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FORECAST OF THE 1970 PINK SALMON RUNS, SOUTHEASTERN ALASKA

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INTRODUCTION

This report constitutes the sixth in the series of pink salmon forecast publications for Southeastern Alaska.

The intended purpose of this report is to present the 1970 forecast and an analysis thereof, and all tabulated data which has been used for previous forecasts. This will provide a single source of reference for data used to forecast runs to Southeastern Alaska prior to and including 1970.

The basic objective of the pre-emergent program is the forecasting of adult pink salmon runs to Southeastern Alaska far enough in advance of actual returns so as to be of value to management and industry in planning activities for each respective pink salmon season.

The value of the Southeastern Alaska pre-emergent program has been demonstrated not only by the successful forecast of pink salmon returns to Southeastern Alaska, but also by the successes realized in the Prince William Sound area where pre-emergent work has been conducted since 1960.

The 1970 forecast analysis has been accomplished using methods basically similar to those employed in past forecasts, however, a few innova-

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1/ This investigation was partially financed by the Commercial Fisheries Research and Development Act (P.L. 88-309) under sub-project 5-4-R-6, Contract No. 14-17-0005-169.

tions have been introduced including regression analyses of the escapement-return data.

Because of the unusually severe 1968-1969 winter experienced in Southeastern Alaska, pre-emergent sampling was completed later than normal. Some of the sampling results have lead us to believe that the obtained fry densities were unrealistically low in some systems due to fry emergence prior to sampling.

The 1969 catch data used in this report is preliminary, however, it will not vary greatly from final data, and should not significantly alter the forecasts.

For the purpose of this report, the Yakutat district is not included as part of this forecast.

PRIOR FORECAST RESULTS

Data collected in Southeastern Alaska since 1964 have been used to establish relationships between observed pre-emergent fry abundances and subsequent adult returns. These relationships are used to forecast the 1970 pink salmon returns from the results of pre-emergent fry sampling conducted in the winter and spring of 1969. Four previous projections have been based on this same relationship beginning with the 1966 forecast (Table 1). The forecasts were computed from a curve established by previous fry index-return relationships beginning with the 1967 prediction.

Of the six forecasts made for Northern and Southern Southeastern Alaska for the years 1967 through 1969, only one, the 1968 forecast for the Northern section, was unacceptable from the standpoint of being usable by management and industry as a reference to the relative magnitude of return. The remaining five were within acceptable forecast limits.

SAMPLING METHODS

Sampling methods have been discussed in detail in past reports (Smedley, 1968) and methodology will be treated only briefly at this time.

The procedures remain essentially unchanged from those employed since the inception of the program in 1963. A few refinements leading toward lighter,

Table 1. History of past forecasts for Southeastern Alaska

ALL SOUTHEASTERN

Escapement Index (millions of salmon)		Fry Indices 1/		Actual Return (millions of salmon)		Forecast (millions of salmon)
1964	4.75 So.	1965	14.1 So.	1966	21.1	10.0
1964	1.95 No.	1965	22.4 No.	1966	7.4	

SOUTHERN SOUTHEASTERN

1965	2.94	1966	5.1	1967	2.2	4.2 - 5.4
1966	5.40	1967	13.4	1968	20.6	21.5
1967	1.51	1968	7.7	1969	3.2	3.0 - 3.3
1968	5.41	1969	12.5	1970	---	18.7

NORTHERN SOUTHEASTERN

1965	2.42	1966	8.1	1967	4.1	4.9
1966	2.65	1967	12.0	1968	12.6	6.2
1967	1.64	1968	5.8	1969	5.8	3.8 - 4.2
1968	2.71	1969	10.3	1970	---	9.0

1/ Fry indices are the result of weighting the average number of fry per square foot of study area (Table 2) with average district escapements to the Northern and Southern sections (Table 3) i.e., the 1968 fry data were weighted with average 1960-68 district escapements to derive the fry indices used for the 1969 Northern and Southern forecasts.

more efficient gear have been made in recent years and increased use of aircraft has speeded coverage, thus increasing the quality and quantity of sampling accomplished. Sampling intensity remains at the rate of one sample per 1,000 square feet of study area but stream selection is no longer random. The larger, more productive streams are now chosen for sampling. These same streams, and the same areas within the streams, are sampled annually, thus establishing an index study area. It is believed that salmon production from the index study area is indicative of production from all Southeastern Alasks salmon streams.

Pre-emergent pink salmon fry data are collected in the period February, March and early April and the data collected in the odd-numbered years are used to project returns for the ensuing even-year run. Conversely, odd-year returns are forecast from pre-emergent data collected during the immediately preceding even-year. For example, parent stocks spawning in the fall of 1968 produce fry that are sampled in the spring of 1969, and that will return as spawning adults in 1970.

Southeastern Alaska, for the purpose of pink salmon forecasting, is divided into two parts: Northern Southeastern and Southern Southeastern (Figure 1). Sampling and data analyses have been conducted on this basis since 1967. In effect, this results in two separate and distinct forecasts.

RESULTS - 1969 PRE-EMERGENT SAMPLE

Pre-emergent field work began in mid-February in the Ketchikan and Sitka areas, and as ice cleared from bays and streams, was extended to encompass the areas around Juneau and Petersburg. A total of four crews worked throughout Southeastern. An unusually harsh winter, with an extended period of cold, clear weather was experienced, with the Juneau area encountering the coldest, dryest winter since records began. Fry sampling operations were slowed considerably throughout the region and as of the last day of March, only 40 streams had been sampled of the 96 streams slated for pre-emergent work. Normally by the end of March most sampling has been completed.

