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MONITORING OF THE KIVCHAK SPAWNING AND NURSERY AREAS IN 1975

by

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(Final Report for the Period June 1, 1975 through June 30, 1976)

INTRODUCTION

Observations on sockeye salmon runs to the Kvichak River system have been made for more than 70 years. Studies by the Fisheries Research Institute began in 1947 upon the request of the Bristol Bay Salmon Industry. During the period 1947-1954 the Institute concentrated on collecting quantitative and qualitative data on the adult returns. The yearly catch and escapement were sampled for age, size and sex, and limited spawning ground surveys were made to assess the escapement pattern.

In 1955 the Institute expanded its studies to include the enumeration of the Kvichak River escapement and a smolt indexing program to assess the relative abundance, age, and size of smolts emigrating from the system. Spawning ground surveys were continued and became more systematic and extensive.

Studies were expanded further in the early 1960's with funds from the salmon emergency program. The programs developed by the Institute for enumerating and sampling the emigrating smolts and returning adults were assumed by the Alaska Department of Fish and Game and the Institute initiated studies directed toward determining the factors limiting the freshwater production of sockeye salmon. Programs were initiated to study juvenile salmon in the system's nursery lakes and to determine the extent of available and utilized spawning areas.

Since 1961 the Institute has maintained continuous records on the escapement of adults and their distribution on the spawning beds, the relative abundance and growth of juveniles and their summer food supply, and the general character of their environment. The purpose of our research program is to determine how the numerical size of the escapement affects the cyclic production of the Kvichak salmon resource so that rational management alternatives can be developed to optimize production. These studies are presently supplementing programs being maintained and developed by the Alaska Department of Fish and Game.

The 1975 field monitoring programs conducted by the Institute were supported by funds procured under contract with the Alaska Department of Fish and Game supplemented with additional funds from the Bristol Bay canning industry through the Association of Pacific Fisheries and the University of Washington. The 1975 field investigations conducted by the Institute concentrated on determining (1) the distribution of the peak year escapement on the spawning beds, and (2) the relative abundance, distribution and growth of juvenile salmon in Iliamna Lake and Lake Clark. In addition, monitored were (1) primary and secondary production, (2) thermodynamics of Iliamna Lake, (3) solar radiation, and (6) other climatic conditions during the summer field season. The following report summarizes the data collected during the 1975 field season with comparisons to records from prior years. An outline of the studies continued in 1975 and reported on in this report is shown in Fig. 1. The format of this report follows that established in the 1973 and 1974 annual reports summarizing field investigations in the Kvichak River system.

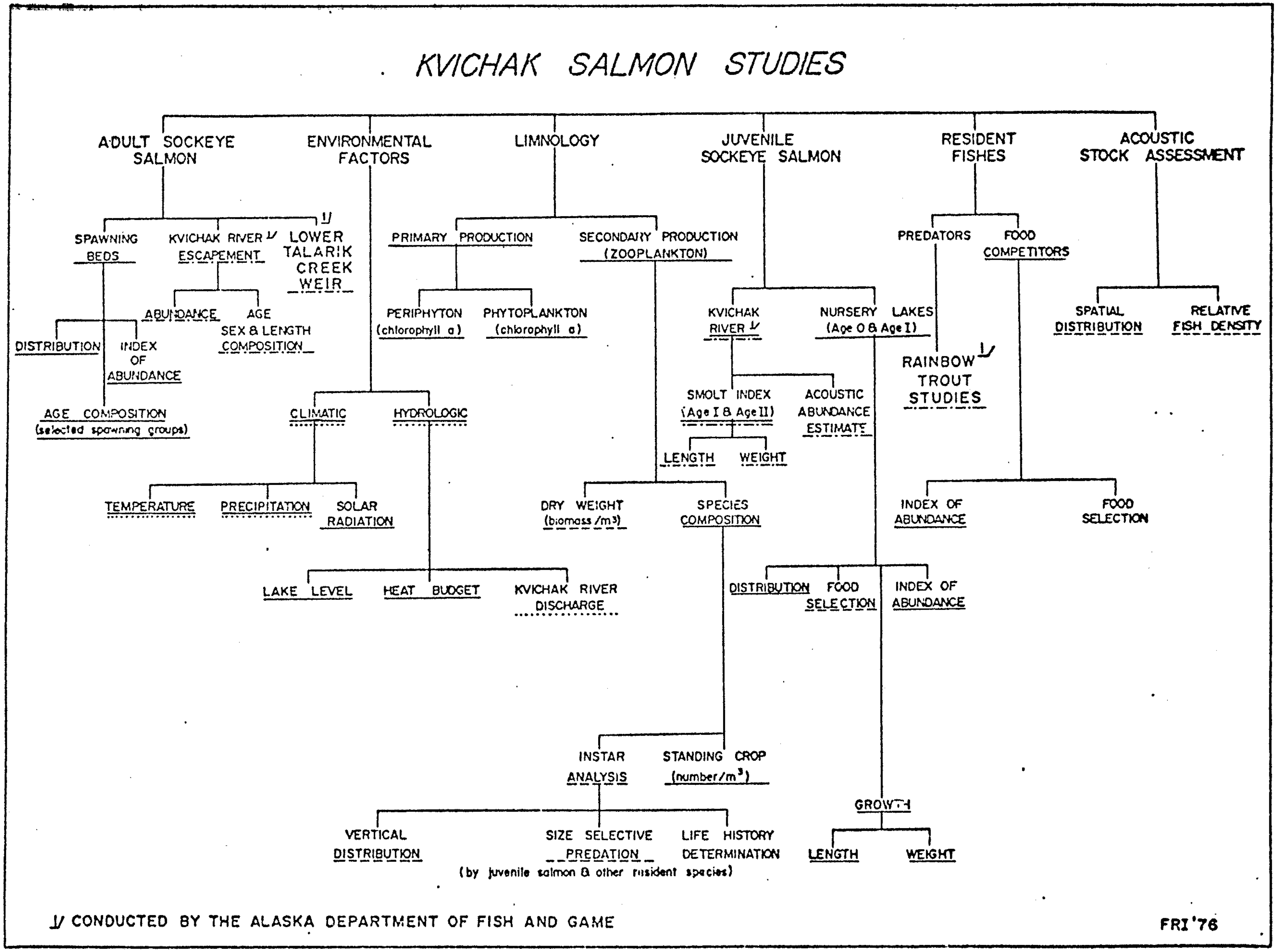


Fig. 1. Schematic outlining Kvichak Salmon Studies: (———) Studies continued in 1975; (----) Studies continued in 1975 but not analyzed at the time of this report; (-·-·) Studies conducted by Alaska Department of Fish and Game: (····) Data collected by other agencies.

ADULT SALMON STUDIES

The 1975 peak year return of 14.88 million sockeye salmon to the Kvichak River system was considerably larger than predicted and represented 62 per cent of the total Bristol Bay inshore return of 24.15 million. Regulation of the inshore commercial fishery resulted, for the second consecutive year, in a very low rate of exploitation. The escapement in 1975 was 13.14 million while the apportioned catch was only 1.74 million, and this was the lowest peak year catch of Kvichak stocks since the initial buildup of the inshore commercial fishery during the early 1900's (Fig. 2). Therefore, it is likely that a five-year cycle having one dominant peak year will continue if environmental conditions are favorable for the progeny of the 1975 escapement.

Spawning Ground Surveys

Observations on the spawning populations of sockeye salmon of the Kvichak River system have been made continuously since 1920, except during the years 1942 and 1943. Continuous records of the annual timing, distribution, and relative abundance indices of returns to the individual spawning units are needed to monitor the effects of the yearly fishing regulations in Bristol Bay and to further define factors limiting the production of sockeye salmon in the Kvichak system.

Distribution of escapement and indices of peak abundance

Observations on the timing, distribution, and relative indices of abundance of returns to the major spawning groups of the Kvichak system in 1975 were determined by aerial and/or ground surveys conducted from late July to mid-September. Aerial surveys were flown on 7/21, 8/09, 8/10, 8/20, 8/23, 8/28, 8/29, and 9/13. The principal pilots and their aircraft were Thomas Hedlund in a Piper 150 on floats and a Cessna 206 on wheels, and Tim La Porte in a Cessna 185 on floats. Observers for the Institute were Patrick H. Poe, Gary D. Cortner, and Robert L. Johnson. Weather, light, and water conditions were generally very good during most of the surveys. All aerial survey data were recorded on a Panasonic cassette and a Westinghouse transistor reel recorder and the tapes were transcribed at a later date. A total of 113 different spawning areas were surveyed as close to time of peak spawning as possible.

Results

During 1974 and 1975 there was virtually no early season fishing on Kvichak stocks. The proportional distribution of the 1974 and 1975 escapements among 15 geographical regions of the Kvichak watershed is compared to the geometric mean percentage in other nonpeak and peak cycle years, 1955-1973, in Fig. 3. Peak indices of abundance to the major spawning units and to the 15 geographical regions in 1975 are compared to information from past peak cycle years in Table 1. All the currently summarized quantitative data on escapement, and the indices of relative abundance for the different spawning area types of the Kvichak system for the years 1920-1975 are summarized in Table 2.

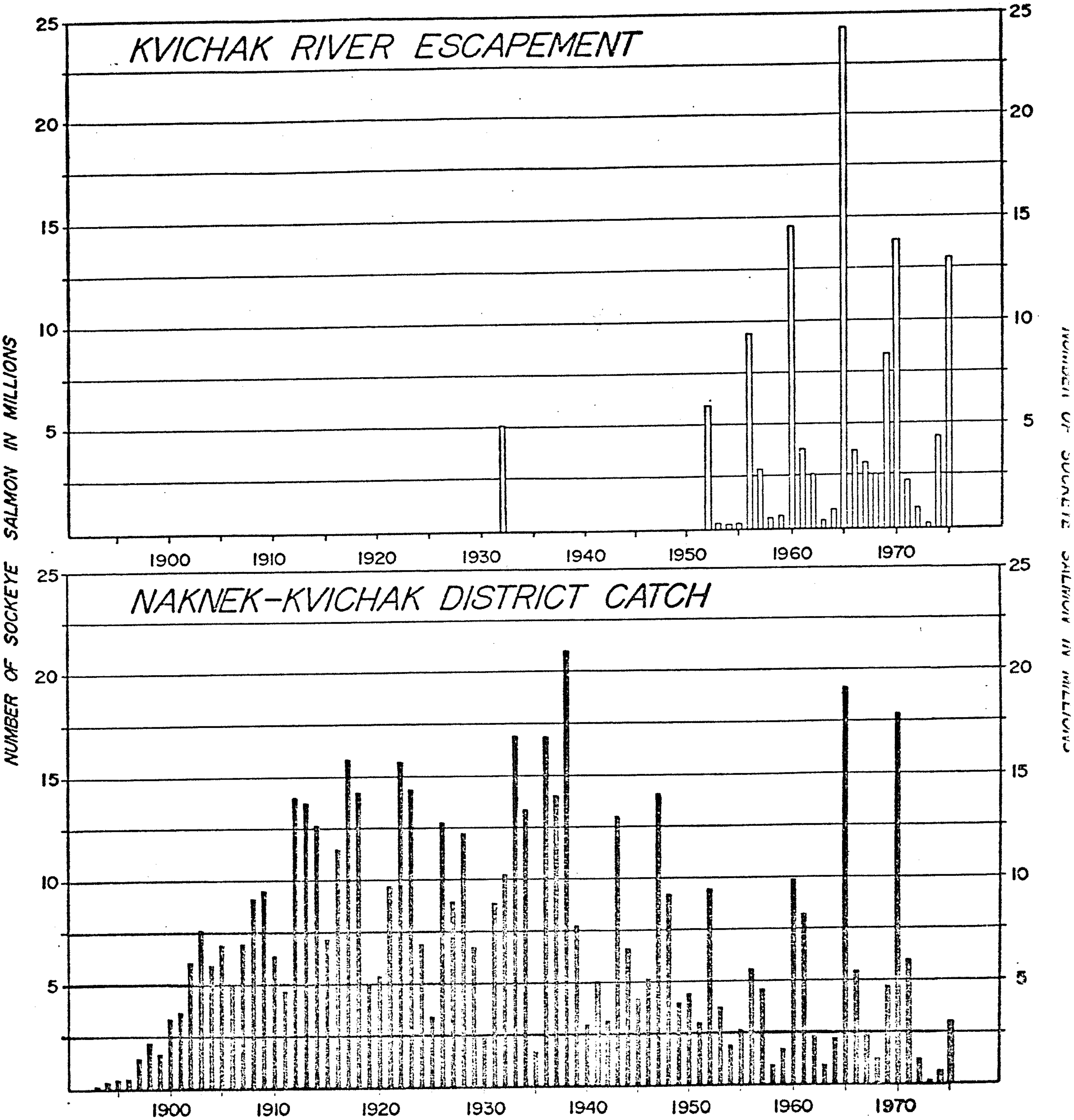


Fig. 2. Naknek-Kvichak district sockeye salmon catch, 1893-1975, and Kvichak River sockeye salmon escapement, 1932 and 1952-1975.

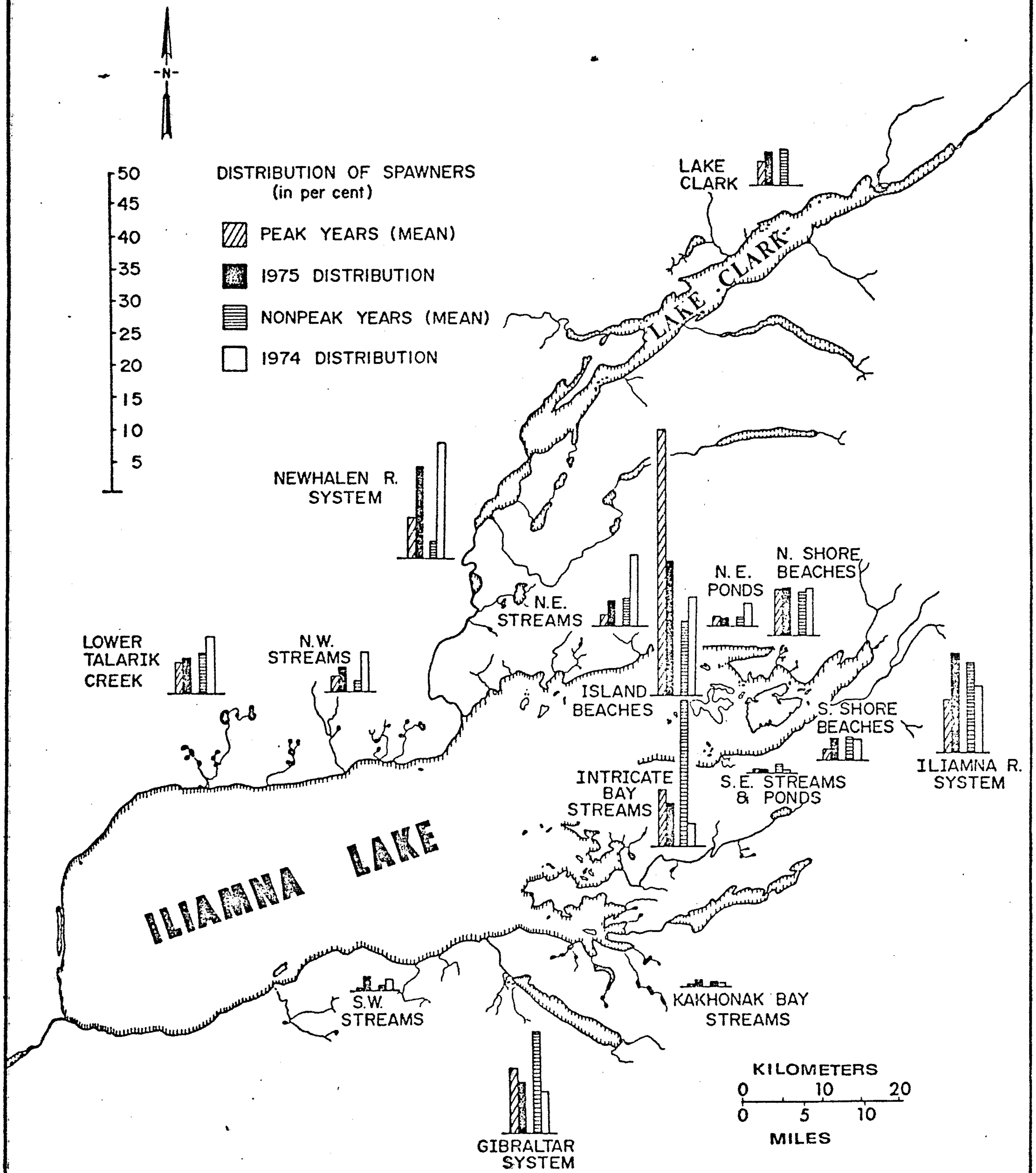


Fig. 3. Comparison of the 1974 and 1975 distribution of spawners on Kvichak spawning grounds to the geometric mean distribution in peak and non-peak years, 1955-1973.

Table 1. Comparison of 1975 indices of abundance of sockeye salmon to 15 geographic regions of the Kvichak River system to mean percentage in other peak cycle years from 1955-74

Area	1975 Index of abundance	Percent of total accounted for on spawning grounds 1975	Geometric mean escapement index other peak cycle years	Percent of total geometric mean escapement index other peak cycle years
Lower Talarik Creek	141,085	5.32	126,754	4.86
N.W. streams				
Middle Talarik Creek	28,305			
Upper Talarik Creek	29,770			
Pete Andrew Creek	28,185			
Car Creek	12,365			
Small streams W of Lower Talarik Creek	3,100			
Tenmile Creek	850			
Total	102,575	3.87	59,874	2.30
Newhalen River system				
Newhalen River	220,850			
Lovers Creek	No survey			
Little Bear Creek & Ponds	1,860			
Alexi Creek	490			
Alexi Lakes	11,110			
Alexi Lake tributaries	1,700			
Steam Bath Creek	405			
Tazimina River	149,950			
Six Mile Lake beaches	No survey			
Pickerel Creek	35			
Pickerel Lakes	25			
Total	386,425	14.58	159,532	6.12
N.E. streams				
Roadhouse Creek	4,712			
NW Eagle Bay Creek	17,562			
NE Eagle Bay Creek & Ponds	12,945			
Young's Creek	14,970			
Chekok Creek & Ponds	2,425			
Tomkok Creek	12,245			
Canyon Creek	7,550			
Mink Creek	2,265			
Knutson Creek	1,210			
Russian Creek	3,735			
Pile River	23,465			
Lonesome Bay streams	2,675			
Total	105,759	3.99	44,356	1.70

Table 1. Comparison of 1975 indices of abundance of sockeye salmon to 15 geographic regions of the Kvichak River system to mean percentage in other peak cycle years from 1955-74 - continued

Area	1975 Index of abundance	Percent of total accounted for on spawning grounds 1975	Geometric mean escapement index other peak cycle years	Percent of total geometric mean escapement index other peak cycle years
N.E. ponds				
Hundson's Creek & Ponds	766			
Prince Creek & Ponds	8,410			
Canyon Springs	400			
Wolf Creek Ponds	15,450			
Knutson Ponds	3,450			
Pedro Creek & Ponds	3,850			
Total	32,326	1.22	43,045	1.65
Iliamna River system				
Iliamna River	364,250			
Bear Creek & Ponds	3,200			
False Creek	2,200			
Old Williams Creek	300			
Chinkelyes Creek	44,905			
Total	414,855	15.65	211,082	8.10
S.E. streams & ponds				
Swamp Creek & adjacent ponds	1,325			
Jack Durand Creek	4,300			
Surprise Creek	75			
N. Squirrel Village Creek	2,345			
S. Squirrel Village Creek	4,175			
Tommy Creek	2,475			
Tommy Springs	600			
Southshore small streams	875			
Total	16,170	0.61	16,588	0.64
Intricate Bay streams				
Copper River	179,490			
Pope Creek	3			
Nancy Creek	0			
Nick G. Creek	1,150			
Total	180,643	6.81	240,386	9.23

Table 1. Comparison of 1975 indices of abundance of sockeye salmon to 15 geographic regions of the Kvichak River system to mean percentage in other peak cycle years from 1955-74 - continued

Area	1975 Index of abundance	Percent of total accounted for on spawning grounds 1975	Geometric mean escapement index other peak cycle years	Percent of total geometric mean escape-ment index other peak cycle years
Kakhonak Bay streams				
Kakhonak River	5,753			
Alec Flyum Creek	575			
Bear Creek	815			
Cabin Creek	295			
Granite Creek	1,691			
Lake Creek	2,325			
Nick N. Creek	15,635			
Total	27,089	1.02	11,271	0.43
Gibraltar system				
Gibraltar Creek (River)	64,700			
Little Gibraltar Creek	9,846			
Dream Creek	66,150			
Southeast Creek	28,460			
Trout Creek	5,340			
Gibraltar Ponds	4,200			
Gibraltar Lake beaches	34,060			
Total	212,756	8.03	265,667	10.20
Lake Clark				
Priest Rock Creek and Ponds	17,815			
Kijik River	3,160			
Little Kijik River	13,130			
Kijik Lake tributaries	800			
Kijik Lake beaches	83,620			
Tlikakila River	2,760			
Chokotonk River	35			
Currant Creek	0			
Tanalian River	250			
22 Creek	10			
Sucker Bay Lake	2,700			
Lake Clark beaches	6,962			
Total	131,242	4.95	96,761	3.71
S.W. streams				
Camp Creek	1,035			
Dennis Creek	8,100			
Belinda Creek	49,078			
Total	58,213	2.20	8,185	0.31

Table 1. Comparison of 1975 indices of abundance of sockeye salmon to 15 geographic regions of the Kvichak River system to mean percentage in other peak cycle years from 1955-74 - continued

Area	1975 Index of abundance	Percent of total accounted for on spawning grounds 1975	Geometric mean escapement index other peak cycle years	Percent of total geometric mean escapement index other peak cycle years
Island beaches (Iliamna Lake)				
Rabbit Island group	41,230			
Eagle Island group	26,110			
Triangle Island group	124,025			
Reefs S & NW of Triangle Is.	68,350			
Halfway Island & reefs	16,800			
Seal Rookery Island	9,750			
E-2 Island group	28,025			
Knutson Island group	12,916			
Knutson Islets	395			
Hedlund Island group	2,985			
Woody Island	99,890			
Pedro Bay Island group	6,860			
Porcupine Island group	49,935			
Ross Island group	70,005			
Kakhonak Bay Is. group	No survey			
Middle Islands	No survey			
Intricate Bay Is. group	No survey			
Total	557,276	21.01	1,085,807	41.67
N. Shore beaches				
Eagle Bay & Severson's Pen.	1,450			
Chekok	625			
Knutson Bay	161,360			
Pedro Peninsula	1,785			
Pedro Bay	4,840			
Lincoln Rock	575			
Lonesome Bay	25,200			
Dumbell Lakes	375			
Chekok Lakes	1,221			
Total	197,431	7.45	191,215	7.34
S. Shore beaches				
Pile Bay	4,100			
Finger	38,950			
Southeast	24,125			
S. Shore	6,685			
Tommy	10,925			
Intricate Bay	2,488			
Kakhonak Bay	No survey			
Total	87,273	3.29	45,252	1.74

Table 2. Peak indices of abundance of sockeye salmon and number of areas surveyed by type of spawning area and as percentages of total number of sockeye salmon observed on the spawning beds, total number of areas surveyed, total Kvichak River escapement, and percentage of the total escapement accounted for on the spawning grounds, Kvichak River system, 1920-1975. 4/

Year	Streams: Escape. Index	Streams: No. Areas Surveyed	Streams: %	Ponds: Escape. Index	Ponds: No. Areas Surveyed	Ponds: %	Mainland Beaches: Escape. Index	Mainland Beaches: No. Areas Surveyed	Mainland Beaches: %	Island Beaches: Escape. Index	Island Beaches: No. Areas Surveyed	Island Beaches: %	Total: Escapement accounted for on spawning grounds	Number areas surveyed	Kvichak River escapement	Percentage of escapement accounted for on spawning grounds
1920	1,500	3			0			0			0		1,500	3		
1921	638,300	8			0			0			0		638,300	8		
1922	1,142,600	6			0			0			0		1,142,600	6		
1923	387,000	6			0			0			0		387,000	6		
1924	367,800	7			0			0		0	1		367,800	8		
1925	40,250	5			0			0		200	1		40,450	6		
1926	469,000	6		2,000	1		50,000	1		2,000	1		523,000	9		
1927	167,850	4			0			0		50	1		167,900	5		
1928	605,020	7		30,000	1		125,000	1			0		760,020	9		
1929	283,000	7			0			0			0		283,000	7		
1930	18,594	8		2,030	1			0			0		20,624	9		
1931	238,000	7		129,000	2		34,000	2			0		401,000	11	5,064,014 1/	
1932		0			0			0			0			0		
1933	50,000	1			0			0			0		50,000	1		
1934		0			0			0			0			0		
1935		0			0			0			0			0		
1936		0			0			0			0			0		
1937	115,000	3			0			0			0		115,000	3		
1938		0			0			0			0			0		
1939		0			0			0			0			0		
1940	500,000	1			0			0			0		500,000	1		
1941		0			0			0			0			0		
1942		0			0			0			0			0		
1943		0			0			0			0			0		
1944	13,450	10			0		2,550	3			0		16,000	13		
1945	55,150	15		450	1		3,350	3			0		58,950	19		
1946		0			0			0			0			0		
1947	24,098	8			0		6,000	2			0		30,098	10		
1948	202	2			0			0			0		202	2		
1949	12,014	9		150	1			0			0		12,164	10		
1950	77,900	10		300	1		12,700	3			0		90,900	14		
1951	194,810	9	84.84	500	1	.22	34,300	3	14.94		0		229,610	13	2/	
1952	464,600	10	99.02	600	1	.13	4,000	1	.85		0		469,200	12	5,970,000 2/	7.86
1953	114,483	14	84.99	1,125	3	.84	19,100	3	14.18		0		134,708	20	321,000 2/	41.97
1954	39,540	17	84.36	300	2	.64	7,030	3	15.00		0		46,870	22	241,000	19.45
1955	28,296	29	87.39	357	3	1.10	3,725	3	11.50		0		32,378	35	250,546	12.92
1956	1,006,050	25	75.56	17,000	4	1.28	265,030	6	19.90	43,400	1	3.26	1,331,480	36	9,443,318	14.10
1957	261,237	35	73.92	7,486	7	2.12	79,500	9	22.49	5,200	1	1.47	353,423	52	2,842,810	12.43
1958	66,972	27	67.95	1,000	6	1.01	26,820	9	27.21	3,770	1	3.83	98,562	43	534,785	18.43
1959	95,533	30	74.52	3,634	9	2.83	11,147	7	8.70	17,880 3/	1	13.95	128,194	47	680,000	18.85
1960	1,333,382	29	46.85	28,950	7	1.02	486,500	8	16.99	1,000,000	1	35.14	2,845,832	45	14,630,000	19.45
1961	392,105	27	59.91	3,120	6	.48	152,350	7	23.28	106,850	4	16.33	654,425	44	3,705,849	17.66
1962	220,430	43	77.06	9,918	8	3.47	45,553	9	15.92	10,150	4	3.55	286,051	64	2,580,884	11.08
1963	36,069	41	69.70	2,598	11	5.02	8,016	9	15.49	5,069	3	9.79	51,752	64	338,760	15.28
1964	70,444	44	73.98	2,595	11	2.73	7,374	10	7.75	14,791	7	15.54	95,204	72	957,120	9.95
1965	1,251,896	43	34.04	80,650	10	2.19	387,174	11	10.53	1,957,500	14	53.23	3,677,220	78	24,325,926	15.12
1966	422,169	46	68.21	14,020	9	2.27	133,939	11	21.64	48,790	9	7.88	618,918	75	3,775,184	16.39
1967	358,810	45	67.09	6,873	8	1.29	150,490	10	28.14	18,645	10	3.49	534,818	73	3,216,208	16.63
1968	215,617	54	63.92	8,463	11	2.51	36,355	13	10.78	76,872	11	22.79	337,307	89	2,557,440	13.19
1969	406,282	56	59.71	27,936	11	4.11	114,345	18	16.81	131,850	11	19.38	680,413	96	8,394,204	8.11
1970	1,309,313	46	49.78	132,161	11	5.02	546,395	18	20.77	642,790	11	24.43	2,630,659	86	13,935,306	18.88
1971	315,193	35	72.18	8,615	7	1.97	51,390	13	11.77	61,460	10	14.08	436,658	65	2,387,392	18.29
1972	145,463	47	78.02	3,828	11	2.05	26,711	13	14.32	10,463	12	5.61	186,470	83	1,010,000	18.46
1973	57,553	55	76.89	834	11	1.11	9,803	14	13.10	6,662	13	8.90	74,852	93	226,554	33.04
1974	587,309	54	65.56	48,305	11	5.39	120,590	18	13.46	139,713	13	15.59	895,917	96	4,433,480	20.21
1955-1974 Average			67.11			2.45			16.53			14.64				16.42
1975	1,621,925	66	61.18	48,736	12	1.84	423,181	20	15.96	557,276	15	21.02	2,651,118	113	13,140,450	20.18

1/ Escapement counted through electronic weir operating from June 28 through August 5, 1932.

