
Biological Escapement Goals for Even and Odd-year Pink Salmon Returning to the Situk River and to Humpy Creek near Yakutat Alaska



Regional Information Report No. 1J95-08

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

March 1995

BIOLOGICAL ESCAPEMENT GOALS FOR EVEN AND ODD-YEAR PINK SALMON
RETURNING TO THE SITUK RIVER AND TO HUMPY CREEK
NEAR YAKUTAT ALASKA

By
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Regional Information Report No.¹ 1J95-08

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

March 1995

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ACKNOWLEDGEMENTS

I thank Robert D. Mecum and Scott A. McPherson for their constructive criticisms of the first draft of this report.

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ABSTRACT

Available data concerning commercial harvests and escapements of pink salmon in the Yakutat Area of Southeast Alaska were coalesced and reviewed to determine if sufficient information was available to develop biological escapement goals for spawning stocks of pink salmon *Oncorhynchus gorbuscha*. Commercial harvests of pink salmon in the Yakutat Area averaged about 32,600, 48,600, and 56,100 fish per year during the decades of the 1960's, 1970's, and 1980's, respectively. Over 90% of the Yakutat Area commercial harvest of pink salmon has occurred in discreet set gill net fisheries, most of which are located in lower rivers and lagoons. Most of these set gill net fisheries are believed to predominantly harvest specific salmon stocks returning to these rivers to spawn. The other commercial gear group, the troll fishery, has accounted for an average annual harvest of about 2,800 pink salmon during the 1985-1994 period (about 9% of the total pink salmon harvest). The troll fishery harvest takes place in marine waters between Cape Fairweather and Cape Suckling, a distance of about 500 kilometers, making it difficult to determine stock origins of harvested salmon based on location of harvest. Only the Situk River set gill net fishery, the Yakutat Bay set gill net fishery, and the Humpy Creek set gill net fishery have accounted for annual average harvests in excess of 1,000 pink salmon per year during the past 10 years. These three set gill net fisheries have accounted for a combined average annual harvest of about 28,000 pink salmon since 1985.

Pink salmon spawning escapements have been surveyed in 20 Yakutat Area streams since 1961. However, consistent annual surveys (surveys taking place during more than 50% of the years) have been limited to the Situk River (30 of the 35 years since 1960) and to Humpy Creek (29 of the 35 years since 1960). Consequently, this study focused on development of biological escapement goals for pink salmon returning to the Situk River and to Humpy Creek.

A comparison of weir counts of pink salmon escapements in the Situk River to peak annual aerial and boat counts of pink salmon in the Situk River led to an assumed expansion of 3-fold for all non-weir counts of pink salmon escapements in the Situk River and in Humpy Creek in an effort to account for total pink salmon escapement levels. Because the Yakutat Bay set gill net fishery is an interception fishery, a simple model was developed to allocate Yakutat Bay set gill net harvests of pink salmon to the Situk River and Humpy Creek stocks. The model was based upon relative abundance of the inshore returns (estimated escapements plus river set gill net harvests) of the two stocks. Brood tables for the Situk River and Humpy Creek stocks of pink salmon for both even and odd years were developed based upon expanded escapements during year i coupled with expanded escapements added to river specific inshore set gill net harvests and the number of Yakutat Bay pink salmon allocated to the stock during year $i+2$. These paired data points were used to develop Ricker-type spawner-recruit curves from which estimates of the escapement levels likely to produce 90% or more of maximum sustained yields were derived.

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:

<u>Pink Salmon Stock</u>	Index	Index	Survey Type
	Escapement Goal	Escapement Goal Range	
Situk River Even-Year Stock	22,000	14,000 to 35,000	Aerial/Boat
Situk River Odd-Year Stock	30,000	18,000 to 67,000	Aerial/Boat
Humpy Creek Even-Year Stock	5,700	3,300 to 8,000	Aerial/Foot
Humpy Creek Odd-Year Stock	12,000	7,000 to 18,000	Aerial/Foot

Review of past escapement surveys for pink salmon in the Situk River and in Humpy Creek reveal that most annual escapements have exceeded the recommendations listed above (29 of 56 cases; 52%). Hence, regulatory management of the Situk, Yakutat Bay, and Humpy Creek set gill net fisheries would become more liberal, on the average, were fishery managers to strive to achieve the recommended biological escapement goals. Payoff in terms of sustainable production of pink salmon is estimated to potentially increase approximately four-fold were these escapement goal ranges to be consistently achieved in comparison to historic pink salmon harvest levels. Even year MSY for Situk River and Humpy Creek pink salmon stocks is estimated to total approximately 110,000 pink salmon as compared to average even year harvests since 1962 of about 28,000 pink salmon in the Situk River, Yakutat Bay, and Humpy Creek set net fisheries. Odd year MSY for Situk River and Humpy Creek pink salmon stocks is estimated to total approximately 220,000 pink salmon as compared to average odd year harvests since 1961 of about 50,000 pink salmon in the Situk River, Yakutat Bay, and Humpy Creek set net fisheries.

Fishery management to achieve MSY for pink salmon is most feasible in the Humpy Creek set gill net fishery because pink salmon are the predominant species harvested in that fishery. Management to achieve MSY for pink salmon is less feasible in the Situk River set gill net fishery because in that fishery, major harvests of sockeye salmon *Oncorhynchus nerka* and coho salmon *Oncorhynchus kisutch* occur, these species overlap in terms of return timing with pink salmon, these species are a more valuable fishery resource than are pink salmon, and fishery managers need to consider status of these sockeye and coho salmon runs in addition to the status of the pink salmon run when making regulatory management decisions concerning the Situk River commercial set gill net fishery.

KEY WORDS: pink salmon, *Oncorhynchus gorbuscha*, Yakutat Alaska, Situk River, Humpy Creek, Yakutat Bay, spawner-recruit, brood tables, escapement goal, maximum sustained yield

INTRODUCTION

Commercial salmon fishing in the Yakutat Area of Southeast Alaska is a major industry providing income and jobs. Commercial salmon fishery harvests in the Yakutat Area average about 500,000 fish annually; this average is composed of about 225,000 coho salmon *Oncorhynchus kisutch*, 220,000 sockeye salmon *O. nerka*, 40,000 pink salmon *O. gorbuscha*, 15,000 chum salmon *O. keta*, and 6,000 chinook salmon *O. tshawytscha*. Ex-vessel value of the Yakutat Area commercial salmon fishery 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 troll fishery takes place in near-shore and offshore marine waters from Cape Fairweather to Cape Suckling (Figure 1). The set gill net fishery takes place in discreet fishing areas, typically located in the lower rivers and lagoons of streams which empty into the Gulf of Alaska between Cape Fairweather and Cape Suckling.

The intent of this study was to review available commercial harvest and escapement survey data for pink salmon in the Yakutat Area to determine if biological escapement goals for pink salmon could be estimated with the existing data; and if so, to determine the escapement levels that would be expected to provide for maximum sustained yield (MSY).

The Integrated Fisheries Data Base (IFDB) computer files maintained by the Commercial Fisheries Management and Development Division of the Alaska Department of Fish and Game at their Douglas, Alaska, office were used to obtain information on commercial harvests of pink salmon in the Yakutat Area. Yakutat Area commercial fishery harvests of pink salmon averaged about 32,600, 48,600, and 56,100 fish during the 1960's, 1970's, and 1980's, respectively. The commercial fishery harvest of pink salmon in the Yakutat Area from 1990-1994 averaged about 17,100 fish. The annual set gill net fishery harvest of pink salmon during the last 10 years has averaged about 29,000 fish (Table 1). Since 1985, pink salmon harvests have taken place in 17 of the commercial set gill net fisheries of the Yakutat Area.

Average harvests in excess of 1,000 pink salmon per year since 1985 have only taken place in three of the set gill net fisheries: (1) the Situk River fishery has averaged about 14,000 pink salmon per year; (2) the Yakutat Bay fishery has averaged about 4,000 pink salmon per year; and, (3) the Humpy Creek fishery has averaged about 10,000 pink salmon per year (Table 1). The Situk River set gill net fishery occurs mainly in the lagoon where the Situk River empties into the Gulf of Alaska. Salmon harvests in this fishery are presumed to be composed of predominantly Situk River origin fish. The Humpy Creek set gill net fishery takes place in marine waters immediately adjacent to the terminus of Humpy Creek in Yakutat Bay. Salmon harvests in this fishery are presumed to be composed of predominantly Humpy Creek origin fish. The Yakutat Bay set gill net fishery takes place in marine waters of the outer part of Yakutat Bay. This fishery is predominantly an interception fishery for sockeye salmon bound for various Yakutat Area streams. Presumably the Yakutat Bay set gill net fishery is an interception fishery for other salmon species as well.