As could be expected, fry development appeared to be slightly depressed. Sampling in the last few streams, however, suggested that even though development was retarded, the low fry densities observed in some systems may have been the result of emergence prior to sampling. Because we have no present method of converting this information back to pre-emergent levels, it has been incorporated into the forecast at face value.

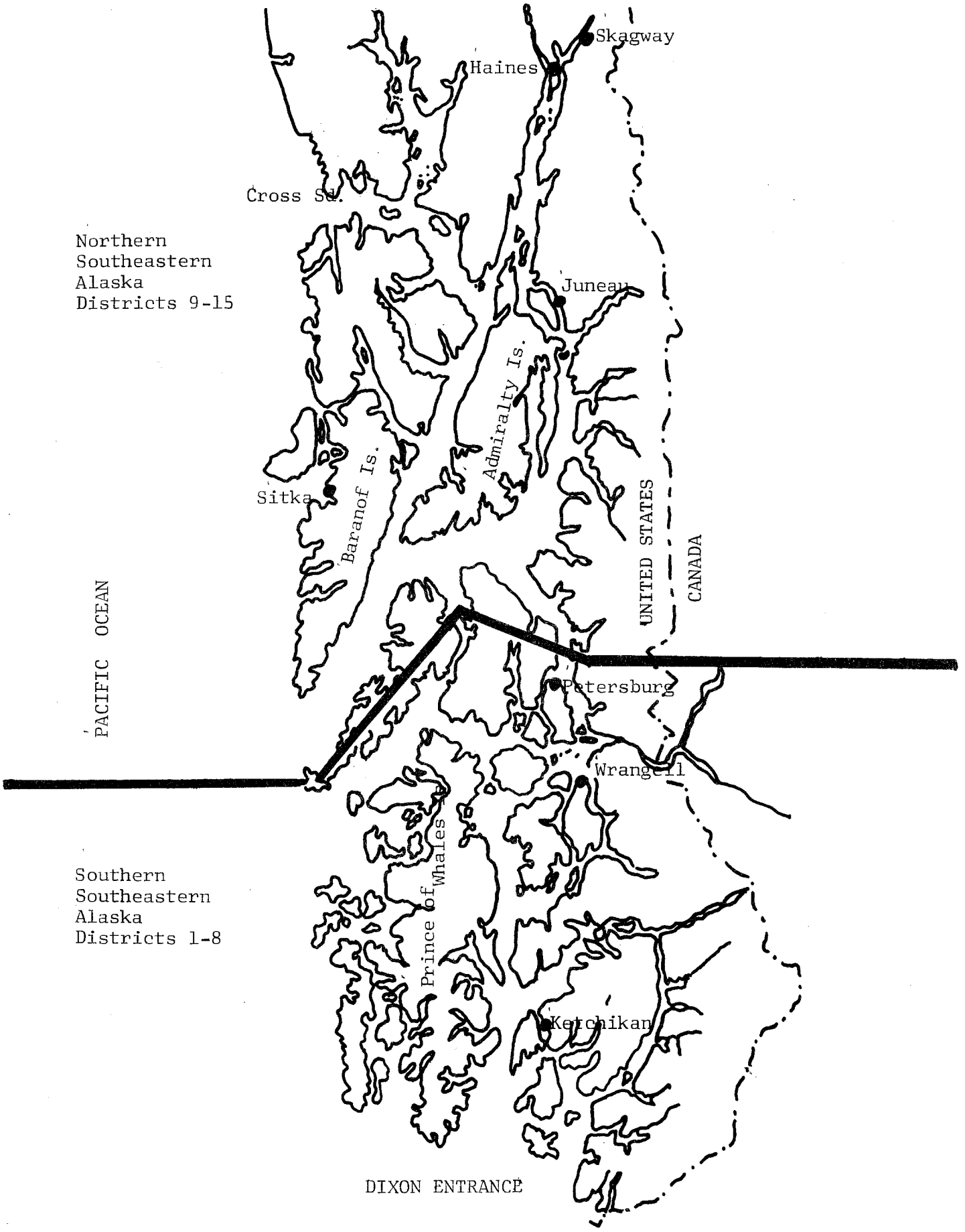


Figure 1. Map of Southeast Alaska showning division between Northern and Southern sections.

In all Southeastern Alaska, 85 streams were sampled in 1969. A total of 39 were located in the Southern half and 46 in the Northern. The severe winter with its attendant ice problems, reduced the sampling effort some 15 percent below that of 1968 with only 6,515 samples taken as compared to a total of 7,699 in 1968. However, it is felt that the reduced sample did not significantly affect the measure of pre-emergent fry density.

Table 2 depicts the total number of salmon alevins sampled from 1964 through 1969 and the sample sizes by district. Also shown are the unweighted fry indices for each district for the years 1964 through 1969. Table 3 lists the escapements, by district, used in developing the weighted fry index for the Northern and Southern sections.

DISCUSSION - 1970 FORECAST

Because only several years of pre-emergent data are available on which to base the 1970 forecast, the use of standard linear regression techniques was deemed unnecessary and a line was fitted by eye to the fry index-return data. The choice of using a line, as opposed to a non-linear curve, for the purpose of describing the fry index-return relationship was based in part on the results of pink salmon forecast studies conducted in Prince William Sound (Roys, 1968). The assumption that the line passes through the origin should be approximately satisfied as a fry index of zero should be associated with a very small adult return.

Corroboration of the forecast points for the Northern and Southern sections was gained through non-linear regression analyses of the 8 years (1960 through 1967) of available escapement-return data. Both forecast methods are discussed below.

