FRI-UW-7512
August 1975

Fisheries Research Institute
College of Fisheries
University of Washington
Seattle, Washington 98195

CHIGNIK SOCKEYE STUDIES

Annual Report - Anadromous Fish Project

Project No. AFC-48-1
Grant No. 04-4-208-31
Project Period: July 1, 1974-June 30, 1977

Prepared by: Scott L. Marshall
and
Robert L. Burgner

Date: August 29, 1975

Cooperator:
Dr. George W. Farwell
University of Washington
Seattle, Washington 98195

This project was financed in part with Anadromous Fish Act (P.L. 89-304) funds through the National Marine Fisheries Service.

Approved

Submitted August 30, 1975

Robert L Burgner
Director

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHIGNIK SOCKEYE STUDIES

(Annual Report for Period July 1, 1974 through June 30, 1975)

INTRODUCTION

Objectives

This report summarizes research conducted by the Fisheries Research Institute (FRI) on Chignik sockeye salmon [*Oncorhynchus nerka* (Walbaum)] during the eighth year of Anadromous Fish Act support (P.L. 89-304). Additional funds were provided by Columbia Wards Fisheries Co. and Alaska Packers Association. The University of Washington provided funds for maintenance of the field facilities.

The primary objective of our research during fiscal year 1975 was to study the circulus formation on the scales of juvenile sockeye salmon to determine if patterns developed which could be confused with annular marks. A second objective was to determine the feasibility of sampling the adult escapement of sockeye salmon to Black Lake as the fish migrated up Black River. A third objective was to further test the use of tow nets as a sampling technique to obtain abundance estimates for juvenile sockeye salmon in Black Lake. Results are discussed under the headings ADULT SALMON STUDIES and JUVENILE SALMON STUDIES. During the course of the work further information was collected on threespine stickleback (*Gasterosteus aculeatus* Linnaeus) described in the section PHENOTYPIC VARIATION IN THREESPINE STICKLEBACK.

Acknowledgments

As in previous years our research was coordinated with biologists of the Alaska Department of Fish and Game (ADF&G). In particular we would like to acknowledge the assistance with data collection provided by Mr. Arnold Shaul, the Chignik Area Management Biologist, and Mr. Philip Rigby, the Assistant Area Management Biologist.

ADULT SALMON STUDIES

Introduction

One objective of our studies during FY 1975 was to determine the feasibility of enumerating and sampling the Black Lake stock of sockeye salmon as the returning adults migrated up Black River. This was a preliminary step in evaluating the current method of separating the annual run into its two main stocks, Black Lake (early) and Chignik Lake (late) using an average time-of-entry curve and scale samples collected from the fishery.

Our three objectives were (1) to test the feasibility of enumerating adult sockeye salmon into Black Lake with the aid of a sonar counter (2) to locate a suitable beach seining site for obtaining age and length information, and (3) to collect age and length information in order to compare alternative methods of stock separation. The first objective was not accomplished because of illness of the individual who was to provide the sonar counter and the technical assistance to get the unit operating. We were, however, able to conduct sampling as planned to provide additional information on the size and age structure of the run.

Feasibility of Enumerating the Black Lake Escapement

Although a sonar counter unit was not tested in Black River, we did collect information on the behavior of the sockeye salmon as they migrated up Black River. This has proved to be useful in helping us to determine potential sites for erecting a weir in FY 1976.

The 1974 run of adult sockeye bound for Black Lake migrated through Black River without schooling up or holding for extended periods of time until they reached an area of the river just below the outlet of Black Lake (Fig. 1, Section A). From this point the fish moved up into Black Lake, formed large schools, and milled for about two weeks until they moved on to the spawning grounds. Early and late run fish bound for Chiaktuak Creek were observed schooling from the mouth of Chiaktuak Creek downstream about 200 meters along the east bank of Black River. There was some concern that fish bound for West Fork and Bearskin Creek may move into the upper reaches of Black River, ripen up, and then drop back to ascend these tributaries. We found no evidence of this occurring. We believe therefore that the installation of a weir in Black River in either the section of the river just above Chiaktuak Creek (Fig. 1, Section B) or from a point about 200 meters downsteam from Chiaktuak Creek to the mouth of West Fork (Fig. 1, Section C) would not significantly interfere with the natural migration patterns of sockeye salmon returning to Black Lake or Black River tributaries.

Feasibility of Sampling the Black Lake Escapement

In order for comparisons to be made between alternative methods of stock separation, it is necessary to have age composition data for the Black Lake escapement. One of our objectives therefore was to determine if the collection of this information was possible. This necessitated that we locate a beach seining site which would produce the required

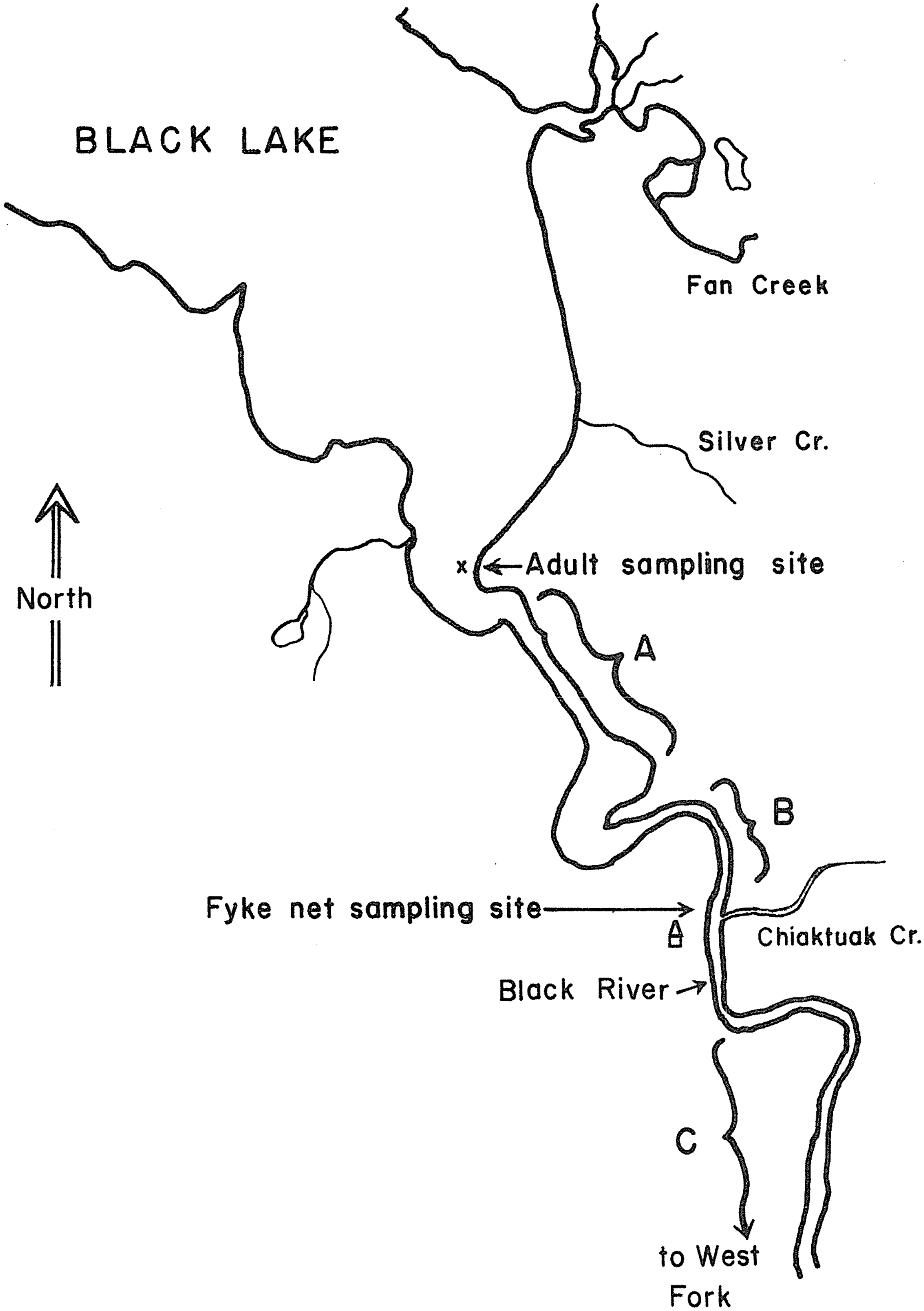

Fig. 1. Map of the upper reaches of Black River.

number of fish in a reasonable amount of time and that the scale samples collected would not show excessive reabsorption of margins which would render them unusable.

