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COLLECTION AND ANALYSIS OF BIOLOGICAL DATA FROM THE WOOD RIVER LAKE SYSTEM, NUSHAGAK DISTRICT, BRISTOL BAY, ALASKA

PREDICTION OF SOCKEYE SALMON RUNS TO THE WOOD RIVER LAKES

by

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INTRODUCTION

The annual sockeye salmon runs to the Nushagak District of Bristol Bay have ranged from 0.85 to 4.76 million during the past 25 years. The runs averaged 2.18 million (S.D. = 0.94) and supported an important commercial fishery that caught an average of 0.90 million (S.D. = 0.41). A preseason forecast of the run is useful to the fishing industry for preparation of the harvest and processing of the fish and to the Alaska Department of Fish and Game (ADF&G) for early-season regulation of the fishery.

Forecasts have been made by ADF&G for each of the lake systems in the Nushagak District based on escapement-return relationships and the average age composition of returns (ADF&G 1970).[1] The forecasts of the Nushagak run and catch were then made by summing the forecasts for the individual river systems. Confidence limits on the forecasts have not been calculated; however, the past forecasts were sufficiently close to the actual runs except in 1974 when a large error in the forecast caused a great underutilization of the run. The following are the forecasts and actual runs and catches (in millions) for the past four years:

Year	Forecast		Actual		
	Run	Catch	Run	Catch	Escapement
1973	1.32	.27	.85	.27	.58
1974	.73	.01	2.78	.51	2.27
1975	2.33	1.08	2.91	.64	2.27
1976	1.99	.74	2.71	1.22	1.49

Escapement goals for the Nushagak District vary somewhat from year to year according to the expected distribution of the run among the river systems; however, the escapement goal is usually about 1.2 million fish. About 65 percent of the runs during the past 25 years were bound for the Wood River system, and these runs were not only larger but also relatively more variable than the runs to the other lake systems. Thus, accurate forecasts of the Wood River runs are particularly important for the Nushagak fishery and its management.

An annual run to the Wood River system is the sum of the runs to the individual lakes and spawning grounds in the lakes. These runs are

[1] A run is the sum of the catches and escapements of each age group in a given year, whereas the return is the sum of the catches and escapements of each age class that returned in successive years from a given year of spawning (brood year).

frequently uncorrelated and the age composition often differs significantly among the individual runs.[2] The spawning and rearing capacity for sockeye salmon varies among the lakes and this causes some variation in the adult returns from a given escapement to the lake system.

The purpose of this report is to examine alternative methods of forecasting the sockeye salmon runs to the Wood River system. The specific objective was to determine the best method based on reliability and cost of obtaining the required statistics.

METHODS

Statistics on the sockeye salmon runs to the Wood River system were obtained from the Fisheries Research Institute (1946-1961) and the Informational Leaflets of the Alaska Department of Fish and Game (1962-1974). Statistics on the 1975 and 1976 runs are preliminary and were obtained from ADF&G. The escapements and returns to individual lakes were estimated from aerial and ground surveys made during the spawning season in August and September.[3] The age compositions of the escapements were estimated from samples collected from the principal spawning grounds in each lake, and the returns were calculated by age group from the rate of exploitation in the Nushagak fishery, i.e., the ratio of run to escapement for an age group in the entire Wood River run was multiplied by the escapement of that age group in the lake.

The escapement-return relationship based on all years (1946-1971 broods) was examined to determine the variability and degree of correlation. Relationships that were based on a four-year cycle were then examined since the predominant age at return was four years (age 1.2). The variability in returns was compared to the variability in runs to determine whether the runs could be forecast directly from past runs rather than past escapements.

The abundance of juvenile sockeye has been estimated during mid-August to early September since 1958. The estimates were made from tow-netting and echosounding in the pelagial regions of the lake system.[4] Adult returns were related to these estimates of abundance to determine whether more precise forecasts could be made when the variability in survival from eggs to fry was omitted. The effects of annual variation in the growth of sockeye fry on the total return and the age at return were also examined.

Estimates of the relative abundance of fry in Lake Aleknagik have been made annually during early summer since 1962. Beach-seine estimates, estimates of pelagic populations, and the number of parent

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[2]Rogers, D. E. 1974. Systems modeling of sockeye salmon in the Wood River lakes. Annual Progress Report. Anadromous Fish Project. FRI-UW-7406.

[3]In recent years the aerial surveys have been conducted by Mr. M. Nelson of ADF&G.

[4]Rogers, D. E. 1975. Systems modeling of sockeye salmon in the Wood River lakes. Annual Report. Anadromous Fish Project. FRI-UW-7511.

spawners were compared to the adult returns to Lake Aleknagik to determine which estimate of abundance was most closely correlated with the adult returns.

RESULTS

The runs and escapements of sockeye salmon to the Wood River lakes from 1946 to 1976 are given in Table 1. Prior to 1953 the number of fish in the escapement was estimated solely from spawning surveys but since then they were estimated from tower counts (Gilbert 1968). The predominant age at return is 1.2, i.e., fish that have spent one winter in freshwater and two winters at sea; next most abundant are fish of age 1.3. Only four brood years produced significant returns of fish that had spent two winters in freshwater (ages 2.2 and 2.3). The escapements and subsequent returns are ordered according to the magnitude of the escapement in Table 2. From escapements that ranged from 100,000 to 870,000, there was a correlation with the subsequent adult returns of only 0.34 and for escapements greater than about 1 million, the correlation with returns was only -0.36. Even when escapements prior to 1953 and those greater than 1.38 million (the maximum return) were excluded, the correlation with the returns was only 0.73, and forecasts of a future return had 80 percent confidence limits of about plus or minus 900,000. Since the age composition of the returns varied, the confidence limits on the forecast of a future run would be even wider.