Fry Index-Return Forecast - Southern Section

Analysis of the 1969 pre-emergent fry data indicates a total return of 18.7 million pink salmon in 1970 to the Southern section. Figure 2 presents the eye-fitted line used for the forecast.

Due to the marked even-year dominance in pink salmon returns to the Southern section, only data pertinent to even-year runs was used for the 1970 forecast. At this writing only two prior years of even-year fry index-return data were available for analysis, the 1965 pre-emergent sample and subsequent 1966 return and the 1967 pre-emergent sample and subsequent 1968 return.

Table 2. Number of pink salmon alevins, sample size, and fry indices per square foot by district for Southern and Northern Southeastern Alaska.

1964-1969

SOUTHERN SOUTHEASTERN

District	1964 X[1]	1964 n[2]	1964 X/2n[3]	1965 X	1965 n	1965 X/2n	1966 X	1966 n	1966 X/2n
1	20,852	486	21.5	6,087	349	8.7	3,481	485	3.6
2	5,491	353	7.8	3,087	245	6.3	4,587	126	18.2
3	9,810	204	24.0	5,214	110	23.7	4,618	307	7.5
5	NO	SAMPLE		4,383	139	15.7	621	170	1.8
6	6,113	299	10.2	9,248	259	17.8	1,603	294	2.8
7	17,624	356	24.8	5,966	364	8.2	363	140	1.3
Totals[4]	59,890	1,698	17.7	33,985	1,466	11.6	15,273	1,522	5.0

District	1967 X	1967 n	1967 X/2n	1968 X	1968 n	1968 X/2n	1969 X	1969 n	1969 X/2n
1	11,218	594	9.5	10,898	1,032	5.3	20,135	972	10.4
2	4,522	220	10.3	4,005	329	6.1	7,477	309	12.1
3	27,949	748	18.7	14,859	872	8.5	21,072	700	15.0
5	1,767	127	6.9	5,069	329	7.7	4,627	314	7.4
6	8,761	314	14.0	5,800	471	6.2	11,735	459	12.8
7	14,424	350	20.6	9,019	341	13.2	9,903	286	17.3
Totals	68,641	2,353	14.6	49,650	3,374	7.4	74,949	3,040	12.4

(Continued)

Table 2. Number of pink salmon alevins, sample size, and fry indices per square foot by district for Southern and Northern Southeastern Alaska (continued).

NORTHERN SOUTHEASTERN

	1964			1965			1966		
District	X	n	X/2n	X	n	X/2n	X	n	X/2n
9	10,455	205	25.5	14,165	627	11.3	10,921	611	9.0
10	3,667	270	6.8	8,753	140	31.3	2,325	126	9.3
11	3,468	110	15.8	669	80	4.2	1,335	116	5.8
12	12,798	236	27.1	6,810	116	29.4	6,160	314	9.8
13	21,859	316	34.6	11,732	223	26.3	4,818	511	4.7
14	NO SAMPLE			6,628	140	23.7	8,984	232	13.6
Totals	52,247	1,137	23.0	48,757	1,326	18.4	34,543	2,010	8.6

	1967			1968			1969		
District	X	n	X/2n	X	n	X/2n	X	n	X/2n
9	6,605	575	5.8	14,996	820	9.2	11,988	593	10.1
10	9,791	294	16.7	4,950	631	3.9	12,236	409	15.1
11	4,838	220	11.0	3,033	483	3.2	10,582	475	11.1
12	16,339	525	15.5	7,549	877	4.3	19,699	736	13.4
13	15,901	658	12.1	15,175	991	7.7	9,277	873	5.3
14	4,023	200	10.0	5,919	523	2.9	7,181	392	9.2
Totals	57,497	2,474	11.6	51,622	4,325	6.0	70,963	3,475	10.2

1/ Number of pink salmon alevins.
2/ Sample size.
3/ X/2n = Fry indices per square foot. The fry index for the Northern and Southern sections is based on the number of pre-emergent fry contained in each square foot of sample area. Since each sample encompasses 2 square feet, the number of alevins in each sample is divided by 2 to arrive at a fry index.
4/ Since a proportionate amount of weight must be given to the more heavily sampled districts, the fry index for the Northern and Southern sections is derived by dividing the total number of alevins found in each section by the total number of samples taken. It is not the average of district indices.

Table 3. Southeastern Alaska pink salmon escapement indices by district in thousands of fish (1960-69) 1/.

SOUTHERN

District	1960	1961	1962	1963	1964	1965
1	712	551	1,225	1,186	1,536	544
2	69	136	470	224	563	221
3	718	496	826	1,173	1,115	917
4	10	11	18	9	19	9
5	99	298	479	271	412	432
6	77	473	542	352	643	437
7	210	256	557	586	276	292
8	32	134	118	114	181	92
Totals	1,927	2,355	4,235	3,915	4,745	2,944
Average	241	294	529	489	593	368

District	1966	1967	1968	1969	Total	Average
1	1,476	442	2,042	682	10,396	1,040
2	650	161	400	349	3,243	324
3	1,554	265	1,504	405	8,973	897
4	19	12	68	40	215	22
5	453	261	418	143	3,266	327
6	467	160	436	175	3,762	376
7	592	171	434	162	3,536	354
8	191	34	103	58	1,057	106
Totals	5,402	1,506	5,405	2,014	34,448	
Average	675	188	676	252		

Table 3. Southeastern Alaska pink salmon escapement indices by district in thousands of fish (1960-69) - continued 1/.

