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Stock Assessment for British Columbia Herring in 1998 and Forecasts of the Potential Catch in 1999

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Abstract

Herring stock abundance in British Columbia waters was assessed for 1998 and forecasts were made for 1999 using two analytical methods: (1) escapement model; and (2) age-structured model. These models have been applied to assess herring abundance since 1984 and no significant changes were implemented in either model in conducting the current assessment. All available biological data on total harvest, spawn deposition, and age and size composition of the spawning runs were used to determine current abundance levels. No significant problems were evident in the extent and comprehensiveness of the data collections. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 1998 was 207,800 tonnes which represents a 12% increase from 1997 abundance levels. This increase reflects the recruitment of a strong 1995 year-class in 1998 in northern areas and average in southern areas.

Forecasts of the pre-fishery spawning stock biomass in 1999 were obtained from the escapement model estimates, a departure from previous years when the estimates from the two analytical models were averaged. Stock forecasts for the northern stock assessment regions are 96,100 and 124,000 tonnes for the southern regions assuming average recruitment to all areas.

The recommended 1999 catch (20% of the 1999 forecast herring run) is 44,000 tonnes for the entire B.C. coast assuming average recruitment to all areas. However, since consensus on stock levels for each assessment region may change as a result of PSARC review of these data forecast run sizes and harvestable surpluses are subject to change.

Résumé

On s'est servi de deux méthodes d'analyse pour évaluer l'abondance des stocks de hareng en Colombie-Britannique en 1998 et pour faire des prévisions pour 1999 : 1) un modèle des échappées et 2) un modèle des populations selon l'âge. On se sert de ces modèles depuis 1984 pour évaluer l'abondance du hareng. Aucun des deux modèles n'a été modifié substantiellement dans le cadre de la présente évaluation. On a utilisé toutes les données biologiques sur le total des captures, la ponte ainsi que la composition des concentrations de géniteurs selon l'âge et la taille pour établir les niveaux d'abondance actuels. Il ne semblait y avoir aucun problème majeur quant à l'étendue et à la composition des données déjà recueillies. Pour l'ensemble de la côte, la biomasse prévue des stocks avant la pêche dans toutes les régions faisant l'objet de l'évaluation était de 207 800 tonnes en 1998, ce qui constitue une augmentation de 12 p. 100 par rapport aux niveaux d'abondance de 1997. Cette augmentation provient du recrutement en 1998 d'une forte classe de 1995 dans les zones au nord et d'une classe de 1995 moyenne dans les zones au sud.

Les prévisions de la biomasse des géniteurs avant la pêche en 1999 proviennent d'estimations du modèle des échappées. Cette méthode est différente de la méthode utilisée par les années passées au cours desquelles les estimations ont été faites à partir d'une moyenne des deux modèles d'analyse. Si l'on tient pour acquis que le recrutement sera moyen dans toutes les zones, les prévisions des stocks étaient de 96 100 tonnes dans le nord et de 124 000 tonnes dans le sud.

Si l'on tient pour acquis que le recrutement sera moyen dans toutes les zones, les captures recommandées en 1999 sont de 44 400 tonnes (20 p. 100 des concentrations de hareng prévues pour 1999) pour l'ensemble de la côte de la C.-B. Toutefois, comme le consensus sur les niveaux des stocks dans chaque région faisant l'objet de l'évaluation peut être modifié à la suite de l'examen des données par le CEESP, le nombre de géniteurs et les excédents récoltables prévus peuvent changer eux aussi.

INTRODUCTION

Herring have been one of the most important components of the British Columbia commercial fishery over the past century with catch records dating from 1877. The fishery has evolved from a dry salted product in the early 1900s, to a reduction fishery in the 1930s that collapsed in the late 1960s. After a four year closure the current roe fishery began in 1972. Roe fisheries occur just prior to spawning when the fish are highly aggregated and very vulnerable to exploitation. Since 1983, herring roe fisheries have been managed with a fixed quota system. Under this system harvest levels are determined prior to the season based on a fixed percentage (20%) of forecast stock size. In addition, threshold biomass or Cutoff levels were introduced in 1985 to restrict harvest during periods of reduced abundance.

In this report we present stock assessments from two analytical models which have been developed explicitly for British Columbia herring: (1) a modification of the escapement model described by Schweigert and Stocker (1988); and (2) a modification of the age-structured model described by Fournier and Archibald (1982). Both models reconstruct stock abundance for the period 1951-1998 and forecast pre-spawning abundance for the 1999 season. Forecasts of upcoming run size are based on the combination of estimates of surviving repeat spawners and newly recruited spawners which are presented as poor, average, and good, based on historical recruitment levels.