When escapements and returns were grouped by four-year lines, the annual variability was reduced in all but one line (Fig. 1). The relative productivity was highest for the 1950 line and lowest for the 1949 line. However, the annual variation in the runs was less than the variation in returns so future runs could be more accurately forecast from past runs than from past returns (Table 3). Furthermore, runs of age 1.2 fish and age 1.3 fish were largely independent because they tended to spawn in different parts of the lake system. Thus, runs of age 1.2 were ordered by four-year lines and runs of age 1.3 by five-year lines (Table 4). Fish of ages 2.2 and 2.3 are those that normally (genetically) would have been ages 1.2 and 1.3 but had poor growth in their first year in freshwater and thus held over a second year.

Forecasts of the runs in 1977-1980 were made from the means of the runs since 1952 and from the means of the runs since 1961 (Table 5). The variance of a forecast was the sum of the variances of the mean runs by age group. The 80 percent confidence limits ranged from plus or minus 140,000 to plus or minus 500,000 when data since 1952 were used, and from plus or minus 130,000 to plus or minus 410,000 when data since 1961 were used. The number of fish in the parent escapement had little effect on the number of fish in the run within a line. The runs were largely independent of the escapements.

The runs to the upper lakes of the system (Beverley, Kulik, and Mikchalk) exhibit a distinct cyclic pattern. These fish are primarily age 1.2 and spawn mainly on lake beaches. The runs to the central part of the system (South and Central Nerka and Little Togiak Lake) also exhibit some cyclic variability and these fish spawn in creeks and lake beaches. The runs to North Nerka and Lake Aleknagik contain a large proportion of river spawners that typically mature at age 1.3; however, North Nerka also contains one important beach spawning population (Anvil Bay) as well as several creek populations. The age 1.2 fish show a four-year cycle whereas the age 1.3 fish in North Nerka exhibit a five-year cycle (Tables 6 and 7).

The runs of ages 2.2 and 2.3 are relatively more variable within a line than are the runs of ages 1.2 and 1.3; however, in 1977 and 1978, the runs of ages 2.2 and 2.3 should be negligible. Forecasts of the runs of ages 1.2 and 1.3 to the major regions of the system in 1977 and 1978 are given in Table 8. The forecasts and confidence limits for the entire lake system are very similar to those given in Table 7, but this method of forecasting is useful to management of the lake system. For example, the expected run to the upper lakes in 1977 is only 73,000 (28-118,000) which is well below the optimum escapement of about 265,000 and unlikely to produce a large return in 1981 even if the entire run were allowed to spawn. The expected runs to North Nerka and Lake Aleknagik (primarily river spawners) total 330,000 and the optimum escapements to these lakes total 204,000. Therefore, these runs could sustain a rate of exploitation of about 40 percent.

Forecasts of adult returns from the abundance and size of fry would be little better than forecasts from the abundance of parent spawners because the relationships are about equally variable (Fig 2). Prior to the returns from the 1970 and 1971 brood years, the relationship between returns and biomass of fry was significantly closer than the return-escapement relationship. Two factors probably contributed to the relatively large returns from the biomass of fry in 1971 and 1972: 1) the fish were less available to tow-net sampling because the spring weather was unusually cold, and 2) high seas fishing in 1974 and 1975 was greatly restricted relative to past years. Nevertheless, a sampling program to annually estimate the abundance of fry (or smolts) solely for the purpose of forecasting future runs to the Wood River lakes appears unjustified at present.

The runs of age 2.2 fish were significantly correlated with the abundance of age I juveniles (Fig. 3). The correlation was 0.89 when the observation for the 1969 brood year was omitted (fish sampled in 1971). The standard deviation of Y on X was 50,000 and thus significantly lower than the standard deviations of the runs of age 2.2 fish by four-year lines which ranged from 70,000 to 270,000. Forecasts of future runs of age 2.2 fish can be made more accurately from the abundance of yearlings than from the past cycle runs. However, a sampling program to estimate the abundance of yearlings solely to forecast runs is probably not justified because the runs of age 2.2 fish to the Wood River lakes are usually small relative to the runs of ages 1.2 and 1.3. Larger-than-average runs of age 2.2 fish could be forecasted simply from the age composition of juveniles or the age composition of smolts and these estimates could be obtained from relatively limited sampling.

The variability in the escapement-return relationship for Lake Aleknagik is greater than the variability in the relationships for the other lakes in the system; however, much of the variation is caused by differences in the relative productivity of the five-year lines (Fig. 4). The dominant lines (1950, 1951) produced returns that were more than double those from the other lines when escapements were near the optimum (ca. 100,000). The largest escapements in each line produced returns that were equal to or below the replacement line. Escapements to Lake Aleknagik have generally been too large for maximum production (catch) except for the 1950 line.

Forecasts of the runs to Lake Aleknagik can best be made from past cycle runs because relationships between fry abundances and adult returns are nearly as variable as the escapement-return relationship (Fig. 5). If observations from the 1970-1971 brood years are omitted, the beach-seine catch of fry in early summer is much more closely related to subsequent returns than is the parent escapement. The growth of fry is density dependent and thus inversely correlated with escapement (Table 9). At present the annual variation in the size of fry is of little value in forecasting future runs because there is relatively little variation within a line and only three observations per line. However, the fry from the 1972 brood year were exceptionally large even for their five-year line (Table 10) and the return of age 1.2 in 1976 was also exceptionally large (about 152,000).

CONCLUSIONS

The annual runs of sockeye salmon to the Wood River lake system can be forecasted from past runs by age group according to four- or five-year lines. Forecasts by this method should be within 25 percent of the actual runs about eight years out of ten. This method requires no additional sampling other than the routine sampling of escapements in the trunk streams and catch statistics. Forecasts of the individual runs to the Wood River lakes can also be made with about equal precision. These forecasts are advantageous to management of the Wood River stocks but they require additional sampling of spawning populations on an annual basis.

Abundances of escapements and juvenile fish presently do not provide for a significant improvement in the precision of forecasts. Annual estimates of the abundances of juvenile fish require additional costs and thus they should not be made solely for the purpose of forecasting future runs.

LITERATURE CITED

Alaska Department of Fish and Game. 1970. Final forecast of 1970 Bristol Bay sockeye run. S. Pennoyer, ed. Alaska Dep. Fish Game Inform. Leafl. 146. 107 pp.

