# Informational Leaflet 14

## FORECAST OF BRISTOL BAY RED SALMON RUN IN 1962

Compiled jointly by:

Alaska Department of Fish and Game

Bureau of Commercial Fisheries

and

Fisheries Research Institute

April 17, 1962

STATE OF ALASKA
WILLIAM A. EGAN - GOVERNOR

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

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## INTRODUCTION

This is the second annual forecast prepared jointly by the Alaska Department of Fish and Game, the Bureau of Commercial Fisheries, and the Fisheries Research Institute of the University of Washington. Scientists from these three agencies have exchanged and studied all pertinent data and believe that the analysis presented here is the best that can be made.

The scientists who have participated in the final analysis of the data include the following: Mr. Dean Paddock, Mr. Wilbur Church, and Mr. Walter Kirkness of the Alaska Department of Fish and Game; Mr. Harry Rietze and Dr. C.J. DiCostanzo of the Juneau Office of the Bureau of Commercial Fisheries; Mr. Clinton Atkinson, Mr. R.A. Fredin, and Mr. Sueto Murai of the Seattle Office of the Bureau of Commercial Fisheries; Dr. Robert L. Burgner, Dr. Ted S.Y. Koo, Mr. O.E. Kerns, Jr., Mr. Allan C. Hartt, and Dr. William F. Royce of the Fisheries Research Institute. Many others have joined in the collection of data and preliminary analysis.

Dr. William F. Royce served as editor throughout the entire process and assembled this material in its present form.

A summary of this forecast was compiled in October, 1961, using preliminary data on the 1961 run. Better estimates were available for this version and were used. Some minor corrections have also been made and hence the forecast total run is changed from 9.3 million to 9.7 million.

## METHODS OF FORECAST

These are scientific forecasts based on the best available indicators of expected return to the major rivers in each fishing district of Bristol Bay. A variety of data is available on these rivers which consists of the following kinds:

1. Cycle analysis based on the preceding cycle catch, escapement, or both. This is believed to be the least reliable in Bristol Bay because the cycles vary from 4 to 6 years and because of the highly fresh water and salt water mortality.

2. Smolt outmigration and return relationship. In the major rivers of Bristol Bay, indices of the number of smolts migrating to sea have been obtained for several years. These data are subject to sampling errors and the variations in salt water mortality.

3. Early returns of certain year groups. Bristol Bay 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 for forecasting in certain situations.

4. Abundance of immature salmon at sea. Abundance indices of the immature red salmon in the vicinity of the eastern and central

Aleutian Islands have been obtained for several years. These data have been obtained independently from two sources: (1) the catches of purse seine vessels operating south of the Aleutian Islands where the immature red salmon pass in very large numbers during the mid summer, and (2) by gill net vessels operated over a somewhat larger area of the Bering Sea and the North Pacific Ocean in the vicinity of the eastern and central Aleutian Islands.

## FORECASTS BY RIVERS

Our first step in the forecast is to bring together the data from cycle analysis or outmigration of smolts for each of the major rivers starting with those flowing into Nushagak Bay and proceeding clockwise around the Bay.

### Nushagak System

The Nushagak escapement enters three major spawning areas: Wood River, Igushik River, and the Tikchik Lakes named in order of their importance. Data on escapement to each of these areas are available since 1946, but the commercial catch from Nushagak Bay cannot be separated directly into parts bound for the separate rivers. Therefore, the annual percentage of each system's escapement has been applied to the catch and the total run to each spawning system estimated for the last eleven years (Table 1).

Indices of the outmigrations of smolts have been obtained in the Wood River system since 1951. These have had a rather variable relation with the return because of marine mortality, but enough data are available to permit regression analysis of the logarithmically transformed data as shown in Figures 1 and 2. The predictions may be read directly from the graphs by using the smolt indices for 1959 and 1960. The expected return in 1962 from 1960 seaward migration is a little under 800,000 adult reds; from the 1959 seaward migration (which was next to the smallest on record), a little under 400,000. Thus, a total return to the Wood River system of 1,200,000 fish is expected.

In the Igushik system we must rely upon cycle analysis. The basis for this is the escapement and return 4 and 5 years later as shown in Table 2. The average indicates a return of about 400,000 in 1962.

The expected return to the Tikchik system is based on similar cycle analysis as shown in Table 3 and the expected total return is about 200,000 fish.

### Naknek-Kvichak Fishing Area

The largest red salmon run in Alaska enters the Kvichak River system which together with the smaller Naknek and Alagnak systems receives the runs going through this fishing area.

Table 1. Escapements[1/] and prorated total runs of red salmon in the Nushagak district.

| Year | Total Nushagak run in thousands | Escapement and prorated run to individual rivers in thousands of fish | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wood River | | Igushik River | | Tikchiks | | Snake River | | Nushagak-Mulchatna | |
| | | Escapement | Total run | Escapement | Total run | Escapement | Total run | Escapement | Total run | Escapement | Total run |
| 1951 | 973 | 458 | 826 | 40 | 72 | 39 | 70 | 3 | 5 | - | - |
| 1952 | 1,099 | 227 | 575 | 150 | 380 | 38 | 96 | 4 | 10 | 15 | 38 |
| 1953 | 1,278 | 516 | 795 | 100 | 154 | 189 | 292 | 4 | 6 | 20 | 31 |
| 1954 | 1,008 | 571 | 831 | 80 | 117 | 29 | 42 | 4 | 6 | 8 | 12 |
| 1955 | 3,000 | 1,383 | 2,145 | 500 | 776 | 16 | 25 | 30 | 46 | 5 | 8 |
| 1956 | 2,477 | 773 | 1,580 | 400 | 818 | 30 | 61 | 4 | 8 | 5 | 10 |
| 1957 | 1,048 | 289 | 607 | 130 | 273 | 67 | 141 | 3 | 6 | 10 | 21 |
| 1958 | 2,364 | 960 | 1,787 | 100 | 186 | 196 | 365 | 9 | 17 | 5 | 9 |
| 1959 | 4,780 | 2,209 | 3,471 | 644 | 1,012 | 49 | 77 | 140 | 220 | - | - |
| 1960 | 3,142 | 1,016 | 1,909 | 495 | 929 | 146 | 273 | 17 | 31 | - | - |
| 1961 | 1,367 | 461 | 731 | 294 | 466 | 80 | 127 | 5 | 8 | 22 | 35 |
| Average | 2,049 | 806 | 1,387 | 267 | 471 | 80 | 143 | 20 | 33 | 11 | 21 |

1/Escapement figures were obtained by the following means:
Wood River, 1951-52, by intensive aerial and surface surveys; 1953-61, by tower enumeration.
Igushik River, 1951-57, by aerial surveys; 1958-61, by tower enumeration.
Tikchiks, 1951-58, by aerial surveys; 1959-61 by tower enumeration.
Snake River, 1951-59, by aerial surveys; 1960-61, by tower enumeration.
Nushagak-Mulchatna, 1952-58 and 1961, by aerial surveys.

