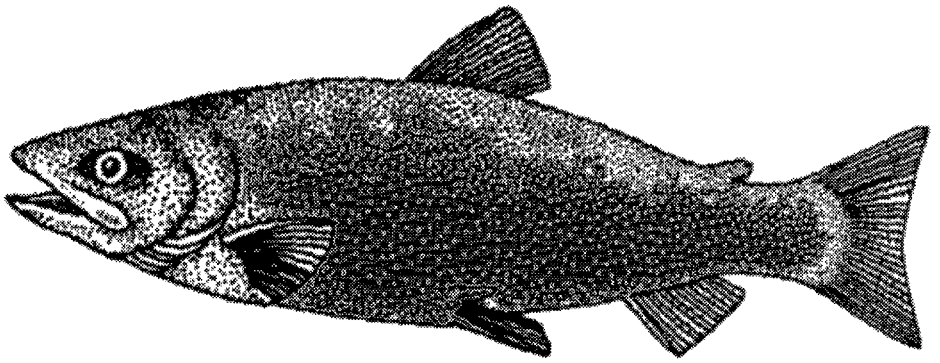
Biological Escapement Goals for five Sockeye Salmon Stocks Returning to Streams in the Yakutat Area of Alaska



By
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Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
Douglas, Alaska

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ABSTRACT

Available information on age compositions, escapements, and harvests of sockeye salmon *Oncorhynchus nerka* returning to the Alsek, Akwe, East Alsek, Italio, and Lost rivers in the Yakutat Area of Southeast, Alaska was used to develop brood tables and to estimate spawner-recruit relationships. Spawner-recruit relationships were used to estimate the number of spawners that would, on average, provide maximum sustained yield fisheries. Based upon spawner-recruit relationships, it is recommended that the following biological escapement goals be formally adopted by the Alaska Department of Fish and Game:

Sockeye Salmon Stock	Index Escapement Goal	Index Escapement Goal Range	Survey Type
Alsek River	9,000	5,500 to 13,500	Kluckshu Weir
Akwe River	1,000	600 to 1,500	Aerial Count
East Alsek River	40,000	26,000 to 57,000	Aerial Count
Italio River	4,500	2,500 to 7,000	Aerial Count
Lost River	1,600	1,000 to 2,300	Aerial/Boat

KEY WORDS: sockeye salmon, *Oncorhynchus nerka*, Yakutat Alaska, Alsek River, Akwe River, East Alsek River, Italio River, Lost River, spawner-recruit, brood table, escapement goal, maximum sustained yield.

INTRODUCTION

Commercial salmon fishing in the Yakutat Area of Southeast Alaska (from Cape Fairweather to Cape Suckling; Figure 1) is a major industry providing income and jobs. Commercial salmon harvests in the Yakutat Area average about 500,000 fish annually; this average is composed of about 44% sockeye salmon *Oncorhynchus nerka*, 44% coho salmon *O. kisutch*, 8% pink salmon *O. gorbuscha*, 3% chum salmon *O. keta*, and 1% chinook salmon *O. tshawytcha*. The ex-vessel values of the Yakutat Area commercial salmon fisheries averages about $5 million annually. Two gear groups participate in the Yakutat Area commercial salmon fishery; set gill net fishermen and troll fishermen. About 160 set gill net permits and about 80 troll permits are fished in the Yakutat Area in a typical year. The set gill net fishery takes place in discreet fishing areas, typically located in the lower rivers and lagoons of streams that empty into the Gulf of Alaska between Cape Fairweather and Cape Suckling.

Yakutat Area commercial harvests of sockeye salmon have been increasing and have averaged about 93,600, 126,900, and 191,400 fish during the 1960's, 1970's, and 1980's, respectively. The commercial harvest of sockeye salmon in the Yakutat Area in the most recent five years, 1990-1994, averaged about 288,800 fish and during the last 10 years has averaged about 258,200 fish. Most of these sockeye salmon are taken in the set gill net fisheries located in the lower portions and lagoons of the Alsek, Akwe, East Alsek-Doame (hereafter referred to as East Alsek River or East River), Italio, Lost, and Situk rivers. Small numbers of sockeye salmon are taken in other terminal set gill net fisheries and moderate numbers are taken in the mixed-stock Manby Shore and Yakutat Bay set gill net fisheries.

Adequate catch, escapement, and age composition information is available to estimate the escapement levels that will produce maximum sustained yield (MSY) for the sockeye salmon stocks that annually return to the Alsek, Akwe, East Alsek, Italio, Lost, and Situk rivers. An analysis of the stock-recruitment relationship for Situk sockeye salmon is currently being conducted and will be the subject of an upcoming report. The intent of this study was to review and analyze available age composition, harvest, and escapement data for sockeye salmon returning to the Alsek, Akwe, East, Italio, and Lost rivers of the Yakutat Area and to make recommendations concerning biological escapement goals that the Alaska Department of Fish and Game (ADF&G) could use to manage these five sockeye salmon stocks in order to provide for maximum sustained yield fisheries.

DATA ANALYSIS

The Integrated Fisheries Data Base (IFDB) computer files maintained by the Commercial Fisheries Management and Development Division, ADF&G, Douglas, Alaska, were used to obtain information on Alaskan commercial harvests of sockeye salmon in the Yakutat Area. Estimates of the Alaskan subsistence harvests of sockeye salmon were obtained from Gordon Woods (Alaska Department of Fish and Game, Post Office Box 49, Yakutat, Alaska; personal communication). Estimated harvests of sockeye salmon in the Alsek River basin by Canadian fisheries were taken from a Pacific Salmon Commission report (PSC

1994). These various sources of fishery mortality were added to develop annual estimates of total harvests of sockeye salmon for each of the five sockeye salmon stocks. Specifics concerning exactly which fishing district catches were included in total harvests are provided as footnotes in tables presenting harvest data.

Annual harvest estimates were apportioned by age class based upon available age composition sampling information when annual sampling took place. Appendix Tables 1-10 provide available age composition estimates for sampled catches and escapements of sockeye salmon returning to the Alsek, Akwe, East Alsek, Italio, and Lost rivers. Specifics concerning exactly what the annual age composition estimate was based on for annual catches that were not directly sampled is provided as footnotes in tables presenting catch data.

Escapement information for sockeye salmon spawning in the Alsek River was obtained through aerial surveys of various portions of the Alsek basin and from a weir constructed across the Kluckshu River. Aerial counts only provide a scattered picture of escapement trends because locations surveyed vary between years. Counts of sockeye salmon as they pass the Kluckshu River weir have been made each year since 1976; this data source (PSC 1994) provides a continuous set of monitored escapements that is believed to represent a reliable index of sockeye salmon escapements in the Alsek basin.

Annual counts of sockeye salmon past the Kluckshu River weir represent an unknown fraction of the total Alsek basin escapement of sockeye salmon. An ADF&G mark-recapture experiment conducted in 1983 estimated that Kluckshu weir counts of sockeye salmon represented 37% of the total escapement (McBride and Bernard, 1984). Professional judgement by Canadian fishery managers places the expansion at 60% (PSC 1994). In this study, we assumed that the Kluckshu weir fraction represents from 40-60% of the total Alsek basin escapement; one spawner-recruit relationship was developed based upon a 40% expansion and a second relationship was developed based upon a 60% expansion.

IFDB computer files were used to obtain information on sockeye salmon escapement surveys in the Akwe, East Alsek, Italio, and Lost river systems of the Yakutat Area. Escapement surveys of sockeye salmon in these rivers were conducted in most years since the early 1970's. Most of these escapement surveys were made with the aid of fixed-wing aircraft. In the case of the Lost River, foot-based and/or boat-based escapement surveys were conducted. Peak annual counts of sockeye salmon in each of these four river systems during each year were selected to represent annual escapement trends.

Peak annual counts of sockeye salmon obtained through aerial surveys as well as foot-based and boat-based surveys represent an index of total escapement abundance; not all of the escapement is counted during any one survey. In order to develop brood tables that include estimated total escapements and estimated total returns for stocks of sockeye salmon that return to the Akwe, East Alsek, Italio, and Lost rivers, assumptions concerning expansion of peak aerial, boat, and foot counts of sockeye salmon had to be made. Professional judgements of staff who have been conducting these counts over the past 20 years were used to develop appropriate expansion factors. Mark-recapture studies or other studies of total escapement have not been conducted for any

of these four stocks of sockeye salmon. The proportion of fish that peak annual counts of sockeye salmon were assumed to represent of the total escapements were:

Akwe River Sockeye Salmon	1973-1984: 50%; 1985-1994: 10%
East Alsek River Sockeye Salmon	All Years: 65%
Italio River Sockeye Salmon	All Years: 50%
Lost River Sockeye Salmon	All Years: 65%

Once annual total escapements of sockeye salmon to the Alsek, Akwe, East, Italio, and Lost rivers were estimated, they were apportioned by age class based upon available age composition sampling information when annual sampling took place. Appendix Tables 1-10 provide age composition estimates for sampled catches and escapements of sockeye salmon returning to these five river systems. Appendix Figures 1-4 graphically show available age composition estimates for the escapements of Akwe, East, Italio, and Lost river stocks of sockeye salmon. Specifics concerning what the escapement age composition estimate was based on for annual escapements that were not sampled is provided as footnotes on tables presenting escapement data.

Annual total returns of sockeye salmon to the Alsek, Akwe, East, Italio, and Lost rivers in any given year were estimated by adding expanded escapements to estimated total harvests. Brood tables for each of the five sockeye salmon stocks were then constructed and spawner-recruit data sets were developed consisting of estimated total escapements in year *i* and the summation of estimated total returns of age 2 fish in year *i+2*, age 3 fish in year *i+3*, age 4 fish in year *i+4*, age 5 fish in year *i+5*, and age 6 fish in year *i+6*.

Some brood years (paired data sets) were not included when the spawner-recruit relationships for the sockeye salmon stocks that return to the Akwe, Italio, and Lost rivers were estimated because of data limitations. For example, the data base from 1973 forward was developed for the stock of sockeye salmon that returns to the Akwe River. The 1975, 1981, 1988, and 1989 brood years were not included because the estimated escapements were suspect due to the dates associated with the peak surveys (too early) or other reasons. As a result, only 13 of the possible 17 paired data points were used to develop the spawner-recruit relationship for Akwe River sockeye salmon. Those brood years deleted from the various analyses are footnoted on tables presenting harvest and escapement data.

Once the six paired data sets were developed (two for the Alsek sockeye salmon stock [40% and 60% expansion assumptions] and one each for the Akwe, East, Italio, and Lost sockeye salmon stocks), spawner-recruit relationships were developed using the following model:

$$R = S \exp[a(1-S/P_m)] \qquad (1)$$

where: R = estimated total return;
S = spawning escapement;
exp = base of the natural system of logarithms;
a = intrinsic rate of population increase in the absence of density-dependent limitations; and,

P_m = carrying capacity.

This model, commonly referred to as a Ricker recruitment curve (Ricker 1975), estimates parameters, a and P_m, given a series of spawner and recruitment observations. We assumed the errors were multiplicative (as is common when variables are counts), resulting in the log-transformed equation:

$$\text{Ln}(R/S) = a - a/P_m(S) + \text{error} \quad (2)$$

Linear regression procedures provided estimates of the intercept (a) and the slope (P_m) of the equation. The estimated number of spawners that produce the maximum number of recruits is:

$$S_{max} = P_m/a; \quad (3)$$

and, the estimated number of spawners that produce MSY is estimated by iteratively solving the equation:

$$S_{MSY} = (P_m/a \{1-\exp[-a(1-S_{MSY}/P_m)]\}. \quad (4)$$

Once spawner-recruit relationships were calculated, a series of parameters were estimated including: (1) natural equilibrium or carrying capacity (the point on the modeled spawner-recruit line where it intersects the replacement line); (2) the estimated escapement that produces the maximum recruits (highest point on the curve); and, (3) the optimum escapement (the point on the modeled spawner-recruit line where harvestable surplus is at a maximum). These estimated optimum escapements were used to make recommendations concerning biological escapement goals for Alsek, Akwe, East, Italio, and Lost rivers stocks of sockeye salmon.

The spawner-recruit relationships were also used to determine the lower and upper escapement bounds that are estimated to provide 90% or more of MSY. This approach used the spawner-recruit relationship regressions for each of the stocks using "scaled back" numbers. Predicted returns were examined to determine an overall range of "index" escapements expected to provide 90% or more of MSY. This range of escapements was used as the basis for recommendations concerning biological escapement goal ranges for use in fishery management as it is a measure of the range of index escapements that is predicted to result in sustainable yields within 10% of the long-term maximum.

The estimated escapements achieved for each of the sockeye salmon stocks since the early 1970's were compared to the recommended escapement goal ranges to determine the proportion of years when escapements: (1) fell within these ranges, (2) fell below these ranges, or (3) exceeded these ranges. A similar analysis was conducted for sockeye salmon escapements during the most recent five years (1990-1994).

Variability and potential bias associated with optimum escapement estimates were examined using a bootstrap technique (McPherson 1990). The Ricker stock-recruit curve was fitted to the original data and a set of predicted values was calculated for each spawning escapement in the data set. Residuals were

calculated as the difference in the natural log of the observed recruits per spawner and the estimated recruits per spawner. The residuals were randomly selected with replacement and matched sequentially with the predicted returns and original escapements. Thus, each bootstrap iteration contained the original escapements but different recruits associated with these escapements depending upon which error was randomly chosen for each paired observation. This computer generated spawner and recruit data set was then used to estimate new values for the parameters a and P_m and the corresponding optimum escapement was calculated. This procedure was repeated 4,001 times and the resulting optimum escapements were ordered from smallest to largest. The 200th and 3,800th of these ordered estimates was chosen to provide a 90% confidence interval and the 2,001st was the median bootstrap estimate of optimum escapement. This procedure was applied to each of the six data sets.

RESULTS AND DISCUSSION

Alsek River Sockeye Salmon

Estimated Alaskan and Canadian harvests of Alsek sockeye salmon since 1976 have ranged from a low of about 7,500 fish in 1985 to a high of about 59,100 fish in 1978. The average harvest during this 19-year period was 25,716 sockeye salmon (Table 1). Counts of sockeye salmon past the Kluckshu River weir since 1976 have ranged from a low of about 7,100 fish in 1979 to a high of about 28,900 fish in 1982. The average count during this 19-year period is about 16,000 sockeye salmon (Table 2). Estimated total returns of sockeye salmon since 1976 have ranged from a low of about 27,600 fish in 1988 to a high of about 106,600 fish in 1978, assuming a 40% expansion factor for Kluckshu River weir counts of sockeye salmon (Table 3). Assuming a 60% expansion factor for Kluckshu River weir counts, estimated total returns of sockeye salmon since 1976 have ranged from a low of about 21,200 fish in 1988 to a high of about 90,800 fish in 1978 (Table 4).

Estimated total recruitments from brood years 1976-1989 (n = 14) were used (Table 5) to develop two alternate spawner-recruit relationships for Alsek sockeye salmon assuming: (1) Kluckshu River weir counts represented 40% of the total escapement (Figure 2); or alternatively, (2) Kluckshu River weir counts represented 60% of the total escapement (Figure 3). Use of the 40% model resulted in 8,817 sockeye salmon counted at Kluckshu weir being the estimate of optimum escapement (Table 6). Use of the 60% model resulted in 9,385 sockeye salmon counted at Kluckshu weir being the estimate of optimum escapement (Table 6). The spawner-recruit curves explained substantial portions of the recruitment variability under both assumptions (R^2 = 0.710 for the 40% model and R^2 = 0.712 for the 60% assumption). No obvious trends in residuals were apparent over the 14 year period for either of the two spawner-recruit relationships (Figure 4).

The bootstrap median estimates of optimum escapement of Alsek sockeye salmon were similar to their respective regression estimates (22,093 for the bootstrap estimate versus 22,043 for the regression estimate for the 40% model; and, 15,673 for the bootstrap estimate versus 15,641 for the regression estimate for the 60% model; Table 7). In terms of Kluckshu weir counts of

sockeye salmon, the bootstrap estimates of optimum escapement and the regression estimates of optimum escapement differed by only 20 fish for the 40% model (0.2%) and differed by only 19 fish for the 60% model (0.2%) indicating that regression estimates of optimum escapement are not biased (Table 8). Kluckshu weir counts of sockeye salmon expected to provide for 90% or more of MSY range from about 5,500 to 12,500 fish with the 40% model and range from about 5,500 to 13,500 with the 60% model (Table 9). These ranges closely correspond to the bootstrap 90% confidence intervals (Figure 5). Because the largest escapements included in the spawner-recruit relationships is over 3-fold the estimated optimums (Figure 5) and because most of the escapements included in the analyses exceed the indicated 90% MSY range (8 of 14 escapements; Figures 2 and 3), it is believed that the indicated optimum escapements are robust estimates.

Assumptions concerning the proportion of total Alsek sockeye salmon escapement indexed by the Kluckshu River weir within the range of 40-60% makes only minor differences in estimates of optimum escapement (8,817 fish versus 9,345 fish, a difference of only 568 fish or 6%). We suggest that a mid-point between the two optimum escapement estimates be used. Specifically, we recommend that 9,000 sockeye salmon counted past the Kluckshu River weir be used as a biological escapement goal with the range being set at 5,500-13,500 (Table 10). Four of the five highest historic returns were associated with escapements beyond the estimated optimal range and the escapements for 1991-1994 are also above the indicated optimal range (Figures 2 and 3). Therefore, reanalysis of these data in about 5 years may better define an optimal escapement range for Alsek River sockeye salmon.

