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STOCK ASSESSMENTS FOR BRITISH COLUMBIA HERRING IN 1991 AND FORECASTS OF THE POTENTIAL CATCH IN 1992

by

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ABSTRACT

Haist, V. and J. F. Schweigert. 1992. Stock assessments for British Columbia herring in 1991 and forecasts of the potential catch in 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2146: 82 p.

Herring stock abundance in British Columbia waters was assessed for 1991 and forecasts were made for 1992 using two analytical methods: (1) escapement model; and (2) age-structured model. Coastwide, the estimated spawning stock biomass was 152,800 tonnes, a 29% decrease from 1990 abundance levels. This is the result of a poor year class recruiting to all assessment regions, with the exception of the Prince Rupert District.

Forecasts of the pre-fishery spawning stock biomass in 1992 are obtained by weighting the estimates from the two models. The forecasting procedure used for the escapement model was modified this year, yielding higher stock forecasts than the previous method. Stock forecasts are 86,250 tonnes to the northern and 88,290 tonnes to the southern stock assessment regions.

The recommended 1992 catch (20% of the 1992 forecast herring run) for the entire B.C. coast is 34,908 tonnes. All areas should be available to the fishery in 1992.

Key words: *Clupea harengus pallasi*, Pacific herring, stock assessment, forecasts, age-structured analysis

RÉSUMÉ

Haist, V. and J. F. Schweigert. 1992. Stock assessments for British Columbia herring in 1991 and forecasts of the potential catch in 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2146: 82 p.

On a évalué l'abondance des stocks de harengs en Colombie-Britannique en 1991 et on a établi des prévisions pour 1992 à l'aide de deux méthodes d'analyse, le modèle des échappées et le modèle de la structure d'âge. Sur toute la côte, on a estimé à 152 800 tonnes la biomasse du stock des géniteurs, soit une diminution de 29% par rapport à 1990. Cela provient d'un mauvais recrutement de la classe annuelle dans toutes les régions évaluées, sauf dans le District de Prince Rupert.

On obtient les prévisions concernant la biomasse des stocks de géniteurs avant les activités de pêche de 1992 en faisant la moyenne des résultats obtenus à l'aide des deux modèles. La méthode de prévision des stocks utilisée dans le cas du modèle des échappées a été modifié cette année, et donne des résultats plus élevées que la méthode précédente. On prévoit des stocks de 86 250 tonnes dans la région d'évaluation du nord et de 88 290, dans la région d'évaluation du sud.

En 1992, on recommande des prises atteignant 34 908 tonnes (20% des prévisions de migration de fraie du hareng) pour toute la Colombie-Britannique. Toutes les régions devraient être ouvertes à la pêche en 1992.

Mots clés: *Clupea harengus pallasi*, hareng du Pacifique, évaluation des stocks, prévisions, analyse de la structure d'âge

1. INTRODUCTION

1.1 GENERAL

Herring are an important component of the British Columbia commercial fishery with catch records dating from 1877. In the early 1900's the fishery was primarily for a dry salted market and catches were relatively low. During the 1930's a fishery for reduction purposes developed and catches steadily increased. Very large catches (200,000 tonnes annually), in the early 1960's in conjunction with a series of poor recruitments led to the collapse of the reduction fishery and closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks.

In 1972 herring fisheries for a roe product developed. These fisheries occur just prior to spawning when the fish are tightly schooled and highly aggregated. Initially the roe fisheries were managed in-season to fixed escapement targets (Hourston 1981b). This management system was untenable because of problems in obtaining accurate in-season stock estimates, uncertainty about appropriate escapement targets, and difficulty in controlling fishing effort. Since 1983 herring fisheries have been managed with a fixed quota system. Under this system catch levels are determined prior to the season based on a fixed percentage (20%) of forecast stock abundance.

In this report we present stock assessments from two analytical models which have been developed explicitly for British Columbia herring: (1) an escapement model (Schweigert and Stocker 1988); and (2) an age-structured model (Fournier and Archibald 1982). Both models reconstruct stock abundance for the period 1951-1991 and forecast pre-spawning abundance for the 1992 season. Forecasts of recruit spawners are presented as poor, average, and good, based on historical recruitment levels. This report does not discuss the development and evaluation of empirical models for forecasting recruitment, as results of these studies are presented elsewhere (e.g. Schweigert and Noakes 1991, Stocker and Noakes 1988).

Results in this report were presented to the PSARC Herring Subcommittee in September, 1991.

1.2 DATA BASE

The primary data sources for the stock assessments are spawn survey data, commercial catch landing data, and age composition data from biological samples of commercial fishery, pre-fishery charter, and research catches. These data are available on computer files for the period 1951 to 1991. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period starting in the early 1970s.

Of the three data sets, the spawn data contain the largest measurement errors. We feel that the quality of spawn surveys has improved greatly over the 41 year span of these observations. This improvement is a result of increased numbers of people and vessels being involved in spawn surveys, increased attention to data measurements, increased coverage of subtidal spawnings, and increased research on estimating egg deposition from spawn observations. The consistent observations made during all years of surveys are the length, the width, and a measure of intensity of spawnings. The escapement model estimates absolute egg numbers from these observations and includes a width conversion to adjust for the inability to survey subtidal spawns adequately. Since 1987 an increasing number of spawn beds have been surveyed using SCUBA methods. We assume these surveys provide reasonably accurate estimates of spawn bed width and egg density and these data have been used in the escapement model where available. The age-structured model uses a spawn index which sums lengths multiplied by standardized widths and intensities (Hay and Kronlund 1987).

Catch information was obtained from landing slip data. Both models use the landing slip data summed by season (seasons run from July 1 to June 30). The 1990/91 catch figures are based on hailed estimates because sales slip data were not available for timely analysis.

Age structure data are used in both models. The information from catch samples are used for years when there were commercial fisheries. Pre-fishery charter samples are used in addition to catch samples for areas with no fisheries or when catch samples do not appear to be representative. Additional data used in both models are annual mean weights-at-age.

For this assessment report our nomenclature for age classes is changed. Previously age classes were named by the age the fish would be at the end of the season. For example, age 3 fish in the 1990/91 season were fish which had their 3rd birthday in the spring of 1991. We have now adopted the year-of-life convention. Fish which were previously named age 3 are now referred to as the 2+ age class.

1.3 STOCK CONSIDERATIONS

The stock concept used for managing British Columbia herring is a compromise between biological and management considerations. Given poor or incomplete knowledge of population structure it is prudent to manage fisheries at the level of the greatest potential diversity. Unfortunately, we do not feel that stock forecasts for smaller geographic regions than used in the current assessments would be accurate enough for fisheries management. Therefore, we recommend that fisheries should be spread throughout the assessment regions to prevent possible overexploitation of individual spawning groups.

The stock groupings used for the current assessments are the same as those used in 1990 (Fig. 1.1 and 1.2). The Queen Charlotte Islands stock assessment region spans from Cumshewa Inlet in the north to Louscoone Inlet in the south. The stock concept for the Prince Rupert District encompasses Statistical Areas 3 to 5. The central coast stock concept separates the major migratory stocks from the minor spawning populations in the mainland inlets. The areas included in the central coast assessment region are Statistical Area 7 plus Kitasu Bay in Area 6 and Kwakshua Channel in Area 8. The Strait of Georgia is separated into two stock groupings. The northern area includes all of Statistical Areas 14 to 16, 17N, and Deepwater Bay and Okisollo Channel in Area 13. The southern stock comprises Areas 17S, 18, and 19. The two stock groupings used for the west coast of Vancouver Island are southern (Areas 23 and 24) and northern (Area 25).

Biomass estimates from the escapement model are also presented for the west coast of the Queen Charlotte Islands. The level of geographic aggregation used for these estimates is the section (Haist and Rosenfeld 1988).

This year stock estimates are not presented for all areas outside the seven major assessment regions, as they had been in the past. We are concerned that both the spawn survey and catch data are incomplete for many of these areas and therefore presentation of stock estimates could lead to erroneous conclusions regarding stock trends.

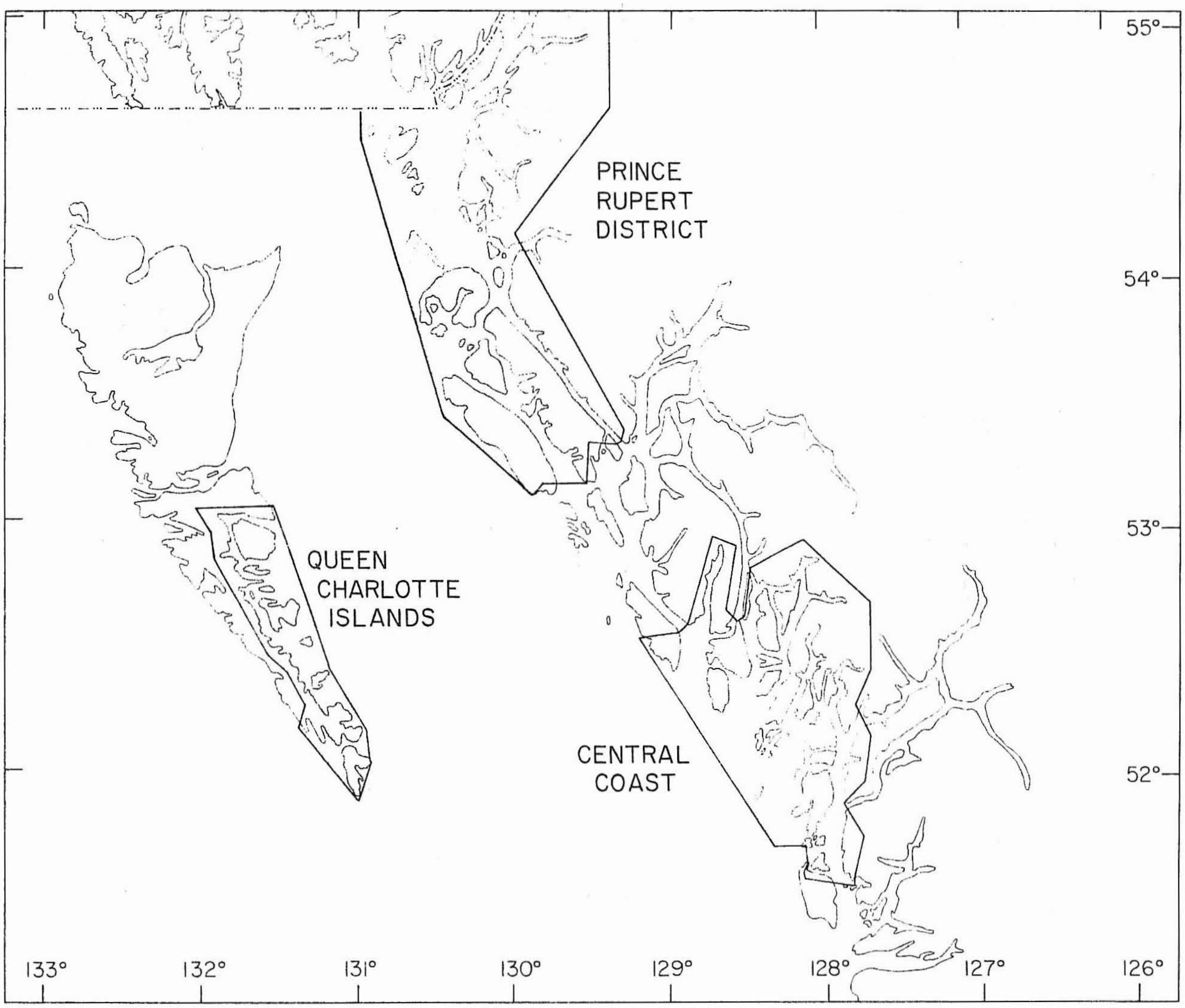

Fig. 1.1. Herring stock assessment regions in northern British Columbia.

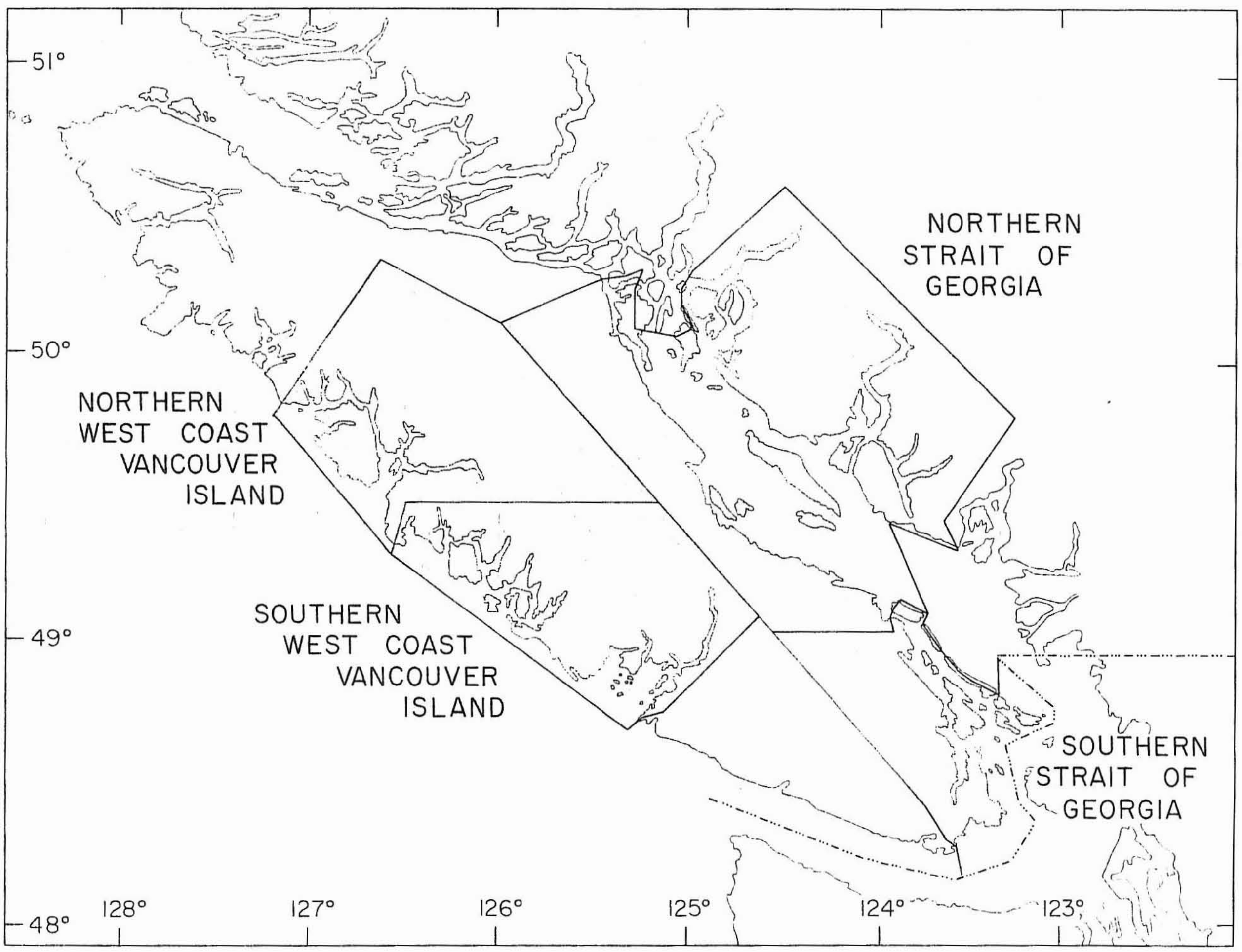

Fig. 1.2. Herring stock assessment regions in southern British Columbia.

2. ESCAPEMENT MODEL

2.1 INTRODUCTION

The escapement model, developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988), is based on information on egg deposition and provides an empirical estimate of escapement from the fishery. For most stock assessment regions recent estimates of escapement are based on a combination of surface and SCUBA survey data. SCUBA surveys have been used routinely since 1987 and since then an increasing proportion of the herring spawning beds have been surveyed using this technique.

A new component in this year's assessment is the use of an empirical estimate of the mean age-specific apparent survival rate in forecasting the number of age 3+ and older fish. This modification is introduced to adjust for apparent underforecasting of returning adults based on their abundance in the previous year's escapement and is described in detail below.

In this assessment, estimates are presented for the major stocks in the 7 assessment regions (Tables 2.2 and 2.3) and for the minor stocks on the west coast of the Queen Charlotte Islands (Table 2.4).

2.2 METHODS

In the escapement model, the forecast run size is based on the estimated escapement in the previous season, growth of the fish during the current season, and beginning this year, an age-specific apparent survival rate replacing the constant survival rate (0.64), and an estimate of recruitment to each stock. Recruitment is estimated for poor, average, and good levels by calculating the means of the third poorest, the middle third, and the third best recruitments observed during the historical time series from 1951-1991. Estimates of total catch (tonnes) and spawn abundance (billions of eggs) are converted to fish-at-age based on the sampling data for each area. For each area the age structure and average weight-at-age are calculated from samples available for that region. For some years no data are available for a region and information from an adjacent area is utilized in the analysis. Forecasts of repeat spawners and recruit fish are converted to forecast tonnages using average weights-at-age as outlined in Haist and Schweigert (1990). The method for estimating escapement from surface and dive survey data is described below.

Biomass estimates

Escapement from the fishery plus total catch provides an estimate of the pre-fishery spawning stock biomass for each assessment region. The estimated escapement for each region is derived from information on spawn deposition. Dive survey observations are used directly while surface survey observations are adjusted based on calibration equations derived from replicate surveys (Schweigert and Stocker 1988). Total egg deposition is calculated as the product of: total spawn length; observed or adjusted spawn width; and egg density as estimated from the average surface layer estimate, or average predicted egg density from quadrat observations, or average egg layer and plant densities in *Macrocystis* sp. beds. Egg deposition estimates for all spawn beds are summed within each assessment region and the total egg deposition is converted to tonnes of spawning fish based on an estimate of 100 eggs per gram of herring on average (Hay 1985).

Surface Surveys

Estimates of spawn width and average egg layers from surface surveys are adjusted to comparable dive survey estimates. The calibration equations used for the 1991 assessment are the same as those used in recent assessments.

The calibration equation, with parameter estimates, used to adjust surface survey spawn width estimates to comparable diver width estimates is:

$$\text{ADJUSTED WIDTH} = 75.275 + 0.816 \ \text{SURFACE SURVEY WIDTH.}$$

The equation used to estimate the average density of eggs (thousands per m^2) for each spawn from the estimate of average egg layers is:

$$\text{EGGS} = 202.093 + 67.345 \ \text{AVERAGE SURFACE LAYERS.}$$

Surface survey data are adjusted using these equations in all areas except for Johnstone Strait (Statistical Areas 9-13). In this area no adjustment is made to the spawn widths because previous dive surveys in the area indicated that widths were accurately assessed from the surface (Schweigert and Haegele 1988a, b). Egg deposition for each egg bed is estimated from the product of total bed length, adjusted width, and egg density predicted from the average surface egg layer estimate.

SCUBA Surveys

For SCUBA surveys spawn bed lengths are determined by exploratory raking or snorkelling and spawn bed widths are estimated as the mean of all transect lengths within the spawn bed. Estimates of mean egg density are based on a two-stage sampling design

(Schweigert et al. 1985, 1990). Average egg density for each spawning area is estimated as the weighted mean of the means of a series of quadrats located along each transect. For each quadrat, observations are made on several variables: type of algal substrate; proportion of the quadrat covered by each algal type; number of layers of eggs on each algal type; proportion of the bottom substrate covered by eggs; and an estimate of the number of egg layers on bottom substrate. In some areas assessments are also made of the egg deposition on the giant kelp as described below.

Egg deposition for each sampling quadrat is estimated from the prediction equation described in the 1989 assessment (Haist and Schweigert 1990). Egg density for each vegetation subfraction is estimated as follows:

$$\mathrm{EGGS}_{ij} = 1033.6694\ L_{ij}^{0.7137}\ P_{ij}^{1.5076}\ V_{ij}\ Q_j.$$

where

EGGS_{ij} = estimated number of eggs in thousands per m^2 on vegetation type i in quadrat j,
L_{ij} = number of layers of eggs on algal substrate i in quadrat j,
P_{ij} = proportion of quadrat covered by algal substrate i in quadrat j,
V_{1j} = 0.9948 parameter for sea grasses in quadrat j,
V_{2j} = 1.2305 parameter for rockweed in quadrat j,
V_{3j} = 0.8378 parameter for flat kelp in quadrat j,
V_{4j} = 1.1583 parameter for other brown algae in quadrat j,
V_{5j} = 0.9824 parameter for leafy red and green algae in quadrat j,
V_{6j} = 1.0000 parameter for stringy red algae in quadrat j,
Q_1 = 0.5668 parameter for 1.00 m^2 quadrats,
Q_2 = 0.5020 parameter for 0.50 m^2 quadrats,
Q_3 = 1.0000 parameter for 0.25 m^2 quadrats.

Total egg density (thousands of eggs per m^2) for each quadrat is then estimated by summing the egg density estimates over the vegetation types,

$$\mathrm{EGGS}_j = \sum \mathrm{Eggs}_{ij}.$$

Eggs on Bottom and *Macrocystis*

Eggs on rock are estimated from the product of the proportion of the quadrat covered by eggs, number of egg layers, and 340,000 eggs/m^2 (Haegele *et al.* 1979). Eggs on rock also includes eggs on other inorganic substrates as well as egg deposition on very short (1-2 cm) red algae, calcareous encrusting algae, worm tubes, logs, etc. Total egg density for each quadrat is the sum of eggs on vegetation plus eggs on rock.

In some northerly areas such as the Queen Charlotte Islands and the Prince Rupert District a significant proportion of the total egg deposition occurs on the giant kelp, *Macrocystis* sp., with smaller amounts in some localities on the central coast and west coast of Vancouver Island. The approach we have adopted for routine SCUBA surveys follows that outlined by Haegele and Schweigert (1985). The transects used to assess egg density on understorey vegetation are enumerated for *Macrocystis* plants and fronds within 1 m on either side of the transect line. An egg prediction equation has been developed (Haegele and Schweigert 1990):

$$EGGS/PLANT = 0.073\ LAYERS^{0.673}\ HEIGHT^{0.932}\ FRONDS^{0.703}$$

where

EGGS/PLANT = total number of eggs on the *Macrocystis* plant in millions,
LAYERS = average number of egg layers on each *Macrocystis* plant,
HEIGHT = total height of the *Macrocystis* plant in metres,
FRONDS = total number of fronds per *Macrocystis* plant.

This equation estimates the number of eggs occurring on a plant of a specific height with a certain number of fronds and egg layers. In practice, the synoptic SCUBA survey estimates only the average number of egg layers per plant, the average plant height, and the average number of fronds per plant along each transect. These quantities are used in the above equation to estimate the total egg numbers per plant for each transect. These estimates are averaged across transects to obtain an average number of eggs per plant for the entire *Macrocystis* bed.

This information may then be combined with the estimate of the density of plants and the estimated area of the *Macrocystis* bed to obtain an estimate of the total number of eggs deposited on the kelp. This egg deposition is then added to the deposition on the understorey vegetation for the area.

Enumerated Egg Samples

Samples of the algae and attached eggs from entire quadrats were collected from the Prince Rupert District again in 1991 due to continuing uncertainty about the status of stocks in the area and as a check on the accuracy of the egg density prediction model. A total of 104 samples have been processed to date. The average egg counts for the preserved samples was 377,668 eggs/m^2 while the average of the predictions from the statistical model is 317,350 eggs/m^2. The paired t-test between observed and predicted egg numbers is not significant ($P=0.1834$). The observed egg density is 26 percent greater than the 298,922 eggs/m^2 determined for the spawn depositions in this area in 1990.

Survival Estimates

Several estimates of the instantaneous natural mortality rate are available for British Columbia herring. Tester (1955) estimated the age-specific mortality for the Strait of Georgia (0.45 to 0.79) and west coast of Vancouver Island (0.43 to 1.14) for ages 3+ to 6+. Taylor (1964) reported a natural mortality rate of 0.55 for ages 5+ to 8+ for Barkley Sound samples taken from unfished stocks. Schweigert and Hourston (1980) estimated natural mortality at 0.36 from Barkley Sound catch and effort data during 1954 to 1967 for ages 2+ to 4+. Since the herring stocks currently consist mostly of ages 2+ to 7+ we used an instantaneous natural mortality of 0.45, implying an annual survival rate of 64 percent, in forecasting the number of returning adults (3+ and older fish) in past assessments. A comparison of the estimated numbers of returning fish at age with the escapement estimate the previous year provides an estimate of the apparent age-specific survival rate:

$$A_{ij} = \frac{E_{ij} + O_{ij}}{E_{i-1,j-1}}$$

where

A_{ij} = apparent survival of age j fish in season i,
E_{ij} = estimated number of spawning fish at age j in season i,
O_{ij} = estimated number of age j fish in the catch in season i.

The estimates of the age specific survival for each stock assessment region are presented for 1952 through 1991 in Appendix Tables 1.1 to 1.7. The tables also contain estimates of the annual apparent survival of all fish age 3+ and older. These values are plotted in Fig. 2.1. It is evident from the tables and the figure that the annual apparent survival rates are often considerably different from 0.64, the value previously assumed, and that age-specific apparent survival decreases with age. The estimates of apparent survival will include not only the effect of survival, but also factors such as: biases in estimates of the spawning stock (i.e. $\sum_j E_{ij}$), partial recruitment of the younger age classes, and inconsistencies in the age composition data. The estimates of apparent survival for the reduction fishery period are generally higher than those for the roe fishery period. This is likely the result of underestimation of spawning stock abundance. Additionally, the effects of partial recruitment are clearly evident in the northern stocks where apparent survival values exceed 1 for the younger age classes. In an effort to make forecasts of stock abundance more consistent with the observed data we use the geometric means of the age-specific apparent survivals for each stock assessment region over the 1972-1991 period (Table 2.5) to forecast 1992 abundance.

The effect of using the apparent survival rate versus the survival rate of 0.64 is presented in Table 2.6. In some instances, particularly for the northern stocks with some delayed recruitment at ages 3+ to 5+, the forecasts using apparent survival values exceed those obtained by assuming a 0.64 survival rate. For the west coast of Vancouver Island where much of the population consists of young fish the impact of the apparent age-specific survival is also significant. For the Strait of Georgia, where recruitment is generally complete at age 2+ there is little impact due to the use of the apparent survival.

In addition to using the apparent age-specific survival rates to provide unbiased forecasts of stock abundance we have used the variance in the estimates over the 1972-1991 period to generate probability distributions for the forecasts. For each assessment region the among year variance in apparent survival was estimated as the variance in the Y_i which were obtained by minimizing the sum of squares of the residuals (ε_{ij}) in the following model,

$$\ln(A_{ij}) = l_j + Y_i + \varepsilon_{ij}$$

where

l_j is the $\log_e$ of the geometric mean apparent survival at age j

Y_i is the estimated survival rate parameter for year i.

The standard deviations of the Y_i and the ε_{ij} for each region are shown in Table 2.5; the means are all zero. To obtain a probability distribution for age-specific survival, 1000 estimates of the Y_i and the ε_{ij} were randomly generated from normal distributions with mean zero and the standard deviations estimated for each assessment region. The resultant 1000 estimates of A_{ij} were used to generate a probability distribution for forecast 1992 age 3+ and older biomass.

2.3 RESULTS

A summary of the spawn survey coverage for the British Columbia coast from 1988 to present is shown in Table 2.1. The relative effort between surface and dive surveys is similar to last year. Few surface surveys were conducted in the Prince Rupert District and only in a few locations in the Queen Charlotte Islands. Due to the large number of spawn locations in the central coast about half of the spawn was again surveyed by surface methods in 1991. In the Strait of Georgia and the west coast of Vancouver Island the majority of spawns were surveyed with SCUBA.

Estimates of stock abundance for the seven stock assessment regions are presented in Tables 2.2 and 2.3 and discussed in Section 4. Estimates of abundance for the minor stocks on the west coast of the Queen Charlotte Islands are presented in Table 2.4.

Table 2.1. Kilometers of spawn surveyed by dive and surface methods for major and minor stocks on the British Columbia coast, 1988-1991.

	1988			1989			1990			1991		
Assessment Region	Dive	Surface	Total	Dive	Surface	Total	Dive	Surface	Total	Dive	Surface	Total
Queen Charlotte Islands	28.2	19.9	48.2	64.8	20.9	85.7	63.0	3.0	66.0	51.9	3.6	55.5
Prince Rupert District	55.0	5.7	60.7	40.1	0.9	41.0	47.4	0.0	47.4	75.2	2.0	77.3
Central Coast	32.6	112.7	145.3	25.1	105.1	130.2	73.6	73.9	147.5	66.0	74.0	140.0
N. Strait of Georgia	39.7	8.6	48.3	65.1	16.6	81.7	77.0	1.1	78.1	67.8	0.1	67.9
S. Strait of Georgia	12.6	5.6	18.2	24.8	6.6	31.4	40.5	0.0	40.5	17.3	4.9	22.3
S.W.C. Vancouver Is.	35.1	23.9	59.0	46.2	6.6	52.8	26.5	10.7	37.2	24.3	7.1	31.4
N.W.C. Vancouver Is.	0.0	12.5	12.5	0.0	5.4	5.4	4.7	11.2	15.9	9.7	0.0	9.7
Other Areas	0.0	225.8	225.8	11.6	156.6	168.2	32.4	173.3	206.7	11.4	137.3	148.7
Coastwide Total	203.4	414.7	618.1	279.9	318.6	596.6	365.1	273.2	638.3	334.9	229.1	552.7

Table 2.2. Estimates of spawning stock biomass, catch, and total stock abundance (tonnes) for the northern stock assessment regions for 1951-1991.

