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Stock Assessment of Early Run Skeena River Coho Salmon and Recommendations for Management

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ABSTRACT

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Concerns have previously been expressed for the stock status of early run Skeena River coho salmon because of declining escapement levels. Available data on spawning escapements and subsequent recruitment were analyzed using a Ricker model under various assumptions about fishery interception rates to derive maximum sustainable yield (MSY) escapement levels. A key feature of this analysis was the use of a test fishing index, collected in a consistent manner since 1956, to derive the escapement to the river-mouth, rather than the usual visual observations made on the spawning grounds. The major weakness of the analysis was the number of assumptions that had to be made about the catch distribution of the stock.

An escapement level of 33,000 spawners is recommended to achieve MSY. Recent estimates of spawning escapement levels (1985 to 1987) are only 61 percent of the MSY level. Previous stock concerns appear to be valid and extremely serious. Recommendations for future research and stock monitoring are also made.

Key words: coho salmon, escapement, maximum sustainable yield, Skeena River, stock assessment, stock recruitment, test fishery

RÉSUMÉ

Kadowaki, R. K. 1988. Stock assessment of early run Skeena River coho salmon and recommendations for management. Can. Tech. Rep. Fish. Aquat. Sci. 1638: 29 p.

L'état du stock de saumon coho de la rivière Skeena à montée précoce a déjà fait l'objet de préoccupations à cause du niveau décroissant de l'échappée. Les données accessibles sur les échappées de géniteurs et sur le recrutement ultérieur ont été analysées à l'aide du modèle Ricker en fonction de différentes hypothèses relatives aux taux d'interception des pêches afin de calculer le niveau des échappées pour obtenir le rendement maximal soutenu (RMS). Un élément-clé de cette analyse était le recours à un indice de pêches expérimentales, obtenu d'une façon uniforme depuis 1956, afin de calculer l'échappée à l'embouchure de la rivière, plutôt que par les observations visuelles ordinaires des frayères. La principale faiblesse de l'analyse était le nombre d'hypothèses qui ont dû être formulées au sujet de la répartition des prises du stock.

Une échappée de 33 000 géniteurs est recommandée pour atteindre le RMS. Les estimations récentes des échappées des géniteurs (1985 à 1987) correspondent à seulement 61 pour cent du RMS. Des préoccupations antérieures relatives au stock semblent être valables et très sérieures. On a également formulé des recommandations en ce qui concerne les recherches dans l'avenir et la surveillance du stock.

Mots-clés: saumon coho, échappée, rendement maximal soutenu, rivière Skeena, évaluation du stock, recrutement, pêche expérimentale

INTRODUCTION

The Skeena River, located in north coastal British Columbia (Fig. 1), is the second largest salmon producing watershed in British Columbia. Coho salmon production ranks third in abundance among the five salmon species in the Skeena. Pink and sockeye salmon are by far the dominant species, while both coho and chinook are more abundant than chum salmon. Ocean troll and net fisheries in both northern B.C. and S.E. Alaska as well as inshore net fisheries targeted on pink and sockeye are the primary harvesters of Skeena River coho while in-river Indian food fisheries and sport fisheries harvest smaller shares (Sprout and Kadowaki 1987).

The upper Skeena River and Bulkley River coho stock complex was highlighted as one of three B.C. coho stock groups with documented conservation concerns in the 1986 Pacific Stock Assessment Review Committee (PSARC) Annual Report (Stocker 1987). These stocks are believed to return earlier than lower Skeena coho stocks and to migrate at the same time as sockeye and pink salmon, the targeted species of the river mouth net fishery. There is no directed management for the upper Skeena coho stock in either the troll or net fisheries.

Walters et al. (1982) performed a stock recruitment analysis on aggregated Skeena River coho data and concluded that Skeena coho were not being overharvested. However, escapement information indicates a declining trend for early run coho since the mid-seventies. To date there has been no analytical work done to demonstrate if, and to what degree, this particular stock is being over-harvested. Stock specific data is not available to perform stock recruitment analysis on individual early run coho stocks; however, aggregate catch and escapement statistics can be reconstructed from available data, given the acceptance of a number of assumptions. Other approaches to estimating spawning escapement targets, such as habitat capacity evaluation, are not yet possible for this stock.

The purpose of this report is to define the basic biological parameters necessary to rebuild this stock and to implement a more rigorous management program.

BASIS FOR STOCK DEFINITION

A basic assumption of the analysis is that a significant portion of early run Skeena coho are produced from upper Skeena and Bulkley River streams. Counts at the Moricetown fishway (Milne 1950) and the Babine fence (Jordan et al. 1972, L. Jantz, DFO, Prince Rupert, pers. comm.) tend to support the early run timing of upper Skeena stocks while Lakelse fence data from the 1950s and 1960s (Anon. 1952, D. Crabtree, PBS, Nanaimo, pers. comm.) indicate a later run timing for the coho stocks in the lower Skeena River.

The analysis presented in this report treats early run Skeena coho as a single mixed stock unit; this was done primarily because of the resolution of most of the "hard" data available (i.e. commercial net catch, test fishing indices, age composition) and not due to conclusive biological evidence. From a management perspective this is also the most practical unit to regulate, since most fisheries take place on stock mixtures rather than on individual stocks.

Major component stocks include the Morice River, a tributary of the Bulkley, and the Babine and Bear Rivers, which are tributaries of the upper Skeena River.

TRENDS IN INDICES OF ABUNDANCE

Declining trends to the Upper Skeena coho stocks have been documented for spawning escapement as estimated by fishery officers (Fig. 2), the Skeena test fishery index (Fig. 3) and the Babine fence count of coho (Fig. 4) (Stocker 1987). The total Area 4 gillnet coho catch has declined slightly but this trend is misleading (Fig. 5); all of the decline has occurred in September (on late run stocks), while the catch in July has actually increased. The terminal fishery impact on the stock of concern has therefore increased, rather than decreased over this period.

STOCK RECRUITMENT ANALYSIS

GENERAL DESCRIPTION

To estimate the MSY spawning escapement and exploitation rate level for this stock a stock recruitment analysis was performed. The data described below were used to calculate the stock recruitment relationship described by Ricker (1975, p. 282-84).

A key feature of this analysis is the use of the Skeena River test fishery coho index to estimate escapement rather than the fishery officer escapement estimates. This is extremely important in light of the inconsistent nature of the latter record which has caused problems in similar analyses (Healey 1982).

The test fishery, located at the mouth of the Skeena River, was designed to monitor the Skeena sockeye and pink runs and has operated continuously since 1956; coincidentally, it also provides an index of the early run coho escapement. In addition, it provides an obvious method for monitoring the escapement in-season, which will be necessary if this stock is to be managed to an escapement goal. Late run coho are not indexed because

the test fishery is usually terminated by the end of August. A simple reconstruction of the catch of this stock was made using a range of estimates of Skeena stock composition in terminal net fisheries and a range of ocean harvest rates.

DATA SOURCES

The catch, escapement, and age composition data described below (Tables 1 and 2) were used to construct the table of spawning stock and subsequent recruitment (Table 3) used in this analysis.

1) Skeena test fishery coho index to August 24th - This data is available from 1956 to 1987 and provides a consistently collected index of the magnitude of the Skeena coho escapement. Fishery officer estimates of escapement were not used because of the incompleteness of the data and inconsistency in how they were collected. The cumulative test fishing index to August 24th was used since it was the latest date for which data exists for all years.

