kim Estimation of the red salmon spawning population in Little Togiak Lake, Alaska, by means tagging.
Detailed data. Primarily concerned with methods.
- 157 1961 E. Finn Little Togiak River red salmon escapement enumeration, 1961.
Describes mainly the direct counting on Little Togiak River.
- 158 1962 D. R. Colby, and S. Y. Koo Lake Kulik red salmon escapement enumeration, 1961.
"Tower" counting on Wind River. No night counting. Detailed data.
- 175 1963 R. A. Marriott Lake Kulik smolt enumeration, 1961.
Fykenetting on Wind River plus photoelectric counting of smolts. Much data.

- 181 1963 N. Aspinwall Little Togiak River smolt enumeration, 1961. Migration estimates, timing, age of smolts and length frequencies.
- 182 1963 R. L. Burgner, and J. H. Green Study of interlake migration of red salmon fry, Agulowak River. Scale studies of 1953 year class adults. Measured 1st annulus to compare growth rates in different Nerka areas. Detailed data for smolt enumeration and length frequencies.
- 208 1964 S. Y. Koo Factors affecting marine age at return in sockeye salmon. Percent age of return by sex, 1946-52 in the Nushagak. Detailed measurements of sockeye annuli by sex, age, and number of freshwater years, 1950-1960.
- 209 1964 D. E. Rogers A summary of climatological observations and water temperatures in the Wood River lake system. Morphometric data for each lake. Mean monthly air temperatures 1957-1963, at Aleknagik, Nerka and Dillingham. Mean monthly precipitation, same areas. Monthly snowfall, Nerka 1951-58. Water temperatures, 1957-58. Heat budgets.
- 219 1964 R. L. Burgner Age composition of Nushagak red salmon runs, 1946-63. Many tables - by system.
- 224 1964 D. E. Rogers Variability in measurement of length and weight of juvenile sockeye salmon and threespine stickleback. Discusses variability in measuring techniques. Effect of formalin. Many tables.
- 229 1965 R. L. Burgner, J. Reeves, and D. E. Rogers Observations on resident fishes in the Tikchik and Wood River lake systems. Gillnetting and beach seining in the Tikchiks. Some lake trout stomach analysis.
- 234 1965 R. L. Burgner Age composition of Nushagak sockeye runs by river system, 1950-64. With escapement data. Some tables, 1946-60.
- 235 1965 W. F. Royce Almanac of Bristol Bay sockeye salmon. Seasonal calendar. Cumulative percentages of runs daily June 20 - August 4 by system.

- 237 1965 N. Aspinwall, and K. Roberson Report on age and size of sockeye salmon sampled from spawning grounds in the Wood River and Tikchik lakes, 1964. Lengths, otoliths, and scales. Survey counts.
- 66-4 1966 N. Aspinwall, and K. Roberson Report on age and size of sockeye sampled from Wood River and Tikchik spawning grounds, 1963. New analyzing techniques - a revision.
- 66-5 1966 N. Aspinwall, and K. Roberson Title of Circular 237 - revised analysis.
- 66-8 1966 K. Roberson Report on age and size of sockeye salmon sampled from spawning grounds in the Wood River lakes, 1965.
- 67-2 1967 B. Waters Abundance, distribution, and species composition of zooplankton in the lakes of the Nushagak District, Alaska, 1961-1965.
- 67-5 1967 K. Roberson Report on age composition and abundance of sockeye salmon sampled from spawning grounds in the Wood River lakes, 1966. No scales or lengths taken. Marking and recovery at Hansen Creek, Agulukpak River, and Anvil Bay.
- 67-10 1967 B. S. Batts, and K. J. Fischler Historical data on the sockeye salmon runs to the Nushagak District, Bristol Bay, Alaska. 1860-1945. Information divided into weather, catch, escapement, timing. Tables of fishing period. No summary.
- 68-1 1968 J. Reeves A quantitative comparison of bottom faunas of freshwater lakes in southwestern Alaska. Wood River lakes, Tikchiks, Igushiks, and Snake River Lake.
- 68-3 1968 K. Roberson Report on the age composition of sockeye salmon sampled from spawning grounds in the Wood River lakes, 1947-1967. Fairly detailed for all years.
- 68-4 1968 K. Roberson Report on abundance of sockeye salmon as determined by marking studies on the spawning grounds in the Wood River lakes, 1967. Two creeks, two rivers, and two beach spawning areas.
- 69-1 1969 O. A. Mathisen Tagging experiments in Bristol Bay, Alaska, in 1946 and 1947. Nushagak Bay, Egegik River, and Naknek/Kvichak