Gilbert, J. R. 1968. Surveys of sockeye salmon spawning populations in the Nushagak District, Bristol Bay, Alaska, 1946-1958. Univ. Washington Publ. Fish., New Ser. 3:200-267.

Table 1. Escapements and inshore returns in millions and the age composition of the returns to the Wood River system for the 1946-1970 brood years

Brood year	Run	Escapement	Return	Age composition (%) 1.2	2.2	1.3	2.3
1946	5.32	3.72	1.07	48	2	48	2
47	3.74	1.78	.50	52	2	44	1
48	3.47	1.48	.93	34	0	66	0
49	.69	.10	.28	61	0	39	0
50	1.26	.45	1.26	56	8	33	3
51	.83	.46	2.23	70	7	22	1
52	.56	.23	1.18	69	1	28	2
53	.79	.52	.63	32	10	52	6
54	.81	.57	2.27	52	34	11	3
55	2.09	1.38	3.68	64	15	17	3
56	1.50	.77	1.08	57	2	41	0
57	.57	.29	.38	28	10	61	1
58	1.61	.96	2.34	82	4	13	1
59	3.49	2.21	1.64	51	23	23	2
60	1.86	1.02	2.28	60	4	32	3
61	.70	.46	1.17	23	1	73	3
62	2.18	.87	1.52	66	7	24	2
63	1.25	.72	1.22	44	5	49	2
64	2.15	1.08	.97	37	31	26	6
65	1.14	.68	1.45	32	5	53	11
66	1.96	1.21	1.63	52	2	43	3
67	1.05	.52	.76	70	8	16	6
68	1.06	.65	.73	51	0	47	3
69	1.06	.60	.73	5	29	53	12
70	1.76	1.16	2.54	58	8	33	1
71	1.44	.85	(1.20)				
72	.59	.43					
73	.44	.33					
74	2.13	1.71					
75	1.57	1.27					
76	1.46	.82					

Table 2. Escapements and returns for the 1946-1976 brood years ordered from smallest to largest escapements

Brood year	Escapement (millions)	Return (millions) Total	1.2	2.2	1.3	2.3	Return minus escapement
1949	.10	.28	.17	.00	.11	.00	.18
52	.23	1.18	.82	.01	.33	.02	.95
57	.29	.38	.10	.04	.23	.00	.09
73	.33						
72	.43		.68				
50	.45	1.26	.70	.10	.42	.04	.81
51	.46	2.23	1.57	.15	.49	.03	1.77
61	.46	1.17	.27	.02	.86	.03	.71
53	.52	.63	.20	.06	.33	.04	.11
67	.52	.76	.53	.06	.12	.05	.24
54	.57	2.27	1.17	.77	.26	.06	1.70
69	.60	.73	.04	.21	.39	.09	.12
68	.65	.73	.37	.00	.34	.02	.03
65	.68	1.45	.46	.07	.76	.15	.77
63	.72	1.22	.53	.06	.59	.03	.50
56	.77	1.08	.61	.02	.45	.00	.31
76	.82						
71	.85	1.20	.42	.18	.52	(.08)	.35
62	.87	1.52	1.01	.11	.37	.03	.65
mean	.55	1.13					
S.D.	.22	.57					
correlation (r)	.34						
58	.96	2.34	1.91	.10	.31	.02	1.38
60	1.02	2.28	1.36	.10	.74	.08	1.26
64	1.08	.97	.36	.30	.26	.06	- .11
70	1.16	2.58	1.51	.19	.84	.04	1.38
66	1.21	1.64	.85	.04	.70	.04	.43
75	1.27						
55	1.38	3.68	2.36	.55	.63	.13	2.30
48	1.48	.93	.32	.00	.61	.00	- .55
74	1.74						
47	1.78	.50	.26	.01	.22	.01	-1.28
59	2.21	1.64	.84	.38	.38	.03	- .57
46	3.72	1.07	.52	.02	.52	.02	-2.65
mean	1.60	1.76					
S.D.	.84	.96					
correlation (r)	-.36						

Table 3. Runs and returns in millions to the Wood River lakes by 4-year lines

Year	Runs	$\bar{x}$	S.D.	Brood year	Escapement	Return	$\bar{x}$	S.D.
1956	1.50			1952	.23	1.18		
60	1.86			56	.77	1.08		
64	2.15			60	1.02	2.28		
68	1.06			64	1.08	.97		
72	.59			68	.65	.73		
		1.43	.62				1.25	.60
57	.57			53	.52	.63		
61	.70			57	.29	.38		
65	1.14			61	.46	1.17		
69	1.06			65	.68	1.45		
73	.44			69	.60	.73		
		.78	.31				.87	.43
58	1.61			54	.57	2.27		
62	2.18			58	.96	2.34		
66	1.96			62	.87	1.52		
70	1.76			66	1.21	1.63		
74	2.13			70	1.16	2.58		
		1.93	.24				2.07	.47
59	3.49			55	1.38	3.68		
63	1.25			59	2.21	1.64		
67	1.05			63	.72	1.22		
71	1.44			67	.52	.76		
75	1.57			71	.85	1.20		
		1.76	.99				1.70	1.15
All years		1.48	.72				1.47	.81
C.O.V.		48.6%					55.1%	

Table 4. Escapements and runs in millions of ages 1.2 and 2.2 by 4-year lines and ages 1.3 and 2.3 by 5-year lines

Year(y)	Escapement y-4	Run 1.2 y	Run 2.2 y+1
1953	.10	.17	.00
57	.52	.20	.06
61	.29	.10	.04
65	.46	.27	.02
69	.68	.46	.07
73	.60	.04	.21
mean		.21	.07
S.D.		.15	.07
1954	.45	.70	.10
58	.57	1.17	.77
62	.96	1.91	.10
66	.87	1.01	.11
70	1.21	.85	.04
74	1.16	1.51	.19
mean		1.19	.22
S.D.		.45	.27
1955	.46	1.57	.15
59	1.38	2.36	.55
63	2.21	.84	.38
67	.72	.53	.06
71	.52	.53	.06
75	.85	.42	.18
mean		1.04	.23
S.D.		.77	.20
1956	.23	.82	.01
60	.77	.61	.02
64	1.02	1.36	.10
68	1.08	.36	.30
72	.65	.37	.00
76	.43	.68	
mean		.70	.09
S.D.		.37	.13