2) Skeena test fishery sockeye index calibration - A size dependent factor is used to convert the test fishery sockeye index to an estimated sockeye escapement (Kadowaki 1985). The mean postorbital-hypural length of coho from the test fishery for the years 1977 to 1986 (510 mm) was used to derive the conversion factor of 543. The test fishing index to August 24th for the years 1956 to 1987 was then multiplied by this factor to generate the estimated coho escapement past the test fishery. For comparison, the mean deviation of the test fishery estimate for sockeye calculated in this way from the actual sockeye escapement (the bulk of which was counted through the Babine fence) has been approximately 11 percent in the last 19 years (R. Kadowaki 1985, L. Jantz, pers. comm.).

3) Skeena River Indian food fish catch - Although records exist for this catch, the proportion taken from the early part of the run is unknown. For this analysis 25 percent of the catch from 1956 to 1981 has been attributed to the early run. Since 1982, 10 percent of the catch was attributed to the early portion, because of an apparent decline in availability of coho during this time period. These data are considered to be very unreliable since there is no formal program for estimating the food fish catch.

4) Skeena River sport catch - The sport catch of this stock is considered to be minor but increasing. An annual catch of 500 was assumed for the 1950s and 1960s while an annual catch of 1000 was assumed for the 1970s and 1980s.

5) Age composition - The test fishery age composition was used to allocate the total stock to the appropriate brood years for the years 1974 to 1982 and 1984 to 1987. Test fishery samples for 1983 and years prior to 1974 were collected but the data could not be located in time for this analysis. Therefore, the mean age composition for the years of available data was used to partition all other years.

6) Terminal net catch - The cumulative net catch in Area 4 to the third week in August and in Areas 3 and 5 to the second week in August were used to estimate the terminal catch of early run Skeena coho. In this analysis the proportion of the early run Skeena stock in the catch in Areas 3 and 5 was fixed at 10 and 5 percent, respectively, while the proportion in the Area 4 catch was adjusted from 15 to 65 percent in 10 percentage point increments. The best point estimate of this interception rate is 45 percent. These guestimates were developed by the author after discussion with local fishery management staff.

7) Ocean harvest - There are currently no direct estimates of the ocean harvest rate on early run Skeena coho. Coded wire tag recoveries from recent releases are beginning to provide an indication of the harvest distribution of this stock, however, and in time these data should be incorporated to give a better indication of ocean harvest. The ocean harvest rate of Pallant Creek coho on the east coast of the Queen Charlotte Islands is estimated to be approximately 30 percent. Ocean harvest rates of 20, 30 and 40 percent were used to calculate the ocean harvest once the remainder of the total stock had been determined.

POTENTIAL BIASES

The following sources of bias were considered in this analysis:

1) Measurement error in escapement - Although there is a subtle mathematical bias attributable to measurement errors in estimating spawning escapement the main effect is to mask real relationships between spawners and recruits (Walters and Ludwig 1981). This is particularly serious in situations where the stock is in an over-exploited state when active management (data collection) begins, since measurement errors will not allow detection of this condition even after many cycles have elapsed.

In this analysis the time series of data (28 brood years) begins in a period of relatively low exploitation (<50%) and spans a wide range of spawner levels. In addition, as mentioned above, the estimate of spawning escapement used in this analysis (from a test fishing index) has been derived in a consistent manner over this entire period. For this reason the measurement error variance is considered to be low.

Hankin and Healey (1986) pointed out that the number of female spawners should be used instead of total spawners in performing stock recruitment analysis on chinook salmon stocks where maturity schedules are different for the two sexes. There is no evidence of a similar difference in maturity schedules for coho stocks, so this source of bias will not be considered.

2) Measurement error in catch - A greater cause for concern than estimating spawning escapement is measurement error in estimating the total catch of this stock. There is almost no information upon which to base stock

composition estimates for fisheries which harvest this stock. To account for this serious information gap the analysis was performed on a range of assumptions about stock composition.

ASSUMPTIONS AND LIMITATIONS

The major assumptions in this analysis are as follows:

1) Early run Skeena coho behave as a discrete mixture of stocks. In other words, the early and late run portions of stocks which span both run timing periods behave as separate stocks, i.e. impacts on one component cannot be mitigated by compensatory action on the other.

2) The test fishery index is a consistent indicator of the abundance of coho escaping the commercial fishery and the length dependent conversion factor for sockeye is appropriate for coho.

3) The Indian food fish catch and the freshwater sport catch estimates are reasonable. There are no formal programs for monitoring these catches but given the level of catch estimated for these fisheries their impact on the total spawning stock is believed to be small. In localized areas, however, even a small catch can have a significant impact on a particular stock.

4) The estimates of the Skeena contribution to catches in Areas 3 and 5 are reasonable. Given the other possible contributing stocks of coho in these areas and the predominantly northward catch distribution of most coho stocks the catch of Skeena coho to these fisheries is likely to be small.

5) The range of contributions of this stock to the Area 4 fishery is reasonable. The location of the fishery at the mouth and approach routes to the Skeena would imply a significant proportion of maturing Skeena coho in the catch. Stocks from adjacent areas and later timing coastal Area 4 stocks might also contribute significantly, however, so higher values are difficult to justify.

6) The range of ocean harvest rates is reasonable. For the reasons mentioned above this range probably covers the actual value. However, increases in the Southeast Alaska troll catch of coho since the mid-seventies could mean that the ocean harvest rate has not been stable over the period of the analysis. Compensation for this change over time might be considered in future analyses.

7) Using the average age composition for the years 1974 to 1987, (excluding 1983) is reasonable for 1983 and years prior to 1974. There appears to be considerable inter-annual variability in age composition, but in almost all cases three year old fish substantially outnumber four year olds.

8) The Ricker stock recruitment relationship assumes a density dependent (curvilinear) relationship between these two parameters over the range of stock sizes observed. For coho salmon, a model which assumes that production is limited by habitat capacity, such as the Beverton-Holt model, might be more suitable.

The major limitations in this analysis are as follows:

1) The major limitation in this analysis is the number of assumptions that have to be made to derive the spawning stock size and the subsequent recruitment. Given the available data, these assumptions are an essential part of the analysis.

2) The assumptions do not account for inter-annual variability in fishing effort, fish availability, test fishing accuracy, and population age structure. For example, it is quite possible that the ocean harvest rate has been increasing since the 1960s. The effect of not accounting for this in the stock reconstruction would be to overestimate the MSY escapement level since returns from recent low escapements would be under-estimated.

RESULTS OF ANALYSIS

The stock recruitment relationship calculated assuming an ocean harvest rate of 30 percent and an Area 4 stock composition of 45 percent is presented in Figure 6 (All point estimates of stock recruitment parameters were calculated using these percentages). Results of the stock recruitment analysis are summarized in Table 4. Stock recruitment regressions were found to be statistically significant ($p<0.05$) under all assumptions about fishery interception rates.

Maximum Sustainable Yield (MSY) - The point estimate of MSY is 53,000, achieved at a total stock size of 86,000. Depending upon the interception rate assumption used this estimate varied from 31,000 to 78,000.

MSY Escapement - The point estimate of MSY escapement is 33,000 spawners with a 95 percent confidence range of 27,000 to 40,000. Varying assumptions about fishery interception rates and therefore total stock size did not appreciably affect this estimate (Fig. 7). MSY escapement varied fro 29,000 to 35,000 while the 95 percent confidence range varied from an extreme low of 23,000 and an extreme high of 41,000.