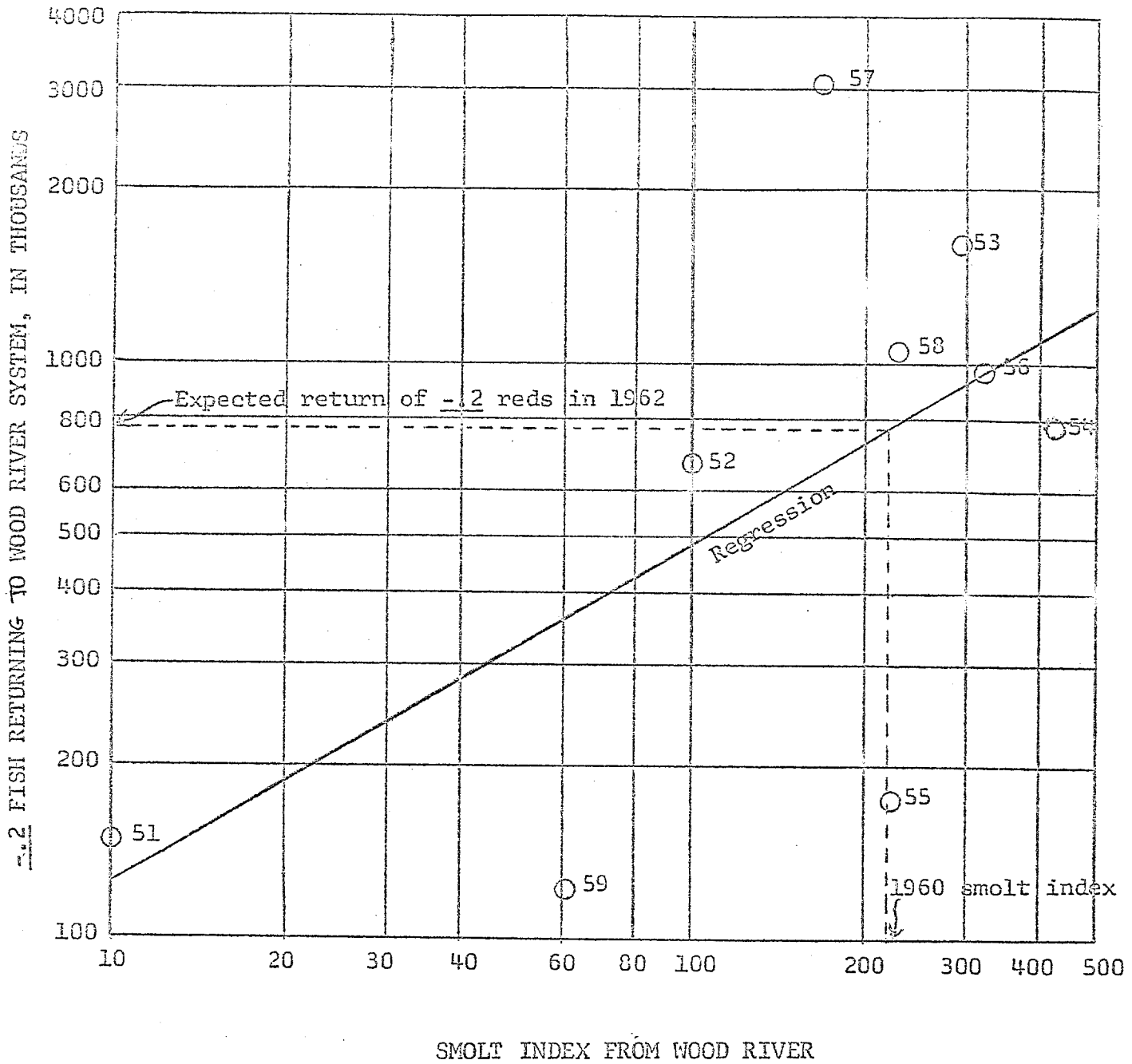


Fig. 1 Relationship between Smolt index in Wood River and return of -.2 fish to Wood River. Year indicates year of seaward migration. (On log-log scale)