70-4	1970	D. Siler	Report on the abundance and age composition of sockeye salmon in sampled spawning grounds in the Wood River lakes, 1968 and 1969.
70-10	1970	D. E. Rogers, D. Siler, and T. Croker	A summary of climatological observations and water temperatures in the Wood River lake system. Information in addition to Circular 209.
72-4	1972	D. E. Rogers	Estimates of abundance and growth in the early summer from beach seine catches in Lake Aleknagik, 1962 through 1971. Much data.
72-7	1972	D. E. Rogers, L. Gilbertson, and D. Eggers	Predator-prey relationship between Arctic char and sockeye salmon smolts at the Agulowak Rivers, Lake Aleknagik, in 1971.
72-6	1972	D. E. Rogers, and A. Hamalainen	Abundance and age composition of sockeye salmon from spawning grounds in the Wood River lakes in 1970-1971 (detailed) and from 1946-1971 (summarized).

QUARTERLY REPORTS FOR THE WOOD RIVER STUDIES

(October 1, 1967 - January 15, 1973)

<u>Quarterly Report No.</u>	<u>Date</u>	<u>Table No.</u>	<u>Contents</u>
2	1/15/73	1	Chlorophyll <i>a</i> densities (mg/m^3 , 0-45 m) during the summer in Lake Aleknagik from two stations, 1961-1972. (Data by month: June 23-28, July 10-19, August 3-11, September 3-11.)
		2	Zooplankton densities (n/m^3) in the Wood River lakes during 1972 by species (and by sampling date).
		3	Zooplankton densities (n/m^3) in the Wood River lakes August 15 to September 11, 1967-1972. (Data presented by year only.)
		4	Comparison of zooplankton densities from paired vertical hauls made with nets of No. 6 and No. 10 mesh, Lake Aleknagik, 1972. (Dates August 3 and September 5, Stations 1-6, by species.)
		5	Analysis of variance of zooplankton catches using data in Table 4.
		6	Comparison of arithmetic means of zooplankton densities using data in Table 4.

- 7 Secondary and primary productivity measurements (C₁₂, Chlorophyll a, zooplankton), means and 95% confidence intervals from 1962-1972. Means on four sampling periods: June 22-28, July 12-20, August 3-11, August 23-September 11.
- 8 Percentage age composition of sockeye in spawning ground samples in the Wood River lakes, 1972.
- 9 Mean lengths of char and 5% significance of observed differences according to sample type. (Six paired sample types).
- 10 Population estimates of char at the mouths of the five major rivers (Agulowak, Agulukpak, Little Togiak, Peace, Wind) in 1972 after adjustment for differences in length among samples. (Estimates presented along with 95% confidence intervals.)
- 1 10/15/72 1 Summary of physical measurements in the Wood River lake system in 1972 and the long-term means and ranges from prior years. (Lists dates of ice breakup, means of water temperatures, solar radiation, lake level.)
- 2 Limnological data collected in Lake Aleknagik in 1972. (Includes surface water temperatures, Secchi depths, conductivity, and alkalinity.)
- 3 Ground survey counts of creek spawning populations, 1972.
- 4 Numbers of sockeye otoliths collected in 1972 (by creek and sex).
- 5 Catches of emergent insects in Lake Aleknagik, June 14-August 19, 1972.
- 6 Mean catches and water surface temperatures for insects traps in Lake Aleknagik for years 1969-1972.
- 7 Data for the 1972 Wood River lakes char population study. (Date, type of sample, gear, number of casts or number of gill net sets, number of char caught, number marked, number of recoveries.)
- 8 1972 char length frequency data summary.
- 3 7/15/72 No tables