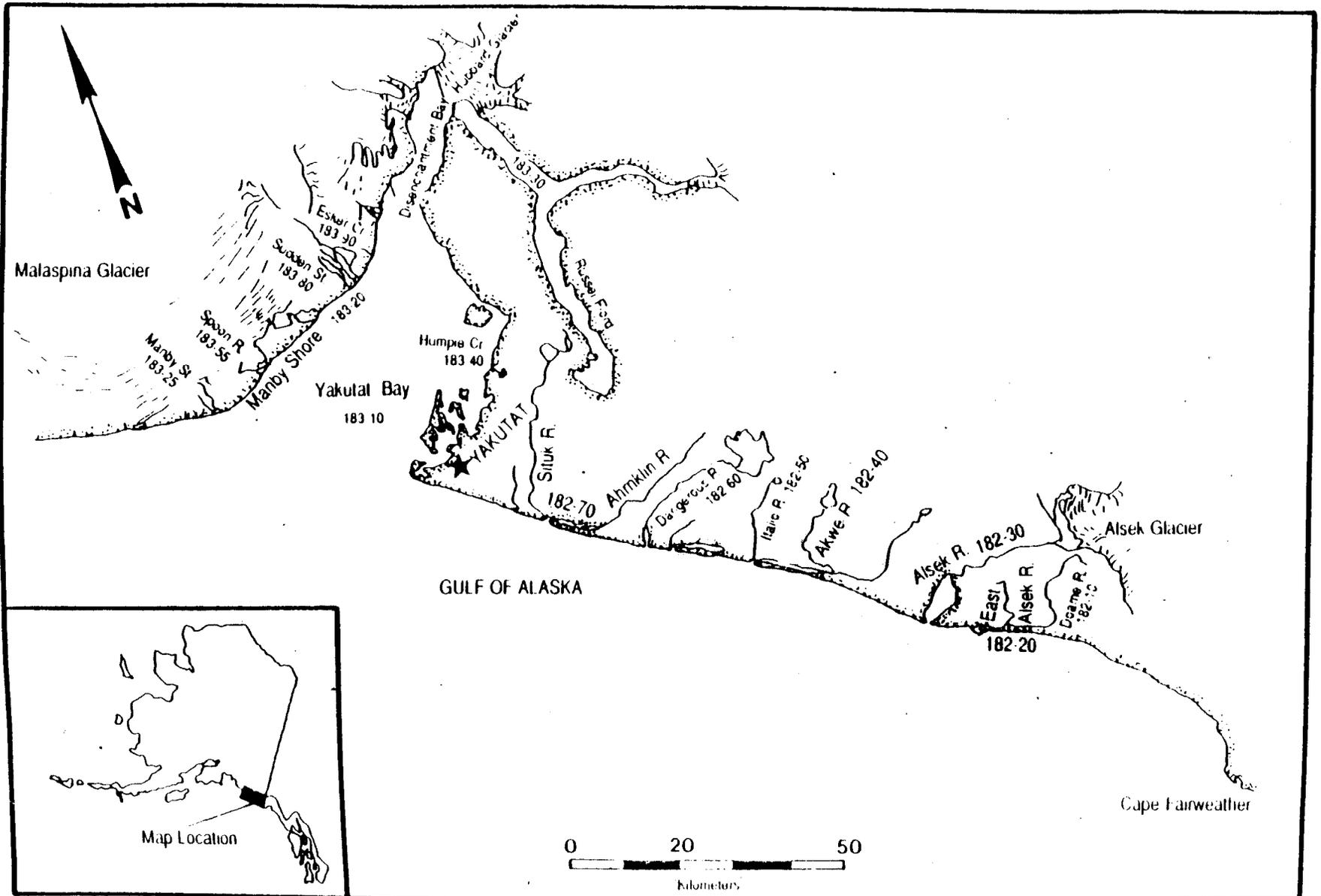


Figure 1. Map of Yakutat area.

Table 1. Commercial harvests of pink salmon in the Yakutat Area during the past 10 years (in number of fish, 1985-1994)^a.

Commercial Gear	Commercial Fishery	Statistical Area	1985-94 Average Harvest	1985-94 Largest Annual Harvest & Year
Set Gill Net	East River	182-20	382	2,025 - 1988
Set Gill Net	East Surf	182-21	70	507 - 1988
Set Gill Net	East Ocean	182-22	90	495 - 1990
Set Gill Net	Alsek River	182-30	3	13 - 1986
Set Gill Net	Alsek Surf	182-31	0	0
Set Gill Net	Akwe River	182-40	238	1,686 - 1988
Set Gill Net	Italio River	182-50	36	359 - 1985
Set Gill Net	Old Italio River	182-55	0	0
Set Gill Net	Dangerous River	182-60	6	22 - 1986
Set Gill Net	Situk River	182-70	13,868	42,974 - 1989
Set Gill Net	Lost River	182-80	220	816 - 1989
Set Gill Net	Yakutat Bay	183-10	4,196	8,501 - 1989
Set Gill Net	Manby Shore	183-20	7	33 - 1985
Set Gill Net	Manby Stream	183-25	4	25 - 1989
Set Gill Net	Humpy Creek	183-40	9,725	92,173 - 1988
Set Gill Net	Spoon River	183-55	9	89 - 1988
Set Gill Net	Sudden Stream	183-80	0	0
Set Gill Net	Esker Creek	183-90	0	0
Set Gill Net	Yana River	185-05	0	0
Set Gill Net	Yahtse River	185-10	1	4 - 1989
Set Gill Net	Icy Bay	186-15	0	0
Set Gill Net	Unnamed	191-10; 20; & 30	0	0
Set Gill Net	Kaliakh River	192-41	0	0
Set Gill Net	Tsiu River	192-42	1	3 - 1986
Set Gill Net	Unnamed	192-50 & 55	0	4 - 1989
Set Gill Net	Eight-Mile	192-60	0	0
<u>All Set Gill Net Fisheries</u>			<u>28,856</u>	
Troll	District 181	181	1,247	4,419 - 1985
Troll	District 182	182	0	0
Troll	District 183	183	694	3,250 - 1985
Troll	District 186	186	2	20 - 1987
Troll	District 189	189	862	1,801 - 1993
Troll	District 191	191	20	103 - 1989
<u>All Troll Fisheries</u>			<u>2,825</u>	
<u>ALL COMMERCIAL FISHERIES</u>			<u>31,681</u>	

^a Data source: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files.

The commercial troll fishery in the Yakutat Area has harvested an average of about 2,800 pink salmon per year since 1985 (Table 1). Troll harvests of pink salmon in the Yakutat Area account for about 9% of the total commercial harvest. Although this harvest can be split into six fishing districts, the districts are large (Figure 1) and it is difficult to make inferences about stock composition based upon area of catch. On the other hand, troll harvests of pink salmon in the Yakutat Area are relatively minor and inclusion or exclusion of these harvests are not likely to significantly affect estimates of total return for any single pink salmon stock.

The IFDB computer files were also used to obtain available information concerning pink salmon escapement surveys in the Yakutat Area. Twenty streams in the Yakutat Area have been surveyed and found to support spawning populations of pink salmon (Table 2). Only two of the 20 streams have been surveyed during more than one-half of the years since 1960: (1) the Situk River where surveys have been conducted in 30 of the past 35 years; and, (2) Humpy Creek where surveys have been conducted in 29 of the past 35 years. Available escapement survey data indicate that these two streams support the largest populations of spawning pink salmon in the Yakutat Area.

Based upon this review of pink salmon harvests and escapements in the Yakutat Area, I decided to concentrate my efforts on the Situk River and Humpy Creek stocks of pink salmon. I made this decision because of the availability of escapement survey data for the Situk River and Humpy creek, because these two stocks are most likely both the largest and the major pink salmon stocks in the Yakutat Area, and because most of the harvest of pink salmon in the Yakutat Area has taken place in terminal locations where it is reasonable to assume that all or at least the bulk of the harvest is composed of these two stocks.

DATA ANALYSIS AND ASSUMPTIONS

Available escapement data for pink salmon spawning in the Situk River has been collected in two ways. Counts of pink salmon obtained through aerial and boat surveys of the Situk River were made in 17 of the past 35 years (Tables 3 and 4). Peak annual counts of pink salmon obtained through aerial and boat surveys represent an index of escapement abundance. During 13 of the past 35 years, counts of pink salmon passing the Situk River weir were made. During most of these years, the weir was operated until the middle or latter part of August. During most of these years, the weir was located just below Nine-Mile Bridge; during recent years the weir was located just above tidewater in the lower portion of the Situk River. Recent weir counts of pink salmon do not appear to be substantially higher than past weir counts of pink salmon as might be expected if the bulk of spawning occurred in the extreme lower portion of the river. On the other hand, average weir counts of pink salmon in the Situk River are substantially higher than average peak aerial and boat survey counts (Figure 2). Weir counts of pink salmon in the Situk River since 1971 have averaged about 192,700; whereas, peak aerial and boat counts have averaged about 62,800, or about one-third of the weir counts.

Table 2. Escapement surveys for pink salmon in the Yakutat Area since 1960^a.

Stream Name	Stream Code	Number of Years with Surveys	Survey Type(s)	Largest Annual Survey & Year
Doame River	182-10-010	6 of 35	Aerial	8,000 - 1981
East Alsek River	182-20-010	2 of 35	Aerial	2,000 - 1986
Tannis River	182-30-011	1 of 35	Aerial	1,200 - 1981
Miller Creek	182-30-013	1 of 35	Aerial	500 - 1971
Cabin Creek	182-30-015	3 of 35	Aerial	300 - 1976
Akwe River	182-40-010	2 of 35	Foot	5 - 1993
Italio River	182-50-010	17 of 35	Aerial & Boat	50,000 - 1981
Situk River	182-70-010	30 of 35	Aerial, Boat, Weir	450,000 - 1979
Antlen River	182-70-120	1 of 35	Foot	105 - 1991
Ahrnklin River	182-70-200	1 of 35	Foot	1,000 - 1988
Lost River	182-80-010	2 of 35	Aerial & Boat	5,000 - 1964
Tawah Creek	182-80-030	7 of 35	Boat	2,700 - 1990
Redfield Cove	183-10-010	4 of 35	Aerial, Boat, Foot	10,000 - 1989
Manby Stream	183-25-080	1 of 35	Aerial	400 - 1993
Humpy Creek	183-40-010	29 of 35	Aerial & Foot	75,000 - 1985
Pudget Cove Creek	183-40-020	1 of 35	Boat	3,050 - 1989
Jetty	186-15-052	2 of 35	Aerial	1,000 - 1991
Stink Creek	192-41-012	1 of 35	Boat	50 - 1986
Tsiu River	192-42-020	5 of 35	Aerial & Foot	3,700 - 1962
Kiklukh River	192-60-010	1 of 35	Aerial	100 - 1964

^a Data source: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files.