2/ Escapement estimates derived from 1952-1954 FRI aerial surveys. Numbers not reliable but may be representative of relative escapement.

3/ The peak spawning times of island beach spawners were not known in 1960 and no direct aerial estimates were made at that time. An indirect estimate of island beach spawners for 1960 was made by comparing the abundance of spent fish in 1960 with that of 1965 and multiplying this ratio by the five peak index count in 1965.

4/ Survey data compiled for the years 1920-1954 is incomplete for many years. Although considerable observations were made on the spawning beds during some years, much of the data available at the time of this compilation was qualitative rather than quantitative in nature and therefore not included. Recently considerable amounts of quantitative data were acquired and hopefully these data can be incorporated into the above summary table in the near future.

The 1975 spawning ground surveys indicate that a very large run returned to the Newhalen River and Lake Clark systems. Results from 1974 stream surveys also indicated a proportionately larger than average return to the Newhalen River system, however, surveys of Lake Clark in 1974 were inadequate due to inclement weather. Local residents have indicated that a larger than normal run did return to Lake Clark in 1974 and observations from 1975 juvenile salmon studies support this conclusion.

Discussion

Runs of sockeye salmon to the Kvichak River system are managed as a unit, however, prior to the decline of the historic Kvichak runs in the late 1930's, there were large early runs of salmon in some years that were documented as returning predominately to the spawning beds of the Newhalen River system and Lake Clark. Juvenile salmon programs indicate that Lake Clark and Iliamna Lake do not behave uniformaly in the production of fry. Perhaps the historic five-year cycle in the Kvichak system, when there was a parity of escapement levels during two or three years out of a five-year cycle, depended on this lag. The Lake Clark runs may have succumbed to heavy fishing pressure that prevailed after a strong Iliamna Lake run. Until it is known whether or not Lake Clark stocks are indeed segregated in time of occurrence in the commercial fishery during certain years of the Kvichak cycle, fishery managers can only manage for the system as a whole.

Age composition

Relative escapement-return relationships and trends in relative production by age group for different spawning area types and individual areas have been procured through the sampling of a selected few spawning groups for age composition. Escapement-return data for the inshore return to the Kvichak system as a whole and for two important spawning groups, namely the Copper River and Woody Island, are summarized in Tables 3-5. These data suggest that the effects of the unfavorable environmental conditions that adversely affected the survival of the 1970 brood year may have been more severe for the island beach spawning stocks than for the system as a whole. The suggested differences may be unfounded, since the data for the individual spawning groups is dependent on the consistency of the aerial survey abundance indices and the representativeness of the limited sampling for age composition, while the data for the Kvichak system as a whole is based on data procured from tower counts and from sampling for age composition throughout the course of the run.

In 1975 spawners from seven selected spawning groups were sampled for description of size and age composition. In addition, a sample of spawners bound for Lake Clark spawning areas was taken from the Nondalton resident fishery. A summary of the spawning ground sampling is given in Table 6. Otoliths were collected from 467 male and 465 female sockeye salmon spawners, respectively. The data on age composition from the sampling conducted on the spawning grounds and from the sampling of the Kvichak escapement at Igiugig by personnel of the Alaska Department of Fish and Game are summarized in Tables 7 and 8.[1/] The sampling shows the expected predominance of five-year

[1/] Data on Kvichak River escapement sampled at Igiugig from Preliminary Review of the Bristol Bay Fishery, 1975, Alaska Department of Fish and Game Division of Commercial Fisheries, 9/02/75 and 8/22/75 summaries.

Table 3

KVICHAK RIVER SYSTEM, 1952-1970 (SIX MAJOR AGE GROUPS) (Inshore returns)

BROOD YEAR	ESCAPEMENT	RETURN 1.1	1.2	2.1	1.3	2.2	2.3	TOTAL RETURN	RETURN PER SPAWNER
1952	5970000.000	2255.000	9259739.860	.000	3906732.240	1848110.190	598958.080	15615795.370	2.616
1953	321000.000	.000	56544.210	.000	56472.240	335043.250	56304.000	504363.700	1.571
1954	241000.000	.000	74014.590	16364.880	27472.000	610504.000	.000	728355.470	3.022
1955	249544.000	.000	239292.000	13600.000	89243.000	533848.700	389296.200	1265279.900	5.070
1956	9443318.000	13600.000	22012005.400	.000	5111624.520	4832353.650	1132702.220	33102285.790	3.505
1957	2842810.000	.000	181327.590	.000	211856.720	3004118.340	218727.260	3616029.910	1.272
1958	534755.000	.000	68384.400	320.000	40576.540	116566.320	24301.480	250148.740	.468
1959	680000.000	.000	182494.670	954.720	108705.460	196845.400	7950.250	496949.900	.731
1960	14622685.000	.000	1252726.090	131211.600	423006.000	41421139.760	5620790.520	48848873.970	3.341
1961	3705849.000	372.000	295041.000	.000	165159.750	2042213.610	601965.610	3104751.970	.838
1962	2580554.000	.000	92991.870	1817.000	134350.560	4212334.280	343133.100	4784626.810	1.854
1963	337670.000	.000	43742.240	3215.000	42029.610	540349.290	223347.960	852684.100	2.525
1964	956867.000	7911.000	1888891.080	96185.500	246284.850	2146333.620	508967.550	4896573.600	5.117
1965	24323472.000	23575.760	9049374.620	484627.360	367218.640	29133252.540	1025185.760	40083234.680	1.648
1966	3767223.000	10931.000	440041.930	10600.000	894602.520	3921265.790	300700.000	5578141.240	1.481
1967	3214673.000	.000	303207.420	2061.840	224680.000	703120.000	70101.360	1303170.620	.405
1968	2549227.000	.000	170100.000	.000	26259.660	66142.440	119959.140	382461.240	.150
1969	8394204.000	.000	111012.300	10556.280	291318.300	4156259.100	522198.600	5091344.580	.607[1]
1970	13935306.000	275.940	41831.220	39642.500	13747.080	13983674.290	.000	14079171.030	1.010[1]

KVICHAK RIVER SYSTEM, 1952-1970 (YEAR OF LIFE RUN) (Inshore returns)

BROOD YEAR	ESCAPEMENT	RETURN (YEAR OF LIFE) 3RD	4TH	5TH	6TH	7TH	8TH	TOTAL RETURN	RETURN PER SPAWNER
1952	5970000.000	2255.000	9259739.860	5762944.320	601632.000	521.000	.000	15627092.180	2.618
1953	321000.000	.000	56544.210	392104.080	56304.000	.000	11678.000	516630.290	1.609
1954	241000.000	.000	90593.580	638112.000	.000	21507.000	.000	750212.580	3.113
1955	250546.000	.000	251600.000	622140.750	404175.060	.000	.000	1277915.810	5.101
1956	9443318.000	13600.000	22012005.400	9957097.440	1132702.220	105.000	.000	33115510.060	3.507
1957	2842810.000	7315.000	181327.590	3205722.870	220678.360	1606.000	.000	3616649.820	1.272
1958	534745.000	.000	68768.400	157387.440	24407.600	2454.000	.000	253017.440	.473
1959	680000.000	320.000	183907.430	305614.440	7950.250	.000	.000	497792.120	.732
1960	14630000.000	369.000	1385330.580	41905893.800	5638941.600	5581.000	.000	48936115.980	3.345
1961	3705849.000	1272.000	295041.000	2200075.040	608116.080	.000	.000	3110504.120	.839
1962	2580884.000	.000	94519.960	4343283.560	353235.090	2445.000	.000	4793483.610	1.857
1963	338760.000	.000	47343.930	581672.520	225604.000	6950.000	.000	861570.450	2.543
1964	957120.000	7911.000	1977988.160	2400159.060	516424.950	1218.000	.000	4903701.170	5.123
1965	24325926.000	23575.760	9532921.170	29587491.300	1029011.080	.000	.000	40172999.310	1.651
1966	3775184.000	13991.680	455727.910	4822484.480	300700.000	.000	.000	5592904.070	1.481
1967	3216208.000	.000	308746.350	926160.000	70101.360	.000	.000	1305007.710	.406
1968	2557440.000	.000	170100.000	92402.100	123302.550	3261.000	.000	389065.650	.152
1969	8394204.000	.000	122678.640	4447577.400	522198.600	.000	.000	5092454.640	.607[1]
1970	13935306.000	275.940	81063.610	13997925.850	.000	.000	.000	14079265.400	1.010[1]

[1] Based on returns only through five-year-old fish.

Table 4

COPPER RIVER SYSTEM, 1958-1970 (6 PREDOMINANT AGE GROUPS)

BROOD YEAR	ESCAPEMENT	RETURN 1.1	1.2	2.1	1.3	2.2	2.3	TOTAL RETURN	RETURN PER SPAWNER
1958	20000.000	.000	1351.200	.000	494.340	1589.640	2383.890	5819.070	.291
1959	35000.000	.000	1458.660	.000	2508.810	5239.560	12196.800	21403.830	.612
1960	139000.000	.000	15962.320	2714.400	.000	489911.040	156362.400	664950.160	4.784
1961	120000.000	.000	.000	.000	.000	12813.030	10085.900	22898.930	.191
1962	43300.000	.000	582.930	.000	4187.000	147732.200	47567.790	200069.920	4.621
1963	10500.000	.000	.000	530.000	476.000	25386.660	21534.480	47927.140	4.564
1964	16015.000	.000	19715.160	420.000	14182.630	39770.180	.000	74087.970	4.626
1965	288000.000	.000	23107.370	1043.840	.000	404861.240	71641.760	500654.210	1.738
1966	76200.000	.000	26082.020	1614.000	16549.600	100595.690	44483.450	189324.760	2.485
1967	106000.000	.000	2821.940	.000	4155.210	16616.480	13120.380	36714.010	.346
1968	80066.000	.000	.000	.000	2013.480	2013.480	5979.460	10006.420	.125
1969	62150.000	.000	511.560	.000	1316.700	26985.000	35898.500	64711.760	1.041
1970	201700.000	.000	.000	.000	.000	164270.360	.000	164270.360	.814[1]

COPPER RIVER SYSTEM, 1958-1970 (YEAR OF LIFE RUN)

BROOD YEAR	ESCAPEMENT	RETURN (YEAR OF LIFE) 3RD	4TH	5TH	6TH	7TH	8TH	TOTAL RETURN	RETURN PER SPAWNER
1958	20000.000	.000	1351.200	2100.000	2394.300	.000	.000	5845.500	.292
1959	35000.000	.000	1458.660	7809.120	12196.800	.000	.000	21464.580	.613
1960	139000.000	.000	19394.040	492759.360	156362.400	1060.000	.000	669575.800	4.817
1961	120000.000	.000	.000	12885.420	10144.200	.000	.000	23029.620	.192
1962	43300.000	.000	575.310	151813.200	49537.020	311.000	.000	202236.530	4.671
1963	10500.000	.000	651.900	25854.660	21752.000	.000	.000	48258.560	4.596
1964	16015.000	.000	19994.220	53856.480	.000	.000	.000	73850.700	4.611
1965	288000.000	.000	24098.310	408592.680	71909.080	.000	.000	504600.070	1.752
1966	76200.000	.000	28894.480	118289.920	44483.450	.000	.000	191667.850	2.515
1967	106000.000	.000	2833.050	20741.360	13121.640	.000	.000	36696.050	.346
1968	80066.000	.000	.000	4025.700	5923.050	.000	.000	9948.750	.124
1969	62150.000	.000	511.560	28301.700	35898.500	.000	.000	64711.760	1.041
1970	201700.000	.000	.000	164270.360	.000	.000	.000	164270.360	.814[1]

[1]Based on returns only through five-year-old fish.

Table 5

WOODY ISLAND, ILIAMNA LAKE, 1958-1970

BROOD YEAR	ESCAPEMENT	RETURN 1.1	1.2	2.1	1.3	2.2	2.3	TOTAL RETURN	RETURN PER SPAWNER
1958	3770.000	.000	240.000	.000	346.680	1574.040	.000	2160.720	.573
1959	17880.000	.000	5223.090	.000	1865.340	671.160	.000	7759.590	.434
1960	305100.000	.000	16570.070	1994.720	.000	1044040.000	28427.040	1091031.830	3.576
1961	66850.000	.000	.000	.000	75.270	12117.420	9253.770	21446.460	.321
1962	8000.000	.000	148.410	.000	589.340	10345.720	221.400	11304.870	1.413
1963	4899.000	.000	.000	.000	.000	1051.830	.000	1051.830	.215
1964	11910.000	.000	37504.860	2075.850	.000	18170.000	.000	57750.710	4.849
1965	607000.000	.000	82525.300	1500.800	16817.720	408771.580	26668.680	536284.080	.883
1966	19450.000	.000	3748.060	.000	11778.000	53119.820	1102.050	69747.930	3.586
1967	12440.000	.000	2776.220	.000	901.460	447.440	66.780	4191.900	.337
1968	35955.000	.000	6153.840	.000	370.440	2440.620	696.420	9661.320	.269
1969	70550.000	.000	1059.660	.000	1726.200	44177.700	2113.100	49076.660	.696
1970	194200.000	.000	.000	.000	.000	110704.970	.000	110704.970	.570[1]

WOODY ISLAND 1958-1970 (YEAR OF LIFE RUN)

BROOD YEAR	ESCAPEMENT	RETURN (YEAR OF LIFE) 3RD	4TH	5TH	6TH	7TH	8TH	TOTAL RETURN	RETURN PER SPAWNER
1958	3770.000	.000	240.000	1967.280	.000	.000	.000	2207.280	.585
1959	17880.000	.000	5223.090	2307.240	.000	.000	.000	7530.330	.421
1960	305100.000	.000	18755.460	1050110.000	28427.040	.000	.000	1097292.500	3.597
1961	66850.000	.000	.000	12255.300	9307.260	.000	.000	21562.560	.323
1962	8000.000	.000	146.470	10920.140	221.400	.000	.000	11288.010	1.411
1963	4899.000	.000	.000	1051.830	.000	.000	.000	1051.830	.215
1964	11910.000	.000	39409.880	18285.000	.000	.000	.000	57694.880	4.844
1965	607000.000	.000	83260.500	421045.020	26768.190	.000	.000	531073.710	.875
1966	19450.000	.000	3709.220	65039.360	1102.050	.000	.000	69850.630	3.591
1967	12440.000	.000	2787.150	1342.320	66.780	.000	.000	4196.250	.337
1968	35955.000	.000	6153.840	2811.060	689.850	.000	.000	9654.750	.269
1969	70550.000	.000	1059.660	45903.900	2113.100	.000	.000	49076.660	.696
1970	194200.000	.000	.000	110704.970	.000	.000	.000	110704.970	.570[1]

[1] Based on returns only through five-year-old fish.

Table 6. Summary of spawning ground sampling of selected groups, Kvichak system, 1975

		Length measurements		Otolith samples		
Locality	Date	Male	Female	Male	Female	Sexes combined
Iliamna Lake						
Lower Talarik Creek	-	-	-	106	107	213
Woody Island	8/26	52	52	52	52	104
Chinkelyes Creek	8/27	69	72	69	72	141
Copper River	9/03	62	59	62	59	121
Gibraltar Creek	9/04	47	48	47	48	95
Newhalen River	9/06	23	26	23	26	49
Knutson Bay	9/11	40	36	40	36	76
Subtotal:		293	293	399	400	799
Lake Clark						
Nondalton	7/21	28	35	28	35	63
Fishery	8/01	40	30	40	30	70
Subtotal:		68	65	68	65	133
GRAND TOTAL:		361	358	467	465	932

Table 7. Percentage age distribution of sockeye salmon and sample sizes by sex and locality, Kvichak District, 1975

Area	1.2		3.1		1.3		2.2		2.3		3.2		Total
	Size	%	Size	%	Size	%	Size	%	Size	%	Size	%	
Streams													
Lower Talarik[1] Creek													
♂							(93)	87.7	(13)	12.3			106
♀							(92)	86.0	(14)	13.1	(1)	0.9	107
Combined							(185)	86.8	(27)	12.7	(1)	0.5	213
Chinkelyes Creek													
♂			(1)	1.4			(66)	95.8	(1)	1.4	(1)	1.4	69
♀							(64)	88.9	(6)	8.3	(2)	2.8	72
Combined			(1)	0.7			(130)	92.2	(7)	5.0	(3)	2.1	141
Copper River													
♂	(1)	1.6					(53)	85.5	(8)	12.9			62
♀							(45)	76.3	(14)	23.7			59
Combined	(1)	0.8					(98)	81.0	(22)	18.2			121
Gibraltar Creek													
♂							(46)	97.9	(1)	2.1			47
♀							(40)	83.3	(8)	16.7			48
Combined							(86)	90.5	(9)	9.5			95
Newhalen River													
♂							(23)	100.0					23
♀							(26)	100.0					26
Combined							(49)	100.0					49
Subtotal													
♂	(1)	0.3	(1)	0.3			(281)	91.6	(23)	7.5	(1)	0.3	307
♀							(267)	85.6	(42)	13.4	(3)	1.0	312
Combined	(1)	0.2	(1)	0.2			(548)	88.5	(65)	10.5	(4)	0.6	619
Beaches													
Woody Island													
♂							(52)	100.0					52
♀							(50)	96.2	(2)	3.8			52
Combined							(102)	98.1	(2)	1.9			104

Table 7. Percentage age distribution of sockeye salmon and sample sizes by sex and locality, Kvichak District, 1975 - continued

Area	1.2 Size	1.2 %	3.1 Size	3.1 %	1.3 Size	1.3 %	2.2 Size	2.2 %	2.3 Size	2.3 %	3.2 Size	3.2 %	Total
Knuston Bay													
♂							(38)	95.0	(2)	5.0			40
♀							(33)	91.7	(3)	8.3			36
Combined							(71)	93.4	(5)	6.6			76
Subtotal													
♂							(90)	97.8	(2)	2.2			92
♀							(83)	94.3	(5)	5.7			88
Combined							(173)	96.1	(7)	3.9			180
Nondalton Fishery													
♂							(66)	96.8	(2)	3.2			68
♀							(60)	92.9	(5)	7.1			65
Combined							(126)	94.7	(7)	5.3			133
Spawning Beds													
♂	(1)	0.2	(1)	0.2			(437)	93.6	(27)	5.8	(1)	0.2	467
♀							(410)	88.2	(52)	11.2	(3)	0.6	465
Combined	(1)	0.1	(1)	0.1			(847)	90.9	(79)	8.5	(4)	0.4	932

Alaska Department of Fish & Game Sampling (weighted apportioned Kvichak River escapement).[2]

		1.2	2.1	1.3	2.2	2.3	Total
Sexes combined	Number	220,186	57,993	12,612	12,374,933	474,726	13,140,450
	Percent	1.68	0.44	0.10	94.17	3.61	100.00

[1] Sample collected by Mr. Don Seagren of the Alaska Department of Fish and Game, Division of Sport Fisheries.

[2] 1975 Preliminary Bristol Bay Sockeye Salmon Catch and Escapement Data Summary, Alaska Department of Fish and Game, Division of Commercial Fisheries, August 22, 1975.

fish from the 1970 brood year in all areas sampled. The sampling also indicates that six-year fish from the 1969 brood year were more abundant in most of the selected spawning areas sampled than in the Kvichak escapement as a whole (Table 8).

ENVIRONMENTAL FACTORS

Climatological Observations

Although the reasons for the differential production of sockeye salmon fry in the Kvichak system are very complex and not entirely understood, there is general agreement that these changes in freshwater production are linked to changes in environmental conditions and, hence, to changes in the food base. Favorable environmental conditions during the period between emergence of juvenile salmon from the gravel and movement into the littoral areas of the lakes and the subsequent commencement of feeding are critical to early survival.

Solar radiation

Records of incident solar radiation may well be an indicator of general environmental conditions during the critical spring period when salmon fry emerge from the gravel and move into the littoral areas of the nursery lakes. Incident solar radiation certainly influences the timing of the breakup of lake ice and the subsequent spring bloom of phytoplankton and insect emergences.

Daily incident solar radiation values have been recorded from mid-June through early September at the Porcupine weather station for most years since 1961. The effect of each season's solar radiation on lake water temperatures has been measured through the annual observations of Iliamna Lake thermodynamics. Annual variations in thermal conditions in the lake have been expressed in terms of changes in the amount of stored heat. Hence, changes in incident solar radiation can be linked to changes on lake productivity and, hence, to the survival and growth of juvenile salmon.

The 1975 spring breakup of lake ice was much later than average. The effect of the 1975 temperature regime on the size of Age 0 sockeye salmon in Iliamna Lake is compared to observations from past years in Fig. 4. A summary of the solar radiation data collected at Porcupine Island during the period July 15 through September 10 for the years 1966-1975 is given in Table 9. In 1975, although there was a late spring breakup and below average temperatures in June and most of July, solar radiation during August was well above average (Table 9). The daily solar radiation values at the Porcupine Island station are summarized in Table 10a.

Lake level, air temperature and precipitation

Since 1961 data on the (1) daily fluctuations in lake level, (2) daily

Table 8. Comparison of percentage returns in 1975, by brood year, from sockeye salmon sampled on Kvichak spawning grounds and from the Kvichak River escapement

Location of Sampling	1968 Brood Year (7-year-old fish) age classes		1969 Brood Year (6-year-old fish) age classes		1970 Brood Year (5-year-old fish) age classes			1971 Brood Year (4-year-old fish) age classes		Sample size, number aged
	2.4	3.3	2.3	3.2	3.1	2.2	1.3	2.1	1.2	
Streams - Iliamna Lake										
Lower Talarik Creek	-	-	12.7	0.5	-	86.8	-	-	-	213
Total	-		13.2			86.8		-		
Chinkelyes Creek	-	-	5.0	2.1	0.7	92.2	-	-	-	141
Total	-		7.1			92.9		-		
Copper River	-	-	18.2	-	-	81.0	-	-	0.8	121
Total	-		18.2			81.0		0.8		
Gibraltar Creek	-	-	9.5	-	-	90.5	-	-	-	95
Total	-		9.5			90.5		-		
Newhalen River	-	-	-	-	-	100.0	-	-	-	49
Total	-		-			100.0		-		
Beaches - Iliamna Lake										
Woody Island	-	-	1.9	-	-	98.1	-	-	-	104
Total	-		1.9			98.1		-		
Knutson Bay	-	-	6.6	-	-	93.4	-	-	-	76
Total	-		6.6			93.4		-		
Lake Clark										
Nondalton Fishery	-	-	5.3	-	-	94.7	-	-	-	133
Total	-		5.3			94.7		-		
Combined Spawning Ground sampling	-	-	8.5	0.4	0.1	90.9	-	-	0.1	932
Total	-		8.9			91.0		0.1		
ADF&G Sampling[1]										
Kvichak Escapement Iguigig (sexes comb.)	-	0.02	3.50	0.04	-	94.18	0.09	0.39	1.78	
Total	0.02		3.54			94.27		2.17		

[1]Data from 1975 Preliminary Bristol Bay Sockeye Salmon Catch and Escapement Data Summary, Alaska Department of Fish and Game, Division of Commercial Fisheries, August 22, 1975.