- 8 Comparison of limnological measurements taken in Bear Bay, Hansen's Bay, and Lake Aleknagik, 1971 (date, chlorophyll *a*, zooplankton, Secchi depth, mean water temperature, alkalinity, conductivity).
- 9 Repeat of No. 8 for Anvil Bay and Ott's Bay (Lake Nerka).
- 10 Mean lengths of sockeye fry and threespine sticklebacks from beach seine and tonet samples in Lake Aleknagik, 1971.
- 11 Repeat of No. 10 for Lake Nerka 1970-1971.
- 12 Average emergent insect catches (number/24 hr) in Lake Aleknagik, 1969-1971, by 10-day periods.
- 13 Average surface water temperature at insect traps, 1969-1971, by 10 day periods.
- 1 10/15/71 1 Limnological data collected in the Wood River lakes in 1971.
- 2 Spawning ground counts in 1971.
- 3 Number of otoliths taken in 1971 (by colony).
- 4 Catches of emergent insects in Lake Aleknagik, June 16-September 11, 1971 (by bay and date; includes water temperatures).
- 5 1971 char study (date, type of sample, gear, units, number caught, number marked, number recoveries).
- 6 Summary of 1971 char study (date, length, sex, number stomachs with smolts, average number smolts per fish, percent parasitized, etc.)
- 7 Summary of statistical tests on char length data.
- 4 7/15/71 1 Same as 1, 10/15/71 No. 4 (less complete).
- 2 Same as 1, 10/15/71 No. 5 (less complete).
- 3 Data in 1, 10/15/71 No. 6 (less complete).
- 4 Data in 1, 10/15/71 No. 6 (less complete).
- 3 4/15/71 Note: Page 2 - Names of zooplankton species.

- 1 Average zooplankton densities and total number of hauls in Lake Aleknagik, 1961-1970 by species and sampling period.
 - 2 Average zooplankton densities and number of hauls in each Wood River lake by species and sampling period 1961, 1962, 1967-70.
 - 3 Limnological measurements taken in Bear Bay, Hansen's Bay and main lake (Lake Aleknagik), 1970 (date, chlorophyll *a*, zooplankton densities, Secchi depth, mean water temperature, alkalinity, conductivity).
 - 4 Mean lengths of sockeye fry and age I threespine sticklebacks from beach seine and tow net samples in Lake Aleknagik, 1970.
 - 5 Escapements of sockeye and abundance of progeny in Lake Aleknagik 1957-1970.
 - 6 Same as Table 3, but for Anvil Bay and Ott's Bay (Lake Nerka).
 - 7 Same as Table 5, but for Lake Nerka.
 - 8 Same as Table 4, but for North Nerka.
 - 9 Emergent insect catches in Lake Aleknagik (by area) in 1969 (Includes Ahayak Island.)
 - 10 Same as Table 9, but for 1970 (Bear Bay, Hansen's Bay, Whitefish Bay, and Anvil Bay).
 - 11 Insect catches by 24 hr periods in Lake Aleknagik 1969-1970.
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| 2 | 1/15/71 | <ol style="list-style-type: none"> 1 Estimated escapements in the Wood River lake system by lake, 1970 (Includes the mean, median, and range for 1951-1969 escapements). 2 Same as Report 2, 1/15/72, Table 2, except years are ranked by size of escapement. 3 Percentage age composition of sockeye in otolith samples from the Wood River lake system, 1970 (by spawning colony). 4 Weighted percentage age composition of spawning populations by lake and sex, Wood River lakes, 1970. |
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- 5 Catches and lengths of sockeye smolts from sampling (fyke net and beach seine) at Mosquito Point, 1970.
- 6 Ages, weights, and lengths of sockeye in fyke net catches at Mosquito Point, 1970.
- 7 Comparison of mean lengths and age composition of juveniles in the Wood Pier lakes and smolts in the following year (1958-1960).
- 8 Freshwater age composition in smolt migration and adult returns from smolts 1954-1970.
- 9 Summary of physical measurements in the Wood River lake system in 1970 and the long-term means and ranges from prior years.
- 10 Average C^{14} assimilation for two stations on Lake Aleknagik, 1962-1970.
- 11 Same as Report 2, 1/15/73 Table 1.
- 12 Composition of stomach contents from northern pike and char from Lake Aleknagik.
- 13 Stomach contents from 1970 Lake Aleknagik fish (whitefish, rainbows, and grayling).
- 1 10/15/70 1 Spawner counts in 1970 for areas in addition to those generally surveyed (Aleknagik and Nerka).
- 2 Number of otoliths taken in 1970 (by colony).
- 3 Beach seine catches of sockeye smolts during the 1970 sampling off Mosquito Point (by date).
- 4 Scheme for the Wood River lakes bay fertilization studies.
- 4 7/1/70 1 Mean numbers of zooplankton per cubic meter, Wood River lakes, 1969.
- 2 Zooplankton densities, mean sockeye fry lengths and spawner densities, Wood River lakes, 1967-1969 (by year).
- 3 4/15/70 1 No tables.
- 2 1/15/70 1 Catch and length data for 1969 Wood River lakes smolt sampling.

