Informational Leaflet 59

BRISTOL BAY RED SALMON
FORECAST OF RUN FOR 1965

Compiled jointly by the:

ALASKA DEPARTMENT OF FISH AND GAME

U. S. BUREAU OF COMMERCIAL FISHERIES

FISHERIES RESEARCH INSTITUTE

Edited by:

Frank J. Ossiander

May 21, 1965

STATE OF ALASKA
WILLIAM A. EGAN - GOVERNOR

DEPARTMENT OF
FISH AND GAME
WALTER KIRKNESS - COMMISSIONER
SUBPORT BUILDING, JUNEAU

BRISTOL BAY RED SALMON FORECAST OF RUN FOR 1965

Edited by:

Frank J. Ossiander, Survey Statistician Biology
Alaska Department of Fish and Game
Division of Biological Research
Juneau, Alaska

INTRODUCTION

The forecast for the 1965 Bristol Bay red salmon run was prepared jointly by the Alaska Department of Fish and Game, the Fisheries Research Institute of the University of Washington, and the U. S. Bureau of Commercial Fisheries.

The following scientists participated in the analysis of the data: Mr. Wallace H. Noerenberg, Mr. Frank J. Ossiander of the Alaska Department of Fish and Game; Dr. Robert L. Burgner, Mr. Allen C. Hartt, Mr. Stephen B. Mathews, Dr. Ole A. Mathisen and Dr. William F. Royce of the Fisheries Research Institute; Dr. C. J. DiCostanzo, Mr. R. A. Fredin, Dr. L. Henrich, Mr. H. Jaenicke of the U. S. Bureau of Commercial Fisheries. Many others participated in the collection of data and contributed to the preliminary analysis.

Mr. Frank J. Ossiander served as editor and assembled the forecast.

A draft of the 1965 forecast was compiled in September, 1964, using preliminary data on the 1964 returns. This forecast uses final 1964 return data from all river systems in Bristol Bay.

METHODS OF FORECAST

Forecasts are made of the expected return to the major river systems in each fishing district of Bristol Bay and of the expected return to Bristol Bay as a whole. Data used in these forecasts are: the inshore abundance and age composition of the catch and escapement, smolt abundance and purse seine catches of immature red salmon at sea. Predictions are based on the relationships of returns to abundance at some preceding stage of the life cycle.

The equations used for each of the river system forecasts are:

$$R = a\,S^b\,,$$

$$R = a + b\,S \quad \text{and}$$

$$R = a + b\,E \quad \text{where,}$$

R: is adult return
S: is smolt index
E: is escapement
a and b: are parameters to be determined from the data

These relationships depend upon the adequacy of the basic data which is influenced by sampling errors and the representativeness of the sampling plans. Additional inaccuracies arise from not having sufficient data pertaining to the different life history stages to formulate truly representative relationships.

ESTIMATES OF TOTAL RUNS TO EACH RIVER SYSTEM

The total returns to Bristol Bay are composed of the inshore catch and escapement and fish which would be expected to return if they were not intercepted on the high seas. From tagging and experimental fishing studies of the migration and distribution of red salmon in the ocean it has been established that at certain times and in certain areas the Japanese high seas fishery catches red salmon bound for Bristol Bay. For mature red salmon these times and areas include the May and June 1-10 catches east of 170° E, the June 11-20 catches east of 175° E, and the June 21-30 catches east of 180°. For immature red salmon it includes the July and August catches east of 170°, and the June 21-30 catches between 175° E and 180°.

For estimating the total run (inshore returns plus high seas catches) to each river system the yearly Japanese high seas catch is apportioned to each river on the basis of each river's contribution to the yearly Bristol Bay return. The age structure is also apportioned on the basis of the age structure of the return of each river. The Japanese high seas catches of mature red salmon were assumed to return to Bristol Bay in the same year as .2-ocean and .3-ocean age fish, the catches of immatures were assumed to return to Bristol Bay as .3-ocean age fish in the following year. The formulas used in the computations are:

For .2-ocean age returns,

$$(1) \quad R'_{ij2} = R_{ij2} + \frac{R_{ij}}{R_{i..}} \frac{R_{ij2}}{R_{ij.}} C_{i2}$$

for .3-ocean age returns,

$$(2) \quad R'_{ij3} = R_{ij3} + \frac{R_{ij3}}{R_{i.3}} C_{i-1,1} + \frac{R_{ij.}}{R_{i..}} \frac{R_{ij3}}{R_{ij.}} C_{i2}$$

where,

R'_{ijk} : total return to Bristol Bay in year i to river j of age class k

R_{ijk} : inshore Bristol Bay return in year i to river j of age class k

C_{i1} : Japanese high seas catch of immatures in year i

C_{i2} : Japanese high seas catch of matures in year i.

