2A97-30

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

by

Beverly A. Cross

Daniel C. Gray

Drew L. Crawford

REGIONAL INFORMATION REPORT[1] NO. 2A97-30

Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
Central Region
333 Raspberry Road
Anchorage, Alaska 99518

October 1997

---

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without approval of the author or the Division of Commercial Fisheries Management and Development.

AUTHORS

Beverly A. Cross is a Region II Bristol Bay Research Project Leader for Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

Daniel C. Gray is a Region II Bristol Bay Research Biologist for Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

Drew L. Crawford is a Region II Bristol Bay Research Biologist for Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Road, Anchorage, AK 99518.

ACKNOWLEDGMENTS

We would like to thank all the individuals who participated in the evaluation of spawning escapement goals for Bristol Bay salmon. Dr. Stephen Fried (ADF&G, Regional Research Supervisor) provided guidance throughout the evaluation process and reviewed the final report. Brian Bue (ADF&G, Regional Biometrician) provided technical supervision throughout the evaluation process and analyzed spawner-return data for Kvichak, Wood, and Nushagak Rivers. Tim Baker (ADF&G, Regional Biometrician) prepared all the final graphs for the report. I would also like to thank Dana Schmidt (ADF&G, Chief Limnologist) for presenting an in-depth analysis of Lake Iliamna limnological and juvenile data. Dr. Ray Hilborn (Fisheries Research Institute, University of Washington) provided a risk analysis of various escapement goal scenarios for Kvichak River and also contributed new ideas for future investigations. I would like to give special acknowledgment to Dr. Donald E. Rogers (Fisheries Research Institute, University of Washington) for sharing his in-depth knowledge of Bristol Bay and for his compilation and analysis of historic data. I would also like to thank Dr. Ole Mathisen (School of Fisheries and Ocean Sciences, University of Alaska) for sharing his information on limnological studies of Becharof and Ugashik Lakes. Finally we would like to thank the area managers (Tom Brookover, Jim Browning, Jeff Regnart, Keith Weiland) for sharing their knowledge of fishery interactions.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF APPENDICES

ABSTRACT

A workshop was held on September 16-18, 1997 in Anchorage by the Alaska Department of Fish and Game to review Pacific salmon *Oncorhynchus* escapement goals for major rivers in Bristol Bay. Spawner-return data were analyzed for Kvichak, Naknek, Egegik, Ugashik, Wood, Igushik, Nushagak, and Togiak Rivers sockeye salmon *O. nerka.* Sockeye smolt information was reviewed for Kvichak, Egegik, and Ugashik Rivers. Available limnological and juvenile information were analyzed from Lake Iliamna. In addition, spawner-return data for Nushagak River chinook salmon O. *tshawytscha* were also reviewed.

With a few exceptions available data supported current escapement goals in Bristol Bay. Based on this most recent escapement goal evaluation, workshop participants recommended the following changes. They recommended restructuring the escapement goal policy for Kvichak River sockeye salmon to a more robust variable escapement goal. Analyses of available data were inconclusive as to whether the underlying cause of cycles in Kvichak River sockeye production were due to inherent depensatory factors or lack of spawners. The recommended policy included an off-cycle escapement range of 2-10 million sockeye salmon with a minimum goal of 2 million and an exploitation rate of 50% on runs of 4 - 20 million. The point goal for a given off-cycle year would be 50% of the inshore Kvichak run but never less than 2 million or greater than 10 million. A 6 -10 million escapement range was proposed for pre-peak and peak cycle years with a minimum of 6 million and an exploitation rate of 50% on runs of 12 - 20 million. The point goal for a given pre-peak or peak cycle year would be 50% of the inshore Kvichak run but never less than 6 million or greater than 10 million.

Workshop participants also recommended managing for escapements within the middle of the current escapement goal ranges for Naknek, Egegik, and Ugashik Rivers. The current management objectives or point goals for those rivers are artifacts of past Ricker stock-recruitment models and are no longer supported by the data. Therefore, it was recommended that the management objectives be changed to 1.1 million sockeye salmon for Naknek River, 1.1 million sockeye salmon for Egegik River, and 0.85 million sockeye salmon for Ugashik River. The final recommendation coming out of the workshop was that the sockeye escapement goal range for Togiak River be changed to 100 - 200 thousand sockeye salmon. Available data supported the current management objective of 150 thousand sockeye salmon for Togiak River, but indicated an escapement range of 100 - 200 thousand would on average produce higher yields.

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 42.2 million for the last 10 years. Nine major river systems produce 98% of the sockeye salmon returning to Bristol Bay: Kvichak, Branch, Naknek, Egegik, Ugashik, Wood, Igushik, Nushagak, and Togiak Rivers (Figure 1). Management of Bristol Bay sockeye runs is based on achieving escapements for each river within a specific escapement goal range. Individual escapement goals have been used for major rivers since the early 1960's. The Alaska Department of Fish and Game (ADF&G) reviews existing biological escapement goals for Bristol Bay rivers on a schedule which corresponds to the Alaska Board of Fisheries triennial cycle for considering area regulatory proposals.

This report summarizes results from the most recent formal evaluation of Bristol Bay sockeye escapement goals, conducted September 16-18, 1997 at the ADF&G office in Anchorage. The meeting was attended by 27 people representing the following organizations: ADF&G, Commercial Fisheries Management and Development Division (Headquarters, Region 2, Bristol Bay Area, and Limnology Laboratory staff); ADF&G, Sport Fish Division (Region 2 and Bristol Bay Area staff); 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 Kvichak, Naknek, Egegik, Ugashik, Wood, Nushagak, Igushik, and Togiak Rivers, and chinook salmon in Nushagak River. Based on this review, biological escapement goal modifications were adopted for sockeye salmon in the Kvichak, Naknek, Egegik, Ugashik and Togiak Rivers.

METHODS

Sockeye Salmon

Spawner-Return Data

Sockeye spawner-return data were analyzed for brood years 1956-1992 for Kvichak, Naknek, Egegik, Ugashik, Wood, Igushik, and Togiak Rivers. Spawner-return data for Nushagak River were only available for brood years 1978-1992. Return information for brood year 1992 was incomplete because six-year-old sockeye salmon do not return until 1998. 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 1992 brood year and the historic relationship between age-2.3 and age-2.2 sockeye salmon.

Methods used to estimate total runs are described by Menard (1997). Numbers of spawners within each river, except Nushagak River, were based on visual counts from towers located below lake outlets. Sockeye escapement into Nushagak River was estimated with side-scan sonar. Annual runs were the sum of tower or sonar counts, and harvests. 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 (Cross *In press).* 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 also used to examine stock-recruitment relationships. For this approach available spawning escapements and returns were arranged into intervals. The proportion of times that a spawning population size within a specific interval produced a recruitment within each recruitment interval was calculated. Average yield within each interval, estimated as recruitment minus parental spawning escapement, was also calculated.

Smolt Information

Smolt production was examined in systems for which this information had been collected. Numbers of sockeye smolt have been counted with hydroacoustic equipment within the Kvichak River since 1971, Egegik River since 1982, and Ugashik River since 1983 (Crawford and Cross 1997). 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. Surveys have been flown by ADF&G staff since 1988, and results are reported each year, including records dating back to 1955 (Regnart 1997). 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 1966-1991 for Nushagak River. Return information for brood year 1991 was incomplete because seven-year-old chinook salmon will not return until 1998. Since this age group 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 1991 brood year and the historic relationship between age-1.4 and age-1.5 chinook salmon

Chinook escapements into Nushagak River were estimated with aerial surveys from 1966-1985 and 1997 and with side-scan sonar from 1986-1996. 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 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 (Ricker 1975) were fitted to chinook 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 information on the proportion of times a spawning

population size within a specific interval produced a recruitment within each recruitment interval as well as the average yield within each interval.

RESULTS

In general, sockeye salmon spawner-return data for Kvichak, Naknek, Egegik, and Ugashik Rivers did not show density dependent mortality, which is a basic assumption of most stock-recruitment models.

Density dependent mortality may not be evident in Bristol Bay east side spawner-return data if there were few or no data points at large enough escapement levels; freshwater or marine production has changed over time; or factors in addition to numbers of spawners have greatly affected survival. Because stock-recruitment models did not describe relationships between numbers of spawners and numbers of returns for most east side rivers, we were unable to estimate the number of spawners required to produce maximum sustained yield (MSY). Instead, spawner-return data were analyzed less formally to determine escapement goals which would produce high sustainable yields.

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 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 which 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 escapement goal evaluation meetings have been held, including the 1997 meeting documented within this report. Results from the 1987, 1991, and 1994 meetings have also been presented to the Board of Fisheries (Cross 1991, Cross 1994).

The Kvichak escapement goal policy adopted in 1987 and continued through 1997 has allowed annual spawning escapement goals to fluctuate within a range of 4 million to 10 million sockeye salmon. The lower limit of 4 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 4 million and 10 million. We now have five returns from off-cycle escapements within the 4 million - 6 million range. Two of those brood years (1987 and 1988) produced good runs ranging from 10 million - 12 million, while the remaining three brood years produced poor runs ranging from 2 million - 5 million.

Spawner-Return Data

The number of Kvichak River spawners has ranged from 0.2 million in 1973 to 24.3 million in 1965; while 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 1956-1992 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). Average number of spawners for pre-peak and peak cycle years has been 11 million, and average number of returning adults has been 28 million. Average number of spawners for off-cycle years has been 3 million, and average number of returning adults have been 5 million. There has been little overlap in spawning population sizes between off-cycle (range: 0.2 million - 6.1 million) and peak (range: 4.4 million - 24.3 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 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 2.5 for all available brood years (Figure 3; Appendix Table B.1). Overall return-per-spawner values have increased slightly since brood year 1972 (Figure 3). Average return-per-spawner value was 1.9 during 1956-1972 and increased to 3.0 during 1973-1989. Additionally, return-per-spawner values fell below replacement for six of 17 brood years (38%) during 1956-1972; while return-per-spawner values only fell below replacement for 2 of 19 brood years (10%) during 1973-1992. When viewing the entire series of

available brood years, no other distinct trends between return-per-spawner values and numbers of spawners. were obvious. In fact, since return-per-spawner values did not decrease as escapements increased, density dependent mortality was not evident (Figure 3). No strong trends were seen 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 1960-1992. Average return per spawner for off-cycle brood years was 2.4, while the average for pre-peak and peak cycle brood years was 2.9 (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, return- per-spawner value was slightly lower for off-cycle brood years than it was for pre-peak and peak brood years, even though 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). However, a Ricker model did produce a significant fit (P=0.03) to off-cycle spawner-return data, and indicated that MSY was achieved with 2.0 million spawners (Figure 6). A Ricker model also produced a significant fit (P=0.09) to pre-peak and peak spawner-return data, and indicated that MSY was achieved at 10 million spawners (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 - 24.3 million), off-cycle years within the available data set have had much smaller escapements (range: 0.2 million - 6.1 million) than pre-peak and peak years (range: 4.4 million - 24.3 million) years. The lack of contrast in number of spawners for both these 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 less than 2 million (7 observations) produced the greatest average surplus yield (2.3 million) for the off-cycle brood years (Figure 7).. Spawning levels 2 million- 4 million (7 observations) and 4 million - 6 million (four observations) produced lower average yields (less than 2.0 million). There was only one available off-cycle brood year for which the spawning population was greater than 6 million, and this escapement produced a relatively good yield (6.0 million). Overall, relatively poor yields have been obtained (average: 1.1 million) from the four escapements falling within the existing biological escapement goal range for off-cycle years (4 million - 6 million). We had no observations within that range when we increased the off-cycle escapement goal in 1985, but available information suggested that the limitation on off-cycle production was due to a lack of spawners rather than an inherent depensatory factor. Although we now have five observed returns from off-cycle escapements greater than 4 million spawners, it is still not clear whether achieving a minimum goal of 4 million spawners during off-cycle years will increase future yield.

Average surplus yields for pre-peak and peak years were more similar across spawning levels than those for off-cycle years (Figure 7). Spawning populations greater than 12 million (5 observations) produced the greatest average surplus yield (16.7 million) for the data set containing only pre-peak and peak years. Spawning populations between 6 million and 12 million and less than 6 million produced decreasing average yields (less than 14.6 million). The current escapement goal for pre-peak and peak cycle years is 6 million - 10 million. The 6 million minimum was set 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

For the past three years, large numbers of smolt were estimated to have migrated from the Kvichak River. (Figure 8). Most of those smolt were age-1, while previous large smolt migrations have been predominantly age-2 smolt. 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). Brood years which experience unusually warm weather (1992-1995) have produced greater proportions of age-1. smolt.

There was a significant ($P<0.005$) positive relationship between numbers of smolt and numbers of spawners for all brood year (Appendix Table C.1 and Figure 9). There was also a significant ($P<0.005$) 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 ($P=0.03$; Figure 10) smolt. With the exception of brood years 1978, 1987, and 1993, most off-cycle brood years have produced 50 million or fewer smolt. High smolt production from off-cycle brood years has predominantly been age-1. smolt from spawning escapements of 4 million or more sockeye salmon. Therefore smolt information suggested that smolt production may be increased by allowing greater numbers of sockeye salmon to spawn during off-cycle years. A significant relationship was not found between numbers of smolt and numbers of spawners for pre-peak and peak years (Figure 10). Most pre-peak and peak years produced more than 100 million smolt, and brood years with escapements in the 10 million to 12 million range produced more than 250 million smolt.

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 107 mm for off-cycle brood years and 100 mm for pre-peak and peak brood years. Similarly, average weight of off-cycle age-1. smolt was 6.0 g and of pre-peak and peak cycle age-1. smolt was 5.3 g. Average weight of off-

cycle age-2. smolt was 10.7 g and of pre-peak and peak cycle age-2. smolt was 8.7 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 26, similarly the average value for pre-peak and peak brood years was 25 smolt per spawner (Appendix C.1). The rate of smolt production was not different between off-cycle years compared to pre-peak and peak years which indicated 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 1965-1994. 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 probably quickly 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 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 lack off spawners.

Analysis of spawner-return data in which off-cycle brood years were examined separately, suggested that yield decreased during off-cycle years for escapements greater than 3 million - 4 million. The five observations from off-cycle escapements greater or equal to 4 million produced lower than expected. Spawner distribution information indicated that cycles appeared to be very pronounced for island beaches. These 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 there is a great deal of uncertainty in what levels of escapement will optimize Kvichak River's production every year. Unless additional information is collected which 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

While no one present wanted to return to a static 2 million goal for off-cycle years, there was no consensus that maintaining the existing escapement goal floor of 4 million would result in increased yield. There was a consensus among all workshop participants that the current 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 escapement goal range for Kvichak River during off-cycle years was changed from 4 million - 6 million to a broader range of 2 million - 10 million. Additionally, an exploitation rate of 50% was set on runs of 4 million - 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 inshore Kvichak run, and would never be less than 2 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. The current escapement goal range for Kvichak River during pre-peak and peak cycle years was retained at 6 million -10 million. As was done for off-cycle years, an exploitation rate of 50% was set on runs of 12 million - 20 million. The management objective for a given pre-peak or peak cycle year would then be defined as 50% of the inshore Kvichak run, and would never be less than 6 million or greater than 10 million.

Naknek River Sockeye Salmon

Spawner-Return Data

The current biological escapement goal for Naknek River is 1.0 million sockeye salmon and the range is 0.8 million - 1.4 million (Table 3). 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 biological

escapement goal 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 3.0 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 which averaged 2.7 from 1956-1972 and 3.3 from 1973-1992 (Figure 14). Return-per-spawner values have only fallen below replacement twice: in 1959 and 1968. Return-per-spawner values for brood years 1991 and 1992, the most recent returns, were the lowest since brood year 1983. Returns from these brood years came from very large consecutive escapements in 1990, 1991, and 1992 (2.1, 3.6, and 1.6 million). The relationship between return-per-spawner values and numbers of spawners showed only slight density dependent mortality (Figure 14). Slightly lower than average return-per-spawner values were produced by escapements greater than 2.0 million.

Large returns have been produced from escapements ranging from 0.8 million to 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 did not fit a Ricker stock-recruitment model, so we were unable to estimate the number of spawners required to produce MSY with this method. However, spawning escapements from 1.0 million to 2.0 million have, on average, produced large returns (Figure 15). Brood years with escapements greater than 1.4 million, the current upper range of the biological escapement goal, have produced some large returns. However, successive large escapements, as occurred in 1990, 1991, and 1992, may result in decreased returns, as was observed for the 1991 and 1992 brood years.

Yield Analysis

Average surplus yield was greatest (4.2 million) from spawning escapements ranging from 1.4 million - 2.0 million, for which there have been five observations (Figure 16) One of these observations was brood year 1986 which had an escapement of 2.0 million and a record return of 13.7 million. Average surplus yield from the other four observations was 2.4 million, which was similar to 2.3 million average yield obtained from 27 escapements within the current biological escapement goal range (0.8 - 1.4 million). Although escapements above the upper end of the biological escapement range have produced large average yields, 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 biological escapement goal range of 0.8 million - 1.4 million sockeye be maintained for Naknek River (Table 3). 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.

Workshop participants also recommended that the current point goal management objective for Naknek River be changed from 1.0 million to 1.1 million sockeye salmon, which is in the middle of the escapement goal range (Table 3). The current point goal of 1.0 million is an artifact from past attempts to fit Ricker stock-recruitment models to earlier data. It is no longer supported by data analyses and is not in the middle of the current escapement goal range. There was no information which suggested that any point other than the middle of the range would on average produce higher yields. Therefore, participants felt that setting the middle of the Naknek escapement goal range as a management objective would generally secure escapements within the central portion of the range.

Egegik River Sockeye Salmon

Spawner-Return Data

The current biological escapement goal for Egegik River is 1.0 million sockeye salmon and the range is 0.8 million - 1.4 million (Table 3). 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 1). Average escapement during the last 10 years was 1.7 million sockeye salmon. Escapements during 1990-1993 were the largest successive escapements to date: 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 5.9 for all available brood years (Appendix Table B.3 and Figure 18). Egegik River sockeye salmon production increased greatly after brood year 1972 as shown by increased return-per-spawner values which averaged 3.1 from 1956-1972 and 8.2 from 1973-1992. Return-per-spawner values have never been below replacement for Egegik River. Return-per-spawner values for brood years 1991 and 1992, the most recent returns, were the lowest since brood year 1975. Returns from these brood years came from very large consecutive escapements in 1990-1993. 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. 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, spawning escapements from 1.0 million to 1.6 million have, on average, produced large returns (Figure 19). Although brood years 1988 and 1990 produced large returns from escapements above the current upper range, most other brood years (1960, 1989-1992) with large escapements showed either a decrease or leveling off of production. Successive large escapements, as occurred during 1990-1993, may result in decreased returns, as was observed for the 1991 and 1992 brood years.

Yield Analysis

Average surplus yield was greatest (10.8 million) from the two spawning escapements greater than 2.0 million (Figure 20). The next highest average yield (8.1 million) was from escapements ranging from 1.4 million - 2.0 million, for which there have been five observations. Although the seven escapements above the current upper end of the biological escapement range have produced large average yields, the last two brood years (1991 and 1992) have shown decreased yield. Escapements into Egegik River within the 1.4 - 2.0 million range may produce large returns, but successive large escapements may result in decreased production.

Smolt Information

Smolt migration from Egegik River for the past two years, 1996 and 1997, has been much below the 1983-1997 average (Figure 21). The 1993 brood year which had an escapement of 1.5 million, following escapements of 2.2 million, 2.8 million, and 1.9 million, produced only 15.5 million smolt. This was much less than the 1980-1994 average of 58.5 million smolt. Smolt production from the 1994 and 1995 brood years was also much lower than previous years.

The relationship between numbers of smolt and numbers of spawners was unclear (Appendix Table C.2 and Figure 22). Numbers of smolt emigrating from Egegik River did not clearly increase as numbers of spawners increased There appeared to be two clusters of data: smolt numbers for brood years 1980-1988 from escapements less than 1.6 million, and smolt numbers for brood years 1989-1991 from escapements greater than 1.6 million (Figure 22). Numbers of smolt produced from escapements less than 1.6 million did not increase as numbers of spawners increased, while the number of smolt produced from escapements greater than 1.6 million showed a slight linear trend. Brood year 1992 produced much greater smolt numbers from an escapement of 1.9 million than would have been predicted from the relationship described by brood years 1989-1991.

There was a significant (P=0.06) positive relationship between numbers of returning adults and numbers of smolt (Figure 22). Interestingly, although the number of smolt produced by brood year 1992 was much greater than expected, the number of returning adults from these smolt was much lower than expected based on the historic smolt-to-adult relationship. Either these smolt experienced

very low marine survival or the number of smolt estimated for the 1992 brood year was too high. 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 biological escapement goal range of 0.8 million - 1.4 million sockeye salmon be maintained for Egegik River (Table 3). The escapement goal 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.

Workshop participants also recommended that the current point goal management objective for Egegik be changed from 1.0 million to 1.1 million, which is in the middle of the escapement goal range (Table 3). This was done for same reasons it was done for Naknek River. The current point goal for Egegik River is also an artifact from past attempts to fit Ricker stock-recruitment models to earlier data. It is no longer supported by data analyses and is not in the middle of the current escapement goal range. There was no information which suggested that any point other than the middle of the range would, on average, produce higher yields. Therefore, participants felt that setting the middle of the Egegik escapement goal range as a management objective would generally secure escapements within the central portion of the range.

Ugashik River Sockeye Salmon

Spawner-Return Data

The current biological escapement goal for Ugashik River is 700 thousand sockeye salmon and the range is 0.5 million - 1.2 million (Table 3). Numbers of sockeye salmon spawners have ranged from 39 thousand in 1973 to 3.3 million in 1980 (Appendix Table B.4 and Figure 23). Average escapements during the last 10 years was 1.3 million sockeye salmon. Escapements during 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 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 4.7 for all available brood years (Appendix Table B.4 and Figure 24). Ugashik River sockeye salmon production increased significantly after brood year 1973 as shown by increased return-per-spawner values which averaged 2.1 from 1956-1972 and 6.8 from 1973-1992.

Return-per-spawner values were below replacement seven times from 1956-1972, but fell below replacement only once since 1973 which occurred for brood year 1992. The relationship between return-per-spawner values and number of spawners showed density dependent mortality (Figure 24). 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 700 thousand - 1.7 million (Figure 25). A Ricker stock-recruitment model could not be fitted to spawner-return data for the Ugashik River when all brood years (1956-1992) were examined. However, a Ricker stock-recruitment model was significant (P=.0.001) when it was fitted through recent brood years (1973-1992). The estimated number of spawners required to produce MSY based on the stock-recruitment model for 1973-1992 brood years was 1.2 million. The 1980 brood year was very influential on the shape of the stock-recruitment curve, so we omitted that year and fitted another stock-recruitment model. The estimated number of spawners to produce MSY based on the stock-recruitment model using 1973-92 and omitting 1980 was 900 thousand.

Yield Analysis

Average surplus yield was greatest (3.3 million) from spawning escapements greater than 1.2 million, for which there were eight observations (Figure 26). The next highest average yield (2.3 million) was from escapements ranging within the current range, 0.5 million - 1.2 million, for which there were 11 observations. Of the four brood years with escapements greater than 2.0 million, 1980 and 1991 produced high yields, while 1960 and 1992 produced virtually no yield (Figure 25). Analysis of observed yields indicated that escapements into the Ugashik River ranging from 1.2 million - 1.7 million could produce high yields, however the past escapements within that range were not consecutive

Smolt Information

Smolt migration from Ugashik River for the past four years, 1994-1997, have been much below the 1983-1997 average (Figure 27). We thoroughly reviewed the very low smolt count during 1996 and suspect it may be lower than actual smolt numbers due to the early spring break-up and smolt migrating prior to counting. However even if the count was erroneously low, we felt the trend of reduced smolt counts indicated for 1994-1997 was real. The 1993 brood year which had an escapement of 1.4 million, following escapements of 2.5 million and 2.2 million, produced extremely low smolt numbers. Smolt production from the 1994 and 1995 brood years was also much lower than previous years.

The relationship between numbers of smolt and numbers of spawners was unclear (Appendix Table C.3 and Figure 28). Numbers of smolt migrating from Ugashik River showed no discernible trend

with numbers of spawners. There was a moderately significant (P=0.13) positive relationship between numbers of adult returns and numbers of smolt (Figure 28).

Escapement Goal Recommendations

Workshop participants recommended that the existing biological escapement goal range of 0.5 million - 1.2 million sockeye salmon be maintained for Ugashik River (Table 3). The escapement goal 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. Recent brood year returns and smolt migrations have shown a decrease in production following large back-to-back escapements.

Workshop participants did recommend a similar strategy for Ugashik River as recommended for Naknek and Egegik Rivers. They recommended that the current point goal management objective for Ugashik be changed from 700 thousand to 850 thousand, which is in the middle of the escapement goal range (Table 3). The current point goal for Ugashik River is also an artifact from past attempts to fit Ricker stock-recruitment models to earlier data. It is no longer supported by data analyses and is not in the middle of the current escapement goal range. There was no information which suggested that any point other than the middle of the range would, on average, produce higher yields. Therefore, participants felt that setting the middle of the Ugashik escapement goal range as a management objective would generally secure escapements within the central portion of the range.

Togiak River Sockeye Salmon

Spawner-Return Data

The current biological escapement goal for Togiak River above the tower is 150 thousand sockeye salmon and the range is 140 - 250 thousand (Table 3). 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 14% 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 29). Average escapement during the last 10 years was 189 thousand sockeye salmon. Returns to Togiak River have ranged from 152 thousand for brood year 1963 to 1.2 million for brood year 1983.

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 3.4 for all available brood years (Appendix Table B.5 and Figure 30). Togiak sockeye salmon production did not show an overall increase during the more recent brood years. Average return-per-spawner value for brood years 1956-1972 was 3.2, while the average for 1973-1992 was 3.5. 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 did show density dependent mortality (Figure 30). Large escapements, especially those greater than 200 thousand showed a lower average return-per-spawner value.

Togiak River total production increased as spawning escapements increased from 50 thousand to 100 thousand and on average good returns were produced from escapements ranging from 100 thousand - 200 thousand (Figure 31). A Ricker stock-recruitment model was significant (P=0.0002) when fitted through all available brood years, 1956-1992 (Figure 32). The estimated number of spawners required to produce MSY for total Togiak River based on all brood years was 175 thousand.. A Ricker stock-recruitment curve was also fitted through Togiak spawner-return data from 1973-1992. The stock-recruitment model through recent data was significant (P=0.0004) and estimated that 150 thousand spawners would produce MSY.

Yield Analysis

Average surplus yield was greatest (517 thousand) from spawning escapements ranging from 140 thousand - 200 thousand for which there were eight observations (Figure 33). Average surplus yields were similar among three other escapement ranges: 1) escapements from 100 thousand - 140 thousand averaged 319 thousand yield; 2) escapements from 200 thousand - 250 thousand averaged 363 thousand yield; and 3) escapements greater than 250 thousand averaged 315 thousand yield. 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

The current escapement goal range and point goal management objective for Togiak River above the tower were established in 1984. They were based on estimates from stock-recruitment curves fitted through total Togiak River spawners and returns for brood years 1973-1979. The average number of spawners below the tower were subtracted from the estimated spawers to produce MSY for all Togiak River to estimate an optimum goal above the tower. The current escapement range was based on the number of total spawners for Togiak River which would produce 95% of MSY.

Workshop participants recommended that the existing biological escapement goal range of 140 thousand - 250 thousand be changed to a range of 100 thousand - 200 thousand for Togiak River above the tower (Table 3). The recommendation of lowering the range was based on a summary of

available spawner, return, and yield data (Table 4). Analysis of observed yield indicated that spawning escapements from 140 thousand - 200 thousand for the entire Togiak River would on average produce the highest surplus yields. Subtraction of the average percentage (14%) of spawners downriver of the tower from this estimated range would result in an estimated optimum range of 120 thousand - 170 thousand above the tower (Table 4). A Ricker stock-recruitment model using all brood years estimated that 95% of MSY would be produced from spawners ranging from 125 thousand - 225 thousand for the entire Togiak River. Similarly, a stock-recruitment model using only recent brood years estimated that 95% MSY would be obtained from spawning escapements for the entire Togiak River ranging from 110 thousand - 200 thousand. The estimated ranges for above the tower, after subtracting downriver spawners, were 110 thousand - 195 thousand for the all years stock-recruitment model and 95 thousand - 170 thousand for the recent years model (Table 4). Based on these various estimates of optimum ranges, participants felt that a range of 100 thousand - 200 thousand spawners above Togiak River tower was better supported by available data than the existing range.

Workshop participants recommended that the current point goal management objective for Togiak River above the tower remain at 150 thousand (Table 3). They felt that analyses of available spawner, return, and yield data supported a point goal of 150 thousand which is in the middle of the biological escapement goal range (Table 4).

Wood River Sockeye Salmon

Spawner-Return Data

The current management objective for Wood River is 1.0 million sockeye salmon and the current biological escapement goal range is 0.7 million - 1.2 million (Table 3). Numbers of Wood River sockeye spawners have ranged from about 0.3 million in 1957 to almost 3.0 million in 1980 (Appendix Table B.6 and Figure 34). Average escapement into Wood River during the last 10 years has been 1.3 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 5.7 million for brood year 1976. 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 2.6 for all available brood years (Appendix Table B.6 and Figure 35). Average return-per-spawner values were 2.1 for 1956-1972 and 3.1 for 1973-1992. Return-per-spawner values were below replacement for only two brood years, 1959 and 1980. Both of those years had escapements greater than 2.0 million.

Wood River total production has increased as spawning escapements have increased above 0.7 million (Figure 36). On average, good returns have been produced from escapements ranging from 0.7 million - 1.4 million. Escapements of 1.7 million in brood years 1974 and 1979 also produced large returns. A Ricker stock-recruitment model fitted through all available brood years for Wood River was significant (P=0.002) and estimated that 1.1 million spawners would produce MSY (Figure 37). The stock-

recruitment model fitted through recent data, 1973-1992 brood years, was also significant (P=0.0001) and estimated that 0.9 million spawners would produce MSY.