- 2 Primary productivity and limnological data for Lake Aleknagik, 1969 (C_{12} , chlorophyll *a*, pH, alkalinity, conductivity, Secchi depth).
- 3 Zooplankton settled volume and average water temperatures of the Wood River lakes, August 15-September 10, 1969 (by lake).
- 4 Mean daily solar radiation by monthly periods in Lake Aleknagik, 1961-1968 (June, July, August, September).
- 1 10/15/69 1 Otolith samples, 1969 (by lake and area).
- 2 Beach seine catches of sockeye smolts at Mosquito Point, 1969.
- 3 Insect trap catches in Lake Aleknagik, 1969.
- 4 7/15/69 No tables.
- 3 4/15/69 1 Percentage age composition of sockeye from otoliths, 1968. All Wood River lakes.
- Note: Page 3 - Mean lengths (and percentage) of age I and II migrating smolts in 1968 and 1954-1967 (mean).
- 2 Percentage age composition of sockeye adults in the Wood River lakes, 1968.
- 3 Comparison of zooplankton density, density of number of spawners and mean length of age 0 fish on September 1, Wood River lakes, 1967-68.
- 4 Comparison of zooplankton density in Lake Aleknagik (July 20 - September 10), sockeye escapement (in previous year), and mean length of age 0 fish on September 1.
- 2 1/15/69 1 Primary productivity and limnological data for Lake Aleknagik, 1968.
- 2 Zooplankton settled volumes and average water temperatures, Wood River lakes, August 15 - September 10, 1968.
- 3 Same as Report 2, 1/15/70, Table 4.
- 1 10/15/69 1 Number of otolith samples, 1967.
- 2 Beach seine catches and preserved samples of sockeye smolts at Mosquito Point, 1968.

