Informational Leaflet 36

FORECAST RESEARCH ON 1964 ALASKAN PINK SALMON FISHERIES

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FORECAST RESEARCH ON 1964 ALASKAN PINK SALMON FISHERIES

INTRODUCTION

A continuing and pressing desire to manage Alaskan salmon resources for maximum sustained yield requires a multitude of biological facts. Some of these facts are basic to the genus *Oncorhynchus*, others to particular species, but most apply to specific races and sub-races in their stream and estuarine environments. In Alaska, these races and sub-races number in the thousands and many of the necessary facts on each must be gathered annually to achieve desired rehabilitation and maximum yield.

In 1963, the Department of Fish and Game expanded research on Alaska's most important species, pink salmon, *O. gorbuscha* (Walbaum), into Southeastern Alaska, Cook Inlet, and Kodiak areas on the basis of work since 1960 in Prince William Sound. Thus, the most important production areas came under study; packs of pink salmon in these areas accounted for over 53 percent of the total Alaska salmon pack of all species in 1963, and 47 percent in 1962 (see Figure 1).

Research reported herein has dealt primarily with the even-year runs which spawned in 1962 and will return in 1964. The history of fluctuating abundance of even-year populations of pink salmon in Southeastern Alaska, Prince William Sound, Cook Inlet, and Kodiak areas from 1920 to 1962 is shown in Figure 2.

Although serious declines had occurred in all three of these areas before 1950, Southeastern Alaska stocks suffered the most serious and persistent loss of production; the three other areas have recently returned to production levels comparable to the best years in the past.

OBJECTIVES

The primary objective of the present pink salmon research program is forecast of annual runs in each area. Accurate forecasts, within 20 percent of actual returns, will make it possible to manage and harvest the major pink salmon stocks far more efficiently, regardless of whether they are at high or low levels of production. The definition of optimum escapement, maximum sustained yield and effects of logging are being studied where possible as secondary projects under the forecast program.

METHODS

The establishment of the relationship between observed pre-emergent fry densities and returns runs is basic to this program in all areas. Similar relationships between estuarine fry abundance and return runs are also under study in Southeastern Alaska and Prince William Sound.

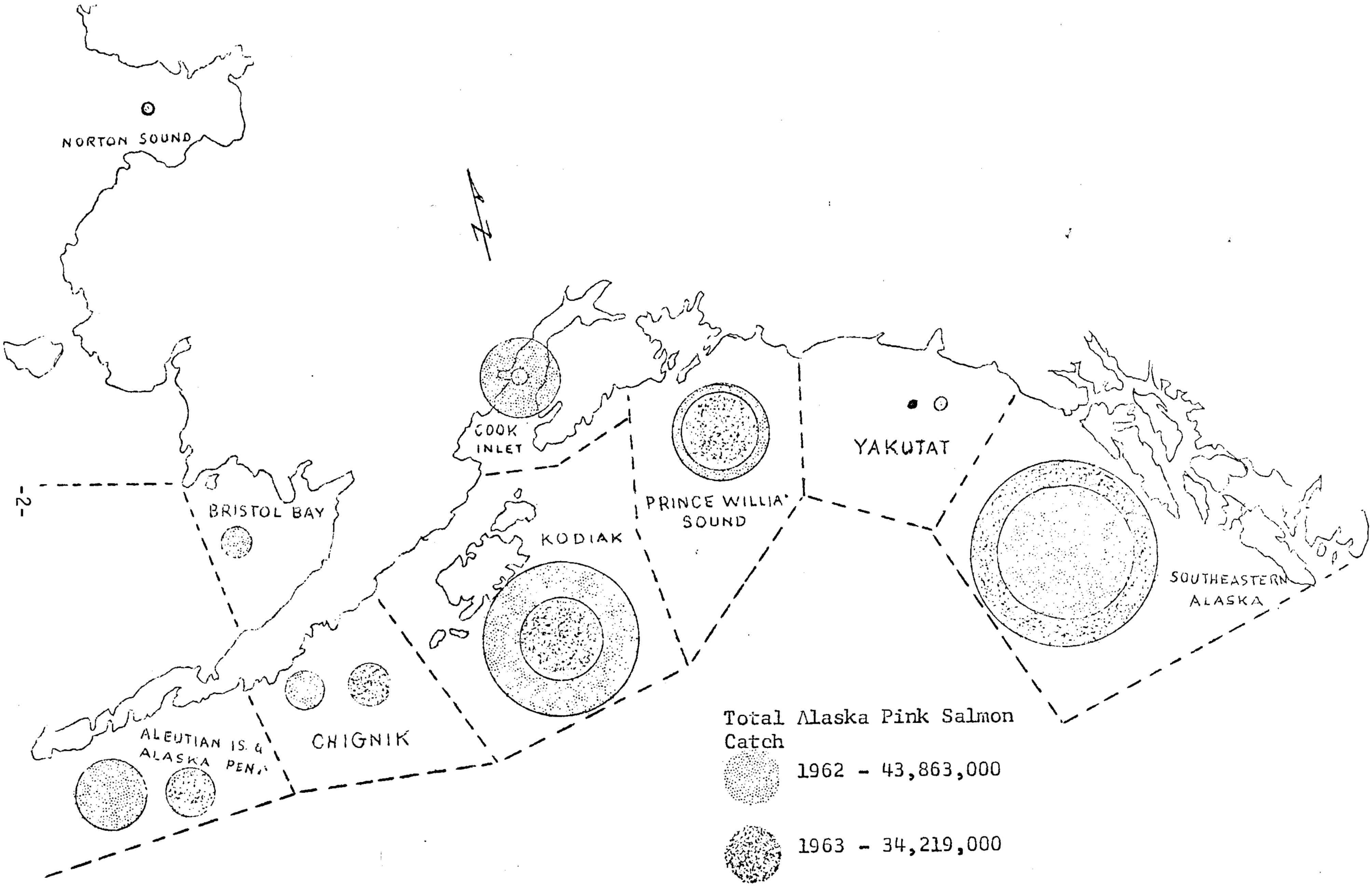

Figure 1. Relative catches of pink salmon in various management areas of Alaska in 1962 and 1963.

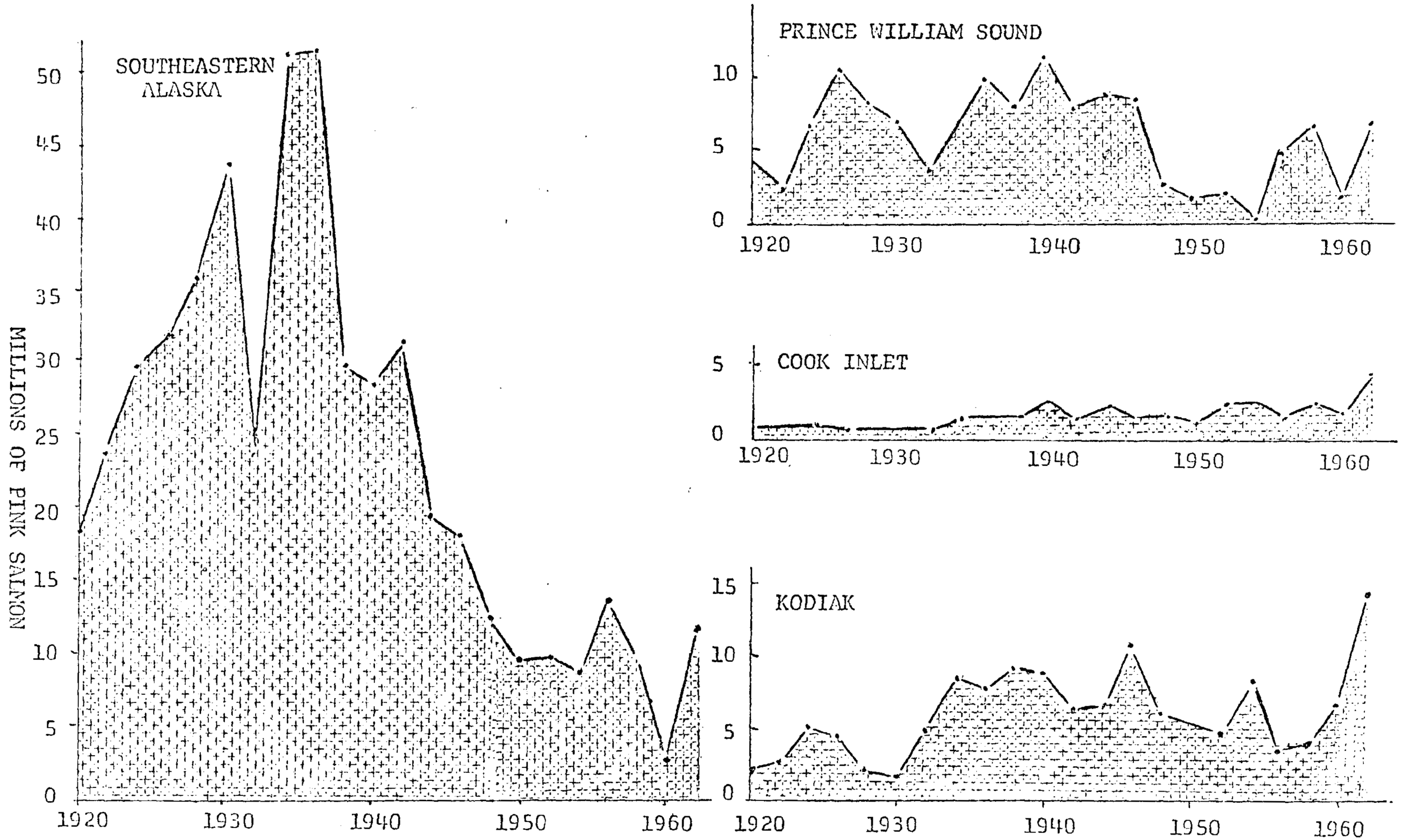

Figure 2. Even-year commercial catches of pink salmon in Southeastern Alaska, Prince William Sound, Cook Inlet, and Kodiak areas, 1920 to 1962.

The standard tool employed in all areas to enable forecasting has been hydraulic sampling of pre-emergent fry in the spawning riffles during the springtime following spawning. Procedures involved have been described by Kirkwood (1962) and McNeil (1962a) as applied to multiple and single-stream situations respectively. Modification of these procedures for the Department's Prince William Sound studies was discussed in Alaska Department of Fish and Game Memorandum #5 (Noerenberg, 1961) and Informational Leaflet #21 (Noerenberg, 1963).

Essentially we are excavating random plots in important and accessible spawning streams in a manner which should give reliable year-to-year comparisons of fry survival or relative abundance. This is accomplished very near the end of freshwater life when many causes of population fluctuations have passed.

Work in estuaries has been more varied since reliable sampling techniques are relatively undeveloped. Emphasis has been on establishing the timing, distribution, and growth rates of young pink salmon in channels and fiords adjacent to spawning streams to provide a basis for proper assessment of annual abundance. Visual counting, tow netting, and beach, purse, and lampara seining were employed in 1963 to conduct this study.

Escapement information given in this report has been collected in part by management biologists of the Commercial Fisheries Division. Research activities with escapement were generally confined to specific populations spawning in streams sampled for pre-emergent fry abundance. Careful assessment of escapement is necessary not because it is itself of much value in forecasting but because it is an integral part of the return run which must be accurately measured to evaluate success of forecasting from other indices.

RESULTS OF RESEARCH

Southeastern Alaska and Kodiak Island projects were conducted by the Biological Research Division and the project in Cook Inlet by the Commercial Fisheries Division. Responsibility for the Prince William Sound project gradually shifted from the Commercial Fisheries Division to the Biological Research Division during the year. Research in the four areas which is covered by this report is written as five separate project reports by the respective biologists in charge. They are as follows: Southeastern Alaska Pre-emergent Sampling by Theodore C. Hoffman; Southeastern Alaska Estuarine Sampling by Asa T. Wright; Prince William Sound Adult Escapement, Pre-emergent and Estuarine Sampling by Wallace H. Noerenberg; Southern Cook Inlet Pre-emergent Sampling by Allen S. Davis ; and Kodiak Adult Escapement and Pre-emergent Sampling by Robert S. Roys.

Since the primary basis of forecast inherent in these studies depends upon relationships of observed early-stage abundance and return runs, there does not exist enough data at present for the Southeastern Alaska, Cook Inlet, or Kodiak areas to justify a forecast for 1964. It is anticipated that no firm forecasts will be available on an area-wide basis until 1966 or 1967 for these areas. Accumulated data on Prince William Sound pink salmon indicate at least one of three early-stage indices may be reliable in predicting return runs. This report therefore merely deals with progress in establishing a forecast program in the several districts other than Prince William Sound. The reader is referred to page 27 for a summary of the Prince William Sound pink salmon forecast.

SOUTHEASTERN ALASKA PINK SALMON FORECAST STUDIES

I. PRE-EMERGENT PROGRAM

INTRODUCTION

The Biological Research Division of the Alaska Department of Fish and Game began preparations in the summer of 1962 for a pre-emergent fry indexing program in Southeastern Alaska, directed toward predicting the abundance and distribution of adult pink salmon returning from estimated levels of fry production. Prior to the spring of 1963, ten streams had been examined to assess spawning area and prepare for random sampling.

In the spring of 1963, these ten streams were sampled, using the hydraulic sampler described by McNeil (1962a). An average number of 45 samples were taken daily by a two-man crew indicating the feasibility of extensive sampling over large areas of spawning at relatively low cost. At this point of the program development the need for expanding the sampling effort was evident.

In the summer of 1963, 85 streams in Southeastern Alaska were examined to determine their suitability for sampling in the spring of 1964. Areas were designated and surveyed in those streams which appeared suitable to include in the sampling stratum. Areas from 60 streams will be sampled in the spring of 1964. Figures 3 and 4 indicate the location of streams that have been sampled in 1963 and those considered for 1964 sampling.

Objectives:

1. To develop a method for predicting the abundance and distribution of pink salmon returning to their respective spawning areas in Southeastern Alaska.

2. To gather basic information on the productivity of the areas sampled.

3. To determine whether the same method can be extended to chum salmon.

Methods:

The sampling system presently in use was suggested by McNeil (1962b). Briefly the goal is to estimate production in all stream areas utilized by pink salmon for spawning which are accessible to sampling crews. Both good and poor producing streams are included in the basic sampling program, but may be considered as separate strata to determine which type of stream provides the best index of major fluctuations in the size of the returning runs of adults. Sampling effort will be allocated to the streams included in the sampling program on the basis of areas available for spawning and accessibility to sampling crews.

