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Stock Assessments for British Columbia Herring in 1989 and Forecasts of the Potential Catch in 1990

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ABSTRACT

Haist, V. and J. F. Schweigert. 1990. Stock assessments for British Columbia herring in 1989 and forecasts of the potential catch in 1990. Can. MS Rep. Fish. Aquat. Sci. 2049: 62 p.

Herring stock abundance in British Columbia waters was assessed for 1989 and forecasts were made for 1990 using two analytical methods: (1) escapement model; and (2) age-structured model. Diving spawn survey data was utilized in the escapement model wherever available.

Forecasts of pre-fishery biomass are obtained by weighting the estimates from the two models. The forecasts are for 104,900 tonnes to the northern and 100,700 tonnes to the southern stock assessment regions. These estimates represented a slight increase (3.3%) in the northern areas and a slight decrease (3.6%) in the southern areas.

The recommended 1990 catch (20% of the 1990 forecast herring run) for the entire B.C. coast is 41,120 tonnes. All areas should be available to the fishery in 1990.

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

RÉSUMÉ

Haist, V. and J. F. Schweigert. 1990. Stock assessments for British Columbia herring in 1989 and forecasts of the potential catch in 1990. Can. MS Rep. Fish. Aquat. Sci. 2049: 62 p.

L'abondance des stocks de hareng dans les eaux de la Colombie-Britannique a été évaluée pour l'année 1989, et des prévisions ont été établies pour 1990 à l'aide de deux méthodes d'analyse, soit un modèle d'échappée et un modèle fondé sur la structure par âge. Les données de relevés faits par des plongeurs dans les frayères ont été utilisées dans le modèle d'échappée lorsqu'elles étaient disponibles.

Des prévisions concernant la biomasse antérieure à la pêche ont été obtenues en pondérant les estimations découlant des deux modèles. Ces prévisions sont de 104 900 tonnes pour les régions du nord et de 100 700 tonnes pour les régions du sud. Ces estimations indiquent une augmentation modeste (3,3 %) dans les régions du nord et une légère diminution dans celles du sud.

La prise recommandée pour toute la côte de la Colombie-Britannique en 1990 (20 % des prévisions de 1990 pour la remontée de harengs) est 41 120 tonnes. Toutes les régions devraient être ouvertes à la pêche en 1990.

Mots-clés: *Clupea harengus pallasi*, hareng du Pacifique, évaluation des stocks, prévisions, analyse en fonction de la structure par âge

1. INTRODUCTION

1.1 GENERAL

Forecasting the potential catch that can be removed from herring stocks requires an assessment of the current stock status and the determination of factors which affect stock dynamics, in particular, recruitment. Traditionally, equilibrium based methods such as yield models have been favoured. They assume constancy in age structure, growth, and mortality. However, herring are strongly affected by changes in environmental conditions thus making equilibrium models unattractive. The methods we use estimate current stock conditions on the basis of which potential catches are recommended. Catch levels have been formulated to ensure conservation of the stocks.

In this report we present two methods to assess present herring stock status: (1) an escapement model (Schweigert and Stocker 1988); and (2) an age-structured model (Fournier and Archibald 1982). Both methods use a 39 year time series of catch and spawn deposition information and age structure and size-at-age data obtained from biological samples.

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 1989. 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 39 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 the 39 years of spawn 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. In recent years many spawning areas have been surveyed using SCUBA methods. We assume these surveys provide reasonably accurate estimates of spawn 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.

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 1988/89 catch figures are based on hailed estimates because sales slip data were not available for timely analysis. The sales slip data of catch in tons have been converted to tonnes. Numbers of fish in the catch were calculated using the average fish weight from catch samples for the season.

Age structure data are used in both models. The information from catch samples are used for years when there were commercial fisheries. For years with no fisheries, or when catch samples do not appear to be representative, pre-fishery and research samples are also used. Additional data used in the age-structured model are age specific fecundity and average weights at age.

1.3 STOCK CONSIDERATIONS

The stock concept introduced for the 1985 herring assessment (Figs 1.1 and 1.2) is again used for these assessments. In addition, assessments for revised stock assessment regions in the Queen Charlotte Islands and the northern west coast of Vancouver Island are presented. The revised areas for these two assessment regions were suggested during the 1988 PSARC herring subcommittee meeting.

Under the original stock concept herring spawning in the area from Skincuttle Inlet to Selwyn Inlet are treated as the major Queen Charlotte Islands stock. For the REVISED Queen Charlotte Islands Stock Assessment Region Cumshewa Inlet and Louscoone Inlet are added to this area. The stock concept for the Prince Rupert District remains unchanged encompassing Statistical Areas 3 to 5. The Central Coast stock concept separates the migratory stocks from the local stocks. The migratory component used in the current analysis includes all of 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, Area 17N and Deepwater Bay and Okisollo Channel in Area 13. The southern stock comprises Areas 17S, 18 and 19. The two original stock groupings used for the west coast of Vancouver Island are southern (Areas 23 and 24) and northern (Areas 25 to 27). In addition, analyses are presented for a REVISED Northern West Coast of Vancouver Island Region which includes data only for Statistical Area 25.

Biomass estimates from the escapement model are also presented for minor and resident stocks. The level of geographic aggregation used for these estimates is the section (Haist and Rosenfeld 1988).

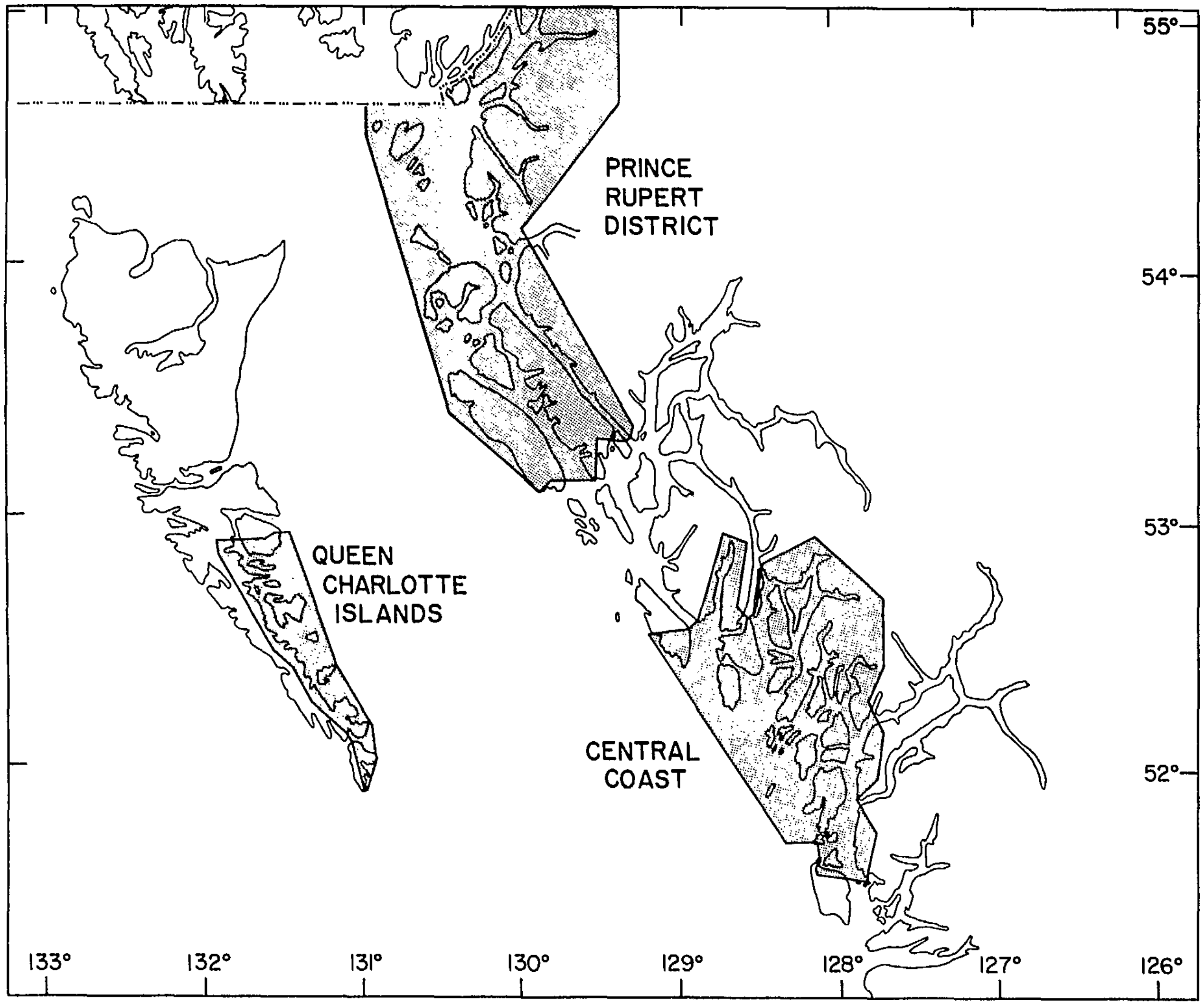

Figure 1.1. Herring Stock assessment regions in northern B.C.

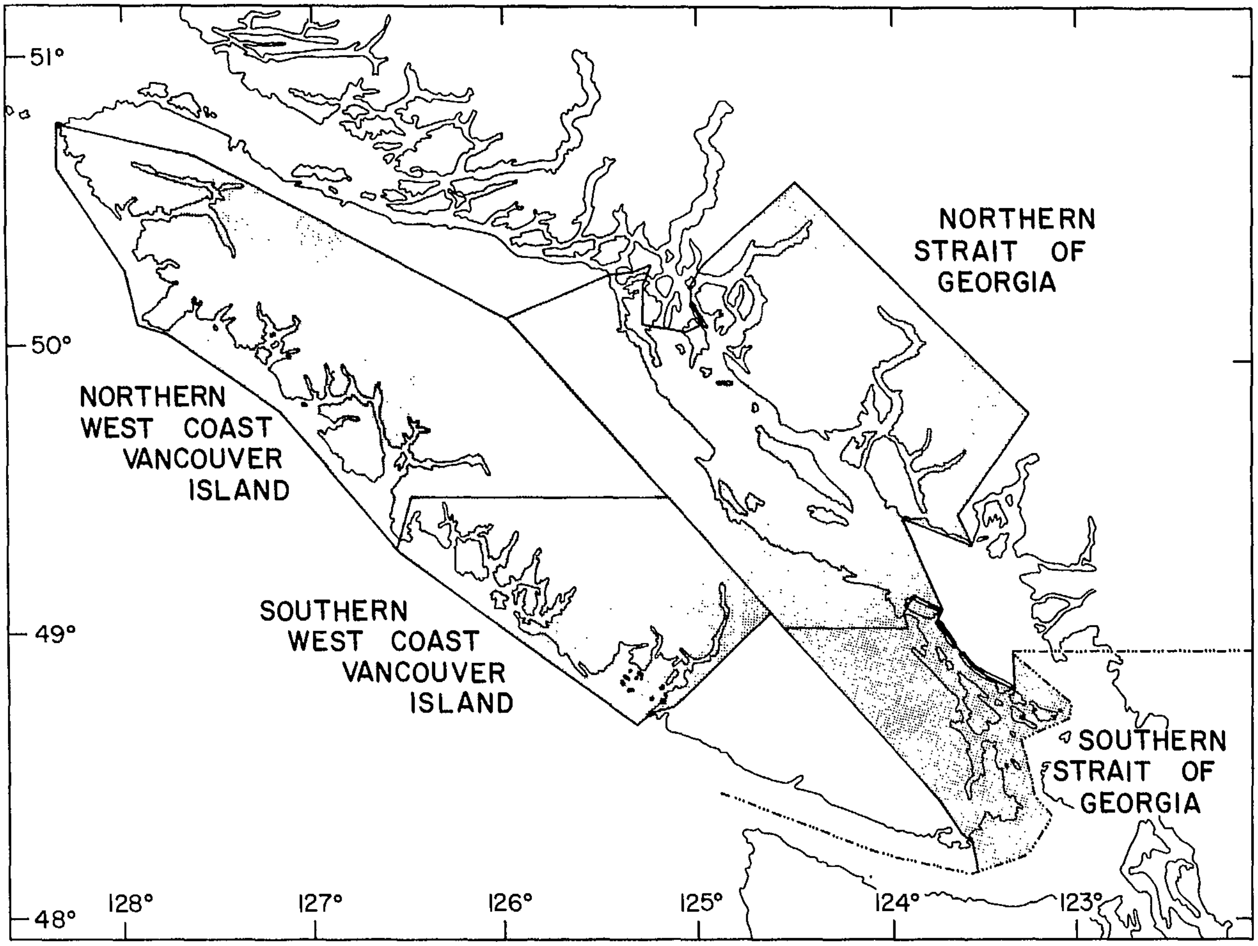

Figure 1.2. Herring stock assessment regions in southern B.C.

2. FORECASTING WEIGHT AT AGE

2.1 INTRODUCTION

For past herring stock assessments different methods were used by the escapement model and the age-structured model to estimate the average weights at age for the forecast year. The escapement model used the weight at age in the final year and the age-structured model used the average weights at age over the time series. For this assessment these two methods plus an additional one are evaluated to determine which provides the most accurate predictions of weight at age.

2.2 METHODS

The data used to evaluate the alternative models to predict weight at age are the time series (1951-1989) of annual weights at age used in the assessment models for each of the seven assessment regions. Where the average weight at age for a season was based on fewer than ten sampled fish the data were not included in this analysis. The three models evaluated for predicting weight at age are:

1) $W_{n+1,j} = W_{nj}$

2) $W_{n+1,j} = \sum_i W_{ij} / m$

3) $W_{n+1,j} = \alpha W_{n,j-1}^{\beta}$

where W_{ij} is the weight at age j in year i, n is the final year, $n+1$ is the forecast year, m is the number of years for which weight at age j data is available. The parameters, α and β in Model 3, are estimated by regression of the time series of $\ln(W_{i+1,j})$ on $\ln(W_{i,j-1})$. The regression parameters are estimated separately for predicting weight at age 3 (i.e., j=3) and for predicting weights at ages 4 through 10 (i.e., $j = 4$ to $j = 10$) for each of the 7 regions. Additionally, data for the seven regions are combined to estimate coastwide α and β growth parameters.

To evaluate the three models we calculate the average residual (in grams) between the forecast and actual weight at age over the 1951-1989 time series for each region as

1) $\sum_{ij}(W_{i+1,j} - W_{ij})/M$

2) $\sum_{ij}[W_{i+1,j} - \sum_i(W_{ij})/m)]/M$

3) $\sum_{ij}(W_{i+1,j} - \alpha W_{i,j-1}^{\beta})/M$

where M is the number of data series for which $W_{i+1,j}$, $W_{i,j-1}$ and W_{ij} are all available. Additionally, Model 3 is evaluated with the α and β parameters which are estimated for the coastwide weight at age data set.

2.3 RESULTS

Results of the regression analyses of $\ln(W_{i+1,j})$ on $\ln(W_{i,j-1})$ are shown in Table 2.1. Of the eight regressions for predicting weight at age 3 based on weight at age 2 in the previous year only four are significant at the 0.05 probability level. The proportion of the total variation in weight at age 3 explained by the regression model ranges from 0.019 for the Prince Rupert District to 0.627 for the Northern West Coast of Vancouver Island Stock Assesment Region. The regression fits are substantially better for predicting weight at age 4 through age 10, with all eight regressions significant at the 0.05 probability level. The proportion of the total variation explained ranges from 0.765 for the Southern Strait of Georgia to 0.901 for the Southern West Coast of Vancouver Island Stock Assessment Regions.

The average residuals from these models, plus a variation of Model 3 where coastwide α and β parameters are used, are shown in Table 2.2. For predicting weight at age 3 Model 1 (the weight at age 3 in the previous year) performed best for two stocks, Model 2 (the average weight at age 3 over all years) performed best for one stock, Model 3 using stock specific growth parameters performed best for three stocks, and Model 3 using coastwide growth parameters performed as well as Model 3 with stock specific parameters for one stock. Averaged over all stocks, Model 3 with stock specific parameters had the lowest average residuals. This model was also the best for predicting weight at ages 4 through 10 for five of the seven stock assessment regions. Model 3 with coastwide growth parameters performed as well as or better than this model for the other two stock assessment regions.

Although Model 3 with stock specific α and β parameters was somewhat better than the same model with coastwide parameters for predicting weight at age, we have opted to use the coastwide parameters for forecasting stock biomass. The main reason for this is that it facilitates the assessments for stock groupings for which the growth parameters have not been estimated.

Table 2.1. Regression parameters for the weight at age prediction model (Model 3) for the seven stock assessment regions and the combined coast.

	Predicting weight at age 3				
	α	β	R^2	P	M
Queen Charlotte Islands	15.8537	0.4363	0.328	0.065	11
Prince Rupert District	106.7084	-0.0816	0.019	0.516	24
Central Coast	22.3695	0.3426	0.371	0.000	29
Northern Strait of Georgia	40.8579	0.1830	0.084	0.120	30
Southern Strait of Gerogia	45.5814	0.1643	0.077	0.154	28
S. West Coast Vancouver Is.	13.2553	0.4706	0.351	0.001	29
N. West Coast Vancouver Is.	9.0530	0.5670	0.627	0.001	20
Combined Coast	23.6651	0.3268	0.313	0.000	171

	Predicting weight at ages 4 to 10				
	α	β	R^2	P	M
Queen Charlotte Islands	4.6693	0.7155	0.880	0.000	108
Prince Rupert District	7.1221	0.6258	0.750	0.000	141
Central Coast	4.3859	0.7237	0.867	0.000	135
Northern Strait of Georgia	6.8332	0.6302	0.771	0.000	114
Southern Strait of Georgia	5.4325	0.6808	0.765	0.000	92
S. West Coast Vancouver Is.	5.5030	0.6823	0.901	0.000	123
N. West Coast Vancouver Is.	4.3579	0.7276	0.840	0.000	90
Combined Coast	5.2598	0.6884	0.833	0.000	803

Table 2.2. Average residuals (in grams) from 3 models for predicting average weight at age for the seven stock assessment regions. The lowest value in each series is underlined.

	Model 1	Model 2	Model 3	
			stock α,β	coastwide α,β
Queen Charlotte Islands	8.8	9.3	6.5	7.1
Prince Rupert District	5.7	8.9	5.8	7.8
Central Coast	7.2	6.8	5.4	5.4
Northern Strait of Georgia	5.8	7.2	5.6	6.8
Southern Strait of Georgia	5.9	7.0	6.0	6.4
S. West Coast Vancouver Is.	7.4	6.3	5.5	6.0
N. West Coast Vancouver Is.	6.7	4.4	4.9	5.3
Average - 7 regions	6.8	7.1	5.7	6.4
Queen Charlotte Islands	10.8	10.2	7.8	8.0
Prince Rupert District	14.4	11.9	10.5	10.2
Central Coast	11.3	8.6	8.0	8.4
Northern Strait of Georgia	9.1	10.1	8.1	8.1
Southern Strait of Georgia	8.6	10.0	8.4	8.5
S. West Coast Vancouver Is.	10.8	9.2	7.1	7.4
N. West Coast Vancouver Is.	16.3	10.0	8.1	8.2
Average - 7 regions	11.6	10.0	8.3	8.4

3. ESCAPEMENT MODEL

3.1 INTRODUCTION

The escapement model was developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988). Subsequently, it has been modified to incorporate age-structure information which allows separation of the growth and recruitment components of stock productivity. This also facilitates comparison of estimates with those from the age-structured model. As in past years, when diver spawn survey information is available it is used in preference to surface survey data. Beginning in 1987, fishery officers have conducted diving surveys of many of the major herring spawns on the British Columbia coast (Table 3.0). Where dive survey data are not available surface survey data are adjusted as described below. Over the past three spawning seasons increasingly greater portions of the coast have been covered by SCUBA surveys. Virtually all of the major spawns on the south coast are now diver surveyed and large portions of the north coast spawns are diver surveyed. Most of the 'other' smaller spawning areas are still covered by surface survey. In this year's assessment, estimates are again presented for the 7 major stock assessment regions which contain distinct migratory stocks. Additionally, estimates for REVISED stock groupings are given in two regions. Stock estimates are also presented for all sections which are not included in the major stock assessment regions. These minor or resident stocks may be capable of supporting very small fisheries, impoundments, or spawn-on-kelp operations.

3.2 METHODS

In the escapement model, estimates of the potential catch in each stock assessment region are calculated as 20% of the forecast run size. The forecast run size is the product of the estimated escapement in the previous year and an average annual survival rate (0.64) plus an estimate of anticipated 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 1951-1989. The estimates of total catch (tonnes) and spawning escapement (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 each age are calculated for all samples available for that region. In some years, no data is available from a region and information from an adjacent area is utilized in the analysis. Estimates of repeat spawners and recruiting fish are converted back to tonnages using average weights as described in Section 2. Estimates of spawning biomass in 1989 and forecasts for 1990 are presented for the seven stock assessment regions plus the two REVISED regions.

Surface Surveys

The estimated escapements for each region are derived from information on spawn deposition. Dive survey observations are used directly while surface survey observations are adjusted to render them comparable to dive estimates based on calibration equations derived from duplicate surveys (Schweigert and Stocker 1988). The calibration equations utilized for the 1989 assessments and 1990 forecasts are slightly different from those used in last year's assessment due to the inclusion of dual survey information obtained for two spawns during the 1989 surveys.

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

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

The regression equation, with new parameter estimates used to estimate the average density of eggs in 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 the foregoing equations in all areas except for Johnstone Strait (Statistical Areas 9-13). In this area no adjustment is applied to the spawn widths as previous dive surveys in the area (Schweigert and Haegele 1988a, b) indicated that widths were accurately assessed from the surface. Egg deposition is estimated from the product of total spawn length, adjusted width, and egg density as estimated from the average surface layer estimate. The total egg deposition is converted to tonnes of spawners based on the average estimate of 100 eggs per gram of spawning fish. Escapement plus catch provides an estimate of the total pre-fishery spawning stock biomass.

SCUBA Surveys

For SCUBA surveys spawn lengths are determined by exploratory raking or snorkelling and spawn widths estimated as the mean of all transect lengths within the spawning bed. Estimates of mean egg density are based on a two-stage sampling design (Schweigert et al. 1985). 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: predominant vegetation type, proportion of the quadrat covered by vegetation, number of layers of eggs on vegetation, proportion of the bottom substrate covered by eggs, and an estimate of the number of egg layers on bottom substrate. Egg density for each quadrat is estimated from the following equation:

$$\text{EGGS} = 1025.0062 \ L^{0.7003} \ P^{1.5374} \ V_i \ Q_j.$$

where EGGS = estimated number of egg in thousands per m^2 on all vegetation types,
L = number of layers of eggs on the predominant vegetation type,
P = proportion of the quadrat covered by vegetation,

V_1 = 1.0419 parameter for sea grasses,
V_2 = 1.2273 parameter for rockweed,
V_3 = 0.8910 parameter for flat kelp,
V_4 = 1.1770 parameter for other brown algae,
V_5 = 0.9013 parameter for leafy red and green algae,
V_6 = 1.0000 parameter for stringy red algae,
Q_1 = 0.4853 parameter for 1.00 m^2 quadrats,
Q_2 = 0.5515 parameter for 0.50 m^2 quadrats,
Q_3 = 1.0000 parameter for 0.25 m^2 quadrats.