	Queen Charlotte Islands			Prince Rupert District			Central Coast		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1950/51	4191	2847	7038	27967	45865	73832	20886	42458	63345
1951/52	3051	10147	13198	9957	52379	62336	10351	33195	43546
1952/53	5702	0	5702	14016	1865	15881	20187	768	20955
1953/54	11514	1786	13301	9951	27277	37228	16308	24616	40925
1954/55	5840	498	6338	12738	17806	30544	16061	11594	27655
1955/56	5592	77461	83053	12506	10182	22688	11557	43627	55185
1956/57	1495	21803	23298	19301	28035	47336	5960	23261	29221
1957/58	783	11147	11930	8514	4523	13037	8276	9849	18125
1958/59	8085	6828	14913	16197	10224	26421	7409	27870	35279
1959/60	7017	0	7017	13146	18476	31621	20331	4037	24368
1960/61	8612	576	9188	14482	42746	57228	8393	31704	40097
1961/62	5338	7632	12970	20094	27660	47754	22499	15709	38208
1962/63	4465	14705	19170	15151	40228	55379	10918	44054	54972
1963/64	4830	28882	33712	16316	30340	46655	11690	32064	43754
1964/65	1889	35448	37337	6278	44211	50488	4486	15670	20156
1965/66	3525	2746	6271	5769	17295	23065	4990	37482	42472
1966/67	942	213	1155	3057	7998	11055	8219	21890	30109
1967/68	817	80	897	6508	2144	8652	8973	1529	10502
1968/69	1799	0	1799	900	547	1447	3959	100	4058
1969/70	8211	0	8211	11904	1498	13403	19352	209	19561
1970/71	12599	102	12701	9685	3500	13185	8029	3614	11642
1971/72	10845	3972	14817	10896	4494	15390	8583	9279	17863

Table 2.2. (Cont'd)

Season	Queen Charlotte Islands			Prince Rupert District			Central Coast		
	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1972/73	11772	7520	19292	11112	1607	12719	23747	7799	31546
1973/74	13139	6318	19457	8843	3819	12663	19662	8887	28550
1974/75	11525	7724	19249	10572	1702	12273	18952	8739	27690
1975/76	18615	14116	32731	15834	4307	20141	30004	12411	42414
1976/77	18206	12635	30841	15617	8142	23758	27962	11106	39067
1977/78	14994	11726	26720	7577	8588	16165	16712	14046	30758
1978/79	12150	7953	20103	13730	4317	18047	14408	5	14413
1979/80	25853	3316	29169	17155	3425	20580	30389	538	30927
1980/81	26983	5631	32613	17131	3090	20221	32771	2573	35344
1981/82	22013	3778	25792	14917	1984	16901	33660	6370	40030
1982/83	19944	5597	25540	26310	0	26310	41185	5640	46825
1983/84	22150	4719	26869	28013	3761	31774	27875	7193	35068
1984/85	17721	6109	23830	31994	6747	38740	24676	5209	29885
1985/86	6719	3503	10222	30186	8679	38865	21633	3386	25019
1986/87	15277	2061	17338	38140	6271	44411	28714	3615	32330
1987/88	16771	32	16802	32092	7968	40060	48385	4527	52912
1988/89	25821	1461	27283	12931	8474	21405	42133	9442	51574
1989/90	25364	6712	32076	19398	4689	24087	42333	8351	50684
1990/91	14575	5379	19954	20828	3313	24141	30478	8863	39341

Table 2.3. Estimates of spawning stock biomass, catch, and total stock abundance (tonnes) for the southern stock assessment regions for 1951-1991.

	Georgia Strait - North			Georgia Strait - South			WCVI - South			WCVI - North		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1950/51	30795	17787	48582	3623	29824	29447	6510	15914	22423	9345	5908	15252
1951/52	27928	17635	45563	12440	28084	40524	6400	10630	17030	1851	16378	18229
1952/53	33442	4376	37817	33092	3966	37058	8918	20	8938	13198	0	13198
1953/54	23291	20560	43851	35352	44284	79635	5292	28699	33991	4522	4510	9032
1954/55	30962	26818	57780	30895	41619	72514	6439	6041	12479	3831	83	3913
1955/56	13908	27273	41181	14745	44572	59318	8769	17098	25867	12302	0	12302
1956/57	12652	21374	34025	6817	38202	45019	6246	2600	8846	16412	13	16424
1957/58	8288	9012	17299	17174	11616	28790	11648	513	12161	5715	43	5758
1958/59	16095	34189	50284	16121	15765	31886	6037	37385	43422	4793	31838	36631
1959/60	20903	22540	43443	9267	43107	52375	5612	17652	23264	948	36259	37207
1960/61	17094	15784	32878	9186	30410	39596	7804	13489	21293	3430	12946	16376
1961/62	16176	30358	46534	5448	34945	40393	9024	15597	24622	12802	8087	20889
1962/63	16106	33746	49852	8572	35101	43673	8544	4019	12563	1537	14187	15724
1963/64	15319	36808	52127	6760	40179	46939	17239	20230	37469	7302	1036	8337
1964/65	13512	27931	41443	2567	19888	22455	7069	14063	21132	5835	1983	7818
1965/66	4824	20996	25821	2805	12337	15142	3377	8169	11546	1935	2673	4608
1966/67	6781	11157	17938	2558	19885	22444	2163	9171	11333	3568	5974	9542
1967/68	6969	966	7935	5247	981	6228	4105	0	4105	3028	0	3028
1968/69	9063	325	9388	7494	420	7914	5539	0	5539	5555	0	5555
1969/70	22274	519	22793	12870	365	13235	16899	0	16899	4813	0	4813
1970/71	27393	948	28341	10879	745	11624	17904	0	17904	6329	0	6329

Table 2.3.(Cont'd.).

	Georgia Strait - North			Georgia Strait - South			WCVI - South			WCVI - North		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1971/72	14022	6443	20465	9153	2368	11521	17370	4285	21655	9929	2609	12538
1972/73	15205	6679	21884	9812	970	10781	6120	10409	16529	6053	7894	13946
1973/74	27546	3212	30758	15425	791	16216	13069	6371	19441	4300	9963	14263
1974/75	34959	5115	40074	16657	1063	17720	20570	18593	39164	7461	7515	14977
1975/76	38858	8163	47021	9295	4075	13370	27971	33441	61412	4216	5384	9601
1976/77	47284	11304	58587	6001	6205	12206	28556	26453	55009	5725	3590	9315
1977/78	52530	13874	66404	13633	10129	23761	18760	18050	36810	5233	4695	9928
1978/79	73180	8638	81819	19573	11699	31273	27937	9876	37813	22912	8817	31729
1979/80	53805	4525	58329	11808	1294	13102	26534	2276	28810	8369	1706	10075
1980/81	32192	7407	39598	12152	4645	16798	24090	4928	29017	7056	3162	10218
1981/82	64906	5746	70652	7852	7086	14939	10921	3110	14031	6466	2377	8843
1982/83	34396	16269	50665	11277	949	12225	10921	6141	17062	4667	2434	7102
1983/84	15927	9869	25797	11413	1175	12588	16033	5718	21751	2668	858	3526
1984/85	20490	6239	26729	7630	791	8421	25889	178	26067	1376	0	1376
1985/86	55423	287	55710	7824	307	8131	28490	204	28694	8893	0	8893
1986/87	29568	5294	34861	9144	4059	13203	24254	13463	37717	6894	2471	9365
1987/88	22913	7500	30413	5206	715	5922	30036	9724	39760	6947	0	6947
1988/89	52364	7077	59441	4481	1292	5773	34002	13289	47291	4258	0	4258
1989/90	45737	4614	50352	13225	3505	16730	29620	9849	39469	7706	0	7706
1990/91	39147	7687	46834	4244	0	4244	21476	6531	28006	2508	1583	4091

Table 2.4. Estimates of the spawning and total stock biomass (tonnes) for minor stocks in Area 2W for the roe fishery period, 1972-1991.

	Spawning stock biomass by section			Total Catch	Total Biomass
Season	002	003	005	(tonnes)	(tonnes)
1971/72	467	489	1995	0	2951
1972/73	139	1480	1641	706	3966
1973/74	0	961	3001	403	4365
1974/75	314	951	1570	449	3284
1975/76	417	489	1857	0	2763
1976/77	302	669	2442	0	3413
1977/78	0	2104	1665	575	4344
1978/79	53	585	292	690	1620
1979/80	1397	1907	2310	0	5614
1980/81	4097	1859	794	770	7520
1981/82	6143	3265	3154	1226	13788
1982/83	3560	3450	3345	2519	12874
1983/84	2654	1148	2095	0	5897
1984/85	2043	909	1993	199	5144
1985/86	1168	314	1442	0	2924
1986/87	2091	0	765	0	2856
1987/88	4307	1413	2334	0	8054
1988/89	2549	2948	3773	0	9270
1989/90	8343	2117	2648	2272	15380
1990/91	1876	597	1221	2563	6257
Average	2096	1383	2017	619	6114

Table 2.5. Geometric mean age-specific apparent survival and the standard deviations of annual (Y_i) and residual (ε_{ij}) components estimated for each stock assessment region (SAR) over the roe fishery period, 1972-1991.

	Age Class					Standard deviation	
SAR	3+	4+	5+	6+	7++	Y_i	ε_{ij}
QCI	1.4865	1.1658	0.9652	0.7576	0.5344	0.4104	0.3643
PRD	1.2462	1.2748	1.0808	0.8015	0.5344	0.3799	0.4675
CENT	1.3144	1.1430	0.9591	0.7720	0.5182	0.2916	0.3156
GULFN	0.8582	0.6958	0.5765	0.4865	0.3534	0.4824	0.4026
GULFS	0.7165	0.5849	0.5325	0.4967	0.3361	0.7886	0.5914
WCVIS	1.2529	0.9667	0.8804	0.7799	0.5014	0.4289	0.3276
WCVIN	0.9322	0.8907	0.8436	0.8575	0.4121	0.7713	0.4420

Table 2.6. Forecast 1992 biomass of age 3+ and older fish (tonnes) assuming an annual survival rate of 0.64 and using the geometric mean age-specific apparent survival.

	Forecast biomass of 3+ and older fish	
Assessment Region	Age-specific Survival	Survival Rate = .64
Queen Charlotte Islands	13569	10046
Prince Rupert District	25745	16044
Central Coast	29135	21962
Georgia Strait - North	29838	29002
Georgia Strait - South	2485	2766
W.C. Vancouver Is. - South	20342	15037
W.C. Vancouver Is. - North	2305	1759

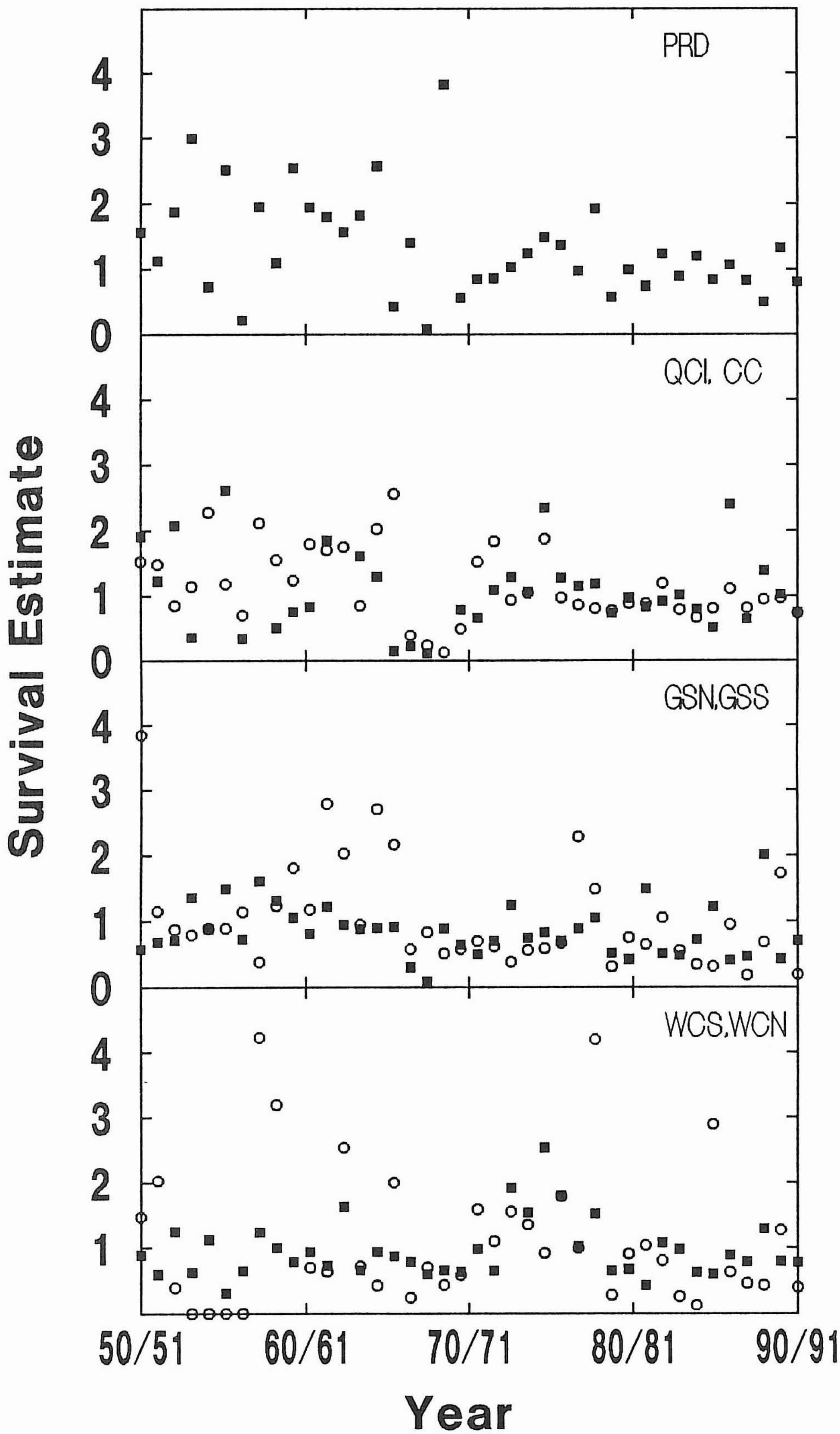

Fig. 2.1 Annual apparent survival rate for seven stock assessment regions, 1951-1991. First series designated by squares. Second series designated by circles.

3. AGE-STRUCTURED MODEL

3.1 INTRODUCTION

An age-structured model, based on the error structure suggested by Fournier and Archibald (1982), has been used to assess B.C. herring stocks since 1982. Ongoing revisions to the model have made it more consistent with the life history of herring and the fisheries which are analyzed. The current version described here uses auxiliary information in the form of spawn survey data, separates catch and age composition data by gear type, and includes availability parameters to estimate partial recruitments to the spawning stock. The model includes realistic assumptions about the form of both measurement and process error. Model parameters are estimated simultaneously using a maximum likelihood method.

Two modifications of the age-structured model are introduced in this assessment. The first change is that the natural mortality rate is estimated rather than fixed at 0.45 as in previous assessments. The reason for this is that a retrospective evaluation of the model showed persistent trends to over- or under-estimate stock abundance when natural mortality was fixed. When the natural mortality rate was estimated simultaneously with other model parameters the persistent trends were eliminated or significantly reduced (Haist 1991). The second modification is the parameterization of gillnet selectivity as a function of weight-at-age rather than as an age-dependent process. This change had been suggested at the 1990 PSARC herring meetings.

3.2 METHODS

The Population Model

Two types of fishing gear are used commonly in B.C. herring fisheries. Seine nets are assumed to be non-selective while gillnets are selective for larger, older fish. Herring fisheries have concentrated primarily on fish which are on, or migrating to the spawning grounds. Therefore, the relative availability of age classes to non-selective gear should be equivalent to the partial recruitment of age classes to the spawning stock. The age-structured model explicitly separates availability (partial recruitment) and gear selectivity. Seine and gillnet fisheries are temporally separate so catch and age-composition are partitioned into fishing periods, separating data for the different gears. Three fishing periods are modelled. The first period encompasses all catch prior to the spring roe herring fisheries. This includes reduction fishery catches prior to 1968 and the winter food and bait fisheries since 1970. Most of this catch was taken by seine gear although small amounts were caught with trawl nets (which are also assumed to be non-size selective). The second fishing period includes all seine roe herring catch and the third period includes all gillnet roe herring catch.

Let T_{ij} be the total number of fish in age class j at the beginning of season i, and λ_{ij} be the proportion of age j fish which are available to the fishery. Then N_{ij1}, the total number of age class j fish which are available at the start of period 1 in season i is given by

$$N_{ij1} = \lambda_{ij} T_{ij} \qquad 3.1$$

To model the fishing process a form of the catch equations which models fishing and natural mortality as continuous processes over time period r, is used:

$$C_{ijr} = \frac{F_{ijr}}{F_{ijr} + M_r}\left(1 - \exp\left(-F_{ijr} - M_r\right)\right) N_{ijr},$$

and, for $r < p$

$$N_{ijr+1} = N_{ijr} \exp\left(-F_{ijr} - M_r\right),$$

where

C_{ijr}	is the catch of age class j in season i for period r,
F_{ijr}	is the fishing mortality of age class j in season i for period r,
M_r	is the natural mortality for period r,
N_{ijr}	is the number of fish in age class j in season i for period r,
p	is the number of fishing periods (p=3),
n	is the number of seasons (n=41),
k	is the number of age classes (k=9).

$N_{i+1,j+1,1}$ is defined by equation 3.1 where for $j+1 < k$

$$T_{i+1,j+1} = N_{ijp} \exp\left(-F_{ijp} - M_p\right) + T_{ij}\left(1 - \lambda_{ij}\right) \exp \sum_r -M_r \qquad 3.2$$

In the model the last age class, k, accumulates all fish aged k and older, so for j+1=k equation 3.2 is replaced by

$$T_{i+1,k} = N_{i,k-1,p} \exp\left(-F_{i,k-1,p} - M_p\right) + T_{i,k-1}\left(1 - \lambda_{i,k-1}\right) \exp\left(\sum_r -M_r\right) + N_{ikp} \exp\left(-F_{ikp} - M_p\right) + T_{ik}\left(1 - \lambda_{ik}\right) \exp\left(\sum_r -M_r\right).$$

To reduce the number of parameters to be estimated assumptions are made about the form of the availabilities and mortalities. The availabilities are formulated to increase with age and are set to 1 for age 6+ and older. For age 3+ to 5+ the availabilities are constant between years, that is,

$$\lambda_{ij} = \lambda_j^{\bullet},$$

Because the proportion of age 2+ fish which are mature appears to vary between years (Haist and Stocker 1985) and some reduction fisheries targetted on immature 1+ fish the availabilities for these two age classes are estimated for each year for which there is age-composition data with the exception of the final year.

For the selective gillnet fishery (i.e. fishing period 3), fishing mortality is separated into age selectivity and fishing intensity components. Following Doubleday (1976),

$$\ln\left(F_{ij3}\right) = a_{i3} + b_j \qquad 3.2a$$

where a_{i3} represents the general level of fishing mortality due to the gillnet fishery in season i, and b_j represents the relative selectivity of the gear for age-class j. For previous assessments age specific selectivites were estimated for each age class from 1+ to 5+ and for fish age 6+ and greater. For the current assessments a different formulation with age selectivity modelled as a function of annual average weights-at-age is also evaluated. A modified logistic equation is used,

$$b_{ij} = \frac{1}{1 + \exp(\rho - \tau g_{ij}^{\omega})}$$

where g_{ij} is $\log_e$ of the geometric mean weight-at-age j in year i. The b_{ij} replace the b_j in equation 3.2a.

For non-selective fisheries (ie. fishing periods 1 and 2) only fishing intensity parameters are estimated, that is

$$\ln\left(F_{ijr}\right) = a_{ir}.$$

For previous stock assessments the natural mortality rate ($M_{\bullet}=\sum_r M_r$) was fixed at 0.45 for all assessment regions. For these assessments the natural mortality parameter, $M_{\bullet}$, is estimated. Natural mortality for the three fishing periods is modelled as,

$$M_1 = 0.95M_\bullet$$

$$M_2 = M_3 = 0.025M_\bullet$$

Additional structure is built into the model through the inclusion of annual spawn data (spawn index, I_i) and the assumption of a stock-recruit relationship. Spawning occurs at the end of the season so the number of spawners at age j in season i (G_{ij}) is estimated by

$$G_{ij} = N_{ijp} \exp\left(-F_{ijp} - M_p\right)$$

and the spawning stock biomass, which is assumed to be equivalent to egg production, in season i (R_i) is

$$R_i = \sum_j w_{ij} G_{ij},$$

where w_{ij} is the average weight-at-age j in season i. The error in the spawn index observations (I_i) are assumed to be multiplicative so that

$$I_i = q R_i \exp\left(\xi_i\right), \qquad 3.3$$

where q is a spawn conversion factor and ξ_i is a normally distributed random variable with mean 0 and variance σ_1^2. A standard Ricker stock-recruit relationship with multiplicative error is assumed,

$$T_{i+1,1} = \alpha R_i \exp\left(-\beta R_i\right) \exp\left(\xi_i\right), \qquad 3.4$$

where ξ_i is a normally distributed random variable with mean 0 and variance σ_2^2.

For the model described above the parameters to be estimated are:

T_{i1}, for all seasons i,
T_{1j}, for age classes 1+ to k,
$\lambda_j^\bullet$, for age classes 1+ to 6+,
λ_{ij}, for age classes 1+ and 2+, for seasons 1 to n-1,
a_{ir}, for all fisheries i,r,

either b_j, for age classes 1+ to 6+, or ρ, τ,
and $\omega, M_\circ, \alpha$, β and q.

The λ_j° and λ_{ij} are parameterized to constrain their values between 0 and 1. The parameters σ_1^2 and σ_2^2 are not estimated in the reconstructions, but are fixed at specified values as discussed later on. The number of parameters for each assessment region are shown in Table 3.1.

The Objective Function

Data input to the stock reconstruction are:

S_{ijr}, the number of sampled fish aged j in season i for period r,
O_{ir}, the estimated number of fish caught in period r of season i,
I_i, the estimated spawn index in season i,
w_{ij}, the mean weight-at-age j in season i,
g_{ij}, the $\log_e$ of the geometric mean weight-at-age j in season i.

The error structure suggested by Fournier and Archibald (1982) for the observations S_{ijr} and O_{ir} is used:

1) the S_{ijr} are obtained from ageing random samples of fish from the catch and there are no ageing errors (i.e. a multinominal sampling distribution).

2) the error structure for the estimated number of fish caught (O_{ir}) is log-normal. That is,

$$O_{ir} = C_{ir} \exp(\xi_i),$$

where C_{ir} is the actual number of fish caught in period j in season i ($C_{ir} = \sum_j C_{ijr}$) and the ξ_i are independent normally distributed random variables with mean 0 and variance σ_3^2.

3) the random variables S_{ijr} and O_{ir} are independent.

Given these stochastic assumptions, the log-likelihood function (ignoring the constant term), for the parameters P_{ijr} $\left(P_{ijr} = C_{ijr}/C_{ir}\right)$, C_{ir}, and σ_3^2 is

$$\sum_{ijr} S_{ijr} \ln(P_{ijr}) - \sum_{ir} \frac{\left(\ln(O_{ir}) - \ln(C_{ir})\right)^2}{2\sigma_3^2} \qquad 3.5$$

The assumptions of log-normal measurement error in the observed spawn-actual spawn relationship and log-normal process error in the spawn-recruit relationship introduce the following contributions to the log-likelihood function

$$-\sum_{i} \frac{\left(\ln(I_i) - \ln(qR_i)\right)^2}{2\sigma_1^2} \qquad 3.6$$

from equation 3.3, and

$$-\sum_{i} \frac{\left(\ln(T_{i+1,1}) - \ln(R_i) - \ln(\alpha) + \beta R_i\right)^2}{2\sigma_2^2} \qquad 3.7$$

from equation 3.4. The w_{ij} and g_{ij} are assumed to be estimated without error.

The objective function described above (eqn. 3.5 + 3.6 + 3.7) incorporates both measurement (observational) and process (deviations from modelled relationships) error assumptions, with the relative magnitude of the errors related through the variance terms σ_1^2, σ_2^2, and σ_3^2, and the sample sizes $\sum_r S_{ijr}$. Because there is not enough information in the data to estimate the relative error in either the observations or processes, with the exception of scaling the S_{ijr}, the variance terms are not estimated but are held at fixed values. The following variances are assumed:

$\sigma_1^2 = 0.05,$

$\sigma_2^2 = 0.25,$

$\sigma_3^2 = 0.0025.$

These correspond to approximately a 4% average error in estimating the total number of fish caught, an 18% average error in spawn index observations, and a 45% average deviation from the spawn-recruit relationship.

The actual number of fish aged could be used in the objective function, however, this may not give a realistic estimate of the precision of the proportion-at-age data. That is, the biological samples obtained may not reflect a homogeneous population. The among-load (ie. samples from different catching vessels) variability in age composition is significantly different between years, and this is related more to the spatial and temporal distribution of the fisheries than to the number of loads sampled or total fish aged. Therefore, the information in the subsamples (between load samples) which are pooled to obtain an estimate of the age composition for a given fishery is used to scale the S_{ijr}.

The theoretical variance of the observed proportion of fish at age j ($\hat{p}_j$) for a random sample of size S is:

$$\sigma^2_{\hat{p}_j} = \frac{p_j(1 - p_j)}{S}$$

where p_j is the true proportion at age j. An estimate of the variance of $\hat{p}_j$ is:

$$s^2_{\hat{p}_j} = \frac{\sum_m (p_{jm} - \hat{p}_j)^2}{M - 1}$$

where p_{jm} is the proportion at age j in subsample m and M is the number of subsamples. This among-subsample variance results from the variance generated by randomly sampling an individual catch plus the variance in the true proportion at age among vessel catches. Using $\hat{p}_j$ as the best estimate for p_j the theoretical sample size (S') which would generate the observed variance at age j is:

$$S' = \frac{\hat{p}_j(1 - \hat{p}_j)}{s^2_{\hat{p}_j}}$$

These theoretical sample sizes, calculated from the among sample variance of age 3+ fish (Appendix Table 2), are used in the objective function.

To facilitate an assessment of the lack of model fit to the age composition data the standard deviates of the observed versus predicted proportions-at-age (Z_{ijr}) are calculated:

$$Z_{ijr} = \frac{S_{ijr} - \left(\sum_r S_{ijr}\right) P_{ijr}}{\sqrt{S_{ijr}\left(1 - \frac{S_{ijr}}{\sum_r S_{ijr}}\right)}}$$

The contribution to the objective function from the lack of fit for the age composition data for a fishery in period r in season i is:

$$V_{ir} = \sum_r S_{ijr} \ln P_{ijr} - \sum_r S_{ijr} \ln\left(\frac{S_{ijr}}{\sum_r S_{ijr}}\right)$$

The second term in this equation is a constant. Inclusion of this term allows comparison of the contribution to the lack of fit for the age composition data for each fishery. If the predicted and observed proportion at age data were identical, the V_{ir} would be zero.

<u>Stock Forecasts</u>

Forecasts of stock abundance for 1992 are calculated by assuming all natural mortality for the first period will occur prior to the fisheries. The numbers of fish at age prior to the fisheries are then the numbers estimated at the beginning of the 1991/92 season multiplied by survival for the first period and the estimated availability at age. Recruitment is calculated for three scenarios based on estimated numbers-at-age 2+ for the 1951-91 time series. Poor, average, and good recruitment are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of historic age 2+ numbers.

To investigate the bias and variance of the estimated parameters, in particular, current stock estimates and stock forecasts, bootstrap techniques (Efron and Gong 1983) are applied to each of the seven data sets. The bootstrap technique involves resampling the original data set, with replacement, to generate a new data matrix which has the same statistical properties as the original data set. To resample the age composition data a two-stage procedure is used. First random subsamples are selected from the original data set, then individual fish are selected at random from the subsample. Because there is no information about the error structure of the spawn observations or the total catch estimates these data are resampled under the same assumptions as used in the analytical model. Log-normal errors with a variance of 0.05 and 0.0025 are used for the observed spawn and the observed catch, respectively. The data for each stock grouping were resampled 100 times and reanalysed producing 100 sets of parameter estimates.

The probability distribution for forecast age 3+ and older biomass is generated from the bootstrap data using the method described in Haist (1991). This method, which includes a prior distribution for the availability of age 2+ fish in the final year, appears to produce consistent estimates of the probability distribution for forecast age 3+ and older biomass.