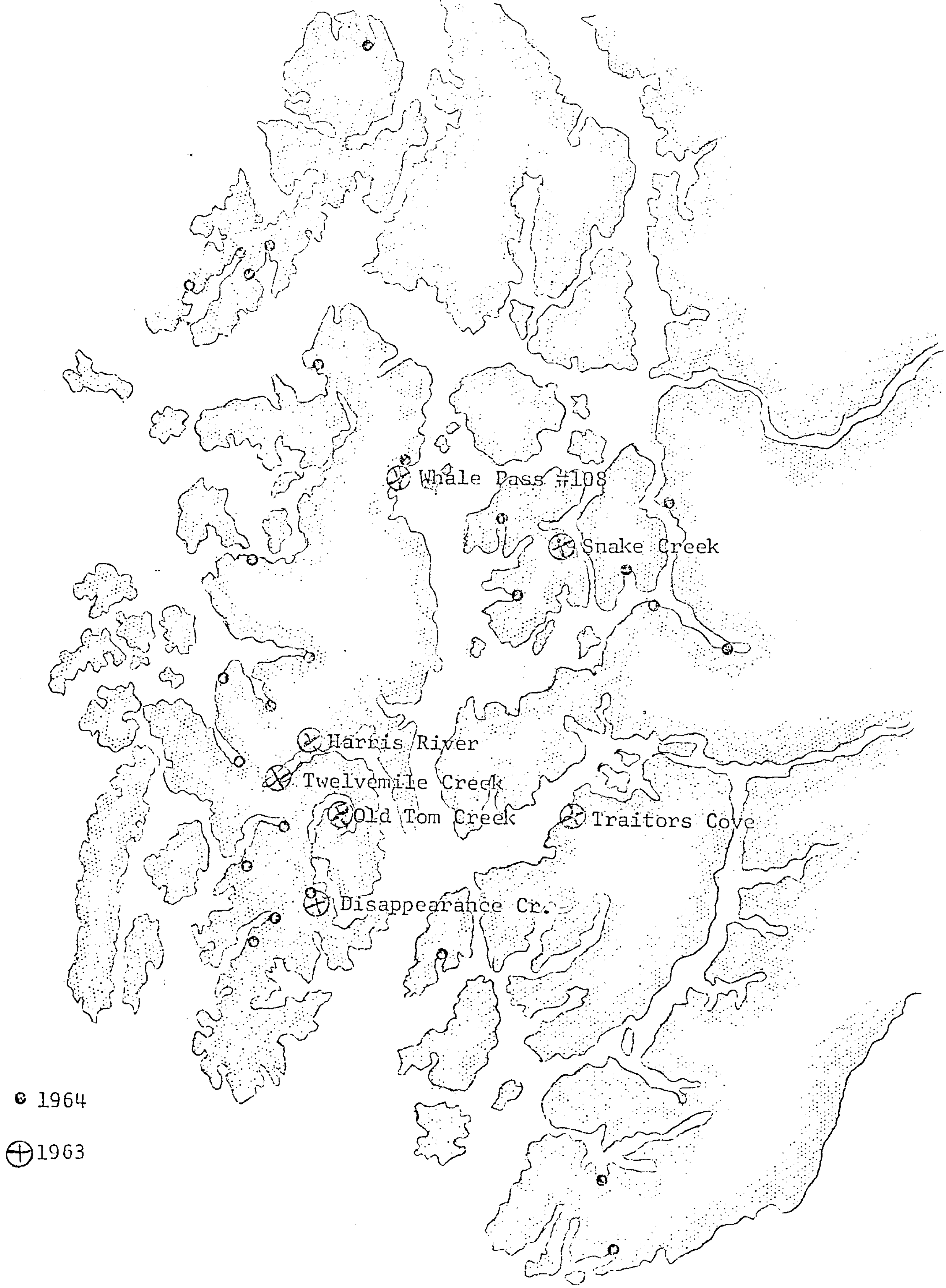

Figure 3. Map of southern Southeastern Alaska showing pre-emergent fry sampling streams in 1963 and 1964.

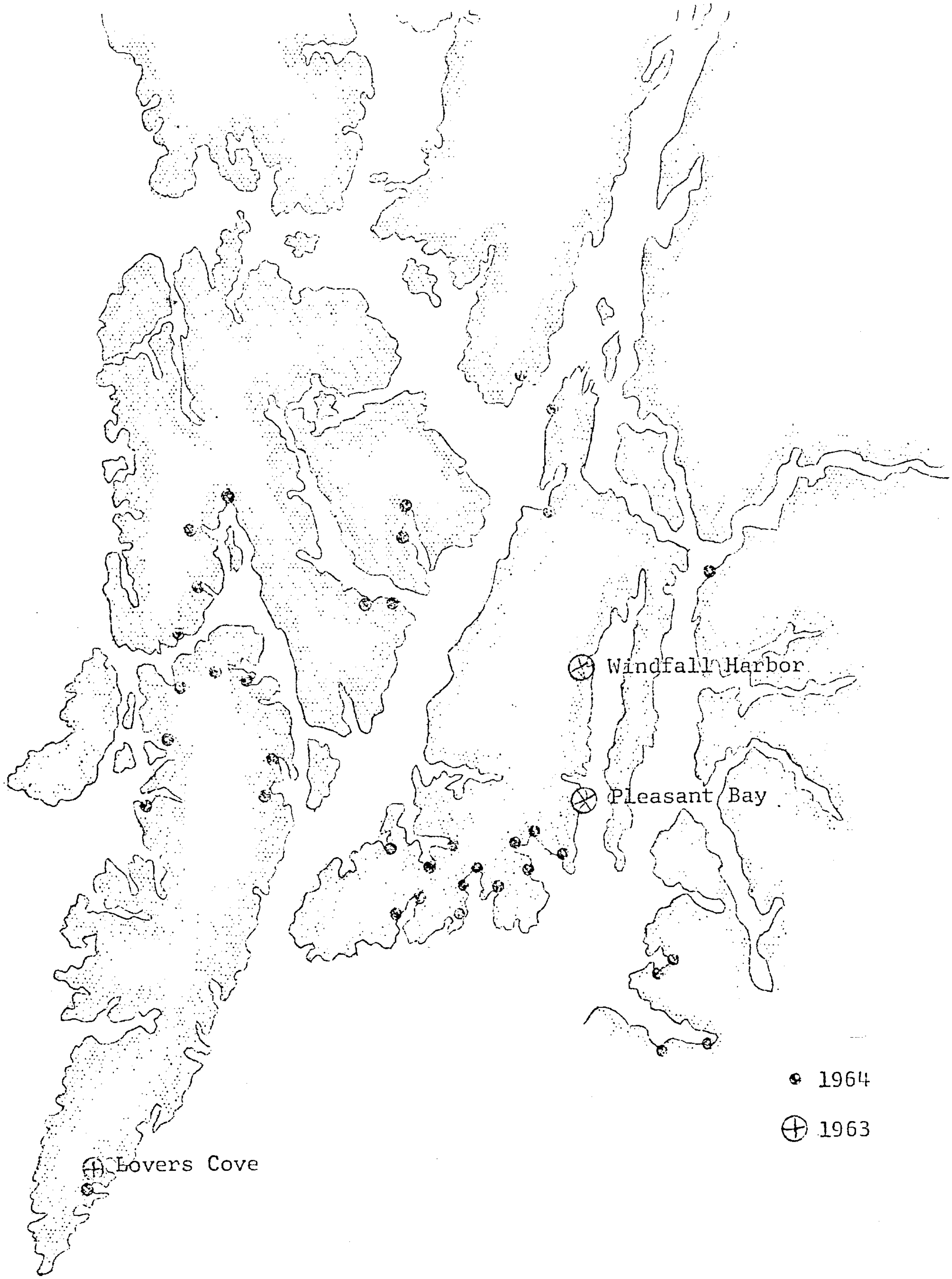

Figure 4. Map of northern Southeastern Alaska showing pre-emergent fry sampling streams in 1963 and 1964.

The basic sampling program is designed so that streams may be added at any future time without sacrificing previously acquired data. With the inclusion of more spawning areas, some scheme of randomized cluster sampling will be adopted to maintain a high degree of efficiency in sampling.

The program will provide estimates of pre-emergent fry abundance per unit area of sampling bed (e.g., per square meter). This estimate multiplied by the area of a stratum will give an estimate of total fry yield from the stratum.

Observations during the spring of 1963

Information on abundance of fry was obtained from ten streams during late March and April of 1963. Hydraulic sampling of pre-emergent fry was employed in all streams except Disappearance Creek, where downstream migrants were trapped at the mouth of the stream. Data on Traitors Cove and Lovers Cove creeks were obtained from the Bureau of Commercial Fisheries and on Twelvemile Creek from the Fisheries Research Institute, University of Washington. Table 1 indicates fry densities observed in the areas sampled in the ten streams, as well as parent escapement estimates.

Although we have no basis for comparison of what a certain fry density might mean in terms of an adult return to the streams with the exception of Harris River and Twelvemile Creek, several indications are apparent in the limited 1963 sampling even though some areas were examined after fry emergence had begun.

Windfall Harbor Stream #14, Seymour Canal

It is evident from the pre-emergent data and other observations that the intertidal spawning of 1962 at Windfall Harbor in Seymour Canal was largely unsuccessful. This area was utilized by 2,500 female salmon in 1962. Evidence of large scale bottom movement was evident in much of the intertidal area. This low fry recovery per unit area in the spring of 1963 indicates we can expect little production from about half of the escapement into this stream. The weir count of the parent escapement reflects primarily upstream spawners in about the same concentration as intertidal spawners. The upstream spawners were distributed primarily in the lower upstream area which is quite unstable. Evidence of considerable bottom movement in the upstream area used for spawning was evident in the spring of 1963, and casts suspicion on the relative success of this segment of the escapement.

The adult return to this stream will probably be less than the parent run.

Pleasant Bay Stream #16

This stream, located in Seymour Canal, had good production in the area sampled. The best overall stream production recorded for Southeastern Alaska is approximately 45 fry per square foot and 39.7 pink fry were recovered for each square foot excavated in the lower area of the Pleasant Bay stream. The adult return to this stream should be at least as good as the parent year and probably better.

Table 1. Parent escapements and pre-emergent fry densities in ten streams of Southeastern Alaska, 1962 and 1963.

Stream Number	Stream Name and Location	Parent Escapement (1962)	Mean fry density per sq. ft. Spring of 1963 Pink	Chum
14	Windfall Harbor Creek, Seymour Canal	2,676 pinks* 3,129 chums	5.2	1.3
16	Pleasant Bay Creek, Seymour Canal	36,552 pinks* 1,697 chums	39.7	0.0
49A	Lovers Cove, Port Walter, Baranof I.	?	8.2	0.2
42	Snake Creek, Olive Cove, Etolin I.	93,645 pinks*	6.8	0.0
108	Whale Pass Creek, Prince of Wales I.	128,339 pinks* 1,357 chums	12.0	0.0
84	Traitors Cove Creek, W. Behm Canal	30,000 pinks* 26,000 chums		
	Intertidal Section		12.5	5.8
	Upstream Section		18.4	15.9
144	Harris River, Kasaan Bay	80,000**		
	Sect. 1A - Intertidal		negligible	negligible
	Sect. 1B - Intertidal		14.4	0.0
	Sect. 2B - Upstream		7.0	0.0
145	Twelvemile Creek, Kasaan Bay	17,000**	4.9	negligible
142	Old Tom Creek, Skowl Arm, Kasaan Bay	5,000**	6.8	3.7
134	Disappearance Creek, Chomley Sound	143 pinks* 23,799 chums	negligible	18.1 1/

1/ Calculated from migrant count divided by area of spawning ground.
* Weir count, not including majority of intertidal spawners.
** Includes all species

Whale Pass Stream #108 and Snake Creek #42

These streams were sampled after the fry emergence was well underway and it is difficult to interpret the data on production per unit area.

At Snake Creek there were few fry in the gravel at the time of sampling and an average number of 93 dead eggs per square foot of bottom. The rather large numbers of dead eggs might indicate a heavy mortality rate and low production of fry, however the stream received very heavy seeding of eggs in 1962. In back calculation using the total spawning area and total deposition of the parent run, the numbers of dead eggs recovered do not indicate poor production of this stream. The presence of large numbers of pink salmon fry in the stream during the day at the time the stream was sampled leads one to believe that the return in 1964 will be no less than the parent run.

Only a small area of lower Whale Pass Creek #108 was sampled and production was 12 fry per square foot. Fry from the upper more productive stream areas had already emerged. The absence of dead eggs in these areas plus the presence of large numbers of pink fry in the estuary at the time of sampling probably indicates that the stream had an overall good production and that a good return should be expected in 1964.

Kasaan Bay - Prince of Wales Island

Harris River #144 and Twelvemile Creek #145, located in Kasaan Bay on Prince of Wales Island, had the best recorded fry production in the areas sampled since observations began by the Fisheries Research Institute in the springs of 1958 and 1959, respectively. Table 2 indicates the mean pink salmon fry density per square foot for Harris River from 1958 to 1963 and for Twelvemile Creek for the years 1959-1961 and 1963.

Shovel sampling at some riffle areas of Karta River in Kasaan Bay also revealed large numbers of fry in the gravels of that stream.

The fry production picture for Kasaan Bay is excellent by comparison with past production with the exception of Skowl Arm where Old Tom Creec, the only stream sampled, had fairly low densities.

In 1964, we should expect to see one of the best runs since 1958 entering the Kasaan Bay area with the majority of fish destined for Karta and Harris Rivers.

Table 2. Pre-emergent pink salmon fry densities and return run escapements in Kasaan area streams, 1958 to 1963.

Year of Fry Sampling	#144 Harris River, Section 1B Pink fry/sq. ft.	Return[1] Escapement	#145 Twelvemile Creek, Section 1 Pink fry/sq. ft.	Return[1] Escapement
1958	1.1	23,400[2]	not sampled	------
1959	9.9	22,800[2]	0.01	2,100
1960	11.4	43,000	0.4	6,200
1961	7.1	80,000	4.7	17,000
1962	8.2	63,000	not sampled	29,800
1963	14.4	? (1964)	5.2	? (1964)

1/ Total stream estimates, all sections.
2/ Includes escapement in Indian Creek tributary.

Source: 1958 to 1962, Fisheries Research Institute, Univ. of Wash., Progress Reports on Effects of Logging research.

SOUTHEASTERN ALASKA PINK SALMON FORECAST STUDIES

II. ESTUARINE PROGRAM

INTRODUCTION

Forecast of adult runs from observations on abundance of fry in the freshwater environment assumes marine mortalities will be relatively constant from year to year. However, the limited data available point to the fact that the marine survival of the salmon fingerlings may vary from year to year. [Royal (1962a, 1962b), Parker (1962), McNeil (1963)].