Yield Analysis

The greatest average surplus yield, 1.8 million, was produced by the six spawning escapements within the range of 1.2 million - 1.4 million (Figure 38). Seventeen spawning escapements within the current biological escapement goal range of 0.7 million - 1.2 million produced an average surplus yield of 1.7 million. Two spawning escapements of 1.7 million also produced good yields. Returns for the next four years will be coming from escapements ranging from 1.5 million - 1.6 million, which are all above the upper limit of the current biological escapement goal range. Since this is the first time returns from successive large escapements will be documented, this information will be important in determining whether the upper limit of the biological escapement goal range should be increased.

Escapement Goal Recommendations

Workshop participants recommended no changes for the Wood River sockeye salmon biological escapement goal. While there are indications that the upper limit of the escapement goal range could be increased, participants felt that returns over the next four years needed to be evaluated, since these will be produced from consecutive escapements greater than the upper limit of the current range.

Igushik River Sockeye Salmon

Spawner-Return Data

The current management objective for Igushik River is 0.2 million sockeye salmon and the current biological escapement goal range is 0.15 million - 0.25 million (Table 3). Numbers of Igushik River sockeye spawners have ranged from about 0.2 million in 1960 to almost 2.0 million in 1980 (Appendix Table B.7 and Figure 39). Average escapement during the last 10 years has been about 0.4 million sockeye salmon. Returns have ranged from about 0.8 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 4.8 for all available brood years (Appendix Table B.7 and Figure 40). Average return-per-spawner value was 3.3 for 1956-1972 and 6.0 for 1973-1992. Return-per-spawner values were below replacement for 10 brood years, seven of which had escapements greater than 0.2 million. This provides evidence of density dependent mortality.

Spawner-return information also indicated that Igushik River total production increased as spawning escapements increased above 0.15 million (Figure 41). On average, good returns were produced from escapements from 0.15 million - 0.25 million. Stock-recruitment models generally fitted Igushik River spawner-return data well. We chose to exclude the extremely large 1980 escapement from our analyses, since it was almost four times greater than most of the other observed spawning escapements. A Ricker stock-recruitment model fitted through all available brood years, excluding 1980, was significant (P=0.0007) and estimated that 0.23 million spawners would produce MSY. A Ricker stock-recruitment curve fitted through spawner-return data from 1973-1992, excluding 1980, was also significant (P=0.004) and estimated that 0.27 million spawners would produce MSY.

Yield Analysis

The greatest average surplus yield, 1.0 million, was produced by the eleven spawning escapements within the current biological escapement goal range of 0.15 million - 0.25 (Figure 42). Average surplus yields for spawning ranges above and below this range were only about half as large.

Escapement Goal Recommendations

Workshop participants recommended no changes for the Igushik River sockeye salmon escapement goal. Available spawner-return information supported the current management objective and escapement goal range.

Nushagak River Sockeye Salmon

Spawner-Return Data

The current management objective for Nushagak River is 0.55 million sockeye salmon and the current biological escapement goal range is 0.34 million to 0.76 million (Table 3). Spawner-return data for the total Nushagak River system have been estimated only since 1978. Prior to that only escapements into the Nuyakuk River, a tributary to the Nushagak River, was monitored. Numbers of Nushagak River sockeye spawners for brood years 1978-1992 ranged from 0.4 million in 1983 to 3.3 million in 1980 (Appendix Table B.8 and Figure 43). Average escapement during the last 10 years have been about 0.5 million sockeye salmon. Returns have ranged from 0.9 million for brood year 1984 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 2.8 for all available brood years (Appendix Table B.8 and Figure 44). There was some evidence of density dependent mortality, since the average-return-per-spawner value decreased for escapements greater than 0.55 million.

Spawner-return information for Nushagak River was very limited in range (Figure 45). The current escapement goal range brackets most observed spawning escapements. Total production from spawners within the 0.34 million - 0.55 million range was generally constant with not obvious increasing or decreasing trend.

Yield Analysis

The greatest average surplus yield, 1.3 million, was produced by the seven spawning escapements within the current biological escapement goal range of 0.34 million - 0.55 million (Figure 46). Average surplus yield for spawning escapements above the current escapement goal range was only 0.7 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 escapement goal. Available spawner-return information was very limited, but generally supported the current management objective and escapement goal range.

Nushagak River Chinook Salmon

Spawner-Return Data

The current biological escapement goal for Nushagak River is 65 thousand chinook salmon and the commercial fishery is 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 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 73 thousand chinook salmon. Chinook 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 2.8 for all available brood years (Appendix Table B.9 and Figure 48). Nushagak River chinook spawner-return data showed evidence of density dependent mortality as return-per-spawner values were lower for escapements greater than 100 thousand.

Chinook spawning escapements ranging from 40 thousand - 100 thousand have, on average, produced large returns (Figure 49). The number of chinook spawners needed to maintain the average Nushagak River run based on the average return-per-spawner value is 60 thousand spawners (Table 5). A Ricker stock-recruitment model fitted through all available brood years was significant (P=0.0001) and

estimated the number of spawners required to produce MSY was 50 thousand (Table 5 and Figure 50). 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. A model was fitted through aerial survey data only because we were unsure how the mixture of aerial and sonar data would affect the spawner-return relationships. There were not enough brood years to estimate a stock-recruitment model from only sonar information.

Yield Analysis

Average surplus yield was greatest (135 thousand) from spawning escapements ranging from 40 thousand - 65 thousand for which there were seven observations (Figure 51). The six spawning escapements greater than 100 thousand chinook salmon did not on average produce any surplus yield. Spawning escapements ranging from 25 thousand - 40 thousand (four observations) and 70 thousand - 100 thousand (nine observations) produced similar average yields. Spawning escapements from 40 thousand - 100 thousand chinook salmon produced similar average yields.

Escapement Quality

The trend in age composition of chinook spawning escapements in 1995 and 1996 raised concerns about the quality of chinook escapements into the Nushagak River (Table 6 and Figure 52) Chinook salmon size and sex composition varies greatly as a result of their life history in which they live from three to eight years. The smaller three and four-year-old chinook returning to spawn are primarily males. The sex composition of the larger and older (age-5 through age-7) chinook salmon varies, but is approximately equal ratios 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 biological escapement goal 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 you would estimate 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 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=.002) and estimated that 41,000 age-5 through age-7 spawners would produce MSY. From 1981-1997 the numbers of age-5 through age-7 chinook salmon spawning were less than 41,000 during only two years, 1990 and 1996. The total number of spawners for those two was also below the current biological goal of 65,000. For the 16 years we have age composition available, the numbers of age-5 through age-7 spawners were below 53,000 during five years. Three of those five years also did not meet the current biological goal of 65,000 total spawners. Based on these results we felt the current biological goal 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 biological goal of 65,000 chinook spawners.

Escapement Goal Recommendations

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

LITERATURE CITED

Alaska Department of Fish and Game (ADF&G). 1996. 1996-1997 Bristol Bay, Alaska Peninsula, Atka-Amilia, and Aleutian Is. Areas commercial fishing regulations. Alaska Department of Fish and Game, Juneau.

Crawford, D. L., and B. A. Cross. 1997. Bristol Bay sockeye salmon smolt studies for 1996. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 2A97-10, Anchorage.

Cross, B. A. 1991. Report to the Alaska Board of Fisheries spawning escapement goal evaluation for Kvichak River sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A91-16, Anchorage.

Cross, B. A. 1994. Report to the Alaska Board of Fisheries on spawning escapement goal evaluation for Bristol Bay sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 2A94-46, Anchorage.

Cross, B. A. *In press.*. Notes from the Bristol Bay sockeye salmon escapement goal workshop 1994. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report, Anchorage.

Eggers, D. M., and D. E. Rogers. 1987. The cycle of runs of sockeye salmon *Oncorhynchus nerka* to the Kvichak River, Bristol Bay, Alaska: cyclic dominance or depensatory fishing? Pages 343-366 in H.D. Smith, L. Margolis, and C.C. Wood, editors. Sockeye salmon *Oncorhynchus nerka* population biology and future management. Canadian Special Publications of Fisheries and Aquatic Sciences 96, Ottawa, Canada.

Fried, S. M. 1984. Bristol Bay Pacific salmon spawning escapement goal workshop. Alaska Department of Fish and Game, Division of Commercial Fisheries, Bristol Bay Data Report 84-12, Anchorage.

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment choice, dynamics and uncertainty. Chapman and Hall. New York.

Menard, J. 1997. Abundance, age, sex, and size statistics for Pacific salmon in Bristol Bay, 1993 - 1995. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 2A97-13, Anchorage.

LITERATURE CITED

Minard, E., J. Skrade, T. Brookover, D. Dunaway, B. Cross, J. Schichnes. 1992. Escapement requirements and fishery descriptions for Nushagak drainage chinook salmon. Alaska Department of Fish and Game, Regional Information Report 1D91-09, Anchorage.

Regnart, J.R.. 1997. Kvichak River sockeye salmon spawning ground surveys, 1955-1996. Alaska Department of Fish and Game, Regional Information Report 2A97-21, Anchorage.

Ricker, W. E. 1975. Computations and interpretations of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191, Ottawa, Canada.

Rogers, D. E., and P. H. Poe. 1984. Escapement goals for the Kvichak River system. Unpublished Report FRI-UW-8407, Fisheries Research Institute, University of Washington, Seattle.

Table 1. History of Kvichak River sockeye escapement goals set under the cyclic goal policy, 1969-1985 and recent goals, 1986-97, set under the 4-10 million range policy.

Year	Policy	Goal	Actual	Percent 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	4-10 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
1969-1997 Avg		6,000,000	5,800,000	- 3
1969-1985 Avg		5,600,000	6,400,000	3
1986-1997 Avg		5,800,000	5,100,000	-12

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

Table 2. Recommended changes to sockeye salmon escapement goals for Kvichak River.

Cycle Years	Current Range	Current Policy	Recommended Range	Recommended Policy
OFFCYCLE	4 - 6 Mil	Minimum 4 Mil Maximum 6 Mil Annual goal based on projection run size and spawner distribution	2 - 10 Mil	Minimum 2 Mil Maximum 10 Mil Annual goal based on 50% of inshore run and spawner distribution
PRE-PEAK **PEAK**	6 - 10 Mil	Minimum 6 Mil Maximum 10 Mil Annual goal based on preseason projection of run size and spawner distribution	6 - 10 Mil	Minimum 6 Mil Maximum 10 Mil Annual goal based on 50% of inshore run and spawner distribution

Table 3. Current spawning escapement goals in millions of sockeye salmon and recommended changes for Bristol Bay Rivers.

River	Current Goals		Recommended Goals	
	Objective	Range	Objective	Range
Naknek	1.0	0.8 - 1.4	1.1	SAME
Egegik	1.0	0.8 - 1.4	1.1	SAME
Ugashik	0.7	0.5 - 1.2	0.85	SAME
Wood	1.0	0.7 - 1.2	NO CHANGE	
Igushik	0.2	0.15 - 0.25	NO CHANGE	
Nushagak	0.55	0.34 - 0.76	NO CHANGE	
Togiak	0.15	0.14 - 0.25	SAME	0.1 - 0.2

Table 4. Summary of estimates of escapement goal ranges and management objectives in thousands of sockeye salmon for the entire Togiak River and above the Togiak River tower.

Analysis	Data Base	Escapement Range	Management Objective
		TOTAL TOGIAK RIVER	
Observed Yield[a]	1956-1992	140 - 200	170
Ricker Stock-Recruitment[b]	1956-1992	125 - 225	175
Ricker Stock-Recruitment	1973-1992	110 - 200	150
		ABOVE TOGIAK TOWER	
Observed Yield	1956-1992	120 - 170	145
Ricker Stock-Recruitment	1956-1992	110 - 195	150
Ricker Stock-Recruitment	1973-1992	95 - 170	130

[a] Estimate of optimum escapement range based on yield analysis is the observed numbers of spawners that have on average produced the highest yields. The management objective is the middle of the escapement range.

[b] Estimate of optimum escapement range based on Ricker stock-recruitment models is the range of escapements which will produce 95% of maximum sustained yield (MSY). The management objective is the number of spawners estimated from a stock-recruitment model which will produce MSY.

Table 5. Summary of estimated numbers of chinook spawners required for high sustained yields for the Nushagak River.

Analysis	Data Base	Escapement Goal
Average Return and Average Return per spawner	1966-1991	60,000
Ricker Stock-Recruitment	1966-1991	50,000
	1966-1979 Aerial	65,000
Observed Yield	1966-1991	65,000 - 100,000

Table 6. Age composition of chinook salmon spawners grouped into two categories, age-3 and age-4 versus age-5 through age-7, Nushagak River, 1981-1997.

Year	Age-3 and Age-4		Age-5 through Age-7		Total
	Percent	Number	Percent	Number	Number
1981	24.7	37,069	73.6	110,345	150,000
1982	7.9	11,634	89.0	130,830	147,000
1983	10.5	16,977	89.2	44,187	161,730
1984	8.2	6,613	91.7	74,214	80,940
1985	7.6	8,829	92.4	106,891	115,720
1987	11.3	8,832	88.7	69,392	78,224
1988	18.2	9,263	81.2	41,245	50,808
1989	14.5	10,575	85.5	62,530	73,105
1990	33.5	19,300	66.5	38,265	57,565
1991	29.0	27,925	70.8	68,293	96,392
1992	29.1	22,248	70.2	53,600	76,369
1993	17.9	15,846	82.0	72,636	88,588
1994	20.0	16,643	80.0	66,697	83,340
1995	40.9	32,374	58.8	46,579	79,162
1996	33.7	15,358	65.6	29,865	45,507
1997	39.2	32,157	60.8	49,843	82,000

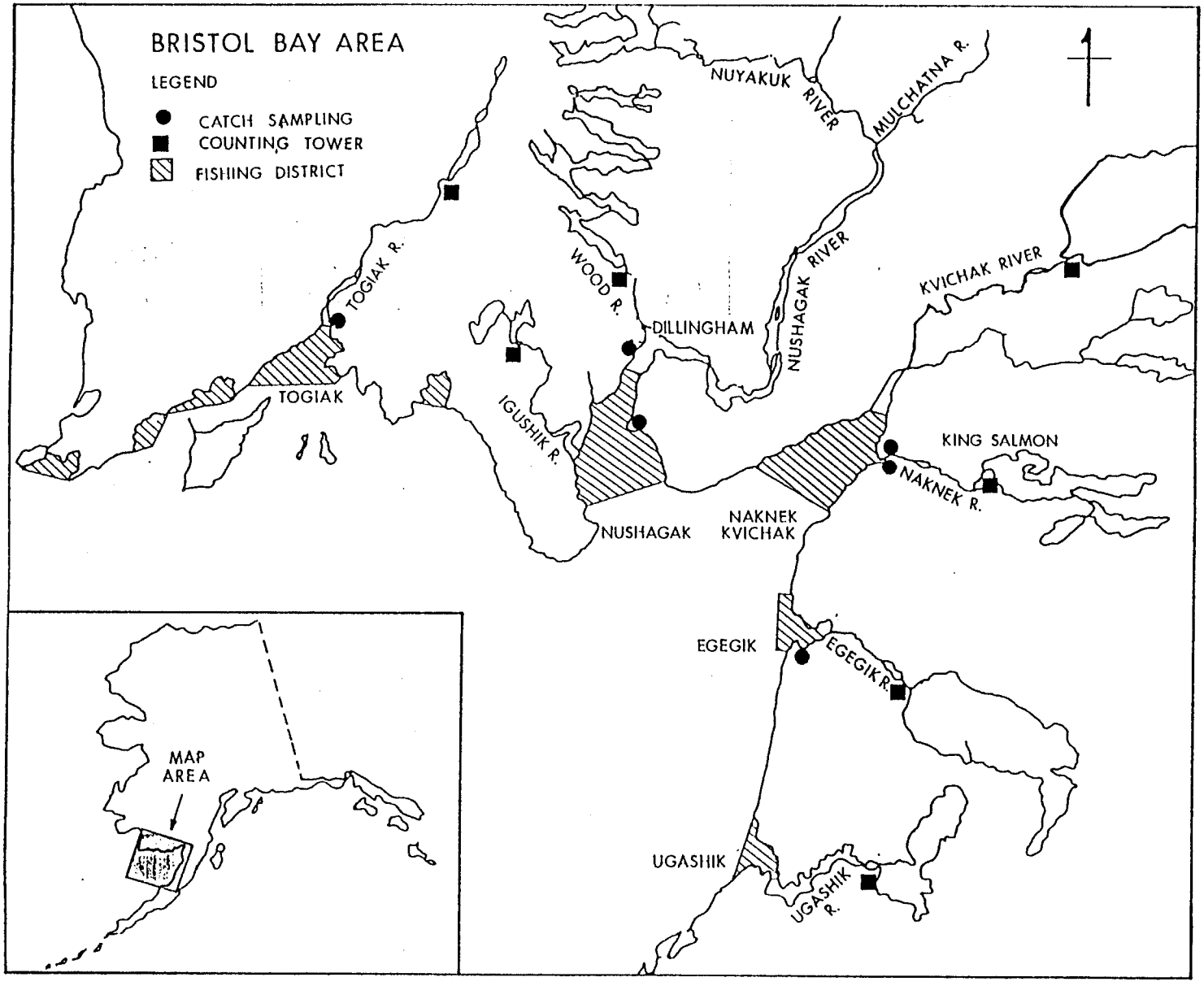

Figure 1. Map of Bristol Bay showing major rivers and fishing districts.

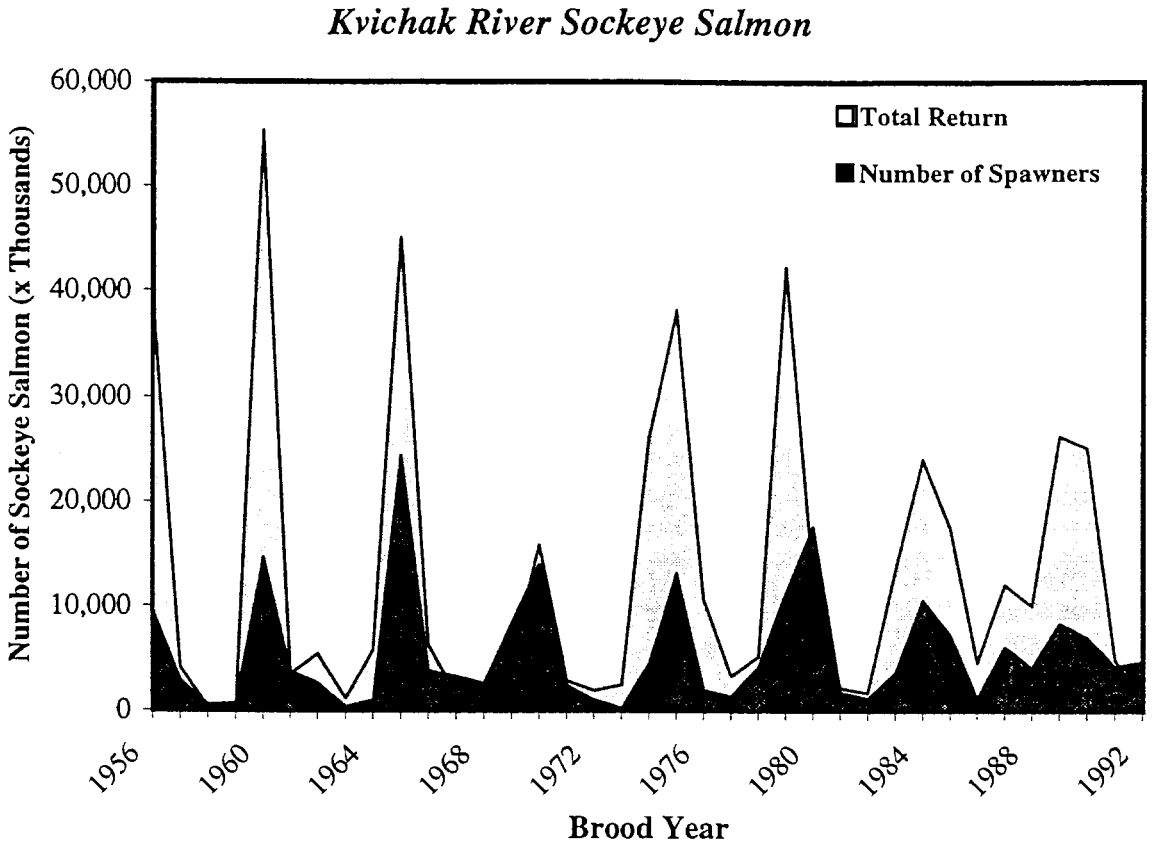

Figure 2. Number of spawners and total return of Kvichak River sockeye salmon by brood year, 1956 - 1992.

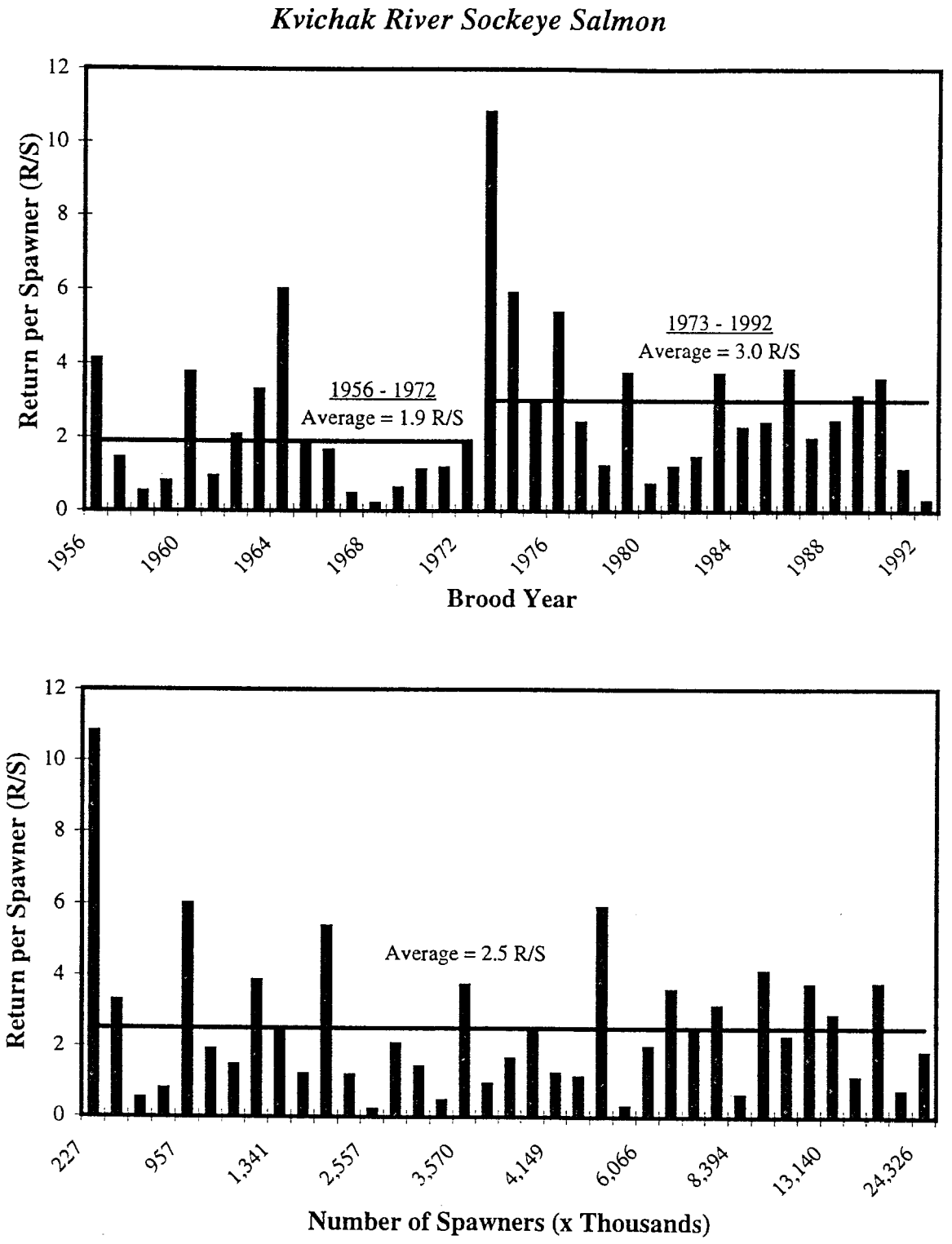

Figure 3. Return per spawner of Kvichak River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

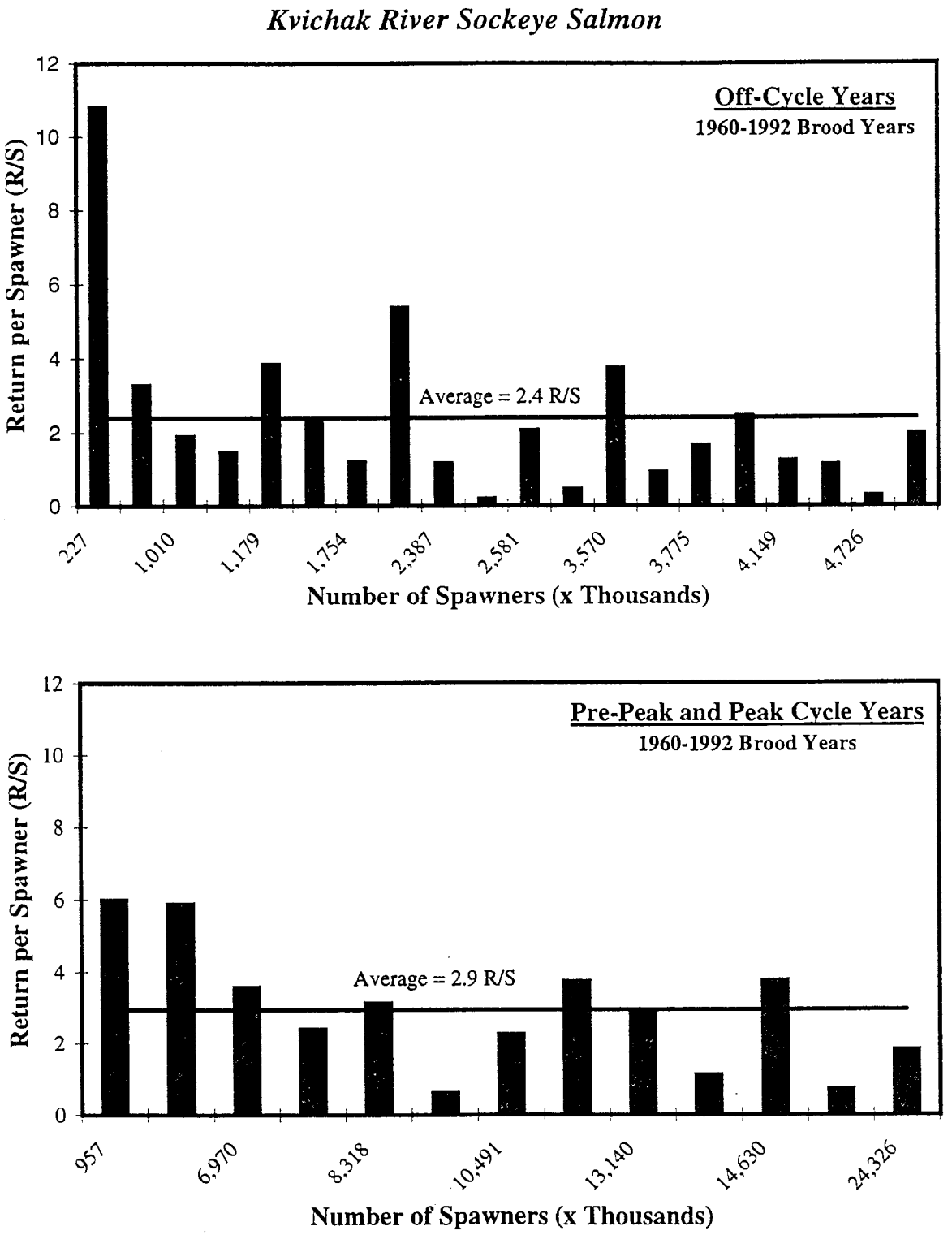

Figure 4. Return per spawner of Kvichak River sockeye salmon versus number of spawners for off-cycle, and pre-peak and peak cycle years (1960-1992 brood years).

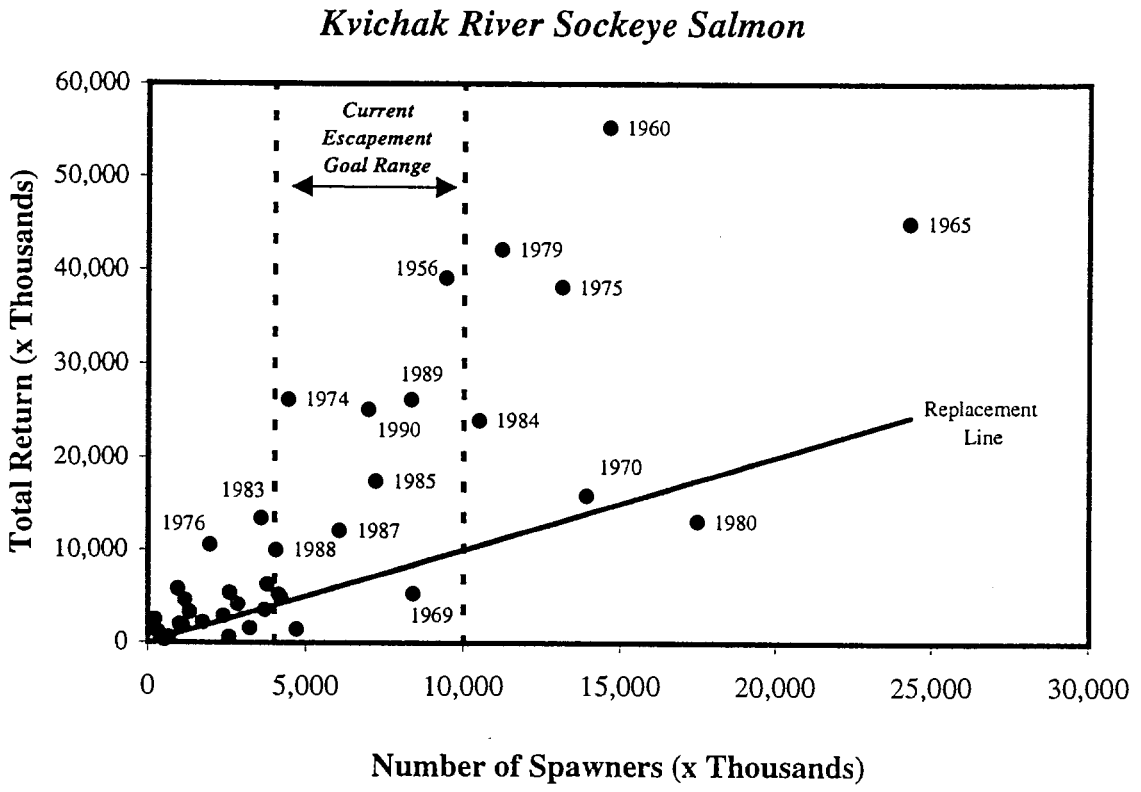

Figure 5. Total return of Kvichak River sockeye salmon versus number of spawners, 1960-1992 brood years.

