REPORT TO THE ALASKA BOARD OF FISHERIES ON SPAWNING ESCAPEMENT GOAL EVALUATIONS FOR BRISTOL BAY SALMON

By

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TABLE OF CONTENTS

Page

LIST OF TABLES v

LIST OF FIGURES vi

LIST OF APPENDICES x

INTRODUCTION 1

METHODS 2

Sockeye Salmon 2
Spawner-Return Data 2
Yield Analysis 2
Smolt Information 3
Distribution Of Spawners 3
Chinook Salmon 3
Spawner-Return Data 3
Yield Analysis 4

RESULTS 4

Kvichak River Sockeye Salmon 4
Escapement Goal History 4
Spawner-Return Data 5
Yield Analysis 7
Smolt Information 7
Spawner Distribution 8
Summary 8
Escapement Goal Recommendations 9
Naknek River Sockeye Salmon 9
Spawner-Return Data 9
Yield Analysis 10
Escapement Goal Recommendations 10

TABLE OF CONTENTS (continued)

Page

Egegik River Sockeye Salmon 11
- Spawner-Return Data 11
- Yield Analysis 11
- Smolt Information 12
- Escapement Goal Recommendations 12

Ugashik River Sockeye Salmon 13
- Spawner-Return Data 13
- Yield Analysis 13
- Smolt Information 14
- Escapement Goal Recommendations 14

Togiak River Sockeye Salmon 15
- Spawner-Return Data 15
- Yield Analysis 15
- Escapement Goal Recommendations 16

Wood River Sockeye Salmon 16
- Spawner-Return Data 16
- Yield Analysis 16
- Escapement Goal Recommendations 17

Igushik River Sockeye Salmon 17
- Spawner-Return Data 17
- Yield Analysis 17
- Escapement Goal Recommendations 18

Nushagak River Sockeye Salmon 18
- Spawner-Return Data 18
- Yield Analysis 19
- Escapement Goal Recommendations 19

Nushagak River Chinook Salmon 19
- Spawner-Return Data 19
- Yield Analysis 20
- Escapement Quality 20
- Escapement Goal Recommendations 21

LITERATURE CITED 22

LIST OF TABLES

Table | Page

1. History of Kvichak River sockeye escapement goals set under the cyclic goal policy, 1969-1985 and recent goals, 1986-2000, set under the 4-10 million policy range. 24

2. Current spawning escapement goals of sockeye salmon and the recommended changes for Bristol Bay Rivers. 25

3. Summary of results from two Markov transition probability tables of Egegik River sockeye salmon spawner-recruit data, 1976-1995 and 1956-1995. Spawner intervals and averages are given in thousands of fish. 26

4. Summary of results from two Markov transition probability tables of Ugashik River sockeye salmon spawner-recruit data, 1974-1995 and 1956-1995. Spawner intervals and averages are given in thousands of fish. 27

5. Summary of results from a Markov transition probability table for Igushik River sockeye salmon spawner-recruit data, 1956-1995. Spawner intervals and averages are given in thousands of fish. 28

LIST OF FIGURES

Figure | Page

1. Map of Bristol Bay showing major rivers and fishing districts 29

2. Number of spawners and total return of Kvichak River sockeye salmon by brood year, 1956-1995 30

3. Return per spawner of Kvichak River sockeye salmon by brood year, 1956-1995, and number of spawners 31

4. Return per spawner of Kvichak River sockeye salmon versus number of spawners for off cycle-cycle, and pre-peak and peak cycle years (1956-1995 brood years) 32

5. Total return of Kvichak River sockeye salmon versus number of spawners, 1960-1995 brood years 33

6. Ricker spawner-recruitment relationship of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1995 brood years) 34

7. Average surplus yield categorized by number of spawners of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1995 brood years) 35

8. Number of sockeye salmon smolt migrating out of Kvichak River, 1971-2000 36

9. Number of spawners versus number of smolt, and number of smolt versus total adult return for Kvichak River sockeye salmon (1969-1995 brood years) 37

10. Number of spawners versus number of smolt of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1969-1995 brood years) 38

11. Average length and weight of age 1 and age 2 smolts versus number of spawners for Kvichak River sockeye salmon (1969-1995 brood years) 39

12. Spawner distribution of Kvichak River sockeye salmon at main beaches, island beaches, rivers and creeks, 1961-2000 40

13. Number of spawners and total return of Naknek River sockeye salmon by brood year, 1956-1995 41

14. Return per spawner of Naknek River sockeye salmon by brood year, 1956-1995 and number of spawners 42

15. Ricker spawner-recruitment relationship of Naknek River sockeye salmon, 1956-1995 43

LIST OF FIGURES (continued)

Figure | Page

16. Average surplus yield categorized by the number of spawners of Naknek River sockeye salmon, 1956-1995 brood years 44

17. Number of spawners and total return of Egegik River sockeye salmon by brood year, 1956-1995 45

18. Return per spawner of Egegik River sockeye salmon by brood year, 1956-1995, and number of spawners 46

19. Total return of Egegik River sockeye salmon versus number of spawners, 1956-1995 brood years 47

20. Ricker spawner-recruitment relationship of Egegik River sockeye salmon, 1976-1995 48

21. Average surplus yield categorized by number of spawners of Egegik River sockeye salmon 1956-1995 and 1976-1995 brood years 49

22. Number of sockeye salmon smolt migrating out of Egegik River, 1983-2000 50

23. Number of spawners versus number of smolt, and number of smolt versus total adult return for Egegik River sockeye salmon, 1980-1995 brood years 51

24. Number of spawners and total return of Ugashik River sockeye salmon by brood years, 1956-1995. 52

25. Return per spawner of Ugashik River sockeye salmon by brood year, 1956-1995, and number of spawners 53

26. Total return of Ugashik River sockeye salmon versus number of spawners, 1956-1995 brood years 54

27. Ricker spawner-recruitment relationship of Ugashik River sockeye salmon, 1974-1995 55

28. Average surplus yield categorized by number of spawners of Ugashik River sockeye salmon 1956-1995 brood years 56

29. Number of sockeye salmon smolt migrating out of Ugashik River, 1983-2000 57

30. Number of spawners versus number of smolt, and number of smolt versus total return for Ugashik River sockeye salmon, 1981-1997 brood years 58

LIST OF FIGURES (continued)

Figure | Page

31. Number of spawners and total return of Togiak River sockeye salmon by brood year, 1956-1995. 59

32. Return per spawner of Togiak River sockeye salmon by brood year, 1956-1995, and number of spawners 60

33. Ricker spawner-recruitment relationship of Togiak River sockeye salmon, 1956-1995 brood years 61

34. Average surplus yield categorized by the number of spawners of Togiak River sockeye salmon, 1956-1995 brood years 62

35. Number of spawners and total return of Wood River sockeye salmon by brood year, 1956-1995 63

36. Return per spawner of Wood River sockeye salmon by brood year, 1956-1995, and number of spawners 64

37. Ricker spawner-recruitment relationship of Wood River sockeye salmon, 1956-1995 brood years 65

38. Average surplus yield categorized by the number of spawners of Wood River sockeye salmon, 1956-1995 brood years 66

39. Number of spawners and total return of Igushik River sockeye salmon by brood year, 1956-1995 67

40. Return per spawner of Igushik River sockeye salmon by brood year, 1956-1995, and number of spawners 68

41. Total return of Igushik River sockeye salmon versus number of spawners, 1956-1995 brood years (excluding 1980 brood year) 69

42. Average surplus yield categorized by the number of spawners of Igushik River sockeye salmon, 1956-1995 brood years (excluding 1980 brood year) 70

43. Number of spawners and total return of Nushagak River sockeye salmon by brood year, 1978-1995 71

44. Return per spawner of Nushagak River sockeye salmon by brood year, 1978-1995, and number of spawners 72

LIST OF FIGURES (continued)

Figure | Page

45. Total return of Nushagak River sockeye salmon versus number of spawners, 1978-1995 brood years 73

46. Average surplus yield categorized by the number of spawners of Nushagak River sockeye salmon, 1978-1995 brood years (excluding 1980 brood year) 74

47. Number of spawners and total return of Nushagak River chinook salmon by brood year, 1966-1994 75

48. Return per spawner of Nushagak River chinook salmon versus number of spawners, 1966-1994 brood years 76

49. Ricker spawner-recruitment relationship of Nushagak River chinook salmon, 1966-1994 brood years 77

50. Average surplus yield categorized by number of spawners of Nushagak River chinook salmon, 1966-1994 brood years 78

51. Percentage of age 3-4 and age 5-7 chinook salmon in Nushagak River spawning escapements, 1981-1985 and 1987-2000. No age data was collected in 1986 79

LIST OF APPENDICES

Appendix | Page

A.1. List of individuals attending the 2000 Bristol Bay sockeye salmon escapement goal workshop. 80

B.1. Kvichak River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 81

B.2. Naknek River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 82

B.3. Egegik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 83

B.4. Ugashik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 84

B.5. Togiak River sockeye salmon escapement and return by brood year including estimated interception catch includes aerial surveys of Togiak River below tower (in thousands), 1956-2000. 85

B.6. Wood River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 86

B.7. Igushik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995 87

B.8. Nushagak River sockeye salmon escapement and return by brood year, in thousands, 1956-1995. 88

B.9. Nushagak chinook salmon escapement and return by brood year, 1966-1995 89

C.1. Kvichak River numbers of sockeye salmon smolt and adult returns by brood year, 1969-95. 90

C.2. Egegik River numbers of sockeye salmon smolt and adult returns by brood year, 1980-95. 91

C.3. Ugashik River numbers of sockeye salmon smolt and adult returns by brood year, 1981-95. 92

ABSTRACT

The Alaska Department of Fish and Game held a workshop in Anchorage on September 26-27, 2000, to review Pacific salmon *Oncorhynchus* escapement goals for the major river systems in Bristol Bay. Spawner-return data for sockeye salmon *O. nerka* were analyzed for the Kvichak, Naknek, Egegik, Ugashik, Togiak, Wood, Igushik, and Nushagak Rivers. Smolt information was reviewed for the Kvichak, Egegik, and Ugashik Rivers and limnological and juvenile salmon information was analyzed from Iliamna, Becharof, and Ugashik Lakes. In addition, spawner-return data for Nushagak River chinook salmon O. *tshawytscha* were reviewed. With few exceptions, the available data supported the current biological escapement goals (BEG) in Bristol Bay.

Workshop participants did recommend modifications to the sockeye salmon BEG for the Wood and Igushik Rivers. Previously, the Wood River BEG ranged from 0.7-1.2 million spawners with a point goal of 1.0 million. Current data indicated that on average, additional yield could be gained by increasing the upper goal from 1.2 million to 1.5 million spawners, thereby setting a new BEG range of 0.7-1.5 million spawners with a point goal of 1.1 million. The Igushik River had a BEG range of 150-250 thousand with a point goal of 200 thousand in 2000. Current data for the Igushik River also indicated that on average, additional yield could be gained by increasing the upper goal. Additionally, the estimated MSY occurred at an escapement of 260 thousand, greater than the upper range of 250 thousand spawners. Therefore, it was decided by the workshop participants to increase the current upper goal from 250 to 300 thousand spawners, thereby changing the BEG range to 150-300 thousand spawners with a point goal of 225 thousand.

KEY WORDS: Pacific salmon, *Oncorhynchus,* sockeye salmon, *Oncorhynchus nerka,* chinook salmon, *Oncorhynchus tshawytscha,* Bristol Bay, Kvichak River, Naknek River, Egegik River, Ugashik River, Wood River, Igushik River, Nushagak River, Togiak River, spawning escapement goal, Ricker stock-recruitment model, smolt.

INTRODUCTION

Bristol Bay, Alaska, supports some of the largest sockeye salmon *Oncorhynchus nerka* runs in the world. Combined sockeye salmon runs to Bristol Bay have averaged 39 million for the last 10 years with nine major river systems producing 98% of the returning sockeye salmon (Kvichak, Branch, Naknek, Egegik, Ugashik, Togiak, Wood, Igushik, and Nushagak Rivers; Figure 1). Management of these sockeye salmon runs is based on achieving escapements for each river within a specific escapement goal range. Individual biological escapement goals (BEG) have been used for the major river systems since the early 1960's. The Alaska Department of Fish and Game (ADF&G) reviews the BEGs for Bristol Bay rivers on a schedule that corresponds to the Alaska Board of Fisheries triennial cycle for considering area regulatory proposals.

This report summarizes results from the most recent formal evaluation conducted September 26-27, 2000, at the ADF&G office in Anchorage. The meeting was attended by 24 people representing the following organizations: ADF&G, Commercial Fisheries Division (Region 2, Bristol Bay, Limnology, and Genetics staff); ADF&G, Sport Fish Division (Region 2 and Cook Inlet staff); United States Fish and Wildlife Service, Office of Subsistence; University of Washington (Fisheries Research Institute staff); and University of Alaska Fairbanks (School of Fisheries and Ocean Science staff; Appendix A.1). The review team examined available data and analyses for sockeye salmon in the Kvichak, Naknek, Egegik, Ugashik, Togiak, Igushik, Wood, and Nushagak Rivers, and chinook salmon in Nushagak River. Based on this review, BEG modifications were adopted for sockeye salmon in the Wood and Igushik Rivers.

Under the new Sustainable Salmon Fisheries Policy for the State of Alaska (ADF&G 2000), some of the existing BEGs defined in Fried (1994) are not evaluated in this review. They will be reclassified to sustainable escapement goals (SEG) because estimates of MSY cannot be determined from the existing data; these systems include:

- Branch River Sockeye Salmon
- Togiak River Chinook Salmon
- Kulukak River Coho Salmon
- Nushagak River Coho Salmon
- Togiak River Coho Salmon
- Nushagak River Pink Salmon

METHODS

Sockeye Salmon

Spawner-Return Data

Sockeye salmon spawner-return data were analyzed for brood years 1956-1995 for the Kvichak, Naknek, Egegik, Ugashik, Togiak, Wood, and Igushik Rivers. Spawner-return data for the Nushagak River were only available for brood years 1978-1995. Return information for brood year 1995 was incomplete because six-year-old sockeye salmon will not return until 2001. Since this age group generally does not comprise a large percent of the total return to any system, age-2.3 returns were estimated based on returns of age-2.2 (siblings) sockeye salmon from the 1995 brood year and the historic relationship between age-2.3 and age-2.2 sockeye salmon.

Numbers of spawners within each river, except the Nushagak River, were based on visual counts from towers located below lake outlets. Sockeye salmon escapement into the Nushagak River was estimated using side-scan sonar. Annual runs were the sum of tower or sonar counts and harvests. Methods used to estimate total runs (catch plus escapement) are described in (Bernard 1983). Sport and subsistence harvests were minor components of each run and were not included in total return estimates.

We assumed that sockeye salmon harvested in each district originated from rivers within the district. Although estimates of interceptions of stocks outside their district of origin, based on differences in scale growth, have shown that this is not true, use of interception estimates obtained during 1983-1994 did not substantially change spawner-return relationships for these systems. Although interception estimates have not been obtained since 1994, information such as age composition differences among district catches and escapements suggests that no great differences in interception rates have occurred.

Ricker stock-recruitment models (Ricker 1975) were fitted to spawner-return data from each system to estimate the number of spawners required to produce maximum sustained yield (MSY). Results were not used if the model fit to the data was poor or model assumptions were violated. Hilborn and Walters (1992) have shown that results from stock-recruitment models can be misleading for the following reasons: 1) errors in measurement of spawners and returns; 2) lack of contrast in sizes of spawning stocks; 3) autocorrelated errors within the model; and 4) changes in spawner-return relationships through time and within stock subunits.

Yield Analysis

A tabular approach was used to examine stock-recruitment relationships. This approach arranged spawning escapements and returns into intervals. The number of times that a spawning escapement within an escapement interval produced a recruitment value within a recruitment interval was calculated. Average surplus yield (ASY) within each interval, estimated as recruitment minus parental spawning escapement, was calculated.

Smolt Information

Smolt production was examined in systems for which this information had been collected. Passage of sockeye salmon smolt has been estimated with hydroacoustic equipment in the Kvichak River since 1971, Egegik River since 1982, and Ugashik River since 1983 (Crawford 2000). Relationships between numbers of smolt and number of spawners, and between size of smolt and numbers of spawners were examined.

Distribution Of Spawners

Information on distribution and relative abundance of spawners within the Kvichak River system has been collected by various agencies. Aerial surveys have been flown by ADF&G staff since 1988, and results are reported each year, including records dating back to 1955 (Glick et al. 2000). D.E. Rogers (University of Washington, Seattle, personal communication) has compiled aerial survey counts from key index areas and classified them into four habitat types: 1) rivers, 2) creeks and ponds, 3) mainland beaches, and 4) island beaches. Survey counts by habitat type were reviewed for trends through time to determine whether relationships existed between spawner distribution or relative abundance with total spawning escapement or cycle year.

Chinook Salmon

Spawner-Return Data

Chinook salmon spawner-return data were analyzed for brood years 1966-1994 for the Nushagak River. Return information for brood year 1994 was incomplete because seven-year-old chinook salmon will not return until 2001. Since this age class generally does not comprise a large percent of the total return, age-1.5 returns were estimated based on returns of age-1.4 (siblings) chinook salmon from the 1994 brood year and the historic relationship between age-1.4 and age-1.5 chinook salmon

Chinook salmon escapements into the Nushagak River were estimated with aerial surveys from 1966-1985 and 1997, and with side-scan sonar from 1986-1996, 1998-2000. Annual runs were the sum of aerial or sonar counts and harvests by commercial, sport, and subsistence fisheries. Sport and subsistence harvests above the Nushagak River sonar site were subtracted from the escapement past the sonar site to estimate the number of spawners (Minard et al. 1992).

We assumed that chinook salmon harvested in Nushagak Districts originated from rivers within the district. As was done for sockeye salmon, Ricker stock-recruitment models were fitted to chinook salmon spawner-return data to estimate the number of spawners required to produce MSY. Results were not used if the model fit to the data was poor or model assumptions were violated.

Yield Analysis

The same tabular approach used for sockeye salmon was also used to examine chinook salmon stock-recruitment relationships. This method provided ASY for specific escapement and recruitment intervals.

RESULTS

In general, sockeye salmon spawner-return data for the Kvichak, Egegik, and Ugashik Rivers did not show density dependent mortality when all available data were included, which is a basic assumption of most stock-recruitment models. However, when the data were divided by cycle (Kvichak pre-peak/peak and off-cycle years) or only more recent years were included (Egegik and Ugashik), density dependent mortality became evident. Density dependent mortality may not be evident in Bristol Bay east side spawner-return data if freshwater or marine production has changed over time or factors in addition to numbers of spawners have greatly affected survival.

Kvichak River Sockeye Salmon

Escapement Goal History

The management strategy for the Kvichak River from 1962 through 1984 was based on the occurrence of cyclic dominance in which some depensatory mechanism, independent of the fishery, was thought to suppress production during each of three years following a subdominant and dominant year. Since the five-year cycle was thought to be a naturally occurring phenomenon, management sought to obtain cyclic spawning escapements. Fishing in the Naknek-Kvichak District was regulated to obtain intermediate spawning escapements (4 million to 6 million) for the pre-peak (sub-dominant) run, large spawning escapements (10 million to 15 million) for the peak (dominant) run, and small spawning escapements (1 million to 2 million) for the three off-cycle years (Table 1).

Changes in the Kvichak River run since 1978, particularly the occurrence of large runs during off-cycle years like 1983, prompted reexamination of management based on the cyclic dominance theory. Results from analyses conducted by Rogers and Poe (1984) and Eggers and Rogers (1987) suggested that the Kvichak River run cycles were largely caused by a combination of: 1) weather; 2) small spawning escapements; and 3) brood year interaction between peak-cycle years which had very large escapements and the following brood years that experienced reduced production. Eggers and Rogers (1987) suggested that the commercial fishery was the depensatory factor responsible for the recent pronounced cycle, because off-cycle runs were exploited at much greater rates than either pre-peak or peak runs.

In 1985, ADF&G adopted an escapement goal policy to moderate the Kvichak run cycle (Fried 1984). Spawning escapement goals were increased for off-cycle years and decreased for the peak year to moderate future fluctuations in production. Since that time, four BEG evaluation meetings have been held, including the 2000 meeting documented within this report. Results from the 1987, 1991, 1994, and 1997 meetings have been presented to the Board of Fisheries (Cross 1991, Cross 1994, Cross et al. 1997).

The Kvichak escapement goal policy adopted in 1987 and continued through 2000 has allowed annual spawning escapement goals to fluctuate within a range of 2 to 10 million sockeye salmon. The lower limit of 2 million spawners was established because escapements below this level had often produced poorly. The upper limit of 10 million spawners was established because escapements greatly above this level appeared to reduce production the following brood year. A range of goals, rather than a single goal, was established to allow for 1) fluctuations in run sizes; 2) variations in spawner distribution; 3) potential effects of brood year interactions between progeny of successive spawning escapements; and 4) increased information on returns from spawning escapements between 2-10 million. We now have five returns from off-cycle escapements between 4-6 million. Two of those brood years (1987 and 1988) produced good runs ranging from 10-12 million, while the remaining three brood years produced poor runs ranging from 2-5 million.

In 1997, BEG workshop participants agreed that the escapement goal policy for Kvichak River should be modified to allow for a more robust variable escapement goal range based on actual run size and a conservative exploitation rate (Table 2). The BEG range for Kvichak River during off-cycle years was changed from 4-6 million to a broader range of 2-10 million. Additionally, an exploitation rate of 50% was set on runs of 4-20 million to provide guidance in setting goals within the range. The management objective for a given off-cycle year would then be defined as 50% of the total inshore Kvichak River run, and would never be less than 2 million or greater than 10 million. The management objective for a given pre-peak or peak cycle year would then be defined as 50% of the total inshore Kvichak River run, and would never be less than 6 million or greater than 10 million. This would provide opportunity to obtain large escapements during the exceptional off-cycle year in which a run was large, but would also allow more harvest during the more usual off-cycle year in which a run was small. For example, under the new policy, an off-cycle total return of 8 million would allow 4 million for escapement and 4 million for catch while a peak or pre-peak return of 14 million would allow for an escapement of 7 million and a harvest of 7 million.

Spawner-Return Data

The number of Kvichak River spawners has ranged from 0.2 million in 1973 to 24.3 million in 1965 and returns have ranged from 0.3 million for brood year 1958 to 55.0 million for brood year 1960 (Figure 2; Appendix Table B.1). Kvichak River spawner-return data from 1956-1995 show very distinct five-year cycles: two years of high production (pre-peak and peak cycle years) followed by three years of low production (off-cycle years). Through 1995, the average number of spawners for pre-peak and peak cycle years has been 10.3 million, and the average number of returning adults has been 22.3 million, however, there has been a downward trend in production since 1960. The average number of spawners for off-cycle years has been 3.0 million with the average number of returning adults at 5.9 million. There has been little overlap in spawning population sizes between off-cycle (10-90th percentile range: 0.7-4.6 million) and peak (10-90th percentile range: 2.7-18.7 million) years. This makes it difficult to determine whether large escapements would produce well during off-cycle years, or whether small escapements obtained during peak years would produce well or result in increased production during subsequent off-cycle years.

Return-per-spawner values for the Kvichak River have ranged from 0.2 for brood year 1968 (2.5 million spawners) to 10.8 for brood year 1973 (0.2 million spawners) and averaged 2.4 for all available brood years (Figure 3; Appendix Table B.1). Return-per-spawner values have increased slightly since brood year 1972 (Figure 3). However, the past five brood year return-per-spawner values have been below the 1956-1972 and 1973-1995 averages, but have been increasing slightly each year since 1992. The average return-per-spawner was 1.9 during 1956-1972 and increased to 2.8 during 1973-1995. Additionally, return-per-spawner values fell below replacement for 6 of 17 brood years (38%) during 1956-1972 while return-per-spawner values only fell below replacement for 4 of 23 brood years (17%) during 1973-1995. When viewing the entire series of available brood years, no distinct trends between return-per-spawner values and numbers of spawners were obvious. Density-dependent mortality was not evident since return-per-spawner values did not decrease as escapements increased (Figure 3). No strong trends were apparent when brood year data were divided into off-cycle and peak years. Return-per-spawner values were similar between off-cycle and peak cycle years during 1956-1995. Average return per spawner for off-cycle brood years was 2.3, while the average for pre-peak and peak cycle brood years was 2.5 (Figure 4). There was a slight trend of decreasing return-per-spawner values with increasing escapements within off-cycle brood years as well as within peak cycle brood years. Unexpectedly however, the average return-per-spawner value was slightly lower for off-cycle brood years than it was for pre-peak and peak brood years, even though the average number of spawners during off-cycle years has been considerably less than that for pre-peak and peak years. Again, return-per-spawner information did not indicate that freshwater density-dependent mortality was an important factor in determining production.

A Ricker stock-recruitment model could not be fitted to spawner-return data for the Kvichak River when all brood years were examined as a set (Figure 5). A significant fit (P=0.11) did occur however, if years 1969-1995 were included in the model; the estimated number of spawners required to produce MSY was 8.2 million. When all the data were separated into off-cycle years, a significant (P=0.11) Ricker model indicated that MSY was achieved with 1.9 million spawners (bootstrapped 80% confidence interval of 1.3-3.7 million, n=1000; Figure 6). A Ricker model also produced a significant fit (P=0.09) to pre-peak and peak spawner-return data (1959 excluded), and indicated that MSY was achieved at 9.5 million spawners (bootstrapped 80% confidence interval of 6.0-19.0 million, n=1000; Figure 6). We must caution the reader that fitting Ricker models to off-cycle and peak cycle data separately could produce misleading results, since this assumes that available spawner-return data can be used to describe the stock-recruitment relationship for both cycle year categories. As mentioned previously however, while the data set as a whole has good contrast in numbers of spawners (range: 0.2 million to 24.3 million), off-cycle years within the available data set have had much smaller escapements than pre-peak and peak years. The lack of contrast in number of spawners for both subsets of the data does not allow us to determine whether off-cycle and peak years actually have different production regimes or whether observed differences are simply due to number of spawners.

Yield Analysis

A tabular approach to examine spawner-return data indicated that spawning populations between 1-2 million (n=6) and 3-4 million (n=4) produced the greatest ASY of 2.6 million for the off-cycle brood years (Figure 7). Other spawning levels produced considerably lower ASYs (less than 1.0 million). Spawning populations between 12-15 million (n=3) produced the greatest ASY (22.5 million) for the data set containing only pre-peak and peak years (Figure 7). The next highest category contained spawning escapements from 9-12 million, which produced an ASY of 15.0 million (n=3). No other categories produced ASYs greater than 10 million. The current BEG for pre-peak and peak cycle years is 6-10 million. The minimum goal of 6 million was established because most pre-peak and peak cycle escapements had been greater than or equal to 6 million spawners and had produced good returns. The 10 million maximum was based on evidence that escapements greater than this depressed production from subsequent escapements (Eggers and Rogers 1987).

Smolt Information

Prior to 2000, there were five consecutive years of large age-1 smolt outmigrations, while previous large smolt migrations were predominantly age-2 smolt (Figure 8). Freshwater age of Kvichak River sockeye salmon appears to be determined by environmental conditions such as warm weather during April through October (Rogers and Poe 1984). However, Lew and Schindler (University of Washington, FRI, personal communication) found that larger escapements in Iliamna Lake tend to produce a larger proportion of age-2 smolts, which in turn, have a higher marine survival. Large escapements increase food competition in Iliamna Lake, slowing the growth of juvenile sockeye salmon. Freshwater age is partially determined by growth, and slower growing fish tend to stay in freshwater longer before leaving the lake systems as smolt. Brood years with unusually warm weather (1992-1995) have produced greater proportions of age-1. smolt.

There was a significant ($P<0.01$) positive relationship between numbers of smolt and numbers of spawners for all brood years (Appendix Table C.1 and Figure 9). There was also a significant ($P=0.01$) positive relationship between numbers of adult returns and numbers of smolt. The relationship between numbers of smolt and numbers of spawners for off-cycle brood years was positive for both age-1 ($P=0.02$), and age-2 ($P=0.06$; Figure 10) smolt. With the exception of brood years 1978, 1987, and 1993, most off-cycle brood years have produced 80 million or fewer smolt. High smolt production from off-cycle brood years has been predominantly age-1. smolt from spawning escapements of 4 million or more sockeye salmon. Smolt information suggested that allowing greater numbers of sockeye salmon to spawn during off-cycle years may increase smolt production. We found no significant relationship between numbers of smolt and numbers of spawners for pre-peak and peak years (Figure 10).

Significant inverse relationships were found among size of age-1. and age-2. smolt and numbers of spawners (Figure 11). Decreasing average size of smolt with increasing numbers of spawners was probably due to juveniles competing for food because more smolt were produced from brood years with greater numbers of spawners. Due to differences in numbers of spawners and numbers of smolt produced by different brood years within the cycle, average size of smolt was larger for off-cycle than for pre-peak and peak brood years. Average length of age-1. smolt was 87 mm for off-cycle brood years and 85 mm for pre-peak and peak brood years. Average length of age-2. smolt was 108 mm for off-cycle brood years and 101 mm for pre-peak and peak brood years. Similarly, average weight of off-cycle age-1. smolt was 6.0 g and for pre-peak and peak cycle age-1. smolt it was 5.5 g. Average weight for off-cycle age-2. smolt was 10.7 g and of pre-peak and peak cycle age-2. smolt it was 9.0 g. Although average size of smolt produced by pre-peak and peak brood years was less than that of smolt produced by off-cycle brood years, marine survival was not statistically different between off-cycle and pre-peak and peak brood years.

The average smolt per spawner for off-cycle brood years was 30 and for pre-peak and peak brood years, it was 27 (Appendix C.1). The rate of smolt production was not different between off-cycle years compared to pre-peak and peak years, indicating that inherent production did not differ, only the numbers of spawners.

Spawner Distribution

Distribution of spawners among spawning habitat types has varied considerably throughout the years, but two trends were evident (Figure 12). Cycles seemed to have moderated after 1987 for runs to the various spawning habitats except for island beaches where runs still show a strong five-year cycle. Spawners occurred in appreciable numbers on the island beaches only during the dominant peak years. Also, there appeared to be a decreasing number of island beach spawners from 1965-2000. Some of this decrease may have been due to a change in the aerial survey program, beginning in 1988, rather than to a real decrease in spawner abundance. Prior to 1988, aerial surveys were conducted over a longer time period each year, which increased the probability of surveying during peak spawning periods. Beginning in 1988, the number of replicate surveys has been reduced, so timing of individual surveys has become more important. The most accurate aerial counts of beach spawners are made during peak spawning activity, since spawners are difficult to see in these areas and carcasses most likely sink into deep water where they are not visible. Some decline in beach spawners was noticeable prior to 1988. This may indicate that the decline is real, but that changes in the aerial survey program may have accentuated its appearance. Large total numbers of spawners may be needed to get appreciable numbers spawning on island beaches, so island beach spawners cycle in abundance along with the total spawning population.

Summary

Extensive review of spawner-recruit, smolt, fry, and limnological information did not provide conclusive evidence supporting either of two hypothesis concerning the production cycles in Kvichak River: 1) the cycle is natural and caused by an unknown depensatory agent (e.g. predators); or 2) the cycle is simply due to low number of spawners during off-cycle years. A review of spawner-recruit data for all brood years suggested that the cycle was only due to a low number of spawners. Smolt-per-spawner values indicated that the rate of production from off-cycle brood years was similar to that for pre-peak and peak cycle years. In addition, smolt information from off-cycle years indicated that for some brood years with 4 million or more spawners, greater numbers of age-1. smolt were produced. These information indicated that the difference in production from off-cycle years compared to pre-peak and peak cycle years was only due to a lack of spawners.

An analysis of spawner-return data with off-cycle brood years examined separately suggested that yield decreased during off-cycle years for escapements greater than 4 million. The five observations from off-cycle escapements greater than 4 million produced lower than expected. Spawner distribution information indicated that cycles appeared to be very pronounced for island beaches. This information indicated that cycles may be caused from some inherent depensatory factor.

Available information was inconclusive about the cause of production cycles in Kvichak River, therefore a great deal of uncertainty exists as to what levels of escapement will optimize Kvichak River's production every year. Unless additional information is collected that explains the cause of the production cycles, we will not be able to adequately address how to optimize the management of Kvichak River sockeye salmon.

Escapement Goal Recommendations

After reviewing the goals for the Kvichak River, there is some evidence that lowering the goal of 2 million spawners may increase yield in off-cycle years. For example, the suggested maximum sustainable yield from a Ricker spawner-recruit model is near the lower goal and an ASY analysis indicates that additional yield could be gained by lowering the goal below 2 million spawners. However, it was the consensus of the participants at the workshop that lowering the goal below 2 million spawners would increase the likelihood that some stocks would not receive an adequate number of spawners to maintain sustainability or genetic biodiversity within the drainage. BEG means the escapement that provides the greatest potential for maximum sustainable yield and ensuring the greatest potential means that diversity needs to be maintained. The Kvichak River run is composed of a complexity of spawning stocks and by maintaining the health of all stocks, periods of high productivity are more likely to result in strong returns.

Additionally, the lower goal of 2.0 million spawners for off-cycle years remained unchanged because if in fact, the cause for cyclic runs in the Kvichak is a lack of spawners meaning that there's no difference in productivity between what we currently consider cycle and off-cycle runs, then by lowering the goal of 2.0 million, we would be allowing escapements that are further from sustainable yield spawning levels. Therefore, the current BEG range for Kvichak River during pre-peak and peak cycle years was retained at 6-10 million and for off-cycle years at 2-6 million (Table 2).

Naknek River Sockeye Salmon

Spawner-Return Data

The current BEG for Naknek River is 1.1 million sockeye salmon and the range is 0.8-1.4 million (Table 2). Numbers of sockeye salmon spawners have ranged from 0.3 million in 1958 to 3.6

million in 1991 (Appendix Table B.2 and Figure 13). Although the BEG is the management objective for the Naknek River, average escapement for the last 10 years has been 1.5 million sockeye salmon. Escapements during 1990-1993 were especially large (1.5-3.6 million). The 1991 record escapement of 3.6 million was the result of low commercial fishing participation due to a price dispute. Other large escapements were usually due to difficulties exploiting large Naknek runs during years with small Kvichak runs. Returns to Naknek River have ranged from 0.7 million for brood year 1968 to 13.7 million for brood year 1986.

Return-per-spawner values have varied from a low of 0.7 for brood year 1968 to a high of 6.9 for brood year 1986 and averaged 3.1 for all available brood years (Appendix Table A.2 and Figure 14). Naknek River sockeye salmon production increased after brood year 1972 as shown by increased return-per-spawner values that averaged 2.7 from 1956-1972 and 3.3 from 1973-1995 (Figure 14). Return-per-spawner values fell below replacement on three occasions: in 1959, 1968, and 1992. Return-per-spawner values have steadily increased for the past four brood years with the 1995 brood year value up to 6.0, the highest since 1986. Returns from these brood years came from average escapements. A significant (P=0.06) density-dependent relationship exists between return-per-spawner values and numbers of spawners (Figure 14). Escapements greater than 2.0 million spawners produced lower than average return-per-spawner values.

Large returns have been produced from escapements ranging from 0.8-2.0 million (Figure 15). The three greatest returns observed were produced from brood years 1976 (1.3 million spawners), 1985 (1.8 million spawners) and 1986 (1.9 million spawners). Spawner-return data significantly (P=0.04) fit a Ricker stock-recruitment model; the estimated number of spawners needed to produce MSY was 1.9 million (bootstrapped 80% confidence interval of 1.3-4.1 million, n=1000; Figure 15). Spawning escapements from 1.0 million to 2.0 million on average, have produced large returns. Brood years with escapements greater than 1.4 million, the current upper range of the BEG, have also produced some large returns.

Yield Analysis

Average surplus yield was greatest (3.6 million) from spawning escapements ranging from 1.4-2.0 million, for which there have been six observations. However, because the 1986 yield (11.7 million - this is more than 5 times greater than the average) is so much larger than any other value it was excluded from the analysis (Figure 16). Average surplus yield from the remaining five observations was 2.0 million, less than the 2.4 million ASY obtained from 20 escapements within the current BEG range (0.8-1.4 million). Although escapements above the upper end of the biological escapement range have produced large ASYs, this was mostly due to one extremely large return from the 1986 brood year. Returns from two other escapements above the current range suggest that large successive escapements, such as those observed for brood years 1990, 1991 and 1992, may result in decreased production.

Escapement Goal Recommendations

Workshop participants recommended that the existing BEG range of 0.8-1.4 million sockeye salmon be maintained for Naknek River (Table 2). In general, available data support that range. Although there is some indication that spawning escapements greater than the current range could produce high yields, participants of the BEG workshop felt that we should be cautious about allowing successive large escapements above the current range into this system.

Egegik River Sockeye Salmon

Spawner-Return Data

The current BEG for Egegik River is 1.1 million sockeye salmon and the range is 0.8-1.4 million (Table 2). Numbers of sockeye salmon spawners have ranged from 0.2 million in 1958 to 2.8 million in 1991 (Appendix Table B.3 and Figure 17). Average escapement during the last 10 years was 1.7 million sockeye salmon. The largest successive escapements occurred from 1990-1993 with 2.2 million for 1990, 2.8 million for 1991, and 1.9 million for 1992. Returns to Egegik River have ranged from 0.5 million for brood year 1968 to 25.9 million for brood year 1987.

Return-per-spawner values have varied from a low of 1.3 for brood year 1963 to a high of 20.4 for brood year 1987 and averaged 5.8 for all available brood years (Appendix Table B.3 and Figure 18). Egegik River sockeye salmon production increased greatly after brood year 1975 as shown by increased return-per-spawner values that averaged 3.2 from 1956-1975 and 8.5 from 1976-1995. Return-per-spawner values have never been below replacement for Egegik River. Return-per-spawner values for the past three brood years, 1993-1995, have shown an increasing trend from 2.0 to 6.9. Returns from these brood years came from average sized, decreasing escapements. The relationship between return-per-spawner values and numbers of spawners did not show any density dependent mortality; larger escapements did not have lower average return-per-spawner values (Figure 18).