Year(y)	Escapement y-5	Run 1.3 y	Run 2.3 y+1
1952	1.78	.22	.01
57	.23	.33	.02
62	.29	.23	.00
67	.87	.37	.03
72	.52	.12	.04
mean		.25	.02
S.D.		.10	.02
1953	1.48	.61	.00
58	.52	.33	.04
63	.96	.31	.02
68	.72	.59	.03
73	.65	.34	.02
mean		.44	.02
S.D.		.15	.01
1954	.10	.11	.00
59	.57	.26	.06
64	2.21	.38	.03
69	1.08	.26	.06
74	.60	.39	.09
mean		.28	.05
S.D.		.11	.03
1955	.45	.42	.04
60	1.38	.63	.13
65	1.02	.74	.08
70	.68	.76	.15
75	1.16	.84	.04
mean		.68	.09
S.D.		.16	.05
1956	.46	.49	.03
61	.77	.45	.00
66	.46	.86	.03
71	1.21	.70	.04
76	.85	.52	
mean		.60	.03
S.D.		.17	.02

Table 5. Forecasts of sockeye salmon runs to Wood River based on past cycle runs from (A) 1952-1976 and (B) 1965-1976, ages 1.2 and 2.2; 1961-1976, ages 1.3 and 2.3

	Year		Age 1.2	2.2	1.3	2.3	Σ	80% C.I.	
A.	1977	Forecast	.21	.09	.25	.03	.58	.44	.72
		Variance	.0038	.0034	.0020	.0001	.0093		
	1978	Forecast	1.19	.07	.44	.02	1.70	1.41	1.99
		Variance	.0323	.0008	.0051	.0001	.0383		
	1979	Forecast	1.04	.22	.28	.02	1.56	1.06	2.06
		Variance	.0988	.0121	.0024	.0000	.1133		
	1980	Forecast	.70	.23	.68	.05	1.66	1.38	1.94
		Variance	.0228	.0067	.0051	.0002	.0348		
B.	1977	Forecast	.26	.13	.24	.02	.65	.34	.96
		Variance	.0140	.0078	.0052	.0001	.0271		
	1978	Forecast	1.12	.09	.41	.02	1.64	1.23	2.05
		Variance	.0345	.0025	.0090	.0001	.0461		
	1979	Forecast	.49	.11	.34	.02	.96	.83	1.09
		Variance	.0013	.0019	.0017	.0000	.0049		
	1980	Forecast	.47	.10	.78	.06	1.41	1.19	1.63
		Variance	.0110	.0016	.0009	.0003	.0138		

Table 6. Runs of sockeye salmon in thousands by 4-year lines

Year (y)	Age:	Beverley, Kulik and Mikchalk 1.2 y	2.2 y+1	1.3 y+1	South and Central Nerka, Little Togiak 1.2 y	2.2 y+1	1.3 y+1	North Nerka 1.2 y	2.2 y+1	1.3 y+1
1953		19	0	8	35	0	24	33	0	20
57		14	22	40	143	4	108	35	15	119
61		30	23	21	46	4	58	25	12	88
65		73	6	44	96	4	145	60	5	231
69		39	2	4	142	20	120	273	6	206
73		18	34	49	25	29	151	6	35	102
mean		32	14	28	81	10	101	72	12	128
S.D.		22	14	19	53	12	50	100	12	78
1954		258	19	45	178	68	46	118	10	76
58		657	570	35	282	124	59	201	56	39
62		1220	94	91	392	3	79	244	3	103
66		446	102	95	311	1	72	164	3	85
70		389	1	80	317	6	142	145	1	244
74		719	57	48	253	44	165	104	16	309
mean		614	140	66	289	41	94	163	15	143
S.D.		342	214	26	71	49	48	53	21	108
1955		490	32	73	302	34	90	285	10	57
59		506	316	37	1209	146	243	497	84	163
63		545	299	86	174	27	84	106	33	81
67		188	52	113	153	9	116	135	4	180
71		395	16	19	124	8	27	71	0	52
75		258	112	47	69	27	32	17	32	181
mean		397	138	62	338	42	99	185	27	119
S.D.		145	135	35	433	52	79	177	31	62
1956		79	1	6	386	4	102	165	1	65
60		153	5	37	285	7	88	152	5	127
64		536	20	67	434	37	126	209	25	222
68		79	23	14	142	20	31	63	55	82
72		92	1	8	136	0	52	86	0	97
76		85			161			119		
mean		171	10	26	257	14	80	132	17	119
S.D.		181	11	26	131	15	38	54	23	62

Table 7. Runs of sockeye salmon in thousands by 5-year lines

Year (y)	Age:	North Nerka 1.2 y-1	North Nerka 2.2 y	North Nerka 1.3 y	Aleknagik 1.2 y-1	Aleknagik 2.2 y	Aleknagik 1.3 y	Aleknagik 2.3 y+1
1952		33	0	50	29	0	65	3
57		165	1	65	191	3	155	17
62		25	12	88	3	0	61	0
67		164	3	85	83	0	119	1
72		71	0	52	14	2	40	0
mean		92	3	68	64	1	88	4
S.D.		69	5	18	77	1	47	7
1953		86	0	201	99	1	305	0
58		35	15	119	11	21	64	16
63		244	3	103	80	0	35	1
68		135	4	180	57	2	252	1
73		86	0	97	70	1	198	0
mean		117	4	140	63	5	171	4
S.D.		79	6	47	33	9	117	7
1954		33	0	20	81	0	51	0
59		201	56	39	45	22	123	5
64		106	33	81	26	18	136	11
69		63	55	82	45	145	82	57
74		6	35	102	3	77	108	39
mean		82	36	65	40	52	100	22
S.D.		76	23	34	29	59	34	25
1955		118	10	76	148	6	261	18
60		497	84	163	160	17	166	43
65		209	25	222	176	18	321	33
70		273	6	206	58	31	395	117
75		104	16	309	103	23	462	29
mean		240	28	195	129	19	321	48
S.D.		159	32	85	48	9	115	40
1956		285	10	57	483	75	269	22
61		152	5	127	27	1	192	0
66		60	5	231	36	3	434	24
71		145	1	244	38	8	216	35
76		17	32	181	41	112	347	
mean		132	11	168	125	40	292	20
S.D.		103	12	77	200	51	99	15