1.1. 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 1998. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period which began in 1972.

Of the three data sets, the spawn data contain the largest measurement errors. While the quality of spawn surveys has generally improved over the 48 year span of these data due to increased effort and better quality control of the surveys, there are occasional problems with equipment and weather which may hamper data completeness and accuracy in some years. The consistent observations made during all years of surveys are the total length, the average width, and a measure of egg density for each spawning site. Since 1987 an increasing number of spawn beds have been assessed using Scuba rather than traditional surface survey methods. We assume all surveys provide reasonably accurate estimates of spawn bed width and egg density and these data have been used in the escapement model where available. All major herring spawnings were surveyed in 1998, although due to limited resources no surveys of any kind were undertaken in the Johnstone Straits area which is outside the major assessment regions.

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 1997/98 catch figures are

based on validated plant weights as a result of the introduction of the pool fishery for all areas except the Strait of Georgia and Prince Rupert gillnet fisheries. In the latter cases, hauled estimates are used as in the past because complete sales slip data are not available in time for analysis. The spawn-on-kelp (SOK) fishery includes a total of 46 licensed operators who pond a substantial quantity of herring of which an unknown quantity dies each year. Since 1990, it has been assumed that the 100 tons (91 tonnes) allocated to each license are killed and this is treated as additional seine catch. At this time, the available records are being reviewed to extend these data back to the initiation of the fishery in 1975.

Age structure data are used in both models. The information from catch samples is used for years when there were commercial fisheries. Pre-fishery charters began in 1975 and these samples are used in addition to catch samples for areas with no fisheries, or when catch samples are few in number or not representative of the entire catch. Additional data used in both models are annual mean weights-at-age. During the 1997/98 season a total of 400 herring samples (375 roe, 25 food fishery and miscellaneous others) were collected and processed compared to 344 in the previous year. Of the roe samples, 30 were taken in the Queen Charlotte Islands assessment area (another 14 from Area 2W), 38 in the Prince Rupert area, 82 in the Central Coast, 115 in the Strait of Georgia, and 87 on the west coast of Vancouver Island (plus 8 from Area 27), with the remaining 1 sample taken from minor stock areas (Area 10). We believe that this provides adequate coverage of all the assessment regions for the age-structured and escapement model assessment analysis.

In the current assessment we continue to use the year of life convention for ageing adopted in the 1991 assessment. Fish which were previously named age 3 are now referred to as the 2⁺ age class. In a few instances the text refers to age class 2⁺⁺ which indicates all fish that are age 2⁺ and older.

1.2. STOCK CONSIDERATIONS

The stock concept used for managing British Columbia herring is a compromise between biological and management considerations. Given incomplete knowledge of population structure it is prudent to manage fisheries to ensure maintenance of the greatest potential diversity. However, we do not feel that stock forecasts for smaller geographic regions than those used in the current assessments would be accurate enough for fisheries management. Therefore, we recommend that fisheries should continue to focus on the major aggregations within each assessment region to minimize the potential over-exploitation of any of the smaller, spatially discrete spawning groups.

The stock groupings used for the current assessments are identical to those used since 1993 (Fig. 1.1). The Queen Charlotte Islands stock assessment region spans from Cumshewa Inlet in the north to Louscoone Inlet in the south. The stock concept for the Prince Rupert District encompasses Statistical Areas 3 to 5. The Central Coast stock management unit separates the major migratory stocks from the minor spawning populations in the mainland inlets. The areas included in the Central Coast assessment region are Statistical Area 7 plus

Kitasu Bay in Area 6 and Kwakshua Channel in Area 8. The Strait of Georgia stock includes all of Statistical Areas 14 to 19, and Deepwater Bay and Okisollo Channel in Area 13, and Areas 28 and 29. The west coast of Vancouver Island assessment region encompasses Statistical Areas 23 to 25. Haist and Rosenfeld (1988) outline current geographical stock boundaries.

Abundance estimates are not presented for other areas outside of the major assessment regions which may support additional small herring runs, because we believe that both the spawn survey and catch data are incomplete for many of these areas; therefore presentation of stock estimates could lead to erroneous conclusions regarding either absolute abundance or stock trends. Recent attempts to conduct a complete age-structured assessment for Areas 2W and 27 have been unsuccessful. However, an escapement model estimate of current stock abundance is available for these areas but no forecast of abundance in the coming year is possible.