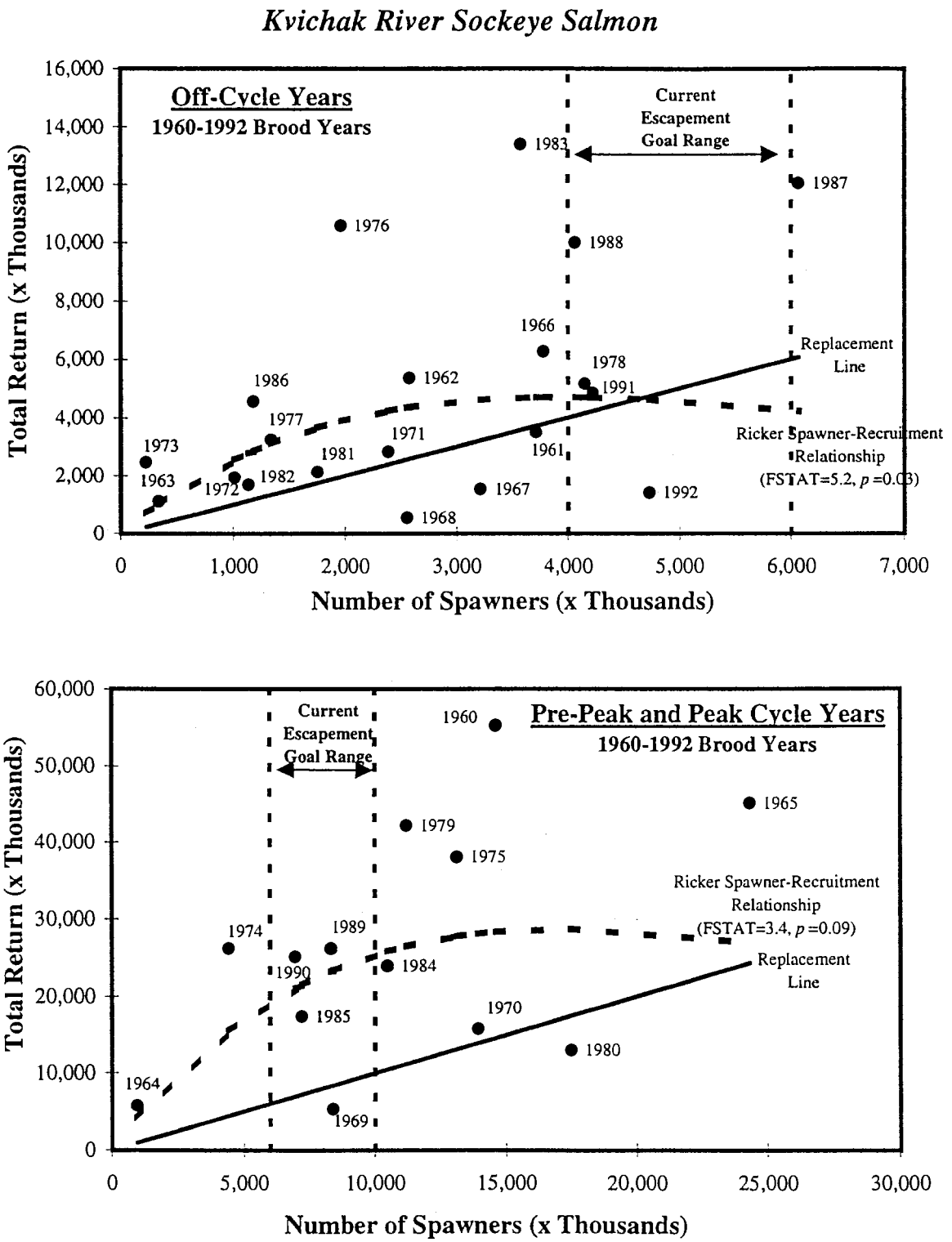

Figure 6. Ricker spawner-recrutiment relationship of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1992 brood years).

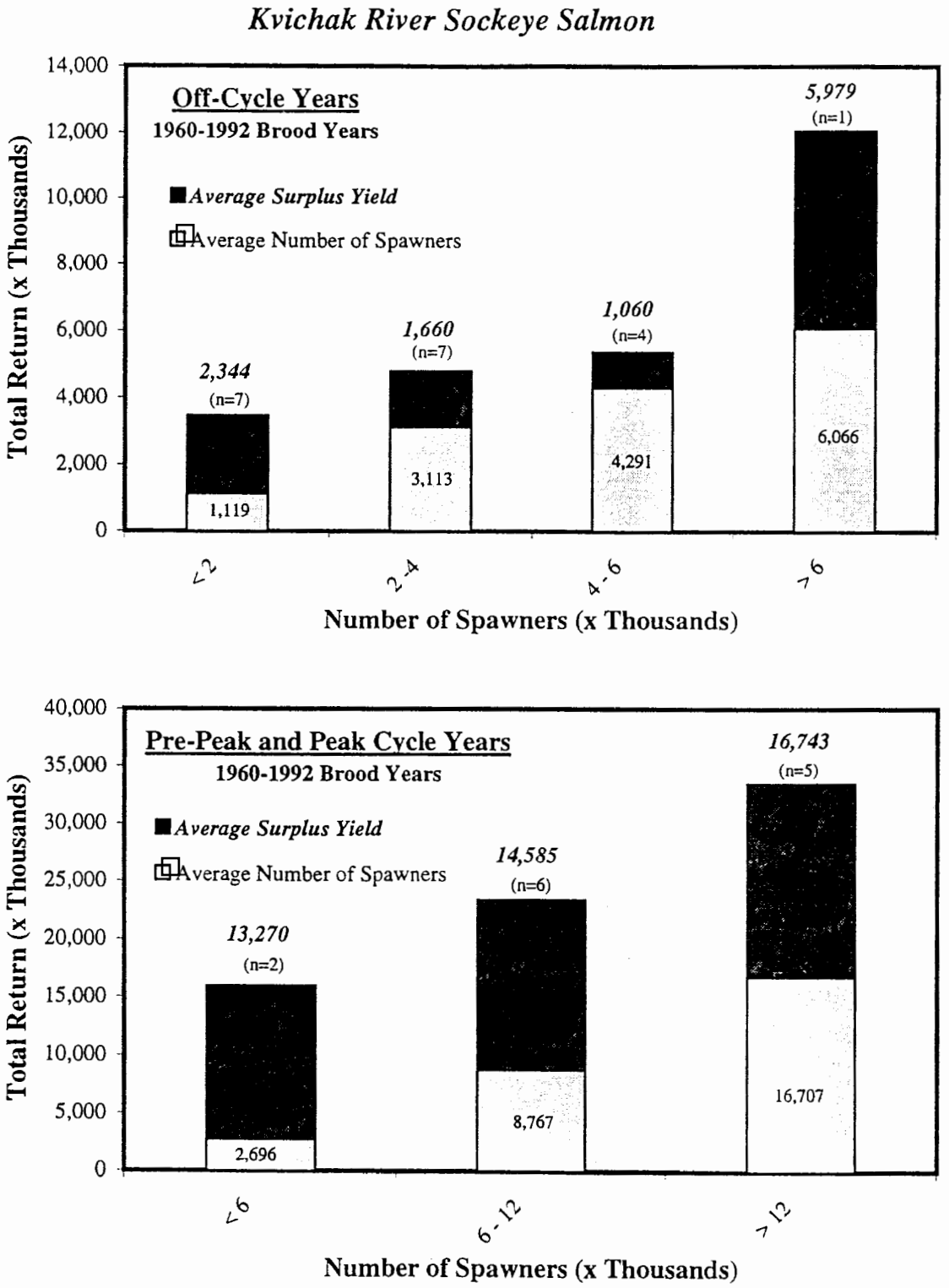

Figure 7. Average surplus yield categorized by number of spawners of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1960-1992 brood years).

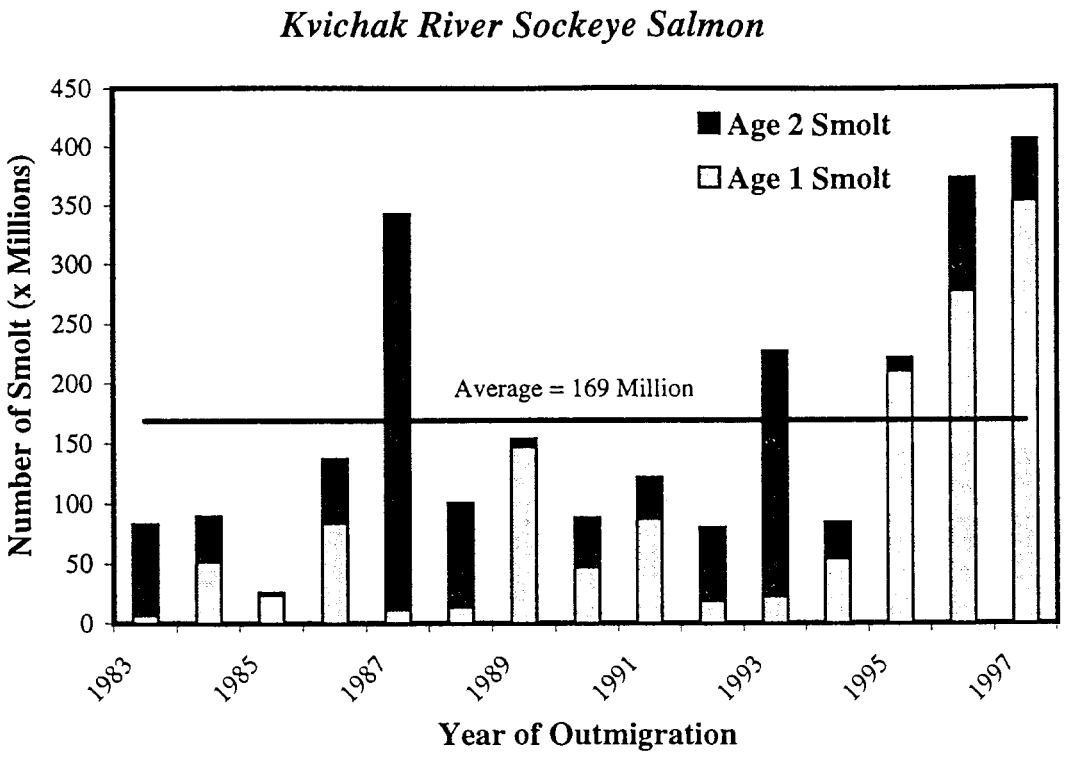

Figure 8. Number of sockeye salmon smolt migrating out of Kvichak River, 1983-1997.

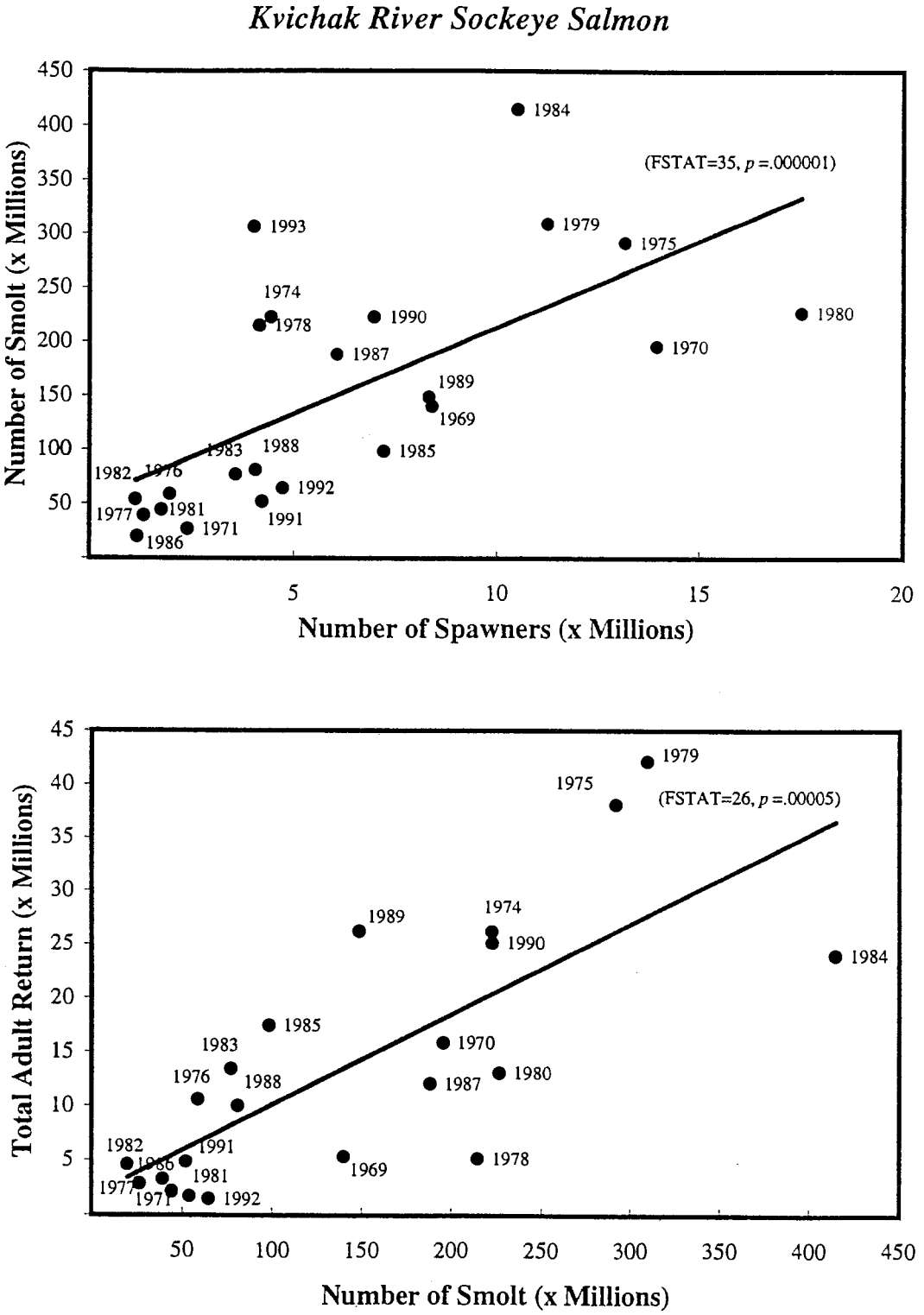

Figure 9. Number of spawners versus number of smolt, and number of smolt versus total adult return for Kvichak River sockeye salmon (1969-1992 brood years).

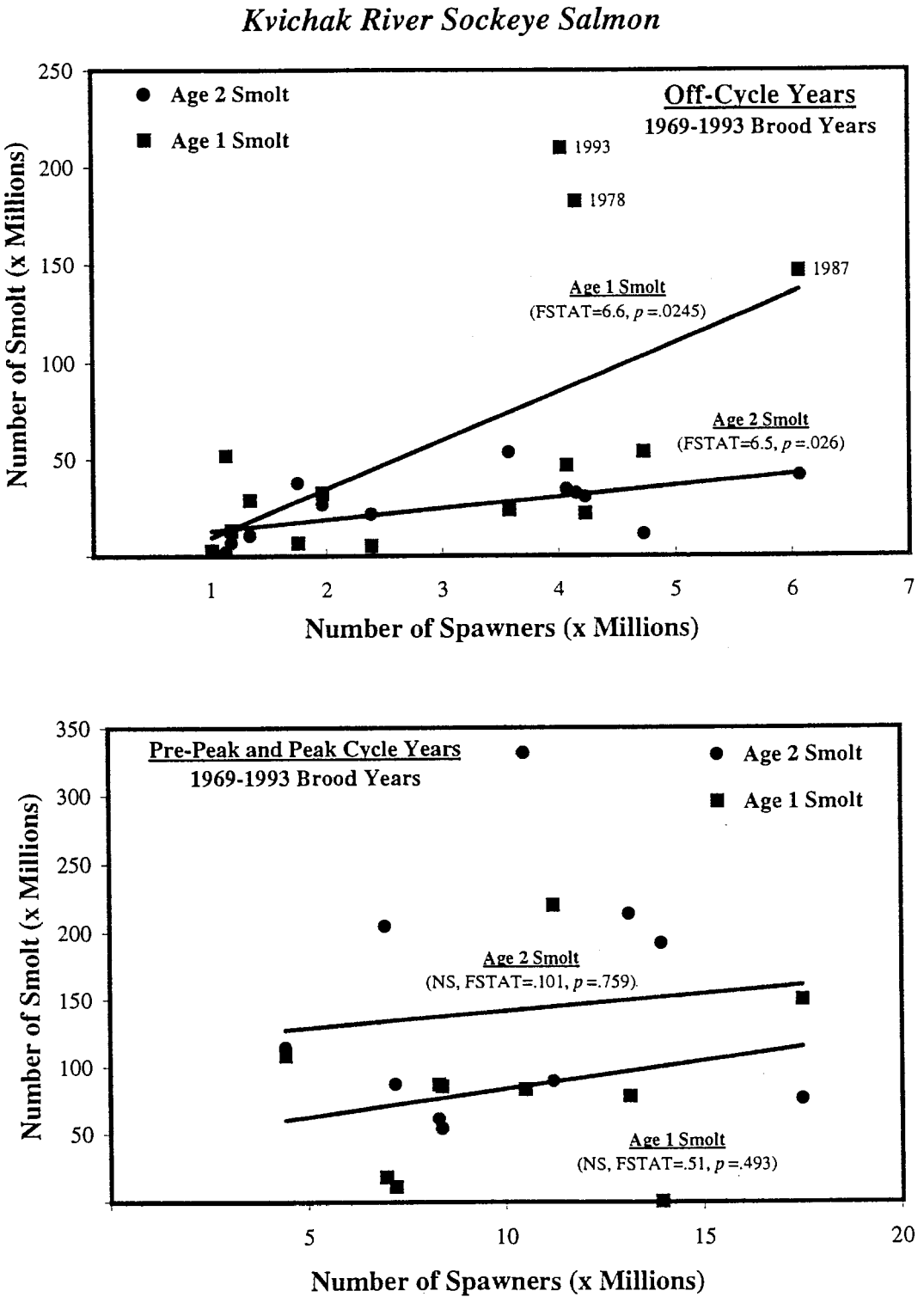

Figure 10. Number of spawners versus number of smolt of Kvichak River sockeye salmon for off-cycle, and pre-peak and peak cycle years (1969-1993 brood years).

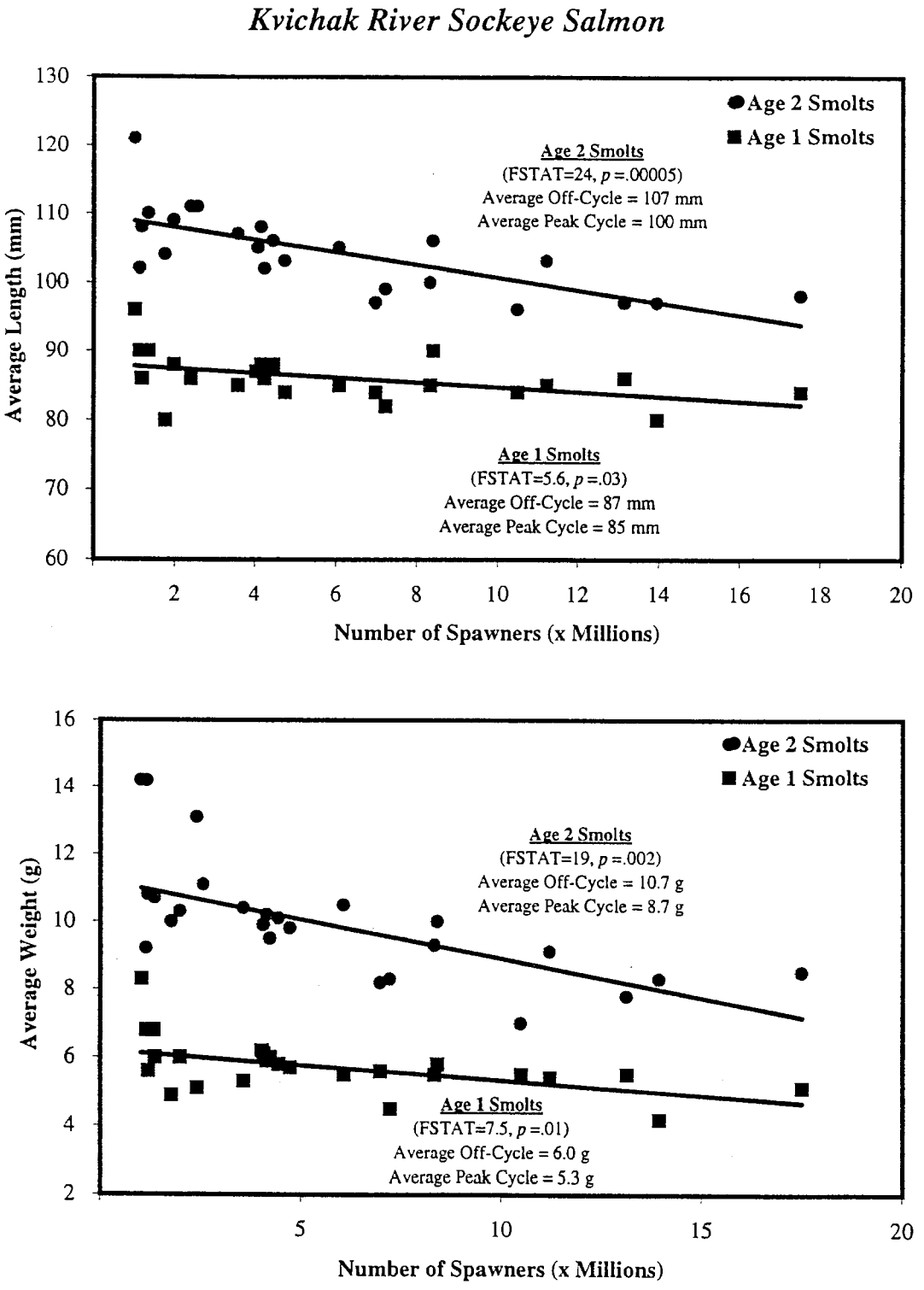

Figure 11. Average length and weight of age 1 and age 2 smolts versus number of spawners for Kvichak River sockeye salmon (1969-1993 brood years).

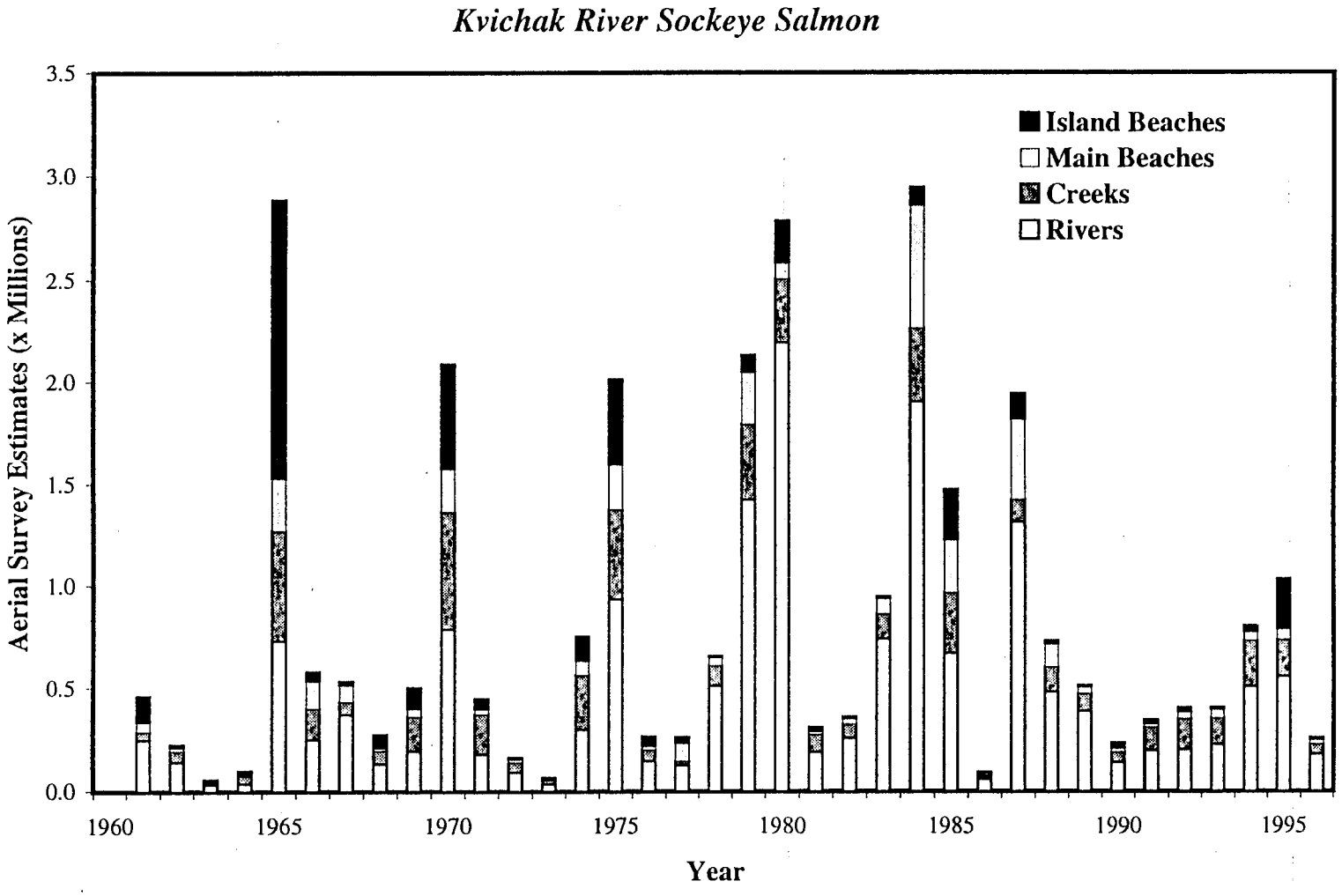

Figure 12. Spawner distribution of Kvichak River sockeye salmon at main beaches, island beaches, rivers and creeks.

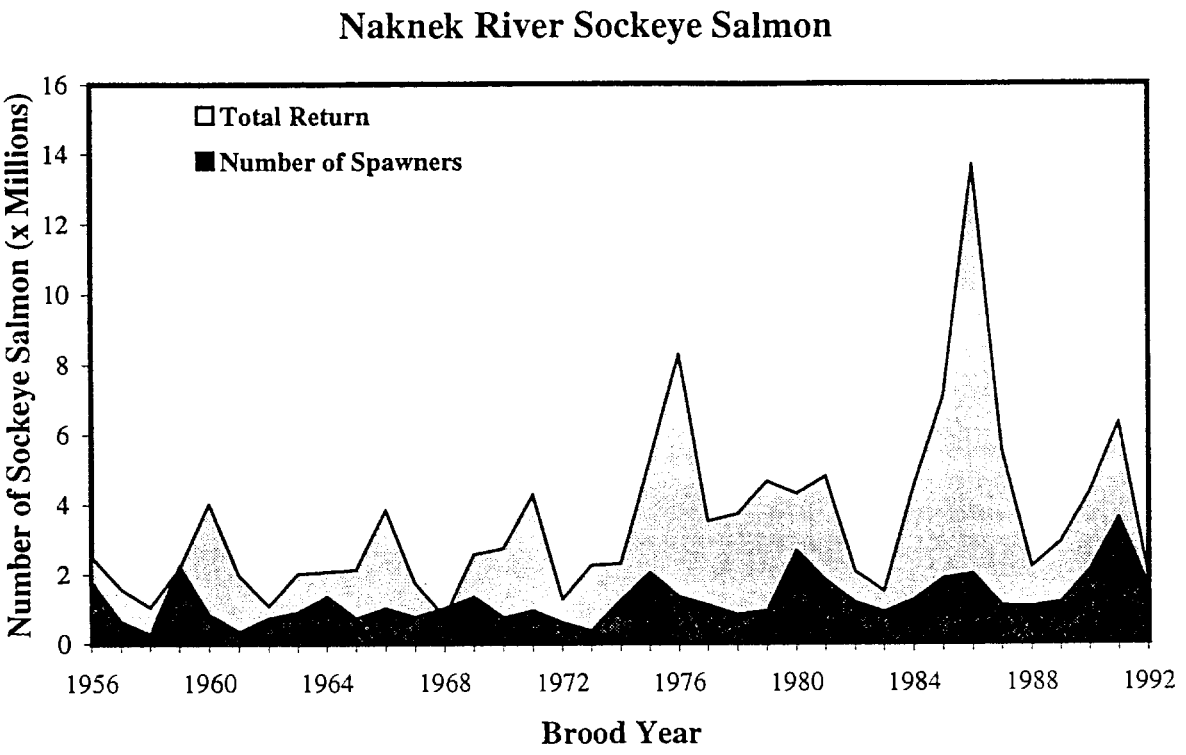

Figure 13. Number of spawners and total return of Naknek River sockeye salmon by brood year, 1956 - 1992.