The life history of young salmon in Southeastern Alaska estuarine waters is virtually unknown and it is very possible that this period of a salmon's life is extremely harzardous. Pink and chum salmon fry upon entering saltwater must abruptly adapt to many new conditions. The fry must find food for the first time, withstand a change in temperature and salinity, as well as cope with many new predators and parasites. Should the young salmon not be able to cope with all of these changes they will not survive.

As conditions are not the same every year in the estuaries when the young salmon migrate seaward, there is reason to think that the survival of the salmon fingerlings may vary from year to year in the estuary. With this in mind, research activities at the Alaska Department of Fish and Game research station at Disappearance Creek, (Chomley Sound, Prince of Wales Island) were extended into the estuary (Figure 5).

The objectives of this program were two-fold: (1) to start early marine life history studies on both the pink and chum salmon in Southeastern Alaska waters, and (2) to develop methods for population enumeration and indexing of the salmon fingerlings in the estuarine waters as they migrate seaward. At present, more problems exist in making valid estuarine population estimates of the young salmon than freshwater estimates, but more accurate forecasts should be possible should we succeed in developing a reliable estuarine index.

Materials and Methods

During the spring of 1963, the salmon fry migration was enumerated from Disappearance Creek, the main salmon producer in Chomley Sound, by means of a total weir. Numbers of downstream migrating fry were also monitored from the other two major salmon producers in the Sound using indexing traps 18 inches wide and 3 feet high. The rest of the streams in this area probably produced less than 10 percent of the Sound's fry migration. The object of the downstream enumeration of fry from these streams was to determine the number of salmon fry entering the estuary, the relative size of the migrating fry, and the survival of the spawned eggs to the fry stage.

Once the number of fry in the estuary was known, study was begun on determining how and when these fry moved out of the estuary, their growth rate, the extent

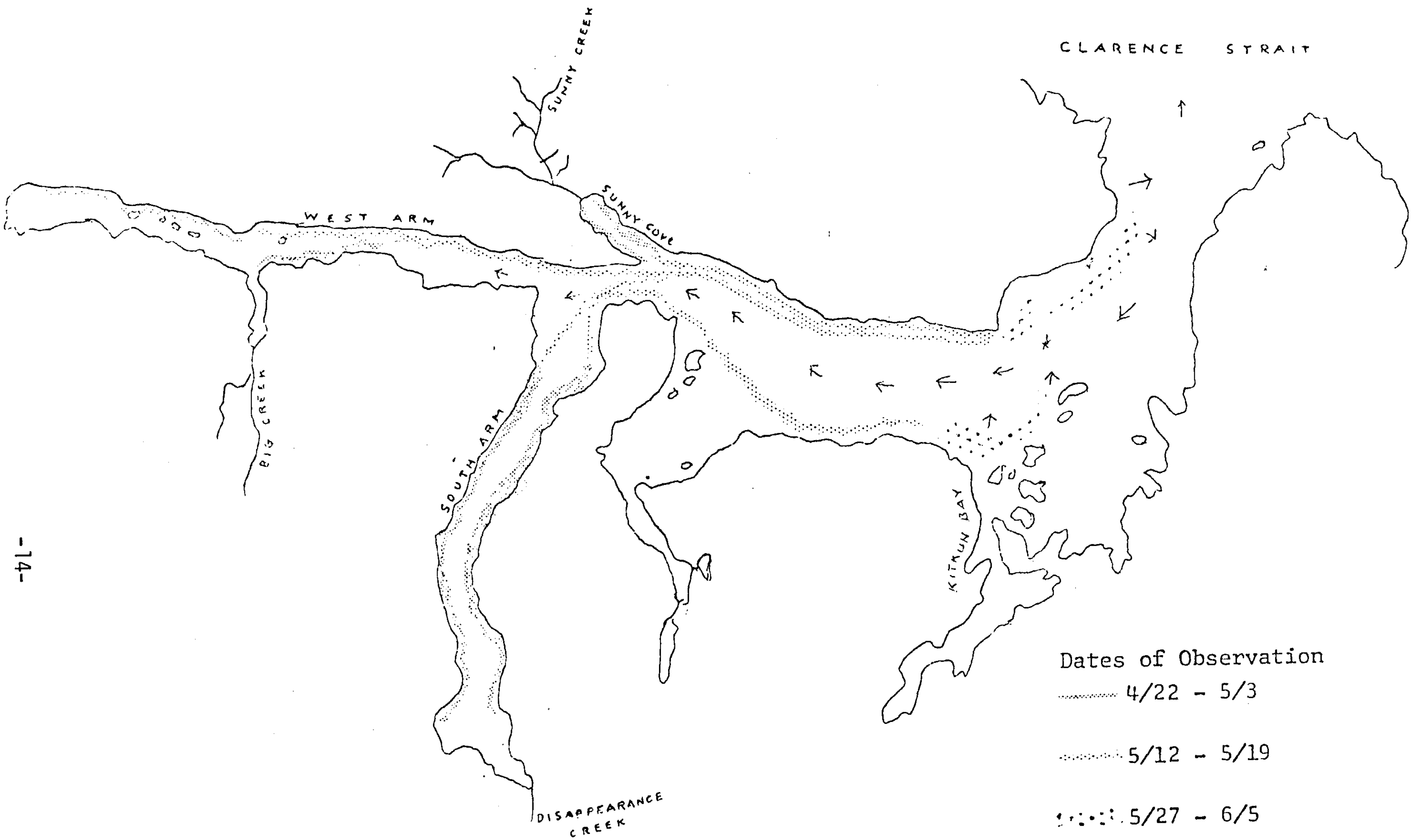

Figure 5. Observed movement of salmon juveniles in Chomley Sound, Prince of Wales Island, March to August 1963.

of predation by predators, population size at various times in the estuary, and causes of any noticeable mortalities. Beach surveys were made weekly by running an open skiff along the Sound's 95 miles of shoreline, for observing the size and distribution of the fry population in the estuary. Also, while the salmon were along the beaches, seining was done to collect specimens for growth and food studies. When the fingerlings moved off the beaches into deeper water, a lampara net was employed to collect specimens and determine the size and position of the population present. An 18' aluminum seine skiff with a power block and a 17' open outboard skiff were used to fish the lampara. The latter skiff was also used to make the beach surveys.

Results

The downstream migration of fry started about the first of March in the streams of Chomley Sound and by the middle of the month approximately 6,000 chum fry were migrating out of the South Arm streams, nightly. However, the migration rate did not reach this level in the West Arm streams until the first of April. Figure 5 shows the progression of these fry as they migrated along the shores of Chomley Sound.

By June first, the downstream migrations were completed and 3,000,000 chum fry had migrated into the South Arm of the Sound; and 2,000,000 chum and 1,260,000 pink into the West Arm of the Sound (Table 3).

By the first week of June, the main body of fingerlings had moved out to the entrance of the Sound, following the shoreline for the most part, and were starting to move offshore. After this date, we were no longer able to trace various segments of the migration from the various streams as the fingerlings were well mixed in the Sound.

Lampara catches showed that the pink salmon fingerlings, for the most part, moved out of the Sound by the 12th of June and were feeding on the outside of Clarence Strait, particularly in the tide rips at the entrance of Chomley Sound. Their movement after this time was undetermined as our equipment did not permit adequate sampling in the open waters of the strait. The chum salmon fingerling, on the other hand, apparently moved both back into the Sound from the entrance where they had congregated the second week of June and also out of the Sound into Clarence Strait with the pink fingerling. The size of these movements was undetermined. Some of the chum fingerling moved back into the Sound as far as the old cannery site at Chomley near where the South and West Arms converge (see Figure 5).

The chum fingerling that moved back into the Sound were intermingled with a few remaining pink and coho fingerlings that had not migrated out of the Sound. They fed in the main section of the Sound until the latter part of August when most of the fingerlings were again out at the mouth of the Sound. After the 25th of August only scattered fingerling could be found in the Sound. These were concentrated in a tide rip where the South and West arms of the Sound converge. Sampling was discontinued after the first of September.

There appeared to be a lessening of mortalities in the fingerling population after they reached approximately 70 millimeters in total length. This was the

Table 3. Outmigration of salmon fry at three streams in Chomley Sound, 1963.

Stream	Pink Fry	Chum Fry
Big Creek	60,000 1/	1,200,000 1/
Sunny Creek	1,200,000 1/	800,000 1/
Disappearance Creek	1,200 2/	3,000,000 2/

1/ Trap estimates

2/ Total weir counts

size at which they moved off the beaches. However, from migration size of 34 mm total length for pink fry and 38-39 mm for chums, until they reach 70 mm, (Table 4), the fingerling fell prey to one possible serious predator, the Shiner sea perch, *Cymatogastor aggregata*, and several minor predators such as the rockfishes, *Sebastodes caurinus* and *S. malinger*, and the Dolly Varden char *Salvelinus malma*. No clupeid predators were observed in the Sound.

The extent to which the Shriner sea perch preyed on the fry in the South Arm of the Sound is unknown at present. However, as their numbers were almost equal to the salmon fry population and they milled in the schools of fry in South Arm it is possible that they were a serious predator on fry there. The South Arm sea perch stomachs examined showed they were primarily invertebrate feeders but the larger specimens almost always contained fry.

At the mouth of Big Creek the sea perch were observed to be a serious predator as were the Dolly Varden char on the downstream migrating fry. In several days observation it appeared that none of the fry migrating downstream during the day, over the mile long tide flat on this stream, were able to get by the voracious Dolly Varden and Shiner sea perch. At the time of observation which was near the peak of the run, between 700-1,000 fry per hour were migrating downstream. On none of the other stream was this heavy predation noticed.

No predators with the exception of *Cottus asper* were observed to feed on the fry migrating from Sunny Creek.

Table 4. Length of salmon fry and juveniles in samples in Chomley Sound, March to August, 1963.

Date	Pink Salmon	Chum Salmon
Average Downstream migration size	34 mm	38-39 mm
June 5	65	71
July 15	82	95
July 31	---1/	127
August 17	---1/	144
August 23	166 2/	162

1/ Only small numbers of pinks were captured at this time. Lengths ranged from 135 to 170 mm. These were probably not average size fingerlings.

2/ Sample collected from Clarence Strait.

PRINCE WILLIAM SOUND PINK AND CHUM SALMON FORECAST STUDIES

INTRODUCTION

This is the third report on forecast studies in Prince William Sound. Results of work on the pink salmon run which returned in 1962 were reported in the Department's Memorandum #5 (November 22, 1961) and that on the 1963 run in Informational Leaflet #21 (January 1, 1963). Techniques employed to forecast the 1964 pink salmon run were basically unchanged from those described in the above reports. Three successive field programs again were used to determine:

(1) Relative abundance of spawners in the 1962 escapement, by district and time,

(2) Relative abundance of pre-emergent fry in stream gravels during March and early April of 1963, and

(3) Relative abundance of early-stage fry along estuary shorelines during May and June, 1963.

A fourth program, employing purse seining during July and August in fiord entrances and Prince William Sound outlets, was again too limited by facilities available to be of value in the forecast.

Background data from research of the U.S. Bureau of Commercial Fisheries and the Fisheries Research Institute, University of Washington, provided escapement and return run information for the period 1939 to 1959, pre-emergent fry abundance data for 1958 and 1959, and estuarine fry abundance for 1956. With these data for comparison, the Department indicated the 1962 pink salmon run would total from 3.0 to 9.8 million, with average expectation 6.4 million according to past escapement-return information. The pre-emergent fry index for 1962 had very limited back data for use in forecasting, but the most reliable forecast was stated as 8.9 million. The estuarine fry index was too new to be of value in forecast. Actual return in 1962 (catch plus observed escapement) was 8.8 million, thus giving credibility to the pre-emergent fry index.

In forecasting the 1963 run, the escapement index in 1961 was the highest ever observed. We had no way of evaluating the reproductive potential of so large an escapement using past escapement-return information. It was simply noted that large escapements in the past had produced total returns from 4.7 to 12.9 million pinks and that the average return was 8.6 million for these large escapements. The pre-emergent fry index led one to be pessimistic, forecasting only 5.0 million from intertidal sampling and 6.4 million from upstream sampling, but this index was recognized as low due to our inability to sample certain upstream areas which have recently become important producers in the odd-year cycle. The estuarine index indicated a very large run of 12.7 million but it was necessarily based upon only one previous return. Actual return in 1963 totaled 6.6 million pink salmon or well below expectations from escapement and estuarine fry indices and slightly above that shown by the pre-emergent fry index. Distribution of the 1963 run in various districts was as predicted, but the Eastern District early runs were weaker than indicated by all indices.

FORECAST INDICES FOR 1964 PINK SALMON RUNS

1. Escapement in 1962

The 1962 run produced the largest even-year catch since 1944 and escapement magnitude was correlated with catch. Total observed escapement in 329 streams surveyed was 2,019,000 pink salmon and the comparable escapement index in 80 major streams was 1,501,000 pinks. Both of these figures exceed those recorded for all previous even-years, but are slightly less than escapement totals in 1961. Distribution of escapement was good, with all district totals, except that of the Southwestern District, exceeding those of recent years. Table 5 gives comparative counts, by district, for the 80 index streams for even-years 1956 to 1962 and for all 329 streams surveyed in 1962.

Table 5. Prince William Sound pink salmon escapements, by management district, 1956-1962.

Management District	Totals for 80 Index Streams Only: 1956	1958	1960	1962	Total for All Streams 1962	(No. of Streams)
EASTERN	470,000	240,100	384,600	508,900	650,700	(100)
NORTHERN	130,700	70,900	108,100	212,200	253,400	(41)
NORTHWESTERN	142,600	148,100	153,100	330,100	417,200	(46)
SOUTHWESTERN	33,500	41,400	82,000	45,200	107,900	(53)
MONTAGUE	66,400	29,900	124,800	210,100	318,200	(46)
SOUTHEASTERN	168,700	53,700	122,400	194,400	271,700	(53)
FWS TOTALS	1,012,800	584,100	975,000	1,500,900	2,019,100	(329)

Note: See Figure 3 for district boundaries. Northwestern district includes Coghill sub-district and Southwestern district includes Eshamy sub-district.

Source: F. R. I., U. of W. 1956, 1958; ADF&G 1960, 1962

The most significant increases from preceding cycle years occurred in the Northern, Northwestern, Montague, and Southeastern Districts. As with all recent even-year runs, the 1962 run consisted primarily of intertidal spawners; foot surveys indicated about 70 percent of the pink salmon spawners selected the intertidal zones.