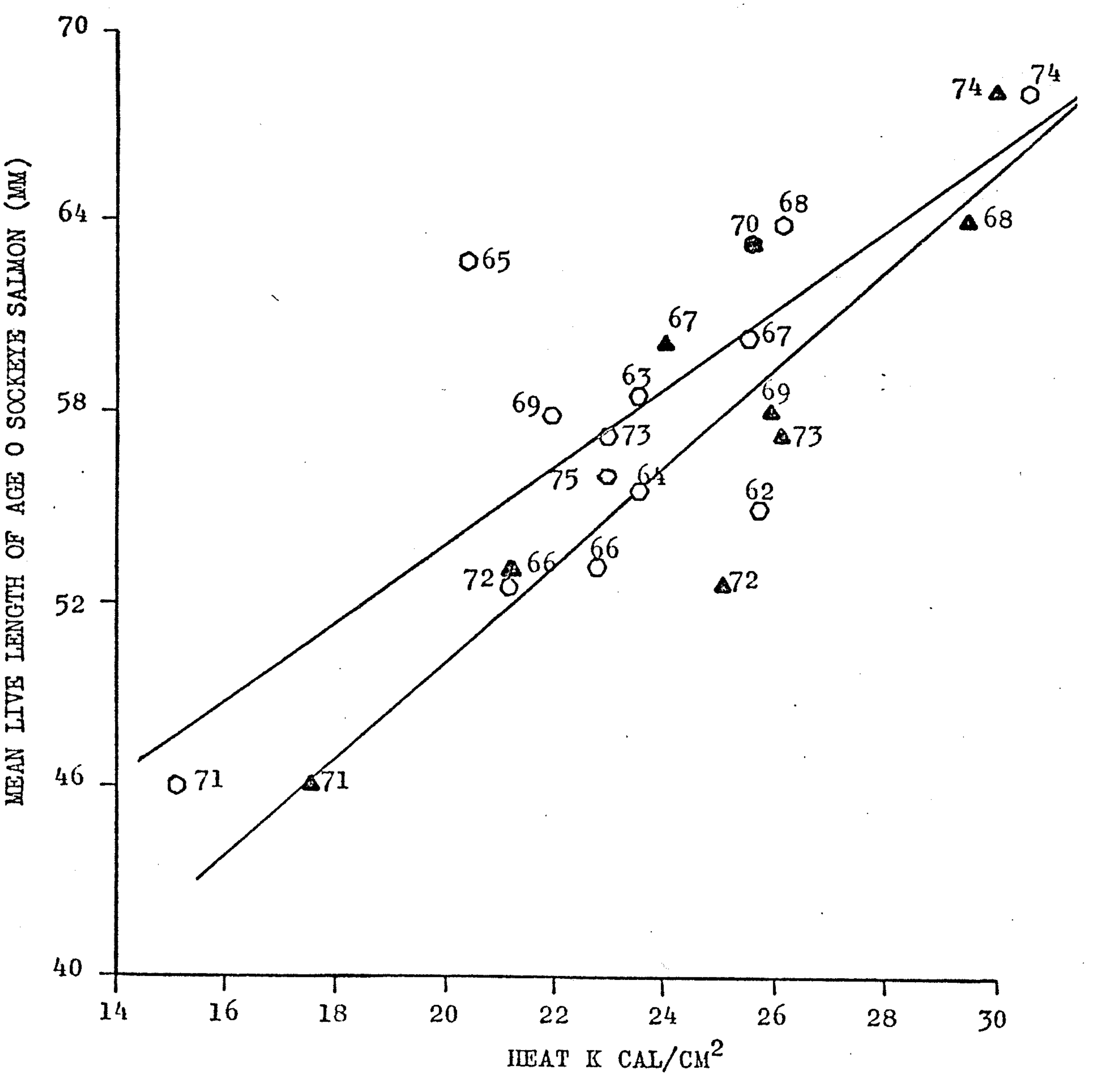


Fig. 4. Size of Age 0 sockeye salmon in Iliamna Lake adjusted to September 1 regressed on (1) the amount of stored heat in excess of 4°C in Iliamna Lake, 1962-1975 (○——○), and (2) the amount of total solar insolation during the period July 1 through September 10, 1966-1974 (▲——▲).

Table 9. Total solar radiation (cal/cm^2), mean radiation per day, and percentage of total summer radiation by month, July 15-September 10, 1966 through 1975, Iliamna Lake, Alaska

	Period									
	July 15-31 Solar radiation			August 1-31 Solar radiation			September 1-10 Solar radiation			
Year	Total	Mean/day	Percent	Total	Mean/day	Percent	Total	Mean/day	Percent	Total
1966	7,719	454	44.7	7,366	238	42.6	2,195	220	12.7	17,280
1967	5,964	351	34.7	9,395	303	54.7	1,818	182	10.6	17,177
1968	9,239	543	38.0	11,776	380	48.5	3,266	327	13.5	24,281
1969	6,018	354	28.8	12,230	395	58.6	2,629	263	12.6	20,877
1970	7,394	435	36.5	9,523	307	47.0	3,333	333	16.5	20,250
1971	3,933	231	31.8	6,247	202	50.5	2,199	220	17.7	12,379
1972	7,210	424	38.6	9,213	297	49.4	2,233	223	12.0	18,656
1973	6,227	366	31.7	10,650	344	54.3	2,739	274	14.0	19,616
1974	8,033	473	34.9	11,785	380	51.1	3,217	322	14.0	23,035
1966-74 Mean	6,860	403	35.6	9,798	316	50.8	2,625	263	13.6	19,283
1975	5,999	353	28.7	12,188	393	58.3	2,707	271	13.0	20,894

Table 10a. Daily precipitation, solar radiation, and lake level at Porcupine Island, July 15 through July 31, 1975

Day of Month	Day of Year	Precipitation (inches)	Solar radiation (cal/cm^2)		Lake level (mm below reference point) 1975	1961-74 mean[2]	Deviation from mean
15	197	.00	446		1856	1898	+42
16	198	.00	422		1839	1886	+47
17	199	.00	385		1822	1882	+60
18	200	.00	403		1824	1866	+42
19	201	.03	257		1809	1851	+42
20	202	.02	293		1814	1848	+34
21	203	.00	324		1789	1834	+45
22	204	T	397		1774	1831	+57
23	205	.01	287		1776	1808	+32
24	206	.04	470		1774	1791	+17
25	207	*	458		(1767)[3]	1785	+18
26	208	*	409		(1760)	1782	+22
27	209	*	257		(1753)	1782	+29
28	210	.04[1]	354		1746	1772	+26
29	211	.19	214		1726	1771	+45
30	212	.41	379		1716	1757	+41
31	213	.02	244		1706	1753	+47
Total 7/15-7/31		.76	5,999	Lake rise	150	145	+38 mean dev. (+1.50 in.)

T Trace of precipitation.

* No observation.

1 Includes precipitation which may have occurred on the previous series of days with missing observations.

2 Calculated from years where either actual or estimated values are given.

3 Values in parentheses are linear estimates between days of observation.

Table 10a. Daily precipitation, solar radiation, and lake level at Porcupine Island, August, 1975

Day of Month	Day of Year	Precipitation (inches)	Solar radiation (cal/cm^2)	Lake Level (mm below reference point) 1975	1961-74 mean[2]	Deviation from mean
1	214	T	373	1709	1739	+ 30
2	215	.00	623	1682	1735	+ 53
3	216	.00	623	(1678)[3]	1726	+ 48
4	217	.01	495	1674	1722	+ 48
5	218	*	556	(1681)	1709	+ 28
6	219	*	605	(1687)	1699	+ 12
7	220	.00	525	1694	1676	- 18
8	221	.03	354	1691	1673	- 19
9	222	*	556	(1690)	1659	- 31
10	223	*	532	(1688)	1645	- 43
11	224	*	391	(1687)	1631	- 56
12	225	*	405	(1685)	1623	- 62
13	226	*	196	(1684)	1610	- 74
14	227	*	189	(1683)	1609	- 74
15	228	*	208	(1681)	1609	- 72
16	229	1.03[1]	324	1680	1595	- 85
17	230	*	336	(1688)	1589	- 99
18	231	*	360	(1696)	1568	-128
19	232	T	232	1704	1559	-145
20	233	.05	403	(1685)	1570	-115
21	234	.00	397	1666	1562	-104
22	235	T	452	1684	1542	-142
23	236	.00	507	(1679)	1535	-144
24	237	.00	385	(1674)	1528	-146

Table 10a. Daily precipitation, solar radiation, and lake level at Porcupine Island, August, 1975, Continued

Day of Month	Day of Year	Precipitation (inches)	Solar radiation (cal/cm^2)		Lake Level (mm below reference point) 1975	1961-74 mean[2]	Deviation from mean
25	238	.00	183		1669	1519	-150
26	239	.14	202		1654	1514	-140
27	240	.00	440		1664	1518	-146
28	241	.00	446		1669	1500	-169
29	242	T	470		1701	1507	-194
30	243	.08	196		1687	1495	-192
31	244	.32	220		1684	1483	-202
Monthly Totals		1.66	12,188	Lake rise	25	256	- 82 mean dev. (-3.21 in.)

T Trace of precipitation.

* No observation.

1 Includes precipitation which may have occurred on the previous series of days with missing observations.

2 Calculated from years where either actual or estimated values are given.

3 Values in parentheses are linear estimates between days of observation.

Table 10a. Daily precipitation, solar radiation, and lake level at Porcupine Island, September 1 through September 14, 1975, Continued

Day of Month	Day of Year	Precipitation (inches)	Solar radiation (cal/cm^2)	Lake Level (mm below reference point) 1975	1961-74 mean[2]	Deviation from mean
1	245	*	293	(1681)[3]	1482	-199
2	246	*	214	(1678)	1468	-210
3	247	*	367	(1675)	1468	-207
4	248	*	214	(1671)	1467	-204
5	249	*	141	(1668)	1460	-208
6	250	*	373	(1665)	1468	-197
7	251	2.00[1]	428	1662	1468	-194
8	252	.03	403	1669	1480	-189
9	253	.22	122	1729	1483	-246
10	254	.03	122	1629	1477	-152
11	255	.18	238	(1628)	1442	-186
12	256	.00	415	1626	1430	-196
13	257	.00	409	1614	1432	-182
14	258	.00	305	1624	1432	-193
Total 9/1-9/14		2.46	4,074 Lake rise	57	51	-197 mean dev. (-7.77 in.)

* No observation.

1 Includes precipitation which may have occurred on the previous series of days with missing observations.

2 Calculated from years where either actual or estimated values are given.

3 Values in parentheses are linear estimates between days of observation.

precipitation, and (3) daily maximum and minimum air temperatures have also been collected at the Porcupine Island weather station during the summer field season. The 1975 data collected from July 15 through September 15 are summarized in Tables 10a and 10b. The drier than normal August caused Iliamna Lake to level off much sooner than normal (Fig. 5 and Table 10a).

Lake Thermodynamics

Iliamna Lake heat budget

The heat budget for Iliamna Lake is calculated each year from data on water temperature collected by vertical bathythermograph hauls. Since 1961 casts have usually been made at from 22 to 30 stations spatially distributed throughout Iliamna Lake. Bathythermograph casts, until recent years, have generally been made in late June to early July, mid-to late July, and mid-to late August.

In 1975 B.T. casts were made at (1) 2 stations in late July, and (2) 15 stations from mid-August to early September. The distribution of the 1975 sampling is shown in Fig. 6 and a summary of the B.T. sampling is given in Table 11. The heat budget values from all the 1975 sampling are presented in Table 11a, and are compared to the years 1961-1974 in Table 12.

PRIMARY PRODUCTION

Periphyton studies

It has been hypothesized that the magnitude of the peak year return of sockeye salmon to the Kvichak River system is in part determined by the survival of the island beach spawning stocks. The progeny of island beach stocks stay close to shore for 1-2 months after emergence from the gravel before moving into pelagic areas. While in the littoral, it has been hypothesized that juvenile salmon feed primarily on insect larvae, which depend on periphyton and detritus for their food. Since dense concentrations of juvenile salmon occur in littoral areas during the spring months of some years, high food production is necessary for favorable survival (Miller, 1970).

Periphyton growth has been monitored at selected locations on certain island beaches since 1969. During the summer of 1975 periphyton growth on artificial substrate was monitored at 5 stations (Fig. 7). The growth of periphyton at the five stations monitored in 1975, measured through determining the content of chlorophyll a in the periphyton samples from slides, is summarized in Table 13 and is compared to observations from previous years in Table 14 and Fig. 8.

Table 10b. Daily maximum and minimum air temperatures (°F)[1] Porcupine Island, July 16 through September 15, 1975

July				August				September			
Day		Temperature		Day		Temperature		Day		Temperature	
Month	Year	Max.	Min.	Month	Year	Max.	Min.	Month	Year	Max.	Min.
				1	214	64	55	1	245	(62)	(49)
				2	215	71	45	2	246	(59)	(49)
				3	216	(66)	(53)	3	247	(64)	(46)
				4	217	(62)	(50)	4	248	(60)	(46)
				5	218	(70)	(46)	5	249	(49)	(44)
				6	219	(65)	(44)	6	250	(59)	(44)
				7	220	(67)	(43)	7	251	55	42
				8	221	69	50	8	252	52	36
				9	222	(71)	(47)	9	253	47	42
				10	223	(75)	(44)	10	254	55	47
				11	224	(66)	(53)	11	255	(58)	(45)
				12	225	(66)	(52)	12	256	60	41
				13	226	(61)	(51)	13	257	58	34
				14	227	(59)	(51)	14	258	60	40
				15	228	(59)	(48)	15	259	--	45
16	198	64	48	16	229	(61)	(47)				
17	199	62	49	17	230	(68)	(49)				
18	200	66	45	18	231	(63)	(53)				
19	201	61	46	19	232	(59)	(50)				
20	202	--	--	20	233	(65)	(45)				
21	203	63	52	21	234	(66)	(44)				
22	204	66	51	22	235	69	44				
23	205	60	44	23	236	(68)	(44)				
24	206	69	49	24	237	(70)	(44)				
25	207	(67)	(42)	25	238	56	51				
26	208	(70)	(48)	26	239	57	50				
27	209	(57)	(48)	27	240	62	48				
28	210	(61)	(47)	28	241	64	45				
29	211	58	52	29	242	71	37				
30	212	60	48	30	243	55	50				
31	213	56	50	31	244	58	48				
Monthly max. and min. temperature		70	42			75	37			64	34
Mean max. and min. temperature		63	48			65	48			57	43

[1]Temperatures in parentheses were estimated from recording thermograph charts.

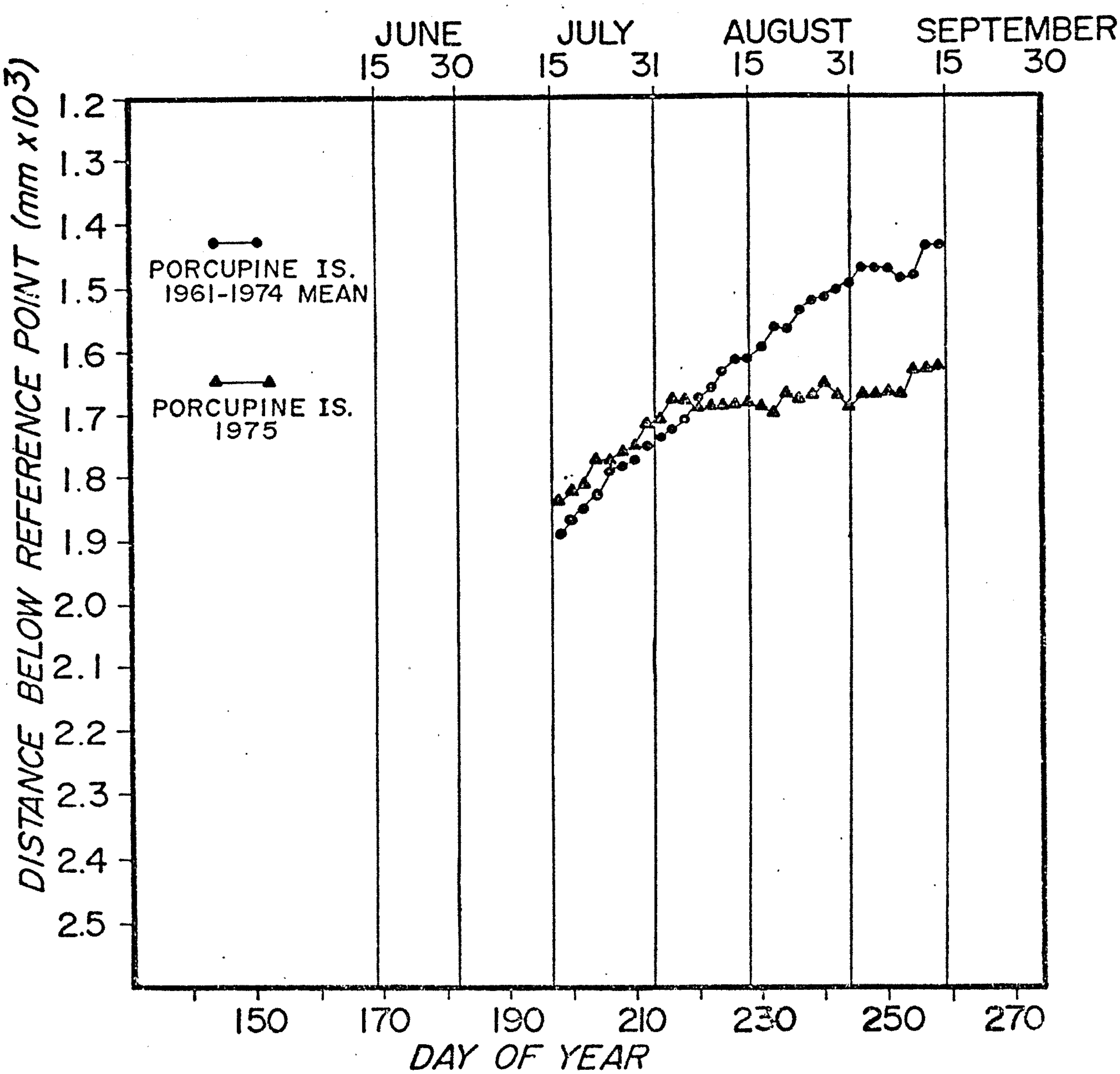


Fig. 5. Fluctuations in water level at Porcupine Island during the summer of 1975 compared with mean fluctuations at Porcupine Island, summers 1961-1974.

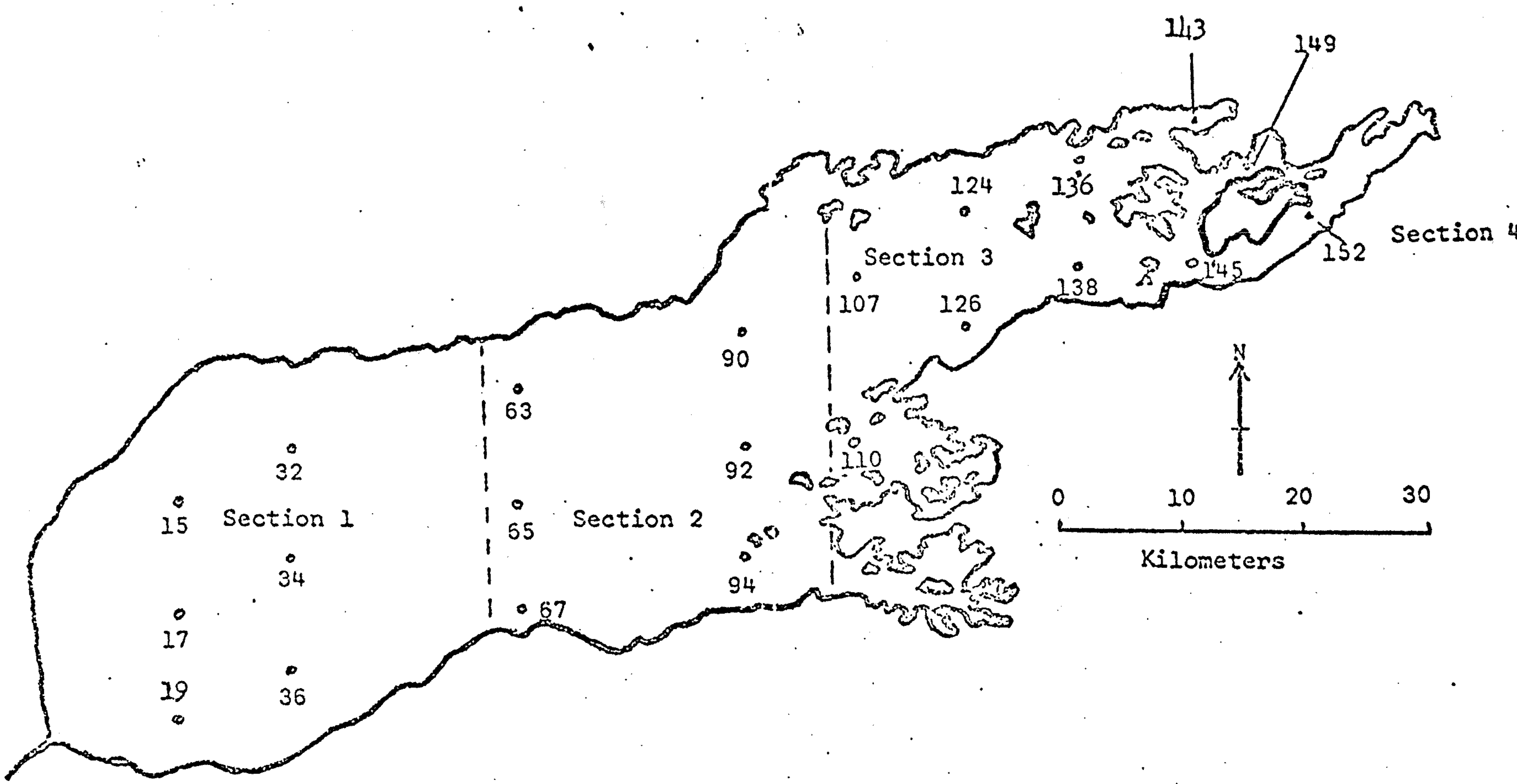


Fig. 6. . Map of Iliamna Lake showing the 22 stations where bathythermograph casts were made in 1975.

Table 11a. Amounts of stored heat in excess of 4°C (cal/cm^2) in Iliamna lake, 1975

Lake Sections	August and September	Station 149 (Date)	Station 149 Stored Heat
1-4	20,232	7/23	5,168
5-6	27,352	7/31	11,144
7-9	22,864	8/22	16,194
10-11	13,368	9/11	17,495
Entire lake	22,342		

Table 11b. Summary of bathythermograph[1/] sampling in Iliamna lake

Date	Cast #'s	Stations
7/23	1	149
7/25	2	19
7/31	3	149
8/16	4	138
8/20	5	143
8/22	6-8	149,152, & 145
8/23	9 -12	124,126,107, & 110
8/24	13-16	110,94,92, & 90
9/01	17-19	19,34, & 67
9/11	20	149

[1/] B.T. #6167 used for all casts less than 65 meters and B.T. #LL04452 used for all casts more than 65 meters in depth.

Table 12. Amounts of stored heat in excess of 4° C (cal/cm^2) in Iliamna Lake, 1961-1975. Annual heat budget is computed from values in August and September.

Sections	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
							June								
1-4	*	*	*	4,765	4,527	5,109	7,623	7,687	6,009	10,640	-6,099	4,692	x	x	x
5-6	*	*	*	-1,251	4,496	-1,619	993	5,882	4,940	8,897	-9,438	1,196	x	x	x
7-9	*	*	*	-8,868	- 894	-1,291	6,508	2,466	7,729	4,021	-8,639	-4,690	6,349	x	x
10-11	*	*	*	9,481	6,150	7,535	5,470	8,573	5,393	8,597	-1,387	-3,348	x	x	x
Entire lake	*	*	*	1,274	4,261	3,692	5,511	6,479	5.945	9,152	-6,285	851	*	x	x
							July								
1-4	*	*	*	11,233	11,116	13,377	17,434	18,346	14,947	x	x	x	18,215	24,168	x
5-6	*	*	*	8,974	13,111	13,660	23,602	18,434	17,474	x	x	x	18,045	29,703	x
7-9	*	*	*	2,549	8,058	12,908	18,727	12,966	23,823	x	x	x	19,414	29,117	x
10-11	*	*	*	10,713	9,221	13,217	20,980	14,204	14,204	x	x	x	11,996	17,254	x
Entire lake	*	*	*	9,331	11,203	13,389	19,207	17,663	16,895	x	x	x	18,129	26,165	x
						August and September									
1-4	24,883	21,805	22,335	21,474	19,895	20,912	24,211	24,909	19,387	23,433	12,546	21,386	20,379	26,427	20,232
5-6	35,775	30,031	28,798	29,560	22,670	24,772	29,115	28,837	27,636	29,879	16,237	14,087	25,986	36,582	27,352
7-9	41,390	35,220	19,780	27,751	23,760	28,448	26,193	27,618	22,087	27,800	23,290	21,263	29,229	37,789	22,864
10-11	18,459	17,013	17,988	18.053	17,273	13,637	19,267	18,534	18,250	13,942	15,038	21,786	15,119	21,245	13,367
Entire lake (Annual budget)	30,175	25,882	23,635	23,688	20,389	22,835	25,712	26,163	22,011	25,514	15,168	21,161	23,005	30,669	22,342

*Data insufficient for determination of values for comparative purposes

xData not taken.