The dot subscript indicates summation over the subscript it replaces.

This procedure makes no allowance for age specific selectivity of Japanese gear. The age structure is simply apportioned on the basis of the age structure of the return to each river in Bristol Bay. No ocean mortality is considered to apply to the Japanese catch as would be expected between the time they are taken on the high seas and when they would have returned to Bristol Bay. Likewise, no drop-out (a drop-out is considered a fish which falls from the gear as a dead fish or subsequently dies because of its encounter with the gear, it is lost from the fishery) factor is applied to the Japanese high seas fishery.

The data used in the computations is given in Tables 1 and 2; and the apportioned total Bristol Bay return is given in Table 3.

FORECASTS BY RIVER SYSTEM BASED ON TOTAL RETURN

Nushagak Fishing District

The Nushagak red salmon return to three major spawning systems, Wood River Lakes, Igushik Lakes, Tikchik Lakes; and several minor systems of which only the Snake, Nushagak and Mulchatna Rivers are included in this report. Since the commercial catch is taken in Nushagak Bay it cannot be separated directly into parts bound for the separate rivers. Therefore, the catch has been prorated to the separate river systems on the basis of the escapement by age groups to each river system.

Wood River

Comparable indices of the annual smolt migrations are used as the basis for forecasting the return to the Wood River (Table 4). These have had a rather variable relation with the return because of varying marine mortality and variable age of return, but enough data are available to permit a regression analysis. Original data are transformed logarithmically to simplify presentation and to help satisfy certain requirements for statistical analysis. The equation used is:

$$R = a\ S^b$$

Transforming logarithmically this equation becomes

$$\log R = \log a + b \log S.$$

The solution of this equation for the .2-ocean returns is

$$\log R = 1.762795 + 0.543059 \log S$$

TABLE 1. BRISTOL BAY INSHORE RETURNS (IN THOUSANDS OF FISH)

Year of run	Igushik 1/	Snake 1/	Tikchik 1/	Wood 1/	Mulchatna 1/	Kvichak 2/	Naknek 2/	Alagnak 2/	Egegik 2/	Ugashik 2/	Togiak & Tributaries 3/	North Side Alaska Pen. 3/	Age Class Total	Yearly Total
						.2-OCEAN								
1956	206	5	8	966	0	11,026*	1,455*	553*	770*	508*	213*	1,719*	17,429	26,198
1957	67	2	38	206	0	1,962	81	174*	168	375	42*	411*	3,526	11,821
1958	50	12	54	1,266	0	411	242	66*	428	411	70*	594*	3,604	6,618
1959	627	212	72	3,325	0	851	2,753	1,124	1,393	400	210*	796*	11,763	14,057
1960	253	17	205	1,059	0	22,517	622	1,730	2,520	2,963	216*	712*	32,814	37,454
1961	11	1	3	119	0	5,036	43	4	724	86	207*	550*	6,784	18,885
1962	30	4	85	1,958	1	3,067	555	80	1,025	375	107*	345*	7,632	10,889
1963	105	60	36	909	5	300	770	284	829	402	180	352*	4,232	7,356
1964	146	20	146	1,750	2	1,454	2,059	217	1,434	940	251	803*	9,222	11,963
						.3-OCEAN								
1956	683	3	61	506	21	3,202	1,221	347	1,431	254	114	926	8,769	
1957	194	4	96	358	22	4,621	1,424	109	1,035	187	23	222	8,295	
1958	202	3	432	336	8	656	285	123	312	299	38	320	3,014	
1959	313	10	4	163	31	84	477	108	333	229	113	429	2,294	
1960	793	13	9	800	39	89	1,252	336	725	84	116	384	4,640	
1961	452	6	119	579	54	5,522	1,308	369	2,664	620	112	296	12,101	
1962	62	0	10	223	10	1,347	551	53	637	121	58	185	3,257	
1963	76	1	261	330	62	260	748	33	857	174	134	189	3,124	
1964	173	7	64	401	31	136	488	296	498	98	117	432	2,741	

* Estimated age composition

1/ Age composition of Nushagak runs FRI Circular No. 219, 1946-1962, and letters dated January 5 and 6, 1965 by Robert L. Burgner.