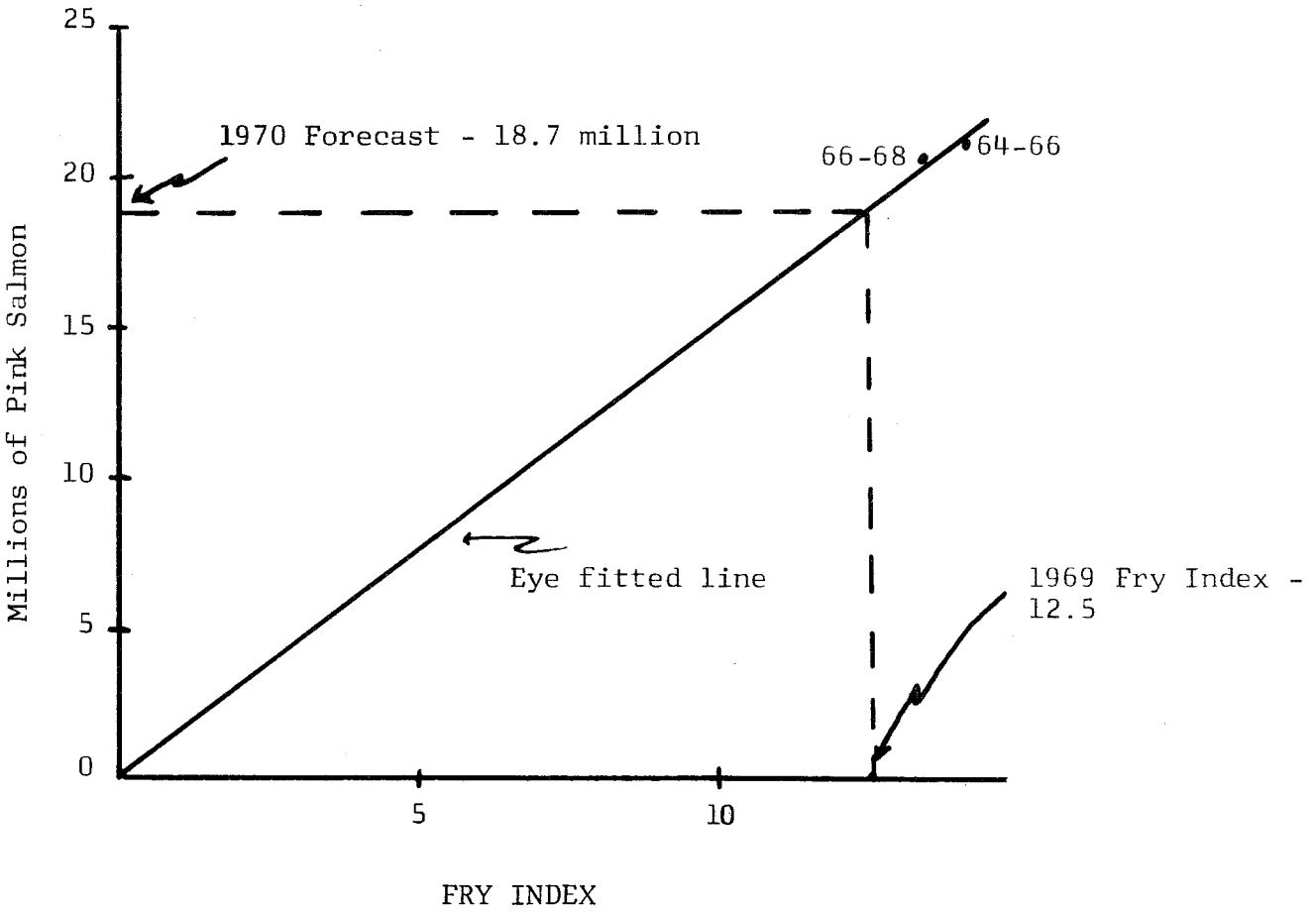
NORTHERN

District	1960	1961	1962	1963	1964	1965
9	86	434	470	404	452	477
10	179	332	424	280	539	255
11	247	260	145	270	189	117
12	109	355	98	644	245	340
13	264	731	280	1,392	442	870
14	103	207	63	589	77	359
15	10	10	10	10	10	4
Totals	998	2,329	1,490	3,589	1,954	2,422
Average	143	333	213	513	279	346

District	1966	1967	1968	1969	Total	Average
9	581	360	535	360	4,149	415
10	644	208	1,064	354	4,279	428
11	386	88	415	144	2,261	226
12	462	223	424	377	3,277	328
13	501	560	205	712	5,957	596
14	73	181	70	240	1,962	196
15	6	16	9	10	95	10
Totals	2,653	1,636	2,712	2,197	21,980	
Average	379	234	387	314		

1/ Index escapements are a measure of the relative magnitude of escapement to Southeastern Alaska streams. They do not constitute actual escapements.

Figure 2. RELATION BETWEEN PINK FRY INDEXES AND SUBSEQUENT RETURNS TO SOUTHERN SOUTHEASTERN ALASKA.



The results of the 1969 winter-spring sampling in the Southern section provided an escapement weighted average of 12.5 fry per square foot of spawning gravel in the study areas. For comparison, weighted estimates of 14.1 and 13.4 fry per square foot of sample area in 1965 and 1967 resulted in returns of 21.1 million and 20.6 million pink salmon in 1966 and 1968 respectively.