Since 1976, none of the Kluckshu River weir counts of sockeye salmon have been below our recommended escapement goal range; 32% have been within this range and 68% have exceeded this range (Table 10). All of the escapements of sockeye salmon counted past the Kluckshu River weir since 1990 (the last 5 years) have exceeded our recommended escapement goal range. Estimated maximum sustained yield from the Alsek sockeye salmon stock is estimated to be 35,400 fish available for Alaskan and Canadian fishermen (Table 11) compared to the average harvest from 1990-1994 of 21,400 sockeye salmon. Assuming fishery managers can successfully control escapements within our recommended range of 5,500 to 13,500 sockeye salmon past the Kluckshu weir, the potential increase in sustainable harvest is about 10,600 fish, an increase of about 50% (Table 11; Figure 6). Adoption of our recommended escapement goal would likely lead to liberalization of Alaskan and Canadian fisheries in the Alsek basin.

Akwe River Sockeye Salmon

Estimated harvests of Akwe River sockeye salmon since 1973 have ranged from a low of about 1,600 fish in 1974 to a high of about 28,700 fish in 1980. The average harvest during this 22-year period is 7,549 sockeye salmon (Table 12). In December 1986, the Italio River channel shifted and the river broke into the Akwe River lagoon rather than entering the Gulf of Alaska through the original Italio River lagoon. Thus since 1987, both Akwe River and Italio River sockeye salmon enter the Akwe lagoon from the Gulf of Alaska as they travel upstream to spawn. This geologic change has likely shifted the stock

composition of sockeye salmon harvested by both the Akwe and Italio river set gill net fisheries even though both fisheries are located upstream of the confluence of the Akwe and Italio rivers. Akwe River set gill net fishery harvests of sockeye salmon during the 1973-1986 period averaged 5,264 fish and harvests during the 1987-1994 period averaged 6,284 fish, a level about 20% above the prior average.

Escapements of sockeye salmon in the Akwe River are indexed with aerial surveys (Table 12). Akwe River counting conditions changed after water visibility deteriorated in 1985. The Ustay River splits and feeds into both the Alsek and Akwe rivers and a larger portion of the Ustay River has entered the Akwe River since 1985. Additionally, the Akwe River water color has become more greenish. These geologic and water clarity changes have greatly affected the ability of ADF&G staff to index sockeye salmon escapements. As a result, peak aerial counts of Akwe River sockeye salmon were expanded by a factor of two for the years 1973-1984 but increased to a factor of ten for the years 1985-1994 (Table 12). The peak aerial surveys for the years 1975, 1981, and 1988-1990 are not considered completely indicative of escapement trends for those years because of timing of the surveys. Also, because the escapement in 1992 was not monitored, an average escapement value was assumed in order to complete the brood table (Table 13). Estimated total escapements of sockeye salmon during the 22-year period (1973-1994) for which reliable peak aerial counts of sockeye salmon are available (n = 16) ranged from a low of about 2,000 fish in 1974 and 1994 to a high of about 40,000 fish in 1980. The average escapement during this period was estimated to be 12,915 sockeye salmon (Table 12).

Estimated total returns of sockeye salmon during the 16 years since 1973 for which reliable estimates of escapement are available have ranged from a low of about 3,600 fish in 1974 to a high of about 68,700 fish in 1980 (Table 13). Estimated total recruitments from brood years 1973-1987 were used (n = 13; (Tables 6 and 12) to develop a spawner-recruit relationship for Akwe River sockeye salmon (Figure 7). Use of these data resulted in 10,791 sockeye salmon being the estimate of optimum escapement (measured as a total escapement; Table 6). Because a change in the stock composition of the Akwe River set gill net fishery occurred in 1987, a historical stock-recruit relationship using brood years 1973, 1974, and 1976-1979 was also developed. Estimated optimum escapement for the historic relationship (n = 6) was about 10,000 fish, very similar to the all-years estimate of 10,791. The all-years spawner-recruit relationship was used for all further analysis because estimates of optimum escapement were similar and because of increased sample size (13 brood years of data versus 6 for the historic relationship).

The spawner-recruit curve explained about one half of the variability in recruitment of Akwe River sockeye salmon (R^2 = 0.474). Residuals in the relationship tended to trend from positive to negative over the 13-year period, possibly reflecting the change in river survey conditions (Figure 7).

The bootstrap median estimate of optimum escapement for Akwe River sockeye salmon of 10,672 was similar to the regression estimate of 10,791 (Table 7). The bootstrap median estimate of optimum escapement and the regression

estimate differed by only 119 fish (1%) indicating that the regression estimate of optimum escapement is not biased.

Aerial surveys of Akwe River sockeye salmon expected to provide for 90% or more of MSY range from about 600 to 1,500 fish under current counting conditions (10-fold expansions; Table 9). This range closely corresponds to the bootstrap 90% confidence interval (Figure 5). Because the largest escapement included in the spawner-recruit relationship is about four-fold the estimated optimum and because 3 of the 13 escapements included in the analysis exceed the indicated 90% MSY range (Figure 7), it is believed that the indicated optimum escapement is a robust estimate.

We recommend that 1,000 sockeye salmon counted during a peak aerial survey under current counting conditions of the Akwe River be used as the biological escapement goal. We recommend that the fishery management range be set at 600 to 1,500 sockeye salmon (Table 10). Since 1973, 19% of the peak aerial counts of Akwe River sockeye salmon have been below our recommended escapement goal range, 37% have been within this range, and 44% have exceeded this range (Table 10). All of the peak aerial counts of escapements of sockeye salmon in the Akwe River since 1990 (the last 5 years) have exceeded our recommended escapement goal range.

Estimated MSY for Akwe River sockeye salmon 12,400 fish (Table 11) compared to the average harvest during the 1990-1994 period of 3,400 sockeye salmon. We believe the potential increase in harvestable surplus, if fishery management can successfully control escapement within our recommended range of 600 to 1,500 sockeye salmon, is about 7,800 fish (Table 11) or an increase in allowable harvests of over 200% over the recent five year period (Figure 6). Thus, adoption of our recommended Akwe River sockeye salmon escapement goal could mean liberalization of the Akwe set gill net fishery.

East Alsek River Sockeye Salmon

Estimated harvests of East Alsek River sockeye salmon since 1972 have ranged from a low of about 9,600 fish in 1972 to a high of about 189,200 fish in 1993. The average harvest during this 23-year period is 74,083 sockeye salmon (Table 14).

Escapements of sockeye salmon in the East Alsek and Doame rivers are indexed with aerial surveys. Both systems are well suited for aerial surveys because water clarity is excellent, they are small systems, and the water in both is relatively shallow. Peak aerial escapement counts of sockeye salmon in the East Alsek and Doame rivers are believed to represent 65% of the total escapement (Table 14). Estimated total escapements of sockeye salmon from 1972-1994 ranged from a low of about 15,400 fish in 1972 to a high of about 123,100 fish in 1986. The average escapement during the 1972-1994 period was estimated to be 59,849 sockeye salmon (Table 14).

Estimated total returns of East Alsek sockeye salmon since 1972 have ranged from a low of about 25,000 fish in 1972 to a high of about 277,300 fish in 1985 (Table 15). Estimated total recruitments from brood years 1972-1990 were

used (n = 19; Table 14) to develop a spawner-recruit relationship for East Alsek sockeye salmon. Estimated optimum escapement for East Alsek sockeye salmon is 62,124 fish (measured as total escapement; Table 6 and Figure 8). The spawner-recruit curve explained about one-third of the variability in recruitment of East Alsek sockeye salmon (R^2 = 0.336). No obvious trend in residuals of the spawner-recruit relationship over the 19-year period was apparent (Figure 8).

The bootstrap median estimate of optimum escapement of East Alsek sockeye salmon was similar to the regression estimate; 62,351 for the bootstrap median versus 62,124 for the regression estimate (Table 7). The bootstrap median estimate of optimum escapement (40,528 fish) and the regression estimate of optimum escapement (40,381 fish in peak aerial count terms), only differed by 147 fish (0.4%) indicating that the regression estimate of optimum escapement is not biased (Table 8).

Aerial surveys of sockeye salmon in the East Alsek-Doame basin expected to provide for 90% or more of MSY range from about 26,000 to 57,000 fish (Table 9). This range closely corresponds to the bootstrap 90% confidence interval (Figure 5). Because the largest escapement included in the spawner-recruit relationship is about double the estimated optimum and because 4 of the 19 escapements included in the analysis exceeds the 90% MSY range (Figure 8), it is believed that the indicated optimum escapement is a robust estimate.

We recommend that 40,000 sockeye salmon counted during a peak aerial survey of the East Alsek and Doame rivers be used as the biological escapement goal. We recommend that the fishery management range be set at 26,000 to 57,000 sockeye salmon (Table 10).

Since 1972, 22% of the peak aerial counts of sockeye salmon in the East Alsek and Doame rivers have been below our recommended escapement goal range, 61% have been within this range, and 17% have exceeded this range (Table 10). All of the last five peak aerial counts of escapements of sockeye salmon in the East Alsek and Doame rivers have been within our recommended range.

The 1990-1994 average harvest for the East Alsek stock of sockeye salmon was 128,000 fish, about 30% over the estimated MSY value of 98,500 (Table 11). All of the East Alsek escapements of sockeye salmon for the years 1990-1994 were within the range estimated to produce 90% or more of MSY. Escapements of East Alsek sockeye salmon during the years 1987-1990 were also within this range and these escapements produced the fish harvested in 1990-1994. Therefore, favorable survival conditions associated with MSY level escapements have led to recent-year yields higher than estimated MSY, not over-fishing. Adoption of our recommended East Alsek sockeye salmon escapement goal at 40,000 fish with a management range of 26,000-57,000 fish would likely mean a fishery regime over the next few years very similar to what has occurred in the recent past.

Italio River Sockeye Salmon

Estimated harvests of Italio River sockeye salmon since 1972 have ranged from a low of 0 in 1972, 1989-1992, and 1994 to a high of about 7,500 fish in 1984. The average harvest during this 23-year period is 1,217 sockeye salmon (Table 16).

As discussed earlier, the Italio River channel shifted in December 1986 and the Italio River now empties into the Akwe River lagoon rather than entering the Gulf of Alaska through the original Italio River lagoon. Italio River set gill net fishery harvests of sockeye salmon during the 1972-1986 period averaged 1,803 fish. Harvests during the 1987-1994 period averaged 117 fish; however, 1987 was the only year in which a significant harvest took place (Table 16).

Escapements of sockeye salmon in the Italio River are indexed with aerial surveys. Peak aerial escapement counts of sockeye salmon in the Italio River are believed to represent about one-half of the total escapement (Table 16). The escapement in 1979 was not monitored; an average value was assumed in order to complete the brood table (Table 17). Estimated total escapements of sockeye salmon during the 23-year period of 1972-1994 for which reliable peak aerial counts of sockeye salmon are available (n = 22) have ranged from a low of 1,650 fish in 1991 to a high of 30,000 fish in 1978. The average escapement during the 1972-1994 period was estimated to be 12,362 sockeye salmon (Table 16).

Estimated total returns of Italio River sockeye salmon since 1972 have ranged from a low of about 1,600 fish in 1991 to a high of about 29,300 fish in 1985 (Table 17). Estimated total recruitments from brood years 1972-1989 were used (n = 17; Table 16) to develop a spawner-recruit relationship for Italio River sockeye salmon (R^2 = 0.318). Use of these data resulted in about 6,000 sockeye salmon being the estimate of optimum escapement (measured as total escapement). Because a change in the migratory corridor for Italio River sockeye salmon occurred in 1987 and because virtually no catch of sockeye salmon by the Italio River set gill net fishery has occurred since 1988, a historic stock-recruit relationship was also developed. The historic relationship used brood years 1972-1978 and 1980-1982 (n = 10). Estimated optimum escapement for the historic relationship (R^2 = 0.762) was 9,136 (measured as total escapement; Tables 6 and 16 and Figure 9), a substantially higher estimate than the all-years estimate of about 6,000 fish. The historic spawner-recruit relationship was used for all further analysis because estimates of optimum escapement were different and the R^2 value for the historic relationship was substantially higher (R^2 = 0.318 for all-years versus R^2 = 0.762 for historic-years).

The historic spawner-recruit curve explained about three-quarters of the variability in recruitment of Italio River sockeye salmon. No obvious trend in residuals of the spawner-recruit relationship over the 10-year period was apparent (Figure 9).

The bootstrap median estimate of optimum escapement of Italio River sockeye salmon was similar to the regression estimate; 9,084 for the bootstrap median

versus 9,136 for the regression estimate (Table 7). The bootstrap median estimate of optimum escapement (4,542 fish) and the regression estimate of optimum escapement (4,568 fish in peak aerial count terms), only differed by 26 fish (0.6%) indicating that the regression estimate of the optimum escapement was not biased (Table 8).

Aerial surveys of Italio sockeye salmon expected to provide for 90% or more of MSY range from about 2,500 to 7,000 fish (Table 9). This range closely corresponds to the bootstrap 90% confidence interval (Figure 5). Because the largest escapement included in the spawner-recruit relationship is over three-fold the estimated optimum and because 5 of the 10 escapements included in the analysis exceed the 90% MSY range (Figure 9), it is believed that the indicated optimum escapement is a robust estimate.

We recommend that 4,500 sockeye salmon counted during a peak aerial survey of the Italio River be used as the biological escapement goal. We recommend that the fishery management range be set at 2,500 to 7,000 sockeye salmon (Table 10).

Since 1972, 23% of the peak aerial counts of Italio River sockeye salmon have been below our recommended escapement goal range, 41% have been within this range, and 36% have exceeded this range (Table 10). Two of the last five peak aerial counts of escapements of sockeye salmon in the Italio River have been below this recommended range while escapements in three of the past five years have been within the range we recommend be used for future fishery management. During the most recent five-year period, virtually no harvest of sockeye salmon has occurred in the Italio River set gill net fishery.

In 1988 through 1991, estimated total returns of Italio River sockeye salmon dropped considerably from prior levels (Table 17). The average annual total return for the 16-year span of 1972-1987 was about 17,400 sockeye salmon. The average total return for the years 1988-1991 was only about 3,400 sockeye salmon, about 20% of the former level. This estimated loss in productivity of about 14,000 sockeye salmon is significant. In fact, this level of loss substantially exceeds the concurrent level of increased harvest in the Akwe River set gill net fishery of about 1,000 fish. It does not seem likely that interception of Italio River sockeye salmon in the Akwe River set gill net fishery adequately explains the apparent loss of Italio River sockeye salmon productivity.

We theorize that when the Italio River changed channel and entered the Akwe River lagoon, the homing migration ability of Italio River sockeye salmon was negatively affected over their next cycle (1988-1991). The total return of Italio River sockeye salmon for the years 1992-1994 increased to an average of about 6,800 fish, about double the prior 1988-1991 level. It may take another cycle or so before productivity of Italio River sockeye salmon returns to historic levels. Estimated maximum sustained yield from the Italio River set gill net fishery is 10,750 sockeye salmon (Table 11). Adoption of our recommended Italio River sockeye salmon escapement goal of 4,500 fish with a management range of 2,500-7,000 fish would likely mean a fishery regime over the next few years similar to what has occurred in recent years as the stock continues to regain its prior level of productivity.

Lost River Sockeye Salmon

Estimated harvests of Lost River sockeye salmon since 1972 have ranged from a low of about 500 fish in 1986 to a high of about 8,900 fish in 1977. The average harvest during this 23-year period is 3,107 sockeye salmon (Table 18).

Escapements of Lost River sockeye salmon are indexed with boat-based and foot-based surveys of the Lost River mainstem and tributaries including Tawah Creek, Ophir Creek, and Coast Guard Lake. The combination of these peak index counts of sockeye salmon in the Lost River basin are believed to represent 65% of the total escapement (Table 18). The escapements in 1984 and 1985 were not monitored; average escapement values were assumed for these years to complete the brood table (Table 19). The peak surveys for the years 1987, 1989, and 1992-1993 are not considered completely indicative of escapement trends for those years because of limited survey areas and timing of the surveys that were conducted. Estimated total escapements of sockeye salmon in the Lost River basin during the 23-year period of 1972-1994 for which reliable peak counts of sockeye salmon are available (n = 17), ranged from a low of about 1,800 fish in 1974 and 1975 to a high of about 9,200 fish in 1982. The average escapement during the 1972-1994 period was estimated to be 4,349 sockeye salmon (Table 18).

Estimated total returns of Lost River sockeye salmon since 1972 have ranged from a low of about 2,800 fish in 1986 to a high of about 14,200 fish in 1982 (Table 19). Estimated total recruitments from brood years 1972-1983, 1986, and 1988 were used (n = 14; Table 18) to develop the spawner-recruit relationship. Estimated optimum escapement for Lost River sockeye salmon is 2,381 fish (measured as total escapement; Table 6 and Figure 10) with the spawner-recruit curve explaining about two-thirds of the variability in recruitment (R^2 = 0.657). Residuals have tended to trend from positive to negative (Figure 10).