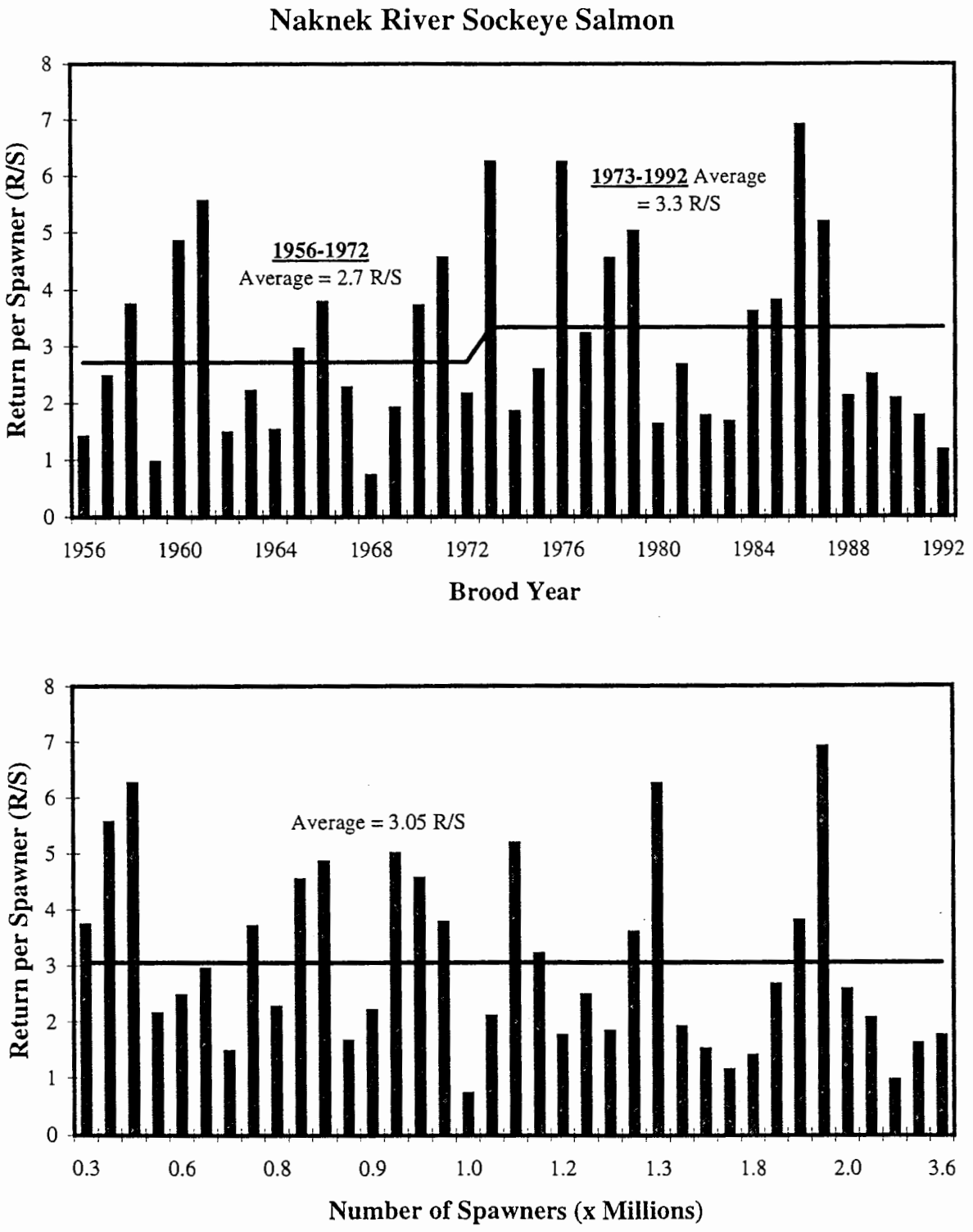

Figure 14. Return per spawner of Naknek River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

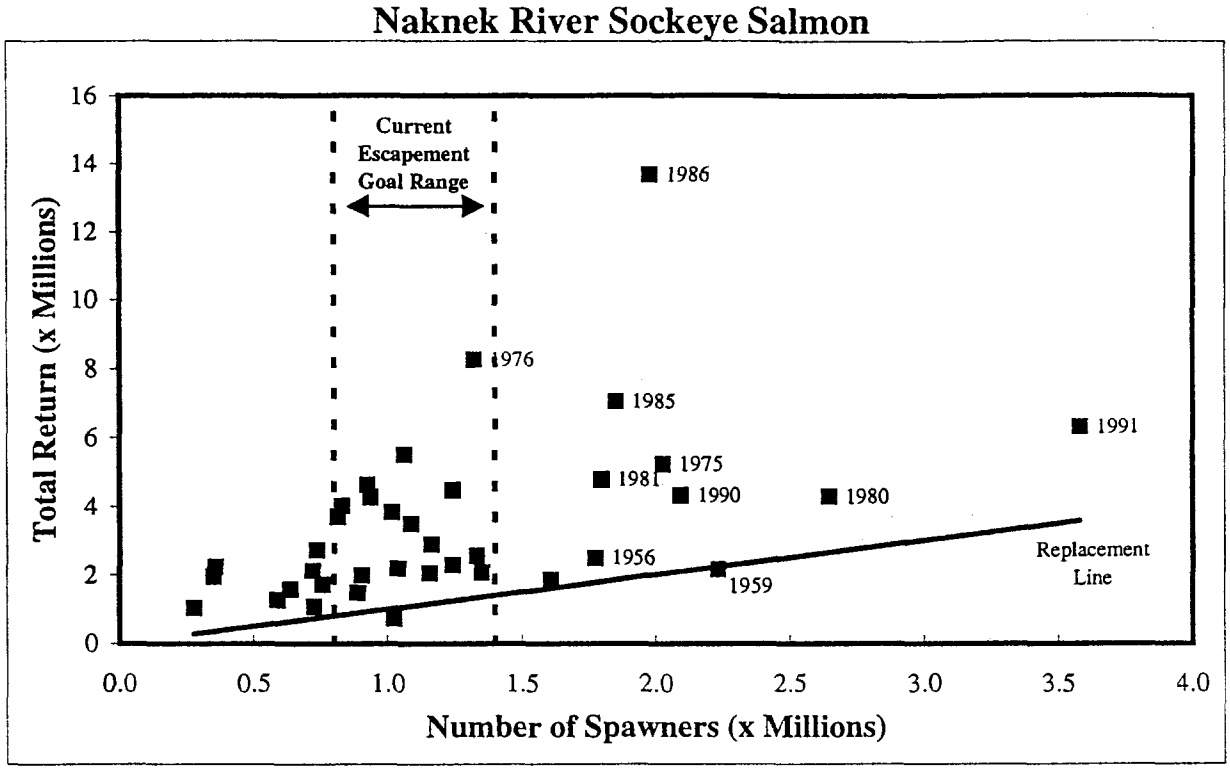

Figure 15. Total return of Naknek River sockeye salmon versus number of spawners, 1956-1992 brood years.

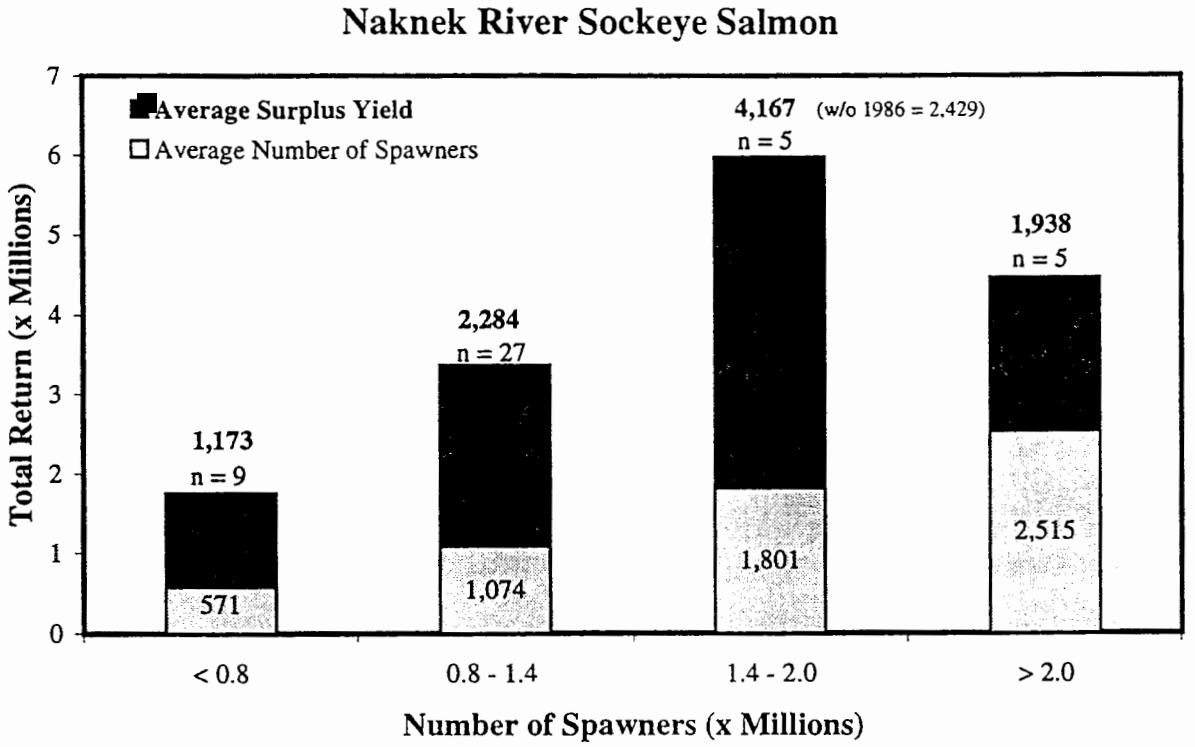

Figure 16. Average surplus yield categorized by the number of spawners of Naknek River sockeye salmon, 1956-1992 brood years.

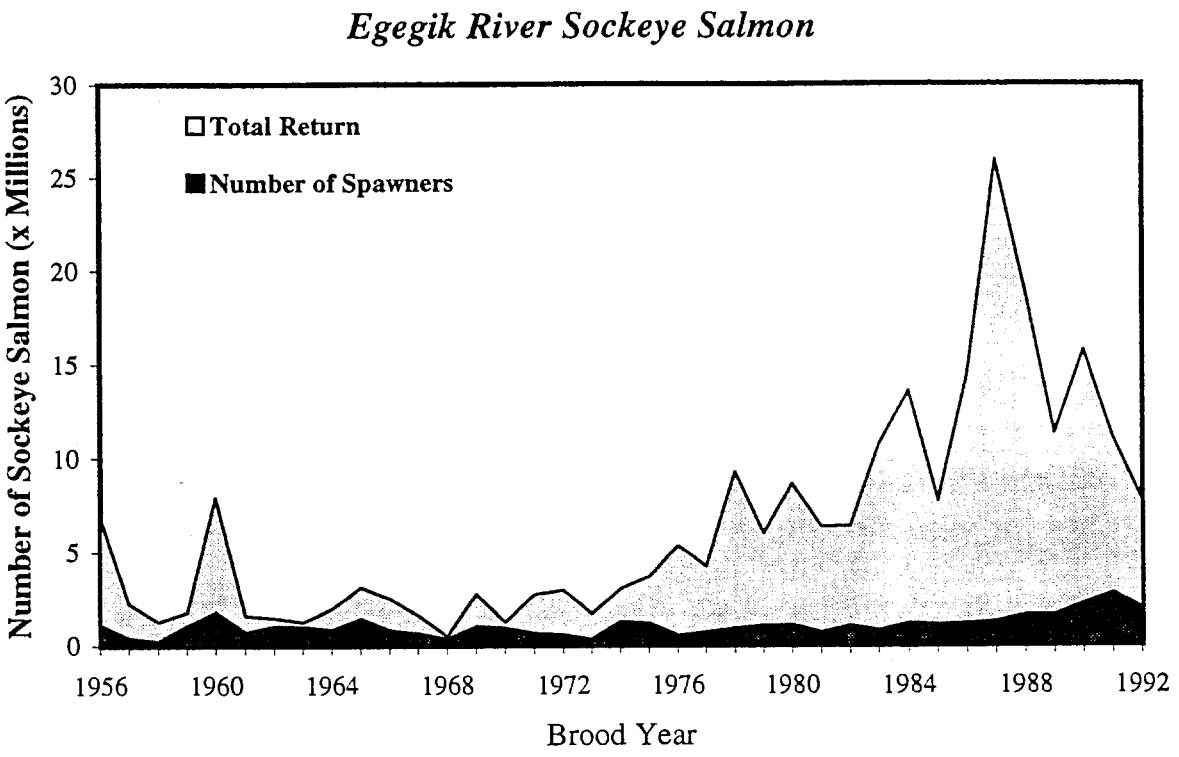

Figure 17. Number of spawners and total return of Egegik River sockeye salmon by brood year, 1956 - 1992.

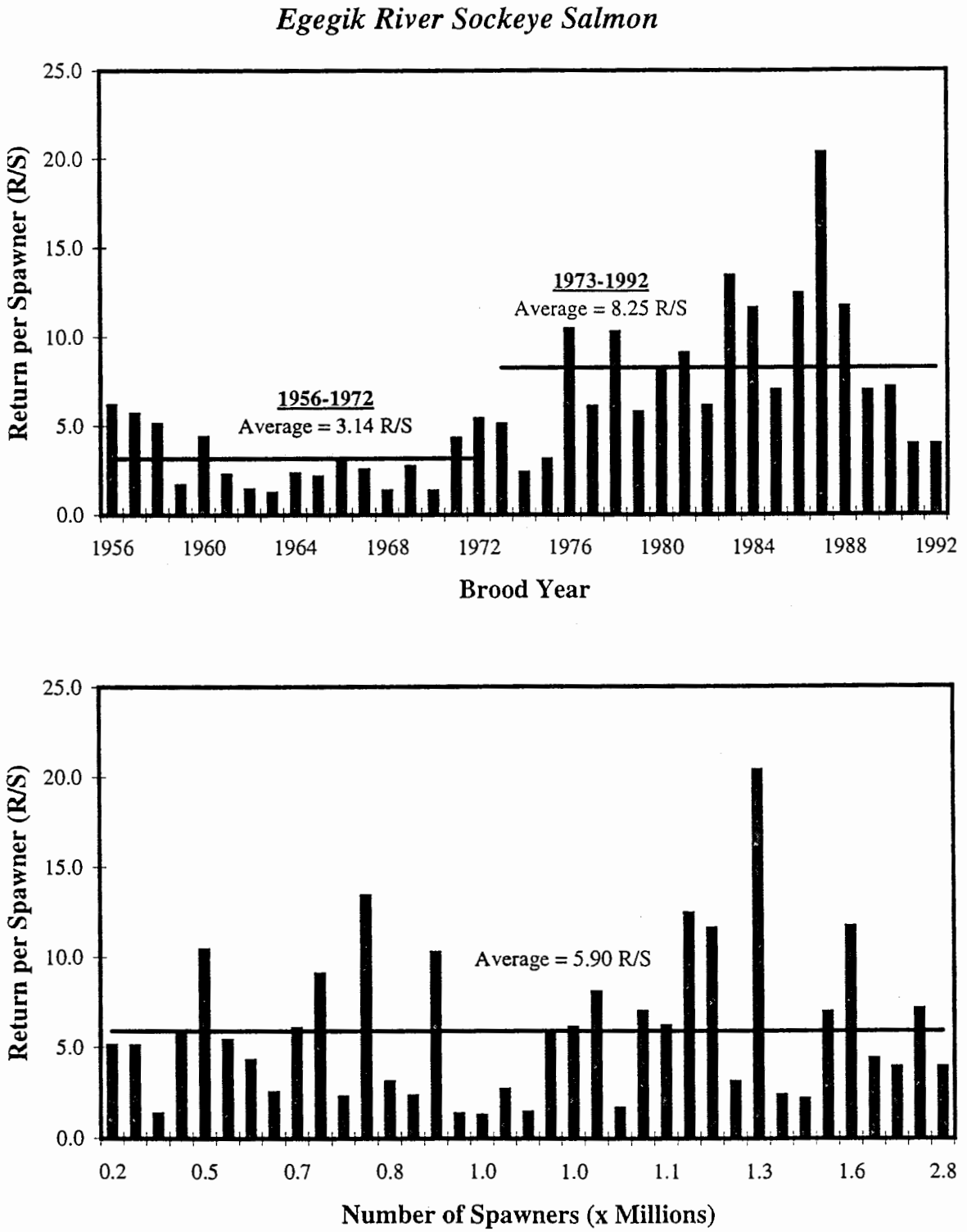

Figure 18. Return per spawner of Egegik River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

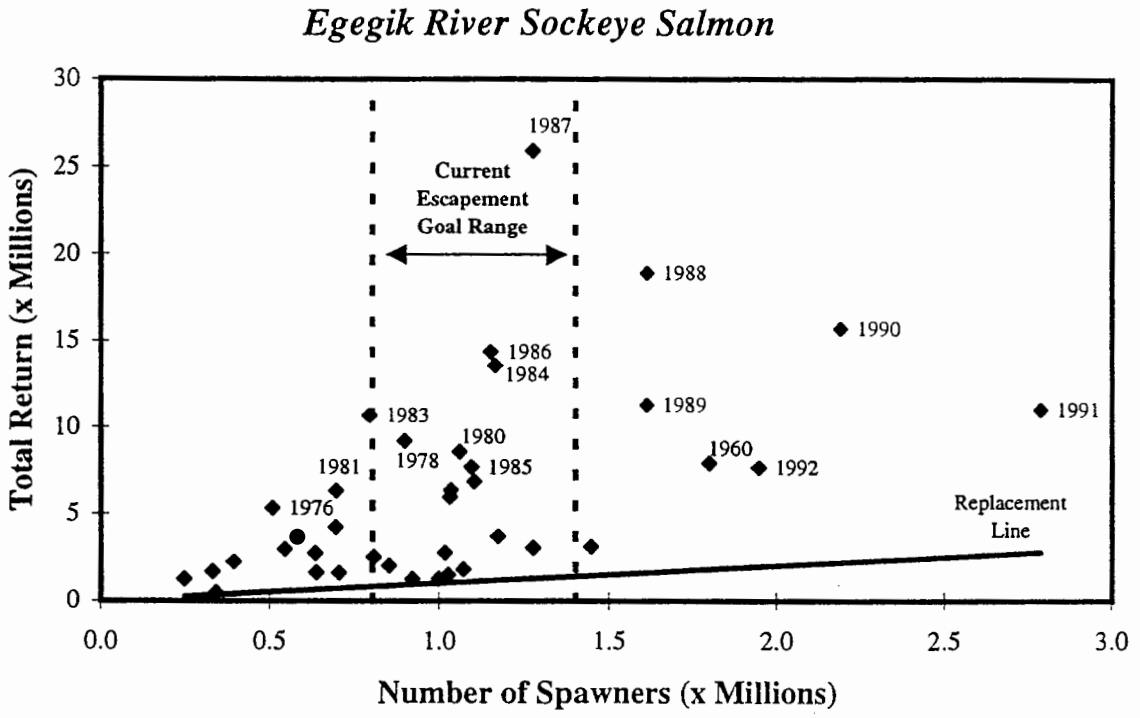

Figure 19. Total return of Egegik River sockeye salmon versus number of spawners, 1956-1992 brood years.

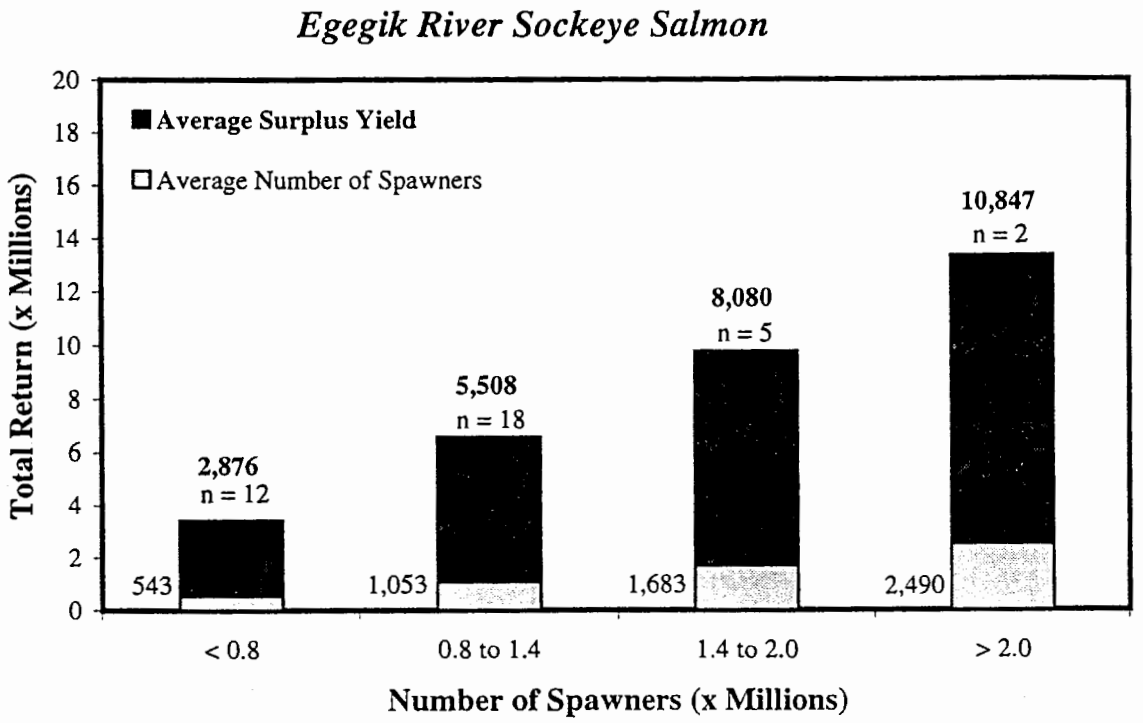

Figure 20. Average surplus yield categorized by the number of spawners of Egegik River sockeye salmon, 1956-1992 brood years.

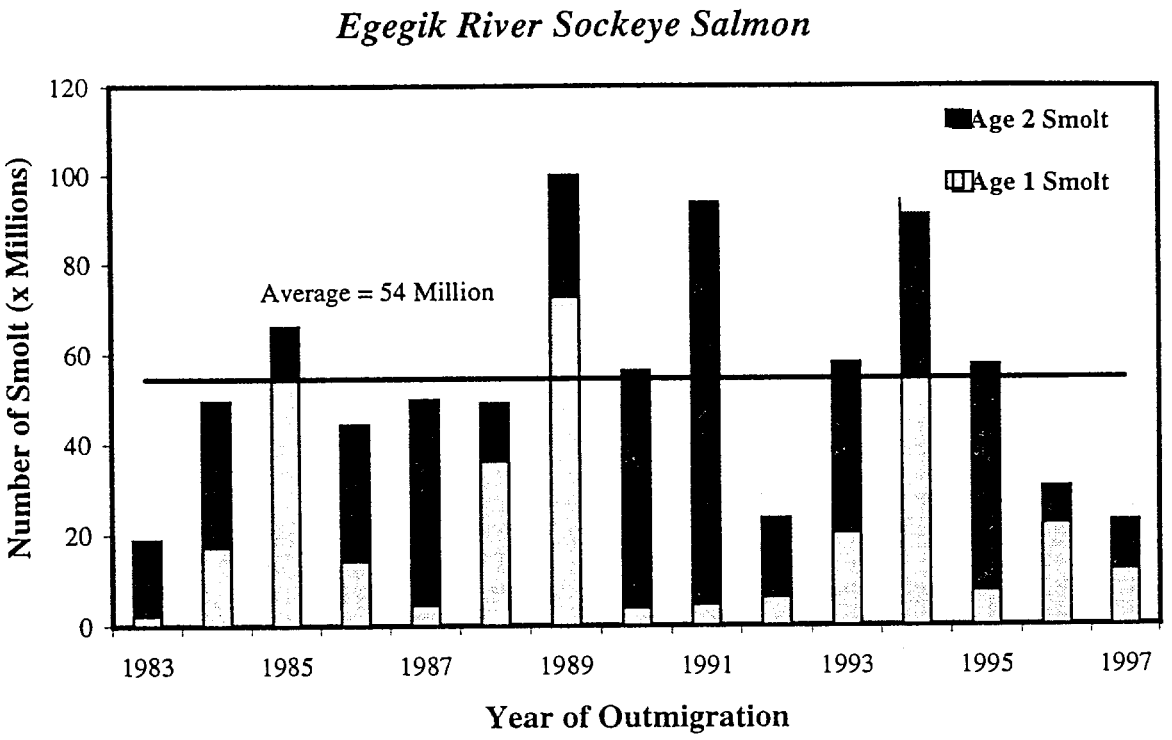

Figure 21. Number of sockeye salmon smolt migrating out of the Egegik River, 1983-1997.

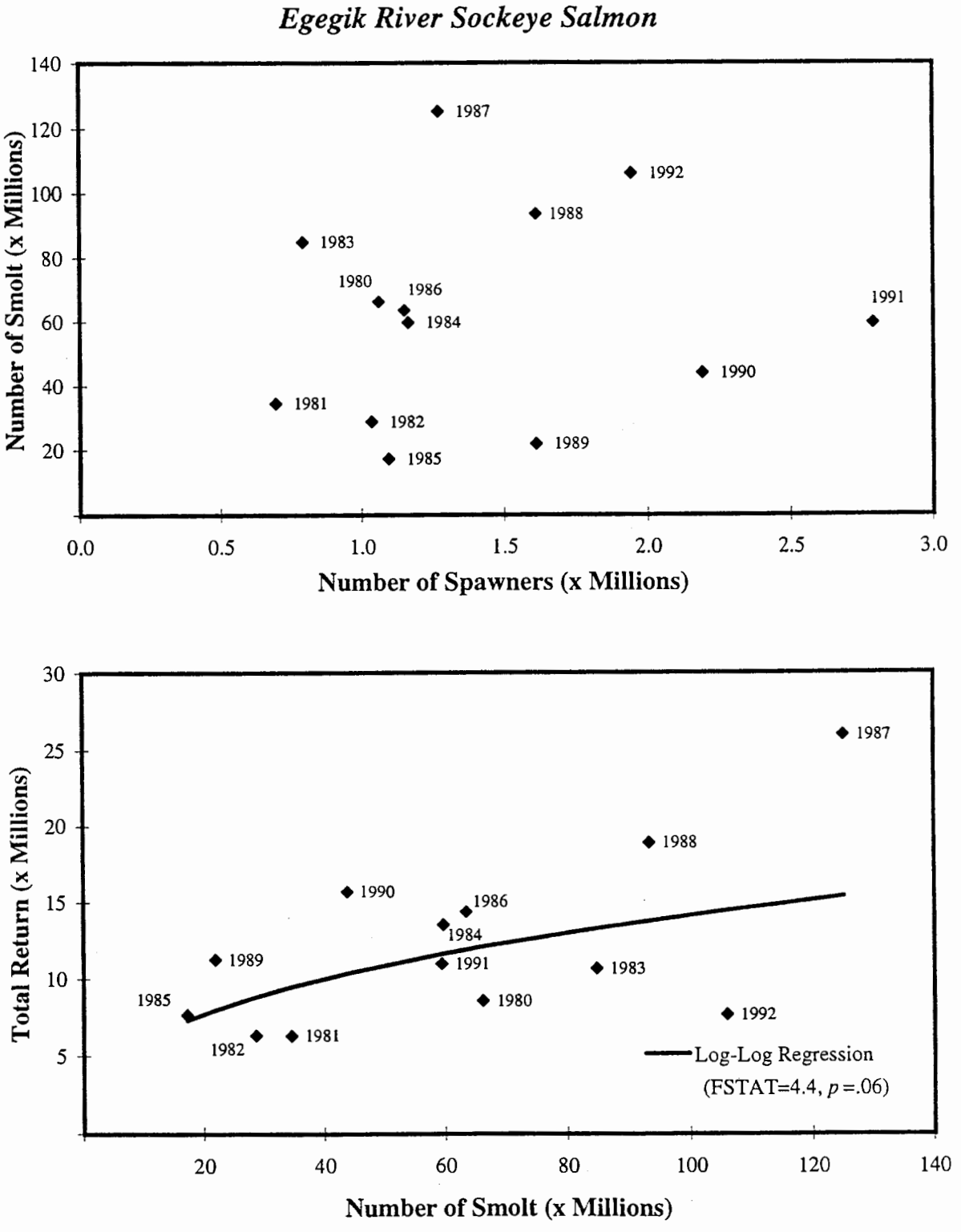

Figure 22. Number of spawners versus number of smolt, and number of smolt versus total return of Egegik River sockeye salmon, 1980-1992 brood years.

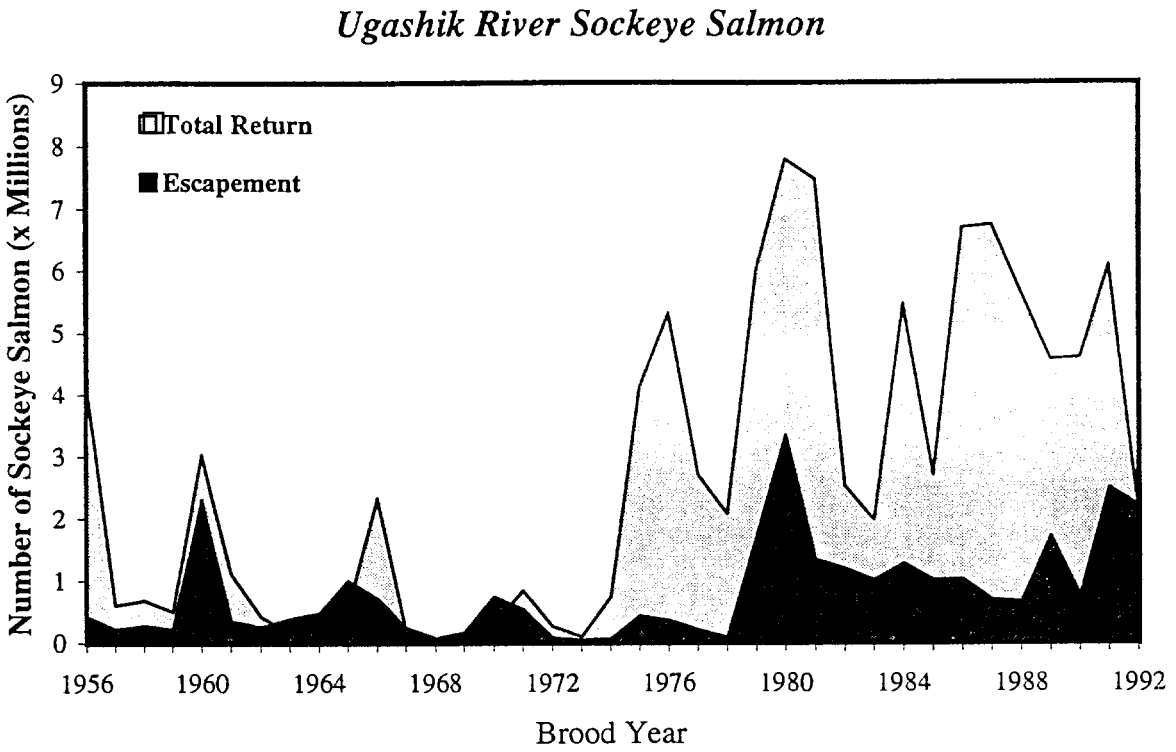

Figure 23. Number of spawners and total return of Ugashik River sockeye salmon by brood year, 1956 - 1992.