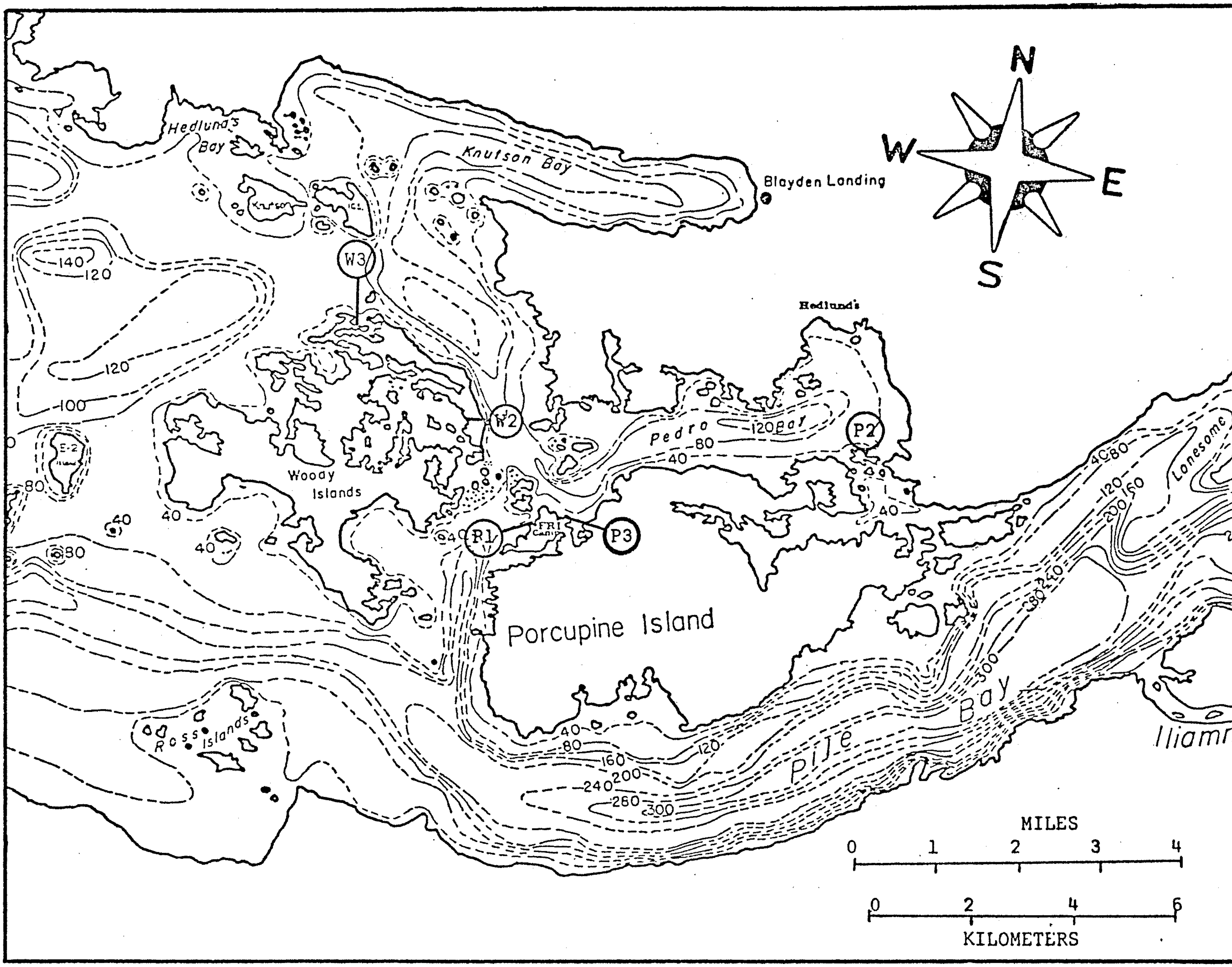


Fig. 7. Locations of the five periphyton stations sampled in 1975.

Table 13. Chlorophyll a in periphyton from sampling at five island beach stations in the eastern end of Iliamna Lake, 1975.

Date	(1) Sample Number	(2) 11.6(665-750)	(3) 1.31(645-750)	(4) .14(630-750)	(5) 2-3-4	(6)[1] Ml acetone / surface area of substrate
8/05	W1-1	1.6124	0.0917	0.0071	1.5136	562.0776
8/31	W1-2	6.8324	0.4297	0.0335	6/3693	4,750.6387
9/13	W1-3	16.1588	0.9838	0.0843	15.0907	44,832.7689
8/05	W2-1	0.5336	0.0393	0.0028	0.4915	182.5238
8/31/	W2-2	0.7076	0.0524	0.0039	0.6513	483.7195
9/13	W2-3	3.1668	0.1913	0.0143	2.9613	2,199.3910
8/05	W3-1	1.9140	0.1218	0.0088	1.7834	662.2660
8/31	W3-2	17.4348	1.0126	0.0872	16.3350	12,132.3158
9/13	W3-3	15.9384	9.8620	0.0843	14.9921	44,539.9287
8/05	P2-1	0.7076	0.0498	0.0039	0.6539	242.8327
8/31	P2-2	3.0392	0.1716	0.0126	2.8550	2,120.4620
9/13	P2-3	16.5416	1.0624	0.0865	15.3913	11,431.4246
8/05	P3-1	1.2760	0.0865	0.0060	1.1835	439.5128
8/31	P3-2	9.9876	0.6616	0.0568	9.2692	6,884.4400
9/13	P3-3	19.2676	1.2196	0.1065	17.8815	53,301.9905

1/ Slides used during 1975 were 3" x 2", or 51 x 66 mm, allowing 1 cm to be placed in the slot on the slide tray. Two slides were processed per station on 8/05, while one slide was processed per station on 8/31 and 9/13.
Calculation of mg chlorophyll a/m^2.

Chlorophyll a = 11.6($^D665$ - $^D750$) - 1.31($^D645$ - $^D750$) - .14(630 - 750)

Chlorophyll a/m^2=(chlorophyll a) $\left(\frac{\text{Ml acetone extract}}{\text{surface area of substrate}}\right)$ 2/

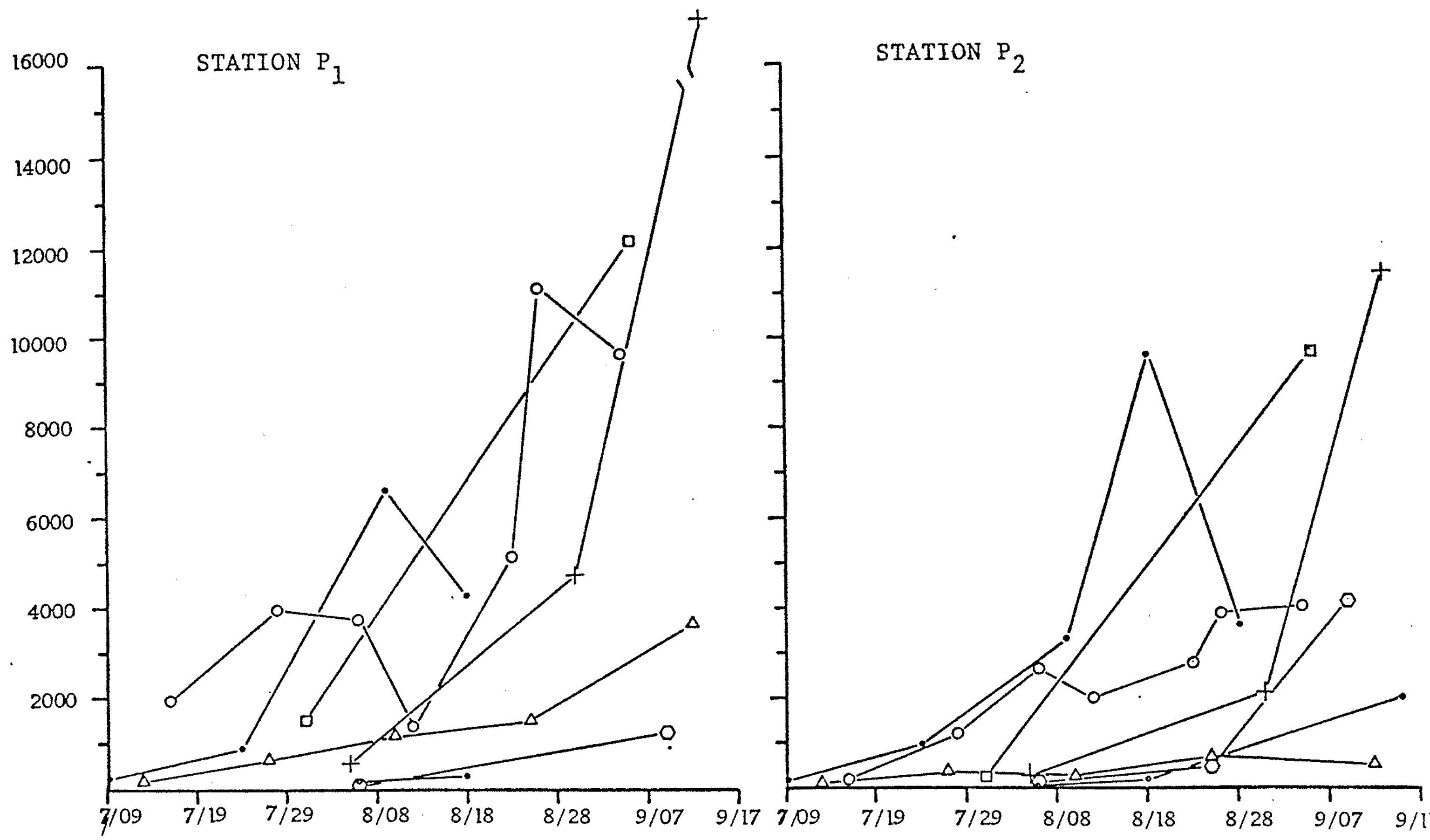
2/ For all samples taken on 8/05: $\frac{\text{5 ml acetone}}{0.013464\text{m}^2}$ (surface area of 2 slides.

For all samples taken 8/31 and 9/13: $\frac{\text{Number ml acetone}}{0.006732\ \text{m}^2}$ (surface area of 1 slide)

Table 14. Chlorophyll a (mg/cm^2) amounts in periphyton samples in Iliamna Lake, Alaska, 1969-75.

Date	Station P 1	Station P 2	Station P 3	Station W 2	Station W 3	Index of abundance of Island Beach Spawners	Estimate date of pe spawning time
7/31/69	1,521	238	*	*	*	131,850	8/17
9/05/	12,185	9,669	*	*	*		
7/16/70	1,987	224	*	*	*	642.790	8/17
7/28/	4,015	1,201	*	*	*		
8/06/	3,796	2,642	*	*	*		
8/12/	1,356	1,957	*	*	*		
8/23/	5,162	2,771	*	*	*		
8/26/	11,100	3,892	*	*	*		
9/04/	9,664	4,026	*	*	*		
7/09/71	232	204	*	*	*	61,460	8/23
7/24/	925	972	529	*	*		
8/09/	6,669	3,339	8,964	*	*		
8/18/	4,323	9,595	18,109	*	*		
8/28/	*	3,646	11,224	*	*		
7/13/72	186	112	313	24	595	10,463	8/13
7/27/	639	347	1,670	183	2,575		
8/10/	1,140	272	5,773	157	3,050		
8/25/	1,490	690	5,216	451	6,336		
9/12/	3,631	503	9,227	205	8,766		
8/06/73	83	92	290	63	331	6,662	8/16
8/25/	*	479	1,594	435	1,921		
9/09/	1,272	4,164	1,117	710	8,800		
8/06/74	160	46	269	172	180	139,713	8/13
8/18/	294	208	1,174	225	358		
9/15/	*	1,981	42,003	280	7,723		
8/05/75	562	243	439	183	662	557,276	8/12
8/31/	4,751	2,120	6,884	484	12,132		
9/13/	44,833	11,431	53,302	2,199	44,540		

* No observations.



-Key-

- □ —— 1969
- ○ —— 1970
- • —— 1971
- △ 1972
- ◯ —— 1973
- • —— 1974
- + —— 1975

fig. 8. Relative abundance of periphyton (in mg. of Chlorophyll a/cm^2) by date, 1969-1975.

Standing crop of phytoplankton

The food chain leading from inorganic nutrients to production of juvenile salmon is complicated by many factors. Studies at the primary trophic level are necessary to understand how cyclic changes in escapement level affect the food base and hence the survival rate and growth rate of juvenile salmon in the Kvichak system. One hypothesis has been that the biogenic elements released by decomposed adult carcasses enrich the productivity of the nursery lakes of the Kvichak system and thereby enhance the survival rate of juvenile salmon proportional to the size of the escapement.

Since 1961 the summer primary production of Iliamna Lake has been measured by estimation of the standing crop of phytoplankton by measuring the amount of chlorophyll a in the water at stations 19, 107, and 143 (Fig. 9). These stations were initially chosen to represent three distinct physical regions in Iliamna Lake (Table 15). Station 19, average depth 27m, represents section A, the lower end and shallow part of Iliamna Lake. Station 107 in section B, or mid-lake area, has an average depth of 110m. Station 143 represents section C, the eastern end of Iliamna Lake.

Monitoring the primary production by estimation of the standing crop of phytoplankton by measuring the amount of chlorophyll a in the water was continued at stations 19, 107, and 143 during the 1975 field season. The concentrations of chlorophyll a from the seasonal sampling at stations 19, 107, and 143 for the years 1961-1975 are summarized in Table 16. The 1975 chlorophyll a concentrations by station and depth are summarized in Table 17 and the weighting factors used for the computations are summarized in Table 18a and 18b.

Data on the relative timing and progression of the breakup of Iliamna Lake ice for the years 1961-1975 has just recently been assembled (Table 19). The mean concentrations of chlorophyll a at stations 19, 107, and 143 for the years 1961-1975 are plotted according to the number of days after the breakup of lake ice (Figs. 10-12). The 1975 yearly mean concentration of chlorophyll a is the lowest observed since observations began in 1961. The 1975 value is based on very limited sampling conducted well after the seasonal peak concentration occurred.

SECONDARY PRODUCTION

Iliamna Lake

Secondary production studies in Iliamna Lake have sought to determine the point at which the lake's zooplankton production becomes a limiting factor in the production of juvenile sockeye salmon. Studies of the limnetic zooplankton community of Iliamna Lake were initiated in 1961. Since 1963 zooplankton samples have generally been taken at from 22-30 stations distributed throughout Iliamna Lake. Zooplankton sampling rounds have generally been made in June, July, and August, although budget limitations the last 3 years have severely curtailed the scope of zooplankton sampling. Vertical hauls have been systematically taken with a No. 6 mesh-nylon open-conical net having a ½ m diameter

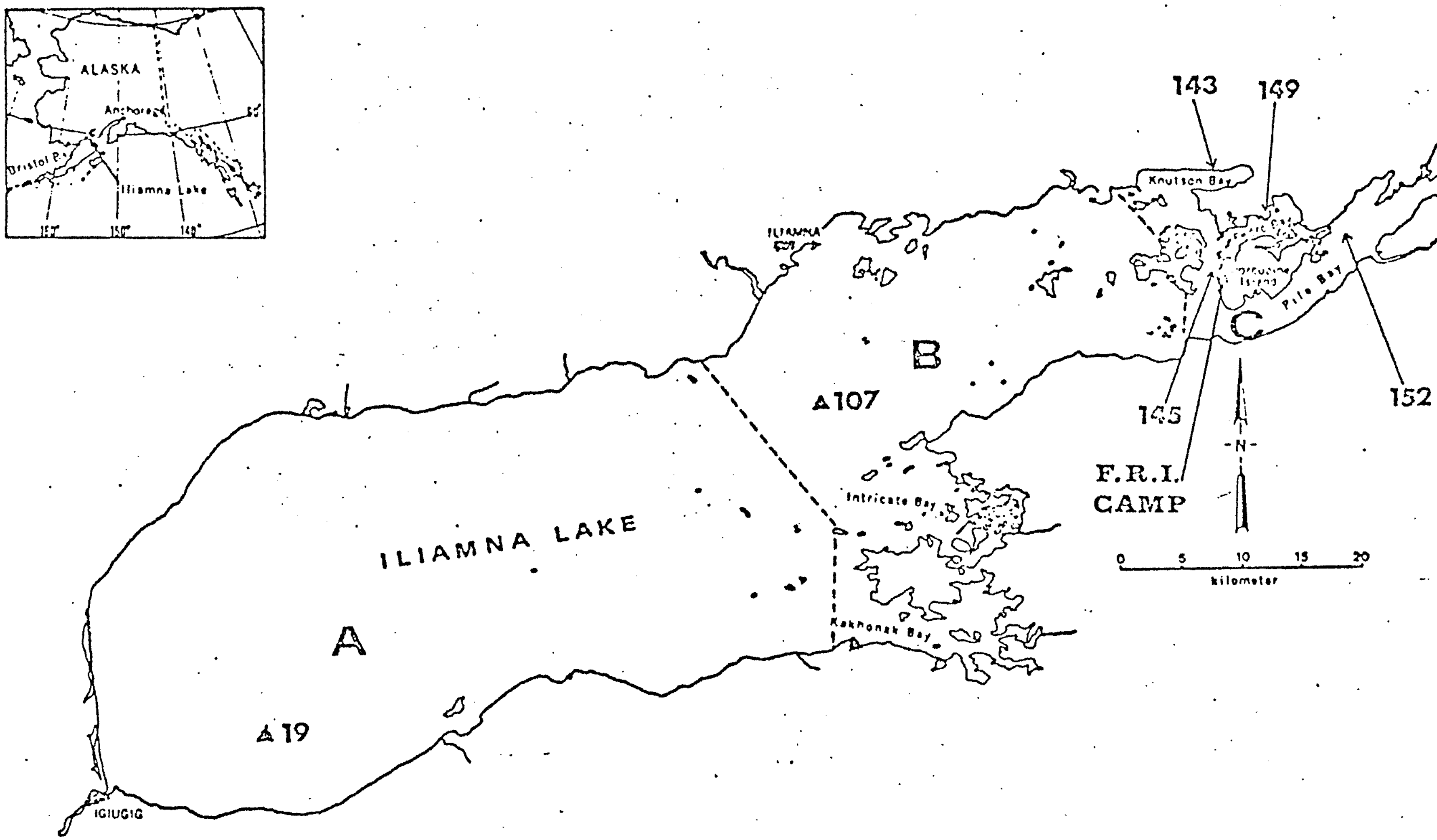


Fig. 9. Map of Iliamna Lake showing the divisions between the three major areas and the positions of stations for measurements of primary production.

Table 15. Physical measurements and characteristic features of three sampling areas in Iliamna Lake.

Measurement	Section A	Section B	Section C	Total
Area (km^2)	1,858.0	610.0	154.0	2,622.0
Per cent of total	70.9	23.2	5.9	100.0
Volume (km^3)	62.4	36.3	16.6	115.3
Per cent of total	54.1	31.5	14.4	100.0
Maximum depth (m)	40.0	240.0	393.0	
Mean depth (m)	33.6	39.5	107.6	44.0
Sampling station	19	107	143	
Potential spawning ground (km^3)				
Streams	0.66	0.57	1.51	2.74
Beaches			0.33	0.33
Total	0.66	0.57	1.84	3.07
Per cent of total	21.0	19.0	60.0	100.0

Source: Low (1972).

Table 21. Volumes of water in the four sections of Iliamna Lake in cubic kilometers and as percentage of total lake volume

Section	Volume (km^3)[1]	Percentage of total volume of section
1	34.733	30.12
2	28.505	24.72
3	35.747	31.00
4	16.325	14.16
TOTAL	115.310	100.00

[1]Data from Anderson, 1969.

Table 16. Concentrations of chlorophyll a (mg/m^3) in June, July, and August at stations 19, 107, and 143, weighted mean yearly concentrations,[1] and standard error of the mean[2], Iliamna Lake, 1961-1975

Year	Station 19				Station 107				Station 143				Weighted mean yearly concentrations	Standard error of the mean
	June	July	Aug.	Mean	June	July	Aug.	Mean	June	July	Aug.	Mean		
1961	0.74*	0.49	0.65	(0.63)	0.80	0.65	0.77	(0.74)	0.65	0.71	0.66	(0.67)	0.67	0.06
Date		7/21	8/23		6/29	7/13	8/23		7/16	8/06	8/24			
1962	0.85	0.59	0.17	(0.54)	0.78	0.77	0.46	(0.67)	0.79	0.65	0.27	(0.57)	0.59	0.16
Date	6/05	7/18	8/15		6/05	7/14	9/09		6/03	7/17	8/18			
1963	0.54*	0.34*	0.27	(0.38)	0.74	0.62	0.24	(0.53)	0.59	0.54	0.49	(0.54)	0.45	0.11
Date			8/16		6/14	7/09	8/06		6/13	7/07	8/12			
1964	0.60	0.45	0.27	(0.44)	0.76	0.52	0.65	(0.64)	0.69	0.61	0.73	(0.68)	0.54	0.10
Date	7/01	7/23	8/14		6/25	7/18	8/11		6/23	7/11	8/07			
1965	0.74	0.48	0.65	(0.62)	0.87	0.37	0.69	(0.64)	0.59	0.68	0.64	(0.64)	0.63	0.10
Date	6/24	7/21	8/29		6/30	7/14	8/06		6/24	7/18	8/02			
1966	0.78	0.56	0.36	(0.57)	0.68	0.56	0.37	(0.54)	1.07	0.90	0.62	(0.86)	0.60	0.16
Date	6/28	7/17	8/14		6/26	7/15	8/11		6/25	7/13	8/10			
1967	0.63	0.33	0.50	(0.49)	0.45	0.61	0.44	(0.50)	0.84	0.61	0.69	(0.71)	0.52	0.10
Date	6/26	7/28	8/22		6/20	8/02	8/27		6/18	8/06	8/29			
1968	0.56	0.50	0.76	(0.61)	0.92	1.00	0.55	(0.82)	0.92	0.92	0.86	(0.91)	0.72	0.13
Date	6/22	7/21	8/20		6/24	7/24	8/23		6/20	7/25	8/26			
1969	1.07	0.62	0.38	(0.69)	1.06	0.93	0.85*	(0.95)	0.91	1.38	0.89	(1.06)	0.83	0.19
Date	6/23	7/22	8/22		6/28	7/29			7/01	8/01	8/30			
1970	0.95*	0.82	0.86	(0.88)	0.76	0.96	0.44	(0.72)	1.31	1.14	0.77	(1.07)	0.86	0.16
Date		7/17	8/16		6/23	7/18	8/24		6/24	7/19	8/22			
1971	1.16	1.20	1.01	(1.12)	0.87	1.39	1.05	(1.10)	1.53	1.42	1.33	(1.43)	1.16	0.14
Date	6/25	7/26	8/11		6/27	7/28	8/12		6/27	7/29	8/31			
1972	0.91	0.37	0.52	(0.60)	0.91	0.97	0.62	(0.83)	1.12	0.98	1.11	(1.07)	0.74	0.18
Date	7/09	8/03	9/08		7/02	8/02	8/28		7/07	8/01	9/05			
1973	**	0.90	0.42	(0.66)	**	1.09	0.52	(0.81)3/	**	1.38	0.86	(1.12)3/	0.77	0.29
Date		7/28	8/16			7/24	8/17	9/05 0.62		7/29	8/20	9/05 0.70		
1974	**	0.34	0.42	(0.38)	**	0.41	0.39	(0.40)	**	0.59	0.54	(0.56)	0.42	0.08
Date		8/03	9/02			7/31	9/08			8/07	9/14			
1975	**	**	0.15	(0.15)	**	**	0.12	(0.12)	**	**	0.26	(0.26)	0.18	0.06
Date			9/02				9/07				8/20			

1/ Yearly mean at each station weighted by the volume of the section of the lake they represent.

2/ ± 2 standard errors.

* Missing observations estimated by randomized block method from Snedecor, 1969, p. 317 (Low, 1972).

**No sampling in June, 1973.

3/ Concentrations of chlorophyll a taken on 9/05/73 not used in calculation of station means.

Table 17. Concentrations of chlorophyll a (mg/m^3)[1] by depth and date of sampling at Stations 19, 107, and 143, in Iliamna Lake, 1975

Depth (m)	Station 19 September 2	Station 107 September 7	Station 143 August 20
1	0.135	0.465	0.195
2	0.13	0.17	0.13
3	0.11	0.18	0.21
4	0.07	0.11	0.20
5	0.105	0.12	0.33
7	0.275	0.30	0.55
10	0.48	0.92	0.84
15	1.275	0.975	2.10
25	1.25	0.80	3.10
35	*	1.00	2.90
45	*	0.30	1.15
Weighted total	0.1532	0.1187	0.2601

[1]Values represent total chlorophyll a calculated by the method of Parsons and Strickland (1963). Source of data: output from computer program No. FRL 323B (Low, 1973).

[2]Calculation of mean chlorophyll a concentration at a station:

$$\overline{Chl}\ a = \frac{\Sigma(Chl\ ai \times Di)}{\Sigma Di}$$

$\overline{Chl}\ a$ = mean concentration of Chl a (mg/m^3)

Chl ai = concentration of Chl a in the i^{th} depth stratum

Di = height of i^{th} depth (m) stratum

ΣDi = depth (m) of deepest sample taken.

*Stations do not have these depths

Table 18a. Weighting factors used for computations of mean chlorophyll a concentrations (mg/m^3) at stations 19, 107, and 143[1/]

Sample depth (i)	Chlorophyll a concentrations: Station 19 — Depth stratum (m)	Chlorophyll a concentrations: Stations 107 and 143 — Depth stratum (m)
1	1.5	1.5
2	1.0	1.0
3	1.0	1.0
4	1.0	1.0
5	1.5	1.5
7	2.5	2.5
10	4.0	4.0
15	7.5	7.5
25	5.0	10.0
35		10.0
45		5.0
Sum	25	45

1/ Data from Low, 1972.

Table 18b. Weighting factors used for computation of weighted yearly mean concentration of chlorophyll a (mg/m^3), Iliamna Lake, Alaska[1/]

Lake section	Sampling station		Weighting factor: Volume (km^3)	Weighting factor: % of total volume
A	19		62.4	54.1
B	107		36.3	31.5
C	143		16.6	14.4
		Total	115.3	100.0

1/ Data from Low, 1972.

Table 19. Estimated date[1] of the breakup of lake ice in three sections[2] of Iliamna Lake, 1961-1975

Year	Section A		Section B		Section C	
	Calendar date	Day of year	Calendar date	Day of year	Calendar date	Day of year
1961	5/26	147	5/16	137	5/12	133
1962	5/31	152	5/23	144	5/20	141
1963	6/01	153	5/16	137	5/06	127
1964	6/21	173	6/11	163	6/07	159
1965	5/22	143	5/15	136	5/08	129
1966	6/18	170	6/03	155	6/02	154
1967	5/21	142	5/19	140	5/14	135
1968	5/23	144	5/17	138	5/17	138
1969	5/31	152	5/24	145	5/18	139
1970	4/15	106	4/15	106	3/19	79
1971	6/17	169	6/16	168	6/06	158
1972	6/11	163	6/07	159	6/05	157
1973	6/05	157	5/20	141	5/15	136
1974	5/24	146	5/23	144	5/19	140
1975	6/10	162	6/07	159	5/28	149

1/ Source of data: Personal logs of FRI biologists and correspondence and/or personal diaries of residents of the Iliamna area.

2/ Primary production division of Iliamna Lake.

