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FORECAST OF THE 2001 RUN OF SOCKEYE SALMON TO BRISTOL BAY

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**ANNUAL REPORT TO
BRISTOL BAY PROCESSORS**

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KEY WORDS

Alaska, Bristol Bay fishery, forecasts, Port Moller, sockeye salmon, recruits-per-spawner

FORECASTS OF THE 2001 SOCKEYE SALMON RUNS TO BRISTOL BAY

A Report to the Bristol Bay Processors

D.E. ROGERS, W. LEW AND R. HILBORN

INTRODUCTION

Since the 1960s, the Fisheries Research Institute¹ has provided a preseason forecast of abundance for Bristol Bay sockeye to the fishing industry. A forecast is made for each district and age group and is done by stepwise multiple regression of possible predictors—including brood year escapement, sibling returns and smolt counts—on returns. Predictors found to be significant are included in the regression. If no predictors are found to be significant, then a 5-year average is used. This method has been used each year since 1989, and up to 1998 it formed the basis of the official SAFS forecast. The forecasts for 1999 and 2000 were modified from these regression method because of the poor performance of the method for the 1997 and 1998 returns. The multiple regression forecast for the 1999 return was 35.1 million while the actual return was 40.5 million—an under-prediction. The multiple regression forecast for 2000 was 43.1 million while the actual return was 28.1 million. For the forecast for 2001, we revert to the basic multiple regression methodology but provide discussion of the uncertainties in this forecast.

REVIEW OF THE 2000 RUN

We had predicted a best estimate total run to Bristol Bay of 37.7 million with a catch of 24.4 million, and the Alaska Department of Fish & Game (ADFG) predictions were similar with an inshore forecast of 33.4 million and a catch of 22.3 million (Table 1). The total 2000 run and catch (28.3 and 20.1 million) were less than forecasted by both agencies.

The run to the Kvichak was lower than forecasted ow-

ing to the low return of age 1.2 sockeye as well as poor return of 2.2 age class, which has dominated the age composition of all but two Kvichak peak runs in the past 50 years. In retrospect, we noticed that the average length of the 2-check smolt (juvenile sockeye that migrate to sea after two winters in freshwater) did not correlate well with the estimated number of 2-check smolt. In 1998, the average length of 2-check smolt was 112 mm—6 mm longer than would normally be expected for a hydroacoustic estimate of 103 million. This indicates that either the 2-check smolt had exceptionally good growing conditions, the hydroacoustic estimate was high, or both. Compared with the preseason forecast, Kvichak, Naknek, Egegik, and Ugashik were all much lower, while the Nushagak, Wood, and Igushik were all stronger than forecast. This continues a pattern that will be discussed below.

In addition to the preseason forecast, we have made inseason forecasts each year since 1987 from a test-fishing program based out of Port Moller (Table 2). This project has provided more accurate predictions (average error of 16%) than preseason forecasts because we are estimating the relative abundance of the run just 6–8 days before it arrives in the fishing districts. Prior to the 2000 season, a Bristol Bay almanac was provided to the processors so they could make daily forecasts of the final 2000 run beginning June 20. The forecast method was based on the past daily cumulative Port Moller indices and the past runs, and assumed average run timing. Very early in 2000 (June 20), the test boat catches indicated that the run was going to be several days early. The age compositions at Port Moller and in the False Pass fisheries showed a lack of age 2.2 sockeye, which were expected to provide slightly more than 20% of the run (Table 3).

The Pt. Moller test fishery was unusual in two respects. First, the run was very far offshore, with almost no catches being recorded at the traditional stations 2-8, but very strong initial catches at station 10 (Figure 1). We thus shifted our sampling to include stations 10, 12 and occasionally 14, and found most of the fish caught at stations 10 and 12.

¹In 1999, FRI was dissolved, with the Alaska Salmon Program continuing its work under the auspices of FRI's parent organization, the UW School of Aquatic & Fishery Sciences (formerly School of Fisheries). However, for historical purposes, FRI is still cited in this document for work conducted prior to 1999.

Second, the Pt. Moller test fishery, and indeed the return of fish to Bristol Bay, were the earliest ever recorded. The early strength at Pt. Moller led to an inseason prediction of a run in the high 30 millions in the first few days in July. But the inseason predictions declined rapidly when we discovered that the run already had peaked in early July.

In summary, neither the preseason nor the inseason forecasts for 2000 were reliable. This indicates, we believe, that the underlying biological system is in a state of flux, and indicators that provided reliable prediction in the past do not do so at present.

FORECASTS FOR 2001

The statistics used to forecast the 2001 Bristol Bay sockeye salmon runs came from several sources: (1) the numbers, ages, lengths, and weights of adult salmon in the catches and escapements and smolt in the seaward migration were from annual reports by ADFG (e.g., Stratton and Crawford 1994, Crawford 2000); (2) the relative numbers, ages, and lengths of fry in the Wood River and Kvichak lake systems were from annual reports by FRI (e.g., Rogers et al. 1998); and (3) air temperatures for Bristol Bay were from monthly reports by the US Weather Bureau. The Bristol Bay run statistics used in forecasting do not include estimates of interceptions (i.e., fish caught on the high seas or at False Pass). We are forecasting the inshore run from inshore statistics.