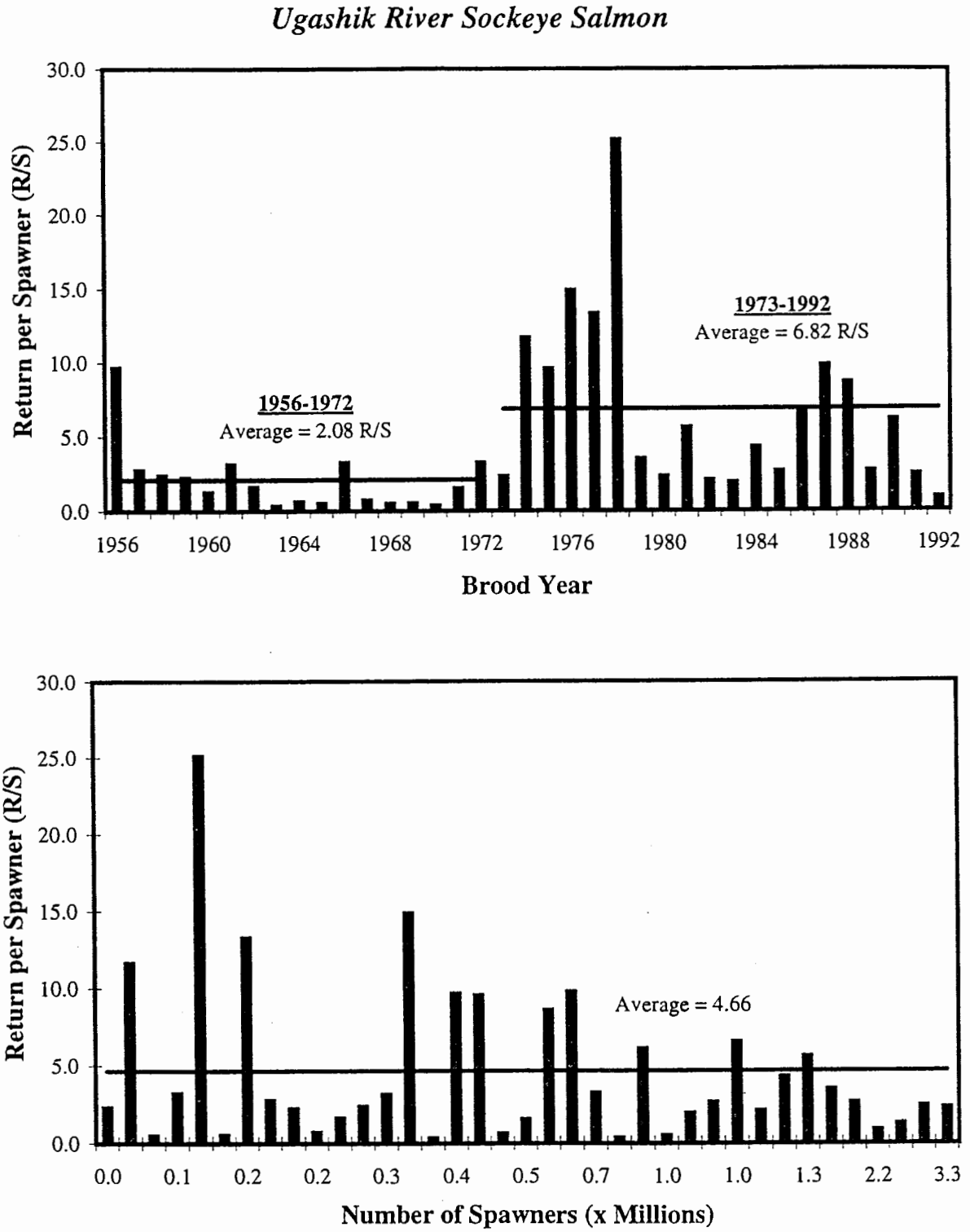

Figure 24. Return per spawner of Ugashik River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

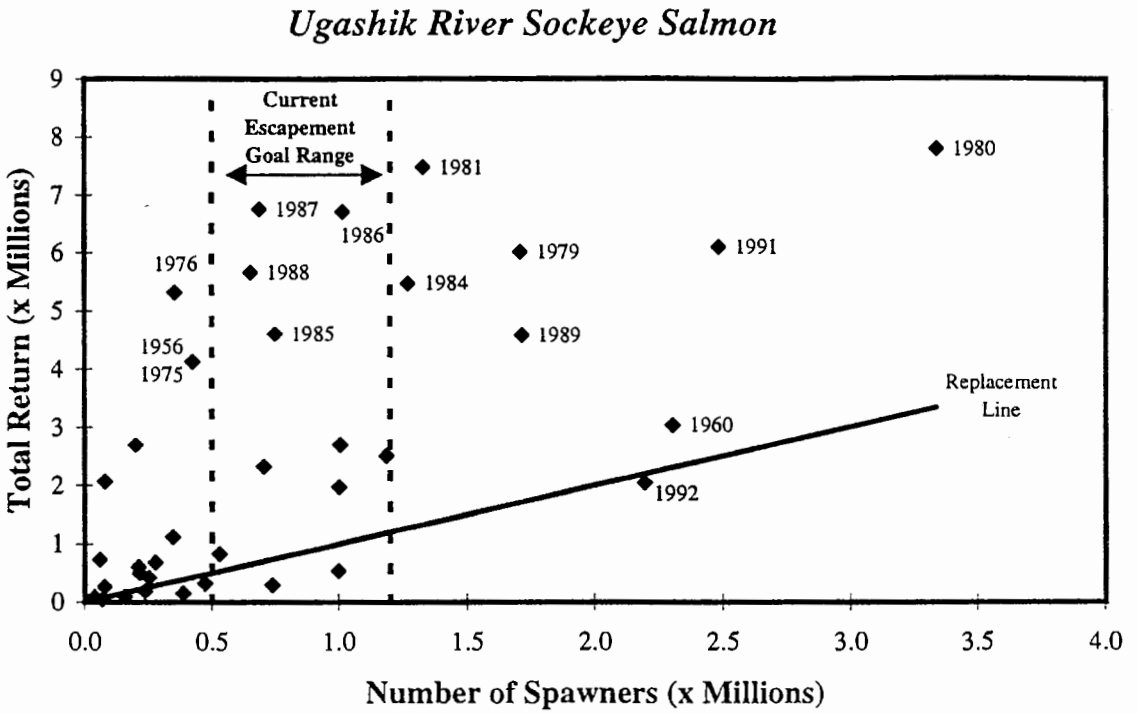

Figure 25. Total return of Ugashik River sockeye salmon versus number of spawners, 1956-1992 brood years.

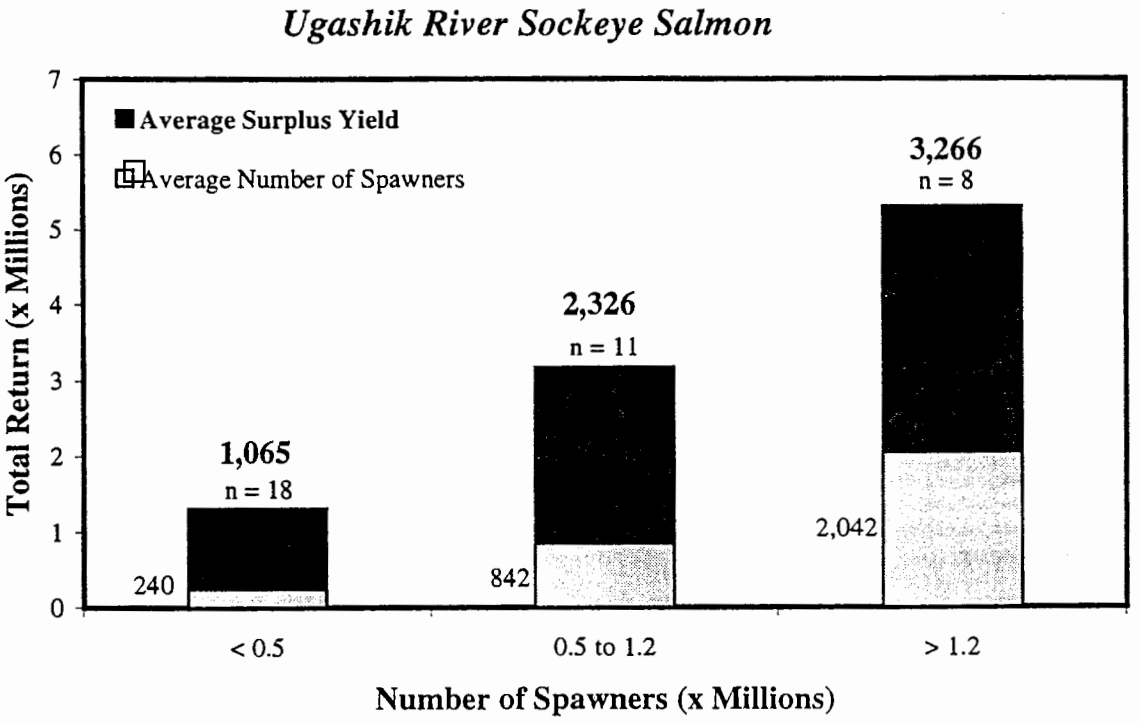

Figure 26. Average surplus yield categorized by the number of spawners of Ugashik River sockeye salmon, 1956-1992 brood years.

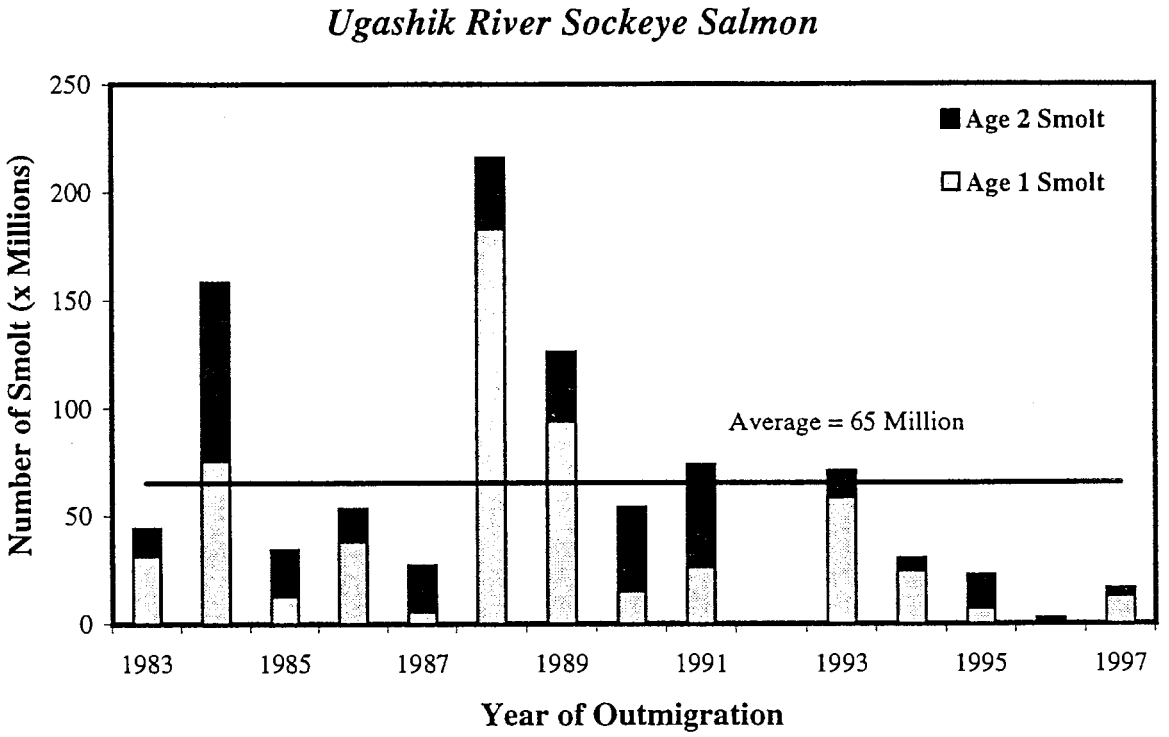

Figure 27. Number of sockeye salmon smolt migrating out of the Ugashik River, 1983-1997.

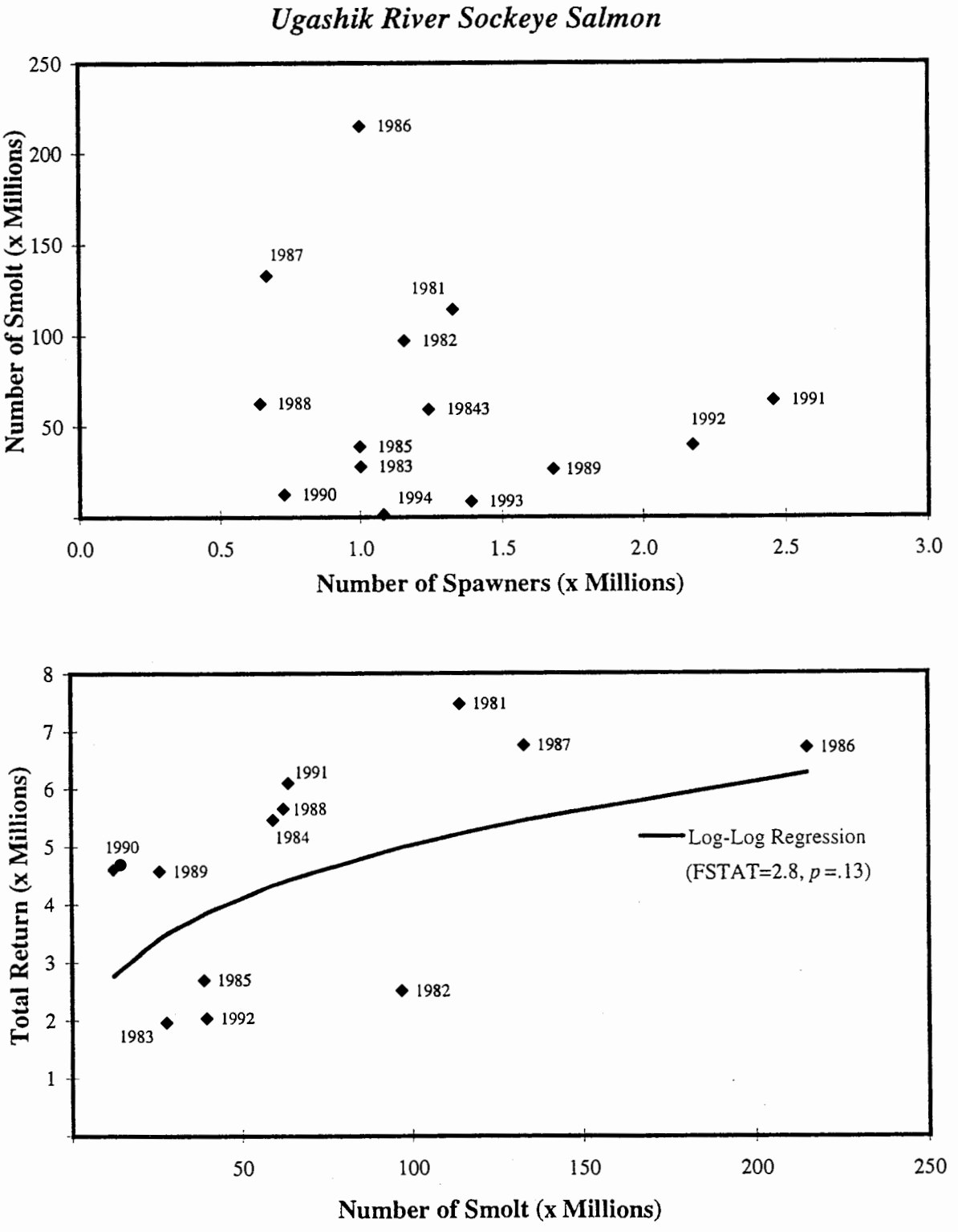

Figure 28. Number of spawners versus number of smolt, and number of smolt versus total return of Ugashik River sockeye salmon, 1981-1992 brood years.

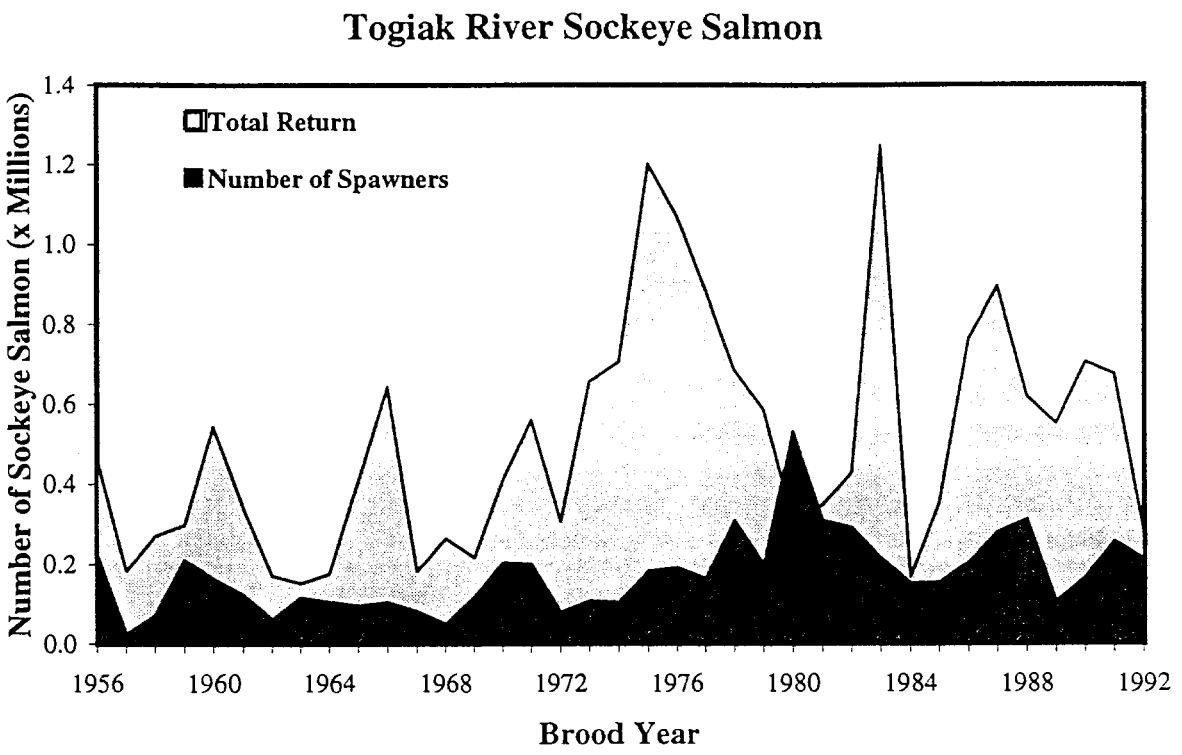

Figure 29. Number of spawners and total return of Togiak River sockeye salmon by brood year, 1956 - 1992.

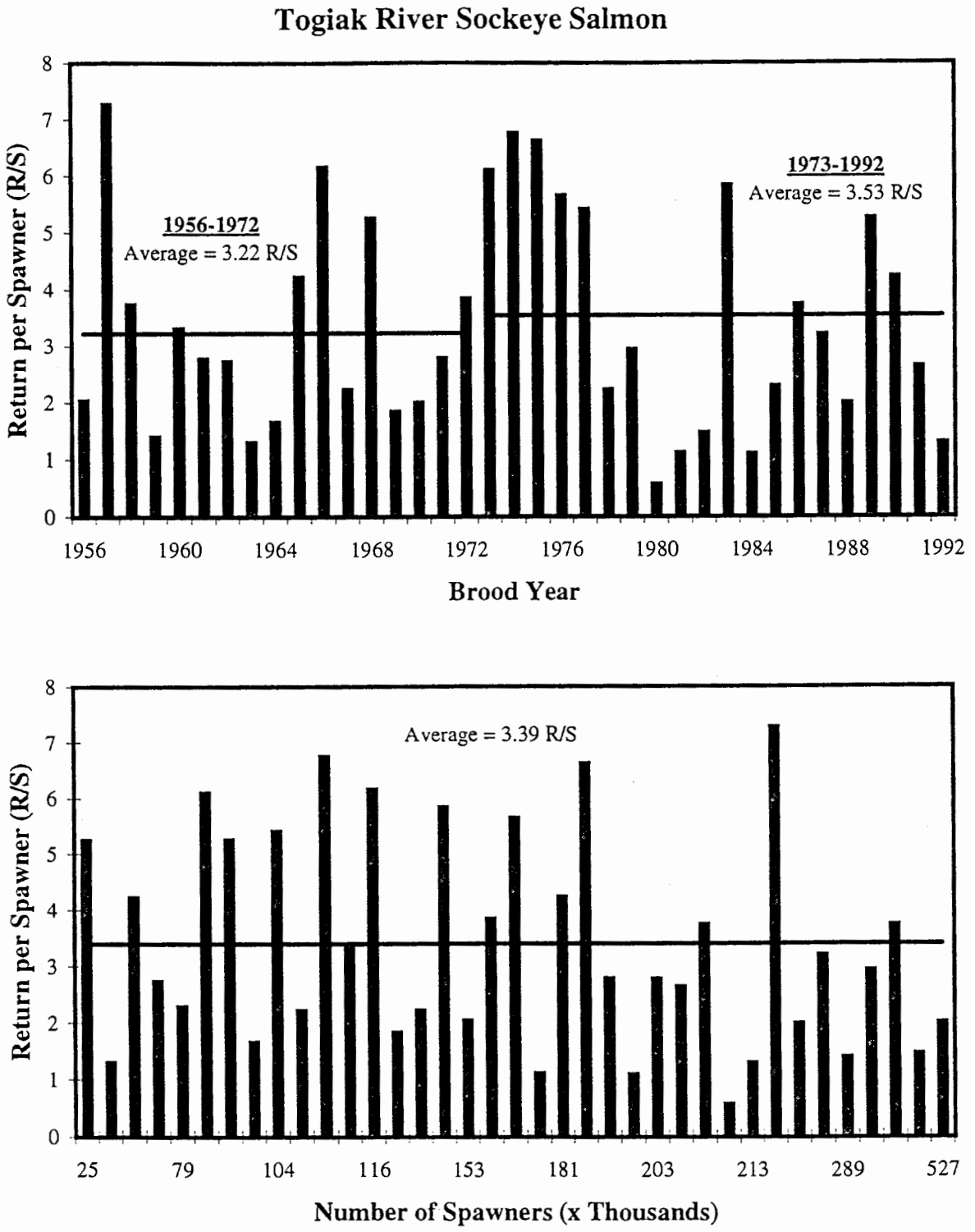

Figure 30. Return per spawner of Togiak River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

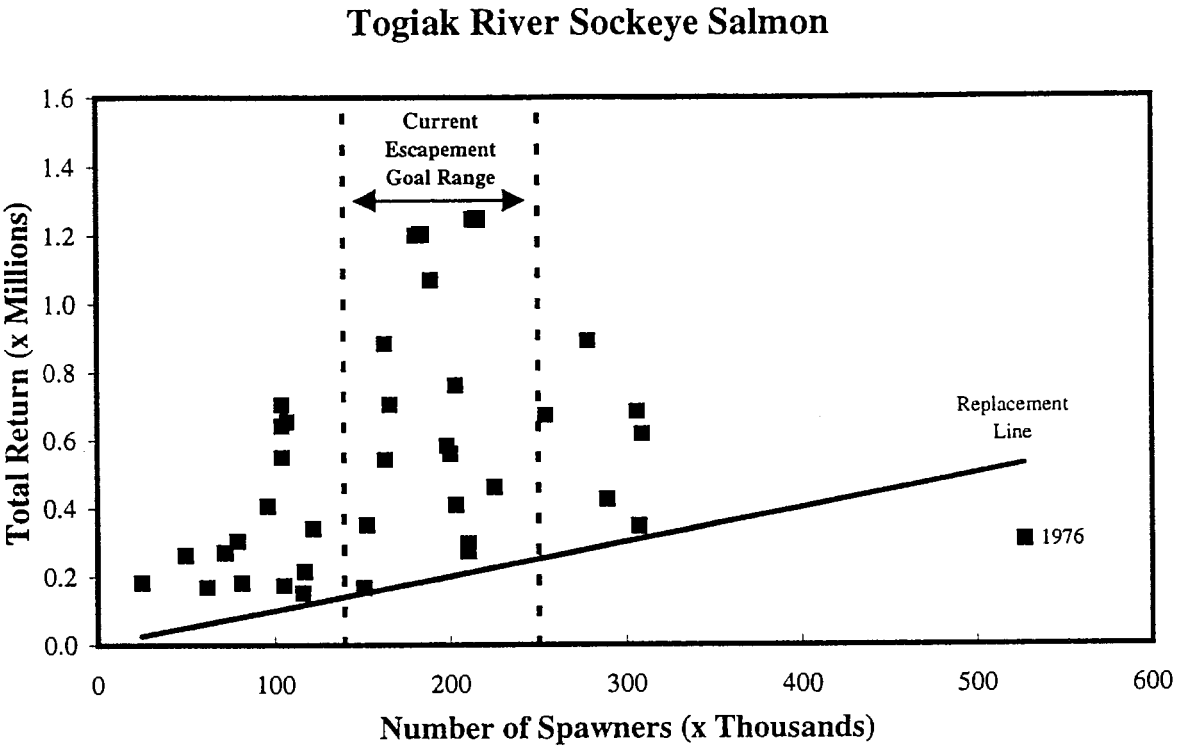

Figure 31. Total return of Togiak River sockeye salmon versus number of spawners, 1956-1992 brood years.

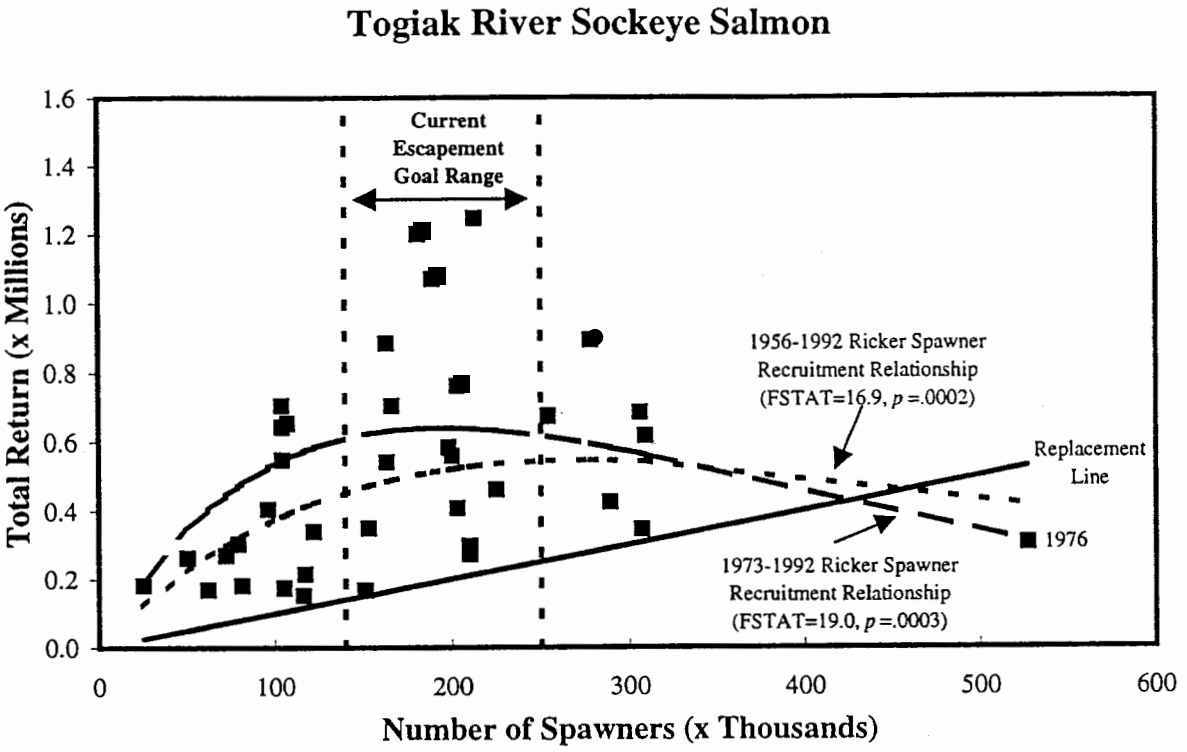

Figure 32. Ricker spawner-recruitment relationship of Togiak River sockeye salmon, 1956-1992 brood years.