1963 data from Bristol Bay Red Salmon Run in 1963, ADF&G Informational Leaflet #35.

1964 data from Bristol Bay Red Salmon Run in 1964, ADF&G Informational Leaflet #45.

2/ 1957-1962 data from tables provided by Dr. Charles DiCostanzo, U.S. Bureau of Commercial Fisheries, Auke Bay, Alaska.

1963 data from Bristol Bay Red Salmon Run in 1963, ADF&G Informational Leaflet #35.

1964 data from Bristol Bay Red Salmon Run in 1964, ADF&G Informational Leaflet #45.

3/ Data compiled from ADF&G area management biologist's yearly reports and from ADF&G Informational Leaflets No. 35 and No. 45.

TABLE 2. JAPANESE HIGH SEAS CATCHES OF RED SALMON BOUND FOR BRISTOL BAY (In thousands of fish)

Year	Matures 1/	Immatures 2/
1952	367	34
1953	406	0
1954	600	0
1955	1,869	60
1956	2,752	2,075
1957	7,660	342
1958	1,014	151
1959	1,070	1,185
1960	4,007	967
1961	6,421	62
1962	1,315	270
1963	1,016	830
1964	614	1,837

1/ Includes the May and June 1-10 catches east of 170° E, the June 11-20 catches east of 175° E, and the June 21-30 catches east of 180°.

2/ Includes red salmon taken on high seas at times and in areas where immature Bristol Bay reds are in large majority. These are mostly .2 age fish that otherwise would be expected to mature and return to Bristol Bay as .3's. Includes July and August catches east of 170°, and June 21-30 catches between 175° E and 180°.

TABLE 3. BRISTOL BAY TOTAL RETURNS. APPORTIONED FOR JAPANESE HIGH SEAS CATCHES
(IN THOUSANDS OF FISH)

Year of run	Igushik	Snake	Tikchik	Wood	Mulchatna	Kvichak	Naknek	Alagnak	Egegik	Ugashik	Togiak & Tributaries	North Side Alaska Pen.	Age Class Total	Yearly Total
						.2-OCEAN								
1956	228	6	9	1,067	0	12,184	1,608	611	851	561	235	1,900	19,260	29,010
1957	110	3	63	339	0	3,233	134	287	277	618	69	677	5,810	21,556
1958	58	14	62	1,460	0	474	279	76	494	474	81	685	4,157	7,975
1959	675	228	77	3,578	0	916	2,963	1,210	1,499	430	226	857	12,659	15,278
1960	280	19	227	1,172	0	24,926	689	1,915	2,790	3,280	239	788	36,325	42,646
1961	15	1	4	159	0	6,748	58	5	970	115	277	737	9,089	26,272
1962	34	5	95	2,194	1	3,437	622	90	1,149	420	120	387	8,554	12,266
1963	120	68	41	1,035	6	341	876	323	944	458	205	401	4,818	8,642
1964	153	21	153	1,840	2	1,529	2,165	228	1,508	988	264	844	9,695	13,407
						.3-OCEAN								
1956	759	3	68	563	23	3,560	1,358	386	1,591	282	127	1,030	9,750	
1957	368	8	182	680	42	8,771	2,703	207	1,965	355	44	421	15,746	
1958	256	4	547	426	10	831	361	156	395	379	48	405	3,818	
1959	357	11	5	186	35	96	545	123	380	262	129	490	2,619	
1960	1,080	18	12	1,090	53	121	1,706	458	988	114	158	523	6,321	
1961	642	9	169	822	77	7,841	1,857	524	3,783	880	159	420	17,183	
1962	71	0	11	254	11	1,536	628	60	726	138	66	211	3,712	
1963	93	1	320	404	76	318	916	40	1,048	213	164	231	3,824	
1964	234	9	87	543	42	184	661	401	675	133	158	585	3,712	

taking the antilogarithm this equation becomes

$$R = 57.916\ S^{0.543059}$$

and for the .3-ocean returns the solution is

$$\log R = 1.599305 + 0.453233 \log S$$

taking the antilogarithm this equation becomes

$$R = 39.747\ S^{0.453233}\ .$$

Using these equations the expected .2-ocean return from the 1963 smolt outmigration is 662,000 fish and the expected .3-ocean return from the 1962 smolt outmigration would be 416,000 fish; however adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 308,000 .3-ocean fish, for a total expected return in 1965 of 970,000 red salmon.