Seining in Black River proved guite difficult and produced few fish. This was due to the swift current and lack of any temporary holding area where the fish schooled up and could be easily captured. The beach on the east side of the outlet did prove to be a satisfactory site for seining fish (Fig. 1). Because this site borders on areas where large schools of sockeye were observed milling in Black Lake for an extended period of time there is some concern that samples taken here may not be representative of a given day's escapement age composition.

In order to eliminate these problems in FY 1976 when we plan to construct a weir on Black River we have adopted an alternative method of seining which is similar to one used at the Bear River weir site (Shaul, personal communication). In this method, one end of a beach seine is anchored on the downstream river bank just behind the weir with the cork line stretched across the river above the water line and supported along its span to the structure of the weir. The lead line is allowed to trail in the current. On the opposite bank the net is tied to a skiff. When a signal is given, the net is released from its points of attachment to the weir and the skiff pulls the unanchored end downstream across the current to the opposite bank. This method should prove adequate in capturing the fish which have schooled up behind the weir overnight and provide a good estimate of the age composition for each day.

Age Composition of the Black Lake Escapement

The difficulties in interpreting the scales of Chignik sockeye have been discussed in Burgner and Marshall (1974) and in Marshall, et al. (1974). Because the data collected at the outlet of Black Lake in 1974 were to be combined and compared with samples collected by ADF&G in the commercial fishery, a small study was undertaken to determine if reader interpretation was a significant error factor. For this study one card of 40 scales was chosen at random from the samples collected at Black Lake. Three readers who had experience with scales from Chignik sockeye each independently read the scales. Out of 40 scales, 9 were unreadable due to: regeneration (7), reverse side up (1), and an unclear impression (1). Of the remaining 31 scales, readers one and two disagreed on the freshwater ages of 10 fish for a 32 percent discrepancy rate, readers one and three disagreed on the freshwater age of 11 fish for a 35.5 percent discrepancy rate, and readers two and three disagreed on the freshwater age of 6 fish and the marine age of 1 fish for a 23.3 percent discrepancy rate.

In comparisons between all three readers, there was disagreement on the freshwater age of 12 fish and on the marine age of 1 fish. Complete agreement was reached on the ages of the remaining 18 fish. From these results, it was obvious that freshwater age interpretation was a significant problem. However, there was an immediate management need for age interpretation of the Black Lake sockeye. In order to have consistency in interpretation it was decided that a single person should read all the scales. Mr. Arnold Shaul, ADF&G, having already read the scales collected in the fishery, volunteered to read the scales collected at Black Lake.

The age compositions of the Black Lake run as determined by (1) scale samples collected in the commercial fishery and the average time-of-entry curve,[1] (2) scale samples collected at the outlet of Black Lake, and (3) otolith samples collected on the spawning grounds are summarized in Table 1. The absolute value of the difference between the highest and lowest estimate of the percent of age classes 2.2 (7.1%), 1.3 (19.1%), and 2.3 (10.9%) are sufficiently large to warrant concern. Some possible reasons for such discrepancies have been discussed in detail in Burgner and Marshall (1974). This re-emphasizes the need to initiate an extensive program to evaluate the relative magnitudes of the various sources of error which have produced these discrepancies.

Lengths of Adult Sockeye

One use of length data collected for the Black Lake stock of sockeye is in forecasting. Burgner and Marshall (1974) have shown that the size of 2-ocean age fish in year i may alter the ratio of return of 3-ocean fish in year i + 1.

Length-frequency histograms for adult sockeye by sex and age class are presented in Figs. 2 and 3 for the 1974 Black Lake run. The mean lengths, confidence intervals, and sample sizes are summarized in Table 2. The small number of 2-ocean age fish in the sample precludes the use of these data alone in forecasting. We therefore combined these data with data collected by ADF&G personnel in the commercial fishery to provide each agency with a more complete set of records for use in forecasting future runs.

[1]The inflection point on the average time-of-entry curve was advanced one week to compensate for the suspected early arrival of the Black Lake run (Shaul, personal communication).

Table 1. Age composition of the Black Lake stock in percent as determined by three different methods (Data from Shaul and Rigby, 1975)

Location	Method	Structure used	Age class 1.2	2.2	3.2	1.3	2.3	1.4
Chignik Lagoon and Chignik River	Catch sampling and beach seine	Scales and otoliths	3.5	11.9	0.5	52.6	30.9	0.6
Black Lake	Beach seine	Scales	4.5	6.4	0.0	65.6	23.2	0.3
Spawning grounds	Collecting dead fish and spearing live fish	Otoliths	3.0	4.8	0.1	71.7	20.0	0.4

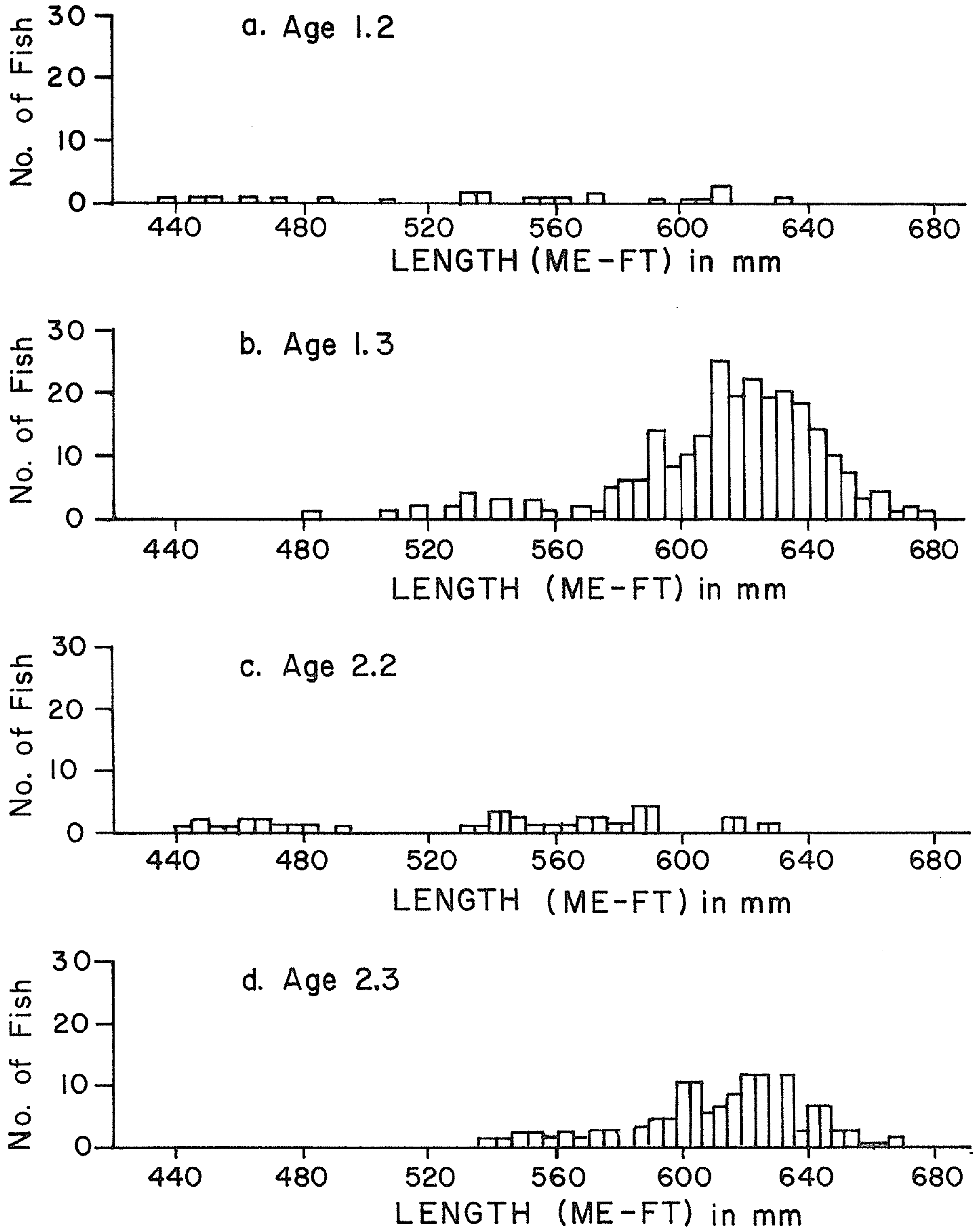

Fig. 2. Length frequency histograms, by age class, for male sockeye salmon in the Black Lake escapement, 1974.