The bootstrap median estimate of optimum escapement of Lost River sockeye salmon was similar to the regression estimate; 2,404 for the bootstrap median estimate versus 2,381 for the regression estimate (Table 7). The bootstrap median estimate of optimum escapement (1,563 fish) and the regression estimate of optimum escapement (1,548 fish), in peak aerial count terms, only differed by 15 fish (1%) indicating that the regression estimate of the optimum escapement is not biased (Table 8).

Peak escapement surveys of sockeye salmon in the Lost River expected to provide for 90% or more of MSY range from about 1,000 to 2,300 fish (Table 9). This range closely corresponds to the bootstrap 90% confidence interval (Figure 5). Because the largest escapement included in the spawner-recruit relationship is about three-fold the estimated optimum escapement and because 8 of the 14 escapements included in the analysis exceed the 90% MSY range (Figure 10), it is believed that the indicated optimum escapement is a robust estimate. Five of the six highest recruitments have been from escapements above our recommended management range and the 1992 and 1993 escapements were also at this higher level (Figure 10). Therefore, reanalysis of these data in

about 5 years may better define an optimal escapement range for Lost River sockeye salmon.

We recommend that 1,600 sockeye salmon counted during a peak survey of the Lost River be used as the biological escapement goal. We recommend that the fishery management range be set at 1,000 to 2,300 sockeye salmon (Table 10).

Since 1972, none of the peak counts of sockeye salmon in the Lost River have been below our recommended escapement goal range, 41% have been within this range, and 59% have exceeded this range (Table 10). Since 1990, one of the peak counts of escapements of sockeye salmon in the Lost River was within our recommended range (33%) and on two occasions the recommended escapement goal range was exceeded (67%). In two of the past five years the escapement was not adequately monitored.

Estimated MSY for Lost River sockeye salmon is estimated to be 4,700 fish (Table 11). Average harvest during the 1990-1994 period was 2,800 sockeye salmon. We believe the potential increase in harvest, if fishery management can successfully control escapements within our recommended range of 1,000 to 2,300 sockeye salmon (peak survey), is about 1,400 fish (Table 11). This represents an increase in allowable harvests of about 50% over the recent five-year period (Figure 6). Adoption of our recommended Lost River sockeye salmon escapement goal of 1,600 fish with a management range of 1,000-2,300 fish, would likely lead to liberalization of the Lost River set gill net fishery.

RECOMMENDATIONS

We recommend that the following biological escapement levels be formally adopted by the Alaska Department of Fish and Game:

Sockeye Salmon Stock	Index Escapement Goal	Index Escapement Goal Range	Survey Type
Alsek River	9,000	5,500 to 13,500	Kluckshu Weir
Akwe River	1,000	600 to 1,500	Aerial Count
East Alsek River	40,000	26,000 to 57,000	Aerial Count
Italio River	4,500	2,500 to 7,000	Aerial Count
Lost River	1,600	1,000 to 2,300	Aerial/Boat

We recommend that this biological escapement goal analysis be updated in about five years because at that time, significantly more information will be available for further development and refinement of the spawner-recruit relationships. Refinement of these relationships may lead to improved escapement goals that will better result in MSY fisheries.

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Table 1. Harvests of Alsek River sockeye salmon, 1976-1994.

	Alaskan Harvests				Canadian Harvests			Total
	Commercial							
Year	River	Surf	Subsis.	Total	Sport	Subsis.	Total	Harvests
1976	19,741	0	51	19,792	600	4,000	4,600	24,392
1977	40,780	0	113	40,893	500	10,000	10,500	51,393
1978	50,580	0	0	50,580	500	8,000	8,500	59,080
1979	41,449	0	35	41,484	750	7,000	7,750	49,234
1980	25,522	0	41	25,563	600	800	1,400	26,963
1981	23,641	0	50	23,691	808	2,000	2,808	26,499
1982	27,423	0	75	27,498	755	5,000	5,755	33,253
1983	17,637	656	25	18,318	732	2,550	3,282	21,600
1984	12,751	1,575	0	14,326	289	2,600	2,889	17,215
1985	5,940	0	95	6,035	100	1,361	1,461	7,496
1986	24,791	0	241	25,032	307	1,914	2,221	27,253
1987	11,393	0	173	11,566	383	1,158	1,541	13,107
1988	6,194	92	148	6,434	322	1,604	1,926	8,360
1989	12,268	1,245	131	13,644	319	1,851	2,170	15,814
1990	17,013	0	144	17,157	392	2,314	2,706	19,863
1991	17,542	0	104	17,646	303	2,111	2,414	20,060
1992	18,832	478	37	19,347	582	2,592	3,174	22,521
1993	19,295	748	80	20,123	329	2,361	2,690	22,813
1994	17,998	1,641	45	19,684	261	1,745	2,006	21,690
Averages	21,621	399	84	22,043	465	3,208	3,673	25,716

Data Sources:

Alaskan commercial harvest data for river (fishing district 182-30) and surf (fishing district 182-31) fisheries taken from IFDB computer run dated 11/25/94; Alaskan subsistence harvest data and Canadian sport and subsistence harvest data taken from PSC (1994).

Table 2. Escapements of Alsek River sockeye salmon, 1976-1994.

Year	Kluckshu Weir Count	Estimates of Total Escapement Associated with Assumptions Concerning Weir Count	
		Weir Count = 60%	Weir Count = 40%
1976	7,941	13,235	19,853
1977	15,441	25,735	38,603
1978	19,017	31,695	47,543
1979	7,051	11,752	17,628
1980	10,850	18,083	27,125
1981	18,448	30,747	46,120
1982	28,899	48,165	72,248
1983	18,017	30,028	45,043
1984	10,227	17,045	25,568
1985	17,259	28,765	43,148
1986	22,936	38,227	57,340
1987	9,346	15,577	23,365
1988	7,737	12,895	19,343
1989	21,636	36,060	54,090
1990	24,607	41,012	61,518
1991	17,645	29,408	44,113
1992	18,269	30,448	45,673
1993	14,921	24,868	37,303
1994	13,892	23,153	34,730
Averages	16,007	26,679	40,018

Data Sources:

Estimates of the escapement of sockeye salmon past Kluckshu weir are taken from PSC (1994). Weir escapement expansion factors used to estimated total escapements are based on professional judgement.

Table 3. Estimated number of sockeye salmon in the Alsek River escapement by age assuming that Kluckshu River weir escapements represented 40% of the total escapements, 1976-1994.

	Estimated Total Return of Alsek Sockeye Salmon by Age				
Year	Age 3	Age 4	Age 5	Age 6	Total
1976	1,260	21,765	19,981	1,238	44,245
1977	627	29,994	56,109	3,265	89,996
1978	454	20,825	80,775	4,568	106,623
1979	379	13,379	49,071	4,033	66,862
1980	207	12,325	40,186	1,369	54,088
1981	803	24,677	45,794	1,345	72,619
1982	333	9,208	92,187	3,773	105,501
1983	216	6,880	59,546	0	66,643
1984	428	2,405	38,838	1,111	42,783
1985	75	8,439	41,041	1,088	50,644
1986	545	12,704	65,135	6,208	84,593
1987	0	6,508	29,337	627	36,472
1988	84	4,516	21,653	1,334	27,586
1989	158	19,232	49,724	791	69,904
1990	199	9,849	70,142	1,192	81,381
1991	441	14,800	46,445	2,487	64,173
1992	682	14,340	51,133	2,040	68,194
1993	373	12,603	43,656	3,484	60,116
1994	347	12,890	41,404	1,779	56,420

Note: See Appendix Tables 1 and 2 for specifics concerning age composition estimates applied annually to catches and escapements.

Table 4. Estimated number of sockeye salmon in the Alsek River escapement by age assuming that Kluckshu River weir escapements represented 60% of the total escapements, 1976-1994.

	Estimated Total Return of Alsek Sockeye Salmon by Age				
Year	Age 3	Age 4	Age 5	Age 6	Total
1976	902	16,067	19,419	1,238	37,627
1977	550	23,277	50,254	3,047	77,128
1978	454	17,655	68,620	4,045	90,775
1979	379	12,063	45,022	3,522	60,986
1980	207	9,938	33,532	1,369	45,046
1981	604	18,143	37,154	1,345	57,246
1982	333	8,245	69,550	3,291	81,418
1983	216	5,379	46,034	0	51,628
1984	343	2,235	30,827	856	34,260
1985	75	6,426	28,960	800	36,261
1986	545	10,468	49,692	4,775	65,480
1987	0	4,950	23,184	549	28,684
1988	84	3,484	16,637	973	21,178
1989	158	13,823	37,103	791	51,874
1990	199	8,618	50,866	1,192	60,875
1991	294	11,271	35,711	2,193	49,468
1992	530	10,686	40,019	1,735	52,969
1993	249	9,618	34,579	3,235	47,681
1994	232	10,112	32,953	1,548	44,843

Note: See Appendix Tables 1 and 2 for specifics concerning age composition estimates applied annually to catches and escapements.

Table 5. Estimated brood escapements and resulting total returns used to estimate spawner-recruit relationships for Alsek River sockeye salmon assuming that Kluckshu River weir escapements represented 40% or 60% of the total escapements, 1976-1994.

	40% Expansion Model		60% Expansion Model	
Year	Brood Escapement	Total Return	Brood Escapement	Total Return
1976	19,853	62,271	13,235	50,762
1977	38,603	117,071	25,735	87,900
1978	47,543	70,669	31,695	55,737
1979	17,628	47,139	11,752	37,339
1980	27,125	49,971	18,083	36,185
1981	46,120	74,629	30,747	57,009
1982	72,248	43,451	48,165	34,700
1983	45,043	29,497	30,028	22,923
1984	25,568	55,431	17,045	41,779
1985	43,148	91,944	28,765	66,965
1986	57,340	58,491	38,227	46,222
1987	23,365	69,614	15,577	54,723
1988	19,343	60,216	12,895	47,107
1989	54,090	54,688	36,060	43,101
1990	61,518	-	41,012	-
1991	44,113	-	29,408	-
1992	45,673	-	30,448	-
1993	37,303	-	24,868	-
1994	34,730	-	23,153	-
Averages	40,018	63,869	26,679	49,181

Note: Estimated brood year returns reflect annual age apportioned catches and escapements (see Appendix Tables 1 and 2 and Tables 3 and 4) combined by brood year.

Table 6. Estimated spawner-recruit parameters based on regressions for five Yakutat Area sockeye salmon stocks.

Sockeye Salmon Stock	Model	Sample Size (n)	Ricker Alpha	Carrying Capacity	R^2	MSE	Escapement @ Prod. Maximum	Maximum Sustain. Yield Escapement Estimate	Maximum Sustain. Yield Escapement Index
Alsek	40%	14	1.6495	57,100	0.710	0.1028	34,617	22,043	8,817
Alsek	60%	14	1.7909	41,621	0.712	0.1003	23,240	15,641	9,385
Akwe	mix	13	1.3009	26,237	0.474	0.3191	20,168	10,791	
	10%								1,079
	50%								5,395
East Alsek	65%	19	1.5635	158,367	0.336	0.1755	101,293	62,124	40,381
Italio	50%	10	1.3185	22,281	0.762	0.0704	16,899	9,136	4,568
Lost	65%	14	1.7490	3,594	0.657	0.1866	3,594	2,381	1,548

Table 7. Estimated spawner-recruit parameters based on regressions and bootstrap statistics for five Yakutat Area sockeye salmon stocks.

Sockeye Salmon Stock	Model	Sample Size (n)	R^2	Regression Estimate of MSY Escapement	Bootstrap Statistics Median MSY Escapement	Lower 90% Bound	Upper 90% Bound
Alsek	40%	14	0.710	22,043	22,093	14,215	31,109
Alsek	60%	14	0.712	15,641	15,673	10,053	22,155
Akwe	mix	13	0.474	10,791	10,672	6,882	14,987
East Alsek	65%	19	0.336	62,124	62,351	40,210	87,545
Italio	50%	10	0.762	9,136	9,084	5,919	12,598
Lost	65%	14	0.657	2,381	2,404	1,540	3,404

Table 8. Estimated spawner-recruit parameters based on regressions and bootstrap statistics for five Yakutat Area sockeye salmon stocks wherein the estimates have been scaled to account for modeled escapement expansions.

Sockeye Salmon Stock	Model	Sample Size (n)	R^2	Regression Estimate of MSY Escapement	Bootstrap Statistics Median MSY Escapement	Lower 90% Bound	Upper 90% Bound
Alsek	40%	14	0.710	8,817	8,837	5,686	12,444
Alsek	60%	14	0.712	9,385	9,404	6,032	13,293
Akwe	10%	13	0.474	1,079	1,067	688	1,499
	50%	13	0.474	5,396	5,336	3,441	7,493
East Alsek	65%	19	0.336	40,381	40,528	26,136	56,904
Italio	50%	10	0.762	4,568	4,542	2,959	6,299
Lost	65%	14	0.657	1,548	1,563	1,001	2,213

Table 9. Optimum escapement estimates and lower and upper escapements that are estimated to produce 90% of the maximum yield based on regressions of the spawner-recruit relationships along with estimates of median optimum escapements with 90% confidence bounds for five Yakutat sockeye salmon stocks. All estimates have been scaled to account for modeled escapement expansions.

		Regression Estimates			Bootstrap Statistics		
			Escapements Where Yield is 90% of Maximum				
Sockeye Salmon Stock	Model	Estimate of MSY Escapement	Lower Bound	Upper Bound	Median MSY Escapement	Lower 90% Bound	Upper 90% Bound
Alsek	40%	8,817	5,500	12,500	8,837	5,686	12,444
Alsek	60%	9,385	5,500	13,500	9,404	6,032	13,293
Akwe	10%	1,079	600	1,500	1,067	688	1,499
	50%	5,396	3,000	7,500	5,336	3,441	7,493
East Alsek	65%	40,381	26,000	57,000	40,528	26,136	56,904
Italio	50%	4,568	2,500	7,000	4,542	2,959	6,299
Lost	65%	1,548	1,000	2,300	1,563	1,001	2,213

Table 10. Recommended escapement goal ranges for fishery management of five Yakutat Area sockeye salmon stocks with the number and percentage of times that monitored escapement was within the range since the early to mid-1970's.

Sockeye Salmon Stock	Recomended Escapement Range	Number of Years Escapement Monitored	Below Range		Within Range		Above Range		No. of Years Since 1990 That Escapement Was Within Range	
			No.	%	No.	%	No.	%	No.	%
Alsek	5,500-13,500	19	0	-	6	32%	13	68%	0	-
Akwe	600-1,500	16	3	19%	6	37%	7	44%	0	-
East Alsek	26,000-57,000	23	5	22%	14	61%	4	17%	5	100%
Italio	2,500-7,000	22	5	23%	9	41%	8	36%	2	40%
Lost	1,000-2,300	17	0	-	7	41%	10	59%	1	33%

Table 11. Estimated sustainable yields (in numbers of fish) acheivable with escapement goal ranges recommended for five Yakutat Area sockeye salmon stocks.

Sockeye Salmon Stock	Recomended Escapement Range	Estimated Maximum Sustained Yield (MSY)	90% of MSY	Average 1990-94 Harvests	Potential Increases in Harvests	
					No.	%
Alsek	5,500 to 13,500	35,400	32,000	21,400	10,600	49%
Akwe	600 to 1,500	12,400	11,200	3,400	7,800	229%
East Alsek	26,000 to 57,000	98,500	88,700	128,000	[a]	-
Italio	2,500 to 7,000	10,750	9,700	0	9,700	-
Lost	1,000 to 2,300	4,700	4,200	2,800	1,400	50%

[a] The 1990-1994 average harvest for the East River stock of sockeye salmon exceeds estimated MSY by about 30%, however, escapements for all of the years during this time frame (see Table 10) are within the range estimated to produce 90% or more of MSY. East River escapements from 1987 to 1990 which were also all within the recommended management range produced these high harvests; hence, favorable survival conditions have led to yields higher than estimated MSY, not over-fishing.

Table 12. Harvests and escapements of Akwe River sockeye salmon, 1973-1994; and, estimated brood year returns.

Year	Commercial Set Gill Net Harvests	Peak Escapement Counts	Escapement Expansion Factor	Estimated Total Escapement	Estimated Brood Year Return
1973	6,132	5,000	2.0	10,000	16,523
1974	1,620	1,000	2.0	2,000	16,691
1975	3,177	500[a]	2.0	1,000[a]	37,895[a]
1976	4,169	5,000	2.0	10,000	55,018
1977	4,936	7,000	2.0	14,000	29,579
1978	2,524	3,000	2.0	6,000	17,891
1979	7,055	15,000	2.0	30,000	27,318
1980	28,687	20,000	2.0	40,000	30,476
1981	15,467	3,500[a]	2.0	7,000[a]	9,199[a]
1982	4,694	8,000	2.0	16,000	18,500
1983	5,822	9,000	2.0	18,000	26,922
1984	17,729	6,900	2.0	13,800	16,590
1985	4,686	500	10.0	5,000	8,647
1986	9,107	1,574	10.0	15,740	9,838
1987	12,175	1,000	10.0	10,000	23,409
1988	12,476	50[a]	10.0	500[a]	21,371[a]
1989	8,653	250[a]	10.0	2,500[a]	30,451[a]
1990	3,996	110[a]	10.0	1,100[a]	-
1991	4,172	3,000	10.0	30,000	-
1992	3,034	1,163[b]	10.0	11,630[b]	-
1993	3,973	3,786	10.0	37,860	-
1994	1,798	200	10.0	2,000	-
Averages	7,549	1,163	-	12,915	23,298

Data Sources:

Akwe commercial harvests (fishing district 182-40) and peak counts of sockeye salmon in the Akwe River (stream number 182-40-010) were taken from IFDB computer runs dated 11/25/94. Escapement expansion factors are based on professional judgement. Estimated brood year returns reflect annual age apportioned catches and escapements (see Appendix Tables 3 and 4 and Table 13) combined by brood year.