Run predictions were made for each major age group and summed to obtain a forecast for a river system. The river system forecasts were summed to predict the run to a fishing district, and the predicted catch was obtained by subtracting the recent 5-year average of escapements. To predict the return of an age group in 2001, all relevant statistics from past brood years (since 1981) were assembled and submitted to a stepwise multiple regression procedure. When no measurement (variable) was significantly correlated with past variation in a run, then the average runs for the past 5 years were used to predict the 2001 run. Only adult returns since 1985 (1981 brood year) were used because there has been a shift in the ocean age composition towards more 3-ocean fish, and the production of sockeye salmon at Egegik has increased greatly since 1980. Egegik was a low producer relative to the size of the lake (second largest in Bristol Bay); now production is more in line with other systems in Bristol Bay.

The forecast of the total 2001 Bristol Bay sockeye salmon run is 21.5 million with a predicted catch of 13.8 million (Table 4). The database and forecast statistics are presented in Tables 5-10.

Prediction Errors

Table 11 shows the observed and predicted. Figure 2 shows that since 1996 we have consistently over-forecast the eastside runs, with the actual run being, on average, 68% of the forecast. The west side shows a different pattern, with under-forecasts more common than over-forecasts (Figure 3).

While FRI did not make preseason forecasts through the early 1980s, ADFG did, and during that period they were generally under-forecasting. It is our belief that the under-forecasts of the early 1980s, and indeed continuing in the early 1990s, reflected the change in ocean survival associated with the Pacific Decadal Oscillation. The fact that for the major runs we have consistently been over-forecasting in the last 5 years is a strong indication that there has been a change in ocean conditions and we may have entered a less productive ocean regime.

Given that we have consistently been over-forecasting with the multiple regression methodology, we do have a concern that our 2001 forecast, as low as it is, may be too high. It is not possible to quantify this concern reliably; we could use the average prediction errors in the past few years to modify our forecast downwards, but we do not have confidence in applying such a correction. The production from the west side has been consistent, and we see no reason to believe that the west side will not continue to produce well based on recent history. The major concern is the east side. We see little reason to expect any significant catch from the Kvichak – its recent history has been poor. Any significant catches from the east side will need to come from Naknek, Egegik, and Ugashik. If recent history is a guide, the estimates of catch from these districts we calculated may not be achieved.

A Final Caution on Forecasting in Periods of Change

Run forecasting depends on establishing historical relationships among variables. For the east side at least, it is clear that our recent forecasts have not been reliable and there is little reason to expect the 2001 forecast to be any more reliable. Bristol Bay run forecasts have historically been accurate during the middle of long-term production regimes, and during these periods they have been of considerable use to participants in the fishery. It seems possible that we are now in a period of changing production regimes, and our hope is to continue to collect the data needed for forecasting so that during more settled regimes the forecasts can be made again reliable.

FIGURES

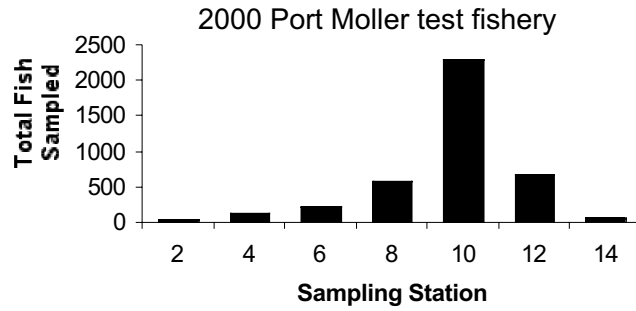


FIGURE 1. Distribution of catches by station at Port Moller, 2000.

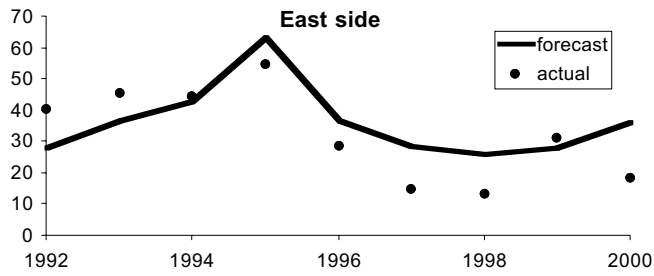


FIGURE 2. Forecast vs. the actual return (in millions) of sockeye salmon to the eastside systems, 1992–2000.

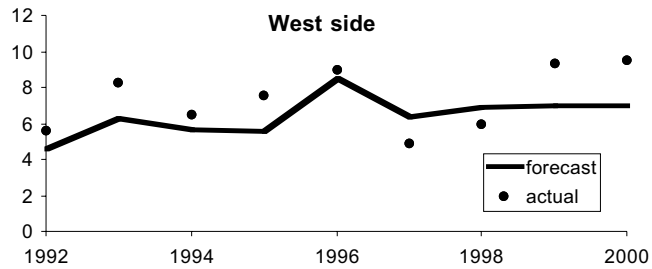


FIGURE 3. Forecast vs. the actual return (in millions) of sockeye salmon to the westside systems, 1992–2000.

TABLES

TABLE 1. Forecast comparison by agency, 1989-2000.

