ESCAPEMENT GOAL REVIEW OF COPPER AND BERING RIVERS, AND PRINCE WILLIAM SOUND PACIFIC SALMON STOCKS

REPORT TO THE ALASKA BOARD OF FISHERIES

By:
Brian G. Bue
James J. Hasbrouck
and
Matthew J. Evenson

Regional Information Report No. 2A02-35

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

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INTRODUCTION

This report is a summary of analyses of escapement goals for the major salmon stocks of the Copper River, Bering River and Prince William Sound areas. Escapement goals were reviewed based on the Policy for the Management of Sustainable Salmon Fisheries (SSFP; 5 AAC 39.222) and the Policy for Statewide Salmon Escapement Goals (EGP; 5 AAC 39.223). The Board of Fisheries adopted these policies into regulation during winter 2000-2001 to ensure that the state's salmon stocks are conserved, managed and developed using the sustained yield principle. These policies state that escapement goals be a range, with a lower and upper value, rather than a single point estimate. Two important terms defined in the SSFP are:

> *biological escapement goal* (BEG): the escapement that provides the greatest potential for maximum sustained yield (MSY); and
>
> *sustainable escapement goal* (SEG): a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period, used in situations where a BEG cannot be estimated due to the absence of a stock specific catch estimate.

This is the third time that an interdivisional team (hereafter referred to as the team) has reviewed escapement goals for these stocks. Previous teams reviewed goals with guidance from the department's Salmon Escapement Goal Policy adopted in 1992 (Fried 1994). The team included staff from Commercial Fisheries (CF) and Sport Fish (SF) Divisions: Dave Bernard (SF), Brian Bue (CF), Don Roach (SF), Matt Evenson (SF), Nancy Gove (CF), Jim Hasbrouck (SF), Rick Merizon (CF) and Steve Moffitt (CF).

The purpose of this year's analysis was to determine the appropriate type of escapement goal (BEG or SEG) for 1 chinook, 5 sockeye, 2 coho, 16 pink and 7 chum salmon stocks. The team limited this review to salmon stocks that have existing goals (Fried 1994), all but one of which are BEG under the old policy. The lone exception is a point goal for sockeye salmon returning to the Upper Copper River. Formal meetings to discuss and develop recommendations were held on March 15, May 7, July 17, and August 13, 2002. A teleconference among team members occurred on October 1, 2002. The team also communicated by email. All team recommendations were reviewed by department regional and headquarters staff prior to being adopted.

METHODS

The team evaluated the type, quality, and amount of data for each stock to determine the appropriate type of escapement goal as defined in regulation. Available data on escapement, harvest, and age composition for each stock were compiled from research reports, management reports, and unpublished historical databases. Biological escapement goals (BEGs) were estimated for stocks with information on a wide range of escapements, with information on catches across this range of escapements, and with information on age composition of returns.

Methods described in Hilborn and Walters (1992), Chinook Technical Committee (1999), and Quinn and Deriso (1999) were followed in estimating BEGs. Sustainable Escapement Goals (SEGs) were determined for stocks that did not have this complete suite of information.

There is still considerable debate within the Department as to methodologies for setting SEGs. The team agreed that while the methodology used in Cook Inlet in 2001 (Bue and Hasbrouck 2001) has a high probability of replicating the returns historically observed for a stock, it is a descriptive method not based on a determination of the relationship between spawners and recruitment. The team thought that every reasonable effort should be made to evaluate the spawner-recruit relationships before using the Bue and Hasbrouck method (Table 2).

Two of these reasonable efforts concerned aggregation and age-structured analysis. Aggregation of stocks across districts, or upriver combined with delta stocks, was examined as a means of improving information used to build spawner-recruit relationships. An age-structured analysis for chinook salmon in the Copper River provided estimates of escapement for this stock back to 1982 (Savereide 2001). The team used this information in setting an SEG for Copper River chinook salmon and used the method to provide information on escapements of sockeye and coho salmon to the Copper River and the Copper/Bering River Delta.

RESULTS

The escapement goal changed for nearly all the salmon stocks examined in the Prince William Sound and Copper River area; however, these changes were mostly due to a change in goal type and the establishment of a range (Table 3). Biological escapement goals were estimated for two stocks and SEGs for the remaining stocks. Appendices A – E document the escapement goal of each stock.

Biological Escapement Goals

Biological escapement goals were determined for two sockeye salmon stocks, Eshamy and Coghill lakes. Both stocks have relatively precise and accurate estimates of escapement, harvest, and age composition of returns along with some limited limnological data. Escapement has been counted and sampled at weirs for both stocks. Exploitation of these stocks has been limited to terminal fisheries with harvest tallies available through the Commercial Fisheries Fish Ticket database. Harvests and escapements have both been sampled to estimate age composition in both stocks.

Coghill Lake Sockeye Salmon

The BEG of 20,000 –30,000 spawners was changed to 20,000-40,000 spawners. Escapement into Coghill Lake has been visually counted since 1960. From 1960-1973 escapement was counted using a partial weir and tower with a full-river weir coming into use in 1974. Age

composition of both the catch and escapement has been collected since 1962. The 1977 brood year produced approximately 40 returns per spawner; nearly eight times the average (Appendix E1). A series of large escapements (greater than 100,000 spawners: 1980-1982 broods) produced better than 3 returns per spawner; however, subsequent brood years (1985-1989) did not replace themselves (return per spawner less than 1.0). Production since 1990 has been in excess of 3 returns per spawner. The ADF&G limnology laboratory in Soldotna suggested that the poor production for the 1985-1989 broods was a result of low densities of cyclopoid copepods (zooplankton), the primary food resource for rearing sockeye juveniles. It was hypothesized that the reduced abundance of zooplankton resulted from top-down or overgrazing effects by high fry densities (Edmundson et al. 1992). The average grazing pressure index, computed as the mean number of spawners per unit lake area (Nr/km^2) divided by zooplankton biomass density (kg/km^2), was relatively high (90) (Edmundson and Edmundson 2002). Subsequently, the lake was fertilized for four years (1993-1996) to increase the zooplankton forage base. Nutrient additions increased zooplankton biomass and the number of smolts produced per spawner (Edmundson et al. 1997). However, there has been no consistent collection of limnological data since termination of the lake fertilization program. In the absence of additional, recent limnological data, we cannot determine whether food resources are now limiting sockeye salmon production. Nonetheless, Coghill Lake is an extremely harsh environment characterized by high inorganic turbidity, cold temperatures, short growing season, and a dense, anoxic saltwater mass that prevents metabolites, derived from the decomposition of organic material, from recirculating into the overlying oxygenated layers (Edmundson et al. 1992, 1997). Consequently, this lake may be more regulated by abiotic factors than biological interactions. Therefore, given our limnological concerns, past data demonstrating some good returns from large escapements, and also poor returns from escapements in excess of 50,000 spawners; we recommend only a slight change to the escapement goal range.

Eshamy Lake Sockeye Salmon

The BEG of 30,000-40,000 spawners was changed to 20,000-40,000 spawners. Escapement into Eshamy Lake has been visually counted through a weir since 1960 but reliable age composition data were not available until 1970; thus, all spawner-recruit analysis were performed using the 1970-1995 brood-year data. The number of spawners most likely to produce maximum sustainable yield as estimated by Ricker spawner-recruit analysis adjusted for lognormal error (Hilborn and Walters 1992) was 21,000 spawners. There was a great deal of contrast in the range of observed escapements (90) and strong evidence of density dependence ($p=0.002$). There is limited limnological data available for this system. However, the grazing pressure index value for this system is considered low (7; Edmundson and Edmundson 2002). This indicates either weak grazing pressure or, as has been suggested in the past, the system is spawning area limited. Previous spawner and hydroacoustic surveys revealed that spawners and rearing fry mainly occupy only one basin of this lake (Koenings and Kyle 1997). This idea is further supported by the observation that total returns of 50,000 fish are routinely observed for levels of spawners between 10,000 and 40,000 (Appendix E2). The limnological data and the spawner-recruit analysis generally support each other. We recommend a slight lowering of the lower bound based on the spawner-recruit analyis. We believe yield should be increased for the 20,000-40,000 spawning range.

Sustainable Escapement Goals

Chinook Salmon

The recommended escapement range of 28,000-55,000 chinook salmon was changed to an SEG of 24,000 or more spawners. Savereide (2001) estimated escapements of this species for the Copper River back to 1980 using catch-at-age data and counts of chinook salmon from aerial surveys over the Gulkana River (Appendix A1). These first-time estimates were imprecise and had low contrast (covered a narrow range), indications that past escapements have moved within a range too narrow to provide information sufficient for estimating a stock-recruit relationship, and hence a BEG. However, the average escapement since 1980 (25,800 salmon) has on average produced an annual harvest near 48,000 salmon. Obviously, this is strong empirical evidence that 25,800 represents a sustainable escapement goal. Information from Savereide (2001), when discounted for imprecision in estimated escapements, indicates that maximum sustained yields could be expected near the average escapement of 25,800. No new information on production by this stock will be forthcoming until escapements move higher than observed in the recent past. Highest estimates of escapement since 1980, adjusted for imprecision, range from 40,000-45,000 salmon, well below the average return of 70,000-75,000. Since actively managing for higher escapements would be disruptive to fisheries on this stock, the team recommended that at least 24,000 chinook salmon be allowed to spawn annually. This threshold was chosen to keep future escapements near the historical average without precluding the possibility that exceptionally large returns will provide new information with higher escapements. Such a goal would increase the possibility of gaining new information at minimal cost to fisheries by keeping expectation of annual yield near 40,000-50,000 chinook salmon.

Chum Salmon

All escapement goals for Prince William Sound chum salmon were changed from BEGs to SEGs. Two goals, Montague and Southwestern District chum salmon, were removed from the list of existing goals. The Unakwik District (Part of the Northern District until 1989) does not contain any chum salmon index streams and no goal was created.

Escapement goals for chum salmon are based on expanded counts from aerial surveys dating back to 1965. Streams are flown multiple times each year with escapement estimated using area-under-the-curve calculations adjusted for estimates of stream life (Bue et al. 1998). Catches of most chum salmon have been incidental to harvest of pink salmon throughout Prince William Sound except in terminal hatchery harvest areas. Reliable estimates of hatchery contributions to commercial catches of chum salmon are unavailable. Likewise, there are no reliable estimates of District of origin for wild fish with the possible exception of the Eastern and Southeastern District. Because of this inability to adequately determine District of origin for catch, much less whether the fish were hatchery or wild, sustainable escapement goals were estimated for the Coghill, Eastern, Northern, and Northwestern Districts using historical aerial indices of escapement and the algorithm described in Bue and Hasbrouck (2001; Appendices B1, B2, B3, and B4). The goal for the Southeastern District was estimated using a Ricker-type spawner-recruit analysis where the escapement estimates for the district were summed and compared

against district-wide harvest. Although a significant stock-recruit relationship was detected in this analysis, the team labeled the resulting goal an SEG because of uncertainty in estimated escapements (Appendix B5).

Escapement goals for the Montague and Southwestern Districts were removed from the list of existing goals. Montague Island was elevated approximately 20 feet by the 1964 Alaskan earthquake, resulting in changes to spawning habitat with subsequent loss of returns to the area. Chum salmon are again being observed in streams on Montague Island, most likely strays from the large hatchery releases in the Port Chalmers area. The Department will continue to survey chum salmon spawning on Montague Island to document any recolonization and if needed, reestablish escapement goals in the future. Escapements to the Southwestern District are extremely small relative to escapements elsewhere. Even with expansion of the counts from 27 streams in the district for stream life, the 25th and 75th percentile observations of escapement from 1965-2001 are 700 and 2,350, respectively. Given the low number of fish observed, the possible error in aerial surveys (Hilborn et al. 1999) and the requirement of establishing a goal as a range by policy, the team recommends dropping the goal entirely for this district. Streams in the District will still be surveyed annually.