Table 8. Forecasts of sockeye salmon runs (in thousands) to areas of the Wood River lake system in 1977 and 1978 based on runs by age in past 3 cycle years

Year of run	Lakes	Age 1.2 Fore-cast	Age 1.2 Var-iance	Age 1.3 Fore-cast	Age 1.3 Var-iance	Total Fore-cast	Total Var-iance
1977	Beverley, Kulik, Mikchalk	43	257	30	315	73	572
	South, Central Nerka, Little Togiak	88	1158	70	830	158	1988
	North Nerka	113	6643	75	133	188	6776
	Aleknagik	69	44	73	558	142	602
	Total	313	8102	248	1836	561 (373,749)	9938
1978	Beverley, Kulik, Mikchalk	518	10371	32	203	550	10574
	South, Central Nerka, Little Togiak	294	416	139	90	433	506
	North Nerka	138	313	127	714	265	1027
	Aleknagik	25	147	162	4254	187	4401
	Total	975	11247	460	5261	1435 (1192,1678)	16508

Table 9. Sockeye salmon statistics for Lake Aleknagik

		Age 0 year + 1			Age 1 year + 2			Adult returns (thousands)				
Brood year	Escapement (thousands)	B.S. catch[1]	Tow net pop. (millions)	$\bar{w}$ on 9/1 (gm)	B.S. catch[2]	Tow net pop. (millions)	$\bar{w}$ on 9/1 (gm)	1.2 (y+4)	1.3 (y+5)	2.2 (y+5)	2.3 (y+6)	Total
1957	88	---	6.3	2.2	---	.1	10.4	3	61	0	0	64
58	63	---	4.6	2.2	---	.1	6.1	80	35	0	1	116
59	205	---	29.5	1.5	---	3.6	5.7	26	136	18	11	191
60	85	---	24.7	1.8	1.1	.6	5.6	176	321	18	33	548
61	153	278	12.4	1.4	.7	.2	6.3	36	434	3	24	497
1962	48	---	6.8	2.2	.9	.2	8.6	83	119	0	1	202
63	31	171	6.6	2.0	.9	.04	7.4	57	252	2	1	312
64	155	565	20.3	1.4	2.1	7.9	4.3	45	82	145	57	329
65	220	380	43.4	1.0	9.7	2.1	2.7	58	395	31	117	601
66	287	335	13.3	0.7	1.0	.1	4.0	38	216	8	35	297
1967	92	34	2.4	1.8	1.0	.01	5.3	14	40	2	0	56
68	177	85	19.2	2.1	1.1	.1	6.6	70	198	1	1	270
69	160	127	10.6	1.8	1.3	.1	5.7	3	108	77	39	227
70	302	405	3.4	1.5	5.1	.3	8.1	103	462	23	29	617
71	182	131	2.2	1.5	.4	.3	5.6	41	347	112	---	(580)
1972	97	22	0.7	2.7	.2	.1	5.4	152	---	---	---	---
73	162	26	10.9	2.2	.7	.00	---	---	---	---	---	---
74	242	97	1.8	1.5	3.0	---	5.3	---	---	---	---	---
75	459	204	---	1.1	---	---	---	---	---	---	---	---
76	340	---	---	---	---	---	---	---	---	---	---	---

[1]Geometric mean of beach seine catches during 6/20 - 7/19.

[2]Geometric mean of beach seine catches during 7/21 - 8/5.

Table 10. Runs, escapements, and returns of sockeye salmon (in thousands) to Lake Aleknagik and the mean weight of fry in September 1 by 5-year lines

Year	Run	Escapements	Return	R/E	$\bar{w}$ (gm)
1947	---	186	97	0.5	---
52	162	67	367	5.5	---
57	191	88	64	0.7	2.2
62	141	48	203	4.2	2.2
67	177	92	56	0.6	1.8
72	112	98	---	---	2.7
1948	---	155	405	2.6	---
53	390	252	112	0.4	---
58	147	63	116	1.8	2.2
63	61	31	312	10.1	2.0
68	300	177	270	1.5	2.1
73	202	162	---	---	2.2
1949	---	33	132	4.0	---
54	199	134	195	1.5	---
59	321	205	191	0.9	1.5
64	331	155	329	2.1	1.4
69	286	160	227	1.4	1.8
74	288	242	---	---	1.5
1950	---	130	433	3.3	---
55	750	493	387	0.8	---
60	215	85	548	6.4	1.8
65	386	220	601	2.7	1.0
70	521	302	617	2.0	1.5
75	565	458	---	---	1.1
1951	---	92	849	9.2	---
56	553	252	220	0.9	---
61	239	153	497	3.2	1.4
66	553	287	297	1.0	0.7
71	355	182	550	3.0	1.5
76	640	340	---	---	---