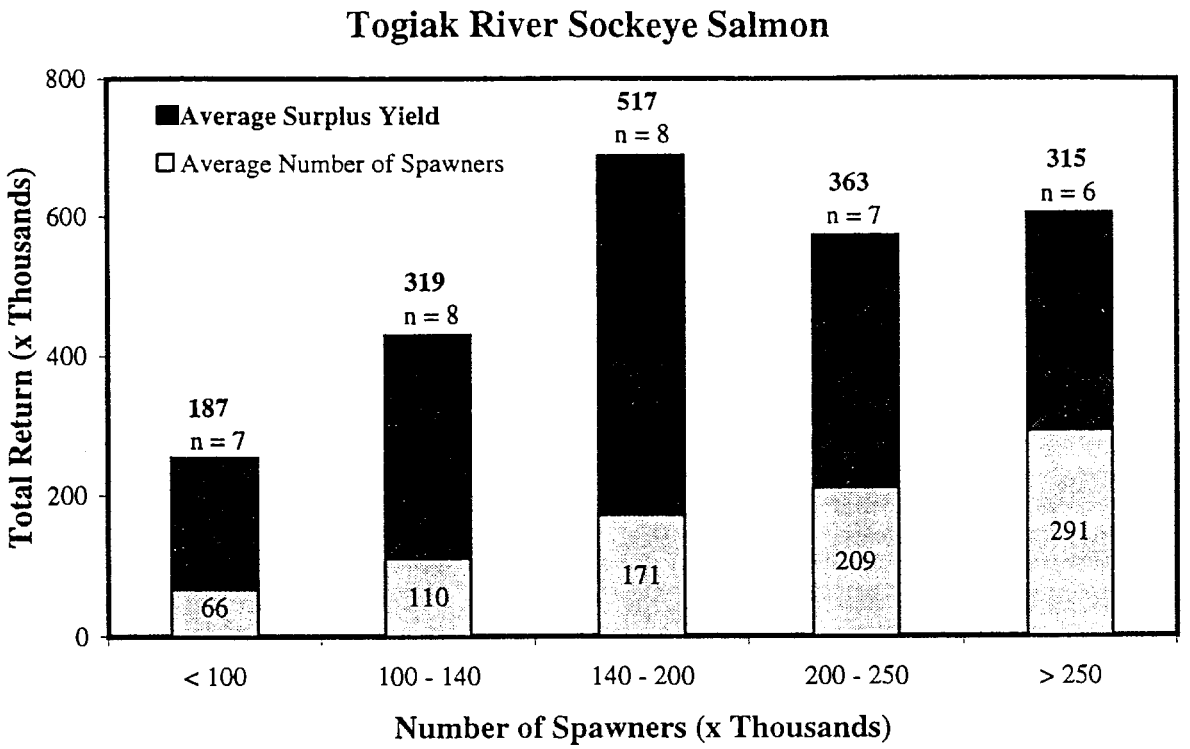

Figure 33. Average surplus yield categorized by the number of spawners of Togiak River sockeye salmon, 1956-1992 brood years.

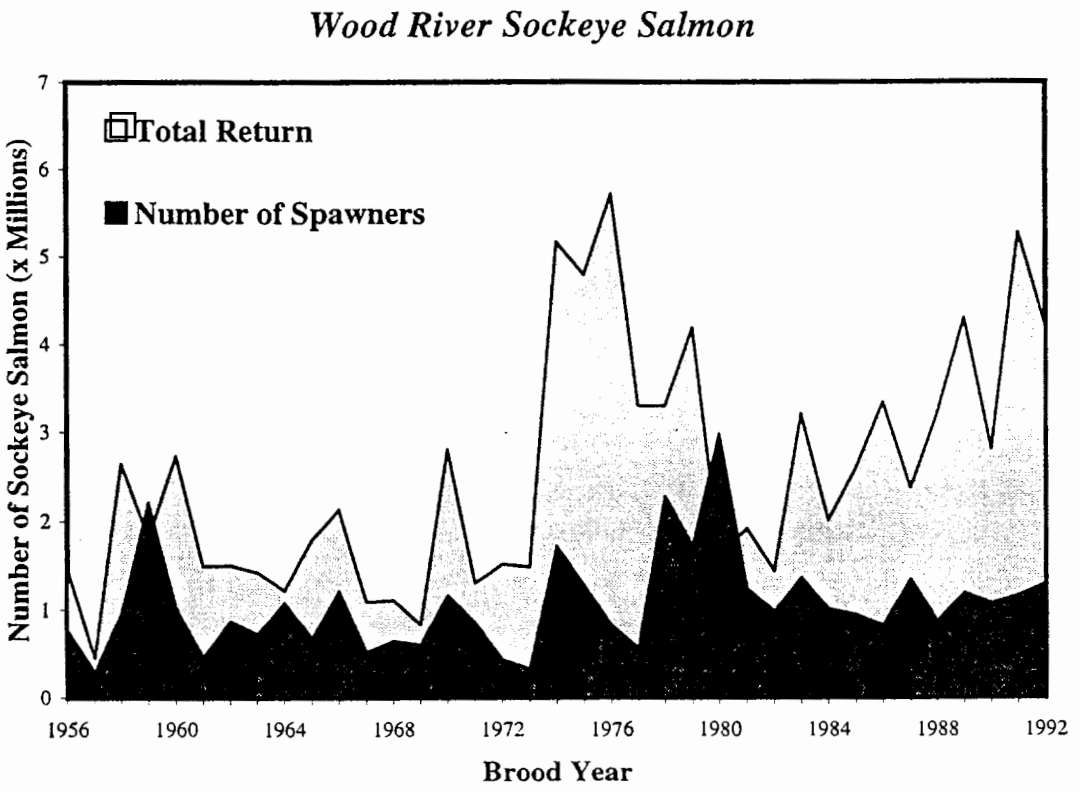

Figure 34. Number of spawners and total return of Wood River sockeye salmon by brood year, 1956 - 1992.

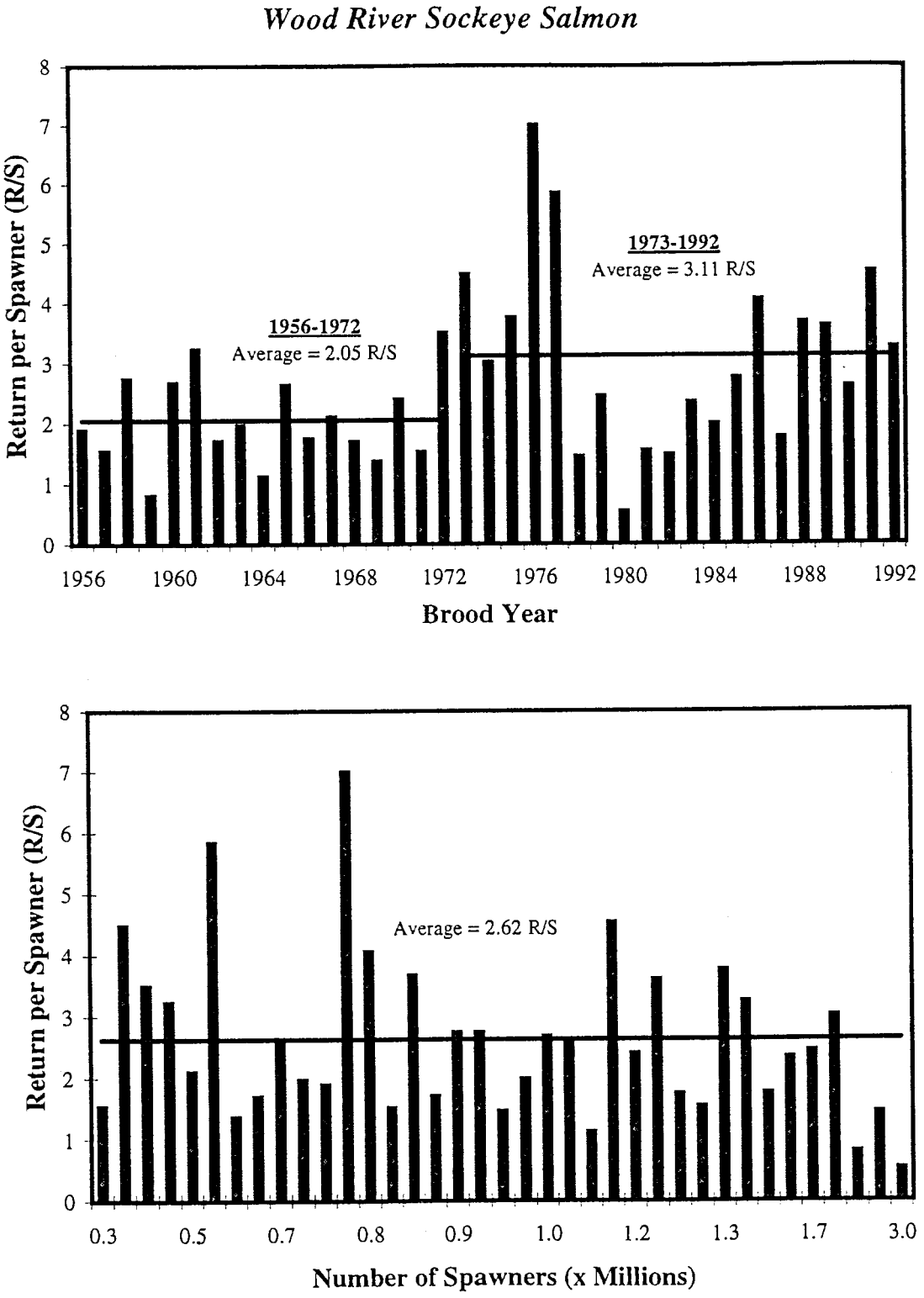

Figure 35. Return per spawner of Wood River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

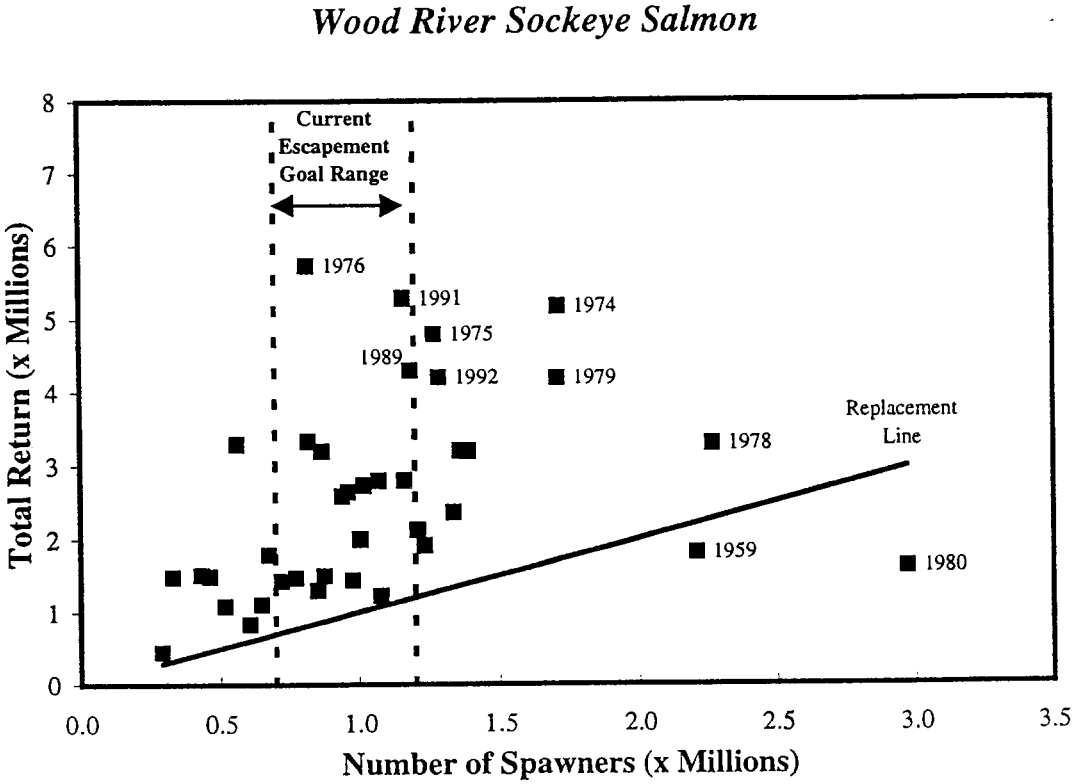

Figure 36. Total return of Wood River sockeye salmon versus number of spawners, 1956-1992 brood years.

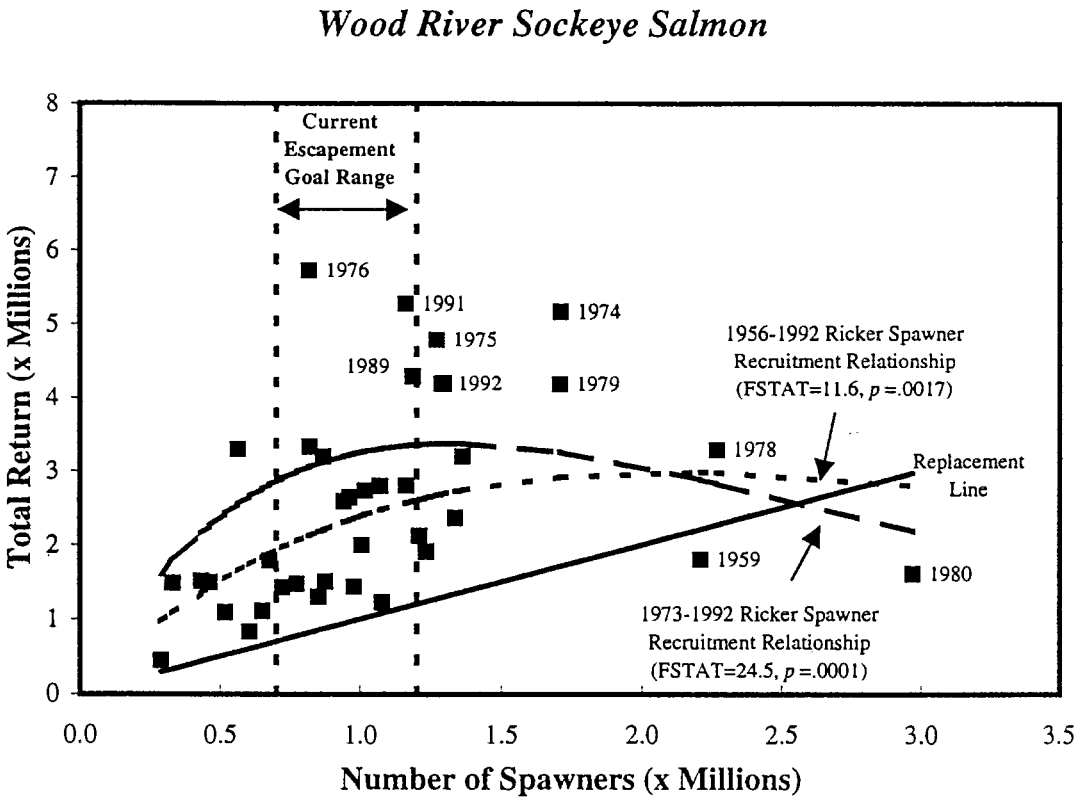

Figure 37. Ricker spawner-recruitment relationship of Wood River sockeye salmon, 1956-1992 brood years.

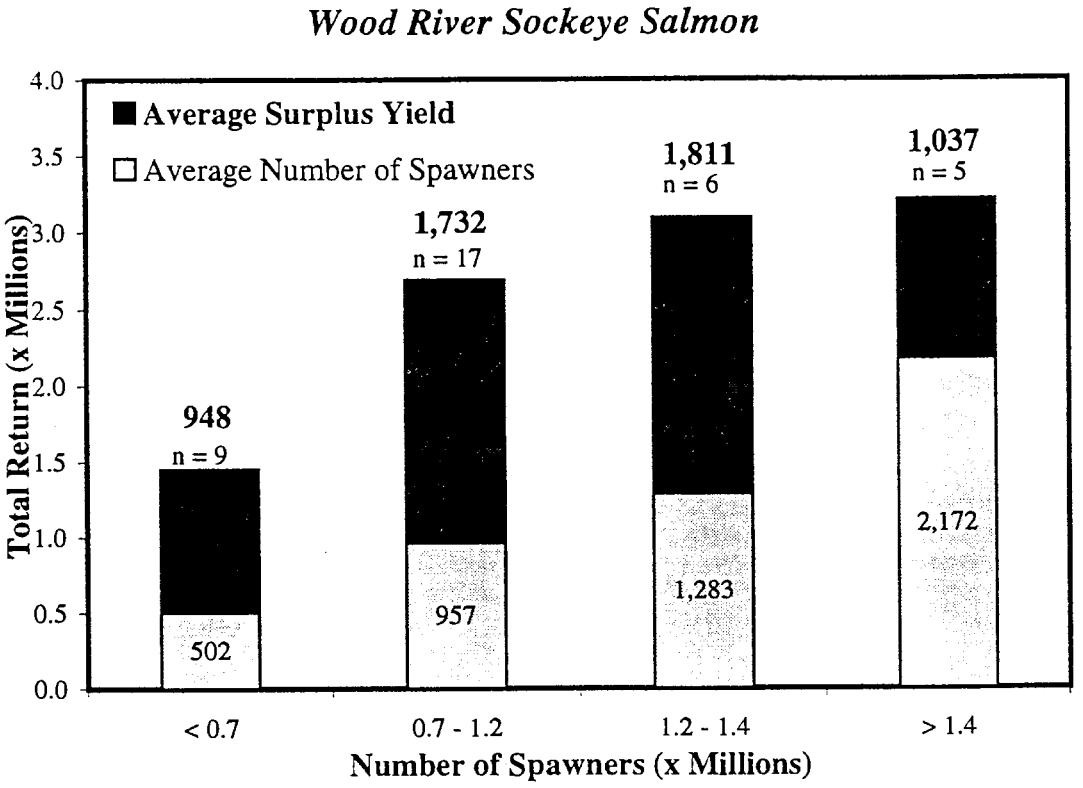

Figure 38. Average surplus yield categorized by the number of spawners of Wood River sockeye salmon, 1956-1992 brood years.

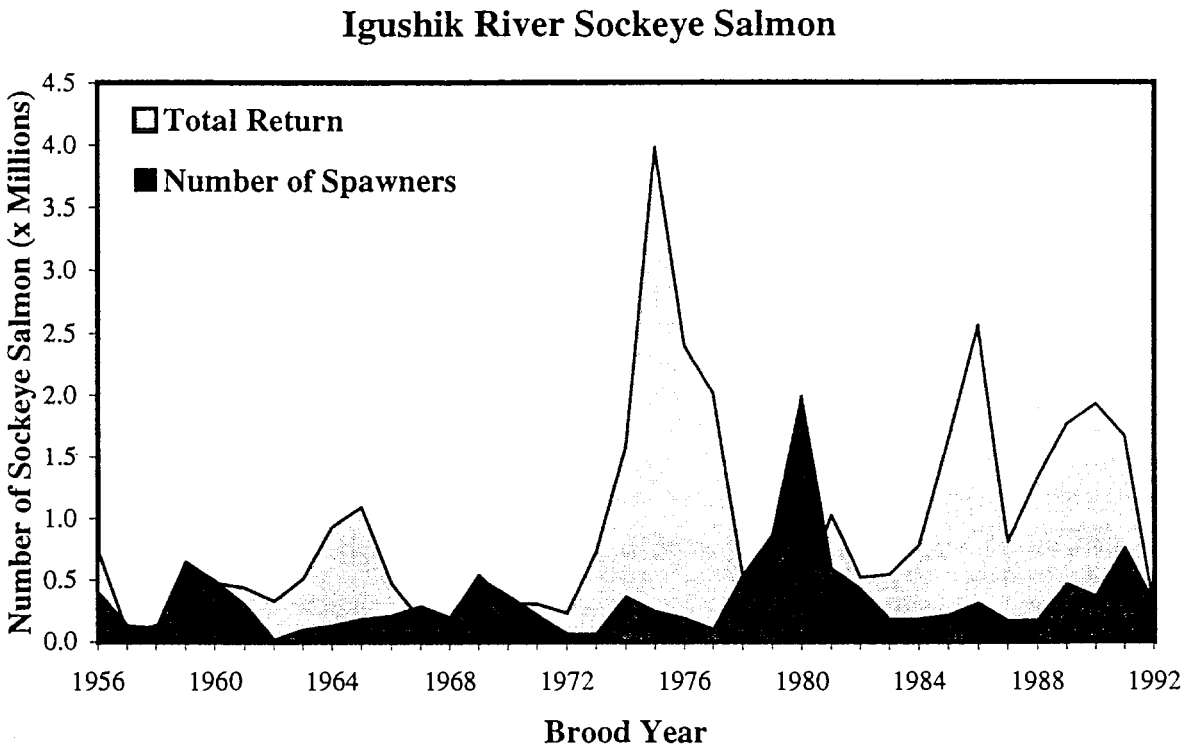

Figure 39. Number of spawners and total return of Igushik River sockeye salmon by brood year, 1956 - 1992.

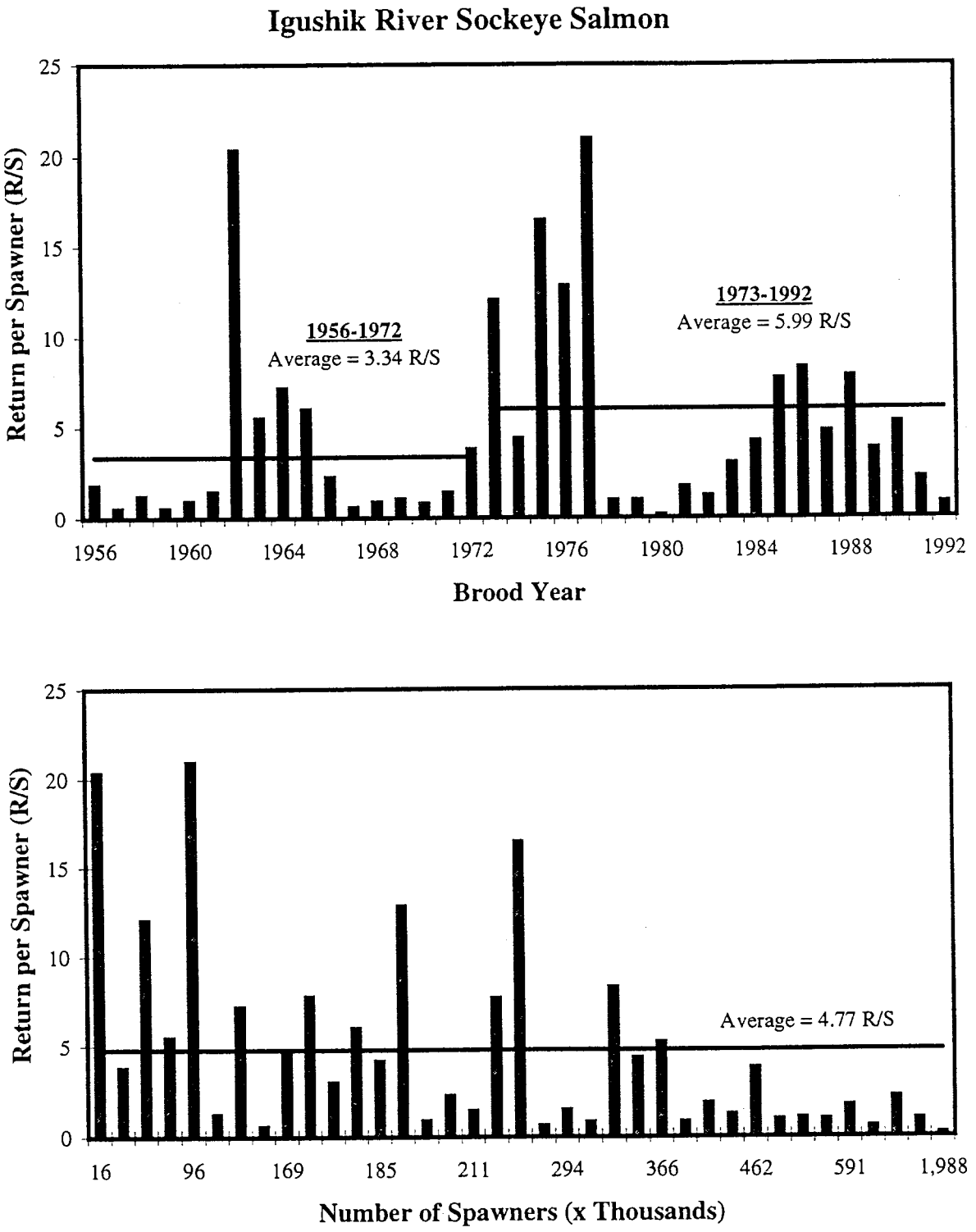

Figure 40. Return per spawner of Igushik River sockeye salmon by brood year, 1956-1992, and versus number of spawners.

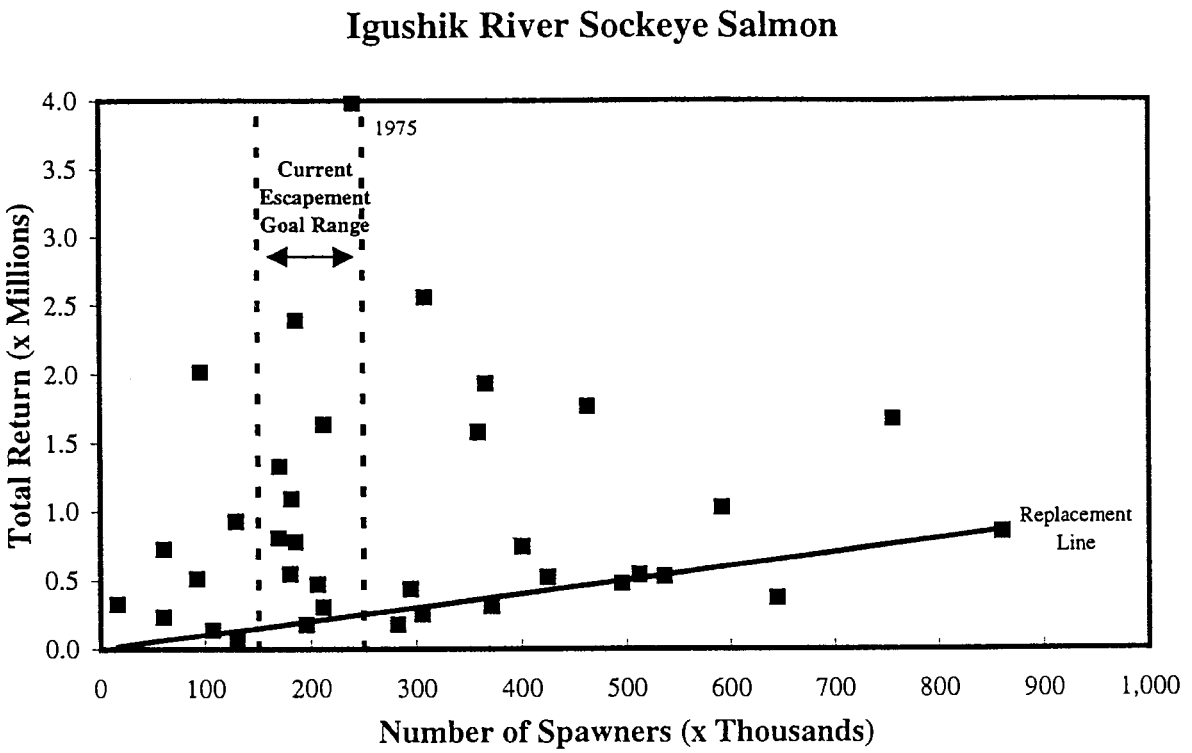

Figure 41. Total return of Igushik River sockeye salmon versus number of spawners, 1956-1992 brood years (excluding 1980 brood year).

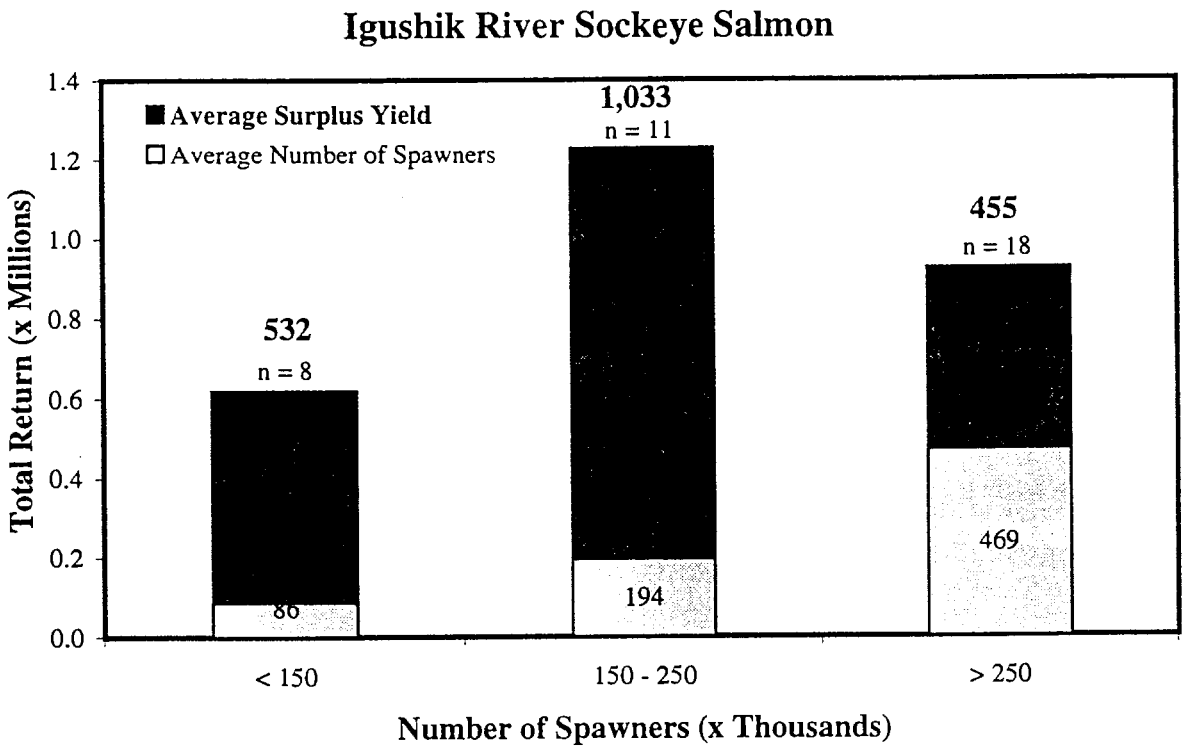

Figure 42. Average surplus yield categorized by the number of spawners of Igushik River sockeye salmon, 1956-1992 brood years (excluding 1980 brood year).