[a] These brood years were not included as paired data points in the spawner-recruit relationship because these escapement counts are not considered to be reflective of spawner abundances; in some cases the counts were made too early (June) and in other cases counting conditions were not conducive to making reliable escapement counts. These estimates were used (because there is no other data) to complete brood tables and hence estimate portions of the total returns for other brood years.

[b] The Akwe escapement was not counted in 1992; the value used is the 1973-1994 average. The brood year is not included in the spawner-recruit relationship; the proxy estimate of the 1992 escapement is only used to complete the brood table and hence estimate portions of the total returns for future brood years.

Table 13. Estimated total returns (in number of fish) of Akwe River sockeye salmon assuming that peak counts of the escapements during the years 1973-1984 represented 50% of the total escapements and that peak counts of the escapements during the years 1985-1994 represented 50% of the total escapements.

	Estimated Total Return of Akwe Sockeye Salmon by Age					
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1973	100	2,591	9,947	3,133	361	16,132
1974	20	550	2,249	725	76	3,620
1975	10	464	2,687	954	62	4,177
1976	100	2,434	8,652	2,642	342	14,169
1977	140	3,335	11,518	3,474	469	18,936
1978	60	1,462	5,206	1,591	205	8,524
1979	300	6,864	22,356	6,564	971	37,055
1980	400	10,695	42,533	13,572	1,487	68,687
1981	70	2,707	14,338	4,987	365	22,467
1982	160	4,017	12,116	3,827	574	20,694
1983	0	6,093	14,643	2,668	418	23,822
1984	0	1,242	21,795	8,492	0	31,529
1985	100	2,675	4,818	1,996	97	9,686
1986	0	7,513	13,865	3,039	431	24,847
1987	100	2,922	17,223	1,831	100	22,175
1988	5	639	10,401	1,802	130	12,976
1989	25	1,306	6,321	3,217	285	11,153
1990	11	628	3,286	1,120	51	5,096
1991	300	8,567	19,744	5,094	467	34,172
1992	116	3,651	8,197	2,554	147	14,664
1993	379	10,680	25,794	4,522	458	41,833
1994	20	596	2,654	454	74	3,798

Note: See Appendix Tables 3 and 4 for specifics concerning age composition estimates applied annually to catches and escapements.

Table 14. Harvests and escapements of East Alsek River sockeye salmon, 1972-1994, assuming peak escapement counts represented 65% of the total escapement; and, estimated brood year returns.

	Commercial Set Gill Net Harvests				Peak Escapement Counts			Estim.	Estim.
					East	Doame		Total	Br. Year
Year	River	Surf	Ocean	Total	River	River	Total	Escape.	Return
1972	9,575	0	0	9,575	10,000	-	10,000	15,385	96,510
1973	12,342	0	0	12,342	15,000	-	15,000	23,077	86,292
1974	14,520	0	0	14,520	35,000	-	35,000	53,846	73,485
1975	18,235	0	0	18,235	22,000	-	22,000	33,846	89,464
1976	29,726	0	0	29,726	50,000	-	50,000	76,923	80,316
1977	21,420	0	0	21,420	40,000	-	40,000	61,538	109,936
1978	30,922	0	0	30,922	25,000	-	25,000	38,462	159,591
1979	47,442	0	0	47,442	30,000	-	30,000	46,154	222,295
1980	48,616	0	0	48,616	18,000	-	18,000	27,692	81,454
1981	49,126	0	0	49,126	35,000	-	35,000	53,846	250,667
1982	98,298	0	0	98,298	70,000	-	70,000	107,692	194,892
1983	62,755	18,607	0	81,362	65,000	-	65,000	100,000	208,033
1984	34,836	4,537	0	39,373	29,000	-	29,000	44,615	101,377
1985	147,137	15,240	22,585	184,962	60,000	-	60,000	92,308	178,418
1986	74,972	0	0	74,972	80,000	-	80,000	123,077	232,000
1987	88,891	24,697	20,152	133,740	34,000	-	34,000	52,308	91,126
1988	42,046	15,850	3,585	61,481	38,000	50	38,050	58,462	212,309
1989	77,713	4,992	24,793	107,498	30,000	500	30,500	46,154	259,522
1990	84,890	47,940	28,554	161,384	42,000	1,270	43,270	64,615	169,489
1991	33,961	9,323	2,050	45,334	38,000	700	38,700	58,462	-
1992	90,986	52,545	847	144,378	45,500	900	46,400	70,000	-
1993	67,822	75,484	45,901	189,207	45,250	3,200	48,450	69,615	-
1994	58,552	20,934	20,512	99,998	38,000	2,900	40,900	58,462	-
Ave.	54,121	12,615	7,347	74,083	38,902	1,360	40,262	59,849	152,483

Data Sources:

East Alsek river commercial harvests (fishing district 182-20), East Alsek surf commercial harvests (fishing district 182-21), East Alsek ocean commercial harvests (fishing district 182-22), and peak counts of sockeye salmon in the East Alsek River (stream number 182-20-010) and in the Doame River (stream number 182-10-010) were taken from IFDB computer runs dated 11/25/94. The escapement expansion factor of 1.54 (65%) is based on professional judgement. Estimated brood year returns reflect annual age apportioned catches and escapements (see Appendix Tables 5 and 6 and Table 15) combined by brood year.

Table 15. Estimated total returns (in number of fish) of East Alsek River sockeye salmon assuming that peak counts of the escapements represented 65% of the total escapements.

	Estimated Total Return of East Alsek Sockeye Salmon by Age					
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1972	90	3,950	19,799	1,113	7	24,960
1973	134	5,648	28,073	1,555	9	35,419
1974	301	11,225	54,014	2,815	11	68,366
1975	196	8,303	41,280	2,288	14	52,081
1976	437	17,265	84,391	4,532	23	106,649
1977	348	13,489	65,614	3,491	16	82,958
1978	231	10,832	55,117	3,180	24	69,384
1979	285	14,413	74,457	4,405	36	93,596
1980	187	11,407	60,888	3,790	37	76,308
1981	328	15,963	81,859	4,785	38	102,972
1982	0	53,232	136,373	16,385	0	205,990
1983	0	12,068	162,226	7,068	0	181,362
1984	446	13,019	64,014	6,509	0	83,988
1985	1,846	48,035	222,767	4,622	0	277,270
1986	1,231	48,381	132,805	14,882	750	198,049
1987	1,860	15,175	155,406	13,606	0	186,048
1988	0	37,182	80,362	2,399	0	119,943
1989	0	32,267	116,775	4,610	0	153,652
1990	0	6,780	196,619	22,600	0	225,999
1991	0	24,911	75,771	3,114	0	103,796
1992	0	23,582	182,221	8,575	0	214,378
1993	0	20,706	232,940	5,176	0	258,822
1994	1,169	5,508	148,783	3,000	0	158,460

Note: See Appendix Tables 5 and 6 for specifics concerning age composition estimates applied annually to catches and escapements.

Table 16. Harvests and escapements of Italio River sockeye salmon, 1972-1994, assuming peak escapement counts represented 50% of the total escapement; and, estimated brood year returns.

Year	Commercial Set Gill Net Harvest			Peak Escapement Count	Expansion Factor	Estimated Total Escapement	Estimated Brood Year Return
	Italio	Old Italio	Total				
1972	0	0	0	7,000	2.0	14,000	17,119
1973	1,723	0	1,723	4,200	2.0	8,400	23,841
1974	99	0	99	2,800	2.0	5,600	21,916
1975	365	0	365	3,500	2.0	7,000	15,309
1976	1,239	0	1,239	8,000	2.0	16,000	20,585
1977	1,166	0	1,166	7,800	2.0	15,600	25,027
1978	1,012	0	1,012	15,000	2.0	30,000	25,043
1979	2,315	0	2,315	6,181[a]	2.0	12,362[a]	-
1980	302	0	302	7,000	2.0	14,000	20,478
1981	1,668	0	1,668	12,000	2.0	24,000	23,591
1982	2,945	0	2,945	9,000	2.0	18,000	15,591
1983	1,349	0	1,349	9,000	2.0	18,000	8,078[b]
1984	7,543	0	7,543	9,500	2.0	19,000	4,603[b]
1985	1,314	0	1,314	14,000	2.0	28,000	3,654[b]
1986	4,010	0	4,010	3,800	2.0	7,600	2,752[b]
1987	932	0	932	6,400	2.0	12,800	5,523[b]
1988	5	0	5	2,300	2.0	4,600	7,358[b]
1989	0	0	0	1,950	2.0	3,900	5,537[b]
1990	0	0	0	1,750	2.0	3,500	-
1991	0	0	0	825	2.0	1,650	-
1992	0	0	0	4,500	2.0	9,000	-
1993	1	1	2	3,200	2.0	6,400	-
1994	0	0	0	2,450	2.0	4,900	-
Ave.	1,217	0	1,217	6,181	2.0	12,362	20,850

Data Sources:

Italio commercial harvests (fishing district 182-50), Old Italio commercial harvests (fishing district 182-55) and peak counts of sockeye salmon observed in the Italio River (stream number 182-40-010) were taken from IFDB computer runs dated 11/25/94. The escapement expansion factor of 2.0 (50%) is based on professional judgement. Estimated brood year returns reflect annual age apportioned catches and escapements (see Appendix Tables 7 and 8 and Table 17) combined by brood year.

[a] Escapement not monitored in 1979; average used as a proxy estimate for brood table development only; brood year not used for development of spawner-recruit relationship.

[b] Paired escapements and total returns for these years (BY 1983-1989) not used for development of spawner-recruit relationship nor for estimation of the escapement goal. The Italio River broke into Akwe Lagoon in December 1986; hence BY 83 4-year olds; BY 84 3-year olds, etc. returned through Akwe Lagoon rather than Italio Lagoon and catch composition from 1987 forward differs from pre-1987 catch composition.

Table 17. Estimated total returns (in number of fish) of Italio River sockeye salmon assuming that peak counts of the escapements represented 50% of the total escapements.

	Estimated Total Return of Italio Sockeye Salmon by Age				
Year	Age 3	Age 4	Age 5	Age 6	Total
1972	420	6,160	7,000	420	14,000
1973	304	4,454	5,062	304	10,123
1974	171	2,508	2,850	171	5,699
1975	221	3,241	3,683	221	7,365
1976	517	7,585	8,620	517	17,239
1977	503	7,377	8,383	503	16,766
1978	930	13,645	15,506	930	31,012
1979	440	6,458	7,339	440	14,677
1980	429	6,293	7,151	429	14,302
1981	770	11,294	12,834	770	25,668
1982	268	6,549	13,110	1,018	20,945
1983	400	3,501	15,255	193	19,349
1984	0	10,645	13,428	2,470	26,543
1985	3,745	16,578	8,991	0	29,314
1986	505	4,268	6,396	441	11,610
1987	521	5,154	7,440	617	13,732
1988	138	2,026	2,303	138	4,605
1989	117	1,716	1,950	117	3,900
1990	105	1,540	1,750	105	3,500
1991	50	726	825	50	1,650
1992	270	3,960	4,500	270	9,000
1993	192	2,817	3,201	192	6,402
1994	147	2,156	2,450	147	4,900

Note: See Appendix Tables 7 and 8 for specifics concerning age composition estimates applied annually to catches and escapements.

Table 18. Harvests and escapements of Lost River sockeye salmon, 1972-1994, assuming peak escapement counts represented 65% of the total escapement; and, estimated brood year returns.

Year	Commercial Set Gill Net Harvest	Peak Escapement Counts: Lost River	Tawah Creek	Ophir Creek	Coast Guard Lake	Total	Estim. Total Escape.	Estim. Brood Year Return
1972	4,076	2,800	-	-	2,251	2,800	4,308	10,546
1973	4,495	3,000	-	-	-	3,000	4,615	10,120
1974	1,948	-	1,200	-	-	1,200	1,846	9,373
1975	1,976	1,200	-	-	-	1,200	1,846	8,335
1976	4,607	2,200	-	-	-	2,200	3,385	7,891
1977	8,925	-	-	-	3,022	3,022	4,649	9,432
1978	3,831	-	800	-	3,000	3,800	5,846	9,285
1979	3,818	-	-	-	3,500	3,500	5,385	9,612
1980	3,880	1,800	-	-	-	1,800	2,769	4,063
1981	2,316	-	630	-	3,500	4,130	6,354	4,286
1982	4,980	6,000	-	-	3,000	6,000	9,231	3,848
1983	2,168	-	3,000	-	-	3,000	4,615	3,364
1984	726	-	-	-	-	2,827[a]	4,349[a]	-
1985	1,418	-	-	-	-	2,827[a]	4,349[a]	-
1986	491	-	10	-	1,500	1,510	2,232	7,990
1987	2,160	-	-	-	200	200[b]	308[b]	-
1988	2,316	-	1,500	-	800	1,500	2,308	3,775
1989	3,090	-	650	-	80	730[b]	1,123[b]	-
1990	3,093	-	100	500	3,600	4,100	6,308	-
1991	2,789	-	50	350	1,500	1,850	2,846	-
1992	3,170	-	737	-	-	737[b]	1,134[b]	-
1993	3,999	-	375	-	-	375[b]	577[b]	-
1994	1,178	-	3,300	3,452	-	3,452	5,311	-
Ave.	3,107	-	-	-	-	2,827	4,349	7,280

Data Sources:

Lost River commercial harvests (fishing district 182-80) and peak counts of sockeye salmon observed in portions of the Lost River drainage including the Lost River (stream number 182-80-010), Tawah Creek (stream number 182-80-030), Ophir Creek (stream number 182-80-030) and Coast Guard Lake (182-80-070) were taken from IFDB computer runs dated 11/25/94. The escapement expansion factor of 1.54 (65%) is based on professional judgement. Estimated brood year returns reflect annual age apportioned catches and escapements (see Appendix Tables 9 and 10 and Table 19) combined by brood year.

[a] Average used as a proxy estimate for brood table development only; brood year not used for development of spawner-recruit relationship.

[b] Escapement not adequately surveyed; value used as a proxy estimate for brood table development only; brood year not used for development of spawner-recruit relationship.

Table 19. Estimated total returns (in number of fish) of Lost River sockeye salmon assuming that peak counts of the escapements represented 65% of the total escapements.

	Estimated Total Return of Lost River Sockeye Salmon by Age					
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1972	34	633	3,433	3,624	659	8,384
1973	37	681	3,714	3,956	723	9,110
1974	15	275	1,528	1,668	309	3,794
1975	15	276	1,535	1,684	312	3,822
1976	27	525	3,091	3,648	700	7,992
1977	37	774	4,972	6,491	1,300	13,574
1978	47	825	4,183	3,949	673	9,677
1979	43	766	3,934	3,802	658	9,203
1980	22	432	2,560	3,048	587	6,649
1981	51	860	4,029	3,239	492	8,670
1982	0	2,585	5,526	4,820	1,280	14,211
1983	92	505	3,564	2,514	108	6,783
1984	0	304	1,196	3,212	363	5,075
1985	35	599	2,753	2,178	201	5,767
1986	0	317	1,381	933	184	2,814
1987	2	104	660	1,497	204	2,468
1988	18	342	2,224	1,670	370	4,624
1989	9	206	1,308	1,884	683	4,089
1990	50	807	4,222	3,482	839	9,401
1991	23	392	2,016	3,035	169	5,635
1992	9	209	1,079	2,498	510	4,304
1993	5	194	1,627	2,054	697	4,576
1994	106	319	4,625	1,238	200	6,489

Note: See Appendix Tables 9 and 10 for specifics concerning age composition estimates applied annually to catches and escapements.