MSY Exploitation Rate - The best estimate of MSY exploitation rate is 62 percent. Not unexpectedly, with relatively stable MSY escapement levels, the exploitation rate at MSY under different interception scenarios varied widely from a low of 51 percent to a high of 69 percent (Fig. 8).

STOCK STATUS

Evidence presented in the 1986 coastwide B.C. coho stock assessment report (Stocker 1987) indicated that declining Babine fence counts, test fishing indices and escapement estimates were cause for concern about the status of the early run Skeena coho stock. The results of this analysis indicate that those concerns were justified and that increases in spawning escapement are required immediately if the declining trend is to be reversed and production maximized.

The MSY spawning escapement level for this stock is estimated to be 33,000 fish. This spawning escapement level was reached in fifteen of the first sixteen years of the data record, and only seven times in the next sixteen years (Table 1, Fig. 9). The last time this level was reached was in 1984. In the most recent cycle (1985 to 1987) the average escapement was only 61 percent of the MSY level, indicating an acceleration in the rate of decline of the stock. The exploitation rate on this stock has been at or above MSY levels for most years since the late seventies, averaging 64 percent in the most recent cycle (Table 1 and Fig. 10).

Walters et al. (1982) estimated an optimum escapement for Skeena River coho of 54,000 based on a stock recruitment analysis which used fishery officer escapement estimates as a measure of spawning stock. The results of the current analysis would suggest a much higher total Skeena River MSY escapement, perhaps in the order of 100,000 fish.

The early run Skeena River coho stock appears to be less productive than other coho stocks for which we have information. The fact that these other stocks are in southern B.C. (Carnation Creek, L. B. Holtby, PBS, Nanaimo, pers. comm.), and Oregon (Beidler et al. 1980) undoubtedly has something to do with this disparity.

In addition to poor escapements, another cause for concern is the apparent decrease in the proportion of four year old coho in the test fishery sampling program. Fish of this age class could be associated with less productive stocks (i.e. slower growth and higher mortality in freshwater) indicating that these stocks might be making up a declining proportion of the escapement.

FORECASTING

A continuation of recent exploitation rates and spawning escapement levels should cause a steady decline in abundance. The prognosis for the next cycle (1988 to 1990) is poor given the spawning escapements in the brood years.

Forecasts based on factors other than spawning escapement level (environmental conditions, inter-specific interactions etc.) have not been developed to date.

INFORMATION NEEDS

The information needs for improved assessment of this stock are related to the assumptions of the stock recruitment analysis. The first priority is to validate the assumptions pertaining to ocean harvest rates and terminal net catch composition. These assumptions have the greatest impact on the analysis in terms of measuring and evaluating MSY exploitation rates. Estimates of historical and MSY exploitation rate should be interpreted cautiously for this reason. Fortunately, the estimation of MSY escapement is not drastically affected by these assumptions. Indian food fish and sportfish catch levels should be more accurately recorded and age composition of 1983 and pre-1974 returns should be confirmed.

It would be desirable to determine the stock composition of the early run stock mixture for more terminal management purposes (i.e. sport and Indian food fish). Furthermore, it would be useful but perhaps not critical, given the expected cost, to investigate the appropriateness of using the test fishery sockeye calibration for coho assessment.

Coded wire tagging of key stocks and recovery of tags in the escapement as well as in all fisheries is the most feasible approach to collecting stock composition and exploitation rate information given current technology.

A natural extension of this analysis could be accomplished by extending the Skeena test fishery to the end of September in order to index the late run stock. The split of the Skeena coho run into early and late timing stocks is largely related to the impacts of the commercial fisheries and the availability of escapement data, rather than on strong biological evidence. With a few years of index data to the end of September, we might learn more about the relative importance of the two run-timing components and with the additional CWT data, perhaps get an insight into the severity of the conservation problem.

An assessment of the range of stock productivities which make up both the early and late run stocks will give us a better understanding of the implications of specific harvest decisions on individual stocks. This can be done by collecting a time series of stock and recruitment data for a cross section of individual stocks or perhaps by a less costly indirect method, such as spawning and rearing capacity assessment.

Finally, although not crucial to an active management program where in-season monitoring and regulation is possible, pre-season forecasts would be useful in management planning. Research in this area could be initiated by examining the relationship between various environmental (freshwater and ocean) variables and recruitment success.

CONCLUSIONS AND RECOMMENDATIONS

1) A spawning escapement goal of 33,000 is recommended to maximize yield from the early run Skeena coho stock. Taking into account about 3,000 fish potentially taken by the Indian food fishery and about 1,000 fish caught by the freshwater sport fishery a river-mouth escapement goal of 37,000 fish is recommended.

The recommended spawning escapement goal could be in conflict with the aggregate goal developed by local management staff for these coho stocks. Putting aside the difficulty and subjectivity of making estimates of MSY escapement for individual stocks based on the data available, I would expect that this aggregate goal would be higher (possibly much higher) than the recommended goal due to the mathematical effect of combining stocks of different productivities in a stock recruitment analysis (Hilborn 1985). If each stock in the mixed stock could be managed independently then this aggregate goal would produce the maximum yield; however, given the fisheries currently harvesting these fish and the information available to manage them, the approach taken in this analysis is recommended. A danger with this approach, however, is that stocks with low natural productivity could be non-viable at the recommended escapement level.

2) Given recent spawning escapement levels, the declining trend of early timing Skeena River coho stocks is expected to continue unless significant management actions are taken. The approximate timing and distribution of coded wire tagged hatchery stocks from the Kispiox and Babine rivers could be used as a guide for such actions in the absence of information on specific wild stocks. Enhancement options may complement and accelerate rebuilding by fishery management actions and should be considered as part of an overall rebuilding strategy.

3) It is extremely important that effort are made to collect information on catch distribution and exploitation rate on key stocks throughout the Skeena watershed. As a minimum, one early run and one late run stock should be monitored. The long term objective of applying coded wire tags throughout the north coast should be to estimate fishery stock compositions and exploitation rates. Management of coho in ocean and inshore mixed stock fisheries is dependent upon knowing the impacts of these fisheries on component stocks.

4) Continuation of the Skeena test fishery until the end of September for a minimum of three years is recommended. This would provide valuable information on the relative magnitude of the early and late timing components of the Skeena coho run. In combination with coded wire tagging programs, this extension could identify alternative options for managing stocks with run timings that span both time periods.

5) The Skeena test fishery coho index should be used to monitor the escapement during the season. Based on a conversion factor of 543 fish per index unit, a target of 68 index units by August 24th should be established.

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Table 1. Early run Skeena River coho stock by return year.