Table 3. Escapement surveys for even-year pink salmon in the Situk River and in Humpy Creek since 1962, expansion factors assumed, and estimated total escapements^a.

Year	Situk River				Humpy Creek			
	Escapement Count	Method	Expansion Factor	Estim. Total Escapement	Escapement Count	Method	Expansion Factor	Estim. Total Escapement
1962	70,000	Aerial	3-fold	210,000	23,000	Foot	3-fold	69,000
1964	70,000	Aerial	3-fold	210,000	11,000	Foot	3-fold	33,000
1966	5,000	Aerial	3-fold	15,000	70	Foot		28,186 ^b
1968	-			156,735 ^c	-			28,186 ^b
1970	-			156,735 ^c	-			28,186 ^b
1972	10,000	Boat	3-fold	30,000	1,630	Foot	3-fold	4,890
1974	20,000	Boat	3-fold	60,000	2,000	Foot	3-fold	6,000
1976	38,081	Weir 8/20	-	38,081	4,672	Foot	3-fold	14,016
1978	120,000	Boat	3-fold	360,000	5,000	Foot	3-fold	15,000
1980	250,000	Weir 8/17	-	250,000	10,000	Foot	3-fold	30,000
1982	40,300	Weir 8/20	-	40,300	8,700	Foot	3-fold	26,100
1984	113,161	Weir 8/18	-	113,161	16,000	Foot	3-fold	48,000
1986	85,000	Boat	3-fold	255,000	10,233	Foot	3-fold	30,699
1988	78,753	Weir 8/22	-	78,753	10,000	Aerial	3-fold	30,000
1990	175,000	Boat	3-fold	525,000	13,800	Foot	3-fold	41,400
1992	3,000	Boat	3-fold	9,000	4,500	Foot	3-fold	13,500
1994	-			156,735 ^c	11,000	Aerial	3-fold	33,000

^a Data source: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files.

^b The count of 70 spawners obtained in 1966 was not used; spawner counts were not obtained in 1968 and 1970. The estimated Humpy Creek escapements of pink salmon in 1962, 1964, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, 1990, 1992, and 1994 averaged 28,186 fish; and this average was used as a proxy escapement estimate for the years 1966, 1968, and 1970 for allocation of the Yakutat Bay harvests and for development of the even year Humpy Creek brood table.

^c Counts of spawning pink salmon in the Situk River were not obtained in 1968, 1970, and 1994. The estimated Situk River escapements of pink salmon in 1962, 1964, 1966, 1972, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, 1990, and 1992 averaged 156,735 fish; and this average was used as a proxy escapement estimate for the years 1968, 1970, and 1994 for allocation of the Yakutat Bay harvests and for development of the even year Situk River brood table.

Table 4. Escapement surveys for odd-year pink salmon in the Situk River and in Humpy Creek since 1961, expansion factors assumed, and estimated total escapements^a.

Year	Situk River				Humpy Creek			
	Escapement Count	Method	Expansion Factor	Estim. Total Escapement	Escapement Count	Method	Expansion Factor	Estim. Total Escapement
1961	30,000	Aerial	3-fold	90,000	25,000	Foot	3-fold	75,000
1963	-			192,359 ^b	-			63,278 ^c
1965	30,000	Aerial	3-fold	90,000	1,000	Foot	3-fold	3,000
1967	80,000	Aerial	3-fold	240,000	-			63,278 ^c
1969	11,500	Aerial	3-fold	34,500	9,723	Foot	3-fold	29,169
1971	27,184	Weir 8/18	-	27,184	-			63,278 ^c
1973	80,000	Boat	3-fold	240,000	1,323	Foot	3-fold	3,969
1975	44,600	Boat	3-fold	133,800	13,000	Foot	3-fold	39,000
1977	177,712	Weir 8/17		177,712	12,000	Foot	3-fold	36,000
1979	450,000	Weir 8/17	-	450,000	15,000	Foot	3-fold	45,000
1981	300,000	Weir 8/15	-	300,000	70,000	Foot	3-fold	210,000
1983	183,577	Weir 8/18	-	183,577	30,000	Foot	3-fold	90,000
1985	366,000	Weir 8/16		366,000	75,000	Foot	3-fold	225,000
1987	24,000	Boat	3-fold	72,000	2,000	Aerial	3-fold	6,000
1989	288,246	Weir 8/17		288,246	20,200	Foot	3-fold	60,600
1991	3,668	Weir 7/27		192,359 ^b	8,050	Foot	3-fold	24,150
1993	7,000	Boat		192,359 ^b	13,000	Aerial	3-fold	39,000

^a Data source: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files.

^b A count of spawning pink salmon in the Situk River was not obtained in 1963; the count of 3,668 obtained with the weir in 1991 is incomplete due to the early termination date of the weir (7/27); and the count of 7,000 in 1993 is considered an outlier (too low). The estimated Situk River escapements of pink salmon in 1961, 1965, 1967, 1969, 1971, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, and 1989 averaged 192,359 fish; and this average was used as a proxy escapement estimate for the years 1963, 1991, and 1993 for allocation of the Yakutat Bay harvests and for development of the odd year Situk River brood table.

^c Spawner counts of pink salmon in Humpy Creek were not obtained in 1963, 1967, and 1971. The estimated Humpy Creek escapements of pink salmon in 1961, 1965, 1969, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, 1989, 1991, and 1993 averaged 63,278 fish; and this average was used as a proxy escapement estimate for the years 1963, 1967, and 1971 for allocation of the Yakutat Bay harvests and for development of the odd year Humpy Creek brood table.

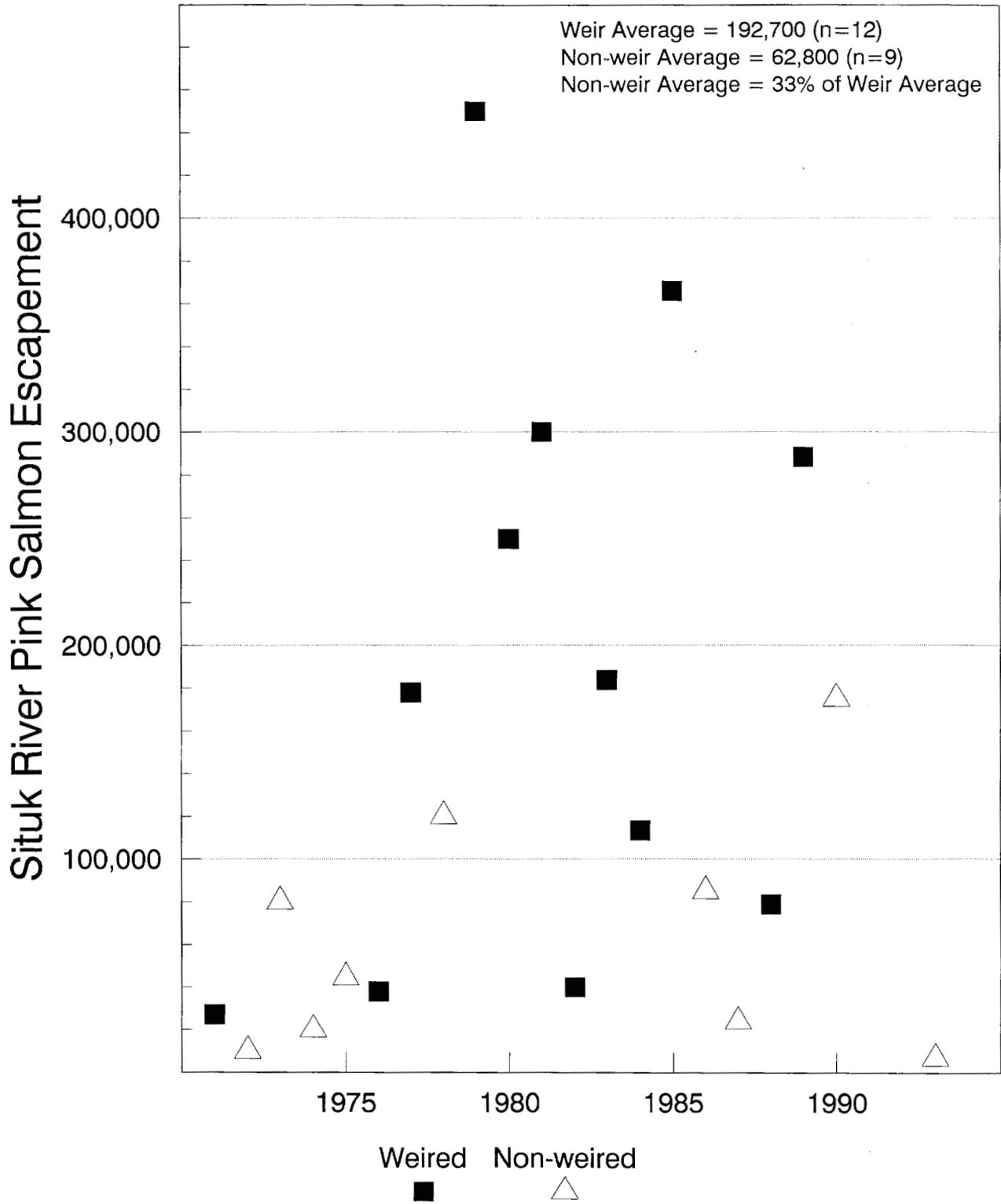


Figure 2. Comparison of estimated Situk River pink salmon escapements based on weir counts versus unexpanded aerial and boat escapement surveys, 1971-1993.