This model was estimated from 5111 data points collected from 1976 through 1987 from all areas of the B.C. coast. This model accounts for about 53% of variation in counted egg samples. The model is statistically significant at less than the 0.01 level.

The foregoing equation has been used to estimate density prior to this year's assessment. Beginning with the 1989 assessment we are utilizing the following model which is more consistent with the stratified estimation procedure used in the field.

<u>Stratified Egg Prediction Model</u>

Beginning in 1986, we initiated the collection of information on the number of egg layers and the percentage cover for each of the vegetation substrates in the quadrat. Prior to this time only the predominant vegetation type was reported. The number of egg layers reported represented the average over all vegetation types and the percent cover was the sum over all vegetation types. A number of divers felt that they could more accurately assess the spawn coverage by breaking the observations down into individual vegetation fractions. For data collected prior to 1986, divers' observations of percent cover and average layers of eggs for each vegetation type were not available. However, the total wet weight of each vegetation sample and the laboratory estimate of average egg layers for each vegetation type had been collected. For samples where both diver and laboratory estimates of egg layers are available these are quite similar. In some instances, when the egg samples are near hatching, or on some algal species, the eggs are prone to sloughing off the vegetation during sample collection which would lead to a downward bias in egg layers estimated in the laboratory relative to the *in situ* estimate. For the historical data set any samples which contained more than a single significant vegetation fraction and for which there was detailed information on the subfraction weights and egg layers we derived a new set of estimates of egg layers, percentage cover, vegetation type, and associated egg numbers. A multiplicative model similar to that used in previous assessments (Schweigert et al 1989, previous section) was fit to this new data set to derive the following parameters:

$$EGGS_i = 1038.5617\ L^{0.6856}\ P^{1.4189}\ V_i\ Q_j.$$

where $EGGS_i$ = estimated number of eggs in thousands per m^2 on vegetation type i,
L = number of layers of eggs on the dominant vegetation type i,
P = proportion of quadrat covered by vegetation type i,

V_1 = 1.0224 parameter for sea grasses,
V_2 = 1.2247 parameter for rockweed,
V_3 = 0.8730 parameter for flat kelp,
V_4 = 1.2254 parameter for other brown algae,
V_5 = 0.9482 parameter for leafy red and green algae,
V_6 = 1.0000 parameter for stringy red algae,
Q_1 = 0.5387 parameter for 1.00 m^2 quadrats,
Q_2 = 0.5664 parameter for 0.50 m^2 quadrats,
Q_3 = 1.0000 parameter for 0.25 m^2 quadrats.

This model was estimated from 6589 samples and explained about 55% of the total variation in egg counts. The model is statistically significant at less than the 0.01 level.

Total egg density in thousands of eggs per m^2 on all vegetation for each quadrat is then estimated by summing the egg density estimates over the vegetation types, i.e.

$$\text{EGGS} = \sum_i \text{Eggs}_i$$

The resulting change in tonnage estimates for the spawns surveyed during the 1989 spawning run relative to the unstratified model are presented in Table 3.8. The results indicate that the new model provides estimates which are slightly lower than previous estimates (about 10%). The reason for this difference is not clear and will be further investigated prior to the next diving survey.

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, times 340,000 egg/m^2 (Haegele *et al.* 1979). Eggs on rock also includes eggs on other inorganic substrate 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.

The estimation of egg numbers on the giant kelp, *Macrocystis* sp., continues to present difficulties. Significant quanities of eggs on the giant kelp appear to occur primarily in the northern areas with smaller amounts in some localities on the Central Coast and West Coast of Vancouver Island. The approach we have adopted follows that outlined by Haegele and Schweigert (1985). The transects used to assess egg density on understory vegetation are enumerated for *Macrocystis* plants and fronds within 1 m on either side of the transect line. From data collected during research surveys of the Queen Charlotte Islands during 1981 and 1987 and smaller quantities of plants collected in the Prince Rupert District, Central Coast and West Coast of Vancouver Island during 1985 and 1986, egg prediction equations were developed from some readily estimated variables, i.e., average plant height, average egg layers, and average frond numbers (Haegele and Schweigert 1989). The prediction equation estimates the number of eggs occuring on a plant of a specific height with a certain number of fronds and egg layers. This information may then be combined with the estimate of the density of plants in the area to estimate the average number of eggs deposited per unit area in the kelp beds. Combining this with the estimated area of the *Macrocystis* bed provides an estimate of the total number of eggs deposited on the kelp. This egg deposition is then added to the deposition on the understory vegetation for the area.

The egg prediction equation we developed for *Macrocystis* is as follows:

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

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.

In practice, the synoptic fishery officer 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 equation differs slightly from that used to calculate the egg deposition for the 1988 assessment (see Haegele and Schweigert 1989 for details). Prior to the 1988 assessment all *Macrocystis* was dealt with as another category of algae within the surface survey or for a few areas in which research surveys were being conducted egg counts were completed on samples of *Macrocystis* plants. The current formulation appears to provide a fairly precise estimator of the egg deposition on this vegetation substrate. However, it is not clear how one could actually determine the accuracy of the model short of harvesting all the plants in a test area and counting samples of eggs from them. Unfortunately, there is still no method available to adequately deal with the surface survey estimate for this vegetation type.

Enumerated Egg Samples

Samples of the algae and attached eggs from entire quadrats were again collected in 1989 as a check on the accuracy of the egg prediction model (Table 3.9). Only a limited number of samples were obtained from most areas and in the Central Coast no sample weights were collected making it impossible to determine egg numbers from the samples. It appears that from the limited data available predictions are higher than egg counts for all areas. In last years data predictions were uniformly lower than egg counts for all statistical areas. Whether these results are due simply to the differences in prediction models or are the result of natural variation in the data will need to be investigated by applying both models to the two years of data prior to the next diving survey.

3.3 RESULTS

The 1990 forecast spawning run to the lower east coast of the Queen Charlotte Islands is 16,600 tonnes assuming average recruitment (Table 3.1, 3.7). The decline in this stock following the demise of the very strong 1977 year-class has been buffered by good recruitment in 1987 and average recruitments in 1988 and 1989. A poor recruitment in 1990 would see a spawning run of 14,900 tonnes while a good recruitment would yield 22,400 tonnes. This stock is now well above the CUTOFF level (as defined in Section 5). The forecast run sizes for the REVISED Queen Charlottes Islands including Louscoone and Cumshewa inlets are for 19,800 tonnes with poor, 22,100 tonnes with average, and 27,700 tonnes with good recruitment.

The forecast runs for the Prince Rupert District with average and good recruitments are for 14,800 and 23,800 tonnes, respectively (Table 3.1, 3.7). This stock has declined dramatically from 1989. A poor recruitment could see the stock drop to as low as 11,600 tonnes, slightly below the CUTOFF level for this area. There are no indications from age structure or recent recruitments of an imminent decline in this area making one suspect that some of this stock may have spawned in other areas, possibly southeast Alaska.

Forecast run sizes for the Central Coast are for 38,800 and 49,900 tonnes with average and good recruitment, respectively. This stock has remained at healthy levels throughout the period of the roe fishery (Table 3.1, 3.7). The 1989 spawning biomass of 39,100 tonnes is down from the historical high in 1988. A poor recruitment in 1990 should result in a spawning biomass of 34,800 tonnes in this area (Table 3.7).

The spawning biomass levels for the south coast stocks continue to surpass the levels of the early 1980s. The Northern Strait of Georgia forecast run in 1990 is for 54,500 and 64,900 tonnes with average and good recruitment, respectively (Table 3.2, 3.7). The 1989 spawning biomass of 39,100 tonnes is up substantially from 1988 and similar to 1986 when the strong 1983 year-class recruited to this stock (Table 3.2). The forecast with poor recruitment is for 48,600 tonnes, almost double the size of the 1988 spawning run.

The Southern Strait of Georgia stock forecast with average recruitment is 7,700 tonnes and 8,500 tonnes with good recruitment. A poor recruitment would yield 5,400 tonnes of spawners in this area (Table 3.2, 3.7). Recent stock levels are continuing to decline and are now down to less than one-third of those in the early years of the roe fishery.

The stocks on the Southern West Coast of Vancouver Island are forecast at 32,000 and 39,400 tonnes with average and good recruitment, respectively (Table 3.2, 3.7). Stock levels have been increasing steadily since the low in 1982. Recent good recruitments in 1985, 1986, and 1988 have significantly increased the size of this stock. Even a poor recruitment in 1990 should see a spawning biomass of 28,400 tonnes, well above the CUTOFF level.

The stocks on the Northern West Coast of Vancouver Island have been stable at about 10,000 tonnes the past four years due to good recruitments in 1986 and 1988 (Table 3.2, 3.7). The forecast run sizes with average and good recruitment in 1990 are 11,600 and 19,100 tonnes, respectively. A poor recruitment would maintain the stock at 8,800 tonnes, similar to present levels of abundance. The REVISED stock grouping for this area results in stock forecasts of 6,000 tonnes with average and 11,300 tonnes with a good recruitment in 1990. A poor recruitment would see this stock drop to 4,000 tonnes.

The minor and resident stock abundance estimates are presented in Tables 3.3 to 3.6. There are problems in assessing the stocks in many of the more remote locations due to inadequate spawn survey coverage and a general absence of age-structure data, so absolute estimates of abundance are probably not very accurate. However, the abundance trends generally follow those of the nearby migratory stocks. Only the stocks in Area 2W appear healthy in relation to historical levels and could perhaps be considered as alternative sites for roe fisheries in the Queen Charlotte Islands Stock Assessment Region. The minor stocks in the Central Coast Stock Assessment Region are also not surveyed with sufficient regularity to discern possible trends, but no major fishable biomasses are apparent. The Johnstone Strait stocks are in many instances below the long term average, reflecting perhaps irregular and incomplete spawn survey coverage of some of the areas in this region. The stocks on the Northern West Coast of Vancouver Island receive intermittent survey coverage and generally follow the trends of the major migratory stocks to the south.

A comparison of observed and predicted mean egg densities are presented by statistical area in Table 3.9. Although there are marked discrepancies for a few areas it is not readily apparent how this information may be best applied to the stock assessments. There are insufficient numbers of samples to attempt any sort of major adjustment to the estimates for any particular spawning area. The best approach appears to be merely to use the comparative results as a frame of reference, i.e., the apparent large upturn in the Queen Charlotte islands may not be as large as it appears because the model is estimating almost twice as many eggs per quadrat as the counted samples indicate. Only in area 14 and 27 do the counts and predictions agree very closely. The main point is that some caution is warranted in attempting to interpret the estimates from the diving surveys too rigidly.

Table 3.0. Kilometers of spawn surveyed by dive and surface survey methods for eight regions of the B.C. coast, 1987-1989.

	1987			1988			1989		
Stock Assessment Region	Surface	Dive	Total	Surface	Dive	Total	Surface	Dive	Total
Queen Charlotte Islands	35.7	0.0	35.7	7.9	28.2	36.1	18.4	48.8	67.2
Prince Rupert District	83.6	0.0	83.6	5.7	55.0	60.8	0.9	40.1	41.0
Central Coast	86.5	0.0	86.5	112.7	32.6	145.3	105.1	25.1	130.1
N. Strait of Georgia	13.9	49.4	63.3	8.6	39.7	48.3	16.6	66.1	82.6
S. Strait of Georgia	2.2	25.2	27.4	5.6	12.6	18.3	2.3	24.8	27.1
S. W. Coast Vancouver Is.	10.4	31.1	41.5	23.9	35.1	59.1	6.6	47.3	53.9
N. W. Coast Vancouver Is.	19.0	10.7	29.8	22.6	0.0	22.6	11.0	11.6	22.6
Other areas	173.6	0.0	173.6	228.5	0.0	228.5	153.4	16.1	169.6
Coastwide total	424.8	116.5	541.3	415.6	203.4	618.9	314.4	279.9	594.3

Table 3.1. Estimates of spawner biomass, catch, and total stock abundance (tonnes) for the northern stock assessment regions for 1951-1989.[a]

Season	Queen Charlotte Is			REVISED Q. Charlottes			Prince Rupert District			Central Coast		
	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1950/51	4194	2847	7041	4194	2847	7041	27976	45865	73841	20912	42458	63370
1951/52	3054	10147	13201	3054	10147	13201	9966	52379	62344	10364	33195	43558
1952/53	5707	0	5707	5707	0	5707	14028	1865	15893	20212	768	20980
1953/54	11527	1786	13313	11527	1786	13313	9961	27277	37238	16329	24616	40945
1954/55	5847	498	6345	5847	498	6345	12752	17806	30558	16081	11594	27675
1955/56	5599	77369	82968	5599	77461	83060	12517	10182	22698	11572	43627	55199
1956/57	1497	21338	22835	1497	21803	23300	19321	28035	47356	5968	23261	29228
1957/58	784	11147	11931	784	11147	11931	8522	4523	13045	8285	9849	18135
1958/59	7033	6828	13861	8094	6828	14923	16209	10224	26433	7418	27870	35289
1959/60	3463	0	3463	7024	0	7024	13157	18476	31633	20355	4037	24392
1960/61	6535	576	7112	8622	576	9199	14491	42746	57237	8403	31704	40107
1961/62	4388	7632	12020	5343	7632	12975	20112	27660	47772	22526	15709	38235
1962/63	4469	14705	19174	4469	14705	19174	15154	40228	55382	10932	44054	54986
1963/64	3187	26958	30145	4835	28882	33717	16327	30340	46667	11704	32064	43768
1964/65	1450	32423	33873	1891	35448	37339	6281	44211	50492	4490	15670	20160
1965/66	3528	2746	6274	3528	2746	6274	5771	17295	23066	4993	37482	42475
1966/67	751	161	912	943	213	1156	3059	7998	11057	8229	21890	30119
1967/68	728	80	808	818	80	898	6512	2144	8655	8984	1529	10513
1968/69	1800	0	1800	1800	0	1800	901	547	1448	3963	100	4063
1969/70	2826	0	2826	8214	0	8214	11915	1498	13413	19368	209	19577
1970/71	4376	0	4376	12610	102	12712	9694	3500	13194	8039	3614	11652
1971/72	2826	1260	4086	10855	3972	14827	10905	4494	15399	8594	9279	17873
1972/73	2414	2231	4645	11785	7520	19305	11119	1607	12726	23773	7799	31572
1973/74	6961	2277	9238	13154	6318	19473	8850	3819	12669	19685	8887	28573
1974/75	3931	4408	8339	11538	7724	19262	10578	1702	12280	18972	8739	27711
1975/76	9137	9425	18561	18637	14116	32752	15845	4307	20152	30039	12199	42239
1976/77	11217	10024	21241	18228	12635	30863	15628	8142	23770	27993	11106	39099
1976/78	10002	9489	19491	15011	11726	26736	7584	8588	16171	16731	14046	30777
1978/79	7633	7953	15586	12164	7953	20117	13739	4317	18055	14424	5	14429
1979/80	24011	2274	26286	25880	3316	29196	17170	3425	20595	30417	538	30955
1980/81	23698	5631	29329	27007	5631	32638	17144	3090	20233	32805	2573	35377
1981/82	19168	3778	22946	22034	3778	25813	14928	1984	16913	33694	6370	40064
1982/83	16747	5597	22344	19963	5597	25560	26323	0	26323	41230	5640	46869
1983/84	19666	4719	24384	22170	4719	26889	28030	3761	31791	27906	7193	35099
1984/85	15352	6109	21461	17738	6109	23847	32011	6747	38758	24703	5209	29912
1985/86	5750	3503	9253	6725	3503	10228	30195	8679	38875	21644	3386	25030
1986/87	13720	2061	15781	15281	2061	17342	38166	6271	44437	28745	3615	32360
1987/88	13919	32	13951	16776	32	16808	32094	7968	40062	48424	4527	52951
1988/89	19651	0	19651	25828	1450	27279	12931	7972	20903	42172	10927	53100

[a]Catch estimates in the current year are hailed values.

Table 3.2. Estimates of spawner biomass, catch, and total stock abundance (tonnes) for the southern stock assessment regions for 1951-1989.[a]

	Georgia Strait - N			Georgia Strait - S			WCVI - South			WCVI - North			REVISED WCVI - North		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1950/51	30815	17787	48602	3628	25824	29451	6517	15914	22431	12685	6117	18801	9349	5908	15257
1951/52	27949	17635	45584	12454	28084	40538	6407	10630	17036	3263	16415	19679	1853	16378	18231
1952/53	33468	4376	37843	33131	3966	37098	8928	20	8948	24675	0	24675	13202	0	13202
1953/54	23303	20560	43863	35394	44284	79678	5298	28699	33997	10864	8875	19738	4527	4510	9037
1954/55	30983	26818	57801	30921	41619	72540	6446	6041	12486	10110	6524	16634	3836	83	3918
1955/56	13915	27273	41188	14759	44572	59331	8779	17098	25877	12826	508	13334	12310	0	12310
1956/57	12663	21374	34037	6824	38202	45025	6253	2600	8853	18304	491	18795	16432	13	16444
1957/58	8295	9012	17306	17189	11616	28805	11660	513	12173	7159	43	7202	5721	43	5764
1958/59	16108	34189	50297	16138	15765	31904	6043	37385	43428	5460	32370	37831	4798	31838	36635
1059/60	20918	22540	43458	9277	43107	52384	5618	17652	23271	3666	38145	41811	949	36259	37208
1960/61	17107	15784	32892	9196	30410	39606	7813	13489	21301	5382	17356	22738	3434	12946	16380
1961/62	16189	30358	46546	5454	34945	40399	9035	15597	24632	13981	12777	26758	12817	8087	20904
1962/63	16121	33746	49867	8581	35101	43682	8552	4019	12571	4394	17230	21624	1539	14187	15726
1963/64	15326	36808	52134	6768	40179	46947	17258	20230	37488	8407	1914	10321	7311	1036	8346
1964/65	13523	27931	41454	2569	19888	22458	7077	14063	21140	8879	4741	13620	5842	1983	7825
1965/66	4829	20996	25825	2808	12337	15145	3381	8169	11550	2870	4207	7077	1937	2673	4610
1966/67	6787	11157	17944	2561	19885	22447	2165	9171	11335	4617	6260	10878	3571	5974	9545
1967/68	6974	966	7940	5253	981	6233	4110	0	4110	3540	0	3540	3031	0	3031
1968/69	9072	325	9397	7502	420	7922	5544	0	5544	9075	0	9075	5556	0	5556
1969/70	22297	519	22817	12885	365	13249	16915	0	16915	8198	0	8198	4818	0	4818
1970/71	27412	948	28361	10890	745	11635	17917	0	17917	8240	0	8240	6336	0	6336
1971/72	14036	6443	20479	9163	2368	11531	17381	4285	21666	12773	2609	15382	9936	2609	12545
1972/73	15214	6679	21892	9822	970	10792	6125	10409	16535	10732	7894	18625	6058	7894	13952
1973/74	27571	3212	30783	15438	791	16229	13075	6371	19446	5373	10489	15862	4304	9963	14266
1974/75	34990	5115	40106	16672	1063	17736	20584	18593	39177	11186	7515	18701	7466	7515	14981
1975/76	38879	8163	47042	9305	4075	13380	27988	33441	61429	5294	5520	10814	4220	5384	9604
1976/77	47309	11304	58613	6006	6205	12211	28574	26453	55027	7470	3688	11158	5726	3590	9316
1977/78	52550	13874	66424	13644	10129	23772	18773	18050	36822	16595	4846	21441	5237	4695	9932
1978/79	73184	8638	81822	19593	11699	31293	27951	9876	37827	36260	9510	45770	22910	8817	31728
1979/80	53818	4525	58343	11819	1294	13113	26548	2276	28824	31207	2226	33432	8371	1706	10077
1980/81	32200	7407	39607	12160	4645	16805	24106	4928	29033	12830	3833	16663	7059	3162	10221
1981/82	64919	5746	70665	7854	7086	14941	10932	3110	14042	14130	2947	17077	6469	2377	8845
1882/83	34406	16220	50626	11283	949	12231	10927	6141	17068	12150	2597	14747	4669	2434	7103
1983/84	15933	9869	25803	11421	1175	12596	16038	5718	21756	6322	1032	7354	2669	858	3527
1984/85	20491	6239	26730	7631	791	8422	25891	178	26069	3817	0	3817	1376	0	1376
1985/86	55424	287	55711	7824	307	8131	28492	204	28695	12700	0	12700	8893	0	8893
1986/87	29570	5294	34864	9145	4059	13204	24256	13463	37719	11289	2471	13761	6897	2471	9368
1987/88	22915	7500	30415	5208	715	5923	30042	9724	39766	11820	0	11820	6949	0	6949
1988/89	53851	6434	60285	3491	893	4384	34004	13365	47369	9908	0	9908	4258	0	4258

[a]Catch estimates in the current year are hailed values.

Table 3.3. Estimates of the total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in the Queen Charlotte Islands for 1951-1989.