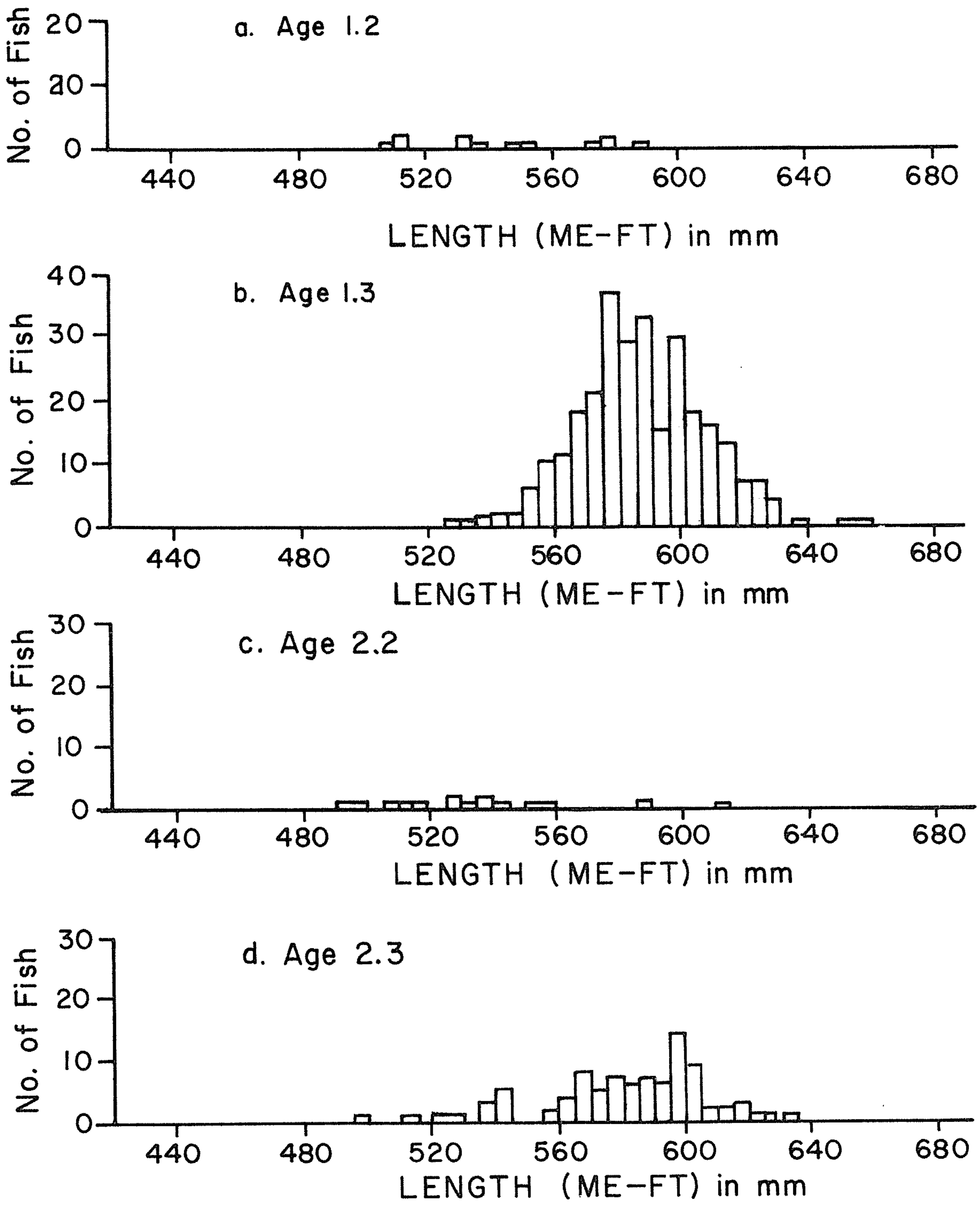

Fig. 3. Length frequency histograms, by age class, for female sockeye salmon in the Black Lake escapement, 1974.

Table 2. Mean lengths (ME-FT) by sex and age class for adult sockeye salmon sampled by beach seine at the outlet of Black Lake, 1974

Sex	Age	Sample size	Mean length (mm)	Confidence interval (95%)
Male	1.2	25	538.0	±24.1
	2.2	35	527.9	19.4
	1.3	248	612.1	3.9
	2.3	99	608.7	5.3
Female	1.2	11	543.3	18.8
	2.2	15	533.7	17.8
	1.3	286	584.4	2.3
	2.3	89	578.2	5.3

JUVENILE SALMON STUDIES

Abundance Estimates for Black Lake Sockeye

Introduction

An important part of our investigations of the lacustrine ecology of the Chignik Lakes is estimation of the abundance of juvenile sockeye in Black Lake. Pelagial abundances were first estimated by Narver (1966) using a 2 m^2 nylon tow net.

During 1973 two indexing sessions were conducted - one on September 3 and one on September 4. The results of that study are summarized in Marshall et al. (1974). The large differences in the abundance estimates for age 0 sockeye (99 vs 252) and for age 0 pond smelt [*Hypomesus olidus* (Pallas)] (137 vs 571) led us to question (1) the use of tow nets as a sampling method and (2) the mathematical model used to analyze the data. This section summarizes a re-evaluation we conducted on the use of tow nets as a technique for obtaining abundance estimates for juvenile sockeye in Black Lake.

Limitations of the Gear

Sampling is conducted in areas with sufficient depth to fish the tow net, which reduces considerably the lake area which can be sampled. In Black Lake this factor may be quite important when comparing seasonal changes in the abundance of those species which have strong inshore orientations during specific periods in their life histories. For example, juvenile sockeye are oriented toward the natal stream early in the summer and move offshore as they grow (Narver, 1966). Associated species such as the threespine stickleback, pond smelt, and ninespine stickleback [*Pungitius pungitius* (Linnaeus)] also exhibit nearshore orientation during early and mid-summer as they spawn in the littoral areas of the lake. Tow-net sampling must therefore underestimate the abundance of these species when such bias is present.

The consistency in the efficiency of the net from set to set cannot be directly measured. Standardization of boats, motors, and approximate motor rpm is attempted in an effort to minimize variation in boat speed which could affect catch. Changes in distance between boats during towing may change efficiency of a tow. Fish may be herded toward the net by the boats and by the concentrated stream of gas bubbles from the exhaust emissions of the motors. If the distance between the boats varies due to difficulty of operator depth perception in darkness, differential herding may affect the catch.

The Statistical Design

Our experience in 1973 also led us to question the statistical model used to derive the index of abundance. The model currently being used was developed by Narver (1966). The method consisted of conducting a series of replicate tows in each statistical area of the lake (Fig. 4), calculating the geometric mean catch by area, weighting these values by the proportional volume in each area[2] and then adding the area values.

Since 1968 the sampling effort had been allocated so that 2 tows are conducted in each area during the June and July sessions, and 3 tows during the August session. When the effort is distributed uniformly over the areas in this manner, and when the areas are of such different sizes, the effect is to use the value obtained in area A, which is based on a small sample size, to estimate the entire index. This is necessarily true due to the high weight given to the value obtained in area A.

---

[2]Weighting factors are: area A = 0.77951, area B = 0.07508, area C = 0.05365, area D = 0.09176.