TABLE 4. WOOD RIVER - SMOLT INDEX AND ADULT RETURN

Year of Outmigration	Smolt Index	Return in Thousands .2-ocean	.3-ocean
1951	9.9	223	85
1952	100.0	715	348
1953	296.1	1,719	563
1954	438.6	1,067	680
1955	221.7	339	426
1956	326.6	1,460	186
1957	165.5	3,578	1,090
1958	230.9	1,172	822
1959	60.5	159	254
1960	223.0	2,194	404
1961	518.7	1,035	543
1962	177.6	1,840	416*
1963	88.9	662*	

* 1965 forecast

Igushik Lakes - Tikchik Lakes

The forecast for the Igushik and Tikchik Lakes systems is based on escapement-return relationships. Linear regression analysis was used to formulate an estimate of the 1965 return based on the relationships of escapement to 4-year and 5-year returns (Table 5). It is assumed that the highly variable freshwater and ocean mortalities do not mask the computed relationships. The equation used is,

$$R = a + b E .$$

For the Igushik Lakes the solution of this equation for the 4-year returns is:

$$R = 42.699 + 0.285 E$$

and for the 5-year returns it is

$$R = 201.177 + 0.726 E .$$

For the Tikchik Lakes the solution of this equation for the 4-year returns is:

$$R = 43.010 + 0.250 E$$

and for the 5-year returns it is

$$R = -10.861 + 2.176 E .$$

Using these equations the expected 4-year return from the 1961 escapement is 126,000 red salmon to the Igushik Lakes and 63,000 red salmon to the Tikchik Lakes. The expected 5-year return from the 1960 escapement would be 561,000 red salmon to the Igushik Lakes and 307,000 red salmon to the Tikchik Lakes; however, adjusting these figures for the Japanese high seas catch of red salmon in 1964 gives an expected 5-year return of 443,000 red salmon to the Igushik Lakes and an expected 5-year return of 242,000 red salmon to the Tikchik Lakes.

Snake, Nushagak and Mulchatna

These river systems contribute only a small portion of the total return to the Nushagak Fishing District, and the available data does not show any significant relationships between escapements and returns (Table 6). The arithmetic mean was used to estimate the returns for 1965.

Naknek-Kvichak Fishing District

This district is composed of the Kvichak, Alagnak and Naknek River systems. The largest red salmon run in Alaska enters this district. In most years the returns to the district are dominated by the Kvichak River system. Since the commercial catch is taken in Kvichak Bay it cannot be separated directly into parts bound for the separate rivers. Therefore, the catch has

TABLE 5. IGUSHIK, TIKCHIK LAKES - ESCAPEMENTS AND RETURNS, IN THOUSANDS OF FISH

Brood Year	IGUSHIK Escapement	IGUSHIK 4-year return	IGUSHIK 5-year return	TIKCHIK Escapement	TIKCHIK 4-year return	TIKCHIK 5-year return
1950				42	14	10
1951				39	13	63
1952	150	161	348	38	6	172
1953	100	101	238	189	57	501
1954	80	52	497	29	56	28
1955	500	465	1,055	16	53	22
1956	400	168	556	30	217	168
1957	130	2	62	67	4	15
1958	107	15	93	196	94	349
1959	644	99	293	49	11	76
1960	495	64	561*	146	158	307*
1961	294	126*		80	63*	

* 1965 forecast

TABLE 6. SNAKE, NUSHAGAK AND MULCHATNA RIVERS, RETURNS IN THOUSANDS OF FISH

	SNAKE			NUSHAGAK and MULCHATNA		
Year of run	Escapement	4-year return	5-year return	Escapement	4-year return	5-year return
1950	4	5	11	1/	27	5
1951	3	34	4	1/	100	16
1952	4	4	7	15	24	0
1953	4	3	5	20	42	2
1954	4	13	80	8	10	0
1955	30	157	23	5	35	1
1956	4	13	7	5	53	3
1957	3	2	1	10	77	18
1958	9	4	3	5	14	0
1959	140	67	16	1/	76	0
1960	17	15	16*	1/	42	5*
1961	5	29*		20	45*	

* 1965 forecast

1/ No escapement estimate available.

been prorated to the separate river systems on the basis of the escapement by age group to each river system.