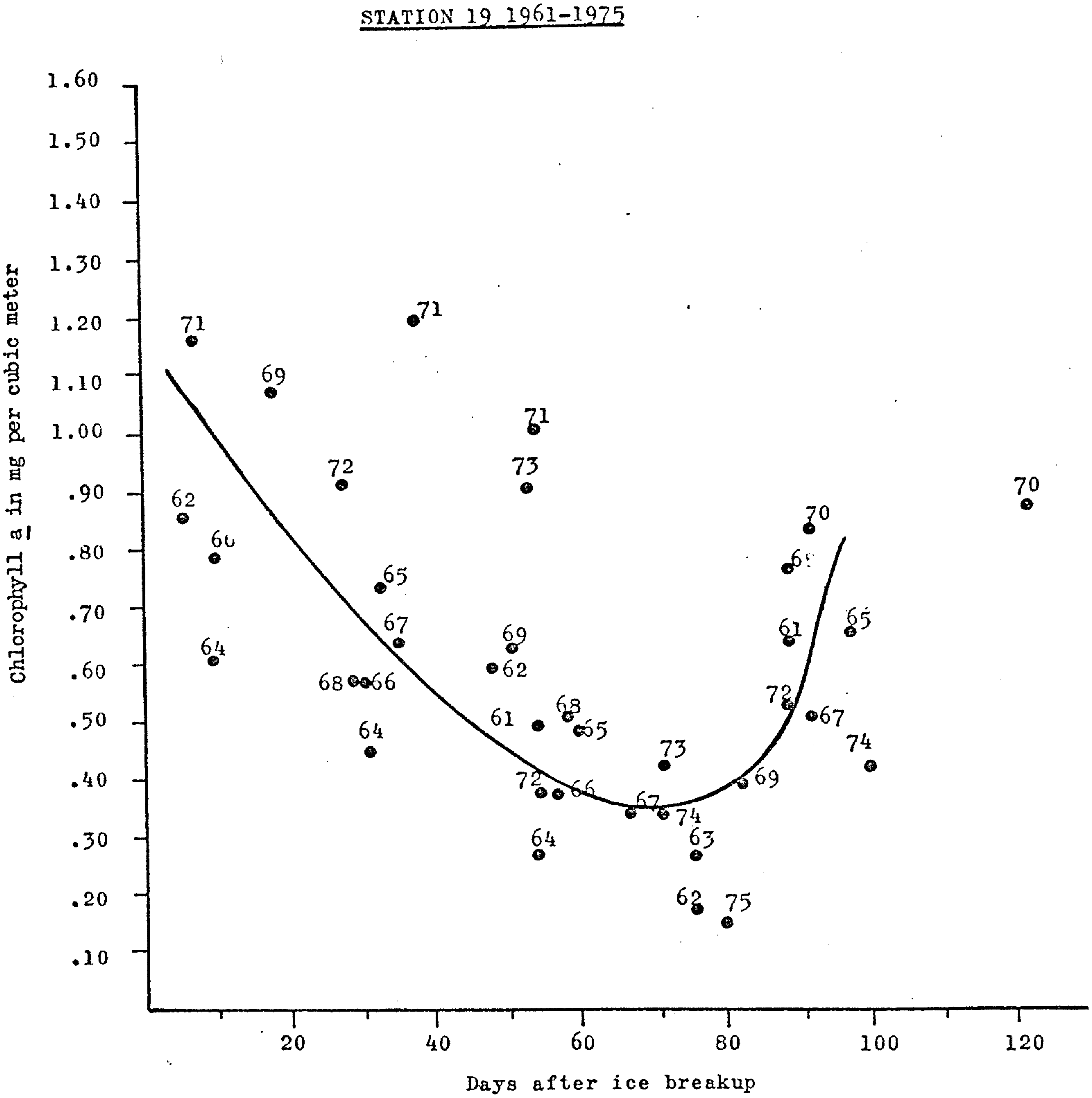


Fig. 10. The mean concentration of chlorophyll a (0-25m) at Station 19, Iliamna Lake, by days after the breakup of lake ice. Data from 1961-1975 (freehand curve).

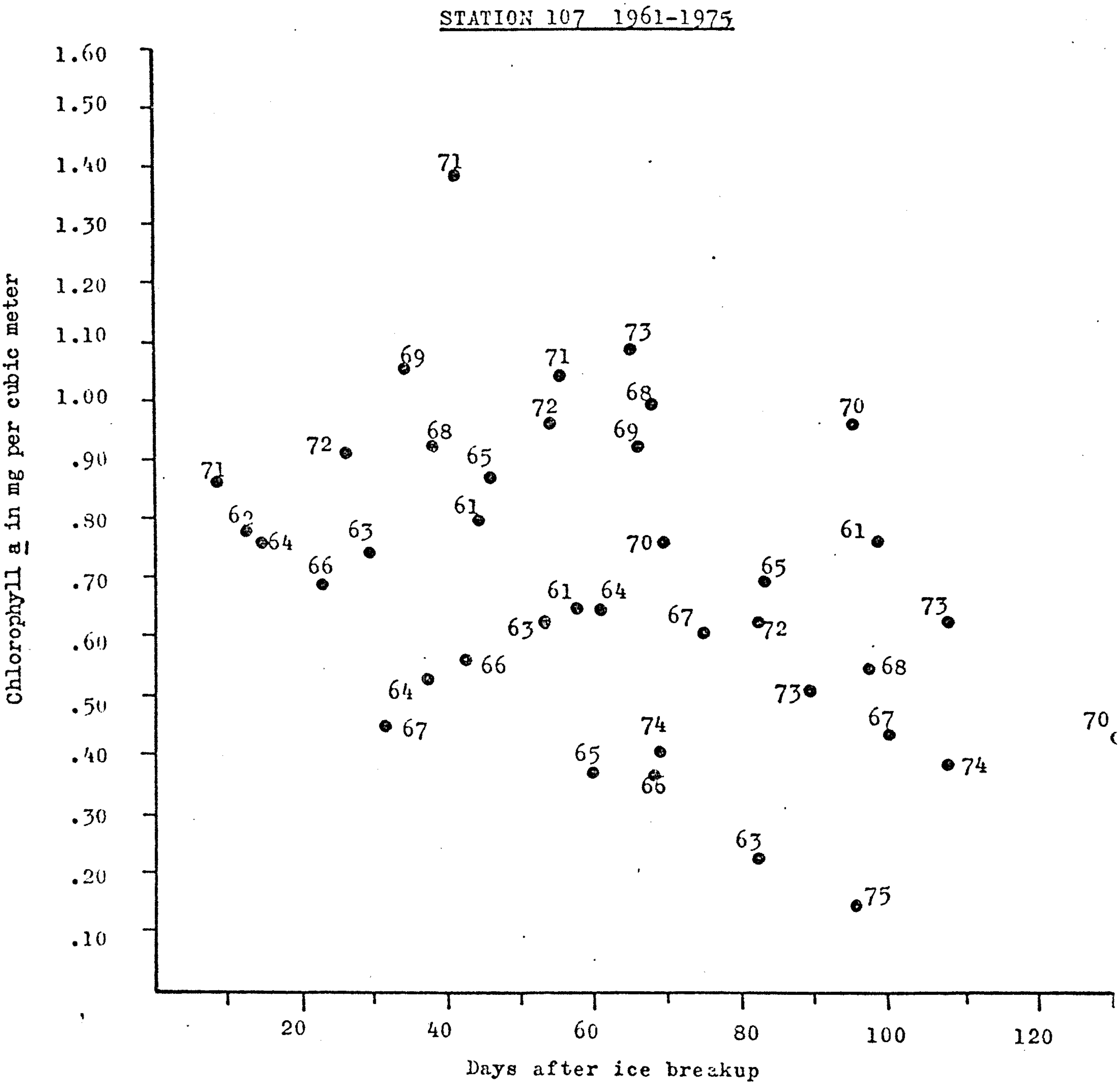


Fig. 11. The mean concentration of chlorophyll a (0-45m) at Station 107, Iliamna Lake, by days after the breakup of lake ice. Data for the years 1961-1975.

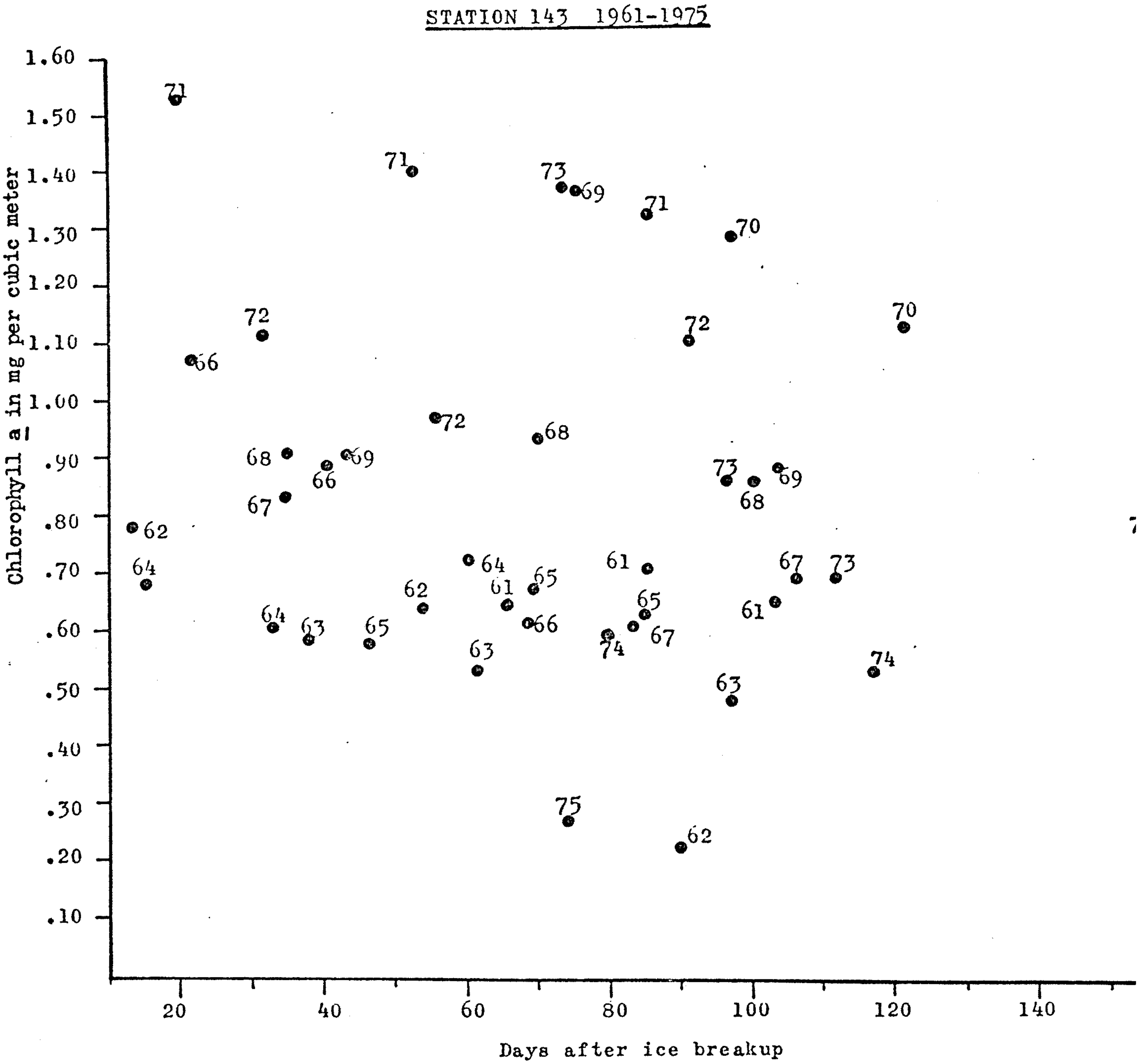


Fig. 12. The mean concentration of chlorophyll a (0-45m) at Station 143, Iliamna Lak by days after the breakup of lake ice. Data for the years 1961-1975.

mouth opening and a mesh aperature of 223 microns fitted with a flowmeter. Annual and seasonal abundances of the standing crop of the different zooplankters have been determined from this sampling procedure. No strong correlation has been demonstrated to date between estimated zooplankton standing crop in Iliamna Lake and the abundance or growth of juvenile sockeye salmon (Mathisen, 1969).

The distribution of the No. 6 net sampling effort during the 1975 field season is shown in Fig. 13. The results of the work are summarized in Table 20. The geometric means for the copepods and the cladocerans from each of the four lake sections, as well as the weighted average for the entire lake are presented. The mean from each section is weighted by the per cent of the total lake volume it represents (Table 21). The annual and seasonal changes in the abundance of total zooplankton, Cyclops scutifer, Bosmina coregoni, the calanoid copepods, Holopedium gibberum, and Daphnia longiremis for the years 1963-1975 are presented in Tables 22-27.

The seasonal abundance of zooplankton is examined at station 149 in Fig. 14. Summary data for the No. 6 net sampling at station 149 is given in Table 28. The nature of selective predation by juvenile salmon on the zooplankton community is being investigated and preliminary results are in press. Zooplankton samples are available from sampling conducted in Iliamna Lake since 1961. A thorough analysis of these samples could provide valuable information on the changes in the available food supply sought by juvenile salmon in Iliamna Lake.

Lake Clark

No. 6 zooplankton sampling was also conducted on a limited scale in Lake Clark in 1975. The distribution of the sampling stations sampled during most years in Lake Clark is shown in Fig. 15. The results of the 1975 sampling are summarized in Table 29 and a summary of all of the No. 6 net sampling in Lake Clark since 1961 is presented in Table 30.

STUDIES OF JUVENILE SALMON AND MAJOR COMPETITOR SPECIES

Continued monitoring of juvenile salmon abundance, growth and distribution fulfills two essential purposes in the total study of the sockeye salmon production in the Kvichak system. First, this monitoring provides the first indication of the success of spawning for each brood year. Second, continuous comparable data over several life cycles is essential when evaluating the productive capacity of salmon producing systems and formulating management decisions. Maintenance of these studies through tow-netting, limited beach seining, and acoustic assessment where applicable is needed to further define and measure the interactions between juvenile salmon and biotic and abiotic factors limiting production of the Kvichak system.

Tow-Netting

Indices of relative abundance, distribution, and growth of juvenile sockeye salmon and threespine sticklebacks in Iliamna Lake and of juvenile salmon and least ciscos in Lake Clark have been determined since 1962. In 1975 the index towing was conducted between August 10-18 in Lake Clark and August 20 to September 12 in Iliamna Lake. The distribution of the tow-netting effort in 1975 is

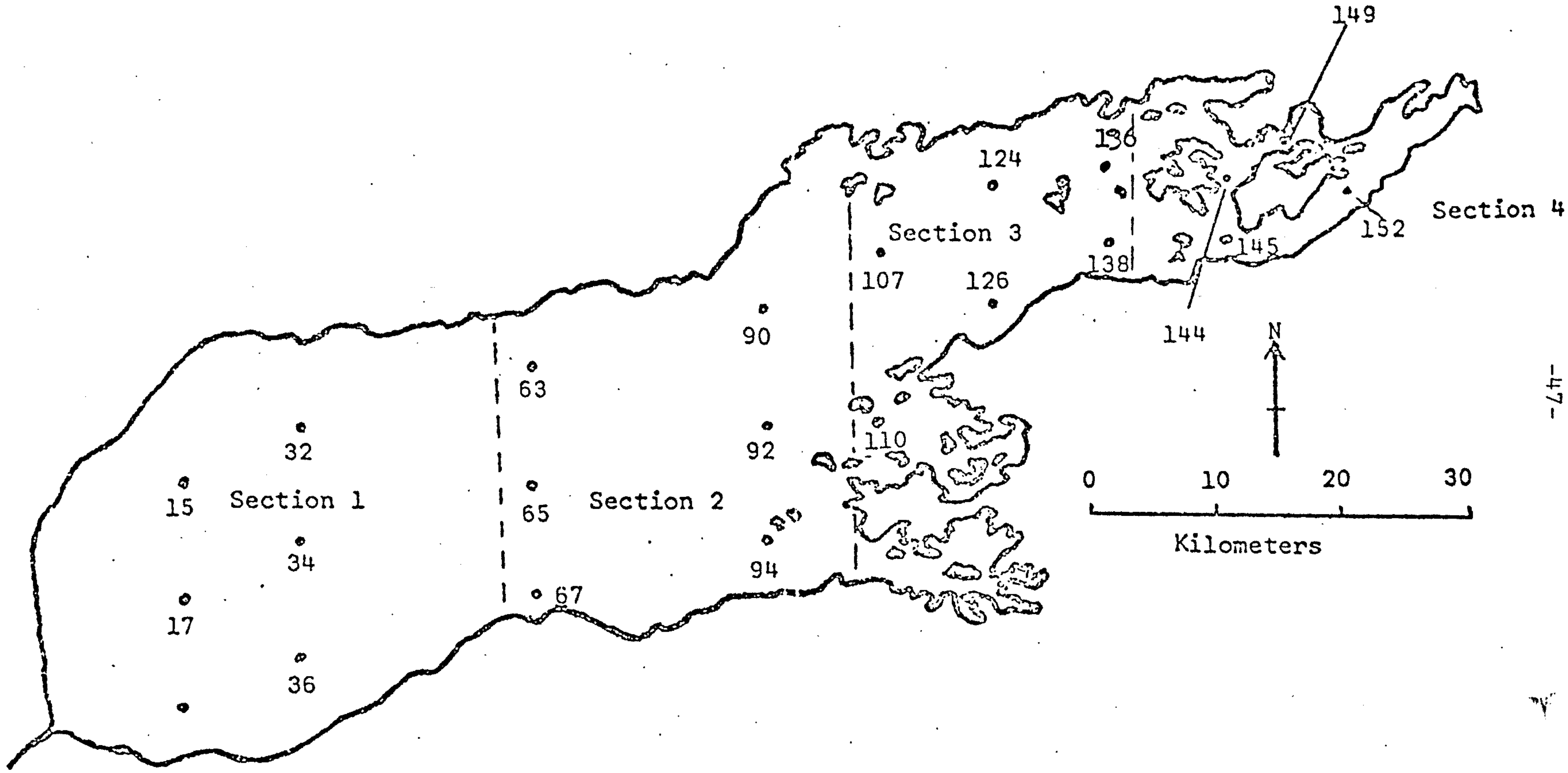


Fig. 13. Map of Iliamna Lake, showing the four limnological lake sections and the distribution of the 22 zooplankton stations sampled in 1975.

Table 20. Composition and distribution of the major species of zooplankton from No. 6 net sampling (geometric mean in number/m^3), Iliamna Lake, 1975

				Geometric Mean					
				Copepoda		Cladocera			
Lake section	Sample period	Number of stations sampled	Date of sampling	Calanoid	Cyclops	Bosmina	Daphnia	Holopedium	Total zooplankton
I	2	1	7/25	608.504	4,563.409	1,106.940	64.589	138.210	6,689.621
IV	2	1	7/23,31	448.229	5,114.739	319.195	36.587	2.707	5,956.229
I	3	2	9/01	1,149.880	5,115.424	8,010.908	1,744.833	319.663	17,435.714
II	3	4	8/23,9/01	731.708	4,115.417	3,967.943	1,368.543	595.161	11,428.047
III	3	5	8/16,23,24	612.166	3,249.314	2,358.927	381.380	277.390	7,193.170
IV	3	4	8/20,22	389.464	2,487.482	869.115	178.232	110.161	4,236.178
Weighted[1] geometric mean (August round)				772.141	3,917.611	4,248.095	1,007.313	344.996	10,906.376
Percent of weighted geometric mean total zooplankton				8.604	48.006	32.618	7.006	3.721	
IV	4	1	9/11	965.156	4,644.261	2,970.970	735.636	47.910	9,467.769

[1] Section values weighted by the percentage of the total lake volume they represent.

Table 21. Volumes of water in the four sections of Iliamna Lake in cubic kilometers and as percentage of total lake volume

Section	Volume (km^3)[1]	Percentage of total volume of section
1	34.733	30.12
2	28.505	24.72
3	35.747	31.00
4	16.325	14.16
TOTAL	115.310	100.00

[1]Data from Anderson, 1969.

Table 22. Standing crop of zooplankton (geometric means in number/m^3) by sampling period and lake section, and weighted lake mean[1] (in number/m^3) total zooplankton, Iliamna Lake, 1963-1975

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
						JUNE							
1	1,938	7,394	6,900	7,294	5,495	6,335	6,614	6,770	3,383	5,080	*	*	*
2	2,755	6,308	5,663	7,570	4,776	6,875	5,039	6,109	3,950	4,259	*	*	*
3	2,048	4,078	4,407	5,210	4,086	4,293	4,695	8,744	2,778	2,851	*	*	*
4	1,802	874	4,137	4,137	3,051	5,409	2,676	5,320	2,494	2,545	6,336	*	*
Lake mean	2,155	5,174	5,430	6,269	4,534	5,704	5,072	7,013	3,210	3,827	X	*	*
						JULY							
1	8,394	10,583	7,043	11,377	8,163	10,945	8,138	*	*	*	9,318	*	6,690
2	5,794	9,015	6,161	13,183	7,179	8,621	8,101	*	*	*	12,786	*	*
3	5,351	5,986	5,408	6,546	4,529	5,889	5,222	*	3,547	*	4,928	*	*
4	5,410	3,978	4,269	8,720	1,982	3,778	4,140	*	3,375	*	5,018	6,986	5,956
Lake mean	6,385	7,835	5,925	9,950	5,918	7,788	6,659	*	X	*	8,206	X	X
						AUGUST							
1	8,513	9,025	11,186	13,828	9,015	8,730	11,052	10,428	8,463	14,107	12,629	15,217	17,436
2	9,141	7,853	10,011	10,762	6,774	8,537	8,097	10,987	6,915	15,977	11,620	16,467	11,428
3	6,931	8,027	6,015	7,159	6,651	8,301	6,315	10,454	5,015	8,521	7,338	11,897	7,193
4	4,336	2,853	4,429	5,907	4,448	6,021	4,861	6,490	4,532	8,069	8,752	10,041	4,236
Lake mean	7,888	7,552	8,336	9,881	7,081	8,166	7,976	10,017	6,455	11,983	10,190	13,764	10,906
						SEPTEMBER							
1	*	*	*	*	*	*	*	*	*	*	*	10,651	*
2	*	*	*	*	*	*	*	*	*	*	*	8,511	*
3	*	*	*	*	*	*	*	*	4,838	*	8,043	8,274	*
4	*	*	*	*	*	*	*	*	4,861	*	7,456	6,192	9,468
Lake mean	*	*	*	*	*	*	*	*	X	*	X	8,754	X

[1] Section values weighted by the percentage of the total lake volume represented by the section volume.

*Data not taken.

X Data insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974.
FRR 347 computer output, 1975.

Notes on methods of sampling:

(1) 1963- Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.

(2) 1964- Vertical samples were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.

(3) 1965-1975- Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

Table 23. Geometric means (number/m^3) by sampling period and Iliamna Lake section, and weighted lake mean[1] (in number/m^3) <u>Cyclops</u> <u>scutifer</u> Sars, Iliamna Lake, 1963-1975 regional sampling rounds

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
						JUNE							
1	1,264	5,633	4,371	5,059	3,970	4,678	4,687	4,695	2,167	3,106	*	*	*
2	1,777	4,972	4,044	5,574	3,747	4,039	3,572	4,429	3,194	2,802	*	*	*
3	1,160	2,746	3,101	3,868	3,486	3,613	3,964	6,951	2,492	2,115	*	*	*
4	1,143	632	2,960	3,078	2,746	4,608	2,336	4,378	2,382	2,200	5,023	*	*
Lake mean	1,341	3,866	3,697	4,537	3,592	4,180	3,854	5,284	2,552	2,595	X	*	*
						JULY							
1	2,877	7,857	4,370	6,878	4,188	3,770	4,205	*	*	*	3,924	*	4,563
2	2,520	6,636	3,622	8,227	2,105	2,616	3,941	*	*	*	4,619	*	*
3	2,509	4,610	3,665	4,723	2,585	3,487	3,697	*	3,263	*	2,508	*	*
4	3,672	3,332	2,870	4,018	1,426	2,791	3,182	*	3,140	*	3,416	4,391	5,115
Lake mean	2,787	5,908	3,754	6,138	2,785	3,258	3,837	*	X	*	3,585	X	X
						AUGUST							
1	1,740	4,718	4,602	5,703	2,268	1,540	3,730	2,147	5,196	5,601	2,630	6,490	5,115
2	1,952	4,422	4,292	4,298	744	1,291	2,305	1,750	4,449	5,423	2,545	5,174	4,115
3	904	5,107	2,625	3,328	2,485	1,864	2,733	2,823	3,599	5,526	2,276	5,369	3,249
4	631	2,030	2,508	3,657	1,922	2,642	2,726	2,986	2,941	6,222	2,869	5,741	2,487
Lake mean	1,376	4,385	3,616	4,330	1,910	1,735	2,927	2,377	4,197	5,622	2,533	5,711	3,918
						SEPTEMBER							
1	*	*	*	*	*	*	*	*	*	*	*	3,831	*
2	*	*	*	*	*	*	*	*	*	*	*	2,680	*
3	*	*	*	*	*	*	*	*	2,949	*	1,844	3,035	*
4	*	*	*	*	*	*	*	*	3,014	*	1,903	2,961	4,644
Lake mean	*	*	*	*	*	*	*	*	X	*	X	3,177	X

[1] Section values weighted by the percentage of the total lake volume represented by the section volume.

* Data not taken.

X Data insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974, 1975 - FRM 347 computer output.

Notes on methods of sampling:

(1) 1963 - Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.

(2) 1964 - Vertical hauls were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.

(3) 1965-1975 - Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

Table 24. Geometric means (number/m^3) by sampling period and Iliamna Lake section, and weighted lake mean[1] (in number/m^3) Bosmina coregoni, Iliamna Lake, 1963-1975

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					JUNE								
1	168	275	454	731	296	392	160	533	119	439	*	*	*
2	191	204	279	535	139	392	128	396	195	309	*	*	*
3	119	93	275	307	38	94	57	359	80	167	*	*	*
4	23	11	224	232	21	106	27	61	56	69	189	*	*
Lake mean	138	164	323	480	138	259	101	378	117	270	X	*	*
					JULY								
1	2,913	749	1,240	2,946	2,080	3,907	1,186	*	*	*	2,497	*	1,107
2	1,603	577	1,103	3,194	1,701	2,610	1,158	*	*	*	4,492	*	*
3	768	213	743	1,100	390	694	395	*	142	*	853	*	*
4	112	76	587	874	42	231	195	*	160	*	585	361	319
Lake mean	1,528	445	960	2,142	1,174	2,070	794	*	X	*	2,210	X	X
					AUGUST								
1	3,012	2,810	4,033	5,014	2,936	3,934	4,357	6,021	1,361	5,520	5,874	4,216	8,011
2	4,525	1,707	3,026	4,303	2,950	4,698	3,070	6,618	877	7,256	4,624	5,790	3,968
3	2,819	823	2,187	2,680	1,760	4,077	1,745	5,088	399	1,686	3,179	3,470	2,359
4	821	103	1,009	1,424	897	1,945	659	2,021	342	699	3,178	1,897	869
Lake mean	3,016	1,538	2,784	3,606	2,286	3,886	2,705	5,313	799	4,078	4,348	4,045	4,248
					SEPTEMBER								
1	*	*	*	*	*	*	*	*	*	*	*	4,136	*
2	*	*	*	*	*	*	*	*	*	*	*	3,404	*
3	*	*	*	*	*	*	*	*	1,004	*	3,933	3,263	*
4	*	*	*	*	*	*	*	*	666	*	3,631	2,041	2,971
Lake mean	*	*	*	*	*	*	*	*	X	*	X	3,388	X

[1]Section values weighted by the percentage of the total lake volume represented by the section volume.