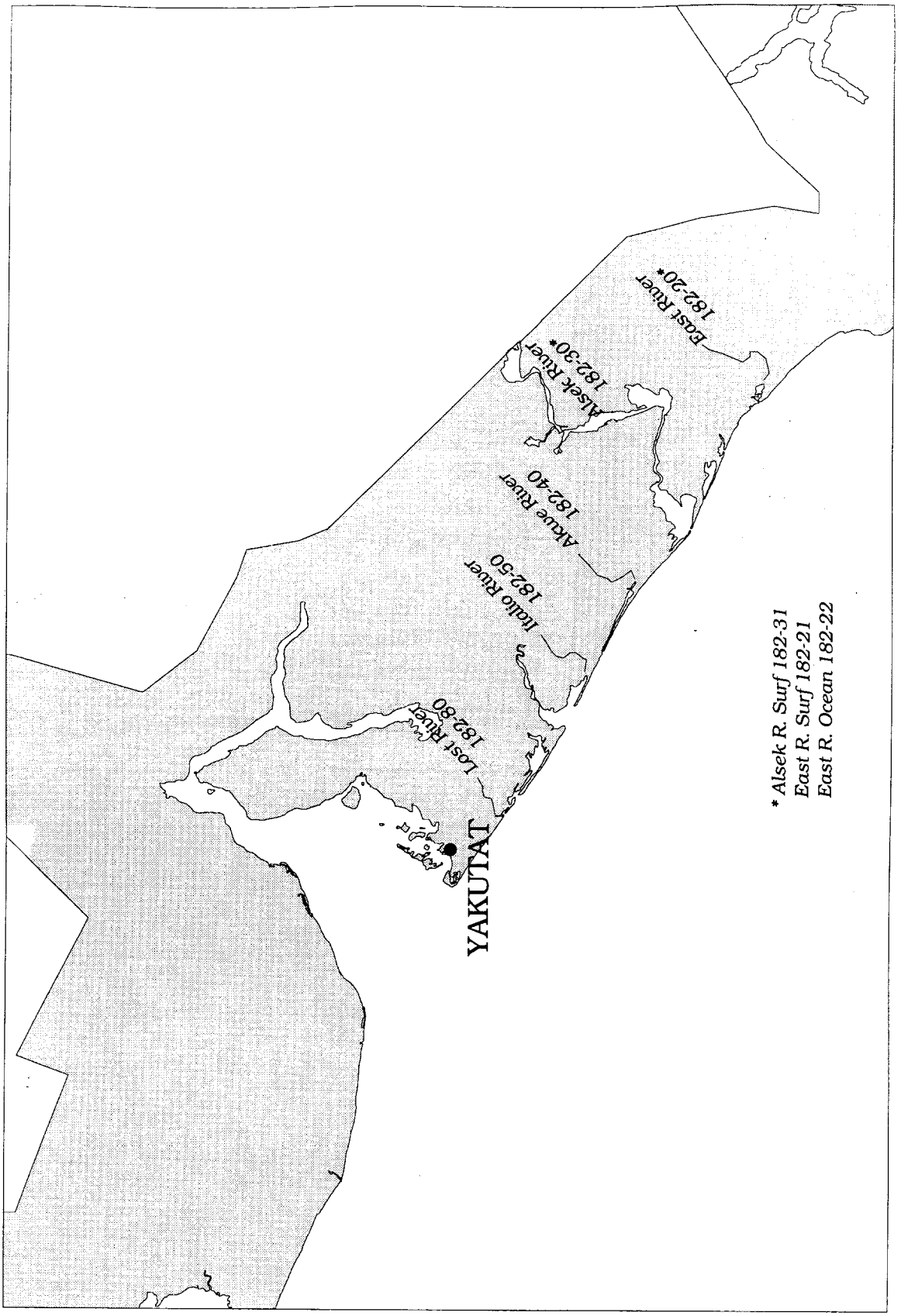


Figure 1. Map of Yakutat Area.

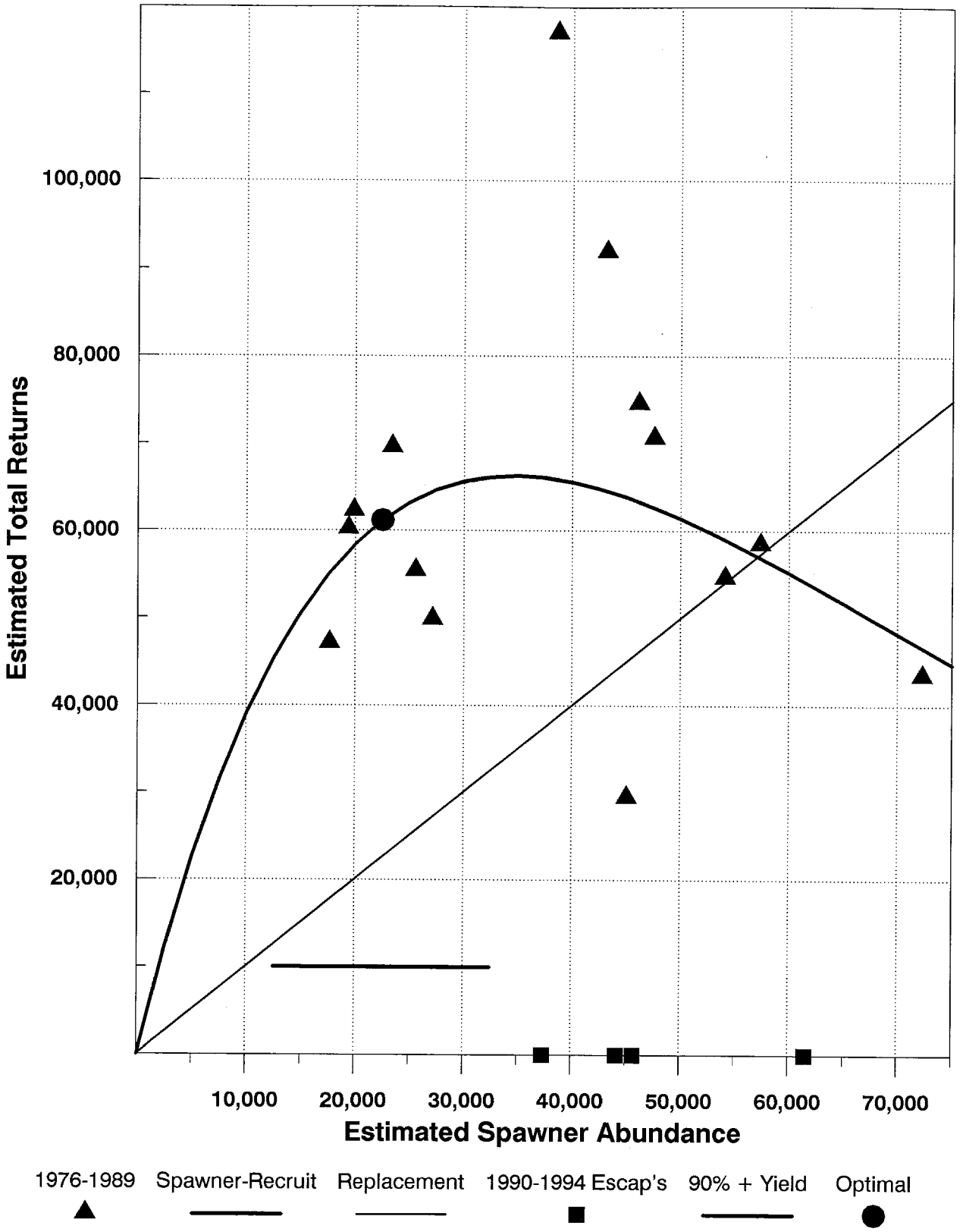


Figure 2. Spawner-recruit relationship for Alsek sockeye salmon using the 40% Kluckshu escapement expansion assumption.

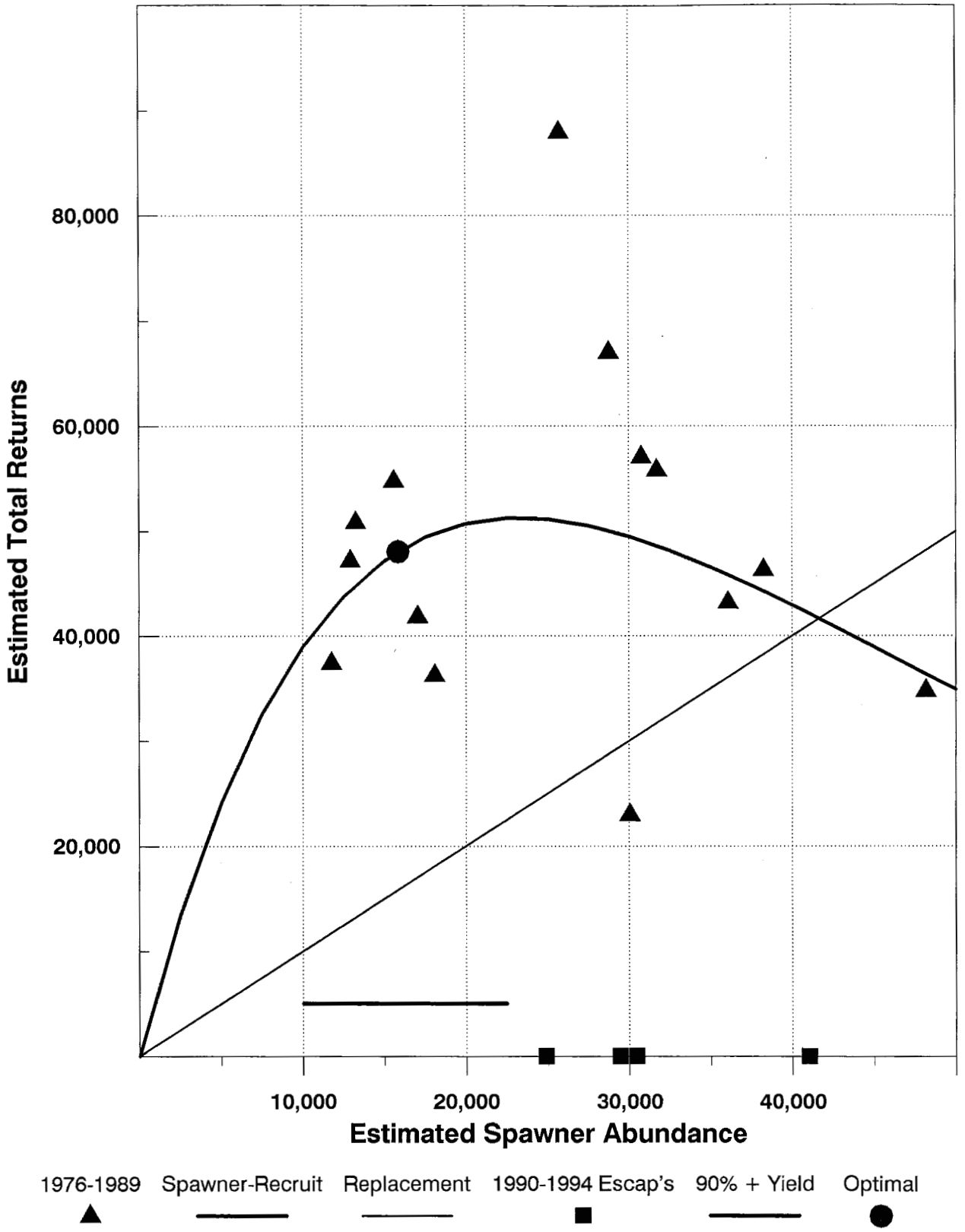


Figure 3. Spawner-recruit relationship for Alsek sockeye salmon using the 60% Kluckshu escapement expansion assumption.

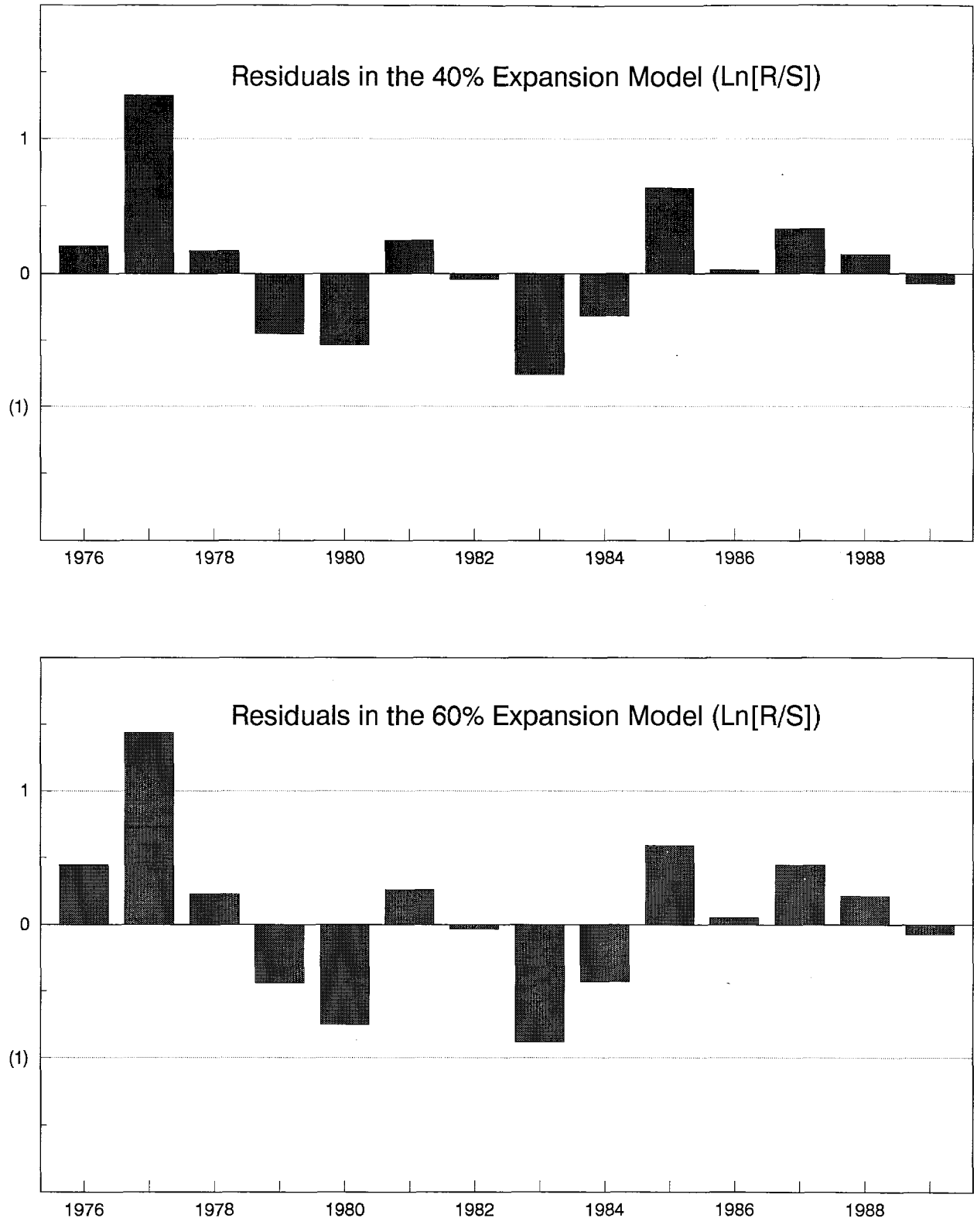


Figure 4. Residuals in the spawner-recruit relationships for Alsek sockeye salmon with the 40% and the 60% escapement expansion models.

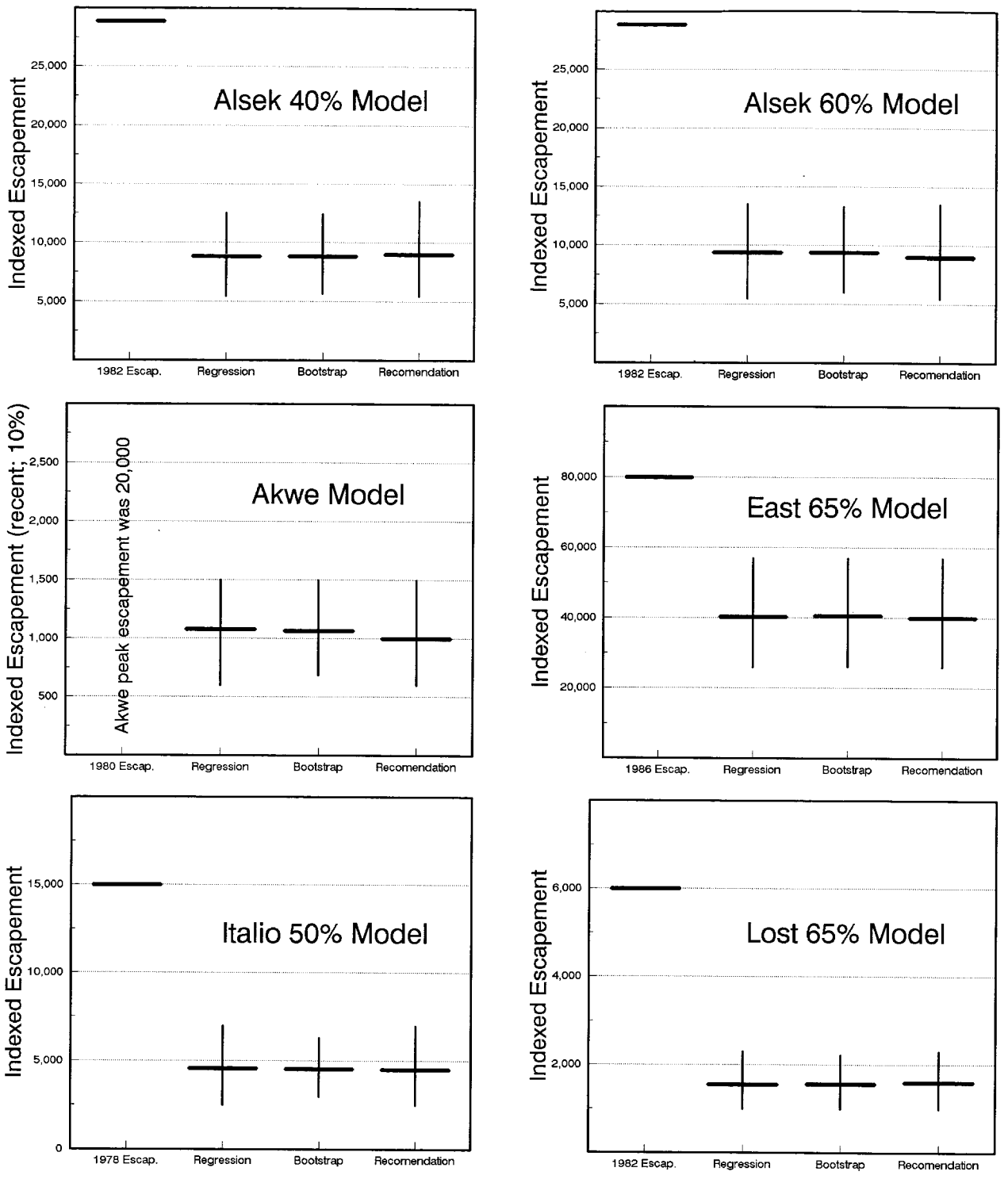


Figure 5. Largest escapements used to estimate MSYs, escapement ranges estmated to produce 90% or more of MSYs and MSY escapements based upon spawner-recruit regressions, bootstrap estimates of MSY escapements and 90% confidence intervals, and recomended escapement goals and ranges for five stocks of sockeye salmon.