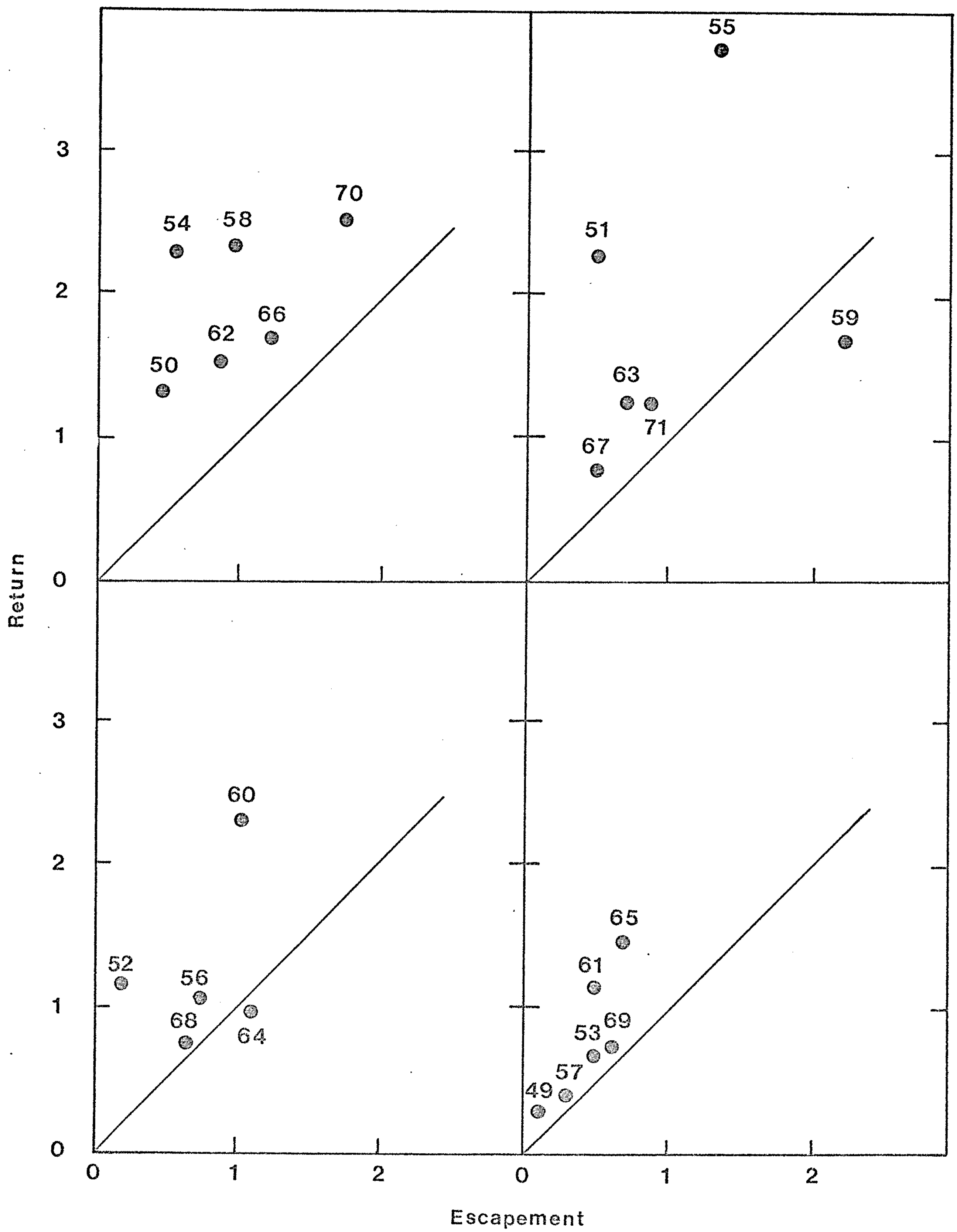

Fig. 1. Escapements and returns (in millions) to the Wood River lakes by 4-year lines (1949-1971 brood years).

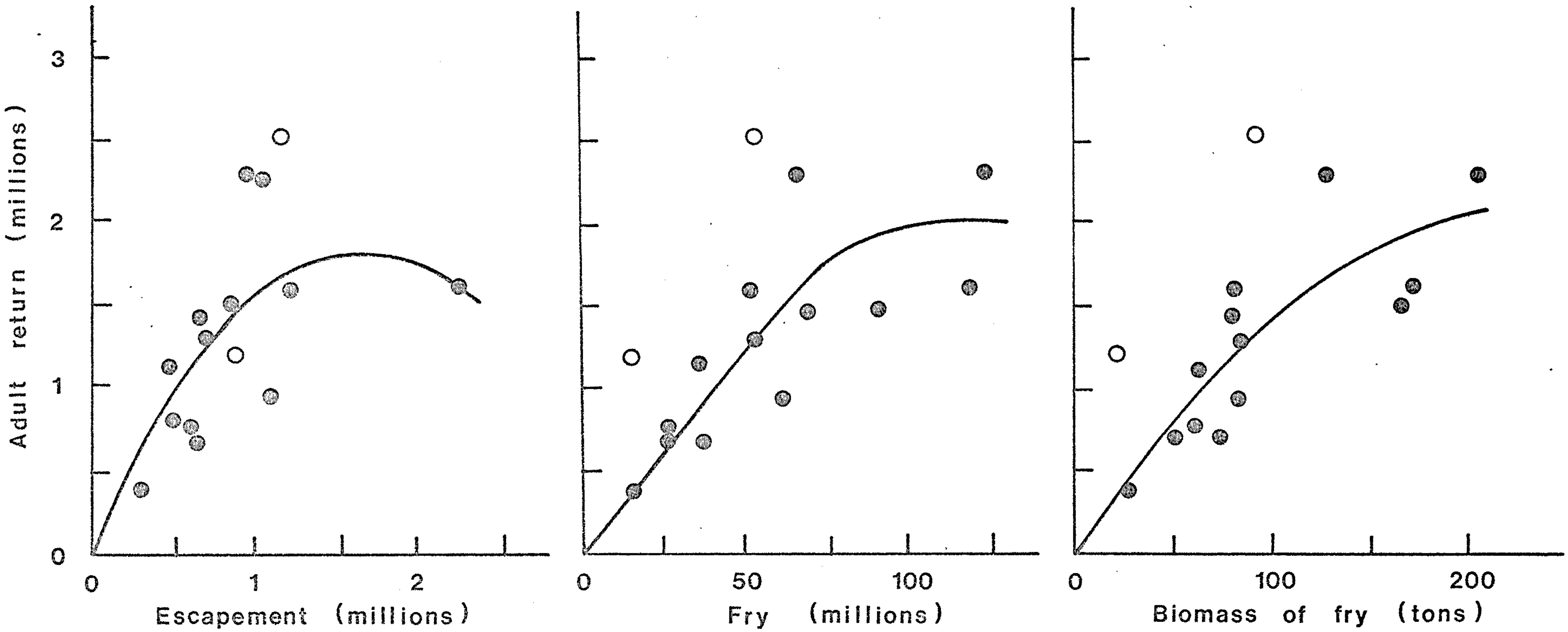

Fig. 2. Adult returns to the Wood River lakes as functions of number of parent spawners (escapement), number of fry in mid-summer, and biomass of fry in mid-summer, 1957-1971 brood years. Free-hand curves. Open circles for the 1970-1971 brood years.