Timing of the 1962 spawning is indicated in Figure 6 which shows weekly total counts of pink salmon in the 80 index streams with comparable information for 1958 and 1960. After July 7, the numbers of spawners in 1962 exceeded those of the two previous cycle years in all sections of the run. Greatest relative gain occurred from mid-July to mid-August; this reflects significant gains in the early-run and middle-run escapements.

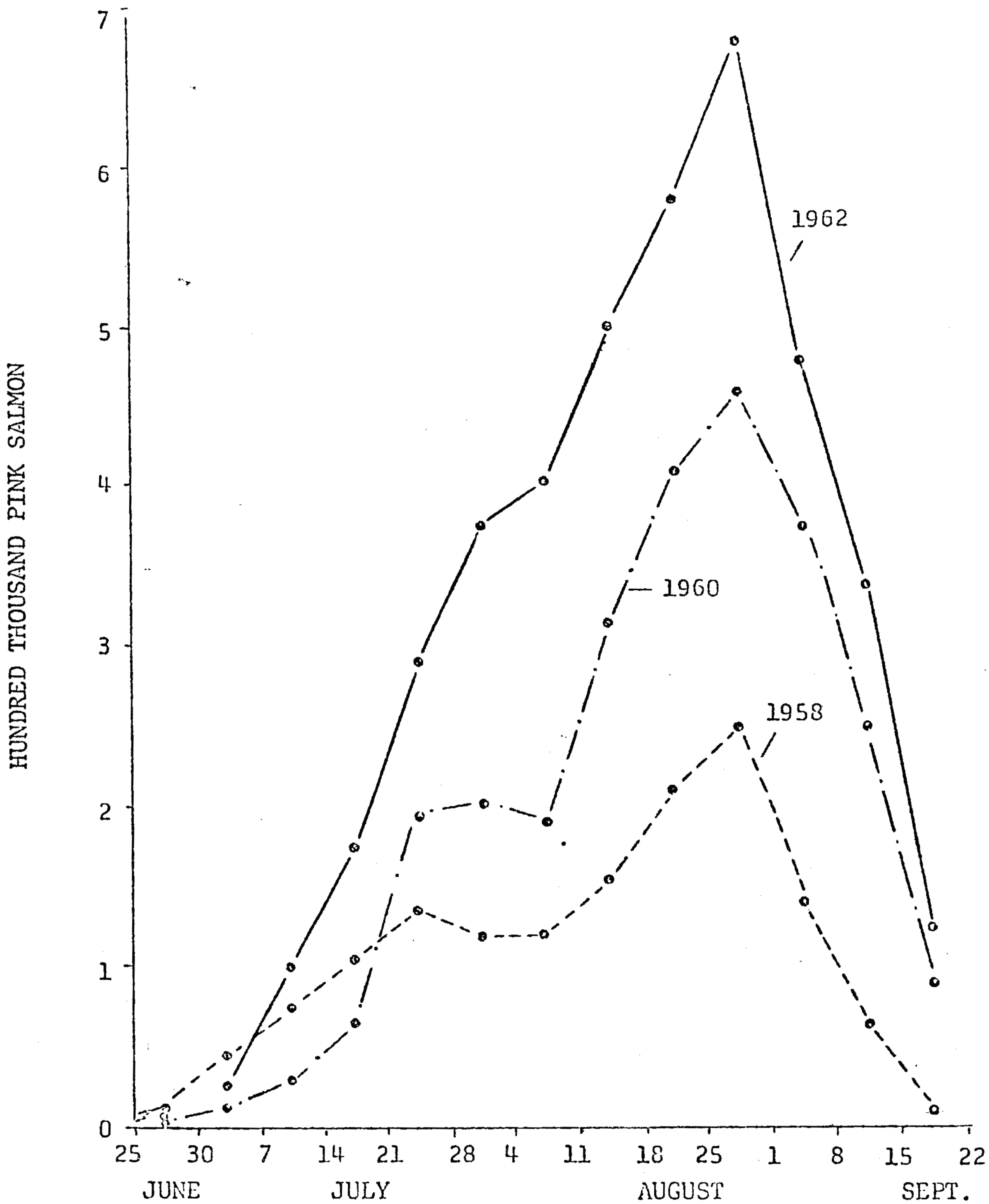

Figure 6. Weekly estimates of live pink salmon in 80 major streams of Prince William Sound, 1958, 1960, and 1962.

The escapement-return run relationship for Prince William Sound pink salmon has shown considerable variability for all periods since escapement data became available. From Figure 7, it is clear that the escapement information from 1939 to 1951 collected by the Bureau of Commercial Fisheries is not comparable to that collected since 1952 by the present observer. The vastly different slopes of the lines fitted to these two groups of data suggest the former observers were far more conservative in estimating numbers of pinks in the escapement.

In relating the 1962 escapement index to probable return in 1964, the relationships established between 1952 and 1963 should therefore be of most value; production from escapements during this recent period indicates the large 1962 escapement should produce a return of from 3.58 to 11.14 million (95% confidence interval) in 1964 with the most probable return of about 7.36 million. The two years with escapements as large as 1962 (1954 and 1961) have given return of less than average size, but too few data exist to establish that these large escapements were above optimum size. We conclude only that escapements above 700,000 on the current index may produce a broad range of returns, with individual returns influenced far less by variations in numbers of spawners than by events in the life history subsequent to spawning.

2. Pre-Emergent Pink Salmon Fry Sampling, Spring of 1963

In the limited history of area-wide pre-emergent fry sampling (1958-1963), the relationship between the fry index and return has been better than that observed between escapement and return. Sampling of the even-year cycle in the springs of 1959 and 1961 revealed a fry increase ratio of 2.78; total return runs in 1960 and 1962, as measured by catch plus total observed escapement, increased by a ratio of 2.75. The even-year escapements from 1952 to 1962 have been predominately (70 to 77%) intertidal spawners. Thus, pre-emergent fry sampling on even-year runs is much simpler and the results more conclusive than odd-year runs, which tend to use more remote upstream zones for spawning. Our forecast for 1964 is therefore based on fry abundance-return relationships established by the 1958-1960 and 1960-1962 cycles.

Techniques of pre-emergent sampling in 1963 varied from previous years in one minor respect; a small portion of the intertidal zones below the half-tide mark which previously had been included in sampling (4' to 6' tide area) was eliminated in 1963. Mortality of eggs in this area has been found to be almost total in previous work. Samples obtained from this area in former years have been eliminated for purposes of comparison with the 1963 samples.

Table 6 summarizes the results of pre-emergent fry sampling in all years. The adjusted fry density is comparable for all years.

Among the data presented in Table 6, the most pertinent and comparable forecast of the 1964 run is that on intertidal zones of major streams. Minor stream sampling in 1958-1959 dealt with a different, less productive group of streams than did sampling in 1961-1963; upstream zone sampling was not conducted prior to 1961. Further, it is questionable whether the fry indices on odd- and even-year stocks are comparable due to wide disparity in proportion of intertidal spawners on the two cycles and the sampling difficulties thereby created.

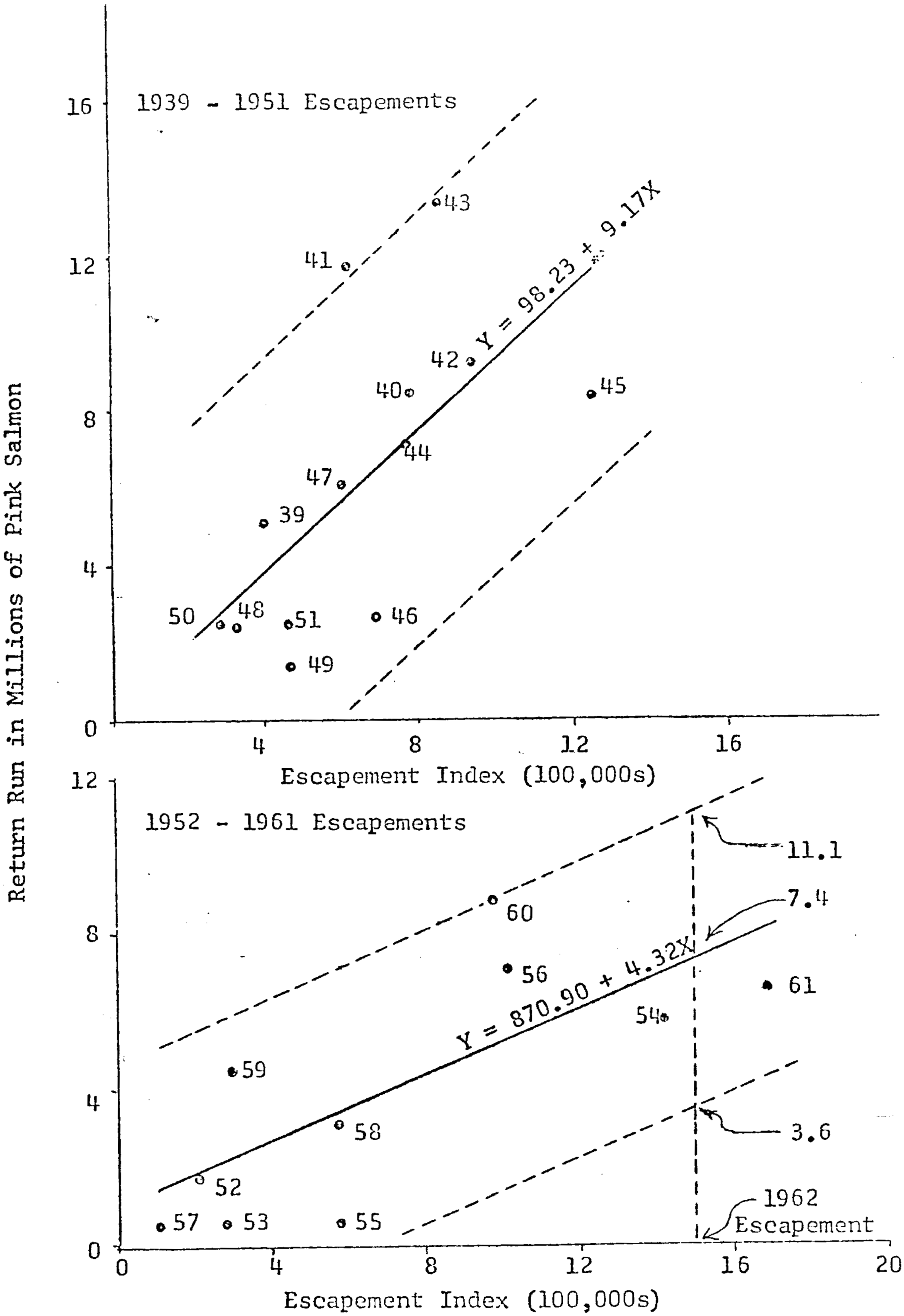

Figure 7. Escapement-return relationships, 80 major stream index, Prince William Sound, pink salmon, 1939-1951 and 1952-1961. Broken lines are 95 percent confidence limits of lines.

Table 6. Results of pre-emergent pink salmon fry sampling, 1958 to 1963 (Prince William Sound).

Sampling Year	No. of Streams	No. of Samples[1]	Mean Fry Density Per Square Foot	Adjusted Fry Density[2]	Percent Error of Means at 90% C.L.[3]
A. INTERTIDAL ZONES, ALL STREAMS SAMPLED					
1958	13	165	1.00	1.10	---
1959	28	453	5.49	6.04	---
1961	29	494	26.52	30.83	± 10.8
1962	31	871	14.42	14.70	± 12.8
1963	38	775	22.92	22.92	± 10.4
B. INTERTIDAL ZONES, MAJOR STREAMS ONLY					
1958	7	90	1.82	2.13	---
1959	9	180	8.48	9.94	---
1961	18	329	23.56	27.61	± 16.1
1962	19	572	13.39	14.60	± 15.9
1963	24	551	19.22	19.22	± 13.2
C. INTERTIDAL AND UPSTREAM ZONES, ALL STREAMS SAMPLED					
1961	29	552	27.06	30.67	± 10.2
1962	31	1114	15.69	16.48	± 10.8
1963	38	1125	23.57	23.57	± 10.9
D. EARLY, MIDDLE AND LATE STREAM GROUPS, ALL ZONES, ALL STREAMS SAMPLED					
EARLY RUN STREAMS					
1961	7	150	19.33	22.87	± 25.4
1962	7	329	13.48	13.81	± 23.2
1963	9	281	25.09	25.09	± 15.2
MIDDLE-RUN STREAMS					
1961	5	105	22.61	26.80	± 27.5
1962	7	247	23.90	24.91	± 19.0
1963	8	261	32.04	32.04	± 15.7
LATE-RUN STREAMS					
1961	17	297	31.82	35.68	± 12.3
1962	17	538	13.28	14.36	± 15.2
1963	21	583	19.04	19.04	± 16.5

1/ Square-yard samples in 1958, 1959 and 1961; 3-square-foot samples in 1962 and 1963.

2/ Samples from 4' - 6' tide stratum eliminated for years 1961 and 1962; adjustment estimated for years 1958 and 1959.

3/ Percentage equivalent of 90% confidence interval, calculated for adjusted means from variation of square-yard and 3-square-foot samples and thus not directly applicable to square-foot means.

Source: 1958-1959, Kirkwood (1962); 1961-1963, ADF&G.

Pre-emergent pink salmon fry abundance in major-stream intertidal zones in the springs of 1959, 1961, and 1963 lead to a forecast of 6.13 million pinks in the total return in 1964. With only two years of background available, the degree of variation or range of return can not be calculated.

Forecasts from other fry indices shown in Table 6 give slightly higher estimates for 1964. This is due to relatively higher densities of fry found in minor streams and upstream areas, than in major stream intertidal zones, during the past three years. The significance of these differences in regard to probable return is not clear at this time. If as suspected, the minor-stream and upstream areas in Prince William Sound are intermittent producers, the current abundance levels noted in them may have an important impact on the return runs of pink salmon.

Part D of Table 6 indicates a most important feature of 1963 pre-emergent sampling. Early-run and middle-run streams had greater fry abundance in 1963 than in either 1961 or 1962, while the late-run stream fry abundance was only about half of 1961 and slightly above that of 1962. Since about 70 percent of the Prince William Sound streams have runs of the late type, their relatively poor production of fry during the current cycle fully accounts for the serious reduction inherent in the 1964 forecast. Our 6.13 million forecast for 1964 represents a one-third reduction from the 8.76 million run of 1962.

Figure 8 summarizes variation of pre-emergent fry abundance during March and April, 1963, in various districts of the Sound[1].