Spawner-return data did not fit a Ricker stock-recruitment model when all years were included (Figure 19). With all available data, there was no evidence of density dependent mortality in the Egegik River spawner-return data, so we were unable to estimate the number of spawners required to produce MSY. However, when the more productive period with years 1976-1995 were used in a Ricker model, a significant (P=0.05) relationship resulted. The estimated escapement necessary to produce MSY was 2.0 million (bootstrapped 80% confidence interval of 1.3-4.6 million, n=1000; Figure 20).

Yield Analysis

Using all available data, the ASY was greatest (11.0 million) from the two spawning escapements greater than 2.0 million (Figure 21). The next highest ASY (7.3 million) came from seven escapements ranging from 1.4-2.0 million. Seven of the nine escapements greater than the upper goal of 1.4 million have resulted in yields greater than 5.6 million, the ASY for escapements within the current escapement goal range. The last three brood years have given progressively higher yields, ranging from 1.5 to 7.6 million.

For years 1976-1995 ASY remained unchanged for escapements greater than 2.0 million because the same two data points as above were included (Figure 21). Spawning intervals with greater than three samples showed that the current BEG range of 0.8-1.4 million had the highest ASY at 10.1 million followed by escapements of 1.4-2.0 million with an ASY of 8.6 million.

Markov transition probability tables were constructed for the periods 1956-1995 and 1976-1995 to provide additional insight into ASYs, their errors, and their relationship to varying escapement levels (Table 3). For the set using all available data, the greatest ASY of 9.1 million occurs at escapements greater than 1.8 million (Table 3). Escapements smaller than 1.8 million down to levels near 1.65 million produced lower yields. The second highest ASY (9.0 million) occurred with escapements between 1.2 and 1.5 million, however, the coefficient of variation was also greatest at this level. In general, the coefficient of variation increases as escapement increases up to 1.65 million spawners. The variation in yields associated with escapement levels for the 1956-1995 data set is greater than the 1976-1995 data set, likely because of their differences in productivity. For the 1976-1995 data set, the greatest ASY of 12.0 million occurs at a spawner interval of 1.2-1.5 million followed by intervals of 1.05-1.35 million and 1.35-1.65 million. In general, as ASY increases so do the coefficients of variation (standard deviation of surplus yield divided by ASY). Thus, larger escapements tend to cause a wider range in yields or more uncertainty.

Smolt Information

Egegik River smolt migration from four of the past five years has been much less than the 1983-2000 average of 52 million (Figure 22). Additionally, the past three brood years have produced below average total smolt emigrations (Appendix C.2).

The relationship between the numbers of smolt and the numbers of spawners was unclear (Appendix Table C.2 and Figure 23). Numbers of smolt emigrating from Egegik River did not clearly increase as numbers of spawners increased. There was a significant (P<0.01) positive relationship between numbers of returning adults and numbers of smolt (Figure 23). The numbers of smolt produced from the 1994 and 1995 brood years, approximately 40 million, fit the smolt-adult return relationship very well. There appeared to be no relationship between number of spawners and size of either age-1. or age-2. smolt.

Escapement Goal Recommendations

Workshop participants recommended that the existing BEG range of 0.8-1.4 million sockeye salmon be maintained for Egegik River (Table 2). The BEG range for this system had been increased in 1995, and there was no compelling reason to increase it again at this time. In general, available data support that range. Although there is some indication that escapements greater than the current range could produce high yields, participants felt we should be cautious about allowing successive large escapements above the current range into this system.

Ugashik River Sockeye Salmon

Spawner-Return Data

The current BEG for Ugashik River is 850 thousand sockeye salmon and the range is 0.5-1.2 million (Table 2). Numbers of sockeye salmon spawners have ranged from 39 thousand in 1973 to 3.3 million in 1980 (Appendix Table B.4 and Figure 24). The average escapement during the last 10 years was 1.3 million sockeye salmon. Escapements from 1991-1993 were the largest consecutive escapements to date: 2.5 million for 1991, 2.2 million for 1992, and 1.4 million for 1993. Returns to Ugashik River have ranged from 39 thousand for brood year 1968 to 7.8 million for brood year 1980.

Return-per-spawner values have varied from a low of 0.4 for brood year 1963 to a high of 25.2 for brood year 1978 and averaged 4.5 for all available brood years (Appendix Table B.4 and Figure 25). Ugashik River sockeye salmon production increased significantly after brood year 1973 as shown by increased return-per-spawner values that averaged 2.1 from 1956-1973 and 6.4 from 1974-1995. Return-per-spawner values were below replacement seven times from 1956-1972, but have since fallen below replacement only once with brood year 1993. The relationship between return-per-spawner values and number of spawners showed density dependent mortality (P=0.08, Figure 25). There were lower average return-per-spawner values from higher escapements, especially those greater than 1.4 million

Ugashik River production increased as spawning escapements increased from 40 thousand to 500 thousand and on average, good returns were produced from escapements ranging from 0.7-1.7 million (Figure 26). A Ricker stock-recruitment model could not be significantly fitted to spawner-return data for the Ugashik River when all brood years (1956-1995) were examined. However, a Ricker stock-recruitment model was significant (P<0.01) when it was fitted through recent brood years (1974-1995). The estimated number of spawners required to produce MSY based on the stock-recruitment model for 1974-1995 brood years was 1.0 million (bootstrapped 80% confidence interval of 0.8-1.4 million, n=1000; Figure 27). The 1980 brood year was very influential on the shape of the stock-recruitment curve, so that year was omitted and another stock-recruitment model fit to the data. The estimated number of spawners to produce MSY based on the stock-recruitment model using 1974-95 and omitting 1980 was 0.8 million (bootstrapped 80% confidence interval of 0.6-1.0 million, n=1000; Figure 27).

Yield Analysis

Using all available data, the ASY was greatest (3.0 million) from spawning escapements greater than 1.2 million, for which there were 10 observations (Figure 28). The next highest ASY (2.2 million) came from escapements ranging within the current BEG range, 0.5-1.2 million, for which there were 12 observations. Of the four brood years with escapements greater than 2.0 million, 1980 and 1991 produced high yields, while 1960 and 1992 produced very low yields. Although escapements into the Ugashik River ranging from 1.2-1.7 million have produced high yields, they were not consecutive.

Using more recent data, 1974-1995, the ASY was again at escapements greater than 1.2 million (Figure 28). However, the difference between that and the next lowest category was much smaller (3.2 million versus 3.1 million).

Next, a Markov transition probability table was developed to examine surplus yields and escapement levels on a finer scale with observed variability. Using the data set that includes all years, the greatest ASY (3.4 million) occurs at spawning levels of 1.2-1.5 million (Table 4). Variability is highest for spawning levels below 1.20 million and greater than 1.65 million. For the data set 1974-1995, the greatest ASY of 3.4 million again occurs at an escapement range of 1.2-1.5 million spawners (Table 4). The greatest coefficient of variation for surplus yield occurred at escapements of 0.9-1.2 million.

Smolt Information

Smolt migration from Ugashik River for the past seven years, 1994-2000, have been much below the 1983-2000 average (Figure 29). Cross et al. (1997) thoroughly reviewed the extremely low smolt count of 1996 and suspected it was lower than actual smolt numbers because of the early spring break-up and smolt migrating prior to counting. Even if the count was erroneously low, they felt the trend of reduced smolt counts observed for 1994-1997 was real. The 1993 brood year that had an escapement of 1.4 million, following escapements of 2.5 million and 2.2 million, produced extremely low smolt numbers.

The relationship between numbers of smolt and numbers of spawners was unclear (Appendix Table C.3 and Figure 30). Numbers of smolt migrating from Ugashik River showed no discernible trend with numbers of spawners when all years are included, however a strong (R^2=0.76) relationship emerged when data prior to 1989 were excluded. There was a significant (P<0.01) nonlinear positive relationship between numbers of adult returns and numbers of smolt (Figure 30).

Escapement Goal Recommendations

Workshop participants recommended that the existing BEG range of 0.5-1.2 million sockeye salmon be maintained for Ugashik River (Table 2). The BEG range for this system was last increased in 1995, and there was no compelling reason to increase it again at this time. In general, available data support that range. Although there is some indication that escapements greater than the current range could produce high yields, participants felt we should be cautious about allowing successive large escapements above the current range into this system. Recent brood year returns and smolt migrations have shown a decrease in production following large back-to-back escapements.

Togiak River Sockeye Salmon

Spawner-Return Data

The current biological escapement point goal for Togiak River above the tower is 150 thousand sockeye salmon with a range of 100-200 thousand (Table 2). The spawner-return information presented below includes spawning escapements counted past the Togiak River tower plus estimates of spawners in the lower river from aerial surveys. The lower river spawners were included in the analyses because on average they comprised 15% of the total Togiak River spawners, and therefore contribute significantly to the Togiak Section catch. To estimate an escapement goal above the tower, the lower river spawners have to be subtracted from the estimate of optimum spawners for the entire drainage.

Numbers of sockeye salmon spawners have ranged from 25 thousand in 1957 to 527 thousand in 1980 (Appendix Table B.5 and Figure 31). Average escapement during the last 10 years was 215 thousand sockeye salmon. Returns to Togiak River have ranged from 152 thousand for brood year 1963 to 1.3 million for brood year 1995.

Return-per-spawner values for the total Togiak River varied from a low of 0.58 for brood year 1980 to a high of 7.3 for brood year 1957 and averaged 3.3 for all available brood years (Appendix Table B.5 and Figure 32). Togiak sockeye salmon production showed a decrease from 1991-1994, but jumped to 6.1 for brood year 1995. Average return-per-spawner value for brood years 1956-1979 was 3.8, while the average for 1980-1995 was 2.8. During the first and more productive period, consistently higher than average return-per-spawner values occurred for brood years 1972-1977. The relationship between return-per-spawner values and numbers of spawners showed density dependent mortality ($P<0.01$, Figure 32). Large escapements, especially those greater than 200 thousand, showed lower than average return-per-spawner values.

Togiak River total production increased as spawning escapements increased from 50 thousand to 100 thousand and on average, good returns came from escapements ranging from 100-300 thousand. A Ricker stock-recruitment model was significant ($P<0.01$) when fitted through all available brood years, 1956-1995 (Figure 33). The estimated number of spawners required to produce MSY for total Togiak River based on all brood years was 180 thousand (bootstrapped 80% confidence interval of 144-245 thousand, n=1000).

Yield Analysis

Average surplus yield was greatest (431 thousand) from spawning escapements ranging between 140-200 thousand for which there were ten observations (Figure 34). Average surplus yields were similar for two other escapement ranges, 100-140 thousand (319 thousand) and from 200-250 thousand (333 thousand). Analysis of observed yields indicated that escapements into the Togiak River greater than 250 thousand could produce high yields, however past high escapements were generally not consecutive.

Escapement Goal Recommendations

Workshop participants recommended that the existing BEG range of 100-200 thousand sockeye salmon be maintained for Togiak River (Table 2). In general, available data support that range. The BEG range for this system was last changed in 1997, and there was no compelling reason to change it again at this time. In 1997, the BEG range of 140-250 thousand was changed to a range of 100-200 thousand for Togiak River above the tower based on a summary of available spawner, return, and yield data (Cross et al. 1997).

Wood River Sockeye Salmon

Spawner-Return Data

The current management objective for Wood River is 1.1 million sockeye salmon and the current BEG range is 0.7-1.2 million (Table 2). Numbers of Wood River sockeye salmon spawners have ranged from about 0.3 million in 1957 to almost 3.0 million in 1980 (Appendix Table B.6 and Figure 35). Average escapement into Wood River during the last 10 years has been 1.4 million sockeye salmon, and since 1994 has been 1.5 million sockeye salmon. Returns to Wood River ranged from 0.4 million for brood year 1957 to 6.2 million for brood year 1995. Return-per-spawner values for Wood River have varied from a low of 0.5 for brood year 1980 to a high of 7.0 for brood year 1976, and averaged 2.7 for all available brood years (Appendix Table B.6 and Figure 36). Average return-per-spawner values were 2.1 for 1956-1972 and 3.2 for 1973-1995. Return-per-spawner values were below replacement for only two brood years, 1959 and 1980, both of which had escapements greater than 2.0 million. The relationship between return-per-spawner values and numbers of spawners showed density dependent mortality (Figure 36).

Wood River total production has increased as spawning escapements have increased above 0.7 million (Figure 37). On average, good returns have been produced from escapements ranging from 0.7-1.7 million. A Ricker stock-recruitment model fitted through all available brood years for Wood River was significant (P=0.01) and estimated that 1.3 million spawners would produce MSY (bootstrapped 80% confidence interval of 1.0-2.1 million, n=1000; Figure 37). The stock-recruitment model fitted through recent data, 1973-1995 brood years, was also significant (P<0.01) and estimated that 1.0 million spawners would produce MSY (bootstrapped 80% confidence interval of 0.8-1.3 million, n=1000).

Yield Analysis

The greatest ASY (3.6 million) came from four spawning escapements within the range of 1.45-1.75 million (Figure 38). Three spawning level categories, each with six or more escapements, had ASYs between 1.7-1.8 million, including 0.70-0.95, 0.95-1.20, and 1.20-1.45. Six of the past seven escapements (since 1994) were greater than the upper range of 1.4 million. Brood year returns from 1994 and 1995 were over 5 million with return-per-spawner values greater than three.

Escapement Goal Recommendations

Workshop participants recommended increasing the upper BEG from 1.2 million to 1.5 million for Wood River sockeye salmon. In addition to the two Ricker models estimating MSY to be near and above the upper goal, the yield analysis supported an increase above 1.2 million spawners. Spawning intervals with six or more samples indicated that large ASYs could occur with escapements up to 1.5 million. Additionally, escapements in 1994 and 1995 were near 1.5 million and produced runs over of 5 million, ranking number one and number four from 40 years of brood year return data.

Igushik River Sockeye Salmon

Spawner-Return Data

The current management objective for Igushik River is 200 thousand sockeye salmon and the current BEG range is 150-250 thousand (Table 2). Numbers of Igushik River sockeye salmon spawners have ranged from about 0.02 million in 1962 to almost 2.0 million in 1980 (Appendix Table B.7 and Figure 39). Average escapement has been about 0.4 million sockeye salmon during the last 10 years. Returns have ranged from about 0.08 million for brood year 1957 to 4.0 million for brood year 1975. Return-per-spawner values have varied from a low of 0.2 for brood year 1980 to a high of 21.0 for brood year 1977 and averaged 4.6 for all available brood years (Appendix Table B.7 and Figure 40). Average return-per-spawner value was 3.3 for 1956-1972 and 5.6 for 1973-1995. Return-per-spawner values were below replacement for 10 brood years, seven of which had escapements greater than 0.2 million, providing evidence of density-dependent mortality. Additionally, a significant (P=0.02) density dependent inverse relationship exists between the number of spawners and the return per spawner; that is, larger escapements typically result in a lower return-per-spawner value (Figure 40).

Spawner-return information indicated that Igushik River total production increased as spawning escapements increased above 150 thousand (Figure 41). On average, good returns were produced from escapements in the 150-250 thousand range. Stock-recruitment models generally fit Igushik River spawner-return data well. The extremely large 1980 escapement was excluded from the analyses, since it was almost four times greater than most of the other observed spawning escapements. A Ricker stock-recruitment model fit through all available brood years, excluding 1980, was significant (P<0.01) and estimated that 265 thousand spawners would produce MSY (bootstrapped 80% confidence interval of 203-395 thousand, n=1000; Figure 41).

Yield Analysis

The greatest ASY (930 thousand) was derived from six spawning escapements in the escapement range of 200-300 thousand (Figure 42). The next greatest ASY (870 thousand) came from escapements ranging from 300-400 thousand. Again, data from 1980 were excluded in this analysis.

Additionally, a Markov transition probability table was developed to examine surplus yields and escapement levels on a finer scale with observed variability. In this analysis, the greatest ASY of 1.0 million occurred at an escapement range of 150-250 spawners (Table 5). This category was followed closely by escapements ranging from 200-300 thousand, which had an ASY of 0.9 million. The coefficient of variation for surplus yield was relatively high at all escapement levels, reflecting the large variability in returns for any given escapement level.

Escapement Goal Recommendations

Workshop participants recommended increasing the upper BEG from 250 thousand to 300 thousand for Igushik River sockeye salmon. A Ricker MSY estimate above the current goal and ASYs that suggest additional yields may be gained by raising the goal to 300 thousand support the change. Associated with an increase in the upper range, the point goal was raised from 200 thousand to 225 thousand spawners.

Nushagak River Sockeye Salmon

Spawner-Return Data

The current management objective for Nushagak River is 0.55 million sockeye salmon and the current BEG range is 0.24-0.76 million (Table 2). Spawner-return data for the total Nushagak River system have been estimated since 1978. The Nushagak River sonar project began estimating sockeye salmon in 1980 and prior to that, only escapements into the Nuyakuk River, a tributary to the Nushagak River, was monitored. Estimates of escapement for the total Nushagak River system in 1978 and 1979 are derived from the sum of Nuyakuk tower estimates and expanded aerial surveys throughout the remainder of the system. Numbers of Nushagak River sockeye salmon spawners for brood years 1978-1995 ranged from 0.3 million in 1995 to 3.3 million in 1980 (Appendix Table B.8 and Figure 43). Average escapement during the last 10 years has been about 0.5 million sockeye salmon. Returns have ranged from 0.9 million for brood year 1994 to 2.5 million for brood year 1988. Return-per-spawner values have varied from a low of 0.4 for brood year 1980 to a high of 5.3 for brood year 1987 and averaged 2.7 for all available brood years (Appendix Table B.8 and Figure 44). There was evidence of density-dependent mortality since the return-per-spawner values decreased for escapements greater than 0.6 million. Significant linear fits to the return-per-spawner data occurred with (P=0.01) and without (P<0.01) the 1980 data point in the analysis.

Spawner-return information for Nushagak River was very limited in escapement range when the 1980 brood year data were excluded (Figure 45). Ricker spawner-recruitment models were fit to the data with and without the 1980 brood year data. Both models produced significant (P<0.01) fits, but with varying estimates of escapement needed to produce MSY. The Ricker model using all data estimated that escapement needed to be 760 thousand to produce MSY (bootstrapped 80%

confidence interval of 575-985 thousand, n=1000), the upper limit of the current BEG range. The shape of this model's predicted line is largely determined from the 1980 data point. The Ricker model excluding 1980 estimated that escapement needed to be 500 thousand at MSY (bootstrapped 80% confidence interval of 390-700 thousand, n=1000). More escapements between 0.7 and 3.0 million are necessary for a better understanding of a spawner-return relationship at larger escapements.

Yield Analysis

The greatest ASY, 1.2 million, was produced from eight spawning escapements within the middle portion (0.34-0.55 million) of the current BEG range (Figure 46).. Average surplus yield for spawning escapements above the current BEG range was 1.0 million. There are no observed returns from escapements below the lower limit of the current escapement range.

Escapement Goal Recommendations

Workshop participants recommended no changes for the Nushagak River sockeye salmon BEG. Available spawner-return information was very limited, but generally supported the current management objective and BEG range. The relationship of Nuyakuk escapement to Nushagak escapement was explored, but the Nuyakuk tower data are sparse. Based on analysis of the available data, maximum yields for the Nuyakuk and Nushagak Rivers are likely to occur at escapements above the point goal of 550,000. The Nuyakuk tower was operated from 1979-1988 and from 1995 to the present. The only recent spawner-recruitment brood year information for the Nuyakuk River is 1995, but as additional tower escapement data are collected, we should gain a better understanding of how Nuyakuk River and Nushagak River production are related.

Nushagak River Chinook Salmon

Spawner-Return Data

The current BEG for Nushagak River chinook salmon is 65 thousand with the commercial fishery managed to achieve an inriver goal of 75 thousand as outlined in the Nushagak-Mulchatna Chinook Salmon Management Plan (ADF&G, 1996). Numbers of chinook salmon spawners ranged from 25 thousand in 1972 to 162 thousand in 1983 (Appendix Table B.9 and Figure 47). The average number of spawners during the last 10 years was 78 thousand chinook salmon. Chinook salmon returns ranged from 49 thousand for brood year 1969 to 476 thousand for brood year 1977. Return-per-spawner values varied from a low of 0.5 for brood year 1982 to a high of 9.2 for brood year 1972 and averaged 2.7 for all available brood years (Appendix Table B.9 and Figure 48). Nushagak River chinook salmon spawner-return data showed significant (P<0.01) evidence of density dependent mortality as return-per-spawner values were lower for escapements greater than 100 thousand.

Chinook salmon spawning escapements ranging from 40-100 thousand have, on average, produced large returns (Figure 49). Ricker stock-recruitment models fit through all available brood years and the years 1978-1995 were significant ($P<0.01$) and estimated that the number of spawners required to produce MSY was 49 thousand (bootstrapped 80% confidence interval of 43-58 thousand, n=1000; Figure 49). A Ricker stock-recruitment curve fitted through spawner-return data estimated from aerial surveys only (1966-1979) was significant ($P=0.09$) and estimated that 65 thousand spawners would produce MSY.

Yield Analysis

Average surplus yield was greatest (133 thousand) from spawning escapements ranging from 40-65 (n=7, Figure 50). The six spawning escapements greater than 100 thousand chinook salmon produced on average, very little surplus yield. Spawning escapements less than 40 thousand (n=4) and from 70-95 thousand (n=10) produced similar ASYs.

Escapement Quality

The trend towards younger fish in chinook salmon spawning escapements from 1995-1997 raised concerns about the quality of chinook salmon escapements into the Nushagak River (Figure 51). Chinook salmon size and sex composition varies greatly with the smaller three and four-year-old chinook salmon returning to spawn primarily as males. The sex composition of the larger and older (age-5 through age-7) chinook salmon varies, but is approximately equal proportions of males and females. Because there is such a difference in size among returning chinook salmon, the commercial gillnet fishery and the sport fishery can be size selective.

We reviewed the current BEG of 65,000 to determine if it adequately addressed differences in age composition observed in recent years. The average percentage that large chinook salmon (age-5 through age-7) comprised of historic spawning escapements from 1981-1991 was 82%. Age composition from other spawning escapements were not available. Based on the current goal of 65,000 and an average percentage of 82% large fish, it was estimated that approximately 53,000 large fish should be allowed to spawn. We also compared the relationship among the number of age-5 through age-7 chinook salmon spawners and corresponding return data for the years available, 1981-1991, and estimated the number of age-5 through age-7 spawners required to produce MSY. The age-5 through age-7 stock recruitment model was significant ($P<0.01$) and estimated that 41,000 age-5 through age-7 spawners would produce MSY. From 1981-2000 age-5 through age-7 chinook salmon spawning escapements fell below 41,000 only twice, 1990 and 1996. Additionally, the total number of spawners for 1990 and 1996 were also below the current BEG of 65,000. For the 16 years with age composition data, the numbers of age-5 through age-7 spawners were below 53,000 during six years. Three of those six years did not meet the current BEG of 65,000 total spawners. Based on these results we felt the current BEG of 65,000 addressed spawner quality adequately, although we continue to urge managers to regulate the commercial and sport fisheries to allow untouched fish through the fisheries and to secure the BEG of 65,000 chinook salmon spawners.

Escapement Goal Recommendations

Workshop participants recommended no changes for the Nushagak River chinook salmon BEG. Available spawner-return information supported the current BEG.

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Table 1. History of Kvichak River sockeye salmon escapement goals set under the cyclic goal policy, 1969-1985 and recent goals, 1986-2000, set under the 4-10 million policy range.

Year	Policy	Goal	Actual	Deviation[a]
1969	Cyclic	6,000,000	8,394,204	40
1970	"	19,000,000	13,935,306	-27
1971	"	2,500,000	2,387,392	-4
1972	"	2,000,000	1,009,962	-49
1973	"	2,000,000	226,554	-89
1974	"	6,000,000	4,433,844	-26
1975	"	14,000,000	13,140,450	-6
1976	"	2,000,000	1,965,282	-2
1977	"	2,000,000	1,341,144	-33
1978	"	2,000,000	4,149,288	107
1979	"	6,000,000	11,218,434	87
1980	"	14,000,000	22,505,268	61
1981	"	2,000,000	1,754,358	-12
1982	"	2,000,000	1,134,840	-45
1983	"	2,000,000	3,569,982	78
1984	"	10,000,000	10,490,670	5
1985	"	10,000,000	7,211,046	-28
1986	2-10 Range	5,000,000	1,179,322	-76
1987	"	5,000,000	6,065,880	21
1988	"	5,000,000	4,065,216	-19
1989	"	8,000,000	8,317,500	4
1990	"	6,000,000	6,970,020	16
1991	"	4,000,000	4,222,788	5
1992	"	6,000,000	4,725,864	-21
1993	"	5,000,000	4,025,166	-19
1994	"	8,000,000	8,337,840	4
1995	"	10,000,000	10,038,720	<1
1996	"	4,000,000	1,450,578	-64
1997	"	4,000,000	1,503,732	-62
1998	"	2,000,000	2,296,074	15
1999	"	6,000,000	6,196,914	3
2000	"	6,000,000	1,827,780	-70
1969-2000 Average		5,900,000	5,600,000	-9
1969-1985 Average		6,100,000	6,400,000	3
1986-2000 Average		5,600,000	4,800,000	-23

[a] Percent deviation = (Actual-Goal)/Goal

Table 2. Current spawning escapement goals of sockeye salmon and the recommended changes for Bristol Bay Rivers.

	Current Goals		*Recommended Goals*	
River	**Objective**	**Range**	**Objective**	**Range**
Kvichak	2,000,000 (Off-cycle)	2,000,000 – 10,000,000		NO CHANGE
	6,000,000 (Pre-peak & Peak)			
Naknek	1,100,00	800,000 – 1,400,000		NO CHANGE
Egegik	1,100,00	800,000 – 1,400,000		NO CHANGE
Ugashik	850,000	500,000 – 1,200,000		NO CHANGE
Wood	1,000,000	700,000 – 1,200,000	1,100,000	700,000 – 1,500,000
Igushik	200,000	150,000 – 250,000	225,000	150,000 – 300,000
Nushagak	550,000	235,000 – 760,000		NO CHANGE
Togiak	150,000	100,000 – 200,000		NO CHANGE

Table 3. Summary of results from two Markov transition probability tables of Egegik River sockeye salmon spawner-recruit data, 1976-1995 and 1956-1995. Spawner intervals and averages are given in thousands of fish.

Data Set: Brood Year 1956-1995

Spawner Interval	N	Avg. # of Spawners	Avg. # of Recruits	Avg. Surplus Yield (ASY)	Coefficient of Variation for ASY	Return / Spawner	Min	Max
0-300	1	246	1,263	1,017	0%	5.1	1,017	1,017
150-450	4	326	1,409	1,083	67%	4.3	119	1,845
300-600	5	423	2,530	2,107	82%	6.0	119	4,808
450-750	7	631	3,535	2,904	63%	5.6	889	5,622
600-900	9	745	4,535	3,791	89%	6.1	889	9,854
750-1050	10	937	4,336	3,399	105%	4.6	260	9,854
900-1200	13	1,065	5,801	4,736	92%	5.4	260	13,179
1050-1350	10	1,166	9,448	8,282	86%	8.1	711	24,678
1200-1500	4	1,319	10,296	8,977	121%	7.8	1,658	24,678
1350-1650	4	1,543	9,063	7,519	100%	5.9	1,484	17,286
1500-1800	4	1,632	10,265	8,633	77%	6.3	1,484	17,286
1650-1950	3	1,880	8,798	6,918	12%	4.7	6,113	7,752
>1800	4	2,205	11,346	9,141	33%	5.1	6,888	13,549

Data Set: Brood Year 1976-1995

Spawner Interval	N	Avg. # of Spawners	Avg. # of Recruits	Avg. Surplus Yield (ASY)	Coefficient of Variation for ASY	Return / Spawner	Min	Max
150-450	0							
300-600	1	509	5,317	4,808		10.4	4,808	4,808
450-750	3	632	5,284	4,651	23%	8.4	3,524	5,622
600-900	4	769	7,597	6,828	41%	9.9	3,524	9,854
750-1050	4	939	8,035	7,097	34%	8.6	4,915	9,854
900-1200	6	1,090	9,399	8,309	43%	8.6	4,915	13,179
1050-1350	6	1,172	13,194	12,022	56%	11.3	6,577	24,678
1200-1500	2	1,278	17,528	16,250	73%	13.7	7,822	24,678
1350-1650	3	1,576	11,049	9,473	83%	7.0	1,484	17,286
1500-1800	3	1,576	11,049	9,473	83%	7.0	1,484	17,286
1650-1950	2	1,921	9,241	7,320	8%	4.8	6,888	7,752
>1800	4	2,205	11,346	9,141	33%	5.1	6,888	13,549

Table 4. Summary of results from two Markov transition probability tables of Ugashik River sockeye salmon spawner-recruit data, 1974-1995 and 1956-1995. Spawner intervals and averages are given in thousands of fish.

Data Set: Brood Year 1956-1995

Spawner Interval	N	Avg. # of Spawners	Avg. # of Recruits	Avg. Surplus Yield (ASY)	Coefficient of Variation for ASY	Return / Spawner	Min	Max
0-300	12	159	696	537	154%	4.4	-68	2,490
150-450	12	293	1,666	1,373	133%	5.7	-240	4,953
300-600	7	421	2,282	1,860	117%	5.4	-240	4,953
450-750	7	647	2,968	2,320	114%	4.6	-440	6,059
600-900	5	706	3,924	3,218	82%	5.6	-440	6,059
750-1050	4	1,005	2,974	1,969	134%	3.0	-458	5,681
900-1200	6	1,050	2,678	1,627	130%	2.5	-458	5,681
1050-1350	5	1,240	4,367	3,127	72%	3.5	565	6,140
1200-1500	4	1,333	4,688	3,355	81%	3.5	-327	6,140
1350-1650	1	1,413	1,086	-327	-----	0.8	-327	-327
1500-1800	6	2,289	5,041	2,751	63%	2.2	508	4,446
1650-1950	12	159	696	537	154%	4.4	-68	2,490
>1800	12	293	1,666	1,373	133%	5.7	-240	4,953

Data Set: Brood Year 1974-1995

Spawner Interval	N	Avg. # of Spawners	Avg. # of Recruits	Avg. Surplus Yield (ASY)	Coefficient of Variation for ASY	Return / Spawner	Min	Max
0-300	3	115	1,827	1,712	55%	15.8	663	2,490
150-450	3	329	4,039	3,710	33%	12.3	2,490	4,953
300-600	2	393	4,712	4,320	21%	12.0	3,686	4,953
450-750	3	697	5,669	4,973	22%	8.1	3,862	6,059
600-900	3	697	5,669	4,973	22%	8.1	3,862	6,059
750-1050	3	1,008	3,786	2,778	91%	3.8	964	5,681
900-1200	5	1,061	3,105	2,044	102%	2.9	565	5,681
1050-1350	5	1,240	4,367	3,127	72%	3.5	565	6,140
1200-1500	4	1,333	4,688	3,355	81%	3.5	-327	6,140
1350-1650	1	1,413	1,086	-327	-----	0.8	-327	-327
>1500	5	2,286	5,443	3,156	51%	2.4	508	4,446

Table 5. Summary of results from a Markov transition probability table for Igushik River sockeye salmon spawner-recruit data, 1956-1995. Spawner intervals and averages are given in thousands of fish.

Spawner Interval	N	Avg. # of Spawners	Avg. # of Recruits	Avg. Surplus Yield (ASY)	Coefficient of Variation for ASY	Return / Spawner	Min	Max
0-100	5	65	761	696	102%	12	169	1,919
50-150	7	96	659	563	100%	7	-54	20.99
100-200	10	163	825	662	103%	5	-54	2,208
150-250	11	194	1,227	1,033	107%	6	-20	3,740
200-300	6	241	1,166	925	160%	5	-107	3,740
250-350	4	297	850	552	206%	3	-107	2,249
300-400	6	352	1,223	872	109%	3	-75	2,249
350-450	7	396	973	577	108%	2	-62	1,559
400-500	7	444	1,083	639	112%	2	-22	1,870
450-550	5	496	1,128	632	141%	2	-22	1,870
500-600	3	546	696	150	164%	1	-10	434
>550	4	713	976	263	197%	1	-273	905

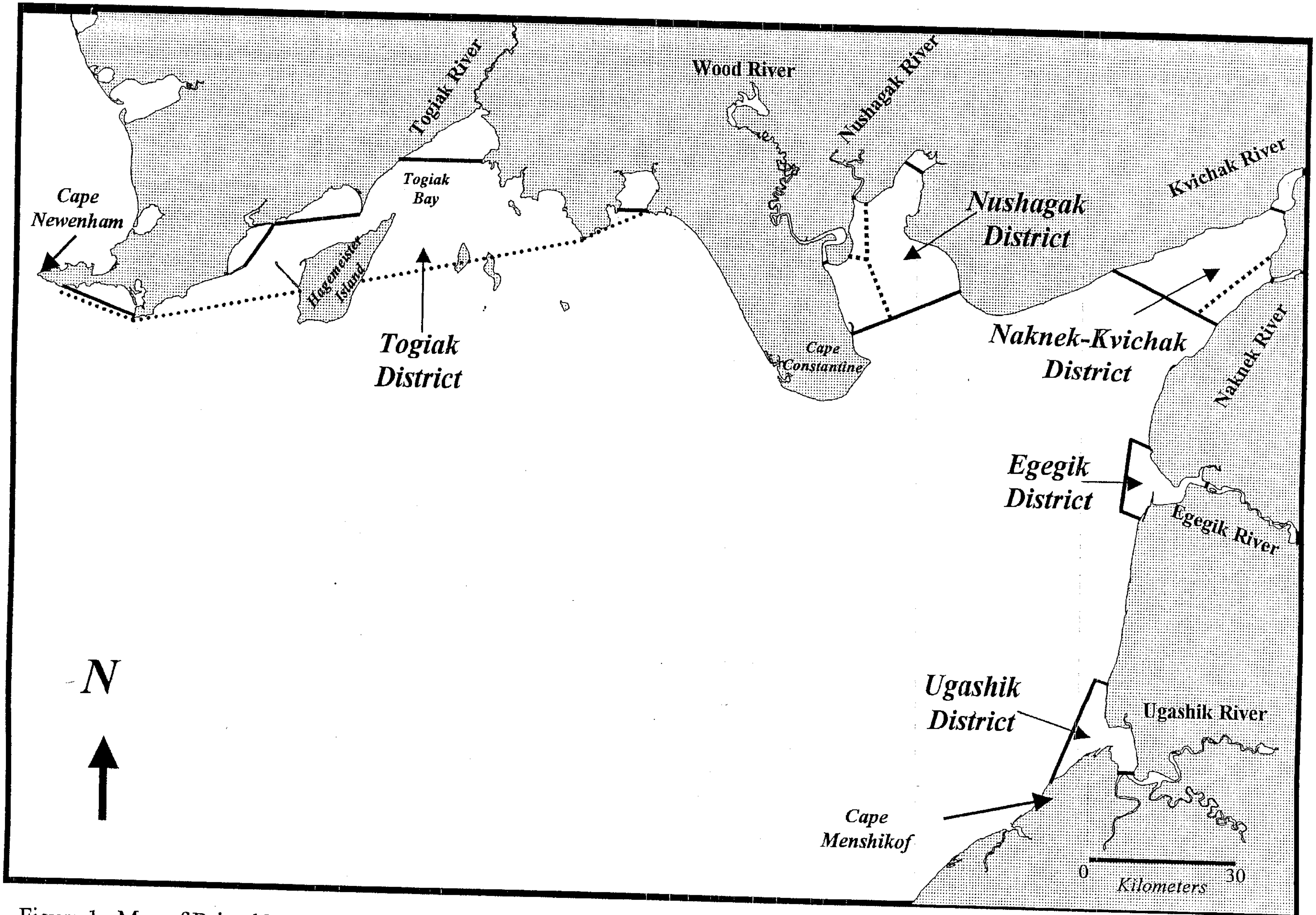


Figure 1. Map of Bristol Bay showing major rivers and fishing districts.