Two minor departures have been made from past Southern section forecast analyses. The 1967 through 1969 forecasts were weighted in various proportions to escapement-return values to arrive at a final forecast figure. It becomes evident when comparing the forecasts with actual returns (Table 4) that the forecasts based on pre-emergent -return data for 1967 and 1968 in the Southern section are more accurate than either the escapement-return based forecast, or the weighted forecast. Further, the 1969 pre-emergent and weighted forecasts were very close to the actual return. For these reasons, and because we have the advantage of one additional year of pre-emergent data, the 1970 forecast has been based entirely on the pre-emergent fry index.

The second change in method involves the use of only even-year escapement data for weighting the pre-emergent index for forecast use. Previously, all available years of escapement data were averaged and the average used for weighting. Because of the highly variable even-odd year escapement levels in the Southern section, it is thought that averages derived by the even-year only method will be more representative.

Fry Index-Return Forecast -- Northern Section

Forecast methods for calculation of the abundance of pink salmon returning to the Northern section of Southeastern Alaska are very similar to those used for the Southern section with two exceptions: (1) runs to the Northern section since 1963 have exhibited less pronounced even-year fluctuations than those to the Southern section, therefore all years of pre-emergent data are used for return projections, and (2) for this same reason, escapement averages from all years of escapement, 1960 through 1969, are used to weight the raw pre-emergent data for calculation of the fry index.

Analysis of the 1969 pre-emergent fry data indicates a total return of 9.0 million pink salmon in 1970 to the Northern section. Figure 3 presents the eye-fitted line used for the 1970 forecast and Table 5 depicts pink salmon escapements, catches and total runs to Southeastern Alaska for the years 1960 through 1969.

Pink salmon pre-emergent sampling in the spring of 1969 resulted in an escapement weighted fry index of 10.3 pre-emergent fry per square foot of

Table 4. Results of pink salmon forecasting for Southeastern Alaska by three methods in millions of fish (1967-1969).

	SOUTHERN			NORTHERN			TOTAL		
Year	Type of forecast	Predicted returns	Actual return	Type of forecast	Predicted returns	Actual return	Type of forecast	Predicted returns	Actual return
1967	Escapement-return	8.1		Escapement-return	9.7		Escapement-return	17.8	
	Pre-emergent	3.2	2.1	Pre-emergent	2.5	4.1	Pre-emergent	5.7	6.2
	Weighted	4.8		Weighted	4.9		Weighted	9.7	
1968	Escapement-return	25.2		Escapement-return	9.1		Escapement-return	34.3	
	Pre-emergent	20.2	20.6	Pre-emergent	5.2	12.6	Pre-emergent	25.4	33.2
	Weighted	21.5		Weighted	6.2		Weighted	27.7	
1969	Escapement-return	3.3		Escapement-return	6.8		Escapement-return	10.1	
	Pre-emergent	3.0	3.2	Pre-emergent	4.2	5.8	Pre-emergent	7.2	9.0
	Weighted	3.1		Weighted	4.8		Weighted	7.9	

Figure 3. RELATION BETWEEN PINK FRY INDEXES AND SUBSEQUENT RETURNS TO NORTHERN SOUTHEASTERN ALASKA.