All hatchery-produced chum salmon in Prince William Sound have been thermally marked since the 1996 brood year, and all returning age classes will be marked in 2003. These marks will allow for the estimation of hatchery contributions, if funding is available, and eventually an estimate of the spawner index-recruit relationship on a Sound-wide basis.

Coho Salmon

Goals for two stocks of coho salmon, one spawning in the Copper River Delta and the other in the Bering River Delta, were changed from BEGs to SEGs in keeping with definitions in the SSFP. Values of these goals were not changed. Escapements for both stocks have been measured as peak index counts from fixed-wing aerial surveys. Although many streams have been surveyed for each stock over the years, only surveys conducted annually over the same streams were used to evaluate escapement goals:15 streams in the Copper River Delta surveyed back to 1981 and 5 streams in the Bering River Delta surveyed back to 1984 (Appendices C! and C2). Contrast of observed escapements in Copper River Delta is 3.9, a low level of contrast for conducting stock-recruit analysis (Chinook Technical Committee 1999). Contrast in observed escapements for Bering River Delta is 13.4 (high), due to a large escapement of 74,500 observed in 1985. Without this observation, the contrast is only 4.3, again a low level of contrast. Given the lack of contrast in observed escapements, likely measurement error in estimated escapements and a lack of correlation among escapement indices across surveyed streams for each stock, estimation of BEGs for these two stocks is not possible at this time. Criteria for using percentiles to estimate SEGs (Bue and Hasbrouck 2001) given observed contrast in escapements gave values near the current escapement goal range for each stock. Therefore, no change in the current goal range of these stocks appears warranted at this time.

Pink Salmon

The escapement goals for Prince William Sound pink salmon were changed from BEGs to SEGs. In addition, the escapement goals were changed from District specific goals to a Sound-wide goal of 1,250,000 to 2,750,000 for both the even and odd-year brood lines. The team recommended that the fishery be managed to spread the Sound-wide goal to the various fishing districts similar to how escapement had been distributed historically (Figures 1 and 2; Table 4).

Since 1960, the Department has conducted aerial surveys of selected pink salmon streams to index the spawning escapement in Prince William Sound. There are approximately 1000 pink salmon spawning systems in the Sound of which 208 are surveyed annually. These 208 streams represent approximately 20-25% of the anadromous streams in each district and 75-85% of the total spawning escapement (Fried 1994; Fried et al. 1998). Indices of spawning escapement are estimated using area-under-the-curve methodology and a 17.5-day stream life (Bue et al. 1998).

Hatchery produced pink salmon have been returning to Prince William Sound since 1977 (Pirtle 1979). Hatchery pink salmon returns have been estimated using wild stock exploitation rates (1977-1986) or mark-recapture methods that employed either coded wire tags or otolith thermal marks (1987-present; Brady et al. 1987; Joyce and Riffe 1998). Since there are no methods to allocate commercial harvests to stream or even district of origin, all analysis were completed on the total wild return by brood line (Appendices D1 and D2).

Analysis of the aerial data indicates that all years except the 1970 brood year replaced its self. In addition, a yield analysis indicates that all levels of escapement observed since 1960 are sustainable and that very good production can be obtained for a Sound-wide aerial index of 1,250,000 and 2,750,000 for both brood lines (Table 5). Pink salmon preemergent fry density was estimated from 25 index streams from 1960-1994. The relationship between aerial escapement index and fry density in the intertidal zone was examined using a Ricker type analysis. Density dependence was detected for both brood lines (P = 0.004 even and P = 0.008 odd for ln[fry/spawner] vs. spawner) but the observed fry density and the predicted fry density did not correlate well (r^2=0.09 and 0.03 for ln[observed fry density] vs. ln[predicted fry density] for even and odd broods, respectively). The estimated number of aerial index points that produce the maximum number of fry on a sustained basis (S_{msy} for preemergent fry) was 1.9 million and 1.4 million for the even and odd-brood lines, respectively.

Sockeye salmon

Upper Copper River. The escapement goal for Upper Copper River sockeye salmon was changed to a SEG of 300,000-500,000 spawners. In addition, the team recommended that the fishery be managed for escapements that on average are similar to the historic average escapement (361,000). While escapement to the Upper Copper River has been monitored reliably at Miles Lake since 1978 using Bendix side-scan sonar, the contribution of the upriver stock to the commercial fishery is not reliably known. Studies in the 1980's based on differences in scale patterns attempted to estimate upriver and delta contributions to the catch; these studies were discontinued because of imprecise estimates (Marshall et al. 1987). Estimated escapements

have medium contrast (4.4; Appendix Table E3) with no evidence to suggest production is reduced with high escapements. Since past escapements have produced high sustainable yields, the team recommends the goal reflect past escapement levels.

Estimating productivity of the wild stock in the Copper River is further complicated by the presence of hatchery-reared sockeye salmon. Past harvests of hatchery-reared fish have been estimated in commercial and subsistence fisheries through the return of coded-wire tags. Starting in 2004, returning sockeye salmon produced by the Gulkana Hatchery should all be otolith marked. This will simplify the estimation of hatchery fish in the commercial harvest and provide a much better chance of obtaining an estimate of the proportion of hatchery fish passing the Miles Lake sonar. The combination of these two estimates and Miles Lake sonar counts should improve precision of estimated salmon production for the Upper Copper River and Copper River Delta sockeye salmon stocks.

Copper River Delta. The escapement goal for this stock was changed to a SEG of 55,000-130,000 peak aerial index counts with a recommendation that escapements on average match the historic average escapement (84,400). The delta aerial index is estimated as the sum of the peak aerial counts for 17 index streams (Fried 1994). No adjustments were made for area-under-the-curve or stream life. Estimates of contribution by delta sockeye salmon stocks to the Copper River catch are unavailable. The method of Bue and Hasbrouck (2001) was used to estimate the SEG (Appendix E4).

Bering River. The escapement goal for this stock was changed to a SEG of 20,000-35,000 aerial index points. The Bering River aerial index is estimated as the sum of the peak aerial counts from four survey sites. All sockeye salmon caught in the Bering River District are assumed to be of Bering River origin. The method of Bue and Hasbrouck (2001) was used to estimate the SEG (Appendix E5).

DISCUSSION

This was the first time that escapement goals have been evaluated for salmon stocks of the Copper and Bering Rivers, and Prince William Sound using the SSFP and EGP. In some cases, such as pink and chum salmon stocks in Prince William Sound, this was the most in depth review conducted to date. During this review, the team had difficulty determining BEGs and SEGs as defined in policy for the following reasons.

> **1. Determining a BEG may be impossible even when catch and escapement by stock is known**. Salmon stocks with a long history of fishing for fixed escapement goals will tend to have escapements spread over a very narrow range. Typically the consequence of successful management is the lack of evidence of what higher or lower escapements can produce. Without this evidence, the relationship between escapement and production for a stock, and hence the BEG, cannot be estimated. Often, the only way to obtain the required information is to disrupt a successful fishery.

2. A BEG as the primary management objective may be unnecessarily disruptive. An interpretation of the SSFP is that fisheries will be managed to obtain the BEG or SEG range. Wild chum salmon are generally caught incidentally in the commercial fishery for pink salmon as a matter of economic choice. Managing the pink salmon fishery to meet SEGs for chum salmon will have undesirable economic consequence.

3. Requiring SEGs be ranges. In some situations, having escapements outside of an escapement goal range may be desirable. For example, estimated escapements of chinook salmon to the Copper River cover a narrow range. While the expected yield is known for these escapements, knowledge of yield for larger escapements is lacking. Since harvest rate on this stock has been on average relatively high, escapements above the historical range represent new information that can eventually be used to establish a BEG for this stock. For this reason, the escapement goal for this stock was set as a lower threshold.

4. Lack of a scientific rationale for determining SEGs as ranges. The methodology of Bue and Hasbrouck (2001) was used to estimate 6 of 13 SEGs. While this method generally produced wide ranges, which indicates our lack of knowledge on these stocks, it also produced a range of escapements that provided sustained yield. However, estimating SEGs based on observed escapements may foster problems in the future. The SEG indicates a lack of knowledge of stock productivity and MSY; managing to keep future escapements within this range will provide little new information. Thus, estimating a SEG may result in continued ignorance of productivity and MSY of a stock, especially those stocks with low contrast in observed escapements. The best way to move from SEG to BEG type data is to obtain accurate and precise estimates of escapement, catch contribution, and age composition over a wide range of escapements.

Determining escapement goals is an evolving process, not only because each year provides more data, but also because approaches to estimate goals are increasingly becoming more standardized and documented. The SSFP and EGP are important steps in this evolution. Ideally, escapement goals should be based in part on ecological theory and principles of sustained yield (Ricker 1954, Caughley 1977). In the past many escapement goals were based on arbitrary decisions and/or descriptive approaches. While the SEG algorithm described by Bue and Hasbrouck (2001) is repeatable and should provide returns similar to what past escapements have produced, it is descriptive, not scientific. The algorithm estimates ranges based merely on summary statistics of observed escapements and there are no real theoretical constructs underlying the approach. In addition, the algorithm does not specifically account for, or consider yield, although sustained yield is part of the definition of SEGs in the SSFP. The department's Escapement Goal Policy Implementation Team (EGPIT) will continue to work on methodology for setting SEGs and Sustained Escapement Thresholds (SETs).

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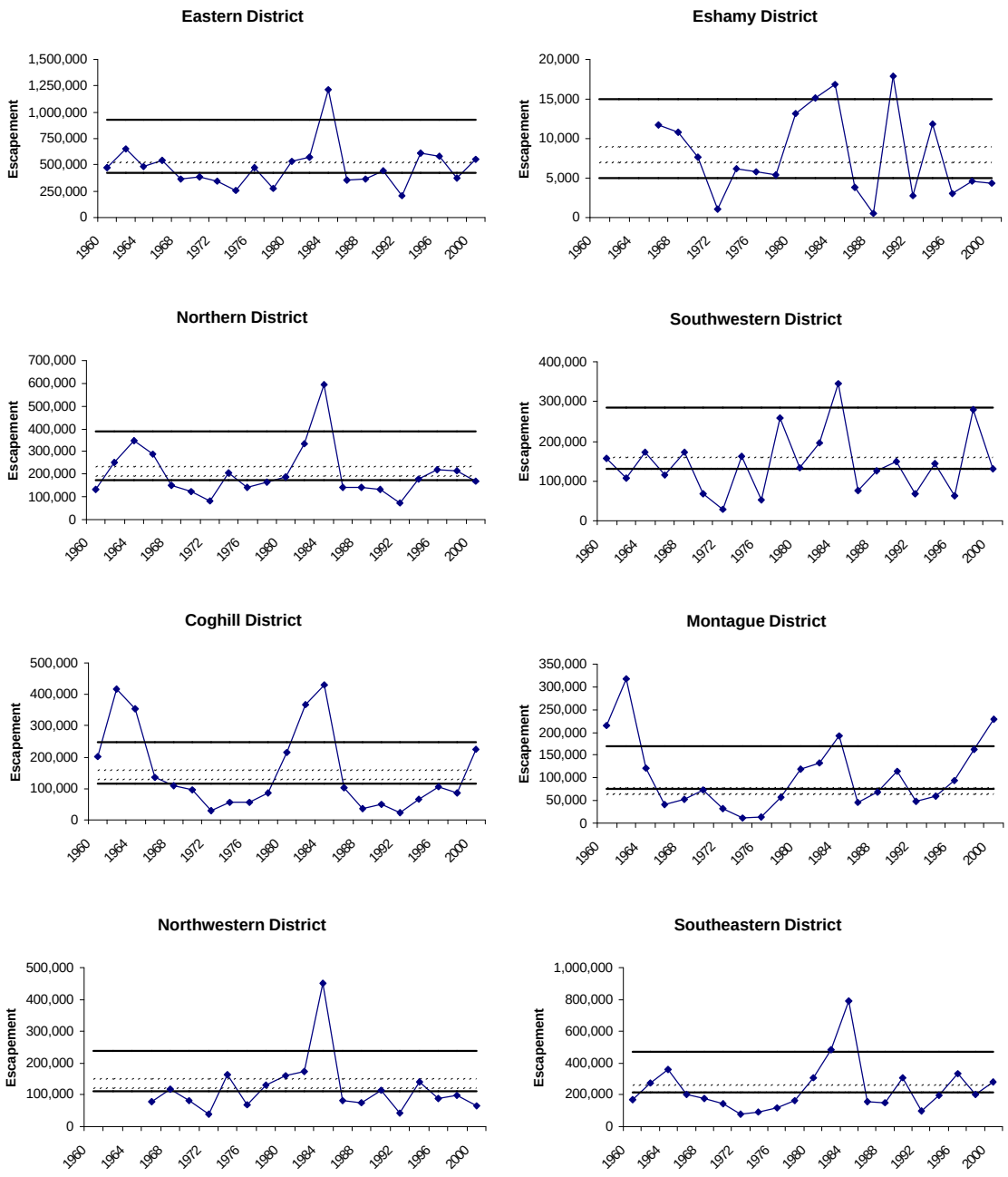


Figure 1. Management targets (solid lines) and old escapement goals (dashed lines) for Prince William Sound pink salmon by district for even years, 1960-2000.