*Data not taken.

XData insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974, 1975 - FRR 347 computer output.
Notes on methods of sampling:

(1) 1963 - Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.

(2) 1964 - Vertical hauls were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.

(3) 1965-1975 - Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

Table 25. Geometric means (number/m^3) by sampling period and Iliamna Lake section, and weighted lake mean[1] (in number/m^3) Calanoid Copepods (_Diaptomus gracilis_ Sars and _Eurytemora yukonensis_ Wilson), Iliamna Lake, 1963-1975 regional sampling rounds

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					JUNE								
1	415	1,263	1,296	1,218	705	329	1,308	823	892	837	*	*	*
2	620	956	964	1,116	519	1,216	942	730	998	749	*	*	*
3	436	1,143	722	846	347	421	481	1,016	650	440	*	*	*
4	495	176	778	725	178	545	231	688	338	155	686	*	*
Lake mean	484	996	963	1,008	473	607	809	841	765	596	X	*	*
					JULY								
1	1,086	1,405	957	740	557	1,272	1,058	*	*	*	1,171	*	609
2	776	1,201	806	828	777	935	1,174	*	*	*	1,392	*	*
3	944	966	656	409	719	623	568	*	728	*	921	*	*
4	1,244	468	568	650	334	280	489	*	420	*	539	782	448
Lake mean	988	1,086	771	646	630	847	854	*	X	*	1,059	X	X
					AUGUST								
1	612	673	1,064	951	1,415	890	800	1,005	1,111	990	733	1,148	1,150
2	744	927	869	680	1,077	806	921	1,179	759	063	769	1,169	732
3	546	1,266	500	469	1,377	907	859	1,053	509	631	579	768	612
4	996	521	389	403	868	646	749	780	395	526	917	677	389
Lake mean	679	898	745	657	1,242	840	841	1,031	736	806	720	969	772
					SEPTEMBER								
1	*	*	*	*	*	*	*	*	*	*	*	1,016	*
2	*	*	*	*	*	*	*	*	*	*	*	952	*
3	*	*	*	*	*	*	*	*	454	*	791	803	*
4	*	*	*	*	*	*	*	*	619	*	639	508	965
Lake mean	*	*	*	*	*	*	*	*	X	*	X	862	X

[1]Section values weighted by the percentage of the total lake volume represented by the section volume.

*Data not taken.

X Data insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974, 1975 data from FRR 347 computer output.

Notes on methods of sampling:

(1) 1963 - Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.
(2) 1964 - Vertical hauls were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.
(3) 1965-1975 - Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

Table 26. Geometric means (number/m^3) by sampling period and Iliamna Lake section, and weighted lake mean[1] (in number/m^3) Holopedium gibberum Zaddach, Iliamna Lake, 1963-1975 regional sampling rounds

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					JUNE								
1	0	2	393	4	280	34	299	386	2	362	*	*	*
2	0	1	77	38	192	142	266	196	3	199	*	*	*
3	3	0	42	8	81	9	97	114	1	2	*	*	*
4	0	0	1	7	9	1	9	17	1	1	0	*	*
Lake mean	1	1	151	14	158	48	187	202	2	159	X	*	*
					JULY								
1	341	240	13	135	427	634	1,172	*	*	*	590	*	138
2	129	37	26	200	1,013	938	1,029	*	*	*	597	*	*
3	85	4	11	44	161	177	152	*	10	*	52	*	*
4	11	5	11	26	15	6	81	*	5	*	14	139	3
Lake mean	163	83	15	107	431	479	666	*	X	*	343	X	X
					AUGUST								
1	697	244	276	641	730	811	1,272	588	207	1,197	1,487	1,248	320
2	564	241	207	407	545	376	799	502	146	1,544	1,453	1,967	595
3	603	208	105	95	285	330	221	281	44	338	350	978	277
4	53	33	110	37	211	136	86	77	8	23	331	410	110
Lake mean	544	202	182	328	473	459	661	399	113	850	962	1,223	345
					SEPTEMBER								
1	*	*	*	*	*	*	*	*	*	*	*	128	*
2	*	*	*	*	*	*	*	*	*	*	*	41	*
3	*	*	*	*	*	*	*	*	55	*	196	32	*
4	*	*	*	*	*	*	*	*	25	*	151	14	48
Lake mean	*	*	*	*	*	*	*	*	X	*	X	61	X

[1] Section values weighted by the percentage of the total lake volume represented by the section volume.

[*] Data not taken.

[X] Data insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974, 1975 - FRR 347 computer output.

Notes on methods of sampling:

(1) 1963 - Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.

(2) 1964 - Vertical hauls were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.

(3) 1965-1975 - Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

Table 27. Geometric means (number/m^3) by sampling period and Iliamna Lake section, and weighted lake mean[1] (in number/m^3) *Daphnia longiremis* Sars, Iliamna Lake, 1963-1975

Lake section	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					JUNE								
1	41	20	300	135	83	92	19	34	91	24	*	*	*
2	68	13	233	158	69	147	20	60	43	2	*	*	*
3	62	2	143	106	30	40	11	111	49	3	*	*	*
4	41	2	112	53	4	19	10	55	18	2	106	*	*
Lake mean	54	10	208	120	52	79	15	68	56	9	X	*	*
					JULY								
1	339	176	353	391	252	689	143	*	*	*	738	*	65
2	216	110	264	437	469	769	182	*	*	*	1,031	*	*
3	413	54	229	190	148	234	50	*	60	*	289	*	*
4	103	3	124	140	23	74	64	*	17	*	216	602	37
Lake mean	298	97	260	305	241	481	113	*	X	*	597	X	X
					AUGUST								
1	724	214	890	931	886	1,132	263	295	565	353	1,304	1,355	1,745
2	640	220	1,085	752	915	868	236	432	507	300	1,285	1,646	1,369
3	1,259	232	429	371	509	743	217	614	159	90	550	879	381
4	760	17	253	221	380	402	167	327	124	41	820	936	178
Lake mean	874	193	705	613	705	843	228	432	362	214	997	1,220	1,007
					SEPTEMBER								
1	*	*	*	*	*	*	*	*	*	*	*	1,172	*
2	*	*	*	*	*	*	*	*	*	*	*	1,181	*
3	*	*	*	*	*	*	*	*	226	*	962	548	*
4	*	*	*	*	*	*	*	*	252	*	719	440	736
Lake mean	*	*	*	*	*	*	*	*	X	*	X	877	X

[1] Section values weighted by the percentage of the total lake volume represented by the section volume.

* Data not taken.

X Data insufficient for determination of lake mean.

Data source: FRM 298 computer output, Iliamna Lake zooplankton, 1963-1974, 1975 - FRR 347 computer output.

Notes on methods of sampling:

(1) 1963 - Vertical hauls were taken from 30 m to the surface or the bottom to the surface if the station depth was less than 30 m.

(2) 1964 - Vertical hauls were taken from the bottom to the surface or 40 m to the surface if the station was deeper than 40 m.

(3) 1965-1975 - Vertical hauls were taken from the bottom to the surface or 100 m to the surface if the station was deeper than 100 m.

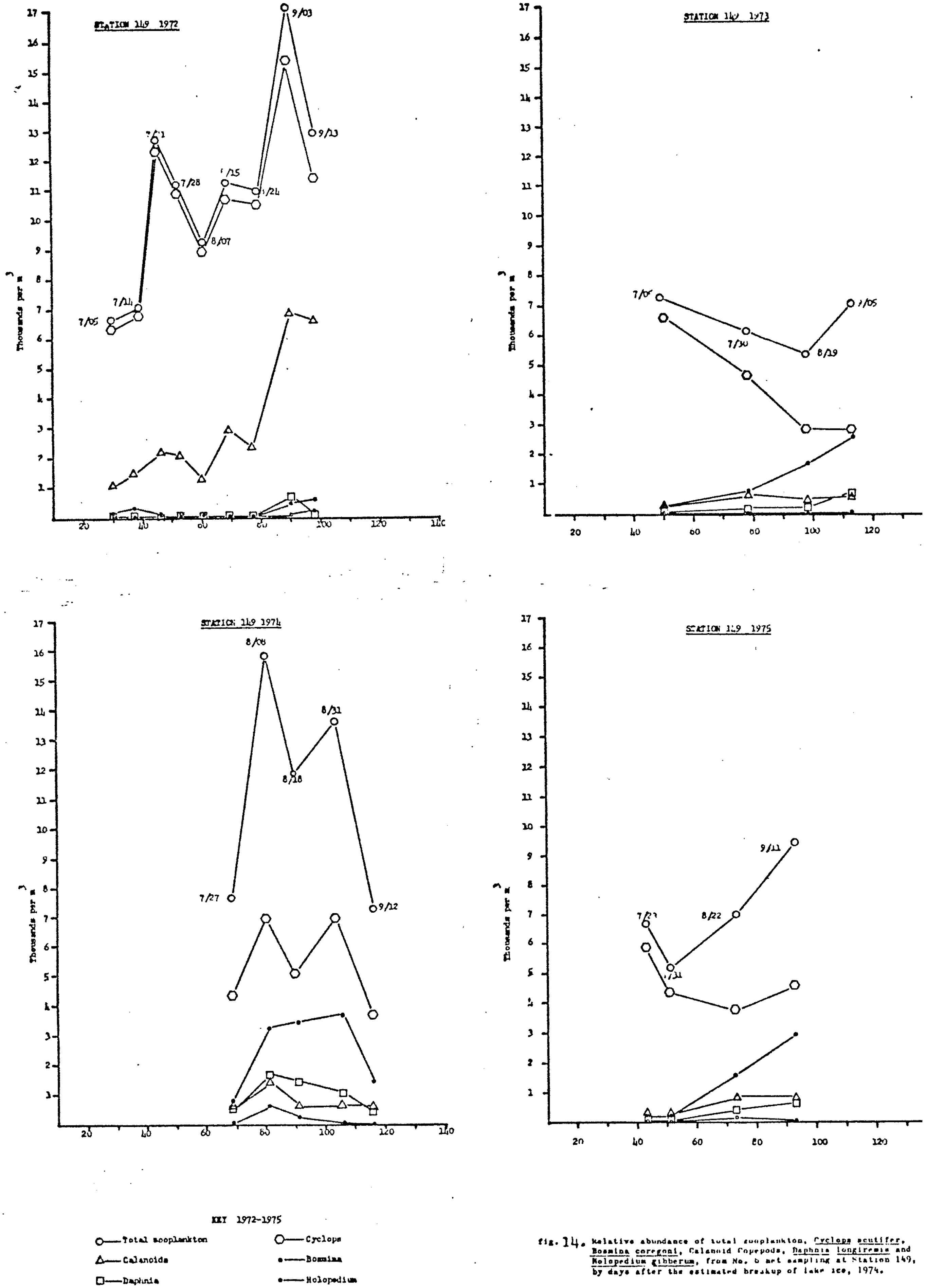


fig. 14. Relative abundance of total zooplankton, *Cyclops scutifer*, *Bosmina coregoni*, Calanoid Copepods, *Daphnia longiremis* and *Holopedium gibberum*, from No. 6 net sampling at Station 149, by days after the estimated breakup of lake ice, 1974.

Table 28. Abundance of Calanoid Copepods (*Diaptomus gracilis* Sars and *Eurytemora yukonesis* Wilson, *Cyclops scutifer* Sars, *Bosmina coregoni* Baird, *Daphnia longiremis* Sars, *Holopedium gibberum* Zaddach, and total zooplankton by sampling dates, No. 6 net sampling, Station 149, Iliamna Lake, 1975

Date of sampling	Geometric Mean in number/m³					
	Copepoda		Cladocera			Total zooplankton
	Calanoid	Cyclops	Bosmina	Daphnia	Holopedium	
7/23	461.128	5,943.363	337.018	24.199	1.397	6,789.724
% of total	6.814	87.827	4.980	.358	.021	
7/31	435.690	4,401.622	302.311	55.065	4.733	5,225.037
% of total	8.375	84.613	5.811	1.059	.091	
8/22	917.613	3,803.329	1,617.349	424.711	200.022	7,017.989
% of total	13.178	54.622	23.228	6.100	2.873	
9/11	965.156	4,644.261	2,970.970	735.636	47.910	9,467.769
% of total	10.279	49.461	31.640	7.834	.510	
Geometric mean for all sampling dates	649.547	4,636.418	836.985	144.081	18.172	6,967.899
Percent of geometric mean total zooplankton for all sampling	10.330	73.737	13.311	2.291	.289	

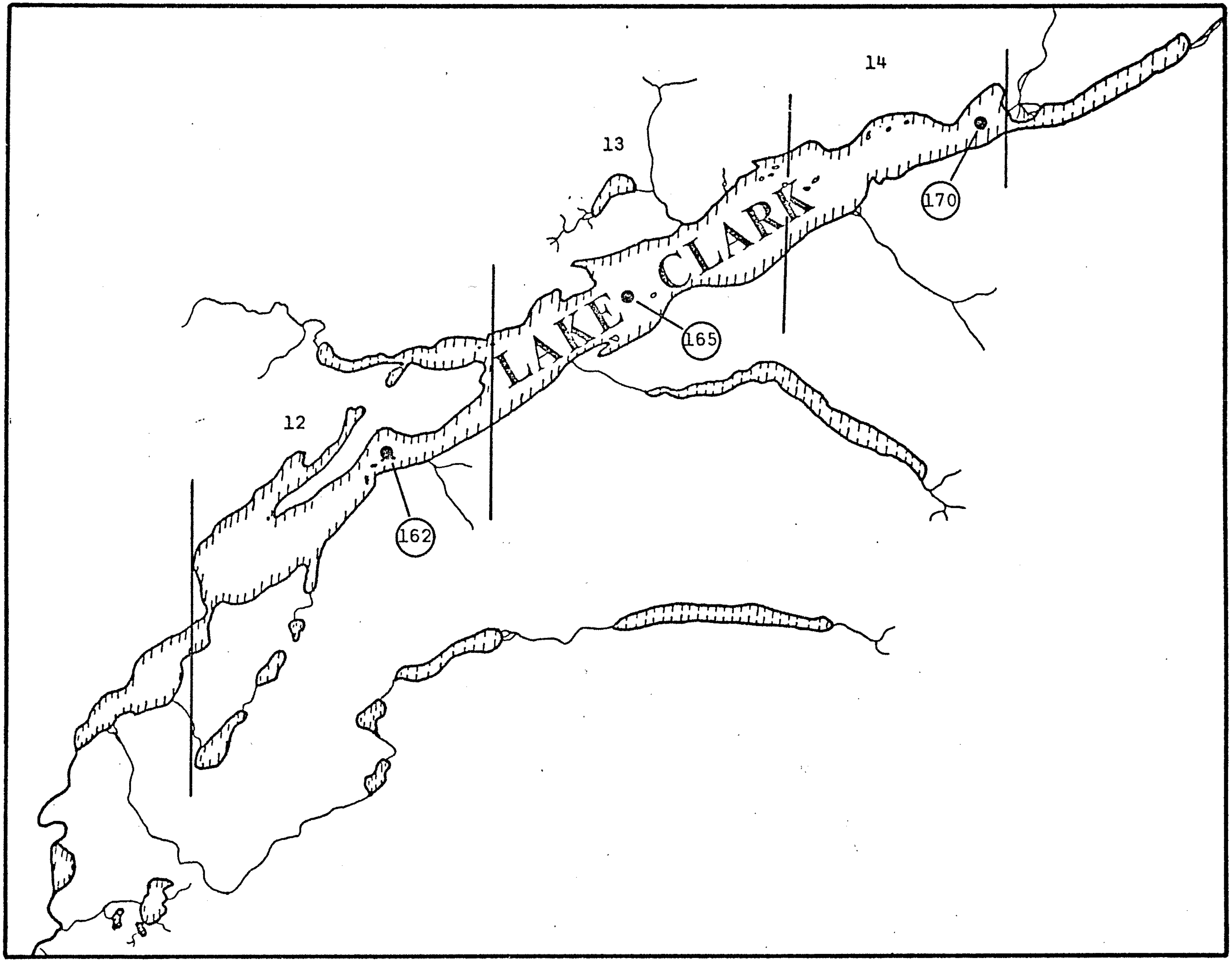


Fig. 15. Map of Lake Clark, showing the three limnological lake sections and the distribution of the three zooplankton stations sampled in 1975.

Table 29. Composition and disribution of the major species of zooplankton (geometric mean in number/m^3), Lake Clark, 1975

Lake section	Station number sampled	Date of sampling	Geometric Mean/m^3					
			Copepoda		Cladocera			Total zooplankton
			Calanoid	Cyclops	Bosmina	Daphnia	Holopedium	
13	165	8/18	517	794	4	5	0	1,341
14	170	8/15	1,579	859	2	14	1	2,471
Weighted[1] geometric mean			797	811	3	7	0	1,638
Percent of weighted geometric mean total zooplankton			56.158	43.165	.139	.512	.025	

[1]Weighting factors by volume:
Section 13 .7370
Section 14 .2630

Table 30. Composition and distribution of the major species of zooplankton (geometric mean in number/m^3), Lake Clark, 1961, 1963, 1969-1975, No. 6 net sampling

Year	Lake section	Number stations sampled	Copepoda: Calanoid	Copepoda: Cyclops	Cladocera: Bosmina	Cladocera: Daphnia	Cladocera: Holopedium	Total zooplankton
1961	12	3	458.920	650.163	.485	15.022	.000	1,167.019
	13 **	3	995.094	1,774.609	1.521	5.700	.347	3,009.966
	Weighted lake mean		758.802	1,279.065	1.064	9.808	.194	2,197.779
1963	14	1	526.000	866.000	.000	34.000	17.000	1,477.000
1969	12	2	380.903	806.521	.000	8.782	.817	1,201.694
1970 1/	13	1	1,535.636	2,598.958	8.058	21.998	.565	4,170.279
	14 ***		810.605	1,293.032	.000	.000	.000	2,133.115
	Weighted lake mean		1,344.953	2,255.499	5.939	16.213	.416	3,634.505
1971	13	1	583.929	1,772.305	.821	4.701	.565	2,369.956
	14 ***	1	410.867	1,336.549	.565	20.692	.565	1,774.654
	Weighted lake mean		538.414	1,657.701	.754	8.906	.565	2,213.391
1972	12	1	508.863	1,034.593	.000	2.000	.000	1,547.661
	13	1	275,825	1,143.395	.000	.000	5.000	1,427.383
	14 *	1	525.053	1,335.807	.587	.000	.587	1,865.122
	Weighted lake mean		376.170	1,161.043	.123	.413	3.046	1,543.557
1973	14	1	611.000	581.000	.000	82.000	.000	1,274.000
1974	12	1	579.415	1,236.950	2.317	63.062	.000	1,891.780
	13	1	655.950	1,458.308	10.000	84.537	.817	2,234.682
	14 *	1	2,347.303	2,703.654	6.100	97.453	.821	5,237.704
	Weighted lake mean		992.946	1,672.333	7.598	82.792	.649	2,790.254
1975	13	1	517.332	794.236	3.583	4.657	.000	1,340.666
	14 ***	1	1,578.833	858.854	2.317	14.199	.821	2,471.010
	Weighted lake mean		796.507	811.230	3.250	7.166	.216	1,637.947

1/ 1970 is the only year a flow meter was used.

Weighting factors by volume:

* All lake sections sampled:
- Section 12 .2067
- Section 13 .5847
- Section 14 .2086

** Only lake sections 12 & 13 sampled:
- Section 12 .4407
- Section 13 .5593

*** Only lake sections 13 & 14 sampled:
- Section 13 .7370
- Section 14 .2630

Data source: FRR 347-Plankton Data Analysis computer output.

Notes on methods of sampling:
(1) 1961 - Vertical hauls were made from depths ranging between 40-50 m to the surface.
(2) 1963 - Vertical hauls were made from 30 m to the surface.
(3) 1969-1975 - Vertical hauls were made from 100 m to the surface.

shown in Fig. 16.

Abundance

Tow net catches of the major groups of fishes in Iliamna Lake and Lake Clark are presented in Table 31. Results from the 1975 combined tow-netting and hydroacoustic program show the relative abundance of fry in Lake Clark to be the highest observed since operations began in 1962 (Fig. 17). These results further corroborate the indication that lack of early season commercial fishing in Bristol Bay favored the Lake Clark escapement.

Prior to 1975 there has been 4 years during which the Iliamna Lake towing index has been expanded from an index value based on incomplete towing coverage of the lake. Since there were no tows made in lake sections 1 and 2 in 1975, indices obtained (Table 32) were expanded to represent the entire lake by using the following equation:

$$\text{Estimated total index} = \frac{\text{Observed index sections 3-11}}{\text{Mean \% from sections 3-11 from years of complete towing (Roger, MS 1973)}}$$

Indices for the years 1962-1975 are presented in Table 33.

Distribution

The distribution of the catch of each fish group in each lake section expressed as a percentage of the total catch of the respective fish groups for Iliamna Lake and Lake Clark are shown in Figs. 18 and 19.

Growth in length

The daily growth rates of juvenile sockeye salmon and Age I threespine sticklebacks were computed as shown in Table 34. Estimated daily growth rates of juvenile sockeye salmon and sticklebacks in the eastern portion of Iliamna Lake for the years 1962-1975 are summarized in Table 35. Growth curves established for sockeye salmon fry, sockeye salmon yearlings, and Age I threespine sticklebacks are illustrated in Fig. 20.

Mean live lengths of juvenile salmon and major competitors by lake section are presented in Table 36. The weighted mean lengths of juvenile salmon and competitors in Iliamna Lake and Lake Clark for the years 1962-1975 are presented in Table 37. In 1975 the mean length of sockeye fry was 4 per cent smaller while the mean length of Age I yearlings was 13 per cent greater, respectively, than the mean length for the years 1962-1974.

Weight

Low fish densities and lack of a stable platform prevented weighing of fish from lake sections other than 6, 7, 8, and 9. Therefore, only the length-weight relationships of juvenile salmon in the eastern portion of Iliamna Lake were studied. The length-weight relationships of juvenile sockeye salmon are shown in Figs. 21 and 22 and were as follows:

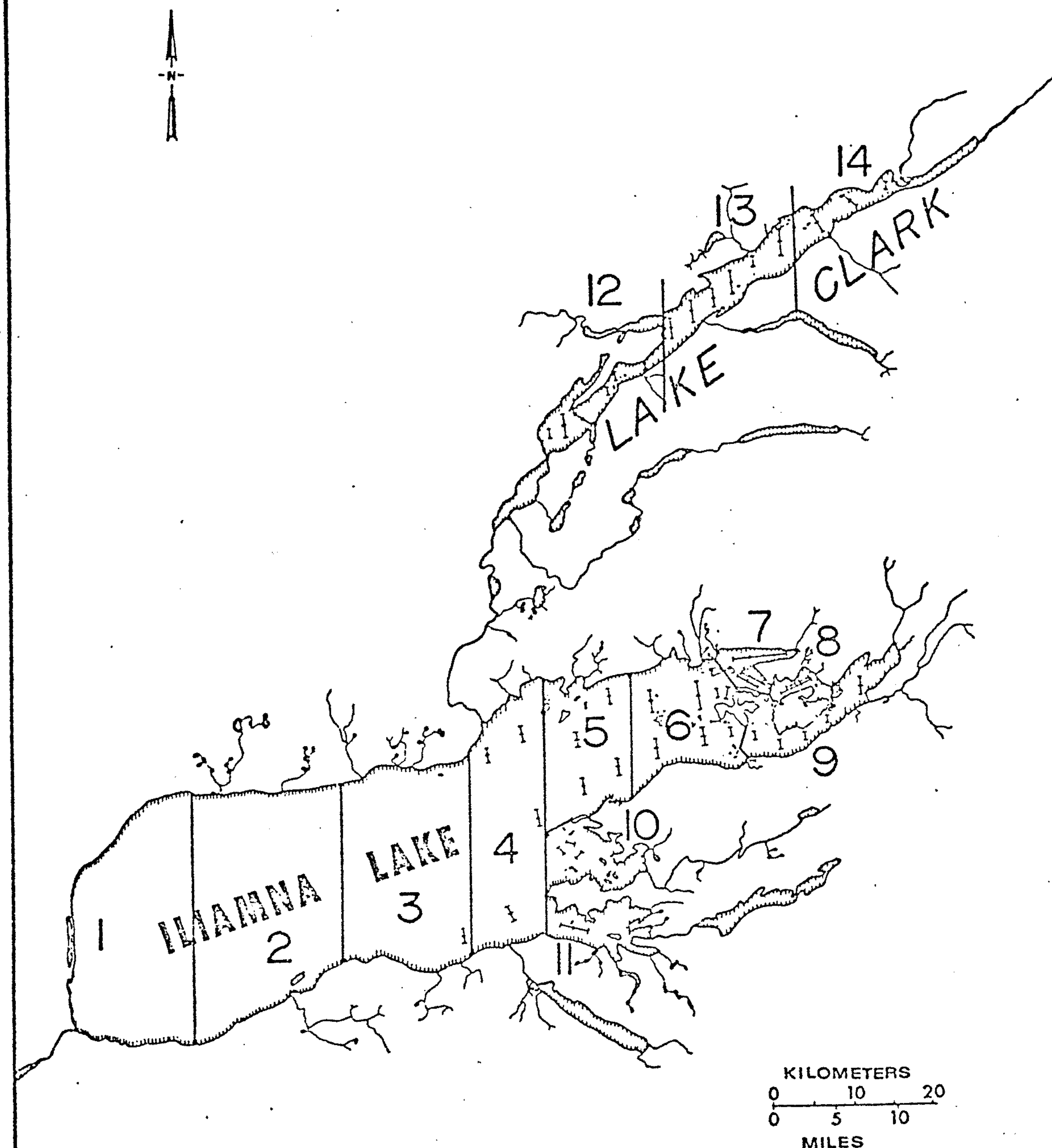


Fig. 16. Distribution of the tow-netting survey in the nursery lakes of the Kvichak River system, 1975.