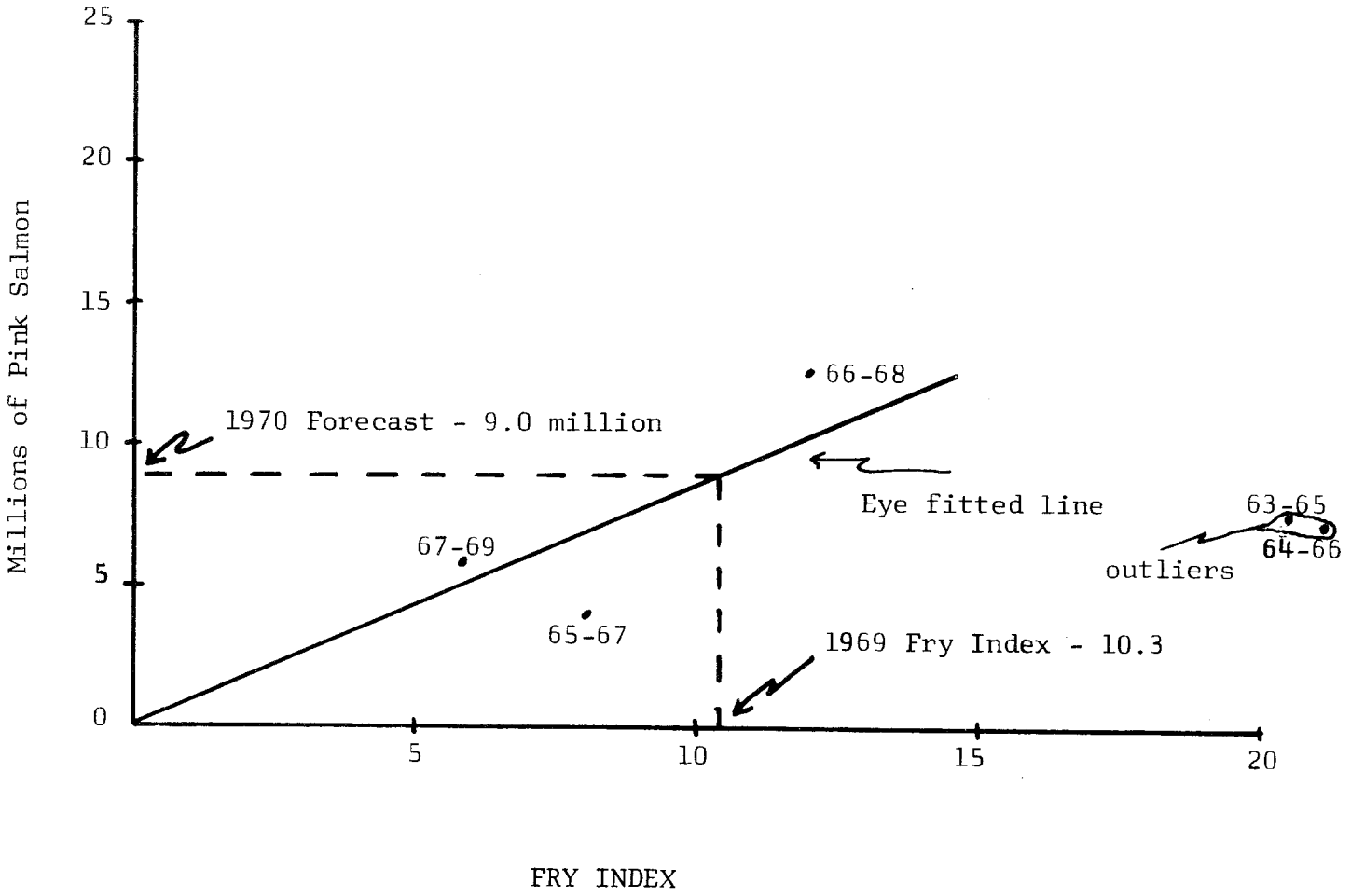


Table 5. Southeastern Alaska pink salmon escapements, catches, and total runs by year in thousands of fish (1960-1969).

	SOUTHERN SOUTHEASTERN			NORTHERN SOUTHEASTERN			ALL SOUTHEASTERN		
Year	Escapement	Catch	Run	Escapement	Catch	Run	Escapement	Catch	Run
1960	1,927	1,542	3,469	998	1,429	2,427	2,925	2,971	5,896
1961	2,355	3,875	6,230	2,329	8,698	11,027	4,684	12,573	17,257
1962	4,235	11,007	15,242	1,490	550	2,040	5,725	11,557	17,282
1963	3,915	5,145	9,060	3,589	13,921	17,510	7,504	19,066	26,570
1964	4,745	11,258	16,006	1,954	7,282	9,236	6,699	18,540	25,239
1965	2,944	5,710	8,654	2,422	5,165	7,587	5,366	10,875	16,241
1966	5,402	15,650	21,052	2,653	4,787	7,440	8,055	20,437	28,492
1967	1,506	642	2,148	1,636	2,437	4,073	3,142	3,079	6,221
1968	5,405	15,201	20,606	2,712	9,882	12,594	8,117	25,083	33,200
1969	2,014	1,160	3,174	2,197	3,594	5,791	4,211	4,709	8,920

study area. For comparison, estimates of 8.1, 12.0 and 5.8 fry per square foot in 1966, 1967 and 1968 resulted in returns of 4.1, 12.6 and 5.8 million pink salmon in 1967, 1968 and 1969 respectively.

The pre-emergent data years 1964 and 1965 have been omitted from the forecast analysis as not being representative of the true fry index-return relationship. At present this is an assumption based on the knowledge that sampling techniques and areas were altered slightly beginning with the 1966 sample year. One or two more years of data should prove or disprove the validity of this assumption. As can be seen in Figure 3, only three years of pre-emergent data remain (1966, 67, and 68) on which to base the 1970 return.

The past three forecasts for 1967, 1968 and 1969 were predicated on the basis of a certain amount of weight given to the 1964 and 1965 pre-emergent years, which, as mentioned above, now have been dropped. Thus the forecasts based on the weighted pre-emergent fry index were, in all three years, lower than actual returns (Table 4). By not including the 1964-65 pre-emergent data in the Northern section forecasts and through elimination of escapement-return weighting, the pre-emergent values were raised closer to actual returns. In addition, by using only fry index-return relationships for the past three years, no weighting with escapement-return data should be necessary in the 1970 forecast.

Escapement-Return Forecast -- Northern & Southern Sections

In Southeastern Alaska, escapement-return data have been compiled by the Alaska Department of Fish and Game since 1960, and are available for analysis. Escapement data are derived primarily from aerial surveys of the major pink salmon watersheds in Southeastern Alaska. Although escapements to the larger production watersheds are monitored frequently through each season, the district escapements are considered to be indices, rather than a true measure of total escapement. Escapement indices are arrived at by totaling observed escapements by district with projections of escapement made to the smaller, unsurveyed streams. Since runs to the Northern section exhibit no pronounced even-odd year variation, seven years of escapement-return data (1960-1969) are available for forecast use. Because of the highly dominant even-year runs to the Southern section, all points can not be used and the 1970 curve is based on the four even years of escapement-return data, 1960 through 1968. Because of the extreme drought conditions prevalent in Southeastern Alaska during the summer of 1965, the 1965-1967 escapement-return data were omitted when constructing the curve on which the 1970 Northern section escapement-return forecast was based. It is assumed that

the data are not representative of the true escapement-return relationship. This omission does not effect the Southern escapement-return forecast, as only even-years are used.

To investigate the use of a spawner-recruit relationship for predicting the magnitude of pink salmon returns to Southeastern Alaska, a Ricker (1958) type curve was empirically fitted by least squares techniques with the aid of an IBM 360/45 computer. The relation is described by an equation of the following form:

$$R = AE^{B} e^{-CE}$$

where A, B, C = parameters to be estimated

E = escapement in year i

R = return in i + 2

e = base for the natural logarithm

Figures 4 and 5 present graphs produced when the data were fitted with the reproduction curve. Based on four points, the estimated 1970 return for the Southern section is 18.6 million pink salmon. Based on seven points, the estimated return for Northern Southeastern is 10.3 million. The equations of the fitted lines are shown in the figures.