In order to develop brood tables of estimated total escapements and total returns for Situk River and Humpy Creek pink salmon stocks, an assumption concerning expansion of peak aerial, boat, and foot counts had to be made. I elected to use a simple three-fold expansion factor for all peak aerial, boat, and foot counts of pink salmon in the Situk River and in Humpy Creek in order to obtain a rough estimate of total spawner abundance. This expansion factor was based on the comparative analysis of the Situk weir and non-weir counts outlined above. It is likely that these expanded escapement estimates for the Situk stock are biased low because of the location of the wier during most of the study period. There is no site specific data available to determine the appropriateness of the three-fold expansion factor for Humpy Creek counts. An expansion factor of 2.5 is currently used to expand peak aerial surveys of pink salmon into total estimates of spawners in Southeast Alaska (Robert D. Mecum, personal communication).

Based upon geography and relative catch trends, I believe that the majority of the pink salmon harvested in the Yakutat Bay set gill net fishery are fish returning to spawn in the Situk River or in Humpy Creek. A simple model was developed to allocate Yakutat Bay set gill net harvests to these two stocks (Tables 5 and 6). The annual in-shore return of pink salmon to the Situk River was estimated by adding expanded escapement data to the annual harvests of pink salmon in the Situk set gill net fishery. Annual in-shore returns of pink salmon to Humpy Creek were estimated in a similar fashion. Next, the Yakutat Bay set gill net harvest of pink salmon was apportioned to the Situk River stock and to the Humpy Creek stock according to their relative abundance in any given year. Thus the assumption used was that all pink salmon harvested in the Yakutat Bay set gill net fishery were of the Situk River stock or the Humpy Creek stock and the proportion allocated to each was determined by the magnitude of their respective in-shore returns.

The total return of the Situk River stock of pink salmon in any given year was estimated by adding the expanded escapement to the Situk River set gill net harvest and then adding to this total, the number of Yakutat Bay pink salmon allocated to the Situk River stock (Tables 7 and 8). The total annual returns of pink salmon to Humpy Creek were estimated in a similar manner. Brood tables for the even and odd year runs of pink salmon returning to the Situk River and to Humpy Creek were constructed and these four data sets were composed of paired data points consisting of estimated total escapements in year i and estimated total returns in year $i+2$.

Some brood years were not included because of data limitations (Tables 7 and 8). The even year data set for the Situk River stock of pink salmon did not include brood years 1966, 1968, 1970, and 1992; hence, only 12 of 16 possible paired data points were included (Table 7). The lack of escapement information in 1968 resulted in the loss of the 1968 brood year data as well as the loss of an estimate of total return for the 1966 brood year. The lack of escapement information in 1970 resulted in the loss of the 1970 brood year and the lack of escapement information in 1994 resulted in the loss of an estimate of total return from the 1992 brood year. Similarly, the odd-year data set for the Situk River stock of pink salmon consisted of 12 of 16 possible paired data points; the even-year data set for the Humpy Creek stock of pink salmon consisted of 12 of 16 possible paired data points; and, the

Table 5. Situk, Humpy Creek, and Yakutat Bay set net harvests of even-year pink salmon since 1962 and the allocation of Yakutat Bay set net harvests to the Situk River and Humpy Creek pink salmon stocks^a.

Year	Situk	Humpy	Yak. Bay	Situk	Humpy	Yakutat Bay Allocation			
	Set Net Fishery Harvest	Set Net Fishery Harvest	Set Net Fishery Harvest	Escap. Plus Harvest	Escap. Plus Harvest	Situk Prop.	Humpy Prop.	Number of Fish Allocated to:	
								Situk	Humpy
1962	12,273	0	11,255	222,273	69,000	0.763	0.237	8,589	2,666
1964	13,431	0	22,160	223,431	33,000	0.871	0.129	19,308	2,852
1966	952	0	202	15,952	28,186	0.361	0.639	73	129
1968	518	445	169	157,253	28,631	0.846	0.154	143	26
1970	1,142	1,235	660	157,877	29,421	0.843	0.157	556	104
1972	966	1,322	492	30,966	6,212	0.833	0.167	410	82
1974	3,263	0	455	63,263	6,000	0.913	0.087	416	39
1976	6,939	18,486	1,639	45,020	32,502	0.581	0.419	952	687
1978	7,294	14,997	6,618	367,294	29,997	0.924	0.076	6,118	500
1980	32,940	91,243	16,228	282,940	121,243	0.700	0.300	11,360	4,868
1982	4,482	0	3,588	44,782	26,100	0.632	0.368	2,237	1,321
1984	12,446	18	2,139	125,607	48,018	0.723	0.277	1,547	592
1986	1,503	0	5,240	256,503	30,699	0.893	0.107	4,680	560
1988	15,323	92,173	7,792	94,076	122,173	0.435	0.565	3,390	4,402
1990	23,895	1,209	4,969	548,895	42,609	0.928	0.072	4,611	358
1992	13,585	0	4,892	22,585	13,500	0.626	0.374	3,062	1,830
1994	10,454	0	1,741	167,189	33,000	0.835	0.165	1,454	287

^a Data source for harvests: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files; estimated escapements of even year pink salmon into the Situk River and Humpy Creek are provided in Table 3.

Table 6. Situk, Humpy Creek, and Yakutat Bay set net harvests of odd-year pink salmon since 1961 and the allocation of Yakutat Bay set net harvests to the Situk River and Humpy Creek pink salmon stocks^a.

Year	Situk	Humpy	Yak. Bay	Situk	Humpy	Yakutat Bay Allocation			
	Set Net	Set Net	Set Net	Escap.	Escap.	Number of Fish			
	Fishery	Fishery	Fishery	Plus	Plus	Situk	Humpy	Allocated to:	
Harvest	Harvest	Harvest	Harvest	Harvest	Harvest	Prop.	Prop.	Situk	Humpy
1961	12,589	0	47,254	102,589	75,000	0.578	0.422	27,298	19,956
1963	14,266	47,324	5,457	206,625	110,602	0.651	0.349	3,554	1,903
1965	3,229	0	525	93,229	3,000	0.969	0.031	509	16
1967	19,832	821	9,605	259,832	64,099	0.802	0.198	7,704	1,901
1969	2,897	58,351	1,504	37,397	87,520	0.299	0.701	450	1,054
1971	2,890	76,080	597	30,074	139,358	0.177	0.832	106	491
1973	11,395	1,738	2,886	251,395	5,707	0.978	0.022	2,822	64
1975	6,686	68,863	3,094	140,486	107,863	0.566	0.434	1,750	1,344
1977	24,347	36,922	8,202	202,059	72,922	0.735	0.265	6,027	2,175
1979	30,131	109,412	3,396	480,131	154,412	0.757	0.243	2,570	826
1981	26,584	88,389	12,024	326,584	298,389	0.523	0.477	6,283	5,741
1983	6,864	9,047	6,793	190,441	99,047	0.658	0.342	4,469	2,324
1985	8,800	210	5,514	374,800	225,210	0.625	0.375	3,444	2,070
1987	10,851	0	1,750	82,851	6,000	0.932	0.068	1,632	118
1989	42,974	3,653	8,501	331,220	64,253	0.838	0.162	7,120	1,381
1991	2,534	0	506	194,893	24,150	0.890	0.110	450	56
1993	8,757	0	1,054	201,116	39,000	0.838	0.162	883	171

^a Data source for harvests: Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Douglas, Alaska, IFDB computer files; estimated escapements of even year pink salmon into the Situk River and Humpy Creek are provided in Table 4.

Table 7. Estimated escapements and estimated total returns for even years of pink salmon from the Situk River and Humpy Creek since 1962 and the paired data points used to develop return per spawner relationships^a.

Brood Year	<u>Situk River Even Year Pink Salmon</u>			<u>Humpy Creek Even Year Pink Salmon</u>		
	Estimated Escapement	Estimated Total Return	Paired Data Point Included in R/S Relation.	Estimated Escapement	Estimated Total Return	Paired Data Point Included in R/S Relation.
1962	210,000	242,739	yes	69,000	35,852	yes
1964	210,000	16,025	yes	33,000	28,315	no: no 66-Esc.
1966	15,000	157,396	no: no 68-Esc.	28,186	28,657	no: no 66-Esc.
1968	156,735	158,434	no: no 68-Esc.	28,186	29,525	no: no 68-Esc.
1970	156,735	31,376	no: no 70-Esc.	28,186	6,294	no: no 70-Esc.
1972	30,000	63,679	yes	4,890	6,039	yes
1974	60,000	45,972	yes	6,000	33,189	yes
1976	38,081	373,412	yes	14,016	30,497	yes
1978	360,000	294,300	yes	15,000	126,111	yes
1980	250,000	47,049	yes	30,000	27,421	yes
1982	40,300	127,154	yes	26,100	48,610	yes
1984	113,161	261,183	yes	48,000	31,259	yes
1986	255,000	97,466	yes	30,699	126,575	yes
1988	78,753	553,506	yes	30,000	42,967	yes
1990	525,000	25,647	yes	41,400	15,330	yes
1992	9,000	168,643	no: no 94-Esc.	13,500	33,287	yes
1994	156,735	N/A	-	33,000	N/A	-

^a Estimated escapements of even year pink salmon into the Situk River and Humpy Creek are from Table 3. Total returns represent terminal escapements added to terminal harvests plus that portion of the Yakutat Bay harvest allocated to each of the terminal runs (see Table 5).

Table 8. Estimated escapements and estimated total returns for odd years of pink salmon from the Situk River and Humpy Creek since 1961 and the paired data points used to develop return per spawner relationships^a.