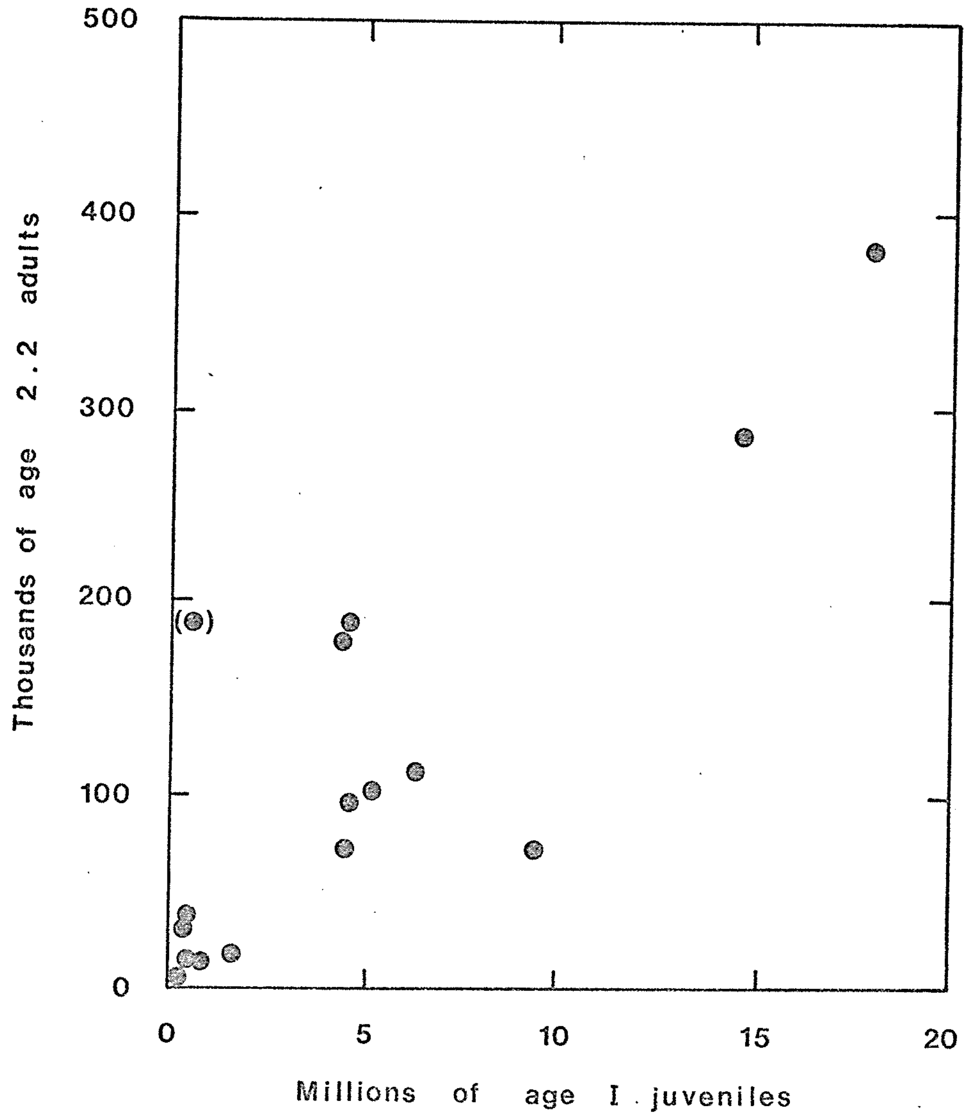

Fig. 3. Plot of the return of age 2.2 adults on the number of age I juveniles in the pelagic areas of the Wood River lakes. The number of age I juveniles in 1974 was 0.2 million.