Mean fry densities shown represent combined intertidal and upstream zones where available. Relatively good abundance was evident in Port Wells and Valdez Arm, the two principal early-run areas, and in the Northern and Southwestern Districts where late runs occur. Fry were moderately abundant in late-run areas of northern Montague Island, the Southeastern District and at Sheep Bay. Except for one small upstream area in Landlocked Bay, Port Fidalgo streams had very poor fry abundance. The off-year run at Coghill River gave poor indications, as expected. No streams in Port Etches were sampled, but subsequent observations on estuarine fry abundance indicated good production.

3. Estuarine Fry Observations, May and June, 1963

Three surveys of bay and estuary beaches, in marked counting sections established in 1961, were accomplished between April 29 and June 9, 1963. In addition to the seven estuaries surveyed in 1961, sampling was also done in Port Fidalgo, Port Valdez, College Fiord, Culross Passage, and Dangerous Passage in 1963 (see Figure 9). A total of 80 nautical miles of shoreline was observed in 1963. Visual estimates were taken from an elevation of 10 feet from the bow of an 18-foot outboard skiff. Weather conditions were somewhat poorer during the survey period of 1963 than was the case in 1961 and 1962. Dip net and beach seine samples were obtained from various populations observed to establish species composition, size, and condition factor.

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[1] Including sampling in Olsen Creek, Port Gravina by the Bureau of Commercial Fisheries.

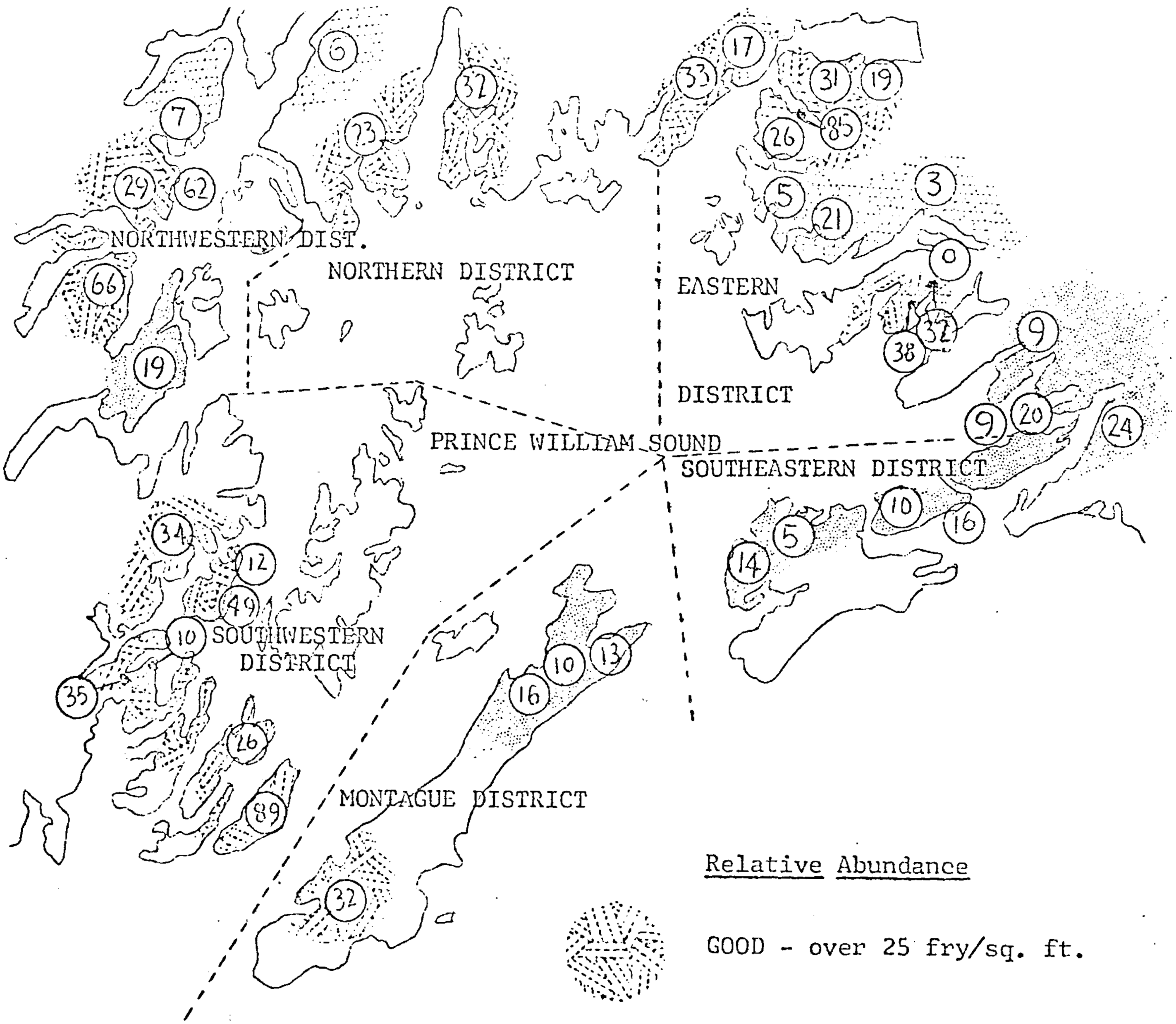

Figure 8. Mean pink salmon fry per square foot in 39 streams sampled in March-April, 1963 and general pattern of abundance by district.

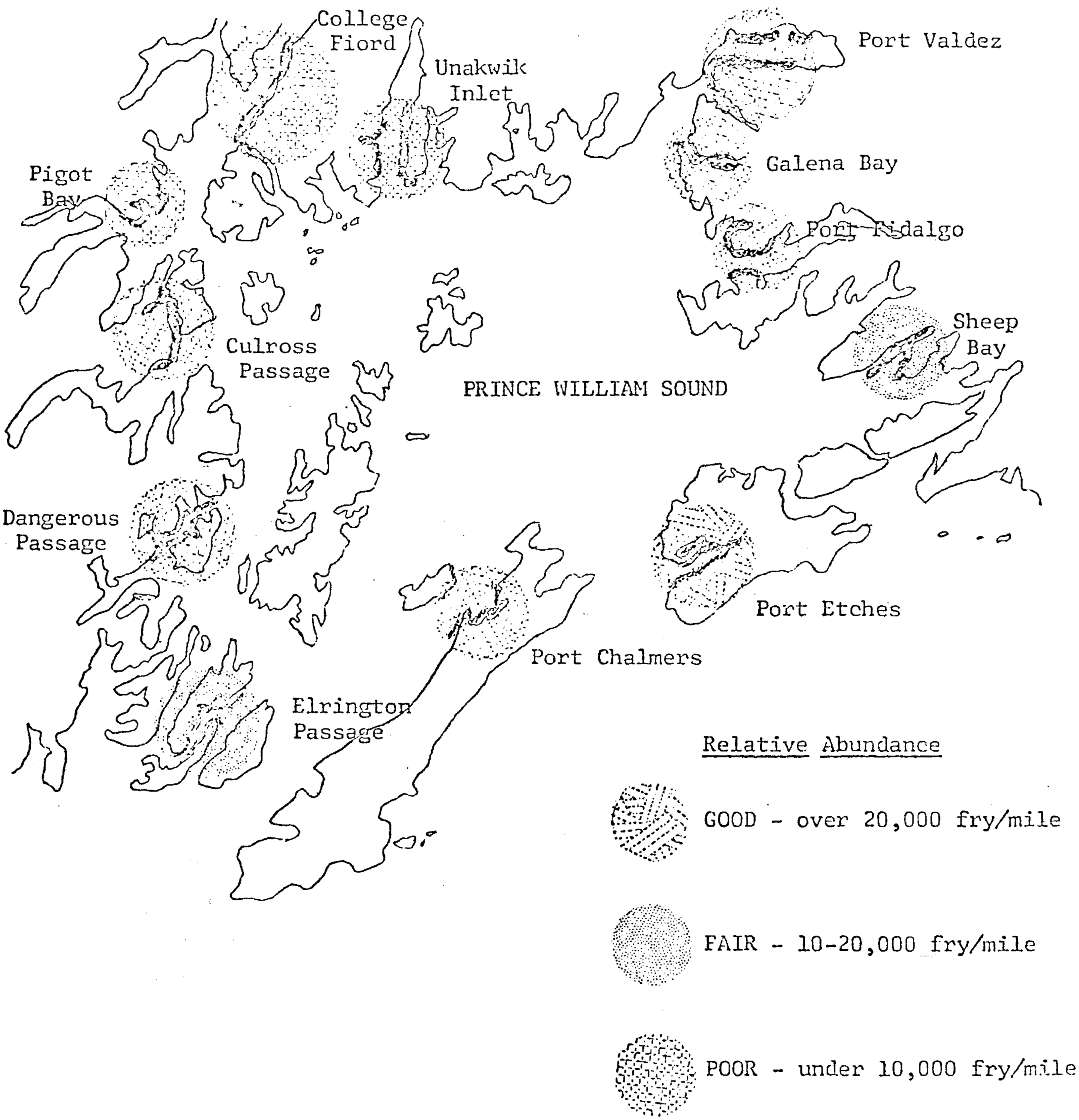

Figure 9. Location of estuarine sampling areas and relative abundance of pink salmon fry, May-June, 1963.

The results of the 1963 survey are shown in Table 7 in terms of average pink salmon fry per mile in each estuary, with comparisons to observed densities in 1961 and 1962. Poor to fair fry densities were recorded in all areas except Port Etches. The sum of 1963 peak counts in the seven estuaries observed for three years was only 55 percent of the count in 1961 and 39 percent of the count in 1962.

Outmigration from streams in 1963 was later than that noted in 1961 and quite similar to the timing in 1962. The later outmigration was manifest in relatively late abundance peaks along the shorelines and poor condition of fish. As noted in Table 7, peak counts in most estuaries occurred in late May or early June. Techniques described by Sheridan and Noerenberg (1963) were used to monitor relative robustness of fry in 1963. Length-volume relationships on both downstream migrants and small fry in estuaries in 1963 were relatively poor in comparison to 1961 fry but very similar to 1962 fry. These differences may in part explain the disparity in rate of return from estuarine fry populations observed in 1961 and 1962.

The relationship of the estuarine index to return run, as applied to the Sound as a whole, has been poor in its limited history. Relationships between fry and return-run abundances in individual bays has been variable in their efficiency for forecast use as indicated in Table 8. With no clear-cut correlation of fry and returning adults yet apparent, we can not interpret the poor estimates of estuarine fry in 1963 with any certainty. Averaging of rates of return for the past two years plus similar data from 1956[1], yields a 2.97 million estimate for the 1964 pink salmon run, with observed variation indicating a range of 1.45 million to 4.85 million pinks.

4. Forecast Summary for 1964 Pink Salmon Run

Forecast material on the Prince William Sound 1964 pink stocks is shown in Figure 10 and can be summarized as follows:

(a) Three abundance checks were made to further establish which point in the life history can be used most efficiently for forecast.

(b) Escapement index in 1962 was the largest on record for an even-year with excellent distribution in all districts. Escapement-return data since 1952 are more comparable with the present index than earlier data but they reveal that a wide variation in return is possible for any escapement index level above 700,000. An average return in 1964 would yield 7.36 million pinks but return may range from 3.58 million to 11.14 million.

(c) Pre-emergent fry sampling in March and April 1963 indicated freshwater mortalities were moderately severe and forecasted a 1964 run of 6.13 million pinks. The late or main-run streams suffered the

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[1] Unpublished data from Fisheries Research Institute, University of Washington.

Table 7. Pink salmon fry abundance estimates in the estuaries of Prince William Sound, 1961 to 1963.

Estuary	Year	Mean Miles Sampled	Mean fry per nautical mile, by survey period: Apr.-May 29 - 9	May 10 - 19	May 20 - 29	May-June 30 - 9	June 10 - 19	Ratios of Peak Estimates 1963/1961
*SHEEP BAY	1961	9.0	1,800	21,200	19,300	1,500	1,700	
	1962	8.9	2,300	27,100	61,100	35,600	5,900	
	1963	7.7	800	5,600	12,400	4,200	---	0.58
PORT FIDALGO	1963	3.0	300	1,500	---	---	---	
*GALENA BAY	1961	8.0	30,100	---	16,000	---	200	
	1962	9.3	4,800	---	22,000	---	1,600	
	1963	6.7	700	8,600	---	3,200	---	0.29
PORT VALDEZ	1962	5.7	5,000	---	6,600	---	---	
	1963	5.3	1,200	1,300	---	---	---	
*UNAKWIK INLET	1961	7.3	42,100	---	17,600	---	14,500	
	1962	7.8	1,900	---	3,800	---	1,200	
	1963	8.5	5,000	6,600	---	7,100	---	0.17
COLLEGE FIORD	1962	6.0	1,100	---	---	---	---	
	1963	3.4	40	300	---	---	---	
*PIGOT BAY	1961	5.3	3,700	---	1,700	---	600	
	1962	4.6	10,700	---	24,300	---	1,000	
	1963	4.5	400	---	7,300	---	---	1.97
CULROSS PASSAGE	1963	6.3	1,400	---	3,200	---	---	
DANGEROUS PASS.	1963	7.0	2,600	---	4,600	---	700	
*ELRINGTON PASS.	1961	9.1	6,200	---	---	---	12,200	
	1962	8.9	800	---	13,600	---	20,100	
	1963	7.5	4,600	---	11,700	---	11,400	0.95
*PORT CHALMERS	1961	7.5	32,100	---	22,200	---	21,900	
	1962	7.3	3,800	---	27,300	---	13,300	
	1963	6.7	4,800	---	6,300	---	7,300	0.23
*PORT ETCHES	1961	4.0	8,800	---	---	---	3,300	
	1962	6.5	16,400	---	52,600	---	---	
	1963	6.6	10,800	---	24,900	---	28,300	3.22
*SUM OF PEAK ESTIMATES, 7 ESTUARIES	1961	50.2		150,400				
	1962	53.3		211,200				
	1963	48.2		82,700				0.55

Table 8. Ratios of population densities at estuarine fry and adult-return phases of 1962 and 1963 pink salmon runs.