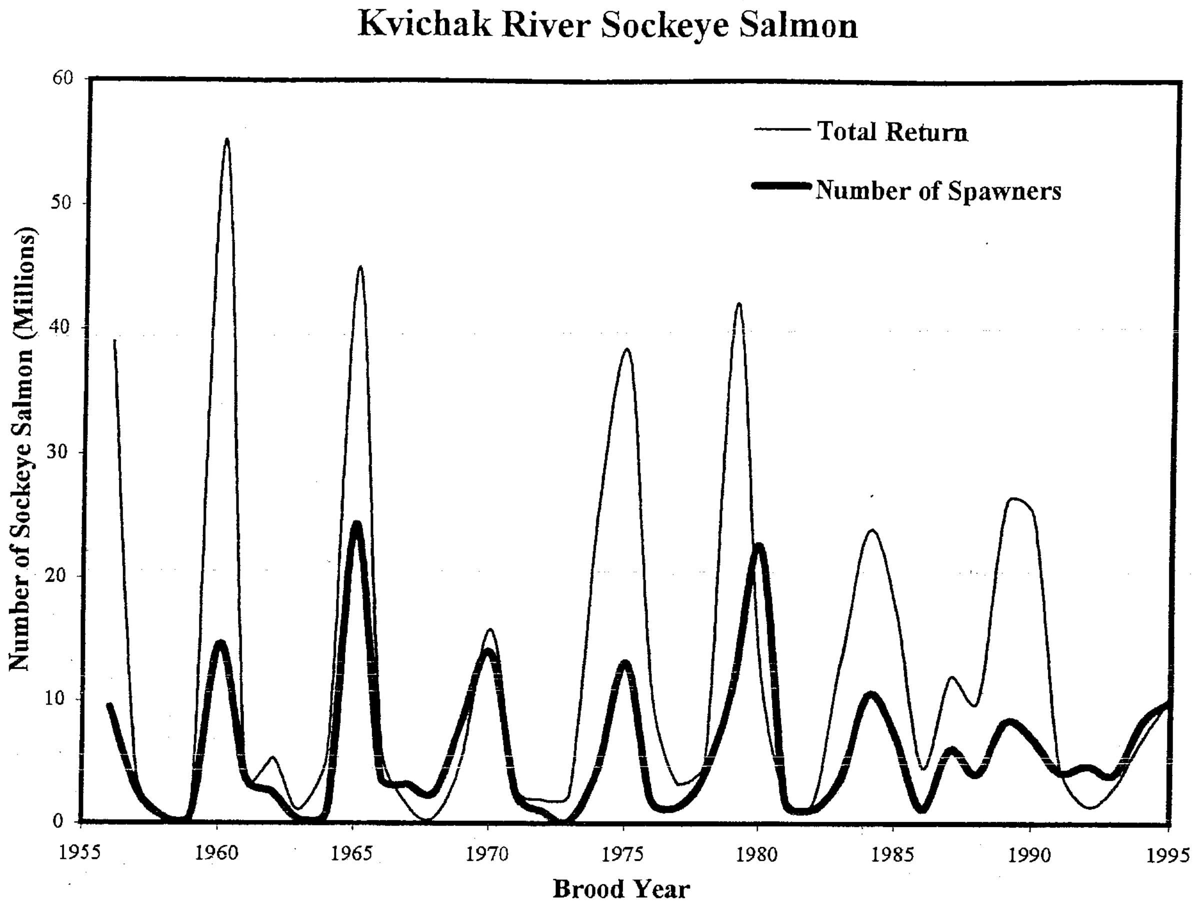


Figure 2. Number of spawners and total return of Kvichak River sockeye salmon by brood year, 1956 - 1995.

Kvichak River Sockeye Salmon

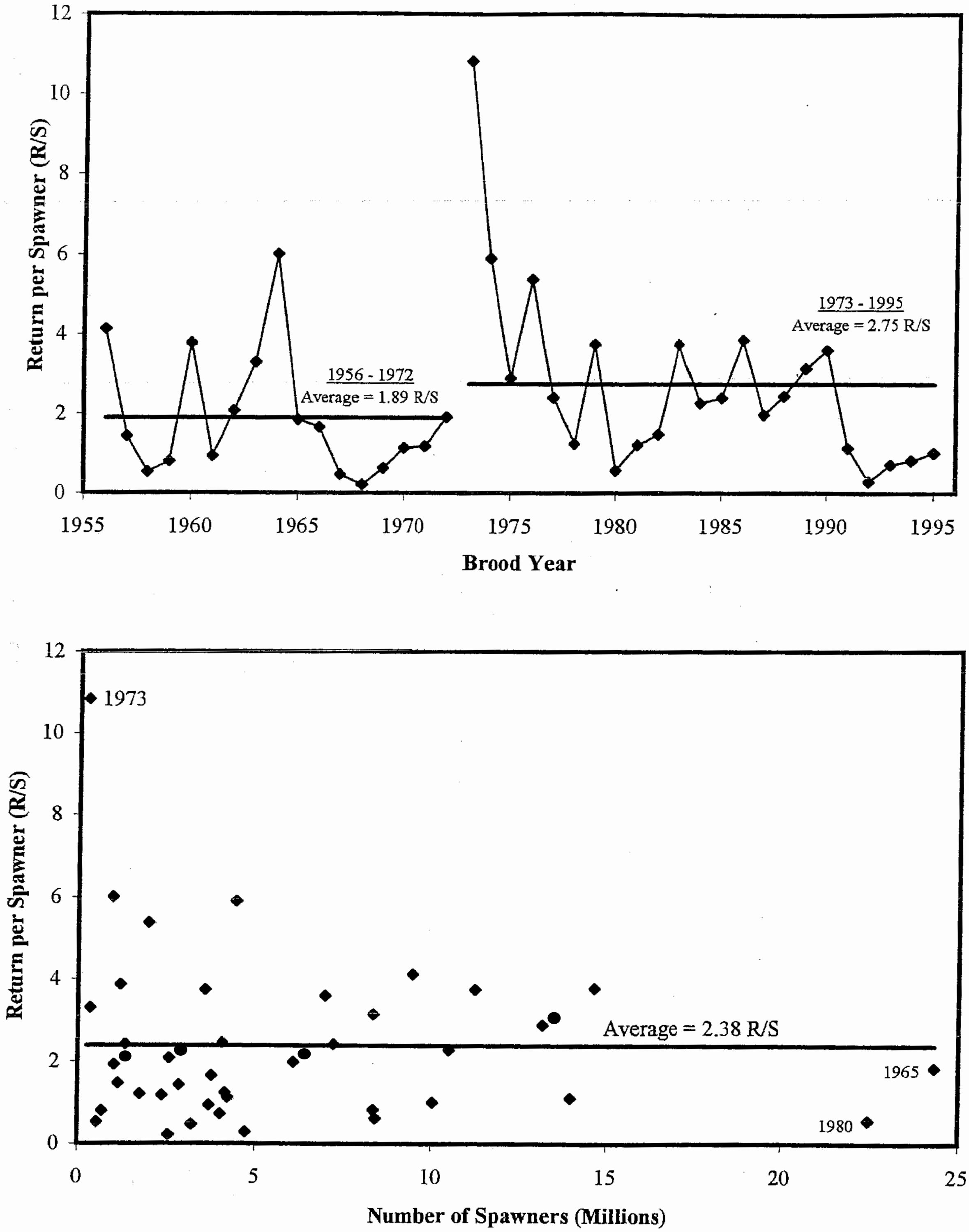


Figure 3. Return per spawner of Kvichak River sockeye salmon by brood year, 1956-1995, and number of spawners.

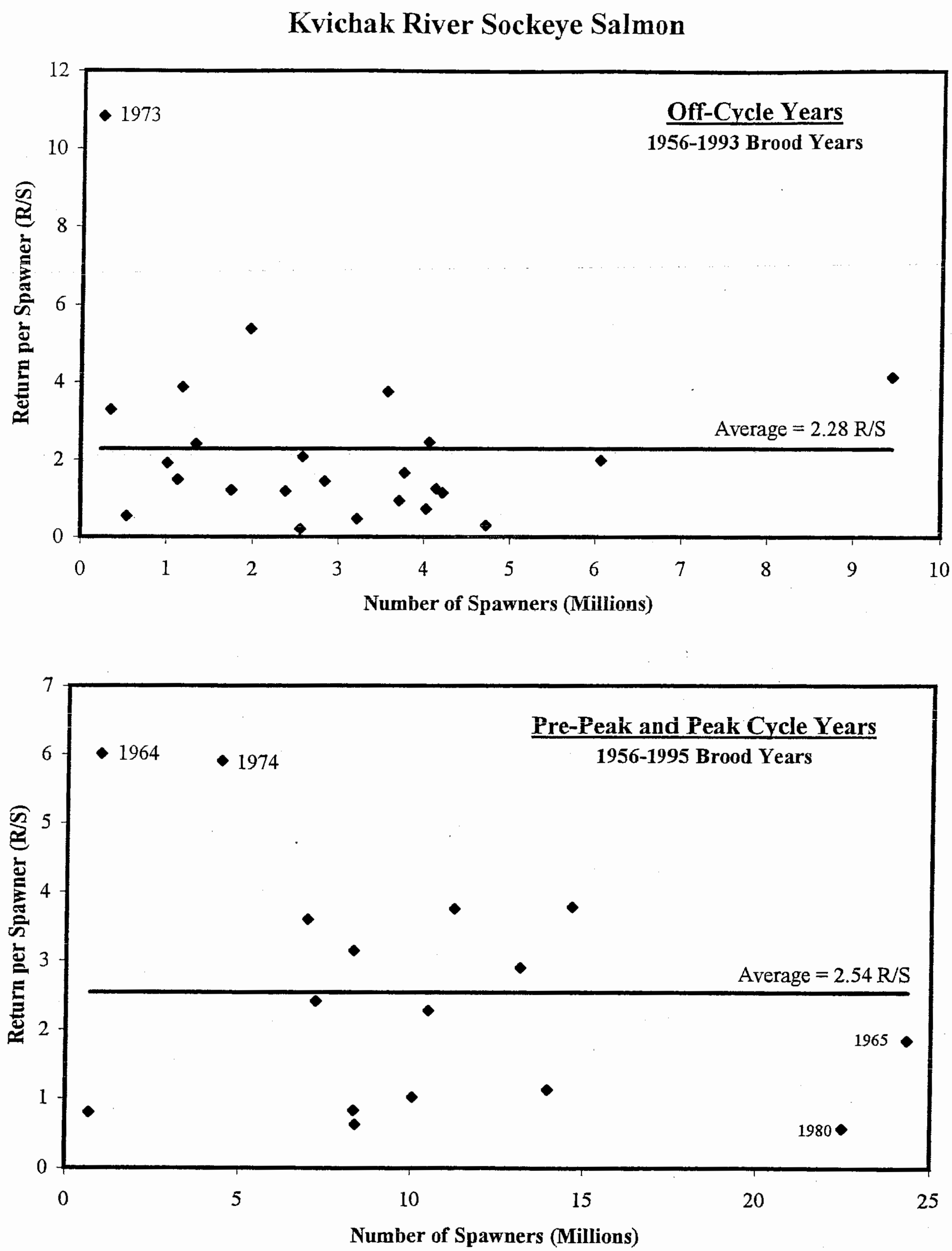


Figure 4. Return per spawner of Kvichak River sockeye salmon versus number of spawners for off-cycle, and pre-peak and peak cycle years (1956-1995 brood years).

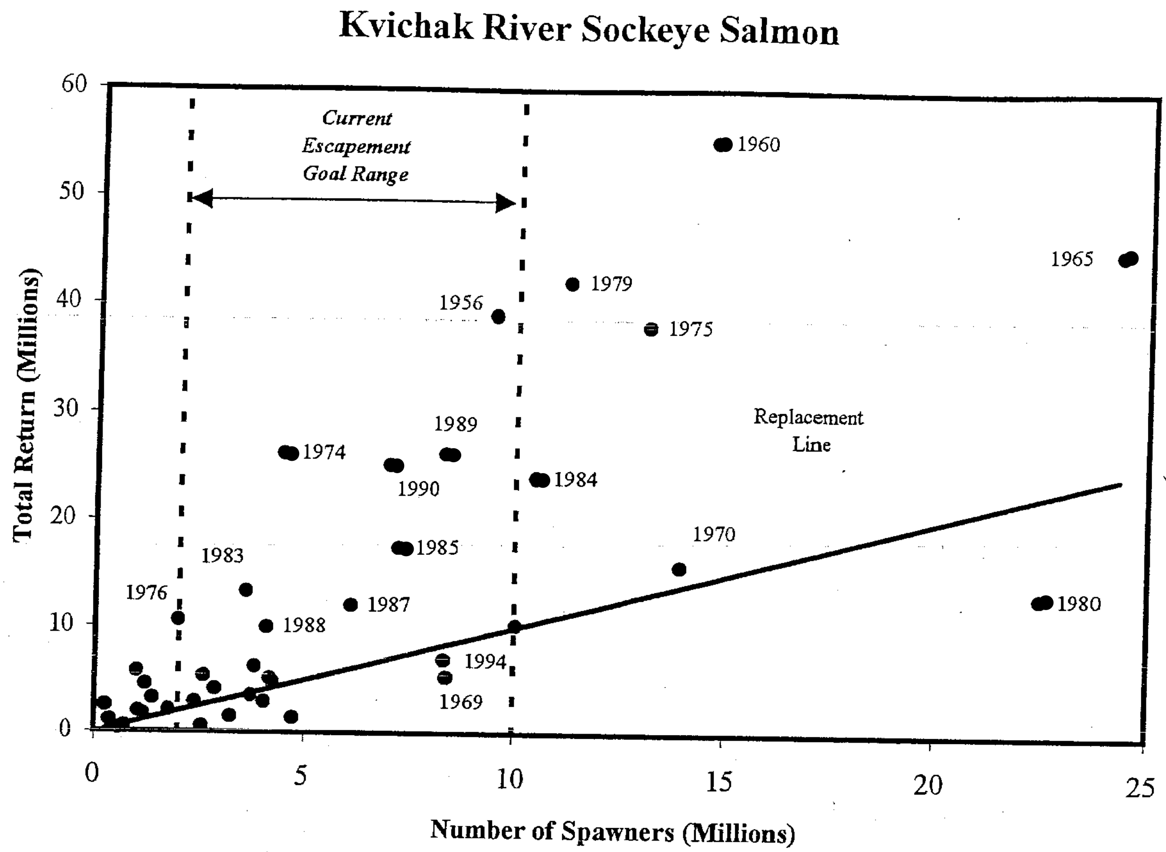


Figure 5. Total return of Kvichak River sockeye salmon versus number of spawners, 1956-1995 brood years.

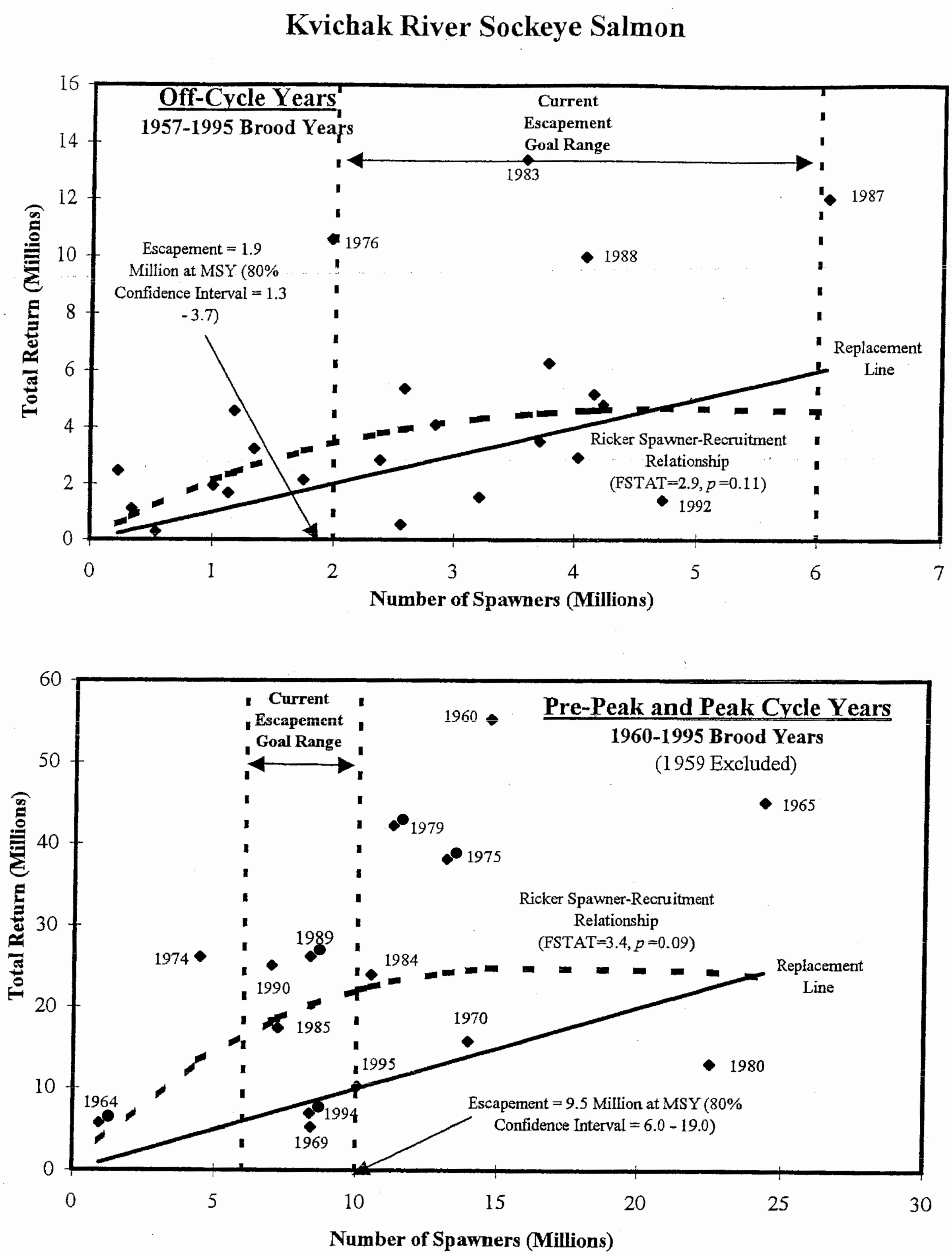


Figure 6. Ricker spawner-recrutiment relationship of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1995 brood years).

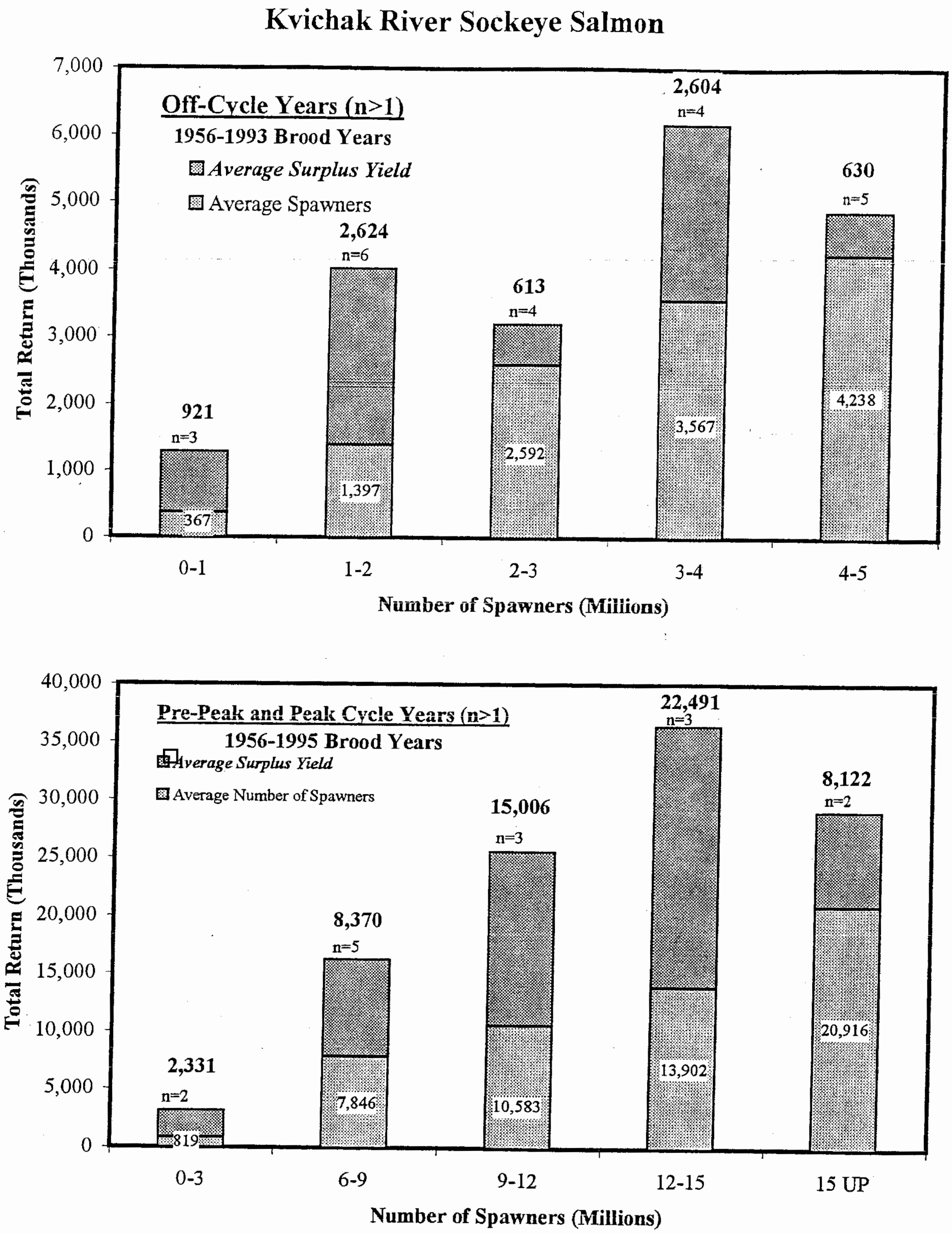


Figure 7. Average surplus yield categorized by number of spawners of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1995 brood years).

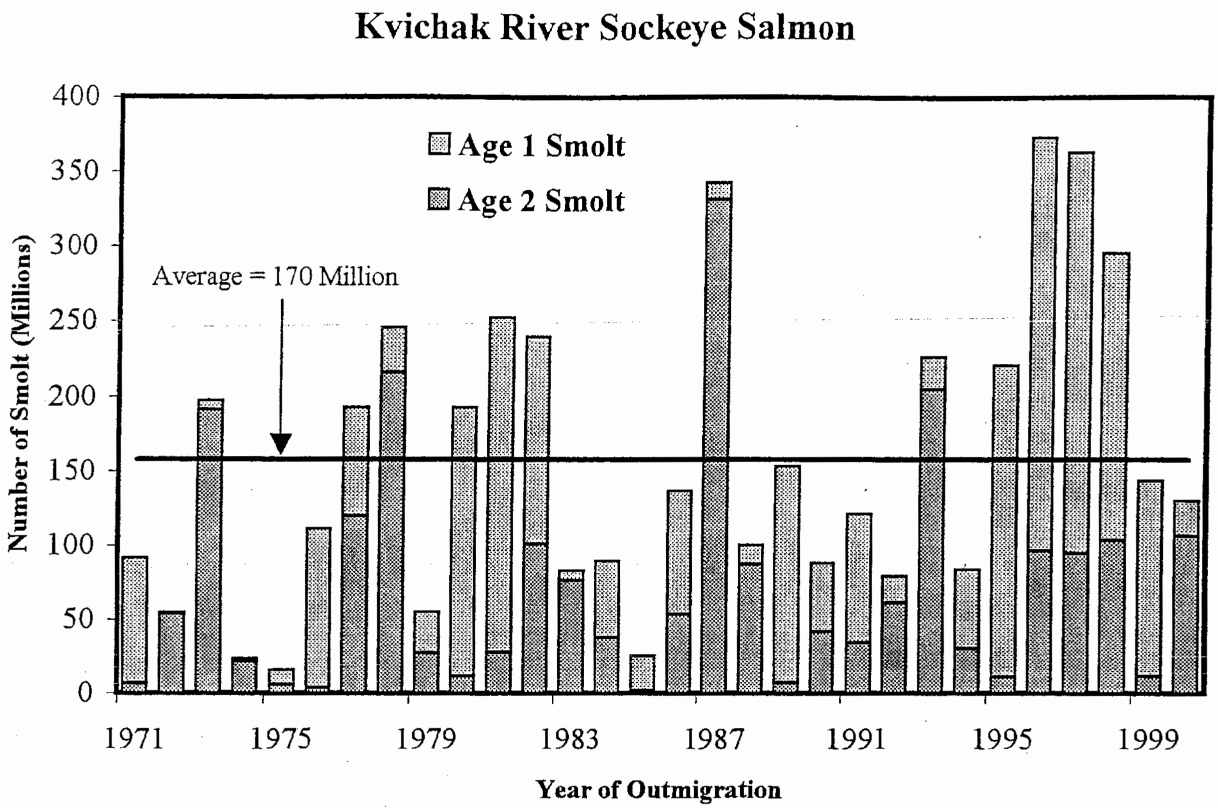


Figure 8. Number of sockeye salmon smolt migrating out of Kvichak River, 1971-2000.

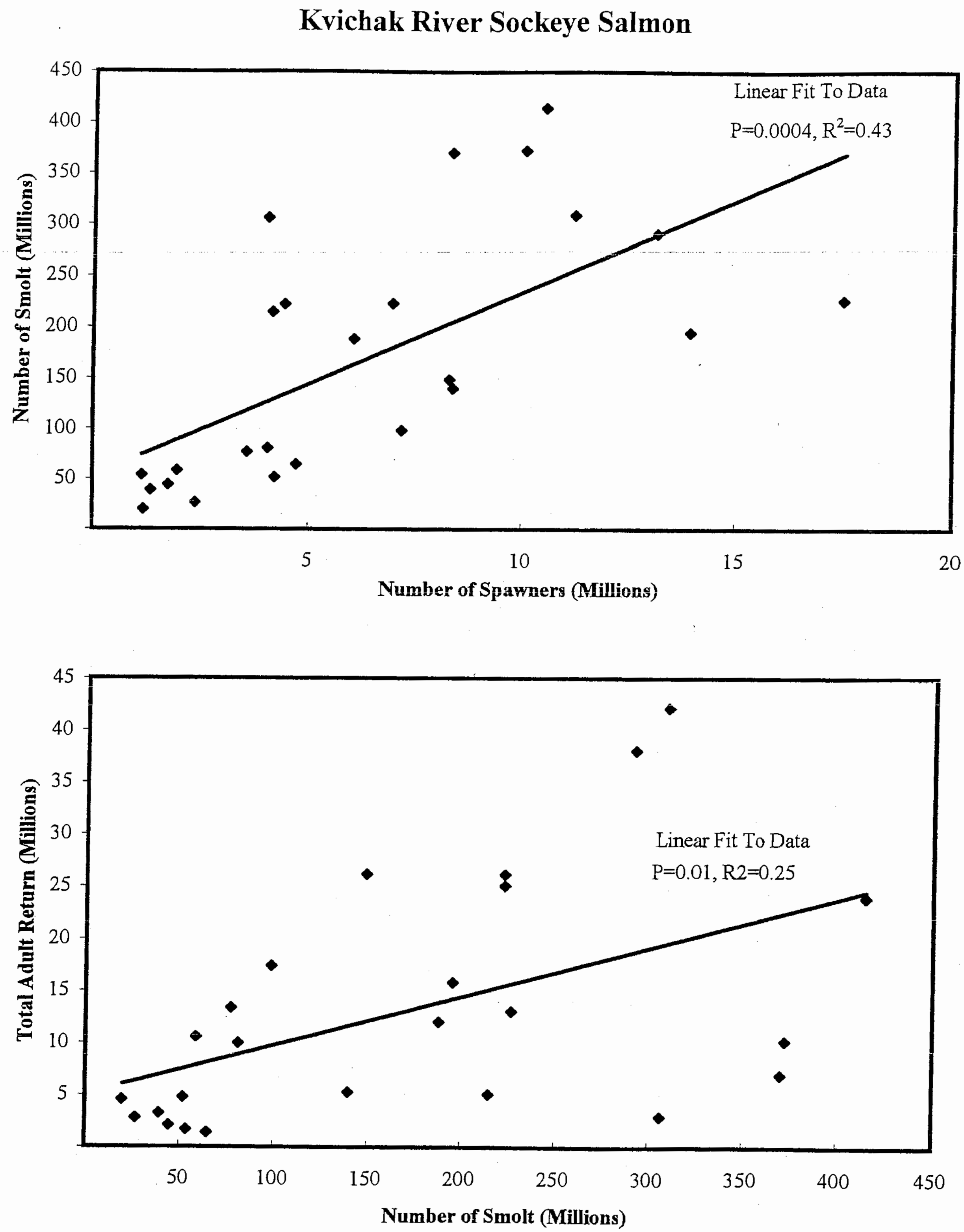


Figure 9. Number of spawners versus number of smolt, and number of smolt versus total adult return for Kvichak River sockeye salmon (1969-1995 brood years).

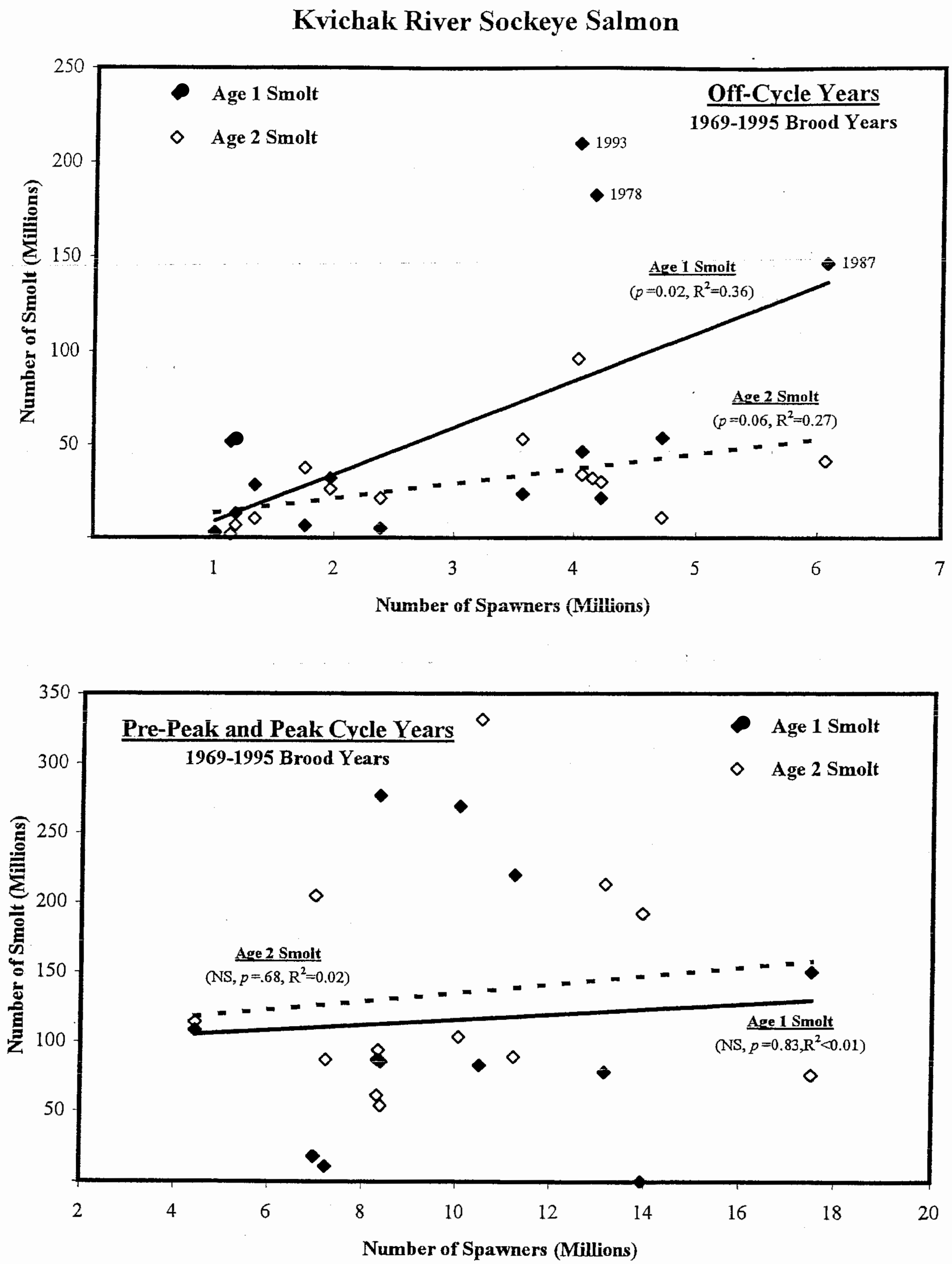


Figure 10. Number of spawners versus number of smolt of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1969-1995 brood years).

Kvichak River Sockeye Salmon

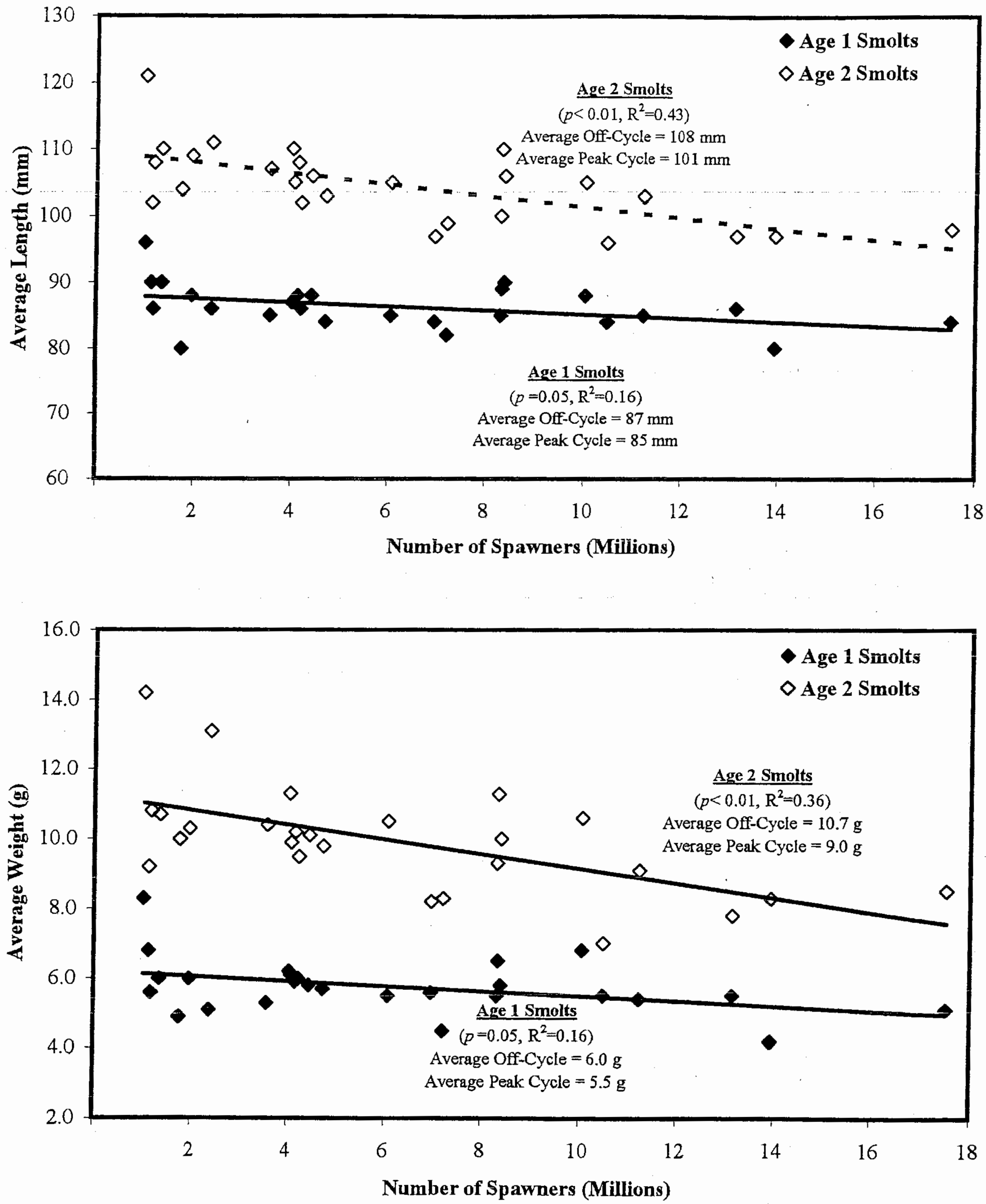


Figure 11. Average length and weight of age 1 and age 2 smolts versus number of spawners for Kvichak River sockeye salmon (1969-1995 brood years).

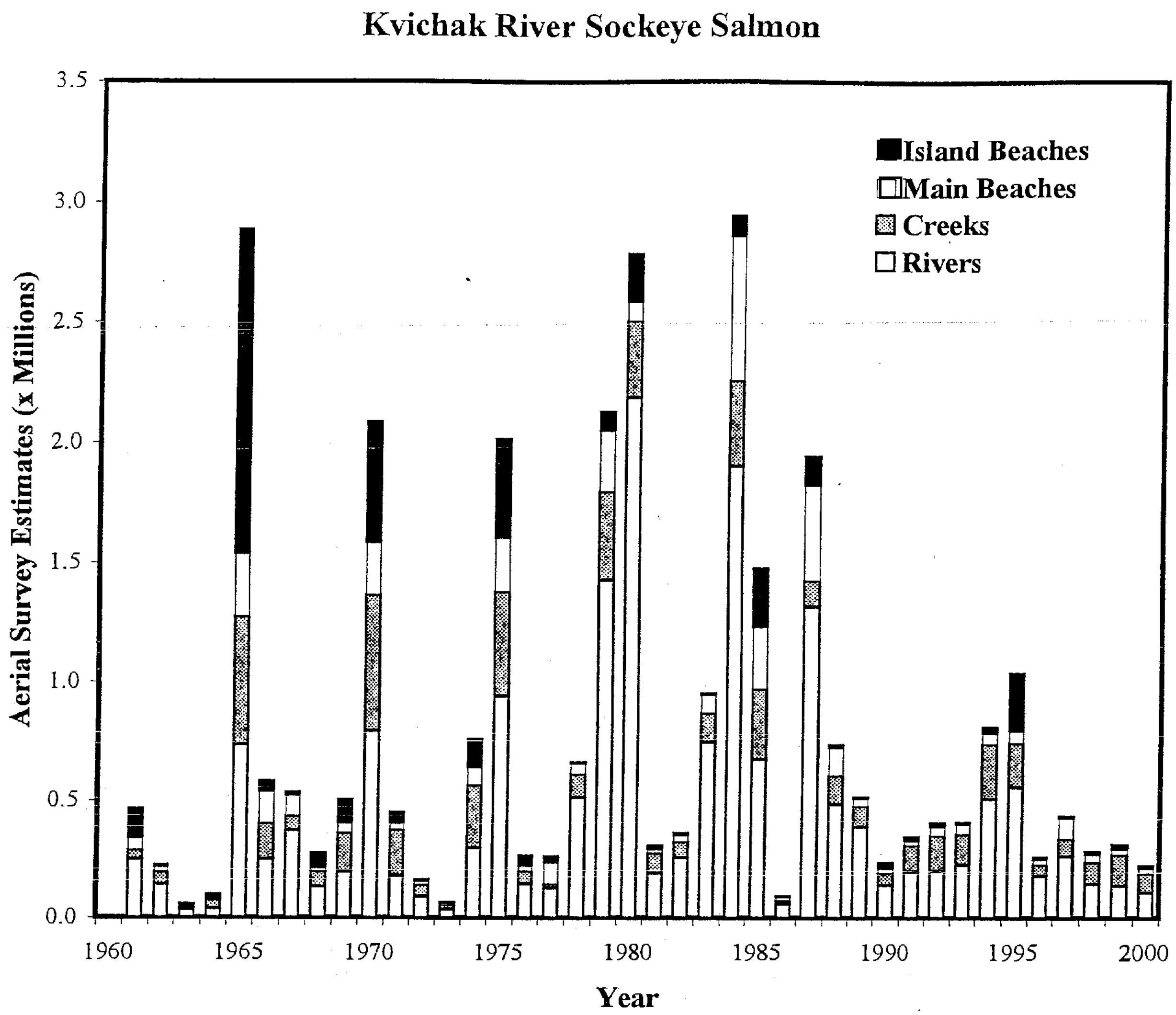


Figure 12. Spawner distribution of Kvichak River sockeye salmon at main beaches, island beaches, rivers and creeks, 1961-2000.