Input data used for age-structured model analysis are shown in Appendix Table 2 for all stock groupings. Where no sample data are available, but catches were taken, the catch is included with an alternate fishery where age-structure data are available. The same spawn index is used as for previous assessments. This index sums the lengths of spawnings multiplied by a width/intensity factor, standardized by section (Hay and Kronlund 1987).

3.3 RESULTS

A comparison of some pertinent model parameters obtained from stock reconstructions assuming either age-specific selectivity or weight-dependent selectivity is presented in Table 3.2. The objective function values from the weight-dependent selectivity model are lower or equal to those of the age-selectivity model for 6 of the 7 assessment regions. Given that there are 3 less parameters in this model, this clearly suggests that the weight-dependent selectivity model is more appropriate. Generally, the average relative selectivities-at-age do not change substantially with the weight dependent model. The exceptions to this are the estimates for age 3+ and 4+ for the Prince Rupert District and the southern Strait of Georgia. The increase in these average relative selectivities is of special interest in the Prince Rupert District where average weights-at-age have been substantially lower during the 1980's relative to the 1970's.

Further discussions related to age-structured model stock reconstructions and forecasts are based on the results from the weight-dependent selectivity model. Results from these stock reconstructions are presented in Appendix tables 3.1 to 3.7 for the seven assessment regions. A discussion of stock trends and forecasts is presented in Section 4. The standard deviates of the observed versus predicted proportions-at-age and the contributions of the various components to the objective function are shown in Appendix tables 4.1 to 4.7.

Table 3.1. Number of parameters estimated by age-structured model analysis for seven assessment regions.

For all assessment regions:

T_{i1}	41
T_{1i}	8
λ_j^*	5
b_j or ρ,τ,ω	6 or 3
M_*	1
α,β,q	3
Total	64 or 61

Stock Specific:

	a_{ir}	λ_{ij}	age-selectivity model total	weight-selectivity model total
Queen Charlotte Islands	51	70	185	182
Prince Rupert District	69	80	213	210
Central Coast	60	78	202	199
N. Strait of Georgia	75	80	219	216
S. Strait of Georgia	66	80	210	207
S. W. Coast Vancouver Is.	52	72	188	185
N. W. Coast Vancouver Is.	43	64	171	168

Table 3.2 Function value, natural mortality estimates and relative selectivity-at-age for two selectivity models for the seven stock assessment regions (SAR).

SAR	Selectivity model	Function value	Natural mortality	1+	2+	3+	4+	5+	6++
				Mean (or range) of estimated relative selectivity at age					
QCI									
	Age-selectivity	628.1	0.431	0.00	0.01	0.18	0.54	0.85	1.00
	Weight-selectivity	596.6	0.452	0.01	0.03	0.19	0.54	0.78	1.00
	-range			0.00-0.07	0.01-0.11	0.04-0.43	0.28-0.75	0.52-0.94	1.00-1.00
PRD									
	Age-selectivity	2486.8	0.359	0.00	0.01	0.14	0.60	1.00	0.81
	Weight-selectivity	2417.1	0.434	0.00	0.02	0.32	0.67	0.88	1.00
	-range			0.00-0.00	0.00-0.08	0.05-0.73	0.33-0.97	0.66-1.00	1.00-1.00
CENT									
	Age-selectivity	424.1	0.373	0.00	0.02	0.20	0.60	0.93	1.00
	Weight-selectivity	389.4	0.378	0.00	0.03	0.20	0.54	0.81	1.00
	-range			0.00-0.00	0.01-0.06	0.06-0.42	0.29-0.81	0.60-0.95	1.00-1.00
GULFN									
	Age-selectivity	1230.7	0.692	0.00	0.02	0.18	0.53	0.89	1.00
	Weight-selectivity	1205.0	0.727	0.00	0.02	0.23	0.62	0.88	1.00
	-range			0.00-0.00	0.01-0.05	0.12-0.61	0.32-0.93	0.73-0.99	1.00-1.00
GULFS									
	Age-selectivity	723.4	0.684	0.00	0.02	0.22	0.58	1.00	0.75
	Weight-selectivity	723.4	0.678	0.00	0.05	0.46	0.89	1.00	0.99
	-range			0.00-0.00	0.01-0.13	0.12-0.97	0.51-1.00	0.99-1.00	0.87-1.00
WCVIS									
	Age-selectivity	643.6	0.292	0.00	0.03	0.23	0.63	1.00	0.90
	Weight-selectivity	653.2	0.298	0.00	0.02	0.23	0.60	0.87	1.00
	-range			0.00-0.00	0.01-0.06	0.07-0.41	0.37-0.83	0.73-0.96	1.00-1.00
WCVIN									
	Age-selectivity	351.2	0.712	0.00	0.01	0.15	0.50	0.81	1.00
	Weight-selectivity	331.0	0.700	0.00	0.01	0.18	0.51	0.85	1.00
	-range			0.00-0.00	0.00-0.05	0.04-0.66	0.27-0.94	0.71-0.98	1.00-1.00

Mean weight	QCI	PRD	CENT	GULFN	GULFS	WCVIS	WCVIN
	Relative selectivity at mean weight for SAR's						
80	0.004	0.014	0.010	0.017	0.018	0.006	0.003
90	0.012	0.042	0.028	0.046	0.051	0.017	0.013
100	0.031	0.110	0.068	0.111	0.148	0.044	0.040
110	0.071	0.247	0.147	0.239	0.381	0.100	0.106
120	0.145	0.452	0.272	0.434	0.706	0.196	0.231
130	0.259	0.664	0.434	0.645	0.911	0.333	0.411
140	0.404	0.820	0.598	0.808	0.979	0.490	0.602
150	0.556	0.910	0.734	0.904	0.996	0.638	0.754
160	0.688	0.956	0.831	0.954	0.999	0.756	0.855
170	0.789	0.978	0.894	0.978	1.000	0.840	0.915
180	0.860	0.989	0.934	0.990	1.000	0.896	0.950
190	0.907	0.994	0.958	0.995	1.000	0.932	0.970
200	0.938	0.997	0.973	0.998	1.000	0.955	0.982
210	0.958	0.998	0.982	0.999	1.000	0.970	0.988
220	0.971	0.999	0.988	0.999	1.000	0.979	0.993
230	0.980	1.000	0.992	1.000	1.000	0.986	0.995
240	0.986	1.000	0.995	1.000	1.000	0.990	0.997

4. SPAWN TRENDS, STOCK FORECASTS AND POTENTIAL CATCH

4.1 SPAWN TRENDS

Estimates of spawning stock biomass over the period 1972 to 1991 from the age-structured and escapement models are shown in Figures 4.1 and 4.2 for the seven major assessment regions.

For the Queen Charlotte Islands region the two models indicate similar trends in spawning stock biomass. However, the age-structured model suggests much higher peaks in abundance in the mid 1970's and the early 1980's resulting from good recruitment of the 1971, 1972 and 1977 year-classes. Both models suggest a decrease in abundance from 1989 to 1991. The above-average 1985 year class remains dominant, with age 5+ fish comprising 37% of the stock. Both the 1987 and 1988 year classes appear to be well below average. The estimates of 1991 spawning stock biomass are 19,800 and 14,600 tonnes from age-structured and escapement model analyses, respectively.

Trends in spawn abundance from the two assessment models do not track each other very closely for the Prince Rupert assessment region (Fig. 4.1). Age-structured model estimates of abundance are consistently higher than those from the escapement model, and for the past three years in particular, the two models indicate divergent stock trends. We had anticipated that the parameterization of gillnet selectivity as a function of weight-at-age would produce closer agreement between the two model estimates, however, this is not the case. The recent estimates of spawning stock biomass from the age-structured model appear unrealistically high, although it is not clear what may be biasing this model. The estimates of 1991 spawning stock biomass are 74,600 tonnes from the age-structured model and 20,800 tonnes from the escapement model. The 1988 year class is dominant in this region with 2+ year old fish comprising 48% of the stock. This may be one of the strongest year classes ever.

Estimates of spawning stock biomass for the central coast assessment region are very similar for the two models (Fig. 4.1). Both models estimate stock abundances at historically high levels in the late 1980's with a decline in abundance in 1991. Currently, the strong 1985 year class is dominant with age 5+ fish comprising 56% of the stock. The 1990 spawning stock biomass estimates are 37,900 and 30,500 tonnes from age-structured and escapement model analyses, respectively.

For the two Strait of Georgia assessment regions the spawning stock trends estimated by the two models are not very similar, with the escapement model suggesting more erratic fluctuations in abundance. However, both models suggest a decline in abundance from 1990 to 1991. The age-structured model estimates of escapement are 58,900 tonnes for the northern stock and 15,600 tonnes for the southern stock. The estimates from the escapement model are 39,100 tonnes and 4,200 tonnes for the northern and southern stocks, respectively.

The spawning biomass estimates for the southern west coast of Vancouver Island stock follow similar trends since the early 1980's (Fig. 4.2). Both models suggest a decrease in spawning stock abundance from 1989 to 1991, with the age-structured model indicating a significantly greater decline. The escapement model estimate for 1991 spawning biomass is 21,500 tonnes while the age-structured model estimate is 9,900 tonnes. The 1985 year class is dominant in this stock with age 5+ fish comprising 38% of the sampled fish while 3+ fish comprised 23% of the stock.

As in past assessments, the age-structured model estimates much greater spawning stock abundance than the escapement model for the northern west coast Vancouver Island assessment region. While the specific reasons for this are unknown, we have identified two factors which may contribute to these differences. The first is that a significant proportion of the reduction fishery catches in Area 25 could have been fish which were destined to spawn in other locations. Tag recovery data, from taggings conducted between 1937 and 1967, showed that only half of the tags recovered in winter fisheries in Area 25 were from fish which had been tagged during the spawning period in Area 25. The remaining recoveries were primarily fish tagged in other areas on the west coast of Vancouver Island (Hourston 1981). This could result in an overestimate of the productivity of this stock. The other factor which could influence the ability of the age-structured model to obtain accurate estimates of recent spawning biomass is the lack of fisheries in recent years. There have been only two fisheries in Area 25 in the past seven years which limits the information content of data available for analysis. The 1991 spawning biomass estimates are 2,500 tonnes and 20,000 tonnes from the escapement and age-structured models, respectively.

Estimates of spawning stock biomass for the inlets on the west coast of the Queen Charlotte Islands are substantially lower in 1991 than the previous three years (Table 2.4). This may be partially the result of poor spawn survey coverage in these areas. However, the apparent decrease in abundance is consistent with the age-composition data. The dominant 1985 year-class (age 5+) comprised 60% of the Port Louis stock, 69% of the Rennell Sound stock, and 68% of the Inskip stock. In Port Louis age 2+ fish comprised an additional 23% of the stock while in Rennell Sound age 6+ fish comprised 20% of the stock. Inskip had equal proportions (11%) of age 2+ and age 6+ fish.

4.2 STOCK FORECASTS AND POTENTIAL CATCH

We recommend catch levels at 20% of the forecast stock biomass for those stocks that are well above CUTOFF. The 20% harvest rate is based on an analysis of stock dynamics which indicates this level will stabilize both catch and spawning biomass while foregoing minimum yield over the long term. A fixed escapement policy would theoretically produce higher yields and spawning stock stability but is not attainable at the operational level. For those stocks which are marginally above CUTOFF we recommend the following reduced catch level:

Catch = Weighted Run - CUTOFF.

This will provide for smaller fisheries for areas where the 20% harvest rate would bring the escapement down to levels below the CUTOFF.

CUTOFF levels are established at one-forth the unfished average biomass. For the seven stock assessment regions the CUTOFF levels are:

Queen Charlotte Islands	11,700 t,
Prince Rupert District	12,100 t,
Central Coast	10,600 t,
Strait of Georgia	22,100 t,
W.C. Vancouver Is.-south	15,100 t,
W.C. Vancouver Is.-north	5,200 t.

Minimum stock levels have not yet been determined for stocks on the west coast of the Queen Charlotte Islands because there is not a consistent time series of information from which unfished average biomass levels can be estimated.

To provide an overall stock forecast we assign subjective probabilities to the two assessment models. The probability frequency distributions of forecast age 3+ and older fish from both the escapement and age-structured models are shown in Figs. 4.3 and 4.4. The bootstrap procedure used to generate these distributions for the age-structured model has been evaluated and it appears to provide consistent forecasts. However, it is still possible that abundance estimates are biased. With the inclusion of estimates of apparent survival in the forecast procedure for the escapement model, forecasts should be consistent with future abundance estimates from this model. However, if escapement estimates from spawn surveys are consistently underestimated, forecasts from this model could also be biased. For three of the assessment regions there is little overlap in the distribution of forecast age 3+ biomass from the two models (Fig. 4.3, 4.4). Two of these regions, the Prince Rupert District and the northern west coast of Vancouver Island, are areas where we feel the age-structured model may produce biased estimates of stock abundance. Consequently, we use a 80:20 weighting in favour of the escapement model for the northern west coast of Vancouver Island and suggest not weighting the age-structured model forecast for the Prince Rupert District. For the remaining assessment areas we assume an equal probability for both models.

The assigned probabilities were used to weight the forecast runs obtained from each method to provide a single "weighted run" for each of the stock groupings (Table 4.1).

The forecast weighted run size to the Queen Charlotte Islands in 1992 is 18,100 tonnes assuming average recruitment. This is lower than the 1991 forecast and yields a potential catch of 3,620 tonnes.

Because of the uncertainty regarding the age-structured model stock estimates for the Prince Rupert District we forecast a run size of 30,500 tonnes based solely on the escapement model estimate. The forecast run is significantly higher than last year, reflecting the strong 1988 year-class. Assuming an average recruitment level, a catch of 6,100 tonnes should be available for the Prince Rupert District in 1991.

The weighted forecast for the central coast with average recruitment is 37,650 tonnes. The recommended catch for this region is 7,530 tonnes. The 1992 forecast is down slightly from levels of the previous three years because the strong 1985 year class is ageing and there is no indication of significant recruitment from the two subsequent year-classes.

The weighted forecast run to the northern Strait of Georgia in 1992 is 48,500 tonnes, and to the southern Strait of Georgia 10,650 tonnes. An average recruitment assumption would yield potential catches of 9,700 and 2,130 tonnes, respectively. Both assessment models indicate slight decreases in stock levels for both assessment regions and stock forecasts are slightly lower than they were for 1991.

The run forecast to the southern west coast of Vancouver Island, assuming average recruitment, is for 21,100 tonnes and an allowable catch of 4,220 tonnes. The forecast for the northern west coast of Vancouver Island with a lower weighting on the age-structured model, is 8,040 tonnes and a recommended catch of 1,608 tonnes.

The catch levels suggested in this summary are based purely on biological considerations, reflecting the best biological analyses given the available data bases. Management of the various fisheries has practical constraints not considered in this report. As well, there are economic considerations which are beyond the scope of our analysis. Hence, the quotas ultimately adopted by DFO may differ from those suggested herein.

Table 4.1. Summary of 1992 forecast spawning stock biomass (thousands of tonnes) from age-structured and escapement models and weighted runs for poor, average, and good recruitment levels.

	AGE-STRUCTURED MODEL				ESCAPEMENT MODEL				WEIGHTED RESULTS			
	Age	Recruitment Level			Age	Recruitment Level			Relative	Recruitment Level		
Stock Assessment Regions	3+	Poor	Avg	Good	3+	Poor	Avg	Good	Weight	Poor	Avg	Good
Queen Charlotte Islands	16.0	17.1	19.6	26.5	13.6	14.4	16.6	21.9	50:50	15.75	18.10	24.20
Prince Rupert District	81.5	83.5	87.7	101.1	25.7	27.4	30.5	39.1	0:100	27.40	30.50	39.10
Central Coast	33.7	36.4	39.8	50.1	29.1	31.9	35.5	46.7	50:50	34.15	37.65	48.40
Strait of Georgia - northern stock	39.2	45.9	53.3	70.2	29.8	37.7	43.7	54.3	50:50	41.80	48.50	62.25
southern stock[a]	9.0	11.6	14.2	20.1	2.5	5.2	7.1	8.8	50:50	8.40	10.65	14.45
W.C. Vancouver Island - southern stock	8.7	11.6	14.7	24.2	20.3	23.9	27.5	34.6	50:50	17.75	21.10	29.40
northern stock	11.9	15.8	21.0	33.8	2.3	3.2	4.8	10.0	20:80	5.72	8.04	14.76

[a]Recruitment estimates based on data from roe fishery only.

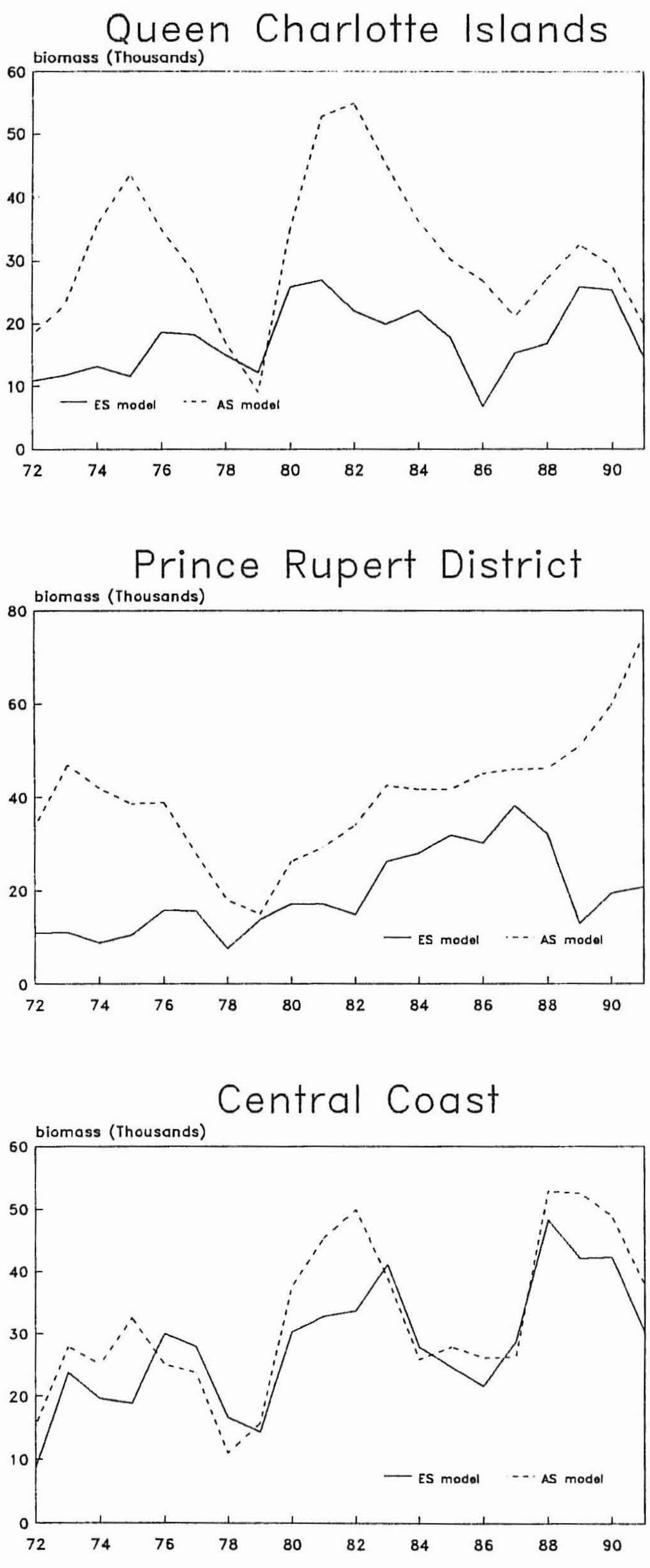

Fig. 4.1 Estimates of spawning stock biomass (tonnes) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1991.

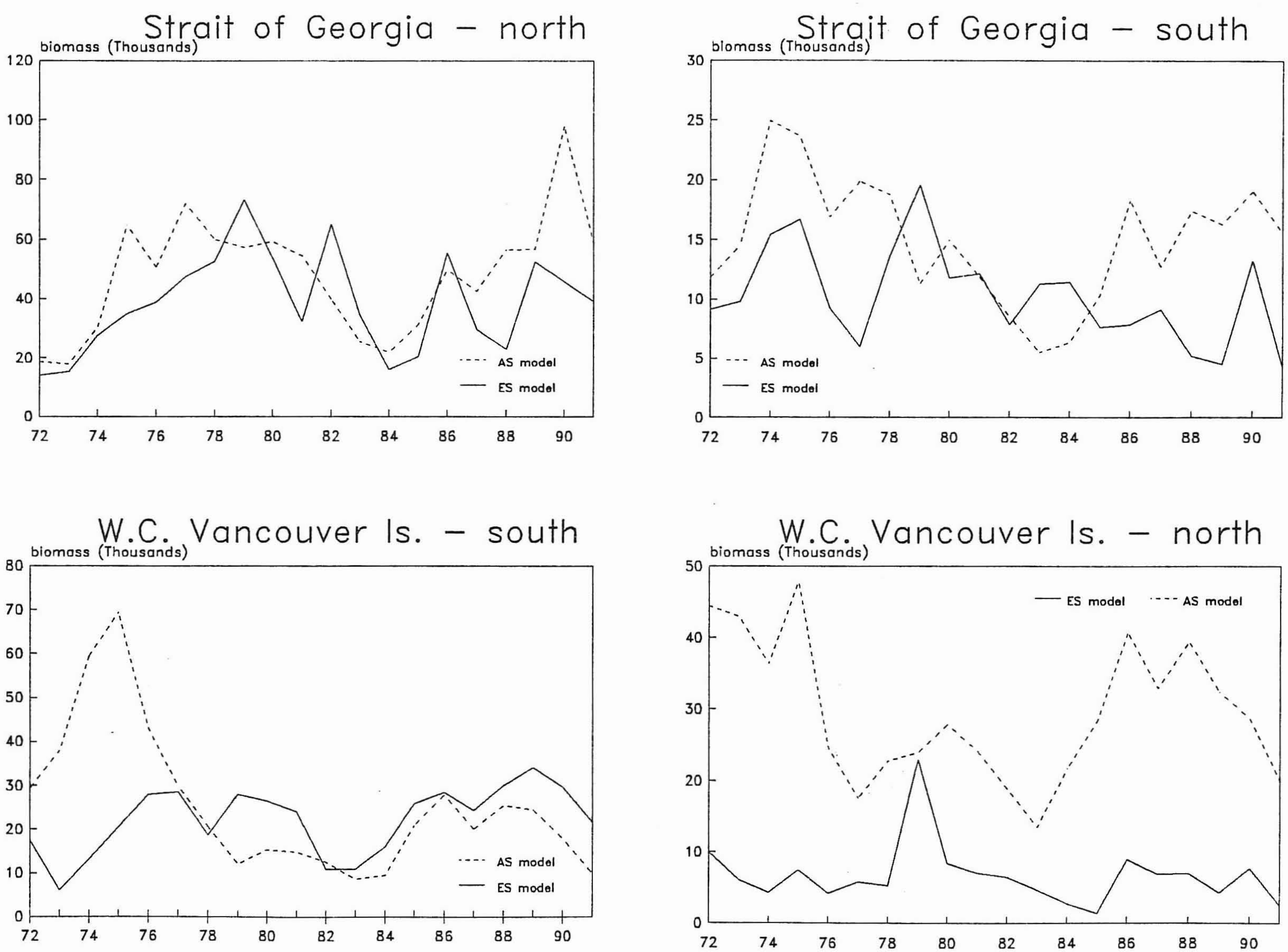

Fig 4.2 Estimates of spawning stock biomass (tonnes) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions, 1972-1991.

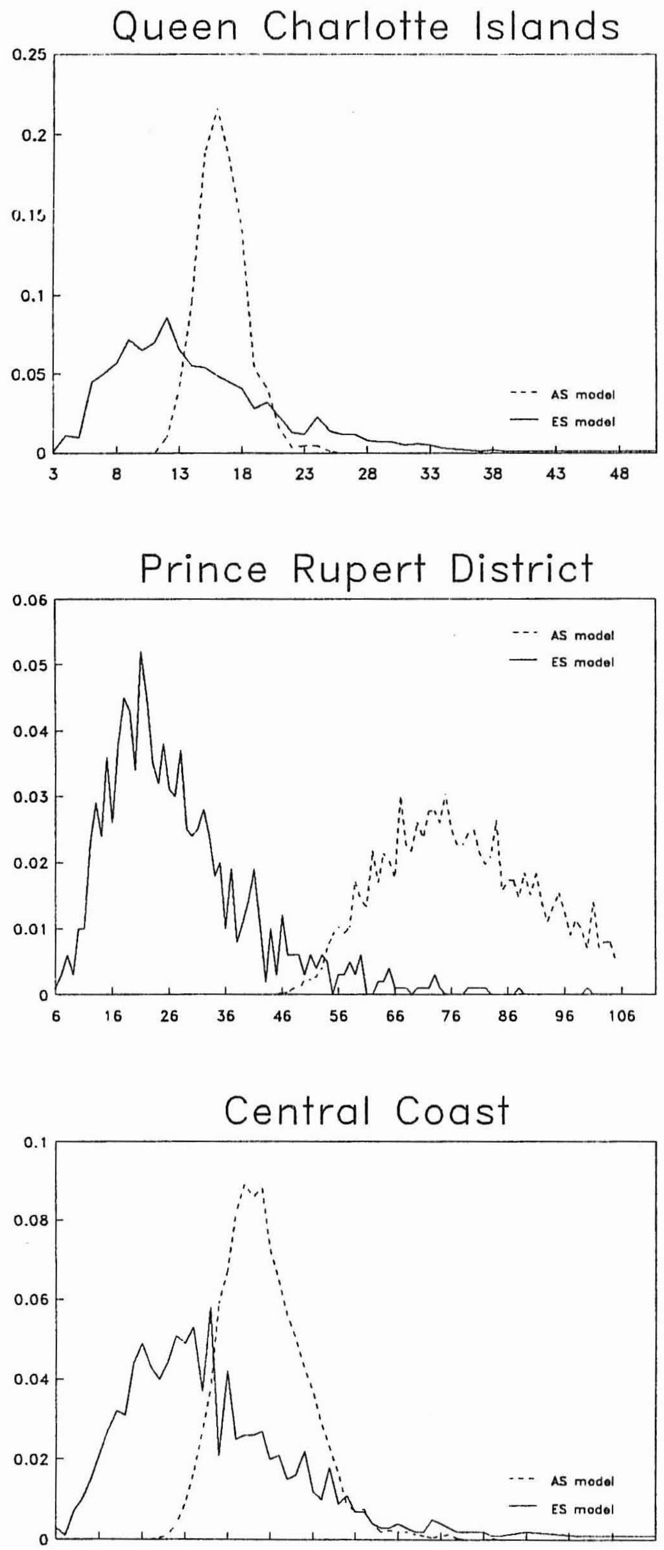

Fig. 4.3 Probability frequency distribution for forecast age 3+ and older biomass (thousand tonnes) from age-structured and escapement models for northern B.C. herring stock assessment regions.

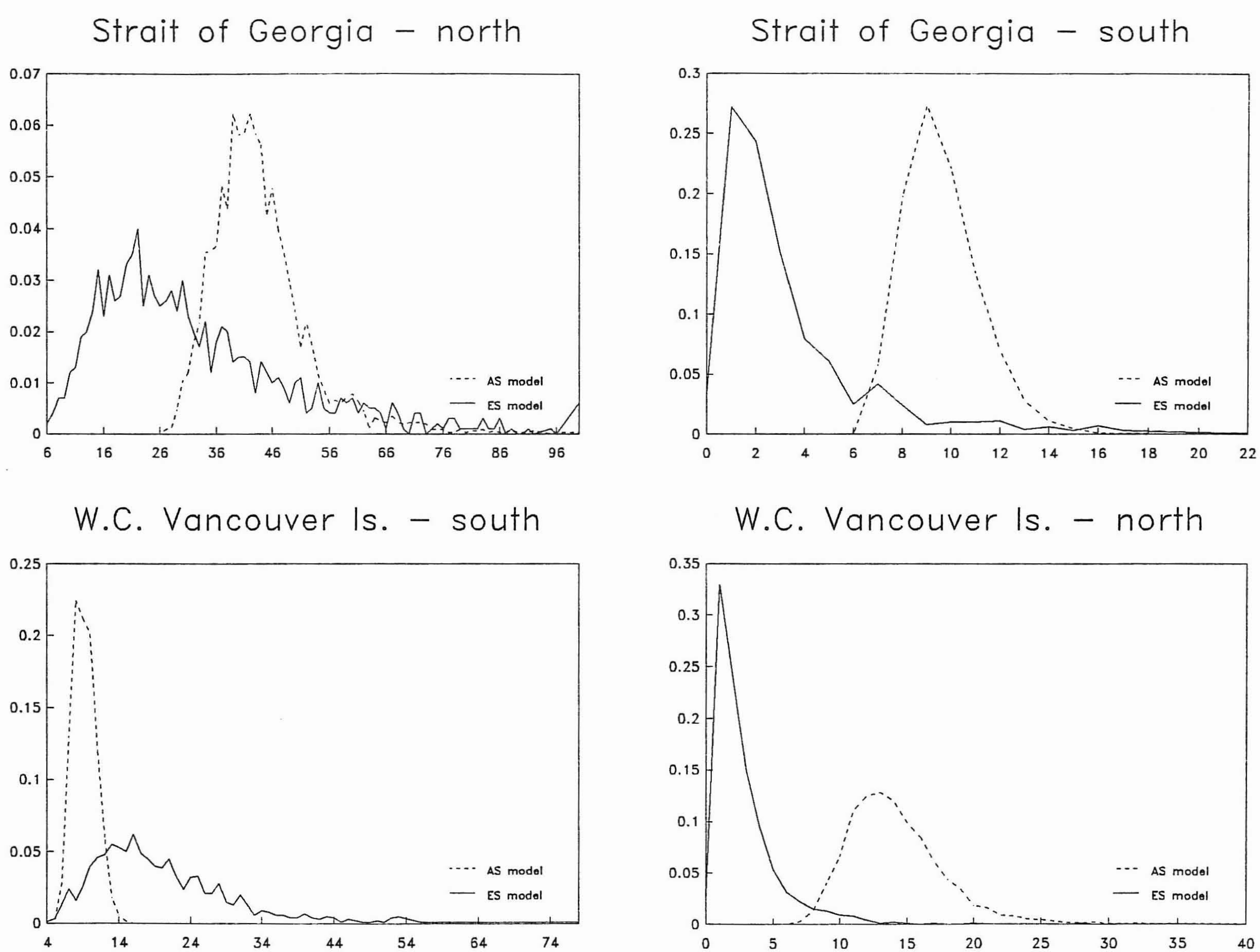

Fig 4.4 Probability frequency distribution for forecast age 3+ and older biomass (thousand tonnes) from age-structured and escapement models for southern B.C. herring stock assessment regions.