SAMPLING AREA	PINK FRY RATIOS 1962/1961	ADULT RETURN RATIOS 1963/1962
SHEEP BAY	2.89	1.86
GALENA BAY	0.73	0.35
UNAKWIK INLET	0.09	0.07
PIGOT BAY	6.52	0.62
PORT CHALMERS	0.85	1.62
PORT ETCHES	5.97	2.05
AVERAGE OF ALL SAMPLING AREAS AND TOTAL PWS RETURN RATIO	1.40	0.74

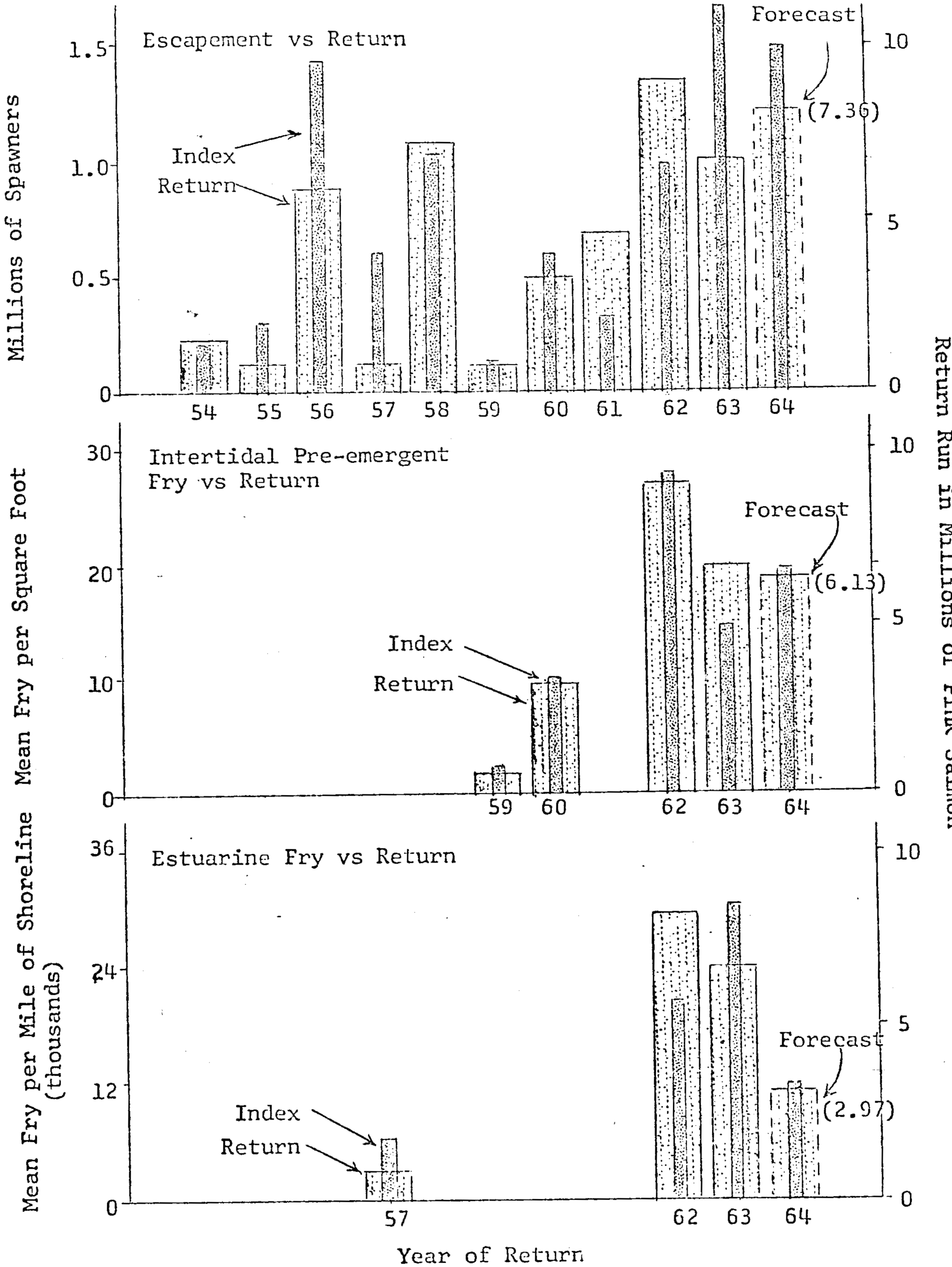

Figure 10. Comparison of three forecast indices and corresponding return runs, pink salmon, 1954 to 1963, with three estimates of 1964 run based upon these indices (Prince William Sound).

most severe mortalities while early-run and middle-run streams contained more fry than during the previous two years.

(d) Estuarine fry sampling gave only poor to fair indices in all areas except Port Etches. Relative abundance in 1963 compared to previous years suggests a 2.97 million run in 1964 but performance of this estuarine index has been extremely poor in past forecasts.

(e) The most efficient index available for forecast is that on pre-emergent fry and we conclude therefore that 6.13 million is the best estimate for 1964. Also reflected from this sampling is that early and middle runs will improve over 1962, yielding some improvement in the July catch from stocks bound for Port Wells and Valdez Arm. It is also evident that the August 1964 catch will decline seriously from that of 1962, the loss probably totaling about 2 million pinks.

FORECAST INFORMATION FOR 1964 CHUM SALMON RUN

Chum salmon have accounted for 15 percent of the commercial catch and 26 percent of the case pack in Prince William Sound since 1950. Variations from this average catch have ranged from 9 to 49 percent of the Sound catch. Chums are closely associated with pink salmon in both the spawning grounds and estuarine rearing areas. The pre-emergent fry sampling phase of forecast research has been gradually modified to include certain key chum streams where sampling of pinks was not already being conducted.

Age analysis by Thorsteinson, Noerenberg, and Smith (1963) on chums of this area from 1952 to 1958 indicated average age composition of runs was 13 percent 3-year-olds, 75 percent 4-year-olds and 12 percent 5-year-olds. Helle (1960) found that 3-year-olds made up 50 percent of the run in 1959. Age analysis on the 1963 runs by the Department of Fish and Game also revealed an unusually high proportion of 3-year-olds: 41 percent 3s, 49 percent 4s, and 10 percent 5s. The 1964 run will thus be the second phase of the return from the Department's first year of young fish sampling in 1961. The appearance of 540,000 3-year-olds in 1963 shows unusual strength of the offspring population produced from 1960 spawning, and confirms the finding from young fish studies reported below. No clear relationship has been shown between numbers of 3-year-olds in one year and numbers of 4-year-olds the following year, but other information suggests a large chum run may occur in 1964.

1. Historic Population Trends

Abundance peaks in pink salmon in the 1930s and 1940s were accompanied by similar abundance peaks in chum salmon about two years later. Very high reproduction rates were manifest in 1961 and 1962 returns of pink salmon and in the 1962 and 1963 returns of chum salmon. This pattern suggests a strong chum salmon run in 1964.

2. Recent Escapement Trends in Chum Salmon

A summary of chum salmon escapement counts by management district, from 1956 to 1962, is presented in Table 9. Except in 1959, the escapement surveys in all years shown were extensive on the approximately 160 streams which contain chum spawners. The 1960 escapement, which should be the most important contributor to the 1964 run, was of intermediate size. The Eastern District contained about 45 percent or a normal proportion of the spawners. Distribution was fair among streams of the other districts.

No clear relationship is evident between escapements in the period 1952-1959 and the return runs produced. As shown in Table 10, which has been developed from the limited age analysis available, some of the smaller escapements have produced the largest returns, but variation in escapement level was relatively limited in this brief period.

3. Results of Pre-Emergent Chum Salmon Fry Sampling

Pre-emergent fry sampling in 1958 and 1959 was less applicable to chum salmon forecast than work in 1961, 1962, and 1963 because so little sampling was accomplished in major chum streams. It is probable that this explains the apparent lack of correlation between fry densities in these two years and the subsequent returns; while 1959 samples of fry indicated a severe decline from 1958 abundance, the return runs from 1959 were nearly twice the returns from 1958. In Table 11 is shown the results of sampling in only those streams normally carrying major chum spawning populations with a breakdown by early, middle, and late stream types.

From Table 11 we note that chum salmon fry densities in early streams, middle streams and for the total samples were greater in the spring of 1961 than in any other year of sampling. The majority of fry observed in 1961 should return as adults in 1964. It is felt that fair reliability can be placed on sampling beginning in 1961 and thus that large early and middle runs of chums will occur in 1964. Galena Bay, Olsen Bay, and Sheep Bay in the Eastern District and Macleod Harbor in the Montague District had the highest fry densities; we would expect these locations to have some of the best runs in the Sound. However, until two more years pass, we will be without a direct comparison of fry abundance versus adult return and cannot accurately forecast numbers in the return until that time.

4. Estuarine Sampling

Beach surveys of young chum salmon in the estuaries revealed relatively high abundance of fry in six of seven areas examined in 1961. This was especially true in the mainland area, Sheep Bay, Galena Bay, Unakwik Inlet, and Pigot Bay, where 4-year-olds nearly always dominate the return. In the three island areas, Port Chalmers, Port Etches, and Elrington Passage, abundance of chum fry in the estuaries was higher in 1962, but 3-year-olds are commonly very important in the return to these late-run areas. These results support the indications from pre-emergent sampling that 1964 adult runs should be relatively large.

Table 9. Chum salmon escapements, by management districts, 1956-1962 (Prince William Sound).

MANAGEMENT DISTRICT	1956	1957	1958	1959	1960	1961	1962
EASTERN	100,200	161,500	42,400	35,100	92,100	118,000	238,700
NORTHERN	46,000	33,200	12,300	4,000	24,700	50,400	67,700
NORTHWESTERN	64,500	46,200	10,500	107,100	40,500	70,900	96,000
SOUTHWESTERN	4,900	5,300	4,400	1,300	4,800	4,800	10,600
MONTAGUE	4,900	9,700	7,000	3,500	16,800	34,400	34,200
SOUTHEASTERN	17,100	13,500	9,200	6,700	23,000	59,900	39,700
PWS TOTAL	237,600	269,400	85,800	157,700	201,900	338,400	486,900

SOURCE: F.R.I., U. of W., 1956-1958; U.S.F.W.S. 1956-1959; A.D.F.& G., 1960-1962

Table 10. Chum salmon escapements and returns, by age class, in Prince William Sound, 1952 to 1963.

ESCAPEMENT YEAR	ESCAPEMENT INDEX	ADULT RETURN AT AGE: 3 YEARS	4 YEARS	5 YEARS	TOTAL RETURN
1952	150,000	22,000*	653,000	206,000	881,000
1953	200,000	83,000	704,000	60,000	847,000
1954	300,000	66,000	595,000	22,000*	683,000
1955	200,000	118,000	57,000*	76,000	251,000*
1956	238,000	79,000*	371,000	73,000*	523,000
1957	269,000	137,000	357,000*	179,000	673,000*
1958	86,000	132,000*	877,000	131,000	1,140,000
1959	158,000	323,000	639,000	?	
1960	202,000	541,000	?	?	
1961	338,000	?	?	?	

* Returns based primarily on escapement index due to lack of fishery, and therefore are low estimates.

Table 11. Results of pre-emergent chum salmon fry sampling in major chum streams, 1958 to 1963 (Prince William Sound).

Sampling Year	Number of Streams	Number of Samples 1/	Mean Fry Density per square foot	Percent Error of Means at 90% Conf. Level 2/
A. EARLY-RUN STREAMS				
1958	3	23	0.20	---
1959	4	40	0.28	---
1961	6	93	8.03	± 44.2
1962	6	220	2.57	± 46.8
1963	7	202	4.51	± 30.5
B. MIDDLE-RUN STREAMS				
1958	2	14	5.40	---
1959	4	40	0.59	---
1961	7	89	9.60	± 42.5
1962	6	153	7.34	± 40.1
1963	7	219	4.38	± 40.1
C. LATE-RUN STREAMS				
1958	1	7	0.02	---
1959	6	59	0.34	---
1961	4	46	2.33	± 96.8
1962	5	136	1.12	± 76.0
1963	4	136	7.61	± 39.2
D. ALL MAJOR CHUM SALMON STREAMS COMBINED				
1958	6	44	1.83	---
1959	14	139	0.40	---
1961	17	228	7.49	± 29.0
1962	17	509	3.62	± 29.3
1963	18	557	5.21	± 21.4

1/ Includes only areas sampled above 6-foot tide level of intertidal zones plus upstream zones; square-yard samples in 1958, 1959 and 1961, 3-square-foot samples in 1962 and 1963.

2/ Percentage equivalent of 90% confidence interval, calculated from variation of square-yard and 3-square-foot samples and thus not directly applicable to square-foot means.

5. Forecast Summary for 1964 Chum Salmon Run

Based upon observed variations in actual runs, the 1964 runs should approach historic maximum levels of over 1.0 million in total. Chums appearing in the Sound in late June and early July will form the bulk of the run. Stocks of the Eastern District, primarily those spawning in Valdez Arm, Port Gravina, and Sheep Bay will be the most important elements in the run. Fair to good runs will appear in the Northern District at several locations, especially Wells Bay in the Northwestern Sound at Coghill River and Port Wells and in the Montague District at Macleod Harbor and Port Chalmers.

COOK INLET PINK SALMON FORECAST STUDIES

1. Pre-Emergent Fry Sampling, 1963

In the spring of 1963, the first sampling of pre-emergent pink salmon fry was completed in Cook Inlet. The ten major pink salmon streams on the lower Kenai Peninsula were selected for the sampling (see Figure 11). Table 12 lists the streams, sampling dates, sample number, and average numbers of pink fry per square foot.

Densities of fry found in the sampled streams agreed closely with those reported for both the Prince William Sound and Kodiak area pink salmon streams. From these limited data, indications are that the pink salmon return to the sampled streams will be in the good to very good range.

2. Catch and Escapement, 1962

The 1962 pink salmon catch and escapement was one of the best on record for the Cook Inlet area. Approximately 4,960,000 pink salmon were taken in the entire Cook Inlet area by commercial gear. Of this total, 2,004,065 were harvested from the region encompassed by the sampling program.

Both catch and escapement figures are listed in Table 13. Catch is listed by statistical area (Figure 11) and escapement is entered for the stream or streams found in the particular statistical area. Escapement figures are peak aerial counts, therefore are conservative estimates of the total actual escapement.

KODIAK PINK SALMON FORECAST STUDIES

INTRODUCTION

The 1960 Kodiak area pink salmon escapement produced in 1962 the largest even-year pink catch on record of 14,100,000 pinks or 565,000 cases. Furthermore, the escapement in 1962 appeared to be greater than any previous even-year level observed in Kodiak by personnel of the Fisheries Research Institute since the beginning of their systematic aerial stream survey program in 1952 (Bevan 1953, 1954, 1956, 1958[1], 1962[1]),(Tyler 1960).

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[1] Personal communication

Table 12. Cook Inlet area pink salmon pre-emergent fry sampling, spring, 1963.

No.	Stream	Date	Sample Points	Pink fry/sqare ft.
1	Humpy Creek	March 26	65	11.0
2	Tutka Lagoon Creek	April 4	13	13.0
3	Seldovia River	April 5	28	21.5
4	Port Graham River	April 13	45	26.0
8	Island Cr. (Port Dick)	April 19	30	10.5
10	Port Dick Creek	April 19	25	22.3

Table 13. 1962 pink salmon catch and escapement in southern Cook Inlet statistical areas (Kachemak Bay to Port Dick), 1962.