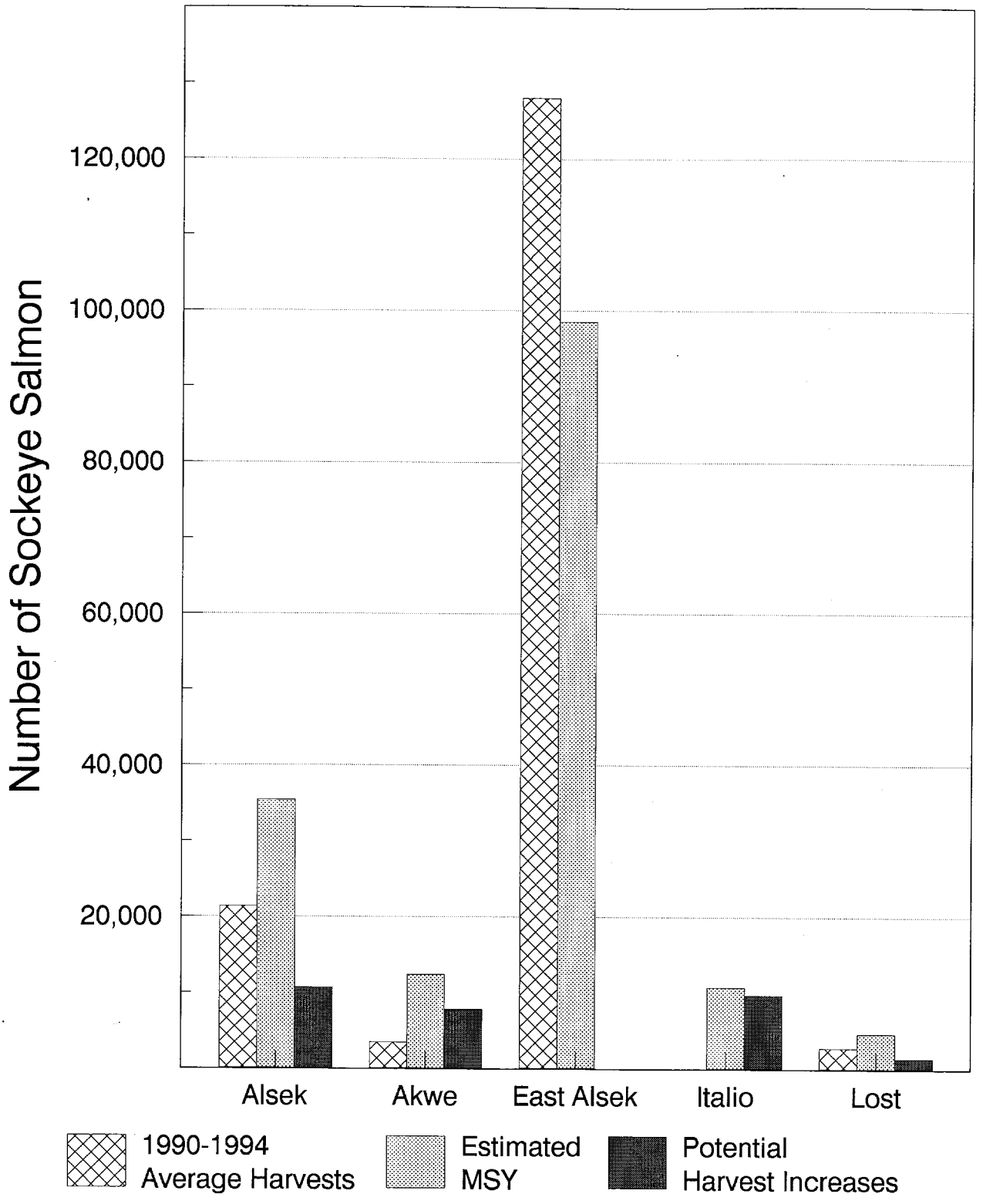


Figure 6. Average harvests during the period 1990-1994, estimated MSY, and estimated gains in harvest potential if five Yakutat Area stocks are managed within the recomended ranges.

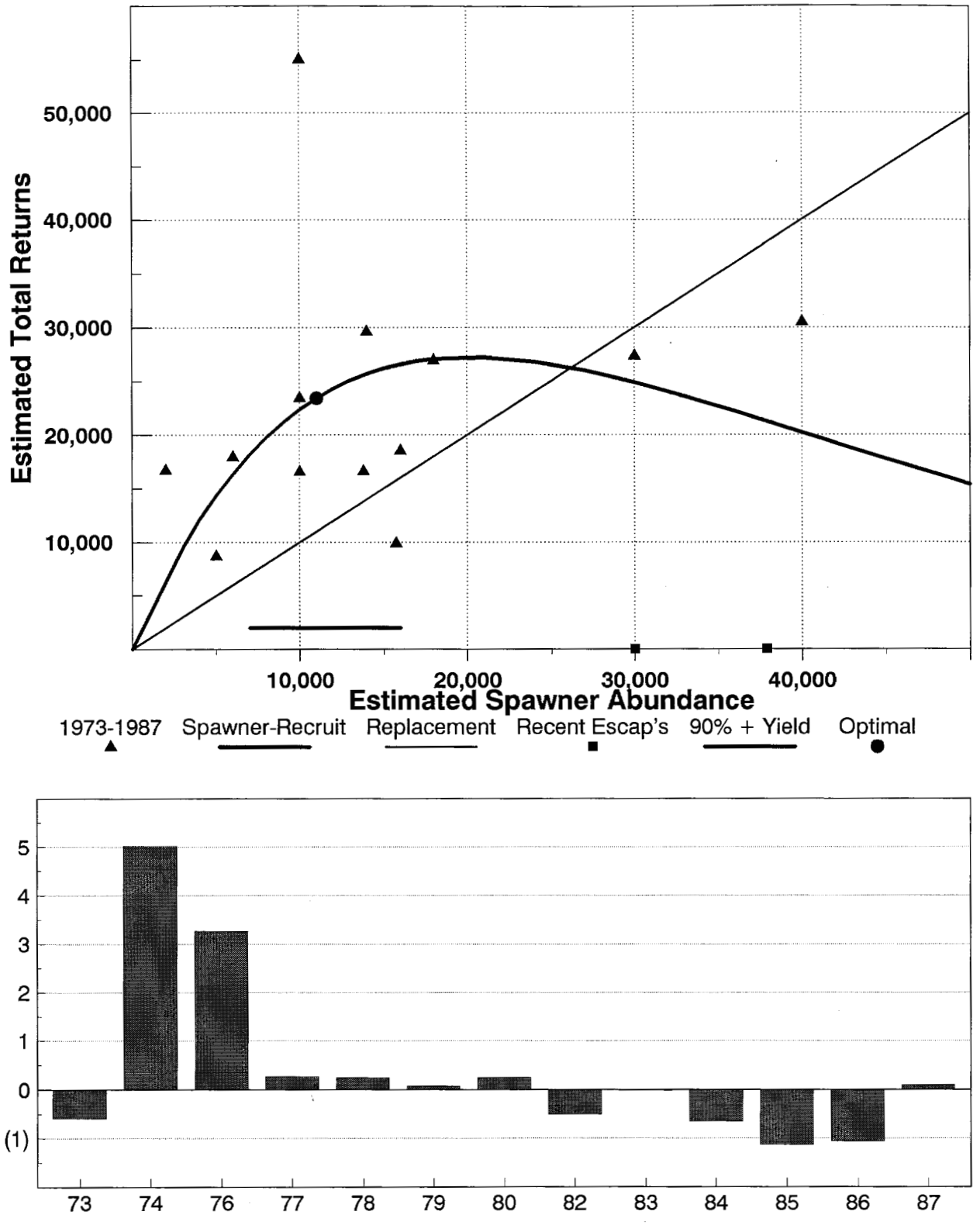


Figure 7. Spawner-recruit relationship for Akwe sockeye salmon using the peak escapement count expansion assumptions (upper) and residuals in the spawner-recruit relationship (lower).

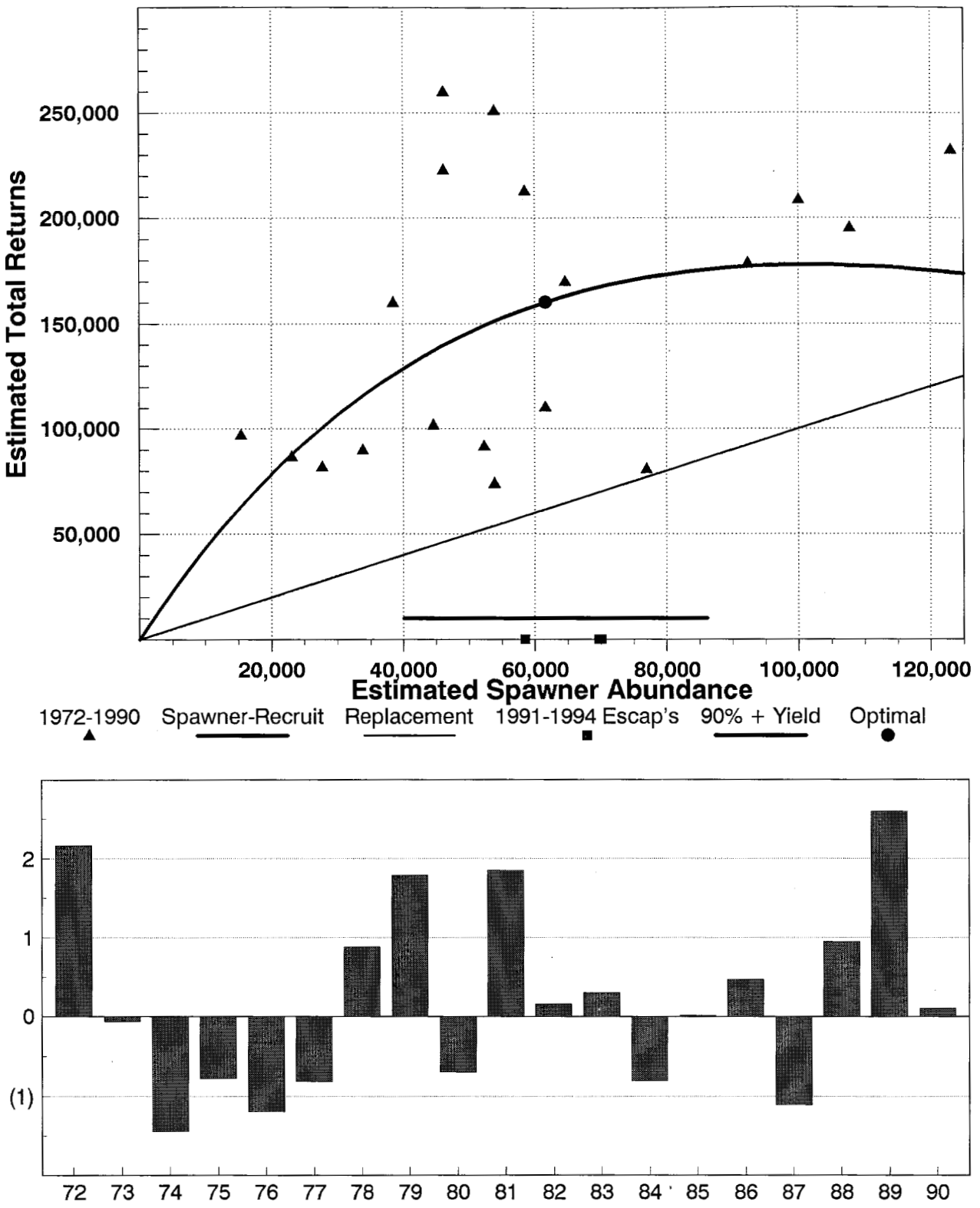


Figure 8. Spawner-recruit relationship for East Alsek sockeye salmon using the 65% peak escapement count expansion assumption (upper) and residuals in the spawner-recruit relationship (lower).

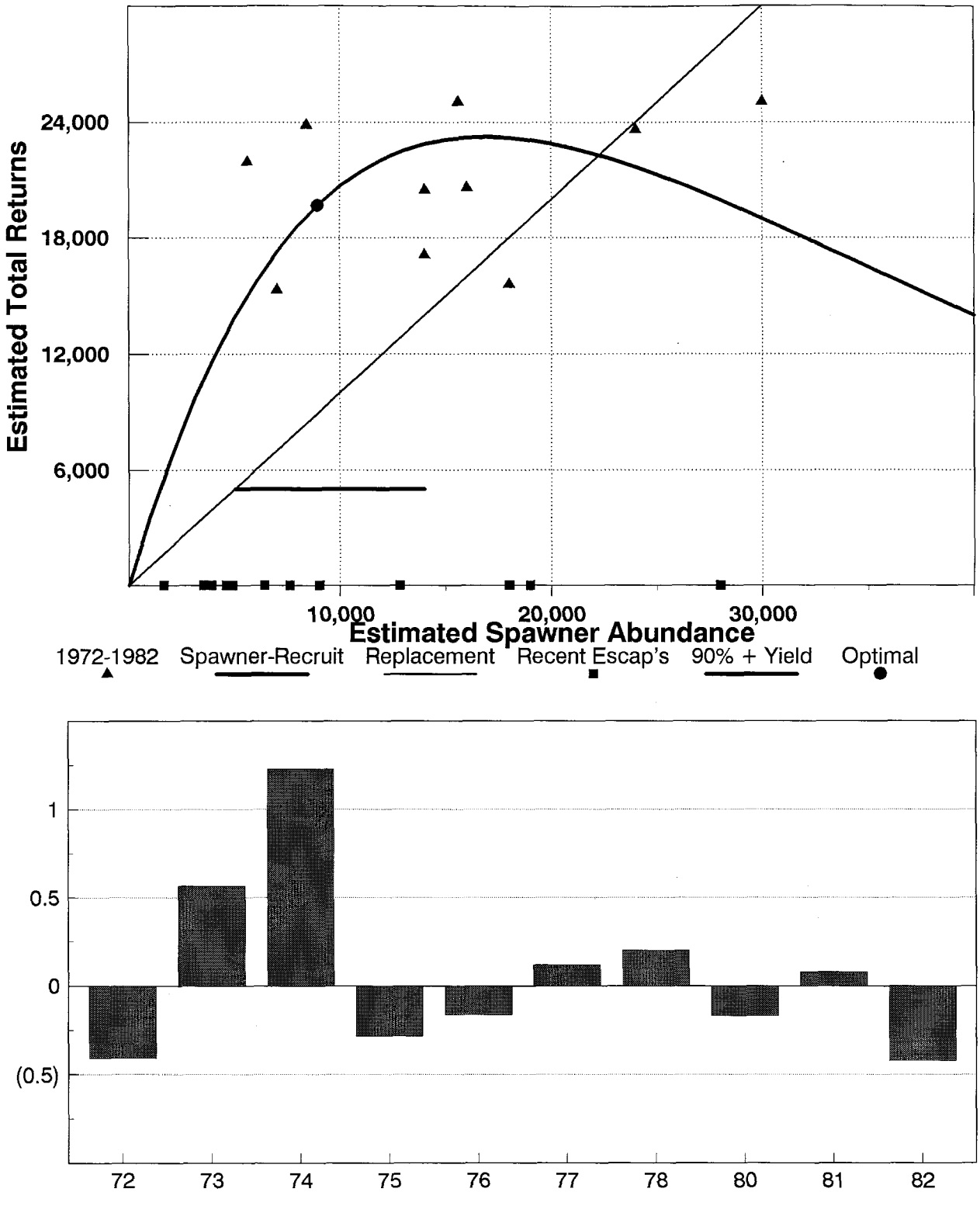


Figure 9. Spawner-recruit relationship for Italio sockeye salmon using the 50% peak escapement count expansion assumption (upper) and residuals in the spawner-recruit relationship (lower).