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6. APPENDIX TABLES

Appendix Table 1.1. Age specific survival estimates from egg deposition and age composition for the Queen Charlotte Islands 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	6.984	1.273	0.846	0.305	0.059	1.911
52	1.594	1.266	1.044	0.408	0	1.233
53	1.675	4.950	1.203	0.432	3.003	2.078
54	0.613	0.383	0.199	0.194	0.078	0.359
55	7.740	17.860	5.243	2.097	2.042	10.392
56	4.648	4.716	2.028	1.375	0.763	2.608
57	0.818	0.181	0.231	0.083	0	0.342
58	14.076	63.506	55.214	155.899	305.302	20.234
59	0.648	0.195	0.232	0.394	0.121	0.505
60	1.025	0.585	0.449	0.268	0.377	0.756
61	1.698	0.356	0.352	1.668	0.294	0.829
62	2.600	1.583	0.793	1.105	0.476	1.847
63	8.564	4.730	2.098	3.878	0	6.051
64	6.172	0.630	1.007	1.532	1.484	1.612
65	0.538	2.476	4.433	7.360	20.714	1.300
66	0.308	0.063	0.099	0	0	0.149
67	0.289	0.095	0	0	0	0.222
68	0.141	0.052	0	0	0	0.115
69	3.087	20.963	101.386	0	0	7.020
70	1.482	0.595	0.356	0.110	0.304	0.785
71	0.734	0.528	0.736	0.542	0.908	0.664
72	1.181	1.271	0.892	0.495	0.367	1.094
73	1.839	1.517	0.618	0.437	0.290	1.285
74	1.618	1.000	0.784	0.307	0.311	1.071
75	3.398	2.044	2.100	1.683	1.126	2.348
76	4.544	1.253	1.242	1.057	1.050	1.283
77	1.279	1.842	1.336	1.060	0.602	1.155
78	1.536	1.452	2.964	0.773	0.215	1.183
79	3.85	0.746	0.653	0.425	0.422	0.736
80	1.019	1.232	0.626	0.694	0.281	0.970
81	1.094	0.877	0.399	0.469	0.484	0.835
82	0.768	1.547	0.875	1.627	0.917	0.919
83	1.423	1.245	2.330	0.914	0.371	1.019
84	0.811	0.738	1.481	1.003	0.707	0.800
85	0.732	0.669	0.535	0.398	0.326	0.510
86	5.723	3.015	2.556	2.586	1.417	2.397
87	1.009	1.138	0.676	0.551	0.459	0.647
88	2.169	0.890	0.556	0.552	0.343	1.387
89	1.130	0.992	1.137	1.403	0.925	1.024
90	0.900	1.328	0.521	0.816	0.844	0.742

Appendix Table 1.2. Age specific survival estimates from egg deposition and age composition for the Prince Rupert District 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	3.202	1.338	1.021	0.317	0.198	1.564
52	4.600	1.327	0.432	0.288	0.131	1.122
53	2.027	2.773	1.381	0.622	1.519	1.871
54	7.837	1.701	0.687	0.258	0.185	2.988
55	4.330	0.603	0.369	0.221	0.513	0.731
56	2.186	4.437	2.692	1.701	1.301	2.509
57	0.382	0.219	0.083	0.172	0	0.219
58	1.778	1.812	2.638	4.141	1.396	1.950
59	1.177	1.004	1.740	0.597	0.516	1.095
60	3.245	2.508	2.286	2.113	1.380	2.537
61	2.009	2.475	1.443	2.078	1.996	1.937
62	2.200	1.807	1.913	1.099	0.459	1.794
63	2.305	1.820	1.222	0.593	0.592	1.563
64	1.720	1.834	2.172	2.056	2.263	1.822
65	4.010	1.326	4.813	4.493	3.489	2.569
66	0.552	0.483	0.395	0.232	0.094	0.433
67	1.428	2.017	0.896	0.258	1.616	1.406
68	0.114	0.044	0.009	0.063	0.005	0.084
69	4.852	2.198	0.013	7.038	7.038	3.818
70	0.499	0.566	1.475	0	3.668	0.567
71	0.296	1.832	0.614	0.735	1.454	0.843
72	1.122	2.175	0.523	0.748	0.422	0.858
73	1.942	2.453	0.741	0.198	0.121	1.034
74	1.716	1.128	2.102	0.814	0.942	1.245
75	1.104	2.107	1.677	1.001	0.483	1.486
76	8.309	5.289	1.936	0.479	0.790	1.368
77	1.996	3.180	1.063	0.607	0.311	0.970
78	2.218	2.109	3.012	2.028	0.971	1.919
79	0.925	1.197	0.355	0.826	0.201	0.574
80	1.124	0.587	0.553	0.641	0.270	0.991
81	0.709	0.735	0.977	1.011	0.532	0.740
82	1.450	1.103	1.143	2.036	1.463	1.232
83	0.897	0.792	3.716	0.682	0.361	0.892
84	1.894	1.101	0.890	1.018	0.514	1.203
85	1.099	0.832	0.959	0.868	0.657	0.837
86	1.161	1.216	1.135	1.018	0.770	1.067
87	1.093	0.678	1.565	0.541	0.416	0.825
88	0.612	0.442	0.660	0.558	0.334	0.501
89	1.562	1.220	1.283	1.468	1.243	1.327
90	0.750	0.848	0.870	0.773	0.653	0.801

Appendix Table 1.3. Age specific survival estimates from egg deposition and age composition for the Central Coast, 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	2.105	1.503	0.746	0.598	0.738	1.529
52	2.682	1.993	0.598	0.660	0.472	1.484
53	2.113	0.560	0.142	0.050	0.133	0.854
54	1.384	0.570	0.423	0.389	0	1.146
55	3.647	2.338	0.970	0.669	0.358	2.277
56	2.399	2.044	0.784	0.750	0.171	1.185
57	0.966	0.472	0.378	0.142	0	0.703
58	2.068	2.297	2.054	2.466	2.959	2.113
59	2.434	0.664	0.592	0.604	0.529	1.551
60	0.632	1.523	2.447	1.140	1.436	1.242
61	2.544	1.101	1.524	1.077	0.456	1.793
62	2.235	0.670	2.436	0.656	0.166	1.700
63	4.041	0.782	1.163	0.129	0	1.750
64	0.951	0.762	0.702	0.318	0.890	0.851
65	3.052	1.615	1.079	0.547	0	2.023
66	3.261	1.418	1.434	0.840	1.930	2.556
67	0.455	0.202	0.182	0	0.390	0.386
68	0.221	0.265	0.355	0.155	0	0.236
69	0.244	0.072	0	0	0	0.128
70	0.407	1.612	6.245	0	0	0.491
71	1.374	1.388	3.593	2.063	2.141	1.522
72	2.225	2.081	1.643	1.006	0.449	1.835
73	0.804	1.358	1.098	0.718	0.573	0.938
74	2.067	1.144	0.717	0.397	0.185	1.046
75	2.504	1.838	1.449	1.322	1.019	1.872
76	2.011	0.881	1.006	0.616	0.500	0.975
77	0.825	1.054	0.903	0.811	0.474	0.862
78	1.098	1.102	0.959	0.586	0.186	0.807
79	4.413	0.887	0.684	0.405	0.228	0.774
80	0.891	1.339	0.815	0.741	0.349	0.886
81	0.859	0.952	0.653	0.693	0.625	0.884
82	1.205	1.298	1.220	1.219	0.785	1.197
83	1.189	1.013	1.320	0.654	0.337	0.790
84	1.033	0.877	0.760	0.800	0.468	0.666
85	1.033	1.140	0.734	0.529	0.596	0.809
86	1.270	1.167	0.981	1.050	0.971	1.110
87	1.273	1.079	0.561	0.803	0.531	0.815
88	1.083	0.836	0.657	0.471	0.479	0.947
89	1.066	0.968	0.887	1.115	0.929	0.968
90	1.060	1.134	0.705	0.794	0.506	0.737

Appendix Table 1.4. Age specific survival estimates from egg deposition and age composition for the northern Strait of Georgia, 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	0.928	0.282	0.250	0.086	0.034	0.577
52	0.935	0.293	0.379	0.322	1.564	0.687
53	0.854	0.430	0.987	0.749	0.752	0.711
54	2.565	0.433	0.377	0.077	0	1.359
55	0.731	0.962	1.319	1.243	5.999	0.888
56	3.194	1.905	0.709	0.417	0.120	1.496
57	0.776	0.714	0.638	0.750	0.907	0.732
58	2.769	0.896	0.378	0.253	0.172	1.613
59	1.471	0.817	0.627	1.502	1.085	1.312
60	1.270	0.913	0.737	0.431	0	1.058
61	1.460	0.634	0.359	0.853	0	0.815
62	1.348	0.886	0.826	1.035	1.048	1.223
63	1.381	0.235	0.406	0.195	0.170	0.950
64	1.136	0.249	1.143	1.668	1.251	0.881
65	0.742	1.009	2.294	4.010	0	0.901
66	1.416	0.595	0.535	0.412	0.072	0.919
67	0.319	0.279	0.234	0.124	0.391	0.303
68	0.097	0.063	0.001	0	0	0.085
69	0.872	0.897	1.920	0	0	0.893
70	0.608	0.661	2.223	1.109	0	0.649
71	0.581	0.437	0.494	0.302	0.034	0.505
72	0.768	0.773	0.564	0.296	0.057	0.703
73	1.224	1.652	1.060	0.526	0.092	1.247
74	1.318	0.484	0.338	0.193	0.372	0.751
75	0.915	0.778	0.580	0.306	0.694	0.832
76	1.124	0.560	0.422	0.449	0.474	0.705
77	0.910	0.822	0.890	1.054	1.324	0.895
78	1.112	1.001	1.111	0.961	1.136	1.053
79	0.928	0.616	0.347	0.279	0.230	0.520
80	0.416	0.518	0.464	0.323	0.177	0.422
81	1.485	1.635	1.070	1.433	1.862	1.497
82	0.621	0.507	0.406	0.541	0.376	0.510
83	0.739	0.427	0.377	0.283	0.189	0.483
84	0.903	0.606	0.684	0.538	0.353	0.721
85	1.499	0.979	0.685	0.679	0.415	1.225
86	0.413	0.402	0.378	0.415	0.433	0.408
87	0.453	0.523	0.385	0.415	0.384	0.467
88	2.420	1.653	1.273	1.220	0.795	2.012
89	0.613	0.400	0.366	0.297	0.277	0.430
90	0.634	0.785	0.812	0.967	0.974	0.710

Appendix Table 1.5. Age specific survival estimates from egg deposition and age composition for the southern Strait of Georgia, 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	4.125	3.253	2.653	5.076	12.301	3.849
52	1.576	0.438	0.311	0.009	0	1.155
53	1.071	0.460	0.412	0.394	0	0.877
54	1.146	0.326	0.191	0.354	0	0.798
55	1.080	0.638	0.556	0.803	0.316	0.892
56	1.218	0.430	0.587	0.522	1.581	0.895
57	1.274	0.627	1.387	0.883	1.821	1.144
58	0.448	0.193	0.333	0.277	0.297	0.383
59	1.442	0.437	0.610	0.763	2.288	1.236
60	2.198	1.227	1.607	0.906	0	1.815
61	1.910	0.550	0.595	0.850	2.642	1.179
62	3.085	1.612	0.609	0.913	0	2.789
63	2.984	0.452	0.747	1.135	2.958	2.033
64	1.392	0.232	0.829	0	5.298	0.952
65	2.556	3.062	2.620	5.079	0	2.708
66	2.919	1.276	0.928	5.103	0	2.164
67	0.611	0.432	0.726	0	3.129	0.579
68	1.007	0.568	0.959	0	0	0.836
69	0.434	0.627	0.456	1.279	0	0.514
70	0.549	0.823	0.410	1.643	0.203	0.579
71	1.182	0.449	0.353	0.382	0.081	0.701
72	0.857	0.581	0.364	0.420	0.588	0.622
73	0.560	0.267	0.151	0.042	0.049	0.385
74	0.451	0.621	1.831	2.623	0	0.564
75	0.602	0.507	0.537	0.958	0.787	0.592
76	1.315	0.592	0.388	0.456	0.179	0.672
77	3.165	1.534	1.317	0.820	0.127	2.284
78	1.753	0.984	2.063	1.711	20.125	1.490
79	0.410	0.341	0.259	0.268	0.118	0.313
80	0.706	1.316	0.739	0.562	0.229	0.755
81	0.734	0.637	0.453	0.559	0.719	0.652
82	1.073	1.184	0.755	1.124	1.241	1.056
83	0.713	0.533	0.567	0.339	0.306	0.557
84	0.506	0.289	0.262	0.135	0.165	0.346
85	0.390	0.246	0.226	0.179	0.086	0.315
86	0.800	1.292	1.523	2.038	1.554	0.952
87	0.204	0.173	0.109	0.228	0.026	0.182
88	0.620	0.864	1.028	0.938	0.708	0.684
89	2.151	1.682	1.617	1.394	1.897	1.731
90	0.162	0.269	0.275	0.164	0.211	0.193

Appendix Table 1.6. Age specific survival estimates from egg deposition and age composition for the southern west coast of Vancouver Island, 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	1.402	0.519	0.340	0.380	0	0.890
52	0.794	0.158	0.100	0	0	0.593
53	1.650	0.579	0.979	0.925	0	1.250
54	0.776	0.326	0.285	0.082	0	0.620
55	1.077	1.235	1.309	1.117	0	1.127
56	0.410	0.021	0.033	0	0	0.307
57	0.753	0.349	0.734	0	0	0.648
58	1.460	0.772	0.781	4.466	0	1.240
59	1.213	0.612	0.355	1.422	1.777	1.001
60	0.893	0.676	0.235	0	0	0.783
61	0.940	0.979	0.781	0	0	0.934
62	0.766	0.611	0.284	0.305	0	0.723
63	2.461	0.949	0.610	1.505	0	1.628
64	0.819	0.394	0.370	0.496	0	0.656
65	1.545	0.681	0.414	0.381	0	0.937
66	1.632	0.415	0.152	0.400	0.906	0.868
67	0.831	0.681	0.577	0.736	0.392	0.783
68	0.782	0.384	0.466	0.129	0	0.597
69	0.581	0.765	0.454	1.666	0	0.653
70	0.608	0.892	0.508	1.456	0	0.634
71	1.616	0.570	0.469	0.418	0.547	0.979
72	1.104	0.578	0.469	0.387	0.199	0.650
73	3.336	2.166	0.791	0.520	0.213	1.916
74	1.171	1.562	2.303	2.691	2.934	1.536
75	2.584	2.898	2.770	2.220	1.161	2.541
76	8.160	1.731	1.290	0.624	0.292	1.802
77	1.867	0.812	1.026	0.866	0.675	1.016
78	1.805	1.734	1.564	1.006	0.915	1.523
79	1.408	0.583	0.630	0.642	0.352	0.648
80	0.619	1.015	0.755	0.822	0.303	0.669
81	0.422	0.517	0.296	0.448	0.307	0.426
82	1.314	1.081	0.986	1.081	0.790	1.076
83	1.319	0.919	1.055	0.819	0.451	0.974
84	0.752	0.499	0.519	0.556	0.445	0.620
85	0.542	0.640	0.952	0.932	0.518	0.596
86	0.902	0.860	0.970	0.915	0.703	0.886
87	0.791	0.787	0.890	0.723	0.476	0.782
88	1.561	1.401	0.898	0.629	0.301	1.295
89	0.814	0.819	0.764	0.756	0.465	0.794
90	0.779	0.855	0.794	0.743	0.561	0.777

Appendix Table 1.7. Age specific survival estimates from egg deposition and age composition for the northern west coast of Vancouver Island, 1951-1990. Estimates are for the year shown so that year 51 implies survival from 1951 to 1952.

	Age					
Year	3+	4+	5+	6+	7++	Annual
51	1.658	1.569	0.906	0.961	0.912	1.478
52	18.400	0.369	0.073	0.179	0	2.035
53	0.415	0.237	1.814	0.510	0	0.394
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
57	0	0	0	0	0	0
58	4.030	4.354	4.034	4.039	5.617	4.231
59	8.001	2.622	1.065	1.137	0.468	3.196
60	9.787	3.882	0	0	0	6.757
61	1.107	0.121	0.710	0	0	0.696
62	0.641	0.582	0.920	0.255	0	0.636
63	3.605	1.697	2.369	0	0	2.543
64	1.236	0.383	0	0	0	0.716
65	0.654	0.281	0.533	0	0	0.427
66	4.867	1.280	0.349	0.060	0.455	2.003
67	0.281	0.175	0.109	0.190	1.898	0.245
68	0.948	0.363	0.082	0.513	0	0.698
69	0.451	0.393	0.499	0	0.790	0.436
70	0.790	0.313	0.258	0.543	4.559	0.583
71	1.212	2.489	1.190	1.187	0.885	1.590
72	2.615	1.315	0.464	0.778	0.227	1.100
73	2.433	1.873	1.080	0.783	0.509	1.554
74	1.572	1.219	1.271	1.085	1.196	1.355
75	0.717	1.253	1.538	1.709	0.674	0.917
76	2.822	1.438	1.654	2.998	1.517	1.789
77	1.219	1.086	0.899	1.294	0.521	0.991
78	4.510	3.823	3.454	4.678	0.465	4.198
79	0.505	0.255	0.169	0.113	0.012	0.281
80	1.189	0.641	0.744	0.808	0.187	0.904
81	1.483	1.023	0.670	0.954	0.846	1.037
82	0.686	0.882	0.862	1.092	0.548	0.802
83	0.262	0.222	0.291	0.282	0.203	0.260
84	0.076	0.244	0.955	0.477	0.125	0.126
85	3.200	1.574	2.108	2.199	1.035	2.889
86	0.383	0.939	1.279	0.809	0.809	0.627
87	0.529	0.470	0.420	0.393	0.437	0.460
88	0.407	0.427	0.540	0.444	0.435	0.430
89	1.337	1.401	1.067	1.284	0.828	1.274
90	0.424	0.532	0.423	0.372	0.189	0.401

Appendix Table 2.1. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Queen Charlotte Islands stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	0.07	15.31	52.91	15.31	11.52	4.20	0.61	0.07	0.00	1476	1544	317.44
1951/52	WINTER	17.13	21.81	34.17	21.54	4.14	1.12	0.09	0.00	0.00	2224	166	1124.25
1953/54	WINTER	2.96	29.02	21.28	33.66	10.19	1.93	0.71	0.19	0.06	0*	25	231.66
1954/55	WINTER	8.74	14.08	39.42	18.06	14.85	4.37	0.29	0.10	0.10	0*	25	52.94
1955/56	WINTER	0.15	16.02	9.64	62.17	8.38	2.74	0.74	0.00	0.15	1348	681	6551.83
1956/57	WINTER	20.77	24.13	15.76	9.59	26.73	2.45	0.44	0.13	0.00	4733	2180	2089.67
1957/58	WINTER	81.89	16.42	1.23	0.18	0.14	0.14	0.00	0.00	0.00	2838	514	2146.22
1958/59	WINTER	1.05	63.16	28.42	7.37	0.00	0.00	0.00	0.00	0.00	95	6	735.74
1960/61	WINTER	4.21	32.63	36.00	24.84	1.26	0.42	0.21	0.42	0.00	0*	25	59.00
1961/62	WINTER	3.04	37.62	41.36	9.58	6.54	1.64	0.23	0.00	0.00	428	170	693.85
1962/63	WINTER	0.37	50.00	27.11	18.16	2.11	1.99	0.00	0.12	0.12	804	411	1342.32
1963/64	WINTER	0.95	15.34	59.47	17.80	5.30	1.14	0.00	0.00	0.00	528	297	2515.06
1964/65	WINTER	1.61	79.77	11.02	4.37	2.09	0.95	0.19	0.00	0.00	1053	165	3424.55
1965/66	WINTER	18.36	32.77	16.38	10.40	7.45	5.89	4.92	2.07	1.75	0*	25	210.12
1966/67	WINTER	0.88	67.26	26.49	2.65	2.72	0.00	0.00	0.00	0.00	0*	25	18.83
1967/68	WINTER	29.95	50.57	17.23	2.25	0.00	0.00	0.00	0.00	0.00	0*	25	8.43
1971/72	ROE-SN	3.04	32.60	38.34	16.05	6.08	2.45	0.93	0.42	0.08	1184	94	276.24"
1972/73	ROE-SN	0.17	40.56	21.55	27.29	8.00	1.68	0.75	0.00	0.00	1726	914	524.51
1973/74	ROE-SN	0.12	30.49	40.38	17.69	9.09	1.86	0.31	0.06	0.00	1617	185	482.78
	ROE-GN	0.00	5.73	48.41	25.48	16.56	3.18	0.00	0.00	0.64	157	25	8.24
1974/75	ROE-SN	0.63	25.31	34.21	27.90	9.53	1.95	0.37	0.10	0.00	6010	655	587.13"
	ROE-GN	0.00	0.00	22.50	40.00	30.00	5.00	2.50	0.00	0.00	40	40	6.19
1975/76	ROE-SN	0.43	2.78	37.34	29.38	22.73	6.31	0.96	0.07	0.00	4170	247	813.57"
	ROE-GN	0.00	0.00	0.75	21.80	60.90	14.29	2.26	0.00	0.00	133	186	91.86
1976/77	ROE-SN	0.09	19.57	8.01	29.41	22.95	15.09	4.47	0.40	0.00	3220	1113	801.25"
1977/78	ROE-SN	0.16	26.18	17.34	9.48	26.18	14.10	5.27	0.97	0.32	1234	1932	620.46
	ROE-GN	0.00	0.61	4.85	11.52	19.39	39.39	20.00	3.64	0.61	165	126	129.55
1978/79	ROE-SN	5.59	4.41	31.57	18.73	21.27	15.10	2.84	0.39	0.10	1020	441	387.56"
	ROE-GN	0.00	0.00	25.13	25.13	25.13	20.10	3.52	0.50	0.50	199	65	128.20
1979/80	ROE-SN	0.50	83.22	4.45	5.37	2.77	1.89	1.15	0.56	0.09	3390	2427	222.15
	ROE-GN	0.00	3.73	4.48	40.09	20.79	22.28	6.93	1.60	0.11	938	1028	74.53
1980/81	ROE-SN	0.18	3.54	84.99	5.40	3.05	1.82	0.71	0.18	0.12	4943	489	331.92"
	ROE-GN	0.00	0.22	74.81	8.29	9.39	4.86	1.88	0.55	0.00	905	339	121.41
1981/82	ROE-SN	0.84	4.46	4.43	84.63	2.42	1.62	0.95	0.53	0.14	3591	1725	185.38"
	ROE-GN	0.00	0.19	3.42	88.21	3.42	2.66	1.14	0.76	0.19	526	341	99.20
1982/83	ROE-SN	4.88	5.23	3.51	6.86	72.87	3.91	1.58	0.91	0.25	1968	1609	317.79"
	ROE-GN	0.00	0.00	1.34	2.81	89.02	3.08	2.54	0.67	0.54	747	637	58.91
1983/84	WINTER	5.91	36.56	2.15	4.30	8.60	39.25	2.15	0.54	0.54	186	186	16.18
	ROE-SN	2.06	35.34	4.90	2.77	10.53	42.85	1.03	0.35	0.16	3104	1554	312.33
	ROE-GN	0.00	2.81	1.28	4.60	8.95	80.05	1.79	0.26	0.26	391	427	34.59
1984/85	ROE-SN	1.32	14.93	31.83	4.05	4.50	11.36	31.47	0.45	0.08	3556	699	311.61"
	ROE-GN	0.00	0.00	15.28	2.08	4.17	11.11	66.67	0.69	0.00	144	83	85.78
1985/86	ROE-SN	0.21	2.83	21.99	40.19	4.04	3.27	8.03	19.12	0.32	4733	2821	157.73
	ROE-GN	0.00	0.00	11.85	50.62	5.43	5.19	10.37	16.05	0.49	405	383	55.79
1986/87	ROE-SN	1.74	10.42	5.85	24.35	37.76	3.84	4.33	5.79	5.91	3281	1144	131.07"
1987/88	ROE-SN	3.64	51.01	7.52	4.77	11.75	14.86	1.37	1.67	3.40	1676	575	2.56"
1988/89	ROE-SN	2.27	17.46	66.35	4.01	1.57	3.90	2.78	0.62	1.04	3563	199	121.30"
1989/90	ROE-SN	0.22	9.67	18.16	60.00	3.94	1.84	3.82	1.70	0.65	5055	409	411.23"
	ROE-GN	0.00	0.46	8.31	43.65	10.16	8.55	17.09	8.55	3.23	433	397	77.90
1990/91	ROE-SN	6.85	4.21	10.69	29.26	37.47	3.73	1.85	4.06	1.88	3301	1869	397.47
	ROE-GN	0.00	0.00	2.54	21.57	44.42	9.14	6.85	10.41	5.08	394	457	35.80

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	52.0	84.4	106.6	125.9	147.7	156.8	172.1	147.3	183.5
ROE-SN	65.9	97.7	125.6	149.6	170.2	186.2	199.7	212.5	211.9
ROE-GN	0.0	119.8	141.4	152.5	169.3	178.5	191.1	188.9	195.8

* - Age composition from published reports.
~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
" - includes catch from winter fisheries
^ - includes catch from seine roe fisheries
' - includes catch from gillnet fisheries