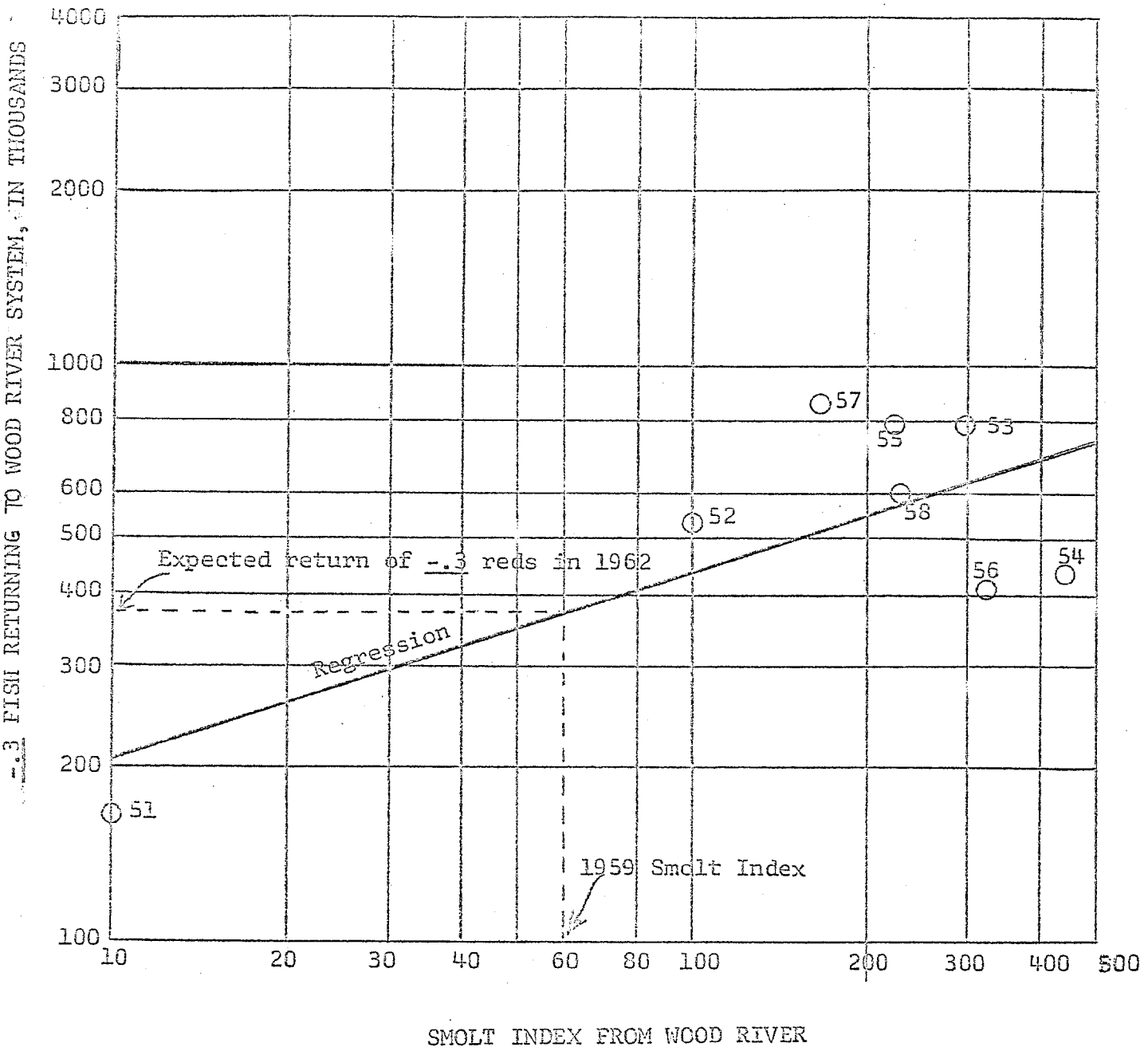


Fig. 2. Relationship between Smolt index and return of -.3 fish to Wood River. Year indicates year of seaward migration. (On log-log scale)

Table 2. Igushik Lakes

Escapements and returns in thousands of fish.

| Year | Escapement | 4 year return | 5 year return |
|---|---|---|---|
| 1950 | 75 | 80 | 250 |
| 1951 | 40 | 525 | 620 |
| 1952 | 150 | 170 | 190 |
| 1953 | 100 | 55 | 125 |
| 1954 | 80 | 40 | 375 |
| 1955 | 500 | 610 | 570 |
| 1956 | 400 | 290 | 427 |
| 1957 | 130 | 15 | (300) |
| 1958 | 100 | (100) | |

Geometric means of return per spawner after 4 years is .903 and after 5 years is 2.407. 1962 forecast is shown in parenthesis and is rounded to the nearest 100,000.

Table 3. Tikchik Lakes

Escapements and returns in thousands of fish.

| Year | Escapement | 4 year return | 5 year return |
|---|---|---|---|
| 1950 | 42 | 7 | 10 |
| 1951 | 39 | 13 | 53 |
| 1952 | 38 | 7 | 97 |
| 1953 | 189 | 39 | 312 |
| 1954 | 29 | 45 | 47 |
| 1955 | 16 | 5 | 63 |
| 1956 | 30 | 206 | 122 |
| 1957 | 67 | 5 | (100) |
| 1958 | 196 | (100) | |

Geometric means of return per spawner after 4 years is .389 and after 5 years is 1.665. 1962 forecast is shown in parenthesis and is rounded to the nearest 100,000.

The 1962 Kvichak run will come from the smolt migrations of 1959 and 1960. The 1959 smolt migration originated predominately from the 1956 parent escapement and the 1960 smolt migration from the 1957 parent escapement.

Indices of the outmigrations of smolts have been obtained since 1955. The indices and the return of adults after two and three years in the ocean are shown in Table 4. The geometric mean of the return per index point times the year group index provides a forecast for the coming year. Thus, the expected return of fish after two years in the ocean from the index of 1960 is approximately 4,500,000; after three years in the ocean from the index of 1959 it is approximately 6,800,000.

This forecast is based on average mortality in the ocean. But two lines of evidence indicate unusually severe mortality for the smolts going to sea in 1959, thus casting doubt on the accuracy of the expected 6.8 million return of three-years-in-ocean fish. This evidence is (1) the low abundance of this year group at sea in 1960 and 1961, and (2) the small return in 1961 to the Kvichak River. This will be discussed later in the final evaluation of the forecast.

Table 4. Kvichak River - smolt index and return of adults in thousands of fish

| | | Return after two years | | Return after three years | |
|---|---|---|---|---|---|
| Year | Smolt index | Return of -.2's | Return per index point | Return of -.3's | Return per index point |
| 1955 | 11.2 | 2,171 | 193.84 | 632 | 56.43 |
| 1956 | 3.3 | 438 | 132.73 | 88 | 26.67 |
| 1957 | 1.3 | 853 | 656.15 | 630 | 484.62 |
| 1958 | 100.0 | 22,083 | 220.83 | 5,520 | 55.20 |
| 1959 | 85.9 | 5,308 | 61.79 | (6,800) | *79.66 |
| 1960 | 23.8 | (4,500) | *187.27 | | |

*Geometric mean

Estimated return in 1962 is shown in parenthesis.

## Alagnak River

The much smaller runs to the Alagnak River must be forecast on the basis of cycle analysis. Data are available since 1955 (Table 5). 1962 will be the low part of the Alagnak cycle with the returning fish coming from parents of 1957 and 1958. The principal parent stock will be 1957, and we may estimate that the run will be about 300,000 which is well below average and about the size of the 1957 run.

## Naknek River

Smolt indices are available for the Naknek River since 1956 (Table 6). The relationship between the index and actual returns after two and three years in the ocean has been highly variable with high returns from the 1957 outmigration and a very low return after two years from the 1959 outmigration.

The averages indicate a return of about 300,000 small fish after two years in the ocean and 1,700,000 fish after three years in the ocean. (The latter is considered to be much too high for the reasons previously discussed under the Kvichak returns).

## Egegik River

Average escapement-return relationships for the Egegik (Table 7, Figure 3) indicate an expected return of about 1,400,000 red salmon after three years in the ocean and 400,000 after two years in the ocean (Table 8). The relationship between parent and actual returns has been slightly variable which reduces the confidence that can be placed in the forecast for this system.

## Ugashik River

Smolt indices have been obtained on the Ugashik River since 1956 (Table 9). The geometric mean of return per index point indicates that about 1,900,000 after two years in the ocean may be expected, about 800,000 after three years in the ocean. The latter is thought to be much too high because of the unusually small return after two years in the ocean in 1961.

# ABUNDANCE OF YOUNG SALMON AT SEA

## Purse Seine Catch Data

The abundance and age composition of immature red salmon at sea as indicated by the purse seine catches south of Adak Island has shown a striking relationship to the abundance and age composition of the following year's run to Bristol Bay (Figure 4 and Table 10).

Table 5. Alagnak River - total runs and escapements in thousands of fish

| Year | Total run | Escapement 1/ |
|---|---|---|
| 1955 | 809 | 166 |
| 1956 | 1,307 | 785 |
| 1957 | 283 | 125 |
| 1958 | 197 | 91 |
| 1959 | 1,166 | 820 |
| 1960 | 2,090 | 1,241 |
| 1961 | 279 | 90 |
| Mean run and escapement | 876 | 474 |

1/ Escapements estimated from aerial surveys 1955-1956 and sample counts from towers 1957-1961.