Stat. Area	Stream	Catch	Peak Escapement
241-11		2,588	
241-12		11,693	
241-14		73,930	
241-15	Humpy Creek, China Poot	35,500	56,000
241-16	Tutka Bay Lagoon	257,161	30,000
241-17	Seldovia River	142,776	50,000
241-20	Port Graham River	10,415	50,000
241-30		7,729	
241-40		374	
242-10	Portlock	95,741	3,000
242-20		16,148	
242-31	Rocky Bay River	198,686	200,000
242-32	Windy Bay (2 streams)	63,209	25,000
242-41		22,962	
242-42	Port Dick (3 streams)	1,043,236	55,000
242-43		33,066	
	TOTAL	2,004,065	469,000

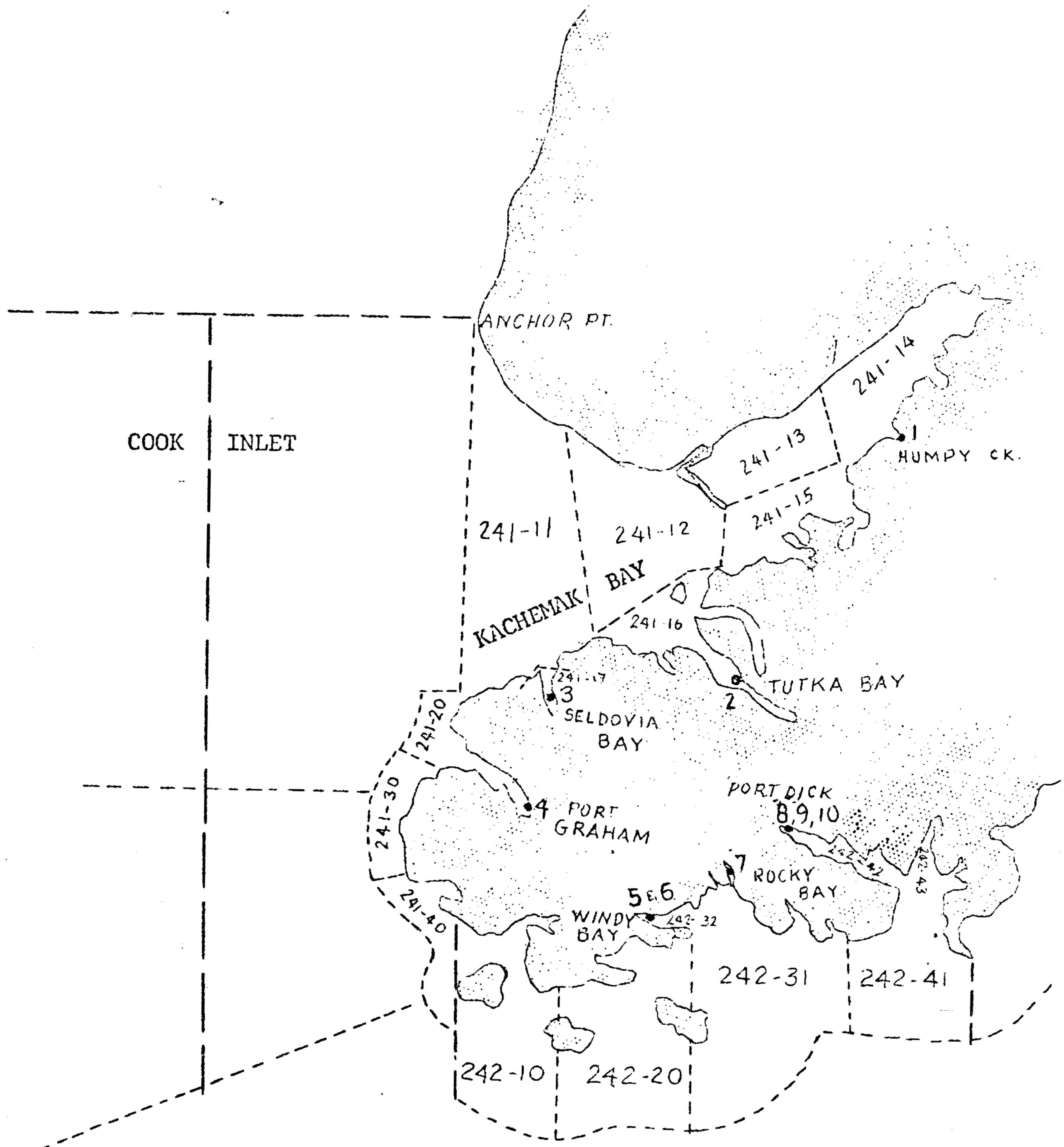

Figure 11. Cook Inlet statistical areas and pink salmon study streams.

If large escapement levels always produced large runs, then the run in 1964 might yield the highest pack in the history of the Kodiak canning industry. However, freshwater, estuarine, and ocean survivals fluctuate considerably and cause differential returns from similar escapement levels. Because of these fluctuating levels of survival, data are being collected in the Kodiak area by pre-emergent fry sampling which may yield a reliable prediction of the annual pink salmon run in the Kodiak area. This program is very similar in methods and objectives to that conducted by Noerenberg in Prince William Sound (1963). However, sufficient data are not yet available in Kodiak from pre-emergent fry densities for an accurate, reliable prediction.

In this report three types of data will be analyzed to see if we can at least approximate in general terms the magnitude of 1964's pink salmon run.

I. Indexed Escapements and Returning Run

Spawning peak aerial counts of twenty-five pink salmon producing index streams in the Kodiak area are listed in Table 14. Peak counts were estimated by the same observer (Bevan 1952 to 1958, and 1962) except in 1960 (Tyler). Assuming that these counts represent comparable pink salmon escapement levels in various districts in the Kodiak area then the following five conclusions may be stated.

1. The 1962 Karluk River escapement of 800,000 was similar to the escapement in 1952 of 700,000 that yield approximately 2.5 million pinks in the adjacent fishery.

2. Peak aerial counts in Red River have fluctuated tremendously. The peak count of 1,100,000 spawners occurred in 1962.

3. Escapements in the Alitak and General Districts have been building up rapidly from 125,000 in 1952 to 800,000 in 1962.

4. Uganik-Terror Bay District escapements have remained relatively constant.

5. The Uyak District escapements, after dropping from 345,000 in 1952 to a low of 56,000 in 1956, have increased to 120,000 in 1962.

No linear relationship appeared to exist between summed peak counts of the twenty-five index streams and the estimated total returning run two years later (Table 15). Total returning run was estimated by adding the total catch in the Kodiak area to the sum of the peak escapement counts of the same year.

The larger 1954 indexed escapement returned fewer fish in 1956 than the lower indexed escapements of 1958 and 1960. Two factors that may have caused these differences were: (1) estimates of peak counts did not reflect actual level of escapement or (2) differential survival.

Peak counts of pink salmon observed in index streams of six districts (Table 16) were summed and compared to the estimated total returning run two years later to the same six districts. Total returning run was estimated by summing the catch and indexed escapement in the selected districts. In this instance, a rather loose linear regression results (Figure 12) ($r = .58557$) with $\overline{Y}_X =$ 6,883,400 + 6.32 (x-1,022,600). The test for independence, using the formula

Table 14. Escapement levels of 25 Kodiak area streams 1952-1962.

District	Number of Streams	1952	1954	1956	1958	1960	1962
Karluk	1	700,000	250,000	210,000	375,000	325,000*	800,000
Sturgeon	1	190,000	152,000	250,000	55,000	25,000	40,000*
Red River	1	400,000	700,000	875,000	200,000	200,000	1,100,000
Alitak	4	56,000	157,000	135,000	285,000	438,000	525,000
General	8	69,000	94,000	41,000	63,000	269,000	275,000
Afognak	5	99,000	58,000	25,000	45,000	72,000	149,000
Uganik-Terror	2	135,000	130,000	32,000	42,000	123,000	130,000
Uyak	3	345,000	210,000	56,000	66,000	111,000*	120,000
TOTALS	25	1,994,000	1,751,000	1,624,000	1,131,000	1,563,000	3,139,000

Note: Mainland districts not included.
Source: Bevan (1953, 1954, 1957, 1958, 1962)
Tyler (1960)
* ADF&G Surveys

Counts represent peak aerial estimates, not actual escapement.

Table 15. Estimated total returning runs from indexed escapement levels even-year cycles, 1954-1962 (Kodiak).

Year of Return	Parent Indexed Escapements	Catch	Estimated Total Run
1954	1,994,000 (52)	8,439,000	10,190,000
1956	1,751,000 (54)	3,319,000	4,943,000
1958	1,624,000 (56)	4,039,000	5,170,000
1960	1,131,000 (58)	6,800,000	8,363,000
1962	1,563,000 (60)	14,113,000	17,252,000
1964	3,139,000 (62)	?	?

Source: Bevan (1953, 1954, 1957, 1958, 1962) Simpson (1960) ADF&G Surveys (1960-1962)

Table 16. Estimated total returning run from pink salmon escapement indices in six districts in the Kodiak area.

Year of Return	Indexed Parent Escapement	Catch in Six Districts	Percent of Total Catch	Estimate Total Run in Six Districts
1954	1,404,000	6,946,000	82	7,845,000
1956	899,000	2,582,000	78	3,082,000
1958	500,000	3,453,000	85	4,329,000
1960	876,000	5,808,000	85	7,182,000
1962	1,374,000	10,049,000	71	11,979,000
1964	1,930,000			

Number of streams included - 22
Districts included - Karluk, Alitak, General, Afognak, Uganik-Terror, and Uyak

Source: Bevan (1953, 1954, 1957, 1958, 1962)
Tyler (1960)
Simpson (1960)
ADF&G Surveys 1960-1962

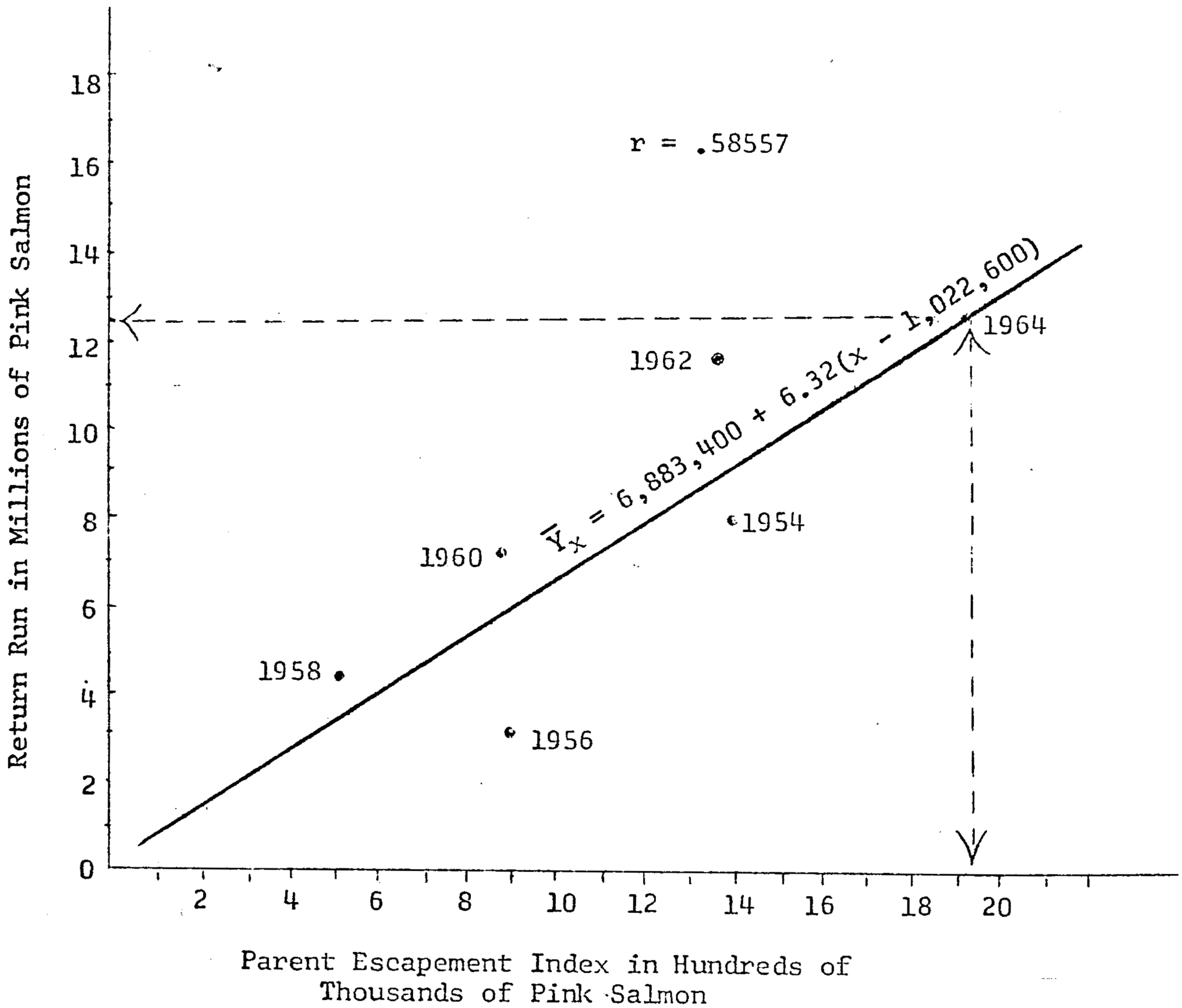

Figure 12. Correlation of escapement and return runs of pink salmon in six districts of the Kodiak area, even-years, 1952-1962.

$$t = \frac{(b-o)S_x\sqrt{n-1}}{S_y(x)}$$ indicates returning run Y is dependent on the escapement x

at the 80% level of significance.

Our prediction of the 1964 run will be accurate if the following assumptions are satisfied by the data in Table 16.

1. Peak counts from the index streams represent escapement levels.

2. Variation in the returning run originating from similar escapement indices is caused by differential survival.

3. The returning run in 1964 will not have experienced higher or a lower mortalities per se than those affecting the 1952-1962 even-year runs.

4. The six districts in Table 16 will contribute 85% of the total returning run. If mortality is within the statistical range calculated from the regression and these six districts contribute less than 85%, then the estimated range of the 1964 run should be higher. If our six districts contribute more than 85% of the total return then the estimated range should be lower.