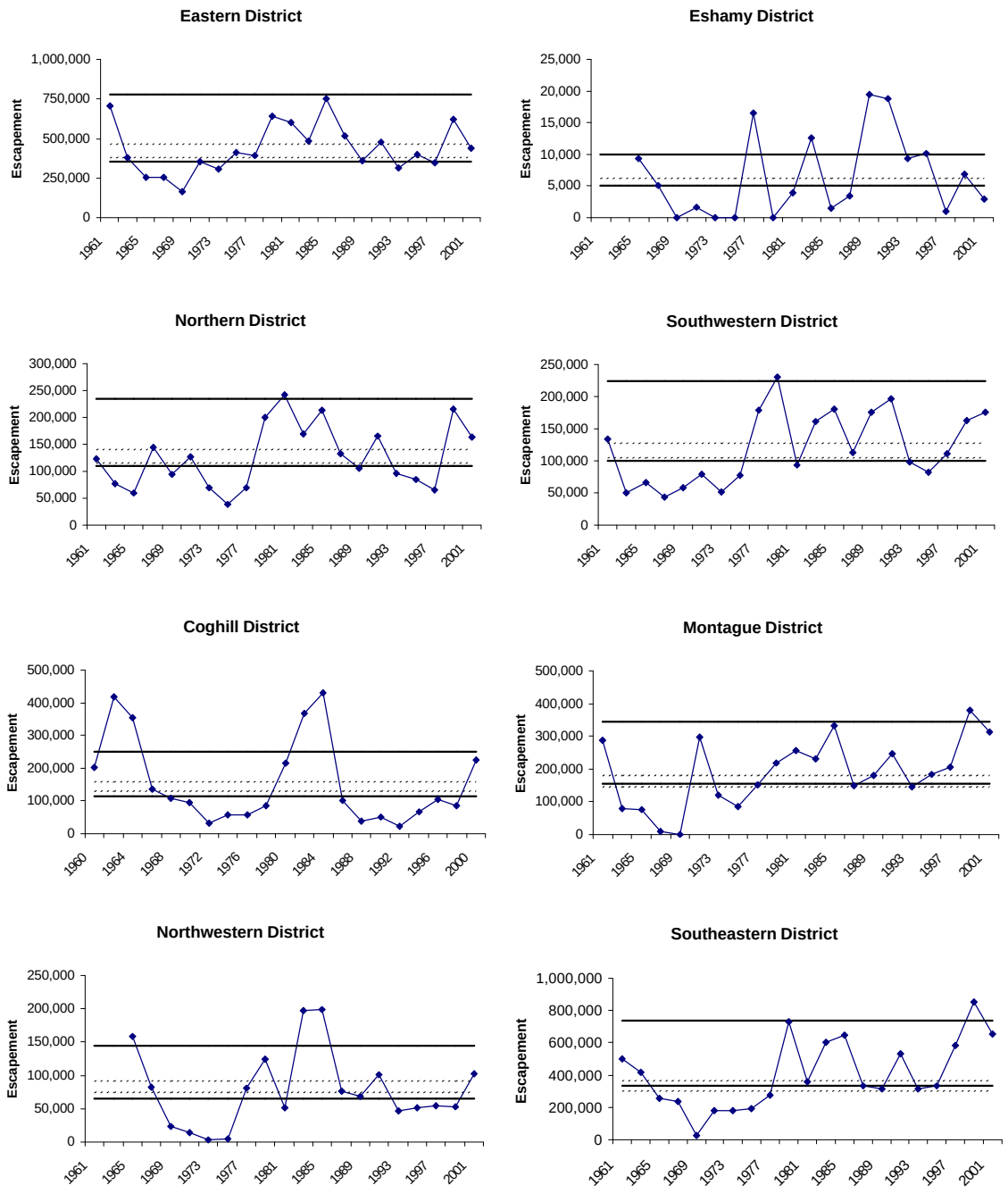


Figure 2. Management targets (solid lines) and old escapement goals (dashed lines) for Prince William Sound pink salmon by district for odd years, 1961-2001.

Table 1. General criteria used to assess quality of data in estimating escapement goals for Copper and Bering Rivers, and Prince William Sound Pacific salmon stocks

Data Quality	Criteria
Excellent	Escapement, harvest, and age all estimated with relatively good accuracy and precision (e.g. escapement estimated by a weir or hydroacoustics, harvest estimated by Statewide Harvest Survey or Fish Tickets); escapement and return estimates can be derived for a sufficient times series to construct a brood table and estimate MSY.
Good	Escapement, harvest, and age estimated with reasonably good accuracy and/or precision (e.g. escapement estimated by capture-recapture experiment or multiple foot/aerial surveys); no age data or data of questionable accuracy and/or precision; data may allow construction of brood table; data time series relatively short to accurately estimate MSY.
Fair	Escapement estimated or indexed and harvest estimated with reasonably good accuracy but precision lacking for one if not both; no age data; data insufficient to estimate total return and construct brood table.
Poor	Escapement indexed (E.G. single foot/aerial survey) such that the index provides a fairly reliable measure of escapement; no harvest and age data.

Table 2. Algorithm used to estimate sustainable escapement goals (SEGs) of Upper Cook Inlet salmon stocks. (Bue and Hasbrouck 2001)

Contrast [a]	Range
Low (<4)	15th percentile - Maximum
Medium (4-8)	15th and 85th percentile
High (>8) and at most low exploitation	15th and 75th percentile
High (>8) and at least moderate exploitation	25th and 75th percentile

[a] Relative range of the entire series of escapement data calculated by dividing the maximum observed escapement by the minimum observed escapement.

Table 3. Summary of escapement goals for Copper and Bering Rivers and Prince William Sound salmon stocks.

	Current Goal		Recommended Goal				
System	Goal	Year Adopted	Type	Range	No. Years	Escapement Data	Action
Chinook Salmon							
Copper River	28,000 - 55,000	1999	SEG	24,000 and up	3	Mark Recapture	Change
Chum Salmon (by District)							
Coghill	29,600 - 37,050	1977	SEG	8,000 - 25,000	37	Aerial Survey	Change
Eastern	87,200 - 109,000	1977	SEG	50,000 - 130,000	37	Aerial Survey	Change
Montague	11,400 - 14,250	1977	No goal recommended for Montague District				
Northern	29,400 - 36,750	1977	SEG	20,000 – 60,000	37	Aerial Survey	Change
Northwestern	19,000 - 23,700	1977	SEG	5,000 – 19,000	37	Aerial Survey	Change
Southeastern	20,000 - 25,000	1977	SEG	15,000 - 20,000	37	Aerial Survey	Change
Southwestern	3,400 - 4,250	1977	No goal recommended for Southwestern District				
Coho Salmon							
Bering River Delta	13,000 - 33,000	1991	SEG	13,000 – 33,000	18	Aerial Survey	No Change
Copper River Delta	32,000 - 67,000	1991	SEG	32,000 – 67,000	20	Aerial Survey	No Change
Pink Salmon (by District)							
Odd-Year Broodline							
Coghill	160,000 - 196,000	1990					
Eastern	380,000 - 465,000	1990					
Eshamy	5,100 - 6,200	1990					
Montague	146,000 - 179,000	1990					
Northern	115,000 - 141,000	1990					
Northwestern	75,000 - 92,000	1990					
Southeastern	300,000 - 366,000	1990					
Southwestern	105,000 - 128,000	1990					
All Districts Combined			SEG	1,250,000 – 2,750,000	21	Aerial Survey	Change
Even-Year Broodline							
Coghill	129,000 - 158,000	1990					
Eastern	427,000 - 521,000	1990					
Eshamy	7,000 - 9,000	1990					
Montague	63,000 - 77,000	1990					
Northern	192,000 - 235,000	1990					
Northwestern	122,000 - 149,000	1990					
Southeastern	215,000 - 263,000	1990					
Southwestern	130,000 - 159,000	1990					
All Districts Combined			SEG	1,250,000 – 2,750,000	21	Aerial Survey	Change
Sockeye Salmon							
Bering River	26,000 - 38,000	1991	SEG	20,000 - 35,000	13	Aerial Survey	Change
Coghill Lake	20,000 - 30,000	1992	BEG	20,000 - 40,000	17	Weir	Change
Copper River Delta	74,000 - 105,000	1991	SEG	55,000 – 130,000	31	Aerial Survey	Change
Upper Copper River	300,000	1980	SEG	300,000 – 500,000	24	Sonar	Change
Eshamy Lake	30,000 - 40,000	1986	BEG	20,000 - 40,000	24	Weir	Change

Table.4. Old escapement goals and new management targets by district for Prince William Sound pink salmon.

Range Bound	Spawning Escapement [a]								
	Eastern	Northern	Coghill	Northwestern	Eshamy	Southwestern	Montague	Southeastern	Total
Even Brood Line									
Old Goal [b]									
Lower	427,000	192,000	129,000	122,000	7,000	130,000	63,000	215,000	1,285,000
Upper	521,000	235,000	158,000	149,000	9,000	159,000	77,000	263,000	1,571,000
Management Target [c]									
Lower	425,000	175,000	115,000	110,000	5,000	130,000	75,000	215,000	1,250,000
Upper	930,000	390,000	250,000	240,000	15,000	285,000	170,000	470,000	2,750,000
Odd Brood Line									
Old Goal [b]									
Lower	380,000	115,000	160,000	75,000	5,100	105,000	146,000	300,000	1,286,100
Upper	465,000	141,000	196,000	92,000	6,200	128,000	179,000	366,000	1,573,200
Management Target [c]									
Lower	355,000	110,000	125,000	65,000	5,000	100,000	155,000	335,000	1,250,000
Upper	780,000	235,000	275,000	145,000	10,000	225,000	345,000	735,000	2,750,000

[a] Spawning escapement is indexed using area-under-the-curve of weekly aerial survey counts adjusted for a 17.5-day stream life.
[b] Old Goals are as reported in Fried (1994).
[c] Management targets by district are calculated as the weighted average escapement by district and brood line (1965-2001) times the Prince William Sound SEG range bounds. Only years after the 1964 earthquake were used to calculate the targets.

Table 5. Yield analysis for even and odd year pink salmon, Prince William Sound, Alaska.