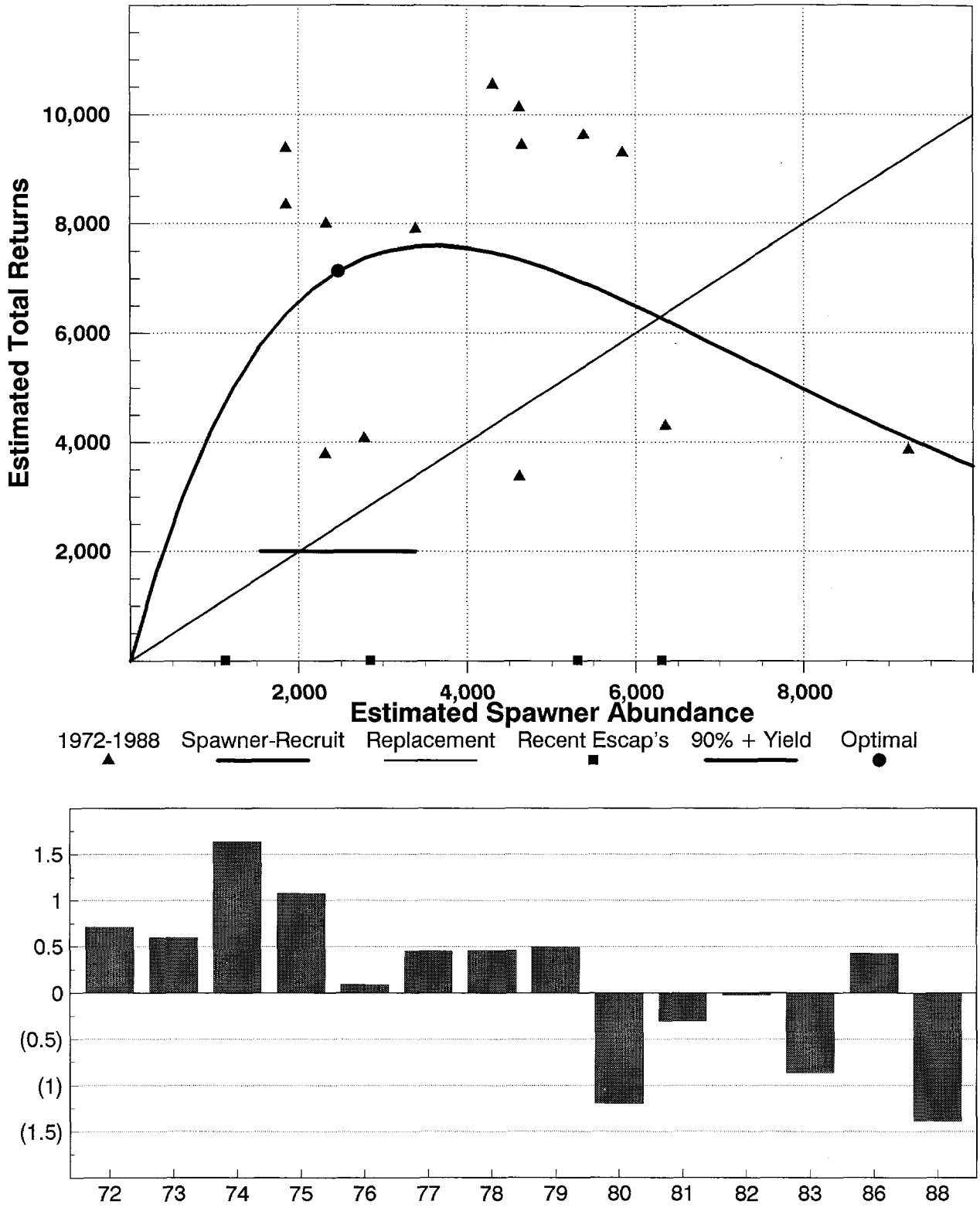


Figure 10. Spawner-recruit relationship for Lost River sockeye salmon using the 65% peak escapement count expansion assumption (upper) and residuals in the spawner-recruit relationship (lower).

Appendix Table 1. Age composition of sockeye salmon sampled from the U.S. Alsek River commercial fishery, 1982-1994.

	Age Composition of Alsek Sockeye Salmon Catch							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	1%	19%	73%	7%	0%	100%	1,556
1983	0%	1%	11%	88%	0%	0%	100%	2,011
1984	0%	1%	11%	86%	2%	0%	100%	1,892
1985	0%	1%	32%	64%	3%	0%	100%	1,521
1986	0%	2%	22%	69%	7%	0%	100%	1,647
1987	0%	0%	14%	83%	3%	0%	100%	1,653
1988	0%	1%	17%	79%	3%	0%	100%	1,338
1989	0%	1%	19%	75%	5%	0%	100%	746
1990	0%	1%	31%	62%	6%	0%	100%	614
1991	0%	0%	21%	71%	8%	0%	100%	483
1992	0%	1%	15%	79%	5%	0%	100%	523
1993	0%	0%	16%	72%	12%	0%	100%	496
1994	0%	0%	21%	74%	5%	0%	100%	455
Ave & Sum	0%	1%	19%	75%	5%	0%	100%	14,935

Note: Average age composition for 1982-1994 catches were used as proxy estimates of the age composition of catches for the years 1976-1981 in brood tables.

Appendix Table 2. Age composition of sockeye salmon sampled from the Kluckshu River escapements, 1976-1994.

	Age Composition of Kluckshu Sockeye Escapement							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1976	0%	5%	86%	9%	0%	0%	100%	446
1977	0%	1%	52%	46%	2%	0%	100%	198
1978	0%	0%	20%	77%	3%	0%	100%	90
1979	0%	0%	22%	69%	9%	0%	100%	174
1980	0%	0%	26%	74%	0%	0%	100%	72
1981	0%	1%	43%	56%	0%	0%	100%	233
1982	0%	0%	4%	94%	2%	0%	100%	394
1983	0%	0%	10%	90%	0%	0%	100%	348
1984	0%	1%	2%	94%	3%	0%	100%	100
1985	0%	0%	14%	84%	2%	0%	100%	207
1986	0%	0%	12%	81%	8%	0%	100%	528
1987	0%	0%	20%	79%	1%	0%	100%	407
1988	0%	0%	16%	78%	6%	0%	100%	485
1989	0%	0%	30%	70%	0%	0%	100%	222
1990	0%	0%	6%	94%	0%	0%	100%	686
1991[a]	0%	1%	24%	73%	2%	0%	100%	-
1992[a]	0%	1%	24%	73%	2%	0%	100%	-
1993[a]	0%	1%	24%	73%	2%	0%	100%	-
1994[a]	0%	1%	24%	73%	2%	0%	100%	-
Ave & Sum	0%	1%	24%	73%	2%	0%	100%	4,590

[a] Age data from sockeye salmon from the Kluckshu escapement are not available; averages for the years 1976-1990 were used as proxy estimates for the 1991-1994 age compositions.

Appendix Table 3. Age composition of sockeye salmon sampled from the Akwe River commercial fishery, 1982-1994.

	Age Composition of Akwe Sockeye Salmon Catch							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	14%	57%	27%	2%	0%	100%	527
1983	0%	15%	66%	18%	1%	0%	100%	602
1984	0%	0%	63%	37%	0%	0%	100%	601
1985	0%	8%	58%	33%	1%	0%	100%	423
1986	0%	22%	52%	23%	3%	0%	100%	725
1987	0%	1%	93%	6%	0%	0%	100%	603
1988	0%	4%	81%	14%	1%	0%	100%	512
1989	0%	7%	56%	34%	3%	0%	100%	322
1990[a]	0%	8%	66%	25%	1%	0%	100%	0
1991	0%	4%	49%	43%	4%	0%	100%	268
1992	0%	13%	44%	42%	1%	0%	100%	328
1993	0%	2%	87%	9%	2%	0%	100%	368
1994	0%	2%	82%	13%	3%	0%	100%	247
Ave & Sum	0%	8%	66%	25%	1%	0%	100%	5,526

Note: Average age composition for 1982-1989 and 1991-1994 catches were used as proxy estimates of the age composition of catches for the years 1973-1981 in brood tables. See Appendix Figure 1 for graphic display of annual data.

[a] Sockeye salmon from the Akwe commercial fishery were not sampled for ages in 1990; 1982-1989 and 1991-1994 averages were used as proxy estimates of the 1990 age composition.

Appendix Table 4. Age composition of sockeye salmon sampled from the Akwe River escapements, 1982-1994.

	Age Composition of Akwe Sockeye Escapement							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	1%	21%	59%	16%	3%	0%	100%	107
1983	0%	29%	60%	9%	2%	0%	100%	309
1984	0%	9%	77%	14%	0%	0%	100%	400
1985	2%	46%	42%	9%	1%	0%	100%	207
1986	0%	35%	58%	6%	1%	0%	100%	411
1987[a]	1%	28%	59%	11%	1%	0%	100%	-
1988[a]	1%	28%	59%	11%	1%	0%	100%	-
1989[a]	1%	28%	59%	11%	1%	0%	100%	-
1990[a]	1%	28%	59%	11%	1%	0%	100%	-
1991[a]	1%	28%	59%	11%	1%	0%	100%	-
1992[a]	1%	28%	59%	11%	1%	0%	100%	-
1993[a]	1%	28%	59%	11%	1%	0%	100%	-
1994[a]	1%	28%	59%	11%	1%	0%	100%	-
Ave & Sum	1%	28%	59%	11%	1%	0%	100%	1,434

Note: Average age composition for 1982-1986 escapements were used as proxy estimates of the age composition of escapements for the years 1973-1981 in brood tables. See Appendix Figure 1 for graphic display of annual data.

[a] Sockeye salmon from the Akwe escapement were not sampled for ages in these years; averages from 1982-1986 were used as proxy estimates.

Appendix Table 5. Age composition of sockeye salmon sampled from the East Alsek River commercial fishery, 1982-1994.

	Age Composition of East Alsek Sockeye Catch							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	18%	73%	9%	0%	0%	100%	624
1983	0%	5%	90%	5%	0%	0%	100%	1,450
1984	0%	24%	64%	12%	0%	0%	100%	1,355
1985	0%	10%	88%	2%	0%	0%	100%	1,268
1986	0%	12%	77%	10%	1%	0%	100%	1,147
1987	1%	9%	81%	9%	0%	0%	100%	1,369
1988	0%	31%	67%	2%	0%	0%	100%	1,012
1989	0%	21%	76%	3%	0%	0%	100%	900
1990	0%	3%	87%	10%	0%	0%	100%	564
1991	0%	24%	73%	3%	0%	0%	100%	418
1992	0%	11%	85%	4%	0%	0%	100%	490
1993	0%	8%	90%	2%	0%	0%	100%	399
1994	0%	2%	95%	3%	0%	0%	100%	396
Ave & Sum	0%	14%	80%	6%	0%	0%	100%	11,392

Note: Average age composition for the 1982-1994 catches were used as proxy estimates of the age composition of catches for the years 1972-1981 in brood tables. See Appendix Figure 2 for graphic display of annual data.

Appendix Table 6. Age composition of sockeye salmon sampled from the East Alsek River escapements, 1982-1994.

	Age Composition of East Alsek Sockeye Escapement							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	33%	60%	7%	0%	0%	100%	539
1983	0%	8%	89%	3%	0%	0%	100%	433
1984	1%	8%	87%	4%	0%	0%	100%	429
1985	2%	32%	65%	1%	0%	0%	100%	424
1986	1%	32%	61%	6%	0%	0%	100%	519
1987	1%	6%	90%	3%	0%	0%	100%	415
1988[a]	0%	31%	67%	2%	0%	0%	100%	-
1989[a]	0%	21%	76%	3%	0%	0%	100%	-
1990[a]	0%	3%	87%	10%	0%	0%	100%	-
1991[a]	0%	24%	73%	3%	0%	0%	100%	-
1992[a]	0%	11%	85%	4%	0%	0%	100%	-
1993[a]	0%	8%	90%	2%	0%	0%	100%	-
1994	2%	6%	92%	0%	0%	0%	100%	424
Ave & Sum	1%	17%	79%	4%	0%	0%	100%	3,183

Note: Average age composition for the 1982-1987 and 1994 escapements were used as proxy estimates of the age composition of escapements for the years 1972-1981 in brood tables. See Appendix Figure 2 for graphic display of annual data.

[a] Sockeye salmon from the East Alsek escapement were not sampled for ages in these years; age composition of sockeye salmon from the catches in the East Alsek commercial fishery in each respective year was used for proxy estimates of the escapement age composition.

Appendix Table 7. Age composition of sockeye salmon sampled from the Italio River commercial fishery, 1982-1994.

	Age Composition of Italio Sockeye Catch							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	3%	39%	54%	4%	0%	100%	386
1983	0%	3%	46%	50%	1%	0%	100%	535
1984	0%	0%	58%	42%	0%	0%	100%	533
1985	0%	8%	47%	45%	0%	0%	100%	253
1986	0%	5%	42%	51%	2%	0%	100%	693
1987	1%	1%	86%	12%	1%	0%	100%	329
1988[a]	0%	3%	44%	50%	3%	0%	100%	-
1989[a]	0%	3%	44%	50%	3%	0%	100%	-
1990[a]	0%	3%	44%	50%	3%	0%	100%	-
1991[a]	0%	3%	44%	50%	3%	0%	100%	-
1992[a]	0%	3%	44%	50%	3%	0%	100%	-
1993[a]	0%	3%	44%	50%	3%	0%	100%	-
1994[a]	0%	3%	44%	50%	3%	0%	100%	-
Ave & Sum	0%	3%	54%	42%	1%	0%	100%	2,729

Note: Average age composition for the 1982-1987 catches and the 1982-1985 escapements were used as proxy estimates of the age compositions for both catches and escapements for the years 1972-1981 in brood tables. See Appendix Figure 3 for graphic display of annual data.

[a] Italio sockeye catches were not age sampled in 1988-1994; average age compositions for combined Italio catch and escapement samples in 1982-1987 were used as proxy estimates for these seven years.

Appendix Table 8. Age composition of sockeye salmon sampled from the Italio River escapements, 1982-1994.

	Age Composition of Italio Sockeye Escapement							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	1%	30%	64%	5%	0%	100%	388
1983	0%	2%	16%	81%	1%	0%	100%	323
1984	0%	0%	22%	54%	13%	0%	100%	310
1985	0%	13%	57%	30%	0%	0%	100%	393
1986[a]	0%	4%	34%	57%	5%	0%	100%	-
1987[a]	0%	4%	34%	57%	5%	0%	100%	-
1988[b]	0%	3%	44%	50%	3%	0%	100%	-
1989[b]	0%	3%	44%	50%	3%	0%	100%	-
1990[b]	0%	3%	44%	50%	3%	0%	100%	-
1991[b]	0%	3%	44%	50%	3%	0%	100%	-
1992[b]	0%	3%	44%	50%	3%	0%	100%	-
1993[b]	0%	3%	44%	50%	3%	0%	100%	-
1994[b]	0%	3%	44%	50%	3%	0%	100%	-
Ave & Sum	0%	4%	34%	57%	5%	0%	100%	1,414

Note: Average age composition for the 1982-1987 catches and the 1982-1985 escapements were used as proxy estimates of the age compositions for both catches and escapements for the years 1972-1981 in brood tables. See Appendix Figure 3 for graphic display of annual data.

[a] Italio sockeye escapements were not age sampled in 1986-1988; annual age compositions for the Italio catch were used for these two years.

[b] Italio sockeye escapements were not age sampled in 1988-1994; average age compositions for combined Italio catch and escapement samples in 1982-1987 were used as proxy estimates for these seven years.

Appendix Table 9. Age composition of sockeye salmon sampled from the Lost River commercial fishery, 1982-1994.

	Age Composition of Lost River Sockeye Catch							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	0%	22%	56%	22%	0%	100%	311
1983	0%	2%	26%	67%	5%	0%	100%	679
1984	0%	0%	21%	71%	8%	0%	100%	83
1985	0%	3%	31%	61%	5%	0%	100%	373
1986	0%	3%	40%	48%	9%	0%	100%	157
1987	0%	3%	23%	65%	9%	0%	100%	504
1988	0%	2%	43%	42%	13%	0%	100%	74
1989	0%	2%	23%	50%	21%	4%	100%	192
1990	0%	0%	28%	51%	21%	0%	100%	76
1991	0%	1%	18%	78%	3%	0%	100%	157
1992	0%	2%	15%	68%	15%	0%	100%	117
1993	0%	3%	33%	47%	17%	0%	100%	315
1994	0%	0%	41%	42%	17%	0%	100%	94
Ave & Sum	0%	2%	28%	57%	13%	0%	100%	3,132

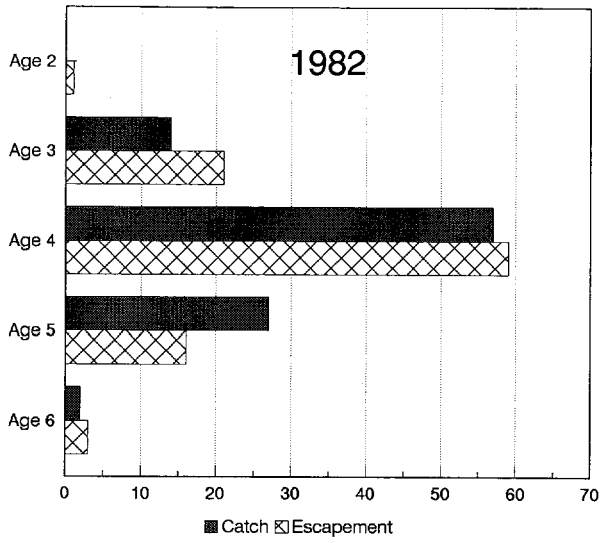
Note: Average age composition for the 1982-1994 catches were used as proxy estimates of the age composition of catches for the years 1972-1981 in brood tables. See Appendix Figure 4 for graphic display of annual data.