Year	Agency	Age 1.2	Age 2.2	Age 1.3	Age 2.3	Total
1989	ADFG	6.40	13.00	6.90	2.60	28.90
	FRI	4.90	23.60	6.80	2.70	38.00
1990	ADFG	4.80	10.70	6.60	3.30	25.40
	FRI	4.80	11.90	8.30	4.80	29.80
1991	ADFG	8.40	7.50	9.30	4.80	30.00
	FRI	15.00	5.10	11.40	5.10	36.70
1992	ADFG	7.00	14.50	10.00	4.80	37.20
	FRI	5.90	12.90	8.90	4.60	33.00
1993	ADFG	9.60	17.10	8.80	5.90	41.80
	FRI	6.90	17.80	8.70	9.10	43.30
1994	ADFG	7.40	22.60	10.00	11.60	52.50
	FRI	8.30	18.10	7.30	14.20	52.40
1995	ADFG	8.80	29.20	9.40	7.20	55.10
	FRI	4.80	26.60	10.10	10.60	53.10
1996	ADFG	7.80	15.60	11.30	8.20	43.40
	FRI	5.90	9.90	14.50	14.00	45.20
1997	ADFG	7.40	10.40	8.40	6.70	33.60
	FRI	9.80	9.50	10.20	5.30	35.10
1998	ADFG	7.60	9.70	7.20	5.40	30.20
	FRI	11.20	8.80	7.80	5.70	33.80
1999	ADFG	6.40	10.20	6.30	2.00	24.90
	FRI	9.80	14.30	8.50	2.40	35.10
2000	ADFG	6.90	9.80	12.90	5.80	33.40
	FRI	6.10	8.10	17.60	5.80	37.70

TABLE 2. Annual catches (millions) of sockeye salmon in Bristol Bay and the pre- and inseason forecasts.

Year	Catch	ADFG pre-season			FRI pre-season			Port Moller FRI in-season		
		Forecast	F-C	Error (%)	Forecast	F-C	Error (%)	Forecast	F-C	Error (%)
1987	16.0	8.7	-7.3	-46	12.4	-3.6	-23	17.0	1.0	6
88	13.8	16.8	3.0	22	20.8	7.0	51	12.0	-1.8	-13
89	28.7	16.2	-12.5	-44	25.4	-3.3	-11	28.0	-0.7	-2
90	33.1	14.7	-18.4	-56	19.0	-14.1	-43	25.0	-8.1	-24
91	26.2	21.2	-5.0	-19	25.0	-1.2	-5	20.5	-5.7	-22
92	32.0	26.3	-5.7	-18	22.0	-10.0	-31	29.0	-3.0	-9
93	40.8	32.0	-8.8	-22	31.9	-8.9	-22	32.3	-8.5	-21
94	35.2	39.7	4.5	13	34.1	-1.1	-3	29.0	-6.2	-18
95	44.4	40.3	-4.1	-9	34.4	-10.0	-23	33.0	-11.4	-26
96	29.7	34.6	4.9	16	33.4	3.7	12	34.0	4.3	14
97	12.3	24.8	12.5	102	25.4	13.1	107	17.0	4.7	38
98	10.0	20.6	10.6	106	23.5	13.5	135	10.7	0.7	7
99	25.8	13.8	-12.0	-47	21.2	-4.6	-18	26.0	0.2	1
00	20.5	22.3	1.8	9	24.4	3.9	19	20.0	-0.5	-2
Means (abs.)	26.8	23.8	8.0	38	25.3	7.0	36	24.1	4.2	16

Pre-season forecasts from October in prior year and in-season forecast about 7/2-5 in year of run.

Error= percent that the forecast differed from the catch.

TABLE 3. Comparison of the age compositions of sockeye salmon in Bristol Bay runs with age compositions in Port Moller catches, the False Pass fishery and preseason forecasts.

Year		Age composition (%)						Forecast/ run (millions)
		1.2	2.2	1.3	2.3	all .2	all .3	
1993	ADF&G	23	41	21	14	64	35	41.8
	FRI	16	41	20	21	56	43	43.3
	False Pass	14	46	14	23	61	38	
	Port Moller	7	27	19	44	34	65	45.0
	BB run	13	33	18	33	46	53	51.9
1994	ADF&G	14	43	19	22	57	43	52.5
	FRI	17	37	15	29	55	45	48.8
	False Pass	8	34	33	22	42	57	
	Port Moller	7	42	20	28	50	50	41.0
	BB run	8	56	14	18	65	34	50.1
1995	ADF&G	16	53	17	13	69	31	55.1
	FRI	9	50	19	20	59	41	53.1
	False Pass	19	57	12	11	76	24	
	Port Moller	14	51	15	19	65	34	49.2
	BB Run	16	56	12	14	73	27	60.7
1996	ADF&G	18	36	26	19	54	48	43.4
	FRI	13	22	32	31	35	65	45.2
	False Pass	15	24	38	20	39	61	
	Port Moller	8	13	51	24	21	79	44.0
	BB Run	10	13	51	24	23	76	36.9
1997	ADF&G	22	31	25	20	53	47	33.6
	FRI	28	27	29	15	56	44	35.1
	False Pass	19	44	23	11	64	36	
	Port Moller	9	26	33	27	36	62	35.0
	BB Run	20	34	26	18	54	44	18.9
1998	ADF&G	25	32	24	18	57	43	30.2
	FRI	33	26	23	17	59	41	33.8
	False Pass	14	9	39	37	24	76	
	Port Moller	18.8	9	38	33	28	72	30.7
	BB Run	34	13	29	22	47	52	18.2
1999	ADF&G	26	41	25	8	67	33	24.6
	FRI	28	41	24	7	69	31	35.1
	False Pass	56	19	21	3	75	25	
	Port Moller	48	28	17	7	76	24	38.0
	BB Run	51	24	17	7	75	24	39.4
2000	ADF&G	20	27	37	16	47	53	33.3
	FRI	14	20	53	12	34	66	42.7
	False Pass	26	20	42	7	46	58	
	Port Moller	19	9	59	13	28	72	37.0
	BB run	18	10	57	15	28	72	28.3

Forecasts and runs do not include jacks (ages 1.1 and 2.1).
The Port Moller forecast is on 6/30 and the age composition is through 6/30 only.