	Section							Section	
Season	001	002	003	004	005	006	Total Area 2W	022	023
1950/51	0	0	0	0	0	0	0	812	0
1051/52	0	0	0	0	0	0	0	638	0
1952/53	0	0	777	161	0	0	938	1725	0
1953/54	0	0	0	0	0	0	0	25306	0
1954/55	0	0	0	0	0	0	0	19017	0
1955/56	0	0	0	0	0	0	0	5896	93
1956/57	0	0	148	0	0	464	612	1193	0
1957/58	0	0	221	0	43	0	264	83	
1958/59	1677	1146	1589	0	1027	1062	6501	11178	0
1959/60	91	656	1377	0	112	3561	5797	3623	0
1960/61	1160	422	531	0	390	2087	4590	4281	0
1961/62	396	1927	1667	0	311	955	5256	8035	0
1062/63	0	2414	0	0	0	0	2414	3027	0
1963/64	433	1405	761	192	168	3572	6531	4005	0
1964/65	285	0	303	106	1482	3467	5643	5671	0
1965/66	0	66	26	0	18	0	110	3792	0
1966/67	81	1272	0	0	155	67	1575	637	178
1967/68	0	6	110	0	77	90	283	273	0
1968/69	26	297	322	0	936	0	1581	1175	0
1969/70	0	423	373	0	806	407	2009	1055	4980
1970/71	0	170	826	0	590	1837	3423	2066	6500
1971/72	0	468	490	0	1998	3337	6293	3554	7405
1972/73	0	139	1481	0	2349	5318	9287	1137	9342
1973/74	0	0	1365	0	3004	3963	8332	1626	6272
1974/75	0	315	1401	254	1572	5654	9196	2213	5269
1975/76	0	417	490	0	1859	9117	11883	2988	5074
1976/77	0	303	670	221	2445	5433	9072	3084	4189
1977/78	641	0	2107	0	2242	3617	8607	4040	3628
1978/79	1293	53	693	111	875	986	4011	1637	3545
1979/80	1159	1399	1909	0	2312	2911	9690	31	0
1980/81	1291	4101	2191	435	1236	1230	10484	712	2080
1981/82	0	6150	3548	440	4105	2303	16546	876	563
1982/83	261	3563	4169	550	5153	1399	15095	578	1817
1983/84	581	2656	1149	0	2098	747	7231	2320	1757
1984/85	0	2245	910	38	1995	1137	6325	411	1249
1985/86	0	1169	314	0	1443	0	2926	2819	975
1986/87	0	2093	0	0	766	593	3452	903	968
1987/88	722	4312	1415	358	2337	2857	12001	425	0
1988/89	0	2550	2951	0	3777	6950	16228	0	677
Avg Biomass	259	1080	930	73	1223	1926	5492	3406	1707
Avg Catch (1951-1967)	35	0	6	0	57	322	420	5197	5
Avg Catch (1972-1989)	0	11	127	0	281	672	1090	179	850

Table 3.4 Estimates of the total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in the Central Coast for 1951-1989.

	Section											
Season	061	062	063	064	065	066	082	083	084	Area 9	Area 10	Total
1950/51	0	0	12	115	0	3111	0	10	0	763	185	4196
1951/52	0	0	0	101	211	0	2374	10	0	554	69	3319
1952/53	0	0	0	0	0	0	0	0	0	196	650	846
1953/54	0	181	0	808	223	58	309	994	0	2170	481	5224
1954/55	0	367	95	2925	2118	113	710	274	270	5332	1400	13604
1955/56	0	271	48	16	280	9	0	307	18	163	148	1260
1956/57	6610	149	22	53	1805	0	1505	767	0	3077	2170	16158
1957/58	186	295	18	1	284	0	0	1754	0	634	440	3612
1958/59	1748	233	693	57	67	366	75	1134	0	2870	1234	8477
1959/60	19	615	2521	249	1644	0	0	330	26	405	586	6395
1960/61	82	673	678	12	3666	0	289	457	0	1041	924	7822
1961/62	70	2298	90	0	5056	138	6478	24	0	5826	1556	21536
1962/63	991	2506	1282	180	65	0	2345	1169	0	4106	497	13141
1963/64	1112	1578	2117	0	934	31	1509	953	529	8392	1203	18358
1964/65	3977	1237	137	0	656	40	353	673	634	1486	315	9508
1965/66	2827	1966	597	277	37	147	3251	822	978	5661	1354	17917
1966/67	2184	1761	131	117	191	0	270	270	530	3184	3507	12145
1967/68	498	59	53	1	0	0	0	913	48	376	442	2390
1968/69	0	0	6	35	0	0	299	16	0	115	46	517
1969/70	0	0	72	62	14	27	670	271	9	1573	339	3037
1970/71	0	0	44	15	28	0	258	484	201	627	809	2466
1971/72	0	0	15	0	0	437	165	420	248	1037	1167	3489
1972/73	0	77	45	0	0	0	147	138	1190	3846	136	5579
1973/74	0	39	37	0	0	0	66	134	625	1045	302	2248
1974/75	0	0	40	0	5	0	378	133	1148	867	299	2870
1975/76	0	193	0	0	30	0	119	146	905	739	179	2311
1976/77	0	0	32	0	2	0	0	140	490	670	60	1394
1977/78	57	0	4	0	0	0	39	67	244	429	214	1054
1978/79	0	211	0	0	0	164	0	43	221	120	81	840
1979/80	0	0	0	0	0	581	0	150	0	320	246	1297
1980/81	189	27	0	0	0	0	0	78	107	75	201	677
1981/82	489	0	0	0	0	0	0	40	0	1017	741	2287
1982/83	0	120	0	0	0	0	0	15	132	243	609	1119
1983/84	0	0	0	0	0	0	0	37	273	58	700	1068
1984/85	11	264	0	0	0	0	0	0	91	152	224	742
1985/86	0	796	0	0	0	0	0	109	49	1702	584	3240
1986/87	385	196	0	0	0	619	0	222	179	1540	78	3219
1987/88	0	0	0	0	0	0	68	256	9	1088	165	1586
1988/89	0	0	0	0	0	0	0	119	50	374	340	883
Avg Biomass	550	413	225	129	444	150	556	356	236	1638	633	5329
Avg catch (1951-1967)	1165	829	471	264	1013	144	1144	576	130	2477	811	9024
Avg catch (1972-1989)	14	0	0	0	0	0	0	0	117	198	86	416

Table 3.5. Estimates of total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in Johnstone Strait for 1951-1989.

Season	Area 11	Section 126	Section 127	Other Area 12	Other Area 13	Total
1950/51	1	989	335	3251	116	4692
1951/52	4	2290	344	5717	90	8445
1952/53	0	202	258	1236	173	1869
1953/54	2	869	408	5102	80	6461
1954/55	6515	323	1073	1124	222	9257
1955/56	257	563	194	1089	518	2621
1955/57	13	636	126	12191	81	13047
1957/58	15	30	180	4023	0	4248
1958/59	144	3431	1091	1625	298	6589
1959/60	668	976	2518	5553	480	10195
1960/61	266	819	282	4693	293	6353
1961/62	781	112	749	9323	404	11369
1962/63	2187	591	1039	8801	769	13387
1963/64	129	446	5753	5858	1618	13804
1964/65	1226	996	2894	11028	3147	19291
1965/66	1171	292	2109	18129	682	22383
1966/67	252	140	998	10660	3299	15349
1967/68	7	50	152	2727	3	2939
1968/69	21	194	189	1509	168	2081
1969/70	48	298	235	2674	176	3431
1970/71	69	153	97	1875	417	2611
1971/72	31	1504	1188	4163	745	7631
1972/73	12	1145	3568	8850	276	13851
1973/74	7	565	3580	1742	290	6184
1974/75	28	1158	3285	1810	619	6900
1975/76	33	1207	2018	805	119	4182
1976/77	15	406	1721	1145	108	3395
1977/78	16	565	576	248	61	1466
1978/79	60	64	71	175	178	548
1979/80	14	245	417	822	264	1762
1980/81	9	192	287	460	1351	2299
1981/82	0	141	550	67	252	1010
1982/83	17	95	243	101	135	591
1983/84	10	165	482	650	2	1309
1984/85	0	415	940	129	228	1712
1985/86	39	166	197	505	42	949
1986/87	13	148	171	488	96	916
1987/88	7	257	396	900	1	1561
1988/89	19	494	162	615	0	1290
Avg Biomass	362	598	1048	3638	456	6102
Avg Catch (1951-1967)	756	714	1083	5966	530	9050
Avg Catch (1972-1989)	1	244	93	814	41	1192

Table 3.6. Estimates of total biomass and average reduction and roe catches (tonnes) for minor and resident stocks in for the northern west coast of Vancouver Island 1951-1989.

	Section		Other Area	Total	Section			Other Area	Total
Season	262	263	26	Area 26	272	273	274	27	Area 27
1950/51	865	269	9	1143	622	1780	0	0	2402
1951/52	365	37	383	785	0	663	0	0	663
1952/53	2336	641	634	3611	273	6888	701	0	7862
1953/54	588	2409	691	3688	952	3160	342	1266	5720
2954/55	4208	889	180	5277	106	1387	0	5947	7440
1955/56	353	524	142	1019	0	6	0	0	6
1956/57	772	763	42	1577	0	773	0	0	773
1957/58	712	241	158	1111	0	327	0	0	327
1958/59	281	240	86	607	0	181	0	407	588
1959/60	2656	674	509	3839	168	185	0	0	353
1960/61	2712	1594	511	4817	305	670	43	456	1474
1961/62	1047	3866	422	5335	0	207	137	173	517
1962/63	3497	428	85	4010	0	1736	122	31	1889
1963/64	1197	456	0	1653	0	90	0	233	323
1964/65	724	1317	0	2041	1889	1804	50	11	3754
1965/66	1316	18	0	1334	213	56	0	862	1131
1966/67	463	660	0	1123	140	70	0	0	210
1967/68	61	0	0	61	0	208	0	240	448
1968/69	283	825	0	1108	1516	896	0	0	2412
1969/70	774	135	0	909	2013	207	250	0	2470
1970/71	742	646	0	1388	0	145	370	0	515
1971/72	2210	132	0	2342	0	69	425	0	494
1972/73	1733	0	0	1733	1802	789	350	0	2941
1973/74	1069	0	0	1069	0	526	0	0	526
1974/75	728	180	0	908	0	2811	0	0	2811
1975/76	575	0	0	575	12	402	221	0	635
1976/77	510	11	0	521	0	1118	155	48	1321
1977/78	0	0	0	0	3147	8237	125	0	11509
1978/79	0	0	0	0	3895	10146	0	0	14041
1979/80	0	0	0	0	8922	14433	0	0	23355
1980/81	0	0	0	0	0	6442	0	0	6442
1981/82	0	0	0	0	3579	4641	11	0	8231
1982/83	0	0	0	0	0	7644	0	0	7644
1983/84	0	0	0	0	0	3827	0	0	3827
1984/85	0	0	0	0	2151	289	0	0	2440
1985/86	0	0	0	0	0	3807	0	0	3807
1986/87	0	0	0	0	1967	2425	0	0	4392
1987/88	0	0	0	0	0	4871	0	0	4871
1988/89	0	0	0	0	2526	3124	0	0	5650
Avg Biomass	840	435	99	1374	928	2488	85	248	3749
Avg catch (1951-1967)	434	620	40	1094	100	48	0	540	688
Avg catch (1972-1989)	8	1	0	9	4	192	1	0	197

Table 3.7. Estimates of 1989 spawning biomass and forecasts of age 4+ and recruit biomass in 1990 (in thousands of tonnes) from escapement model analysis.

		1990 Forecasts			
	1989 Spawning Biomass	Age 4+	Age 3 recruits		
Stock Assessment Region			Poor	Average	Good
Queen Charlotte Islands	19.7	14.3	0.7	2.3	8.1
REVISED Queen Charlottes	25.8	18.9	0.9	3.2	8.8
Prince Rupert District	12.9	10.0	1.6	4.8	13.8
Central Coast	42.2	32.0	2.8	6.8	17.9
Strait of Georgia					
Northern stock	53.9	40.8	7.8	13.7	24.1
Southern stock	3.5	2.4	3.0	5.3	6.1
West Coast of Vancouver Is					
Southern stock	34.0	24.8	3.6	7.2	14.6
Northern stock	9.9	7.0	1.8	4.6	12.1
REVISED Northern stock	4.3	3.0	1.0	3.0	8.3

Table 3.8. Estimates of the mean egg densities from SCUBA surveys based on the new stratified and old unstratified parameterization of the egg prediction model.

Spawning Area	New Parameterization 1989/90 Assessment	Old Parameterization 1988/89 Assessment	Percent Difference
Louscoone Inlet	344	390	-12
Huston Inlet	329	364	-11
Section Cove	334	391	-17
Big Bay	276	312	-12
Kitkatla	407	472	-14
Kitasu Bay	483	546	-12
Norman Morrison Bay	545	590	- 8
Denman Island	264	287	- 8
Hornby Island	645	651	- 1
Qualicum Beach	218	257	-15
Yellow Point	202	230	-12
Barkley Sound	389	413	- 6
Hesquiat Harbour	455	512	-11
Klaskish Inlet	446	523	-15

Table 3.9. Comparison of 1989 egg counts and egg density predictions for the stratified spawn model (in thousands of eggs per m^2).

Statistical area[a]	Number of samples	Mean egg density	
		Observed	Predicted
0	3	37.341	292.333
2	15	156.654	301.600
14	42	253.449	291.095
17	1	36.223	57.000
23	26	195.048	340.308
27	14	427.920	393.357

[a]In addition, a number of samples were collected from areas 6 and 7 but no weights were taken so the egg numbers could not be determined.

4. AGE-STRUCTURED MODEL

4.1 INTRODUCTION

A modified version of the age-structured model described in Fournier and Archibald (1982) has been used to assess B.C. herring stocks since 1982. The model has undergone numerous revisions to make it more consistent with the life history of herring and the fisheries being analyzed. The current version, which is described here, incorporates auxiliary information in the form of spawn survey data, separates catch-at-age data by gear type, and includes an availability term to model partial recruitments to the spawning stock. The model includes realistic assumptions about the form of both measurement and process error. A maximum likelihood method is used to simultaneously estimate all model parameters.

4.2 METHODS

The Population Model

Two types of fishing gear are commonly used in B.C. herring fisheries. Of these, seine nets are assumed to be non-selective while gillnets are selective for larger, older fish. Herring fisheries have primarily concentrated on spawning fish or fish migrating to spawning grounds, so the relative availability of age classes to the non-selective gear should be equivalent to the partial recruitment of age classes to the spawning stock. We have therefore developed a model which explicitly separates availability (partial recruitment) and gear selectivity. Seine and gillnet fisheries are temporally separate so catch-at-age data is partitioned into fishing periods, separating data for the different gears. Three fishing periods are modelled. The first period encompasses all catch data prior to the spring roe-herring fisheries. This includes all the 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 not size selective). The second fishing period includes all seine caught roe-herring fishery data and the third period includes all gillnet caught roe-herring data.

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 we use a form of catch equations which model fishing and natural mortality as continuous processes over the time period r,

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

and, for $r < p$

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

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=39),
k is the number of age classes (k=10).

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

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

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

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

To reduce the number of parameters to be estimated we make certain assumptions with respect to the availabilities and mortalities. We assume that availability increases with age, reaching a value of 1 by age 7. Additionally, we assume that the availability of fish age 4 and older does not vary from year to year. However, the proportion of mature 3-year-old herring does vary between years (Haist and Stocker 1985) and some fisheries have targetted on immature 2-year-old stocks (eg. 1957/58 Queen Charlotte Islands fishery, Appendix Table 1.1). We therefore parameterize availability for these two age classes with annual deviations from an average availability for the age class ($\bar{\lambda}_j$). Availability for ages 2 and 3 for seasons 1 to n-1 (only those seasons where there is age data) is

$$\lambda_{ij} = \bar{\lambda}_j + d_{ij},$$

where the d_{ij} are constrained such that

$$\sum_{i=1}^{n-1} d_{ij} = 0.$$

For ages 4 to 6 and ages 2 and 3 in year n (and seasons where there is no age data)

$$\lambda_{ij} = \bar{\lambda}_j ,$$

and for ages 7 and older,

$$\lambda_{ij} = 1.$$

Deviations from the average availability are not estimated for ages 2 and 3 in the final year because there is not enough information in the data to estimate these parameters.

For the selective fishery (i.e., the gillnet fishery) we assume that fishing mortality is separable into an age selectivity component and a fishing intensity component. Following Doubleday (1976),

$$\ln(F_{ijr}) = a_{ir} + b_{jr}$$

where a_{ir} represents the general level of fishing mortality due to fishery r in season i, and b_{jr} represents the relative vulnerability of age-class j in fishery r. For ages greater than 7, b_{jr} is fixed at b_{7r}. For non-selective fisheries the model is

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

We assume that natural mortality is constant over ages and seasons.

Additional structure is built into the model through the inclusion of annual spawning stock egg production 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

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

and the reproductive potential (R_i) in season i is

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

where f_j is the relative fecundity at age j. We assume the error in the spawn index observations (I_i) is multiplicative so that

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

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

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

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 2 to k,
$\bar{\lambda}_j$, for age classes 2 to 7,
d_{ij}, for age classes 2 and 3, for seasons 1 to n-1,
a_{ir}, for all fisheries i,r,
b_{jr}, for all selective fisheries (ie. r=3),
α, β, and q.

The $\bar{\lambda}_j$ and d_{ij} are reparameterized to constrain the values of λ_{ij} 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 4.1.

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,
f_j, the estimated fecundity at age j.

We assume the same error structure for the observations S_{ijr} and O_{ir} as employed by Fournier and Archibald (1982), that is:

1) The S_{ijr} are obtained from ageing a random sample of fish from the catch and there are no ageing errors (i.e. a multinomial 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 the above stochastic assumptions the log-likelihood function for the parameters P_{ijr} ($P_{ijr} = C_{ijr}/C_{ir}$), C_{ir}, and σ_3^2 is

$$\sum_{ijr} S_{ijr} \ln(P_{ijr}) - \sum_{ir} ½ \frac{[\ln(O_{ir}) - \ln(C_{ir})]^2}{\sigma_3^2} - n \ln(\sigma_3). \qquad (3.5)$$

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

$$- \sum_{i} ½ \frac{[\ln(I_i) - \ln(R_i)]^2}{\sigma_1^2} \qquad (3.6)$$

from equation 3.2, and

$$- \sum_{i} ½ \frac{[\ln(T_{i+1,1}) - \ln(R_i) - \ln(\alpha) + \beta R_i]^2}{\sigma_2^2} \qquad (3.7)$$

from equation 3.3.

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. We assume the following variances:

$$\sigma_1^2 = 0.05,$$
$$\sigma_2^2 = 0.25,$$
$$\sigma_3^2 = 0.0025.$$

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, S_{ijr}, could be used in the objective function, however, we do not feel this would give a realistic estimate of the precision of the proportion-at-age data. That is, we do not feel that the sampling process strictly adheres to multinomial sampling assumptions. The between load (samples from different catching vessels) variability in age composition is significantly different between years, and this is more related to the spatial and temporal distribution of the fisheries than to the number of loads sampled or total fish aged.

Therefore, we make use of the information in the subsamples (between load samples) which are pooled to obtain an estimate of the age composition for a given fishery.

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. We can calculate an estimate of the variance of $\hat{p}_j$:

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

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

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

We use these theoretical sample sizes, calculated from the between sample variance for 4-year-old fish (Appendix Table 1), in the objective function.

Stock Forecasts

Forecasts of stock abundance for 1990 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 1989/90 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 3 for the 1951-89 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 3 numbers. Biomass is calculated using the weight-at-age model described in section 2.

To investigate the bias and variance of the estimated parameters, in particular, current stock estimates and the stock forecast, we applied bootstrap techniques (Efron and Gong 1983) 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 we used a two-stage procedure. First random subsamples were selected from the original data set, then individual fish were randomly selected from the subsample. Because we have no information about the error structure of the spawn observations or the total catch estimates these data were resampled under the same assumptions as used in the analytical model. We assumed log-normal errors with a variance of 0.05 and 0.0025 for the observed spawn and observed catch, respectively. The data for each stock grouping were resampled 100 times and reanalysed producing 100 sets of parameter estimates.

Input data used for age-structured model analysis are shown in Appendix Table 1 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 1985).

4.3 RESULTS

Results from age-structured model stock reconstructions are shown in Appendix Table 2 for the seven original stock assessment regions and the two revised regions. Estimates of spawning biomass in 1989 and forecasts of age 4 and recruit biomass for 1990 are shown in Table 4.2, and results of the bootstrap analysis are shown in Table 4.3.

For the 1988 stock assessments confidence limits on stock forecasts were calculated using the same bootstrap techniques as this year (Haist and Schweigert 1989). A second set of bootstrap analyses were done with greater random error on the spawn data (variance = 0.15). Current estimates of 1989 pre-fishery biomass are compared with these forecast confidence intervals (95%) in Table 4.4. For two of the seven assessment regions the current estimates of age 4+ biomass are outside the 95% confidence interval for both levels of variance in the spawn data. A similar comparison of forecast confidence limits for 1988 with 1988 estimates of biomass indicated that four of the seven were outside the 95% limits (Haist and Schweigert 1989). This frequency of estimates outside the forecast confidence limits (6 times in 14) suggests that the bootstrap methods used do not provide accurate estimates of the conficence intervals. A comparison of the 1989 forecasts for age 4+ and age 5+ biomass (Table 4.4) suggests that the estimated confidence interval for age 4 fish is in error; none of the current estimates of age 5+ biomass are outside the forecast confidence interval. The inability to estimate reasonable confidence limits for age 4 biomass likely results from the availability of 3-yr olds in the final year (λ_{n3}) being fixed at the average 3-yr-old availability ($\bar{\lambda}_3$). If this availability changes substantially with an additional year's data the estimate of the total cohort size will also change substantially. Alternate methods for estimating confidence limits of the forecast 4-yr-old biomass need to be developed and evaluated.

For the Queen Charlotte Islands, the stock reconstruction indicates a substantial increase in spawning biomass in 1989 following the steady decline from 1983 to 1987. This trend is consistent with the spawn index data. The 1985 year-class, which showed up as 4-yr olds this year, comprised 50% of the stock and is above average in size relative to historic year classes. Forecast pre-fishery biomass for the Queen Charlotte Islands Stock Assessment Region in 1990 is 34,500 tonnes assuming average recruitment. For the REVISED Queen Charlotte

Islands Stock Assessment Region the estimated 1989 spawning biomass is 44,400 tonnes with a forecast for 1990 of 48,400 tonnes given average recruitment.

For the Prince Rupert District, age-structured analysis shows a relatively stable spawning biomass since 1984 with an estimated 47,800 tonnes of spawners in 1989. Current spawning stocks are well above the long term average. Given average recruitment a run size of 57,400 tonnes is forecast for this area.

The estimated 1989 spawning biomass for the Central Coast is 39,400 tonnes, a slight decrease from 1988 levels. The 1985 year class comprised 76.2% of the stock (as 4-yr olds) and appears to be one of the largest year classes in the historic time series. The forecast 1990 pre-fishery biomass for the Central Coast is 47,600 tonnes given average recruitment.

Spawning biomass estimates for 1989 indicate a slight decrease in the Northern Strait of Georgia and a slight increase in the Southern Strait of Georgia from 1988 levels. Forecasts for the northern and southern stocks in 1990, given average recruitment, are 41,000 tonnes and 11,200 tonnes, respectively.

The spawning biomass estimate for the Southern West Coast of Vancouver Island is down slightly from 1988, which is consistent with the spawn index. Recruitment of 3-yr olds in 1989 appears to be below average. The forecast 1990 stock abundance is 25,600 tonnes assuming average recruitment.