Return Year	Test Fish Index	Estim. Escap.	Indian Food	Sport Catch	Spawning Escap.	Area 4 Catch	Area 3 Catch	Area 5 Catch	Ocean Harvest	Total Catch	Total Stock	Exp. Rate
1956	90.63	49212	1195	500	47517	9452	1128	587	25877	38739	86256	0.45
1957	98.74	53616	2314	500	50802	10493	1032	209	28007	42555	93357	0.46
1958	151.98	82525	2324	500	79701	12006	1145	525	41229	57728	137430	0.42
1959	76.20	41377	2428	500	38449	835	642	211	18456	23071	61520	0.38
1960	71.51	38830	645	500	37685	6789	598	288	19931	28750	66435	0.43
1961	54.38	29528	712	500	28316	7974	841	415	16610	27051	55368	0.49
1962	115.01	62450	705	500	61245	14556	2147	1659	34634	54201	115446	0.47
1963	90.23	48995	932	500	47563	7879	83	1380	25002	35776	83338	0.43
1964	119.09	64666	791	500	63375	19262	1104	1530	37098	60285	123660	0.49
1965	173.33	94118	1479	500	92139	4814	739	1165	43215	51912	144051	0.36
1966	168.46	91474	1290	500	89684	18783	1240	2522	48865	73199	162883	0.45
1967	160.89	87363	739	500	86124	17974	2235	298	46230	67975	154100	0.44
1968	77.37	42012	1135	500	40377	12389	2740	1609	25178	43551	83928	0.52
1969	141.43	76796	548	500	75748	6848	624	124	36168	44812	120560	0.37
1970	136.01	73853	622	1000	72231	6671	636	1691	35508	46127	118359	0.39
1971	160.78	87304	1348	1000	84956	7046	572	133	40738	50836	135792	0.37
1972	65.43	35528	396	1000	34132	12135	1627	648	21402	37208	71341	0.52
1973	87.77	47659	408	1000	46251	8328	469	61	24221	34487	80738	0.43
1974	47.27	25668	433	1000	24235	9033	916	70	15294	26746	50980	0.52
1975	63.04	34231	1186	1000	32045	6446	1026	104	17917	27679	59724	0.46
1976	67.13	36452	745	1000	34707	5296	528	180	18195	25943	60650	0.43
1977	99.30	53920	876	1000	52044	11589	1208	67	28622	43361	95405	0.45
1978	110.10	59784	1504	1000	57280	15415	5370	464	34729	58483	115763	0.51
1979	28.16	15291	619	1000	13672	19574	2963	208	16301	40664	54336	0.75
1980	73.50	39911	1156	1000	37755	9247	2930	277	22442	37052	74806	0.50
1981	57.81	31391	1263	1000	29128	11654	1302	113	19054	34386	63514	0.54
1982	62.46	33916	2400	1000	30516	24773	2887	395	26559	58014	88530	0.66
1983	61.97	33650	2550	1000	30100	9732	9181	220	22621	45305	75405	0.60
1984	70.98	38542	2480	1000	35062	13557	2920	147	23643	43746	78808	0.56
1985	45.29	24592	1060	1000	22532	25575	5691	104	23984	57413	79946	0.72
1986	50.70	27530	2060	1000	24470	10635	4201	152	18222	36269	60739	0.60
1987	29.71	16133	2110	1000	13023	4606	2536	71	10005	20327	33350	0.61

Notes: - 1) Test fishing index is standardized to August 24th for all years.
2) Estimated escapement is derived by multiplying the test fish index by 543.
3) Indian food fish catch for 1987 is an estimate based on the previous five year average.
4) Area 4 catch of this stock is calculated by multiplying the total net catch up to and including the third week of August by 0.45.
5) Area 3 catch of this stock is calculated by multiplying the total net catch up to and including the second week of August by 0.10.
6) Area 5 catch of this stock is calculated by multiplying the total net catch up to and including the second week of August by 0.05.
7) Ocean harvest is assumed to be 30 percent of the total stock.
8) Total stock is the total catch plus the spawning escapement.
9) Exploitation rate is the total catch divided by the total stock.

Table 2. Skeena River test fishery coho age composition.

Return Year	Proportion by Age	
	Age 3	Age 4
1956 to 1973	0.69	0.31
1974	0.71	0.29
1975	0.60	0.40
1976	0.60	0.40
1977	0.46	0.54
1978	0.78	0.18
1979	0.77	0.24
1980	0.78	0.22
1981	0.36	0.64
1982	0.79	0.21
1983	0.69	0.31
1984	0.54	0.46
1985	0.85	0.14
1986	0.81	0.19
1987	0.90	0.10

Note - 1956 to 1973 and 1983 age composition were based on 1974 to 1982 and 1984 to 1987 average.
- 1974 to 1982 and 1984 to 1987 data from L. Jantz, Management Biologist, DFO, Prince Rupert

Table 3. Early run Skeena River coho stock by brood year.

Brood Year	Brood Spawners	Age 3 Return	Age 4 Return	Total Return
1956	47517	42449	20595	63044
1957	50802	45840	17164	63004
1958	79701	38204	35788	73992
1959	38449	79658	25835	105493
1960	37685	57504	38335	95838
1961	28316	85325	44656	129981
1962	61245	99395	50494	149889
1963	47563	112389	47771	160160
1964	63375	106329	26018	132346
1965	92139	57910	37374	95284
1966	89684	83186	36691	119878
1967	86124	81667	42096	123763
1968	40377	93696	22116	115812
1969	75748	49225	25029	74254
1970	72231	55709	15804	71513
1971	84956	35176	18514	53691
1972	34132	41210	18801	60011
1973	46251	41848	29576	71424
1974	24235	67356	34034	101390
1975	32045	69458	21735	91192
1976	34707	32602	29922	62524
1977	52044	34112	34552	68663
1978	57280	49732	16024	65756
1979	13672	67726	17720	85446
1980	37755	58665	17495	76160
1981	29128	28529	51005	79534
1982	30516	62997	12877	75874
1983	30100	41910	10338	52249
1984	35062	18019		
1985	22532			
1986	24470			
1987	13023			

Table 4. Results of Ricker stock-recruit analyses under various assumptions about the magnitude of early run Skeena coho catch.

Ocean Harvest Rate	Area 4 Percent Skeena	Ricker Parameters			Reg. r^2	Optimum Escapement			Maximum Sustainable Yield		
		a	alpha	beta		Point Estimate	95% Confidence Lower	95% Confidence Upper	Recruits	Yield	E.R.[a]
0.2	0.15	1.23	3.42	-0.0000174	0.54	29313	23141	37444	60203	30890	0.51
	0.25	1.31	3.71	-0.0000180	0.57	29824	23932	37421	64650	34826	0.54
	0.35	1.39	4.01	-0.0000185	0.59	30235	24595	37325	68957	38722	0.56
	0.45	1.45	4.26	-0.0000189	0.61	30575	25193	37414	73159	42584	0.58
	0.55	1.52	4.57	-0.0000193	0.62	30890	25698	37394	77307	46417	0.60
	0.65	1.58	4.85	-0.0000197	0.64	31146	26092	37497	81372	50226	0.62
0.3	0.15	1.37	3.94	-0.0000174	0.54	31713	25341	40044	71379	39666	0.56
	0.25	1.45	4.26	-0.0000180	0.57	32024	26032	39821	76249	44225	0.58
	0.35	1.52	4.57	-0.0000185	0.59	32335	26595	39625	81063	48728	0.60
	0.45	1.59	4.90	-0.0000189	0.61	32575	27093	39514	85760	53185	0.62
	0.55	1.65	5.21	-0.0000193	0.62	32790	27498	39494	90395	57605	0.64
	0.65	1.71	5.53	-0.0000197	0.64	32946	27892	39397	94937	61991	0.65
0.4	0.15	1.52	4.57	-0.0000174	0.54	34313	27841	42944	86100	51787	0.60
	0.25	1.60	4.95	-0.0000180	0.57	34524	28332	42421	91671	57147	0.62
	0.35	1.67	5.31	-0.0000185	0.59	34635	28795	42125	97072	62437	0.64
	0.45	1.74	5.70	-0.0000189	0.61	34775	29093	41814	102442	67667	0.66
	0.55	1.80	6.05	-0.0000193	0.62	34790	29398	41594	107600	72810	0.68
	0.65	1.86	6.42	-0.0000197	0.64	34946	29692	41397	112934	77988	0.69

[a]Exploitation rate at maximum sustainable yield.