TABLE 4. Forecasts of the 2001 Bristol Bay sockeye runs.

River system District	Runs by age group (millions)							Total	Catch
	1.2	2.2	2-ocean	0.3	1.3	2.3	3-ocean		
Kvichak	2.0	1.2	3.2		0.7	0.3	1.0	4.2	
Naknek	0.2	0.2	0.4		0.8	0.6	1.4	1.8	
Branch	0.3	0.1	0.4		0.1	0.0	0.1	0.5	
Naknek/Kvichak	2.5	1.5	4.0		1.6	0.9	2.5	6.5	3.0
Egegik	0.6	1.2	1.8		2.2	1.3	3.5	5.3	4.0
Ugashik	0.4	0.3	0.7		0.2	0.5	0.7	1.4	0.7
Wood	2.1	0.2	2.3		2.1	0.2	2.3	4.6	
Igushik	0.2	0.0	0.2		0.7	0.0	0.7	0.9	
Nush/Nuy	0.2	0.0	0.2	0.1	2.0	0.1	2.2	2.4	
Nushagak	2.5	0.2	2.7	0.1	4.8	0.3	5.2	7.9	5.9
Togiak	0.1	0.0	0.1		0.3	0.0	0.3	0.4	0.2
Bristol Bay	6.1	3.2	9.3	0.1	9.1	3.0	12.2	21.5	13.8

TABLE 5. Kvichak sockeye salmon statistics to forecast 2001 runs by freshwater age.

Brood year	Escapement		Age 1 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 1.2
	Number millions	Percent age .2	Number millions	Mean weight	1.1	1.2	1.3	Total		
77	1.34	86	29	6.0	.039	1.82	.84	2.70	9.3	518
78	4.15	81	182	5.9	.000	1.66	1.09	2.75	1.5	513
79	11.22	90	220	5.4	.057	17.60	2.14	19.80	9.0	510
80	17.50	96	150	5.1	.002	2.81	1.49	4.30	2.9	478
81	1.75	82	7	4.9	.000	.77	.22	.99	14.1	523
82	1.14	65	52	6.8	.000	.44	.52	.96	1.8	528
83	3.57	93	24	5.3	.001	8.38	2.98	11.36	47.3	515
84	10.49	80	83	5.5	.000	2.46	1.87	4.33	5.2	512
85	7.21	68	11	4.5	.007	1.00	1.24	2.25	20.4	505
86	1.18	74	13	5.6	.000	.66	1.05	1.71	13.2	490
87	6.07	96	147	5.5	.004	4.04	2.38	6.42	4.4	493
88	4.06	56	47	5.8	.004	2.43	2.37	4.80	10.2	495
89	8.32	92	87	5.5	.002	2.01	1.56	3.57	4.1	511
90	7.00	91	18	5.6	.008	1.50	1.14	2.65	14.7	487
91	4.20	77	22	6.0	.001	2.59	1.23	3.82	17.4	506
92	4.73	77	54	5.7	.000	.41	.21	.62	1.1	517
93	4.05	69	210	6.2	.001	.79	.84	1.63	0.8	518
94	8.34	94	277	6.5	.003	1.75	1.12	2.87	1.0	506
95	10.04	87	269	6.8	.017	7.31	1.80	9.13	3.4	501
96	1.45	40	192	6.7	.000	.34	.74			504
97	1.50	79	131	5.5	.000	1.95				

1) 2001 forecast of age 1.2 from return of age 1.1 (.000) and regression of age 1.2 on age 1.1 for 1974-96.
R²= .49 Y= 1.95 + 197 (age 1.1)

2) 2001 forecast of age 1.3 from return of age 1.2 (.34) and regression of age 1.3 on age 1.2 for 1981-95.
R²= .61 Y= 0.74 + .26 (age 1.2)

Brood year	Escapement		Age 2 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 2.2
	Number millions	Percent age .2	Number millions	Mean weight	2.1	2.2	2.3	Total		
77	1.34	86	10	10.7	.002	.18	.09	.27	2.7	531
78	4.15	81	32	10.2	.016	1.24	.80	2.06	6.4	524
79	11.22	90	89	9.1	.073	17.01	3.28	20.36	22.9	504
80	17.50	96	76	8.5	.020	7.79	.38	8.19	10.8	523
81	1.75	82	38	10.0	.000	.91	.16	1.07	2.8	536
82	1.14	65	2	9.2	.001	.50	.14	.64	32.1	521
83	3.57	93	53	10.4	.003	1.13	.54	1.67	3.2	533
84	10.49	80	330	7.0	.043	16.35	2.39	18.78	5.7	513
85	7.21	68	87	8.3	.028	13.08	1.51	14.62	16.8	497
86	1.18	74	7	10.0	.000	1.34	1.23	2.57	36.7	506
87	6.07	96	41	10.5	.030	4.24	.68	4.95	12.1	514
88	4.06	56	34	9.9	.019	4.02	.53	4.57	13.4	538
89	8.32	92	61	9.3	.117	18.47	3.24	21.83	35.8	502
90	7.00	91	205	8.2	.082	20.55	1.22	21.85	10.7	510
91	4.20	77	30	9.5	.002	.67	.16	.83	2.8	522
92	4.73	77	11	9.8	.002	.51	.14	.65	5.9	533
93	4.03	69	96	11.3	.001	.59	.55	1.14	1.2	520
94	8.34	94	94	10.7	.029	3.60	.24	3.87	4.1	518
95	10.04	87	103	11.9	.000	.47	.33			524
96	1.45	40	12	10.5	.000	1.23				