Appendix Table 2.2. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Prince Rupert District stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	1+	2+	3+	4+	PERCENT AT AGE 5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	4.34	18.20	58.50	10.38	5.62	2.65	0.26	0.04	0.02	4682	2200	4953.11
1951/52	WINTER	4.76	8.81	33.67	45.24	6.15	1.03	0.30	0.03	0.00	5922	2508	4390.81
1952/53	WINTER	1.20	38.13	23.04	25.44	11.13	0.99	0.07	0.00	0.00	1419	752	173.50
1953/54	WINTER	2.11	28.35	29.07	24.02	13.22	2.60	0.60	0.04	0.00	2656	891	2522.89
1954/55	WINTER	2.74	4.86	70.29	15.65	5.22	1.06	0.18	0.00	0.00	1131	467	1698.85
1955/56	WINTER	10.04	58.11	9.51	18.95	2.55	0.53	0.18	0.12	0.00	1683	555	1218.10
1956/57	WINTER	11.49	17.76	39.79	13.21	16.04	1.37	0.32	0.03	0.00	3491	515	2827.98
1957/58	WINTER	45.81	30.22	8.03	11.81	1.77	2.36	0.00	0.00	0.00	847	123	644.16
1958/59	WINTER	3.10	56.69	20.85	5.80	9.88	1.72	1.90	0.06	0.00	1741	349	1037.09
1959/60	WINTER	49.14	6.25	28.20	8.89	4.14	2.52	0.67	0.19	0.00	4206	337	2451.31
1960/61	WINTER	9.74	58.33	7.28	18.00	4.35	1.60	0.58	0.12	0.00	4300	763	4815.52
1961/62	WINTER	3.04	30.30	44.66	6.88	9.92	3.41	0.92	0.54	0.33	1845	752	2476.36
1962/63	WINTER	39.30	13.29	18.18	22.05	3.60	2.96	0.50	0.06	0.06	3415	433	4788.66
1963/64	WINTER	3.71	64.94	10.12	10.94	8.85	0.71	0.59	0.12	0.03	3400	1914	3555.87
1964/65	WINTER	5.98	13.57	50.95	8.54	11.01	8.45	1.04	0.33	0.12	3360	459	3649.12
1965/66	WINTER	0.00	5.29	21.38	23.45	16.32	19.08	9.66	3.22	1.61	435	59	1071.96
1966/67	WINTER	57.22	32.21	5.37	1.88	2.70	0.41	0.20	0.00	0.00	0*	25	1218.55
1967/68	WINTER	34.87	39.74	19.40	4.59	0.73	0.26	0.14	0.27	0.00	0*	25	274.98
1968/69	WINTER	30.04	45.04	20.58	3.90	0.18	0.21	0.04	0.00	0.00	0*	25	69.11
1969/70	WINTER	18.67	62.91	15.11	3.12	0.03	0.08	0.08	0.00	0.00	0*	25	183.69
1970/71	WINTER	6.49	50.42	29.28	7.99	4.33	0.83	0.50	0.17	0.00	601	38	413.67
1971/72	ROE-SN	0.00	5.32	17.93	64.43	5.88	3.78	2.38	0.14	0.14	714	209	278.66"'
1972/73	WINTER	22.88	47.71	7.84	13.07	4.58	2.61	1.31	0.00	0.00	153	14	35.70
	ROE-SN	0.25	33.00	4.39	30.36	26.60	3.39	1.25	0.75	0.00	797	662	94.37
1973/74	ROE-SN	0.16	17.88	53.16	7.44	16.46	4.43	0.32	0.16	0.00	632	121	174.36"
	ROE-GN	0.00	0.96	39.42	21.15	34.62	2.88	0.96	0.00	0.00	104	83	90.07
1974/75	WINTER	1.16	10.47	15.12	43.02	13.95	11.63	2.33	2.33	0.00	86	86	14.18
	ROE-SN	1.30	9.40	22.19	43.10	11.16	9.63	2.47	0.59	0.16	3074	778	116.23
	ROE-GN	0.00	0.00	31.91	59.57	8.51	0.00	0.00	0.00	0.00	47	47	0.76
1975/76	WINTER	0.00	4.94	6.79	9.88	16.67	17.90	35.19	8.64	0.00	162	1661	30.99
	ROE-SN	0.00	0.84	6.87	31.70	50.07	7.29	2.38	0.84	0.00	713	654	204.01
	ROE-GN	0.00	0.00	15.79	57.89	22.81	3.51	0.00	0.00	0.00	57	57	17.93
1976/77	WINTER	0.39	23.48	15.66	22.90	16.63	10.76	7.44	2.35	0.39	511	276	61.55
	ROE-SN	0.08	16.03	3.74	22.67	37.79	15.04	3.28	0.92	0.46	1310	1344	370.40
	ROE-GN	0.00	1.07	2.14	19.93	54.09	14.59	6.76	1.42	0.00	281	1104	89.48
1977/78	WINTER	1.32	9.57	27.80	18.23	18.13	14.56	6.92	2.44	1.02	982	124	238.36
	ROE-SN	1.13	11.70	32.83	9.56	21.13	20.38	2.39	0.63	0.25	795	131	136.94
	ROE-GN	0.00	0.00	20.53	5.96	32.45	33.11	6.62	1.32	0.00	151	37	181.42
1978/79	WINTER	1.81	9.27	9.83	25.85	17.77	16.17	9.55	5.71	4.04	1435	856	118.66
	ROE-SN	2.71	18.16	11.48	29.23	11.48	18.27	6.47	1.36	0.84	958	1475	84.40
	ROE-GN	1.15	1.15	8.05	41.38	15.71	22.22	8.05	1.92	0.38	261	255	74.00
1979/80	WINTER	1.12	61.15	6.55	7.92	8.18	6.55	4.91	2.07	1.55	1161	560	66.18
	ROE-SN	0.64	77.94	7.26	5.09	3.81	3.49	1.28	0.39	0.11	2811	535	171.81
	ROE-GN	0.00	3.45	8.72	31.24	22.31	21.10	9.13	3.45	0.61	493	915	63.73
1980/81	WINTER	1.01	7.37	54.61	9.33	10.22	9.29	4.31	2.31	1.53	6524	1129	137.14
	ROE-SN	0.46	11.18	81.22	3.30	1.73	1.51	0.37	0.15	0.06	3238	1059	106.00
	ROE-GN	0.00	0.47	38.88	15.46	22.95	14.75	5.62	1.87	0.00	427	557	23.77
1981/82	WINTER	1.54	11.54	20.53	41.10	10.49	6.59	5.02	2.06	1.12	2669	555	138.82
	ROE-SN	2.72	18.78	7.38	66.32	2.85	1.36	0.39	0.19	0.00	1544	576	16.50
1982/83	ROE-SN	1.35	20.82	17.74	5.26	49.16	3.73	1.13	0.59	0.22	4583	1448	1.00~
1983/84	WINTER	2.75	36.24	15.75	13.91	9.79	16.36	2.75	1.07	1.38	654	303	23.68
	ROE-SN	0.49	35.46	14.42	10.29	14.38	23.62	0.99	0.25	0.11	2837	618	159.00
	ROE-GN	0.00	0.99	1.98	12.87	21.39	57.43	3.37	1.19	0.79	505	961	127.31
1984/85	WINTER	15.37	8.24	25.83	28.21	11.73	5.39	4.12	0.79	0.32	631	45	28.24
	ROE-SN	0.22	7.75	54.69	11.93	6.39	10.56	8.19	0.14	0.14	3664	969	278.16
	ROE-GN	0.00	0.36	16.36	14.91	15.82	21.82	29.82	0.36	0.55	550	543	235.00
1985/86	WINTER	11.73	9.91	7.95	21.25	18.64	11.73	6.65	6.91	5.22	767	512	25.39
	ROE-SN	1.75	13.76	9.44	46.26	10.80	5.27	7.09	5.53	0.09	5655	4566	277.60
	ROE-GN	0.00	0.39	4.32	53.85	19.00	8.71	7.77	5.73	0.24	1274	558	311.02
1986/87	ROE-SN	0.89	38.64	10.21	6.89	29.87	5.90	3.49	2.87	1.25	4731	4068	187.95"
	ROE-GN	0.00	0.57	3.01	6.93	55.25	16.07	8.80	5.96	3.41	1761	819	270.57
1987/88	ROE-SN	0.45	30.93	38.99	5.95	8.36	11.56	1.94	1.44	0.38	4222	2993	353.56"
	ROE-GN	0.00	0.42	6.48	7.18	21.55	44.79	11.69	5.07	2.82	710	421	276.81
1988/89	ROE-SN	0.61	21.68	36.14	27.68	4.92	4.48	3.57	0.64	0.28	3616	1265	357.83"
	ROE-GN	0.00	0.00	4.62	30.46	13.66	23.53	21.85	3.36	2.52	476	432	317.93
1989/90	ROE-SN	0.65	18.15	22.55	28.24	20.52	4.01	3.31	2.15	0.41	5068	3572	194.38"
	ROE-GN	0.00	0.00	6.25	21.32	42.46	10.29	11.58	6.07	2.02	544	180	161.00
1990/91	ROE-SN	0.95	48.02	9.49	12.62	15.75	9.49	1.65	0.87	1.16	4121	2449	226.13
	ROE-GN	0.00	0.00	4.26	18.67	31.44	31.33	6.66	4.37	3.28	916	502	131.95

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	43.9	79.3	107.9	128.2	146.1	163.1	173.5	188.7	206.8
ROE-SN	53.2	83.7	113.2	136.5	154.8	169.0	182.2	191.1	202.8
ROE-GN	90.3	115.5	135.6	146.5	159.5	166.7	173.8	183.9	189.8

Appendix Table 2.3. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the central coast stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	2.43	28.56	50.66	12.00	5.06	1.24	0.06	0.00	0.00	5316	2487	3904.06
1951/52	WINTER	5.18	20.07	30.08	38.13	4.50	1.53	0.45	0.04	0.02	5156	1431	2925.93
1952/53	WINTER	9.36	28.09	23.99	26.62	10.15	1.33	0.44	0.00	0.00	2926	543	73.57
1953/54	WINTER	3.95	69.68	20.26	4.61	1.29	0.16	0.00	0.06	0.00	3189	478	3476.95
1954/55	WINTER	6.66	7.72	74.62	9.09	1.54	0.38	0.00	0.00	0.00	2344	165	1235.03
1955/56	WINTER	16.88	13.62	9.20	57.01	2.89	0.34	0.04	0.00	0.02	5052	1347	4134.75
1956/57	WINTER	16.74	50.70	10.79	6.23	14.78	0.73	0.02	0.00	0.00	4688	1703	2635.45
1957/58	WINTER	23.51	61.39	12.66	1.28	0.59	0.56	0.00	0.00	0.00	3743	847	1445.86
1958/59	WINTER	3.80	49.52	36.89	8.10	0.80	0.44	0.42	0.02	0.00	4974	1352	3293.36
1959/60	WINTER	43.50	23.16	26.48	5.58	1.13	0.07	0.07	0.00	0.00	1416	165	639.45
1960/61	WINTER	16.08	32.23	10.79	29.69	10.08	0.93	0.11	0.07	0.04	2799	1227	3463.55
1961/62	WINTER	9.65	57.43	17.95	2.60	9.90	2.35	0.12	0.00	0.00	808	146	1721.99
1962/63	WINTER	0.37	30.27	57.96	5.43	2.85	2.94	0.18	0.00	0.00	1087	885	4376.33
1963/64	WINTER	13.12	47.38	27.74	10.25	1.43	0.08	0.00	0.00	0.00	1258	198	3507.73
1964/65	WINTER	8.17	36.40	33.77	15.83	5.43	0.34	0.06	0.00	0.00	1750	684	1326.51
1965/66	WINTER	67.32	20.43	7.33	3.60	1.13	0.19	0.00	0.00	0.00	0*	25	5216.79
1966/67	WINTER	37.40	46.19	13.10	2.04	1.02	0.17	0.07	0.01	0.00	0*	25	2514.89
1967/68	WINTER	32.53	48.02	17.02	2.11	0.25	0.00	0.06	0.00	0.00	0*	25	170.14
1968/69	WINTER	32.21	27.70	26.72	11.30	1.95	0.12	0.00	0.00	0.00	0*	25	10.08
1969/70	WINTER	54.02	44.42	1.16	0.40	0.00	0.00	0.00	0.00	0.00	0*	25	28.32
1970/71	WINTER	14.39	39.60	36.87	3.78	4.20	0.95	0.11	0.11	0.00	952	136	339.30
1971/72	ROE-SN	4.35	29.83	27.65	25.69	6.91	4.35	1.14	0.05	0.00	1837	598	762.73*
	ROE-GN	0.00	0.91	14.89	65.05	10.64	7.90	0.61	0.00	0.00	329	503	8.47
1972/73	ROE-SN	1.20	50.45	18.60	15.51	11.75	1.88	0.45	0.15	0.00	1328	593	539.55*
	ROE-GN	0.00	2.53	25.32	44.94	20.89	4.43	1.27	0.63	0.00	158	114	71.26
1973/74	ROE-SN	2.77	17.71	38.63	19.72	13.36	6.62	0.95	0.25	0.00	1587	202	282.57
	ROE-GN	0.00	0.40	22.78	37.70	24.80	12.30	1.81	0.20	0.00	496	101	332.81
1974/75	ROE-SN	1.16	32.96	25.51	27.84	8.59	3.18	0.67	0.07	0.02	8896	3314	278.00
	ROE-GN	0.00	3.28	25.63	46.24	16.38	6.36	2.12	0.00	0.00	519	117	348.42
1975/76	ROE-SN	3.01	11.76	41.23	20.89	16.83	4.54	1.48	0.24	0.02	5418	973	511.14
	ROE-GN	0.00	0.82	18.82	29.79	35.27	11.78	3.03	0.41	0.08	1222	253	383.45
1976/77	WINTER	1.01	32.83	18.69	29.80	8.08	6.57	3.03	0.00	0.00	198	144	32.75
	ROE-SN	0.68	17.43	22.64	31.77	16.59	8.53	1.92	0.40	0.04	2496	925	284.27
	ROE-GN	0.00	1.10	13.02	35.54	31.57	13.47	3.97	1.32	0.00	453	169	411.71
1977/78	ROE-SN	0.21	25.72	15.19	19.91	23.14	10.89	3.51	1.07	0.36	1396	589	354.31
	ROE-GN	0.00	1.30	8.93	29.58	38.14	17.67	3.81	0.47	0.09	1075	474	576.00
1979/80	ROE-SN	3.68	73.08	6.43	9.02	3.99	2.59	0.70	0.39	0.12	2582	1401	1.12*
	ROE-GN	0.00	3.28	2.55	24.82	23.72	26.28	11.31	6.57	1.46	274	210	32.46
1980/81	ROE-SN	1.96	12.30	66.57	8.40	7.05	2.64	0.64	0.34	0.10	2952	492	25.75*
	ROE-GN	0.26	1.50	50.72	13.61	15.36	10.61	5.47	1.82	0.65	1536	276	163.04
1981/82	ROE-SN	1.68	15.62	10.72	60.21	5.19	4.56	1.45	0.48	0.09	3508	2296	188.15*
	ROE-GN	0.00	2.39	5.91	75.99	6.66	5.91	2.32	0.75	0.07	1337	301	287.08
1982/83	ROE-SN	0.53	7.00	15.43	10.82	57.10	5.03	3.10	0.73	0.26	5445	1082	154.75
	ROE-GN	0.00	0.50	7.19	13.05	69.44	5.02	3.90	0.61	0.28	1793	994	244.49
1983/84	ROE-SN	4.35	7.31	10.12	18.16	16.14	40.73	2.26	0.83	0.10	6293	2210	284.12*
	ROE-GN	0.00	0.26	2.93	13.11	17.26	60.05	4.75	1.12	0.52	1159	338	242.25
1984/85	ROE-SN	2.66	37.54	7.47	8.55	13.11	11.94	18.19	0.45	0.10	5157	5529	222.13
	ROE-GN	0.00	3.18	5.43	9.39	19.49	22.52	38.20	1.01	0.78	1288	1407	143.53
1985/86	ROE-SN	3.92	16.39	40.25	8.59	6.27	6.68	6.08	11.26	0.55	5819	2074	163.81*
	ROE-GN	0.00	1.78	23.95	11.97	10.01	16.00	13.19	22.26	0.84	1069	262	73.95
1986/87	ROE-SN	4.13	22.57	14.59	32.18	5.72	4.55	5.84	4.66	5.78	5038	2319	193.73
	ROE-GN	0.00	0.82	7.75	44.85	11.72	7.85	9.89	8.15	8.97	981	1199	55.71
1987/88	ROE-SN	1.13	67.90	11.68	6.26	7.15	1.69	1.46	1.50	1.23	5205	2732	343.86*
	ROE-GN	0.00	4.24	10.25	14.84	27.21	15.19	7.42	10.07	10.78	566	158	59.81
1988/89	ROE-SN	1.28	4.61	76.20	9.16	3.58	2.80	0.76	0.80	0.82	5643	1937	596.32
	ROE-GN	0.00	0.28	27.61	25.07	17.32	16.48	5.77	3.66	3.80	710	259	195.14
1989/90	ROE-SN	0.97	5.66	4.98	72.60	7.50	3.82	2.95	0.75	0.78	6682	6348	415.10
	ROE-GN	0.00	0.00	1.18	65.05	16.88	6.26	7.79	1.06	1.77	847	502	203.56
1990/91	ROE-SN	2.03	18.81	6.75	6.19	55.57	6.37	2.34	1.48	0.46	7108	5046	582.02
	ROE-GN	0.00	0.50	2.32	6.80	69.15	9.95	7.30	3.15	0.83	603	423	112.11

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	43.8	79.8	104.7	125.6	138.1	150.4	156.2	153.5	179.0
ROE-SN	54.9	88.1	113.7	135.5	154.1	169.9	183.0	194.9	205.7
ROE-GN	39.3	115.0	137.5	149.6	160.4	170.4	180.1	185.3	184.2

Appendix Table 2.4. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the northern Strait of Georgia stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	3.52	45.50	38.57	9.52	2.06	0.62	0.20	0.03	0.00	3552	524	1732.70
1951/52	WINTER	12.98	52.20	26.41	6.78	1.46	0.13	0.04	0.00	0.00	4529	571	1856.15
1952/53	WINTER	12.95	49.85	30.44	4.77	1.62	0.30	0.08	0.00	0.00	5322	709	543.74
1953/54	WINTER	2.29	33.96	39.21	16.72	5.75	1.69	0.36	0.03	0.00	6856	2388	1934.55
1954/55	WINTER	5.46	40.91	44.22	7.72	1.58	0.11	0.00	0.00	0.00	2657	360	2903.78
1955/56	WINTER	9.53	16.39	28.07	36.88	7.36	1.22	0.41	0.10	0.04	4919	925	2587.73
1956/57	WINTER	0.91	36.78	25.12	24.30	11.49	1.32	0.08	0.00	0.00	2420	497	1848.17
1957/58	WINTER	6.39	44.31	23.41	9.47	9.62	5.85	0.81	0.14	0.00	3473	617	890.18
1958/59	WINTER	16.97	62.85	16.40	2.78	0.48	0.34	0.14	0.02	0.02	4420	1809	4162.95
1959/60	WINTER	14.06	39.70	39.22	5.75	0.80	0.32	0.08	0.00	0.08	1252	231	2428.73
1960/61	WINTER	21.66	22.81	30.03	22.04	3.07	0.38	0.00	0.00	0.00	1302	222	1771.58
1961/62	WINTER	13.35	63.41	12.68	7.17	2.79	0.60	0.00	0.00	0.00	1506	584	3439.44
1962/63	WINTER	20.84	48.32	24.55	3.36	1.81	0.95	0.17	0.00	0.00	1161	144	4278.29
1963/64	WINTER	5.76	64.70	26.48	2.29	0.58	0.13	0.04	0.00	0.00	2224	639	3714.95
1964/65	WINTER	14.11	53.37	28.31	2.68	1.10	0.29	0.14	0.00	0.00	2091	533	2664.28
1965/66	WINTER	19.54	36.78	22.99	15.86	3.22	1.61	0.00	0.00	0.00	435	77	1851.57
1966/67	WINTER	30.88	51.94	11.44	3.30	2.05	0.36	0.04	0.00	0.00	0*	25	1120.81
1967/68	WINTER	22.95	58.16	14.94	2.91	0.68	0.24	0.11	0.00	0.00	0*	25	92.93
1968/69	WINTER	72.57	23.97	2.88	0.55	0.02	0.00	0.00	0.00	0.00	0*	25	45.98
1969/70	WINTER	23.73	63.25	11.18	1.38	0.46	0.00	0.00	0.00	0.00	0*	25	51.41
1970/71	WINTER	12.99	42.46	34.60	6.64	2.84	0.47	0.00	0.00	0.00	1055	238	82.41
1971/72	WINTER	1.54	27.62	36.77	26.08	5.39	2.31	0.29	0.00	0.00	1039	3596	73.26
	ROE-SN	4.00	42.26	30.29	18.39	4.00	1.01	0.04	0.00	0.00	2773	265	518.15
	ROE-GN	1.08	12.54	50.18	27.96	6.45	1.08	0.36	0.36	0.00	279	214	0.22
1972/73	WINTER	0.51	23.53	33.02	26.85	13.94	1.87	0.26	0.03	0.00	3910	1784	265.97
	ROE-SN	4.22	54.88	21.37	12.93	6.07	0.53	0.00	0.00	0.00	379	615	141.70
	ROE-GN	0.00	5.45	27.27	52.73	10.91	3.64	0.00	0.00	0.00	55	55	88.52
1973/74	ROE-GN	0.00	3.63	43.12	33.13	16.94	2.87	0.30	0.00	0.00	661	320	204.10*^
1974/75	WINTER	22.35	61.06	12.44	2.07	1.38	0.46	0.00	0.23	0.00	434	16	65.30
	ROE-SN	3.52	58.29	27.47	7.27	2.66	0.56	0.16	0.07	0.00	3040	618	49.45
	ROE-GN	0.00	6.72	31.93	43.70	13.45	3.36	0.84	0.00	0.00	119	26	283.37
1975/76	WINTER	7.91	17.63	34.98	25.54	8.64	3.70	1.31	0.22	0.07	1378	546	150.34
	ROE-SN	13.31	26.34	43.35	14.13	2.19	0.27	0.41	0.00	0.00	729	97	20.92
	ROE-GN	0.00	0.54	39.08	43.96	12.89	2.99	0.41	0.14	0.00	737	269	405.21
1976/77	WINTER	3.18	19.75	24.84	36.94	14.65	0.64	0.00	0.00	0.00	157	254	46.34
	ROE-SN	3.27	57.89	20.79	14.43	3.00	0.45	0.18	0.00	0.00	2232	1278	370.55
	ROE-GN	0.00	3.23	26.07	48.70	17.22	4.08	0.56	0.14	0.00	1423	162	466.14
1977/78	WINTER	4.76	38.04	28.40	9.64	11.62	5.68	1.19	0.53	0.13	757	207	363.68
	ROE-SN	0.83	34.85	42.86	11.92	7.66	1.46	0.32	0.03	0.06	3145	2312	353.43
	ROE-GN	0.00	0.43	19.70	31.39	35.06	11.26	1.73	0.43	0.00	462	690	426.90
1978/79	WINTER	1.18	16.23	36.65	25.26	10.86	7.72	1.57	0.39	0.13	764	201	164.24
	ROE-SN	1.01	17.66	31.05	32.51	10.24	5.85	1.46	0.22	0.00	889	311	1.00~
	ROE-GN	0.00	1.15	23.23	54.70	13.51	5.77	1.48	0.00	0.16	607	290	441.80
1979/80	WINTER	5.12	40.97	22.20	18.82	8.20	2.80	1.50	0.34	0.05	2072	1171	125.21
	ROE-SN	2.40	48.48	16.54	18.01	10.37	2.56	1.30	0.28	0.06	3548	1368	16.93
	ROE-GN	0.00	1.99	9.15	44.56	33.42	8.75	1.86	0.27	0.00	754	1139	215.21
1980/81	WINTER	1.83	40.61	36.49	13.28	4.73	2.14	0.46	0.46	0.00	655	212	26.24
	ROE-SN	6.76	36.86	30.52	11.39	9.69	3.81	0.64	0.30	0.03	7083	2254	202.01
	ROE-GN	0.09	2.19	18.16	22.98	37.37	16.05	2.81	0.26	0.09	1140	338	333.10
1981/82	WINTER	0.00	25.79	35.22	28.30	4.40	2.52	2.52	0.00	1.26	159	123	12.34
	ROE-SN	4.78	31.54	26.30	23.09	5.24	5.66	2.69	0.61	0.09	3304	1659	1.28
	ROE-GN	0.00	4.44	15.37	28.45	14.77	20.77	14.17	1.68	0.36	833	543	367.36
1982/83	WINTER	27.22	47.22	13.89	7.78	2.78	0.00	1.11	0.00	0.00	180	523	16.90
	ROE-SN	2.39	31.77	28.43	17.75	12.08	3.26	2.91	1.17	0.24	9836	6124	676.25
	ROE-GN	0.00	0.49	27.76	29.48	23.59	9.34	7.37	1.72	0.25	407	305	563.81
1983/84	WINTER	8.73	39.44	28.45	10.99	7.32	3.66	1.41	0.00	0.00	355	66	19.33
	ROE-SN	4.70	39.30	31.45	12.81	6.63	3.50	1.04	0.45	0.12	5746	1919	351.48
	ROE-GN	0.00	7.05	30.16	31.07	19.19	9.27	1.70	0.65	0.91	766	759	421.50
1984/85	WINTER	13.11	50.81	20.32	10.16	3.98	1.33	0.29	0.00	0.00	679	380	11.60
	ROE-SN	21.88	45.62	19.13	8.53	3.08	1.25	0.46	0.05	0.00	5677	2317	288.55
	ROE-GN	0.09	3.10	26.09	32.48	23.63	9.22	3.74	0.82	0.82	1096	650	237.16
1985/86	WINTER	16.28	48.84	27.91	2.33	4.65	0.00	0.00	0.00	0.00	86	86	14.64
	ROE-SN	8.94	54.85	25.91	7.10	2.18	0.79	0.16	0.07	0.00	4450	1575	17.15
1986/87	ROE-SN	5.77	32.63	38.79	17.04	3.98	1.17	0.40	0.16	0.06	6432	2408	321.45*
	ROE-GN	0.00	1.96	32.73	34.46	17.62	9.71	2.66	0.55	0.31	1277	652	145.34
1987/88	WINTER	0.00	45.45	22.73	22.73	7.95	1.14	0.00	0.00	0.00	88	88	4.04
	ROE-SN	3.76	57.75	15.61	16.73	4.68	1.12	0.26	0.08	0.00	4996	1541	145.97
	ROE-GN	0.00	9.14	14.86	48.11	19.49	5.48	2.31	0.37	0.24	821	383	414.24
1988/89	ROE-SN	7.13	19.33	55.40	9.11	6.90	1.77	0.31	0.04	0.00	4796	1287	117.25*
	ROE-GN	0.00	1.58	40.22	21.99	25.88	7.78	2.19	0.36	0.00	823	1143	421.70
1989/90	WINTER	5.38	70.97	9.14	13.98	0.00	0.54	0.00	0.00	0.00	186	2053	19.24
	ROE-SN	6.56	56.18	12.13	20.30	2.84	1.52	0.43	0.05	0.00	3950	1901	1.00~
	ROE-GN	0.00	5.69	11.38	57.11	12.63	11.15	1.71	0.23	0.11	879	461	318.29
1990/91	ROE-SN	6.18	21.78	42.93	9.85	15.28	2.38	1.36	0.22	0.02	4123	1737	84.28
	ROE-GN	0.00	1.29	28.15	17.20	40.11	7.27	4.69	1.20	0.09	1087	637	611.63

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	46.3	83.7	109.9	131.6	149.0	168.8	174.4	194.0	188.3
ROE-SN	57.3	82.7	109.7	130.5	148.2	164.4	173.6	172.4	185.6
ROE-GN	67.2	118.8	136.8	148.3	159.4	167.0	178.8	176.3	184.8