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| 4 | 7/15/69 | 1 | Percent transmission of incident solar radiation per meter (Lakes Chauekuktuli, Iliamna, Aleknagik, Chignik, and Black Lakes). |
| | | 2 | Limnological data for Lake Aleknagik and Lake Chauekuktuli, 1967. |
| 3 | 4/1/68 | 1 | Number of zooplankton hauls (No. 6 mesh) and average density of organisms, 1967. |
| 2 | 1/1/68 | 1 | Estimated populations of isolated spawning population units in the Wood River system as determined by ground count, tagging, and recovery and aerial survey (areas in Aleknagik and Nerka). |
| | | 2 | Percentage age composition of sockeye samples from the Wood River lakes, 1967. |
| | | 3 | Weighted percentage age compositions for individual lakes and the total Wood River system, 1967. |
| | | Fig. | Observed average lengths and fitted Chapman-Richards growth curves for char in Lakes Aleknagik, Snake River, Ananka, and Ualik. |
| | | 4 | Percent numerical composition of bottom fauna in four major Nushagak lake systems in June and July, 1965 (Wood River, Snake River, Igushik, Tikchik). |
| | | 5 | Densities of total bottom fauna, summer 1965 of above systems. |
| 1 | 10/1/67 | 1 | Numbers of sockeye otolith samples from the Wood River lakes, 1967 (area, number otoliths). |
| | | 2 | Summary of gill-net catches in the Tikchik lakes. |
| | | 3 | Research fishing success (in July) for 2 years before and one year after the 1966 year of commercial fishery operations in the Tikchik lakes. |
| | | Fig. | Length frequencies of lake trout before and after the Tikchik fisheries. |
| | | Fig. | Length frequencies of humpback whitefish before and after the Tikchik fisheries. |
| | | 4 | Mean lengths of lake trout and humpback whitefish from Tikchik Lake samples in 1964, 1965, and 1967 (July). |

UNPUBLISHED REPORTS (WOOD RIVER STUDIES)

<u>Date</u>	<u>Author</u>	<u>Adult Identification</u>
1954	R. L. Burgner	Regarding the use of the Nushagak red salmon as a tracer population to identify Bristol Bay reds at sea. 7 pp. and figures. Discusses three distinctive characteristics in Wood River sockeye: <i>Tricnophorus</i> infestation, freshwater age and freshwater scale patterns. These are compared with sockeye from other systems in Bristol Bay and Russia.

Nushagak Bay Tagging and Mesh Studies

1946	R. T. Baade	Tagging program, Nushagak, 1946. Reports a study on the length of time adult Nushagak sockeye are exposed to the fishery. Tagging was done at Clark's Point. This report is primarily a presentation of little-analyzed data.
1947a	R. L. Burgner	Mesh experiment-Ekuk Beach, 1946. (Graphs included) 47 pp. A report on a study to determine the selectivity of set net mesh size on the salmon catch. Data summarized and presented in graphs and tables.
1947b	J. W. MacRae	Mesh experiments-Clarks Point, Alaska. 26 pp. As in preceding report.

Parasite Study

1952	R. L. Burgner	Preliminary notes on cestode infestation. Includes handwritten and typed notes plus the rough draft of a report. Information on distribution of <i>T. crassus</i> in Alaska, its life cycle, and the magnitude of smolt infestation in the Wood River lakes. Much data is included.
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Spawning Ground Studies

1947a	R. L. Burgner	Spawning ground survey study. 1. Lake Aleknagik 2. Tikchik Region. Reports on the extensive 1946 survey in which nearly every stream and beach was examined. Contains excellent detailed maps of lakes Aleknagik, Chauekuktuli, and Nuyakuk that are complete with notes about spawning colonies and stream and beach characteristics.
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- 1947b J. W. MacRae Spawning ground survey study. Wood River lakes region. As in preceding report. Excludes Lake Aleknagik. With a detailed map of the lakes surveyed from Nerka to Grant Lake.
- 1955 FRI Staff Small streams study - Quarterly report, July - September, 1955.
Observations of migration behavior in Hansen's, Whitefish, and Bear Creeks. Data presented on the timing and rate of upstream movement of adult sockeye. Notes that the majority of fish enter Whitefish Creek between 2030 and 2400.