1) 2001 forecast of age 2.2 from return of age 2.1 (.000) and regression of 2.2 on 2.1 for 1981-95.
R²= .80; F1,14= 56.3 Y= 1.23 + 190.4(age 2.1)

2) 2001 forecast of age 2.3 from return of age 2.2 (.47) and regression of age 2.3 on 2.2 for 1981-94.
F1,11=23.1, R²=.67 Y= .102 (age 2.2) + 0.28

TABLE 7. Egegik sockeye salmon statistics to forecast runs by freshwater age.

Brood Year	Escapement		Age 1 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 1.2
	Number millions	Percent age .2	Number millions	Mean weight	1.1	1.2	1.3	Total		
81	0.69	71	2	9.5	.000	.52	.95	1.47	73.5	519
82	1.03	88	17	10.1	.002	1.01	1.79	2.80	16.5	510
83	0.79	88	55	10.4	.002	1.72	2.69	4.41	8.0	509
84	1.17	69	14	9.0	.001	.58	.93	1.51	10.8	502
85	1.10	67	4	11.6	.000	.54	1.33	1.87	46.8	511
86	1.15	74	36	10.2	.002	1.76	3.59	5.35	14.9	483
87	1.27	54	72	8.9	.000	.86	4.34	5.20	7.2	496
88	1.61	57	4	9.6	.001	.40	1.43	1.83	45.7	472
89	1.61	58	5	10.3	.000	.59	.43	1.02	20.4	522
90	2.19	70	6	9.7	.000	.40	.84	1.24	20.7	480
91	2.79	56	20	9.3	.001	1.33	3.87	5.20	26.0	502
92	1.94	63	55	9.7	.000	.32	1.04	1.36	2.5	508
93	1.52	44	7	9.3	.002	.46	.53	0.99	14.1	502
94	1.90	70	22	10.5	.008	.36	.94	1.30	5.9	484
95	1.27	76	12	9.2	.007	3.05	3.10	6.15	51.3	498
96	1.08	37	50	9.0	.001	.47	2.16			490
97	1.10	69	1	9.5	.000	.63				

1) 2001 forecast of age 1.2 from return of 1.1 (0) and regression of 1.2 on 1.1

$$R^2=.25 \quad F_{1,14}=4.6 \quad Y= .63 + 151.5 (\text{age}1.1)$$

2) 2001 forecast of age 1.3 from number of age 1 smolt (50) and return age 1.2 (.47)

$$R^2= .66; F_{1,12}= 11.7 \quad Y= .30 + .028 (\text{age 1 smolt}) + .988 (\text{age 1.2})$$

Brood Year	Escapement		Age 2 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 2.2
	Number millions	Percent age .2	Number millions	Mean weight	2.1	2.2	2.3	Total		
81	0.70	71	32	12.2	.060	3.30	1.39	4.69	14.7	528
82	1.03	29	11	16.8	.012	1.74	1.59	3.33	30.3	529
83	0.79	88	30	15.7	.007	3.03	2.61	5.64	18.8	520
84	1.17	69	45	14.1	.083	6.17	4.74	10.91	24.2	524
85	1.10	67	13	14.3	.031	4.17	1.22	5.39	41.5	498
86	1.15	74	27	15.4	.010	3.79	4.21	8.00	29.6	502
87	1.27	54	52	14.5	.064	8.41	10.73	19.20	36.9	492
88	1.61	58	89	15.6	.063	10.24	5.48	15.78	17.7	520
89	1.61	54	18	12.4	.034	5.98	3.92	9.90	55.0	488
90	2.19	70	38	12.2	.065	9.28	4.61	13.89	36.6	512
91	2.77	56	39	13.7	.020	2.98	2.49	5.47	14.0	520
92	1.95	65	50	11.6	.053	4.51	2.80	7.36	14.7	502
93	1.52	44	8	16.1	.029	0.84	0.98	1.85	23.1	502
94	1.90	70	15	13.7	.065	4.13	3.03	7.23	48.2	500
95	1.27	76	28	13.7	.004	1.52	1.32			510
96	1.08	37	8	17.6	.005	1.23				

1) 2001 forecast of age 2.2 from age 2 smolt (8) and regression of age 2.2 on age 2 smolt

$$R^2= .66; F_{2,12}= 11.9$$

$$Y= .49 + .068 (\text{age}2 \text{ smolt}) + 48.11 (\text{age } 2.1)$$

2) 2001 forecast of age 2.3 from return of age 2.2 (1.52) and regression of age 2.3 on 2.2

$$R^2= .55; F_{1,12}=14.7$$

$$Y= .30 + .67(\text{age } 2.2)$$

TABLE 8. Ugashik sockeye salmon statistics to forecast runs by freshwater age.