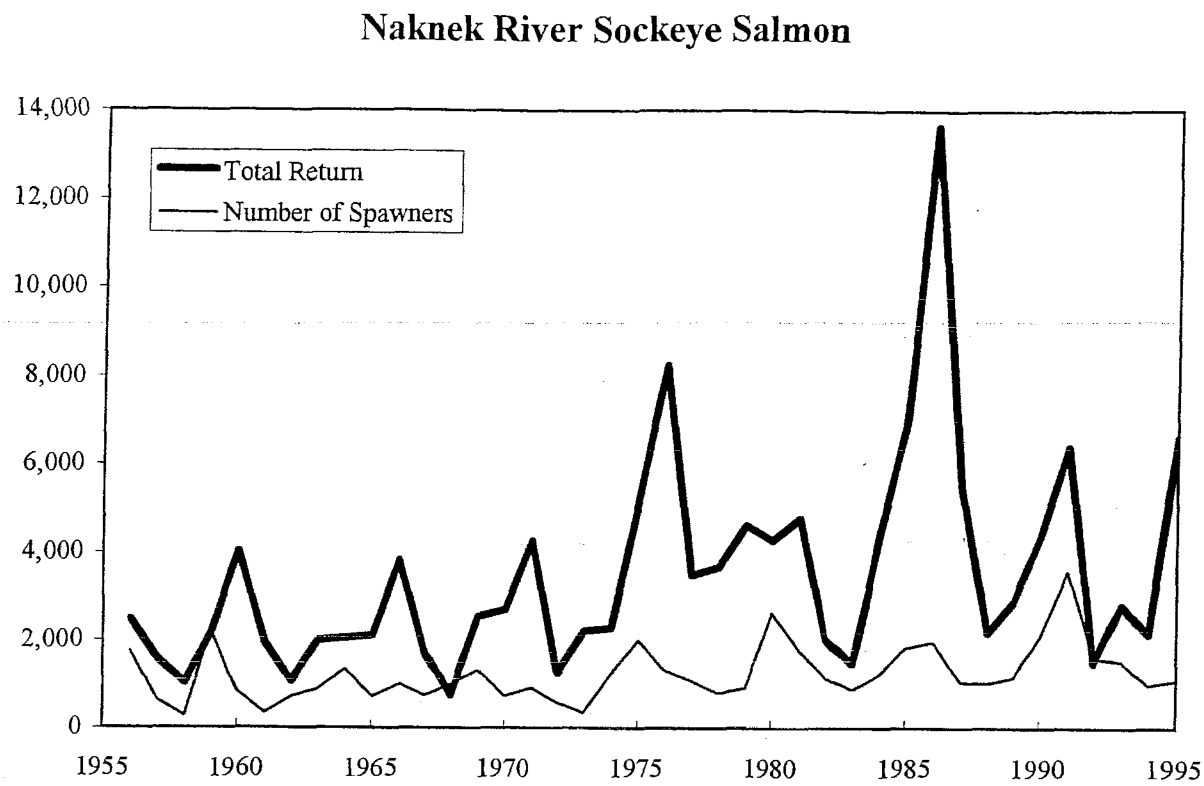


Figure 13. Number of spawners and total return of Naknek River sockeye salmon by brood year, 1956 - 1995.

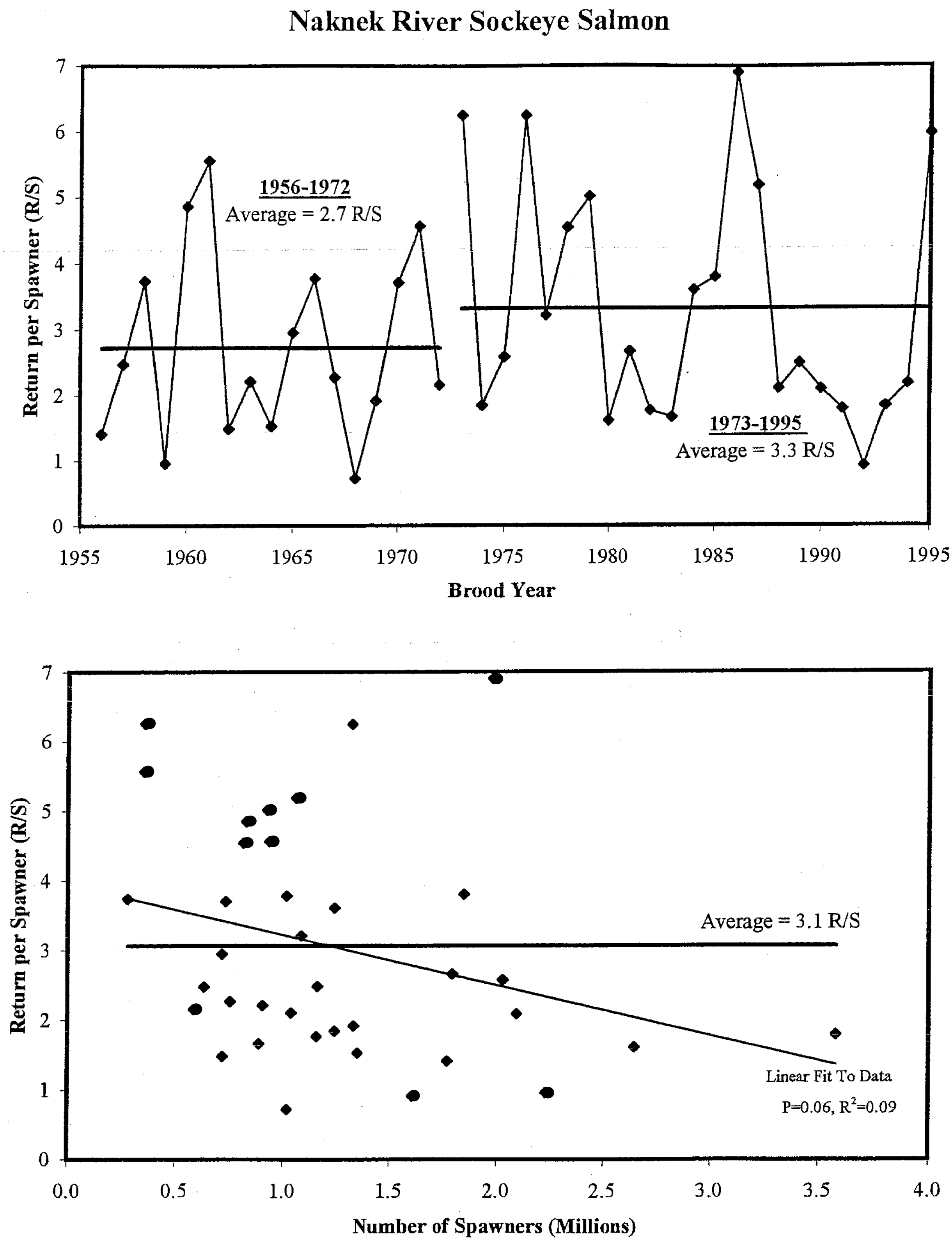


Figure 14. Return per spawner of Naknek River sockeye salmon by brood year, 1956-1995, and number of spawners.

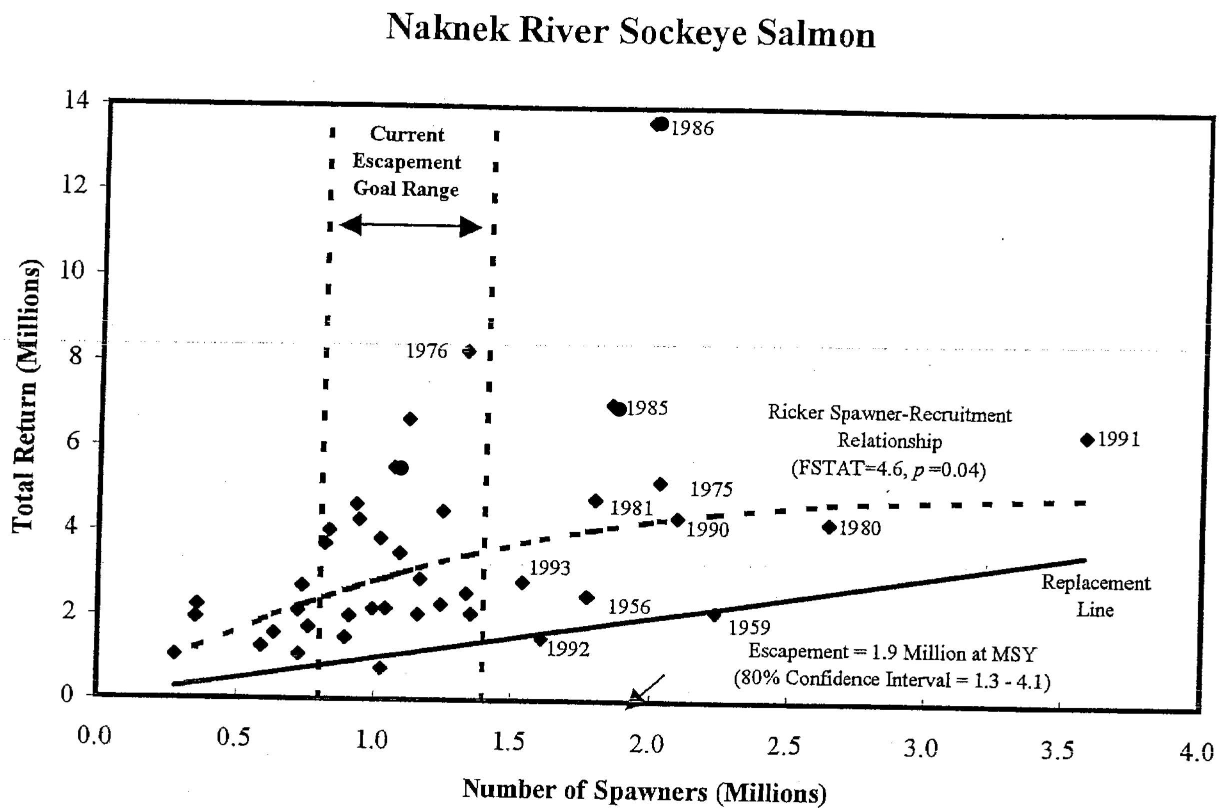


Figure 15. Ricker spawner-recruitment relationship of Naknek River sockeye salmon, 1956-1995.

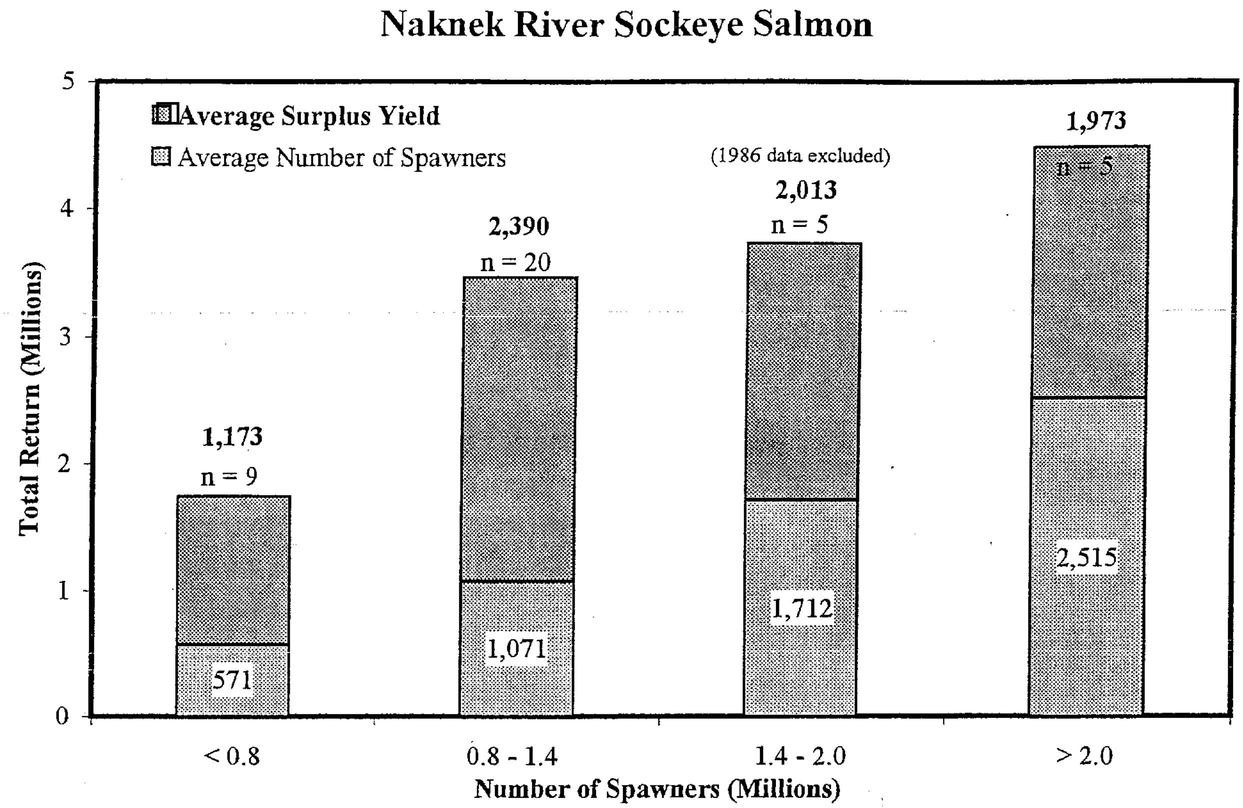


Figure 16. Average surplus yield categorized by the number of spawners of Naknek River sockeye salmon, 1956-1995 brood years.

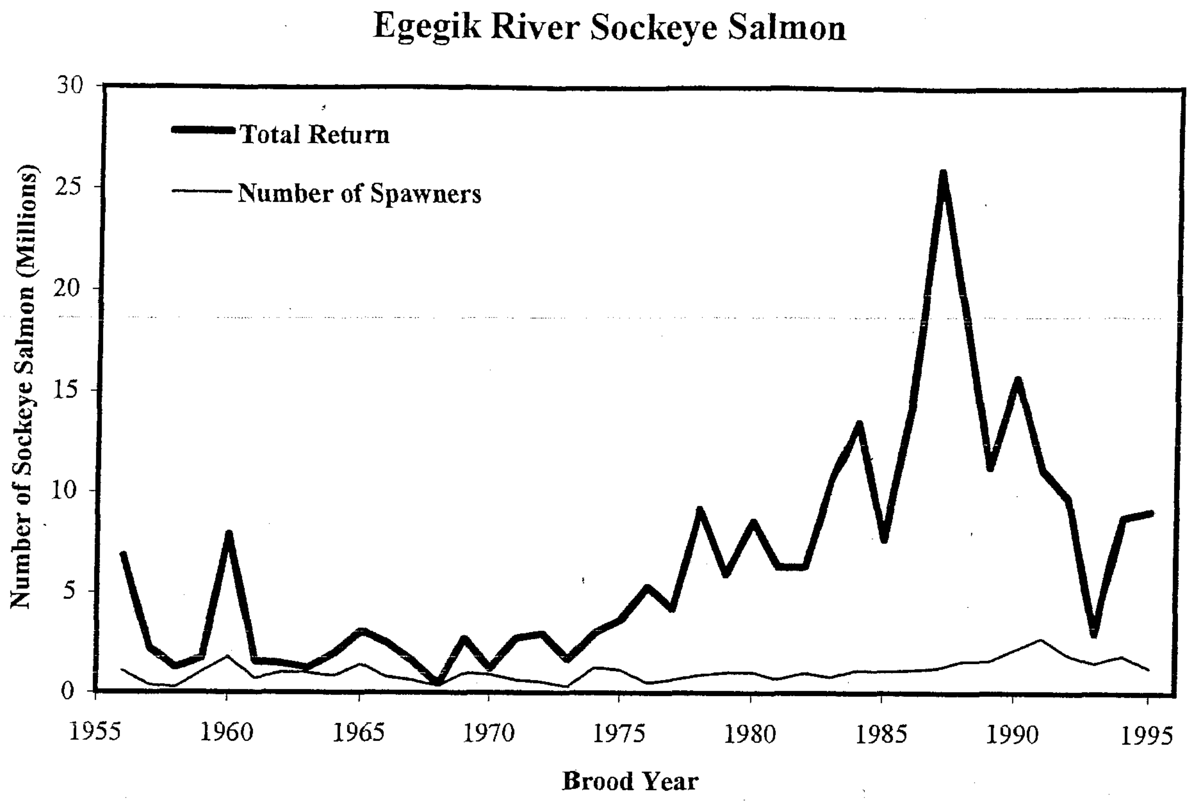
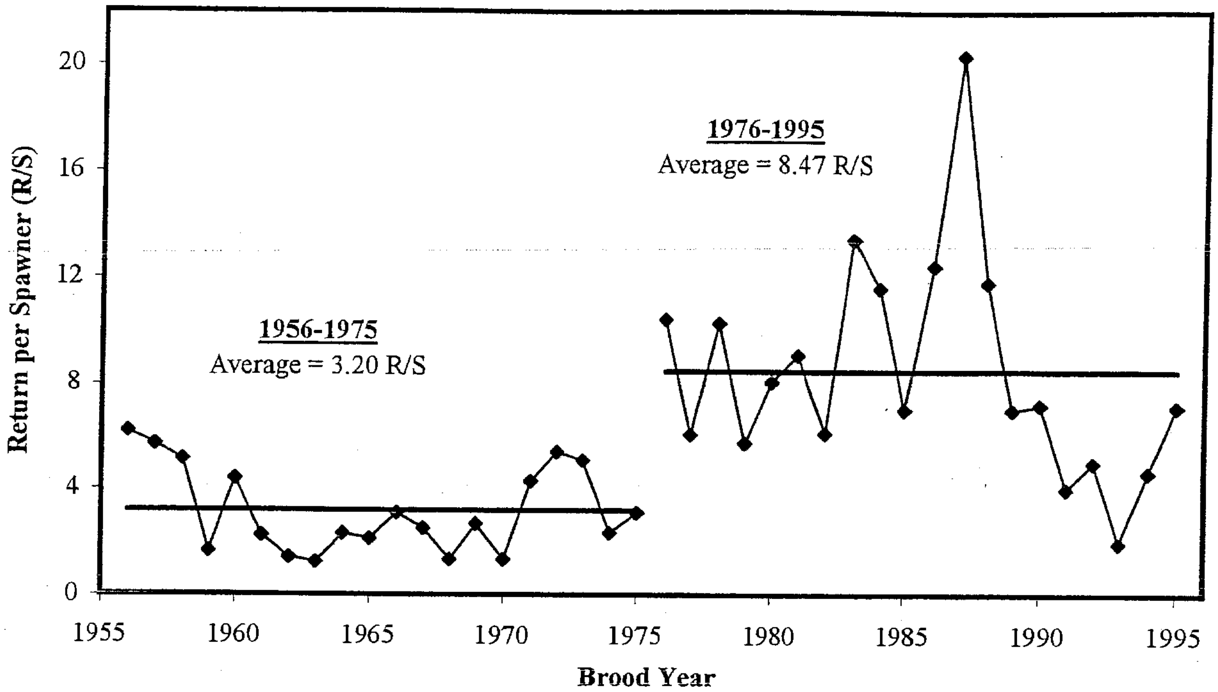


Figure 17. Number of spawners and total return of Egegik River sockeye salmon by brood year, 1956 - 1995.

Egegik River Sockeye Salmon



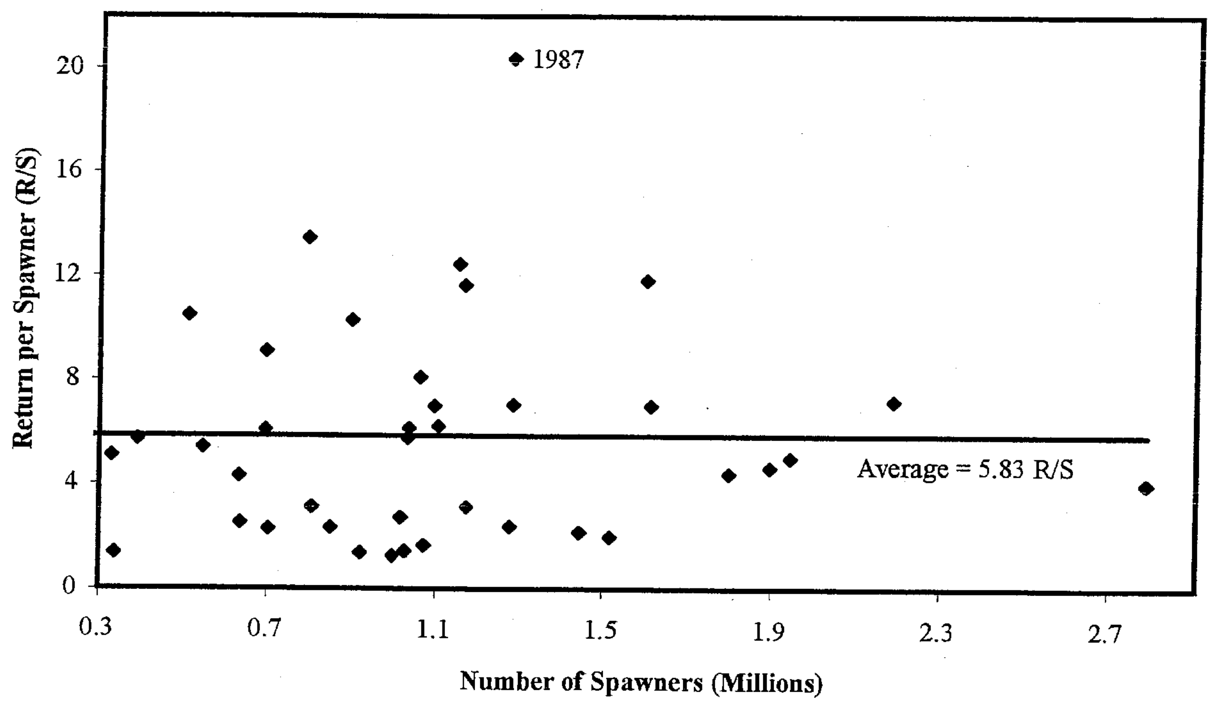


Figure 18. Return per spawner of Egegik River sockeye salmon by brood year, 1956-1995, and number of spawners.

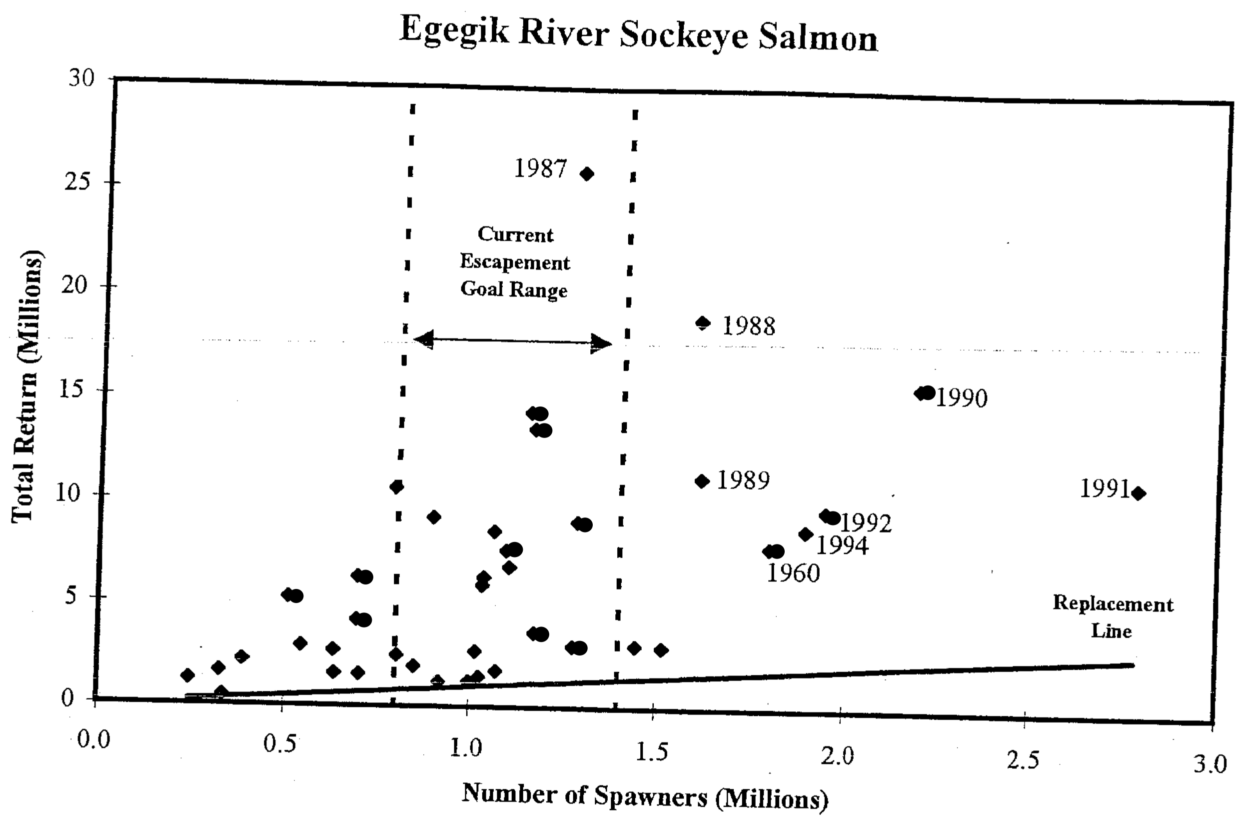


Figure 19. Total return of Egegik River sockeye salmon versus number of spawners, 1956-1995 brood years.

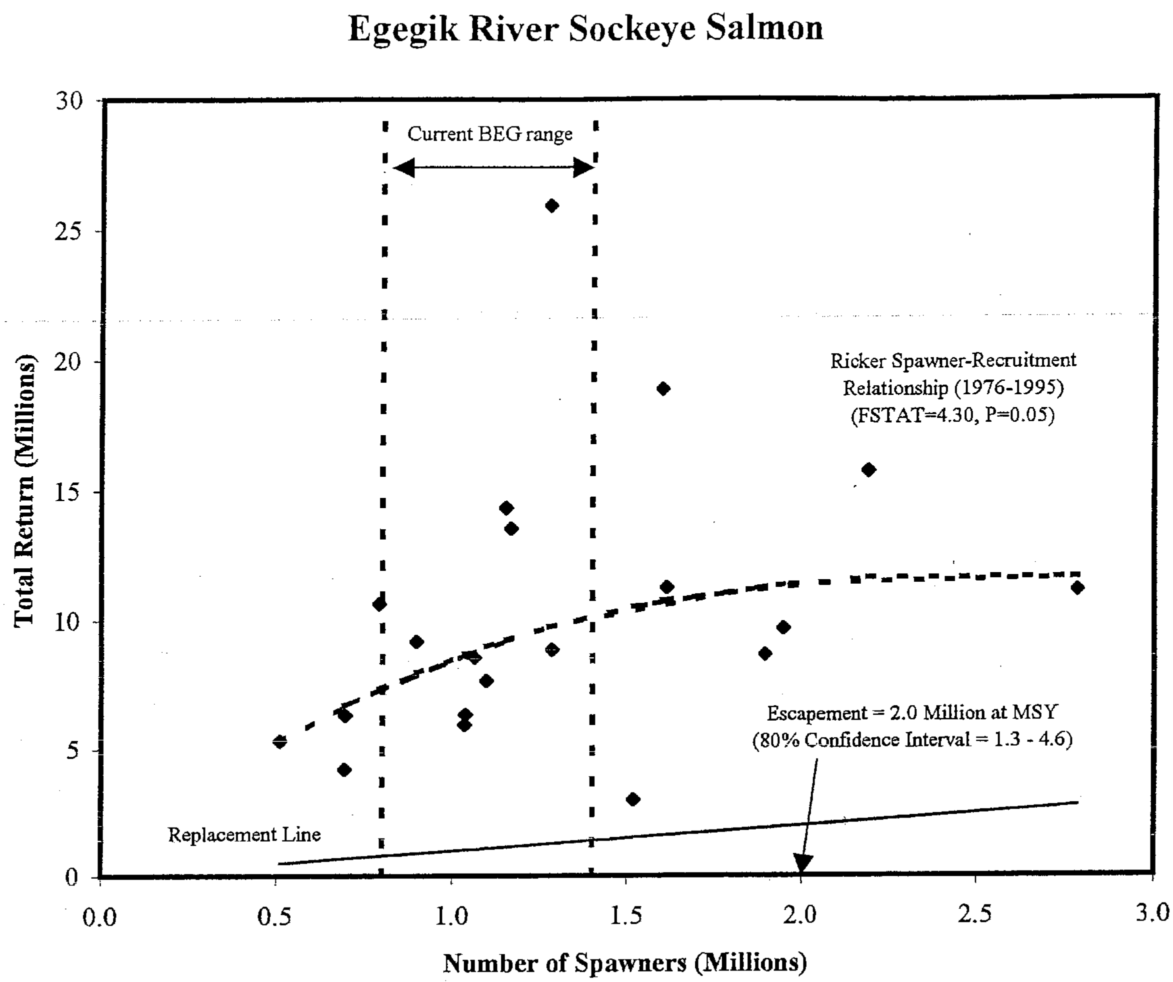


Figure 20. Ricker spawner-recruitment relationship of Egegik River sockeye salmon, 1976-1995.

Egegik River Sockeye Salmon

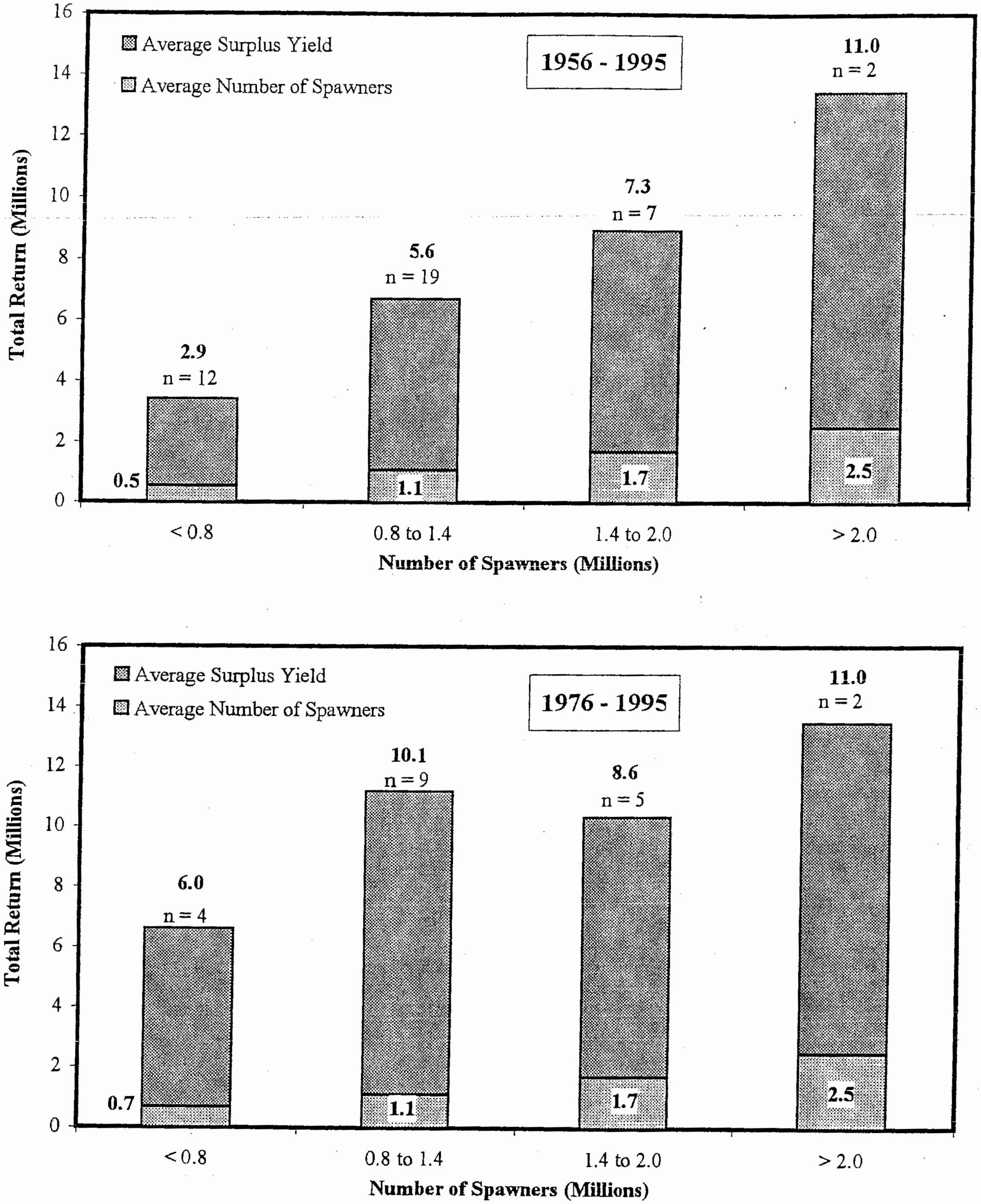


Figure 21. Average surplus yield categorized by the number of spawners of Egegik River sockeye salmon, 1956-1995 and 1976-1995 brood years.