Kvichak River

Comparable indices of the smolt migration are used as the basis for forecasting the return to the Kvichak River (Table 7). Linear regression was used to estimate the 1965 return based on the relationships of smolt migration to .2-ocean and .3-ocean returns. The equation used is,

$$R = a + b S .$$

The solution of this equation for the .2-ocean returns is

$$R = - 225.559 + 178.338 S$$

and for the .3-ocean returns it is

$$R = -196.141 + 54.014 S .$$

Using these equations the expected .2-ocean return from the 1963 smolt migration is 12,650,000 red salmon and the expected .3-ocean return from the 1962 smolt migration would be 652,000 red salmon; however, adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 516,000 .3-ocean red salmon, for a total expected return in 1965 of 13,166,000 red salmon.

TABLE 7. KVICHAK RIVER - SMOLT INDEX AND ADULT RETURN

Year of Outmigration	Smolt Index 1/	Return in thousands of fish .2-ocean	.3-ocean
1955	11.2	3,233	831
1956	3.3	474	96
1957	1.3	916	121
1958	100.0	24,926	7,841
1959	85.9	6,748	1,535
1960	24.4	3,437	318
1961	1.6	341	184
1962	15.7	1,528	652*
1963	72.2	12,650*	

1/ Based on the enumeration of the smolt outmigration for the three-hour index period extending from 2200 to 0100.

* 1965 forecast

Alagnak River

The forecast for the Alagnak River system is based on escapement-return relationships. Linear regression analysis was used to formulate an estimate of the 1965 return based on the relationships of escapement to 4-year and 5-year returns (Table 8). The equation used is

$$R = a + b E .$$

The solution of this equation for the 4-year returns is

$$R = 383.159 + 0.262 E$$

and the solution for the 5-year returns is

$$R = 78.986 + 0.491 E .$$

Using these equations the expected 4-year returns from the 1961 escapement is 407,000 red salmon and the expected 5-year return from the 1960 escapement is 688,000 red salmon; however, adjusting this figure for the Japanese high seas catch of immature red salmon in 1964 gives an expected 5-year return of 550,000 red salmon, for a total expected return in 1965 of 957,000 red salmon.

TABLE 8. ALAGNAK RIVER - ESCAPEMENTS AND RETURNS, IN THOUSANDS OF FISH

Brood Year	Escapement	4-year Returns	5-year Returns
1955	166	807	314
1956	785	1,888	478
1957	125	5	69
1958	91	44	53
1959	825	297	459
1960	1,241	105	688*
1961	90	407*	

* 1965 forecast

Naknek River

Indices of the numerical magnitude of the smolt outmigration are used as the basis for forecasting the return to the Naknek River (Table 9). These have had a rather variable relation with the return and the geometric mean of the return per index point is used to compute the forecast.

Using this procedure the expected return of .2-ocean fish from the 1963 smolt outmigration is 1,239,000 fish and the expected return of .3-ocean fish from the 1962 smolt outmigration would be 2,311,000 fish; however, adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 1,828,000 .3-ocean fish, for a total expected return in 1965 of 3,067,000 fish.

TABLE 9. NAKNEK RIVER - SMOLT INDICES AND ADULT RETURNS IN THOUSANDS OF FISH

Year of Outmigration	Smolt Index	.2-ocean return Number of Fish	.2-ocean return Return per Index Point	.3-ocean return Number of Fish	.3-ocean return Return per Index Point
1956	59.64	279	4.678	545	9.138
1957	30.22	2,963	98.048	1,706	56.452
1958	100.00	689	6.890	1,857	18.570
1959	123.92	58	0.468	628	5.068
1960	66.51	622	9.352	916	13.772
1961	55.80	876	15.699	661	11.846
1962	163.65	2,165	13.229	2,311*	14.119 1/
1963	148.12	1,239*	8.368 1/		

* 1965 forecast

1/ Geometric mean of the return per index point.

Egegik River

The forecast for the Egegik River system is based on escapement-return relationships (Tables 10 and 11). Linear regression was used to estimate the 1965 return by computing the relationship of escapement to total return from the data given in Table 10 and then this regression equation is used to determine the contribution of the brood years 1958, 1959, 1960 and

1961 to the age classes of the expected 1965 return as given in Table 11. The equation used is

$$R = a + b E .$$

The solution of the regression equation is

$$R = - 424.148 + 3.599 E .$$

This equation is used to obtain the estimated return figures given in Table 11. The expected return to the Egegik River system would be 4,665,000 fish; however, adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 4,175,000 fish in 1965.