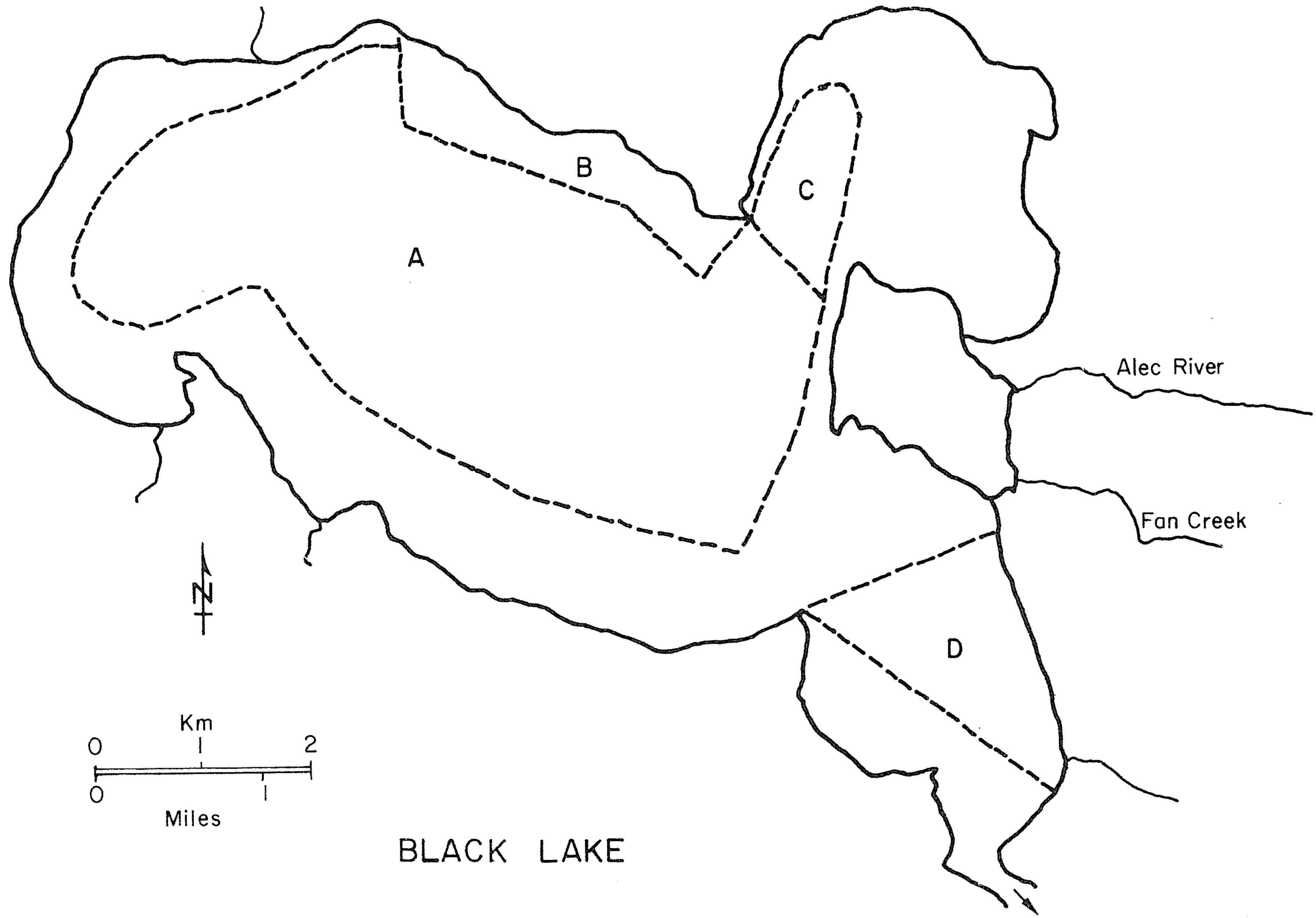

Fig. 4. Map of Black Lake, showing sampling areas discussed in text.

These concepts are illustrated by the data collected on September 3 and 4, 1973 and September 1 and 2, 1974 (Table 3). The data for 1973 show that while the mean catch per tow for areas B, C, and D was quite similar for the two nights, the mean catch per tow in area A was quite different (96.3 vs 294.0) and therefore the indexes are also quite different (99.5 vs 251.6). It seems quite unlikely that either mass movements or changing availability to the net caused these differences due to the short time period between the sampling periods and the similar weather conditions which existed on the two nights. The observed differences seem therefore to be attributable to a poor estimate of the abundance of sockeye in area A due to a high degree of variability and insufficient sampling effort. In 1974 the increased effort in area A seems to have provided a better estimate of the abundance of sockeye in this area as is suggested by the similarity of the indexes derived on the successive nights (35.2 vs 37.5).

In light of these findings, one is led to question the indexes obtained in years previous to 1974 when the sampling effort was not allocated on a basis proportional to the size of the area. An alternative method for obtaining abundance estimates in these years would be to assume that the fish are distributed randomly in the lake and to calculate the average catch per unit of effort for the entire lake. The degree to which departures from this assumption would affect the results would be dependent upon (1) the degree of departure from a random distribution in the lake and (2) amount of effort expended in those areas of either relatively high or low abundance. This approach was taken by Marshall et al. (1974) who calculated the arithmetic mean catch per minute for juvenile sockeye by period for the years 1961-1972. There is some concern however that departures from the assumption of a random distribution have influenced those results.

In 1974 an extensive series of tows was conducted to determine if such factors may have influenced the results. Our approach was to calculate the catch per unit of effort as a function of effort in successively pooled hauls. It was felt that if the resulting plot leveled off as effort increased then the influence of departures from the assumptions could probably be considered insignificant. If, however, the plot did not level off, then departures from the assumptions could be considered significant. If the plot levels off, then the amount of effort required for this to occur would be of interest since in most years 8 to 12 five-minute tows were conducted during each indexing session. The plot must therefore level off at or before this amount of effort in order for the technique to be generally applicable to previous years. These data were plotted in this manner and are presented in Fig. 5. The form of the plot shows that the average catch per minute does not level off; conversely it continues to be influenced by extremely large catches in areas B and D and small catches in area C (Table 4). This method seems, therefore, to provide little relief in the analysis of the historical data.

In view of these findings, only one alternative to the analysis of the historical data seems readily apparent. This would be to test for differences in the mean catch per tow by area for each sampling session

Table 3. The geometric mean catch, catch weighted by area, and the index of abundance for age 0 sockeye salmon in Black Lake, September, 1973 and 1974

Date	Area	Sample size	Geometric mean catch	Geometric mean catch weighted
9/3/73	A	2	96.3	75.1
	B	2	140.1	10.5
	C	2	20.2	1.1
	D	1	132.0	12.8
	Index			99.5
9/4/73	A	2	294.0	229.1
	B	2	130.8	9.8
	C	2	7.5	0.4
	D	2	134.5	12.3
	Index			251.6
9/1/74	A	11	33.2	25.9
	B	2	41.6	3.1
	C	3	13.1	0.7
	D	2	54.9	5.0
	Index			35.2
9/2/74	A	5	27.4	21.1
	B	3	65.7	4.9
	C	2	4.4	0.2
	D	2	82.7	7.6
	Index			37.5

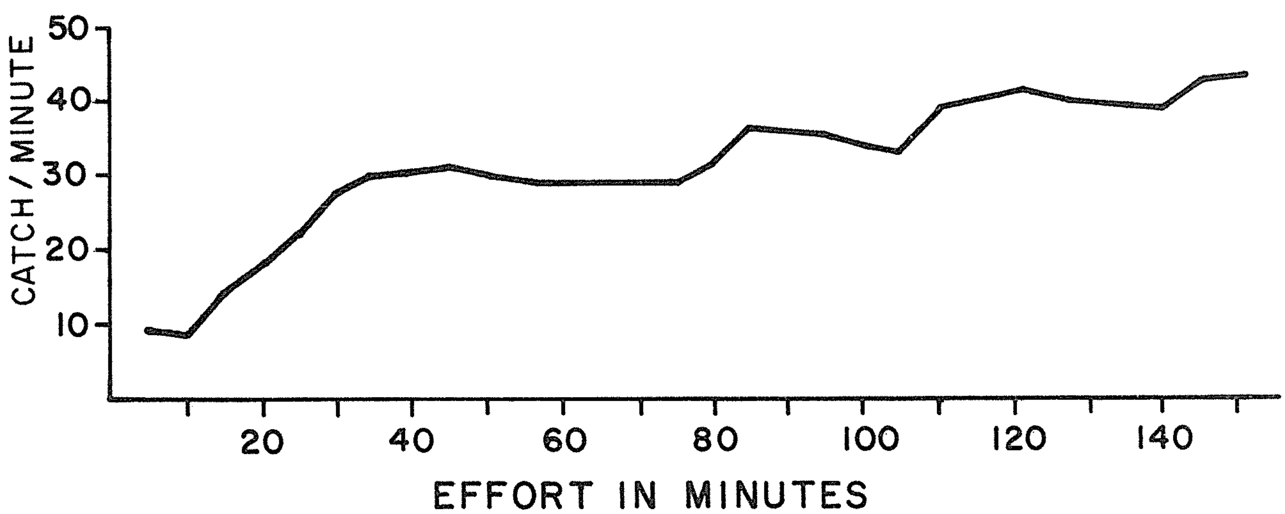

Fig. 5. The relationship between catch per minute and effort in successively pooled samples for age 0 sockeye salmon in Black Lake, September 1 and 2, 1974.