Brood Year	<u>Situk River Odd Year Pink Salmon</u>			<u>Humpy Creek Odd Year Pink Salmon</u>		
	Estimated Escapement	Estimated Total Return	Paired Data Point Included in R/S Relation.	Estimated Escapement	Estimated Total Return	Paired Data Point Included in R/S Relation.
1961	90,000	210,179	no: no 63-Esc.	75,000	112,504	no: no 63-Esc
1963	192,359	93,738	no: no 63-Esc.	63,278	3,016	no: no 63-Esc
1965	90,000	267,536	yes	3,000	65,999	no: no 67-Esc
1967	240,000	37,847	yes	63,278	88,574	no: no 67-Esc
1969	34,500	30,180	yes	29,169	139,849	no: no 71-Esc
1971	27,184	254,217	yes	63,278	5,771	no: no 71-Esc
1973	240,000	142,236	yes	3,969	109,207	yes
1975	133,800	208,086	yes	39,000	75,097	yes
1977	177,712	482,701	yes	36,000	155,238	yes
1979	450,000	332,867	yes	45,000	304,130	yes
1981	300,000	194,910	yes	210,000	101,371	yes
1983	183,577	378,244	yes	90,000	227,280	yes
1985	366,000	84,483	yes	225,000	6,118	yes
1987	72,000	338,340	yes	6,000	65,634	yes
1989	288,246	195,343	no ^b	60,600	24,206	yes
1991	192,359	201,998	no ^b	24,150	39,171	yes
1993	192,359	N/A	-	39,000	N/A	-

^a Estimated escapements of odd year pink salmon into the Situk River and Humpy Creek are from Table 4. Total returns represent terminal escapements added to terminal harvests plus that portion of the Yakutat Bay harvest allocated to each of the terminal runs (see Table 6).

^b The count of 3,668 obtained with the weir in 1991 is incomplete due to the early termination date of the weir (7/27); and the count of 7,000 in 1993 is considered an outlier (too low). The estimated Situk River escapements of pink salmon in 1961, 1965, 1967, 1969, 1971, 1973, 1975, 1977, 1979, 1981, 1983, 1985, 1987, and 1989 averaged 192,359 fish; and this average was used as a proxy escapement estimate for the years 1963, 1991, and 1993 for allocation of the Yakutat Bay harvests and for development of the odd year Situk River brood table. Because the 1991 escapement was not estimated reliably, the datum is not included in the R/S relationship.

odd-year data set for the Humpy Creek stock of pink salmon consisted of 10 of 16 possible paired data points.

Once the four paired data sets were developed, each was used to develop a spawner-recruit relationship by fitting them with the following model:

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

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. I assumed the errors were multiplicative (as is common when variables are counts), resulting in the log-transformed equation:

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

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:

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

The range of escapements that produce 90% or more of MSY was estimated by multiplying MSY by 0.9 and determining the range of escapements predicted to provide at least this level of sustainable harvest.

RESULTS AND DISCUSSION

Estimated MSY for even-year pink salmon returning to the Situk River is 87,000 fish. The escapement level estimated to provide for MSY (OY) is 66,000 fish counted through the Situk River weir or 22,000 pink salmon counted during peak aerial or boat surveys (Table 9). The range of escapements estimated to provide 90% or more of MSY is 42,000 to 105,000 fish counted through the Situk River weir or a range of 14,000 to 35,000 pink salmon counted during a peak aerial or boat survey. Estimated exploitation rate at MSY and OY is 57%. Escapements of even-year pink salmon in the Situk River in excess of 225,000 fish have all failed to replace themselves (Figure 3). Since 1962, 50% of the escapements have exceeded the range estimated to provide 90% or more of MSY, while 36% have been below this range and 14% have been within this range (Table 10).

Table 9. Return per spawner relationships for even and odd-year races of pink salmon returning to the Situk River and to Humpy Creek with estimates of optimum escapement (OY), maximum sustained yields (MSY), and exploitation rates at MSY and OY.

PART 1:

Stock	Sample Size (n)	Ricker Alpha	Carrying Capacity	r ²	Escapement @ Prod. Maximum	Optimum Escap.	Escapement Bounds that Produce 90% or More of MSY
Even-Year Situk	12	1.3985	165,000	58.9%	120,000	66,000	42,000-105,000
Even-Year Humpy	12	1.4598	42,000	47.4%	28,000	17,000	10,000- 24,000
Odd-Year Situk	12	1.3761	225,000	45.5%	162,000	90,000	54,000-200,000 ^a
Odd-Year Humpy	10	2.0995	104,000	68.4%	48,000	36,000	21,000- 54,000

PART 2:

Stock	Optimum Escapement as Index	Exploitation Rate at MSY & OY	Maximum Harvestable Surplus	Average Harvest (1961-1994)	Average Harvests as % of MSY
Even-Year Situk	22,000	57%	87,000	9,494	
Even-Year Humpy	5,700	58%	23,250	13,008	
Even Year Yak. Bay				5,308	
Subtotals			110,250	27,810	25.2%
Odd-Year Situk	30,000	56%	115,323	13,860	
Odd-Year Humpy	12,000	74%	104,900	29,459	
Odd Year Yak. Bay				6,980	
Subtotals			220,223	50,299	22.8%

^a Upper end of range modified from 132,000 to 200,000; see text for explanation.

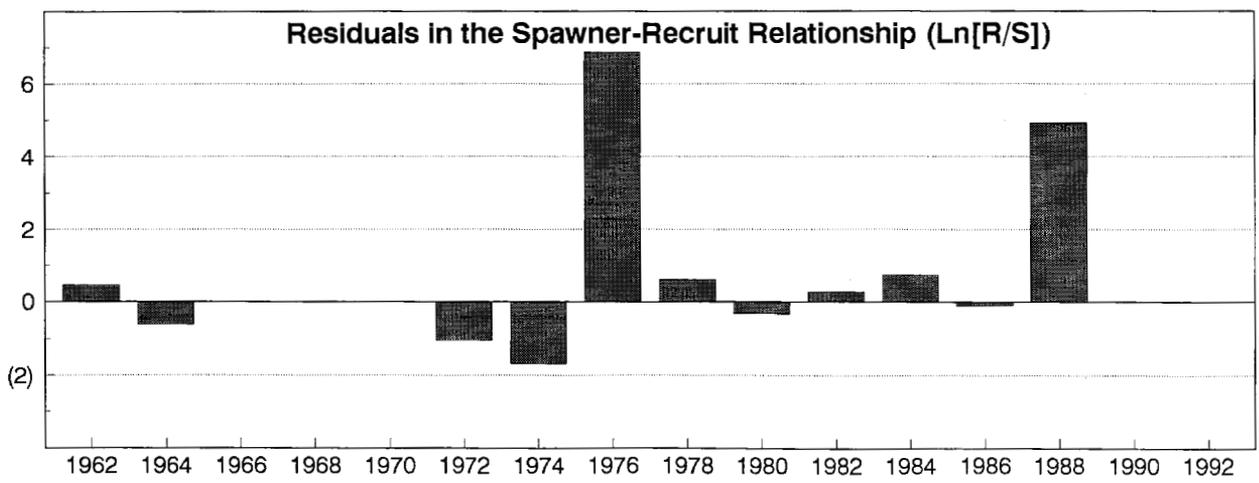
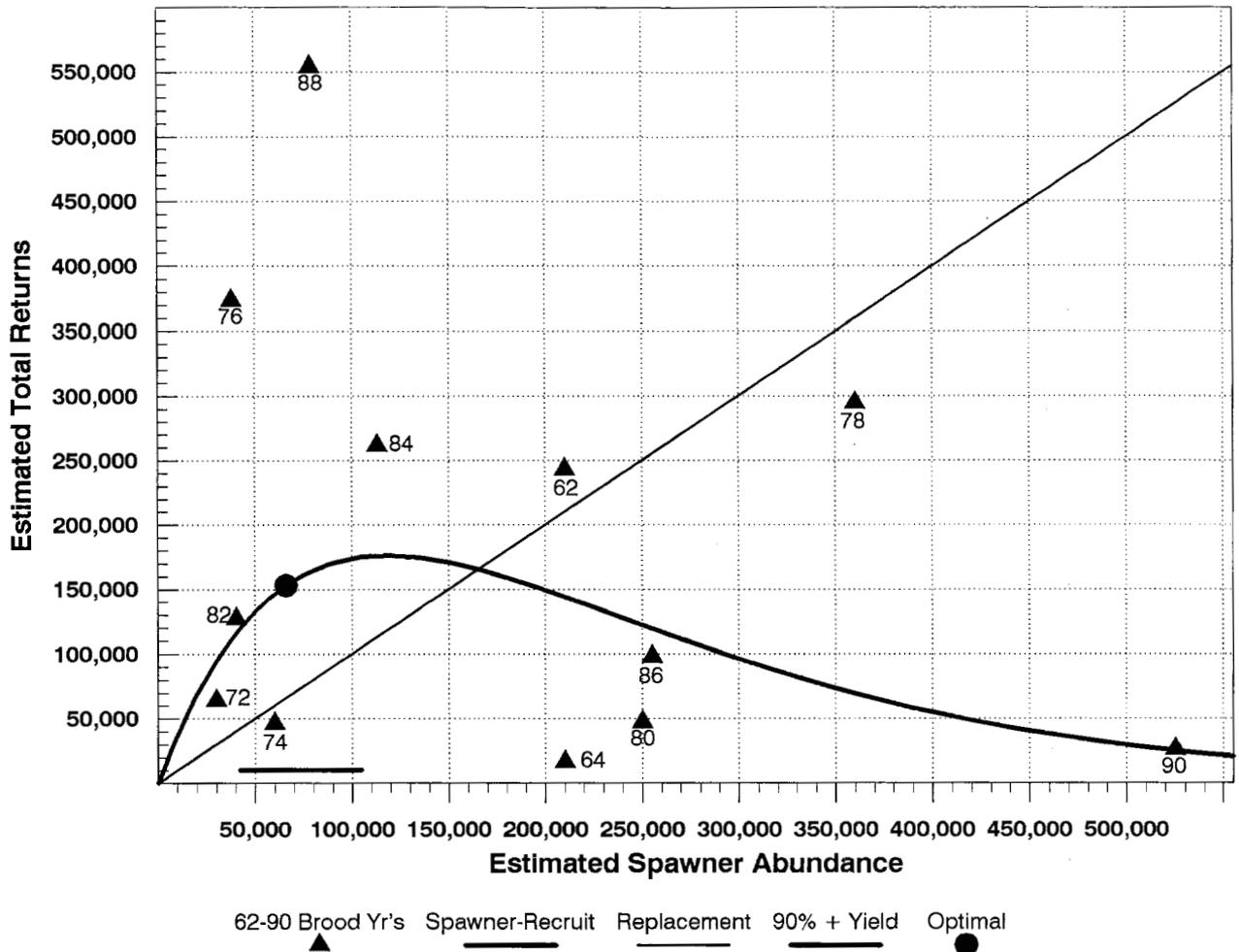


Figure 3. Spawner-recruit relationship for even-year Situk River pink salmon stock (upper) and plot of residuals (lower).