Appendix Table 2.5. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the southern Strait of Georgia stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	4.72	65.64	23.49	5.12	0.87	0.12	0.02	0.02	0.00	4261	1607	2687.75
1951/52	WINTER	9.34	58.56	23.71	6.69	1.18	0.40	0.09	0.02	0.00	4496	1224	2964.47
1952/53	WINTER	3.89	65.91	26.58	2.98	0.60	0.03	0.00	0.00	0.00	3318	1262	492.88
1953/54	WINTER	0.68	58.40	34.21	5.93	0.60	0.13	0.03	0.02	0.00	6306	2318	4668.76
1954/55	WINTER	3.34	56.42	33.83	5.73	0.57	0.11	0.00	0.00	0.00	2634	714	4115.48
1955/56	WINTER	4.46	53.80	29.49	10.44	1.55	0.24	0.02	0.00	0.00	4913	2414	4726.81
1956/57	WINTER	1.64	70.78	21.00	4.19	2.02	0.26	0.06	0.02	0.04	5058	2140	4145.72
1957/58	WINTER	11.26	63.48	21.00	2.91	1.02	0.28	0.05	0.00	0.00	3924	1050	1379.36
1958/59	WINTER	17.23	64.72	14.74	2.42	0.61	0.16	0.11	0.02	0.00	5544	2101	1935.54
1959/60	WINTER	4.50	57.19	35.22	2.53	0.40	0.08	0.08	0.00	0.00	2490	1351	4499.74
1960/61	WINTER	35.75	29.09	25.52	8.76	0.82	0.07	0.00	0.00	0.00	3049	620	3469.79
1961/62	WINTER	5.24	75.96	13.61	3.59	1.36	0.18	0.06	0.00	0.00	1697	412	3696.98
1962/63	WINTER	14.37	53.57	29.18	2.61	0.17	0.09	0.00	0.00	0.00	1148	308	3870.31
1963/64	WINTER	6.16	56.33	34.07	2.89	0.44	0.06	0.06	0.00	0.00	1802	626	3793.08
1964/65	WINTER	16.20	58.06	22.56	2.30	0.71	0.00	0.16	0.00	0.00	1259	451	1965.81
1965/66	WINTER	31.01	32.69	23.80	11.06	0.96	0.48	0.00	0.00	0.00	416	36	1332.91
1966/67	WINTER	43.30	39.10	12.97	3.12	1.11	0.22	0.06	0.13	0.00	0*	25	2253.00
1967/68	WINTER	51.40	29.22	13.96	3.39	1.47	0.00	0.55	0.00	0.00	0*	25	115.07
1968/69	WINTER	50.60	30.50	13.73	3.70	1.47	0.00	0.00	0.00	0.00	0*	25	49.24
1969/70	WINTER	27.54	57.40	7.79	5.16	0.98	1.12	0.00	0.00	0.00	0*	25	38.03
1970/71	WINTER	10.58	33.43	42.06	8.64	2.79	2.23	0.28	0.00	0.00	359	162	64.38
1971/72	WINTER	13.80	33.54	33.77	15.09	2.74	0.95	0.08	0.04	0.00	2624	809	154.89
	ROE-SN	14.01	28.59	36.01	17.37	2.78	0.97	0.22	0.04	0.00	2263	597	38.49
	ROE-GN	5.69	11.11	45.11	29.37	7.01	1.59	0.13	0.00	0.00	756	151	9.59
1972/73	WINTER	3.39	49.56	21.20	18.57	5.52	1.13	0.50	0.13	0.00	797	203	27.12
	ROE-GN	0.00	21.30	31.36	32.54	11.24	2.96	0.59	0.00	0.00	169	56	43.63
1973/74	WINTER	17.44	73.26	8.14	1.16	0.00	0.00	0.00	0.00	0.00	86	86	39.04
	ROE-GN	0.00	7.29	40.43	27.66	16.11	6.38	2.13	0.00	0.00	329	268	30.21
1974/75	ROE-SN	3.90	50.14	28.64	8.68	4.32	3.06	0.93	0.32	0.00	2154	597	2.49*
	ROE-GN	0.00	1.61	64.52	20.97	9.68	3.23	0.00	0.00	0.00	62	62	68.22
1975/76	WINTER	5.49	21.73	44.26	19.68	5.19	2.35	0.76	0.50	0.03	3023	965	249.87
	ROE-SN	9.64	22.08	35.53	15.99	5.58	6.09	3.55	1.27	0.25	394	108	1.00~
	ROE-GN	0.00	0.68	41.50	41.50	11.56	2.72	2.04	0.00	0.00	147	126	63.84
1976/77	WINTER	4.21	52.80	21.83	15.26	3.81	1.28	0.52	0.16	0.12	2496	805	470.19
	ROE-SN	4.80	18.40	8.00	15.20	19.20	16.00	11.20	4.80	2.40	125	136	23.00
	ROE-GN	0.00	4.57	48.57	35.43	10.29	1.14	0.00	0.00	0.00	175	5	48.06
1977/78	WINTER	1.23	35.11	45.82	10.65	5.56	1.29	0.06	0.18	0.12	1709	391	819.26
	ROE-SN	1.08	40.50	46.24	7.53	4.30	0.36	0.00	0.00	0.00	279	132	1.00~
	ROE-GN	0.00	1.92	23.08	24.04	38.46	12.50	0.00	0.00	0.00	104	433	57.85
1978/79	WINTER	1.85	18.58	37.82	29.05	7.98	3.34	1.00	0.26	0.13	4699	1796	922.01
	ROE-SN	2.69	24.04	35.58	20.19	7.88	4.04	3.08	1.35	1.15	520	98	1.00~
1979/80	WINTER	1.44	45.36	24.03	17.66	8.37	1.69	1.06	0.28	0.11	2842	1954	109.21
	ROE-SN	3.05	57.87	12.01	15.91	6.77	2.88	0.85	0.17	0.51	591	189	1.00~
1980/81	WINTER	3.93	33.34	33.87	15.94	9.12	3.15	0.53	0.11	0.00	4505	2225	390.60
	ROE-SN	8.64	38.43	29.94	10.65	8.80	2.78	0.62	0.15	0.00	648	255	1.00~
1981/82	WINTER	3.59	38.96	31.49	15.32	5.83	3.88	0.80	0.08	0.04	2369	1384	303.92
	ROE-SN	8.73	39.69	23.14	17.37	3.82	4.53	2.19	0.48	0.05	2096	1168	302.55
1982/83	WINTER	0.79	16.65	31.99	23.25	13.19	4.87	5.65	3.04	0.58	1910	1526	47.33
	ROE-SN	5.79	29.82	28.74	18.25	8.65	2.82	3.76	1.65	0.52	2126	975	22.47
1983/84	WINTER	16.24	29.99	21.87	18.47	8.32	3.27	0.92	0.52	0.39	1527	555	52.95
	ROE-SN	21.91	31.44	18.85	13.44	9.32	2.63	1.49	0.64	0.28	1406	790	43.55
1984/85	WINTER	33.42	37.06	18.67	6.67	2.77	0.92	0.38	0.11	0.00	1843	288	64.51
	ROE-SN	29.28	39.12	18.47	6.31	4.22	1.53	0.93	0.09	0.05	2155	693	12.24
1985/86	WINTER	13.13	59.07	19.69	6.18	1.42	0.39	0.13	0.00	0.00	777	156	27.93
	ROE-SN	20.75	59.20	13.77	4.08	1.33	0.66	0.10	0.10	0.00	1961	542	1.00~
1986/87	WINTER	21.77	34.69	30.95	9.98	1.93	0.45	0.23	0.00	0.00	882	204	14.91
	ROE-SN	27.61	35.80	28.00	6.36	1.35	0.56	0.24	0.00	0.08	1257	246	1.00~
	ROE-GN	0.00	3.58	41.37	31.42	14.31	6.07	2.49	0.62	0.16	643	926	266.33
1987/88	WINTER	3.87	61.79	16.69	14.51	2.18	0.60	0.24	0.12	0.00	827	1109	64.88
	ROE-SN	8.03	72.34	11.06	7.05	0.98	0.54	0.00	0.00	0.00	922	494	1.00~
1988/89	WINTER	26.50	16.59	42.90	7.05	5.91	0.86	0.19	0.00	0.00	1049	298	59.24
	ROE-SN	18.43	14.08	47.83	10.47	7.78	1.04	0.31	0.00	0.06	1633	479	59.99
1989/90	WINTER	4.79	52.30	15.07	21.81	2.84	3.19	0.00	0.00	0.00	564	256	8.01
	ROE-SN	11.08	59.40	7.54	15.91	3.42	2.18	0.35	0.06	0.06	1697	1549	1.00~
	ROE-GN	0.00	13.21	12.20	54.67	11.38	7.11	1.02	0.41	0.00	492	325	237.75
1990/91	ROE-SN	23.07	21.54	31.00	6.50	14.13	1.83	1.83	0.10	0.00	984	385	1.00~

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	58.7	93.9	118.6	142.6	159.5	172.6	186.2	193.1	222.2
ROE-SN	60.1	87.5	113.3	135.4	159.3	170.9	189.3	195.1	210.4
ROE-GN	59.4	112.8	139.3	153.1	167.2	175.8	175.3	180.8	213.0

Appendix Table 2.6. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the southern west coast of Vancouver Island stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	1+	2+	3+	4+	PERCENT AT AGE 5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	13.15	38.17	40.61	6.43	1.33	0.26	0.03	0.03	0.00	3841	552	1629.93
1951/52	WINTER	5.34	65.58	20.12	7.95	0.83	0.18	0.00	0.00	0.00	1685	594	1105.12
1952/53	WINTER	8.87	55.77	32.80	1.98	0.54	0.04	0.00	0.00	0.00	2774	1425	2.36
1953/54	WINTER	2.85	64.32	26.54	5.48	0.56	0.14	0.09	0.02	0.02	5728	2472	3085.28
1954/55	WINTER	16.82	59.39	19.69	3.43	0.64	0.04	0.00	0.00	0.00	2509	698	706.04
1955/56	WINTER	12.36	64.26	15.97	6.06	1.12	0.15	0.04	0.04	0.00	4653	2257	1931.15
1956/57	WINTER	2.72	71.94	24.83	0.34	0.17	0.00	0.00	0.00	0.00	588	497	312.93
1957/58	WINTER	15.56	55.30	25.04	3.96	0.14	0.00	0.00	0.00	0.00	707	432	68.62
1958/59	WINTER	6.44	60.99	25.12	6.00	0.97	0.15	0.24	0.10	0.00	2066	1383	4315.70
1959/60	WINTER	26.90	48.24	19.67	4.08	0.56	0.37	0.19	0.00	0.00	539	189	1988.85
1960/61	WINTER	52.74	33.89	10.02	3.10	0.24	0.00	0.00	0.00	0.00	419	54	1719.68
1961/62	WINTER	5.06	78.16	12.12	3.73	0.93	0.00	0.00	0.00	0.00	751	386	1659.51
1962/63	WINTER	3.50	44.36	45.49	5.64	0.79	0.23	0.00	0.00	0.00	886	316	404.28
1963/64	WINTER	2.65	60.76	25.49	10.05	0.79	0.26	0.00	0.00	0.00	1134	1003	1989.83
1964/65	WINTER	2.32	34.71	49.29	9.81	3.48	0.39	0.00	0.00	0.00	775	344	1141.93
1965/66	WINTER	0.33	41.33	33.33	21.33	2.67	1.00	0.00	0.00	0.00	300	403	636.21
1966/67	WINTER	21.23	56.84	17.10	3.52	0.82	0.27	0.19	0.04	0.00	0*	25	842.75
1971/72	ROE-SN	4.09	19.89	50.82	20.05	3.27	1.06	0.82	0.00	0.00	1222	843	319.50
1972/73	ROE-SN	0.86	32.28	24.10	31.01	10.07	1.32	0.31	0.05	0.00	1967	1330	678.19
	ROE-GN	0.00	7.85	22.92	51.76	13.46	2.88	0.96	0.16	0.00	624	526	63.80
1973/74	ROE-SN	12.08	45.14	25.71	10.99	4.96	1.03	0.10	0.00	0.00	3022	1434	341.88
	ROE-GN	0.00	26.14	30.68	26.14	13.64	3.41	0.00	0.00	0.00	176	30	207.72
1974/75	ROE-SN	0.69	46.52	21.88	14.23	9.45	5.67	1.37	0.18	0.00	6189	3014	900.98*
	ROE-GN	0.00	2.97	30.48	37.92	21.19	7.06	0.37	0.00	0.00	269	145	407.98
1975/76	ROE-SN	0.13	7.63	45.49	20.78	14.45	8.26	2.80	0.47	0.00	7026	1218	1358.83
	ROE-GN	0.00	0.73	41.76	33.60	15.35	5.90	2.26	0.32	0.08	1238	125	932.28
1976/77	ROE-SN	0.49	11.76	32.09	37.47	12.46	4.05	1.47	0.16	0.05	6171	1298	1226.50*
	ROE-GN	1.02	6.12	22.96	45.41	16.84	6.12	1.53	0.00	0.00	196	26	669.58
1977/78	WINTER	1.27	41.86	26.23	13.67	13.49	2.03	0.87	0.29	0.29	1727	416	183.29
	ROE-SN	0.51	35.09	18.69	18.61	20.76	4.82	1.26	0.20	0.06	5067	2353	381.15
	ROE-GN	0.00	1.20	5.28	20.14	49.64	17.27	5.76	0.48	0.24	417	84	730.95
1978/79	ROE-SN	0.46	9.88	39.17	18.52	16.44	11.92	2.59	0.83	0.18	2165	1149	411.88*
	ROE-GN	0.00	0.97	25.10	27.22	26.25	17.95	2.12	0.39	0.00	518	214	263.70
1979/80	ROE-SN	3.49	44.97	11.39	18.16	9.18	8.44	3.53	0.69	0.15	2037	1241	146.54*
	ROE-GN	0.00	0.00	4.40	40.67	25.65	16.84	11.40	0.78	0.26	386	717	36.65
1980/81	ROE-SN	3.98	37.73	26.38	10.56	11.51	6.42	2.81	0.60	0.00	3162	1247	251.13*
	ROE-GN	0.00	1.78	21.00	14.95	36.30	18.86	7.12	0.00	0.00	281	81	136.27
1981/82	ROE-SN	3.97	24.83	28.65	23.51	5.34	8.50	3.08	1.73	0.38	3930	2036	201.06*
	ROE-GN	0.00	0.28	17.33	39.49	11.36	23.30	5.40	2.56	0.28	352	216	49.47
1982/83	ROE-SN	4.49	23.32	22.78	21.70	16.19	4.02	5.25	1.20	1.05	2761	1911	476.41
1983/84	ROE-SN	20.50	36.76	14.12	9.65	10.51	6.06	1.10	1.07	0.24	2903	1266	485.38
1984/85	ROE-SN	21.10	50.23	16.10	4.06	2.86	3.37	1.84	0.13	0.30	2341	603	15.98*
1985/86	ROE-SN	4.19	48.77	27.18	10.33	3.87	2.69	2.14	0.74	0.10	3127	1073	16.49*
1986/87	ROE-SN	15.14	15.98	35.73	18.96	8.12	2.89	1.56	1.19	0.44	4050	2121	1014.35
1987/88	ROE-SN	2.46	60.86	7.31	15.49	9.17	3.15	0.81	0.49	0.25	6293	4239	666.23
	ROE-GN	0.00	5.40	7.00	40.80	29.40	12.80	3.00	1.20	0.40	500	607	86.65
1988/89	ROE-SN	2.80	15.70	62.65	6.36	8.23	3.42	0.66	0.14	0.04	4969	3549	774.27
	ROE-GN	0.00	0.26	54.45	10.99	22.25	9.42	1.57	1.05	0.00	382	145	232.76
1989/90	ROE-SN	0.48	27.12	12.39	48.00	4.46	5.74	1.53	0.21	0.08	6294	5736	567.79
	ROE-GN	0.00	1.35	7.87	68.99	8.31	10.34	2.47	0.67	0.00	445	428	125.93
1990/91	ROE-SN	5.39	15.20	22.90	10.96	38.21	3.22	3.48	0.60	0.04	4507	3278	355.73
	ROE-GN	0.00	0.29	7.16	11.75	63.90	8.02	8.02	0.57	0.29	349	223	117.94

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	57.2	89.9	112.9	132.2	149.3	156.4	166.8	173.2	237.6
ROE-SN	63.8	94.5	124.6	149.4	169.8	183.7	193.9	203.5	206.3
ROE-GN	45.5	110.7	136.9	153.6	166.7	178.4	182.5	188.2	188.5

Appendix Table 2.7. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the northern west coast of Vancouver Island stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	1+	2+	3+	4+	PERCENT AT AGE 5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	WINTER	1.53	27.04	54.08	12.76	3.57	1.02	0.00	0.00	0.00	196	190	546.82
1951/52	WINTER	0.22	10.20	27.53	52.22	7.14	2.13	0.49	0.06	0.00	3236	3206	1263.43
1953/54	WINTER	0.00	46.15	44.23	6.59	2.75	0.27	0.00	0.00	0.00	364	21	494.70
1957/58	WINTER	9.11	38.92	30.02	9.73	6.83	4.14	1.04	0.21	0.00	483	80	4.98
1958/59	WINTER	1.38	24.39	30.33	25.27	7.57	5.32	4.32	1.19	0.25	1599	1014	3141.73
1959/60	WINTER	4.70	56.24	24.17	9.84	3.34	1.07	0.38	0.17	0.09	2338	2403	3724.70
1960/61	WINTER	21.37	42.74	30.65	5.24	0.00	0.00	0.00	0.00	0.00	248	57	1382.75
1961/62	WINTER	4.12	87.06	7.65	0.59	0.59	0.00	0.00	0.00	0.00	510	193	880.29
1962/63	WINTER	0.58	43.15	51.53	4.08	0.51	0.15	0.00	0.00	0.00	1372	609	1361.92
1963/64	WINTER	0.00	48.00	32.00	18.00	2.00	0.00	0.00	0.00	0.00	50	50	88.97
1964/65	WINTER	0.00	28.57	59.18	12.24	0.00	0.00	0.00	0.00	0.00	49	49	159.49
1965/66	WINTER	13.59	26.83	26.12	23.17	9.07	1.23	0.00	0.00	0.00	0*	25	195.14
1966/67	WINTER	4.69	63.64	23.87	6.13	1.47	0.10	0.10	0.00	0.00	0*	25	482.92
1971/72	ROE-SN	0.29	13.75	38.68	40.69	4.30	1.43	0.57	0.29	0.00	349	99	177.82
1972/73	ROE-SN	0.16	24.47	24.79	34.98	12.97	2.30	0.16	0.16	0.00	609	358	557.43'
1973/74	ROE-SN	2.96	40.41	21.73	16.93	13.76	3.71	0.38	0.08	0.04	2398	2045	819.44'
1974/75	ROE-SN	0.43	65.17	16.59	6.93	5.63	3.92	1.15	0.15	0.03	3925	2181	679.06"'
1975/76	ROE-SN	0.45	12.79	51.54	16.70	8.21	7.53	2.45	0.32	0.00	2204	492	259.12
	ROE-GN	0.00	0.00	15.79	38.16	21.05	18.42	6.58	0.00	0.00	76	76	115.02
1976/77	ROE-SN	0.87	19.48	20.35	33.91	11.30	8.87	3.65	1.57	0.00	575	1613	52.30
	ROE-GN	0.00	0.00	8.64	39.51	18.52	19.75	9.88	3.09	0.62	162	92	174.14
1977/78	WINTER	1.27	49.21	16.03	13.81	16.19	2.54	0.63	0.32	0.00	630	273	74.55
	ROE-SN	1.67	68.97	13.28	6.36	5.80	2.23	1.45	0.11	0.11	896	650	78.36
	ROE-GN	0.00	1.06	2.66	21.81	40.96	23.40	8.51	1.06	0.53	188	65	204.38
1978/79	ROE-SN	1.16	18.37	65.00	8.90	3.37	2.79	0.23	0.12	0.06	1720	674	455.13
	ROE-GN	0.00	3.77	33.96	20.75	13.21	28.30	0.00	0.00	0.00	53	191	293.99
1979/80	ROE-SN	1.55	41.51	22.46	30.12	3.21	1.04	0.10	0.00	0.00	966	84	1.00~
	ROE-GN	0.00	0.00	10.61	84.85	4.55	0.00	0.00	0.00	0.00	66	66	125.00
1980/81	ROE-SN	0.00	17.50	45.80	13.38	20.75	2.40	0.17	0.00	0.00	583	331	275.37'
1981/82	ROE-SN	0.36	20.97	24.64	35.13	5.82	11.83	0.99	0.27	0.00	1116	790	1.00~
	ROE-GN	0.00	0.78	8.22	45.99	11.94	29.75	3.13	0.20	0.00	511	426	176.17
1982/83	ROE-SN	2.48	17.79	16.22	23.20	26.80	6.98	6.31	0.23	0.00	444	195	1.00~
	ROE-GN	0.00	0.35	14.19	23.82	44.83	6.48	9.81	0.35	0.18	571	159	176.62
1983/84	ROE-SN	42.05	44.89	4.55	1.14	2.27	3.41	0.57	1.14	0.00	176	369	1.00~
	ROE-GN	0.00	1.68	6.72	17.98	32.61	31.93	5.38	3.36	0.34	595	464	55.40
1984/85	ROE-SN	18.20	65.75	7.49	2.45	2.29	2.45	1.22	0.15	0.00	654	215	1.00~
1985/86	ROE-SN	2.54	55.57	37.40	2.05	0.88	0.88	0.59	0.10	0.00	1024	64	1.00~
1986/87	ROE-SN	12.92	20.36	26.14	36.78	2.58	0.46	0.30	0.46	0.00	658	268	1.00~
	ROE-GN	0.00	1.82	24.55	61.82	5.45	2.18	2.91	0.91	0.36	550	408	144.31
1987/88	ROE-SN	3.08	61.59	9.50	10.78	13.60	0.94	0.34	0.17	0.00	1169	644	0.02'
1988/89	ROE-SN	0.94	16.89	49.46	8.04	11.53	11.93	0.80	0.40	0.00	746	241	1.00~
1989/90	ROE-SN	0.55	28.55	12.71	39.04	4.79	8.29	5.34	0.55	0.18	543	489	1.00~
1990/91	ROE-SN	8.52	31.38	18.22	10.20	24.89	2.67	3.35	0.75	0.00	2804	2052	135.12

FISHERY	1+	2+	3+	4+	AVERAGE WEIGHT AT AGE (gms) 5+	6+	7+	8+	9+
WINTER	53.4	89.7	111.2	131.7	143.5	154.8	172.8	179.5	156.6
ROE-SN	62.8	92.2	121.3	145.9	167.0	179.6	187.5	196.1	207.0
ROE-GN	0.0	120.1	133.8	146.4	158.1	165.0	172.6	163.5	182.0

Appendix Table 3.1. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the Queen Charlotte Islands stock assessment region.

	Estimated numbers at age (x10^{-5}) for period one										
Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
1950/51	1792	1075	215	142	0	0	0	61	6492	5161	0.229
1951/52	1823	1103	555	99	63	0	0	27	4605	4813	-0.044
1952/53	2566	977	431	156	24	15	0	6	9588	17568	-0.606
1953/54	12970	1633	622	274	99	15	9	4	17024	12874	0.279
1954/55	1612	8198	981	364	159	57	9	8	10456	42573	-1.404
1955/56	2170	1023	5192	620	230	100	36	10	14042	6992	0.697
1956/57	710	635	299	722	48	18	8	4	2680	1608	0.511
1957/58	883	78	178	36	42	3	1	1	1548	2854	-0.612
1958/59	1363	300	26	35	5	6	0	0	13853	8468	0.492
1959/60	660	616	157	12	16	2	3	0	7625	5166	0.389
1960/61	2107	420	392	100	8	10	2	2	15967	8850	0.590
1961/62	2611	1320	260	239	61	5	6	2	9097	9690	-0.063
1962/63	5183	1468	639	108	93	24	2	3	8040	11631	-0.369
1963/64	1120	2798	647	225	34	30	7	2	6832	3481	0.674
1964/65	3006	408	846	99	21	3	3	1	2869	1729	0.507
1965/66	234	112	109	87	4	1	0	0	5473	2618	0.737
1966/67	222	84	52	42	31	1	0	0	1246	2632	-0.748
1967/68	277	134	51	31	25	18	1	0	1585	3570	-0.812
1968/69	361	174	84	32	19	16	11	1	2227	4300	-0.658
1969/70	1112	230	111	54	20	12	10	8	8946	8109	0.098
1970/71	2553	708	146	71	34	13	8	11	18080	16039	0.120
1971/72	2269	1625	451	93	45	22	8	12	17627	18205	-0.032
1972/73	6192	1358	923	242	49	24	11	11	21176	22979	-0.082
1973/74	4997	3733	735	460	117	24	11	11	26951	35640	-0.279
1974/75	4437	3037	2163	406	248	63	13	12	21553	43551	-0.703
1975/76	1169	2682	1757	1192	219	134	34	13	34425	35032	-0.017
1976/77	1521	722	1436	840	534	97	60	21	39860	28083	0.350
1977/78	1674	814	374	667	372	237	43	36	32915	16982	0.662
1978/79	934	905	405	153	244	132	84	28	24611	8990	1.007
1979/80	17630	577	435	146	48	73	40	34	39973	34960	0.134
1980/81	1295	11040	353	235	72	23	35	35	43710	52781	-0.189
1981/82	543	813	6668	200	122	36	11	35	37444	54953	-0.384
1982/83	579	337	501	4016	117	69	20	26	30386	45246	-0.398
1983/84	3810	353	202	290	2276	66	39	26	31594	36445	-0.143
1984/85	1699	2311	210	116	164	1276	37	36	29178	30154	-0.033
1985/86	410	1036	1344	115	61	84	659	38	12041	26886	-0.803
1986/87	828	256	618	768	64	34	47	387	26989	21152	0.244
1987/88	5676	514	154	362	446	37	20	252	22836	27143	-0.173
1988/89	2725	3612	327	98	230	284	24	173	46013	32477	0.348
1989/90	915	1714	2237	200	60	140	173	120	35066	29152	0.185
1990/91	250	543	983	1190	101	29	69	144	27026	19838	0.309

Estimated average availability at age

0.44	0.62	0.89	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

0.03	0.19	0.54	0.78	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruit curve are: alpha =0.6239, beta =0.5798E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.265E-01

Appendix Table 3.2. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the Prince Rupert District stock assessment region.

Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
	Estimated numbers at age (x10^{-5}) for period one										
1950/51	6095	7777	1073	394	0	0	3	205	25730	10602	0.887
1951/52	3185	3290	3001	287	62	0	0	33	15589	4172	1.318
1952/53	3282	1793	1110	593	19	4	0	2	23371	26426	-0.123
1953/54	7405	2074	1128	689	364	12	3	1	20307	7624	0.980
1954/55	2150	4217	800	302	109	57	2	1	21133	10549	0.695
1955/56	5816	1328	1878	283	81	29	15	1	23128	33522	-0.371
1956/57	1859	3217	768	1028	147	42	15	8	31104	11211	1.020
1957/58	3377	807	1343	241	223	32	9	5	12330	26967	-0.783
1958/59	7117	2056	486	781	135	126	18	8	31250	31997	-0.024
1959/60	2378	4153	1185	264	401	70	65	13	26435	28225	-0.066
1960/61	12131	1421	2196	563	112	171	30	33	24076	26827	-0.108
1961/62	6074	5707	647	811	163	32	49	18	37209	28935	0.251
1962/63	3528	3350	2856	281	302	61	12	25	19042	21803	-0.135
1963/64	9280	1799	1484	1001	74	80	16	10	28818	35236	-0.201
1964/65	1365	4238	917	664	390	29	31	10	12184	9399	0.260
1965/66	455	503	1612	238	98	58	4	6	8074	6093	0.281
1966/67	792	247	214	525	55	23	13	2	5399	5941	-0.096
1967/68	724	256	109	75	138	15	6	4	10530	8113	0.261
1968/69	1118	382	149	60	39	73	8	5	1800	5525	-1.122
1969/70	5786	711	235	90	35	23	43	8	21547	21452	0.004
1970/71	4311	3656	447	146	55	22	14	31	17413	25882	-0.396
1971/72	1989	2651	2242	267	85	32	13	26	24319	33762	-0.328
1972/73	3846	1274	1614	1326	154	49	18	22	17753	46988	-0.973
1973/74	3667	2452	810	1017	829	96	31	26	16294	42009	-0.947
1974/75	1634	2346	1525	485	594	484	56	33	19796	38654	-0.669
1975/76	955	1047	1485	955	301	368	300	55	28162	38882	-0.323
1976/77	1850	610	642	887	556	175	215	207	34971	28068	0.220
1977/78	982	1125	348	341	441	276	87	209	18239	17985	0.014
1978/79	986	600	619	169	148	191	119	128	19796	14990	0.278
1979/80	9618	611	347	333	85	74	96	124	37184	26275	0.347
1980/81	2186	6075	373	197	180	46	40	119	28575	29291	-0.025
1981/82	2685	1397	3778	224	114	104	27	92	31737	34097	-0.072
1982/83	2994	1720	886	2376	140	71	65	74	44407	42568	0.042
1983/84	8994	1939	1114	574	1538	91	46	90	49417	41690	0.170
1984/85	1860	5762	1227	685	338	880	52	78	50001	41707	0.181
1985/86	1911	1181	3567	721	371	173	451	66	50681	45099	0.117
1986/87	8164	1196	716	2017	384	195	91	272	62136	46065	0.299
1987/88	7734	5212	746	419	1106	207	105	195	45356	46217	-0.019
1988/89	5203	4901	3229	433	216	547	102	149	36795	50879	-0.324
1989/90	3218	3293	3040	1877	220	105	266	122	42364	59887	-0.346
1990/91	16964	2048	2077	1866	1109	128	61	226	62452	74566	-0.177

Estimated average availability at age

0.37	0.53	0.78	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

0.02	0.32	0.67	0.88	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruit curve are: alpha =0.7851, beta =0.4974E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.411E-01

Appendix Table 3.3. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the central coast stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one								I_i / q	R_i	RES_i
	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	3490	4422	795	321	4	0	77	1	20122	14505	0.327
1951/52	1307	1514	1477	178	67	1	0	16	8275	3654	0.817
1952/53	1963	437	370	157	15	6	0	1	15176	9254	0.495
1953/54	11628	1328	286	238	101	10	4	1	11750	7674	0.426
1954/55	1228	6026	419	57	43	18	2	1	13342	27152	-0.711
1955/56	1345	772	3337	215	29	22	9	1	9506	8289	0.137
1956/57	2719	478	216	511	29	4	3	1	5139	3233	0.463
1957/58	4801	838	124	27	54	3	0	0	8854	15239	-0.543
1958/59	5677	2580	426	56	12	24	1	0	8782	8237	0.064
1959/60	1375	2611	822	87	10	2	4	0	16430	28796	-0.561
1960/61	2458	842	1649	506	53	6	1	3	7576	9303	-0.205
1961/62	7271	819	270	340	96	10	1	1	20749	16151	0.251
1962/63	3567	4146	384	108	133	37	4	1	9506	5096	0.623
1963/64	3382	1442	1038	44	10	12	3	0	10374	6465	0.473
1964/65	1510	1015	403	159	6	1	2	1	4126	5753	-0.332
1965/66	1753	650	341	91	33	1	0	0	3812	3250	0.160
1966/67	1380	233	148	29	6	2	0	0	7769	5047	0.431
1967/68	430	235	71	28	5	1	0	0	9072	5842	0.440
1968/69	513	242	140	41	16	3	1	0	4150	5475	-0.277
1969/70	2240	350	163	94	27	11	2	1	15369	17664	-0.139
1970/71	1850	1523	237	110	64	18	7	2	8227	19803	-0.878
1971/72	2291	1170	941	141	65	38	11	5	10495	15356	-0.381
1972/73	3897	1361	583	410	60	28	16	7	23258	27946	-0.184
1973/74	2646	2403	786	307	211	31	14	12	21545	25059	-0.151
1974/75	3461	1761	1407	378	131	87	13	11	19181	32584	-0.530
1975/76	1697	2277	1073	717	176	59	39	10	34404	25096	0.315
1976/77	966	1102	1319	490	280	63	21	18	29507	23769	0.216
1977/78	1289	597	641	622	199	109	25	15	17661	11088	0.465
1978/79	965	784	305	202	117	31	17	6	16744	15751	0.061
1979/80	9130	661	537	209	139	80	21	16	27963	37613	-0.296
1980/81	1698	6252	451	359	136	88	51	23	31847	45283	-0.352
1981/82	1786	1159	4202	287	211	72	47	40	31413	49979	-0.464
1982/83	773	1192	757	2553	168	118	40	48	38723	38913	-0.005
1983/84	656	518	777	464	1501	96	67	51	25936	25872	0.002
1984/85	2516	428	319	443	248	773	50	61	27866	27929	-0.002
1985/86	1073	1637	266	185	249	136	424	60	30448	26195	0.150
1986/87	2006	708	1040	162	111	148	80	286	27987	26331	0.061
1987/88	11829	1331	448	627	96	65	87	217	45141	52912	-0.159
1988/89	757	7872	865	279	381	58	39	184	42994	52585	-0.201
1989/90	754	491	4920	492	149	192	29	113	43090	48934	-0.127
1990/91	2033	493	311	2938	278	82	105	77	42680	37908	0.119

Estimated average availability at age

0.53	0.74	0.97	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

0.03	0.20	0.54	0.81	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruit curve are: alpha =0.8348, beta =0.7075E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.414E-01

Appendix Table 3.4. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the northern Strait of Georgia stock assessment region.