Table 6. Naknek River - smolt indices and returns in thousands of fish

| | | Return after two years | | Return after three years | |
|---|---|---|---|---|---|
| Year | Smolt Index | Return of -.2's | Return per index point | Return of -.3's | Return per index point |
| 1956 | 60 | 277 | 4.62 | 415 | 6.92 |
| 1957 | 30 | 2,821 | 94.03 | 1,357 | 45.23 |
| 1958 | 100 | 590 | 5.90 | 1,045 | 10.45 |
| 1959 | 116 | 35 | 0.30 | (1,700) | 14.84* |
| 1960 | 66 | (300) | 5.27* | | |

*Geometric mean

Estimated return in 1962 is shown in parenthesis.

Table 7. Egegik River - escapement[1/] and return in millions

| Year | Escapement | Return, 4 to 7 years later |
|---|---|---|
| 1921 | 1.40 | 4.91 |
| 1922 | 0.84 | 1.30 |
| 1923 | 0.77 | 2.33 |
| 1924 | 0.84 | 0.89 |
| 1925 | 0.42 | 0.73 |
| 1926 | 1.40 | 4.09 |
| 1927 | 1.12 | 3.20 |
| 1928 | 0.84 | 3.82 |
| 1929 | 0.70 | 1.43 |
| 1930 | 0.24 | 0.93 |
| 1931 | 0.84 | 2.96 |
| 1932 | 2.00 | 1.57 |
| 1933 | 1.26 | 1.72 |
| 1934 | 1.26 | 0.94 |
| 1935 | 0.56 | 0.48 |
| 1936 | 0.84 | 0.76 |
| 1937 | 0.35 | 1.44 |
| 1938 | 0.63 | 1.45 |
| 1939 | 0.61 | 0.49 |
| 1940 | 0.36 | 0.44 |
| 1941 | 0.31 | 0.87 |
| 1942 | 1.26 | 3.04 |
| 1943 | 1.26 | 3.20 |
| 1944 | 0.31 | 0.77 |
| 1945 | 0.53 | 1.04 |
| 1946 | 0.66 | 1.44 |
| 1947 | 0.91 | 2.03 |
| 1948 | 0.89 | 2.47 |
| 1949 | 0.92 | 0.94 |
| 1950 | 0.63 | 0.95 |
| 1951 | 0.95 | 2.28 |
| 1952 | 0.71 | 0.93 |

1/ All escapements are estimates from foot and aerial surveys except 1932 and 1952 which were counts at weirs.

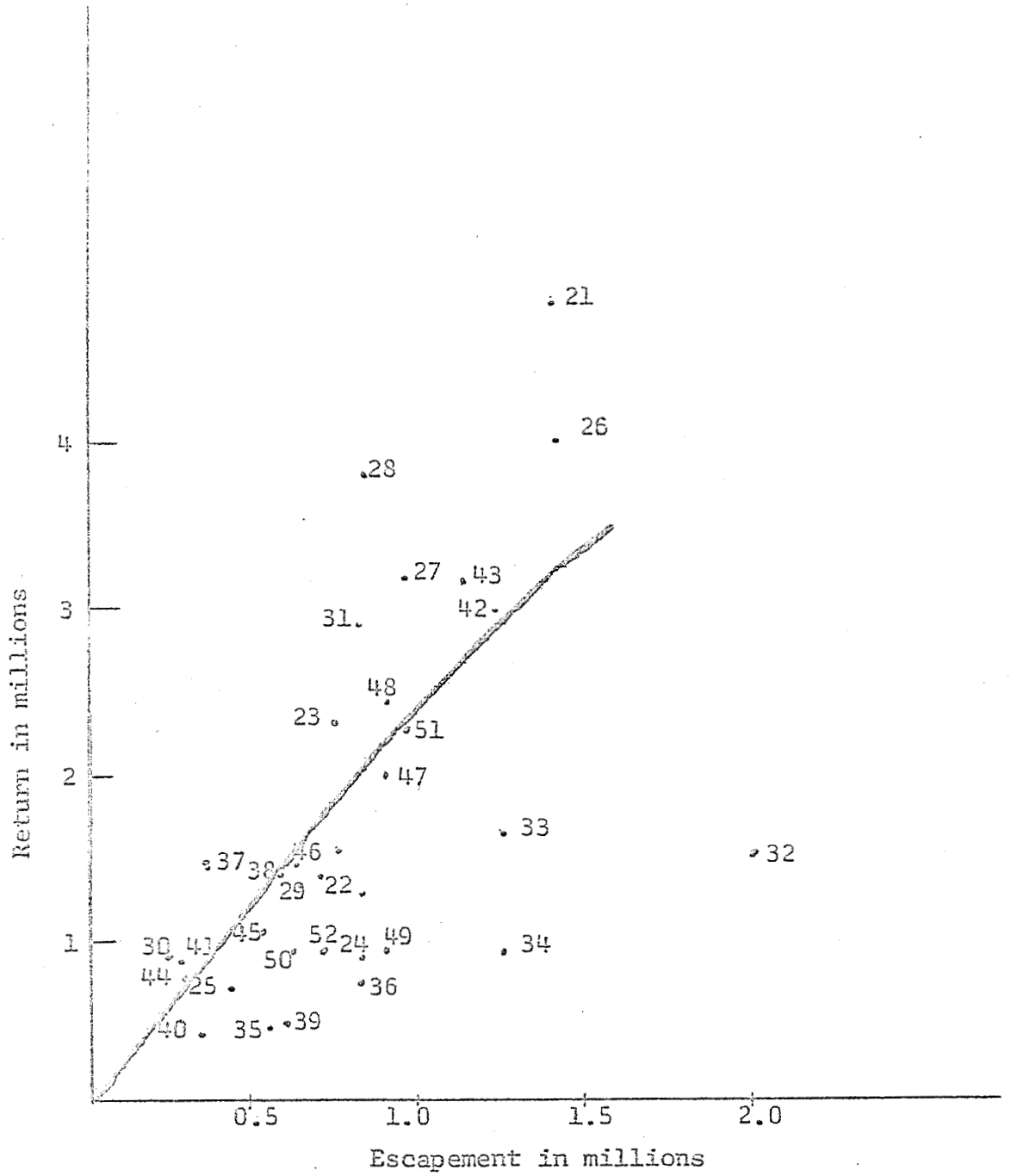


Figure 3. Relation of escapement to return; Egegik River red salmon

Table 8. Egegik River - escapement and average return by age groups from spawning of 1955 through 1958 in thousands of fish

| Brood Year | Escapement | Estimated average return by age group 1.2 | 2.2 | 3.2 | 1.3 | 2.3 | 3.3 1/ | Total |
|---|---|---|---|---|---|---|---|---|
| 1955 | 270 | - | - | - | - | - | 49 | 700 |
| 1956 | 1,100 | - | - | 80 | - | 1,219 | - | 2,650 |
| 1957 | 390 | - | 266 | - | 114 | - | - | 950 |
| 1958 | 250 | 26 | - | - | - | - | - | 650 |

1/ Based on average age composition of 1.2, 4 percent; 2.2, 28 percent, 3.2, 3 percent; 1.3, 12 percent; 2.3, 46 percent; 3.3, 7 percent.