Table 10. Recommended escapement goal ranges for Situk River and Humpy Creek even and odd-year pink salmon stocks with the number and percentage of times that monitored escapements were within the recommended ranges since 1961.

Pink Salmon Stock	Survey Type	Recommended Escapement Range	Number of Years Escapement Monitored	No. of Years Escapement Was:					
				Below Range:		Within Range:		Above Range:	
				No.	%	No.	%	No.	%
Situk Even	Weir	42,000-105,000	5	2	40%	1	20%	2	40%
Situk Even	Other ^a	14,000-35,000	9	3	33%	1	11%	5	56%
Situk Even Subtotal:			14	5	36%	2	14%	7	50%
Situk Odd	Weir	54,000-200,000 ^b	7	1	14%	0	0%	6	86%
Situk Odd	Other ^a	18,000-44,000	7	1	14%	3	43%	3	43%
Situk Odd Subtotal:			14	2	14%	3	22%	9	64%
Situk Total			28	7	25%	5	18%	16	57%
Humpy Even	Aerial	3,300-8,000	14	2	14%	3	22%	9	64%
Humpy Odd	Aerial	7,000-18,000	14	3	21%	7	50%	4	29%
Humpy Combined			28	5	18%	10	36%	13	46%

^a Aerial and boat counts.

^b Upper end of range modified from 132,000 to 200,000; see text for explanation.

Estimated MSY for even-year pink salmon returning to Humpy Creek is about 23,000 fish; the escapement level estimated to provide for MSY is 17,000 fish in the total escapement or about 5,700 fish counted during peak aerial or foot surveys (Table 9). The range of escapements estimated to provide 90% or more of MSY is 3,300 to 8,000 fish counted during a peak aerial or foot survey. Estimated exploitation rate at MSY and OY is 58%. Expanded escapements of even-year pink salmon in Humpy Creek in excess of about 35,000 fish have all failed to replace themselves (Figure 4) and since 1962, 64% of the escapements have exceeded the range estimated to provide 90% or more of MSY while 14% have been below this range and 22% have been within this range (Table 10).

Estimated MSY for odd-year pink salmon returning to the Situk River is about 115,000 fish; the escapement level estimated to provide for MSY is 90,000 fish counted through the Situk River weir or 30,000 pink salmon counted during peak aerial or boat surveys (Table 9). The range of escapements estimated to provide 90% or more of MSY is 54,000 to 132,000 fish counted through the Situk River weir or a range of 18,000 to 44,000 pink salmon counted during a peak aerial or boat survey. Estimated exploitation rate at MSY and OY is 56%. Escapements of odd-year pink salmon in the Situk River in excess of about 200,000 fish have all failed to replace themselves (Figure 5). The escapements for brood years 1977 (177,712) and 1983 (183,577) both exceed the 90% or more of MSY range (54,000 to 132,000). Yet these escapements have produced the largest returns and are data points wherein both the escapements and returns were counted with weirs. Because this provides direct evidence that the MSY escapement range may be larger than that indicated by the spawner-recruit relationship, I suggest that an escapement goal range of 54,000 to 200,000 be adopted rather than a range of 54,000 to 132,000 fish. The appropriate range based on peak aerial or boat surveys would then be 18,000 to 67,000 fish. Since 1961, 64% of the escapements have exceeded the range estimated to provide 90% or more of MSY while 14% have been below this range and 22% have been within this range (Table 10).

Estimated MSY for odd-year pink salmon returning to Humpy Creek is about 105,000 fish; the escapement level estimated to provide for MSY is 36,000 fish in the total escapement or about 12,000 fish counted during peak aerial or foot surveys (Table 9). The range of escapements estimated to provide 90% or more of MSY is 7,000 to 18,000 fish counted during a peak aerial or foot survey. Estimated exploitation rate at MSY and OY is 74%. Expanded escapements of odd-year pink salmon in Humpy Creek in excess of about 90,000 fish have all failed to replace themselves (Figure 6) and since 1961, 29% of the escapements have exceeded the range estimated to provide 90% or more of MSY while 21% have been below this range and 50% have been within this range (Table 10).

Review of past escapement surveys for pink salmon in the Situk River and in Humpy Creek reveal that 52% of annual escapements have exceeded the escapement ranges predicted to provide 90% or more of MSY (29 of 56 cases; Table 10). Current management of the Situk River, Yakutat Bay, and Humpy Creek set gill net fisheries imposes limits on the amount of legal fishing time. The results of my analysis indicate that management of the Situk, Yakutat Bay, and Humpy Creek set gill net fisheries could become more liberal (more days open for

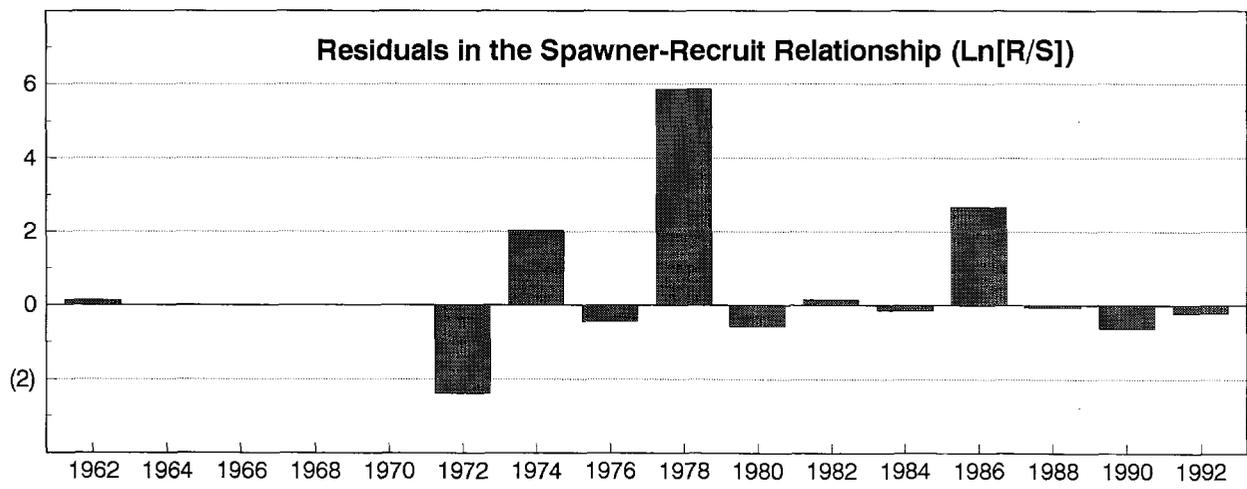
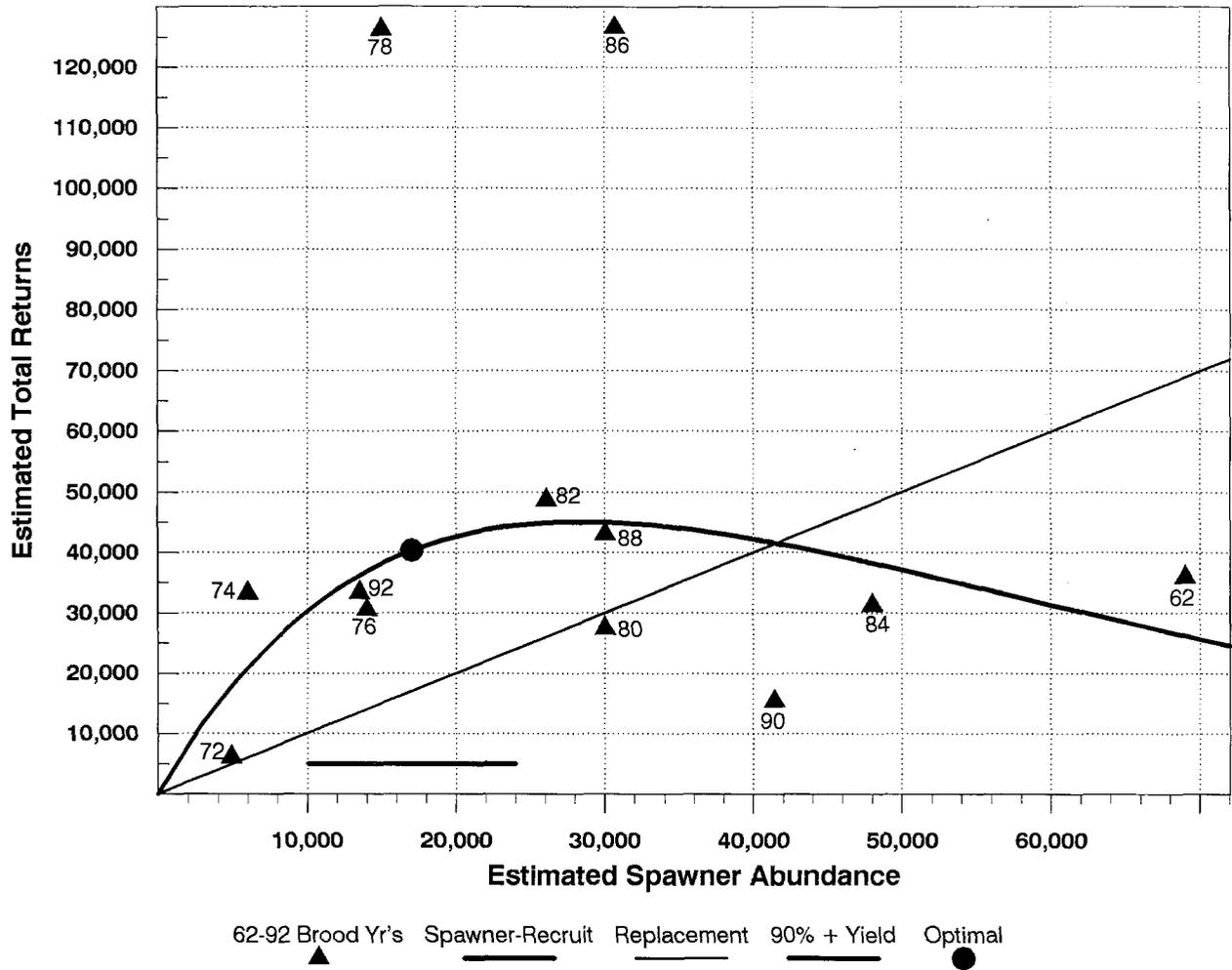