TABLE 10. EGEGIK RIVER - ESCAPEMENT AND RETURN IN THOUSANDS OF FISH

Brood Year	Escapement	Return
1944	310	631
1945	530	800
1946	660	1,042
1947	910	2,071
1948	890	2,571
1949	920	1,247
1950	630	1,700
1951	950	2,538
1952	757	1,209
1953	519	1,168
1954	507	2,155
1955	271	1,314
1956	1,104	6,970
1957	391	2,293

TABLE 11. EGEGIK RIVER - ESTIMATED RETURNS FROM BROOD YEARS 1958, 1959, 1960 AND 1961 IN THOUSANDS OF FISH

Brood Year	Escapement	Estimated Return 1/	Estimated return in 1965 by age groups 2/						Total
			4_2	5_2	5_3	6_3	6_4	7_4	
1958	246	461						9	9
1959	1,072	3,435				893	206		1,099
1960	1,799	6,050		545	2,844				3,389
1961	702	2,102	168						168
									4,665

1/ Estimated returns obtained from equation, R = -424.148 + 3.599 E.

2/ Based on average age composition:

4_2, 8 percent; 5_2, 9 percent; 5_3, 47 percent; 6_3, 28 percent; 6_4, 6 percent; 7_4, 2 percent.

Ugashik River

Indices of the numerical magnitude of the smolt outmigration are used as the basis for forecasting the return to the Ugashik River (Table 12). These have had a rather variable relation with the return and the geometric mean of the return per index point is used to compute the forecast.

Using this procedure the expected return of .2-ocean fish from the 1963 smolt outmigration is 3,057,000 fish and the expected return of .3-ocean fish from the 1962 smolt outmigration would be 785,000 fish; however, adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 621,000 .3-ocean fish, for a total expected return in 1965 of 3,678,000 fish.

TABLE 12. UGASHIK RIVER - SMOLT INDICES AND ADULT RETURNS IN THOUSANDS OF FISH

Year of Outmigration	Smolt Index	.2-ocean Return Number of Fish	.2-ocean Return Return per Index Point	.3-ocean Return Number of Fish	.3-ocean Return Return per Index Point
1958	100.00	3,280	32.800	880	8.800
1959	24.76	115	4.645	138	5.574
1960	47.20	420	8.898	213	4.513
1961	32.61	458	14.045	133	4.078
1962	143.16	988	6.901	785	5.481 1/
1963	289.46	3,057*	10.561 1/		

* 1965 forecast.

1/ Geometric mean of the return per index point.

Togiak and North Side Alaska Peninsula Systems

Formal forecasts have not been provided for the Togiak and the North Side Alaska Peninsula River Systems. An expected return to these systems for 1965 can be estimated by using the arithmetic average of the yearly returns. The return data and expected returns for 1965 are given in Table 13.

FORECAST OF TOTAL RETURN BASED ON HIGH SEAS PURSE SEINE CATCHES

Forecast Method

The abundance and age composition of immature red salmon at sea as indicated by purse seine catches south of Adak Island have been used as an index to the abundance and age composition of the following year's run to Bristol Bay. Seining has been conducted in June, July and August each year since 1956. Certain basic assumptions which underlie the use of this index are 1.) the assumption of a representative sample from the flow of immature reds through the index area, and 2.) that these samples contain a high and relatively constant proportion of reds of Bristol Bay origin and represent a major and relatively constant proportion of the immature Bristol Bay reds at sea. Extrapolation from the seine catch data as to total numbers of fish passing Adak Island, and tag returns and age composition analysis indicate that assumption 2.) is reasonably satisfied; therefore, if our indexing is

TABLE 13. TOGIAK AND NORTH SIDE ALASKA PENINSULA RIVER SYSTEM RETURNS IN THOUSANDS OF FISH

Year of run	TOGIAK .2-ocean	TOGIAK .3-ocean	NORTH SIDE ALASKA PENINSULA .2-ocean	NORTH SIDE ALASKA PENINSULA .3-ocean
1956	235	127	1,900	1,030
1957	69	44	677	421
1958	81	48	685	405
1959	226	129	857	490
1960	239	158	788	523
1961	277	159	737	420
1962	120	66	387	211
1963	205	164	401	231
1964	264	158	844	585
Expected Return in 1965	191 1/	117 1/	808 1/	480 1/
Adjusted .3-ocean Return		93 2/		380 2/

1/ Arithmetic average of yearly returns.

2/ The .3-ocean age figures are adjusted for the Japanese high seas catch of immature red salmon in 1964.

truly representative then this should give a reliable method of forecasting the run.