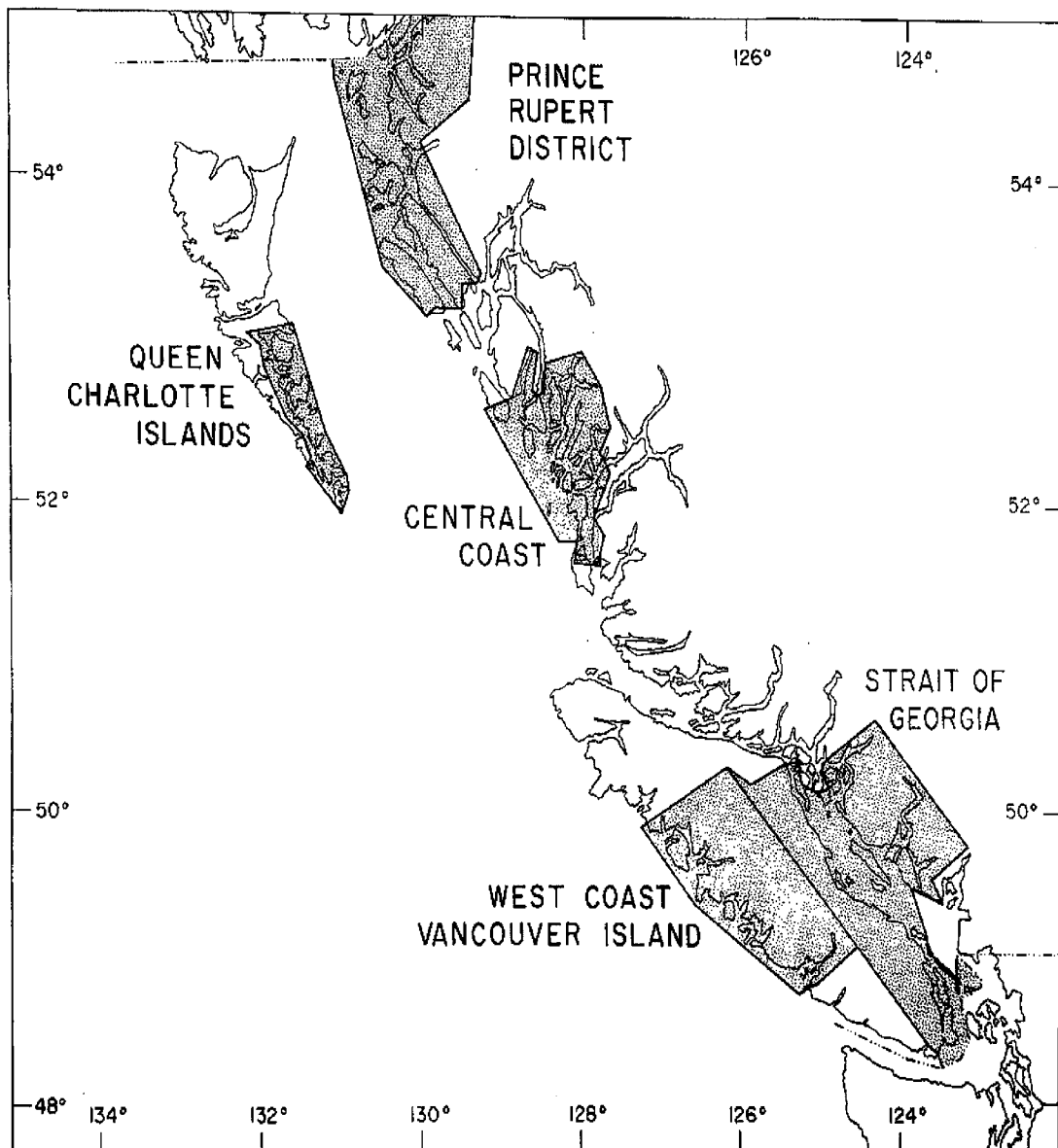


Fig. 1. Herring stock assessment regions in British Columbia.