Age-structured model stock reconstructions for the Northern West Coast of Vancouver Island continue to suggest a major increase in stock size over the past five seasons. The estimate of 28,500 tonnes of spawners in 1989 seems unrealistically high given spawning estimates from synoptic dive surveys and in-season hydroacoustic surveys. The age-structured model appears to have consistently overestimated stock size for this area in recent years. For the REVISED Northern West Coast of Vancouver Island Region Assessment Region these inconsistencies are not improved. The estimated 1989 spawning biomass is 23,800 tonnes.

Table 4.1. Number of parameters for age-structured analysis for nine assessment regions.

For all assessment regions:	T_{i1}	39
	T_{1i}	9
	$\bar{\lambda}_j$	7
	b_{jr}	7
	α, β, q	3
		65

Stock Specific:	a_{ir}	d_{ij}	Total
Queen Charlotte Islands	45	66	177
REVISED QCI	47	66	179
Prince Rupert District	65	76	207
Central Coast	56	74	196
N. Strait of Georgia	70	76	212
S. Strait of Georgia	61	76	203
S. W. Coast Vancouver Is.	48	68	182
N. W. Coast Vancouver Is.	45	66	177
REVISED N. WCVI	41	60	167

Table 4.2. Estimates of 1989 spawning biomass and forecasts of age 4+ and recruit biomass in 1990 (in thousands of tonnes) from age-structured model analysis.

Stock Assessment Region	1989 Spawning Biomass	1990 Forecasts			
			Age 3 recruits		
		Age 4+	Poor	Average	Good
Queen Charlotte Islands	31.4	31.4	0.9	3.1	10.4
REVISED Queen Charlottes	43.8	44.4	1.2	4.0	11.6
Prince Rupert District	47.8	50.9	2.3	6.5	20.0
Central Coast	39.4	40.6	3.1	6.9	17.1
Strait of Georgia					
Northern stock	36.5	31.1	4.6	9.9	19.8
Southern stock	11.2	8.2	1.1	3.1	6.2
West Coast of Vancouver Is.					
Southern stock	20.9	17.6	3.8	7.9	19.4
Northern stock	28.5	22.3	1.9	5.9	12.1
REVISED Northern stock	23.8	18.5	1.9	5.4	11.7

Table 4.3. Bootstrap results of estimates of 1989 spawning biomass (tonnes) and forecast 1990 age 4, age 4+, and age 5+ biomass (tonnes) for herring stock assessment regions. The original estimates and bootstrap means and standard deviations are given.

	1989 Spawning Biomass	1990 Biomass Forecast		
		Age 4	Age 4+	Age 5+
Queen Charlotte Islands	31,427		31,376	
bootstrap - mean	30,615	7,550	30,533	22,983
- st. dev.	3,943	1,276	3,954	2,939
Prince Rupert District	47,780		50,887	
bootstrap - mean	48,199	10,500	51,208	40,708
- st. dev.	5,386	1,474	5,495	4,310
Central Coast	39,397		40,633	
bootstrap - mean	40,078	1,865	41,238	39,373
- st. dev.	5,635	309	5,545	5,289
Strait of Georgia				
Northern Stock	36,466		31,100	
bootstrap - mean	37,299	7,782	31,810	24,028
- st. dev.	5,725	1,227	4,930	3,871
Southern Stock	11,222		8,174	
bootstrap - mean	11,165	1,435	8,144	6,708
- st. dev.	1,385	265	978	785
W. Coast Vancouver Island				
Southern Stock	20,917		17,627	
bootstrap - mean	20,808	3,459	17,551	14,091
- st. dev.	4,159	655	3,312	2,715
Northern Stock	28,536		22,350	
bootstrap - mean	28,335	3,178	22,224	19,046
- st. dev.	3,326	787	2,751	2,281

Table 4.4. Comparison of forecast and estimated 1989 age 4, age 4+, and age 5+ biomass (tonnes) for herring stock assessment regions. The forecast 95% confidence intervals are from bootstrap analyses from last year's assessment. The estimated values are from the current year's age-structured model analyses. Current estimates which are outside the forecast confidence limits are marked.*

	1988 Bootstrap Forecast		
Stock Assessment Region	$\sigma^2_2 = 0.05$	$\sigma^2_2 = 0.15$	1989 Estimate
Queen Charlotte Islands			
age 4+	11468 - 22454*	10135 - 24822*	25001
age 5+	7356 - 12452	6348 - 13845	9797
age 4	3285 - 10828*	2969 - 11794*	15204
Prince Rupert District			
age 4+	31872 - 51111	29573 - 52847	47468
age 5+	23291 - 35052	21513 - 36452	31024
age 4	7998 - 16640	7472 - 16982	16444
Central Coast			
age 4+	36080 - 55597	30776 - 60485	46673
age 5+	12112 - 19022	10245 - 20792	13953
age 4	23318 - 37224	20081 - 40141	32720
Northern Strait of Georgia			
age 4+	30661 - 56697	25637 - 63437	35402
age 5+	9614 - 19065	7645 - 21690	11610
age 4	20393 - 38285	17522 - 42216	23792
Southern Strait of Georgia			
age 4+	10317 - 17521*	8764 - 18954*	8908
age 5+	2633 - 4305	2208 - 4732	3232
age 4	7288 - 13612*	6234 - 14542*	5676
Southern W. coast Van. Is.			
age 4+	17254 - 33578	13773 - 38196	30035
age 5+	6292 - 11762	4930 - 13546	8439
age 4	10734 - 22043	8671 - 24822	21596
Northern W. coast Van. Is.			
age 4+	25567 - 42798	22034 - 47246	26000
age 5+	9969 - 15709	8345 - 17702	12601
age 4	14281 - 28404*	12639 - 30593	13999

5. 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	10,600 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	8,700 t.

To provide an overall stock forecast we assigned subjective probabilities to the alternate assessment models. Based on intuition and past performance, we believe the age-structured model makes the most likely predictions of forecast runs. The escapement model incorporates diving survey information on most major spawns in 1989, and we feel these direct estimates of egg deposition provide a reasonably accurate estimate of current stock size. Hence, we used equal probabilities for the two models in most assessment regions. The only exception to this was for the Northern West Coast of Vancouver Island where age-structured analysis has produced inconsistent forecasts in recent years. This may result from a limited number of representative ageing samples for this area. Consequently, we felt that the age-structured model estimates for this region may be biased and we used a 80:20 weighting in favour of the escapement model for this area.

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 5.1).

The forecast weighted run size to the Queen Charlotte Islands in 1990 is 25,600 tonnes assuming average recruitment. The above average 1985 year class has substantially improved the forecasts for this stock, and should allow for a moderate fishery in 1990. For the revised Queen Charlotte Islands Stock Assessment Region the 1990 forecast assuming average recruitment is 35,300 tonnes.

The Prince Rupert District spawning stock may be declining slightly from historically high levels. Given the average to good recruitment levels in recent years, an optimistic recruitment assumption may again be warranted for 1990. Assuming average recruitment yields a forecast biomass of 36,100 tonnes. This produces a potential catch of 7,220 tonnes for the Prince Rupert District in 1990.

The forecast for the Central Coast with average recruitment is 43,200 tonnes. The recommended catch for this region is 8,640 tonnes. Given the very healthy state of this stock more optimistic recruitment estimates may be warranted.

The weighted forecast run to the Northern Strait of Georgia in 1990 is 47,800 tonnes, and to the Southern Strait of Georgia 9,500 tonnes. An average recruitment assumption would yield potential catches of 9,560 and 1,900 tonnes, respectively.

The forecast run to the Southern West Coast of Vancouver Island is 28,800 tonnes for an allowable catch of 5,760 tonnes. The forecast for the Northern West Coast of Vancouver Island even with the low weighting on the age-structured model, is 15,000 tonnes for a recommended catch of 3,000 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 recommended herein.

Table 5.1. Summary of 1990 forecast 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			
		Recruitment level				Recruitment level				Recruitment level		
	AGE 4+	Poor	Avg.	Good	AGE 4+	Poor	Avg.	Good	Rel. Weight	Poor	Avg.	Good
Queen Charlotte Islands	31.4	32.3	34.5	41.8	14.3	14.9	16.6	22.4	50:50	23.6	25.6	32.1
REVISED QCI	44.4	45.6	48.4	55.9	18.9	19.8	22.1	27.7	50:50	32.7	35.3	41.8
Prince Rupert District	50.9	53.2	57.4	70.9	10.0	11.6	14.8	23.8	50:50	32.4	36.1	47.4
Central Coast	40.6	43.7	47.6	57.7	32.0	34.8	38.8	49.9	50:50	39.3	43.2	53.8
Strait of Georgia												
northern stock	31.1	35.7	41.0	51.0	40.8	48.6	54.5	64.9	50:50	42.2	47.8	58.0
southern stock[a]	8.2	9.3	11.2	14.4	2.4	5.4	7.7	8.5	50:50	7.4	9.1	11.5
West Coast Vancouver Is.												
southern stock	17.6	21.4	25.6	37.0	24.8	28.4	32.0	39.4	50:50	24.9	28.8	38.2
northern stock	22.3	24.3	28.3	34.5	7.0	8.8	11.6	19.1	20:80	11.9	15.0	22.2
REVISED northern	18.5	20.4	23.9	30.2	3.0	4.0	6.0	11.3	20:80	7.1	9.6	15.1

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

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Appendix Table 1.1. 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	REDUCTION	0.0	0.1	15.3	52.9	15.3	11.5	4.2	0.6	0.1	0.0	1476	1544	317.44
1951/52	REDUCTION	1.2	16.9	21.5	33.8	21.3	4.1	1.1	0.1	0.0	0.0	2251	165	1136.50
1953/54	REDUCTION	0.1	3.0	29.0	21.3	33.6	10.2	1.9	0.7	0.2	0.1	0*	25	231.77
1954/55	REDUCTION	0.0	8.7	14.1	39.4	18.1	14.8	4.4	0.3	0.1	0.1	0*	25	52.94
1955/56	REDUCTION	0.0	0.1	16.0	9.6	62.2	8.4	2.7	0.7	0.0	0.1	1348	681	6544.00
1956/57	REDUCTION	0.2	21.1	23.7	15.7	9.5	26.9	2.3	0.4	0.1	0.0	4649	2106	2051.45
1957/58	REDUCTION	0.0	81.9	16.4	1.2	0.2	0.1	0.1	0.0	0.0	0.0	2838	514	2146.22
1958/59	REDUCTION	0.0	1.1	63.2	28.4	7.4	0.0	0.0	0.0	0.0	0.0	95	6	735.74
1960/61	REDUCTION	0.0	4.2	32.6	36.0	24.8	1.3	0.4	0.2	0.4	0.0	0*	25	59.00
1961/62	REDUCTION	0.0	3.0	37.6	41.4	9.6	6.5	1.6	0.2	0.0	0.0	428	170	693.85
1962/63	REDUCTION	0.0	0.4	50.0	27.1	18.2	2.1	2.0	0.0	0.1	0.1	804	411	1342.32
1963/64	REDUCTION	0.0	0.9	15.3	59.5	17.8	5.3	1.1	0.0	0.0	0.0	528	297	2347.52
1964/65	REDUCTION	0.0	1.6	79.8	11.0	4.4	2.1	0.9	0.2	0.0	0.0	1053	165	3132.24
1965/66	REDUCTION	1.7	18.0	32.2	16.1	10.2	7.3	5.8	4.8	2.0	1.7	0*	25	213.13
1966/67	REDUCTION	0.0	0.9	67.3	26.5	2.7	2.7	0.0	0.0	0.0	0.0	0*	25	14.23
1967/68	REDUCTION	0.8	29.7	50.2	17.1	2.2	0.0	0.0	0.0	0.0	0.0	0*	25	8.48
1971/72	ROE-SN	0.0	4.7	37.6	46.5	4.5	4.5	1.5	0.4	0.2	0.0	465	54	90.92
1972/73	ROE-SN	0.0	0.3	37.3	19.7	32.8	6.8	2.4	0.7	0.0	0.0	702	869	148.90
1973/74	ROE-SN	0.0	0.3	59.7	23.4	9.6	5.3	1.1	0.4	0.1	0.0	697	272	195.48
	ROE-GN	0.0	0.0	1.4	37.5	29.2	25.0	5.6	0.0	0.0	1.4	72	72	4.02
1974/75	ROE-SN	0.0	0.1	33.3	45.4	13.5	5.3	1.7	0.5	0.2	0.0	3026	788	370.01"
	ROE-GN	0.0	0.0	0.0	22.5	40.0	30.0	5.0	2.5	0.0	0.0	40	40	6.19
1975/76	ROE-SN	0.0	0.3	2.9	52.8	33.5	7.6	2.2	0.6	0.0	0.0	2629	1293	690.30‘
1976/77	ROE-SN	0.0	0.0	17.3	10.3	43.1	22.6	5.5	1.0	0.2	0.0	1824	653	688.84"‘
1977/78	ROE-SN	0.0	0.1	24.7	17.1	11.1	33.0	12.2	1.7	0.0	0.0	784	1347	661.74‘
1978/79	ROE-SN	0.0	5.6	4.4	31.6	18.7	21.3	15.1	2.8	0.4	0.1	1020	441	387.56"
	ROE-GN	0.0	0.0	0.0	25.1	25.1	25.1	20.1	3.5	0.5	0.5	199	65	128.20
1979/80	ROE-SN	0.0	0.3	85.3	4.5	4.9	2.5	1.8	0.6	0.1	0.0	2223	1399	143.46
	ROE-GN	0.0	0.0	4.5	4.0	40.5	20.5	24.5	5.0	1.1	0.0	756	1008	60.13
1980/81	ROE-SN	0.0	0.2	3.0	85.3	5.4	3.2	2.0	0.7	0.2	0.1	4586	424	331.01"
	ROE-GN	0.0	0.0	0.2	74.8	8.3	9.4	4.9	1.9	0.6	0.0	905	339	121.41
1981/82	ROE-SN	0.0	0.5	3.4	3.7	87.6	2.1	1.4	0.8	0.5	0.1	2813	1889	186.62"
	ROE-GN	0.0	0.0	0.2	3.4	88.2	3.4	2.7	1.1	0.8	0.2	526	341	99.20
1982/83	ROE-SN	0.0	4.1	4.8	3.5	6.4	74.9	3.7	1.5	0.8	0.2	1706	1282	316.02"
	ROE-GN	0.0	0.0	0.0	1.3	2.8	89.0	3.1	2.5	0.7	0.5	747	637	58.91
1983/84	OTHER	0.0	5.9	36.6	2.2	4.3	8.6	39.2	2.2	0.5	0.5	186	186	16.18
	ROE-SN	0.0	1.9	35.8	4.8	2.7	10.4	42.9	1.1	0.4	0.2	3013	1473	313.87
	ROE-GN	0.0	0.0	2.8	1.3	4.6	9.0	80.1	1.8	0.3	0.3	391	427	34.59
1984/85	ROE-SN	0.0	1.3	14.9	31.8	4.0	4.5	11.4	31.5	0.4	0.1	3556	699	311.61"
	ROE-GN	0.0	0.0	0.0	15.3	2.1	4.2	11.1	66.7	0.7	0.0	144	83	85.78
1985/86	ROE-SN	0.0	0.2	2.8	22.0	40.2	4.0	3.3	8.0	19.1	0.3	4733	2821	157.73
	ROE-GN	0.0	0.0	0.0	11.9	50.6	5.4	5.2	10.4	16.0	0.5	405	383	55.79
1986/87	ROE-SN	0.0	1.8	9.9	5.4	25.1	37.9	3.8	4.3	5.7	6.1	3096	1221	130.61"
1987/88	ROE-SN	0.0	4.2	41.8	8.6	5.7	14.1	17.9	1.6	2.0	4.1	1394	619	2.43"
1988/89	ROE-SN	0.0	1.3	27.8	50.0	4.2	2.7	6.5	4.7	1.1	1.7	1981	403	1.00~

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	11.7	52.0	84.4	106.6	126.0	147.7	156.8	172.2	147.3	183.5
ROE-SN	0.0	66.1	98.1	126.4	150.7	172.6	188.3	200.9	209.7	208.9
ROE-GN	0.0	0.0	117.5	139.9	151.7	168.0	176.7	188.6	188.8	193.4
OTHER	11.7	60.7	93.4	119.5	142.4	165.3	179.0	194.2	200.2	202.6

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

Appendix Table 1.2. 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	PERCENT AT AGE 1	2	3	4	5	6	7	8	9	10	NUMBER AGED	SAMPLE WEIGHT	CATCH ($x 10^{-5}$)
1950/51	REDUCTION	0.0	4.3	18.2	58.5	10.4	5.6	2.6	0.3	0.0	0.0	4684	2202	4954.74
1951/52	REDUCTION	0.1	4.8	8.8	33.7	45.2	6.1	1.0	0.3	0.0	0.0	5925	2500	4392.63
1952/53	REDUCTION	0.0	1.2	38.1	23.0	25.4	11.1	1.0	0.1	0.0	0.0	1419	752	173.50
1953/54	REDUCTION	0.0	2.1	28.4	29.1	24.0	13.2	2.6	0.6	0.0	0.0	2656	891	2522.89
1954/55	REDUCTION	0.0	2.7	4.9	70.3	15.6	5.2	1.1	0.2	0.0	0.0	1131	467	1698.85
1955/56	REDUCTION	0.0	10.0	58.1	9.5	19.0	2.6	0.5	0.2	0.1	0.0	1683	555	1218.10
1956/57	REDUCTION	0.0	11.5	17.8	39.8	13.2	16.0	1.4	0.3	0.0	0.0	3491	515	2827.98
1957/58	REDUCTION	0.0	45.8	30.2	8.0	11.8	1.8	2.4	0.0	0.0	0.0	847	123	644.16
1958/59	REDUCTION	0.0	3.1	56.7	20.9	5.8	9.9	1.7	1.9	0.1	0.0	1741	349	1037.09
1959/60	REDUCTION	0.0	49.1	6.3	28.2	8.9	4.1	2.5	0.7	0.2	0.0	4206	337	2451.31
1960/61	REDUCTION	0.0	9.7	58.3	7.3	18.0	4.3	1.6	0.6	0.1	0.0	4300	763	4815.52
1961/62	REDUCTION	0.0	3.0	30.3	44.7	6.9	9.9	3.4	0.9	0.5	0.3	1845	752	2476.36
1962/63	REDUCTION	0.0	39.3	13.3	18.2	22.0	3.6	3.0	0.5	0.1	0.1	3415	433	4788.66
1963/64	REDUCTION	0.0	3.7	64.9	10.1	10.9	8.9	0.7	0.6	0.1	0.0	3400	1914	3555.87
1964/65	REDUCTION	0.0	6.0	13.6	51.0	8.5	11.0	8.5	1.0	0.3	0.1	3360	459	3649.12
1965/66	REDUCTION	0.0	0.0	5.3	21.4	23.4	16.3	19.1	9.7	3.2	1.6	435	59	1071.96
1966/67	REDUCTION	0.9	56.7	31.9	5.3	1.9	2.7	0.4	0.2	0.0	0.0	0*	25	1225.88
1967/68	REDUCTION	3.2	33.7	38.5	18.8	4.4	0.7	0.3	0.1	0.3	0.0	0*	25	281.72
1968/69	OTHER	1.3	29.7	44.5	20.3	3.8	0.2	0.2	0.0	0.0	0.0	0*	25	69.79
1969/70	OTHER	0.7	18.5	62.4	15.0	3.1	0.0	0.1	0.1	0.0	0.0	0*	25	184.71
1970/71	OTHER	0.0	6.5	50.4	29.3	8.0	4.3	0.8	0.5	0.2	0.0	601	38	413.67
1971/72	ROE-SN	0.0	0.0	5.3	17.9	64.4	5.9	3.8	2.4	0.1	0.1	714	209	278.66"'
1972/73	OTHER	0.0	22.9	47.7	7.8	13.1	4.6	2.6	1.3	0.0	0.0	153	14	35.70
	ROE-SN	0.0	0.3	33.0	4.4	30.4	26.6	3.4	1.3	0.8	0.0	797	662	94.37
1973/74	ROE-SN	0.0	0.2	17.9	53.2	7.4	16.5	4.4	0.3	0.2	0.0	632	121	174.36"
	ROE-GN	0.0	0.0	1.0	39.4	21.2	34.6	2.9	1.0	0.0	0.0	104	83	90.07
1974/75	OTHER	0.0	1.2	10.5	15.1	43.0	14.0	11.6	2.3	2.3	0.0	86	86	14.18
	ROE-SN	0.3	1.3	9.4	22.1	43.0	11.1	9.6	2.5	0.6	0.2	3084	769	116.58
	ROE-GN	0.0	0.0	0.0	31.9	59.6	8.5	0.0	0.0	0.0	0.0	47	47	0.76
1975/76	OTHER	0.0	0.0	4.9	6.8	9.9	16.7	17.9	35.2	8.6	0.0	162	1661	30.99
	ROE-SN	0.0	0.0	0.8	6.9	31.7	50.1	7.3	2.4	0.8	0.0	713	654	204.01
	ROE-GN	0.0	0.0	0.0	15.8	57.9	22.8	3.5	0.0	0.0	0.0	57	57	17.93
1976/77	OTHER	0.0	0.4	23.5	15.7	22.9	16.6	10.8	7.4	2.3	0.4	511	276	61.55
	ROE-SN	0.0	0.1	16.0	3.7	22.7	37.8	15.0	3.3	0.9	0.5	1310	1344	370.40
	ROE-GN	0.0	0.0	1.1	2.1	19.9	54.1	14.6	6.8	1.4	0.0	281	1104	89.48
1977/78	OTHER	0.0	1.3	9.6	27.8	18.2	18.1	14.6	6.9	2.4	1.0	982	124	238.36
	ROE-SN	0.0	1.1	11.7	32.8	9.6	21.1	20.4	2.4	0.6	0.3	795	131	136.94
	ROE-GN	0.0	0.0	0.0	20.5	6.0	32.5	33.1	6.6	1.3	0.0	151	37	181.42
1978/79	OTHER	0.0	1.8	9.3	9.8	25.9	17.8	16.2	9.5	5.7	4.0	1435	856	118.66
	ROE-SN	0.0	2.7	18.2	11.5	29.2	11.5	18.3	6.5	1.4	0.8	958	1475	84.40
	ROE-GN	0.0	1.1	1.1	8.0	41.4	15.7	22.2	8.0	1.9	0.4	261	255	74.00
1979/80	OTHER	0.0	1.1	61.2	6.5	7.9	8.2	6.5	4.9	2.1	1.6	1161	560	66.18
	ROE-SN	0.0	0.6	77.9	7.3	5.1	3.8	3.5	1.3	0.4	0.1	2811	535	171.81
	ROE-GN	0.0	0.0	3.4	8.7	31.2	22.3	21.1	9.1	3.4	0.6	493	915	63.73
1980/81	OTHER	0.0	1.0	7.4	54.6	9.3	10.2	9.3	4.3	2.3	1.5	6524	1129	137.14
	ROE-SN	0.0	0.5	11.2	81.2	3.3	1.7	1.5	0.4	0.2	0.1	3238	1059	106.00
	ROE-GN	0.0	0.0	0.5	38.9	15.5	23.0	14.8	5.6	1.9	0.0	427	557	23.77
1981/82	OTHER	0.0	1.5	11.5	20.5	41.1	10.5	6.6	5.0	2.1	1.1	2669	555	138.82
	ROE-SN	0.0	2.7	18.8	7.4	66.3	2.8	1.4	0.4	0.2	0.0	1544	576	16.50
1982/83	ROE-SN	0.0	1.4	20.8	17.7	5.3	49.2	3.7	1.1	0.6	0.2	4583	1448	1.00~
1983/84	OTHER	0.0	2.8	36.2	15.7	13.9	9.8	16.4	2.8	1.1	1.4	654	303	23.68
	ROE-SN	0.0	0.5	35.5	14.4	10.3	14.4	23.6	1.0	0.2	0.1	2837	618	159.00
	ROE-GN	0.0	0.0	1.0	2.0	12.9	21.4	57.4	3.4	1.2	0.8	505	961	127.31
1984/85	OTHER	0.0	15.4	8.2	25.8	28.2	11.7	5.4	4.1	0.8	0.3	631	45	28.24
	ROE-SN	0.0	0.2	7.8	54.7	11.9	6.4	10.6	8.2	0.1	0.1	3664	969	278.16
	ROE-GN	0.0	0.0	0.4	16.4	14.9	15.8	21.8	29.8	0.4	0.5	550	543	235.00
1985/86	OTHER	0.0	11.7	9.9	8.0	21.3	18.6	11.7	6.6	6.9	5.2	767	512	25.39
	ROE-SN	0.0	1.8	13.8	9.4	46.3	10.8	5.3	7.1	5.5	0.1	5655	4566	277.60
	ROE-GN	0.0	0.0	0.4	4.3	53.8	19.0	8.7	7.8	5.7	0.2	1274	558	311.02
1986/87	ROE-SN	0.0	0.9	38.6	10.2	6.9	29.9	5.9	3.5	2.9	1.2	4731	4068	187.95"
	ROE-GN	0.0	0.0	0.6	3.0	6.9	55.3	16.1	8.8	6.0	3.4	1761	819	270.57
1987/88	ROE-SN	0.0	0.5	30.9	39.0	5.9	8.4	11.6	1.9	1.4	0.4	4222	2993	353.56"
	ROE-GN	0.0	0.0	0.4	6.5	7.2	21.5	44.8	11.7	5.1	2.8	710	421	276.81
1988/89	ROE-SN	0.0	0.6	21.7	36.1	27.7	4.9	4.5	3.6	0.6	0.3	3616	1265	321.70
	ROE-GN	0.0	0.0	0.0	4.6	30.5	13.7	23.5	21.8	3.4	2.5	476	432	309.49