Figure 4. Spawner-recruit relationship for even-year Humpy Creek pink salmon stock (upper) and plot of residuals (lower).

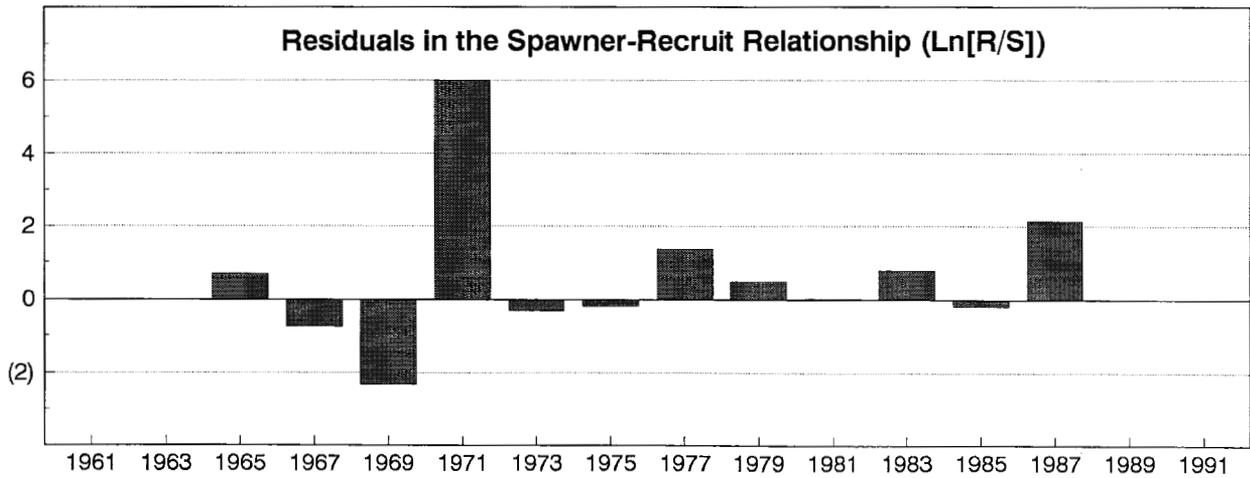
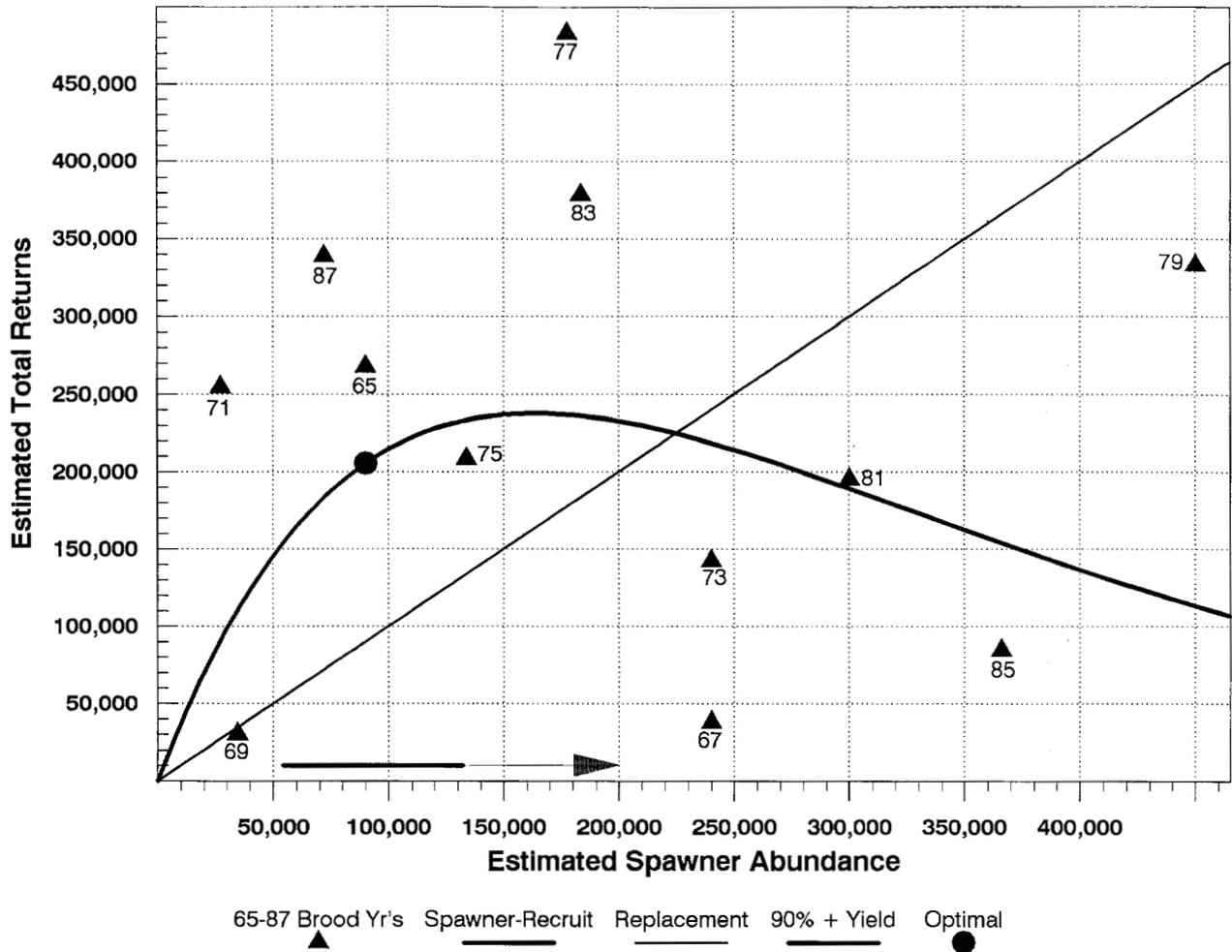


Figure 5. Spawner-recruit relationship for odd-year Situk River pink salmon stock (upper) and plot of residuals (lower).