Table 4. Tow net catch-effort data for age 0 sockeye salmon in Black Lake, September 1 and 2, 1974

Date	Tow number	Area	Duration (min)	Catch	Catch per min	Cumulative effort (min)	Cumulative catch	Cumulative catch per min
9/1/74	1	C	5.0	47	9.4	5	47	9.4
	2	C	5.0	43	8.6	10	90	9.0
	3	C	5.0	139	27.8	15	229	15.3
	4	B	5.0	161	32.2	20	390	19.5
	5	B	5.0	180	36.0	25	570	22.8
	6	A	5.0	269	53.8	30	839	28.0
	7	A	5.0	229	45.8	35	1068	30.5
	8	A	5.0	168	33.6	40	1236	30.9
	9	A	5.0	189	37.8	45	1425	31.7
	10	A	5.0	132	26.4	50	1557	31.1
	11	A	5.0	78	15.6	55	1635	29.7
	12	A	5.0	82	16.4	60	1717	28.6
	13	A	5.0	178	35.6	65	1895	29.0
	14	A	5.0	195	39.0	70	2090	29.9
	15	A	5.0	138	27.6	75	2228	29.7
	16	A	5.0	330	66.0	80	2558	32.0
	17	D	5.0	638	127.6	85	3196	37.6
	18	D	5.0	118	23.6	90	3314	36.8
9/2/74	19	C	5.0	30	6.0	95	3344	35.2
	20	C	5.0	16	3.2	100	3360	33.6
	21	B	5.0	127	25.4	105	3487	33.2
	22	B	5.0	839	167.8	110	4326	39.3
	23	B	5.0	333	66.6	115	4659	40.5
	24	A	5.0	391	78.2	120	5050	42.1
	25	A	5.0	90	18.0	125	5140	41.1
	26	A	5.0	56	11.2	130	5196	40.0
	27	A	5.0	109	21.8	135	5305	39.3
	28	A	5.0	225	45.0	140	5530	39.5
	29	D	5.0	704	140.8	145	6234	43.0
	30	D	5.0	243	48.6	150	6477	43.2

in each year and then to combine areas of similar densities. The object of such an approach would be to combine the data in area A with those of another area. In this way sampling effort would become more proportional to the size of the area since the effort expended would increase by a factor of 2 while the size or weighting factor would only slightly increase.

Suggestions for Further Studies

It has been shown that by reallocating the effort so that it is proportional to the size of the statistical areas that a reliable index of abundance can probably be obtained. As mentioned previously however seasonal nearshore orientations of the fish species preclude reliable estimates of the lakes' carrying capacity by use of tow-net gear alone. There is a need, therefore, to supplement sampling in the pelagic areas of the lake with quantitative littoral sampling. The use of drop nets as developed by Kjelson et al. (1975) or some similar device needs to be investigated.

Another problem with the current sampling design is that changes in the distribution of the fish species cannot be followed except on a very gross level. This is due to the size of the statistical areas (especially area A) and our inability to determine precisely our location within these areas at night. This problem can be eliminated by reducing the size of the statistical areas and by marking them with lighted buoys anchored in strategic locations.

Scale Patterns Study

Introduction

The major objective of our research efforts during FY 75 was to initiate a study of the freshwater scale patterns of Chignik sockeye salmon. This study was undertaken because of the difficulty in some years of interpreting the freshwater age of returning adults. By following the circulus formation in the juvenile fish, we hoped to determine if any patterns formed which could be confused with annular marks.

Methods

Samples were collected at monthly intervals throughout the summer in Chignik and Black Lakes. Additional samples were collected in Chignik Lake in November. Fyke netting provided samples of pre-smolt sockeye emigrating out of Black Lake.

Length frequencies were determined for each sampling period and scale samples were collected by stratified random sampling. Three to four scale samples were taken from fish in each length interval (1 mm).

Scales were taken by scraping the lateral surface of the body just behind the posterior insertion of the dorsal fin above and/or below the lateral line (Clutter and Whitesel, 1956) and mounted on glass slides.

Scale images were projected at 226 diameters onto a working surface using a microprojector developed by Dahlberg and Phinney (1968). Measurements were recorded directly from this image onto a form which was devised for this purpose. The radius along which measurements were recorded approximates 16 degrees from the primary scale axis (Narver, 1963). In addition to the measurement data, each circulus was classified as to type following a scheme similar to that of Mosher (1968). Since the morphology of an individual circulus becomes very irregular towards the posterior or unsculptured field, only the morphology of the circulus in the anterior field perpendicular to the measuring axis through the center of the focus was recorded.

Circuli were classified according to the following scheme: 1) complete - a circulus which is more than one-half the length of the arc in the sculptured field in which it is found and which shows no breaks in continuity; 2) broken - a circulus which is more than one-half the length of the arc in the sculptured field in which it is found and which shows breaks in continuity; 3) annulus - a complete or broken circulus which is preceded by circuli which form a presumed annular growth check; 4) incomplete - a circulus which is less than one-half but more than one-fourth the length of the arc in the sculptured field in which it is found and which has no breaks in continuity; 5) fragmented - a circulus which is less than one-half but more than one-fourth the length of the arc in the sculptured field in which it is found and which shows breaks in continuity; 6) crossover - any circulus (except one which is interpreted as an annulus) which in its lateral margins appears to cross over into the field of an adjoining circulus. Loops and islands were ignored unless they occurred along the measuring axis.

A series of computer programs was written by Gales (1975) to summarize these scale reading data.

Some Preliminary Results

The proportions of the various types of circuli which occurred on age 0 sockeye salmon scales collected in Black Lake during 1974 are summarized in Fig. 6. When fewer than 10 fish had developed the n^{th} circulus, the sample size was considered too small, and the data were omitted. In the graphical display, the various types of circuli are presented in an hierarchial fashion with respect to being indicative of check formation. As the scales developed, it is apparent from Fig. 6 that some patterns formed which were confusing. This is indicated by the occurrence of (1) circuli which crossed-over into the field of another circulus, (2) circuli which were fragmented, or (3) circuli which were incomplete.

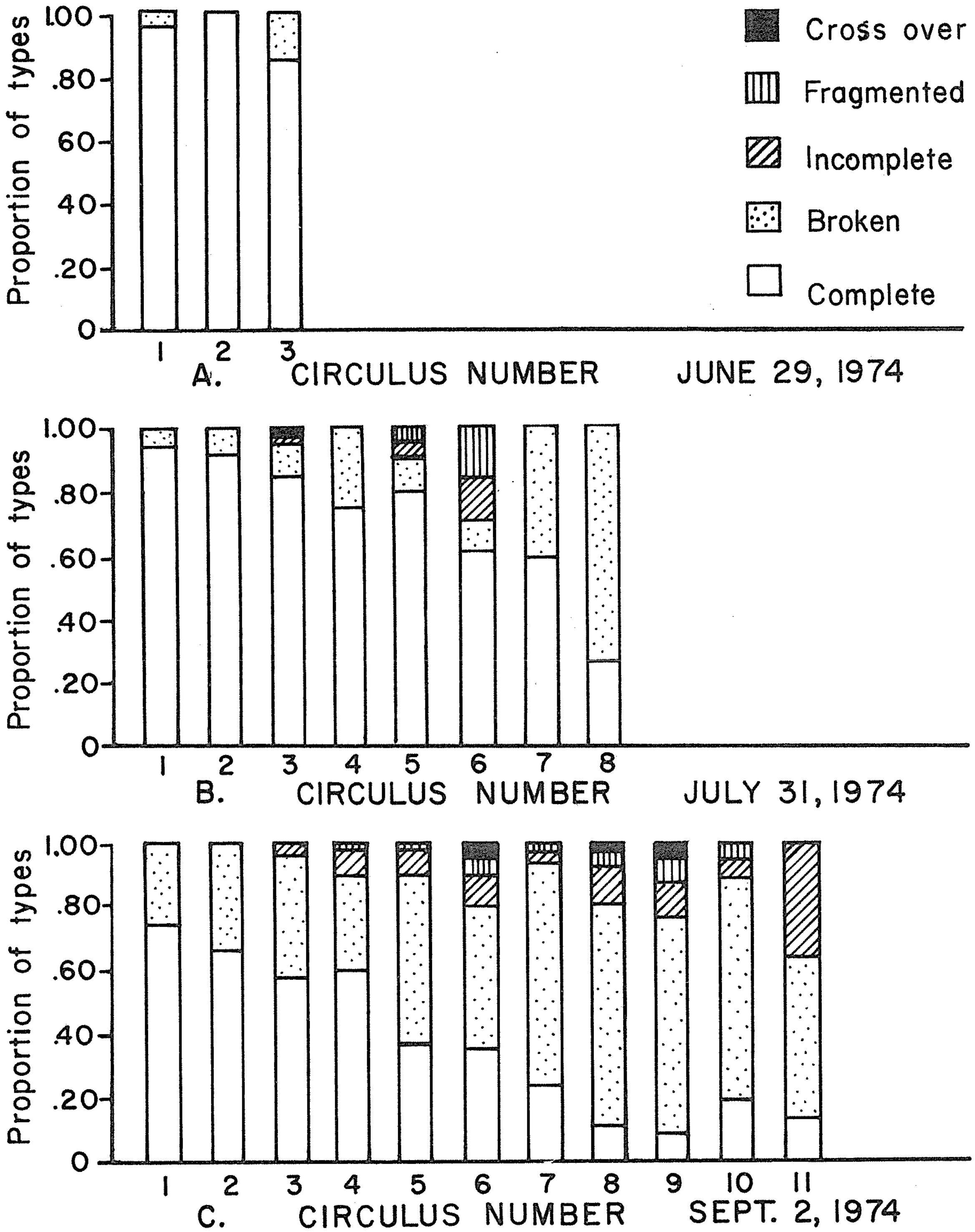

Fig. 6. The proportion of the various types of circuli, by circulus number, occurring on the scales of the 1973 year class of Black Lake sockeye salmon.