Winter Studies

- 1950 R. Charlton Report on winter survey - Bristol Bay, February - March 1950.
Contains sketches of ice covering on selected areas of Lakes Aleknagik, Nerka, and Little Togiak. Also sketches of Little Togiak River, Pick Creek, and Hansen's Creek. Some data on egg and fry survival. Fyke net catches (Little Togiak River) from six sampling dates are reported.
- 1955 W. A. Church Preliminary studies on the effect of winter environment on red salmon, Lake Nerka.
Summary of 1953-55 data. Emphasis on physical data - air temperatures, snowfall, water and gravel temperatures in selected spawning beds.
- 1956 W. A. Church Report on the 1955-56 studies of the effect of winter conditions on survival of red salmon eggs and larvae in the Wood River lakes. 69 pp.
In two parts, Part I deals with weather conditions and Part II deals with egg and larvae survival. Much data.
- 1959a W. A. Church Report on the 1956-1957 studies on the effect of winter environment on red salmon eggs and larvae in the Wood River lakes. 24 pp., 33 figs., and 19 tables.
Includes contour/spawning distribution maps of the areas sampled.
- 1959b W. A. Church Report on the 1957 studies of recently emerged red salmon fry in the Wood River lakes.
Fry traps in Little Togiak River, Pick Creek, Elva Creek, and Cabin Bay. 11 pp. 3 figs., and 6 tables.

- 1953c W. A. Church Studies on the effect of winter climate on survival of red salmon embryos in the Wood River lakes, Alaska, 1952-1959. 33 pp.

Weather Reports

- 1947a F. Bruckelmeyer Weather report. Lake Aleknagik, Sourdough Camp 1947. No lake data.
- 1947b FRI Staff Bathythermograph observations and graphs, Lake Aleknagik, Wood River, 1947.
Detailed weather observations in conjunction with BT readings. Much data with little analysis. Concerned mainly with the technique and its accuracy.
- 1947a W. A. Church Weather report, Lake Chauekuktuli, Allen River, November 1956-March 1947.
No lake data.
- 1952-1959 W. A. Church Weather compilations, Nerka station, 1952-1959.
No lake data.

Young Fish Studies

- 1951a R. L. Burgner Preliminary report on the young red salmon index sampling problem in Bristol Bay, with particular reference to the 1951 studies into the use of floating lake traps in the Wood River lakes.
- 1951b T. Coulton Marking experiments of fingerling silver salmon by the injection of biological stains.
Concerned with technique and finding the optimal stain for use in the field.
- 1953a R. L. Burgner Age composition of young red salmon in the Wood River lakes as shown by length frequency and subsequent scale study of samples taken during single sampling period.
- 1953b R. L. Burgner A preliminary comparison of Kvichak and Nushagak red salmon fingerling samples.
- 1953c S. Y. Koo Report on red salmon smolt enumeration at Mosquito Point, Lake Aleknagik, 1953.
Contains a comparison of catch by winged versus unwinged fyke nets.

- 1953⁷ S. Y. Koo An adjusted appraisal of the relative abundance of red salmon smolt migration at Mosquito Point in the years 1951, 1952, and 1953.
Catches from fykenetting.
- 1954 R. L. Burgner An evaluation of the sampling procedure used at Mosquito Point, Lake Aleknagik, to determine the age and size composition of red salmon smolts at time of seaward migration.
- 1954
1955^a R. L. Burgner Age composition of the 1953 (and 1954) smolt migration, Wood River lakes.
- 1954-
1955^b R. L. Burgner Seasonal changes in size of smolts passing Mosquito Point, 1953 and 1954.
- 1954 S. Y. Koo Is the 2100-2300 hour fishing period for smolt migrants adequate for enumeration purpose?
- 1954-
1958 S. Y. Koo Report on red salmon smolt enumeration at Mosquito Point, Lake Aleknagik, (1954-58).
- 1955 R. L. Burgner Second report on sampling procedures used at Mosquito Point, Lake Aleknagik, to determine size and age composition of the red salmon smolts.
- 1956 R. L. Burgner Study of migration and movements of red salmon fingerlings by tattooing release, and recovery procedures.
Concerned mainly with technique. Migration studies conducted on the Little Togiak River and Lake Nerka. Data presented in graphs and tables.
- 1957 R. L. Burgner Factors affecting timing of the Mosquito Point seaward migration.
- 1958 R. L. Burgner Methods of measuring condition of red salmon fingerlings
Paper concerned primarily with length/weight ratios, but it also mentions parasites.

Modeling

- 1971 D. M. Eggers and
D. E. Rogers Trophic relation model in aquatic communities sockeye salmon model, Wood River lakes, Alaska.
Yearly progress report.