Total return at age -.2 is 400,000, total -.3 is 1,400,000 when rounded to the nearest 100,000.

Age groups are designated as number of years as fish in fresh water plus number of years in ocean. To these is added one year as egg or larvae to obtain total age.

Table 9. Ugashik River - smolt indices and returns in thousands of fish

| Year | Smolt Index | Return after two years: Return of -.2's | Return after two years: Return per index point | Return after three years: Return of -.3's | Return after three years: Return per index point |
|---|---|---|---|---|---|
| 1956 | 7.03 | 426 | 60.7 | 276 | 39.3 |
| 1957 | 4.18 | 306 | 73.1 | 101 | 24.2 |
| 1958 | 100.00 | 2,856 | 28.6 | 613 | 6.1 |
| 1959 | 41.98 | 132 | 3.1 | (800) | 18.0* |
| 1960 | 76.49 | (1,900) | 25.0* | | |

*Geometric mean

Estimated return in 1962 is shown in parenthesis.

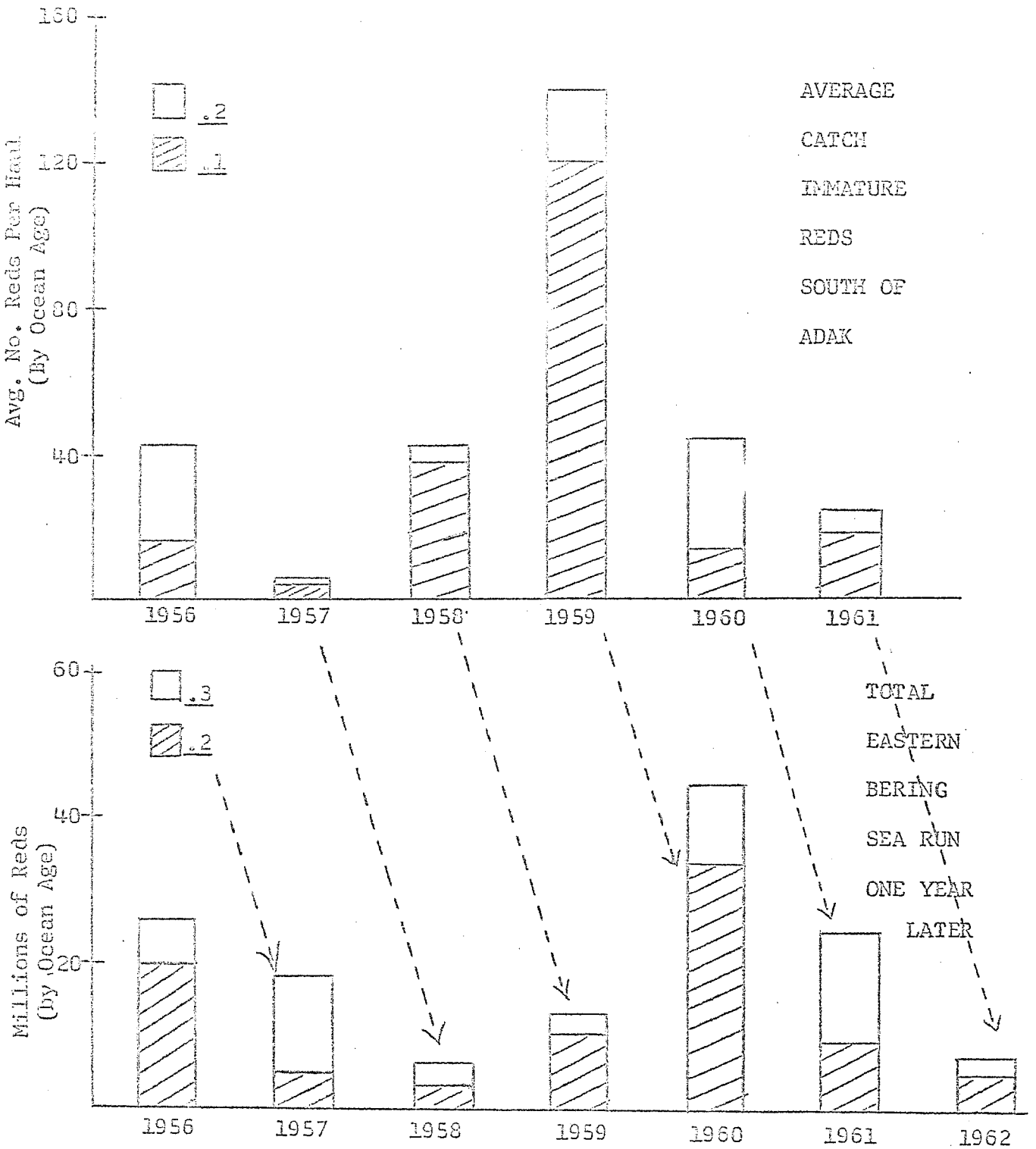


Figure 4. Abundance of immature reds at sea vs. following year's run to Bristol Bay.

Table 10. Average catch/seine set of immature red salmon south of Adak Island compared with following year's return to Bristol Bay, with 1962 estimate based on 1961 index of immatures.

| Year of catch at sea | Average catch/set (index points) | | | Year of B.B. catch | "Bristol Bay" Red run (millions)1/ | | | Millions of salmon per "Index Point" | |
|---|---|---|---|---|---|---|---|---|---|
| | .1 | .2 | All ages | | .2 | .3 | All Ages | .2 | .3 |
| 1955 | -- | -- | -- | 1956 | 19.9 | 7.3 | 27.2 | -- | -- |
| 1956 | 15.7 | 30.4 | 46.1 | 1957 | 4.3 | 13.2 | 17.5 | 0.27 | 0.43 |
| 1957 2/ | 4.3 | 2.1 | 6.4 | 1958 | 3.4 | 3.1 | 6.5 | 0.79 2/ | 1.48 2/ |
| 1958 | 39.2 | 3.1 | 42.4 | 1959 | 10.7 | 1.8 | 12.5 | 0.27 | 0.58 |
| 1959 | 123.0 | 20.0 | 143.0 | 1960 | 38.4 | 5.1 | 43.5 | 0.31 | 0.26 |
| 1960 | 12.0 | 30.9 | 42.9 | 1961 | 7.8 | 16.2 | 24.0 | 0.65 | 0.52 |
| 1961 | 20.0 | 4.1 | 24.1 | 1962 3/ | (7.6) | (1.8) | (9.4) | (0.38) | (0.45) |
| 1962 | | | | 1963 | | | | | |

1/ Western Alaska catches from INPFC Statistical Yearbooks, plus estimated Japanese high seas catch of Alaskan reds. Age breakdown based on weighted samples of Bristol Bay commercial catches and escapements where available (ADF, FWS, FRI). Four-winter fish included with three-winter fish.

2/ 1957 data not used because it was biased by greater offshore distribution of salmon in index area.

3/ Numbers in brackets are 1962 estimates based on average of 1956, 1958, 1959, and 1960 index rates (1957 excluded).