Estimated returns from these data are quite close to predictions derived from fry index-return analyses. It must be emphasized, however, that both the pre-emergent and the escapement-return forecasts are based on a minimum of observations. At this early stage, the addition of just one years data could significantly alter the shape of the curves and predicted values.

Estimate of 1970 Catch and Escapement -- Northern & Southern Sections

It is apparent that the basic step in achieving a large run of pink salmon is that sufficient spawning stock be provided to the approximate 2,000 spawning streams in Southeastern Alaska. Poor escapements may result in fair returns because of exceptionally favorable environmental conditions, and fair escapements may result in poor returns due to exceptionally hostile environmental conditions. However, the fact remains that the magnitude of return is dependent on the magnitude of escapement, given average survival conditions in the freshwater and ocean environments.

Figure 4. Plot of Pink Salmon Return versus Escapement for 1970 Southern Southeastern Forecast.

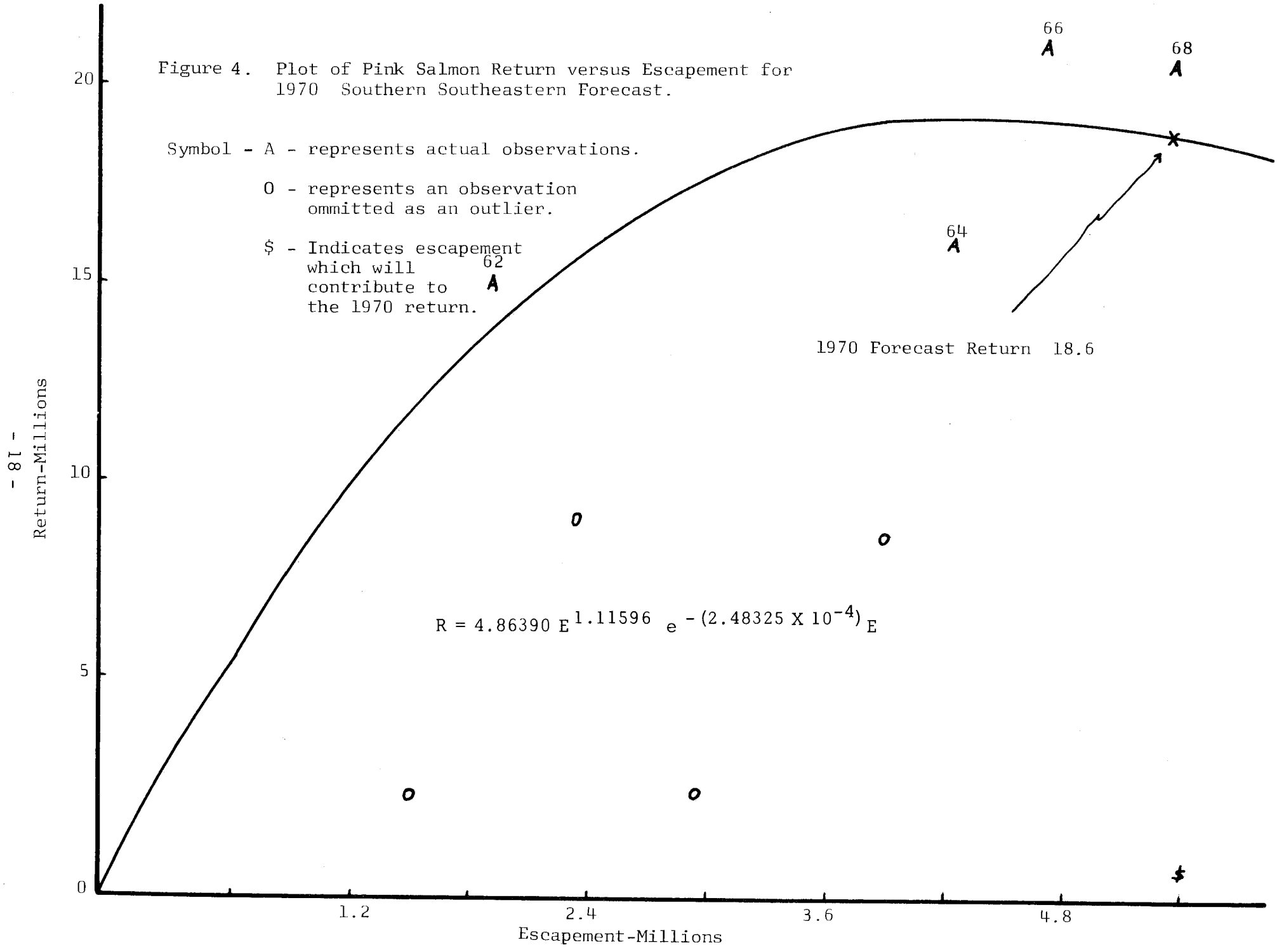
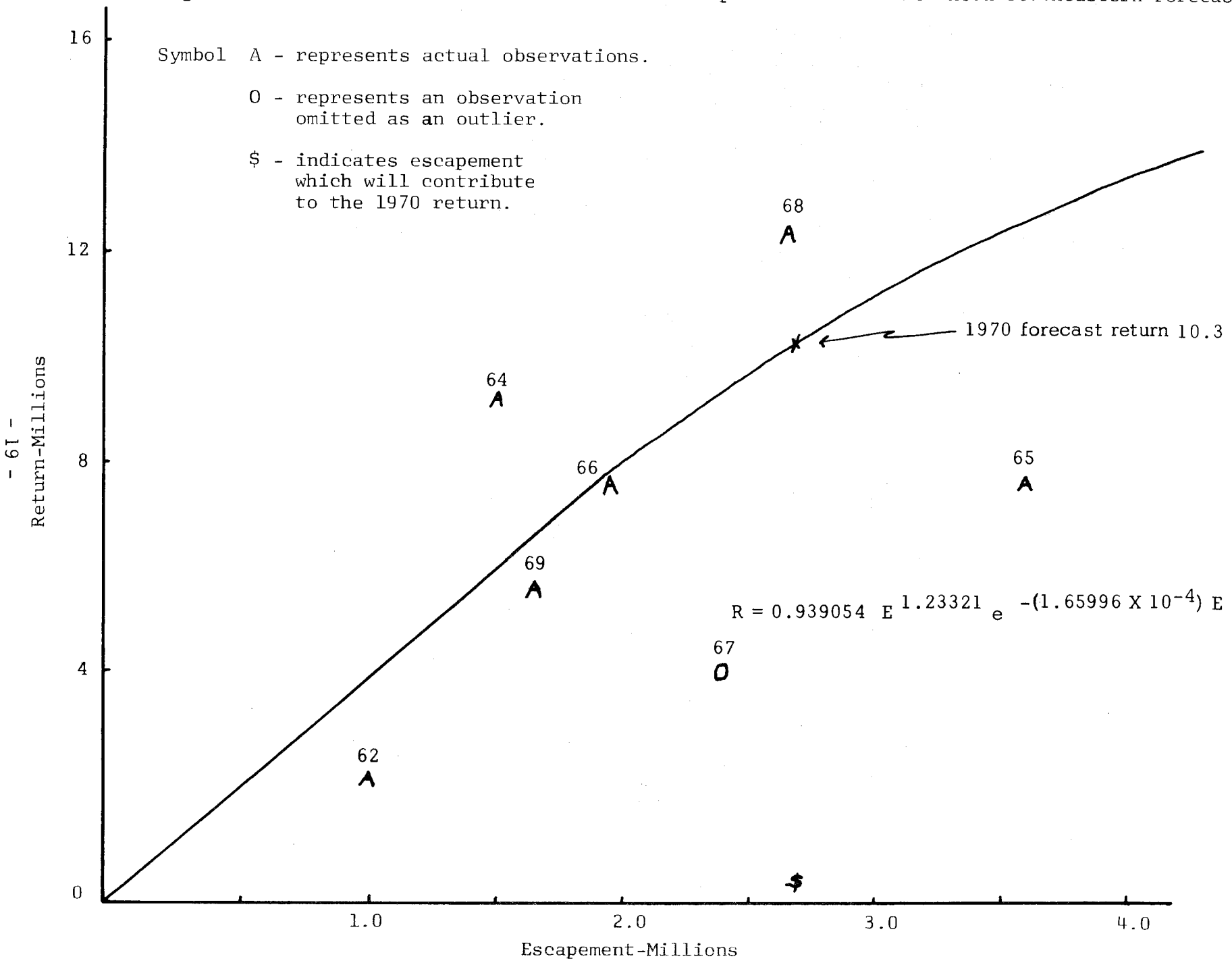