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1	2	3	4	5	6	7	8	9	10
REDUCTION	21.8	43.9	79.3	107.9	128.2	146.1	163.1	173.5	188.7	206.8
ROE-SN	8.6	53.3	83.9	113.9	138.2	157.2	171.4	185.0	193.7	205.7
ROE-GN	0.0	90.3	115.5	136.7	147.8	162.0	169.1	176.6	187.8	192.7
OTHER	17.4	46.9	80.7	110.0	132.8	151.0	166.3	178.4	188.0	203.6

Appendix Table 1.3. 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-3})
1950/51	REDUCTION	0.0	2.4	28.5	50.6	12.0	5.1	1.2	0.1	0.0	0.0	5318	2484	3905.26
1951/52	REDUCTION	1.1	5.1	19.9	29.7	37.7	4.4	1.5	0.4	0.0	0.0	5214	1352	2954.66
1952/53	REDUCTION	0.4	9.3	28.0	23.9	26.5	10.1	1.3	0.4	0.0	0.0	2939	537	73.85
1953/54	REDUCTION	0.1	3.9	69.6	20.2	4.6	1.3	0.2	0.0	0.1	0.0	3191	477	3478.53
1954/55	REDUCTION	0.3	6.6	7.7	74.4	9.1	1.5	0.4	0.0	0.0	0.0	2350	164	1237.50
1955/56	REDUCTION	0.0	16.9	13.6	9.2	57.0	2.9	0.3	0.0	0.0	0.0	5054	1351	4136.15
1956/57	REDUCTION	0.0	16.7	50.7	10.8	6.2	14.8	0.7	0.0	0.0	0.0	4688	1703	2635.45
1957/58	REDUCTION	0.0	23.5	61.4	12.7	1.3	0.6	0.6	0.0	0.0	0.0	3743	847	1445.86
1958/59	REDUCTION	0.4	3.8	49.3	36.7	8.1	0.8	0.4	0.4	0.0	0.0	4996	1337	3305.21
1959/60	REDUCTION	0.0	43.5	23.2	26.5	5.6	1.1	0.1	0.1	0.0	0.0	1416	165	639.45
1960/61	REDUCTION	0.0	16.1	32.2	10.8	29.7	10.1	0.9	0.1	0.1	0.0	2799	1227	3463.55
1961/62	REDUCTION	0.0	9.7	57.4	17.9	2.6	9.9	2.4	0.1	0.0	0.0	808	146	1721.99
1962/63	REDUCTION	0.0	0.4	30.3	58.0	5.4	2.9	2.9	0.2	0.0	0.0	1087	885	4376.33
1963/64	REDUCTION	0.0	13.1	47.4	27.7	10.3	1.4	0.1	0.0	0.0	0.0	1258	198	3507.73
1964/65	REDUCTION	0.0	8.2	36.4	33.8	15.8	5.4	0.3	0.1	0.0	0.0	1750	684	1326.51
1965/66	REDUCTION	8.7	61.5	18.7	6.7	3.3	1.0	0.2	0.0	0.0	0.0	0*	25	5565.20
1966/67	REDUCTION	1.2	37.0	45.6	12.9	2.0	1.0	0.2	0.1	0.0	0.0	0*	25	2538.06
1967/68	REDUCTION	1.8	32.0	47.2	16.7	2.1	0.3	0.0	0.1	0.0	0.0	0*	25	172.48
1968/69	OTHER	16.1	27.0	23.2	22.4	9.5	1.6	0.1	0.0	0.0	0.0	0*	25	11.56
1969/70	OTHER	39.5	32.7	26.9	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0*	25	39.77
1970/71	OTHER	0.1	14.4	39.6	36.8	3.8	4.2	0.9	0.1	0.1	0.0	953	135	339.63
1971/72	ROE-SN	0.0	4.4	29.8	27.7	25.7	6.9	4.4	1.1	0.1	0.0	1837	598	762.73"
	ROE-GN	0.0	0.0	0.9	14.9	65.0	10.6	7.9	0.6	0.0	0.0	329	503	8.47
1972/73	ROE-SN	0.0	1.2	50.5	18.6	15.5	11.7	1.9	0.5	0.2	0.0	1328	593	539.55"
	ROE-GN	0.0	0.0	2.5	25.3	44.9	20.9	4.4	1.3	0.6	0.0	158	114	71.26
1973/74	ROE-SN	0.0	2.8	17.7	38.6	19.7	13.4	6.6	0.9	0.3	0.0	1587	202	282.57
	ROE-GN	0.0	0.0	0.4	22.8	37.7	24.8	12.3	1.8	0.2	0.0	496	101	332.81
1974/75	ROE-SN	0.3	1.2	32.9	25.4	27.8	8.6	3.2	0.7	0.1	0.0	8923	3300	278.78
	ROE-GN	0.0	0.0	3.3	25.6	46.2	16.4	6.4	2.1	0.0	0.0	519	117	348.42
1975/76	ROE-SN	0.0	3.0	11.8	41.2	20.9	16.8	4.5	1.5	0.2	0.0	5418	973	493.71
	ROE-GN	0.0	0.0	0.8	18.8	29.8	35.3	11.8	3.0	0.4	0.1	1222	253	383.45
1976/77	OTHER	0.0	1.0	32.8	18.7	29.8	8.1	6.6	3.0	0.0	0.0	198	144	32.75
	ROE-SN	0.0	0.7	17.4	22.6	31.8	16.6	8.5	1.9	0.4	0.0	2496	925	284.27
	ROE-GN	0.0	0.0	1.1	13.0	35.5	31.6	13.5	4.0	1.3	0.0	453	169	411.71
1977/78	ROE-SN	0.0	0.2	25.7	15.2	19.9	23.1	10.9	3.5	1.1	0.4	1396	589	354.31
	ROE-GN	0.0	0.0	1.3	8.9	29.6	38.1	17.7	3.8	0.5	0.1	1075	474	576.00
1979/80	ROE-SN	0.0	3.7	73.1	6.4	9.0	4.0	2.6	0.7	0.4	0.1	2582	1401	1.12"
	ROE-GN	0.0	0.0	3.3	2.6	24.8	23.7	26.3	11.3	6.6	1.5	274	210	32.46
1980/81	ROE-SN	0.0	2.0	12.3	66.6	8.4	7.0	2.6	0.6	0.3	0.1	2952	492	25.75"
	ROE-GN	0.0	0.3	1.5	50.7	13.6	15.4	10.6	5.5	1.8	0.7	1536	276	163.04
1981/82	ROE-SN	0.0	1.7	15.6	10.7	60.2	5.2	4.6	1.5	0.5	0.1	3508	2296	188.15"
	ROE-GN	0.0	0.0	2.4	5.9	76.0	6.7	5.9	2.3	0.7	0.1	1337	301	287.08
1982/83	ROE-SN	0.0	0.5	7.0	15.4	10.8	57.1	5.0	3.1	0.7	0.3	5445	1082	154.75
	ROE-GN	0.0	0.0	0.5	7.2	13.1	69.4	5.0	3.9	0.6	0.3	1793	994	244.49
1983/84	ROE-SN	0.0	4.4	7.3	10.1	18.2	16.1	40.7	2.3	0.8	0.1	6294	2209	284.16"
	ROE-GN	0.0	0.0	0.3	2.9	13.1	17.3	60.1	4.7	1.1	0.5	1159	338	242.25
1984/85	ROE-SN	0.0	2.7	37.5	7.5	8.6	13.1	11.9	18.2	0.4	0.1	5157	5529	222.13
	ROE-GN	0.0	0.0	3.2	5.4	9.4	19.5	22.5	38.2	1.0	0.8	1288	1407	143.53
1985/86	ROE-SN	0.0	3.9	16.4	40.2	8.6	6.3	6.7	6.1	11.3	0.5	5819	2074	163.81"
	ROE-GN	0.0	0.0	1.8	23.9	12.0	10.0	16.0	13.2	22.3	0.8	1069	262	73.95
1986/87	ROE-SN	0.0	4.1	22.6	14.6	32.2	5.7	4.5	5.8	4.7	5.8	5038	2318	193.73
	ROE-GN	0.0	0.0	0.8	7.7	44.9	11.7	7.8	9.9	8.2	9.0	981	1199	55.71
1987/88	ROE-SN	0.0	1.1	67.9	11.7	6.3	7.1	1.7	1.5	1.5	1.2	5205	2732	343.86"
	ROE-GN	0.0	0.0	4.2	10.2	14.8	27.2	15.2	7.4	10.1	10.8	566	158	59.81
1988/89	ROE-SN	0.0	1.3	4.6	76.2	9.2	3.6	2.8	0.8	0.8	0.8	5643	1937	551.12
	ROE-GN	0.0	0.0	0.3	27.6	25.1	17.3	16.5	5.8	3.7	3.8	710	259	163.97

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	16.1	43.8	79.8	104.7	125.6	138.1	150.4	156.2	153.5	179.0
ROE-SN	16.2	54.6	88.5	114.6	136.5	155.0	170.3	183.6	195.9	206.4
ROE-GN	0.0	39.3	114.1	138.0	150.2	161.3	170.7	180.9	187.0	185.7
OTHER	16.1	48.9	84.7	110.1	131.6	147.1	161.4	172.3	186.3	201.5

Appendix Table 1.4. 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-3})
1950/51	REDUCTION	0.1	3.5	45.5	38.5	9.5	2.1	0.6	0.2	0.0	0.0	3554	526	1733.55
1951/52	REDUCTION	0.1	13.0	52.2	26.4	6.8	1.5	0.1	0.0	0.0	0.0	4533	570	1857.54
1952/53	REDUCTION	0.4	12.9	49.7	30.3	4.8	1.6	0.3	0.1	0.0	0.0	5343	707	545.54
1953/54	REDUCTION	0.0	2.3	34.0	39.2	16.7	5.7	1.7	0.4	0.0	0.0	6856	2388	1934.55
1954/55	REDUCTION	0.0	5.5	40.9	44.2	7.7	1.6	0.1	0.0	0.0	0.0	2657	360	2903.78
1955/56	REDUCTION	0.0	9.5	16.4	28.1	36.9	7.4	1.2	0.4	0.1	0.0	4919	925	2587.73
1956/57	REDUCTION	0.0	0.9	36.8	25.1	24.3	11.5	1.3	0.1	0.0	0.0	2420	497	1848.17
1957/58	REDUCTION	0.0	6.4	44.3	23.4	9.5	9.6	5.8	0.8	0.1	0.0	3473	617	890.18
1958/59	REDUCTION	0.8	16.8	62.4	16.3	2.8	0.5	0.3	0.1	0.0	0.0	4454	1799	4185.81
1959/60	REDUCTION	0.0	14.1	39.7	39.2	5.8	0.8	0.3	0.1	0.0	0.1	1252	231	2428.73
1960/61	REDUCTION	0.0	21.7	22.8	30.0	22.0	3.1	0.4	0.0	0.0	0.0	1302	222	1771.58
1961/62	REDUCTION	0.0	13.3	63.4	12.7	7.2	2.8	0.6	0.0	0.0	0.0	1506	584	3439.44
1962/63	REDUCTION	0.0	20.8	48.3	24.5	3.4	1.8	0.9	0.2	0.0	0.0	1161	144	4278.29
1963/64	REDUCTION	0.0	5.8	64.7	26.5	2.3	0.6	0.1	0.0	0.0	0.0	2224	639	3714.95
1964/65	REDUCTION	0.2	14.1	53.3	28.3	2.7	1.1	0.3	0.1	0.0	0.0	2095	529	2668.48
1965/66	REDUCTION	0.0	19.5	36.8	23.0	15.9	3.2	1.6	0.0	0.0	0.0	435	77	1851.57
1966/67	REDUCTION	8.1	28.4	47.7	10.5	3.0	1.9	0.3	0.0	0.0	0.0	0*	25	1198.37
1967/68	REDUCTION	13.0	20.0	50.6	13.0	2.5	0.6	0.2	0.1	0.0	0.0	0*	25	103.87
1968/69	OTHER	18.2	59.4	19.6	2.4	0.4	0.0	0.0	0.0	0.0	0.0	0*	25	52.86
1969/70	OTHER	0.6	23.6	62.9	11.1	1.4	0.5	0.0	0.0	0.0	0.0	0*	25	51.64
1970/71	OTHER	0.5	12.9	42.3	34.4	6.6	2.8	0.5	0.0	0.0	0.0	1060	239	82.74
1971/72	OTHER	0.0	1.5	27.6	36.8	26.1	5.4	2.3	0.3	0.0	0.0	1039	3596	73.26
	ROE-SN	0.0	4.0	42.3	30.3	18.4	4.0	1.0	0.0	0.0	0.0	2773	265	518.15
	ROE-GN	0.0	1.1	12.5	50.2	28.0	6.5	1.1	0.4	0.4	0.0	279	214	0.22
1972/73	OTHER	0.1	0.5	23.5	33.0	26.8	13.9	1.9	0.3	0.0	0.0	3915	1785	266.29
	ROE-SN	0.0	4.2	54.9	21.4	12.9	6.1	0.5	0.0	0.0	0.0	379	615	141.70
	ROE-GN	0.0	0.0	5.5	27.3	52.7	10.9	3.6	0.0	0.0	0.0	55	55	88.52
1973/74	ROE-GN	0.0	0.0	3.6	43.1	33.1	16.9	2.9	0.3	0.0	0.0	661	320	204.10"^
1974/75	OTHER	1.1	22.1	60.4	12.3	2.1	1.4	0.5	0.0	0.2	0.0	439	15	65.94
	ROE-SN	1.7	3.5	57.3	27.0	7.1	2.6	0.5	0.2	0.1	0.0	3092	662	50.23
	ROE-GN	0.0	0.0	6.7	31.9	43.7	13.4	3.4	0.8	0.0	0.0	119	26	283.37
1975/76	OTHER	0.1	7.9	17.6	34.9	25.5	8.6	3.7	1.3	0.2	0.1	1380	553	150.55
	ROE-SN	0.0	13.3	26.3	43.3	14.1	2.2	0.3	0.4	0.0	0.0	729	97	20.92
	ROE-GN	0.0	0.0	0.5	39.1	44.0	12.9	3.0	0.4	0.1	0.0	737	269	405.21
1976/77	OTHER	0.0	3.2	19.7	24.8	36.9	14.6	0.6	0.0	0.0	0.0	157	254	46.34
	ROE-SN	0.1	3.3	57.8	20.8	14.4	3.0	0.4	0.2	0.0	0.0	2234	1269	370.86
	ROE-GN	0.0	0.0	3.2	26.1	48.7	17.2	4.1	0.6	0.1	0.0	1423	162	466.14
1977/78	OTHER	0.1	4.7	38.0	28.4	9.6	11.6	5.7	1.2	0.5	0.1	758	205	364.13
	ROE-SN	0.0	0.8	34.8	42.8	11.9	7.7	1.5	0.3	0.0	0.1	3146	2299	353.53
	ROE-GN	0.0	0.0	0.4	19.7	31.4	35.1	11.3	1.7	0.4	0.0	462	690	426.90
1978/79	OTHER	0.0	1.2	16.2	36.6	25.3	10.9	7.7	1.6	0.4	0.1	764	201	164.24
	ROE-SN	0.0	1.0	17.7	31.0	32.5	10.2	5.8	1.5	0.2	0.0	889	311	1.00~
	ROE-GN	0.0	0.0	1.2	23.2	54.7	13.5	5.8	1.5	0.0	0.2	607	290	441.80
1979/80	OTHER	1.4	5.0	40.4	21.9	18.6	8.1	2.8	1.5	0.3	0.0	2101	1071	126.33
	ROE-SN	0.0	2.4	48.5	16.5	18.0	10.4	2.6	1.3	0.3	0.1	3548	1368	16.93
	ROE-GN	0.0	0.0	2.0	9.2	44.6	33.4	8.8	1.9	0.3	0.0	754	1139	215.21
1980/81	OTHER	0.0	1.8	40.6	36.5	13.3	4.7	2.1	0.5	0.5	0.0	655	212	26.24
	ROE-SN	0.0	6.8	36.9	30.5	11.4	9.7	3.8	0.6	0.3	0.0	7083	2254	202.01
	ROE-GN	0.0	0.1	2.2	18.2	23.0	37.4	16.1	2.8	0.3	0.1	1140	338	333.10
1981/82	OTHER	0.0	0.0	25.8	35.2	28.3	4.4	2.5	2.5	0.0	1.3	159	123	12.34
	ROE-SN	0.0	4.8	31.5	26.3	23.1	5.2	5.7	2.7	0.6	0.1	3304	1659	1.28
	ROE-GN	0.0	0.0	4.4	15.4	28.5	14.8	20.8	14.2	1.7	0.4	833	543	367.36
1982/83	OTHER	0.0	27.2	47.2	13.9	7.8	2.8	0.0	1.1	0.0	0.0	180	523	10.56
	ROE-SN	0.0	2.4	31.8	28.4	17.8	12.1	3.3	2.9	1.2	0.2	9836	6124	676.25
	ROE-GN	0.0	0.0	0.5	27.8	29.5	23.6	9.3	7.4	1.7	0.2	407	305	563.81
1983/84	OTHER	0.0	8.7	39.4	28.5	11.0	7.3	3.7	1.4	0.0	0.0	355	66	19.33
	ROE-SN	0.0	4.7	39.3	31.4	12.8	6.6	3.5	1.0	0.5	0.1	5747	1917	351.51
	ROE-GN	0.0	0.0	7.0	30.2	31.1	19.2	9.3	1.7	0.7	0.9	766	759	421.50
1984/85	OTHER	0.0	13.1	50.8	20.3	10.2	4.0	1.3	0.3	0.0	0.0	679	380	11.60
	ROE-SN	0.0	21.9	45.6	19.1	8.5	3.1	1.3	0.5	0.1	0.0	5677	2317	288.55
	ROE-GN	0.0	0.1	3.1	26.1	32.5	23.6	9.2	3.7	0.8	0.8	1096	650	237.16
1985/86	OTHER	0.0	16.3	48.8	27.9	2.3	4.7	0.0	0.0	0.0	0.0	86	86	14.64
	ROE-SN	0.1	8.9	54.8	25.9	7.1	2.2	0.8	0.2	0.1	0.0	4454	1587	17.16
1986/87	ROE-SN	0.0	5.8	32.6	38.8	17.0	4.0	1.2	0.4	0.2	0.1	6433	2405	321.49"
	ROE-GN	0.0	0.0	2.0	32.7	34.5	17.6	9.7	2.7	0.5	0.3	1277	652	145.34
1987/88	OTHER	0.0	0.0	45.5	22.7	22.7	8.0	1.1	0.0	0.0	0.0	88	88	4.04
	ROE-SN	0.0	3.8	57.7	15.6	16.7	4.7	1.1	0.3	0.1	0.0	4996	1541	145.97
	ROE-GN	0.0	0.0	9.1	14.9	48.1	19.5	5.5	2.3	0.4	0.2	821	383	414.24
1988/89	ROE-SN	0.0	7.1	19.3	55.4	9.1	6.9	1.8	0.3	0.0	0.0	4797	1287	157.69
	ROE-GN	0.0	0.0	1.6	40.2	22.0	25.9	7.8	2.2	0.4	0.0	823	1143	411.07

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	14.9	45.6	83.8	110.5	132.7	149.2	169.0	174.4	194.0	188.3
ROE-SN	15.7	56.9	82.5	110.2	131.2	149.1	165.6	175.4	176.5	185.7
ROE-GN	0.0	67.2	119.0	137.3	149.0	160.4	168.6	181.0	178.0	186.4
OTHER	16.0	51.7	84.3	110.7	132.9	150.7	168.3	170.2	177.5	181.0