Even year brood line

Escapement Interval	n	Average Escapement	Average Returns	Average R/S	Average Yield
0.50-1.00	7	0.85	5.09	6.44	4.23
0.75-1.25	7	1.01	6.11	5.93	5.09
1.00- 1.50	8	1.34	6.68	5.12	5.34
1.25-1.75	7	1.44	7.40	5.00	5.96
1.50-2.00	2	1.76	10.23	6.01	8.48
1.75-2.25	2	1.93	5.09	2.62	3.16
> 2.00	3	2.77	11.23	4.68	8.46

Odd-year brood line

Escapement Interval	n	Average Escapement	Average Returns	Average R/S	Average Yield
0.50-1.00	3	0.74	5.71	10.20	4.97
0.75-1.25	6	1.07	4.25	4.04	3.18
1.00- 1.50	10	1.27	6.84	5.31	5.57
1.25-1.75	8	1.38	8.52	6.21	7.15
1.50-2.00	2	1.78	6.86	3.95	5.09
1.75-2.25	4	2.10	12.49	5.76	10.39
2.00-2.50	4	2.26	13.98	6.27	11.72
> 2.25	3	2.43	14.18	5.95	11.74

APPENDIX A.
SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR CHINOOK SALMON OF PRINCE WILLIAM SOUND

Appendix A1.-Escapement goal for Copper River chinook salmon.

System: **Copper River District**
Species: **chinook salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet
Previous Escapement Goal:	28,000 - 55,000 (1999)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	24,000 and up
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Mark-recapture estimates 1999-2001, age-structured model estimates of escapement 1980-1999.
Summary:	
Data Quality	Good
Data Type	Mark-recapture enumeration of inriver abundance, commercial harvest and age data, inriver subsistence and recreational harvest data, inriver age data.
Contrast	1.7 from mark-recapture estimates; 6.7 from model estimates
Criteria for SEG	Few direct estimates of spawning escapement; age-structured model estimates had low contrast and large measurement error.
25th - 75th percentile	16,528 - 31,737 from age-structured model estimates
Years within recommended BEG	2 of 3 mark-recapture estimates; 9 of 20 model estimates
Comments	Age-structured analysis indicated the spawning escapement that produces MSY was 20,000 (rounded), but was known to be biased low because of large measurement error (from model) in escapement estimates.

Appendix A1.-Continued.

System: **Copper River District**
Species: **chinook salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Escapement[a]	Modeled Escapement[b]	Total Return[c]
1980		14,283	28,760
1981		15,084	39,387
1982		29,956	80,955
1983		16,757	75,445
1984		41,962	85,417
1985		8,254	55,024
1986		55,424	101,386
1987		22,744	54,668
1988		19,434	55,132
1989		37,080	72,526
1990		25,466	52,583
1991		22,956	66,483
1992		14,933	63,358
1993		22,827	65,107
1994		29,813	87,560
1995		15,841	93,745
1996		41,484	107,771
1997		38,642	104,141
1998		24,952	108,938
1999	16,149	19,019	95,269
2000	24,492		
2001	28,208		

[a] Estimated by mark-recapture experiment.

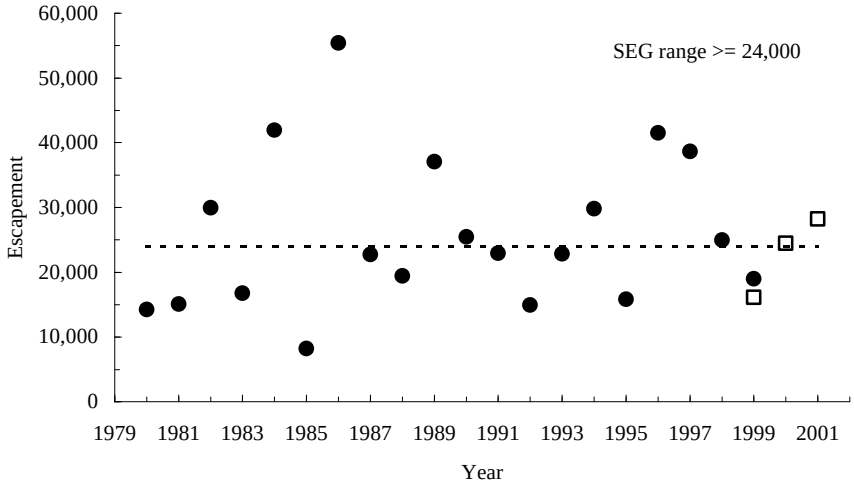
[b] From age-structured model.

[c] Total return estimated by age-structured model estimates of escapement and subsistence, sport, and commercial catch information.

Appendix A1.-Continued.

System: **Copper River District**
Species: **chinook salmon**
Stock Unit: **N/A**

Estimated escapement by year, estimated with an age-structured model (closed circles) and mark-recapture experiment (open boxes), and recommended SEG (dashed line).



APPENDIX B.
SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR CHUM SALMON OF PRINCE WILLIAM SOUND

Appendix B1.-Escapement goal for Coghill District chum salmon.

System: **Coghill District**
Species: **chum salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet and Purse Seine
Previous Escapement Goal:	29,600 - 37,050 (1977)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	8,000 - 25,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1960.
Summary:	
Data Quality	Fair
Data Type	Fixed-wing aerial surveys, commercial harvest[a] by district, and sporadic age data.
Contrast	65.1
Criteria for SEG	high contrast, at least moderate exploitation
25th-75th Percentile	8,430 - 24,510
Years within recommended SEG	20 of 37
Comments	The goal represents an index rather than an estimate of total spawner abundance. Hatchery contribution to the commercial harvest has not been estimated.

[a] Does not include cost recovery or brood harvests from Wally H. Noerenberg Hatchery.

Appendix B1.-Continued.

System: **Coghill District**
Species: **chum salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement [a]	Commercial Harvest [b]
1965	20,768	
1966	10,540	
1967	7,450	
1968	8,780	
1969	8,410	33,829
1970	11,880	26,870
1971	6,600	109,635
1972	28,160	18,503
1973	72,610	104,331
1974	29,280	56,236
1975	3,640	44,667
1976	25,670	166,803
1977	43,940	164,578
1978	18,160	124,686
1979	6,330	62,625
1980	23,340	72,773
1981	2,050	154,686
1982	22,130	387,662
1983	61,410	242,980
1984	19,690	294,741
1985	22,140	266,154
1986	13,140	246,049
1987	24,510	378,094
1988	39,240	358,143
1989	22,680	319,223
1990	26,020	312,160
1991	6,070	45,742
1992	10,003	184,036
1993	8,430	638,853
1994	14,176	557,756
1995	11,596	382,256
1996	19,669	613,432
1997	3,101	723,116
1998	22,764	368,917
1999	5,057	1,310,559
2000	20,488	1,645,139
2001	13,388	1,146,251

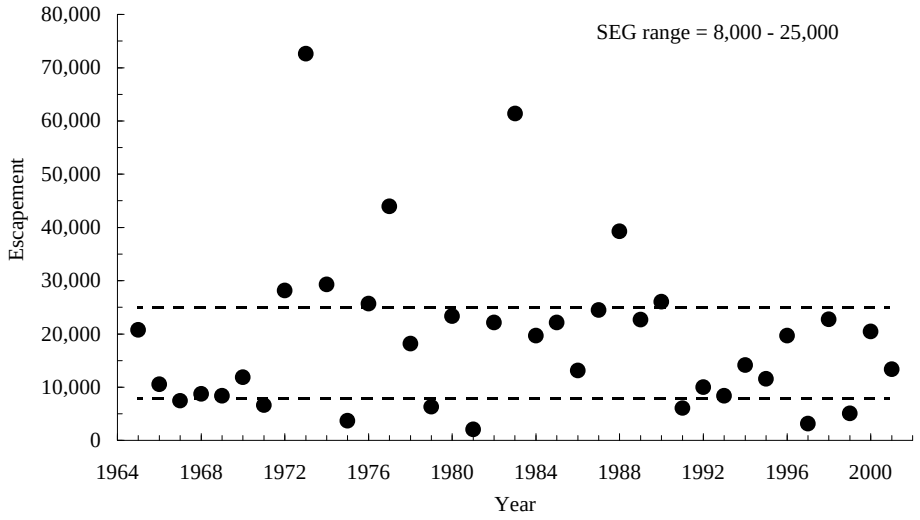
[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[b] Accurate commercial harvest data do not exist between 1965 - 1968. Commercial harvest data are district totals and reflect both hatchery and wild chum salmon.

Appendix B1.-Continued.

System: **Coghill District**
Species: **chum salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix B2.-Escapement goal for Eastern District chum salmon.

System: **Eastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Purse Seine
Previous Escapement Goal:	87,200 - 109,000 (1977)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	50,000 - 130,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1960.
Summary:	
Data Quality	Fair
Data Type	Fixed-wing aerial surveys, commercial harvest[a] by district, and sporadic age data.
Contrast	15.9
Criteria for SEG	high contrast, at least moderate exploitation
25th-75th Percentile	49,730 - 129,910
Years within recommended SEG	21 of 37
Comments	The goal represents an index rather than an estimate of total spawner abundance. Hatchery contribution to the commercial harvest has not been estimated.

[a] Does not include cost recovery or brood harvests from Solomon Gulch Hatchery.

Appendix B2.-Continued.

System: **Eastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement [a]	Commercial Harvest [b]
1965	69,180	
1966	75,690	
1967	74,570	
1968	48,960	
1969	58,690	88,420
1970	34,430	73,355
1971	49,730	164,204
1972	112,950	0
1973	213,170	330,630
1974	72,010	0
1975	30,040	15,709
1976	16,260	69,421
1977	47,880	248,388
1978	90,250	261,522
1979	42,630	147,245
1980	26,720	169,463
1981	71,560	805,706
1982	146,120	583,365
1983	143,800	391,472
1984	129,190	401,130
1985	111,310	556,781
1986	126,690	848,472
1987	183,620	843,084
1988	258,560	812,753
1989	112,080	341,142
1990	115,100	153,344
1991	86,360	10,557
1992	48,804	5,458
1993	54,102	0
1994	40,476	42,447
1995	75,655	52,113
1996	137,908	340,398
1997	93,146	446,757
1998	86,227	107,854
1999	242,713	106,966
2000	196,253	240,229
2001	198,683	258,569

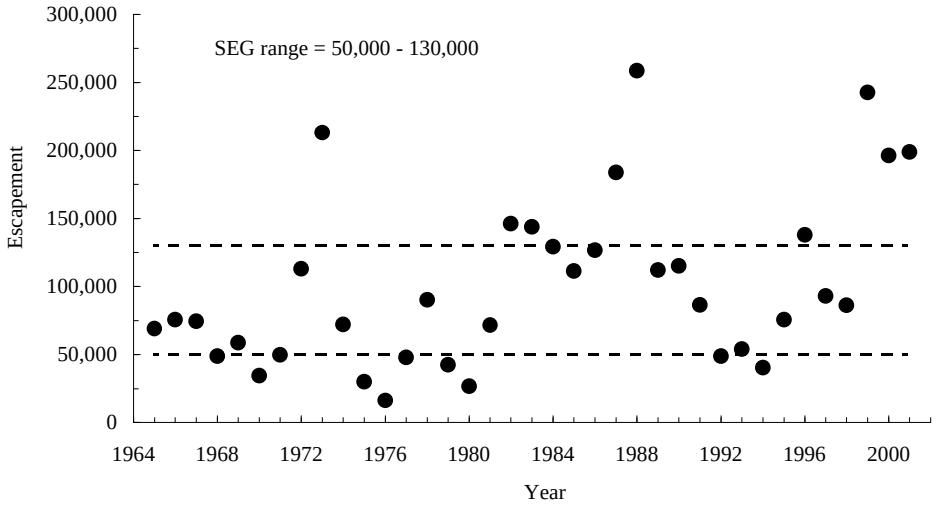
[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[b] Accurate commercial harvest data do not exist between 1965-1968. Commercial harvest data are district totals and reflect both hatchery and wild chum salmon.