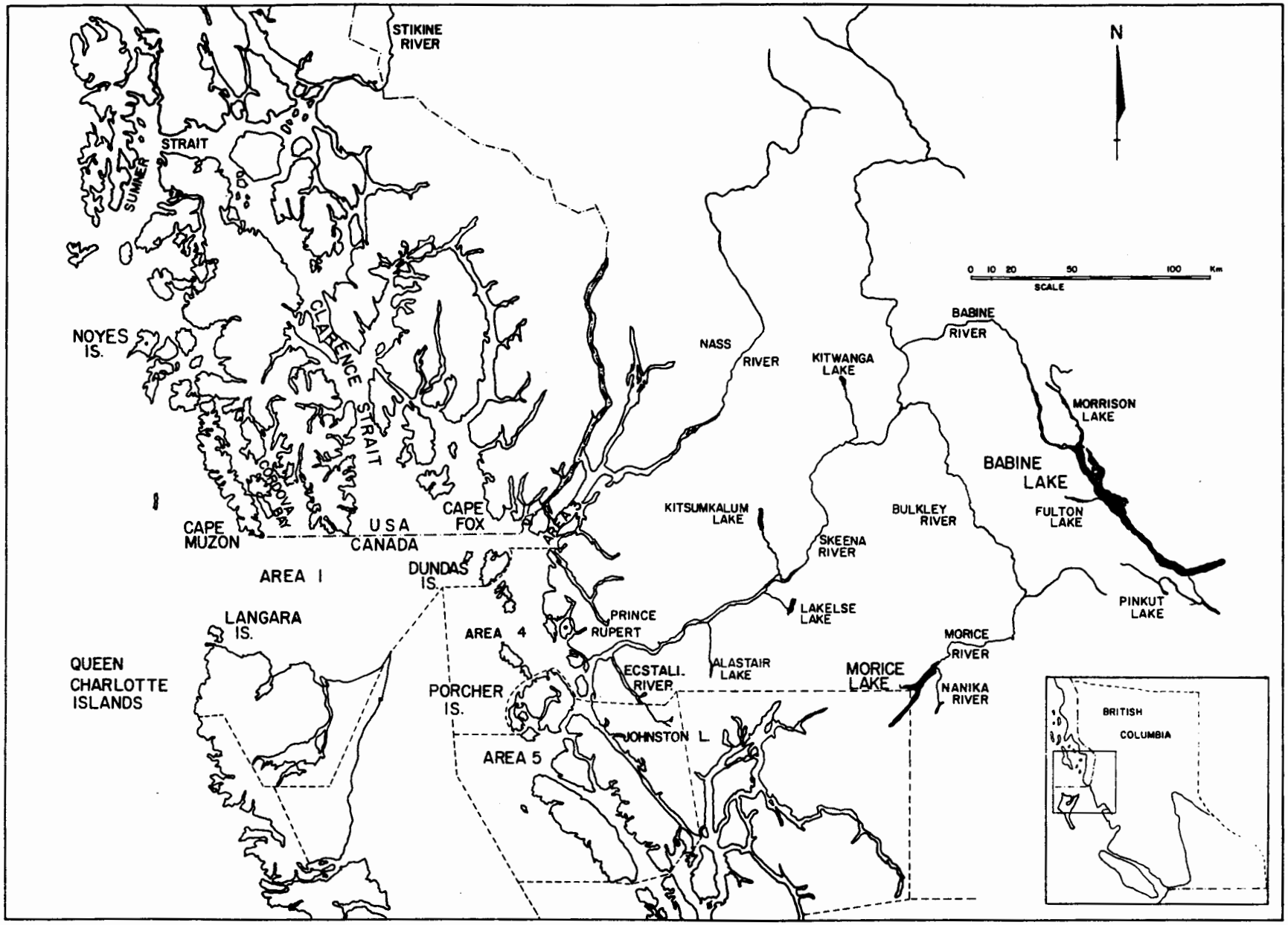

Fig. 1. Map of the Skeena River watershed, with major fishing and spawning areas.

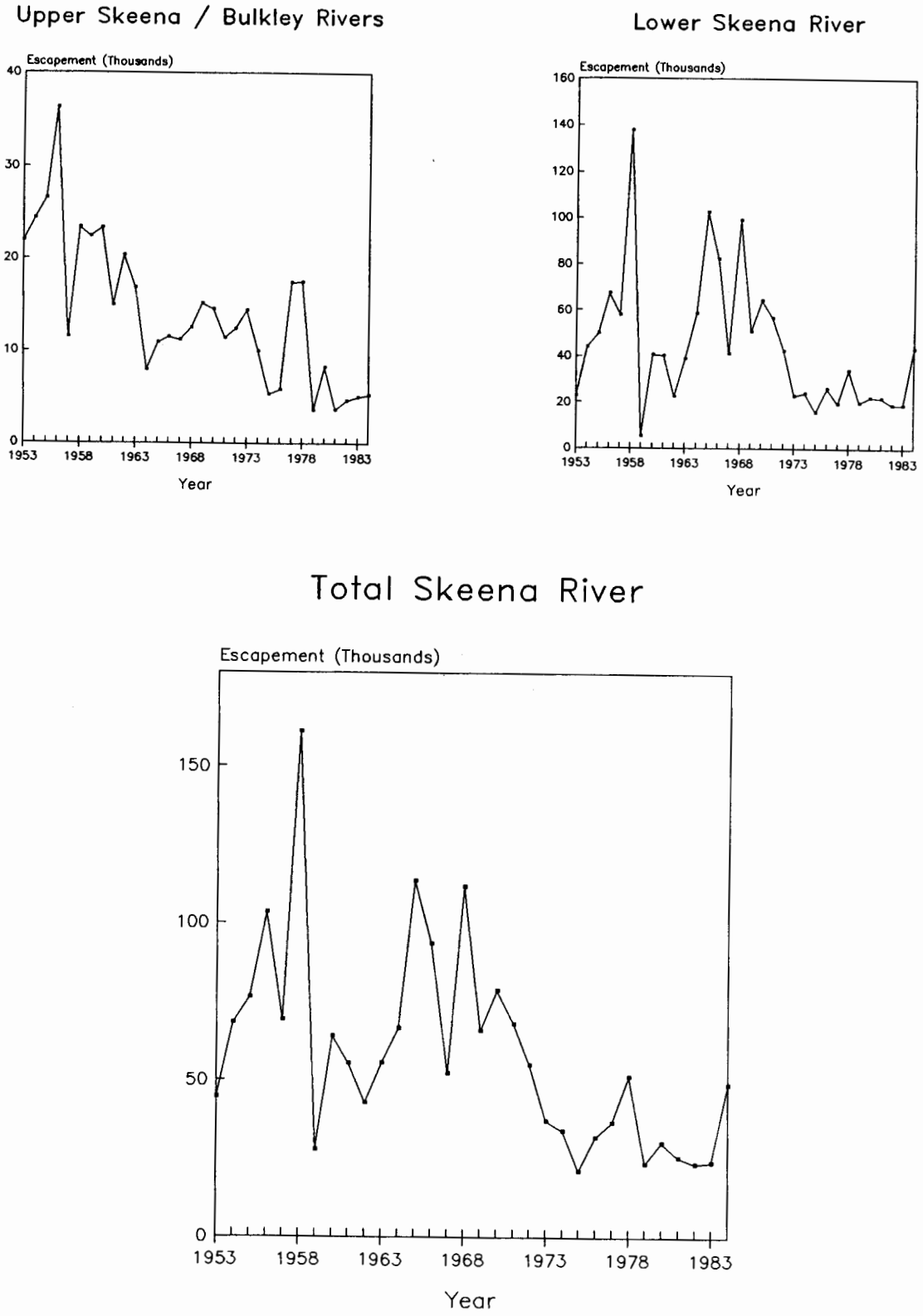

Fig. 2. Fishery officer estimates of coho spawning escapement for lower and upper Skeena River coho stock aggregates and the total Skeena watershed for the years 1953 to 1984 (data from the Salmon Stock Assessment database maintained at the Pacific Biological Station, Nanaimo, B.C.).