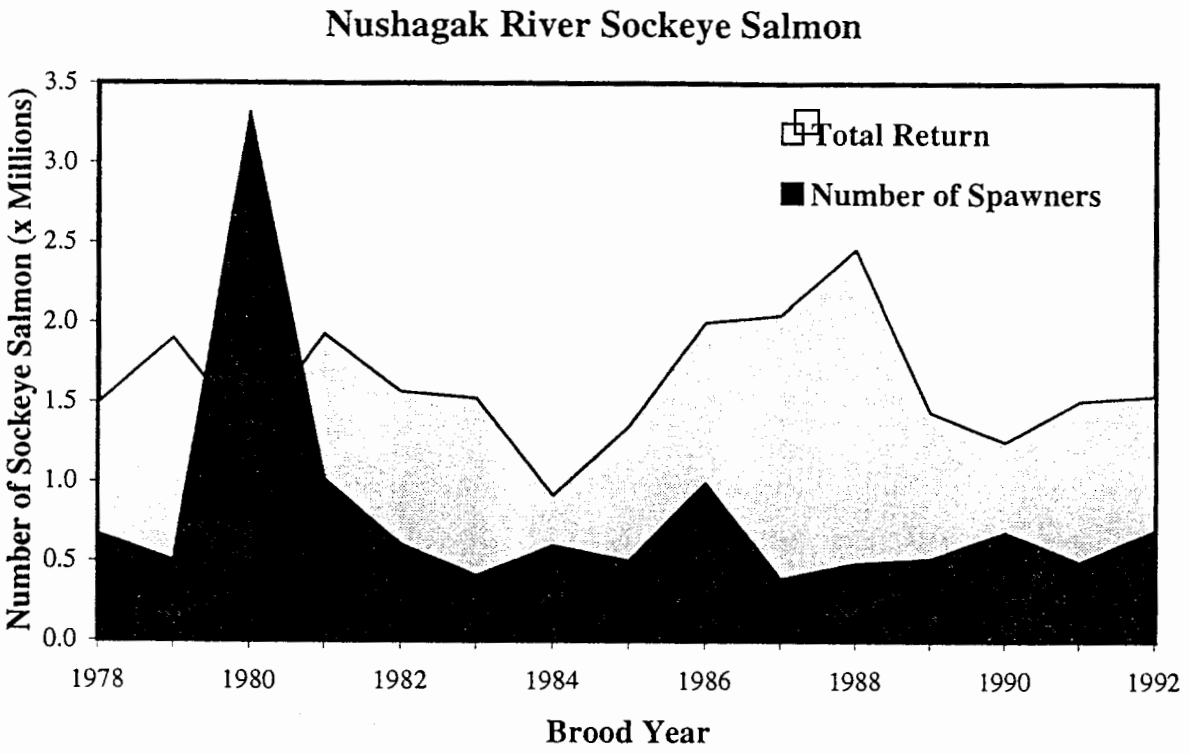

Figure 43. Number of spawners and total return of Nushagak River sockeye salmon by brood year, 1978-1992.

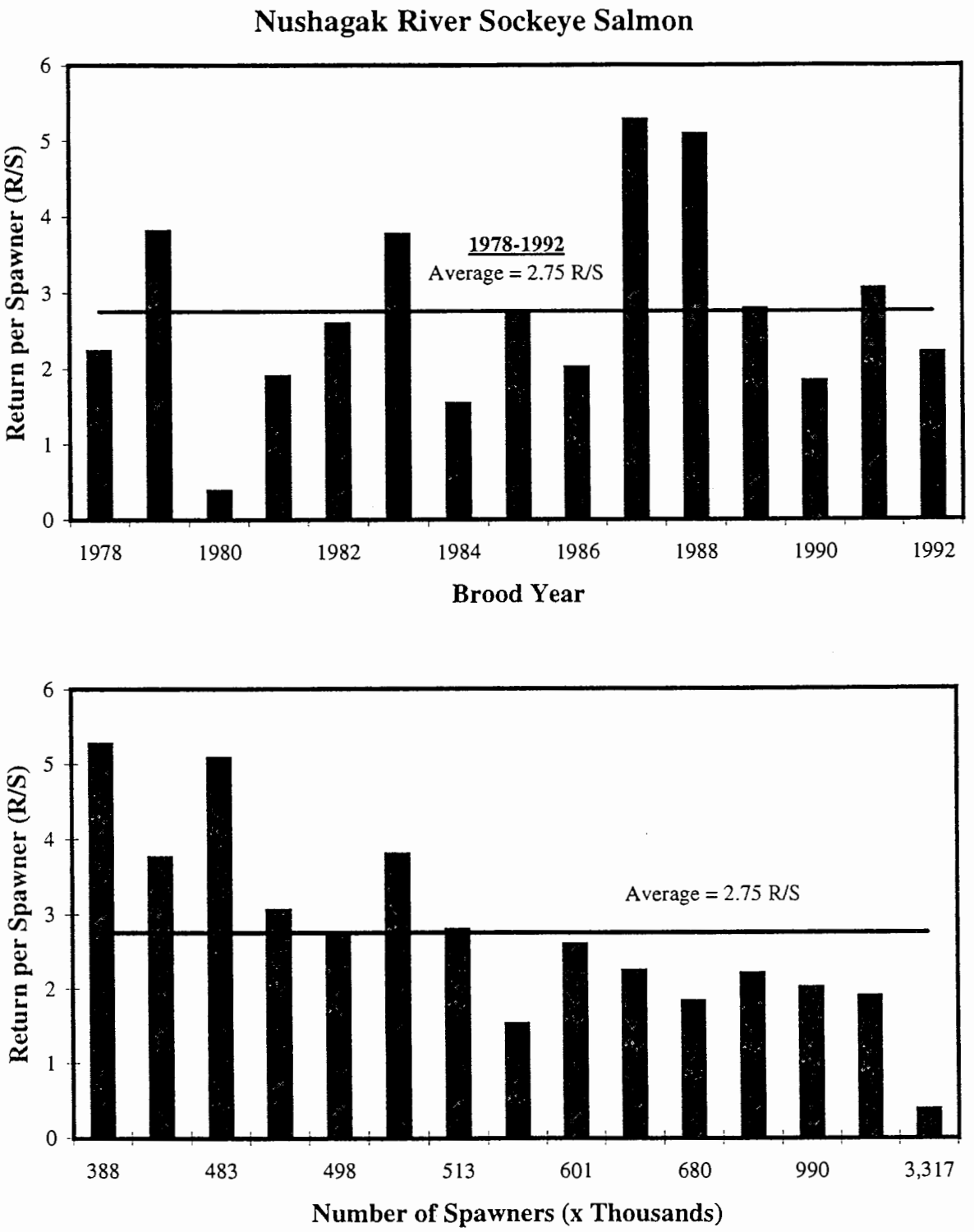

Figure 44. Return per spawner of Nushagak River sockeye salmon by brood year, 1978-1992, and versus number of spawners.

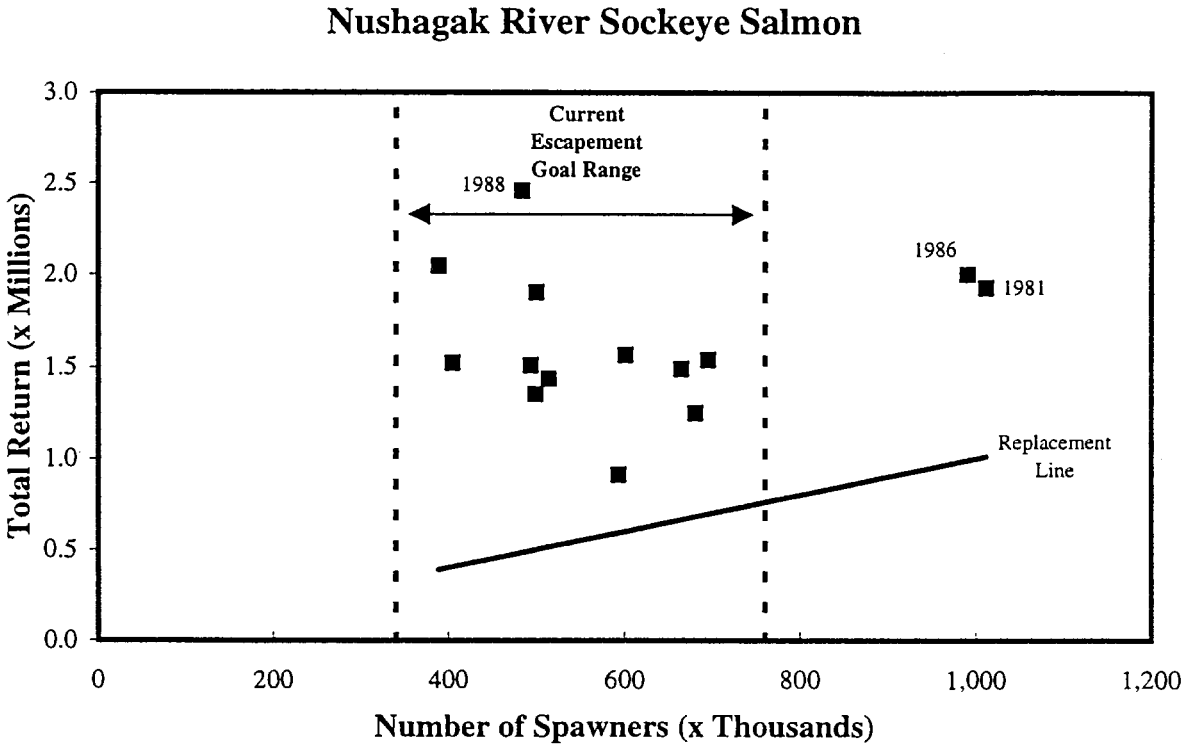

Figure 45. Total return of Nushagak River sockeye salmon versus number of spawners, 1978-1992 brood years (excluding 1980 brood year).

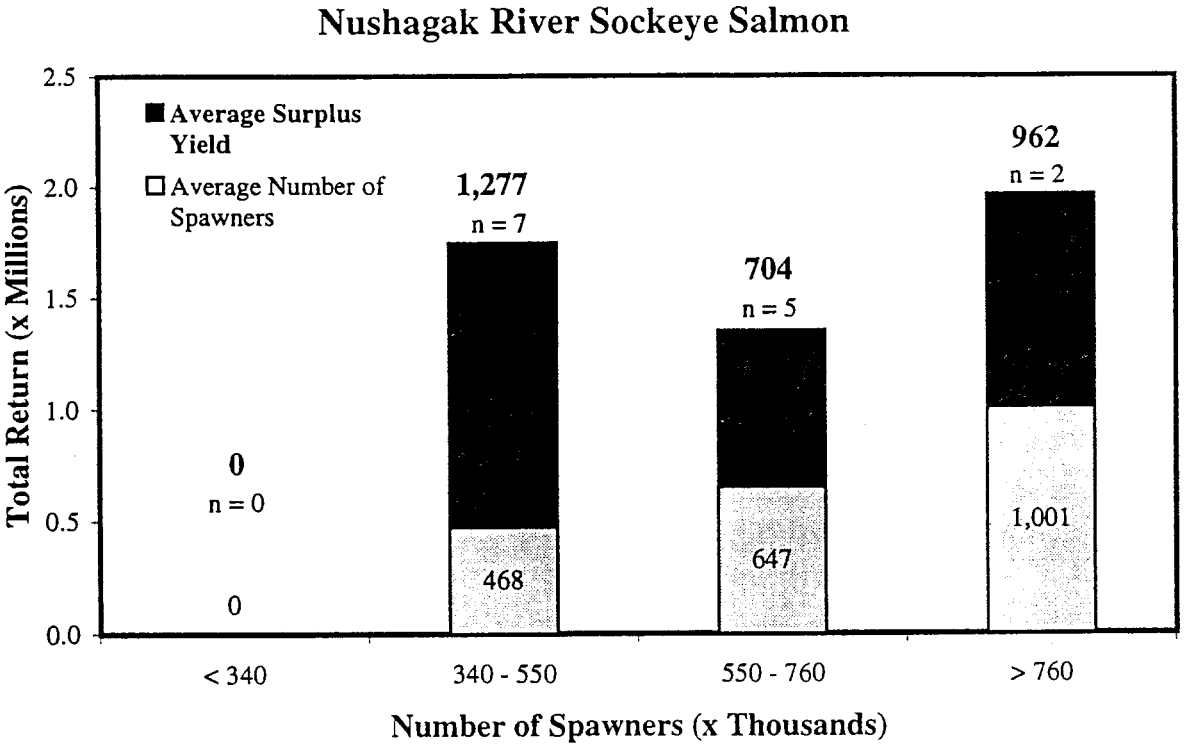

Figure 46. Average surplus yield categorized by the number of spawners of Nushagak River sockeye salmon, 1978-1992 brood years (excluding 1980 brood year).

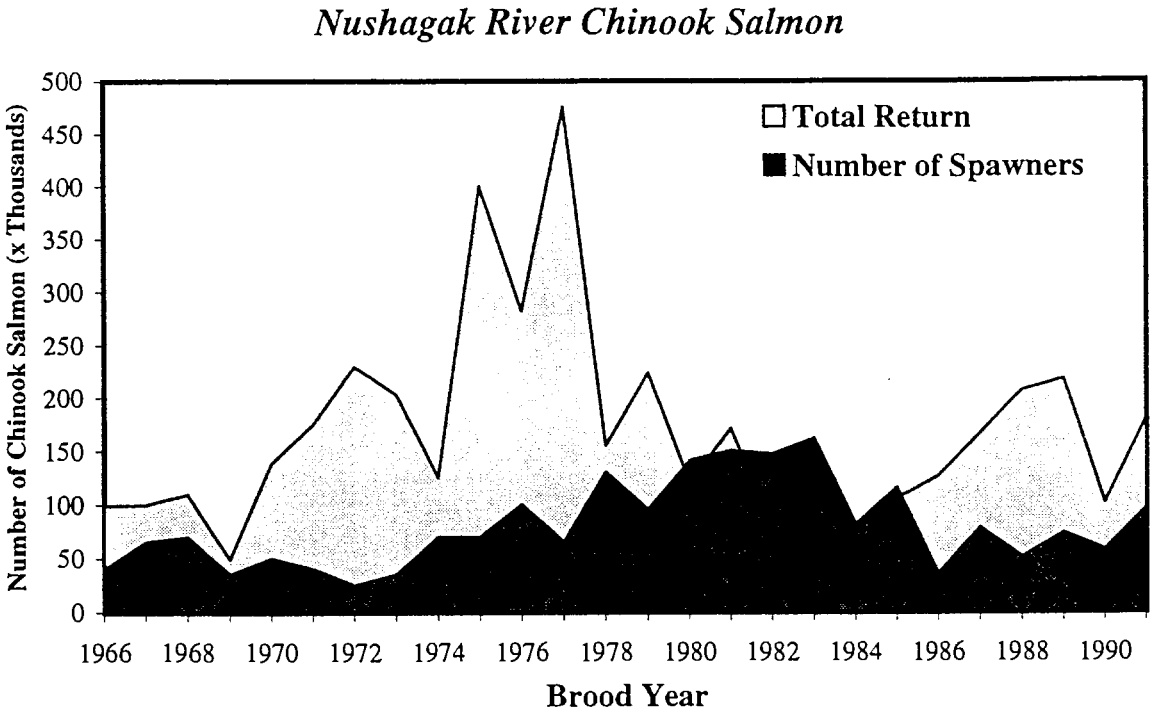

Figure 47. Number of spawners and total return of Nushagak River chinook salmon by brood year, 1966-1991.

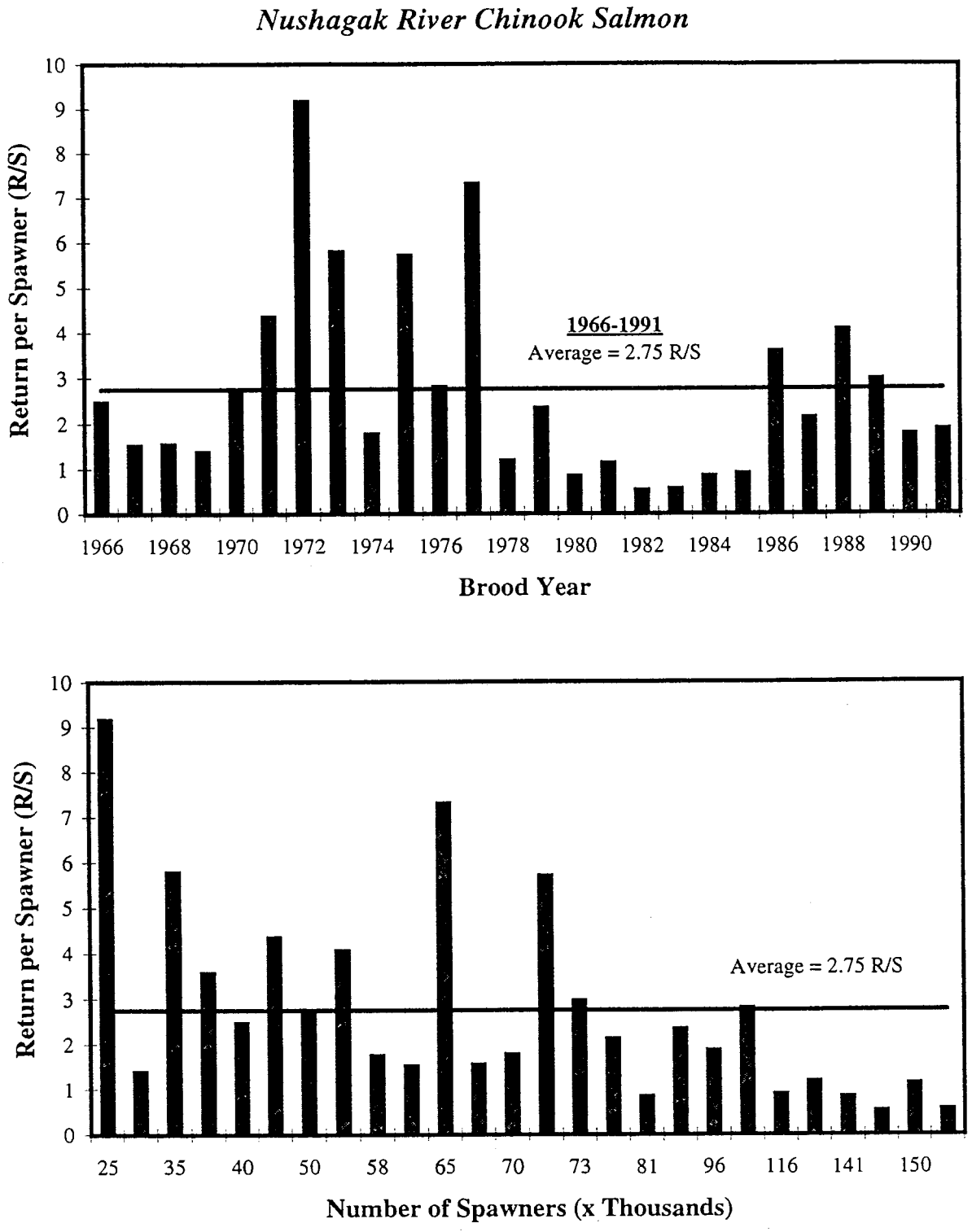

Figure 48. Return per spawner of Nushagak River chinook salmon versus number of spawners, 1966-1991 brood years.

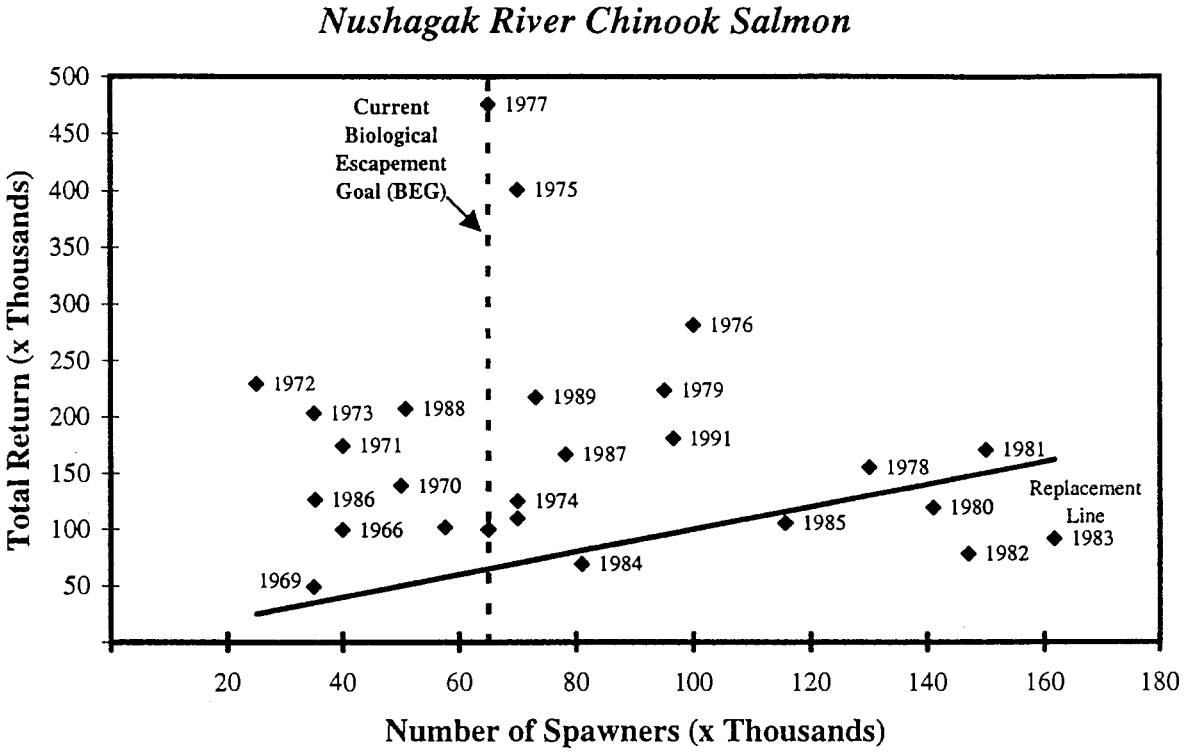

Figure 49. Total return of Nushagak River chinook salmon versus number of spawners, 1966-1991 brood years.

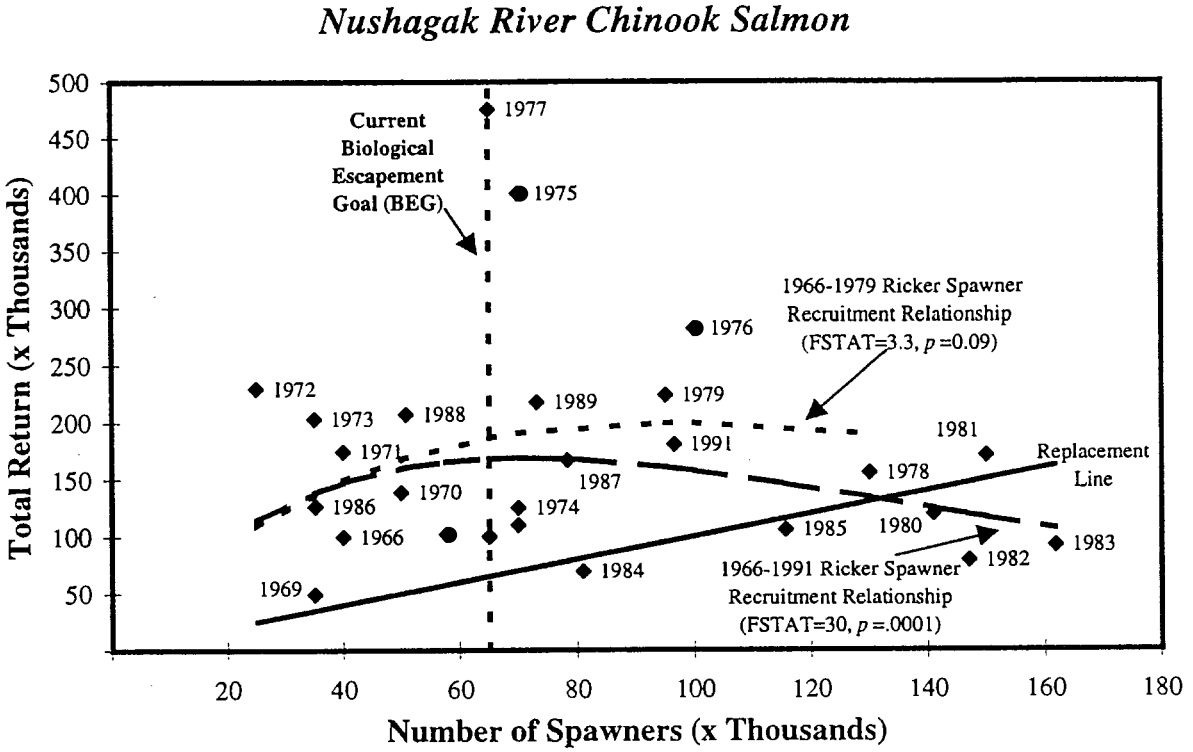

Figure 50. Ricker spawner-recruitment relationship of Nushagak River chinook salmon, 1966-1991 brood years.

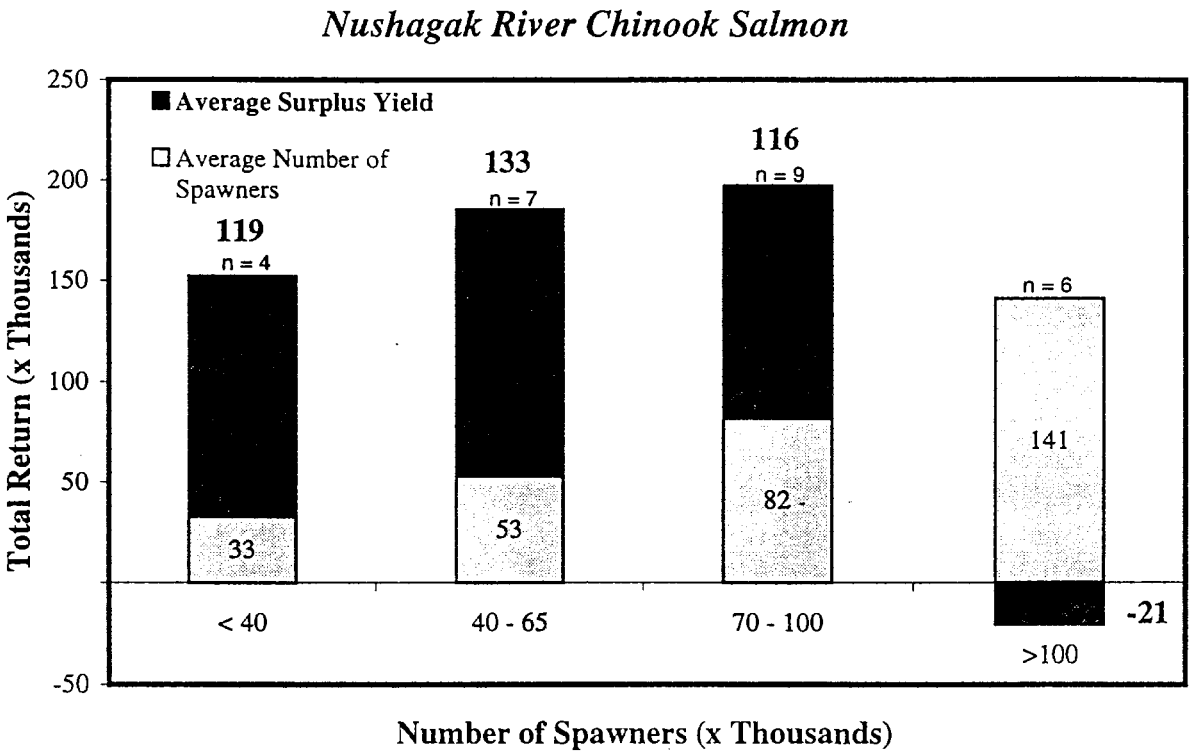

Figure 51. Average surplus yield categorized by number of spawners of Nushagak River chinook salmon, 1966-1991 brood years.

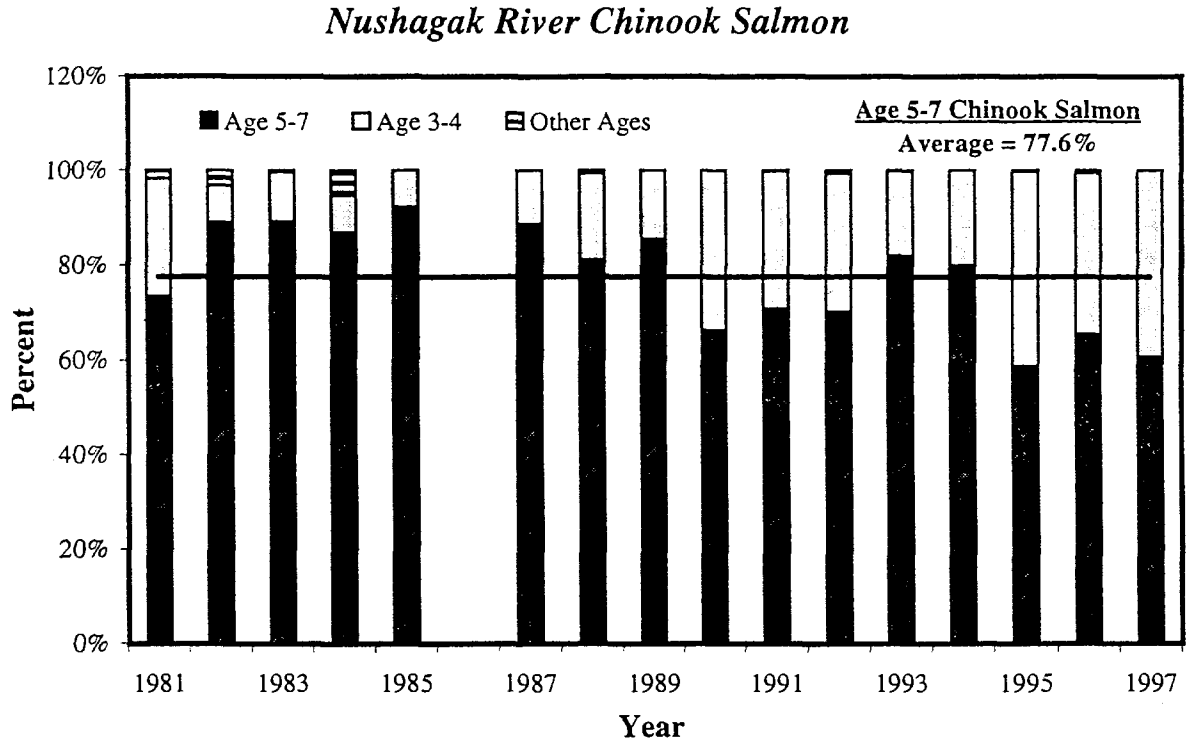

Figure 52. Percentage of age 3-4 and age 5-7 chinook salmon in Nushagak River spawning escapements, 1981-1985 and 1987-1997. No age data was collected in 1986.