Appendix B2.-Continued.

System: **Eastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix B3.-Escapement goal for Northern District chum salmon.

System: **Northern District**
Species: **chum salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Purse Seine
Previous Escapement Goal:	29,400 - 36,750 (1977)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	20,000 - 60,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1960.
Summary:	
Data Quality	Fair
Data Type	Fixed-wing aerial surveys, commercial harvest by district.
Contrast	34.8
Criteria for SEG	high contrast, at least moderate exploitation
25th-75th Percentile	20,980 - 55,510
Years within recommended SEG	20 of 37
Comments	The goal represents an index rather than an estimate of total spawner abundance. Hatchery contribution to the commercial harvest has not been estimated.

Appendix B3.-Continued.

System: **Northern District**
Species: **chum salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement [a]	Commercial Harvest [b]
1965	20,980	
1966	24,870	
1967	23,270	
1968	10,620	
1969	17,340	33,699
1970	4,020	36,097
1971	11,870	134,323
1972	70,760	859
1973	140,030	132,610
1974	55,510	500
1975	8,910	13,049
1976	29,430	67,601
1977	48,600	67,925
1978	27,480	95,597
1979	17,320	13,892
1980	27,880	126,628
1981	28,670	450,531
1982	68,580	166,281
1983	85,720	176,382
1984	59,080	229,166
1985	33,410	163,577
1986	50,740	251,558
1987	38,700	372,630
1988	75,420	224,851
1989	46,470	193,559
1990	112,480	75,466
1991	19,080	5,541
1992	12,903	14,662
1993	24,975	3,199
1994	23,942	26,743
1995	28,899	5,812
1996	55,568	11,432
1997	19,429	5,054
1998	28,867	57,088
1999	36,691	11,300
2000	23,655	9,894
2001	75,473	9,602

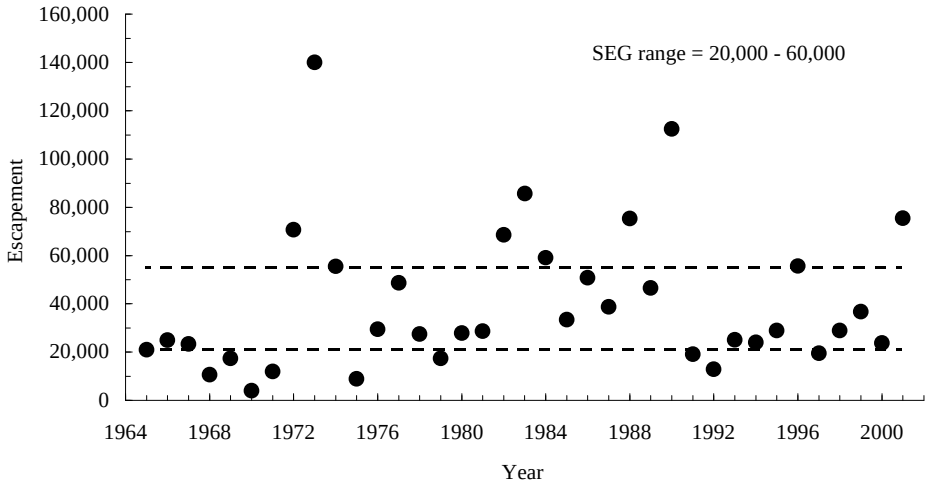
[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[b] Accurate commercial harvest data do not exist between 1965-1968. Commercial harvest data are district totals and reflect both hatchery and wild chum salmon.

Appendix B3.-Continued.

System: **Northern District**
Species: **chum salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix B4.-Escapement goal for Northwestern District chum salmon.

System: **Northwestern District**
Species: **chum salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Purse Seine
Previous Escapement Goal:	19,000 - 23,700 (1977)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	5,000 - 19,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1960.
Summary:	
Data Quality	Fair
Data Type	Fixed-wing aerial surveys, commercial harvest by district.
Contrast	94.8
Criteria for SEG	high contrast, at least moderate exploitation
25th-75th Percentile	5,770 - 18,907
Years within recommended SEG	21 of 37
Comments	The goal represents an index rather than an estimate of total spawner abundance. Hatchery contribution to the commercial harvest has not been estimated.

Appendix B4.-Continued.

System: **Northwestern District**
Species: **chum salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement [a]	Commercial Harvest [b]
1965	18,907	
1966	5,770	
1967	1,670	
1968	800	
1969	780	37,599
1970	2,720	33,142
1971	5,600	83,446
1972	22,980	0
1973	13,250	35,306
1974	6,580	2,912
1975	430	8,179
1976	8,300	24,304
1977	10,090	22,929
1978	12,940	0
1979	8,770	22,178
1980	3,060	14,688
1981	15,130	12,349
1982	21,880	107,185
1983	31,660	136,365
1984	7,920	78,895
1985	13,290	78,266
1986	17,420	75,064
1987	26,460	71,116
1988	40,780	14,063
1989	27,430	7,862
1990	37,020	4,591
1991	8,960	0
1992	11,072	0
1993	18,966	0
1994	12,992	0
1995	4,883	0
1996	24,405	0
1997	8,387	0
1998	7,553	0
1999	4,544	0
2000	10,150	581
2001	6,373	0

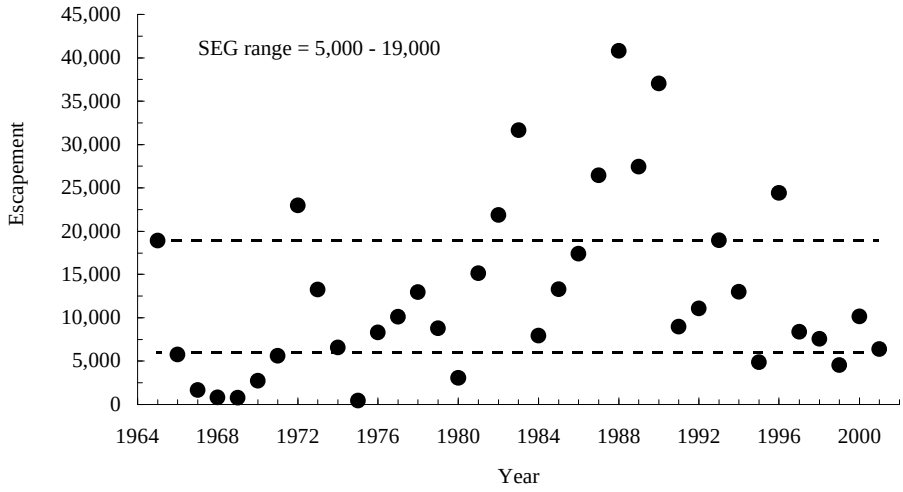
[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

[b] Accurate commercial harvest data do not exist between 1965-1968. Commercial harvest data are district totals and reflect both hatchery and wild chum salmon.

Appendix B4.-Continued.

System: **Northwestern District**
Species: **chum salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix B5.-Escapement goal for Southeastern District chum salmon.

System: **Southeastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Purse Seine
Previous Escapement Goal:	20,000 - 25,000 (1977)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	15,000 - 20,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1960.
Summary:	
Data Quality	Fair
Data Type	Fixed-wing aerial surveys, commercial harvest and age data.
Contrast	86.9
Criteria for SEG	high contrast, at least moderate exploitation
25th-75th Percentile	6,450 - 34,969
Years within recommended SEG	2 of 32 (16 of 32 are within or above the recommended SEG).
Comments	The goal represents an index rather than an estimate of total spawner abundance. Southeastern district commercial harvest estimates have little to zero hatchery influence, allowing brood table construction and estimation of MSY resulting in the recommended goal.

Appendix B5.-Continued.

System: **Southeastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement [a]	Total Return [b]	R / S	Yield [c]
1970	7,950	30,038	3.8	22,088
1971	6,450	35,267	5.5	28,817
1972	26,990	26,990	1.0	0
1973	48,080	109,477	2.3	61,397
1974	3,200	3,200	1.0	0
1975	2,850	7,437	2.6	4,587
1976	770	6,619	8.6	5,849
1977	8,280	29,314	3.5	21,034
1978	6,550	9,892	1.5	3,342
1979	5,140	31,373	6.1	26,233
1980	6,710	35,940	5.4	29,230
1981	16,010	169,311	10.6	153,301
1982	25,260	39,504	1.6	14,244
1983	21,410	41,758	2.0	20,348
1984	8,650	67,402	7.8	58,752
1985	4,470	58,677	13.1	54,207
1986	8,830	45,733	5.2	36,903
1987	44,020	76,901	1.7	32,881
1988	66,930	69,409	1.0	2,479
1989	22,640	23,405	1.0	765
1990	7,275	7,487	1.0	212
1991	9,203	9,203	1.0	0
1992	3,881	3,881	1.0	0
1993	19,172	19,172	1.0	0
1994	4,057	4,057	1.0	0
1995	23,200	23,240	1.0	40
1996	47,334	47,334	1.0	0
1997	43,274	46,526	1.1	3,252
1998	52,103	56,788	1.1	4,685
1999	36,181	119,328	3.3	83,147
2000	34,969	106,534	3.0	71,565
2001	37,526	82,019	2.2	44,493

[a] The chum salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

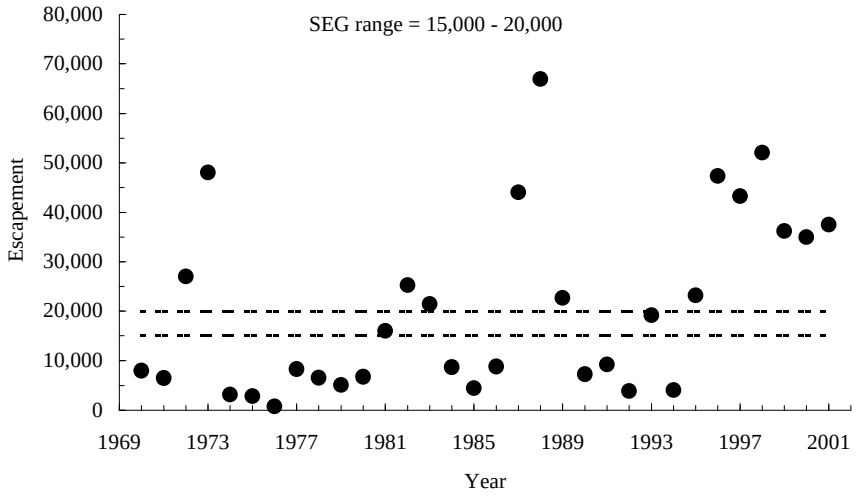
[b] There has been little to no hatchery influence in the Southeastern district; therefore, the total return estimate is a total of commercial harvest and aerial escapements.

[c] Yield is total return minus escapement.

Appendix B5.-Continued.

System: **Southeastern District**
Species: **chum salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



APPENDIX C.
SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR COHO SALMON OF PRINCE WILLIAM SOUND

Appendix C1.-Escapement goal for Bering River Delta coho salmon.

System: **Bering River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries Management
Primary Fishery:	Commercial Drift Gillnet
Previous Escapement Goal:	13,000 - 33,000 (1991)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	13,000 - 33,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Peak annual aerial surveys; 17 years of data available
Summary:	
Data Quality	good
Data Type	aerial surveys, harvests, ages
Contrast	13.4
Criteria for SEG	high contrast due to one large escapement in 1985, but without this escapement contrast of 4.3 is medium
25th-75th percentile	15,700 - 28,200
Years within recommended SEG	12 of 17
Comments	The goal represents an index rather than a total estimate of spawner abundance. Only surveys conducted in the same systems annually since 1984 were used to evaluate the goal. Surveys were often hindered by wind, rain and high and turbid water.