A basic assumption underlying the use of this index is that we are obtaining a representative sample from the flow of immature reds through the index area. The evidence from the direction of catch of the purse seines and from the width of the column of fish passing Adak Island suggests that a large proportion of the immature Bristol Bay red salmon present in the sea travel past Adak during the summer months. Hence if an index of the number of salmon in this flow is obtained, it should be representative of the numbers in the Bristol Bay stock.

Our sampling off Adak has usually been in an area about 12 miles offshore, and it appears that this place is in the main path of immature red salmon in most years. But in 1957 the main body of the run was apparently further offshore, (according to the distribution found by research vessels using gill nets) and thus we obtained an abnormally low index value that year.

In 1961 we sampled both inshore and offshore to test for such bias in sampling, and it was evident that abundance was considerably greater offshore. The average of 12 sets (July 3 - Aug. 22) between 15 and 45 miles offshore, was 54.7 immature reds, while 22 sets (June 18 - August 23) within 15 miles of shore averaged only 7.4 reds. Thus, only the fringes of the run passed through the usual index area in 1961 as was presumed to be the case in 1957.

The question thus arises whether to use only the offshore samples or both offshore and inshore samples in calculating the 1961 average. Since a too low or too high index would result from sampling only the fringe or only the center of abundance respectively, we have decided to average catches from the two areas. The overall average for 1961 (24.1) seems more reasonable until we better understand variations in distribution with distance from shore.

One of the features about the relationship between the high seas catches and the following year's run to Bristol Bay has been the rather remarkable correspondence in age composition. The percentages of -.1 red salmon (one winter in the sea) in the catches are shown in Table 11. These percentages have been followed by similar percentages of -.2 red salmon (two winters in the sea) in the following year in Bristol Bay even though only part of the age -.2 red salmon are mature. The number of fish per case varies according to this proportion and the expected proportion of two winter in the sea fish next year in Bristol Bay indicates that the fish per case will average between 13 and 14, assuming that 5-1/2 inch mesh gill nets are used. If smaller size mesh is used, fish per case will be greater.

## Gill Net Catch Data

Gill net catch data are obtained from the Aleutian Island area by research vessels.

The method of calculation is the same as for the 1961 forecast. As before, the abundance of -.1 and -.2 immature red salmon are estimated by the catches in the 2-1/2 - 3-1/4 inch mesh and 4-1/2 and 5-1/4 inch mesh, respectively. Assuming that the 1961 returns were 24 million fish with an age composition of 32.3 percent .2 and 67.7 percent .3, new equations for computing the adjusted

Table 11. Percentage of .1 immature red salmon at sea south of Adak Island compared with following year's percentage of .2 reds in Bristol Bay catch, 1956-1961. (Also fish/case).

| Year of Catch At sea | Percentage .1 Reds At Sea | Year of Bristol Bay Catch | Percentage .2 Reds Bristol Bay 1/ | Fish Per Case 2/ |
|---|---|---|---|---|
| 1955 | --- | 1956 | 72.5 | 13.6 |
| 1956 | 34.0 | 1957 | 24.3 | 10.9 |
| 1957 | 66.9 | 1958 | 52.8 | 10.8 |
| 1958 | 92.6 | 1959 | 85.9 | 13.5 |
| 1959 | 86.0 | 1960 | 88.2 | 14.5 |
| 1960 | 27.9 | 1961 | 32.3 | 11.8 |
| 1961 | 83.1 | 1962 | (77.0) 3/ | (13.5) 3/ |

1/ From weighted samples of Bristol Bay catches and escapements.

2/ Figures obtained from a small sample of Bristol Bay canneries and may not be representative of Bristol Bay as a whole.

3/ Estimate for 1962 is based on the assumption that 5-1/2" mesh will be used.

catch per unit of shackle and returns were derived (Table 12). This gave us one more point on our curves. In addition, the 1958 point, not previously used in determining the return of .1 red salmon, was used. The regression lines for .1 and .2 red salmon returns are shown in Figures 5 and 6.

The most probable returns in 1962 are 4.8 million after two years in the ocean, 2.3 million after three years in the ocean, or a total of 7.1 million.

## SUMMARY OF BRISTOL BAY FORECAST FOR 1962

The data from the preceding smolt indices, cycle analysis, and high seas operations are brought together in Table 13. The smolt indices and cycle analysis indicate an expected return in 1962 of 8.2 million after two years in the ocean, plus 11.7 million after three years in the ocean, or a total of 19.9 million.

The independent estimates from high seas operations show totals of both age groups of 7.1 million from the gill netting and 9.4 million from the purse seining.

To these two sources of data may be added a third method which applies only to the return after three years in the ocean. This is the ratio of the return after three years to the preceding two year return for Bristol Bay as a whole. Data are available since 1956 (Table 10). The ratio has ranged from .72 to .42 and averages .56. With the 1961 return after two years in the ocean, estimated at 7.8 million, this indicates an expected 1962 return of about 4.4 million.

## DISCUSSION AND RECONCILIATION OF BRISTOL BAY FORECAST FOR 1962

Evaluation of the rather variable data in the preceding tables is guided by certain assumptions. The first is that the major marine mortality occurs during the first year of life at sea. Hence, if we have observations indicating the extent of marine mortality of a year group, we give these more weight than the indications from cycle analysis or the abundance of smolts.

A second assumption is that our estimates of Japanese catches of mature Brisol Bay red salmon are reasonably reliable. Information on catches of mature Bristol Bay red salmon from the Japanese is very limited and if our estimates have been high then the forecast is high or vice versa.

The third assumption is that the Japanese fishing on immature Bristol Bay red salmon at age -.2 has been at a constant intensity so that their fleets have taken a constant proportion of this age group each year. Immature red salmon from Bristol Bay which have spent two winters in the sea are readily available to the Japanese fleet, but to date it has not been possible to estimate the Japanese catch of immature red salmon and such catches have been ignored in the compilations.