	Estimated numbers at age ($x10^{-5}$) for period one										
Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
1950/51	5543	2276	499	0	0	0	0	46	32216	13024	0.906
1951/52	6968	2190	696	137	0	0	0	12	33484	23362	0.360
1952/53	7137	2771	780	232	45	0	0	4	37564	32631	0.141
1953/54	14980	3321	1266	352	104	20	0	2	21324	20700	0.030
1954/55	7376	6916	1119	394	106	31	6	1	28735	41897	-0.377
1955/56	3025	2850	2570	393	136	37	11	2	14235	19188	-0.299
1956/57	2631	1207	849	683	100	34	9	3	15918	10540	0.412
1957/58	4989	846	323	195	148	22	7	3	8472	7723	0.093
1958/59	10927	2189	268	93	54	41	6	3	23733	22215	0.066
1959/60	5421	3647	632	68	23	13	10	2	23560	21594	0.087
1960/61	3205	2027	1194	190	20	7	4	4	17958	13609	0.277
1961/62	6239	1303	645	345	53	6	2	2	16713	17625	-0.053
1962/63	6937	1649	363	157	79	12	1	1	13808	7770	0.575
1963/64	7590	2002	331	55	21	11	2	0	15607	10291	0.416
1964/65	3500	2189	422	54	8	3	2	0	16586	16066	0.032
1965/66	1513	795	604	101	12	2	1	0	3078	3212	-0.043
1966/67	1432	331	132	67	9	1	0	0	5740	5734	0.001
1967/68	1315	298	86	29	14	2	0	0	6409	7223	-0.120
1968/69	1729	608	135	39	13	6	1	0	9647	12420	-0.253
1969/70	4780	843	293	65	18	6	3	0	28170	30200	-0.070
1970/71	4285	2326	410	142	31	9	3	2	27087	30520	-0.119
1971/72	3219	2080	1123	197	68	15	4	2	18200	18656	-0.025
1972/73	6231	1418	808	417	72	25	6	2	15849	17831	-0.118
1973/74	10037	2956	564	299	150	26	9	3	32735	30255	0.079
1974/75	12982	4920	1372	226	109	53	9	4	43892	64759	-0.389
1975/76	8433	6304	2297	542	84	40	20	5	43166	50527	-0.157
1976/77	14265	4115	2894	923	197	30	14	9	64835	72044	-0.105
1977/78	11939	6778	1829	1144	343	71	11	8	52860	59992	-0.127
1978/79	6016	5646	2975	698	399	117	24	7	52398	57240	-0.088
1979/80	9010	2932	2569	1244	281	160	47	12	51557	59305	-0.140
1980/81	6047	4374	1402	1155	528	118	67	25	34775	54612	-0.451
1981/82	5143	2881	2033	583	442	197	44	34	57044	39758	0.361
1982/83	4896	2507	1359	891	218	150	67	27	33956	25433	0.289
1983/84	4185	2165	915	374	215	44	30	19	25381	21883	0.148
1984/85	7016	1895	857	260	84	45	9	10	22707	31275	-0.320
1985/86	9833	3297	815	300	78	24	13	6	46958	49709	-0.057
1986/87	5219	4813	1612	398	147	38	12	9	43466	42539	0.022
1987/88	18523	2455	2192	689	159	55	14	8	38025	56439	-0.395
1988/89	5860	8977	1100	866	250	54	19	8	62519	56755	0.097
1989/90	14096	2848	4186	436	310	82	18	9	52836	97885	-0.617
1990/91	3671	6885	1368	1876	178	123	32	10	54923	58856	-0.069

Estimated average availability at age

	2+	3+	4+	5+	6+	7+	8+	9+
	0.55	0.81	0.95	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

	2+	3+	4+	5+	6+	7+	8+	9+
	0.02	0.23	0.62	0.88	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruit curve are: alpha =1.1179, beta =0.2636E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.868E-01

Appendix Table 3.5. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the southern Strait of Georgia stock assessment region.

	Estimated numbers at age ($x10^{-5}$) for period one										
Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
1950/51	4683	1415	289	57	0	0	11	0	5964	11240	-0.634
1951/52	5003	1226	296	58	12	0	0	2	14335	6709	0.759
1952/53	7176	1420	183	41	8	2	0	0	36309	19867	0.603
1953/54	10631	3418	635	82	18	4	1	0	37125	18295	0.708
1954/55	7836	3557	677	120	15	3	1	0	28879	25568	0.122
1955/56	6022	2429	879	163	29	4	1	0	18625	10679	0.556
1956/57	5282	1402	355	120	22	4	1	0	8559	6580	0.263
1957/58	3085	774	165	38	13	2	0	0	18730	8973	0.736
1958/59	7878	971	215	45	10	3	1	0	22476	16950	0.282
1959/60	6598	3140	305	67	14	3	1	0	10547	15066	-0.357
1960/61	3122	1663	557	51	11	2	1	0	12598	9410	0.292
1961/62	7056	925	290	92	8	2	0	0	6780	8026	-0.169
1962/63	6378	1798	133	39	12	1	0	0	10233	7297	0.338
1963/64	4208	1885	243	17	5	2	0	0	10736	5517	0.666
1964/65	2658	761	191	22	1	0	0	0	3160	4221	-0.290
1965/66	1735	627	101	23	3	0	0	0	4039	3504	0.142
1966/67	1556	573	100	15	3	0	0	0	2888	3037	-0.050
1967/68	425	192	59	9	1	0	0	0	4813	4779	0.007
1968/69	608	167	76	23	4	1	0	0	7241	6635	0.087
1969/70	1536	295	81	37	11	2	0	0	12054	12025	0.002
1970/71	1688	765	147	40	18	6	1	0	10275	9501	0.078
1971/72	1378	842	369	71	19	9	3	0	9731	11813	-0.194
1972/73	1802	653	373	162	31	9	4	1	9522	14579	-0.426
1973/74	2826	902	314	170	73	14	4	2	14628	24959	-0.534
1974/75	3598	1416	443	149	80	35	7	3	14733	23673	-0.474
1975/76	2279	1821	686	206	69	37	16	4	11322	16913	-0.401
1976/77	4353	1119	830	293	82	28	15	8	6592	19891	-1.104
1977/78	3132	2044	471	347	123	34	11	10	14565	18789	-0.255
1978/79	1728	1395	788	170	123	44	12	8	31223	11312	1.015
1979/80	1895	762	450	251	54	39	14	6	15612	14980	0.041
1980/81	1569	927	368	217	121	26	19	10	11531	11895	-0.031
1981/82	1063	706	381	150	89	49	11	12	4311	8531	-0.683
1982/83	563	343	221	117	46	27	15	7	8768	5497	0.467
1983/84	892	274	156	100	53	21	12	10	9752	6378	0.425
1984/85	1132	428	122	69	45	24	9	10	9731	10342	-0.061
1985/86	2214	553	207	59	34	22	11	9	9961	18278	-0.607
1986/87	1189	1112	278	104	30	17	11	10	13372	12736	0.049
1987/88	3135	585	460	55	18	5	3	4	8894	17389	-0.670
1988/89	790	1562	290	228	27	9	3	3	13184	16257	-0.210
1989/90	2418	386	747	138	109	13	4	3	19755	19027	0.038
1990/91	823	1201	164	249	46	36	4	2	9187	15569	-0.527

Estimated average availability at age

0.69	0.97	1.00	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

0.05	0.46	0.89	1.00	0.99	0.99	0.99	0.99

The coefficients for the Ricker stock-recruit curve are: alpha =0.9633, beta =0.6062E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.478E-01

Appendix Table 3.6. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the southern west coast of Vancouver Island stock assessment region.

	Estimated numbers at age ($x10^{-5}$) for period one										
Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
1950/51	1077	890	132	27	0	0	0	6	6901	2958	0.847
1951/52	1329	271	135	18	4	0	0	1	5622	1654	1.223
1952/53	1415	359	35	15	2	0	0	0	9588	7255	0.279
1953/54	2794	1050	266	26	11	2	0	0	6581	2714	0.886
1954/55	1026	363	93	19	2	1	0	0	8745	6277	0.332
1955/56	1782	414	149	37	8	1	0	0	8673	2702	1.166
1956/57	979	267	54	17	4	1	0	0	6160	5718	0.074
1957/58	1982	535	143	29	9	2	0	0	12450	13070	-0.049
1958/59	3701	1439	385	103	21	7	2	0	5622	5444	0.032
1959/60	1482	555	177	42	11	2	1	0	6523	5500	0.170
1960/61	1080	306	118	36	8	2	0	0	5753	5720	0.006
1961/62	2299	309	78	29	9	2	1	0	9748	5935	0.496
1962/63	1291	611	76	18	7	2	0	0	5390	6325	-0.160
1963/64	2599	810	297	36	9	3	1	0	13293	7117	0.625
1964/65	913	922	189	66	8	2	1	0	9472	5092	0.621
1965/66	571	342	217	42	15	2	0	0	3472	2949	0.163
1966/67	691	204	80	48	9	3	0	0	1700	2035	-0.180
1967/68	54	193	34	12	7	1	0	0	5288	3086	0.539
1968/69	215	40	143	25	9	5	1	0	6232	4419	0.344
1969/70	1051	159	30	106	19	7	4	1	13932	11367	0.203
1970/71	2513	780	118	22	79	14	5	4	18246	29099	-0.467
1971/72	2051	1866	579	88	16	59	10	7	16082	29391	-0.603
1972/73	3095	1461	1215	376	57	11	38	11	6842	37866	-1.711
1973/74	3389	2075	865	701	215	33	6	28	9850	59436	-1.797
1974/75	6024	2375	1406	554	426	129	19	20	17854	69454	-1.358
1975/76	2517	4057	1445	765	293	224	68	21	20716	43040	-0.731
1976/77	1274	1768	2051	534	238	88	67	27	22634	29852	-0.277
1977/78	1446	806	820	790	172	73	27	29	19685	20615	-0.046
1978/79	439	886	454	321	213	36	15	11	18755	11982	0.448
1979/80	995	284	451	177	104	64	11	8	18363	15282	0.184
1980/81	870	674	190	289	110	63	39	11	18479	14879	0.217
1981/82	560	548	413	99	134	46	27	21	11927	12534	-0.050
1982/83	498	365	340	246	56	72	25	26	7758	8671	-0.111
1983/84	815	258	161	147	106	24	31	22	11607	9520	0.198
1984/85	1225	426	121	74	68	49	11	25	12261	20869	-0.532
1985/86	1723	902	314	89	55	50	36	26	13714	27781	-0.706
1986/87	712	1271	665	232	66	40	37	46	16532	20016	-0.191
1987/88	3988	369	578	298	104	29	18	37	23491	25437	-0.080
1988/89	627	2557	203	295	149	51	15	27	19830	24419	-0.208
1989/90	718	342	1295	90	119	58	20	16	17273	17839	-0.032
1990/91	327	380	174	606	41	53	26	16	12537	9890	0.237

Estimated average availability at age

0.77	0.98	1.00	1.00	1.00	1.00	1.00	1.00

Estimated average relative selectivity at age for gillnet fisheries

0.02	0.23	0.60	0.87	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruit curve are: alpha =0.4060, beta =0.5292E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.688E-01

Appendix Table 3.7. Estimates of numbers at age, spawn index (I_i / q), estimated spawning stock biomass (R_i), estimated spawn-spawn index residuals (RES_i), and other parameters from age-structured model analysis for the northern west coast of Vancouver Island stock assessment region.

	Estimated numbers at age ($x10^{-5}$) for period one										
Season	2+	3+	4+	5+	6+	7+	8+	9+	I_i / q	R_i	RES_i
1950/51	3143	4751	670	195	50	1	3	2	34053	29930	0.129
1951/52	1983	1460	2149	295	86	22	1	2	14469	15184	-0.048
1952/53	7840	900	495	632	85	25	6	1	38294	37487	0.021
1953/54	4520	3894	447	246	314	42	12	4	30124	31101	-0.032
1954/55	4940	2096	1796	202	111	141	19	7	21829	44911	-0.721
1955/56	3533	2453	1041	892	100	55	70	13	66297	38793	0.536
1956/57	6059	1754	1218	517	443	50	27	41	100849	48688	0.728
1957/58	4920	3009	871	605	257	220	25	34	33991	35724	-0.050
1958/59	4742	2442	1494	432	300	127	109	29	30685	8822	1.247
1959/60	3821	1853	568	235	65	45	19	21	4989	5345	-0.069
1960/61	1843	548	348	57	21	6	4	4	11538	7121	0.483
1961/62	5842	439	159	81	13	5	1	2	35487	25397	0.335
1962/63	3438	2382	188	65	33	5	2	1	6985	9567	-0.314
1963/64	4211	1324	732	48	16	8	1	1	33679	22202	0.417
1964/65	1843	2058	643	353	23	8	4	1	33429	23014	0.373
1965/66	1993	880	978	301	165	11	4	2	14906	20343	-0.311
1966/67	2187	962	409	445	137	75	5	3	20519	23411	-0.132
1967/68	1402	915	420	172	186	57	31	3	14968	19206	-0.249
1968/69	1581	696	454	209	85	92	28	17	16278	20489	-0.230
1969/70	6443	785	346	226	104	42	46	23	29188	42407	-0.374
1970/71	9878	3200	390	172	112	51	21	34	26818	69550	-0.953
1971/72	6072	4906	1589	194	85	56	26	27	51267	44434	0.143
1972/73	4558	2991	2339	749	91	40	26	25	27567	42906	-0.442
1973/74	4803	2133	1317	992	317	39	17	22	15031	36397	-0.884
1974/75	6394	2070	891	521	390	125	15	15	27068	47922	-0.571
1975/76	1930	2758	925	386	225	168	54	13	24573	24635	-0.003
1976/77	2150	926	1231	369	148	86	64	26	27629	17561	0.453
1977/78	10729	1057	437	516	136	53	31	32	29874	22803	0.270
1978/79	2509	5246	499	155	161	36	14	17	51454	23869	0.768
1979/80	6135	1157	2210	138	26	23	5	4	36610	27824	0.274
1980/81	2619	3045	561	1009	55	10	8	3	31683	24153	0.271
1981/82	1486	1253	1382	248	444	24	4	5	33928	18855	0.587
1982/83	706	736	611	609	99	164	9	3	25134	13427	0.627
1983/84	1665	349	349	254	228	35	59	4	18149	21762	-0.182
1984/85	7688	824	170	166	109	96	15	27	11725	28454	-0.887
1985/86	3138	3818	409	84	82	54	48	21	30373	40783	-0.295
1986/87	1432	1558	1896	203	42	41	27	34	34926	33012	0.056
1987/88	6574	708	735	856	91	19	18	27	35612	39395	-0.101
1988/89	1443	3264	352	365	425	45	9	23	15654	32395	-0.727
1989/90	1686	716	1621	175	181	211	22	16	29500	28696	0.028
1990/91	1407	837	356	804	87	90	105	19	16839	20008	-0.172

Estimated average availability at age

0.63 0.76 0.98 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.01 0.18 0.51 0.85 1.00 1.00 1.00 1.00

The coefficients for the Ricker stock-recruit curve are: alpha =0.7092, beta =0.3460E-04

The spawn index-spawning stock biomass conversion factor (q) is 0.160E-01

Appendix Table 4.1. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the Queen Charlotte Islands stock assessment region.

	fishing	standard deviate (Z_{ijr})						
season	period	1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	0.007•	-0.093	-0.026	-0.042	0.164	0.043	-0.02
51/52	1	0.201	0.232	0.802	-0.342	-0.274	-3.401•	-2.64
53/54	1	-0.075•	-0.484	-1.490	1.495	0.215•	-0.362•	-2.07
54/55	1	0.498•	0.810•	-3.716	0.818•	1.338•	0.403•	-4.37
55/56	1	-0.140•	-1.130	1.191	0.703	0.209	-1.845	-2.65
56/57	1	-0.006	-0.262	1.344	-0.722	-0.489	0.291	-1.19
57/58	1	2.820	0.705	-0.286	-24.185•	-5.525•	-7.280•	-28.55
58/59	1	-15.433•	0.771•	1.054•	0.599•	0.000	0.000	-4.71
60/61	1	-0.197•	-1.775	1.745	0.229	-2.411•	-0.152•	-3.51
61/62	1	0.140	0.565	1.130	-0.415	-2.339	-1.440•	-3.00
62/63	1	0.032•	0.849	-0.167	0.443	-1.660	-2.015	-2.65
63/64	1	-0.188•	-1.115	1.821	-0.101	-1.363	-1.871•	-3.06
64/65	1	-0.943•	2.389	2.038	-9.078	-0.221•	0.580•	-16.37
65/66	1	0.066•	-0.705	0.637•	-0.974•	-1.397•	1.802•	-8.28
66/67	1	0.114•	1.808	1.105	-3.934•	-3.413•	0.000	-7.81
67/68	1	0.691	1.418	-0.010•	-2.517•	0.000	0.000	-5.97
71/72	2	0.025•	0.127	-0.566	-0.122	0.906	0.154•	-0.65
72/73	2	0.008•	0.097	-2.515	1.864	0.859	-0.756	-4.18
73/74	2	0.025•	-0.012	-1.201	1.727	0.073	-0.862•	-2.27
73/74	3	0.000	0.986•	1.527	-0.243	-1.902•	-1.980•	-4.06
74/75	2	0.009•	0.187	1.874	-2.151	2.471	-5.247	-13.61
74/75	3	0.000	0.000	1.564	-2.373	1.628	-1.892•	-5.36
75/76	2	-0.032•	-0.019	1.302	-0.740	-0.480	-0.438	-0.96
75/76	3	0.000	0.000	-17.318•	-4.379	4.705	0.676	-29.36
76/77	2	0.009•	-0.020	-3.606	-1.442	1.835	2.059	-8.72
77/78	2	-0.014•	-0.136	0.602	-2.581	3.676	-2.700	-11.21
77/78	3	0.000	-0.705•	-2.086	-0.760	-4.798	4.014	-12.85
78/79	2	-0.104	-0.145	-0.236	-1.109	5.951	-5.579	-36.71
78/79	3	0.000	0.000	1.631	-0.170	2.148	-4.503	-8.47
79/80	2	-0.006	0.976	-2.720	-1.592	1.423	1.633	-6.75
79/80	3	0.000	-3.731	2.678	1.529	-0.551	-0.876	-10.68
80/81	2	0.011•	0.390	-1.643	1.321	0.037	0.947	-1.79
80/81	3	0.000	-1.371•	4.461	-0.958	-3.547	-4.180	-14.12
81/82	2	0.022	0.230	-5.132	2.502	-0.935	0.945	-10.44
81/82	3	0.000	-2.008•	-0.558	3.407	-1.662	-4.452	-8.53
82/83	2	0.020	0.143	-0.659	-2.128	-0.781	3.805	-11.35
82/83	3	0.000	0.000	0.008	-5.425	2.516	0.129	-9.74
83/84	1	1.953	0.236	-2.078•	0.475	1.347	-1.630	-6.32
83/84	2	-1.151	-0.314	1.021	-1.982	5.938	-3.031	-29.25
83/84	3	0.000	1.176	0.022	0.660	1.249	-2.029	-2.26
84/85	2	-0.002	0.149	-2.962	-1.086	1.896	2.127	-6.75
84/85	3	0.000	0.000	-0.462	-2.006•	-0.117•	1.202	-2.11
85/86	2	0.001	0.221	-0.213	-1.551	0.135	1.666	-1.75
85/86	3	0.000	0.000	-0.946	3.424	0.644	-3.718	-9.78
86/87	2	-0.021	-0.074	-1.511	0.253	2.830	-2.940	-6.84
87/88	2	0.025	0.109	-1.521	0.878	0.916	-0.359	-1.79
88/89	2	-0.061•	-0.231	3.321	-2.159	-0.890•	-4.659	-10.21
89/90	2	-0.008•	0.023	-3.990	4.334	-0.924	-2.932	-13.61
89/90	3	0.000	-0.610•	0.330	-4.124	1.248	2.811	-7.69
90/91	2	-0.027	0.018	-0.198	0.849	-1.007	0.496	-0.70
90/91	3	0.000	0.000	-0.511	0.915	-2.403	1.787	-3.48

Total for age composition	-411.19
Total for observed catch-predicted catch	-5.54
Total for observed spawn-predicted spawn	-109.26
Total for stock-recruitment relationship	-70.64

• S_{ijr} less that 5

Appendix Table 4.2. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the Prince Rupert District stock assessment region.

season	fishing period	standard deviate (Z_{ijr}) 1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	-0.131	-0.375	1.096	-1.693	0.390	0.274	-1.62
51/52	1	-0.179	-0.301	-0.272	0.363	1.254	-2.002	-2.52
52/53	1	0.016	0.197	-0.620	2.388	-3.306	1.102	-7.30
53/54	1	0.173	0.646	2.196	2.581	-2.446	-9.621	-27.90
54/55	1	0.099	0.099	3.328	-0.909	-3.108	-6.826	-14.13
55/56	1	0.182	0.884	0.117	-0.151	-1.773	-2.186*	-2.81
56/57	1	-0.014	-0.265	2.570	0.952	-2.719	-4.396	-10.27
57/58	1	0.975	1.089	0.330	-1.994	-1.930*	-1.589*	-3.86
58/59	1	0.045	0.393	1.354	-0.254	-1.778	-0.982	-2.46
59/60	1	0.308	0.057	1.052	-1.102	1.001	-3.043	-4.34
60/61	1	0.058	0.304	-0.055	1.115	-1.481	-1.918	-2.84
61/62	1	-0.022	-0.108	0.449	-0.359	-1.602	1.759	-2.97
62/63	1	0.283	0.125	-0.144	-0.388	0.784	-0.610	-0.60
63/64	1	-0.056	-0.116	1.453	0.057	-0.978	-0.973	-1.86
64/65	1	-0.693	-0.664	2.996	-4.013	-1.187	0.795	-9.11
65/66	1	0.000	-0.125*	1.467	-9.705	0.940	3.532	-24.05
66/67	1	1.620	0.613	0.042*	-1.726*	-6.082*	-2.010*	-5.36
67/68	1	-0.131	0.063	1.392*	0.005*	-1.917*	-4.967*	-3.64
68/69	1	1.003	1.737	-0.208	-2.355*	-8.205*	-14.530*	-7.73
69/70	1	-0.010*	-0.014	0.809*	-0.363*	-5.283*	-3.075*	-1.44
70/71	1	0.123*	0.821	-1.353	0.259*	0.438*	-0.462*	-0.92
71/72	2	0.000	0.052	-8.467	4.513	-0.738	1.342	-21.50
72/73	1	1.724*	0.974	-0.717*	-1.260*	-4.115*	-0.132*	-10.62
72/73	2	-2.322*	0.099	-11.233	3.532	0.825	0.876	-32.65
73/74	2	0.020*	0.258	4.527	-2.499	-1.514	-8.767	-24.30
73/74	3	0.000	0.311*	3.428	0.472	0.553	-14.961*	-23.74
74/75	1	-0.110*	0.292	-3.429	2.826	0.885	-2.444	-9.03
74/75	2	0.028	-0.088	-3.575	8.470	0.503	-11.281	-70.38
74/75	3	0.000	0.000	2.622	2.967	-2.024*	0.000	-29.93
75/76	1	0.000	2.198	-13.207	-31.248	-9.489	21.220	-501.39
75/76	2	0.000	-8.300	-8.148	0.904	10.493	-14.907	-133.62
75/76	3	0.000	0.000	0.838	3.165	-0.805	-12.554*	-16.30
76/77	1	0.695*	2.274	2.769	3.215	-4.197	-5.437	-25.91
76/77	2	-0.705*	-1.446	-11.232	6.939	8.476	-13.621	-135.85
76/77	3	0.000	0.761	-15.607	2.298	12.288	-17.317	-171.92
77/78	1	0.058*	-0.521	0.987	2.092	1.313	-4.323	-8.23
77/78	2	-0.144*	0.271	2.079	-0.430	2.050	-4.946	-9.68
77/78	3	0.000	0.000	0.238	-1.761*	1.824	-1.308	-3.61
78/79	1	-1.567	-5.831	-7.371	0.237	6.392	2.581	-57.83
78/79	2	0.449	3.220	-6.889	3.070	2.968	-3.726	-33.04
78/79	3	1.709*	-0.628*	-4.329	3.174	1.723	-3.022	-28.94
79/80	1	0.528	-4.373	-0.895	1.533	0.480	4.078	-15.41
79/80	2	-0.713*	4.135	-0.196	-1.132	-4.708	-3.599	-14.06
79/80	3	0.000	-1.251	-0.756	5.787	-5.860	-0.220	-27.29
80/81	1	0.890	-2.349	-13.850	3.413	6.347	7.593	-107.42
80/81	2	-1.360*	2.040	6.846	-5.597	-6.541	-14.809	-66.13
80/81	3	0.000	-0.463*	5.872	-1.476	2.292	-9.629	-40.38
81/82	1	-1.166	-2.787	3.360	-8.990	4.551	5.217	-61.17
81/82	2	0.851	2.131	-6.857	4.141	-2.212	-8.235	-33.88
82/83	2	0.019	-0.023	1.207	-12.560	4.652	-1.001	-45.52
83/84	1	1.599	0.208	0.151	0.529	0.723	-2.055	-3.85
83/84	2	-2.657*	-0.105	-0.724	-2.130	4.003	-0.759	-14.13
83/84	3	0.000	-0.151	-0.160	1.199	4.406	-5.166	-14.62
84/85	1	2.494	0.105*	-3.714	1.899	0.295	-2.237*	-19.34
84/85	2	-4.540*	-0.062	4.774	-2.335	-5.101	-1.002	-21.22
84/85	3	0.000	-0.049*	2.002	0.641	-1.819	-0.668	-3.51
85/86	1	6.013	-2.626	-1.931	-15.567	3.880	5.990	-114.72
85/86	2	-5.194	0.877	-1.839	1.928	-1.923	1.374	-14.77
85/86	3	0.000	-1.992*	-2.091	0.853	2.006	-1.688	-5.80
86/87	2	0.001	0.297	1.822	-3.104	0.548	-0.497	-5.80
86/87	3	0.000	-4.753*	-1.727	-4.863	0.657	3.090	-17.40
87/88	2	0.003	0.005	3.877	-3.295	5.903	-8.124	-53.06
87/88	3	0.000	-1.013*	-2.664	-1.792	3.688	-0.908	-11.94
88/89	2	0.000	0.217	3.606	-1.628	-0.355	-3.898	-11.38
88/89	3	0.000	0.000	-3.853	-2.897	-0.213	4.097	-15.30
89/90	2	-0.007	0.142	1.729	-0.445	-3.330	2.474	-8.35
89/90	3	0.000	0.000	-1.821	-3.287	0.721	3.083	-12.00
90/91	2	0.029	0.328	0.444	-1.432	0.036	0.480	-1.07
90/91	3	0.000	0.000	-1.086	-1.119	-1.336	2.951	-11.30

Total for age composition	-2257.00
Total for observed catch-predicted catch	-6.97
Total for observed spawn-predicted spawn	-107.30
Total for stock-recruitment relationship	-45.85

Appendix Table 4.3. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the central coast stock assessment region.