Appendix C1.-Continued.

System: **Bering River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement[a]	Commercial Harvest[b]
1984	24,500	214,632
1985	74,500	419,276
1986	9,410	115,809
1987	5,540	15,864
1988	11,345	86,539
1989	14,340	26,952
1990	23,790	42,952
1991	29,840	110,951
1992	15,700	125,616
1993	28,200	115,833
1994	26,700	259,003
1995	25,300	282,045
1996	25,800	93,763
1997	40,500	97
1998[c]		12,284
1999	28,090	9,852
2000	25,330	56,329
2001	28,807	2,715

[a] Calculated as fixed-wing peak aerial survey from 5 index systems surveyed annually since 1984: Bering River, Bering Lake, Controller Bay streams, Katalla River, and Nichawak River.

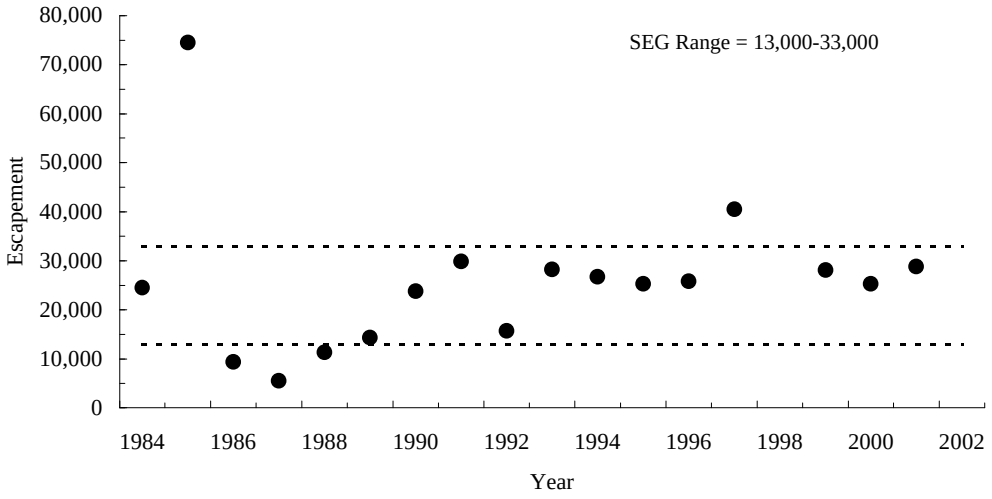
[b] There are no estimates of sport or subsistence harvests.

[c] No peak estimate available due to weather conditions and timing of surveys.

Appendix C1.-Continued.

System: **Bering River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix C2.-Escapement goal for Copper River Delta coho salmon.

System: **Copper River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries Management
Primary Fishery:	Commercial Drift Gillnet
Previous Escapement Goal:	32,000 - 67,000 (1991)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	32,000 - 67,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Peak annual aerial surveys; 20 years of data available
Summary:	
Data Quality	good
Data Type	aerial surveys, harvests, ages
Contrast	3.9
Criteria for SEG	low, though very near medium, contrast
15th-85th percentile	28,903 - 54,388
Years within reccommended SEG	14 of 20
Comments	The goal represents an index rather than a total estimate of spawner abundance. Only surveys conducted in the same systems annually since 1981 were used to evaluate the goal. Surveys were often hindered by wind, rain and high and turbid water. Counts have increased at Ibek Creek since 1998 as a result of decreasing glacial turbidity from the Scott River.

Appendix C2.-Continued.

System: **Copper River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Return Year	Wild Escapement[a]	Harvest		
		Commercial	Sport[b]	Subsistence
1981	43,300	310,154		104
1982	39,925	454,763		106
1983	59,700	234,243	52	57
1984	62,525	382,432	150	135
1985	96,410	587,990	76	83
1986	25,150	295,980	244	47
1987	26,145	111,599	651	14
1988	25,025	315,568	291	42
1989	37,595	194,454	207	51
1990	37,980	246,797	14	82
1991	53,450	385,086	68	38
1992	42,790	291,627	113	42
1993	29,390	281,469	78	29
1994	40,610	677,633	266	67
1995	31,530	542,658	39	31
1996	42,130	193,042	439	47
1997	51,380	18,656	302	1,777
1998[c]		108,232	119	680
1999	41,295	153,061	577	682
2000	42,120	304,944	514	
2001	39,476	251,473		

[a] Calculated as fixed-wing peak aerial survey from 15 index systems surveyed annually since 1981: Eyak Lake, Goat Mountain streams, Hatchery Creek, Ibek Creek, Little Martin Lake, Martin Lake, Martin River, Martin Slough, McKinley Creek, Power Creek, Ragged Point River/Lake, Salmon Creek, 39 Mile Creek, Tokun River/Lake, and 26/27 Mile Creek.

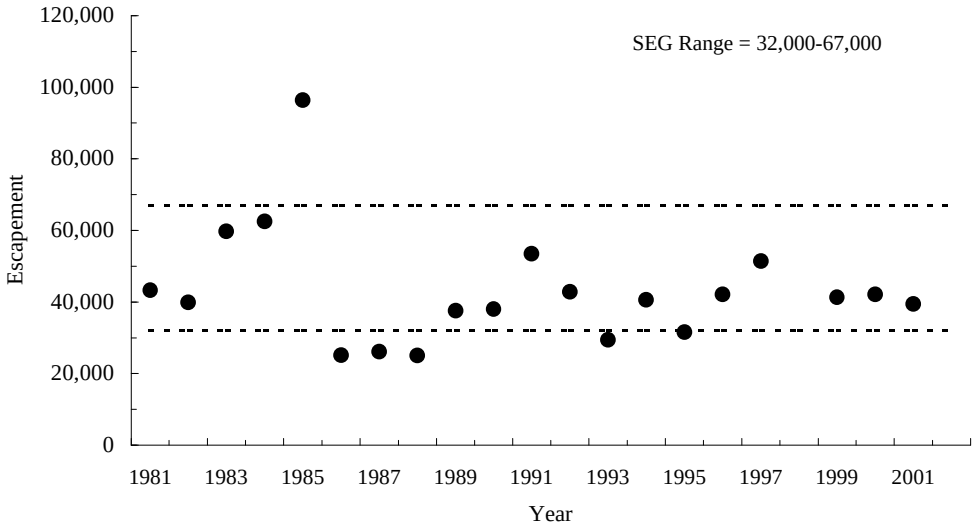
[b] From Statewide Harvest Survey.

[c] No peak estimate available due to weather conditions and timing of surveys.

Appendix C2.-Continued.

System: **Copper River Delta District**
Species: **coho salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



APPENDIX D.
SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR PINK SALMON OF PRINCE WILLIAM SOUND

Appendix D1.-Escapement goal for even-year pink salmon.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **even year**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Purse Seine
Previous Escapement Goal:	1,370,000 - 1,675,000 (PWS even-year total, 1990)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	1,250,000 - 2,750,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys, 1960 - 2001.
Summary:	
Data Quality	Good
Data Type	Fixed-wing aerial surveys, commercial harvest[a] data, coded-wire tag (CWT) hatchery contribution estimates beginning in brood year 1985, and thermally marked otolith estimates beginning in brood year 1995. Spring fry/egg densities for brood years 1960-1994.
Contrast	7.3
Criteria for SEG	medium contrast, variability in escapement estimates
Years within recommended SEG	11 of 21
Comments	The goal represents an index, rather than an estimate of total spawner abundance.

[a] Does not include hatchery cost recovery or brood harvests.

Appendix D1.-Continued.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **even year**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[a]	Intertidal Fry Density[b]	Yield[c]
1960	1,350,722		7,409,604
1962	2,018,010	146.74	4,030,566
1964	1,841,680	116.71	2,280,908
1966	1,423,170	80.98	2,185,508
1968	1,156,510	187.38	2,632,706
1970	979,220	123.10	-283,257
1972	641,180	99.20	765,713
1974	958,120	157.30	2,987,135
1976	926,260	179.90	2,897,594
1978	1,145,010	237.23	13,067,293
1980	1,671,940	164.73	14,671,058
1982	2,274,570	327.37	19,571,165
1984	4,031,860	200.67	1,764,097
1986	960,220	221.61	906,716
1988	964,530	242.97	13,454,166
1990	1,325,852	176.72	862,358
1992	555,105	61.60	8,889,016
1994	1,413,184	221.24	6,240,973
1996	1,483,336		4,257,643
1998	1,420,105		6,086,528
2000	1,659,028		

[a] The pink salmon escapement index is estimated from the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

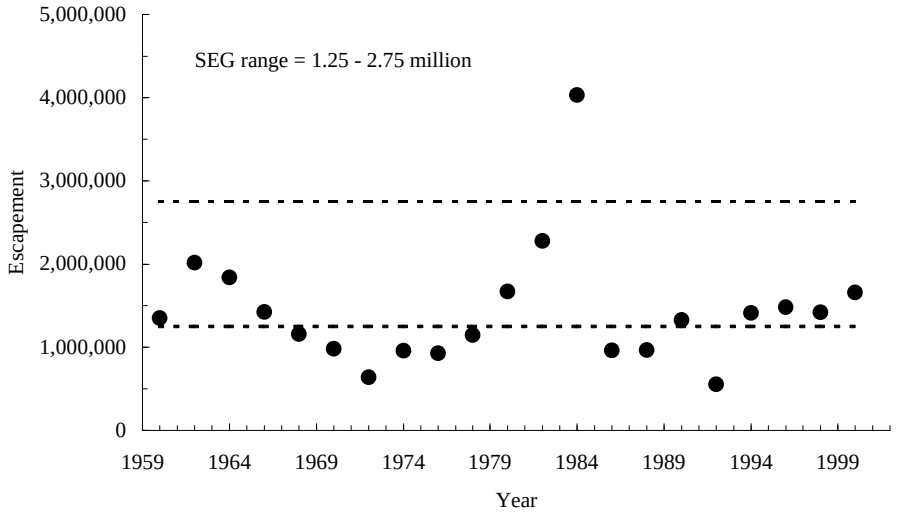
[b] Intertidal fry density was measured as the number of live eggs and fry per m^2 of intertidal stream bottom. Fry densities were last estimated in spring, 1995.

[c] Yield is total return minus escapement. Total wild pink salmon harvest was estimated by subtracting coded-wire tag (CWT) and thermally marked otolith hatchery estimates from total commercial harvest.

Appendix D1.-Continued.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **even year**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix D2.-Escapement goal for odd-year pink salmon.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **odd year**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Purse Seine
Previous Escapement Goal:	1,481,000 - 1,811,200 (PWS odd-year total, 1990)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	1,250,000 - 2,750,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys, 1960 - 2001.
Summary:	
Data Quality	Good
Data Type	Fixed-wing aerial surveys, commercial harvest[a] data, coded-wire tag (CWT) hatchery contribution estimates beginning in brood year 1985, and thermally marked otolith estimates beginning in brood year 1995. Spring fry/egg densities estimated for brood years 1961-1993
Contrast	6.5
Criteria for SEG	medium contrast, variability in escapement estimates.
Years within recommended SEG	14 of 21
Comments	The goal represents an index, rather than an estimate of total spawner abundance.

[a] Does not include hatchery cost recovery or brood harvests.