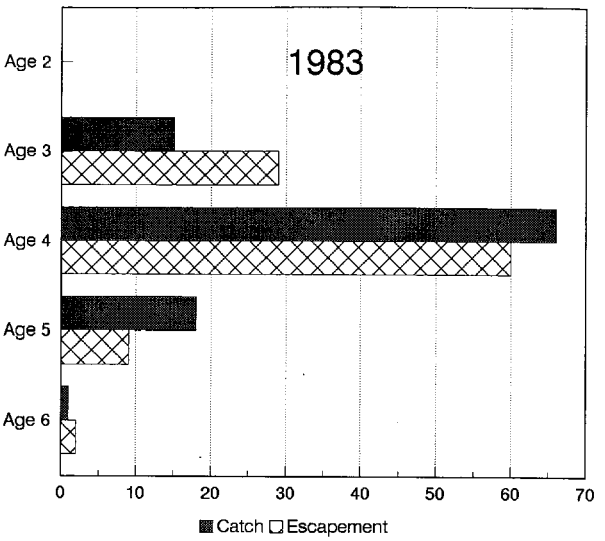
Appendix Table 10. Age composition of sockeye salmon sampled from the Lost River escapements, 1982-1994.

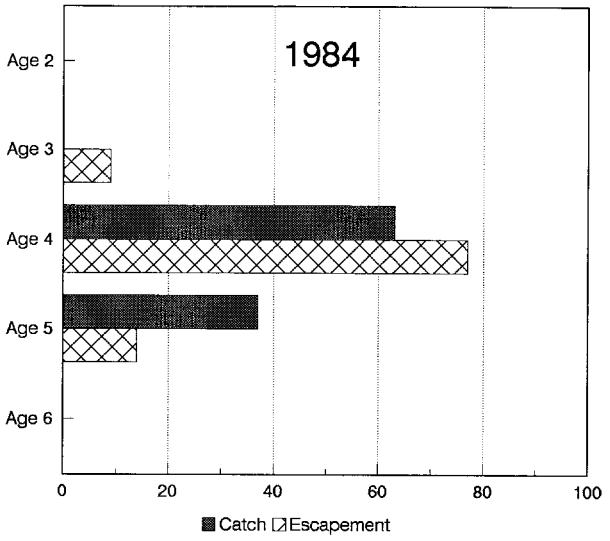
	Age Composition of Lost River Sockeye Escapement							Sample
Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Total	Size
1982	0%	28%	48%	22%	2%	0%	100%	220
1983	2%	10%	65%	23%	0%	0%	100%	260
1984	0%	7%	24%	62%	7%	0%	100%	321
1985[a]	1%	13%	53%	30%	3%	0%	100%	-
1986	0%	13%	51%	30%	6%	0%	100%	97
1987[a]	1%	13%	53%	30%	3%	0%	100%	-
1988[a]	1%	13%	53%	30%	3%	0%	100%	-
1989[a]	1%	13%	53%	30%	3%	0%	100%	-
1990[a]	1%	13%	53%	30%	3%	0%	100%	-
1991[a]	1%	13%	53%	30%	3%	0%	100%	-
1992[a]	1%	13%	53%	30%	3%	0%	100%	-
1993[a]	1%	13%	53%	30%	3%	0%	100%	-
1994	2%	6%	78%	14%	0%	0%	100%	155
Ave & Sum	1%	13%	53%	30%	3%	0%	100%	1,053

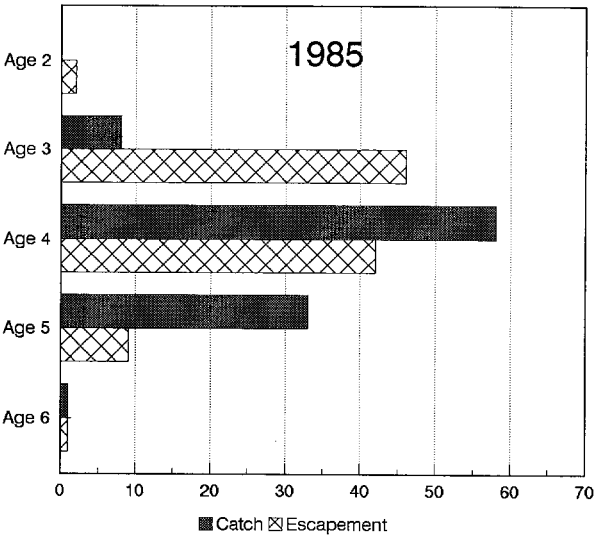
Note: Average age composition for the 1982-1984, 1986, and 1994 escapements were used as proxy estimates of the age composition of escapements for the years 1972-1981 in brood tables. See Appendix Figure 4 for graphic display of annual data.

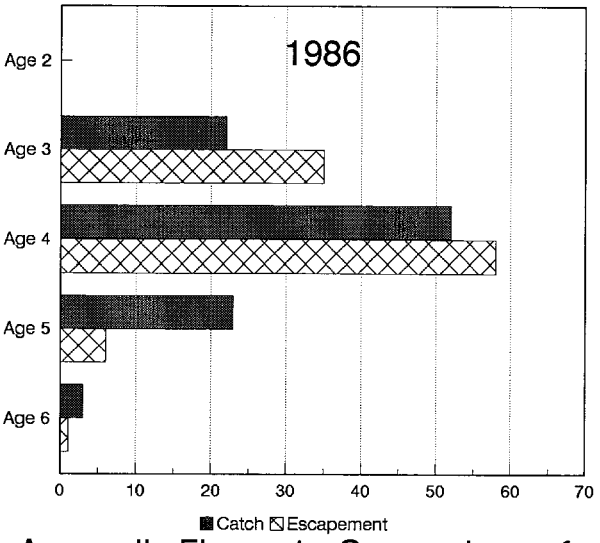
[a] Age data from sockeye salmon sampled from the Lost River escapement were not collected in 1985 nor in 1987-1993; averages for the years 1982-1984, 1986, and 1994 were used as proxy estimates for the 1985 and 1987-1993 escapement age compositions.



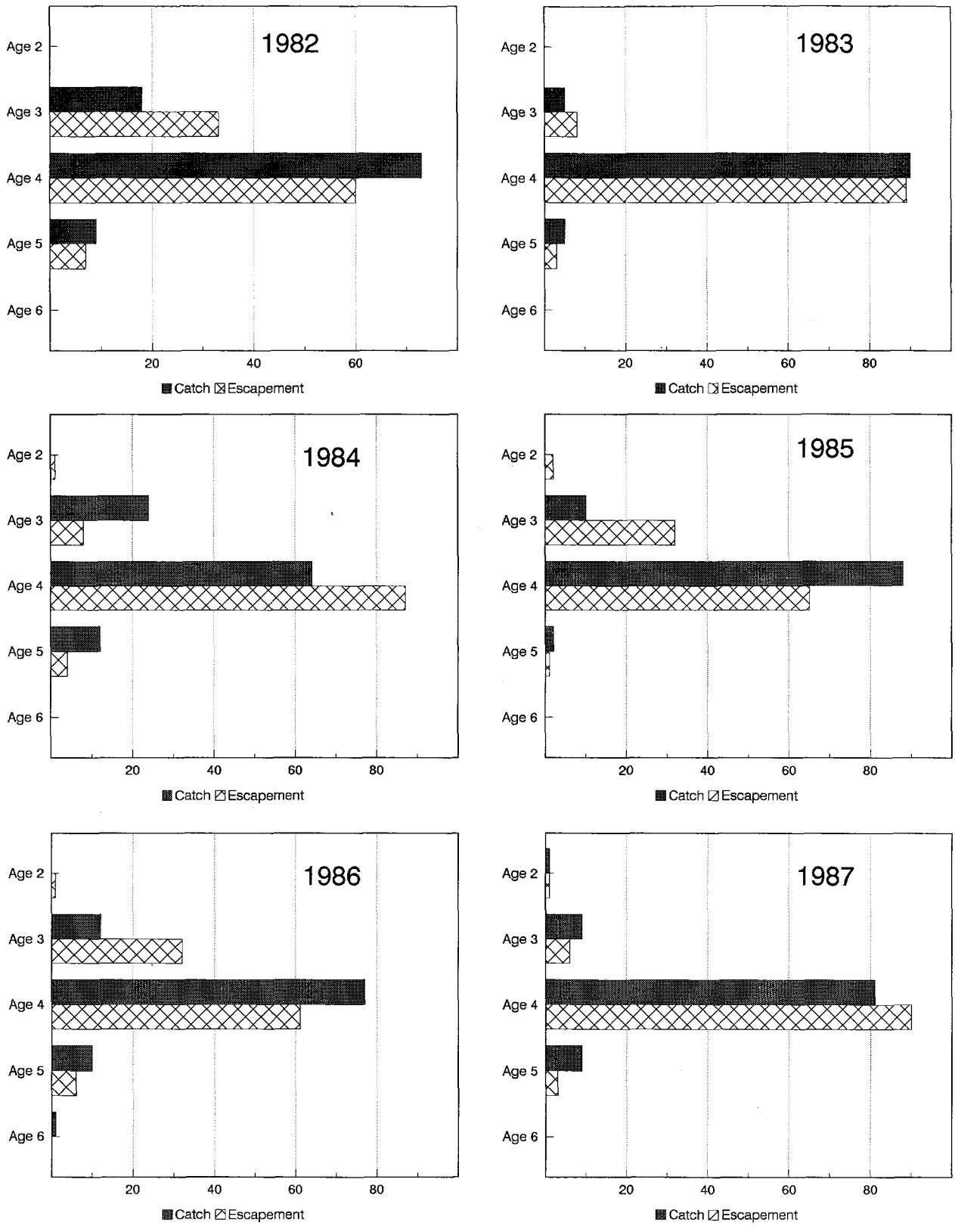




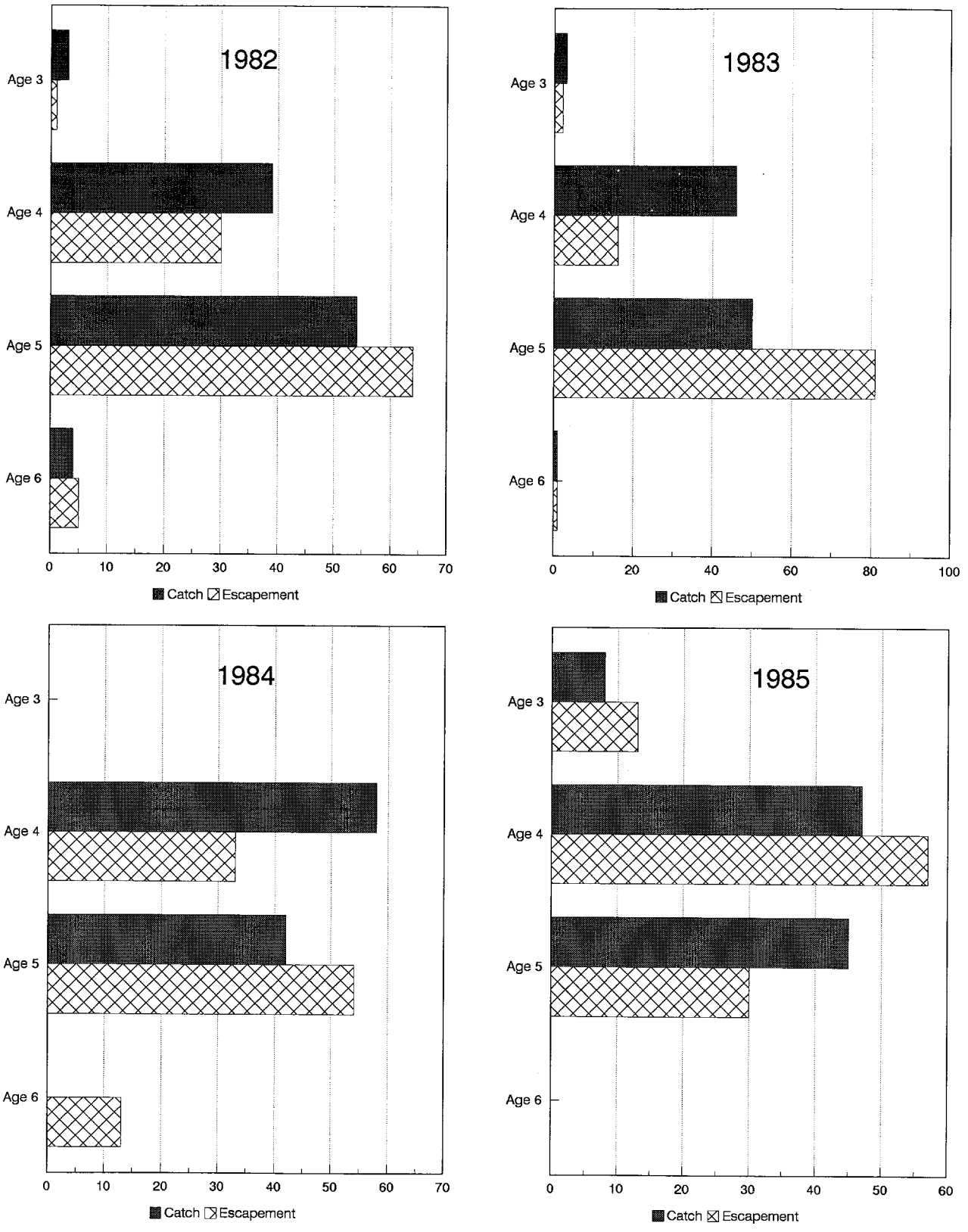




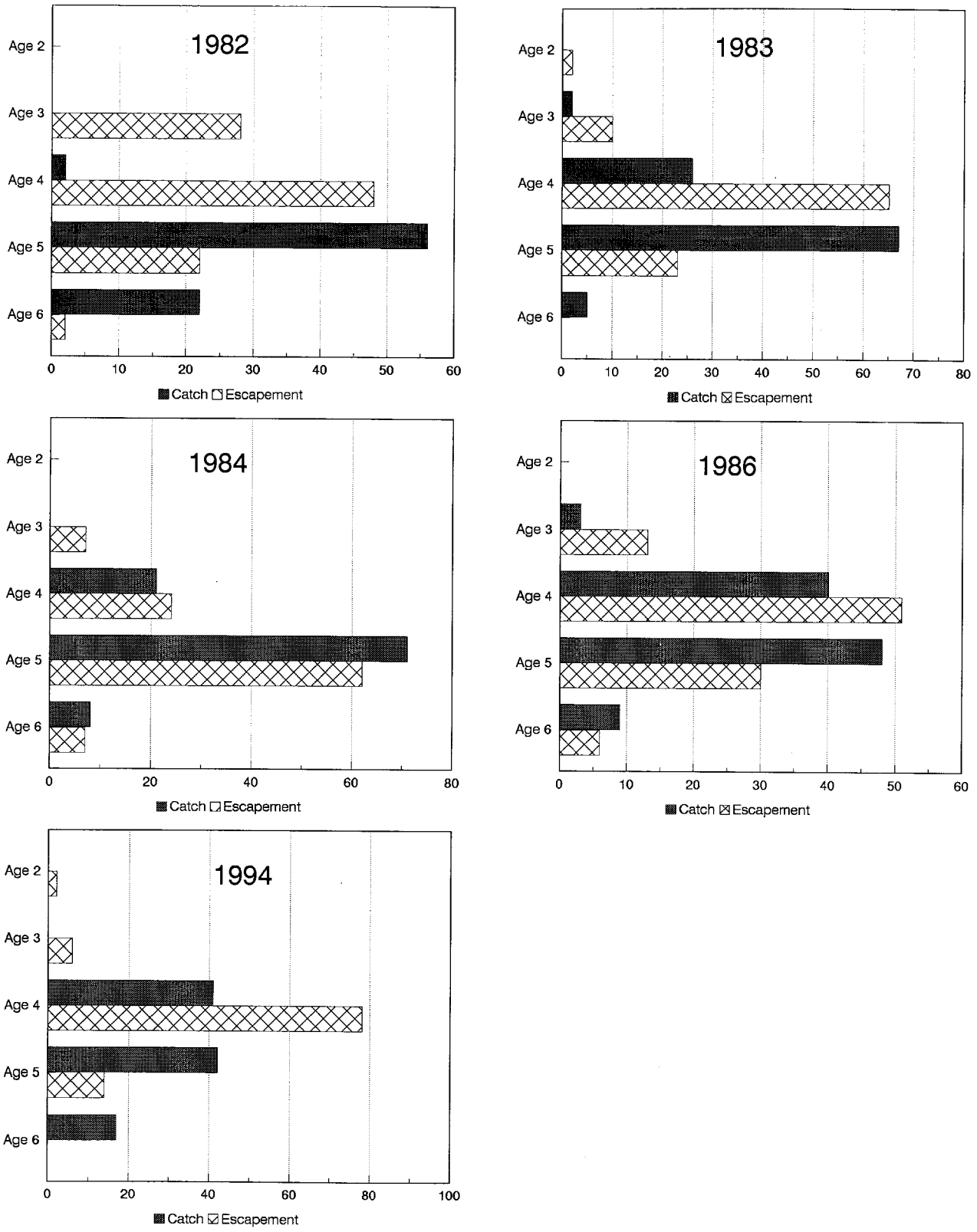
Appendix Figure 1. Comparison of age composition of Akwe River sockeye salmon catches and escapements during the years 1982-1986.



Appendix Figure 2. Comparison of age compositions of East River sockeye salmon catches and escapements during the years 1982-1987.



Appendix Figure 3. Comparison of age composition of Italio River sockeye salmon catches and escapements during the years 1982-1985.



Appendix Figure 4. Comparison of age composition of Lost River sockeye salmon catches and escapements during the years 1982-1984; 1986; and 1994.