Another point of interest is the increasing proportion of broken circuli through time which appeared in the samples. One possible explanation of this is that, when formed, the circuli were complete but that with time the morphology changed. Bilton (1974) has reported that circuli spacing, nuclear radius, and other characteristics on juvenile sockeye scales which were once thought to be stable after being laid down may change significantly. It does not seem impossible, therefore, that morphology of the circuli may also be subject to change.

A potentially quite useful outcome of this study would be to find a scale characteristic(s) which was expressed differentially in the major stocks. If such a character could be found, it may be possible to identify the racial origin of individuals from a mixed population. One characteristic which may prove useful in this regard is the distance from the focus to the third circulus. Figure 7 summarizes this information by stock, location, and data. Age 0 Black Lake sockeye were identified in Chignik Lake by length-frequency analysis. The graphical presentation was adapted from Hubbs and Hubbs (1953). When the hollow bars just meet, an overlap of 32 percent is indicated. When the solid bars just meet, the means are statistically different. It can be seen that the average distance from the focus to the third circulus is considerably greater for the 1973 year class of Black Lake sockeye than for 1973 year class of Chignik Lake sockeye. The age I fish of the 1972 year class have a mean value in between that of the two stocks of age 0 fish. The age I fish from which these values were obtained are probably comprised of fish from both stocks.

The large changes which occurred between September 9 and November 11 in the 1973 year class of Chignik Lake fish may be due to the recruitment to the pelagic areas of late-emerging fish or to the dynamic nature of such measurements which Bilton (1974) reported.

Black Lake Emigration Studies

Introduction

During the summer of 1974 a fyke net was fished just above Chiaktuak Creek to obtain length frequencies of juvenile sockeye emigrating out of Black Lake. Our principal objective was to use these data to identify these emigrants in Chignik Lake as part of our scale patterns study. In the course of this investigation, additional information was obtained on the seasonal timing and diel pattern of the sockeye emigration.

Diel Pattern of the Sockeye Emigration

In order to estimate the diel pattern of the emigration, a single fyke net was fished at a fixed location in Black River about 20 meters upstream from the mouth of Chiaktuak Creek for a period of 26 hours on July 8 and 9 and for 22 hours on July 19 and 20. The average duration of the sets was 2.45 hours on July 8 and 9 and 4.12 hours on July 19 and 20.

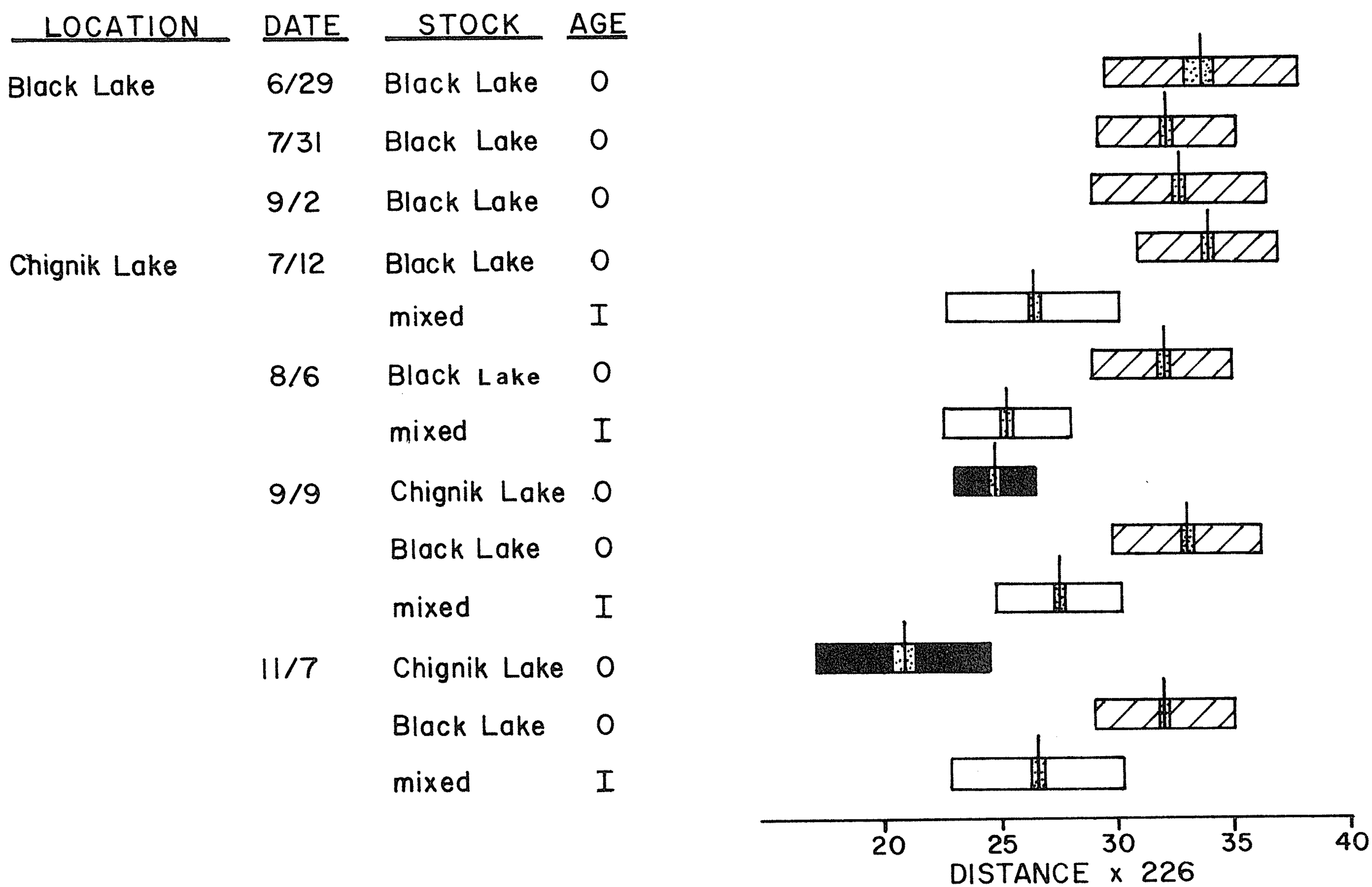

Fig. 7. Comparison of the mean distance from the focus to the third circulus of the scales of sockeye salmon by location, date, stock, and age. Presented for each sample are the mean, twice the standard error each side of the mean (stippled area), and one standard deviation each side of the mean (solid, striped, and hollow areas).

The estimated percent of the daily emigration occurring per hour during these studies is presented in Fig. 8. On July 9 (Fig. 8a) these data indicate a pulse of fish emigrating between 1300 and 1700 hours. The remainder of the catches during this first sampling period were at a lower and relatively constant level. On July 19 and 20 the average catch was considerably lower than during the first period (313 vs 5515). The largest catches during this period occurred between 1700 and 2400 hours on July 19 (Fig. 8b) with smaller catches occurring on July 20. These data tend to indicate that the emigration is not confined to any specific time period during the daily solar cycle as are many smolt migrations. Since only one net was fished and in a single location, it is possible that the higher catches represent the random capture of a school of fish and not a daily peak migration period.

Seasonal Timing of the Sockeye Emigration

There was no study specifically undertaken to estimate the daily magnitude of the emigration. The average daily catch per hour can be used however to estimate the seasonal timing. These data tend to indicate that the migration was at a low level until early June (Fig. 9). The majority of the fish seems to have migrated from early July through mid-August with low catches occurring in late August and early September. This pattern is similar to that observed in previous years (Burgner and Marshall, 1974).

PHENOTYPIC VARIATION IN THREESPINE STICKLEBACK

Introduction

Threespine stickleback have received considerable study as competitors to juvenile sockeye salmon in the Chignik lakes system (Narver 1966, Dahlberg 1968, Parr 1972). Analysis of samples collected in 1974 provided additional information relative to sub-populations in the Chignik system. Narver (1969) reported the occurrence of four phenotypes of threespine stickleback in the Chignik lakes: unplated (2-6 anterior plates); half-plated (7-15 anterior plates); fully-plated lacustrine (18-22 plates); and fully-plated estuarine (18-22 plates). Distinctions were based on the number and size of lateral plates and the extent of development of the lateral keel on the caudal peduncle.