Brood year	Escapement		Age 1 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 1.2
	Number millions	Percent age .2	Number millions	Mean weight	1.1	1.2	1.3	Total		
81	1.33	42	31	7.6	.002	1.51	2.51	4.02	13.0	514
82	1.16	20	75	6.8	.001	.41	.69	1.10	1.5	514
83	1.00	90	13	8.3	.000	.60	.34	0.94	7.2	512
84	1.24	81	38	5.8	.000	.45	.55	1.00	2.6	512
85	1.00	75	6	7.9	.001	.49	.69	1.18	19.7	507
86	1.00	41	183	5.7	.001	.48	2.38	2.86	1.6	488
87	0.67	56	89	6.5	.001	.81	1.55	2.36	2.7	502
88	0.64	54	15	6.7	.002	.45	.67	1.12	7.5	498
89	1.68	84	26	7.7	.007	.66	.37	1.04	4.0	517
90	0.73	60			.001	.34	.67	1.01		488
91	2.48	57	58	8.0	.006	1.93	3.08	5.02	8.6	504
92	2.17	49	24	6.7	.003	.18	.54	0.72	3.0	498
93	1.41	48	7	7.8	.002	.24	.32	0.56	8.0	490
94	1.08	79	1	9.9	.011	.32	.31	0.64	53.4	488
95	1.30	80	14	7.8	.018	2.71	1.51	4.24	29.6	509
96	0.67	16	10	6.4	.000	.22	.26			499
97	0.62	65	11	6.6	.000	.40				

- 1) 2001 forecast of age 1.2 from regression of age 1.2 on age 1.1
 $R^2=.44$, $F_{1,13}=9.8$ $Y= .40 + 96.3$ (age 1.1)
- 2) 2001 forecast of age 1.3 from age 1.2 (.22) and number age 1 smolt(10).
 $R^2= .73$; $F_{2,11}= 15.2$ $Y= .011$ (smolt) +.84 (age 1.2) -.03

Brood year	Escapement		Age 2 smolt		Adult return (millions)				Smolt/ adult survival (%)	Mean length age 2.2
	Number millions	Percent age.2	Number millions	Mean weight	2.1	2.2	2.3	Total		
79	1.70	53			.008	1.39	.52	1.91		502
80	3.32	59	13	13.3	.039	3.19	.78	3.97	30.5	520
81	1.33	42	83	10.3	.004	2.20	.90	3.10	3.7	524
82	1.16	22	21	11.8	.001	.58	.72	1.30	6.2	517
83	1.00	90	15	10.9	.006	.59	.30	.89	5.9	528
84	1.24	80	21	11.1	.054	3.50	.69	4.24	20.2	523
85	1.00	75	33	10.8	.002	.95	.46	1.41	4.3	504
86	1.00	41	32	10.7	.001	1.83	1.63	3.46	10.8	506
87	0.67	56	39	11.8	.010	1.78	2.26	4.04	10.4	499
88	0.64	58	48	11.6	.026	2.03	2.18	4.24	8.8	527
89	1.68	84			.014	2.43	.93	3.37		490
90	0.73	61	12	12.5	.015	2.23	1.18	3.43	27.6	517
91	2.48	57	6	11.2	.001	.57	.30	.87	15.3	512
92	2.17	49	15	11.1	.004	.88	.74	1.62	10.6	506
93	1.41	48	1	13.5	.006	.23	.20	.44	31.1	508
94	1.08	79	1	12.7	.012	.67	.27	.95	79.3	509
95	1.30	80	2	11.1	.001	.17	.52			516
96	0.67	16	<1	19.6	.000	.28				

- 1) 2001 forecast of age 2.2 from age 2.1 (.000) and number of age 2 smolt (0)
 $R^2= .82$; $F_{2,11}= 24.1$ $Y= .28 + 49.2$ (age 2.1) + .022(age 2 smolt)
- 2) 2001 forecast of age 2.3 from age 2 smolt (2)
 $R^2= .28$, $F_{1,11}= 4.2$ $Y= .49 + .016$ (smolt)

TABLE 9. Sockeye salmon escapements and returns to the Wood and Igushik rivers.

Wood River												
Brood year	Escapement		Temperatures for		Adult return (millions)						Mean length of 1.2	
	Number millions	Percent age .2	Fry Apr-Oct	Smolt Apr-June	1.1	1.2	2.2	1.3	2.3	Total		
81	1.23	37	5.4	7.0	.000	.60	.08	1.14	.09	1.91	490	
82	.98	34	7.5	4.9	.003	.50	.13	.90	.02	1.55	501	
83	1.36	75	6.8	1.8	.001	1.91	.02	1.23	.07	3.23	495	
84	1.00	22	5.0	4.3	.000	.52	.03	1.32	.02	1.89	502	
85	.94	49	6.7	4.9	.003	1.11	.03	1.37	.01	2.52	501	
86	.82	36	7.5	5.3	.002	1.16	.07	1.94	.06	3.23	480	
87	1.34	82	6.9	6.1	.000	1.36	.09	.74	.09	2.28	486	
88	.87	37	8.3	6.9	.001	1.59	.09	1.39	.03	3.10	482	
89	1.19	49	7.8	6.1	.004	2.17	.01	1.82	.04	4.04	496	
90	1.07	50	8.0	5.4	.001	1.08	.28	1.15	.16	2.67	477	
91	1.16	36	6.5	8.2	.012	2.53	.05	2.43	.07	5.08	496	
92	1.29	73	9.1	6.5	.001	2.32	.09	1.60	.05	4.06	495	
93	1.18	59	7.5	7.6	.000	1.67	.13	.98	.19	2.97	491	
94	1.47	52	8.7	6.8	.010	2.77	.43	1.93	.09	5.22	488	
95	1.48	73	7.1	8.0	.005	3.37	.14	2.51	.21		501	
96	1.65	49	8.7	6.1	.000	2.54	.17	2.12			502	
97	1.51	56	7.5	4.6	.000	2.14						
1)	2001 return of age 1.2 from return age 1.1 (.000) and parent escapement (1.51) R ² = .66; F _{2,13} = 12.6 Y= 106.7(age 1.1) + 2.28(esc.) -1.30											
2)	2001 forecast of age 1.3 was from return age 1.2 (2.54) and percent age .2 in escapement (49) R ² = .81; F _{2,12} = 26.4 Y= 1.34 + .652 (age 1.2) - .018(%age .2 esc)											
3)	2001 return of age 2.2 from recent 5-year average (.17)											
4)	2001 return of age 2.3 from return of 2.2 (.14) and regression of 2.3 on 2.2 R ² = .21, F _{1,12} =7.4 Y= .2085 + .048(age 2.2)											