Appendix Table 1.5. 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	REDUCTION	0.0	4.7	65.6	23.5	5.1	0.9	0.1	0.0	0.0	0.0	4262	1605	2688.26
1951/52	REDUCTION	0.1	9.3	58.5	23.7	6.7	1.2	0.4	0.1	0.0	0.0	4499	1222	2966.21
1952/53	REDUCTION	0.1	3.9	65.9	26.6	3.0	0.6	0.0	0.0	0.0	0.0	3320	1258	493.14
1953/54	REDUCTION	0.0	0.7	58.4	34.2	5.9	0.6	0.1	0.0	0.0	0.0	6306	2318	4668.76
1954/55	REDUCTION	0.0	3.3	56.4	33.8	5.7	0.6	0.1	0.0	0.0	0.0	2634	714	4115.48
1955/56	REDUCTION	0.0	4.5	53.8	29.5	10.4	1.5	0.2	0.0	0.0	0.0	4913	2414	4726.81
1956/57	REDUCTION	0.0	1.6	70.8	21.0	4.2	2.0	0.3	0.1	0.0	0.0	5059	2139	4146.45
1957/58	REDUCTION	0.0	11.3	63.5	21.0	2.9	1.0	0.3	0.1	0.0	0.0	3924	1050	1379.36
1958/59	REDUCTION	0.8	17.1	64.2	14.6	2.4	0.6	0.2	0.1	0.0	0.0	5586	2067	1946.50
1959/60	REDUCTION	0.0	4.5	57.2	35.2	2.5	0.4	0.1	0.1	0.0	0.0	2490	1351	4499.74
1960/61	REDUCTION	0.0	35.7	29.1	25.5	8.8	0.8	0.1	0.0	0.0	0.0	3049	620	3469.79
1961/62	REDUCTION	0.0	5.2	76.0	13.6	3.6	1.4	0.2	0.1	0.0	0.0	1697	412	3696.98
1962/63	REDUCTION	0.0	14.4	53.6	29.2	2.6	0.2	0.1	0.0	0.0	0.0	1148	308	3870.31
1963/64	REDUCTION	0.1	6.2	56.3	34.0	2.9	0.4	0.1	0.1	0.0	0.0	1804	625	3796.46
1964/65	REDUCTION	0.0	16.2	58.1	22.6	2.3	0.7	0.0	0.2	0.0	0.0	1259	451	1965.81
1965/66	REDUCTION	0.0	31.0	32.7	23.8	11.1	1.0	0.5	0.0	0.0	0.0	416	36	1332.91
1966/67	REDUCTION	13.6	37.4	33.8	11.2	2.7	1.0	0.2	0.0	0.1	0.0	0*	25	2516.94
1967/68	REDUCTION	69.3	15.8	9.0	4.3	1.0	0.4	0.0	0.2	0.0	0.0	0*	25	245.19
1968/69	OTHER	24.6	38.1	23.0	10.4	2.8	1.1	0.0	0.0	0.0	0.0	0*	25	60.68
1969/70	OTHER	0.4	27.4	57.2	7.8	5.1	1.0	1.1	0.0	0.0	0.0	0*	25	38.15
1970/71	OTHER	0.0	10.6	33.4	42.1	8.6	2.8	2.2	0.3	0.0	0.0	359	162	64.38
1971/72	OTHER	0.0	13.8	33.5	33.8	15.1	2.7	1.0	0.1	0.0	0.0	2625	807	154.95
	ROE-SN	0.0	14.0	28.6	36.0	17.4	2.8	1.0	0.2	0.0	0.0	2263	597	38.49
	ROE-GN	0.0	5.7	11.1	45.1	29.4	7.0	1.6	0.1	0.0	0.0	756	151	9.59
1972/73	OTHER	0.0	3.4	49.6	21.2	18.6	5.5	1.1	0.5	0.1	0.0	797	203	27.12
	ROE-GN	0.0	0.0	21.3	31.4	32.5	11.2	3.0	0.6	0.0	0.0	169	56	43.63
1973/74	OTHER	0.0	17.4	73.3	8.1	1.2	0.0	0.0	0.0	0.0	0.0	86	86	39.04
	ROE-GN	0.0	0.0	7.3	40.4	27.7	16.1	6.4	2.1	0.0	0.0	329	268	30.21
1974/75	ROE-SN	0.0	3.9	50.1	28.6	8.7	4.3	3.1	0.9	0.3	0.0	2154	597	2.49"
	ROE-GN	0.0	0.0	1.6	64.5	21.0	9.7	3.2	0.0	0.0	0.0	62	62	68.22
1975/76	OTHER	0.0	5.5	21.7	44.3	19.7	5.2	2.3	0.8	0.5	0.0	3023	965	249.87
	ROE-SN	0.0	9.6	22.1	35.5	16.0	5.6	6.1	3.6	1.3	0.3	394	108	1.00~
	ROE-GN	0.0	0.0	0.7	41.5	41.5	11.6	2.7	2.0	0.0	0.0	147	126	63.84
1976/77	OTHER	0.6	4.2	52.5	21.7	15.2	3.8	1.3	0.5	0.2	0.1	2512	788	472.92
	ROE-SN	0.0	4.8	18.4	8.0	15.2	19.2	16.0	11.2	4.8	2.4	125	136	23.00
	ROE-GN	0.0	0.0	4.6	48.6	35.4	10.3	1.1	0.0	0.0	0.0	175	5	48.06
1977/78	OTHER	0.0	1.2	35.1	45.8	10.6	5.6	1.3	0.1	0.2	0.1	1709	391	819.26
	ROE-SN	0.0	1.1	40.5	46.2	7.5	4.3	0.4	0.0	0.0	0.0	279	132	1.00~
	ROE-GN	0.0	0.0	1.9	23.1	24.0	38.5	12.5	0.0	0.0	0.0	104	433	57.85
1978/79	OTHER	0.0	1.9	18.6	37.8	29.0	8.0	3.3	1.0	0.3	0.1	4699	1796	922.01
	ROE-SN	0.0	2.7	24.0	35.6	20.2	7.9	4.0	3.1	1.3	1.2	520	98	1.00~
1979/80	OTHER	0.0	1.4	45.4	24.0	17.7	8.4	1.7	1.1	0.3	0.1	2842	1954	109.21
	ROE-SN	0.0	3.0	57.9	12.0	15.9	6.8	2.9	0.8	0.2	0.5	591	189	1.00~
1980/81	OTHER	0.0	3.9	33.3	33.9	15.9	9.1	3.2	0.5	0.1	0.0	4505	2225	390.60
	ROE-SN	0.0	8.6	38.4	29.9	10.6	8.8	2.8	0.6	0.2	0.0	648	255	1.00~
1981/82	OTHER	0.0	3.6	39.0	31.5	15.3	5.8	3.9	0.8	0.1	0.0	2369	1384	303.92
	ROE-SN	0.0	8.7	39.7	23.1	17.4	3.8	4.5	2.2	0.5	0.0	2096	1168	302.55
1982/83	OTHER	0.0	0.8	16.6	32.0	23.2	13.2	4.9	5.7	3.0	0.6	1910	1526	47.33
	ROE-SN	0.0	5.8	29.8	28.7	18.3	8.7	2.8	3.8	1.6	0.5	2126	975	22.47
1983/84	OTHER	0.0	16.2	30.0	21.9	18.5	8.3	3.3	0.9	0.5	0.4	1527	555	52.95
	ROE-SN	0.0	21.9	31.4	18.8	13.4	9.3	2.6	1.5	0.6	0.3	1406	790	43.55
1984/85	OTHER	0.0	33.4	37.1	18.7	6.7	2.8	0.9	0.4	0.1	0.0	1843	288	64.51
	ROE-SN	0.0	29.3	39.1	18.5	6.3	4.2	1.5	0.9	0.1	0.0	2155	693	12.24
1985/86	OTHER	0.0	13.1	59.1	19.7	6.2	1.4	0.4	0.1	0.0	0.0	777	156	27.93
	ROE-SN	0.0	20.8	59.2	13.8	4.1	1.3	0.7	0.1	0.1	0.0	1961	542	1.00~
1986/87	OTHER	0.0	21.8	34.7	31.0	10.0	1.9	0.5	0.2	0.0	0.0	882	204	14.91
	ROE-SN	0.0	27.6	35.8	28.0	6.4	1.4	0.6	0.2	0.0	0.1	1257	246	1.00~
	ROE-GN	0.0	0.0	3.6	41.4	31.4	14.3	6.1	2.5	0.6	0.2	643	926	266.33
1987/88	OTHER	0.2	3.9	61.6	16.6	14.5	2.2	0.6	0.2	0.1	0.0	829	1087	65.03
	ROE-SN	0.0	8.0	72.3	11.1	7.0	1.0	0.5	0.0	0.0	0.0	922	494	1.00~
1988/89	ROE-SN	0.0	18.4	14.1	47.8	10.5	7.8	1.0	0.3	0.0	0.1	1633	479	1.00~

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	13.1	58.3	93.8	118.7	143.0	160.2	174.4	187.2	193.1	222.2
ROE-SN	0.0	59.8	87.4	113.0	135.1	160.3	171.9	192.0	201.4	208.9
ROE-GN	0.0	59.4	112.0	140.0	154.0	167.8	178.1	176.7	199.0	213.0
OTHER	15.2	56.2	88.9	112.5	134.7	158.6	168.7	181.6	197.1	207.8

Appendix Table 1.6. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the southern west coast Vancouver Island 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^-3)
1950/51	REDUCTION	0.1	13.1	38.1	40.6	6.4	1.3	0.3	0.0	0.0	0.0	3843	551	1630.59
1951/52	REDUCTION	0.1	5.3	65.5	20.1	7.9	0.8	0.2	0.0	0.0	0.0	1686	593	1105.57
1952/53	REDUCTION	0.1	8.9	55.7	32.8	2.0	0.5	0.0	0.0	0.0	0.0	2777	1417	2.36
1953/54	REDUCTION	0.0	2.8	64.3	26.5	5.5	0.6	0.1	0.1	0.0	0.0	5730	2473	3086.25
1954/55	REDUCTION	0.0	16.8	59.4	19.7	3.4	0.6	0.0	0.0	0.0	0.0	2510	699	706.20
1955/56	REDUCTION	0.0	12.4	64.3	16.0	6.1	1.1	0.2	0.0	0.0	0.0	4653	2257	1931.15
1956/57	REDUCTION	0.0	2.7	71.9	24.8	0.3	0.2	0.0	0.0	0.0	0.0	588	497	312.93
1957/58	REDUCTION	0.0	15.6	55.3	25.0	4.0	0.1	0.0	0.0	0.0	0.0	707	432	68.62
1958/59	REDUCTION	0.0	6.4	61.0	25.1	6.0	1.0	0.1	0.2	0.1	0.0	2066	1383	4315.70
1959/60	REDUCTION	0.0	26.9	48.2	19.7	4.1	0.6	0.4	0.2	0.0	0.0	539	189	1988.85
1960/61	REDUCTION	0.0	52.7	33.9	10.0	3.1	0.2	0.0	0.0	0.0	0.0	419	54	1719.68
1961/62	REDUCTION	0.0	5.1	78.2	12.1	3.7	0.9	0.0	0.0	0.0	0.0	751	386	1659.51
1962/63	REDUCTION	0.0	3.5	44.4	45.5	5.6	0.8	0.2	0.0	0.0	0.0	886	316	404.28
1963/64	REDUCTION	0.0	2.6	60.8	25.5	10.1	0.8	0.3	0.0	0.0	0.0	1134	1003	1989.83
1964/65	REDUCTION	0.0	2.3	34.7	49.3	9.8	3.5	0.4	0.0	0.0	0.0	775	344	1141.93
1965/66	REDUCTION	0.0	0.3	41.3	33.3	21.3	2.7	1.0	0.0	0.0	0.0	300	403	636.21
1966/67	REDUCTION	2.4	20.7	55.5	16.7	3.4	0.8	0.3	0.2	0.0	0.0	0*	25	859.81
1971/72	ROE-SN	0.0	4.1	19.9	50.8	20.0	3.3	1.1	0.8	0.0	0.0	1222	843	319.50
1972/73	ROE-SN	0.0	0.9	32.3	24.1	31.0	10.1	1.3	0.3	0.1	0.0	1967	1330	678.19
	ROE-GN	0.0	0.0	7.9	22.9	51.8	13.5	2.9	1.0	0.2	0.0	624	526	63.80
1973/74	ROE-SN	0.0	12.1	45.1	25.7	11.0	5.0	1.0	0.1	0.0	0.0	3022	1434	341.88
	ROE-GN	0.0	0.0	26.1	30.7	26.1	13.6	3.4	0.0	0.0	0.0	176	30	207.72
1974/75	ROE-SN	0.0	0.7	46.5	21.9	14.2	9.4	5.7	1.4	0.2	0.0	6191	3025	901.22"
	ROE-GN	0.0	0.0	3.0	30.5	37.9	21.2	7.1	0.4	0.0	0.0	269	145	407.98
1975/76	ROE-SN	0.0	0.1	7.6	45.5	20.8	14.4	8.3	2.8	0.5	0.0	7026	1218	1358.83
	ROE-GN	0.0	0.0	0.7	41.8	33.6	15.3	5.9	2.3	0.3	0.1	1238	125	932.28
1976/77	ROE-SN	0.0	0.5	11.8	32.1	37.5	12.5	4.1	1.5	0.2	0.0	6171	1298	1226.50"
	ROE-GN	0.0	1.0	6.1	23.0	45.4	16.8	6.1	1.5	0.0	0.0	196	26	669.58
1977/78	OTHER	0.0	1.3	41.9	26.2	13.7	13.5	2.0	0.9	0.3	0.3	1727	416	183.29
	ROE-SN	0.0	0.5	35.1	18.7	18.6	20.8	4.8	1.3	0.2	0.1	5067	2353	381.15
	ROE-GN	0.0	0.0	1.2	5.3	20.1	49.6	17.3	5.8	0.5	0.2	417	84	730.95
1978/79	ROE-SN	0.0	0.5	9.9	39.2	18.5	16.4	11.9	2.6	0.8	0.2	2165	1149	411.88"
	ROE-GN	0.0	0.0	1.0	25.1	27.2	26.3	18.0	2.1	0.4	0.0	518	214	263.70
1979/80	ROE-SN	0.0	3.5	45.0	11.4	18.2	9.2	8.4	3.5	0.7	0.1	2037	1241	146.54"
	ROE-GN	0.0	0.0	0.0	4.4	40.7	25.6	16.8	11.4	0.8	0.3	386	717	36.65
1980/81	ROE-SN	0.0	4.0	37.7	26.4	10.6	11.5	6.4	2.8	0.6	0.0	3162	1247	251.13"
	ROE-GN	0.0	0.0	1.8	21.0	14.9	36.3	18.9	7.1	0.0	0.0	281	81	136.27
1981/82	ROE-SN	0.0	4.0	24.8	28.7	23.5	5.3	8.5	3.1	1.7	0.4	3930	2036	201.06"
	ROE-GN	0.0	0.0	0.3	17.3	39.5	11.4	23.3	5.4	2.6	0.3	352	216	49.47
1982/83	ROE-SN	0.0	4.5	23.3	22.8	21.7	16.2	4.0	5.3	1.2	1.1	2761	1911	476.41
1983/84	ROE-SN	0.0	20.5	36.8	14.1	9.6	10.5	6.1	1.1	1.1	0.2	2903	1266	485.38
1984/85	ROE-SN	0.0	21.1	50.2	16.1	4.1	2.9	3.4	1.8	0.1	0.3	2341	603	15.98"
1985/86	ROE-SN	0.0	4.2	48.8	27.2	10.3	3.9	2.7	2.1	0.7	0.1	3127	1073	16.49"
1986/87	ROE-SN	0.0	15.1	16.0	35.7	19.0	8.1	2.9	1.6	1.2	0.4	4050	2121	1014.35
1987/88	ROE-SN	0.0	2.5	60.9	7.3	15.5	9.2	3.1	0.8	0.5	0.3	6293	4239	666.23
	ROE-GN	0.0	0.0	5.4	7.0	40.8	29.4	12.8	3.0	1.2	0.4	500	607	86.65
1988/89	ROE-SN	0.0	2.8	15.7	62.6	6.4	8.2	3.4	0.7	0.1	0.0	4969	3549	793.42
	ROE-GN	0.0	0.0	0.3	54.5	11.0	22.3	9.4	1.6	1.0	0.0	382	145	221.81

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1	2	3	4	5	6	7	8	9	10
REDUCTION	22.9	57.2	89.9	112.9	132.2	149.3	156.4	166.8	173.2	237.6
ROE-SN	21.0	63.8	94.1	124.4	149.6	170.2	184.2	194.5	203.5	207.3
ROE-GN	0.0	45.5	107.9	137.0	154.0	168.2	179.9	183.2	187.5	194.6
OTHER	22.6	60.5	92.2	119.3	141.4	160.1	171.3	188.4	196.6	207.3

Appendix Table 1.7. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the northern west coast Vancouver Island 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	REDUCTION	0.0	1.5	27.0	54.1	12.8	3.6	1.0	0.0	0.0	0.0	196	190	566.14
1951/52	REDUCTION	0.0	0.2	10.2	27.5	52.2	7.1	2.1	0.5	0.1	0.0	3236	3206	1266.30
1953/54	REDUCTION	0.0	0.0	45.8	42.6	8.8	2.0	0.8	0.0	0.0	0.0	712	96	960.00
1954/55	REDUCTION	0.0	6.7	34.5	50.1	6.7	1.6	0.3	0.1	0.0	0.0	1486	558	628.76
1955/56	REDUCTION	0.0	10.0	58.1	9.5	19.0	2.6	0.5	0.2	0.1	0.0	0*	25	52.03
1956/57	REDUCTION	0.0	0.0	51.5	28.9	15.5	4.1	0.0	0.0	0.0	0.0	97	81	48.52
1957/58	REDUCTION	0.0	9.1	38.9	30.0	9.7	6.8	4.1	1.0	0.2	0.0	483	80	4.98
1958/59	REDUCTION	0.0	1.4	24.4	30.3	25.3	7.6	5.3	4.3	1.2	0.3	1599	1014	3194.28
1959/60	REDUCTION	0.0	5.0	56.8	23.8	9.6	3.2	1.0	0.4	0.2	0.1	2435	2242	3941.18
1960/61	REDUCTION	0.0	19.3	42.4	31.9	6.1	0.3	0.0	0.0	0.0	0.0	295	82	1840.47
1961/62	REDUCTION	0.0	7.1	78.7	9.4	3.1	1.1	0.6	0.0	0.0	0.0	1090	574	1362.97
1962/63	REDUCTION	0.0	0.5	47.3	47.4	3.7	0.9	0.1	0.0	0.0	0.0	1718	553	1658.16
1963/64	REDUCTION	0.0	1.0	53.8	28.2	15.9	1.0	0.0	0.0	0.0	0.0	195	239	182.93
1964/65	REDUCTION	0.0	0.9	22.2	43.6	26.5	4.7	0.4	0.9	0.9	0.0	234	93	352.62
1965/66	REDUCTION	0.0	13.6	26.8	26.1	23.2	9.1	1.2	0.0	0.0	0.0	0*	25	307.10
1966/67	REDUCTION	0.0	4.7	63.6	23.9	6.1	1.5	0.1	0.1	0.0	0.0	0*	25	506.07
1971/72	ROE-SN	0.0	0.3	13.8	38.7	40.7	4.3	1.4	0.6	0.3	0.0	349	99	177.82
1972/73	ROE-SN	0.0	0.2	24.5	24.8	35.0	13.0	2.3	0.2	0.2	0.0	609	358	557.43'
1973/74	ROE-SN	0.0	3.0	40.4	21.7	16.9	13.8	3.7	0.4	0.1	0.0	2398	2045	862.72'
1974/75	ROE-SN	0.0	0.5	66.3	16.3	6.6	5.4	3.7	1.1	0.1	0.0	4185	2248	685.51"'
1975/76	ROE-SN	0.0	0.5	12.8	51.5	16.7	8.2	7.5	2.5	0.3	0.0	2204	492	259.12
	ROE-GN	0.0	0.0	2.7	33.8	30.4	18.6	9.9	4.6	0.0	0.0	263	24	139.02
1976/77	ROE-SN	0.0	0.9	19.5	20.3	33.9	11.3	8.9	3.7	1.6	0.0	575	1613	52.30
	ROE-GN	0.0	0.0	0.0	8.6	39.5	18.5	19.8	9.9	3.1	0.6	162	92	180.00
1977/78	OTHER	0.0	1.3	49.6	15.0	14.4	16.3	2.6	0.6	0.3	0.0	701	259	81.77
	ROE-SN	0.0	1.7	69.0	13.3	6.4	5.8	2.2	1.5	0.1	0.1	896	650	78.36
	ROE-GN	0.0	0.0	1.1	2.7	21.8	41.0	23.4	8.5	1.1	0.5	188	65	209.21
1978/79	ROE-SN	0.0	1.2	18.1	65.2	9.1	3.3	2.7	0.3	0.1	0.1	1800	724	495.07
	ROE-GN	0.0	0.0	2.0	43.5	18.4	17.7	17.7	0.7	0.0	0.0	147	126	299.06
1979/80	ROE-SN	0.0	1.6	41.5	22.5	30.1	3.2	1.0	0.1	0.0	0.0	966	84	1.00~
	ROE-GN	0.0	0.0	2.1	9.9	77.3	8.5	1.4	0.7	0.0	0.0	141	123	159.85
1980/81	ROE-SN	0.0	1.3	15.2	54.5	10.5	16.5	1.9	0.1	0.0	0.0	1346	386	185.26
	ROE-GN	0.0	0.0	0.0	98.1	1.9	0.0	0.0	0.0	0.0	0.0	53	53	154.75
1981/82	ROE-SN	0.0	0.5	27.8	17.5	38.2	5.0	9.9	0.9	0.2	0.0	2173	499	21.25
	ROE-GN	0.0	0.0	0.8	7.9	47.6	11.5	29.0	3.1	0.2	0.0	620	564	197.84
1982/83	ROE-SN	0.0	2.8	18.3	19.1	20.9	27.2	5.7	5.9	0.2	0.0	545	132	1.00~
	ROE-GN	0.0	0.0	0.3	13.5	22.7	47.0	6.0	10.0	0.3	0.2	651	191	188.25
1983/84	ROE-SN	0.0	42.0	44.9	4.5	1.1	2.3	3.4	0.6	1.1	0.0	176	369	0.29"
	ROE-GN	0.0	0.0	1.0	5.6	28.1	25.9	32.5	4.2	2.4	0.2	1027	626	66.55
1984/85	ROE-SN	0.0	18.2	65.7	7.5	2.4	2.3	2.4	1.2	0.2	0.0	654	215	1.00~
1985/86	ROE-SN	0.0	2.4	47.2	44.1	2.5	1.1	1.2	0.9	0.6	0.0	1389	85	1.00~
1986/87	ROE-SN	0.0	14.1	22.6	23.1	36.4	2.1	0.3	0.5	0.4	0.4	940	289	1.00~
	ROE-GN	0.0	0.0	1.8	24.5	61.8	5.5	2.2	2.9	0.9	0.4	550	408	144.31
1987/88	ROE-SN	0.0	2.9	63.7	9.3	9.2	13.2	1.0	0.4	0.1	0.1	1637	814	0.02'
1988/89	ROE-SN	0.0	0.7	17.1	50.9	8.1	10.0	11.8	1.0	0.4	0.0	1304	283	1.00~