Table 31. Tow net catches of resident fish in Iliamna Lake and Lake Clark, 1975

Lake Section	Sockeye salmon Fry	Sockeye salmon Yearlings	Sticklebacks Threespine	Sticklebacks Ninespine	Least Cisco	Number of index tows
			Iliamna Lake			
1	-	-	-	-	-	0
2	-	-	-	-	-	0
3	12	0	7	1	0	2
4	234	5	8	20	4	6
5	151	4	12	2	0	8
6	1,301	14	699	125	1	10
7	1,287	6	386	175	7	7
8	5,224	0	2,073	113	10	3
9	111	12	59	11	0	6
10	103	3	83	8	0	3
11	839	9	1,921	632	4	2
Total:	9,262	53	5,248	1,087	26	47
			Lake Clark			
12	2,694	27	0	2	38	8
13	1,071	66	5	0	54	11
14	335	8	0	12	128	5
Total:	4,100	101	5	14	220	24

Data source: FRK 317R computer output for 1975.

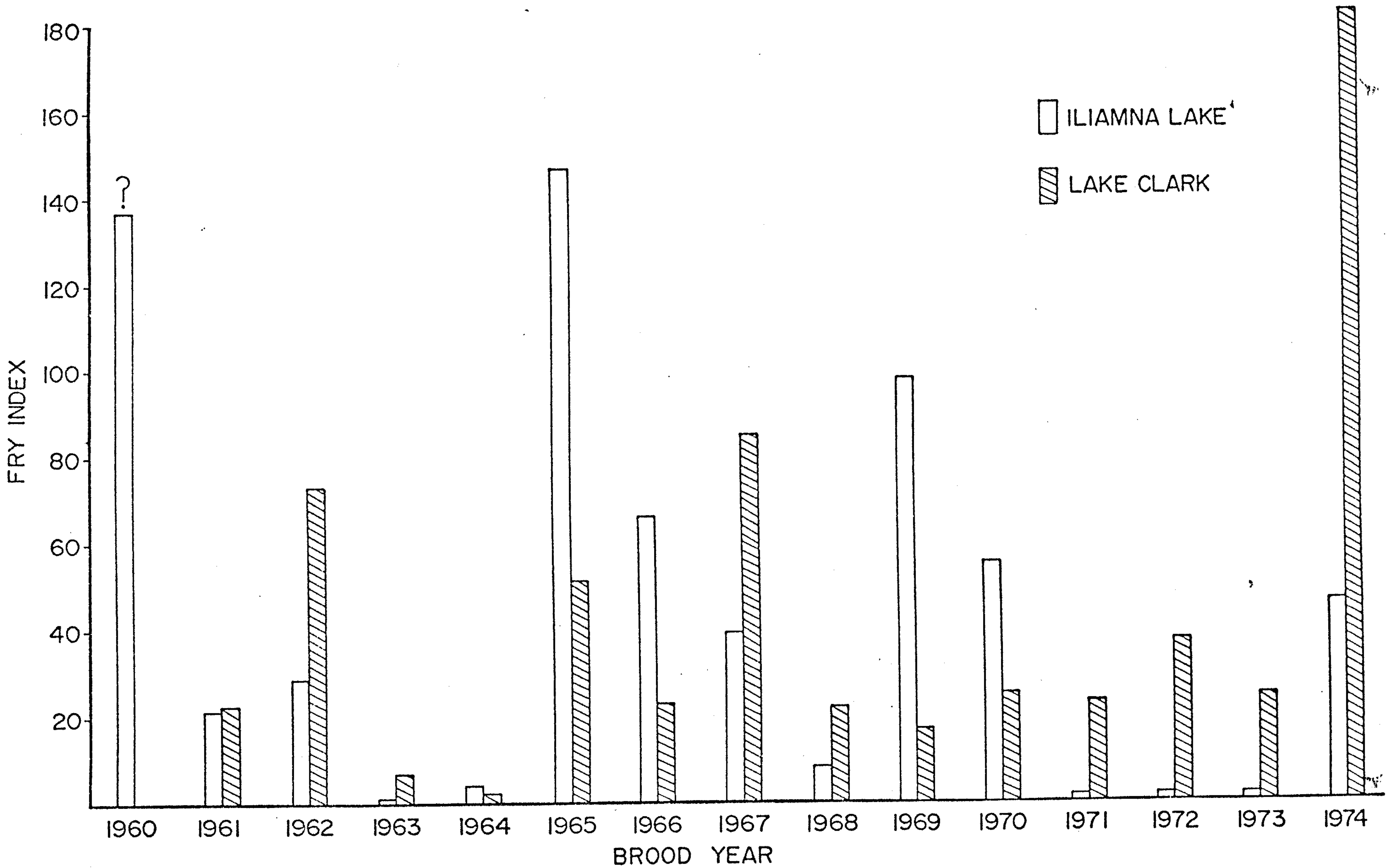


Fig. 17. Relative production of sockeye salmon fry in Iliamna Lake and Lake Clark, 1961-1975.

Table 32. Weighted mean catches of resident fish from index towing for Iliamna Lake, Lake Clark and the Kvichak system, 1975

Section	Sockeye salmon		Sticklebacks		Least	Weighting	Number of
	Fry	Yearlings	Threespine	Ninespine	Ciscos	factor	index tows
			Iliamna Lake				
1	-	-	-	-	-	0.2130	0
2	-	-	-	-	-	0.1837	0
3	1.161	0.000	0.677	0.097	0.000	0.1935	2
4	5.179	0.111	0.177	0.443	0.089	0.1328	6
5	1.801	0.048	0.143	0.024	0.000	0.0954	8
6	8.886	0.096	4.774	0.854	0.007	0.0683	10
7	2.059	0.010	0.618	0.280	0.011	0.0112	7
8	14.627	0.000	5.804	0.316	0.028	0.0084	3
9	0.673	0.073	0.358	0.067	0.000	0.0364	6
10	1.130	0.033	0.910	0.088	0.000	0.0329	3
11	10.278	0.110	23.532	7.742	0.049	0.0245	2
Total:	45.798	0.480	36.994	9.910	0.184	1.0001	47
Expanded[1/]	49.030	0.528	38.495				
			Lake Clark				
12	128.234	1.285	0.000	0.095	1.809	0.3808	8
13	41.272	2.543	0.193	0.000	2.081	0.4239	11
14	13.085	0.312	0.000	0.469	5.000	0.1953	5
Total:	182.592	4.141	0.193	0.564	8.889	1.0000	24
			Kvichak System[2/]				
Iliamna Lake Sections 3-11	41.562	0.436	33.572	8.993	0.167	0.9075	47
Expanded to represent entire lake	44.495	0.479	34.934				
Lake Clark	16.890	0.383	0.018	0.052	0.822	0.0925	24
Total (unexpanded)	58.452	0.818	33.590	9.045	0.989	1.0000	71
Expanded Index	61.385	0.862	34.952				

1/ Since there were no tows made in lake sections 1 and 2 during 1975, indexes of juvenile salmon and threespine sticklebacks (sections 3-11) were expanded to represent the entire lake by using the following relationship: (Roger, MS 1973)

$$\text{Estimated total index} = \frac{\text{Observed index sections 3-11}}{\text{Mean \% from sections 3-11 from years of complete towing}}$$

2/ Weighted mean catches = (Iliamna Lake index)(0.9075) + (Lake Clark index)(0.0925) for Kvichak system.

Table 33. Relative abundance of juvenile sockeye salmon, threespine sticklebacks and least ciscos in the Kvichak River system and the relative production of Age 0 sockeye, 1962-1975

	Index of abundance[1]								
	Iliamna Lake			Lake Clark			Kvichak system[2]		
ear of mpling	Age 0	Age 1	Threespine sticklebacks	Age 0	Age I	Least Ciscos	Age 0	Age I	Mean catch of Age 0 per million spawners
962	21.6	87.8	132.3	22.3	0.0	2.4	21.7	79.7	5.84
63	28.3	11.2	26.6	72.9	1.5	4.5	32.4	10.3	12.56
64	0.9	21.1	95.3	6.5	0.9	3.6	1.4	19.2	4.11
65	3.9	2.7	91.2	2.2	1.2	2.4	3.7	2.6	3.85
66	146.5	0.9	36.7	51.4	0.7	10.6	137.7	0.9	5.66
967	66.0	75.3	37.0	22.5	3.5	13.6	62.0	68.7	16.40
68	38.8	20.5	90.3	84.7	19.8	12.6	43.0	20.4	13.35
969	8.1	2.4	80.6	22.1	11.6	22.5	9.4	3.3	3.67
70	98.2	4.8	31.0	17.4	12.1	17.4	90.7	5.5	10.81
971[3]	55.4	20.7	39.5	25.3	5.5	16.4	52.6	19.3	3.77
72	1.7	20.7	5.9	23.3	6.4	6.1	3.7	19.4	1.54
973[3]	1.8	1.9	17.8	36.7	2.2	2.1	5.0	1.9	4.95
74[3]	1.7	0.3	5.0	24.4	2.6	14.9	3.8	0.5	16.52
75[3]	49.0	0.5	38.5	182.6	4.1	8.9	61.4	0.9	14.18
1962-1974 mean:									
	36.4	20.8	53.0	31.7	5.2	9.9	35.9	19.4	7.93

[1] Weighted mean catches of juvenile sockeye salmon, threespine sticklebacks and least ciscos per standard tow (all the above indices are derived from the computer program FRK 317R which uses the 1968 method of computing indices of abundance and defining lake sections.)

[2] Iliamna index given a weight of 0.9075 and Lake Clark index a weight of .0925 based on total surface area.

[3] Indices estimated from incomplete towing.

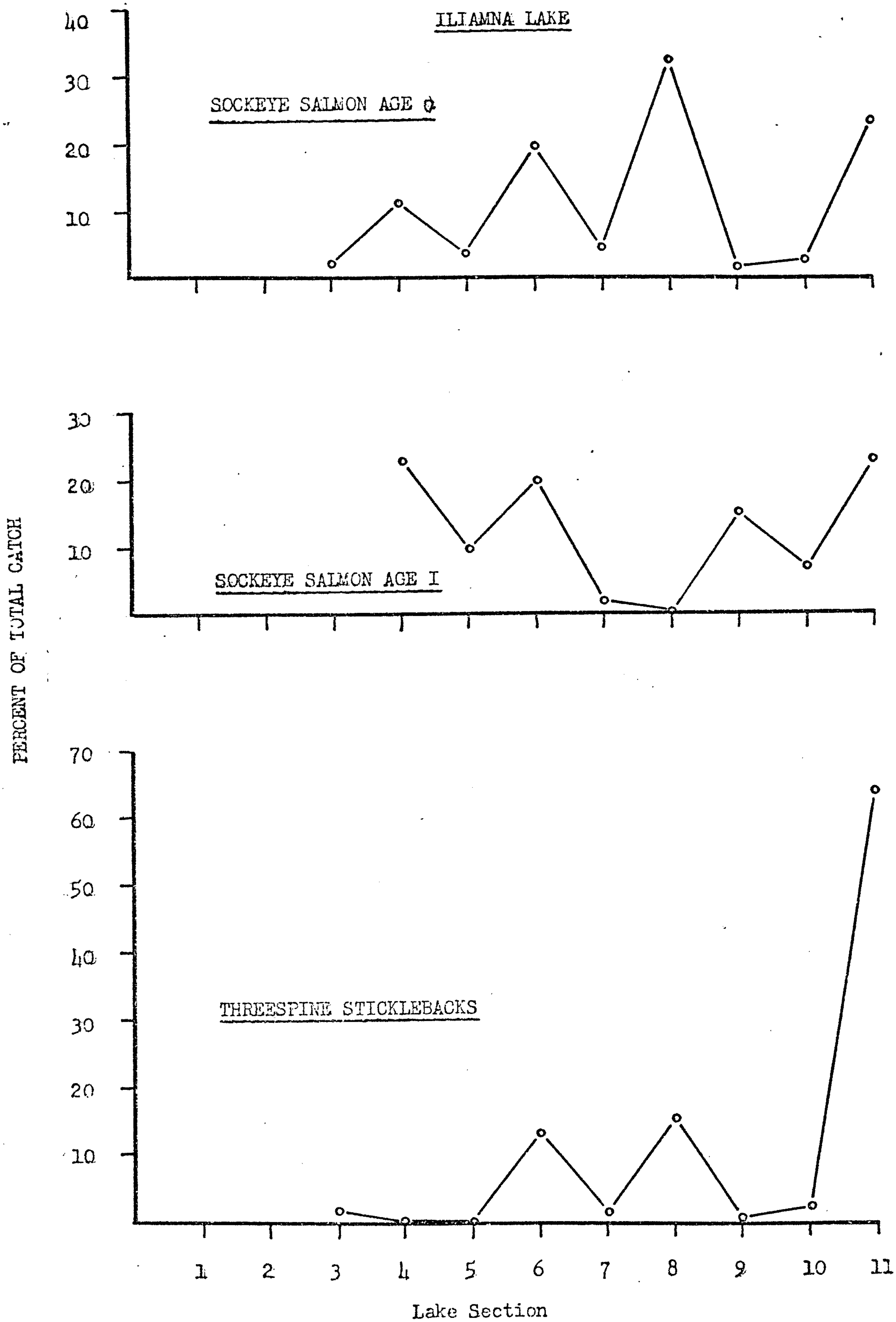


Fig. 18. Distribution of juvenile sockeye salmon and threespine sticklebacks in Iliamna Lake, 1975

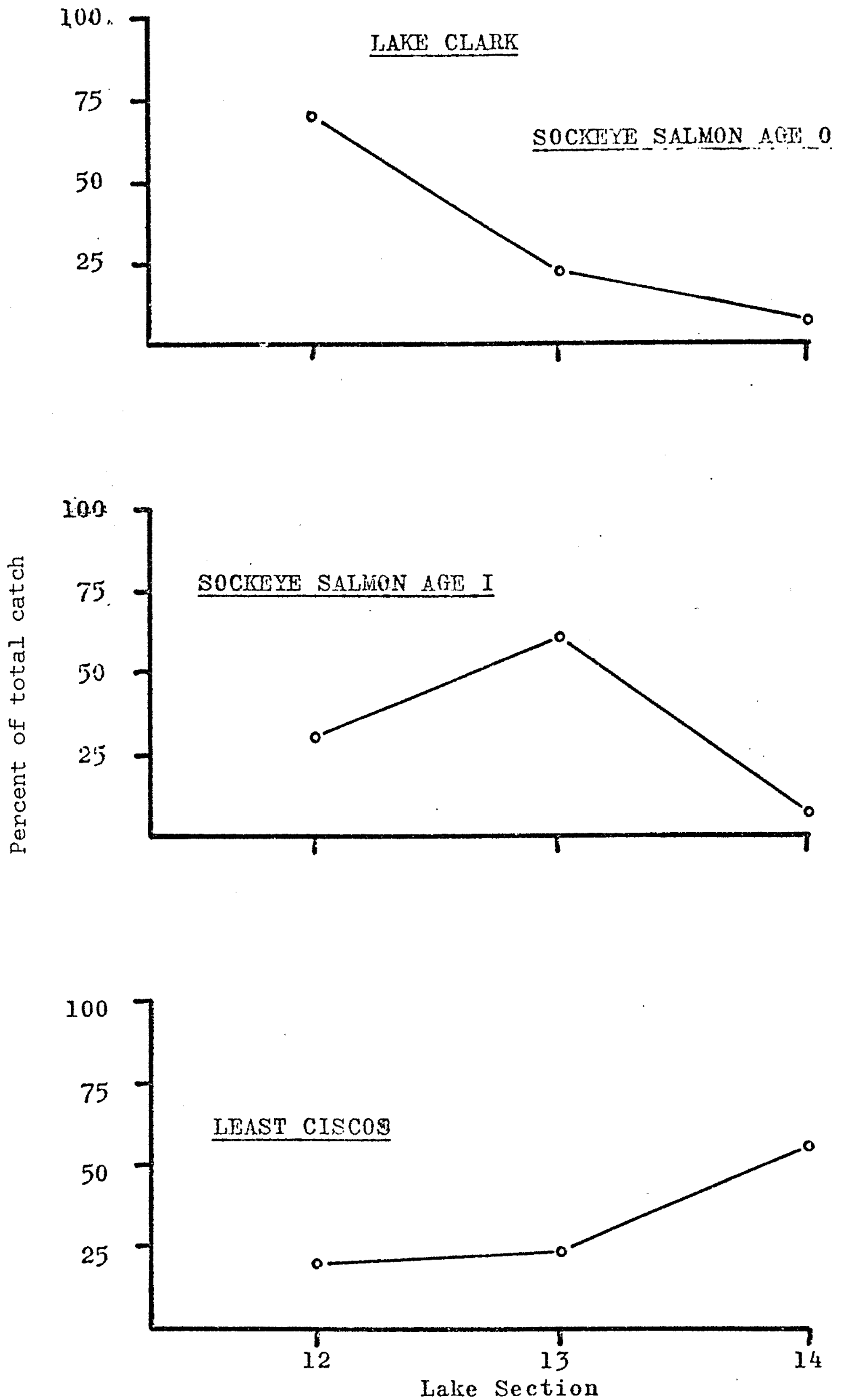


Fig. 19. Distribution of juvenile sockeye salmon and least ciscos in Lake Clark, 1975

Table 34. Daily growth rates (in mm) of juvenile sockeye salmon and Age I threespine sticklebacks in the eastern portion of Iliamna Lake, 1975

Fish species	Date	Sample size	Mean live length	Length increment	# days between sampling	Average increase per day
Sockeye salmon fry (Age 0)	7/19	355	36.23			
	9/11	168	61.54	25.31	54	0.47
Sockeye salmon yearlings (Age I)						
	8/30	10	113.30			
	9/11	10	117.23	3.93	10	0.39
Threespine sticklebacks (Age I)	8/05	154	33.19			
	8/29	139	40.35	7.16	54	0.13

Length-weight sampling information, 1975

	Date	Type of sampling	Sampling area	Mean live length	Sample size
Sockeye Age 0	7/19	beach seine	W3, P2, and P3	36.23	355
	7/30 7/31	tow net	151 149	38.75	156
	8/05	beach seine	P2	34.97	79
	8/07	beach seine	65	37.37	270
	8/20	tow net	141	48.81	512
	8/29	tow net	149	55.03	167
	8/30	tow net	146 and 147	53.00	15
	8/31	beach seine	P2	34.60	30
	9/11	tow net	144	61.54	168
Sockeye Age I	7/30 7/31	tow net	151 149	82.67	3
	8/07	tow net	141	96.00	3
	8/20	" "	141	105.00	3
	8/30	" "	146 and 147	113.30	10
	9/09	" "	134	117.33	10
	9/11	" "	144	99.67	3
Threespine Sticklebacks Age I	7/19	beach seine	W3, P2, and P3	33.32	162
	7/30 7/31	tow net	151 and 149	35.96	123
	8/05	beach seine	P2	33.19	154
	8/07	" "	65	37.45	28
	8/07	tow net	141	35.10	20
	8/29	" "	149	40.35	139
	9/11	" "	143	44.69	16

Table 35. Estimated daily growth rates (in mm) of juvenile sockeye salmon and sticklebacks in the eastern portion of Iliamna Lake, 1962 - 1975[1/]

Year of towing	Sockeye salmon Age 0	Sockeye salmon Age 1	Sticklebacks Age 1
1962	.33	.18	.09
1963	.30	.20	.18
1964	.43	.37	.24
1965	.51	.58	.12
1966	.42	.56	.22
1967	.50	.27	.17
1968	.45	.33	.02
1969	.54	.31	.04
1970	.36	.53	.09
1971	.26	.21	.06
1972	.29	.30	.29
1973	.37	.46	.17
1974	.57	.79	.30
1962-1974 mean:	.41	.39	.15
1975	.47	.39	.13

1/ Sources of data for estimated daily growth rates (in mm) of juvenile sockeye salmon and Age 1 3-spine sticklebacks for the years 1962-1975 are Kerns (1965, 1966 and 1968), Mathisen (1970), Mathisen, Poe and Roger (1971), Roger (MS, 1973), Poe (MS, 1975) and Poe, et al. (1975).

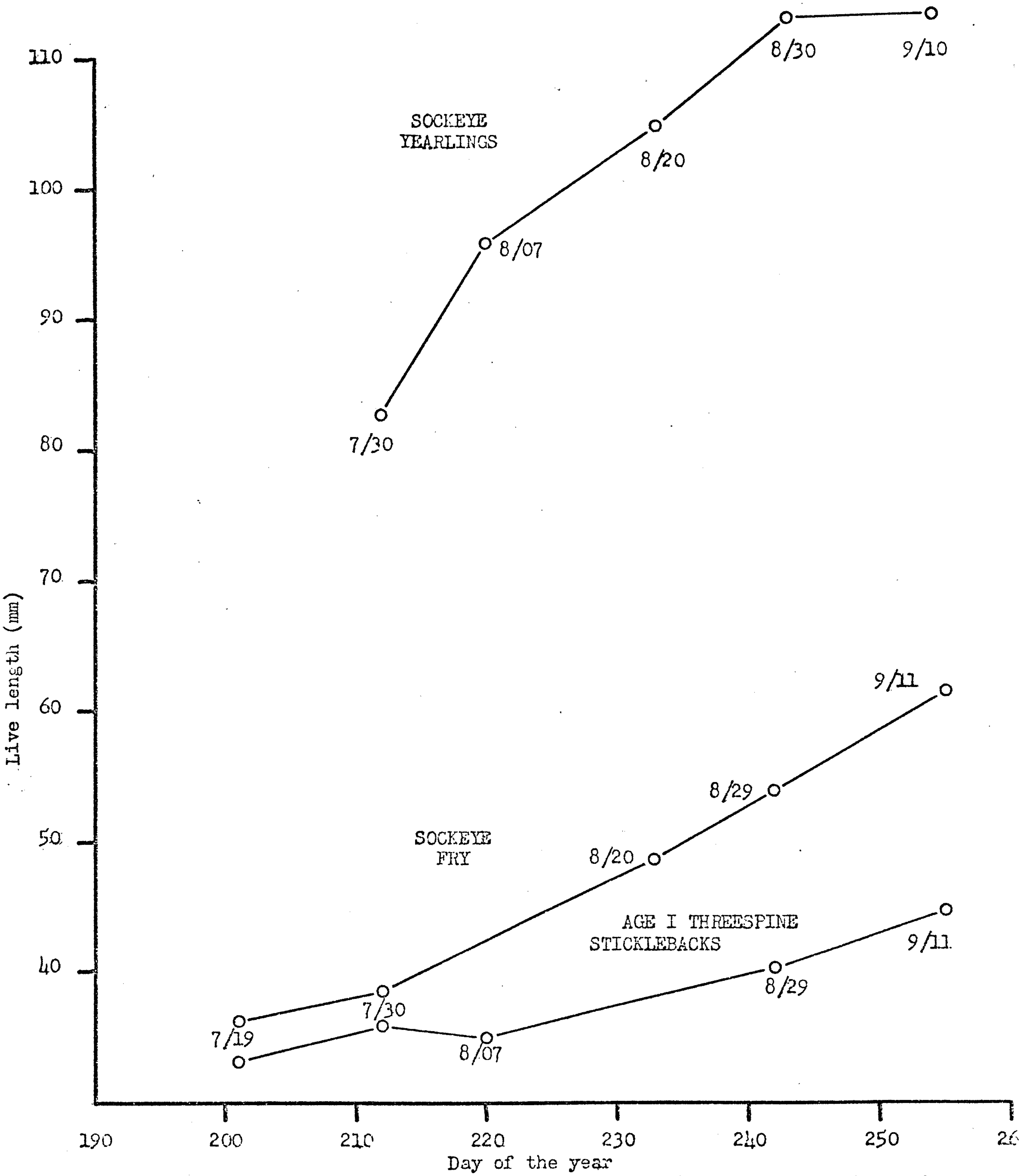


Fig. 20. Increase in length of juvenile sockeye salmon and Age I threespine sticklebacks in sections 6, 7 and 9, Iliamna Lake, 1975 (sample sizes less than 10 not included).

Table 36. Mean live lengths[1/] (in mm) and numbers measured of juvenile sockeye salmon, total threespine sticklebacks, ninespine sticklebacks, and least ciscos, Iliamna Lake and Lake Clark, 1975 (lengths adjusted to Sept. 1 for all species except least ciscos)

Lake section	Sockeye salmon Fry (Age 0)[2/] Size	#meas.	Sockeye salmon Yearlings[3/] Size	#meas.	Threespine sticklebacks[4/] Size	#meas.	Ninespine sticklebacks[4/] Size	#meas.	Least ciscos[5/] Size	#meas.
Iliamna Lake										
1	****	-	****	-	****	-	****	-	****	-
2	****	-	****	-	****	-	****	-	****	-
3	56.9	(12)	-	-	43.5	(7)	59.5	(1)	-	-
4	54.2	(127)	109.8	(5)	51.5	(8)	52.3	(20)	105.5	(4)
5	58.1	(151)	115.6	(4)	55.7	(12)	58.7	(2)	-	-
6	58.7	(949)	113.1	(14)	51.3	(399)	48.0	(118)	112.0	(1)
7	53.9	(1285)	102.6	(6)	46.5	(386)	47.9	(174)	103.9	(7)
8	53.6	(473)	-	-	43.3	(420)	46.5	(18)	105.0	(2)
9	49.0	(111)	112.3	(12)	47.3	(59)	54.8	(11)	-	-
10	66.1	(103)	116.3	(3)	46.0	(83)	46.6	(8)	-	-
11	56.7	(264)	107.2	(3)	49.2	(201)	50.5	(94)	131.8	(4)
Lake mean [6/]	55.9	(475)	111.1	(47)	48.3	(1575)	50.2	(446)	112.6	(18)
Lake Clark										
12	53.9	(1709)	99.3	(26)	-	-	35.4	(1)	150.6	(35)
13	56.7	(1071)	95.9	(66)	51.0	(5)	-	-	164.3	(54)
14	57.5	(335)	97.6	(8)	-	-	43.2	(12)	165.3	(69)
Lake mean[6/]	54.8	(3115)	97.1	(100.0)	51.0	(5)	41.9	(13)	162.1	(158)

Data Source: FRK 317R computer output (arithmetic mean run)

1/ Mean live lengths for all species except least ciscos (preserved lengths). Most of the measurements taken from catches from index tows in 1975 were taken from fish that had been preserved in formalin and preserved lengths were converted to live lengths by multiplication with the following factors (Rogers, 1964).