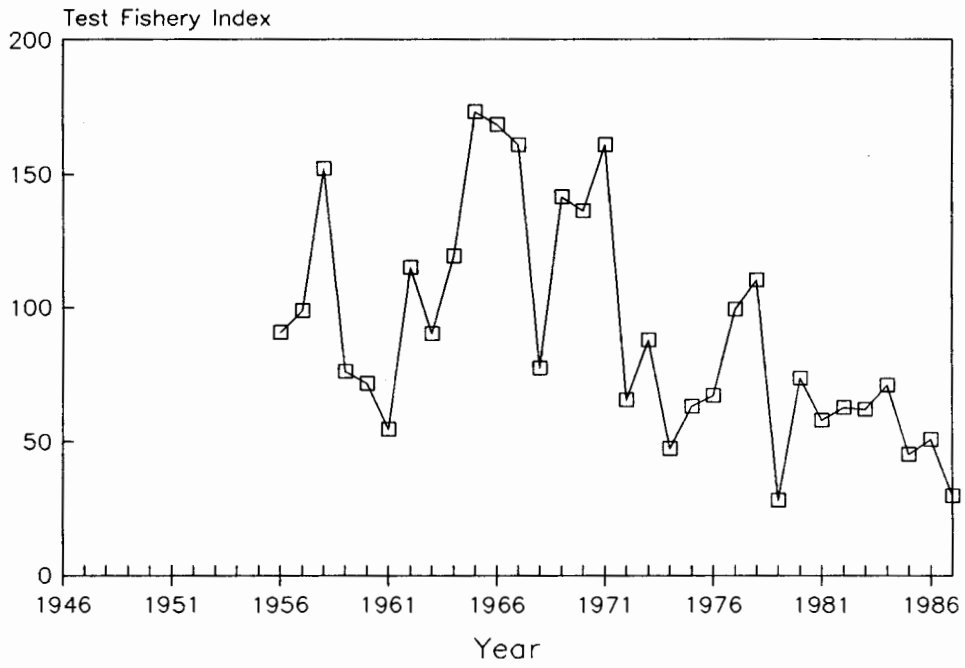

Fig. 3. The cumulative Skeena River test fishery coho index, standardized to an August 24th ending date, for the years 1956 to 1987.

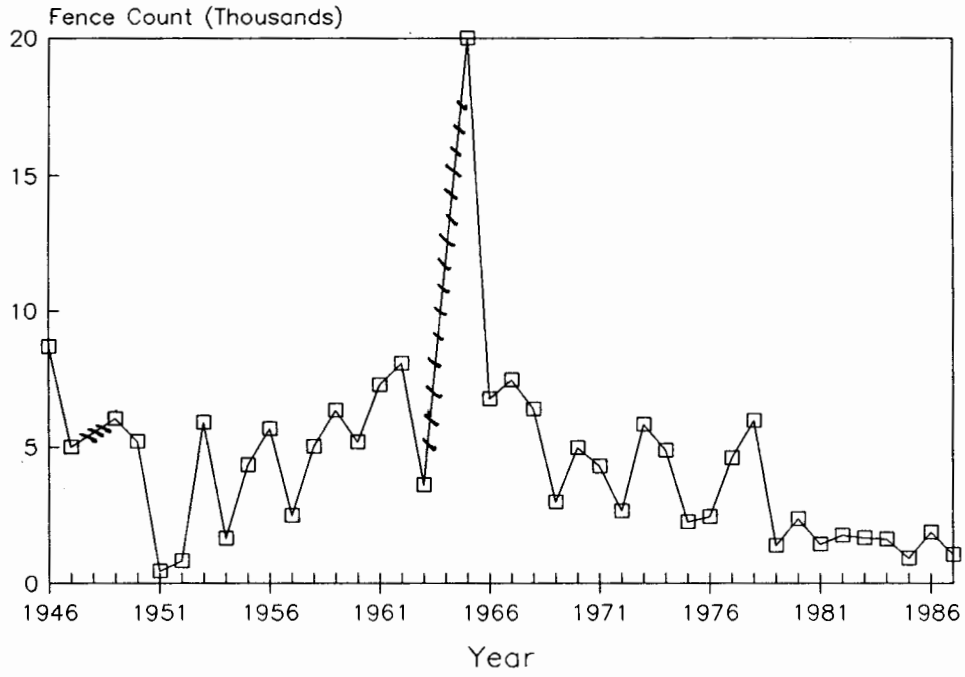

Fig. 4. The cumulative Babine River fence coho count, standardized to a September 13th ending date, for the years 1946 to 1987. (crosshatched lines indicate no data due to high water for the years 1948 and 1964).