Appendix D2.-Continued.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **odd year**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[b]	Intertidal Fry Density[c]	Yield[d]
1961	2,198,980	285.09	4,452,138
1963	1,355,740	251.38	2,080,687
1965	975,956	197.98	2,492,644
1967	842,260	136.81	4,390,889
1969	404,570	254.65	8,018,944
1971	1,112,550	118.07	2,169,338
1973	1,225,010	162.85	4,493,355
1975	1,265,560	311.24	4,120,507
1977	1,298,170	305.21	15,977,422
1979	2,217,280	356.67	18,009,653
1981	1,713,080	537.15	9,148,037
1983	2,163,100	364.75	18,051,533
1985	2,621,330	372.96	10,860,291
1987	1,466,240	285.81	5,338,102
1989 [a]	1,272,770	270.56	8,022,686
		330.00	
1991	1,837,165	212.54	1,029,203
1993	1,066,469	220.30	2,325,832
1995	1,190,184	242.75	3,199,402
1997	1,422,688		7,991,096
1999	2,462,871		6,364,497
2001	2,000,386		

[a] Two rounds of fry digs were completed due to the Exxon Valdez oil spill.

[b] The pink salmon escapement index is the area under the curve of weekly aerial survey counts adjusted for 17.5 days stream life.

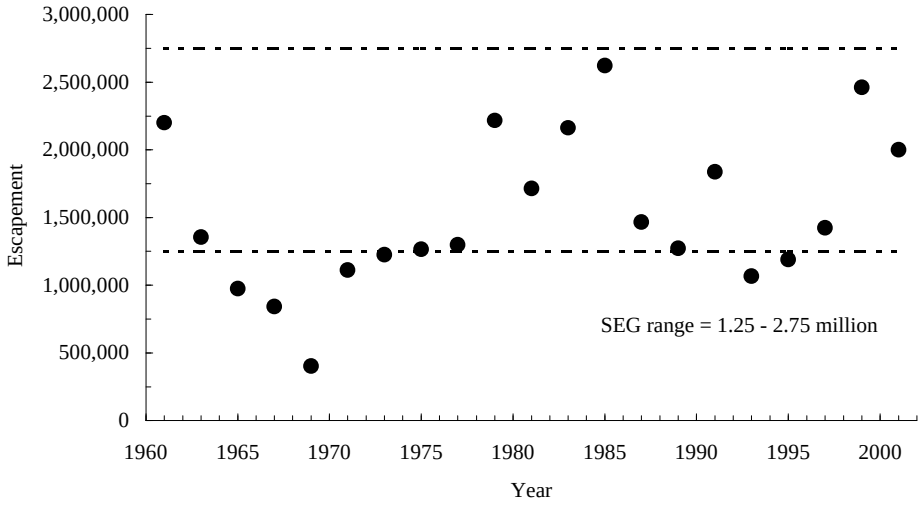
[c] Intertidal fry density was measured as the number of live eggs and fry per m^2 of intertidal stream bottom. Fry densities were last estimated in spring, 1995.

[d] Yield is total return minus escapement. Total wild pink salmon harvest was estimated by subtracting coded-wire tag (CWT) and thermally marked otolith hatchery estimates from total commercial harvest.

Appendix D2.-Continued.

System: **Prince William Sound**
Species: **pink salmon**
Stock Unit: **odd year**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



APPENDIX E.
SUPPORTING INFORMATION FOR ESCAPEMENT GOALS FOR SOCKEYE SALMON OF PRINCE WILLIAM SOUND

Appendix E1.-Escapement goal for Coghill Lake District sockeye salmon.

System: **Coghill Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet and Purse Seine
Previous Escapement Goal:	20,000 - 30,000 (1992)
Escapement Goal Type:	BEG
Recommended Escapement Goal:	20,000 - 40,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Weir escapement enumeration, 1974 - 2001. Visual counts were made from a tower and partial weir from 1960 - 1973. Visual counts were made during fixed-wing aerial and foot surveys in 1960 , 1964 , 1968 , and 1971.
Summary:	
Data Quality	Excellent
Data Type	Weir escapement enumeration, commercial harvest data, escapement and commercial harvest age data, limnology data available from 1988 - 1996.
Contrast	25.8
Criteria for BEG	high contrast
25th - 75th percentile	28,097 - 60,389
Years within recommended BEG	4 of 32, 26 of 32 have been within or above the escapement range.
Comments	Limnology data suggest Coghill Lake is a zooplankton limited system. As a result of limnology work completed in the 1980s and 1990s, observed stock declines, and Ricker spawner-recruit analysis, the escapement goal was returned to 20,000-30,000 sockeye salmon in 1992.

Appendix E1.-Continued.

System: **Coghill Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement	Total Return[b]	R/S	Yield[c]
1962[a]	26,866	54,520	2.0	27,654
1963[a]	63,984	63,949	1.0	-35
1964[a]	22,200	163,130	7.3	140,930
1965[a]	62,500	77,666	1.2	15,166
1966[a]	82,500	86,158	1.0	3,658
1967[a]	33,000	153,332	4.6	120,332
1968[a]	11,800	137,508	11.7	125,708
1969[a]	81,000	91,748	1.1	10,748
1970[a]	35,200	220,866	6.3	185,666
1971[a]	15,000	46,728	3.1	31,728
1972[a]	51,000	218,568	4.3	167,568
1973[a]	55,000	233,688	4.2	178,688
1974	22,334	110,825	5.0	88,491
1975	34,855	191,528	5.5	156,673
1976	9,056	173,531	19.2	164,475
1977	31,562	1,251,048	39.6	1,219,486
1978	42,284	70,303	1.7	28,019
1979	48,281	150,407	3.1	102,126
1980	142,253	473,656	3.3	331,403
1981	156,112	496,238	3.2	340,126
1982	180,314	612,159	3.4	431,845
1983	38,783	106,297	2.7	67,514
1984	63,622	203,086	3.2	139,464
1985	163,342	16,598	0.1	-146,744
1986	74,135	26,918	0.4	-47,217
1987	187,263	60,053	0.3	-127,210
1988	72,023	50,495	0.7	-21,528
1989	36,881	9,410	0.3	-27,471
1990	8,250	26,127	3.2	17,877
1991	9,701	153,809	15.9	144,108
1992	29,642	114,127	3.9	84,485
1993	9,232	67,466	7.3	58,234
1994	7,264	27,939	3.8	20,675
1995	30,382	317,508	10.5	287,126

[a] A partial weir and tower were used to enumerate sockeye salmon escapement into Coghill Lake.

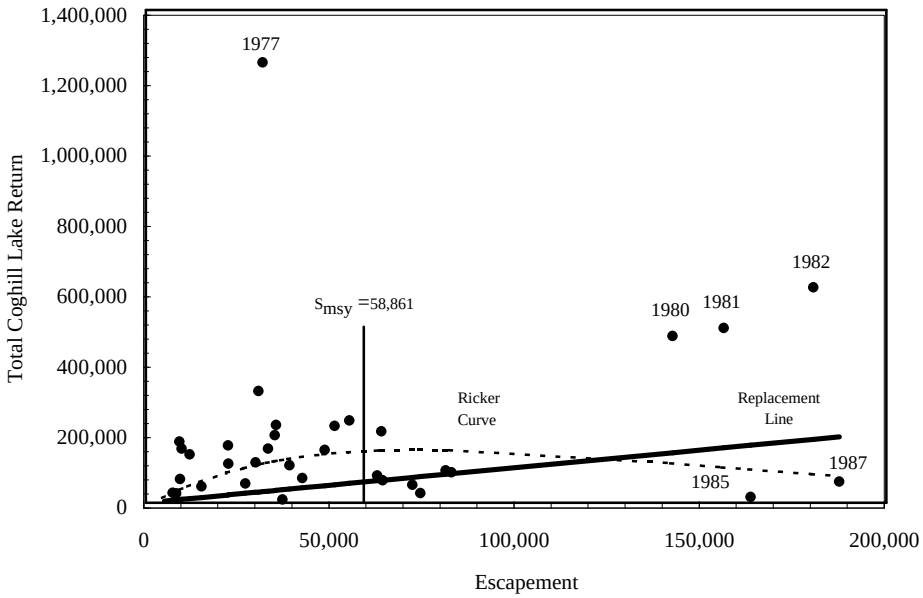
[b] Total return was calculated as escapement plus total Coghill District commercial harvest plus sockeye salmon harvested in subdistricts 225-10 and 225-20 by drift and set gillnet.

[c] Calculated as total return minus escapement.

Appendix E1.-Continued.

System: **Coghill Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Fitted Ricker curve, line of replacement, and actual data for Coghill Lake sockeye salmon.



Notes: S_{msy} = Escapement which will result in maximum sustained yield (maximum distance between Ricker Curve and Replacement Line).

Appendix E2.-Escapement goal for Eshamy Lake District sockeye salmon.

System: **Eshamy Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet and Set Gillnet
Previous Escapement Goal:	30,000 - 40,000 (1986)
Escapement Goal Type:	BEG
Recommended Escapement Goal:	20,000 - 40,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Weir escapement enumeration, 1960 - 2001. There was no weir in place in 1987 or 1998.
Summary:	
Data Quality	Excellent
Data Type	Weir escapement enumeration, commercial harvest data, escapement and commercial harvest age data, and limnology data available from 1982 -1985, and 1995.
Contrast	90.2
Criteria for BEG	high contrast
25th - 75th percentile	10,348 - 30,627
Years within recommended BEG	8 of 25
Comments	Limnology data suggests Eshamy Lake is spawning area limited and is capable of producing ~1,000,000 sockeye salmon smolt with ~40,000 spawners.

Appendix E2.-Continued.

System: **Eshamy Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement	Total Return[b]	R/S	Yield[c]
1970	11,460	11,690	1.02	230
1971	954	6,667	6.99	5,713
1972	28,683	59,976	2.09	31,293
1973	10,202	34,411	3.37	24,209
1974	633	15,946	25.19	15,313
1975	1,724	31,355	18.19	29,631
1976	19,367	178,061	9.19	158,694
1977	11,746	38,453	3.27	26,707
1978	12,580	36,904	2.93	24,324
1979	12,169	39,724	3.26	27,555
1980	44,263	270,623	6.11	226,360
1981	23,048	30,841	1.34	7,793
1982	6,782	51,290	7.56	44,508
1983	10,348	51,162	4.94	40,814
1984	36,121	117,761	3.26	81,640
1985	26,178	58,163	2.22	31,985
1986	6,949	39,946	5.75	32,997
1987[a]				
1988	31,747	93,876	2.96	62,129
1989	57,106	70,390	1.64	36,770
1990	14,191	58,447	4.96	56,199
1991	45,814	23,930	1.28	12,633
1992	30,627	24,468	0.78	-6,697
1993	34,657	61,820	0.71	-10,189
1994	23,910	54,750	2.59	37,910
1995	15,292	27,986	3.58	39,458

[a] Eshamy Lake weir was not in place in 1987.

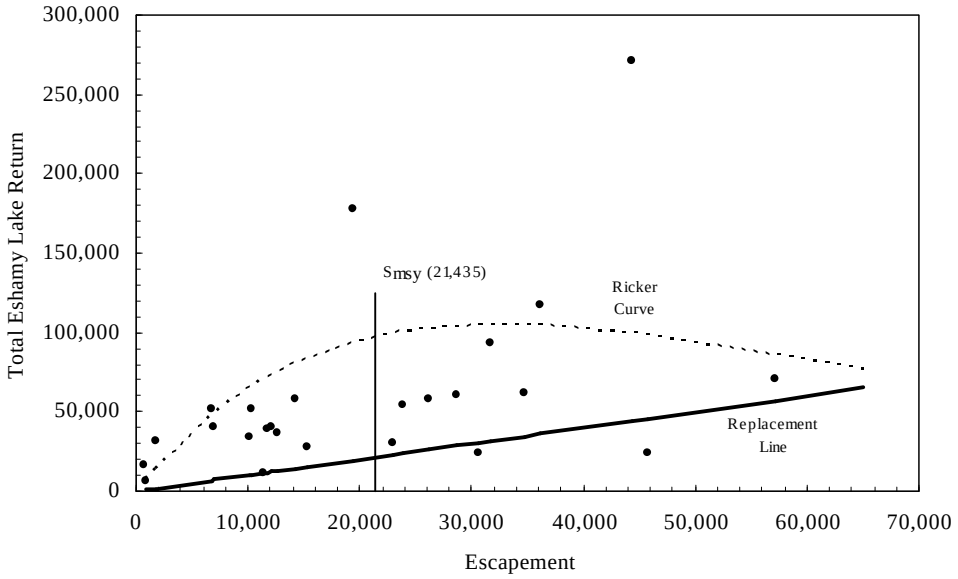
[b] Total return was calculated as escapement plus total Eshamy District commercial harvest minus hatchery contribution estimates from sockeye salmon returning to Main Bay Hatchery.