Igushik												
Brood Year	Escapement		Mean air temp. for:		Adult returns (millions)						Mean length of 1.2	
	Number millions	Percent age.2	Fry Apr-Oct	Smolt Apr-June	1.2	2.2	1.3	2.3	Total			
81	.59	24	5.4	7.0	.15	.00	.83	.05	1.03	512		
82	.42	5	7.5	4.9	.05	.01	.48	.01	.55	548		
83	.18	73	6.8	1.8	.15	.01	.33	.03	.52	508		
84	.19	9	5.0	4.3	.03	.05	.63	.03	.74	525		
85	.21	37	6.7	4.9	.51	.08	.90	.08	1.57	525		
86	.31	7	7.5	5.3	.23	.03	2.20	.03	2.49	494		
87	.17	40	6.9	6.1	.16	.01	.57	.03	.77	516		
88	.17	12	8.3	6.9	.19	.04	1.02	.04	1.29	503		
89	.46	49	7.8	6.1	.48	.06	1.05	.05	1.64	519		
90	.37	25	8.0	5.4	.16	.18	1.36	.15	1.85	494		
91	.76	6	6.5	8.2	.31	.00	1.31	.02	1.64	507		
92	.31	26	9.1	6.5	.04	.01	.13	.02	.20	517		
93	.41	31	7.5	7.6	.12	.02	.29	.04	.47	507		
94	.45	27	8.7	6.8	.24	.09	.84	.03	1.20	488		
95	.47	30	7.1	8.0	.65	.02	1.60	.03		512		
96	.40	3	8.7	6.1	.16	.03	.73			516		
97	.13	52	7.5	4.6	.24							
1)	2001 returns of age 1.2 and 2.2 from recent 5-year averages.											
2)	2001 returns of age 1.3 from return age 1.2 (.16) and regression of 1.3 on 1.2 R ² = .54 Y= .454 + 1.709(age 1.2)											
3)	2001 returns of age 2.3 from return of 2.2 (.02) and regression of 2.3 on 2.2 R ² =.72 Y= .016 + .616(age 2.2)											

TABLE 10. Sockeye salmon escapements and returns to the Nushagak and Togiak rivers.

Nushagak/Nuyakuk											
Brood year	Escapement		Adult return (millions)							Mean length	
	Number millions	Percent age .2	0.2	0.3	0.4	1.2	1.3	1.4	Total	1.2	1.3
81	1.01	13	.01	.12	.01	.16	1.43	.06	1.79	487	554
82	.60	7	.04	.33	.05	.16	.85	.06	1.49	497	572
83	.40	35	.10	.57	.12	.11	.62	.02	1.54	502	570
84	.59	16	.01	.22	.03	.12	.55	.02	.95	493	568
85	.50	48	.06	.49	.06	.06	.59	.01	1.27	459	558
86	.99	6	.06	.83	.06	.11	.67	.21	1.94	471	554
87	.39	28	.14	.92	.25	.04	.52	.10	1.97	462	541
88	.48	16	.07	.52	.12	.21	1.39	.06	2.37	468	573
89	.50	14	.07	.47	.03	.12	.66	.02	1.37	480	555
90	.67	22	.05	.75	.10	.04	.24	.01	1.19	454	556
91	.50	5	.01	.13	.01	.17	.99	.12	1.43	461	569
92	.70	31	.08	.49	.01	.22	.59	.05	1.44	486	563
93	.72	11	.04	.03	.00	.06	.68	.12	.93	474	546
94	.51	6	.00	.04	.00	.08	.66	.01	.79	456	565
95	.28	39	.00	.01	.00	.14	.90	.06	1.11	462	559
96	.50	18	.00	.00	.00	.47	2.02			501	
97	.37	9	.00	.07		.19					
98	.46	8									

- 1) 2001 returns of age 1.2 from recent 5-year average.
- 2) 2001 forecast of age 0.3 from return of age 0.2 (0) and regression of return 0.3 on 0.2
R²= .83 Y= .074 + 6.70 (age 0.2)
- 3) 2001 forecast of age 1.3 from return of age 1.2 (.47) and regression of return 1.3 on 1.2
R²= .42 Y= .31 + 3.64 (age 1.2)