2. ESCAPEMENT MODEL

2.1 INTRODUCTION

The escapement model, developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988), is based on egg deposition information and provides a direct estimate of escapement from the fishery. For most stock assessment regions, recent estimates of escapement are based on a combination of surface and Scuba survey data. Scuba surveys have been used routinely since 1987 and an increasing proportion of the herring spawning beds have been surveyed using this technique. A summary of the recent spawn survey coverage for the British Columbia coast is presented below. As a result of reductions in DFO resources and the consequent contracting of diving surveys to industry there was virtually no DFO effort directed to surface surveys in 1998, particularly outside of the assessment regions. No surface surveys were conducted in the Queen Charlotte Islands, Prince Rupert District, and Central Coast assessment areas or in Johnstone Strait. However, all but the last area did receive good Scuba survey coverage. Limited surface surveys occurred in the Strait of Georgia and Central coast, primarily outside of the major assessment areas. Coastwide there was a very small decrease in the total length of spawn surveyed by Scuba and surface surveys relative to 1997. Total length of spawn outside of the major assessment areas declined in 1998 reflecting a decline in effort rather than a real decline in abundance.

Summary of the kilometres of herring spawning beds surveyed by Scuba and surface methods for major and minor stocks on the British Columbia coast in recent years, 1995-1998.

Assessment Region	1995			1996			1997			1998		
	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total
Queen Charlotte Is.	20.7	2.4	23.1	25.3	0.0	25.3	36.4	0.0	36.4	58.4	0.0	58.4
Prince Rupert District	42.3	0.0	42.3	49.9	0.0	49.9	68.9	0.0	68.9	47.1	0.0	47.1
Central Coast	123.8	12.4	136.2	114.1	0.0	114.1	142.4	0.0	142.4	141.0	23.4	164.4
Strait of Georgia	133.8	1.3	135.1	128.4	3.1	131.5	119.1	3.5	122.6	140.8	6.2	147.0
W.C. Vancouver Is.	42.9	6.0	48.9	39.2	0.0	39.2	78.3	0.0	78.3	42.9	0.5	43.4
Other Areas	16.5	77.3	93.8	15.7	111.2	126.8	14.3	46.5	60.8	26.1	13.8	39.9
Coastwide Total	379.9	99.4	479.2	372.6	114.3	486.8	459.3	50.0	509.4	456.3	43.9	500.2

2.2 METHODS

In the escapement model, the forecast run size is based on the estimated escapement in the previous season, growth of the escaped fish during the current season, an age-specific apparent survival rate which accounts for both survival and partial recruitment of recruited year-classes, and an estimate of age 2⁺ 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 1951-1998. Estimates of total catch (tonnes) and spawn abundance (billions of eggs) are converted to fish-at-age based on the sampling data for each area. For each area the age structure and average weight-at-age are calculated from samples available for that region. In rare instances, no data are available for a region and information from an adjacent area is utilized in the analysis. Forecasts of repeat spawners and recruit fish are converted to forecast tonnages using predicted average weights-at-age as outlined in Haist and Schweigert (1990).

Pre-Fishery Biomass and Spawn Index Estimates

Escapement from the fishery plus total catch provides an estimate of the pre-fishery spawning stock biomass for each assessment region. The following relationship is used to estimate pre-fishery biomass for each area (Schweigert 1993):

$$B_j = C_j + Eggs_j \bullet \left(\frac{\sum_{i=3}^{10} P_{ij} F_{ij} SR_{ij}}{\sum_{i=3}^{10} P_{ij} W_{ij}} \right)^{-1}$$

where

- B_j = total pre-fishery mature biomass in tonnes in year j ,
- C_j = total catch in tonnes in year j ,
- $Eggs_j$ = total egg deposition in billions in year j ,
- P_{ij} = proportion of fish at age i in year j in the spawning run,
- F_{ij} = fecundity of females of age i in year j ,
- SR_{ij} = sex ratio or proportion of females at age i in year j ,
- W_{ij} = mean weight of fish at age i in year j in tonnes.

The total catch is obtained from sales slip information except for the current season when the hailed catch estimate is used. The estimated escapement for each region is derived from information on spawn deposition. The estimate of total spawn deposition is also used as the spawn index in the age-structured model. Dive survey observations of egg deposition

are used directly while surface survey observations are adjusted to emulate Scuba estimates. Total egg deposition is calculated as the product of: total length parallel to the shore of each spawning bed; the observed or adjusted width of the spawning bed; and egg density as estimated from the average number of egg layers determined from the surface survey, or average predicted egg density from quadrat observations of egg layers, or average egg layer and plant density estimates in giant kelp (*Macrocystis* sp.) beds from Scuba surveys. Total egg deposition estimates for all spawning beds are summed within each assessment region and the total egg deposition is converted to tonnes of spawning fish based on an estimate of 100 eggs per gram of herring on average (Hay 1985) as described above.