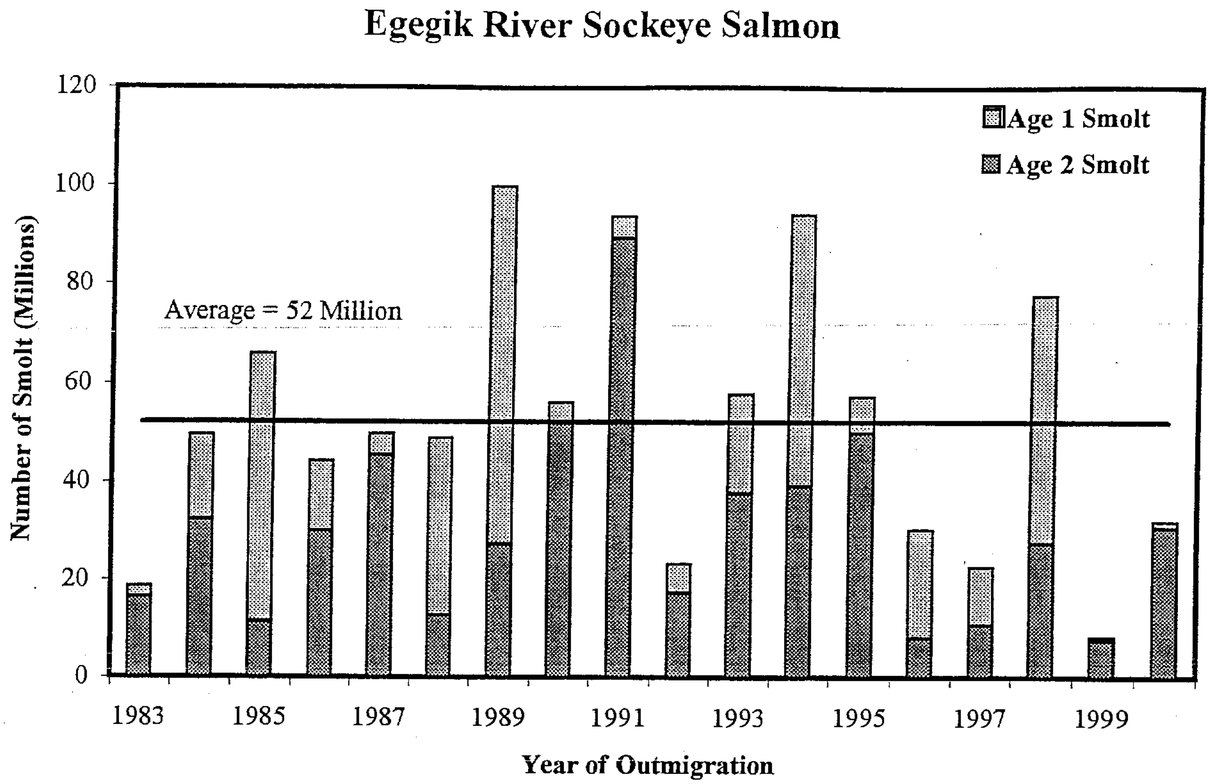
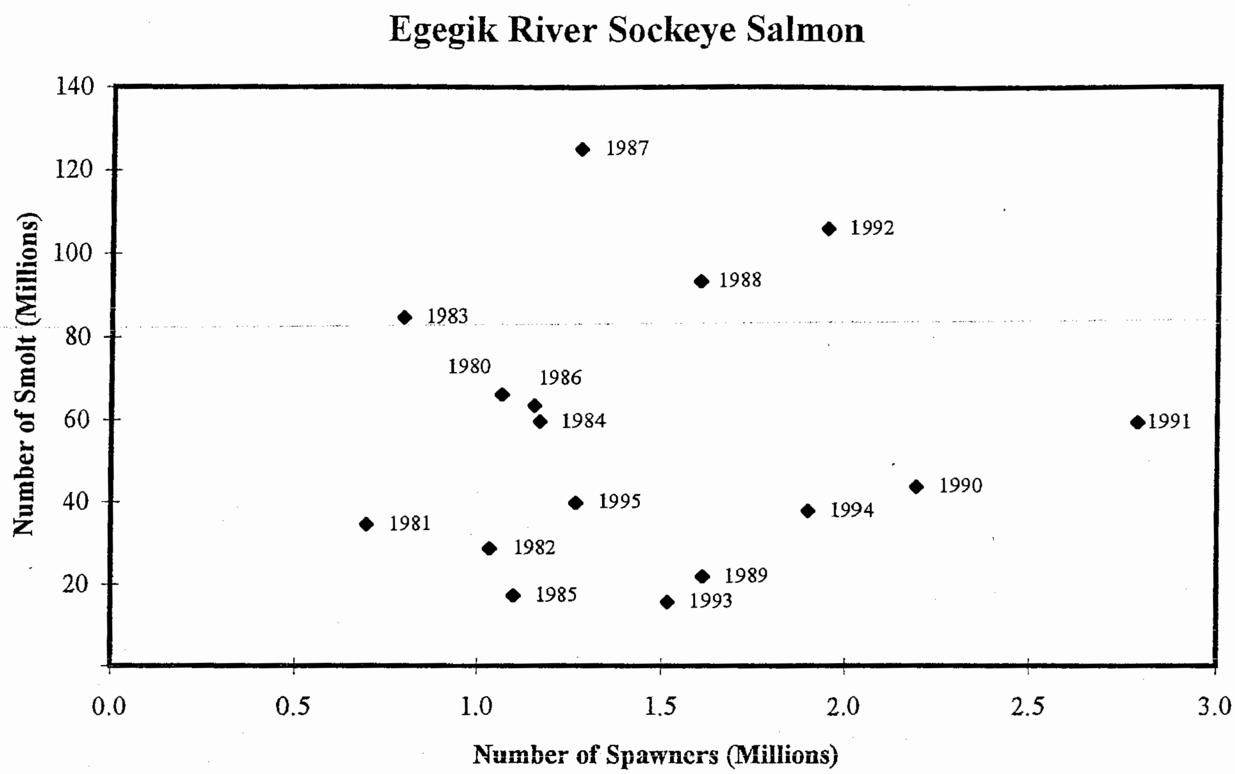


Figure 22. Number of sockeye salmon smolt migrating out of the Egegik River, 1983-2000.



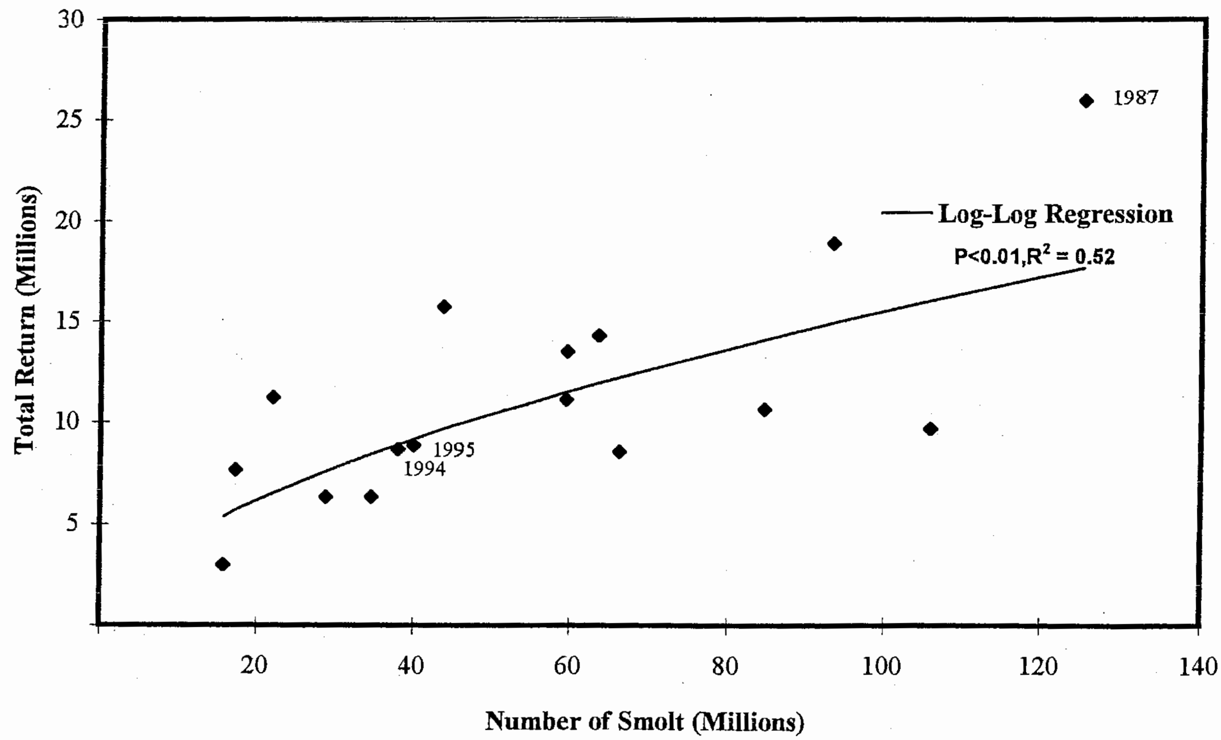


Figure 23. Number of spawners versus number of smolt, and number of smolt versus total return of Egegik River sockeye salmon, 1980-1995 brood years.

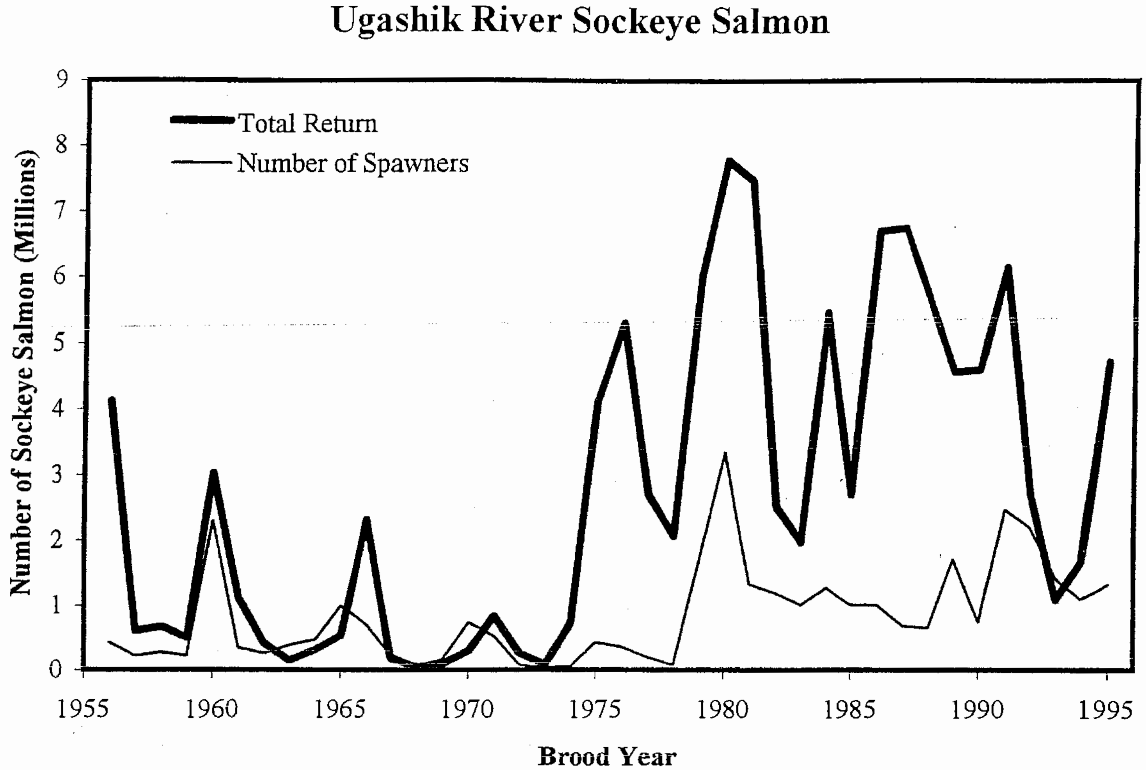
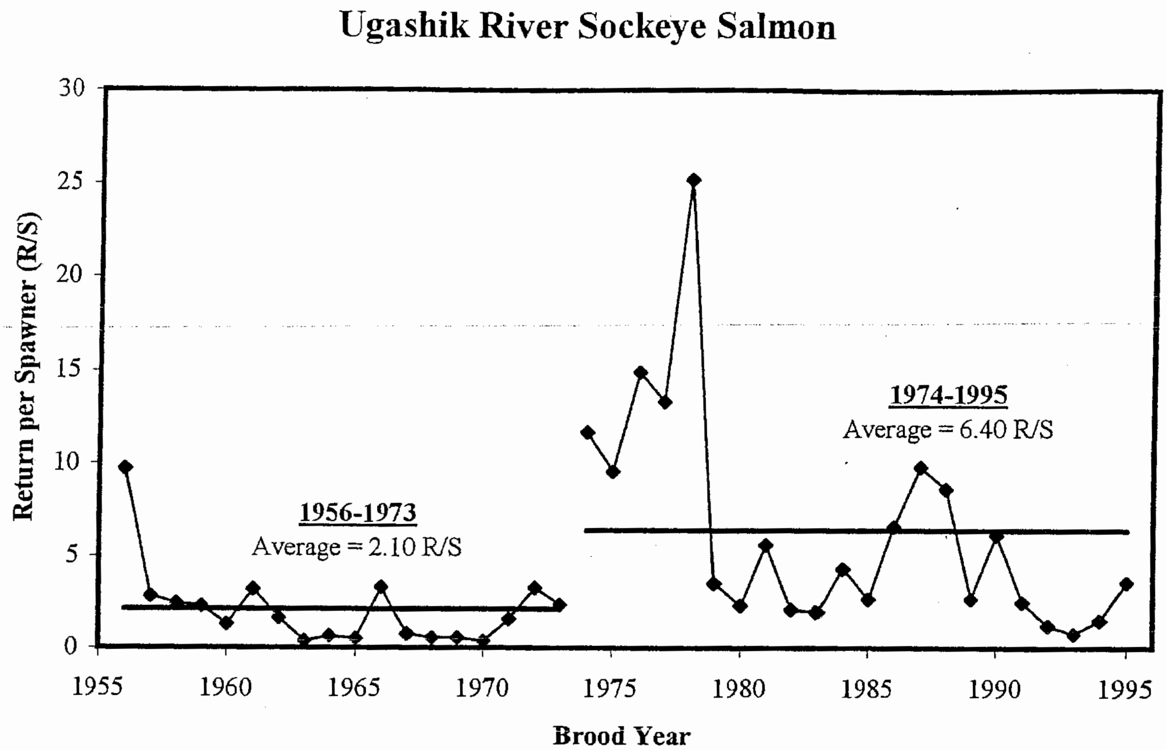


Figure 24. Number of spawners and total return of Ugashik River sockeye salmon by brood year, 1956 - 1995.



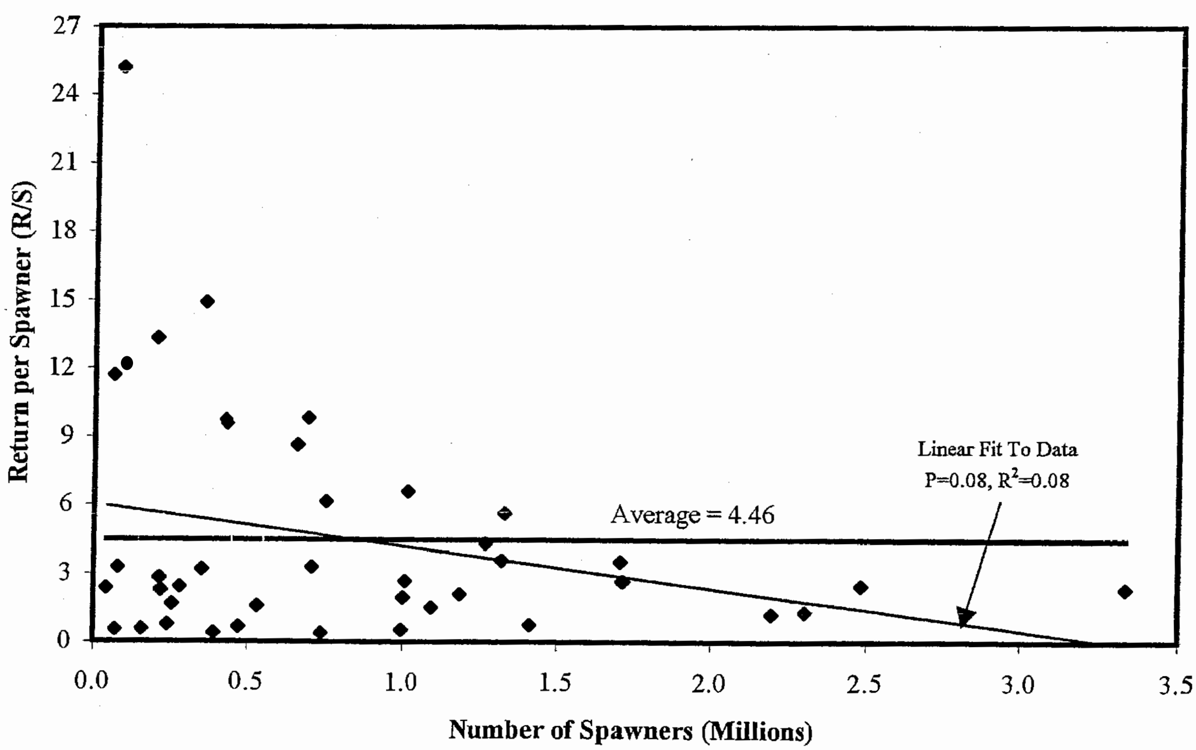


Figure 25. Return per spawner of Ugashik River sockeye salmon by brood year, 1956-1995, and number of spawners.

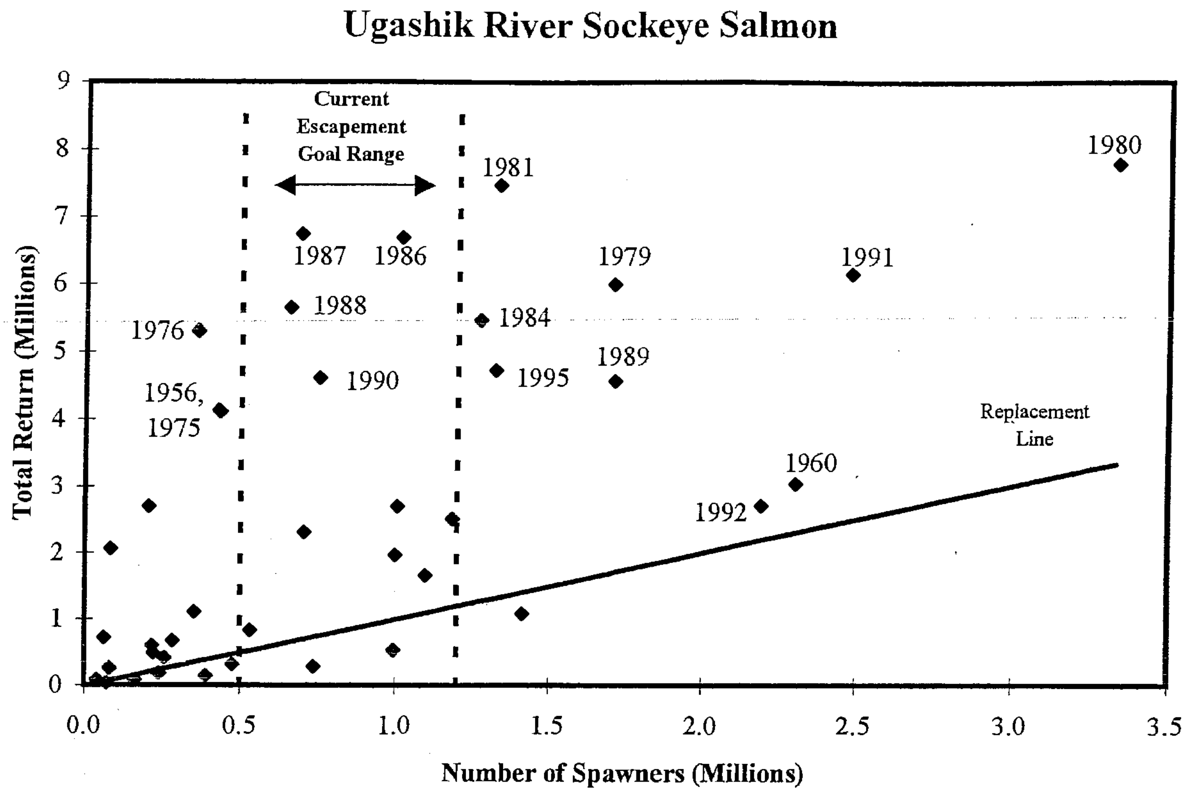


Figure 26. Total return of Ugashik River sockeye salmon versus number of spawners, 1956-1995 brood years.

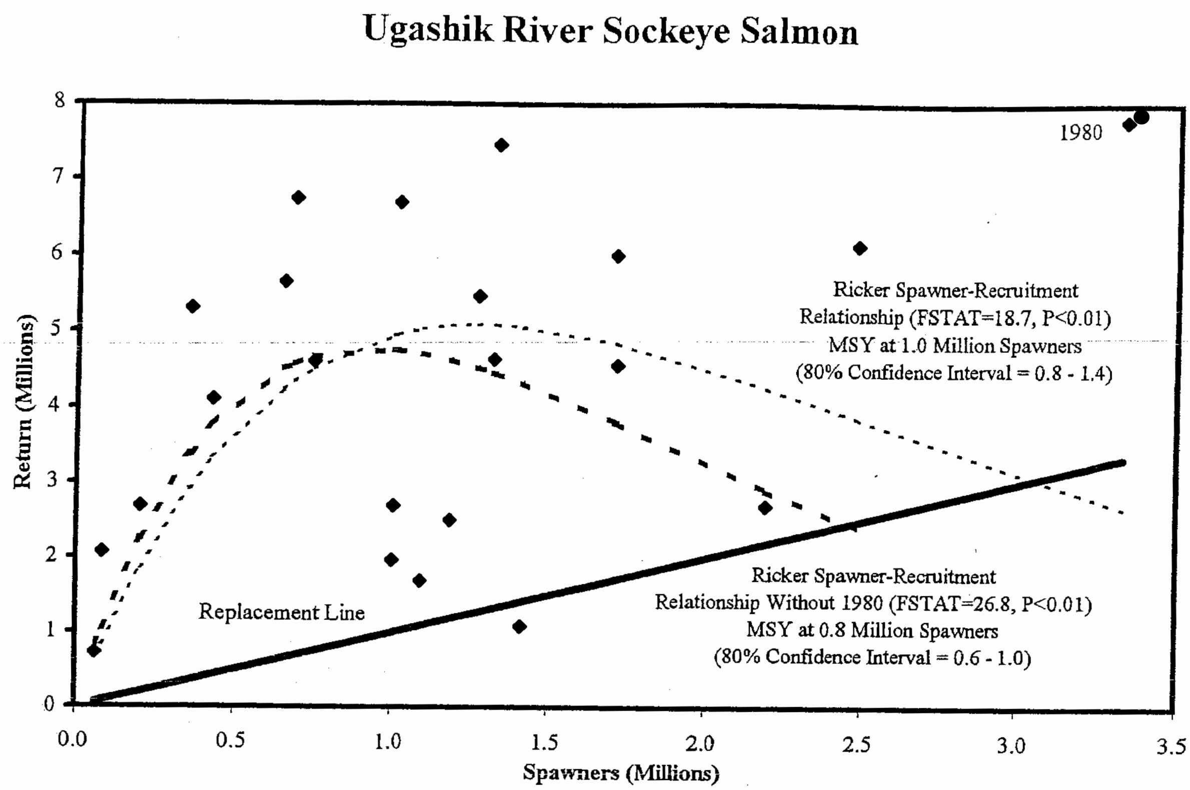


Figure 27. Ricker spawner-recruitment relationship of Ugashik River sockeye salmon, 1974-1995.

Ugashik River Sockeye Salmon

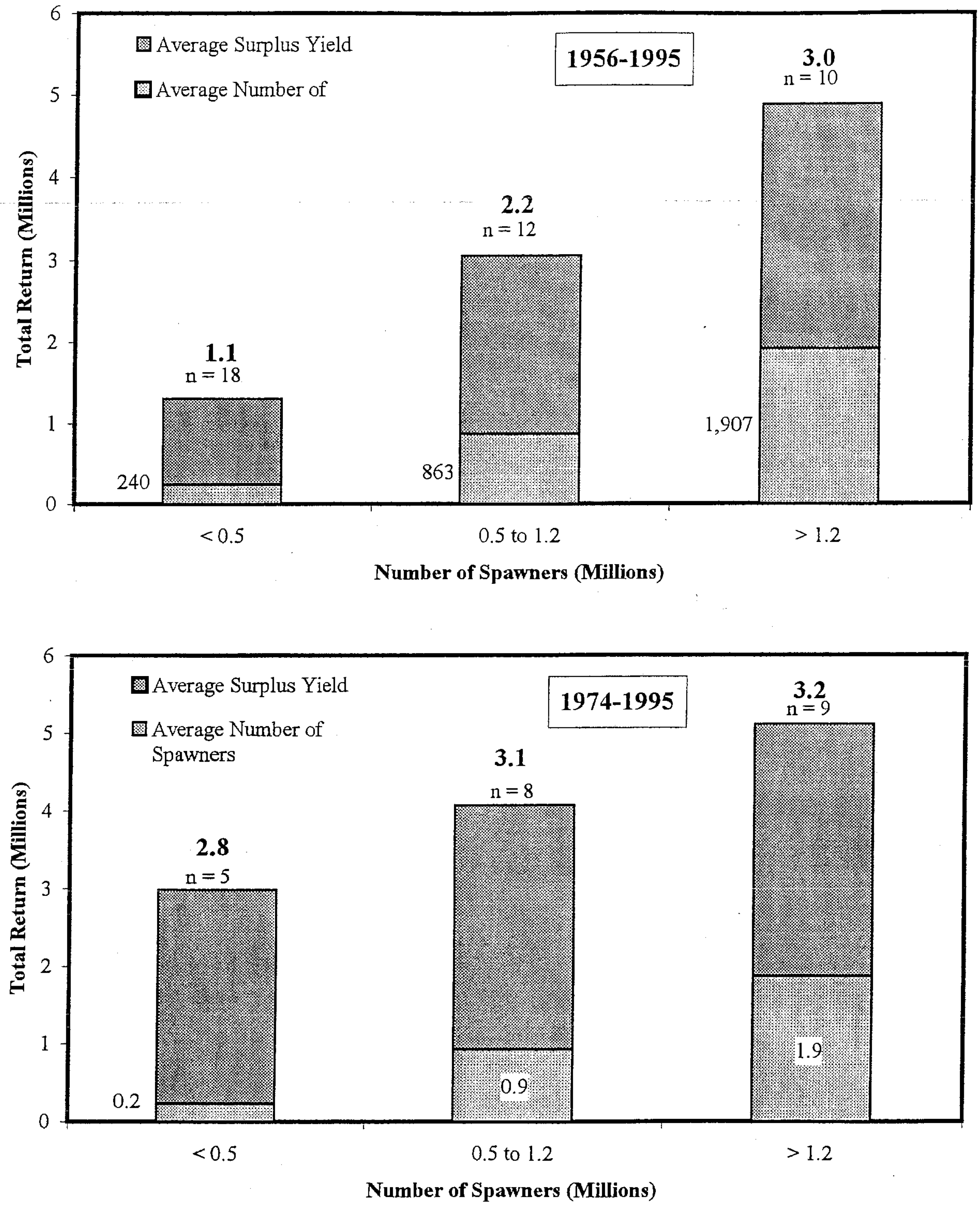


Figure 28. Average surplus yield categorized by the number of spawners of Ugashik River sockeye salmon, 1956-1995 brood years.

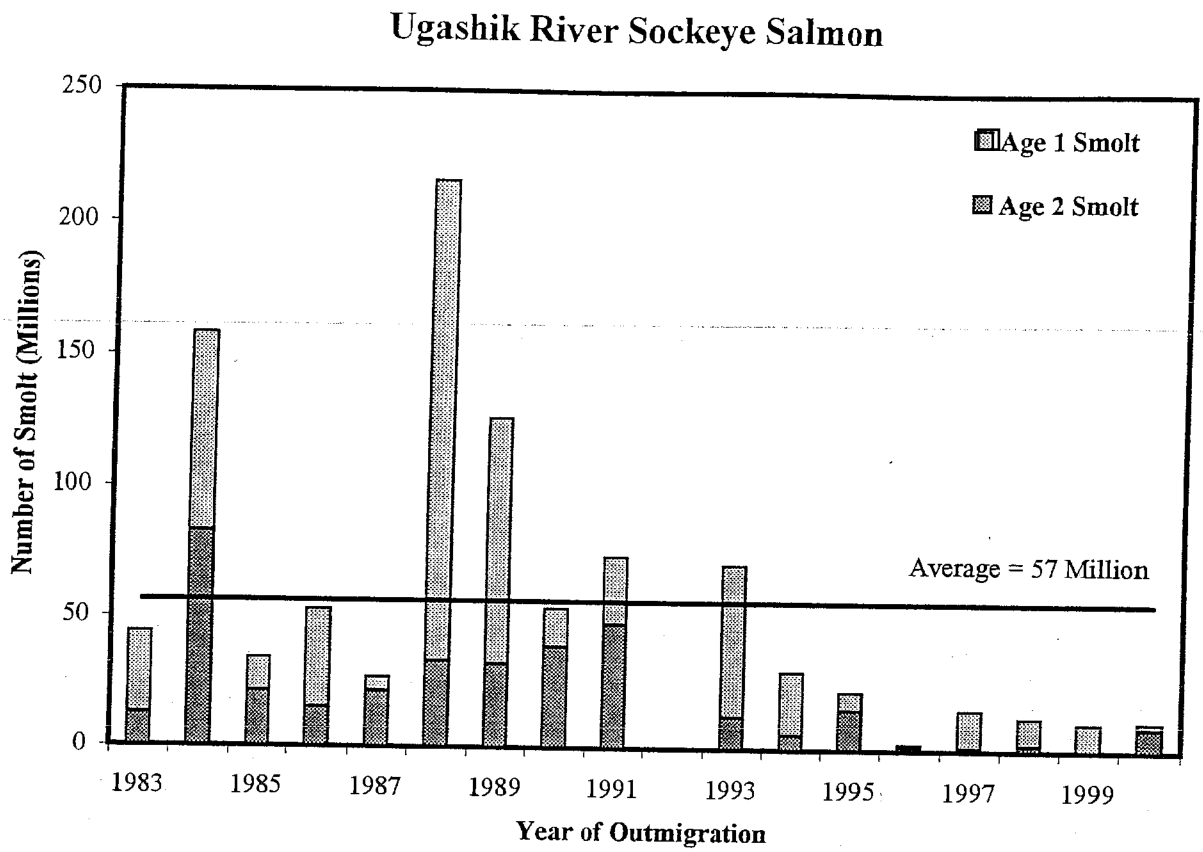


Figure 29. Number of sockeye salmon smolt migrating out of the Ugashik River, 1983-2000.

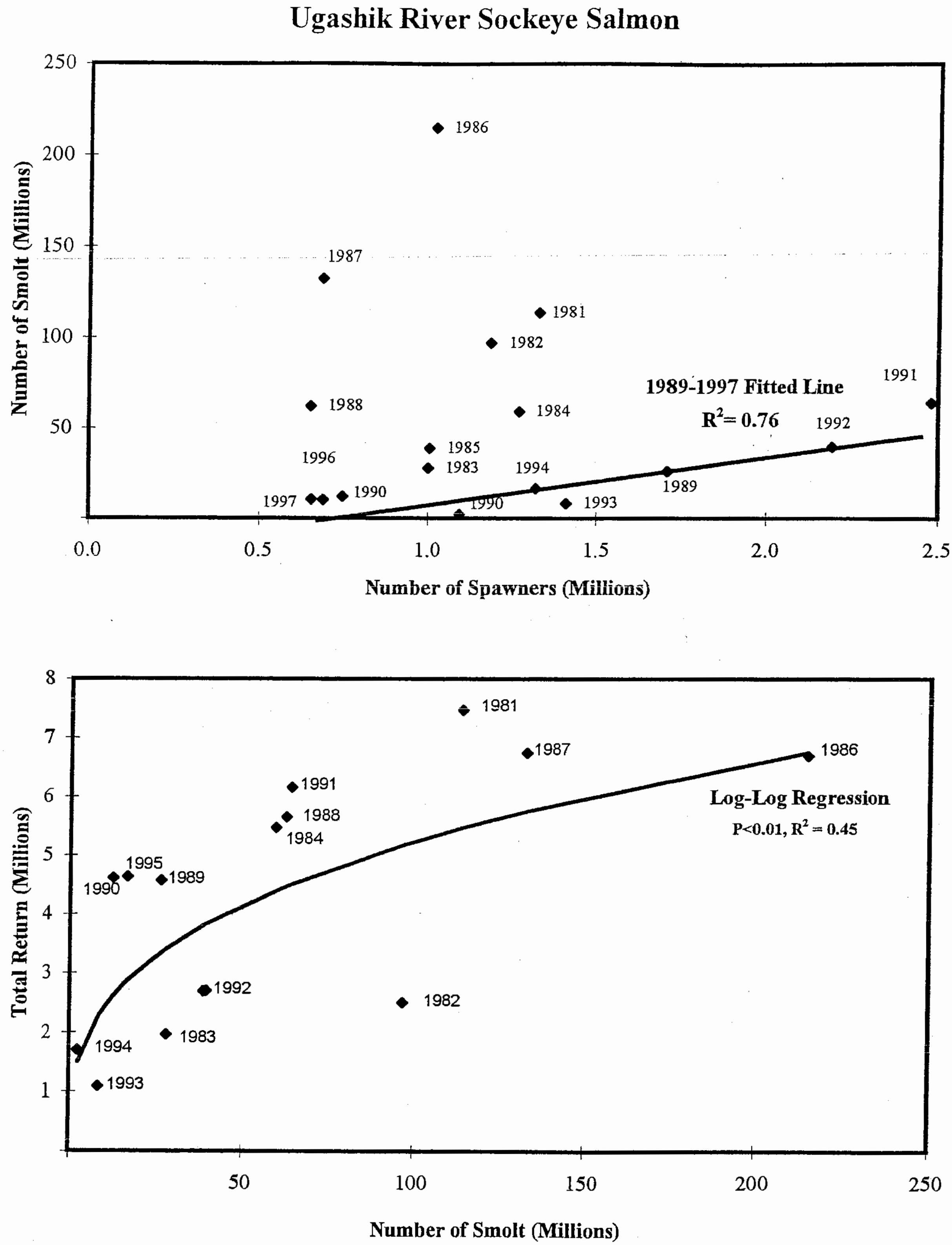


Figure 30. Number of spawners versus number of smolt, and number of smolt versus total return of Ugashik River sockeye salmon, 1981-1997 brood years.

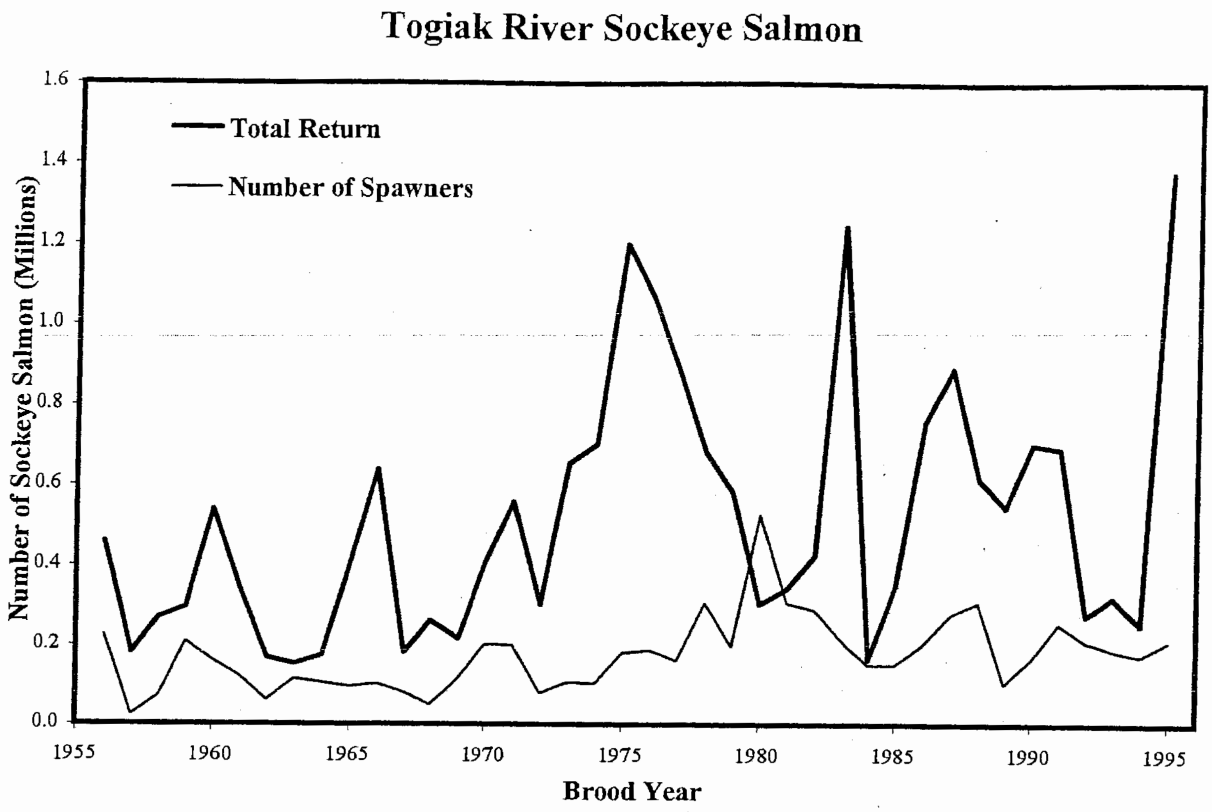


Figure 31. Number of spawners and total return of Togiak River sockeye salmon by brood year, 1956 - 1995.

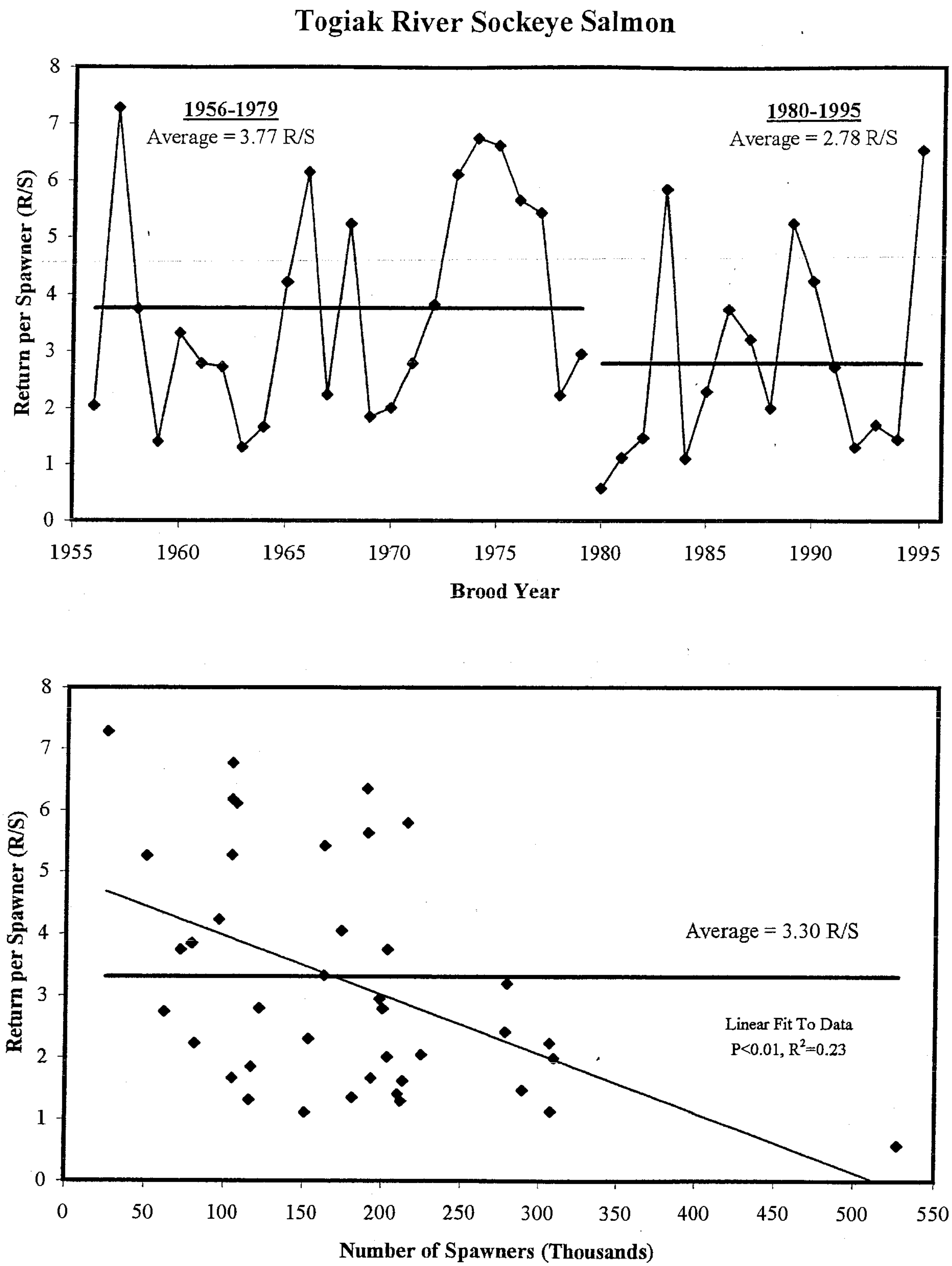


Figure 32. Return per spawner of Togiak River sockeye salmon by brood year, 1956-1995, and number of spawners.