Data collected on the proportion of each phenotype in the two lakes from 1962 to 1964 indicated that while the fully-plated estuarine phenotype was common in Chignik Lake it was extremely scarce in Black Lake. The occurrence of a high proportion of the estuarine phenotype in fyke-net samples from Black River in 1974 has led us to re-evaluate the importance of Black Lake as a spawning area for this subpopulation of stickleback.

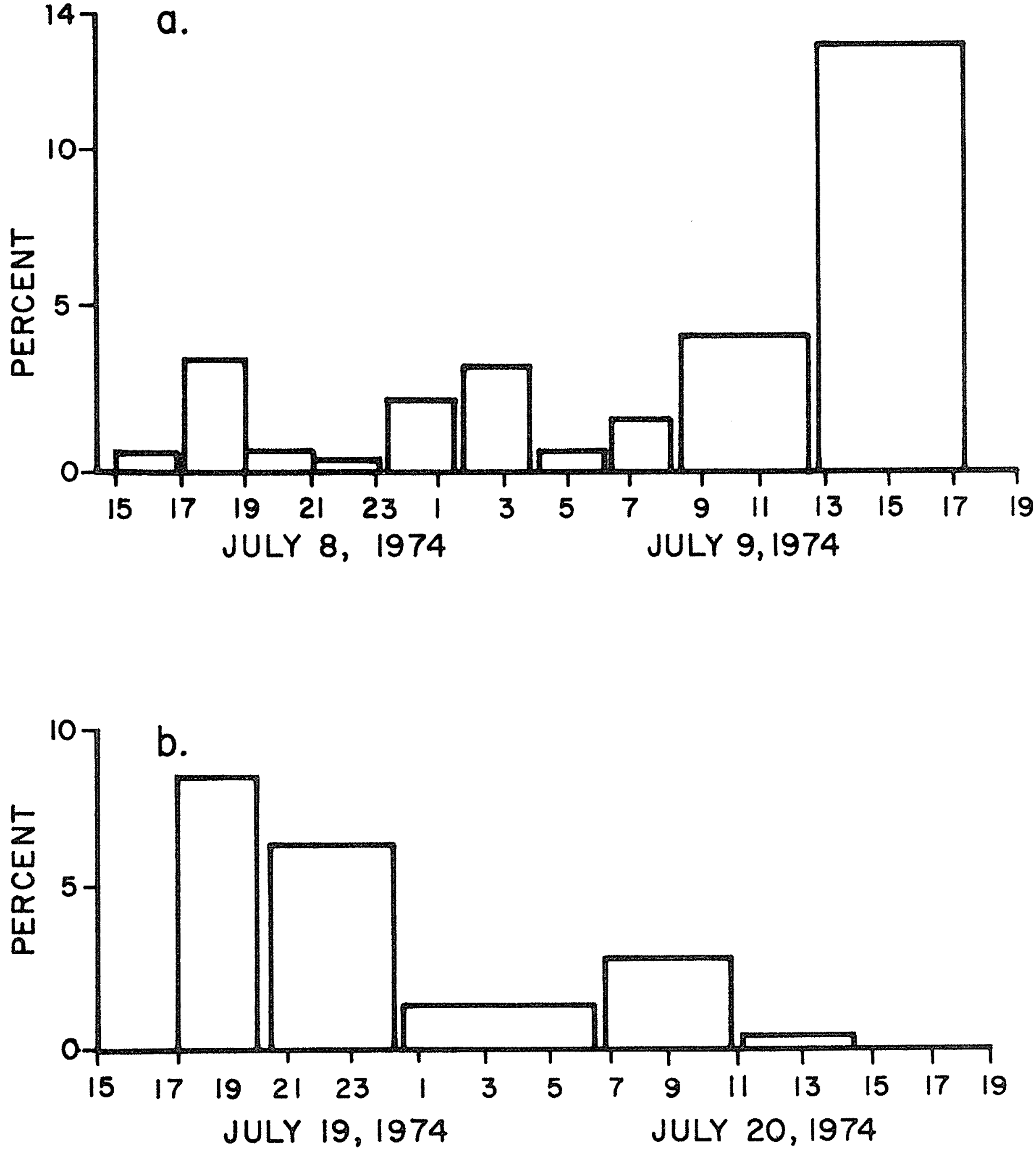

Fig. 8. The percent per hour of the daily presmolt sockeye salmon emigration from Black Lake.

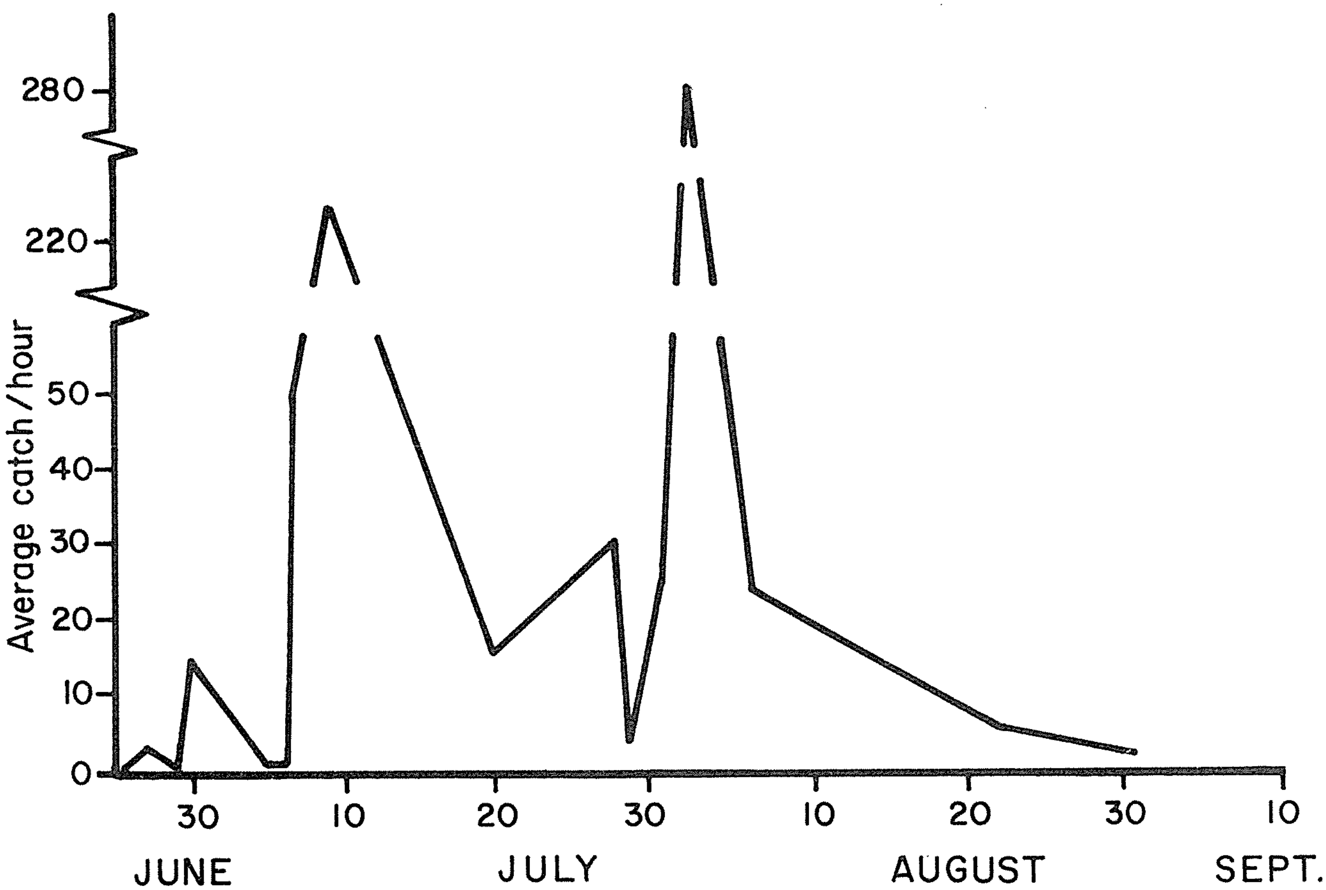

Fig. 9. The average daily fyke-net catch per hour of sockeye salmon in Black River, 1974.