[c] Calculated as total return minus escapement.

Appendix E2.-Continued.

System: **Eshamy Lake District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Fitted Ricker curve, line of replacement, and actual data for Eshamy Lake sockeye salmon.



Notes: S_{msy} = Escapement which will result in maximum sustained yield (maximum distance between Ricker Curve and Replacement Line).

Appendix E3.-Escapement goal for Upper Copper River District sockeye salmon.

System: **Upper Copper River District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries and Sport Fish
Primary Fishery:	Commercial Drift Gillnet, Subsistence (Dipnet and Fishwheel)
Previous Escapement Goal:	300,000 (1972)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	300,000 - 500,000
Optimal Escapement Goal:	none
Inriver Goal [a]:	announced annually
Action Points	If >50,000 weekly harvestable surplus past Miles Lake sonar, supplemental permits for 10 additional sockeye salmon for Chitina Subdistrict subsistence users that have met seasonal limit. See 5 AAC 01.630
Escapement Enumeration:	Miles Lake single beam hydroacoustic sonar, and fixed-wing aerial surveys upriver.
Summary:	
Data Quality	Good
Data Type	Bendix sonar counts from the Miles Lake site; 24 years of wild stock estimates. Sport and subsistence harvests, and age composition for subsistence harvests.
Contrast	4.4 (1979-2001)
Criteria for SEG	medium contrast
15th-85th percentile	300,575 - 500,571
Years within recommended SEG	16 of 24; 20 of 24 within or above the SEG range.
Comments	Better estimates of escapement with Miles Lake sonar starting in 1978; however, total return estimates are not possible as the commercial harvest cannot be allocated to upriver or lower river stocks.

[a] See the Copper River District Salmon Management Plan (5 AAC 24.360) for complete details.

Appendix E3.-Continued.

System: **Upper Copper River District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[a]	Harvest[b] Sport	Harvest[b] Sub/PU[c]	Yield[d]
1978	67,278	1,606	25,783	1,179,327
1979	169,717	1,599	33,096	1,580,459
1980	200,916	2,109	31,041	912,140
1981	437,391	1,523	65,168	439,615
1982	342,259	3,343	105,432	1,423,953
1983	391,100	2,619	110,794	383,640
1984	433,743	3,267	76,177	835,653
1985	332,121	4,752	61,551	711,235
1986	387,877	4,137	68,495	1,226,741
1987	353,994	4,876	76,598	1,364,089
1988	295,284	3,038	71,525	1,364,013
1989	378,545	4,509	84,138	1,710,880
1990	401,635	3,569	98,197	1,385,160
1991	359,299	5,511	117,188	2,521,865
1992	376,043	4,560	131,956	2,567,484
1993	557,715	5,288	146,724	1,863,980
1994	448,471	6,533	162,301	1,211,312
1995	349,663	6,068	131,522	922,404
1996	585,554	11,851	147,059	819,614
1997	748,105	12,293	231,534	
1998	500,236	11,184	201,624	
1999	442,474	11,101	219,027	
2000	307,043	12,361	167,353	
2001	501,172	8,072	214,966	

[a] Wild spawning escapements after 1977 were estimated as the Miles Lake sonar index minus subsistence, personal use and sport harvests in addition to the Gulkana Hatchery brood stock and excess brood escapement.

[b] The sport and subsistence/personal use harvests include both wild and hatchery stocks. Prior to 1995, no scanning for coded wire tags was completed in the upper Copper River subsistence or personal use fisheries.

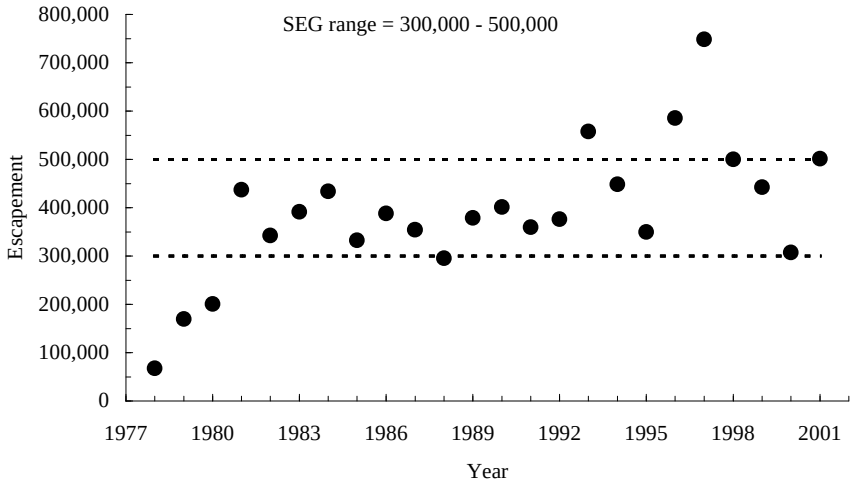
[c] Subsistence and personal use.

[d] Yield is total brood year return minus escapement. Shown is the total yield for both upper Copper River and the Copper River delta because we currently have no method to separate the stock groups in the commercial harvest.

Appendix E3.-Continued.

System: **Upper Copper River District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix E4.-Escapement goal for Copper River Delta District sockeye salmon.

System: **Copper River Delta District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet
Previous Escapement Goal:	74,000 - 105,000 (1991)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	55,000 - 130,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Aerial Surveys, 1964 - 2001.
Summary:	
Data Quality	Good
Data Type	Fixed-wing aerial surveys since 1964, commercial harvest data, escapement and commercial harvest age data.
Contrast	7.1
Criteria for SEG	medium contrast
25th - 75th percentile	56,585 - 99,485
Years within recommended SEG	21 of 30
Comments	The goal represents an index, rather than an estimate, of total spawner abundance.

Appendix E4.-Continued.

System: **Copper River Delta District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

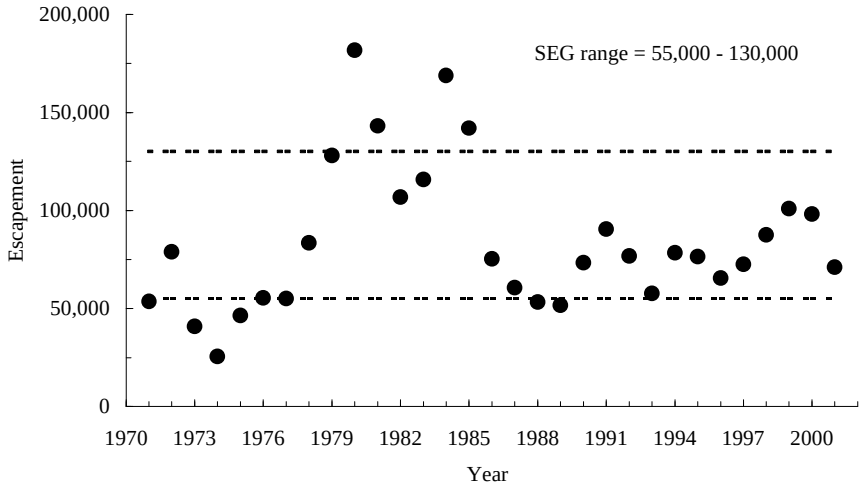
Brood Year	Escapement[a]
1971	53,647
1972	78,942
1973	40,970
1974	25,651
1975	46,475
1976	55,450
1977	55,144
1978	83,469
1979	127,900
1980	181,750
1981	143,050
1982	106,770
1983	115,750
1984	168,840
1985	142,050
1986	75,295
1987	60,698
1988	53,315
1989	51,700
1990	73,345
1991	90,500
1992	76,827
1993	57,720
1994	78,370
1995	76,370
1996	65,470
1997	72,563
1998	87,500
1999	100,925
2000	98,045
2001	71,065

[a] Escapement calculated as the peak aerial counts from 21 survey sites.

Appendix E4.-Continued.

System: **Copper River Delta District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



Appendix E5.-Escapement goal for Bering River District sockeye salmon.

System: **Bering River Delta District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Description of stock and escapement goals.

Regulatory Area:	Prince William Sound - Central Region
Management Division:	Commercial Fisheries
Primary Fishery:	Commercial Drift Gillnet
Previous Escapement Goal:	26,000 - 38,000 (1991)
Escapement Goal Type:	SEG
Recommended Escapement Goal:	23,000 - 35,000
Optimal Escapement Goal:	none
Inriver Goal:	none
Action Points	none
Escapement Enumeration:	Fixed-wing aerial surveys since 1970.
Summary:	
Data Quality	Good
Data Type	Fixed-wing aerial surveys since 1970, commercial harvest, escapement and commercial harvest age data since 1980.
Contrast	4.1
Criteria for SEG	medium contrast
25th - 75th percentile	23,000 - 33,500
Years within recommended SEG	7 of 13
Comments	The goal represents an index, rather than an estimate of total spawner abundance.

Appendix E5.-Continued.

System: **Bering River District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Data available for analysis of escapement goals.

Brood Year	Wild Escapement[b]	Commercial Harvest	Total Return[c]
1983[a]	41,200	179,273	220,473
1984[a]	48,500	91,784	140,284
1985[a]	24,300	26,561	50,861
1986	18,975	19,038	38,013
1987	26,525	16,926	43,451
1988	13,330	7,152	20,482
1989	23,300	9,225	32,525
1990	19,741	8,332	28,073
1991	32,220	19,181	51,401
1992	55,895	19,721	75,616
1993	27,725	33,951	61,676
1994	26,550	27,926	54,476
1995	33,450	21,585	55,035

[a] Before 1986 Kayak Island subdistrict was included in total harvest inflating total return estimates. Brood year total return data was generated from 1986 through 1995.

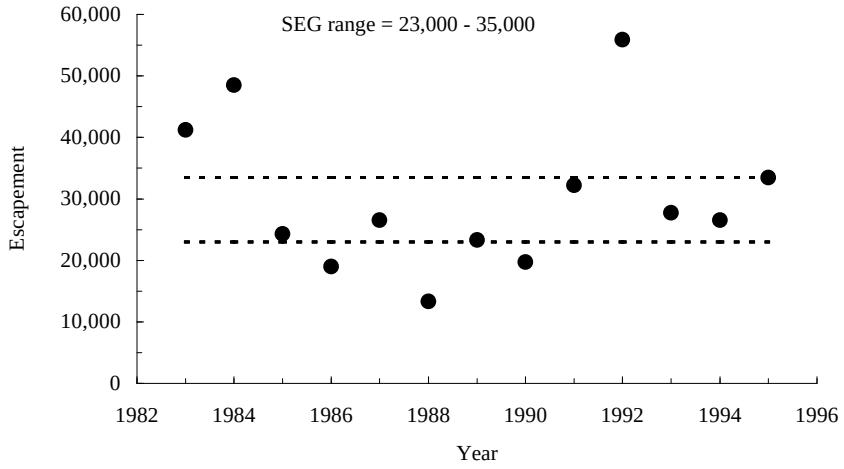
[b] Calculated as peak aerial survey from the seven primary index systems.

[c] Wild escapement plus commercial harvest.

Appendix E5.-Continued.

System: **Bering River District**
Species: **sockeye salmon**
Stock Unit: **N/A**

Observed escapement by year (solid circles) and recommended SEG range (dashed lines).



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