APPENDIX A: WORKSHOP PARTICIPANTS

Appendix A.1. List of individuals attending the 1997 Bristol Bay sockeye salmon escapement goal workshop.

Name	Affiliation
Milo Adkinson	University of Alaska, School of Fisheries and Ocean Sciences
Cindy Anderson	ADF&G, Division of Commercial Fisheries Management and Development
Tim Baker	ADF&G, Division of Commercial Fisheries Management and Development
James Brady	ADF&G, Division of Commercial Fisheries Management and Development
Tom Brookover	ADF&G, Division of Commercial Fisheries Management and Development
Jim Browning	ADF&G, Division of Commercial Fisheries Management and Development
Brian Bue	ADF&G, Division of Commercial Fisheries Management and Development
Stan Carlson	ADF&G, Division of Commercial Fisheries Management and Development
Bob Clark	ADF&G, Sport Fish Division
Drew Crawford	ADF&G, Division of Commercial Fisheries Management and Development
Beverly Cross	ADF&G, Division of Commercial Fisheries Management and Development
Doug Eggers	ADF&G, Division of Commercial Fisheries Management and Development
David Evans	ADF&G, Division of Commercial Fisheries Management and Development
Chris Foote	University of Washington, Fisheries Research Institute
Stephen Fried	ADF&G, Division of Commercial Fisheries Management and Development
Dan Gray	ADF&G, Division of Commercial Fisheries Management and Development
Ray Hilborn	University of Washington, Fisheries Research Institute
Gary Kyle	ADF&G, Division of Commercial Fisheries Management and Development
Doug McBride	ADF&G, Sport Fish Division
Ole Mathisen	University of Alaska, School of Fisheries and Ocean Sciences
Jim Miller	ADF&G, Division of Commercial Fisheries Management and Development
Eric Minard	ADF&G, Sport Fish Division
Jeff Regnart	ADF&G, Division of Commercial Fisheries Management and Development
Donald Rogers	University of Washington, Fisheries Research Institute
Dana Schmidt	ADF&G, Division of Commercial Fisheries Management and Development
Ken Tarbox	ADF&G, Division of Commercial Fisheries Management and Development
Keith Weiland	ADF&G, Division of Commercial Fisheries Management and Development

Appendix B.1. Kvichak River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
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	17,505	0	2	5	2,889	20	0	1,641	8,076	0	2	413	0	0	0	0	13,048	0.75
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 [c]	9,992 [c]	2.46
1989	8,318	29	2	54	2,147	117	2	1,678	18,826	0	2	3,316	13	1 [d]	0 [d]	0 [c]	26,187 [c]	3.15
1990	6,970	6	8	11	1,541	83	0	1,192	21,105	0	0	1,163 [d]	0 [d]	0 [c]	0 [c]	0 [c]	25,109 [c]	3.60
1991	4,223	0	1	4	2,688	2	0 [d]	1,255 [d]	704 [d]	0 [d]	0 [c]	*179* [e]	0 [c]	0 [c]	0 [c]	0 [c]	4,833 [c]	1.14
1992	4,726	2	0	14 [d]	422 [d]	2 [d]	0 [c]	*206* [e]	*572* [e]	0 [c]	0 [c]	*200* [f]	0 [c]	0 [c]	0 [c]	0 [c]	1,418 [c]	0.30
1993	4,025	0 [d]	1 [d]	0 [c]	*735* [e]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	1 [c]	
1994	8,338																	
1995	10,039																	
1996	1,451																	
1997	1,504																	
1956-92 Avg	5,649	4	6	8	2,998	52	0	1,071	7,850	0	3	904	16	1	2	0	12,914	2.51
1956-72 Avg	5,607	1	3	1	2,382	48	0	658	7,471	0	2	828	28	0	3	0	11,424	1.89
1973-92 Avg	5,684	6	7	14	3,521	55	1	1,423	8,173	0	3	969	5	1	1	0	14,180	3.04

[a] Escapement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.2. Naknek River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
1956	1,773	0	1	0	473	0	0	1,701	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	2,232	0	0	0	349	7	0	351	742	0	0	705	0	0	0	0	2,154	0.97
1960	828	0	1	1	1,408	9	0	625	696	0	0	1,278	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	1,350	0	1	0	447	24	0	264	1,135	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	1,016	1	4	0	728	2	0	2,304	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	1,023	0	3	0	152	0	0	234	83	0	0	269	2	0	2	0	745	0.73
1969	1,331	0	0	0	47	3	0	307	976	0	0	1,211	5	0	3	0	2,552	1.92
1970	733	0	1	0	154	19	0	318	1,845	0	0	370	12	0	0	0	2,719	3.71
1971	936	0	1	0	397	24	0	559	1,428	0	0	1,844	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	1,241	0	2	0	232	3	0	228	1,026	0	1	783	5	0	5	0	2,285	1.84
1975	2,027	0	1	0	425	11	0	1,746	1,393	0	0	1,641	1	8	0	0	5,226	2.58
1976	1,321	0	4	0	1,084	3	0	4,048	1,575	0	21	1,491	0	28	1	0	8,255	6.25
1977	1,086	2	10	7	635	0	0	2,272	95	0	64	401	0	1	5	0	3,492	3.22
1978	813	0	1	0	331	4	0	1,695	1,121	0	11	530	2	0	0	0	3,695	4.54
1979	925	0	4	1	2,438	4	0	973	792	0	9	408	4	0	3	0	4,636	5.01
1980	2,645	0	1	1	723	14	0	1,505	1,192	0	9	828	0	2	0	0	4,275	1.62
1981	1,796	0	4	0	782	9	0	2,568	473	0	12	937	0	3	0	0	4,788	2.67
1982	1,156	0	3	3	185	0	0	1,172	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	1,242	0	1	0	469	23	0	911	1,214	0	21	1,828	5	1	4	0	4,477	3.60
1985	1,850	0	2	6	656	20	1	3,533	1,293	0	44	1,441	0	28	10	0	7,034	3.80
1986	1,978	0	3	6	1,981	6	1	7,167	1,276	0	367	2,817	1	38	2	0	13,665	6.91
1987	1,062	3	0	12	336	4	1	1,251	565	0	95	3,225	2	12	0	0	5,506	5.18
1988	1,038	0	0	0	273	13	0	796	516	0	37	544	2	2	1	0 [d]	2,184 [c]	2.10
1989	1,162	0	1	0	226	5	0	930	1,154	0	0	566	4	1 [d]	2 [d]	0 [c]	2,889 [c]	2.49
1990	2,093	0	0	0	405	46	0	1,236	1,345	0	13	1,287 [d]	1 [d]	0 [c]	0 [c]	0 [c]	4,333 [c]	2.07
1991	3,579	1	13	0	546	1	0 [d]	5,186 [d]	248 [d]	0 [d]	0 [c]	*298* [e]	0 [c]	0 [c]	0 [c]	0 [c]	6,293 [c]	1.76
1992	1,607	0 [d]	0 [d]	16 [d]	262 [d]	1 [d]	0 [c]	*552* [e]	*220* [e]	0 [c]	0 [c]	*800* [f]	0 [c]	0 [c]	0 [c]	0 [c]	1,851 [c]	1.15
1993	1,536	0 [d]	0 [d]		272 [e]													
1994	991																	
1995	1,111																	
1996	1,078																	
1997	1,026																	
1956-92 Avg	1,244	0	2	2	501	9	0	1,315	742	0	21	866	3	4	2	0	3,466	3.05
1956-72 Avg	951	0	1	0	346	10	0	576	642	0	2	629	4	1	2	0	2,212	2.72
1973-92 Avg	1,493	0	3	3	632	9	0	1,944	827	0	37	1,068	1	7	2	0	4,532	3.32

[a] Escapement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.3. Egegik River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
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	1,613	0	1	0	413	62	0	1,278	11,061	0	4	5,650	261	3	152	0 [d]	18,885 [c]	11.71
1989	1,612	1	0	6	513	34	0	456	6,063	1	6	3,979	170	1 [d]	27 [d]	0 [c]	11,257 [c]	6.98
1990	2,192	0	0	2	403	66	0	867	9,598	1	3 [d]	4,722 [d]	20 [d]	0 [c]	0 [c]	0 [c]	15,682 [c]	7.15
1991	2,787	4	1	3	1,397	20	2 [d]	3,946 [d]	3,135 [d]	0 [d]	0 [c]	*2,482* [e]	0 [c]	0 [c]	0 [c]	0 [c]	10,990 [c]	3.94
1992	1,946	5	0	31 [d]	337 [d]	55 [d]	0 [c]	*967* [e]	*4,464* [e]	0 [c]	0 [c]	*1,800* [f]	0 [c]	0 [c]	0 [c]	0 [c]	7,659 [c]	3.94
1993	1,517	0 [d]	2 [d]	0 [c]	*451* [e]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	2 [c]	
1994	1,898																	
1995	1,267																	
1996	1,076																	
1997	1,104																	
1956-92 Avg	1,050	1	1	3	472	19	0	974	2,943	0	8	1,838	54	5	23	0	6,341	5.90
1956-72 Avg	855	0	0	0	206	4	0	340	1,174	0	1	766	51	1	27	0	2,572	3.14
1973-92 Avg	1,216	1	1	5	698	32	0	1,513	4,447	1	14	2,749	56	8	19	0	9,545	8.25

[a] Esacpement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.4. Ugashik River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
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 [d]	5,651 [c]	8.64
1989	1,713	3	7	7	694	14	0	391	2,479	0	12	955	6	1 [d]	3 [d]	0 [c]	4,572 [c]	2.67
1990	749	0	1	13	345	15	2	709	2,302	0	2 [d]	1,213 [d]	2 [d]	0 [c]	0 [c]	0 [c]	4,604 [c]	6.15
1991	2,482	1	6	0	2,034	1	0 [d]	3,165 [d]	599 [d]	0 [d]	0 [c]	*292* [e]	0 [c]	0 [c]	0 [c]	0 [c]	6,098 [c]	2.46
1992	2,195	6	3	49 [d]	191 [d]	4 [d]	0 [c]	*565* [e]	*821* [e]	0 [c]	0 [c]	*400* [f]	0 [c]	0 [c]	0 [c]	0 [c]	2,039 [c]	0.93
1993	1,413	1 [d]	2 [d]	0 [c]	*251* [e]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	3 [c]	
1994	1,095																	
1995	1,321																	
1996	692																	
1997	618																	
1956-92 Avg.	809	1	2	6	615	8	0	697	930	0	6	454	2	2	2	0	2,724	4.66
1956-72 Avg.	495	0	1	0	319	2	0	231	273	0	0	85	1	0	1	0	912	2.08
1973-92 Avg.	1,075	1	3	11	867	13	0	1,093	1,489	0	11	768	3	3	2	0	4,265	6.84

[a] Escapement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.5. Togiak River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
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 [d]	617 [c]	2.00
1989	104	0	0	36	132	0	1	328	7	0	1	41	0	0 [d]	0 [d]	0 [c]	546 [c]	5.25
1990	166	1	0	23	101	0	1	460	75	0	5 [d]	36 [d]	0 [d]	0 [c]	0 [c]	0 [c]	702 [c]	4.23
1991	254	1	3	3	189	0	1 [d]	427 [d]	28 [d]	0 [d]	0 [c]	*20* [e]	0 [c]	0 [c]	0 [c]	0 [c]	672 [c]	2.65
1992	210	1	0	35 [d]	50 [d]	0 [d]	0 [c]	*144* [e]	*8* [e]	0 [c]	0 [c]	*35* [f]	0 [c]	0 [c]	0 [c]	0 [c]	273 [c]	1.30
1993	189	0 [d]	0 [d]	0 [c]	*36* [e]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	36 [c]	
1994	174																	
1995	211																	
1996	187																	
1997	152																	
1956-92 Avg.	174	0	0	8	117	0	0	305	34	0	2	38	0	0	0	0	503	3.38
1956-72 Avg.	119	0	0	3	87	0	0	179	28	0	1	28	0	0	0	0	327	3.21
1973-92 Avg.	221	1	0	11	143	0	1	411	38	0	3	46	0	0	0	0	654	3.53

[a] Escapement not avialable.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.6. Wood River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
1956	773	0	0	48	774	0	0	627	24	0	0	0	0	0	0	0	1,473	1.91
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	2,145	1	0	389	75	0	0	32	0	0	0	0	2,643	2.75
1959	2,209	0	0	1	979	10	0	398	359	0	1	55	0	0	2	0	1,805	0.82
1960	1,016	0	6	0	1,474	0	0	1,039	106	0	2	105	1	0	0	0	2,733	2.69
1961	461	0	0	10	255	0	0	1,183	24	0	2	20	0	1	1	0	1,496	3.25
1962	874	1	2	0	992	1	2	340	116	0	6	43	0	0	0	0	1,503	1.72
1963	721	0	0	0	536	1	0	769	76	0	0	46	0	0	0	0	1,428	1.98
1964	1,076	0	1	6	452	0	0	347	338	0	0	74	0	0	2	0	1,220	1.13
1965	675	2	1	8	472	1	0	999	90	0	0	213	0	0	1	0	1,787	2.65
1966	1,209	0	7	29	974	0	0	988	46	0	7	69	0	0	1	0	2,121	1.75
1967	516	0	3	21	642	0	0	269	75	0	2	80	0	0	0	0	1,092	2.12
1968	649	0	1	0	514	0	0	565	5	0	4	19	0	0	0	0	1,108	1.71
1969	604	0	0	4	57	0	0	445	201	0	10	116	0	0	0	0	833	1.38
1970	1,162	0	2	0	1,539	0	0	1,002	231	0	0	26	0	0	0	0	2,800	2.41
1971	851	3	0	18	456	0	0	576	198	0	1	49	0	0	0	0	1,301	1.53
1972	431	2	1	22	779	0	0	631	32	0	20	27	0	0	0	0	1,514	3.51
1973	330	1	1	0	213	0	0	1,148	74	0	3	44	0	0	0	0	1,484	4.50
1974	1,709	0	3	6	2,956	4	0	1,698	421	0	5	71	0	0	0	0	5,164	3.02
1975	1,270	13	47	12	1,592	2	0	1,977	406	0	2	734	0	0	0	0	4,785	3.77
1976	817	0	3	0	2,278	3	0	2,589	572	0	10	265	0	0	0	0	5,720	7.00
1977	562	0	20	0	1,029	0	0	2,173	40	0	0	26	2	0	0	0	3,290	5.85
1978	2,267	0	0	0	1,364	3	0	1,029	784	0	12	96	0	0	0	0	3,288	1.45
1979	1,706	0	10	0	2,643	0	0	1,491	24	0	1	13	0	0	0	0	4,182	2.45
1980	2,969	0	0	0	453	0	0	978	72	0	1	101	0	0	0	0	1,605	0.54
1981	1,233	0	0	0	626	0	0	1,137	60	0	0	86	0	0	0	0	1,909	1.55
1982	976	0	4	0	522	0	0	765	121	0	12	14	0	0	0	0	1,438	1.47
1983	1,361	0	1	5	1,940	0	2	1,154	15	0	2	75	0	0	0	0	3,194	2.35
1984	1,003	0	0	0	586	0	2	1,340	32	0	15	23	0	0	0	0	1,998	1.99
1985	939	8	3	15	1,127	0	1	1,390	29	0	2	12	0	1	0	0	2,588	2.76
1986	819	7	2	25	1,179	0	1	1,970	70	0	12	64	0	0	0	0	3,330	4.07
1987	1,337	25	0	30	1,334	0	14	756	98	0	8	92	0	1	0	0	2,358	1.76
1988	867	4	1	8	1,613	0	3	1,425	90	0	15	34	0	0	0	0 [c]	3,193 [c]	3.68
1989	1,186	1	4	16	2,293	0	0	1,922	13	0	2	39	0	0 [d]	0 [d]	0 [c]	4,290 [c]	3.62
1990	1,069	10	1	10	1,104	1	3	1,208	286	0	2 [d]	168 [d]	0 [d]	0 [c]	0 [c]	0 [c]	2,793 [c]	2.61
1991	1,160	0	12	9	2,633	0	0 [d]	2,475 [d]	55 [d]	0 [d]	0 [c]	*87* [e]	0 [c]	0 [c]	0 [c]	0 [c]	5,271 [c]	4.54
1992	1,286	10	1	57 [d]	2,411 [d]	0 [d]	0 [c]	1,550 [e]	82 [e]	0 [c]	0 [c]	*80* [f]	0 [c]	0 [c]	0 [c]	0 [c]	4,191 [c]	3.26
1993	1,176	14 [d]	0 [d]	0 [c]	1,628 [e]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	0 [c]	1,642 [c]	
1994	1,472																	
1995	1,482																	
1996	1,650																	
1997	1,512																	
1956-92 Avg.	1,063	2	4	10	1,164	1	1	1,108	145	0	4	84	0	0	0	0	2,524	2.62
1956-72 Avg.	852	0	1	11	775	1	0	637	119	0	3	57	0	0	0	0	1,606	2.05
1973-92 Avg.	1,243	4	6	10	1,495	1	1	1,509	167	0	5	106	0	0	0	0	3,304	3.11

[a] Escapement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.7. Igushik River sockeye salmon spawners and returns in thousands of fish by brood year, 1956-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
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	1,988	0	0	0	20	0	0	271	25	0	0	56	0	0	0	0	372	0.19
1981	591	0	0	0	188	0	0	779	8	0	1	49	0	0	0	0	1,025	1.73
1982	424	0	0	7	57	0	0	434	9	0	2	10	0	0	0	0	519	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	780	4.22
1985	212	0	0	7	515	0	0	938	86	0	7	79	0	1	0	0	1,633	7.70
1986	308	3	0	14	236	0	1	2,231	27	0	15	30	0	0	0	0	2,557	8.30
1987	169	2	0	11	158	0	0	587	7	0	12	29	0	0	0	0	806	4.77
1988	170	0	0	1	189	0	1	1,056	41	0	3	36	0	0	0	0 [d]	1,327 [c]	7.81
1989	462	0	0	15	508	0	0	1,119	59	0	7	53	0	0 [d]	0 [d]	0 [c]	1,761 [c]	3.81
1990	366	1	0	3	159	0	0	1,429	183	0	4 [d]	149 [d]	0 [d]	0 [c]	0 [c]	0 [c]	1,928 [c]	5.27
1991	756	0	0	1	318	0	0	1,332 [d]	3 [d]	0 [d]	0 [c]	*12* [e]	0 [c]	0 [c]	0 [c]	0 [c]	1,666 [c]	2.20
1992	305	0 [d]	0 [d]	3 [d]	44 [d]	0 [d]	0 [c]	*148* [e]	*1* [e]	0 [c]	0 [c]	*55* [f]	0 [c]	0 [c]	0 [c]	0 [c]	251 [c]	0.82
1993	406	0 [d]	0 [d]		*98* [e]													
1994	446																	
1995	473																	
1996	401																	
1997	128																	
1956-92 Avg.	345	0	0	3	181	0	0	628	63	0	3	55	0	0	0	0	933	4.77
1956-72 Avg.	254	0	0	1	89	0	0	242	60	0	1	35	0	0	0	0	429	3.34
1973-92 Avg.	423	0	0	4	260	0	0	956	66	0	5	71	0	0	0	0	1,362	5.99

[a] Escapement not available.

[b] Younger age groups not available.

[c] Incomplete returns from brood year escapement.

[d] Estimate from 1996 preliminary return numbers.

[e] Estimate from 1997 preliminary return numbers.

[f] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.8. Nushagak River sockeye salmon spawners and returns in thousands of fish by brood year, 1978-1992.

Brood Year	Spawners	Return by Age Class															Total Return	Return per Spawner
		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		
1978	664	[a]	[a]	436	100	0	149	779	20	0	1	6	0	1	0	0	1,491	2.24
1979	499	18	0	466	494	0	16	654	6	0	42	5	0	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 [d]	1,436	2.80
1990	680	53	0	761	36	0	104	253	18	0	11 [c]	7 [c]	0 [c]	6 [d]	1 [d]		1,250	1.84
1991	493	10	1	137	172	0	7 [c]	1,014 [c]	3 [c]	0 [c]	147 [d]	13 [d]					1,506	3.06
1992	695	85	0	498 [c]	228 [c]	0 [c]	8 [d]	609 [d]	10 [d]	[d]	60 [e]	39 [e]					1,537	2.21
1993	715	45	0	32 [d]	50 [d]												127 [b]	
1994	509																	
1995	281																	
1996	504																	
1997	373																	
1978-92 Avg.	789	54	0	492	144	0	73	753	19	0	55	25	0	1	0	0	1,612	2.75

[a] Younger age groups not available.

[b] Incomplete returns from brood year escapement.

[c] Estimate from 1996 preliminary return numbers.

[d] Estimate from 1997 preliminary return numbers.

[e] Estimated 1998 return of age-2.3 so the 1992 brood year could be used.

Appendix B.9. Nushagak River chinook salmon spawners and returns in numbers of fish by brood year, 1966-1992.

Brood Year	Spawners	Return by Age Class																Total Return	Return per Spawner
		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		
1966	40,000	149	62	7,406	13,979		4,668	27,454			38,557	130		5,044	376	1,043	342	99,210	2.48
1967	65,000		0	283	9,795		1,575	16,353	76	188	46,066	380		24,552	342	275		99,885	1.54
1968	70,000		0	834	13,485		376	18,291			67,765			8,368	542			109,661	1.57
1969	35,000	230	0	384	965			14,524			29,429	808		2,430	268			49,038	1.40
1970	50,000		0		1,385			56,699			73,517	1,323		4,043	874		847	138,688	2.77
1971	40,000		0		2,433		389	55,755	501		94,828	1,266		12,572	6,976			174,720	4.37
1972	25,000		0	137	33,264		686	52,295			125,392	2,842		7,275	7,489			229,380	9.18
1973	35,000		0		2,204			82,126			105,777			13,089				203,196	5.81
1974	70,000		0	431	23,817			42,053	2,175		51,264			2,174	3,078			124,992	1.79
1975	70,000		587		95,530			146,534			137,063	3,614		9,963	7,149			400,440	5.72
1976	100,000		1,576		7,628			111,415	839		143,981	8,701		6,052	1,171	116		281,479	2.81
1977	65,000		0		96,260			152,290	3,400		208,444	231		14,837		74		475,536	7.32
1978	130,000		1,738		27,569			46,773	402		56,434			22,029			110	155,055	1.19
1979	95,000		3,137		49,377			70,843			87,467			11,862	689			223,375	2.35
1980	141,000		205		11,241			48,427			56,050	439		3,045				119,407	0.85
1981	150,000		967		33,684	37		45,639	221		83,045			7,328	23			170,944	1.14
1982	147,000		1,494		3,770			35,480			31,861			5,760				78,365	0.53
1983	161,730		118		17,640		339	20,445			51,476			1,454				91,472	0.57
1984	80,940		682		17,261			27,222			21,998			1,826	189			69,178	0.85
1985	115,720		3,205		17,998			37,021			44,991			2,065	143			105,423	0.91
1986	35,200		22		26,879			51,113			45,991	285		1,937	118			126,345	3.59
1987	78,223		514		36,480			54,921	80		69,535			5,019	96			166,645	2.13
1988	50,809		688	31	36,480			62,020			105,743			2,088	175			207,225	4.08
1989	73,106	143	2,138		40,969			84,848			85,773			3,422	166			217,459	2.97
1990	57,565		593		31,755			34,884			33,814			650				101,696	1.77
1991	96,392		1,477		53,696			70,911			54,597							180,681	1.87
1992	76,369		914	228	27,244			55,184											
1993	88,588		2,151	166	52,082														
1994	83,340		769																
1995	79,162																		
1996	45,508																		
1997	82,000																		
1966-92 Avg	79,145		794		28,031			56,353			75,033			7,155	1,659			169,211	2.75

Appendix C.1. Kvichak River numbers of sockeye salmon smolt and adult returns by brood year, 1969-1992.

Brood Year [a]		Spawners	Total Smolt	Adult Return	Smolt per Spawner	Marine Survival
1969	[b]	8,394,204	139,882,770	5,304,000	16.66	0.04
1970	[b]	13,935,306	195,225,917	15,834,000	14.01	0.08
1971	[c]	2,387,392	26,546,646	2,829,000	11.12	0.11
1974	[b]	4,433,844	222,626,740	26,179,000	50.21	0.12
1975	[b]	13,140,450	291,672,721	38,087,000	22.20	0.13
1976	[c]	1,965,282	58,649,892	10,575,000	29.84	0.18
1977	[c]	1,341,144	39,168,658	3,238,000	29.21	0.08
1978	[c]	4,149,288	214,737,076	5,160,000	51.75	0.02
1979	[b]	11,218,434	309,228,935	42,142,000	27.56	0.14
1980	[b]	17,505,268	226,665,799	13,048,000	12.95	0.06
1981	[c]	1,754,358	44,145,112	2,129,000	25.16	0.05
1982	[c]	1,134,840	53,833,461	1,685,000	47.44	0.03
1983	[c]	3,569,982	76,975,111	13,392,000	21.56	0.17
1984	[b]	10,490,670	414,898,140	23,949,000	39.55	0.06
1985	[b]	7,211,046	98,212,937	17,419,000	13.62	0.18
1986	[c]	1,179,322	19,957,080	4,557,000	16.92	0.23
1987	[c]	6,065,880	188,037,688	12,044,000	31.00	0.06
1988	[c]	4,065,216	80,835,990	9,991,000 [d]	19.88	0.12 [d]
1989	[b]	8,317,500	148,505,069	26,188,000 [d]	17.85	0.18 [d]
1990	[b]	6,970,020	222,799,579	25,108,000 [d]	31.97	0.11 [d]
1991	[c]	4,222,788	51,988,277	4,833,000 [d]	12.31	0.09 [d]
1992	[c]	4,725,864	64,672,348	1,418,000 [d]	13.68	0.02 [d]
1993		4,025,166	306,292,537		76.09	
1994		8,337,840				
1995		10,038,720				
1996		1,450,578				
1997		1,503,732				
1969-92 Avg		6,280,823	144,966,634	13,868,591	25.29	0.10
Off Cycle Year Avg		3,046,780	76,628,945	5,987,583	25.82	0.10
Pre-Peak & Peak Years Avg		10,161,674	226,971,861	23,325,800	24.66	0.11

[a] Brood years 1972 and 1973 are not included because the smolt data for these years are incomplete. Extensive damage to smolt sonar equipment in 1975 from ice flows in the river prevented the collection of this data.

[b] Pre-peak and peak cycle years = 1969-70, 1974-75, 1979-80, 1984-85, and 1989-90.

[c] Off cycle years = 1971-73, 1976-78, 1981-83, 1986-88, and 1991-92.

[d] Incomplete returns from brood year escapements. Future returns will increase these values.

Appendix C.2. Egegik River numbers of sockeye salmon smolt and adult returns by brood year, 1980-1992.

Brood Year	Spawners	Total Smolt	Adult Return	Smolt per Spawner	Marine Survival
1980	1,060,860	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	84,707,631	10,646,000	106.92	0.13
1984	1,165,320	59,628,052	13,527,000	51.17	0.23
1985	1,095,192	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	1,612,680	93,318,905	18,885,000 [a]	57.87	0.20 [a]
1989	1,610,916	21,895,567	11,257,000 [a]	13.59	0.51 [a]
1990	2,191,582	43,787,169	15,682,000 [a]	19.98	0.36 [a]
1991	2,786,925	59,373,530	10,990,000 [a]	21.30	0.19 [a]
1992	1,945,632	105,939,012	7,659,000 [a]	54.45	0.07 [a]
1993	1,517,000	15,501,941		10.22	
1994	1,897,977				
1995	1,266,692				
1996	1,075,596				
1997	1,103,964				
1981-92 Avg	1,416,538	61,837,699	12,141,077	48.79	0.24

[a] Incomplete returns from brood year escapements. Future returns will increase these values.

Appendix C.3. Ugashik River numbers of sockeye salmon smolt and adult returns by brood year, 1981-1992.

Brood Year	Spawners	Total Smolt	Adult Return	Smolt per Spawner	Marine Survival
1981	1,326,762	113,954,425	7,468,000	85.89	0.07
1982	1,157,526	96,899,011	2,508,000	83.71	0.03
1983	1,000,614	27,881,406	1,965,000	27.86	0.07
1984	1,241,418	59,383,477	5,464,000	47.84	0.09
1985	998,232	38,700,560	2,696,000	38.77	0.07
1986	1,001,493	214,998,421	6,697,000	214.68	0.03
1987	668,964	132,808,766	6,744,000	198.53	0.05
1988	642,972	62,551,046	5,651,000 [a]	97.28	0.09 [a]
1989	1,681,302	26,056,791	4,572,000 [a]	15.50	0.18 [a]
1990	749,478	12,415,518	4,603,000 [a]	16.57	0.37 [a]
1991	2,482,016	64,057,099	6,098,000 [a]	25.81	0.10 [a]
1992	2,194,927	39,577,888	2,039,000 [a]	18.03	0.05 [a]
1993	1,413,454	8,390,955		5.94	
1994	1,095,068				
1995	1,321,108				
1996	692,167				
1997	618,396				
1981-92 Avg	1,262,142	74,107,034	4,708,750	72.54	0.10

[a] Incomplete returns from brood year escapements. Future returns will increase these values.