Table 12. Data for calculations of expected returns from gill net catches

-.1 ocean-age

| Year | Number caught | Percent North American | Percent return as 2 ocean | Number of shackles used | Unadjusted catch per shackle | Adjusted number caught | Adjusted catch per shackle | Year + 1 return (in millio |
|---|---|---|---|---|---|---|---|---|
| 1955 | 17 | - | 60.12 | 16 | 1.062 | - | - | 19.9 |
| 1956 | 158 | 61.76 | 58.11 | 51 | 3.098 | 57 | 1.118 | 4.3 |
| 1957 | 265 | 65.35 | 65.38 | 168 | 1.577 | 113 | 0.673 | 3.4 |
| 1958 | 279 | 48.17 | 51.69 | 128 | 2.180 | 69 | 0.539 | 10.7 |
| 1959 | 1,070 | 73.44 | 68.17 | 80 | 13.375 | 536 | 6.700 | 38.4 |
| 1960 | 457 | 68.06 | 64.83 | 192 | 2.380 | 202 | 1.050 | 7.8 |
| 1961 | 292 | - | - | 176 | 1.659 | - | .507 | (4.8) |

Unadjusted catch/shackle 1.659

Adjusted catch/shackle $Y_C = .367 + .527(1.659) = .507$

Estimated return $\hat{Y}_R = 2.13 + 5.354(.507) = 4.84$ millio

-.2 ocean-age

| Year | Number caught | Percent North American | Percent return as 3 ocean | Number of shackles used | Unadjusted catch per shackle | Adjusted number caught | Adjusted catch per shackle | Year + 1 return (in millio |
|---|---|---|---|---|---|---|---|---|
| 1955 | 28 | - | - | 36 | 0.778 | - | - | 7.3 |
| 1956 | 370 | 76.10 | 100 | 99 | 3.737 | 282 | 2.848 | 13.2 |
| 1957 | 1,003 | 67.13 | 100 | 330 | 3.039 | 673 | 2.039 | 3.1 |
| 1958 | 207 | 52.11 | 100 | 256 | 0.809 | 108 | 0.422 | 1.8 |
| 1959 | 938 | 59.86 | 100 | 280 | 3.350 | 561 | 2.004 | 5.1 |
| 1960 | 3,003 | 61.89 | 100 | 672 | 4.469 | 1,859 | 2.766 | 16.2 |
| 1961 | 950 | - | - | 448 | 1.542 | - | 0.966 | (2.3) |

Unadjusted catch/shackle 1.542

Adjusted catch/shackle $Y_C = -.090 + .685(1.542) = .966$

Estimated return $\hat{Y}_R = -2.89 + 5.341(.966) = 2.27$ millio

Figures in brackets indicates forecast.

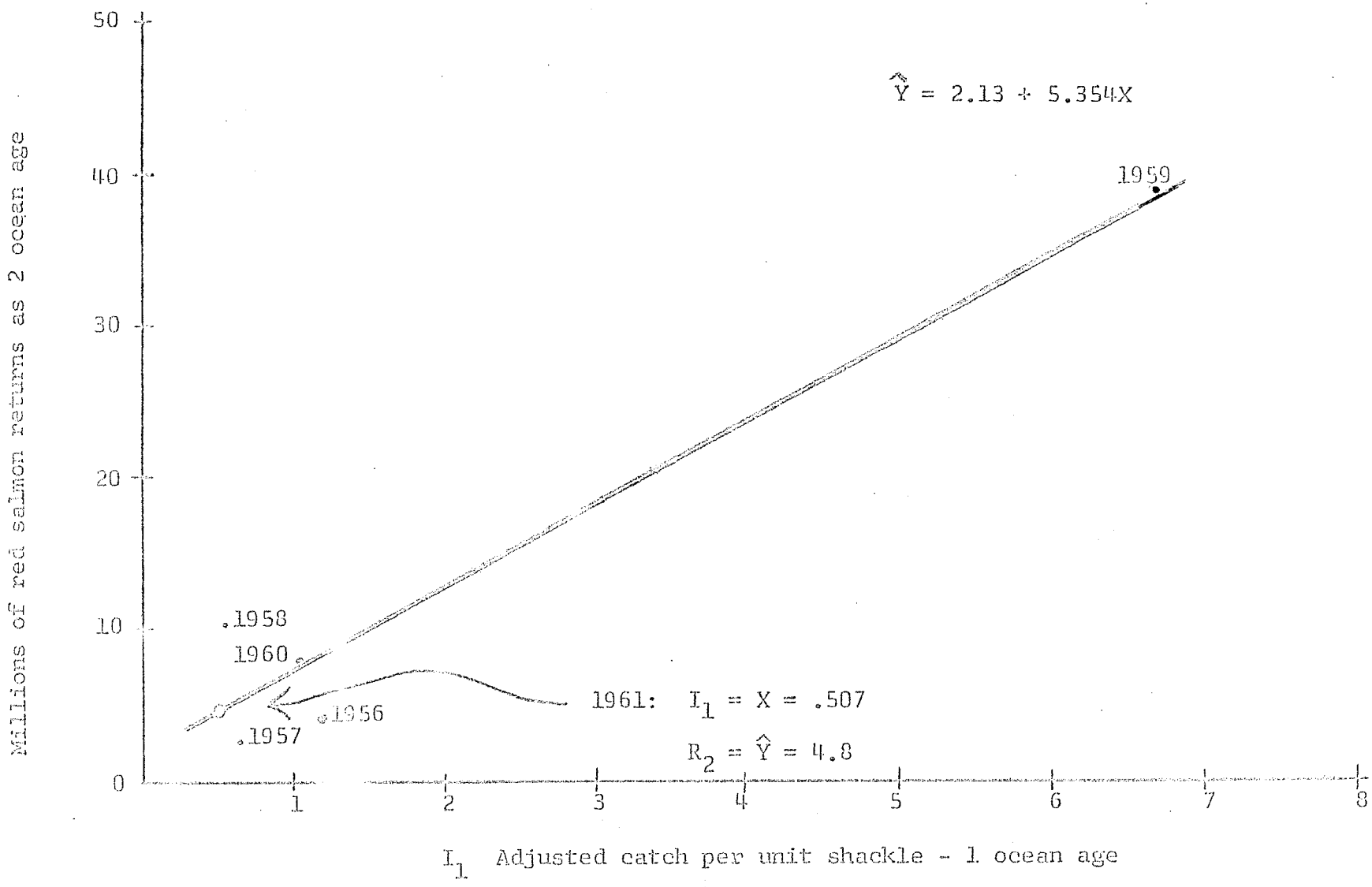


Figure 5. Regression of returns of red salmon on the adjusted catch per unit shackle - 1 ocean age.