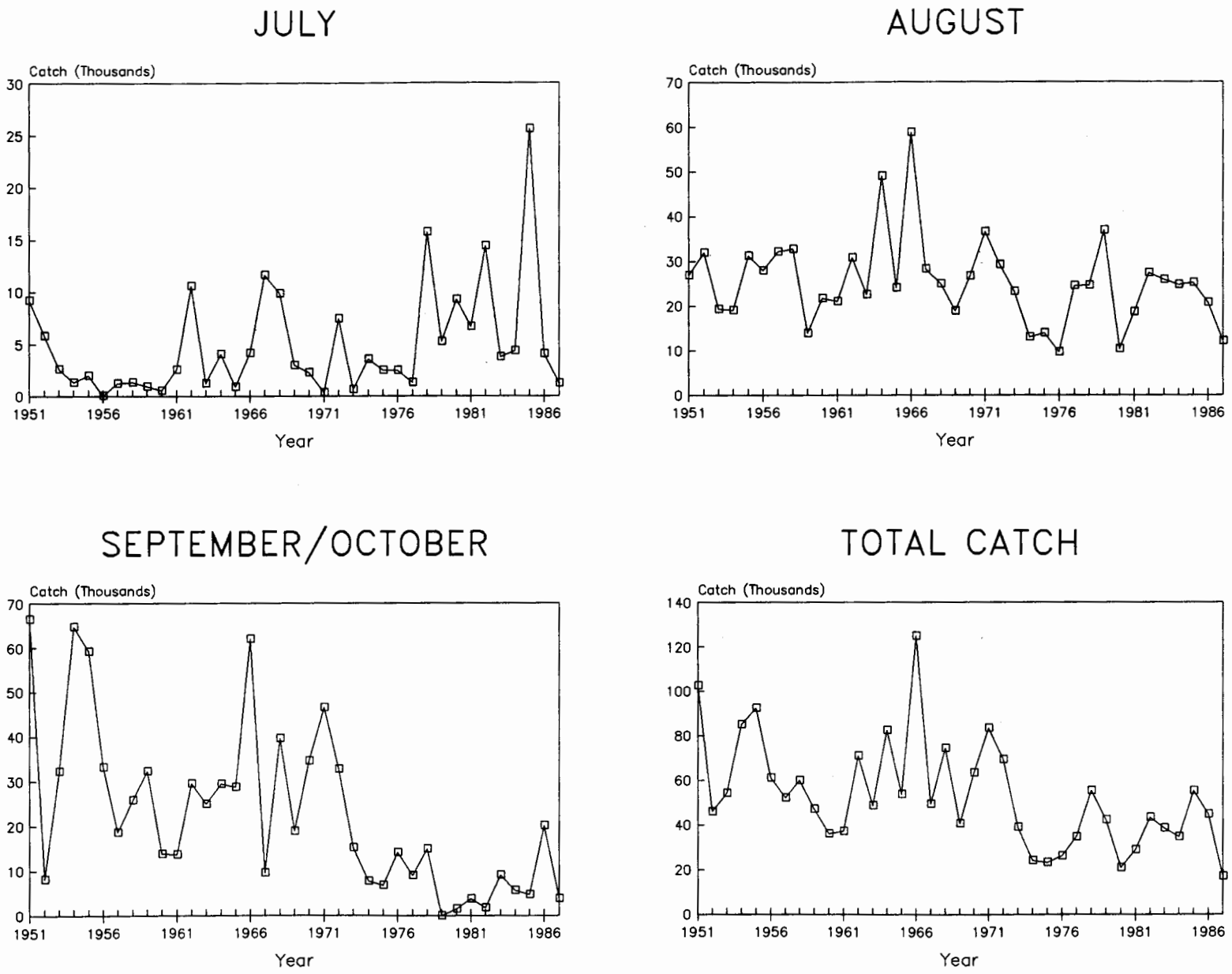

Fig. 5. Coho salmon catch by gillnets in Statistical Area 4 by month for the years 1951 to 1987 (data from the Salmon Stock Assessment database maintained at the Pacific Biological Station, Nanaimo, B.C.).

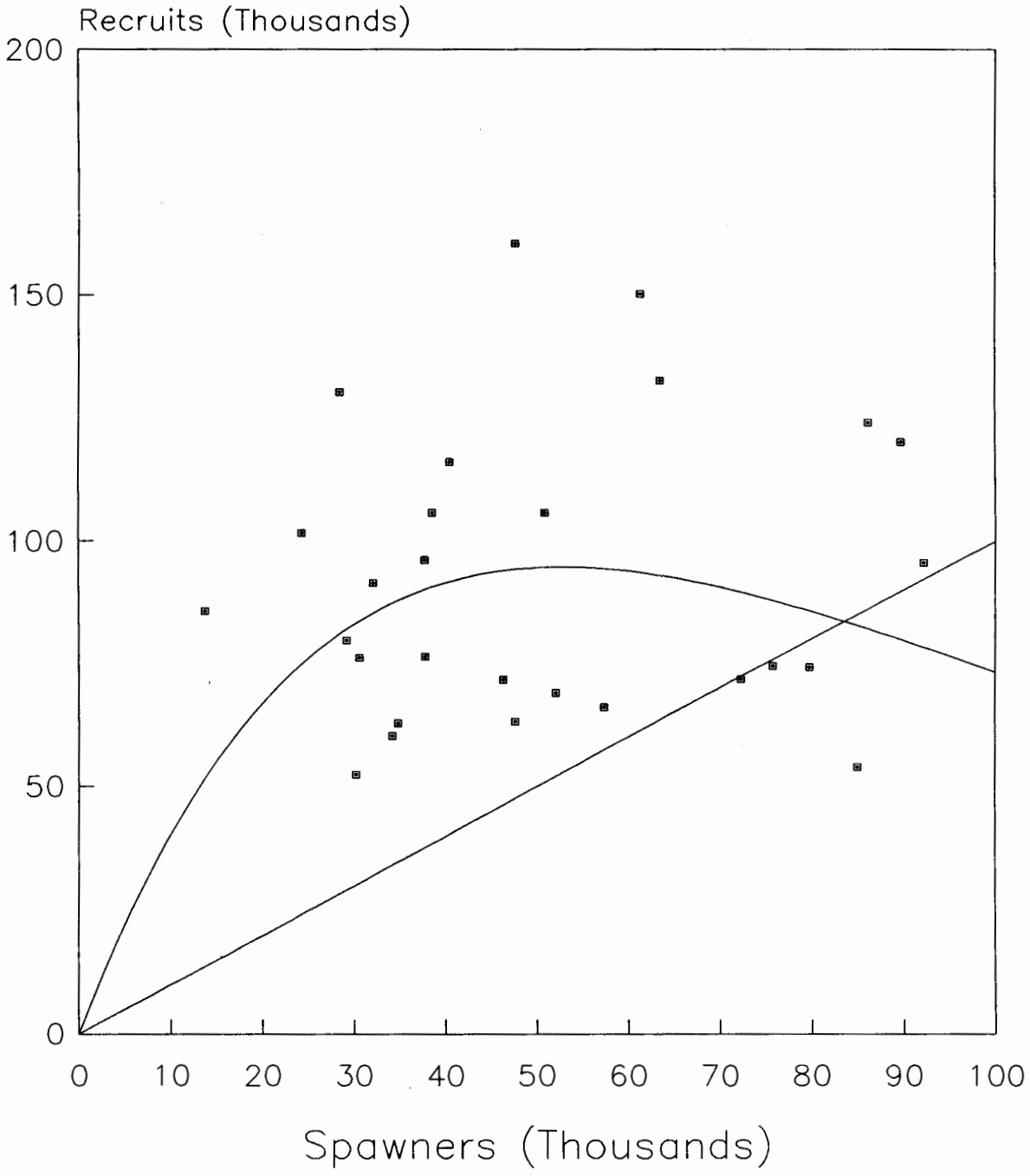

Fig. 6. Spawning stock and recruitment relationship for early run timing Skeena River coho salmon (assumed 30 percent ocean harvest rate and 45 percent early Skeena run stock composition in the Area 4 net catch).

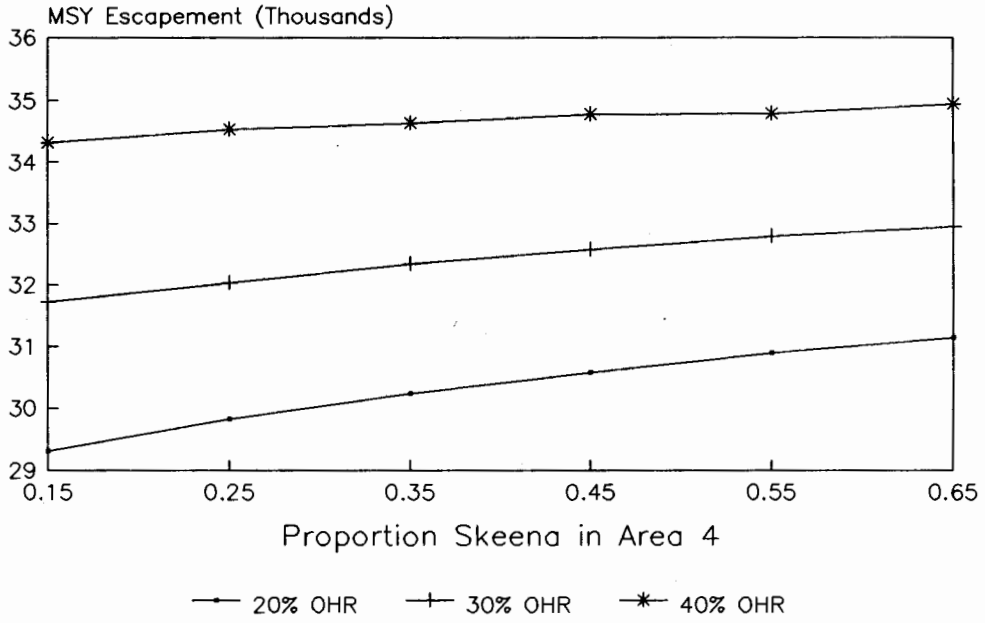

Fig. 7. MSY spawning escapement under various assumptions about Area 4 stock composition and ocean harvest rate (OHR).