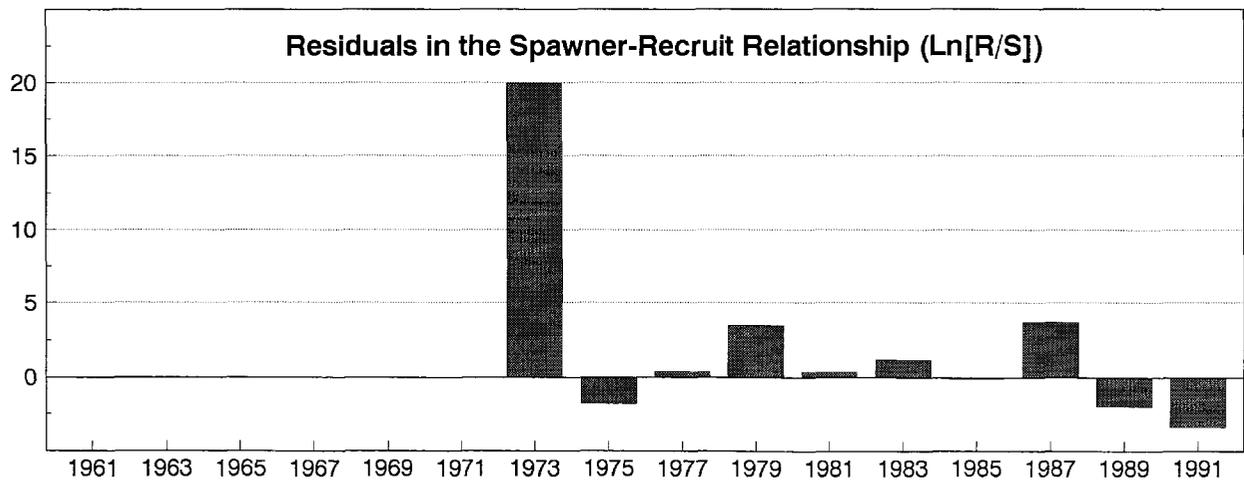
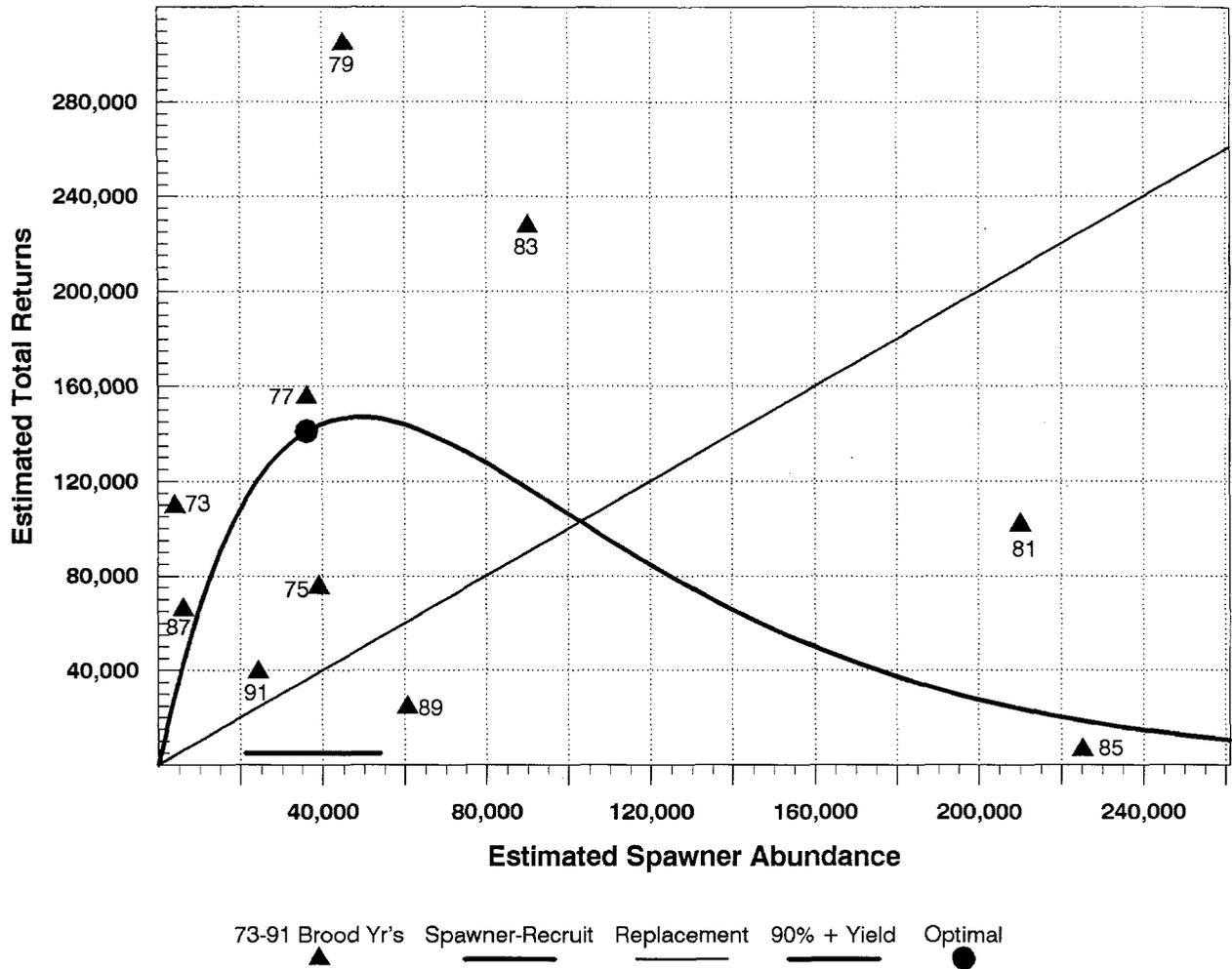


Figure 6. Spawner-recruit relationship for odd-year Humpy Creek pink salmon stock (upper) and plot of residuals (lower).

legal fishing on the average) were fishery managers to strive to achieve the escapement ranges predicted to provide for 90% or more of MSY.

The sustainable production of pink salmon is estimated to increase approximately four-fold if pink salmon escapements estimated to produce MSY were consistently achieved (Figure 7). Even-year MSY for Situk River and Humpy Creek pink salmon stocks is estimated to total approximately 110,000 pink salmon as compared to average even-year harvests since 1962 of about 28,000 pink salmon in the Situk River, Yakutat Bay, and Humpy Creek set net fisheries (Table 9). Odd-year MSY for Situk River and Humpy Creek pink salmon stocks is estimated to total approximately 220,000 pink salmon as compared to average odd-year harvests since 1961 of about 50,000 pink salmon in the Situk River, Yakutat Bay, and Humpy Creek set gill net fisheries (Table 9).

Fishery management actions intended to achieve MSY for pink salmon are most feasible in the Humpy Creek set gill net fishery because pink salmon are the predominant species harvested. Management actions implemented to achieve MSY for pink salmon are least feasible in the Situk River set gill net fishery. This is because major harvests of sockeye and coho salmon occur in the Situk fishery, these species overlap in terms of return timing with pink salmon, these species are a more valuable fishery resource than are pink salmon, and fishery managers need to consider status of these sockeye and coho salmon runs in addition to the status of the pink salmon run. Thus, although I am recommending that the Alaska Department of Fish and Game formally adopt escapement goals for even and odd-year runs of pink salmon returning to the Situk River and to Humpy Creek, fishery management options available to fully realize MSY for the Situk River stock are substantially more limited than for the Humpy Creek stock.

RECOMMENDATIONS

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

Pink Salmon Stock	Index	Index	Survey
	Escapement Goal	Escapement Goal Range	
Situk River Even-Year Stock	22,000	14,000 to 35,000	Aerial/Boat
Situk River Odd-Year Stock	30,000	18,000 to 67,000	Aerial/Boat
Humpy Creek Even-Year Stock	5,700	3,300 to 8,000	Aerial/Foot
Humpy Creek Odd-Year Stock	12,000	7,000 to 18,000	Aerial/Foot

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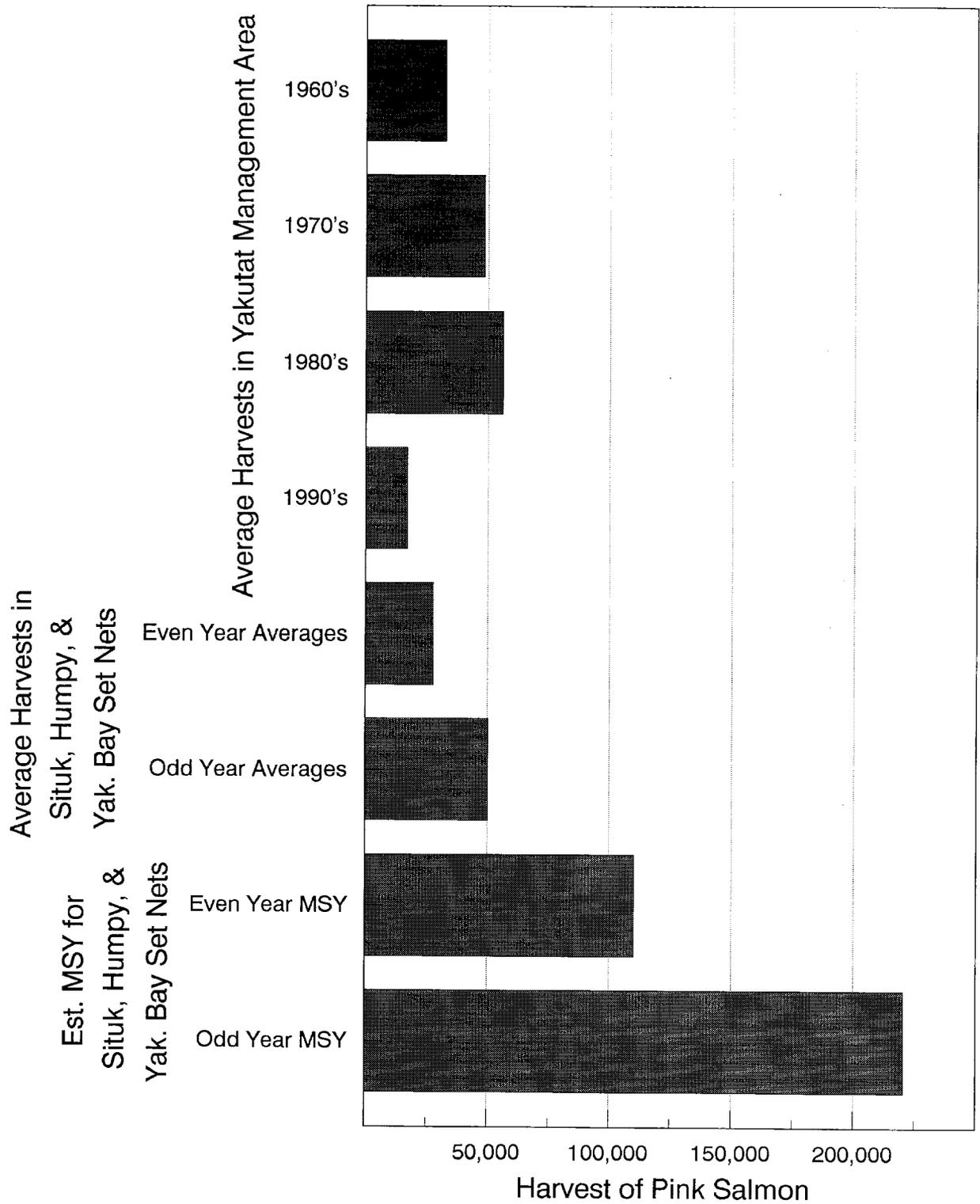


Figure 7. Comparison of average pink salmon harvests in the Yakutat Area to estimated MSY for the Situk River and Humpy Creek stocks.

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