Methods

Lateral plates were counted with the aid of a binocular microscope and a probe for small fish and with the naked eye and probe for large fish. The criteria for determining phenotypes was the same as used by Narver (1969). Ages were determined by constructing length frequency histograms for each phenotype and observing modes. The small size of age 0 fish made phenotypic determinations impossible for all but the September 2 tow-net sample and the September 1 fyke-net sample. For these fish, however, no distinction could be made between fully-plated estuarine and lacustrine individuals, and they were therefore combined.

Results

A total of 1293 fish were examined in this study of which 517 were from Black Lake tow-net samples, 686 were from Black River fyke-net samples and 90 were from a Chignik River beach-seine sample. Table 5 summarizes the percent of each phenotype by age for these samples.

Among the age I and II fish captured by tow net in Black Lake only one specimen was classified as an estuarine phenotype. This is in sharp contrast to the high proportion (61.9 to 89.5 percent) of estuarine phenotypes among the age I fish captured by fyke net in Black River. No fish of the estuarine phenotype were classified as age II. The small sample collected by beach seine at the outlet of Chignik Lakes in mid-June was composed of a high proportion (93 percent) of age I estuarine phenotype.

Discussion

Narver (1969) found no significant difference in the phenotypic composition of samples collected in Black Lake for the years 1962-1964. In a comparison between samples collected by tow net in Black Lake in 1974 with Narver's data for those years, I found no significant difference ($P = 0.01$, $X^2(6\ df) = 14.08$). While no data exist for the intervening years (1965-1973), a relatively stable polymorphism is suggested.

The extremely low proportion of the estuarine phenotype which occurred in tow-net samples from Black Lake in 1974 agrees with Narver's (1969) findings of the early 1960's. However, the high proportion of age I estuarine phenotype which occurred in fyke-net samples from Black River is in apparent disagreement. It is possible that the age I estuarine phenotypes migrated up Black River in the spring or early summer and spawned in the profuse growth of *Potamogeton* sp. which occurs in the southeast end of the lake near the outlet and/or in Alec River Bay without ever moving into the pelagic area. Our beach seining would produce these fish only during a limited time along the east shore, a movement which could be missed easily.

Table 5. The phenotypic composition of threespine stickleback by age, 1974

Location	Gear	Date	Age	N	Percent of sample: Unplated lacustrine	Half-plated lacustrine	Fully-plated lacustrine	Estuarine
Black Lake	Tow net	7/31	I	257	21.0	32.3	46.7	0.0
			II	34	11.8	26.5	61.8	0.0
Black Lake	Tow net	9/2	0	67	23.9	32.8	[43.3][1]	
			I	141	22.0	22.0	55.3	0.7
			II	17	23.5	23.5	52.9	0.0
Black River	Fyke net	7/27-8/3	I	57	5.2	0.0	5.2	89.5
			II	132	15.9	15.2	68.9	0.0
Black River	Fyke net	8/15-16	I	31	16.1	3.2	9.7	71.0
			II	86	19.8	29.1	51.2	0.0
Black River	Fyke net	8/20-21	I	21	9.5	9.5	19.0	61.9
			II	116	19.8	19.0	61.2	0.0
Black River	Fyke net	9/1	0	154	0.0	0.6	[99.4][1]	
			I	11	0.0	18.2	9.1	72.7
			II	18	44.4	27.8	27.8	0.0
Chignik River	Beach seine	6/17	I	86	0.0	0.0	0.0	100.0
			II	4	50.0	50.0	0.0	0.0

[1]Due to the small size of the age 0's no distinction could be made between lacustrine and estuarine phenotypes for fully-plated individuals; therefore they were combined.

A large proportion of the age I and II lacustrine phenotypes captured in the fyke net were post-spawning mortalities. Among the estuarine phenotypes post-spawning mortality appeared to be quite low, even though most of the fish captured were post-spawners. The absence of two age classes in the estuarine phenotypes suggests that while they may not die immediately after spawning they probably do not live through the year to spawn a second time.

The phenotypic composition of the age 0 threespine stickleback from fyke-net samples in Black River on September 1 and from tow-net samples in Black Lake on September 2 were significantly different ($P = 0.01$, X^2 (2 df) = 100.43). This was related to the higher proportion of fully-plated individuals in the fyke-net sample. Additionally, the fish captured in Black River were very bright and silvery as compared with the majority of the fish from the Black Lake tow-net sample which were brown with yellowish vertical bands. It seems plausible, therefore, that the age 0 fish from the Black River sample represent the progeny of estuarine phenotypes which were migrating out of Black Lake to either Chignik Lake or Chignik Lagoon.

In mid-June of 1974 threespine stickleback were observed swimming up the Chignik River in a narrow band near the outlet. Lateral plate counts showed that 93 percent of these fish were age I estuarine phenotypes. While no observation of such a movement from the lagoon to the lakes has been previously recorded, Narver (1969) inferred its existence.

Just what role the estuarine phenotype may play in maintaining this polymorphism in the lacustrine environment is still unknown. This study has shown, however, that the fully-plated phenotype does spawn in freshwater and is perhaps not as uncommon in Black Lake as previously thought.

CHIGNIK DATA FILE

During FY 75 key data which had been collected over the years at Chignik were organized in preparation for placing the data on magnetic tape for speedy retrieval and analysis. It became apparent that due to the large volume of data which had never been keypunched, the variable formats of the same type of data, and the possible inclusion of erroneous data (e.g., freshwater age interpretation of returning adults) that extensive programming, keypunching, and editing services would be required in order to create a complete and usable data file. Due to budget constraints this aspect of our work has been discontinued until such time as additional funds are available.

PERSONNEL

Principal Investigator	-	Dr. Robert L. Burgner
Co-Principal Investigator	-	Dr. Donald E. Rogers
Project Leader	-	Scott L. Marshall
Technician	-	John A. Knutzen

LITERATURE CITED

Bilton, H. T. 1974. Effects of starvation and feeding on circulus formation on scales of young sockeye salmon of four racial origins and one race of young kokanee, coho and chinook salmon. Pages 40-62 *in* T. S. Bagenal, ed. Aging of Fish. Unwin Brothers.

Burgner, Robert L., and Scott L. Marshall. 1974. Optimum escapement studies of Chignik sockeye salmon. Anadromous Fish Project Final Report for period ending June 30, 1973. AFC-34, Segment 3. Report No. FRI-UW-7401, Fish. Res. Inst., Univ. Washington, Seattle. 91 pp.

Clutter, R. I., and L. E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Int. Pac. Salmon Fish. Comm. Bull. 9. 159 pp.

Dahlberg, Michael L. 1968. Analysis of the dynamics of sockeye salmon returns to the Chignik lakes, Alaska. Ph.D. Thesis, Univ. Washington, Seattle. 337 pp.

Dahlberg, Michael L., and Duane E. Phinney. 1968. A microprojector for use in scale studies. The Progr. Fish-Cult. 30(2):118-119.

Gales, Lawrence. 1975. Chignik scale analysis. Univ. Washington, Fish. Res. Inst., Comp. Prog. FRG 344. 10 pp. [Ditto].

Hubbs, C. L., and C. Hubbs. 1953. An improved graphical analysis and comparison of series of samples. Syst. Zool. 2(2):49-57.

Kjelson, Martin A., William R. Turner, and George N. Johnson. 1975. Description of a stationary drop-net for estimating nekton abundance in shallow waters. Trans. Amer. Fish. Soc. 104(1):46-49.

Marshall, Scott L., Robert L. Burgner, and James J. Dawson. 1974. Chignik sockeye studies. Anadromous Fish Project Final Report for period ending June 30, 1974. AFC-48-1. Report No. FRI-UW-7405, Fish. Res. Inst., Univ. Washington, Seattle. 27 pp.

Mosher, Kenneth H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish Wildl. Serv. Fish. Bull. 67(2):243-280.

Narver, Davis W. 1963. Identification of adult red salmon groups by lacustrine scale measurements, time of entry, and spawning characteristics. M.S. Thesis, Univ. Washington, Seattle. 96 pp.

Narver, David W. 1966. Pelagial ecology and carrying capacity of sockeye salmon in the Chignik lakes, Alaska. Ph.D. Thesis, Univ. Washington, Seattle. 348 pp.

Narver, David W. 1969. Phenotypic variation in threespine sticklebacks (*Gasterosteus aculeatus*) of the Chignik River system, Alaska. J. Fish. Res. Bd. Canada 26:405-412.

Parr, William H., Jr. 1972. Interactions between sockeye salmon and lake resident fish in the Chignik lakes, Alaska. M.S. Thesis, Univ. Washington, Seattle. 103 pp.

Shaul, Arnold R., and Philip W. Rigby. 1975. Chignik area finfish annual report, 1974. Alaska Dep. Fish Game. 84 pp.