Sockeye fry k=1.031
Sockeye yearlings k=1.042
3-sp. sticklebacks k=1.015
9-sp. sticklebacks k=1.015

2/ Lengths adjusted to September 1 by addition or subtraction of 0.47 mm/day.

3/ Lengths adjusted to September 1 by addition or subtraction of 0.39 mm/day.

4/ Lengths adjusted to September 1 by addition or subtraction of 0.13 mm/day.

5/ Preserved lengths.

6/ Lake mean is total of section means weighted by section indexes.

Table 37. Weighted mean live lengths[1] (in mm) of juvenile sockeye salmon, threespine sticklebacks, and weighted mean preserved lengths of least ciscos, 1962 - 1975[2]

Year of towing	Iliamna Lake				Lake Clark			Kvichak system[4]	
	Sockeye salmon		Threespine sticklebacks		Sockeye Salmon		Least Ciscos	Sockeye salmon	
	Fry	Yearlings	Total	Age I [3]	Fry	Yearlings		Fry	Yearlings
1962	55.1	89.9	52.0	42.8	50.3	86.3	----	54.6	89.9
1963	58.4	97.6	54.8	44.0	49.9	86.2	165.0	56.7	97.5
1964	55.5	95.8	54.3	45.1	50.4	83.3	153.9	54.0	95.9
1965	62.7	108.6	56.5	44.3	50.2	80.0	----	61.3	106.7
1966	53.3	112.0	59.2	44.0	52.5	100.7	136.4	53.1	108.9
1967	60.8	89.9	51.3	43.7	44.7	94.1	159.9	60.2	89.9
1968	64.1	109.6	50.6	47.3	59.3	99.0	157.2	63.3	108.8
1969	58.1	98.2	54.6	47.9	50.4	95.5	166.1	56.4	95.9
1970	63.2	100.8	52.9	44.9	55.4	108.6	171.5	63.1	101.9
1971	45.5	92.8	54.8	37.3	38.0	88.3	156.8	45.1	92.7
1972	52.4	74.0	51.5	44.4	40.6	83.7	146.7	45.5	74.2
1973	57.5	100.6	60.1	45.4	47.8	93.9	167.4	51.2	99.9
1974	68.1	112.2	43.7	50.6	57.3	109.6	163.5	61.6	110.9
1975	55.9	111.1	56.2		54.8	97.1	162.1	55.5	109.0
1962 - 1974 mean:	58.1	98.6	53.6	44.7	49.8	93.0	158.6	55.9	97.9

[1] Lengths adjusted to September 1 for all species except least ciscos (data were not available on the effect of formalin on least ciscos nor on the growth rates of least ciscos with age).

[2] Source of data for all weighted mean lengths except those of Age I threespine sticklebacks for the years 1962-1970 and 1972 are from the arithmetic mean compute[r] output from program No. FRK 317R (Roger, 1972).

[3] Sources of data for weighted mean lengths of Age I threespine sticklebacks for the years 1962-1970 and 1972 are Kerns (1965, 1966 and 1968), Mathisen (1970), Mathisen, Poe, and Roger (1971), Roger (MS, 1973), Poe (MS, 1975) and Poe, et al., 1975.

[4] Weighting procedure:

$$\left[\frac{(\text{Iliamna Lk. index})\ (0.9075)}{\text{Kvichak system index}}\right] \text{mean live length Iliamna Lake} + \left[\frac{(\text{Lk. Clark index})\ (0.0925)}{\text{Kvichak system index}}\right] \text{mean live length Lk. Cl[ark]}$$

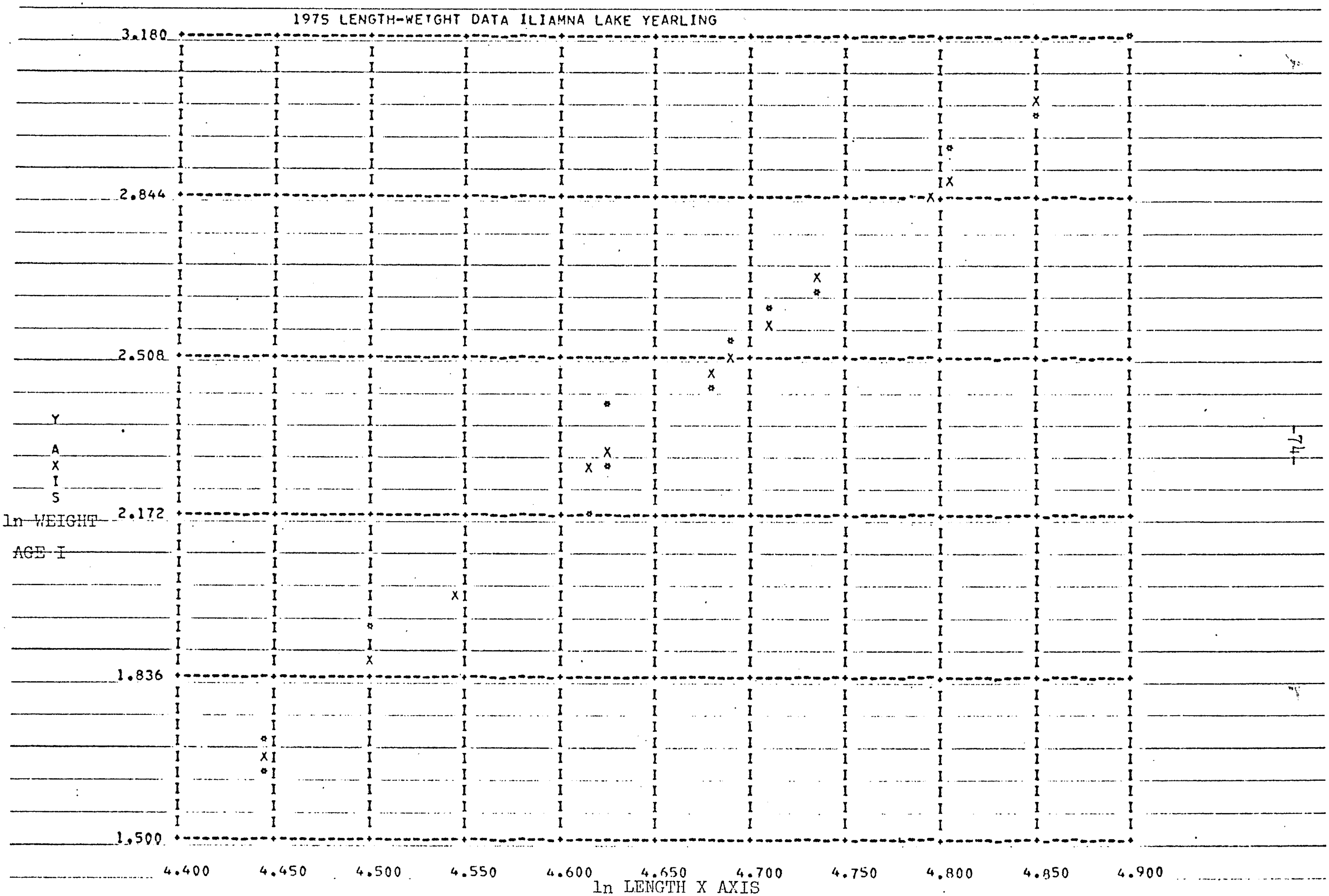


Fig. 22. Length-weight relationship, Iliamna Lake sockeye Age I, 1975.

$W = 1.0679 \times 10^{-6} \times L^{3.3360}$

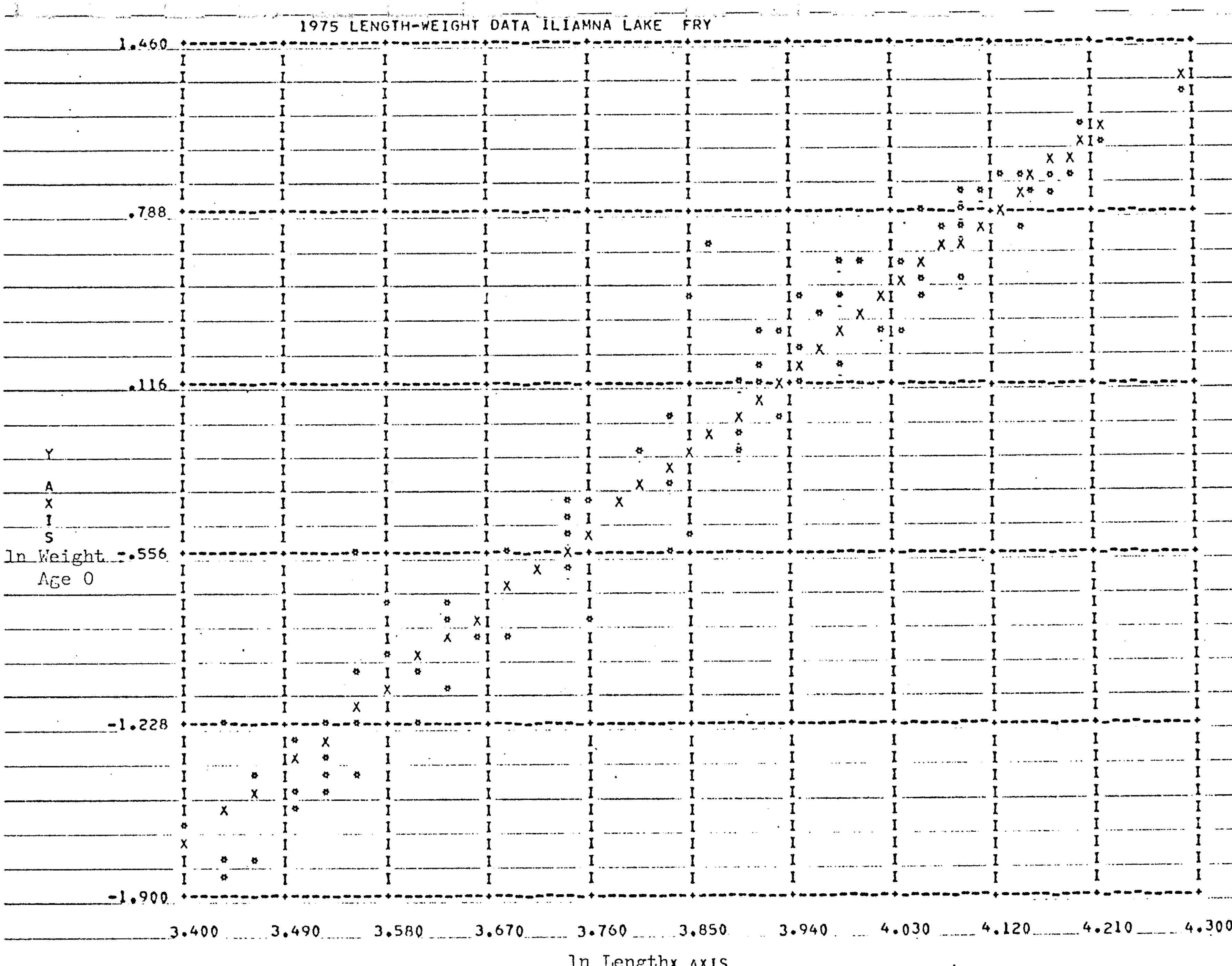


Fig. 23. Length-weight relationship, Iliamna Lake sockeye Age 0, 1975.

$$W = 1.5140 \times 10^{-6} \times L^{3.4401}$$

Fry

$$W = 1.5140 \times 10^{-6} \times L^{3.4401}$$

Yearlings

$$W = 1.9679 \times 10^{-6} \times L^{3.3360}$$

Beach seining

Limited sampling by beach seine was conducted in the eastern portion of Iliamna Lake to monitor the early size and growth of sockeye salmon fry and sticklebacks and to monitor the timing of the movement of these fishes from the littoral area into the pelagic zone. The 1975 sampling stations are shown in Fig. 23. The catch data indicate that the movement of salmon fry and sticklebacks into the pelagic zone may have not been complete before towing operations began (Table 38).

Relative production

Results from the combined tow-netting and hydroacoustic program conducted in lakes Iliamna and Clark in 1975 show a high relative production of salmon fry for the second consecutive year (Table 39). The fry index of 182.6 for Lake Clark (Table 33) as mentioned before may have resulted from the absence of early fishing and a very low rate of exploitation of Kvichak stocks in 1974. The same situation may occur in 1976 since the 1975 peak year escapement was not subjected to any early commercial fishing.

HYDROACOUSTIC SURVEYS

Regional surveys of juvenile sockeye salmon

Systematic hydroacoustic surveys in nursery lakes Iliamna and Clark have been made since 1971. Results of the 1975 Iliamna Lake surveys show a distribution similar to that found in 1971. Most of the salmon fry were concentrated in the bays in the eastern end of Iliamna Lake and in Kakhonak Bay.

A diel study was conducted in Lake Clark and showed salmon fry and least ciscos concentrated near the surface during daylight hours. The study was conducted near shore and the results may not be very representative of conditions in the open water areas of the lake.

Survey of pygmy whitefish in Iliamna Lake

The pygmy whitefish population distributed throughout the western and central portions of Iliamna Lake was surveyed for the third consecutive year. Additional information on this population was procured from mid-water trawl hauls.

INDICES OF FRESHWATER PRODUCTION

Indices of the relative production of juvenile sockeye salmon in the Kvichak system obtained from the tow-netting programs in the nursery lakes and from the smolt indexing programs conducted in the Kvichak River show the same trends. There is now a sufficient number of years of observation to

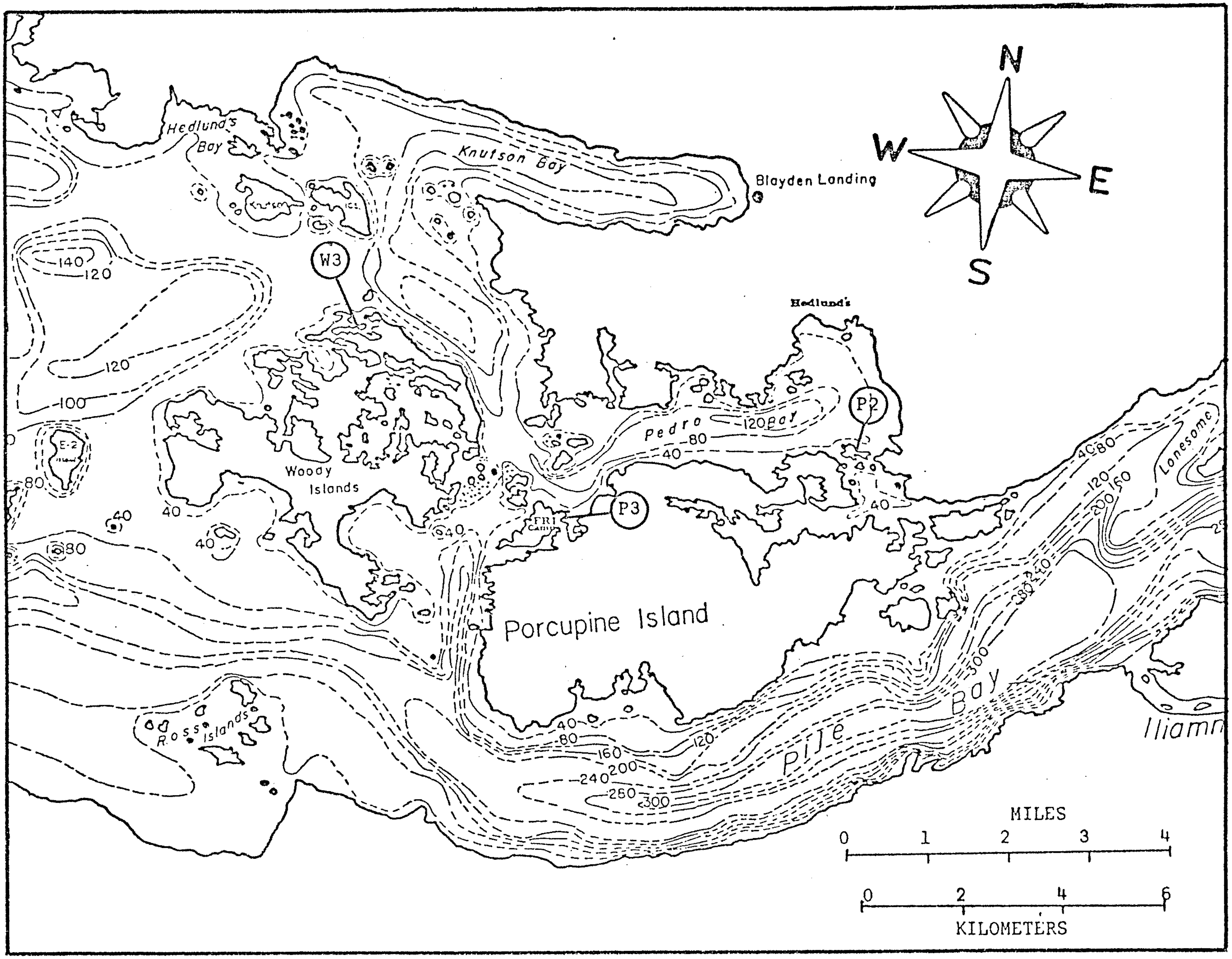


Fig. 23. Beach seine sites during the 1975 field season.

Table 38. Catches of resident fishes from beach seine sampling in the eastern end of Iliamna Lake, 1975

Date	Area	Sample #	Sockeye salmon Age 0	Sockeye salmon Age 1	Sticklebacks 3-spine	Sticklebacks 9-spine	Sculpins	Arctic char fry
7/19	74 (W3)	701	86	--	130	8	19	5
7/19	83 (P2)	702	380	--	16	-	--	2
7/19	84 (P3)	703	292	--	159	8	1	2
8/05	83 (P2)	704	79	--	206	51	--	-
8/06	84 (P3)	705	--	--	10	1	--	1
8/31	83 (P2)	712	30	--	341	17	--	5
8/31	84 (P3)	713	4	--	83	-	1	2

Table 39. Abundances, sizes, and relative production of juvenile salmon in freshwater and adult escapements, total inshore returns, returns per indexed smolt ratio, and returns per spawner ratio for sockeye salmon of the Kvichak River system, brood years 1952 through 1974

Brood year	Index of abundance: By tow net[1] Age 0	Index of abundance: By tow net[1] Age I	Index of abundance: By fyke net[2] Age I	Index of abundance: By fyke net[2] Age II	Index of abundance: By fyke net[2] Total	Average length (mm): By tow net[3] Age 0	Average length (mm): By tow net[3] Age I	Average length (mm): By fyke net Age I	Average length (mm): By fyke net Age II	Escapement x 10^6	Relative production: By tow net Mean catch Age 0 per million spawners	Relative production: By fyke net Total smolt index per million spawners	Adult return: Total inshore return x 10^6	Adult return: Ret./smolt (indexed)	Adult return: Ret./spawner
1952				7.3					109.0	5.97			15.6		2.6
1953			0.6	1.4	2.0			89.0	116.0	.32		6.25	0.5	7.9	1.6
1954			0.9	0.3	1.2			92.0	120.0	.24		5.00	0.7	19.3	3.1
1955			0.7	2.0	2.7			96.0	114.0	.25		10.80	1.3	14.4	5.1
1956			98.0	83.3	181.3			84.0	99.0	9.44		19.21	33.1	5.5	3.5
1957			2.6	16.6	19.2			80.0	108.0	2.96		6.49	3.6	5.7	1.3
1958			1.8	0.3	2.1			91.0	117.0	.53		3.96	0.3	3.5	0.5
1959			0.8	2.2	3.0			92.0	110.0	.68		4.41	0.5	5.1	0.7
1960	137.0	79.7	33.9	123.5	157.4		89.9	82.0	98.0	14.63		10.76	48.9	9.3	3.3
1961	21.7	10.3	3.4	48.1	51.5	55.1	97.6	83.0	108.0	3.71	5.84	13.88	3.1	1.8	0.8
1962	32.4	19.2	13.7	52.4	66.1	58.4	95.8	87.0	109.0	2.58	12.56	25.62	4.8	2.2	1.9
1963	1.4	2.6	1.9	0.7	2.6	55.5	108.6	90.0	114.0	.34	4.11	7.65	0.9	9.7	2.5
1964	3.7	0.9	7.6	6.7	14.3	62.7	112.0	94.0	118.0	.96	3.85	14.90	4.9	10.3	5.1
1965	137.7	68.7	86.0	164.2	250.2	53.3	89.9	86.0	104.0	24.33	5.66	10.28	40.1	4.8	1.7
1966	62.0	20.4	19.4	16.2	35.6	60.8	109.6	88.0	109.0	3.78	16.40	9.42	5.6	4.7	1.5
1967	43.0	3.3	17.8	9.0	26.8	64.1	98.2	92.0	110.0	3.22	13.35	8.32	1.3	1.5	0.4
1968	9.4	5.5[5]	5.6	3.7	9.3	58.1	100.8	91.0	111.0	2.56	3.67	3.63	0.4	1.2	0.2
1969	90.7[5]	19.3[5]	54.1	42.2	96.3	63.2	92.8	90.0	106.0	8.39	10.81	11.48	5.1[4]	1.7[4]	0.6[4]
1970	52.6[5]	19.4[5]	0.3	37.2	37.5	45.9	74.0	80.0	97.1	13.94	3.77	2.69	17.1[4]	13.7[4]	1.2[4]
1971	3.7[5]	1.9[5]	1.3	14.8	16.1	52.4	100.6	85.6	111.9	2.39	1.54	6.74			
1972	5.0[5]	0.5[5]	2.5			57.5	112.3	95.5		1.01	4.95				
1973	3.8[5]	0.9[5]				68.1	111.1			.23	16.52				
1974	61.4[5]					55.9				4.33	14.18				

1 FRI weighted mean catches of juvenile sockeye salmon Age 0 and Age I per standard tow.

2 ADF&G Igiugig 24-hr indices of smolt abundance (one index point = 33,340 smolts).

3 Lengths adjusted to September 1.

4 Returns of six year - old fish estimated from forecast data.

5 Indices estimated from incomplete towing.

make reasonable comparisons between these two indices of freshwater production of juvenile salmon.

The fry index obtained from tow-netting operations is compared with the total smolt index of each brood year in Fig. 24. The regression equation is:

$y = -2.65859 + 1.33076X$ From this equation the expected smolt migration from the 1974 escapement of 4.33 million estimated from the 1975 tow net index has a point estimate of 79.05 index points with a .95 CI giving a range extending from 56.48 to 101.62 (Fig. 24).

The index values used in the above regression are summarized in Table 39.

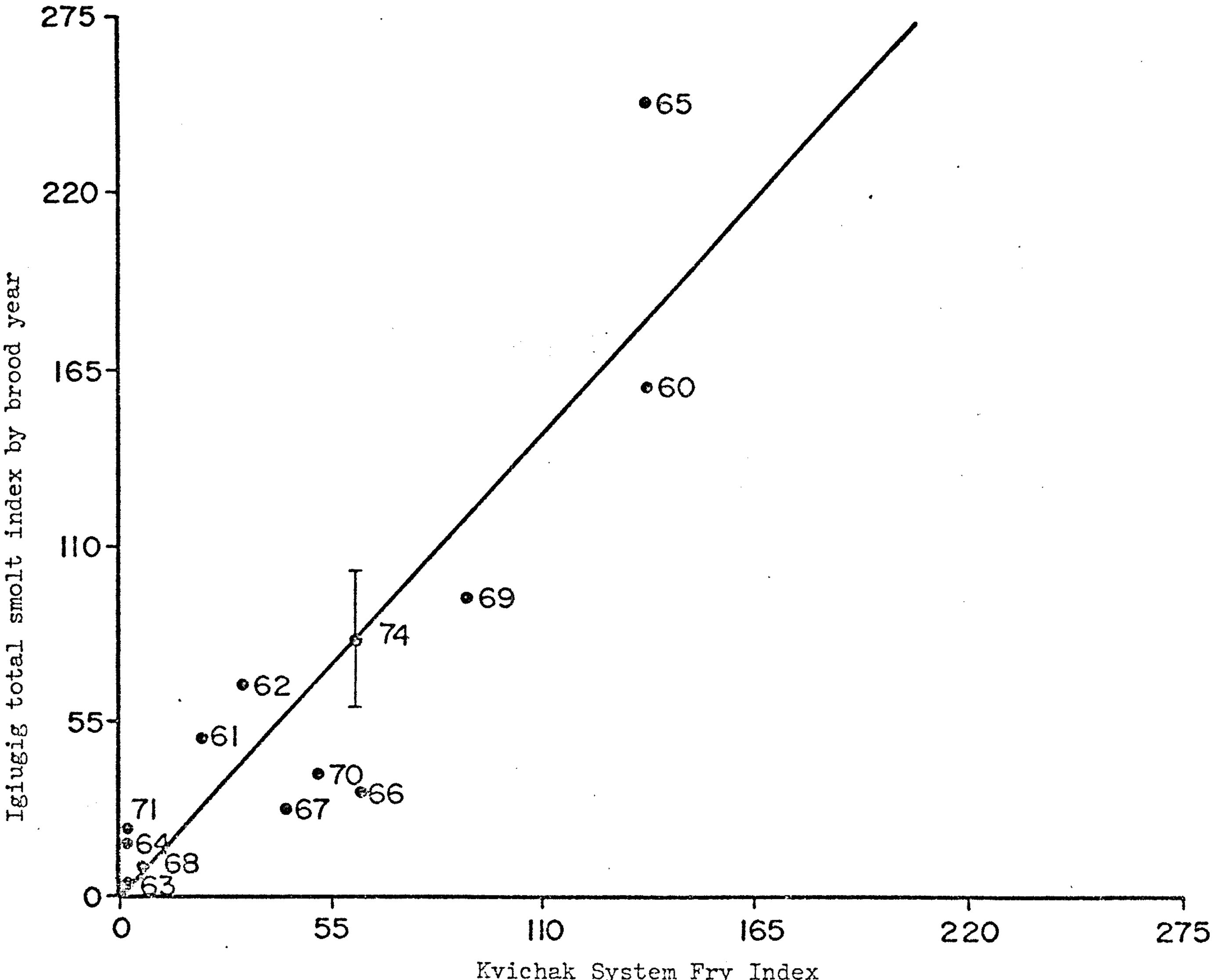


Fig. 24. Regression line of the Igiugig total smolt index by brood year on preceding Kvichak system fry index, brood years 1960-1971 (dates on graph represent brood years). The equation for the regression line is $y = -2.65859 + 1.33076X$

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