Linear regression analysis is used to estimate the 1965 return based on the relationship of average catches per seine set for a given year to the run to Bristol Bay the following year. Separate regression equations were calculated for forecasting numbers of .2-ocean age and .3-ocean age fish. The number of .2-ocean age fish in the Bristol Bay run is related to the index catch of .1-ocean age immatures the previous year, and similarly the .3-ocean age fish in the Bristol Bay run is related to the index catch of .2-ocean age fish the previous year (Table 14).

The 1965 forecast figures, together with the 90% statistical confidence limits for the predicted values, are given in millions of fish as follows:

.2-ocean age : 24.2 ± 6.3

.3-ocean age : 4.1 ± 3.6

The predicted total return is 28.3 million red salmon with an empirical confidence limit of ± 7.5 million fish. The 28.3 million total includes the Japanese high seas catch of immature .2-ocean age red salmon already removed in the summer of 1964, since in the regression analysis we have added into each years total for the Bristol Bay run of .3-ocean age red salmon an estimate of the preceding year's Japanese catch of immature .2-ocean age fish. The estimated catch of immature .2-ocean age red salmon in the summer of 1964 is 1.8 million (ref. Table 2). Subtracting this from the predicted total of 28.3 million gives an expected total return of 26.5 million red salmon in 1965.

Qualifying Factors

There are several factors that could grossly affect the 1965 forecast. These factors have not been used to modify the forecast because of insufficient data to evaluate their effect. They are listed below with comments on their possible influence.

1.) Fresh water age of the .1-ocean age immature reds.

This is the first season in which we have obtained a high index of .1-ocean age immature reds (85.1, Table 14) and at the same time a high proportion of fish that have spent 2 winters in fresh water. Over 89% of the .1 ocean age fish had spent 2 winters in fresh water, thus making them 4 years old from their year of spawning. In the only other year that .1-ocean age reds were comparably abundant (1959, index value 126.1, Table 14) the great majority, (83%) had spent only one winter in fresh water, and were thus 3-year-olds. If the older age of the 1964 fish causes a larger proportion to mature after 2 winters at sea (5 years of age in 1965), the result would be a larger run in 1965 than forecast.

TABLE 14. AVERAGE CATCH PER INDEX SEINE SET OF IMMATURE RED SALMON SOUTH OF ADAK ISLAND COMPARED WITH THE FOLLOWING YEAR'S BRISTOL BAY RUN.

Year of Index Catch	Average Catch/Set .1-ocean	Average Catch/Set .2-ocean	Year of Bristol Bay Return	Bristol Bay Total Returns (Millions) .2-ocean	Bristol Bay Total Returns (Millions) .3-ocean
1956	16.4	29.2	1957	5.8	15.7
1957	4.1	2.9	1958	4.2	3.8
1958	39.0	3.2	1959	12.6	2.6
1959	126.1	14.5	1960	36.3	6.3
1960	12.9	28.6	1961	9.1	17.2
1961	19.8	1.9	1962	8.6	3.7
1962	20.5	10.2	1963	4.8	3.8
1963	46.6	6.9	1964	9.7	3.7
1964	85.1	6.2	1965	24.2 1/	4.1 1/

1/ 1965 forecast values based on linear regression equations:

$R_2 = 2.1342 + 0.2594\ C_1$

$R_3 = 0.9232 + 0.5073\ C_2$ where,

R_2 : is .2-ocean age return

R_3 : is .3-ocean age return

C_1 : is .1-ocean age index catch

C_2 : is .2-ocean age index catch

2.) Small size of .1-ocean age immature reds at Adak Island.

The .1-ocean age immature reds in the index sets at Adak in 1964 averaged only 33.2 cm long, which is the smallest since sampling began in 1956. The 1956-1964 average is 35.0 cm. Since most fish in 1964 had spent an extra year in fresh water, we would expect an average size of at least 35.0 cm. If the smaller size in 1964 is due to an inverse relationship between size and abundance, the actual abundance may be greater than that indicated by our 1964 seine index. Thus, this factor suggests the possibility of a larger run in 1965 than forecast. On the other hand, the small size may mean poor physical condition, which may cause poor future survival and thus produce a smaller run than indicated by the index. Whatever its implications as to abundance, the small size of fish in 1964 may well indicate small-sized fish in the Bristol Bay run in 1965; probably even smaller than in 1960.

3.) Distribution at sea in 1965.