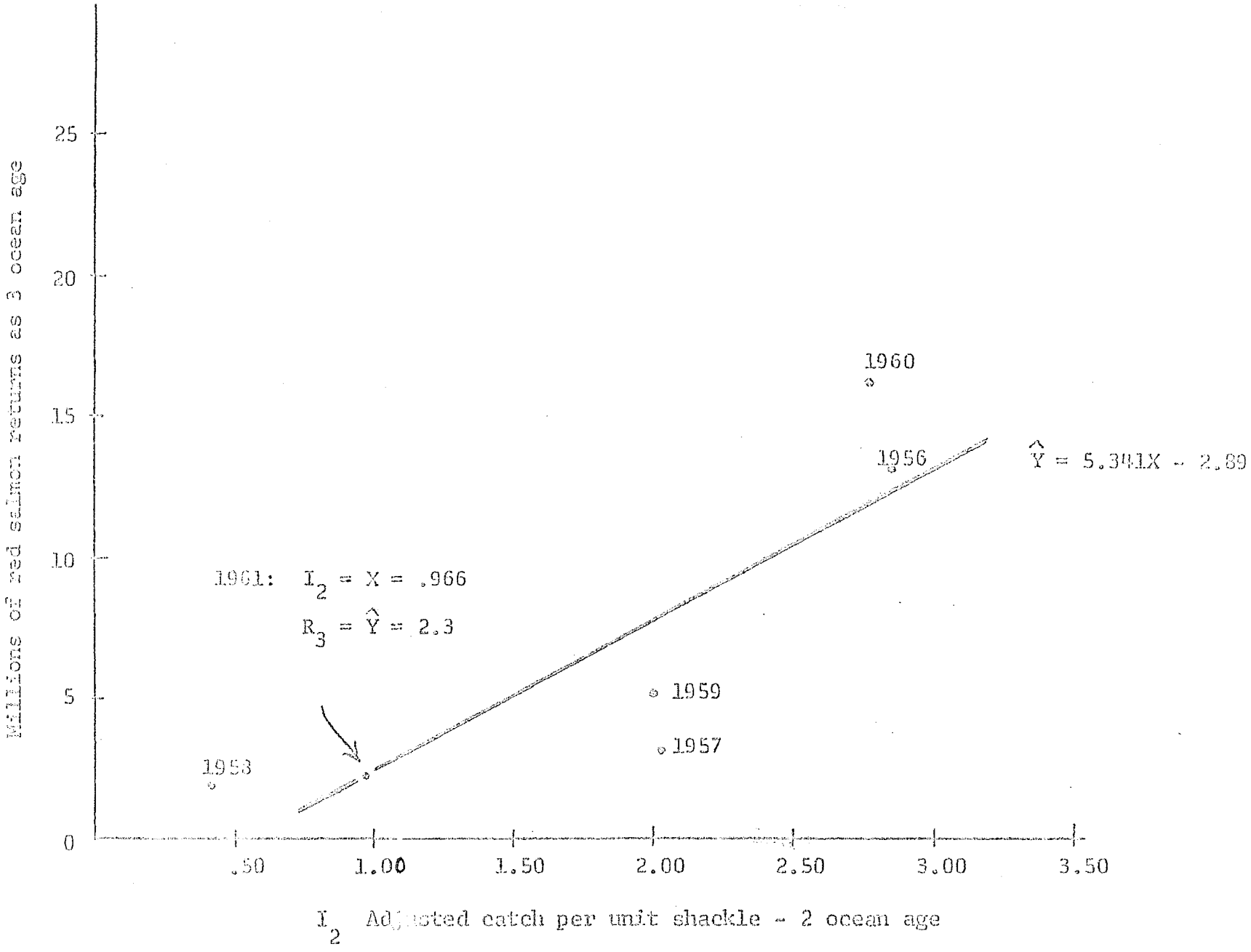


Figure 6. Regression of returns of red salmon on the adjusted catch per unit shackle - 2 ocean age.

Table 13. Summary of Bristol Bay forecast for 1962

A. Estimates from Smolt Indexes and Cycle Analysis

| River | Expected return in millions of fish -.2 | -.3 | Total | Basis |
|---|---|---|---|---|
| Igushik[1/] | .1 | .3 | .4 | cycle analysis |
| Wood River | .8 | .4 | 1.2 | smolts |
| Tikchik[1/] | .1 | .1 | .2 | cycle analysis |
| Total Nushagak | 1.0 | .8 | 1.8 | |
| Kvichak | 4.5 | 6.8 | 11.3 | smolts |
| Alagnak[1/] | .1 | .2 | .3 | cycle analysis |
| Naknek | .3 | 1.7 | 2.0 | smolts |
| Total Naknek-Kvichak | 4.9 | 8.7 | 13.6 | |
| Egegik | .4 | 1.4 | 1.8 | cycle analysis |
| Ugashik | 1.9 | .8 | 2.7 | smolts |
| TOTAL | 8.2 | 11.7 | 19.9 | |

[1/] Original forecasts not broken down by ocean age -- arbitrary division made in order to complete table.

B. Estimates from High Seas Operations

| | Expected return in millions of fish -.2 | -.3 | Total |
|---|---|---|---|
| Gillnetting | 4.8 | 2.3 | 7.1 |
| Purse seining | 7.6 | 1.8 | 9.4 |

C. Estimate of -.3 Return from Preceding -.2 Return: 4.4 million

A fourth assumption is that the marine survival of each successive ocean year group is quite independent, and thus we may break our forecast down into two parts, the red salmon returning after two years in the ocean, and those returning after three years in the ocean.

Forecast of Age -.2

From the preceding discussion and the summary in Table 12, we have the following estimates:

1. Cycle analysis of smolt data - 8.2 million.

2. Gill netting on the high seas - 4.8 million.

3. Purse seining on the high seas - 7.6 million.

If we accept these as three independent estimates and give the high seas abundance twice as much weight, we may simply average them and estimate that the return after two years in the ocean will be 6.9 million red salmon.

Estimate of Return of Age -.3

For this year group we have four independent sources of data as follows:

1. Cycle analysis and smolt data - 11.7 million.

2. Gill netting on the high seas - 2.3 million.

3. Purse seining on the high seas - 1.8 million.

4. Ratio of return of -.3 to -.2 - 4.4 million.

This is the age group which apparently experienced extra-ordinary marine mortality. The evidence for this is from the indices of abundance at sea in 1960 and again in 1961 as well as the return of the mature fraction to Bristol Bay in 1961. All of these have indicated that the abundance is only one-third or less than the abundance expected from the cycle analysis and smolt data. Hence we discard completely the estimate from cycle analysis and smolt data of 11.7 million. Instead, (again giving the high seas data twice as much weight) we merely average the forecasts from the other three sources and forecast the return of -.3 in 1962 as 2.8 million.

If we assume that marine mortality among rivers has been constant for each year group, we may estimate the returns to the individual rivers by allocating the total estimated from smolt indices and cycle analysis proportionately. This is a reduction from 8.2 million to 6.9 million for the -.2 age group and from 11.7 million to 2.8 million for the -.3 age group. Such allocation gives us the estimates for each major fishing area as shown in Table 14.

Table 14. Estimated forecast by fishing area using averages of ages -.2 and -.3.

| Area | Age Group -.2 | Age Group -.3 | Total |
|---|---|---|---|
| | Millions of Fish | | |
| Nushagak | .8 | .2 | 1.0 |
| Naknek-Kvichak | 4.1 | 2.1 | 6.2 |
| Egegik | .4 | .3 | .7 |
| Ugashik | 1.6 | .2 | 1.8 |
| Total | 6.9 | 2.8 | 9.7 |

Note on Japanese Fishing

The data upon which our ratios are based have not included the Japanese catch of immature Bristol Bay red salmon, and our estimates of the Japanese catch of mature Bristol Bay red salmon are uncertain. Hence, it is important to note that this forecast assumes the same fishing intensity on the immature Bristol Bay red salmon of age -.2 in 1961 as the average of the years since 1956. Furthermore, Japanese catch of mature Bristol Bay red salmon in 1962 is included in the run which is forecast and will mean a reduction in the number reaching Bristol Bay.

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