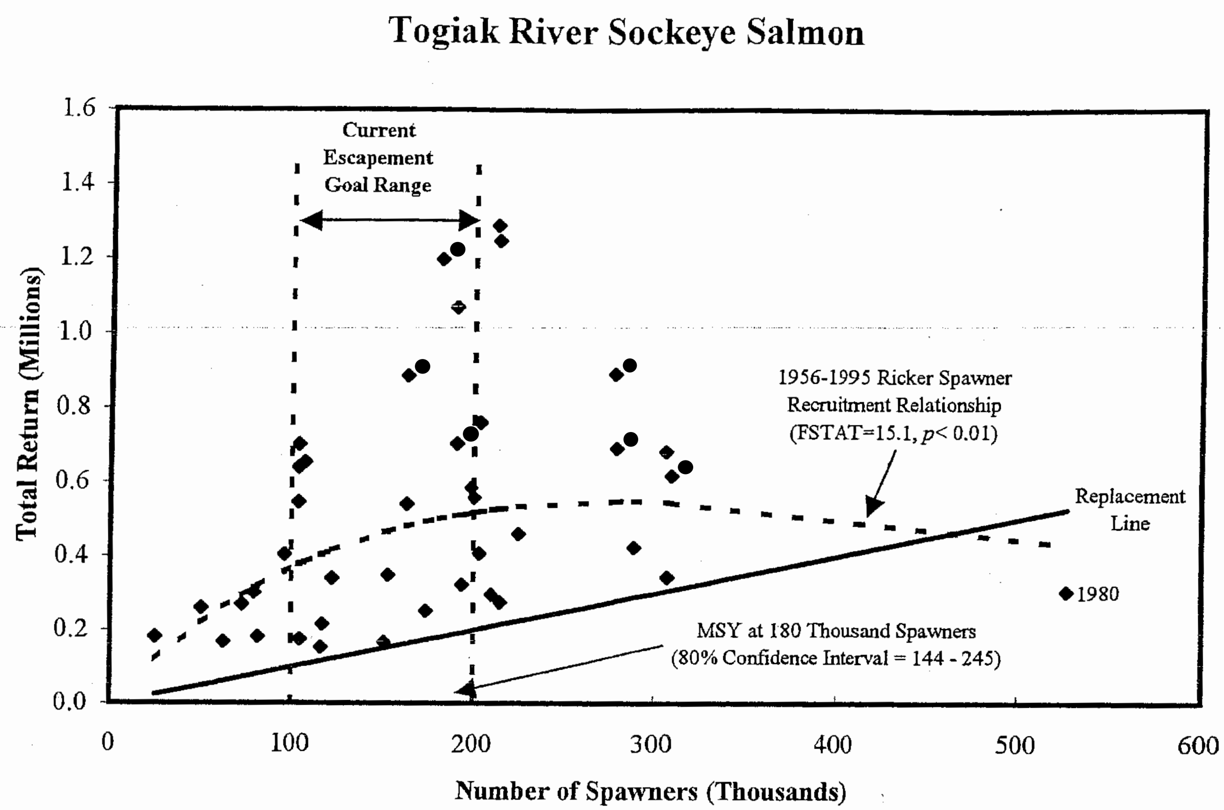


Figure 33. Ricker spawner-recruitment relationship of Togiak River sockeye salmon, 1956-1995 brood years.

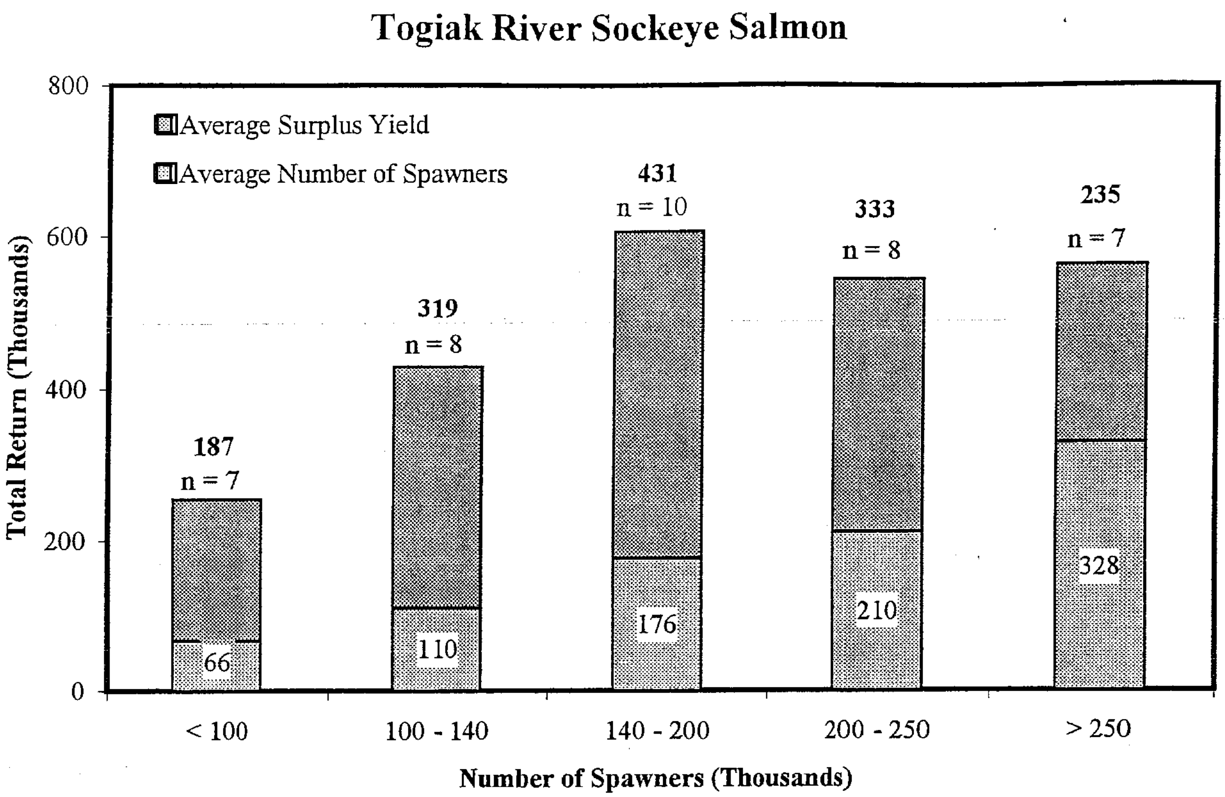


Figure 34. Average surplus yield categorized by the number of spawners of Togiak River sockeye salmon, 1956-1995 brood years.

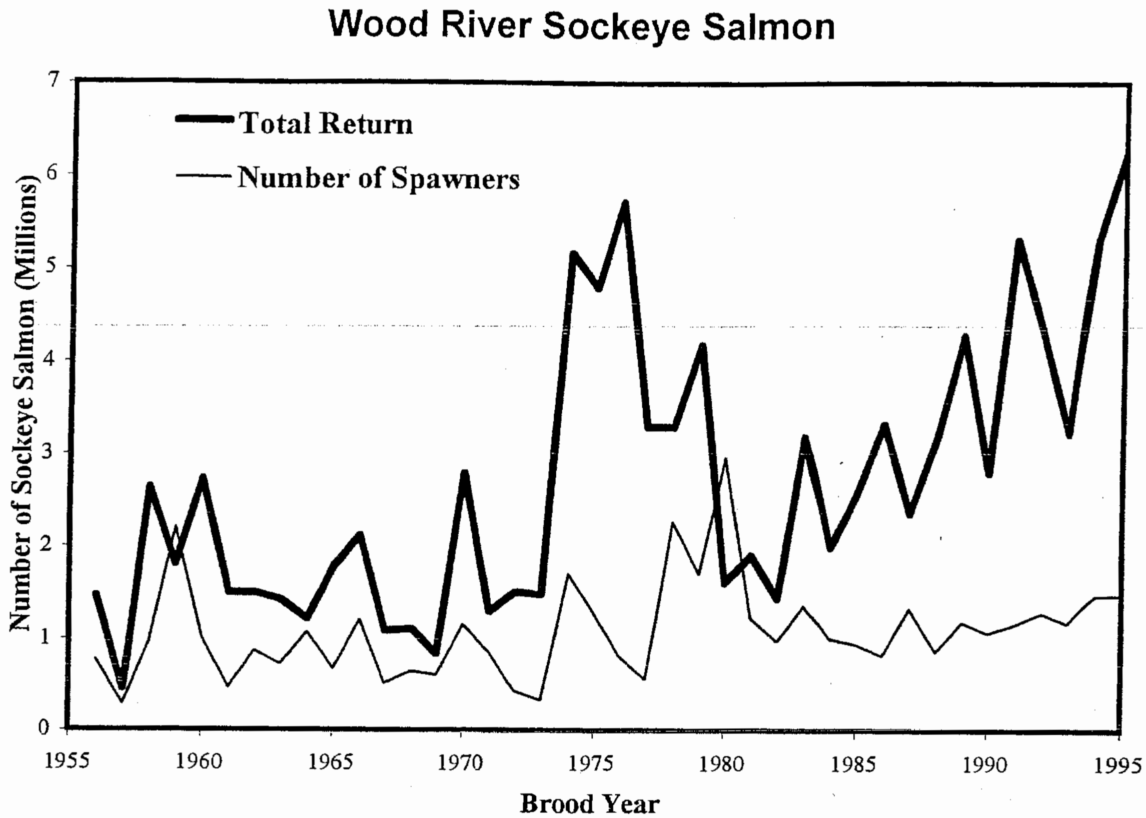


Figure 35. Number of spawners and total return of Wood River sockeye salmon by brood year, 1956 - 1995.

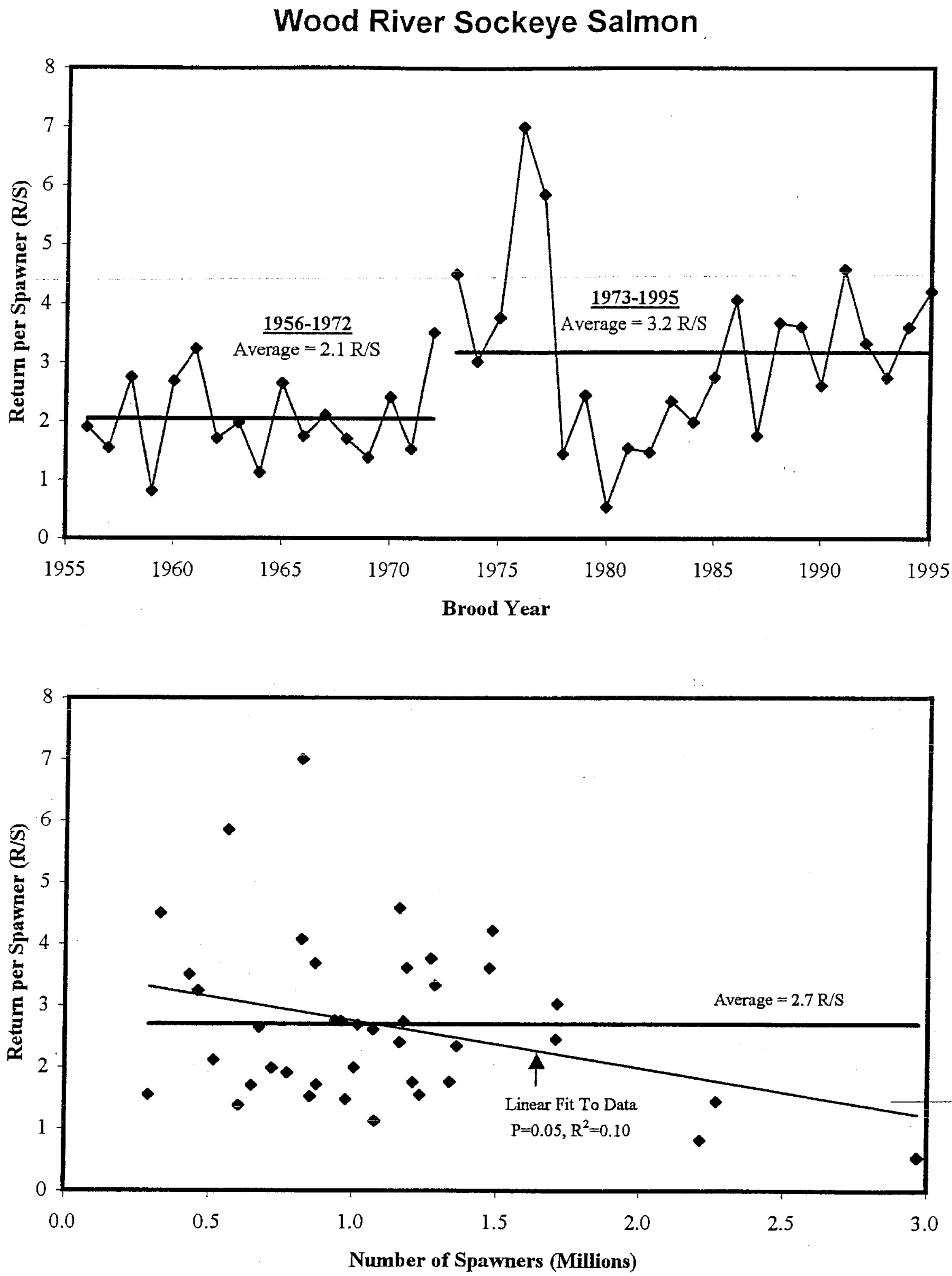


Figure 36. Return per spawner of Wood River sockeye salmon by brood year, 1956-1995, and number of spawners.

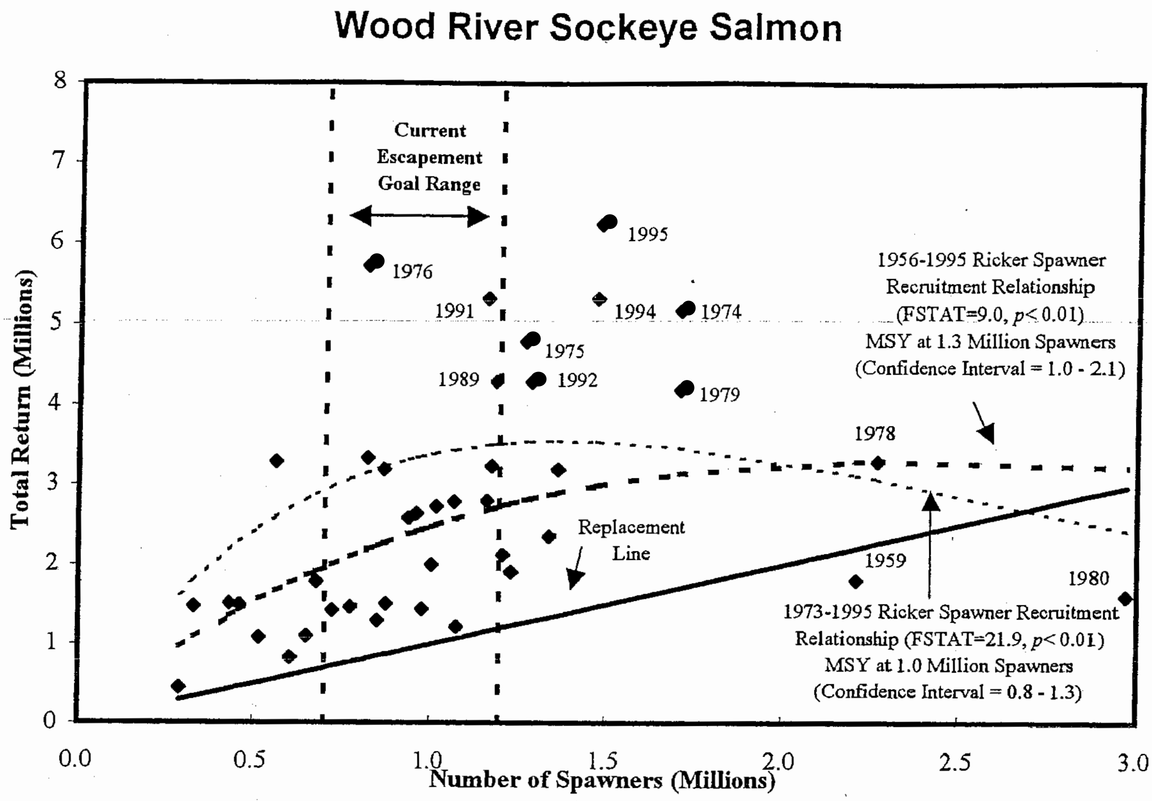


Figure 37. Ricker spawner-recruitment relationship of Wood River sockeye salmon, 1956-1995 brood years.

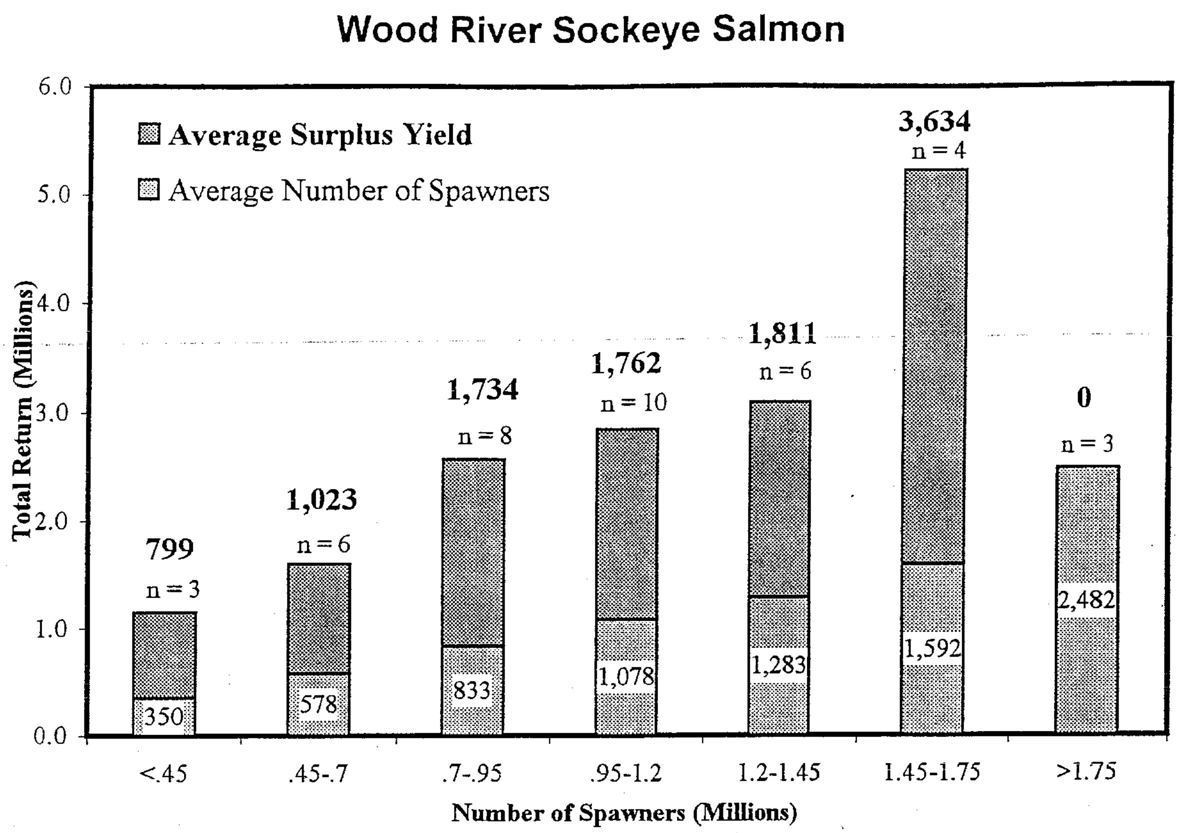


Figure 38. Average surplus yield categorized by the number of spawners of Wood River sockeye salmon, 1956-1995 brood years.

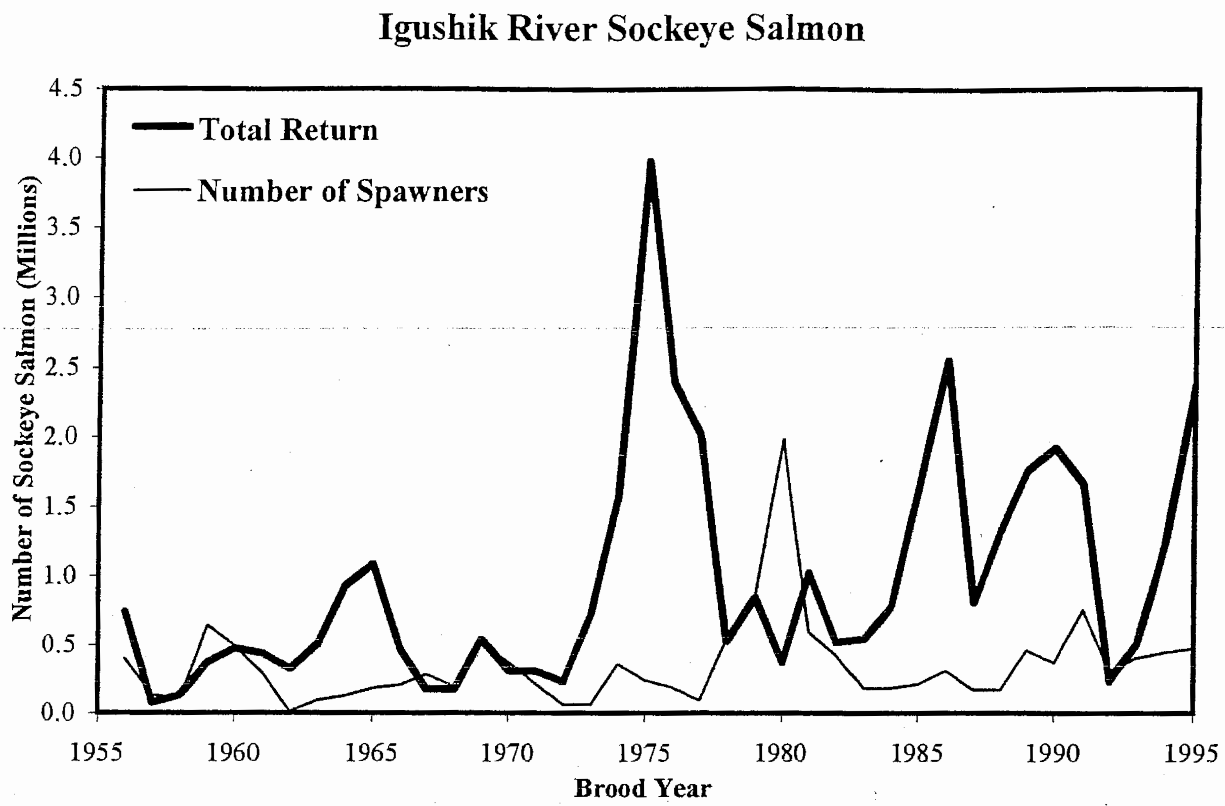


Figure 39. Number of spawners and total return of Igushik River sockeye salmon by brood year, 1956 - 1995.

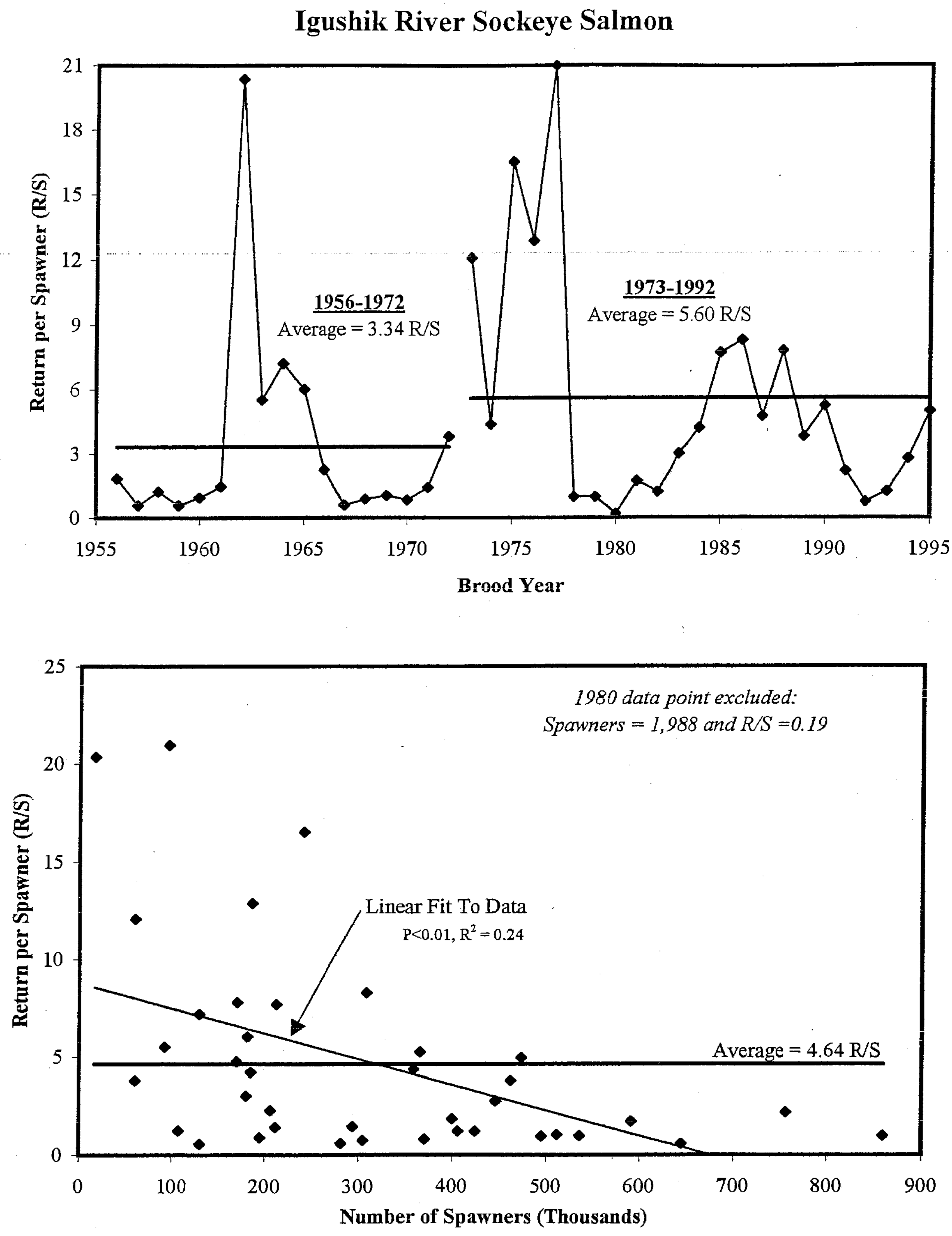


Figure 40. Return per spawner of Igushik River sockeye salmon by brood year, 1956-1995, and number of spawners.

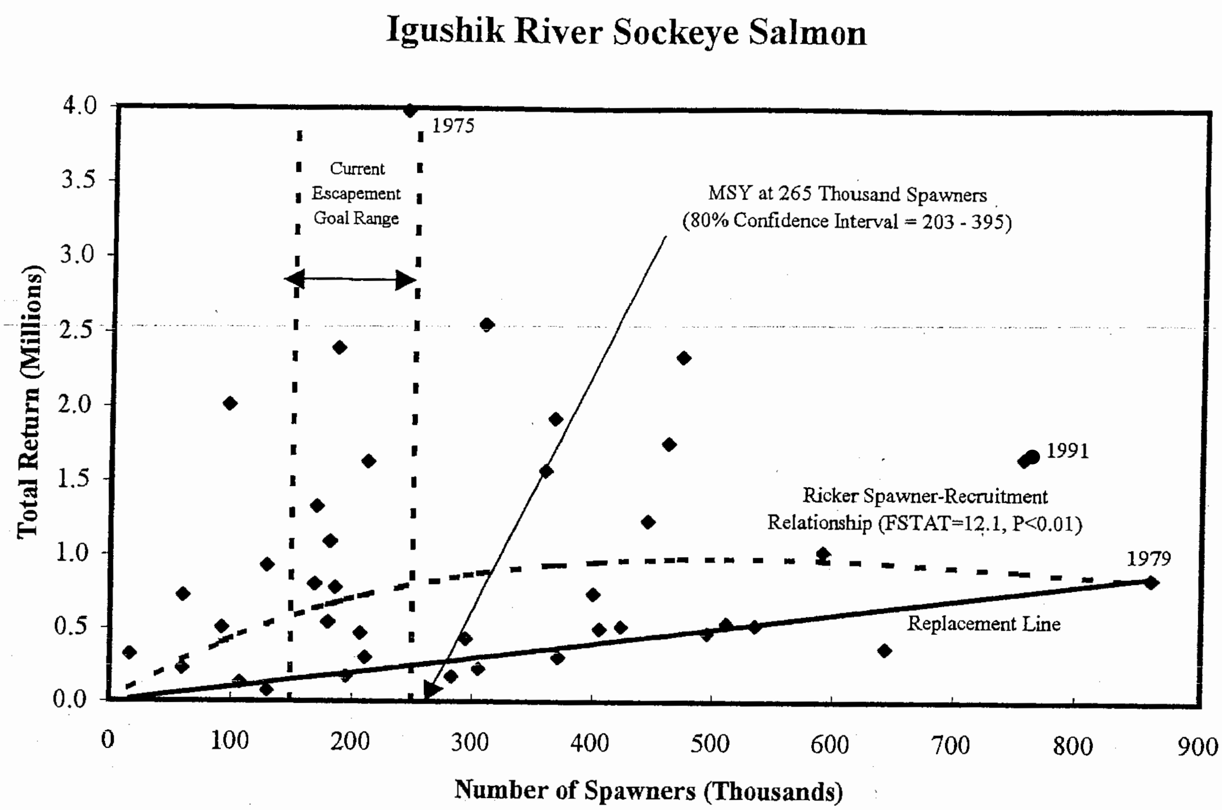


Figure 41. Total return of Igushik River sockeye salmon versus number of spawners, 1956-1995 brood years (excluding 1980 brood year).

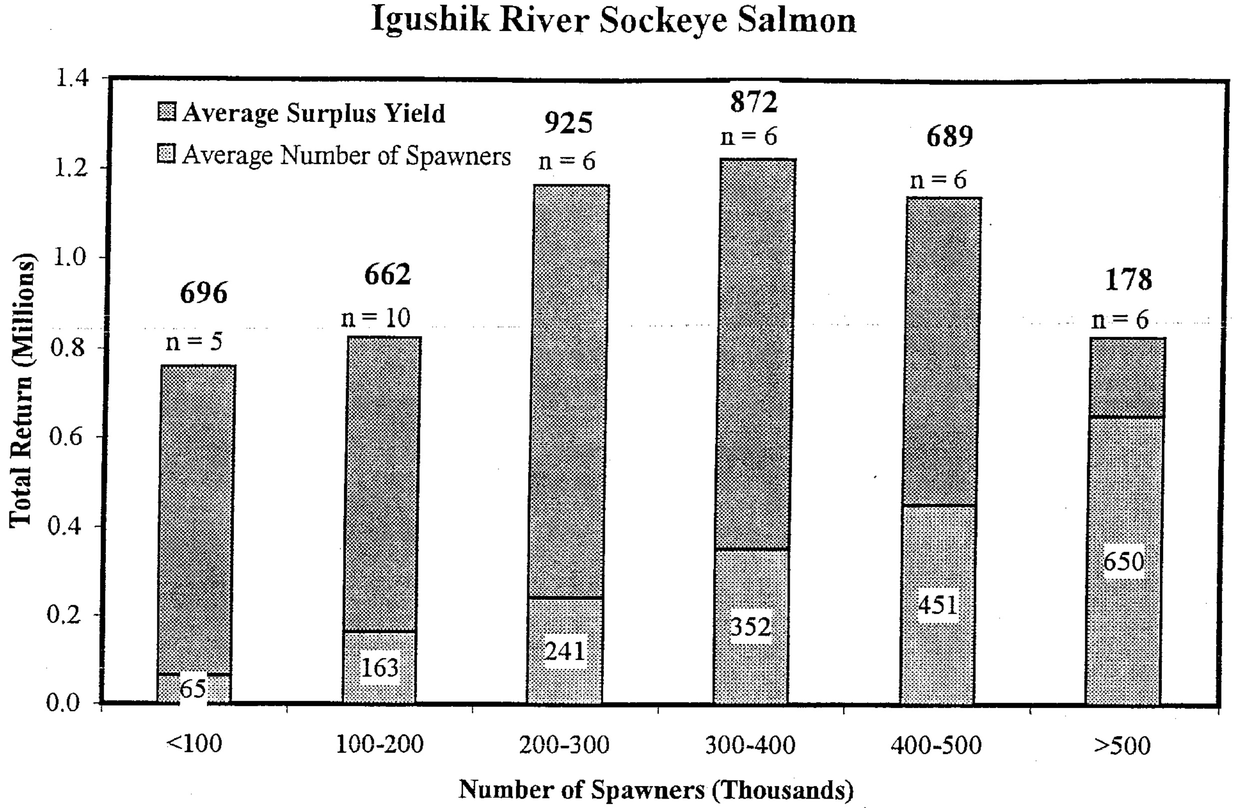


Figure 42. Average surplus yield categorized by the number of spawners of Igushik River sockeye salmon, 1956-1995 brood years (excluding 1980 brood year).

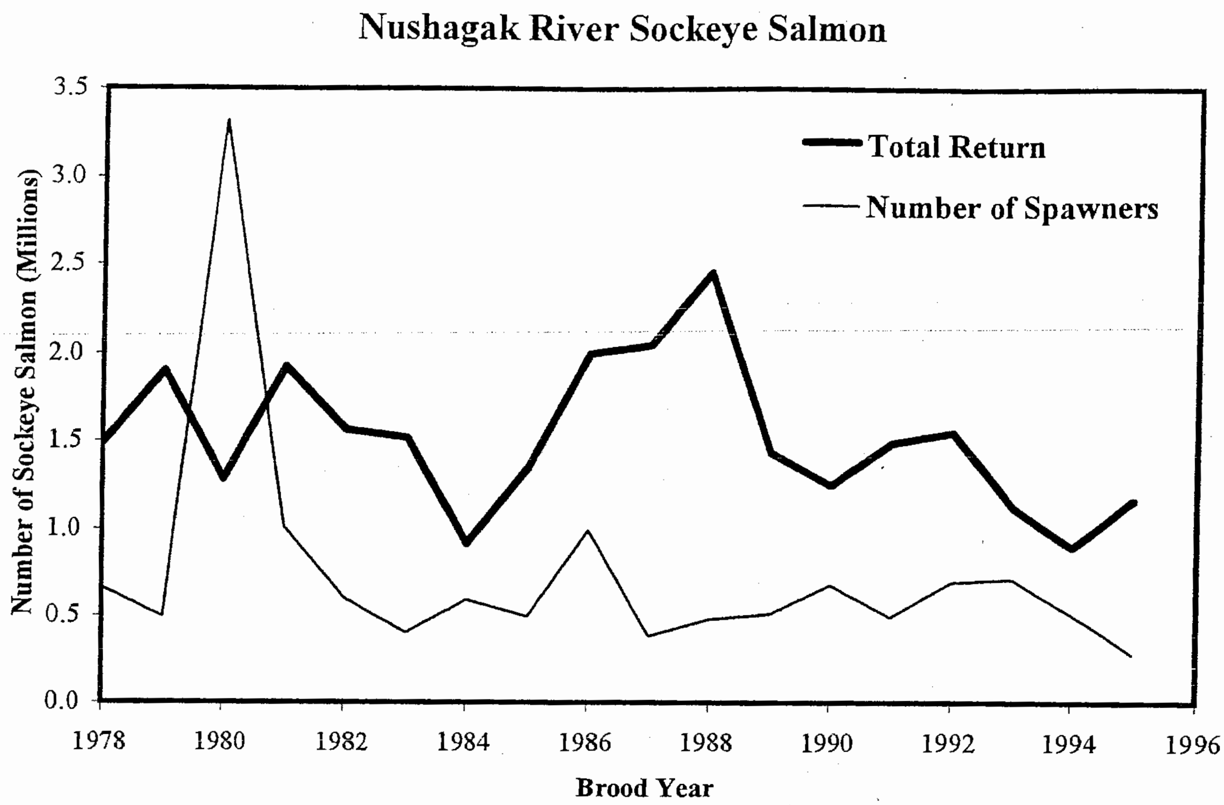


Figure 43. Number of spawners and total return of Nushagak River sockeye salmon by brood year, 1978-1995.