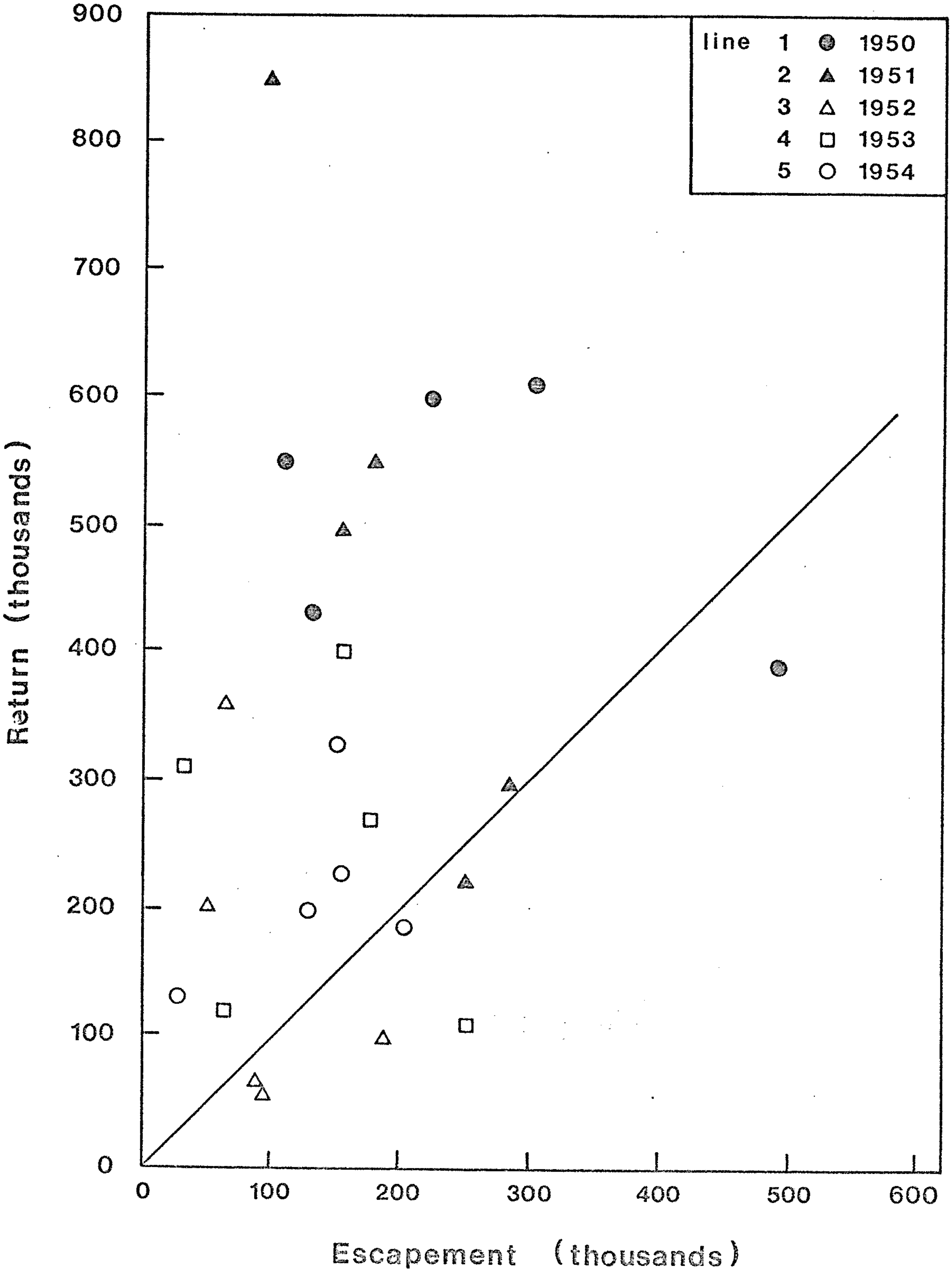

Fig. 4. Escapement-return relationships for sockeye salmon in Lake Aleknagik by 5-year lines, 1947-1971 brood years.

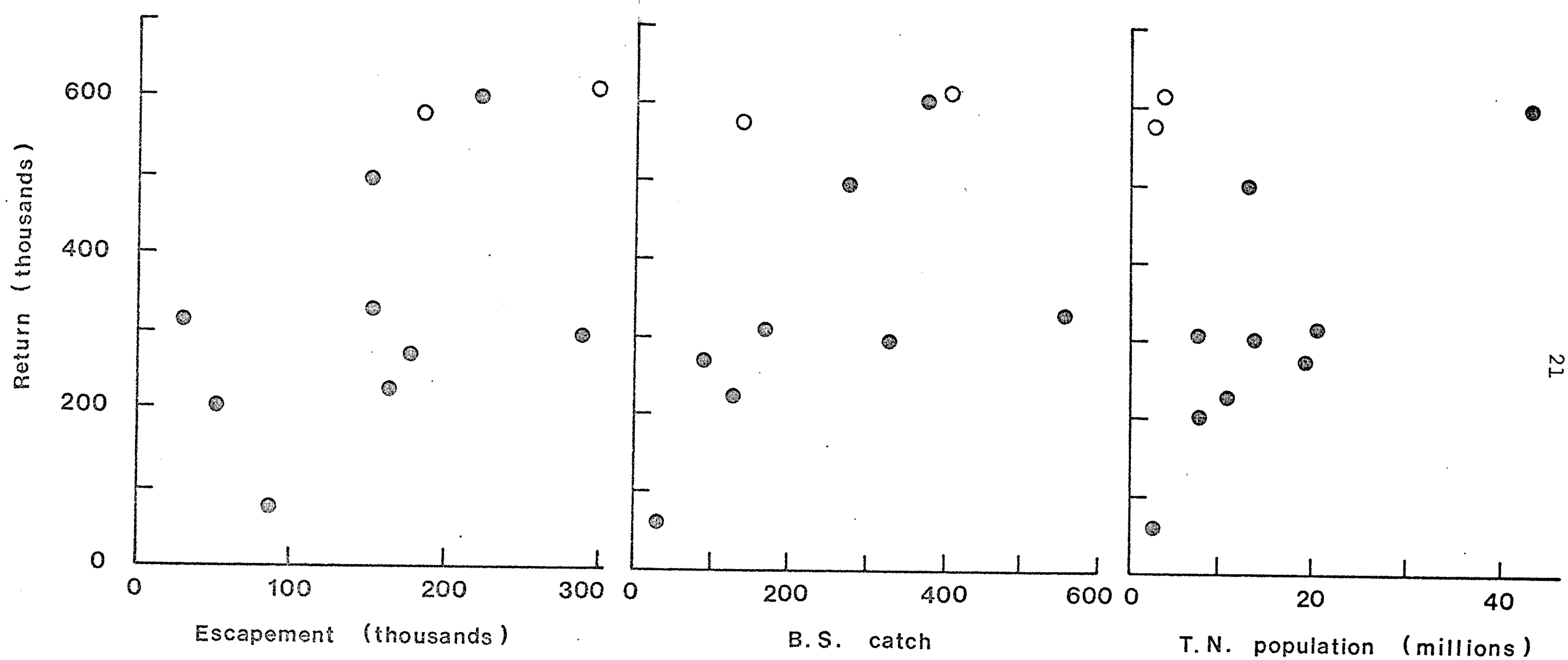

Fig. 5. Adult returns to Lake Aleknagik plotted against parent escapement, beach-seine catch of fry, and tow-net population estimates of pelagic fry, 1961-1971 brood years. Open circles for the 1970-1971 brood years.