Figure 5. Plot of Pink Salmon Return versus Escapement for 1970 Northern Southeastern Forecast.



In viewing escapements to the Southern section, and the total runs which they produced, escapement indices in excess of 4 million pinks have produced good returns, while escapement indices of less than 4 million have produced fair to very poor returns. Further, an escapement index in excess of 5 million produced the largest run to Southern Southeastern Alaska in many years. In the face of this evidence, the minimum number of escaping pink salmon essential as a base for good return runs could be set at 5.0 million.

Annual escapements to the Northern section have been generally less than those to the Southern and the runs resulting from a given escapement have been more variable; e.g., an escapement index of 2.3 million pink salmon in 1961 produced a returning run of 17.5 million in 1963 while only 7.6 million pinks were produced in 1965 from an apparent 1963 escapement index of 3.6 million. In review of the 1960 through 1969 escapements and the resultant returns, it appears at this time that a minimum escapement goal of 3.0 million pink salmon could be set as a basis to assuring good returns to Northern Southeastern.

Assuming 5.0 million pink salmon escape to Southern section streams, a balance of 13.7 million would remain for harvest. Again assuming 3.0 million pink salmon escape to Northern section streams, a balance of 6.0 million would be available for harvest. It is entirely possible that these escapement estimates will be revised upward as optimum spawning distribution among streams and maximum utilization of available spawning area is approached.

CONCLUSIONS - 1970 FORECAST

Forecasts of the 1970 returns of pink salmon to Southeastern Alaska are based on eye-fitted curves established by previous fry index-return relationships. From these curves, returns of 18.7 million and 9.0 million pink salmon are projected for the Southern and Northern sections respectively. The total pink salmon forecast to Southeastern Alaska is 27.7 million.

Corroboration of the fry index forecast was gained through the use of regression analyses of available escapement-return data, however, it is considered supplementary, and is not part of the formal 1970 forecast. Escapement-return estimates indicate returns of 18.6 million pink salmon to the Southern section and 10.3 million pink salmon to the Northern section.

Assuming a fair degree of accuracy in the 1970 forecast, the catches in the Southern and Northern sections of Southeastern Alaska should amount to

approximately 13.7 million and 6.0 million respectively. If the total runs to each section are larger or smaller than the forecast points, the catches will vary proportionately.

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