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1	2	3	4	5	6	7	8	9	10
REDUCTION	9.8	57.3	89.2	111.2	131.7	145.4	157.3	175.4	190.2	156.6
ROE-SN	0.0	62.0	92.1	121.2	145.4	166.6	178.4	186.9	198.5	213.6
ROE-GN	0.0	0.0	117.2	131.7	147.3	156.9	162.4	170.3	163.7	182.0
OTHER	9.8	60.1	91.0	117.1	139.2	156.7	169.8	182.5	195.2	199.4

Appendix Table 1.8. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the REVISED 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^{-5})
1950/51	REDUCTION	0.0	0.1	15.3	52.9	15.3	11.5	4.2	0.6	0.1	0.0	1476	1544	317.44
1951/52	REDUCTION	1.2	16.9	21.5	33.8	21.3	4.1	1.1	0.1	0.0	0.0	2251	165	1136.50
1953/54	REDUCTION	0.1	3.0	29.0	21.3	33.6	10.2	1.9	0.7	0.2	0.1	0*	25	231.77
1954/55	REDUCTION	0.0	8.7	14.1	39.4	18.1	14.8	4.4	0.3	0.1	0.1	0*	25	52.94
1955/56	REDUCTION	0.0	0.1	16.0	9.6	62.2	8.4	2.7	0.7	0.0	0.1	1348	681	6551.83
1956/57	REDUCTION	0.1	20.7	24.1	15.7	9.6	26.7	2.4	0.4	0.1	0.0	4740	2177	2092.34
1957/58	REDUCTION	0.0	81.9	16.4	1.2	0.2	0.1	0.1	0.0	0.0	0.0	2838	514	2146.22
1958/59	REDUCTION	0.0	1.1	63.2	28.4	7.4	0.0	0.0	0.0	0.0	0.0	95	6	735.74
1960/61	REDUCTION	0.0	4.2	32.6	36.0	24.8	1.3	0.4	0.2	0.4	0.0	0*	25	59.00
1961/62	REDUCTION	0.0	3.0	37.6	41.4	9.6	6.5	1.6	0.2	0.0	0.0	428	170	693.85
1962/63	REDUCTION	0.0	0.4	50.0	27.1	18.2	2.1	2.0	0.0	0.1	0.1	804	411	1342.32
1963/64	REDUCTION	0.0	0.9	15.3	59.5	17.8	5.3	1.1	0.0	0.0	0.0	528	297	2515.06
1964/65	REDUCTION	0.0	1.6	79.8	11.0	4.4	2.1	0.9	0.2	0.0	0.0	1053	165	3424.55
1965/66	REDUCTION	1.7	18.0	32.2	16.1	10.2	7.3	5.8	4.8	2.0	1.7	0*	25	213.13
1966/67	REDUCTION	0.0	0.9	67.3	26.5	2.7	2.7	0.0	0.0	0.0	0.0	0*	25	18.83
1967/68	REDUCTION	0.8	29.7	50.2	17.1	2.2	0.0	0.0	0.0	0.0	0.0	0*	25	8.48
1971/72	ROE-SN	0.0	3.0	32.6	38.3	16.0	6.1	2.4	0.9	0.4	0.1	1184	94	276.24"
1972/73	ROE-SN	0.0	0.2	40.6	21.6	27.3	8.0	1.7	0.8	0.0	0.0	1726	914	524.51
1973/74	ROE-SN	0.0	0.1	30.5	40.4	17.7	9.1	1.9	0.3	0.1	0.0	1617	185	482.78
	ROE-GN	0.0	0.0	5.7	48.4	25.5	16.6	3.2	0.0	0.0	0.6	157	25	8.24
1974/75	ROE-SN	0.0	0.6	25.3	34.2	27.9	9.5	1.9	0.4	0.1	0.0	6010	655	587.13"
	ROE-GN	0.0	0.0	0.0	22.5	40.0	30.0	5.0	2.5	0.0	0.0	40	40	6.19
1975/76	ROE-SN	0.0	0.4	2.8	37.3	29.4	22.7	6.3	1.0	0.1	0.0	4170	247	813.57"
	ROE-GN	0.0	0.0	0.0	0.8	21.8	60.9	14.3	2.3	0.0	0.0	133	186	91.86
1976/77	ROE-SN	0.0	0.1	19.6	8.0	29.4	23.0	15.1	4.5	0.4	0.0	3220	1113	801.25"'
1977/78	ROE-SN	0.0	0.2	26.2	17.3	9.5	26.2	14.1	5.3	1.0	0.3	1234	1932	620.46
	ROE-GN	0.0	0.0	0.6	4.8	11.5	19.4	39.4	20.0	3.6	0.6	165	126	129.55
1978/79	ROE-SN	0.0	5.6	4.4	31.6	18.7	21.3	15.1	2.8	0.4	0.1	1020	441	387.56"
	ROE-GN	0.0	0.0	0.0	25.1	25.1	25.1	20.1	3.5	0.5	0.5	199	65	128.20
1979/80	ROE-SN	0.0	0.5	83.2	4.5	5.4	2.8	1.9	1.2	0.6	0.1	3390	2427	222.15
	ROE-GN	0.0	0.0	3.7	4.5	40.1	20.8	22.3	6.9	1.6	0.1	938	1028	74.53
1980/81	ROE-SN	0.0	0.2	3.5	85.0	5.4	3.1	1.8	0.7	0.2	0.1	4943	489	331.92"
	ROE-GN	0.0	0.0	0.2	74.8	8.3	9.4	4.9	1.9	0.6	0.0	905	339	121.41
1981/82	ROE-SN	0.0	0.8	4.5	4.4	84.6	2.4	1.6	0.9	0.5	0.1	3591	1725	185.38"
	ROE-GN	0.0	0.0	0.2	3.4	88.2	3.4	2.7	1.1	0.8	0.2	526	341	99.20
1982/83	ROE-SN	0.0	4.9	5.2	3.5	6.9	72.9	3.9	1.6	0.9	0.3	1968	1609	317.79"
	ROE-GN	0.0	0.0	0.0	1.3	2.8	89.0	3.1	2.5	0.7	0.5	747	637	58.91
1983/84	OTHER	0.0	5.9	36.6	2.2	4.3	8.6	39.2	2.2	0.5	0.5	186	****	16.18
	ROE-SN	0.0	2.1	35.3	4.9	2.8	10.5	42.8	1.0	0.4	0.2	3104	1554	312.33
	ROE-GN	0.0	0.0	2.8	1.3	4.6	9.0	80.1	1.8	0.3	0.3	391	427	34.59
1984/85	ROE-SN	0.0	1.3	14.9	31.8	4.0	4.5	11.4	31.5	0.4	0.1	3556	699	311.61"
	ROE-GN	0.0	0.0	0.0	15.3	2.1	4.2	11.1	66.7	0.7	0.0	144	83	85.78
1985/86	ROE-SN	0.0	0.2	2.8	22.0	40.2	4.0	3.3	8.0	19.1	0.3	4733	2821	157.73
	ROE-GN	0.0	0.0	0.0	11.9	50.6	5.4	5.2	10.4	16.0	0.5	405	383	55.79
1986/87	ROE-SN	0.0	1.7	10.4	5.9	24.4	37.8	3.8	4.3	5.8	5.9	3281	1144	131.07"
1987/88	ROE-SN	0.0	3.6	51.0	7.5	4.8	11.8	14.9	1.4	1.7	3.4	1676	575	2.56"
1988/89	ROE-SN	0.0	2.3	17.5	66.3	4.0	1.6	3.9	2.8	0.6	1.0	3563	199	120.37

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1	2	3	4	5	6	7	8	9	10
REDUCTION	11.7	52.0	84.4	106.6	125.9	147.7	156.8	172.1	147.3	183.5
ROE-SN	0.0	66.2	98.4	126.8	151.4	172.7	188.9	202.6	215.8	215.3
ROE-GN	0.0	0.0	122.9	142.9	154.9	172.6	181.9	194.8	192.5	200.4
OTHER	11.7	60.9	93.6	119.8	142.9	165.5	179.4	195.4	205.9	209.5

Appendix Table 1.9. Age composition and catch in numbers by fishery and season and weight at age averaged over all seasons for the REVISED northern west coast of Vancouver Island 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	10	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10^-3)
1950/51	REDUCTION	0.0	1.5	27.0	54.1	12.8	3.6	1.0	0.0	0.0	0.0	196	190	546.82
1951/52	REDUCTION	0.0	0.2	10.2	27.5	52.2	7.1	2.1	0.5	0.1	0.0	3236	3206	1263.43
1953/54	REDUCTION	0.0	0.0	46.2	44.2	6.6	2.7	0.3	0.0	0.0	0.0	364	21	494.70
1957/58	REDUCTION	0.0	9.1	38.9	30.0	9.7	6.8	4.1	1.0	0.2	0.0	483	80	4.98
1958/59	REDUCTION	0.0	1.4	24.4	30.3	25.3	7.6	5.3	4.3	1.2	0.3	1599	1014	3141.73
1959/60	REDUCTION	0.0	4.7	56.2	24.2	9.8	3.3	1.1	0.4	0.2	0.1	2338	2403	3724.70
1960/61	REDUCTION	0.0	21.4	42.7	30.6	5.2	0.0	0.0	0.0	0.0	0.0	248	57	1382.75
1961/62	REDUCTION	0.0	4.1	87.1	7.6	0.6	0.6	0.0	0.0	0.0	0.0	510	193	880.29
1962/63	REDUCTION	0.0	0.6	43.1	51.5	4.1	0.5	0.1	0.0	0.0	0.0	1372	609	1361.92
1963/64	REDUCTION	0.0	0.0	48.0	32.0	18.0	2.0	0.0	0.0	0.0	0.0	50	50	88.97
1964/65	REDUCTION	0.0	0.0	28.6	59.2	12.2	0.0	0.0	0.0	0.0	0.0	49	49	159.49
1965/66	REDUCTION	0.0	13.6	26.8	26.1	23.2	9.1	1.2	0.0	0.0	0.0	0*	25	195.14
1966/67	REDUCTION	0.0	4.7	63.6	23.9	6.1	1.5	0.1	0.1	0.0	0.0	0*	25	482.92
1971/72	ROE-SN	0.0	0.3	13.8	38.7	40.7	4.3	1.4	0.6	0.3	0.0	349	99	177.82
1972/73	ROE-SN	0.0	0.2	24.5	24.8	35.0	13.0	2.3	0.2	0.2	0.0	609	358	557.43‘
1973/74	ROE-SN	0.0	3.0	40.4	21.7	16.9	13.8	3.7	0.4	0.1	0.0	2398	2045	819.44‘
1974/75	ROE-SN	0.0	0.4	65.2	16.6	6.9	5.6	3.9	1.1	0.2	0.0	3925	2181	679.06"‘
1975/76	ROE-SN	0.0	0.5	12.8	51.5	16.7	8.2	7.5	2.5	0.3	0.0	2204	492	259.12
	ROE-GN	0.0	0.0	0.0	15.8	38.2	21.1	18.4	6.6	0.0	0.0	76	76	115.02
1976/77	ROE-SN	0.0	0.9	19.5	20.3	33.9	11.3	8.9	3.7	1.6	0.0	575	1613	52.30
	ROE-GN	0.0	0.0	0.0	8.6	39.5	18.5	19.8	9.9	3.1	0.6	162	92	174.14
1977/78	OTHER	0.0	1.3	49.2	16.0	13.8	16.2	2.5	0.6	0.3	0.0	630	273	74.55
	ROE-SN	0.0	1.7	69.0	13.3	6.4	5.8	2.2	1.5	0.1	0.1	896	650	78.36
	ROE-GN	0.0	0.0	1.1	2.7	21.8	41.0	23.4	8.5	1.1	0.5	188	65	204.38
1978/79	ROE-SN	0.0	1.2	18.4	65.0	8.9	3.4	2.8	0.2	0.1	0.1	1720	674	455.13
	ROE-GN	0.0	0.0	3.8	34.0	20.8	13.2	28.3	0.0	0.0	0.0	53	191	293.99
1979/80	ROE-SN	0.0	1.6	41.5	22.5	30.1	3.2	1.0	0.1	0.0	0.0	966	84	1.00~
	ROE-GN	0.0	0.0	0.0	10.6	84.8	4.5	0.0	0.0	0.0	0.0	66	66	125.00
1980/81	ROE-SN	0.0	0.0	17.5	45.8	13.4	20.8	2.4	0.2	0.0	0.0	583	331	275.37‘
1981/82	ROE-SN	0.0	0.4	21.0	24.6	35.1	5.8	11.8	1.0	0.3	0.0	1116	790	1.00~
	ROE-GN	0.0	0.0	0.8	8.2	46.0	11.9	29.7	3.1	0.2	0.0	511	426	176.17
1982/83	ROE-SN	0.0	2.5	17.8	16.2	23.2	26.8	7.0	6.3	0.2	0.0	444	195	1.00~
	ROE-GN	0.0	0.0	0.4	14.2	23.8	44.8	6.5	9.8	0.4	0.2	571	159	176.62
1983/84	ROE-SN	0.0	42.0	44.9	4.5	1.1	2.3	3.4	0.6	1.1	0.0	176	369	1.00~
	ROE-GN	0.0	0.0	1.7	6.7	18.0	32.6	31.9	5.4	3.4	0.3	595	464	55.40
1984/85	ROE-SN	0.0	18.2	65.7	7.5	2.4	2.3	2.4	1.2	0.2	0.0	654	215	1.00~
1985/86	ROE-SN	0.0	2.5	55.6	37.4	2.1	0.9	0.9	0.6	0.1	0.0	1024	64	1.00~
1986/87	ROE-SN	0.0	12.9	20.4	26.1	36.8	2.6	0.5	0.3	0.5	0.0	658	268	1.00~
	ROE-GN	0.0	0.0	1.8	24.5	61.8	5.5	2.2	2.9	0.9	0.4	550	408	144.31
1987/88	ROE-SN	0.0	3.1	61.6	9.5	10.8	13.6	0.9	0.3	0.2	0.0	1169	644	0.02‘
1988/89	ROE-SN	0.0	0.9	16.9	49.5	8.0	11.5	11.9	0.8	0.4	0.0	746	241	1.00~

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1	2	3	4	5	6	7	8	9	10
REDUCTION	9.8	53.4	89.7	111.2	131.7	143.5	154.8	172.8	179.5	156.6
ROE-SN	0.0	62.9	91.6	120.9	145.0	166.3	177.7	185.7	194.4	206.0
ROE-GN	0.0	0.0	120.1	133.8	146.4	158.1	165.0	172.6	163.5	182.0
OTHER	9.8	59.3	91.1	116.9	139.3	157.2	169.8	181.5	189.7	189.5

Appendix Table 2.1. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Queen Charlotte Islands stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one 3	4	5	6	7	8	9	10	Spawn Index	Estimated Spawn	Spawning Biomass (t)
1950/51	1733	1032	206	138	12	12	21	13	172	145	4773
1951/52	1695	1067	528	94	60	5	5	15	122	120	4551
1952/53	2403	897	409	142	22	14	1	5	254	522	18410
1953/54	12893	1532	572	261	90	14	9	4	451	410	11694
1954/55	1552	8165	915	331	150	52	8	7	277	1236	41603
1955/56	2113	986	5178	579	209	95	33	10	372	183	7334
1956/57	674	606	287	695	47	17	8	3	71	39	1666
1957/58	750	73	169	33	43	3	1	1	41	72	2561
1958/59	1277	217	24	30	4	6	0	0	332	211	7571
1959/60	606	561	112	11	13	2	2	0	134	147	4849
1960/61	2064	386	357	71	7	8	1	2	343	195	7829
1961/62	2524	1294	238	217	43	4	5	2	210	202	9237
1962/63	4835	1411	621	97	83	17	2	3	213	241	11231
1963/64	1082	2577	616	214	31	26	5	1	128	72	3141
1964/65	2753	410	764	87	19	3	2	1	56	34	1717
1965/66	242	111	109	74	4	1	0	0	145	51	2706
1966/67	184	89	52	43	27	1	0	0	24	48	2649
1967/68	161	112	55	32	26	16	1	0	36	65	3443
1968/69	150	101	70	34	20	16	10	1	59	54	2929
1969/70	318	96	64	45	22	13	10	7	81	75	3968
1970/71	1022	203	61	41	29	14	8	11	121	119	6437
1971/72	696	651	129	39	26	18	9	12	121	141	8366
1972/73	1623	412	380	72	21	14	10	12	123	154	8886
1973/74	4271	980	230	199	37	11	7	11	416	347	17583
1974/75	5699	2608	581	131	111	21	6	10	209	486	22631
1975/76	1386	3515	1496	315	69	59	11	9	471	570	26988
1976/77	1508	864	1885	733	149	33	28	9	621	528	25783
1977/78	1761	844	457	903	339	69	15	17	509	372	18540
1978/79	675	962	426	203	384	144	29	14	397	220	11267
1979/80	16174	413	480	165	68	134	50	15	981	927	42949
1980/81	1052	10190	254	275	90	38	74	36	966	1140	50206
1981/82	468	661	6129	143	148	49	21	61	870	1241	50478
1982/83	493	292	408	3666	84	87	29	48	603	885	40661
1983/84	3261	299	174	233	2054	47	49	43	677	716	32485
1984/85	1470	1962	177	98	128	1138	26	51	610	509	25744
1985/86	324	891	1124	92	49	65	572	39	205	431	22591
1986/87	546	202	529	627	50	26	35	333	538	343	17315
1987/88	5133	335	121	305	358	28	15	210	435	383	19087
1988/89	2554	3272	213	77	194	228	18	143	998	671	31427

Estimated availability at age (λ_j)

0.45	0.62	0.91	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.01	0.23	0.72	1.00	0.85	0.85	0.85	0.85

The coefficients for the Ricker stock-recruitment curve are: α = 35.44, β = 0.2536E-02

The estimated spawn index-escapement conversion factor is 0.986E-02

Appendix Table 2.2. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the Prince Rupert District stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one 3	4	5	6	7	8	9	10	Spawn Index	Estimated Spawn	Spawning Biomass (t)
1950/51	6283	7980	1103	405	27	8	108	70	1058	506	11634
1951/52	3271	3347	3026	290	67	5	1	30	641	174	4684
1952/53	3382	1814	1100	574	21	5	0	2	961	976	26351
1953/54	7720	2105	1123	672	347	13	3	2	835	308	8088
1954/55	2253	4352	799	296	112	58	2	1	869	456	11335
1955/56	6083	1372	1920	282	82	31	16	1	951	1409	34845
1956/57	1957	3333	783	1039	145	43	16	9	1279	488	12155
1957/58	3589	856	1377	244	236	33	10	6	507	1126	27752
1958/59	7484	2157	507	788	136	131	18	8	1285	1208	33725
1959/60	2493	4316	1228	273	404	70	67	14	1087	1304	29730
1960/61	12647	1471	2255	578	117	173	30	35	990	1116	29052
1961/62	6325	5932	665	831	173	35	52	19	1530	1100	31113
1962/63	3644	3453	2945	288	315	65	13	27	783	987	23827
1963/64	9589	1841	1517	1031	79	87	18	11	1185	1486	37006
1964/65	1447	4357	927	672	404	31	34	11	501	366	10540
1965/66	516	544	1638	239	107	64	5	7	332	256	6755
1966/67	858	283	230	535	59	26	16	3	222	258	6684
1967/68	813	298	125	81	149	16	7	5	433	350	9240
1968/69	1445	433	173	69	43	79	9	7	74	233	6289
1969/70	7360	907	263	103	40	25	46	9	886	895	24582
1970/71	5271	4603	564	162	63	25	15	34	716	1282	31341
1971/72	2515	3230	2800	335	94	37	14	29	1000	1276	42719
1972/73	4802	1589	1958	1658	195	55	21	25	730	1741	58118
1973/74	4285	3022	997	1220	1026	120	34	29	670	1600	51986
1974/75	2083	2703	1872	598	705	600	70	37	814	1622	46694
1975/76	1359	1317	1690	1160	368	433	369	66	1158	1366	47025
1976/77	2255	858	803	1007	676	215	253	254	1438	1068	35578
1977/78	1358	1364	500	437	510	348	111	261	750	737	24219
1978/79	1439	831	784	254	192	235	160	171	814	634	21026
1979/80	12274	891	494	435	130	100	123	173	1529	1257	37644
1980/81	2346	7671	547	288	239	73	56	166	1175	1547	39356
1981/82	2526	1477	4736	330	169	141	43	132	1305	1846	43352
1982/83	3038	1592	926	2948	204	105	87	108	1826	1906	49596
1983/84	9304	1937	1015	590	1879	130	67	124	2032	1876	46048
1984/85	1884	5869	1204	607	338	1092	76	111	2056	1795	44044
1985/86	1801	1178	3571	681	315	181	585	100	2084	1618	46254
1986/87	7563	1108	713	1990	343	165	95	358	2555	1626	45211
1987/88	7718	4749	683	410	1049	187	90	247	1865	1705	43121
1988/89	4592	4812	2865	372	197	530	95	170	1516	1931	47780

Estimated availability at age (λ_i)

0.37	0.55	0.79	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.01	0.14	0.61	1.00	0.77	0.77	0.77	0.77

The coefficients for the Ricker stock-recruitment curve are: α = 33.07, β = 0.1210E-02