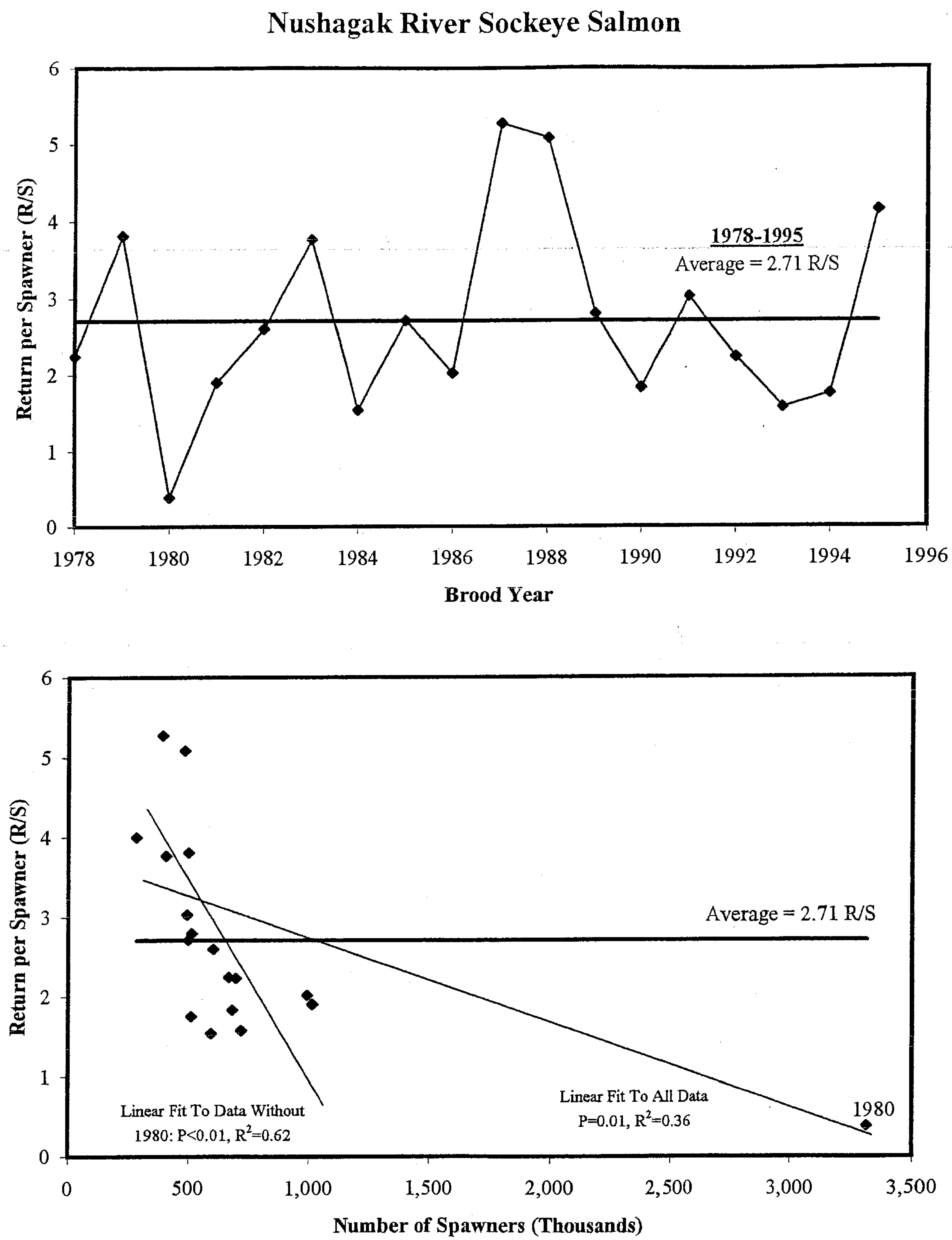


Figure 44. Return per spawner of Nushagak River sockeye salmon by brood year, 1978-1995, and number of spawners.

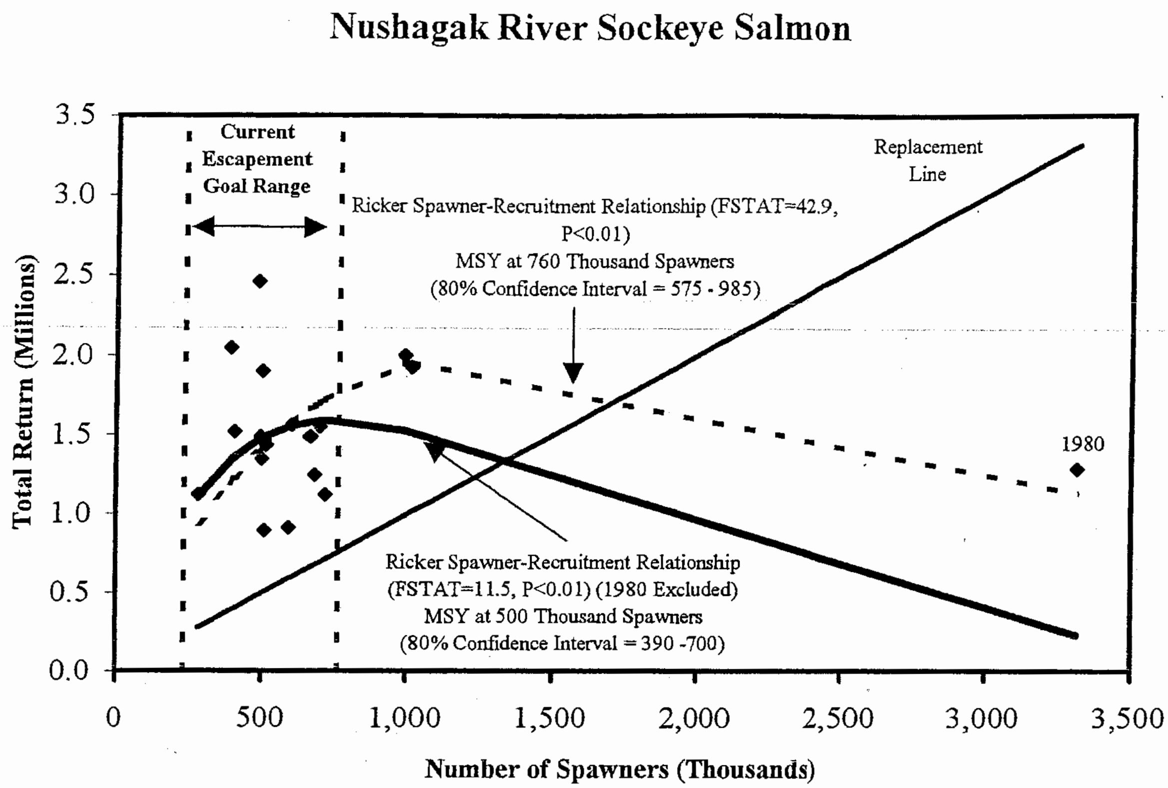


Figure 45. Total return of Nushagak River sockeye salmon versus number of spawners, 1978-1995 brood years.

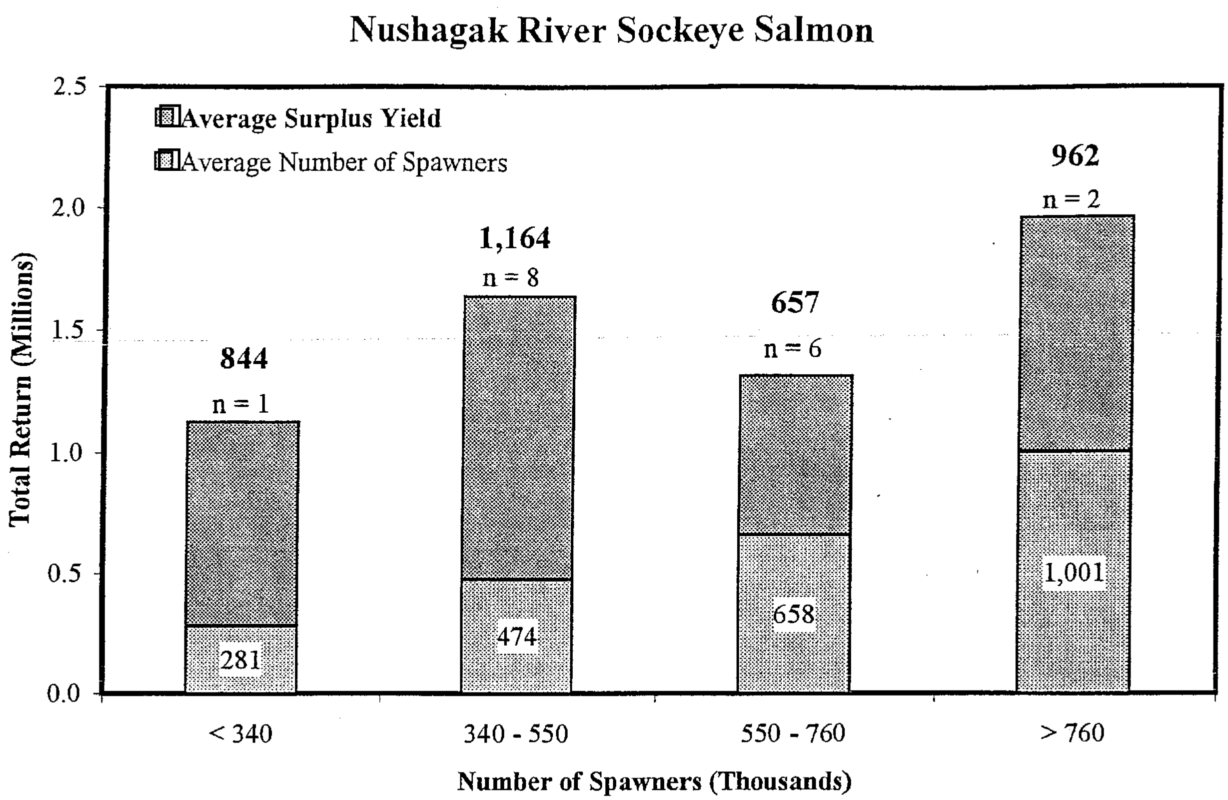


Figure 46. Average surplus yield categorized by the number of spawners of Nushagak River sockeye salmon, 1978-1995 brood years (excluding 1980 brood year).

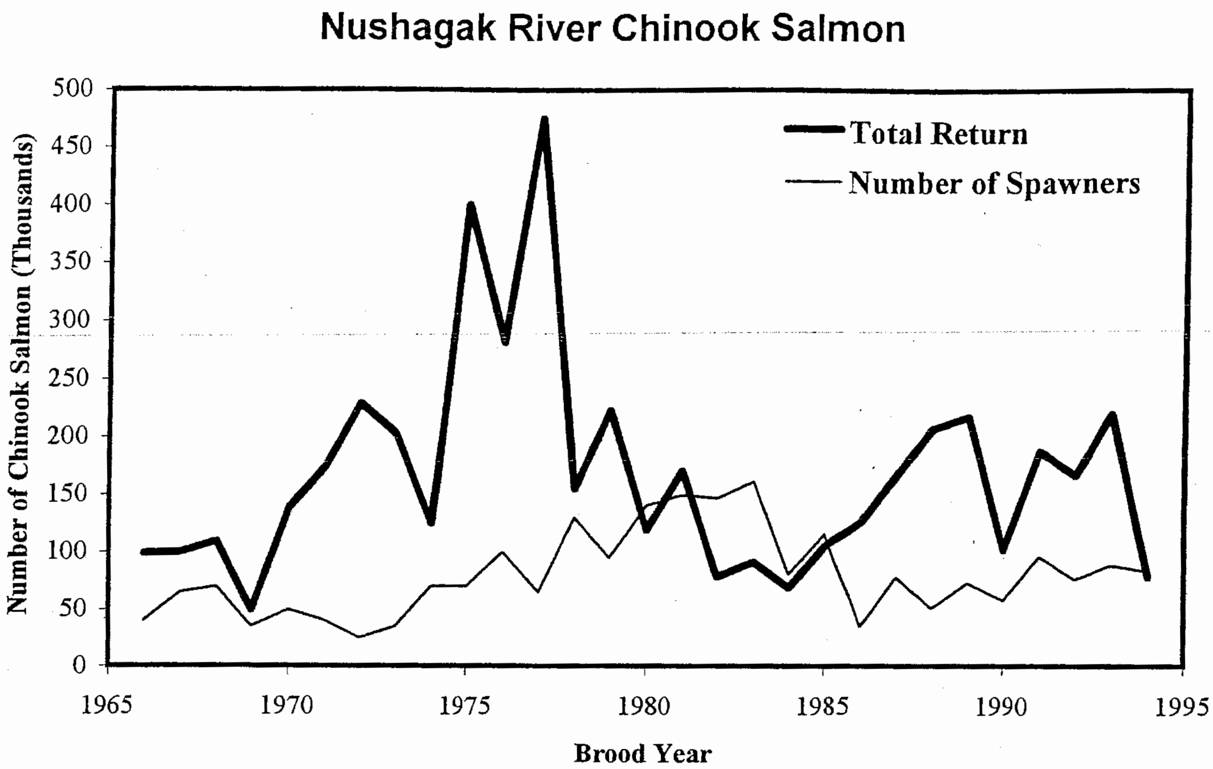


Figure 47. Number of spawners and total return of Nushagak Rvier chinook salmon by brood year, 1966-1994.

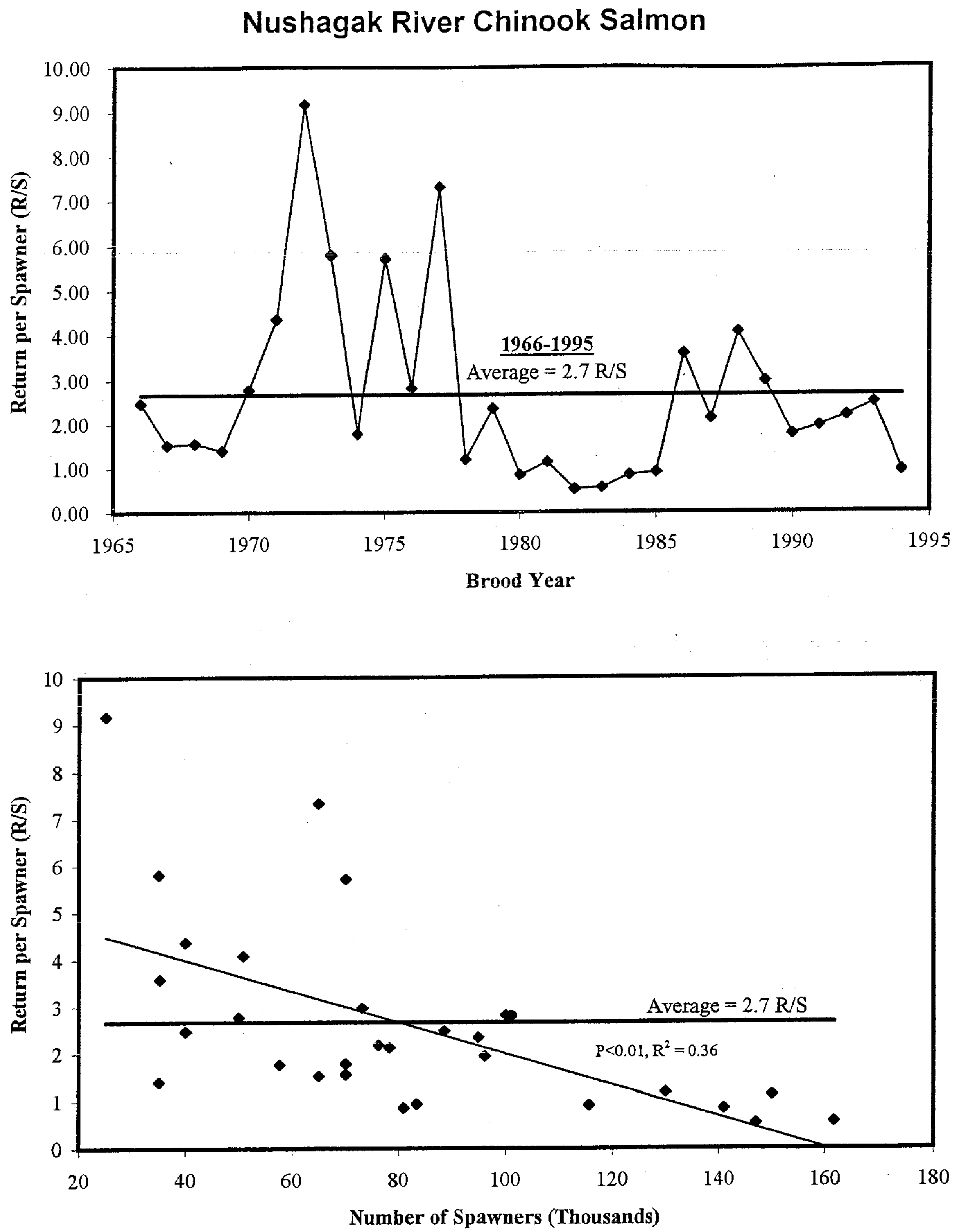


Figure 48. Return per spawner of Nushagak River chinook salmon versus number of spawners, 1966-1994 brood years.

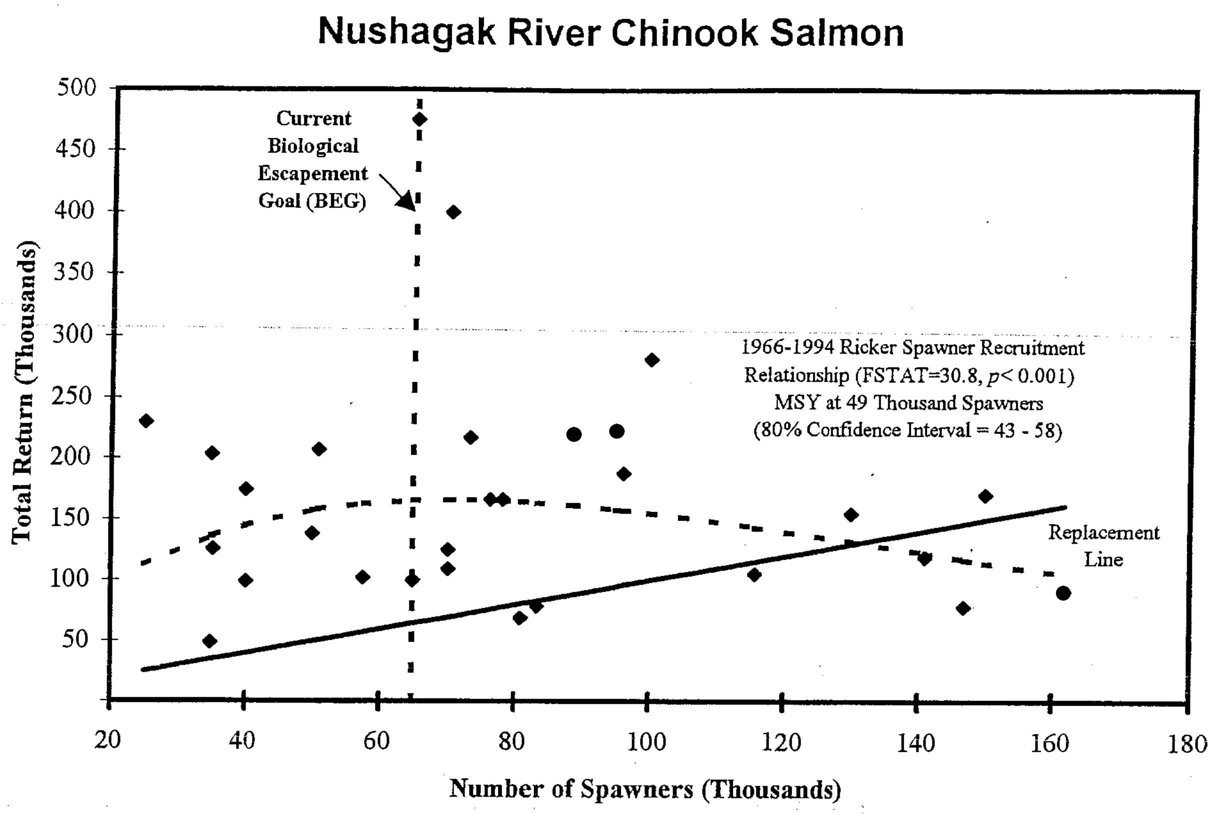


Figure 49. Ricker spawner-recruitment relationship of Nushagak River chinook salmon, 1966-1994 brood years.

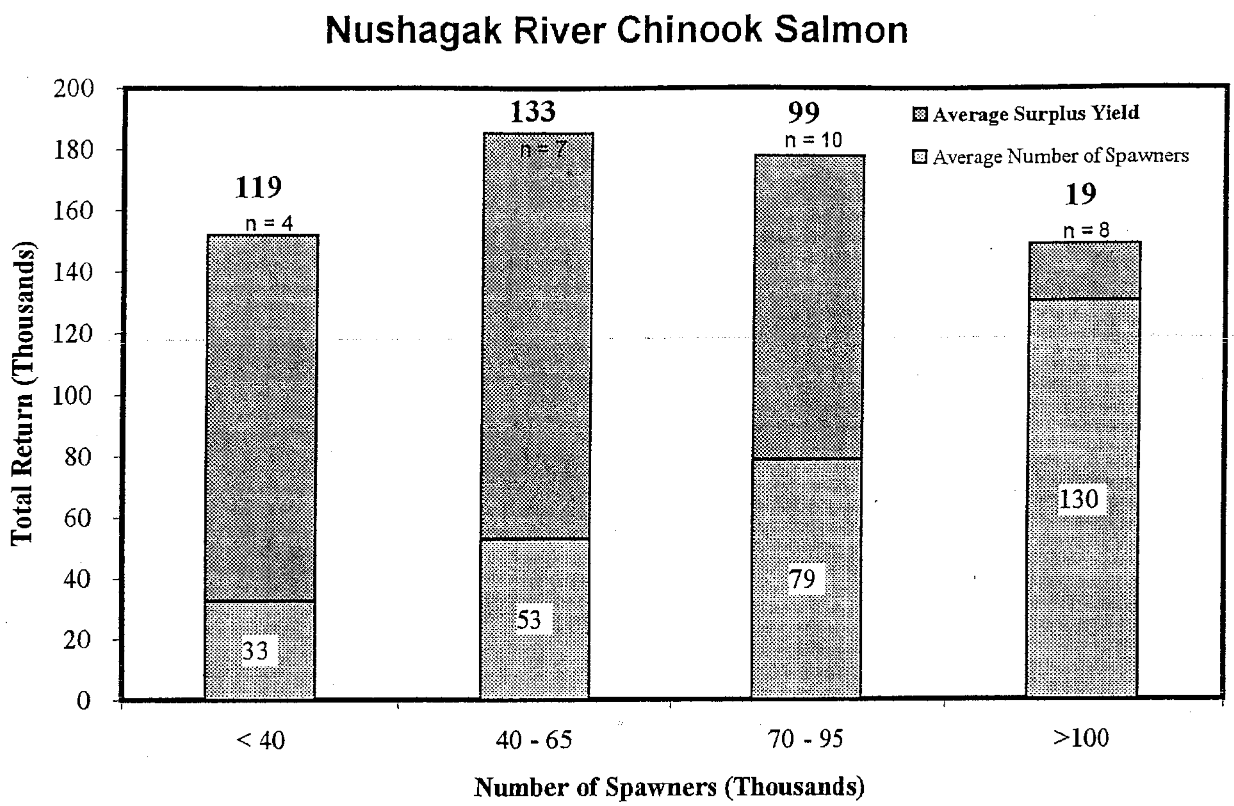


Figure 50. Average surplus yield categorized by number of spawners of Nushagak River chinook salmon, 1966-1994 brood years.

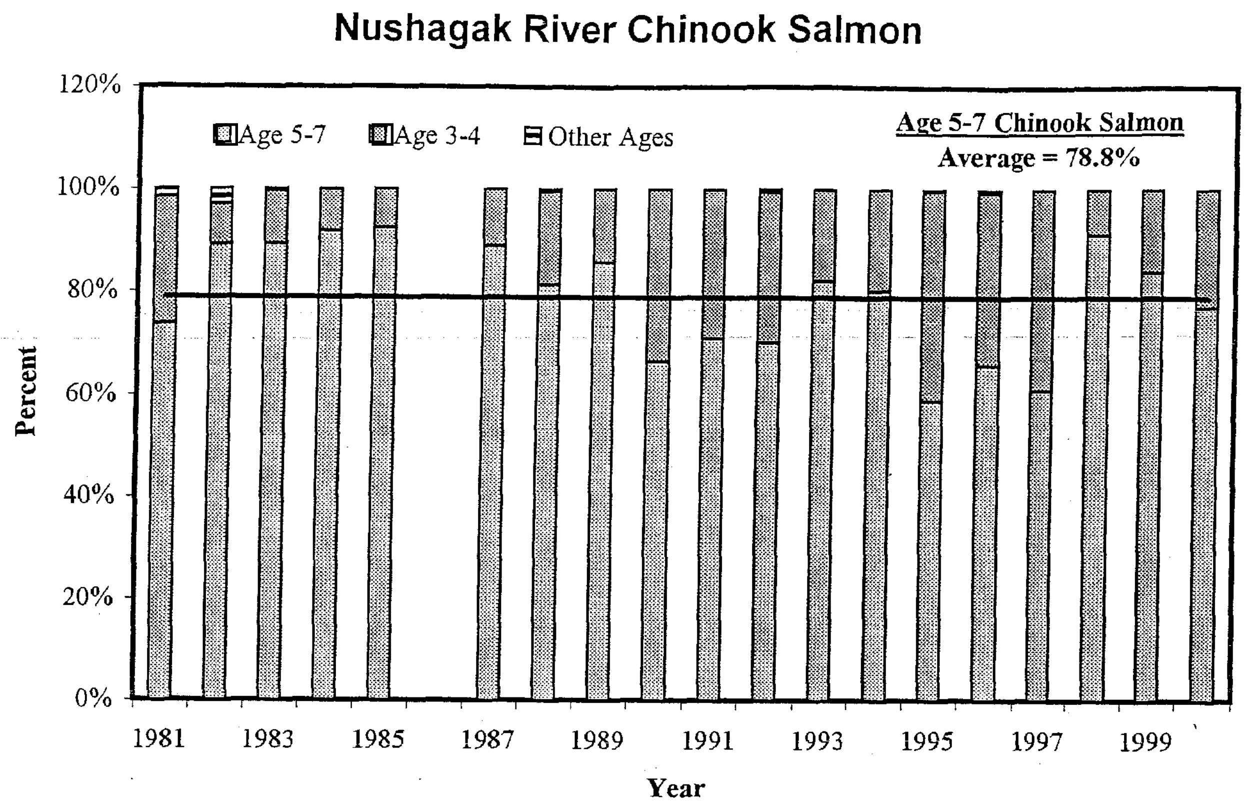


Figure 51. Percentage of age 3-4 and age 5-7 chinook salmon in Nushagak River spawning escapements, 1981-1985 and 1987-2000. No age data was collected in 1986.

Appendix A.1. List of individuals attending the 2000 Bristol Bay sockeye salmon escapement goal workshop.

Name	Affiliation
Milo Adkison	University of Alaska, School of Fisheries and Ocean Sciences
Cindy Anderson	ADF&G, Division of Commercial Fisheries
Tim Baker	ADF&G, Division of Commercial Fisheries
James Brady	ADF&G, Division of Commercial Fisheries
Linda Brannian	ADF&G, Division of Commercial Fisheries
Jim Browning	ADF&G, Division of Commercial Fisheries
Brian Bue	ADF&G, Division of Commercial Fisheries
Bob Clark	ADF&G, Sport Fish Division
Drew Crawford	ADF&G, Division of Commercial Fisheries
Jim Edmundson	ADF&G, Division of Commercial Fisheries
David Evans	ADF&G, Division of Commercial Fisheries
Lowell Fair	ADF&G, Division of Commercial Fisheries
Stephen Fried	United States Fish and Wildlife Service
Dan Gray	ADF&G, Division of Commercial Fisheries
Ray Hilborn	University of Washington, Fisheries Research Institute
Lee McKinley	ADF&G, Division of Commercial Fisheries
Steve Morstad	ADF&G, Division of Commercial Fisheries
Jeff Regnart	ADF&G, Division of Commercial Fisheries
Tim Sands	ADF&G, Division of Commercial Fisheries
James Seeb	ADF&G, Division of Commercial Fisheries
Keith Weiland	ADF&G, Division of Commercial Fisheries
Fred West	ADF&G, Division of Commercial Fisheries
Craig Whitmore	ADF&G, Sport Fish Division
Richard Yanusz	ADF&G, Sport Fish Division

Appendix B.1. Kvichak River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

Brood Year	Escapement	Return by Age Class 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	9,443	0	14	0	24,273	0	0	6,968	6,472	0	0	1,308	0	0	0	0	39,035	4.13
1957	2,843	8	0	0	243	0	0	244	3,333	0	2	259	0	0	2	0	4,091	1.44
1958	535	0	0	0	76	0	0	48	135	0	0	26	0	0	3	0	288	0.54
1959	680	0	0	0	212	1	0	117	206	0	0	11	0	0	0	0	547	0.80
1960	14,630	0	0	1	1,314	134	0	563	46,746	0	0	6,485	10	0	6	0	55,259	3.78
1961	3,706	1	0	0	334	0	0	190	2,293	0	0	679	5	0	0	0	3,502	0.94
1962	2,581	0	0	0	104	2	0	152	4,675	0	0	408	12	0	4	0	5,357	2.08
1963	339	0	0	0	49	3	0	50	639	0	0	366	3	0	9	0	1,119	3.30
1964	957	0	8	0	2,232	105	0	407	2,341	0	0	647	8	0	3	0	5,751	6.01
1965	24,326	0	25	0	9,853	484	0	471	32,951	0	0	1,239	2	0	1	0	45,026	1.85
1966	3,775	4	11	6	497	11	0	1,086	4,262	0	0	385	0	1	0	0	6,263	1.66
1967	3,216	0	0	5	349	2	0	272	812	0	0	86	0	0	0	0	1,526	0.47
1968	2,557	0	0	0	293	0	0	34	77	0	5	132	0	0	2	0	543	0.21
1969	8,394	0	0	1	129	7	0	321	4,221	0	0	595	19	0	11	0	5,304	0.63
1970	13,935	0	1	0	43	40	0	13	14,463	6	0	848	412	0	7	0	15,833	1.14
1971	2,387	0	0	0	244	18	0	93	2,169	0	0	303	2	0	0	0	2,829	1.19
1972	1,010	0	0	0	255	1	0	159	1,206	0	22	297	0	0	0	0	1,940	1.92
1973	227	0	0	2	576	2	2	1,028	274	0	3	543	28	0	0	0	2,458	10.83
1974	4,434	0	9	1	6,328	309	0	2,009	16,725	0	8	763	23	0	5	0	26,180	5.90
1975	13,140	0	5	0	5,683	302	0	1,232	30,263	0	0	599	2	0	0	0	38,086	2.90
1976	1,965	0	5	11	5,298	43	0	826	4,115	0	4	273	0	0	0	0	10,575	5.38
1977	1,341	11	43	6	1,934	2	0	935	208	0	0	99	0	0	0	0	3,238	2.41
1978	4,149	0	0	0	1,835	16	0	1,157	1,318	0	0	817	11	0	6	0	5,160	1.24
1979	11,218	1	57	3	18,331	73	0	2,234	17,931	0	0	3,512	0	0	0	0	42,142	3.76
1980	22,505	0	2	5	2,889	20	0	1,641	8,076	0	2	413	0	0	0	0	13,048	0.58
1981	1,754	0	0	12	789	0	0	231	931	0	0	167	0	0	0	0	2,130	1.21
1982	1,135	25	0	2	445	1	0	544	524	0	6	139	0	0	0	0	1,686	1.49
1983	3,570	0	1	5	8,596	3	0	3,010	1,195	0	5	573	0	2	1	0	13,391	3.75
1984	10,491	0	0	4	2,532	44	1	1,924	16,952	0	0	2,483	8	0	2	0	23,950	2.28
1985	7,211	4	7	30	1,024	29	0	1,282	13,465	0	2	1,560	1	15	2	0	17,421	2.42
1986	1,179	10	0	27	688	0	1	1,079	1,390	0	25	1,332	2	0	4	0	4,558	3.87
1987	6,066	29	4	69	4,179	31	4	2,519	4,499	0	5	700	4	0	2	0	12,045	1.99
1988	4,065	11	5	19	2,503	19	1	2,470	4,385	0	5	557	11	0	6	0	9,992	2.46
1989	8,318	29	2	54	2,147	117	2	1,678	18,826	0	2	3,316	13	1	0	0	26,187	3.15
1990	6,970	6	8	11	1,541	83	0	1,192	21,105	0	0	1,162	0	0	0	0	25,108	3.60
1991	4,223	0	1	4	2,688	2	0	1,232	699	0	6	170	0	0	0	0	4,802	1.14
1992	4,726	2	0	13	429	2	0	226	567	0	0	175	0	0	6	0	1,420	0.30
1993	4,025	0	1	1	852	1	4	890	624	0	7	556	0	0	0	0[a]	2,936[a]	0.73
1994	8,338	0	3	0	1,811	29	0	1,173	3,700	0	1	244	1	0[a]	0[a]	0[a]	6,962[a]	0.83
1995	10,039	0	17	0	7593	0	0	1864	514	0	0	262[b]	0[a]	0[a]	0[a]	0[a]	10,250[a]	1.02
1996	1,451	3	0	0	363	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	366[a]	
1997	1,504																	
1998	2,296																	
1999	6,197																	
2000	1.027																	
56-95 Avg	5,910				3,030			1,089	7,382			862					12,448	2.38
56-72 Avg	5,607				2,382			658	7,471			828					11,424	1.89
73-95 Avg	6,134				3,508			1,408	7,317			888					13,205	2.75
peak	10,349																22,316	2.5
off	2,951																5,870	2.3

[a] Incomplete returns from brood year escapement.
[b] Estimated 1998 return of age-2.3 so the 1995 brood year could be used.

Appendix B.2. Naknek River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

Brood Year	Escapement	Return by Age Class 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	1773	0	1	0	473	0	0	1701	3	0	17	304	0	0	0	0	2,499	1.41
1957	635	0	0	0	53	2	0	329	505	0	1	674	5	0	3	0	1,572	2.48
1958	278	0	0	0	112	4	0	211	539	0	0	168	3	0	2	0	1,039	3.74
1959	2232	0	0	0	349	7	0	351	742	0	0	705	0	0	0	0	2,154	0.97
1960	828	0	1	1	1408	9	0	625	696	0	0	1278	1	1	2	0	4,022	4.86
1961	351	0	0	0	239	3	0	744	315	0	3	640	0	0	8	0	1,952	5.56
1962	723	0	0	0	76	4	0	230	351	0	2	397	13	0	1	0	1,074	1.49
1963	905	0	0	0	136	8	0	390	833	0	0	627	7	0	1	0	2,002	2.21
1964	1350	0	1	0	447	24	0	264	1135	0	0	177	11	0	1	0	2,060	1.53
1965	718	0	5	0	540	44	0	360	732	0	0	437	1	0	1	0	2,120	2.95
1966	1016	1	4	0	728	2	0	2304	167	0	1	630	0	1	0	0	3,838	3.78
1967	756	0	0	2	326	6	0	625	401	0	0	356	0	1	0	0	1,717	2.27
1968	1023	0	3	0	152	0	0	234	83	0	0	269	2	0	2	0	745	0.73
1969	1331	0	0	0	47	3	0	307	976	0	0	1211	5	0	3	0	2,552	1.92
1970	733	0	1	0	154	19	0	318	1845	0	0	370	12	0	0	0	2,719	3.71
1971	936	0	1	0	397	24	0	559	1428	0	0	1844	3	9	8	0	4,273	4.57
1972	587	0	3	0	245	3	0	241	161	0	3	599	9	0	1	0	1,265	2.16
1973	357	0	0	0	494	0	0	618	524	0	0	598	0	0	0	0	2,234	6.26
1974	1241	0	2	0	232	3	0	228	1026	0	1	783	5	0	5	0	2,285	1.84
1975	2027	0	1	0	425	11	0	1746	1393	0	0	1641	1	8	0	0	5,226	2.58
1976	1321	0	4	0	1084	3	0	4048	1575	0	21	1491	0	28	1	0	8,255	6.25
1977	1086	2	10	7	635	0	0	2272	95	0	64	401	0	1	5	0	3,492	3.22
1978	813	0	1	0	331	4	0	1695	1121	0	11	530	2	0	0	0	3,695	4.54
1979	925	0	4	1	2438	4	0	973	792	0	9	408	4	0	3	0	4,636	5.01
1980	2645	0	1	1	723	14	0	1505	1192	0	9	828	0	2	0	0	4,275	1.62
1981	1796	0	4	0	782	9	0	2568	473	0	12	937	0	3	0	0	4,788	2.67
1982	1156	0	3	3	185	0	0	1172	191	0	23	457	0	9	0	0	2,043	1.77
1983	888	0	0	1	163	7	0	484	336	0	5	480	0	0	1	0	1,477	1.66
1984	1242	0	1	0	469	23	0	911	1214	0	21	1828	5	1	4	0	4,477	3.60
1985	1850	0	2	6	656	20	1	3533	1293	0	44	1441	0	28	10	0	7,034	3.80
1986	1978	0	3	6	1981	6	1	7167	1276	0	367	2817	1	38	2	0	13,665	6.91
1987	1062	3	0	12	336	4	1	1251	565	0	95	3225	2	12	0	0	5,506	5.18
1988	1038	0	0	0	273	13	0	796	516	0	37	544	2	2	1	0	2,184	2.10
1989	1162	0	1	0	226	5	0	930	1154	0	0	566	4	0	1	0	2,887	2.48
1990	2093	0	0	0	405	46	0	1236	1345	0	12	1316	3	12	0	0	4,375	2.09
1991	3579	1	13	0	546	1	0	5209	250	0	45	343	0	1	0	0	6,409	1.79
1992	1607	0	0	16	268	1	0	552	250	1	10	379	5	0	2	0	1,484	0.92
1993	1536	0	0	2	293	12	0	1390	473	0	20	634	0	0	0	0[a]	2,824[a]	1.84
1994	991	0	6	0	503	15	0	596	513	0	4	520	2	0[a]	0[a]	0[a]	2,159[a]	2.18
1995	1111	0	9	0	1978	1	0	3713	339	0	0[a]	603[b]	0[a]	0[a]	0[a]	0[a]	6,643[a]	5.98
1996	1078	1	1	0	352	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	354[a]	
1997	1026																	
1998	1202																	
1999	1625																	
2000	1375																	
56-95 Avg	1,242				533			1,360	720			836					3,491	3.07
56-72 Avg	951				346			576	642			629					2,212	2.72
73-95 Avg	1,457				671			1,939	779			990					4,437	3.32

[a] Incomplete returns from brood year escapement.
[b] Estimated 1998 return of age-2.3 so the 1995 brood year could be used.