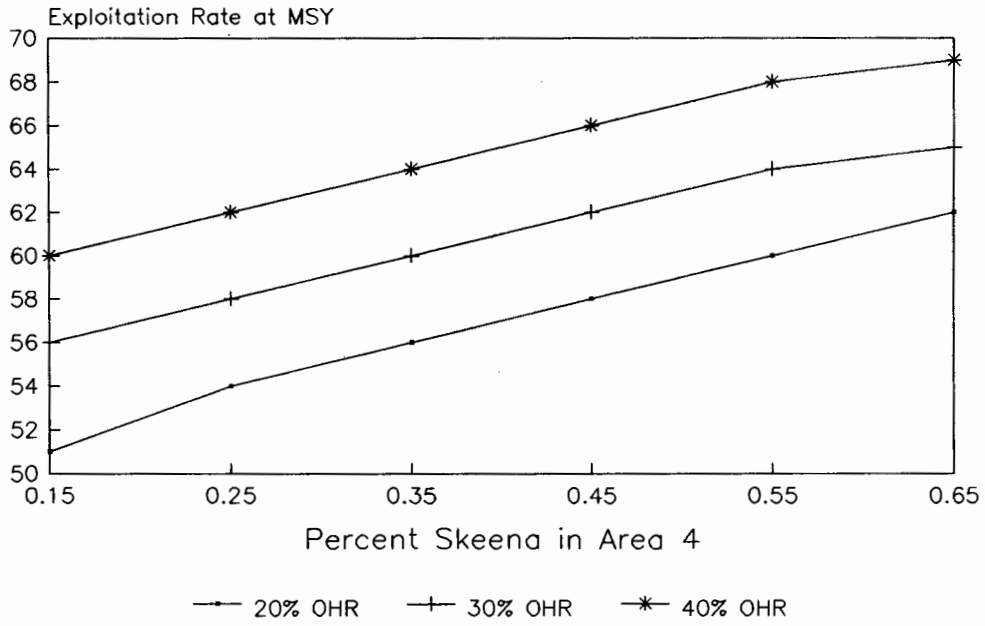

Fig. 8. MSY exploitation rate under various assumptions about Area 4 stock composition and ocean harvest rate.

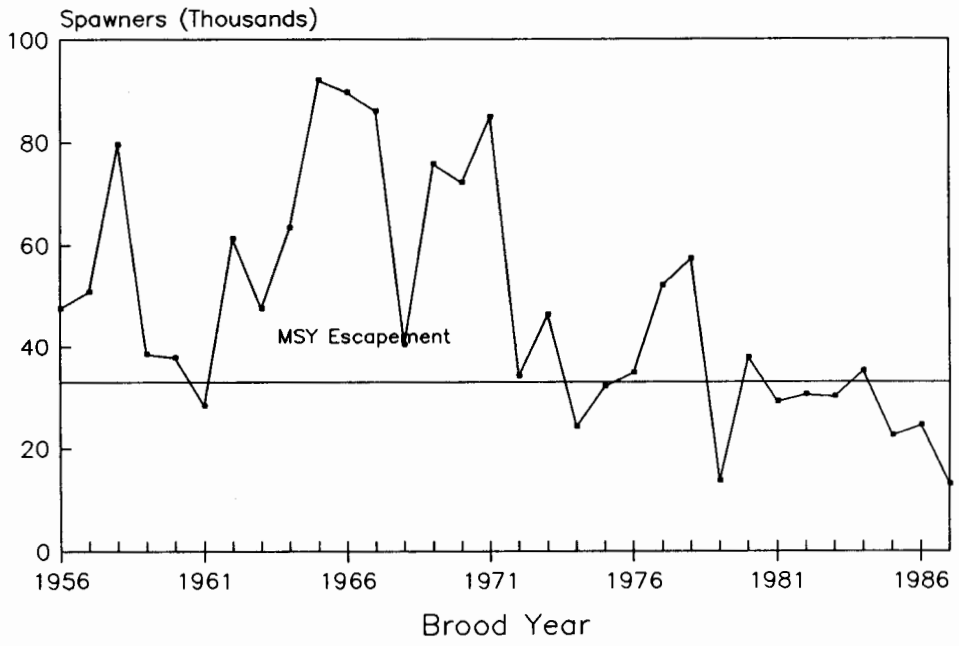

Fig. 9. Early run Skeena River coho escapement, as estimated using the test fishery index, for the years 1956 to 1987. A line representing the estimated MSY escapement is included for comparison.

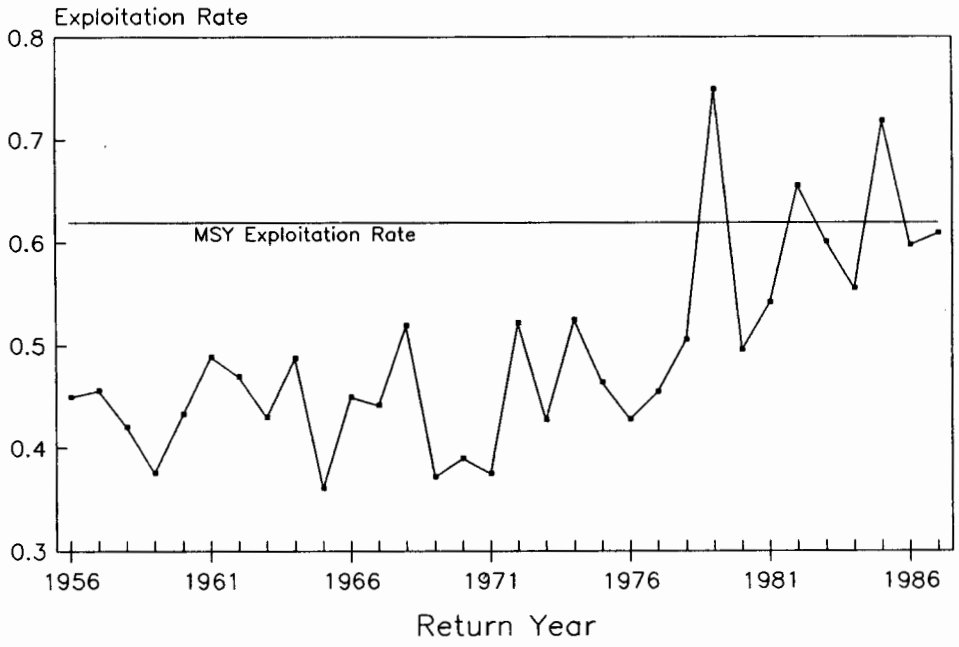

Fig. 10. Early run Skeena River coho exploitation rate for the years 1956 to 1987. A line representing the estimated exploitation rate at MSY is included for comparison.