It is expected that the ocean distribution of maturing Bristol Bay red salmon in the spring of 1965 will be centered further to the east than in years when fish of older ocean age predominate, thus making a smaller proportion available for interception by the Japanese mothership fishery. In years when .2-ocean age fish have predominated in Bristol Bay, the mothership fleet has taken a much smaller proportion of the run than in years when .3-ocean age fish have predominated as shown in Table 15.

Thus, in 1965 when .2-ocean age fish will predominate, the proportion available to the mothership fleet will probably be less than in 1966 when .3-ocean age fish are expected to predominate.

FORECAST OF TOTAL .3-OCEAN RETURNS BASED ON .2-OCEAN RETURNS IN THE PREVIOUS YEAR

Bristol Bay red salmon commonly spend two years or three years in the ocean and the relation of the return after three years to the return after two years may be used to forecast the expected total return of .3-ocean age red salmon. The data in Table 16 was used to compute a linear regression equation relating these age classes. The equation used is,

$$R_3 = 0.800 + 0.502\ R_2$$

where

R_3 : is .3-ocean age return

R_2 : is .2-ocean age return.

Using this equation the expected .3-ocean return is 5,667,000 red salmon; however, adjusting this figure for the Japanese high seas catch of red salmon in 1964 gives an expected return of 3,867,000 .3-ocean red salmon in 1965.

TABLE 15. HIGH SEAS CATCH OF .2 OCEAN AGE FISH.

Year	Run to W. Alaska (millions) 1/	Percent .2-ocean age 1/	No. taken by mothership fleet (millions) 1/	Percent of W. Alaska run taken at sea	Catch per tan (shackle by mothership fleet 2/
1956	29.0	66	3.2	9.6	1.3
1957	18.9	34	8.1	51.3	5.8
1960	42.6	85	5.2	12.2	2.9
1961	26.3	35	7.4	28.1	3.5

1/ See sources in Table 2 and 3.

2/ In areas E of 175°E June 1-20, and E of 180° June 21-30, where majority of Bristol Bay fish are taken. (Source, INPFC statistical yearbooks).

TABLE 16. TOTAL RETURNS OF .2-OCEAN AGE AND .3-OCEAN AGE RED SALMON IN SUCCESSIVE YEARS, IN MILLIONS OF FISH

.2-ocean age		.3-ocean age	
Year	Return	Year	Return
1956	19.260	1957	15.746
1957	5.811	1958	3.818
1958	4.157	1959	2.619
1959	12.659	1960	6.321
1960	36.325	1961	17.183
1961	9.089	1962	3.712
1962	8.554	1963	3.824
1963	4.818	1964	3.712
1964	9.695	1965	5.667*

* 1965 forecast

TABLE 17. SUMMARY OF FORECASTS OF THE BRISTOL BAY RED SALMON RUN IN 1965 (IN MILLIONS OF FISH)

FORECAST BY RIVER SYSTEM

RIVER	.2-ocean (or 4-year)	.3-ocean (or 5-year) 1/	TOTAL
WOOD	.66	.31	.97
TIKCHIK	.06	.24	.30
IGUSHIK	.13	.44	.57
SNAKE	.03	.02	.05
MULCHATNA and NUSHAGAK	.05	.01	.06
TOTAL NUSHAGAK	.93	1.02	1.95
KVICHAK	12.65	.52	13.17
ALAGNAK	.41	.55	.96
NAKNEK	1.24	1.83	3.07
TOTAL NAKNEK-KVICHAK	14.30	2.90	17.20
EGEGIK	3.22	.96	4.18
UGASHIK	3.06	.62	3.68
TOGIAK	.19	.09	.28
NORTH SIDE ALASKA PENINSULA	.81	.38	1.19
TOTAL BRISTOL BAY	22.51	6.46	28.97
HIGH SEAS PURSE SEINE	24.2	2.3	26.5
REGRESSION OF .3-OCEAN RETURNS ON .2-OCEAN RETURNS		3.87	

1/ The .3-ocean (or 5-year) return figures have been adjusted by subtracting the Japanese high seas catch of Bristol Bay immature red salmon in 1964.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information please write to ADF&G, P.O. Box 25526, Juneau, AK 99802-5526; U.S. Fish and Wildlife Service, 4040 N. Fairfax Drive, Suite 300 Webb, Arlington, VA 22203 or O.E.O., U.S. Department of the Interior, Washington DC 20240.

For information on alternative formats for this and other department publications, please contact the department ADA Coordinator at (voice) 907-465-6077, (TDD) 907-465-3646, or (FAX) 907-465-6078.