The estimated spawn index-escapement conversion factor is 0.154E-01

Appendix Table 2.3. Estimates of numbers at age, spawn, 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 3	4	5	6	7	8	9	10	Spawn Index	Estimated Spawn	Spawning Biomass (t)
1950/51	3866	4746	836	335	0	0	1	85	834	525	14300
1951/52	1460	1631	1557	185	66	0	0	17	343	146	3843
1952/53	2304	500	408	181	16	6	0	1	629	371	9509
1953/54	13471	1453	305	246	109	10	3	1	487	355	7752
1954/55	1422	6734	455	61	43	19	2	1	553	1203	27327
1955/56	1490	838	3532	221	29	21	9	1	394	333	8183
1956/57	3012	524	234	546	28	4	3	1	213	136	3461
1957/58	5451	930	139	32	59	3	0	0	367	668	15378
1958/59	6441	2795	452	60	13	25	1	0	364	349	8284
1959/60	1562	2900	885	93	11	2	4	0	681	1442	28958
1960/61	2763	894	1716	510	53	6	1	3	314	384	9010
1961/62	8267	934	281	349	91	10	1	1	860	630	16661
1962/63	4054	4463	423	110	131	34	4	1	394	204	5183
1963/64	3871	1634	1133	51	10	12	3	0	430	276	7263
1964/65	1725	1236	471	189	7	1	2	1	171	256	7924
1965/66	1944	730	449	126	47	2	0	1	158	133	3650
1966/67	1482	287	172	44	8	3	0	0	322	230	6479
1967/68	644	289	93	38	9	2	1	0	376	265	7867
1968/69	708	356	167	52	21	5	1	0	172	212	6286
1969/70	3100	450	225	105	33	13	3	1	637	488	14340
1970/71	2591	1966	283	140	66	20	8	2	341	772	23267
1971/72	3309	1557	1155	161	80	37	12	6	435	666	19112
1972/73	5498	1894	769	510	69	34	16	7	964	1107	35540
1973/74	3816	3238	1065	397	252	34	17	12	893	1096	31523
1974/75	5103	2382	1845	506	166	104	14	12	795	1424	40748
1975/76	2546	3156	1391	933	232	75	47	12	1426	1238	33030
1976/77	1613	1564	1753	652	392	96	31	24	1223	1106	32297
1977/78	1924	965	889	839	278	164	40	23	732	662	19061
1978/79	1407	1129	505	328	242	77	46	18	694	1154	28872
1979/80	13104	897	720	322	209	154	49	40	1159	1838	49513
1980/81	2318	8352	569	449	199	129	95	55	1320	2244	55286
1981/82	2275	1473	5227	339	258	113	74	86	1302	2253	58442
1982/83	962	1420	902	3009	187	142	62	87	1605	1655	43459
1983/84	790	602	866	520	1671	103	78	83	1075	1092	27356
1984/85	2867	483	349	456	259	825	51	79	1155	921	27880
1985/86	1145	1743	284	188	234	132	420	66	1262	809	24410
1986/87	1882	703	1037	159	102	126	71	262	1160	747	22841
1987/88	11202	1157	413	575	86	55	68	179	1871	1425	41728
1988/89	610	6909	691	234	316	47	30	135	1786	1566	39397

Estimated availability at age (λ_j)

0.50	0.70	0.95	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.02	0.21	0.64	0.94	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruitment curve are: α = 41.49, β = 0.1567E-02

The estimated spawn index-escapement conversion factor is 0.159E-01

Appendix Table 2.4. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the northern Strait of Georgia stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one								Spawn Index	Estimated Spawn	Spawning Biomass (t)
	3	4	5	6	7	8	9	10			
1950/51	2876	1380	326	65	0	9	9	9	2795	1316	9403
1951/52	3447	1217	384	85	17	0	2	5	2905	2076	15044
1952/53	3384	1440	418	127	28	6	0	2	3259	3869	23721
1953/54	7624	1941	803	232	70	16	3	1	1850	2294	14709
1954/55	4367	4341	639	253	73	22	5	1	2493	5427	34238
1955/56	1774	1895	1773	255	101	29	9	3	1235	2454	15597
1956/57	1608	813	554	492	71	28	8	3	1381	1114	7875
1957/58	2446	508	192	121	107	15	6	2	735	777	5278
1958/59	6632	1256	149	53	34	30	4	2	2059	1914	13087
1959/60	3159	2301	294	32	12	7	6	1	2044	2336	15853
1960/61	1976	1288	738	90	10	4	2	2	1558	1605	9833
1961/62	4752	932	391	213	26	3	1	1	1450	1804	12537
1962/63	4749	1392	226	88	48	6	1	1	1198	948	5808
1963/64	5076	1447	203	28	11	6	1	0	1354	1031	8063
1964/65	2619	1445	237	29	4	2	1	0	1439	1476	12031
1965/66	1061	601	356	54	7	1	0	0	267	241	2057
1966/67	787	165	58	26	4	0	0	0	498	358	2896
1967/68	263	132	31	10	4	1	0	0	556	370	3155
1968/69	435	132	67	15	5	2	0	0	837	750	5687
1969/70	1497	268	79	40	9	3	1	0	2444	1878	16234
1970/71	1585	928	166	49	25	6	2	1	2350	2146	17982
1971/72	1266	980	568	102	30	15	4	2	1579	1519	10963
1972/73	1845	636	397	224	40	12	6	2	1375	1246	9980
1973/74	2812	1061	276	148	73	13	4	3	2840	2190	16415
1974/75	3830	1779	600	123	52	25	4	2	3808	4959	34362
1975/76	2597	2354	999	274	46	19	9	2	3745	4033	26533
1976/77	4484	1619	1288	437	97	16	7	4	5625	5497	39718
1977/78	3599	2623	856	549	152	33	5	4	4586	4611	31335
1978/79	1713	2060	1293	344	183	49	11	3	4546	4036	29239
1979/80	3009	1062	1142	589	130	67	18	5	4473	4957	32580
1980/81	2269	1855	628	619	294	64	33	11	3017	4937	33589
1981/82	2050	1353	1046	310	269	126	27	19	4949	4230	27540
1982/83	1915	1292	795	527	135	115	53	20	2946	2523	17469
1983/84	1423	982	533	221	102	25	21	13	2202	1965	13532
1984/85	2191	742	421	144	39	17	4	6	1970	2474	17477
1985/86	3284	1243	357	145	36	9	4	2	4074	4098	28929
1986/87	2023	2072	783	225	91	23	6	4	3771	4140	27017
1987/88	6080	1179	1143	394	104	42	10	5	3299	5505	39775
1988/89	1841	3755	657	516	146	38	15	5	5488	5816	36466

Estimated availability at age (λ_i)

0.71	0.96	1.00	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.02	0.20	0.58	0.95	1.00	1.00	1.00	1.00

The coefficients for the Ricker stock-recruitment curve are: $\alpha = 8.654$, $\beta = 0.4071E-03$

The estimated spawn index-escapement conversion factor is 0.621E-01

Appendix Table 2.5. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the southern Strait of Georgia stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one								Spawn Index	Estimated Spawn	Spawning Biomass (t)
	3	4	5	6	7	8	9	10			
1950/51	3600	1123	230	46	0	0	0	9	285	724	8626
1951/52	3438	973	229	45	9	0	0	2	685	369	4301
1952/53	4598	915	121	26	5	1	0	0	1735	1491	15082
1953/54	7639	2677	484	64	14	3	1	0	1774	1168	13223
1954/55	5856	2785	497	85	11	2	0	0	1380	1702	20312
1955/56	4724	1997	712	123	21	3	1	0	890	755	8263
1956/57	4239	1153	279	92	16	3	0	0	409	379	4263
1957/58	2074	539	112	24	8	1	0	0	895	529	5650
1958/59	5375	646	138	28	6	2	0	0	1074	969	10538
1959/60	5028	2474	196	41	8	2	1	0	504	876	10583
1960/61	2516	1316	402	30	6	1	0	0	602	574	6377
1961/62	5584	831	202	57	4	1	0	0	324	440	5285
1962/63	4937	1527	100	22	6	0	0	0	489	449	5157
1963/64	3430	1618	182	11	2	1	0	0	513	311	3974
1964/65	2073	619	144	14	1	0	0	0	151	204	2656
1965/66	1304	492	66	14	1	0	0	0	193	164	2088
1966/67	1129	475	62	8	2	0	0	0	138	128	1576
1967/68	119	67	34	4	0	0	0	0	230	135	1567
1968/69	142	39	22	11	1	0	0	0	346	195	2312
1969/70	441	78	22	12	6	1	0	0	576	360	4646
1970/71	553	265	47	13	7	4	0	0	491	301	3817
1971/72	455	335	147	26	7	4	2	0	465	399	4864
1972/73	591	238	155	65	11	3	2	1	455	539	6713
1973/74	1004	363	136	79	29	5	2	1	699	937	11532
1974/75	1353	622	217	76	41	16	3	2	704	1095	13348
1975/76	993	858	372	117	37	22	8	2	541	964	9554
1976/77	2035	590	440	175	51	17	10	5	315	1113	11773
1977/78	1551	1115	280	195	73	22	7	7	696	984	10691
1978/79	730	767	438	100	64	26	8	5	1492	468	5000
1979/80	813	334	200	110	25	16	6	3	746	716	7858
1980/81	743	478	192	114	63	14	9	6	551	575	6352
1981/82	546	370	203	80	48	26	6	6	206	298	3465
1982/83	203	138	90	48	19	11	6	3	419	218	2444
1983/84	322	117	69	45	24	9	6	5	466	243	3041
1984/85	474	179	57	33	22	11	5	5	465	453	5452
1985/86	858	278	103	33	19	12	7	5	476	803	9835
1986/87	492	535	173	64	20	12	8	7	639	639	7173
1987/88	1279	298	223	36	7	4	2	3	425	945	10853
1988/89	308	782	182	136	22	4	2	3	584	1004	11222

Estimated availability at age (λ_j)

0.74	0.98	1.00	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.02	0.23	0.60	1.00	0.69	0.69	0.69	0.69

The coefficients for the Ricker stock-recruitment curve are: α = 9.633, β = 0.5725E-03

The estimated spawn index-escapement conversion factor is 0.388E-01

Appendix Table 2.6. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the southern west coast of Vancouver Island stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one								Spawn	Estimated	Spawning
	3	4	5	6	7	8	9	10	Index	Spawn	Biomass (t)
1950/51	1227	989	147	30	0	0	0	7	475	170	3215
1951/52	1621	303	164	20	4	0	0	1	387	103	2061
1952/53	1819	465	47	21	3	1	0	0	660	452	7878
1953/54	3121	1159	296	30	13	2	0	0	453	168	3173
1954/55	1270	446	127	23	2	1	0	0	602	396	7381
1955/56	2107	488	178	49	9	1	0	0	597	193	3670
1956/57	1363	374	81	24	7	1	0	0	424	419	7377
1957/58	2609	693	189	40	12	3	1	0	857	899	14345
1958/59	4154	1634	431	117	25	8	2	0	387	363	6416
1959/60	1705	653	236	50	14	3	1	0	449	352	6887
1960/61	1299	365	155	50	11	3	1	0	396	367	7184
1961/62	2810	375	101	39	13	3	1	0	671	373	7750
1962/63	1748	787	102	25	10	3	1	0	371	399	7474
1963/64	3252	978	361	46	11	4	1	0	915	438	8841
1964/65	1247	1149	250	84	11	3	1	0	652	321	6987
1965/66	772	487	311	62	21	3	1	0	239	244	5509
1966/67	1056	291	152	91	18	6	1	0	117	155	3606
1967/68	365	380	66	31	19	4	1	0	364	289	6720
1968/69	592	232	242	42	20	12	2	1	429	427	9660
1969/70	2436	377	148	154	27	13	8	2	959	945	22412
1970/71	5433	1553	241	95	98	17	8	6	1256	1981	50920
1971/72	4318	3465	990	153	60	63	11	9	1107	2091	46724
1972/73	5878	2691	2037	579	90	35	37	12	471	2655	60384
1973/74	5891	3523	1495	1102	309	48	19	26	678	4382	87989
1974/75	10425	3605	2118	858	611	174	27	25	1229	4130	93202
1975/76	4491	6230	1998	1074	408	298	85	25	1426	2948	60648
1976/77	2437	2760	2956	763	351	142	103	38	1558	2166	44321
1977/78	2662	1412	1279	1141	259	125	51	51	1355	1786	33583
1978/79	824	1494	711	503	374	91	44	36	1291	1066	21573
1979/80	1979	484	744	306	195	151	37	32	1264	1232	24240
1980/81	1612	1199	288	431	174	112	87	40	1272	1196	23716
1981/82	1005	931	663	145	203	84	54	61	821	1000	19058
1982/83	873	592	526	360	77	108	45	61	534	680	13826
1983/84	1479	448	269	234	160	34	48	47	799	714	15906
1984/85	2141	769	215	127	110	75	16	45	844	1339	31130
1985/86	2675	1357	487	137	81	70	48	39	944	1546	35360
1986/87	904	1698	861	309	87	51	44	55	1138	1069	23923
1987/88	5013	419	723	356	128	36	21	41	1617	1160	27063
1988/89	918	2794	204	324	152	56	16	27	1393	1007	20900

Estimated availability at age (λ_i)

0.72	0.94	1.00	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.03	0.23	0.66	1.00	0.87	0.87	0.87	0.87

The coefficients for the Ricker stock-recruitment curve are: α = 16.59, β = 0.7065E-03

The estimated spawn index-escapement conversion factor is 0.231E-01

Appendix Table 2.7. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the northern west coast of Vancouver Island stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one								Spawn Index	Estimated Spawn	Spawning Biomass (t)
	3	4	5	6	7	8	9	10			
1950/51	1146	1999	287	85	14	5	3	2	792	911	15498
1951/52	677	613	1018	141	41	7	2	2	316	213	3765
1952/53	1375	336	133	162	21	6	1	1	1133	644	10490
1953/54	3368	877	214	85	103	14	4	1	839	409	6521
1954/55	1400	1791	306	66	26	31	4	2	724	972	17183
1955/56	1442	725	911	150	32	13	15	3	1098	1313	23030
1956/57	2861	903	455	571	94	20	8	11	1790	1543	26553
1957/58	3000	1804	568	286	359	59	13	12	625	1886	27354
1958/59	3097	1911	1149	362	182	228	38	16	529	498	7348
1959/60	3533	1396	414	183	55	27	34	8	253	246	4296
1960/61	1553	656	225	40	16	5	2	4	308	217	3911
1961/62	3511	335	142	36	6	2	1	1	639	494	9502
1962/63	1888	1415	119	45	11	2	1	1	449	277	4998
1963/64	1116	612	339	22	8	2	0	0	612	639	11622
1964/65	549	635	351	192	12	5	1	0	809	446	8996
1965/66	629	285	302	159	86	6	2	1	284	326	7130
1966/67	817	354	130	130	68	37	2	1	394	360	8243
1967/68	315	319	150	51	51	26	14	1	272	344	7589
1968/69	314	201	203	96	33	32	17	10	485	371	8238
1969/70	1326	200	128	129	61	21	21	17	676	598	13918
1970/71	2581	845	128	82	83	39	13	24	495	1073	25980
1971/72	1872	1646	539	81	52	53	25	24	923	993	20752
1972/73	1546	1170	951	307	46	30	30	28	727	999	20433
1973/74	1789	853	569	443	142	21	14	27	301	847	16407
1974/75	2634	803	362	225	174	56	8	16	659	1138	22533
1975/76	701	1262	402	175	108	83	27	12	453	701	13189
1976/77	766	414	640	180	71	39	30	14	589	574	10159
1977/78	3288	478	231	306	76	25	13	15	1000	863	14340
1978/79	691	2000	248	95	103	19	6	7	1364	616	10039
1979/80	1816	347	794	67	19	13	2	2	1516	775	12691
1980/81	536	1155	201	393	29	7	5	1	728	615	10263
1981/82	365	313	587	87	149	9	2	2	909	481	7883
1982/83	127	226	173	267	33	44	3	1	669	244	4139
1983/84	450	80	119	67	79	7	9	1	482	387	7258
1984/85	2465	285	46	58	28	27	2	3	296	634	12937
1985/86	1244	1571	182	29	37	18	17	4	741	1110	23098
1986/87	698	793	1002	116	19	23	11	13	1023	1081	23398
1987/88	2681	444	476	550	59	8	11	11	860	1562	33398
1988/89	710	1709	283	304	351	37	5	14	718	1315	28520
	Estimated availability at age (λ_i)										
	0.70	0.86	0.98	1.00	1.00	1.00	1.00	1.00			
	Estimated relative selectivity at age for gillnet gear										
	0.01	0.20	0.44	0.66	1.00	1.00	1.00	1.00			

The coefficients for the Ricker stock-recruitment curve are: α = 9.259, β = 0.8356E-03

The estimated spawn index-escapement conversion factor is 0.250E-01

Appendix Table 2.8. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the REVISED Queen Charlotte Islands stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one 3	4	5	6	7	8	9	10	Spawn Index	Estimated Spawn	Spawning Biomass (t)
1950/51	1655	974	199	131	9	4	26	18	172	154	4443
1951/52	1747	1018	491	89	56	4	2	18	122	118	3900
1952/53	2474	930	375	126	19	12	1	4	254	542	17010
1953/54	12610	1577	593	239	80	12	7	3	451	460	11418
1954/55	1602	7988	940	343	136	46	7	6	277	1395	41064
1955/56	2114	1018	5065	595	217	86	29	8	372	195	6866
1956/57	689	608	291	705	47	17	7	3	71	40	1493
1957/58	827	71	165	35	39	3	1	1	41	68	2107
1958/59	1421	266	22	28	4	4	0	0	367	227	7280
1959/60	636	607	134	10	12	2	2	0	202	173	4983
1960/61	2119	405	387	86	6	8	1	1	423	238	8349
1961/62	2608	1330	250	236	52	4	5	1	241	246	9822
1962/63	5183	1467	643	105	93	20	1	2	213	294	11983
1963/64	1198	2800	646	230	34	30	7	1	181	95	3638
1964/65	3049	461	833	100	22	3	3	1	76	46	2076
1965/66	272	135	122	91	4	1	0	0	145	71	3275
1966/67	261	107	65	51	36	2	0	0	33	70	3333
1967/68	320	159	66	39	31	21	1	0	42	94	4370
1968/69	428	202	100	41	25	19	13	1	59	112	5167
1969/70	1233	273	129	64	26	16	12	9	237	201	9224
1970/71	2833	786	174	82	41	17	10	14	479	369	17145
1971/72	2470	1807	501	111	52	26	11	15	467	429	21475
1972/73	6507	1486	1041	276	60	28	14	14	561	548	27054
1973/74	5264	3939	820	537	138	30	14	14	714	918	40150
1974/75	4767	3212	2301	459	295	76	16	15	571	1129	48239
1975/76	1294	2896	1872	1286	252	162	42	18	912	898	39637
1976/77	1663	802	1570	919	596	117	75	28	1056	714	32663
1977/78	1899	905	423	757	425	276	54	48	872	465	21203
1978/79	776	1050	467	185	296	169	110	41	652	278	12555
1979/80	16620	478	533	191	65	106	61	54	1059	1035	42660
1980/81	1189	10412	290	299	100	34	57	61	1158	1363	52455
1981/82	506	746	6277	164	161	55	19	64	992	1463	52717
1982/83	525	314	461	3768	96	95	32	49	805	1065	42879
1983/84	3503	319	188	265	2124	55	54	46	837	862	34344
1984/85	1563	2118	189	107	148	1185	30	55	773	631	27881
1985/86	360	951	1223	101	54	75	603	44	319	534	24480
1986/87	651	225	567	691	55	30	41	355	715	430	18995
1987/88	9194	402	135	330	398	32	17	228	570	550	24025
1988/89	2324	5861	256	86	210	253	20	156	1219	1066	43811

Estimated availability at age (λ_i)

0.44	0.63	0.89	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.01	0.21	0.66	1.00	0.89	0.89	0.89	0.89

The coefficients for the Ricker stock-recruitment curve are: α = 40.60, β = 0.2313E-02

The estimated spawn index-escapement conversion factor is 0.113E-01

Appendix Table 2.9. Estimates of numbers at age, spawn, and other parameters from age-structured model analysis for the REVISED northern west coast of Vancouver Island stock assessment region.

Season	Estimated numbers at age ($x10^{-5}$) for period one 3	4	5	6	7	8	9	10	Spawn Index	Estimated Spawn	Spawning Biomass (t)
1950/51	1277	2186	314	92	1	4	9	12	546	669	17247
1951/52	590	701	1145	159	47	0	2	11	232	213	5701
1952/53	1937	280	187	240	32	9	0	3	614	515	13300
1953/54	1184	1235	178	119	153	21	6	2	483	527	12783
1954/55	1263	591	634	88	59	75	10	4	350	631	18038
1955/56	1265	806	377	404	56	37	48	9	1063	733	19424
1956/57	2806	807	514	240	258	36	24	36	1617	1006	29459
1957/58	2883	1789	514	328	153	164	23	38	545	1225	27100
1958/59	2887	1837	1140	328	209	98	105	39	492	299	6694
1959/60	2890	1270	395	171	47	30	14	20	80	84	2222
1960/61	1186	350	174	24	9	2	1	2	185	119	3315
1961/62	2824	216	82	30	4	1	0	1	569	431	12659
1962/63	1334	1207	98	35	13	2	1	0	112	111	2990
1963/64	1143	415	255	14	5	2	0	0	540	322	9628
1964/65	572	689	247	151	8	3	1	0	536	341	10288
1965/66	551	326	389	137	83	5	2	1	239	294	9692
1966/67	822	320	175	202	71	43	2	1	329	279	9616
1967/68	300	342	144	73	84	30	18	1	240	251	8400
1968/69	308	191	218	92	47	54	19	12	261	261	8763
1969/70	1338	197	122	139	58	30	34	20	468	410	14465
1970/71	2600	853	125	78	89	37	19	35	430	726	25547
1971/72	1859	1658	544	80	50	57	24	34	822	662	20953
1972/73	1552	1161	960	310	45	28	32	33	442	655	20299
1973/74	1793	857	565	445	143	21	13	30	241	574	16829
1974/75	2588	820	374	229	179	57	8	17	434	753	22631
1975/76	700	1241	412	180	110	86	28	12	394	471	13449
1976/77	736	414	643	187	75	42	33	15	443	389	10453
1977/78	2877	458	237	309	79	27	15	17	479	562	14150
1978/79	649	1741	248	98	105	21	7	9	825	353	8720
1979/80	1463	322	697	57	15	10	2	2	587	423	10398
1980/81	619	930	192	353	25	6	4	1	508	360	8993
1981/82	240	347	462	91	167	12	3	3	544	289	6824
1982/83	139	152	202	217	36	54	4	2	403	149	3897
1983/84	411	87	84	78	64	8	11	1	291	236	6731
1984/85	2109	260	52	42	34	23	3	5	188	389	12026
1985/86	1274	1344	166	33	26	22	15	5	487	672	20772
1986/87	584	812	857	106	21	17	14	13	560	623	20455
1987/88	2157	371	491	456	51	9	7	11	571	877	28616
1988/89	549	1375	236	313	291	33	6	12	251	727	23815

Estimated availability at age (λ_i)

0.72	0.85	0.98	1.00	1.00	1.00	1.00	1.00

Estimated relative selectivity at age for gillnet gear

0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02

The coefficients for the Ricker stock-recruitment curve are: α = 13.43, β = 0.1395E-02

The estimated spawn index-escapement conversion factor is 0.165E-01