	fishing	standard deviate (Z_{ijr})						
season	period	1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	-0.012	-0.081	-0.029	0.067	0.109	0.063	-0.01
51/52	1	-0.066	-0.226	0.386	0.169	-0.410	-0.493	-0.27
52/53	1	-0.026	-0.147	0.371	0.379	-0.962	0.263	-0.53
53/54	1	0.117	0.807	1.647	-0.247	-5.700	-8.498*	-14.27
54/55	1	0.249	0.403	-0.974	0.873	0.554*	-1.543*	-1.37
55/56	1	0.002	-0.124	-0.608	1.471	-1.717	-3.858	-5.52
56/57	1	-0.100	-0.380	0.854	0.348	0.029	-1.558	-1.38
57/58	1	0.218	0.739	0.135	-2.984	0.134*	-2.413*	-4.62
58/59	1	-0.028	-0.117	0.130	0.183	-1.162	0.584	-0.76
59/60	1	0.602	1.147	-0.136	-3.216	-0.109*	-0.344*	-3.58
60/61	1	-0.049	-0.082	-0.774	0.141	0.814	-0.140	-0.59
61/62	1	-0.222	-1.026	1.501	-2.348*	1.012	0.108*	-3.50
62/63	1	-0.058*	-0.657	0.987	-1.867	1.526	-0.167	-3.20
63/64	1	0.190	0.411	2.138	-4.511	0.685*	-2.148*	-8.37
64/65	1	0.222	0.609	0.695	-0.822	-1.724	-0.037*	-1.76
65/66	1	0.362	-0.280*	0.060*	-0.315*	-0.089*	-0.390*	-0.13
66/67	1	-2.159	0.954	1.218*	-0.579*	0.129*	0.034*	-2.63
67/68	1	-0.667	0.957	0.258*	-1.367*	-2.219*	-0.816*	-1.38
68/69	1	0.360	0.533	0.326	-0.988*	-1.148*	-2.952*	-1.23
69/70	1	0.525	0.657	-2.674*	-3.006*	0.000	0.000	-2.20
70/71	1	0.326	0.998	-0.057	-2.362	0.315	-2.033*	-3.04
71/72	2	0.051	1.171	-0.666	-2.767	2.068	1.642	-7.25
71/72	3	0.000	-5.358*	-2.465	3.944	-0.613	-2.067	-13.33
72/73	2	-0.001	0.536	-3.329	1.440	1.503	-0.222	-5.82
72/73	3	0.000	-3.602*	-0.875	2.758	-1.304	-0.435	-6.95
73/74	2	-0.010	0.072	-2.102	0.075	2.218	0.488	-4.38
73/74	3	0.000	-0.808*	-2.853	1.165	1.679	-0.553	-4.35
74/75	2	0.021	-0.033	-0.731	0.643	1.988	-2.675	-5.28
74/75	3	0.000	1.250*	1.804	-0.841	-0.532	-1.664	-4.30
75/76	2	-0.071	-0.289	1.816	-2.200	0.358	-0.278	-2.89
75/76	3	0.000	0.779*	2.003	-1.693	0.037	-0.412	-3.53
76/77	1	0.340*	3.116	-0.998	-1.244	-2.337	-0.290	-8.05
76/77	2	-0.171	-1.684	0.562	-1.732	2.689	0.573	-5.92
76/77	3	0.000	-0.390*	0.602	-2.246	2.074	-0.446	-3.54
77/78	2	-0.012*	-0.203	-0.520	-1.604	0.294	2.099	-3.31
77/78	3	0.000	-0.091	0.547	1.175	-0.560	-1.033	-1.16
79/80	2	0.005	0.561	-2.275	0.760	1.122	-0.725	-3.30
79/80	3	0.000	-3.341	-2.041	-0.561	0.230	1.967	-5.68
80/81	2	-0.224	-0.295	-1.087	1.489	1.432	-0.867	-2.94
80/81	3	0.845*	1.215*	3.471	0.499	-2.436	-3.921	-15.15
81/82	2	0.024	-0.101	-3.030	-0.013	1.997	2.093	-8.09
81/82	3	0.000	1.615	0.757	0.734	-0.383	-2.344	-4.60
82/83	2	-0.001	-0.133	-2.238	-4.407	3.196	1.705	-12.64
82/83	3	0.000	0.413*	2.394	0.098	0.298	-2.815	-6.43
83/84	2	-0.003	0.021	-0.064	-2.278	4.694	-1.809	-14.28
83/84	3	0.000	-0.557*	0.002	-0.453	1.152	-0.564	-0.89
84/85	2	0.017	0.197	-3.198	0.367	2.263	-0.290	-6.74
84/85	3	0.000	-0.651	-0.530	-1.905	0.461	1.222	-2.24
85/86	2	-0.014	-0.062	1.948	0.730	0.787	-3.182	-5.18
85/86	3	0.000	-0.146*	-1.543	0.897	0.471	0.444	-1.36
86/87	2	0.034	0.248	-2.712	0.234	1.163	1.115	-4.06
86/87	3	0.000	-1.937	-1.678	0.818	3.125	-1.735	-9.05
87/88	2	0.000	0.061	-0.725	1.940	-1.272	0.246	-2.93
87/88	3	0.000	-0.052	-0.196	-0.428	-3.336	2.900	-6.46
88/89	2	-0.012	-0.032	4.000	-1.880	0.246	-6.179	-16.51
88/89	3	0.000	-0.018*	-0.513	1.391	2.361	-3.057	-6.60
89/90	2	-0.009	0.055	-2.050	-0.501	-0.156	2.513	-5.04
89/90	3	0.000	0.000	-0.593	-0.642	1.839	-0.785	-3.15
90/91	2	-0.005	-0.010	-0.486	1.340	-0.813	0.661	-1.34
90/91	3	0.000	-0.101*	1.344	1.821	-2.501	0.954	-4.49

Total for age composition	-289.56
Total for observed catch-predicted catch	-2.55
Total for observed spawn-predicted spawn	-60.53
Total for stock-recruitment relationship	-36.75

Appendix Table 4.4. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the northern Strait of Georgia stock assessment region.

	fishing	standard deviate (Z_{ijr})						
season	period	1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	-0.087	-0.816	0.712	0.060	0.231	0.157▪	-0.38
51/52	1	0.040	-0.043	1.486	-2.008	-0.736	-1.728▪	-3.39
52/53	1	0.009	-0.027	2.787	-4.638	-2.205	-1.157▪	-12.02
53/54	1	0.022	0.159	-0.110	-1.104	1.274	0.608	-1.52
54/55	1	0.061	0.413	0.665	-0.333	-2.211	-5.715▪	-4.44
55/56	1	0.054	0.079	-2.832	1.815	2.101	-1.971	-7.59
56/57	1	-0.038▪	-0.510	1.142	2.705	-3.186	-3.999	-11.54
57/58	1	0.042	0.129	-0.850	-1.408	2.105	0.243	-3.60
58/59	1	0.028	0.085	0.277	1.151	-2.309	-2.586	-4.68
59/60	1	0.006	0.017	0.630	-1.259	-0.134▪	-0.311▪	-0.78
60/61	1	-0.081	-0.162	0.023	0.461	-0.379	-0.602▪	-0.29
61/62	1	0.099	0.364	0.329	0.041	-1.816	-0.439▪	-1.39
62/63	1	-0.294	-0.997	1.814	-0.888▪	-0.291▪	-0.191▪	-2.28
63/64	1	-0.011	-0.027	1.636	-3.908	-0.778▪	-1.962▪	-6.72
64/65	1	0.113	0.467	0.846	-4.898	0.615	0.795▪	-7.37
65/66	1	0.237	0.315	0.118	-1.020	-0.160▪	0.740▪	-0.95
66/67	1	0.048	-0.022	0.228▪	-0.354▪	-0.151▪	-0.010▪	-0.08
67/68	1	0.150▪	0.392	-0.149▪	-0.729▪	-0.719▪	-0.567▪	-0.41
68/69	1	1.041	0.711▪	-4.050▪	-2.265▪	0.000	0.000	-3.21
69/70	1	0.090	0.418	-0.085▪	-1.512▪	-0.418▪	0.000	-0.64
70/71	1	0.027	0.112	0.049	-0.300	0.207	-0.703▪	-0.24
71/72	1	-1.049	-2.256	-1.935	2.578	2.467	2.141	-11.93
71/72	2	1.846	3.864	-3.018	-2.520	-0.376	-1.573▪	-14.70
71/72	3	1.515▪	4.916	2.473	-5.946	-1.958	-3.165▪	-78.99
72/73	1	-5.729	-8.493	1.243	5.307	3.075	-2.080	-47.77
72/73	2	3.341	9.426	-6.648	-6.320	-5.680	-8.078▪	-94.41
72/73	3	0.000	0.806▪	-1.522	2.182	-2.393	-0.622▪	-4.67
73/74	3	0.000	-0.212	1.321	2.825	-0.862	-10.314	-21.06
74/75	1	1.551▪	0.259	-1.889▪	-1.870▪	-0.041▪	-0.208▪	-4.45
74/75	2	-0.559	0.324	0.267	-1.459	1.829	-1.108	-3.88
74/75	3	0.000	0.196▪	-0.176	-0.055	0.630▪	-0.819▪	-0.47
75/76	1	-0.675	-0.798	-6.257	3.036	3.082	4.073	-38.38
75/76	2	1.304	1.578	-0.644	-1.622	-1.825▪	-0.763▪	-4.30
75/76	3	0.000	0.324▪	1.260	-0.115	-1.337	-0.852	-1.64
76/77	1	-0.060	-16.173	1.383	5.687	3.818	-1.859▪	-67.67
76/77	2	0.039	4.458	-0.182	-2.867	-5.812	-4.239	-22.97
76/77	3	0.000	-1.588	0.635	0.683	-0.617	-0.566	-1.47
77/78	1	2.384	1.053	-4.157	-1.492	1.454	2.319	-17.38
77/78	2	-1.703	0.482	2.383	-1.105	-1.171	-4.563	-11.11
77/78	3	0.000	-10.916▪	-5.777	0.639	3.991	1.657	-30.46
78/79	1	0.135▪	-0.484	-2.039	-0.424	1.925	2.169	-6.97
78/79	2	-0.109▪	0.084	-5.114	2.150	2.113	1.578	-12.16
78/79	3	0.000	1.148▪	-5.159	3.751	0.588	-1.651	-13.69
79/80	1	2.254	-3.021	2.783	-0.132	-1.701	1.228	-10.96
79/80	2	-2.872	2.232	-2.031	-0.940	0.898	0.586	-6.90
79/80	3	0.000	0.965	0.273	2.576	-0.543	-4.204	-9.02
80/81	1	-5.007▪	1.025	1.932	0.923	-3.422	-2.654	-12.24
80/81	2	0.811	-0.192	0.764	0.426	0.155	-3.054	-4.32
80/81	3	0.252▪	-0.556	0.992	-1.108	1.655	-1.778	-3.14
81/82	1	0.000	-1.462	1.792	1.426	-1.246	-0.897	-9.29
81/82	2	0.618	0.178	-0.671	0.795	-2.663	1.149	-4.06
81/82	3	0.000	0.126	0.134	-0.776	-3.075	2.656	-6.24
82/83	1	10.254	5.819	-9.731	-8.587	-13.314	-11.334	-237.74
82/83	2	-10.078	-1.908	1.761	0.916	0.458	4.139	-44.01
82/83	3	0.000	-6.745▪	1.612	-0.796	-0.747	1.008	-7.39
83/84	1	1.101	-0.189	-0.133	-0.861	0.375▪	-0.003▪	-1.20
83/84	2	-0.273	-1.145	2.104	-1.884	0.898	0.083	-3.88
83/84	3	0.000	3.216	2.741	-1.890	-0.085	-3.846	-16.54
84/85	1	-4.473	2.000	0.599	0.112	0.804	-0.348	-7.59
84/85	2	1.576	0.207	0.064	-2.541	-0.237	-0.308	-3.73
84/85	3	-2.550▪	-5.231	0.175	-3.855	3.689	2.693	-23.43
85/86	1	1.680	-1.118	0.582	-3.086▪	0.816▪	0.000	-5.59
85/86	2	-0.522	0.269	0.789	-0.176	-1.642	-0.490	-1.61
86/87	2	0.005	0.871	-1.694	1.590	-0.234	-1.167	-2.84
86/87	3	0.000	-5.607	1.254	-1.235	0.753	1.388	-10.46
87/88	1	0.000	-2.444	1.486	1.354	0.872	-0.633▪	-6.94
87/88	2	0.461	0.608	-0.200	0.313	-1.344	-1.272	-1.70
87/88	3	0.000	0.542	-2.830	1.256	0.149	0.435	-3.48
88/89	2	0.103	0.112	-0.800	1.306	0.362	-1.029	-1.52
88/89	3	0.000	-0.486	1.874	-0.501	0.115	-2.302	-4.46
89/90	1	-1.102	7.459	-1.745	-4.834	0.000	-8.134	-74.00
89/90	2	1.113	-5.977	2.489	2.883	2.392	0.491	-17.47
89/90	3	0.000	-2.855	1.460	-0.223	0.636	0.281	-4.47
90/91	2	0.044	0.503	-1.331	-0.772	0.399	2.623	-5.17
90/91	3	0.000	-3.044	-0.527	-1.592	-0.081	3.511	-11.69

Total for age composition	-1147.13
Total for observed catch-predicted catch	-1.66
Total for observed spawn-predicted spawn	-33.64
Total for stock-recruitment relationship	-22.32

Appendix Table 4.5. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the southern Strait of Georgia stock assessment region.

	fishing	standard deviate (Z_{ijr})						
season	period	1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	0.028	0.362	-0.380	0.191	-0.551	-0.237▪	-0.26
51/52	1	-0.161	-0.918	0.213	1.210	0.119	1.182	-2.00
52/53	1	-0.025	-0.353	0.940	-0.807	-0.724	-3.148▪	-2.12
53/54	1	0.014	0.082	0.666	-0.960	-1.372	-0.647▪	-1.49
54/55	1	0.062	0.434	0.326	-0.888	-2.086▪	-0.611▪	-1.85
55/56	1	-0.009	-0.110	0.942	-0.326	-1.675	-1.362	-2.23
56/57	1	0.014	0.128	0.825	-2.504	0.786	-0.156	-3.16
57/58	1	-0.042	-0.371	1.473	-2.482	0.185	-0.368▪	-3.33
58/59	1	0.047	0.086	0.823	-2.349	-0.316	0.606	-2.77
59/60	1	0.075	0.568	0.402	-2.206	-2.060	-0.429▪	-3.45
60/61	1	-0.210	-0.223	0.405	0.192	0.088	-1.481▪	-0.57
61/62	1	0.061	0.629	-0.281	-1.028	-0.146	0.276▪	-0.57
62/63	1	-0.176	-0.550	0.724	0.596	-1.798▪	-0.749▪	-1.28
63/64	1	-0.069	-0.474	1.132	-2.013	0.584▪	-0.012▪	-2.22
64/65	1	0.295	0.946	0.241	-4.902	0.150▪	0.518▪	-6.43
65/66	1	-0.296	-0.428	-0.243	1.269▪	-0.008▪	0.304▪	-1.60
66/67	1	-0.150	0.153	-0.221▪	0.135▪	0.318▪	0.227▪	-0.20
67/68	1	-0.106▪	0.008▪	0.092▪	-0.096▪	0.188▪	0.155▪	-0.07
68/69	1	-0.071	-0.172	0.464▪	-0.221▪	0.025▪	0.000	-0.20
69/70	1	0.035	0.122	-0.682▪	0.434▪	-0.251▪	0.284▪	-0.37
70/71	1	-0.022	-0.080	-0.328	0.042	0.348▪	0.863▪	-0.62
71/72	1	-0.554	0.881	-0.113	-0.164	-0.325	-0.636	-0.64
71/72	2	-0.323	-1.921	1.033	1.318	-0.218	-0.133	-2.40
71/72	3	2.895	2.457	-2.939	-0.403	0.470	-0.902▪	-37.04
72/73	1	0.060	-0.644	-0.802	1.704	-0.301	0.105▪	-1.89
72/73	3	0.000	2.509	0.244	-1.290	-1.806	-0.642▪	-7.68
73/74	1	0.406	2.872	-3.266	-4.459▪	0.000	0.000	-11.96
73/74	3	0.000	-2.105	1.814	-0.430	-0.195	-0.374	-3.32
74/75	2	0.039	0.600	-1.335	-1.143	1.139	1.801	-4.03
74/75	3	0.000	-3.542▪	2.190	-1.282	0.099	-2.070▪	-4.99
75/76	1	-0.555	0.023	-1.080	1.466	-0.221	0.555	-1.57
75/76	2	1.295	0.095	-2.474	-0.515	0.105	2.487	-8.77
75/76	3	0.000	0.055▪	3.330	0.598	-3.892	-4.885	-14.51
76/77	1	-0.065	3.093	-0.568	-1.580	-3.398	-1.312	-8.42
76/77	2	0.297	-10.678	-6.891	-0.682	3.605	6.393	-111.91
76/77	3	0.000	-0.792▪	0.337▪	0.168▪	-0.071▪	-0.782▪	-0.29
77/78	1	0.067▪	-0.211	1.426	0.428	-1.558	-3.348	-4.64
77/78	2	-0.133▪	1.101	0.920	-1.083	-1.755	-6.708▪	-5.51
77/78	3	0.000	-2.389	-6.753	-0.937	5.522	1.036	-29.22
78/79	1	-0.211	-0.604	-4.564	3.784	4.019	-2.311	-23.63
78/79	2	0.472▪	1.099	-1.588	-1.187	0.907	1.228	-3.27
79/80	1	-0.527	-1.000	-0.756	2.998	0.014	-1.658	-6.01
79/80	2	1.162	2.818	-5.833	0.326	-0.883	0.411	-11.59
80/81	1	-1.179	-0.519	0.391	2.888	1.722	-6.813	-21.11
80/81	2	2.348	1.447	-1.267	-1.589	0.411	-2.603	-8.34
81/82	1	-4.746	-0.138	3.209	0.149	-0.263	-2.770	-14.58
81/82	2	3.339	0.383	-3.523	1.949	-3.922	1.129	-18.50
82/83	1	-8.742	-5.649	-0.655	1.404	1.916	5.174	-43.72
82/83	2	4.007	5.146	-2.861	-2.860	-3.230	-0.717	-34.49
83/84	1	-2.202	-0.510	0.356	3.527	0.268	-2.821	-11.68
83/84	2	1.532	0.276	-1.749	0.815	1.263	-3.458	-7.39
84/85	1	1.046	-0.496	0.020	0.822	-0.346	-3.652▪	-3.96
84/85	2	-0.683	0.354	-0.101	0.918	1.459	-2.188	-3.63
85/86	1	-2.180	0.246	1.694	0.386	-0.138▪	-2.599▪	-4.35
85/86	2	1.095	0.519	-0.235	-1.601	-0.452	-2.836▪	-3.87
86/87	1	-0.728	1.278	-0.454	0.785	-1.241▪	-2.352▪	-2.96
86/87	2	1.287	1.729	-1.589	-1.267	-2.413▪	-1.945▪	-5.82
86/87	3	0.000	-4.170	1.565	-0.856	0.939	0.721	-12.54
87/88	1	-2.190	-1.960	1.076	1.849	1.519	0.522	-6.29
87/88	2	2.323	3.411	-3.196	-4.888	-1.188▪	-0.818▪	-16.83
88/89	1	1.909	0.731	-1.276	-1.224	-0.776	-0.406▪	-3.21
88/89	2	-1.737	-0.578	0.598	1.147	0.660	0.226	-2.22
89/90	1	-4.153	-1.601	2.681	1.583	-0.413	0.136	-10.93
89/90	2	1.141	1.832	-1.987	-1.857	0.337	-0.957	-4.76
89/90	3	0.000	1.695	-0.844	-0.456	0.511	-0.814	-2.72
90/91	2	0.177	0.231	-3.781	0.779	3.124	0.798	-10.63

Total for age composition	-594.65
Total for observed catch-predicted catch	-1.44
Total for observed spawn-predicted spawn	-89.96
Total for stock-recruitment relationship	-37.39

Appendix Table 4.6. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the southern west coast of Vancouver Island stock assessment region.

	fishing	standard deviate (Z_{ijr})						
season	period	1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	-0.214	-0.733	0.582	0.428	0.222	0.080•	-0.40
51/52	1	0.018	-0.499	1.505	-0.959	-1.030•	-0.748•	-2.04
52/53	1	-0.030	-0.169	1.799	-2.834	-4.130	-3.783•	-10.24
53/54	1	0.083	0.425	0.997	-2.575	-0.573	-0.705	-3.49
54/55	1	0.096	1.158	-0.040	-2.531	-1.462•	-1.562•	-3.77
55/56	1	-0.023	-0.398	0.628	0.690	-1.408	-1.039	-1.68
56/57	1	0.059	0.541	2.199	-15.317•	-6.489•	0.000	-23.72
57/58	1	0.036	0.109	1.523	-2.154	-5.905•	0.000	-8.10
58/59	1	0.095	0.618	0.562	-1.090	-3.124	-0.146	-3.85
59/60	1	0.009	0.115	0.674	-1.193	-1.497•	0.163•	-1.33
60/61	1	0.429	-0.051	-0.075	-0.427•	-1.481•	0.000	-0.65
61/62	1	-0.052	-0.595	0.588	0.876	-0.275•	0.000	-2.30
62/63	1	0.072	0.392	0.008	-0.091	-1.199•	-1.849•	-1.26
63/64	1	-0.053	-0.347	0.318	0.664	-1.279	-0.961•	-1.23
64/65	1	-0.021	-0.045	0.291	-0.240	-0.068	-0.617•	-0.19
65/66	1	0.022•	0.266	0.446	0.176	-1.779	-1.336•	-1.85
66/67	1	-0.879	1.109	0.115•	-0.798•	-1.707•	-0.406•	-1.32
71/72	2	0.067	0.240	-1.873	2.069	1.098	-1.794	-4.67
72/73	2	0.046	-0.529	-5.372	4.072	2.550	-2.233	-21.10
72/73	3	0.000	2.953	-2.875	2.824	-2.378	-1.799	-14.31
73/74	2	0.214	2.958	0.967	0.597	-6.290	-8.324	-30.67
73/74	3	0.000	2.655	0.579	0.001	-3.399•	-3.453•	-19.02
74/75	2	0.014	0.396	-4.643	-1.733	6.294	1.553	-34.56
74/75	3	0.000	-0.469•	1.450	0.295	1.341	-5.375	-8.07
75/76	2	-0.016•	-0.167	-6.373	0.974	3.933	3.541	-24.51
75/76	3	0.000	0.569•	2.474	0.568	-1.884	-3.787	-7.75
76/77	2	-0.143	-0.332	0.138	-0.320	2.797	-3.177	-7.99
76/77	3	0.510•	1.171•	0.336	-0.169	-0.092•	-1.436•	-5.00
77/78	1	1.167	2.805	3.253	-3.699	-3.366	-4.236	-22.17
77/78	2	-0.799	0.424	-0.227	-1.336	2.141	-1.731	-4.30
77/78	3	0.000	0.328•	-0.783•	-2.209	1.088	0.901	-2.38
78/79	2	-0.006	-0.250	-0.885	-2.361	1.331	2.465	-6.06
78/79	3	0.000	1.119•	2.837	-0.341	-0.749	-2.417	-7.98
79/80	2	0.010	0.445	-2.093	-3.157	0.849	4.036	-14.99
79/80	3	0.000	0.000	1.043	1.463	-0.046	-1.437	-9.66
80/81	2	0.003	0.205	-1.576	2.699	-1.045	0.256	-5.30
80/81	3	0.000	-0.666•	1.925	-0.173	0.094	-1.749	-3.37
81/82	2	0.018	0.187	-1.336	0.445	-0.385	1.191	-1.41
81/82	3	0.000	-3.831•	1.411	2.864	-1.011	-3.594	-9.96
82/83	2	0.034	0.031	-0.211	-0.240	0.439	0.014	-0.12
83/84	2	0.047	0.009	-0.385	0.468	2.322	-2.717	-5.84
84/85	2	0.141	0.741	-0.311	-0.940	-0.142	-0.484	-0.68
85/86	2	0.041	0.293	-1.231	0.051	1.613	0.250	-2.09
86/87	2	-0.004	-0.066	-0.969	-0.826	2.135	0.923	-3.36
87/88	2	-0.006	1.130	-5.529	0.476	2.966	-0.801	-16.72
87/88	3	0.000	-6.537	-3.010	0.899	3.065	0.752	-19.21
88/89	2	-0.013	0.055	-0.298	3.032	1.716	-5.460	-17.46
88/89	3	0.000	-3.256•	0.128	0.710	1.008	-1.740	-3.04
89/90	2	-0.003	0.296	-0.381	-0.919	3.895	-1.361	-9.89
89/90	3	0.000	-2.267	-0.365	0.475	1.781	-1.076	-3.99
90/91	2	-0.020	0.012	0.002	0.411	0.953	-2.293	-2.57
90/91	3	0.000	-1.585•	-3.054	-0.125	1.328	0.568	-3.92

Total for age composition	-421.53
Total for observed catch-predicted catch	-8.93
Total for observed spawn-predicted spawn	-165.99
Total for stock-recruitment relationship	-56.76

Appendix Table 4.7. Standard deviates for the observed versus predicted proportions-at-age (Z_{ijr}) and contributions to the objective function from age composition data (V_{ir}) and other components for the northern west coast of Vancouver Island stock assessment region.

season	fishing period	standard deviate (Z_{ijr}) 1+	2+	3+	4+	5+	6+	V_{ir}
50/51	1	-0.011*	-0.092	-0.797	1.002	0.371	0.192*	-0.75
51/52	1	0.001	0.008	0.022	0.189	-0.328	-0.138	-0.07
53/54	1	0.000	0.164	0.282	0.102*	-0.181*	-4.292*	-0.90
57/58	1	0.008	0.028	0.408	-0.196	-0.187	-0.450*	-0.18
58/59	1	-0.035	-0.279	-1.027	0.206	0.214	1.406	-1.39
59/60	1	0.054	0.356	0.565	0.851	-1.646	-3.027	-5.09
60/61	1	-0.185	-1.603	2.658	-1.709*	0.000	0.000	-8.33
61/62	1	-0.008	0.003	1.371	-3.177*	-1.122*	0.000	-3.93
62/63	1	0.037*	0.553	0.997	-1.186	-4.407*	-6.370*	-8.91
63/64	1	0.000	-1.119	1.005	0.038	0.410*	0.000	-1.14
64/65	1	0.000	-0.594	2.149	-0.925	0.000	0.000	-7.11
65/66	1	0.356*	0.629	0.503	-0.949	-0.106*	-2.135*	-1.29
66/67	1	0.088*	1.009	0.707	-0.742*	-4.004*	-5.279*	-3.35
71/72	2	-0.009*	-0.086	-4.282	3.073	0.673*	-0.421*	-8.57
72/73	2	0.001*	0.072	-2.980	1.363	1.490	0.147	-4.46
73/74	2	0.002	0.095	0.318	-0.095	0.870	-2.221	-2.42
74/75	2	-0.001	0.901	0.927	-3.412	0.799	-0.483	-5.47
75/76	2	-0.025*	-0.126	1.845	-2.220	-0.369	-0.027	-2.74
75/76	3	0.000	0.000	-0.896	0.318	0.275	0.152	-0.50
76/77	2	-0.015	-0.094	-1.221	-2.521	0.046	4.712	-15.03
76/77	3	0.000	0.000	0.442	-1.111	-1.548	1.951	-3.18
77/78	1	-0.434*	-5.591	0.881	2.939	3.097	-0.819	-17.74
77/78	2	0.223	2.768	-0.583	-1.148	-3.549	-0.650	-6.61
77/78	3	0.000	0.221*	-0.820*	-0.851	-0.185	1.091	-1.01
78/79	2	-0.047	-0.874	0.007	0.868	1.208	-0.741	-1.76
78/79	3	0.000	2.101	-1.043	-1.727	-0.219	1.763	-7.98
79/80	2	-0.039*	-0.227	1.540	-1.487	0.435*	0.123*	-2.04
79/80	3	0.000	0.000	0.052	2.220	-2.524*	0.000	-7.21
80/81	2	0.000	-0.071	-0.940	1.022	-0.114	1.122	-1.58
81/82	2	-0.015*	-0.099	-0.046	0.062	-0.718	0.587	-0.39
81/82	3	0.000	-0.680*	1.292	0.848	-1.240	-0.713	-2.07
82/83	2	-0.082*	-0.305	-2.119	0.044	1.019	1.164	-2.63
82/83	3	0.000	-0.474*	1.829	-1.071	0.734	-1.534	-3.46
83/84	2	0.223	3.791	-0.844	-10.975*	-3.852	-1.388	-24.65
83/84	3	0.000	-5.280	-0.054	2.566	0.638	-1.252	-10.98
84/85	2	0.360	1.360	-2.158	-0.513	-0.682*	-0.475	-2.39
85/86	2	0.054*	1.469	-0.810	-2.154*	-0.295*	-0.925*	-2.18
86/87	2	-0.011	0.070	0.996	0.058	-1.477	-2.440*	-2.77
86/87	3	0.000	-0.262	-1.196	1.029	-1.204	1.213	-2.20
87/88	2	0.008	0.083	0.912	-0.383	0.160	-2.079	-1.96
88/89	2	0.046*	0.273	-2.078	0.188	1.602	0.857	-2.77
89/90	2	0.000*	-0.010	-0.956	-0.940	0.277	1.993	-2.74
90/91	2	0.015	0.042	-0.142	0.275	1.810	-3.392	-5.82

Total for age composition	-197.73
Total for observed catch-predicted catch	-1.02
Total for observed spawn-predicted spawn	-95.12
Total for stock-recruitment relationship	-37.09