We can now calculate the returning run on the basis of these six districts contributing 85 percent of the total return. At the 80% confidence level the 1964 Kodiak pink salmon run should be in the neighborhood of 14,800,000 but can go as low as 8,300,000 or as high as 21,300,000. The run in 1964 can be expected to be at least fair with an excellent possibility of being good.

II. Pre-Emergent Fry Densities

Noerenberg (1961, 1963) accurately forecast the 1962 and 1963 pink salmon runs in Prince William Sound on the basis of the relationship that existed between mean pre-emergent fry densities and returning adult runs. A similar program is being carried on in the Kodiak area but sufficient data are not yet available to determine whether a relationship exists between pre-emergent fry densities and the adult run. Twenty streams were sampled in the spring of 1963 and these densities are presented in Table 17 along with densities obtained from lesser sampling in previous years. See Figure 13 which indicates the location of streams sampled in the spring of 1963.

It is apparent that mean fry densities obtained from the various systems in the spring of 1963 varied considerably from stream to stream. Several things were noticed during this sampling that are worthy of mention and may nor may not effect the returning runs.

1. Sampling at Red River indicated that 8 percent of the fry excavated were dead.

2. Sampling at Portage Creek (Perenosa Bay) indicated that 22 percent of the fry excavated were dead.

Table 17. Results of pre-emergent pink salmon fry sampling in Kodiak area streams, 1963, and comparative densities from sampling during March and April, 1961 and 1962.

Stream	1963 Sampling Program: Dates Sampled	No. of Samples	Fry Recovered	Density of Fry (per square foot): 1961	1962	1963
Buskin River	March 4-5	75	5,100	----	2.3	34.0
American River	March 6-7	150	3,381	---	---	11.3
Sid Olds Creek	March 8-9	155	2,302	---	---	7.4
Kaiugnak Lagoon Creek	March 14	30	2,406	---	56.1	40.1
Narrows Creek	March 16	40	2,771	---	---	34.6
Seven Rivers	March 17-18	50	1,280	---	12.6	12.8
Saltery Cove Lake Creek	March 23	70	685	---	5.0	4.9
Paramanof Creek (S. Arm)	March 17-18	50	492	---	---	5.4
Afognak River	March 25-26	60	2,612	---	---	21.8
Sharatin Creek	March 29	35	732	---	---	10.5
Kazakof (North) Creek	March 30-Apr 1	80	2,513	---	---	15.7
Baumans Creek	April 1	50	709	---	---	7.1
Uganik River	April 2	70	1,960	---	---	14.0
Terror River	April 3	70	609	---	---	4.4
Portage Creek (Perenosa)	April 4-5	50	4,710	---	---	47.1
Zacher River	April 4	30	718	---	---	12.0
Browns Lagoon	April 4	20	565	---	---	14.0
Red River	April 9-11	150	8,316	---	---	25.4
Frazer River	April 12-14	150	4,320	---	---	14.4
Big Kitoi Creek	April 16	20	668	46.4	61.5	16.7
	TOTAL	1,405			MEAN	14.98

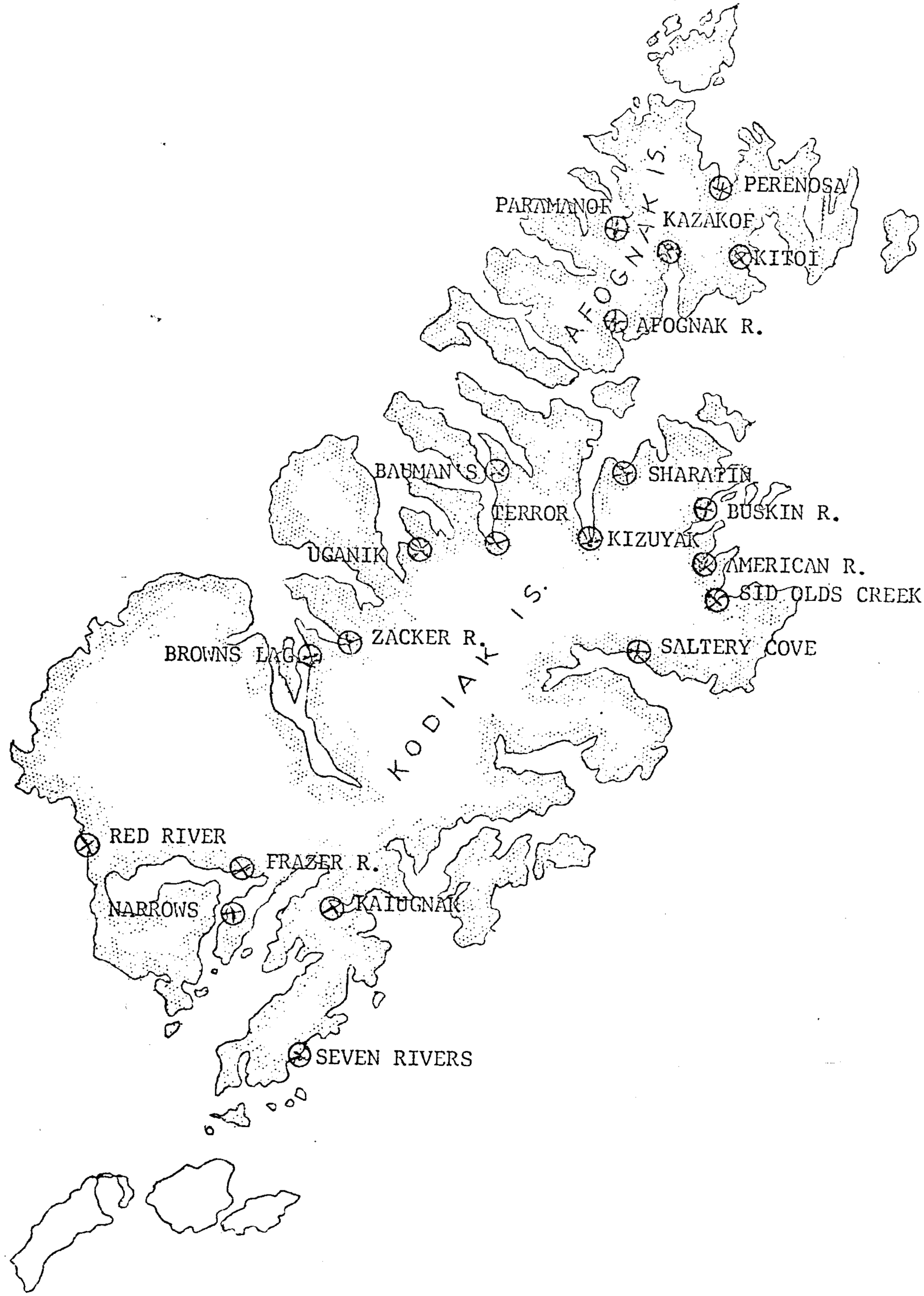

Figure 13. Location of streams sampled for pre-emergent pink salmon fry abundance in the spring of 1963.

3. Although the ratio of dead eggs to live fry was not computed, the large number of dead eggs and the calculated low density of fry per square foot found in the Saltery Cove Lake stream may by an indication of low return to this system. This assumption is further substantiated by the sampling done in 1962 when the Saltery Cove samples were collected by shovel and during the outmigration of fry. Similar levels of dead eggs were not noticed in the spring of 1962 even though the estimated escapements for both years were similar.

Because of differences in sampling equipment, timing of sample, (Saltery and Seven Rivers), unnatural rearrangement of stream gravels (Big Kitoi), and the difficulty of assigning catch data to individual streams, (Kaiugnak and Buskin) little can be learned from the fry densities collected prior to 1963.

III. Environmental Conditions

Temperature and precipitation levels have been measured at the Kodiak Naval Station almost continuously since 1940. Although these measurements do not necessarily reflect stream conditions that have existed throughout the Kodiak area, some of these data will be presented to determine whether unusual temperature or precipitation extremes occurred from July 1962 to April 1963 when pink salmon spawn from 1962 was in the gravel.

In Figure 14 mean monthly precipitation levels and mean monthly temperatures have been plotted for those years where the pack of 48 one-pound cases either increased over the parent year's pack (positive) or decreased from the parent year's pack (negative).

These data cannot for many reasons be considered an absolute measure of environmental conditions that have affected returning runs in the Kodiak area. But certain trends are apparent and these should be noted such as:

1. Mean monthly temperatures of positive parent pack years from December 1 through February were high, slightly above or below freezing, and mean precipitation levels were fairly constant. Precipitation was probably rain or if snow, thaws occurred frequently.

2. Mean monthly temperatures of negative parent pack years from December 1 through February were low, four degrees below freezing in December, and one of the lowest mean precipitation levels came during the coldest month December. Moreover, mean monthly precipitation levels fluctuated considerably with two peaks, one during October and the other in February, which probably caused flooding.

3. The eggs and fry originating from spawning in 1962 apparently were subjected to intermediate conditions of temperature and precipitation. Mean monthly temperatures were similar to the positive pack means until January when they became lower and remained this way until April. Precipitation peaked in September, 1962 and again in December of that year. Flooding did occur on the north and west sides of Kodiak Island in September and December of 1962. Precipitation in March of 1963, the coldest month, was only .9 of an inch.

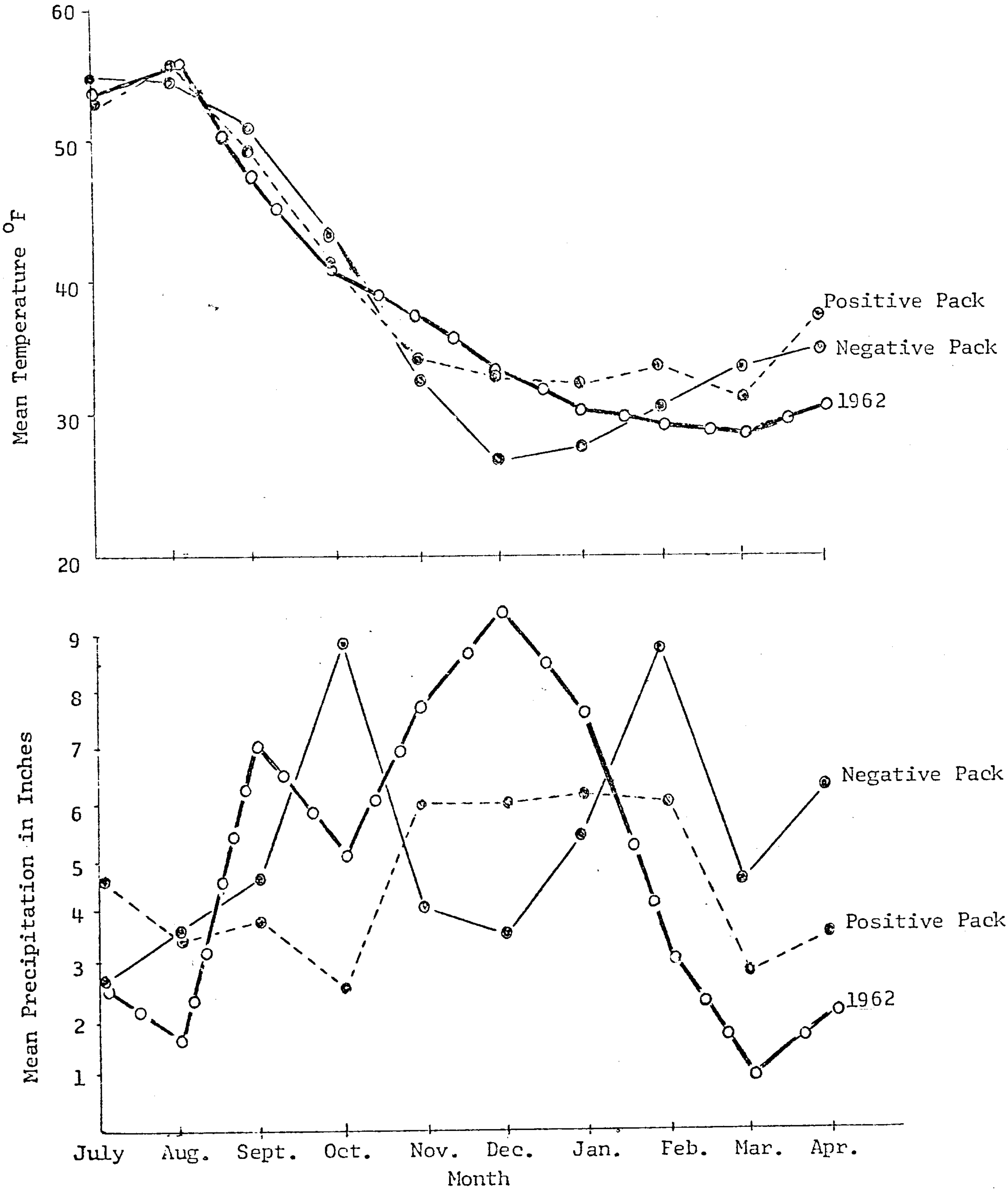

Figure 14. Monthly air temperature and precipitation averages at Kodiak Air Station for even-numbered years producing increase (positive) and decrease (negative) in case pack of pink salmon, 1940 to 1960, with monthly temperatures and precipitations during the stream incubation period of 1962 spawn.

Stream flows at this time, when pre-emergent fry sampling was being carried out, were very low and with low temperatures considerable mortality may have occurred after sampling.

In general, if we assume the comparisons in Figure 14 are valid, and omitting escapement fluctuations, the run may fall into the negative pack category due to the unusual conditions in late spring, 1963. Thus the 1964 runs may be in the lower range of our estimate calculated from the escapement (8.3 to 14.8 million pinks).

SUMMARY AND CONCLUSIONS

1. Sufficient data are not yet available that will permit an accurate, reliable pink salmon forecast for the Kodiak area.

2. Three types of data were analyzed to determine if the approximate magnitude of the 1964 pink salmon run could be ascertained in general terms.

3. An indexed-escapement-to-returning-run correlation from six districts, when extrapolated to all districts, indicated that the returning pink salmon run should be above eight million and less than 21 million.

4. Pre-emergent fry sampling data collected in the spring of 1963 from 20 streams revealed variable fry densities. Evidences of apparent high egg mortality (corresponding low fry density) were found in some streams. Significant fry mortality may have occurred after sampling in some areas.

5. Weather records from the Kodiak Naval Station suggest that spawn from 1962 may have been subjected to lower than average spring temperatures and precipitation levels of either negative parent pack years or positive parent pack years. From this we adduce that the run in 1964 may be in the lower range (8,300,000 to 14,840,000) of the return range calculated from escapement-return data.

6. The best overall estimate of 1964's pink salmon run from the meager data that is available is that the run will be <u>at least</u> fair.

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