Togiak											
Brood year	Escapement		Adult return (millions)							Mean length	
	Number millions	Percent age .2	0.2	0.3	1.2	1.3	2.2	2.3	Total	1.2	1.3
81	.31	19	.002	.01	.05	.24	.01	.02	.33	501	568
82	.29	30	.000	.02	.11	.24	.01	.02	.40	513	579
83	.21	28	.001	.00	.28	.91	.01	.02	1.22	516	586
84	.15	41	.000	.01	.02	.11	.00	.02	.16	520	583
85	.15	20	.000	.01	.03	.21	.04	.08	.37	513	579
86	.20	27	.000	.03	.08	.44	.08	.11	.74	504	572
87	.28	39	.000	.01	.19	.53	.03	.08	.84	514	567
88	.31	73	.001	.01	.11	.39	.03	.05	.59	515	592
89	.10	3	.000	.04	.12	.31	.01	.04	.52	522	561
90	.19	24	.001	.02	.10	.43	.07	.04	.66	495	570
91	.28	41	.001	.00	.18	.42	.03	.03	.66	516	589
92	.20	23	.001	.03	.05	.11	.03	.03	.25	525	581
93	.19	24	.000	.00	.06	.25	.01	.02	.34	512	561
94	.17	45	.000	.00	.04	.16	.03	.01	.24	515	552
95	.21	36	.000	.00	.33	.97	.01	.03	1.34	498	584
96	.19	20	.001	.00	.08	.32	.02			522	
97	.15	49	.000		.12						

- 1) 2001 forecasts of ages 1.2 and 2.2 from recent 5-year averages
- 2) 2001 forecast of age 1.3 from return age 1.2 (.08) and regression of return of 1.3 on 1.2
R²= .89 Y= .032 + 3.62 (age 1.2)
- 3) 2001 forecast of age 2.3 from return age 2.2
R²= .47 F_{1,12}=10.7 Y= .016 + .87 (age 2.2)

TABLE 11. Annual inshore runs of sockeye salmon to Bristol Bay and the pre- and inseason forecasts.

Year	Run	ADFG preseason			FRI preseason*			FRI inseason**		
		Forecast	F-R	Error (%)	Forecast	F-R	Error (%)	Forecast	F-R	Error (%)
1962	10.4	8.2	-2.2	-21	7.6	-2.8	-27			
63	6.9	8.6	1.7	25	15.3	8.4	122			
64	10.7	17.4	6.7	63	19.3	8.6	80			
65	53.1	27.8	-25.3	-48	25.3	-27.8	-52			
66	17.5	31.3	13.8	79	32.6	15.1	86			
67	10.3	14.2	3.9	38	21.5	11.2	109			
Means (abs.)	18.2	17.9	8.9	46	20.3	12.3	79			
1968	7.8	10.7	2.9	37	10.5	2.7	35			
69	18.4	21.3	2.9	16	16.2	-2.2	-12			
70	39.4	56.0	16.6	42	57.2	17.8	45			
71	15.8	16.9	1.1	7	18.1	2.3	15			
72	5.4	10.3	4.9	91	6.6	1.2	22			
73	2.4	6.2	3.8	158	5.8	3.4	142			
74	10.8	5.3	-5.5	-51	3.9	-6.9	-64			
75	24.2	12.9	-11.3	-47	12.0	-12.2	-50			
76	11.5	12.0	0.5	4	9.8	-1.7	-15			
77	9.6	8.4	-1.2	-13	8.8	-0.8	-8			
78	19.4	11.5	-7.9	-41	16.5	-2.9	-15			
79	39.5	22.7	-16.8	-43	14.7	-24.8	-63			
Means (abs.)	17.0	16.2	6.3	46	15.0	6.6	40			
1987	27.3	16.8	-10.5	-38	19.5	-7.8	-29	27.0	-0.3	-1
88	23.0	26.5	3.5	15	30.6	7.6	33	15.0	-8.0	-35
89	43.8	28.9	-14.9	-34	38.0	-5.8	-13	43.5	-0.3	-1
90	47.8	25.4	-22.4	-47	29.8	-18.0	-38	49.0	1.2	3
91	42.1	30.0	-12.1	-29	36.7	-5.4	-13	42.5	0.4	1
92	44.9	37.1	-7.8	-17	33.0	-11.9	-27	47.0	2.1	5
93	51.9	41.8	-10.1	-19	43.1	-8.8	-17	59.0	7.1	14
94	50.1	52.4	2.3	5	48.8	-1.3	-3	39.0	-11.1	-22
95	60.8	55.1	-5.7	-9	53.1	-7.7	-13	48.0	-12.8	-21
96	36.9	43.4	6.5	18	45.2	8.3	22	44.5	7.6	21
97	18.8	33.6	14.8	79	35.1	16.3	87	40.0	21.2	113
98	18.2	30.2	12.0	66	33.8	15.6	86	30.0	11.8	65
99	39.4	24.6	-14.8	-38	35.1	-4.3	-11	34.0	-5.4	-14
00	28.3	35.4	7.1	25	37.7	9.4	33	40.0	11.7	41
Means (abs.)	38.8	34.3	10.6	32	37.1	9.2	28	39.9	6.9	24

* FRI preseason forecasts for 1962-1979 were from purse seine sampling of immature sockeye south of Adak Is. in the year prior to the run (1962-67 was without a sampling plan) and the forecasts for 1987-99 were based on the same inshore data (escapement and smolt numbers) used by ADF&G, but with different analyses.

** Average of forecasts made on 6/25 and 6/30, final forecast made about 7/3-5.

Error= percent that the forecast differed from the run.