Appendix B.3. Egegik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

		Return by Age Class																
Brood Year	Escapement	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	1,104	0	6	0	2,025	0	0	3,190	925	0	2	685	1	0	12	0	6,846	6.20
1957	391	0	0	0	37	0	0	43	1,096	0	0	927	70	0	62	0	2,236	5.72
1958	246	0	0	0	42	2	0	73	817	0	0	308	16	0	3	0	1,263	5.13
1959	1,072	0	0	0	73	2	0	164	1,037	0	0	467	14	0	24	0	1,783	1.66
1960	1,799	8	0	0	447	21	0	328	4,447	0	1	2,560	49	0	50	0	7,912	4.40
1961	702	0	0	3	82	0	0	229	446	0	1	791	28	0	10	0	1,591	2.27
1962	1,027	0	0	0	22	0	0	69	950	0	0	375	28	0	30	0	1,475	1.44
1963	998	0	0	1	16	2	0	112	538	1	1	506	74	0	7	0	1,258	1.26
1964	850	0	1	0	126	6	0	69	1,454	1	0	242	73	0	12	0	1,983	2.33
1965	1,445	0	0	0	104	35	0	72	2,016	0	4	845	6	2	20	0	3,103	2.15
1966	804	0	0	1	249	0	0	752	600	0	2	890	7	0	10	0	2,511	3.12
1967	637	0	0	2	60	2	0	257	665	0	0	622	1	1	2	0	1,613	2.53
1968	339	0	0	0	41	0	0	56	87	0	0	258	3	5	9	0	458	1.35
1969	1,016	0	0	0	12	1	0	111	1,096	0	0	1,141	279	2	113	0	2,756	2.71
1970	920	0	0	0	59	0	0	89	796	0	1	175	95	0	25	0	1,240	1.35
1971	634	0	0	0	45	2	0	109	1,477	0	0	970	74	1	55	0	2,732	4.31
1972	546	0	0	1	57	2	0	61	1,508	0	0	1,264	48	0	18	0	2,959	5.42
1973	329	0	0	0	76	0	0	135	578	0	0	851	35	0	4	0	1,679	5.10
1974	1,276	0	0	0	131	18	0	99	2,224	0	0	496	54	0	3	0	3,025	2.37
1975	1,174	0	0	0	148	9	0	241	2,449	2	0	797	14	2	1	0	3,663	3.12
1976	509	1	1	2	612	59	0	789	3,003	0	4	846	0	0	0	0	5,317	10.45
1977	693	0	2	0	823	1	0	1,969	688	0	14	655	52	0	13	0	4,217	6.09
1978	896	0	0	2	398	6	0	510	6,071	0	0	2,184	25	4	8	0	9,208	10.28
1979	1,032	0	3	0	712	9	3	520	3,036	0	4	1,659	0	0	0	0	5,947	5.76
1980	1,061	0	1	13	803	26	0	2,225	4,576	0	6	917	7	0	0	0	8,576	8.08
1981	695	0	0	6	544	64	0	953	3,284	0	11	1,438	9	0	7	0	6,317	9.09
1982	1,035	2	2	4	988	12	0	1,874	1,796	0	9	1,638	11	2	2	0	6,340	6.13
1983	792	0	3	0	1,748	7	1	2,763	3,235	0	7	2,822	21	23	16	0	10,646	13.44
1984	1,165	0	1	8	608	85	0	978	6,539	3	10	5,029	215	13	39	0	13,527	11.61
1985	1,095	4	0	9	567	32	0	1,404	4,358	0	9	1,262	8	0	18	0	7,672	7.01
1986	1,152	0	2	14	1,850	10	0	3,733	3,912	0	92	4,515	86	83	34	0	14,331	12.44
1987	1,274	2	0	9	886	66	0	4,561	8,863	3	101	11,239	133	31	57	0	25,952	20.37
1988	1,599	0	1	0	413	62	0	1,278	11,061	0	4	5,650	261	3	152	0	18,885	11.81
1989	1,612	1	0	6	513	34	0	456	6,063	1	6	3,979	170	1	31	0	11,261	6.99
1990	2,191	0	0	2	403	66	0	867	9,598	1	3	4,721	21	28	30	0	15,740	7.18
1991	2,787	4	1	3	1,397	20	2	3,939	3,113	0	47	2,607	19	2	9	0	11,163	4.01
1992	1,946	5	0	32	335	54	3	1,117	4,963	2	4	3,099	53	15	16	0	9,698	4.98
1993	1,517	0	2	10	497	31	0	573	880	0	10	993	5	0	0	0[a]	3,001[a]	1.98
1994	1,895	1	8	0	368	65	0	985	4,246	0	0	3,099	11	0[a]	0[a]	0[a]	8,783[a]	4.63
1995	1,282	0	7	0	3,173	4	0	3,206	1,657	0	0	1,057[b]	0[a]	0[a]	0[a]	0[a]	9,104[a]	7.10
1996	1,076	0	1	0	500	5	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	506[a]	
1997	1,104																	
1998	1,111																	
1999	1,728																	
2000	1,032																	
56-95 Avg	1,088				537			1,024	2,904			1,864					6,444	5.83
56-75 Avg	865				193			313	1,260			759					2,604	3.20
76-95 Avg	1,311				882			1,735	4,547			2,970					10,284	8.47

[a] Incomplete returns from brood year escapement.
[b] Estimated 2001 return of age-2.3 so the 1995 brood year could be used.

Appendix B.4. Ugashik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

Brood Year	Escapement	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return / Spawner
		Return by Age Class																
1956	425	1	12	0	3,165	0	0	837	80	0	2	35	0	0	0	0	4,132	9.72
1957	215	0	0	1	35	0	0	105	354	0	2	100	4	0	2	0	603	2.80
1958	280	0	0	0	63	0	0	105	444	0	0	66	0	0	0	0	678	2.42
1959	219	0	0	0	18	0	0	38	310	0	0	132	0	0	1	0	499	2.28
1960	2,304	0	0	0	674	11	0	296	1,563	0	0	487	0	0	0	0	3,031	1.32
1961	349	0	0	3	240	2	0	500	247	0	1	120	0	0	0	0	1,113	3.19
1962	255	0	0	2	77	2	0	130	185	0	0	27	0	0	0	0	423	1.66
1963	388	0	0	0	13	0	0	21	91	0	0	23	0	0	0	0	148	0.38
1964	473	0	0	0	31	9	0	16	245	0	0	18	0	0	2	0	321	0.68
1965	997	0	0	0	86	2	0	38	249	0	1	162	1	0	0	0	539	0.54
1966	704	1	0	2	723	0	0	1,478	90	0	0	21	0	0	0	0	2,315	3.29
1967	239	0	0	0	56	0	0	50	44	0	0	34	0	0	0	0	184	0.77
1968	71	0	0	0	14	0	0	7	15	0	0	3	0	0	0	0	39	0.55
1969	160	0	0	0	4	0	0	5	53	0	0	26	2	0	2	0	92	0.58
1970	735	0	0	0	4	1	0	2	256	0	1	28	2	0	1	0	295	0.40
1971	530	0	0	0	178	0	0	236	290	0	0	130	0	0	1	0	835	1.58
1972	79	0	0	0	35	0	0	58	119	0	0	41	2	0	3	0	258	3.27
1973	39	0	0	1	16	0	0	8	17	0	0	46	4	0	0	0	92	2.36
1974	62	0	0	0	13	10	0	15	602	0	0	83	2	0	0	0	725	11.69
1975	429	0	3	0	1,484	4	0	575	1,721	0	0	325	2	1	0	0	4,115	9.59
1976	356	0	0	2	2,027	58	0	1,527	1,248	0	7	437	0	0	3	0	5,309	14.91
1977	202	0	2	18	585	0	0	1,614	266	0	10	186	6	1	4	0	2,692	13.33
1978	82	0	0	5	247	7	0	413	863	0	6	523	1	0	0	0	2,065	25.18
1979	1,707	0	20	0	3,076	8	0	851	1,471	0	14	562	0	5	0	0	6,007	3.52
1980	3,335	0	1	13	1,183	39	0	2,309	3,371	0	10	850	3	2	0	0	7,781	2.33
1981	1,328	0	2	10	1,603	4	0	2,632	2,278	0	4	933	1	1	0	0	7,468	5.62
1982	1,186	0	1	15	423	1	1	713	606	0	9	737	0	2	0	0	2,508	2.11
1983	1,001	0	0	10	650	6	1	342	632	0	3	319	1	1	0	0	1,965	1.96
1984	1,270	0	0	5	472	55	0	568	3,635	0	13	709	3	0	4	0	5,464	4.30
1985	1,006	2	1	6	508	2	0	721	978	0	4	469	0	5	0	0	2,696	2.68
1986	1,016	5	1	46	503	1	0	2,427	1,874	0	71	1,750	4	15	0	0	6,697	6.59
1987	687	7	1	9	828	11	0	1,626	1,875	0	25	2,310	10	20	24	0	6,746	9.82
1988	654	1	2	1	463	27	0	692	2,144	0	37	2,252	22	3	7	0	5,651	8.64
1989	1,713	3	7	7	694	14	0	391	2,479	0	12	955	6	1	3	0	4,572	2.67
1990	749	0	1	13	345	15	2	709	2302	0	2	1218	2	2	0	0	4,611	6.16
1991	2482	1	6	0	2034	1	0	3167	597	0	14	326	0	4	0	0	6,150	2.48
1992	2195	6	3	49	191	4	1	597	1013	0	1	827	0	10	1	0	2,703	1.23
1993	1413	1	2	2	265	7	0	352	241	0	17	198	0	0	1	0[a]	1,086[a]	0.77
1994	1095	0	12	4	333	12	0	328	692	0	6	272	1	0[a]	0[a]	0[a]	1,660[a]	1.52
1995	1321	3	18	5	2816	1	0	1558	184	0	0	148[b]	0[a]	0[a]	0[a]	0[a]	4,734[a]	3.58
1996	692	0	0	41	230	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	271[a]	0.39
1997	657																	
1998	925																	
1999	1,662																	
2000	632																	
56-95 Avg	844				654			701	893									
56-73 Avg	470				302			218	258			447					2,725	4.46
74-95 Avg	1,150				943			1,097	1,412			83					867	2.10

[a] Incomplete returns from brood year escapement.
[b] Estimated 2001 return of age-2.3 so the 1995 brood year could be used.

Appendix B.5. Togiak River sockeye salmon escapement and return by brood year including estimated interception catch includes aerial surveys of Togiak River below tower (in thousands), 1956-2000.

		Return by Age Class																
Brood Year	Escapement	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	225	0	0	4	114	0	0	306	22	0	1	13	0	0	0	0	460	2.04
1957	25	2	0	5	48	0	0	70	20	0	0	36	1	0	0	0	182	7.28
1958	72	0	1	2	68	0	0	115	59	0	0	25	0	0	0	0	270	3.75
1959	210	0	0	0	141	0	0	92	56	0	0	7	0	0	0	0	296	1.41
1960	163	0	0	2	191	0	0	274	22	0	0	52	0	0	0	0	541	3.32
1961	122	1	0	3	85	0	0	216	15	0	1	19	0	0	0	0	340	2.79
1962	62	0	0	7	48	0	0	102	4	0	0	8	0	0	0	0	169	2.73
1963	116	0	0	2	43	0	0	65	18	0	0	24	0	0	0	0	152	1.31
1964	105	0	0	1	43	0	0	84	41	0	0	6	0	0	0	0	175	1.67
1965	96	0	0	2	154	0	0	181	31	0	0	37	0	0	0	0	405	4.22
1966	104	1	0	6	200	0	0	419	4	0	1	9	0	0	0	0	640	6.15
1967	81	1	0	6	18	0	0	99	16	0	1	40	0	0	0	0	181	2.23
1968	50	0	0	1	49	0	0	190	6	0	3	13	0	0	0	0	262	5.24
1969	117	0	0	5	28	0	0	142	25	0	3	13	0	0	0	0	216	1.85
1970	203	0	0	1	54	0	0	226	55	0	1	70	0	0	0	0	407	2.00
1971	200	0	0	4	106	0	0	317	62	0	1	68	0	0	0	0	558	2.79
1972	79	0	0	2	93	0	0	150	21	0	2	34	0	0	0	0	302	3.82
1973	107	1	0	10	151	0	0	442	18	0	1	31	0	0	0	0	654	6.11
1974	104	0	0	2	271	0	0	307	73	0	3	45	0	1	0	0	702	6.75
1975	181	1	0	7	195	0	0	848	87	0	2	59	0	0	0	0	1,199	6.62
1976	189	0	0	1	189	0	0	558	142	0	4	175	0	0	0	0	1,069	5.66
1977	163	0	0	5	232	0	0	617	14	0	4	14	0	0	0	0	886	5.44
1978	306	0	0	12	149	0	0	430	65	0	1	25	0	0	0	0	682	2.23
1979	198	1	0	1	270	0	0	293	12	0	2	5	0	0	0	0	584	2.95
1980	527	0	0	5	45	0	1	224	10	0	0	19	0	0	0	0	304	0.58
1981	307	2	0	11	53	0	0	245	15	0	1	16	0	0	0	0	343	1.12
1982	289	0	0	16	109	0	0	255	14	0	5	26	0	0	0	0	425	1.47
1983	213	1	0	3	285	0	2	924	9	0	2	21	0	0	0	0	1,247	5.85
1984	151	0	0	14	21	0	0	109	4	0	1	17	0	0	0	0	166	1.10
1985	153	0	0	7	35	0	0	194	35	0	1	77	0	1	0	0	350	2.29
1986	203	0	0	18	77	0	1	445	83	0	14	121	0	0	0	0	759	3.74
1987	278	0	0	7	190	0	1	575	31	0	7	81	0	0	0	0	892	3.21
1988	309	1	0	9	111	0	3	403	34	0	3	53	0	0	0	0	617	2.00
1989	104	0	0	36	132	0	1	328	7	0	1	41	0	0	0	0	546	5.25
1990	166	1	0	23	101	0	1	460	75	0	5	37	0	0	0	0	703	4.23
1991	254	1	3	3	189	0	1	429	28	0	8	29	0	0	0	0	691	2.72
1992	210	1	0	35	50	0	1	124	33	0	1	30	0	0	0	0	275	1.31
1993	189	0	0	4	64	0	0	229	6	0	4	15	0	0	0	0[a]	322[a]	1.70
1994	174	1	0	3	43	0	0	166	31	0	1	7	0	0[a]	0[a]	0[a]	252[a]	1.45
1995	211	0	1	4	341	0	1	1004	11	0	0[a]	18[b]	0[a]	0[a]	0[a]	0[a]	1,380[a]	6.54
1996	187	1	0	9	87	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	97[a]	0.52
1997	152																	
1998	176																	
1999	196																	
2000	370																	
56-95 Avg	180				119			309	32			35					505	3.30
56-79 Avg	137				123			273	37			35					472	3.77
80-95 Avg	229				114			360	25			36					551	2.78

[a] Incomplete returns from brood year escapement.
[b] Estimated 2001 return of age-2.3 so the 1995 brood year could be used.

Appendix B.6. Wood River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

Brood Year	Escapement	Return by Age Class 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	773	0	0	48	774	0	0	627	24	0	0	0	0	0	0	0	1472	1.90
1957	289	0	0	21	136	0	0	257	35	0	0	0	0	0	0	0	449	1.55
1958	960	0	1	0	2145	1	0	389	75	0	0	32	0	0	0	0	2643	2.75
1959	2209	0	0	1	979	10	0	398	359	0	1	55	0	0	2	0	1805	0.82
1960	1016	0	6	0	1474	0	0	1039	106	0	2	105	1	0	0	0	2732	2.69
1961	461	0	0	10	255	0	0	1183	24	0	2	20	0	1	1	0	1495	3.24
1962	874	1	2	0	992	1	2	340	116	0	6	43	0	0	0	0	1503	1.72
1963	721	0	0	0	536	1	0	769	76	0	0	46	0	0	0	0	1427	1.98
1964	1076	0	1	6	452	0	0	347	338	0	0	74	0	0	2	0	1219	1.13
1965	675	2	1	8	472	1	0	999	90	0	0	213	0	0	1	0	1787	2.65
1966	1209	0	7	29	974	0	0	988	46	0	7	69	0	0	1	0	2122	1.76
1967	516	0	3	21	642	0	0	269	75	0	2	80	0	0	0	0	1090	2.11
1968	649	0	1	0	514	0	0	565	5	0	4	19	0	0	0	0	1108	1.71
1969	604	0	0	4	57	0	0	445	201	0	10	116	0	0	0	0	834	1.38
1970	1162	0	2	0	1539	0	0	1002	231	0	0	26	0	0	0	0	2799	2.41
1971	851	3	0	18	456	0	0	576	198	0	1	49	0	0	0	0	1301	1.53
1972	431	2	1	22	779	0	0	631	32	0	20	27	0	0	0	0	1514	3.51
1973	330	1	1	0	213	0	0	1148	74	0	3	44	0	0	0	0	1484	4.50
1974	1709	0	3	6	2956	4	0	1698	421	0	5	71	0	0	0	0	5164	3.02
1975	1270	13	47	12	1592	2	0	1977	406	0	2	734	0	0	0	0	4784	3.77
1976	817	0	3	0	2278	3	0	2589	572	0	10	265	0	0	0	0	5721	7.00
1977	562	0	20	0	1029	0	0	2173	40	0	0	26	2	0	0	0	3289	5.85
1978	2267	0	0	0	1364	3	0	1029	784	0	12	96	0	0	0	0	3288	1.45
1979	1706	0	10	0	2643	0	0	1491	24	0	1	13	0	0	0	0	4182	2.45
1980	2969	0	0	0	453	0	0	978	72	0	1	101	0	0	0	0	1606	0.54
1981	1233	0	0	0	626	0	0	1137	60	0	0	86	0	0	0	0	1909	1.55
1982	976	0	4	0	522	0	0	765	121	0	12	14	0	0	0	0	1438	1.47
1983	1361	0	1	5	1940	0	2	1154	15	0	2	75	0	0	0	0	3194	2.35
1984	1003	0	0	0	586	0	2	1340	32	0	15	23	0	0	0	0	1998	1.99
1985	939	8	3	15	1127	0	1	1390	29	0	2	12	0	1	0	0	2587	2.76
1986	819	7	2	25	1179	0	1	1970	70	0	12	64	0	0	0	0	3330	4.07
1987	1337	25	0	30	1334	0	14	756	98	0	8	92	0	1	0	0	2360	1.77
1988	867	4	1	8	1613	0	3	1425	90	0	15	34	0	0	0	0	3193	3.68
1989	1186	1	4	16	2293	0	0	1922	13	0	2	39	0	0	0	0	4288	3.62
1990	1069	10	1	10	1104	1	3	1208	286	0	2	169	0	0	0	0	2794	2.61
1991	1160	0	12	9	2633	0	0	2466	54	0	65	71	0	0	0	0	5312	4.58
1992	1286	10	1	57	2398	0	2	1674	90	0	0	49	0	0	1	0	4283	3.33
1993	1176	14	0	3	1715	0	9	1161	129	0	3	193	0	0	0	0[a]	3227[a]	2.74
1994	1472	0	10	0	2747	1	0	2015	446	0	2	91	0	0[a]	0[a]	0[a]	5311[a]	3.61
1995	1482	1	5	0	3499	0	0	2592	149	0	0[a]	87[b]	0[a]	0[a]	0[a]	0[a]	6246[a]	4.21
1996	1650	0	0	0	2702	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	2702[a]	
1997	1512																	
1998	1756																	
1999	1512																	
2000	1300																	
56-95 AVG	1,087				1,276			1,172	153			86					2,707	2.69
56-72 AVG	852				775			637	119			57					1,606	2.05
73-95 AVG	1,261				1,645			1,568	177			106					3,521	3.17

[a] Incomplete returns from brood year escapement.
[b] Estimated 1998 return of age-2.3 so the 1995 brood year could be used.

Appendix B.7. Igushik River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

		Return by Age Class																
Brood Year	Escapement	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1956	400	0	0	0	169	0	0	523	12	0	3	36	0	0	0	0	743	1.86
1957	130	0	0	0	2	0	0	35	19	0	0	20	0	0	0	0	76	0.58
1958	107	0	0	0	14	0	0	71	20	0	0	28	0	0	0	0	133	1.24
1959	644	0	0	0	101	0	0	155	93	0	0	22	0	0	0	0	371	0.58
1960	495	0	0	1	61	0	0	310	44	0	0	57	0	0	0	0	473	0.96
1961	294	0	0	1	33	0	1	364	20	0	0	17	0	0	0	0	436	1.48
1962	16	0	0	8	20	0	0	280	9	0	0	9	0	0	0	0	326	20.38
1963	92	0	0	3	254	0	0	190	36	0	0	25	0	0	0	0	508	5.52
1964	129	0	0	1	162	0	0	585	133	0	0	49	0	0	0	0	930	7.21
1965	181	0	0	0	371	0	0	436	203	0	0	80	0	0	0	0	1,090	6.02
1966	206	0	0	0	66	0	0	383	6	0	0	15	0	0	0	0	470	2.28
1967	282	0	0	3	57	0	0	90	13	0	0	12	0	0	0	0	175	0.62
1968	195	0	0	0	43	0	0	120	0	0	2	10	0	0	0	0	175	0.90
1969	512	0	0	0	1	0	0	131	301	0	2	103	0	0	0	0	538	1.05
1970	371	0	0	1	26	0	0	170	41	0	0	71	0	0	0	0	309	0.83
1971	211	0	0	1	48	0	0	164	60	0	0	30	0	0	0	0	303	1.44
1972	60	0	0	4	89	0	0	109	6	0	8	13	0	0	0	0	229	3.82
1973	60	0	0	0	19	0	0	650	25	0	2	29	0	0	0	0	725	12.08
1974	359	0	0	7	441	1	0	750	346	0	4	25	0	0	0	0	1,574	4.38
1975	241	0	0	0	783	0	0	2,556	137	0	2	503	0	0	0	0	3,981	16.52
1976	186	0	0	0	551	3	0	1,411	194	0	20	215	0	0	0	0	2,394	12.87
1977	96	0	0	6	294	0	0	1,689	9	0	8	9	0	0	0	0	2,015	20.99
1978	536	0	0	0	96	0	0	330	84	0	1	15	0	0	0	0	526	0.98
1979	860	0	0	0	422	0	0	406	13	0	0	5	0	0	0	0	846	0.98
1980	1988	0	0	0	20	0	0	271	25	0	0	56	0	0	0	0	373	0.19
1981	591	0	0	0	188	0	0	779	8	0	1	49	0	0	0	0	1025	1.73
1982	424	0	0	7	57	0	0	434	9	0	2	10	0	0	0	0	518	1.22
1983	180	1	0	0	151	0	0	353	8	0	2	29	0	0	0	0	544	3.02
1984	185	0	0	0	41	0	0	641	56	0	5	36	0	1	0	0	781	4.22
1985	212	0	0	7	515	0	0	938	86	0	7	79	0	1	0	0	1633	7.70
1986	308	3	0	14	236	0	1	2231	27	0	15	30	0	0	0	0	2557	8.30
1987	169	2	0	11	158	0	0	587	7	0	12	29	0	0	0	0	804	4.76
1988	170	0	0	1	189	0	1	1056	41	0	3	36	0	0	0	0	1327	7.81
1989	462	0	0	15	508	0	0	1119	59	0	7	53	0	0	0	0	1760	3.81
1990	366	1	0	3	159	0	0	1429	183	0	4	146	0	0	0	0	1925	5.26
1991	756	0	0	1	318	0	0	1314	3	0	5	20	0	0	0	0	1661	2.20
1992	305	0	0	3	44	0	0	148	8	0	0	26	0	0	0	0	230	0.75
1993	406	0	0	1	132	0	2	316	20	0	0	36	0	0	0	0[a]	506[a]	1.25
1994	446	0	0	0	238	0	0	875	96	0	1	29	0	0[a]	0[a]	0[a]	1238[a]	2.78
1995	473	0	0	0	677	0	0	1650	16	0	0[a]	34[d]	0[a]	0[a]	0[a]	0[a]	2343[a]	4.95
1996	401	0	0	0	175	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	175[a]	
1997	128																	
1998	216																	
1999	446																	
2000	413																	
56-95 AVG	353				194			651	62			52					964	4.64
56-72 AVG	254				89			242	60			35					429	3.34
73-95 AVG	425				271			954	63			65					1,360	5.60

[a] Incomplete returns from brood year escapement.
[b] Estimated 1998 return of age-2.3 so the 1995 brood year could be used.

Appendix B.8. Nushagak River sockeye salmon escapement and return by brood year, in thousands, 1956-1995.

		Return by Age Class																
Brood Year	Escapement	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	3.1	1.4	2.3	3.2	2.4	3.3	3.4	Total	Return/ Spawner
1978	664			436	100	0	149	779	20	0	1	6	0	1	0		1,491	2.24
1979	499	18	0	466	494	0	16	854	6	0	42	5	0	0	0		1,901	3.81
1980	3,317	19	0	447	84	0	67	344	162	0	4	156	0	0	0	0	1,284	0.39
1981	1,012	9	0	137	170	0	14	1,476	2	0	86	32	0	0	0	0	1,926	1.90
1982	601	35	0	351	164	0	49	894	2	0	62	7	0	0	0	0	1,563	2.60
1983	404	100	0	608	114	0	122	553	6	0	16	3	0	0	0	0	1,521	3.77
1984	593	10	0	226	51	0	32	566	2	0	20	6	0	0	0	0	912	1.54
1985	498	68	0	510	64	0	62	612	6	0	13	16	0	1	0	0	1,351	2.71
1986	990	68	0	837	114	0	58	676	0	0	182	64	0	0	0	0	1,999	2.02
1987	388	140	0	933	36	0	253	535	36	0	101	10	0	1	0	0	2,047	5.28
1988	483	68	0	546	214	0	120	1,426	12	0	62	8	0	0	0	0	2,457	5.09
1989	513	68	0	483	124	0	35	703	1	0	18	4	0	0	0	0	1,436	2.80
1990	680	53	0	761	36	0	104	253	18	0	11	7	0	4	0	0	1,247	1.83
1991	493	10	1	137	172	0	6	1,010	3	0	131	19	0	0	0	0	1,491	3.03
1992	695	85	0	496	228	0	11	650	9	0	63	11	0	0	0	0	1,551	2.23
1993	715	43	0	43	63	0	2	803	1	0	119	51	0	0	0	0[a]	1,126[a]	1.57
1994	509	0	0	55	81	0	2	687	6	0	9	54	0	0[a]	0[a]	0[a]	894[a]	1.76
1995	281	5	1	6	148	0	0	931	35	0	0[a]	40[b]	0[a]	0[a]	0[a]	0[a]	1,165[a]	4.14
1996	504	0	0	6	504	0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	510[a]	1.01
1997																		
1998																		
1999																		
2000																		
78-95 AVE	741	47		415	136		61	764			52	28					1,520	2.71

[a] Incomplete returns from brood year escapement.
[b] Estimated 1998 return of age-2.3 so the 1995 brood year could be used.

Appendix B.9. Nushagak chinook salmon escapement and return by brood year, 1966-1995.

Brood Year	Spawners	Return by Age Class 0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	2.4	1.6	2.5	Total Return	Return per Spawner
1966	40,000	149	62	7,406	13,979	0	4,668	27,454	0	0	38,557	130	0	5,044	376	1,043	342	99,210	2.48
1967	65,000	0	0	283	9,795	0	1,575	16,353	76	188	46,066	380	0	24,552	342	275	0	99,885	1.54
1968	70,000	0	0	834	13,485	0	376	18,291	0	0	67,765		0	8,368	542	0	0	109,661	1.57
1969	35,000	230	0	384	965	0	0	14,524	0	0	29,429	808	0	2,430	268	0	0	49,038	1.40
1970	50,000	0	0	0	1,385	0	0	56,699	0	0	73,517	1,323	0	4,043	874	0	847	138,688	2.77
1971	40,000	0	0	0	2,433	0	389	55,755	501	0	94,828	1,266	0	12,572	6,976	0	0	174,720	4.37
1972	25,000	0	0	137	33,264	0	686	52,295	0	0	125,392	2,842	0	7,275	7,489	0	0	229,380	9.18
1973	35,000	0	0	0	2,204	0	0	82,126	0	0	105,777		0	13,089	0	0	0	203,196	5.81
1974	70,000	0	0	431	23,817	0	0	42,053	2,175	0	51,264		0	2,174	3,078	0	0	124,992	1.79
1975	70,000	0	587	0	95,530	0	0	146,534	0	0	137,063	3,614	0	9,963	7,149	0	0	400,440	5.72
1976	100,000	0	1,576	0	7,628	0	0	111,415	839	0	143,981	8,701	0	6,052	1,171	116	0	281,479	2.81
1977	65,000	0	0	0	96,260	0	0	152,290	3,400	0	208,444	231	0	14,837	0	74	0	475,536	7.32
1978	130,000	0	1,738	0	27,569	0	0	46,773	402	0	56,434		0	22,029	0	0	110	155,055	1.19
1979	95,000	0	3,137	0	49,377	0	0	70,843	0	0	87,467		0	11,862	689	0	0	223,375	2.35
1980	141,000	0	205	0	11,241	0	0	48,427	0	0	56,050	439	0	3,045	0	0	0	119,407	0.85
1981	150,000	0	967	0	33,684	37	0	45,639	221	0	83,042		0	7,327	23	0	0	170,940	1.14
1982	147,000	0	1,494	0	3,770	0	0	35,478	0	0	31,858		0	5,759	0	0	0	78,359	0.53
1983	161,730	0	118	0	17,639	0	339	20,443	0	0	51,470		0	1,454	0	0	0	91,463	0.57
1984	80,940	0	682	0	17,260	0	0	27,219	0	0	21,995		0	1,826	189	0	0	69,171	0.85
1985	115,720	0	3,205	0	17,996	0	0	37,014	0	0	44,987		0	2,065	143	0	0	105,410	0.91
1986	35,200	0	22	0	26,874	0	0	51,108	0	0	45,980	285	0	1,936	118	0	0	126,323	3.59
1987	78,217	0	514	0	36,476	0	0	54,908	80	0	69,526		0	5,019	96	0	0	166,619	2.13
1988	50,803	0	688	31	36,470	0	0	62,013	0	0	105,738		0	2,088	174	0	0	207,202	4.08
1989	73,095	143	2,137	0	40,966	0	0	84,843	0	0	85,767		0	3,471	166	0	0	217,493	2.98
1990	57,549	0	593	0	31,752	0	0	34,881	0	0	34,192		0	609	0	0	0	102,027	1.77
1991	96,162	0	1,477	0	53,690	0	0	71,742	0	0	57,258		0	3,853	0	0	0	188,020	1.96
1992	76,258	0	913	228	27,482	0	0	50,728	0	0	86,867	46	0	642	0	0	0	166,906	2.19
1993	88,550	0	2,159	166	50,015	0	0	128,277	94	0	37,709	0	0	1,930	0	0	0	220,350	2.49
1994	83,308	0	1,072	0	20,644	0	0	23,085	0	0	29,457	0	0	4,538	0	0	0	78,796	0.95
1995	79,147	0	1,046	0	11,380	0	0	21,223	0									33,649	0.43
1996	47,928	0	477	0	15,563	0													
1997	82,000	0	257																
1998	111,095																		
1999	62,331																		
2000	56,372																		
Mean (all)	80,191		805		27,712			57,559			72,686	1,433		6,547	1,030			168,039	2.66

Appendix C.1. Kvichak River numbers of sockeye salmon smolt and adult returns by brood year, 1969-95.

Brood Year	Spawners	Total Smolt	Adult Return	Smolt/ Spawner	Marine Survival
1969	8,394,204	139,882,770	5,304,000	16.66	0.04
1970	13,935,306	195,225,917	15,834,000	14.01	0.08
1971	2,387,392	26,546,646	2,829,000	11.12	0.11
1974	4,433,844	222,626,740	26,180,000	50.21	0.12
1975	13,140,450	291,672,721	38,086,000	22.20	0.13
1976	1,965,282	58,649,892	10,575,000	29.84	0.18
1977	1,341,144	39,168,658	3,238,000	29.21	0.08
1978	4,149,288	214,737,076	5,160,000	51.75	0.02
1979	11,218,434	309,228,935	42,142,000	27.56	0.14
1980	17,505,268	226,665,799	13,048,000	12.95	0.06
1981	1,754,358	44,145,112	2,130,000	25.16	0.05
1982	1,134,840	53,833,461	1,686,000	47.44	0.03
1983	3,569,982	76,975,111	13,391,000	21.56	0.17
1984	10,490,670	414,898,140	23,950,000	39.55	0.06
1985	7,211,046	98,212,937	17,421,000	13.62	0.18
1986	1,179,322	19,957,080	4,558,000	16.92	0.23
1987	6,065,880	188,037,688	12,045,000	31.00	0.06
1988	4,065,216	80,835,990	9,992,000	19.88	0.12
1989	8,317,500	148,505,069	26,187,000	17.85	0.18
1990	6,970,020	222,799,579	25,108,000	31.97	0.11
1991	4,222,788	51,988,277	4,802,000	12.31	0.09
1992	4,725,864	64,672,348	1,420,000	13.68	0.02
1993	4,025,166	306,292,537	2,936,000	76.09	0.01
1994	8,337,840	370,781,942	6,962,000	44.47	0.02
1995	10,038,720	372,829,148	10,250,000	37.14	0.03
1996	1,450,578	204,190,128			
1997	1,503,732	155,202,138			
1998	2,296,074				
1999	6,196,914				
2000	1,827,780				
Avg 69-95	6,423,193	169,566,783	12,583,615	28.57	0.09

Appendix C.2. Egegik River numbers of sockeye salmon smolt and adult returns by brood year, 1980-95.

Brood Year	Spawners	Total Smolt	Adult Return	Smolt/ Spawner	Marine Survival
1980	1,060,920	66,179,555	8,576,000	62.38	0.13
1981	694,680	34,530,912	6,317,000	49.71	0.18
1982	1,034,628	28,669,681	6,340,000	27.71	0.22
1983	792,282	84,655,055	10,646,000	106.85	0.13
1984	1,165,320	59,483,908	13,527,000	51.05	0.23
1985	1,095,204	17,236,372	7,672,000	15.74	0.45
1986	1,151,320	63,469,761	14,331,000	55.13	0.23
1987	1,272,978	125,153,934	25,952,000	98.32	0.21
1988	1,599,096	93,318,905	18,885,000	58.36	0.20
1989	1,610,916	21,895,567	11,261,000	13.59	0.51
1990	2,191,362	43,787,169	15,740,000	19.98	0.36
1991	2,786,880	59,373,530	11,163,000	21.30	0.19
1992	1,945,332	105,939,012	9,698,000	54.46	0.09
1993	1,516,980	15,704,159	3,001,000	10.35	0.00
1994	1,897,932	37,863,769	8,783,000	19.95	0.23
1995	1,265,862	39,894,363	9,033,000	31.52	0.23
1996	1,076,460	57,897,336			
1997	1,104,004	32,000,983			
1998	1,110,882				
1999	1,727,772				
2000	1,032,138				
Avg. 80-95	1,405,041	56,072,228	11,307,813	43.52	0.22

Appendix C.3. Ugashik River numbers of sockeye salmon smolt and adult returns by brood year, 1981-95.

Brood Year	Spawners	Total Smolt	Adult Return	Smolt/ Spawner	Marine Survival
1981	1,328,000	113,954,425	7,468,000	85.81	0.07
1982	1,186,000	96,899,011	2,508,000	81.70	0.03
1983	1,001,000	27,881,406	1,965,000	27.85	0.07
1984	1,270,000	59,383,477	5,464,000	46.76	0.09
1985	1,006,000	38,700,560	2,696,000	38.47	0.07
1986	1,016,000	214,998,421	6,697,000	211.61	0.03
1987	687,000	132,808,766	6,746,000	193.32	0.05
1988	654,000	62,551,046	5,651,000	95.64	0.09
1989	1,713,000	26,056,791	4,572,000	15.21	0.18
1990	749,000	12,415,518	4,611,000	16.58	0.37
1991	2,482,000	64,057,099	6,150,000	25.81	0.10
1992	2,195,000	39,577,888	2,703,000	18.03	0.07
1993	1,413,000	8,390,955	1,086,000	5.94	0.13
1994	1,095,000	2,347,136	1,660,000	2.14	0.72
1995	1,321,000	16,611,933	4,585,000	12.58	0.28
1996	692,167	10,388,526			
1997	656,641	19,422,155			
1998	924,853				
1999	1,662,042				
2000	638,420				
Avg. 81-95	1,213,248	61,108,962	4,304,133	58.50	0.15