Surface Surveys

Since the late 1920s there have been organized efforts to assess the amount of herring eggs deposited throughout the British Columbia coast as an indicator of stock abundance. The parameters which have been monitored consistently are total length of each spawning bed measured parallel to the shoreline, the average width of each spawning bed, and an estimate of intensity of the spawn deposition. Prior to 1981 intensity was estimated subjectively on either a 1-5 or 1-9 scale of light to heavy (Hay and Kronlund 1987). Subsequently, intensity of egg deposition was recorded as the number of egg layers observed on each of several types of algal substrate. Beginning in 1987 an increasing proportion of the spawning beds have been surveyed using Scuba techniques as outlined below.

To provide a consistent coastwide assessment of total egg deposition throughout the time period from 1951-1998, it was necessary to intercalibrate the surface and Scuba surveys of egg deposition. Initially, the intercalibration took the form of linear equations which converted the surface survey estimates of spawning bed width and egg layers to comparable Scuba estimates (Schweigert and Stocker 1988). However, the data available for this intercalibration were limited in time and space to particular spawning beds over the course of a few years. As Scuba surveys of the spawning beds became widespread, an extensive database of estimates of the dimensions of herring spawning beds in most areas of the coast became available and a new procedure for calibrating the width of herring spawning beds estimated by surface surveys was proposed (Schweigert et al. 1993). The methodology consisted of defining spawn pools which consisted of one or more geographically adjacent and geomorphologically similar herring spawning locations. Hence, diver width estimates developed for such a 'pool' were felt to be characteristic of all locations within that pool. For the small number of locations which could not be assigned to a pool, the median width for the section (Rosenfeld and Haist 1988) was used to adjust width estimates for the location. The median width was preferable to the mean because of the non-normal distribution of the spawn width estimates. Any pools for which fewer than 25 observations of median width existed were also adjusted using the section median. For the rare instances where no median estimate was available at the section level the median width for the assessment region was applied to calculate spawn area. The long term median spawn width for each pool was then applied to each surface survey record to estimate a 'diver' width and combined with the estimated surface length to determine the total area of egg deposition.

To estimate egg density we assumed that surface and dive survey estimates of the

number of egg layers in a spawning bed were equivalent and employed the database of 5111 observations of egg density per square meter from laboratory egg counts of Scuba surveyed quadrat samples to develop a predictive model of egg density from egg layers:

$$\text{Eggs} / m^2 = 14.698 + 212.218 \text{ Layers}$$

The relationship is statistically significant ($P < 0.001$). Total egg deposition for each egg bed is then estimated from the product of total spawning bed area, and egg density predicted from the average surface egg layer estimate.

At present no methods exist for adjusting surface survey data in most areas outside the major assessment regions except in a few locations such as Johnstone Strait (Statistical Areas 9-13) where some dive surveys have been conducted. These surveys indicated that no adjustments are required for the spawn widths in Johnstone Strait because widths are very narrow and were accurately assessed from the surface in this area (Schweigert and Haegele 1988a, b). Additional dive surveys still need to be conducted in other areas outside of the major assessment regions to develop width adjustments for the spawn pools in these locations.

Scuba Surveys

For Scuba surveys spawning bed lengths are determined by exploratory raking or snorkelling to define the limits of the areas of egg deposition. Corresponding spawning bed widths are 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, 1990). Average egg density for each spawning area is estimated as the weighted mean of the means of a series of quadrats located along each transect. For each quadrat, observations are made on several variables: type of algal substrate; proportion of the quadrat covered by each algal type; number of layers of eggs on each algal type; proportion of the bottom substrate covered by eggs; and an estimate of the number of egg layers on the bottom substrate. In some areas, assessments are also made of the egg deposition on the giant kelp as described in a following section.

Egg deposition for each sampling quadrat is estimated from the predictive equation described in the 1989 assessment (Haist and Schweigert 1990, Schweigert 1993). Egg density for each vegetation subfraction is estimated as follows:

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

where

Eggs_{ij} = estimated number of eggs in thousands per m^2 on vegetation type i in quadrat j ,
 L_{ij} = number of layers of eggs on algal substrate i in quadrat j ,
 P_{ij} = proportion of quadrat covered by algal substrate i in quadrat j ,
 V_{1j} = 0.9948 parameter for sea grasses in quadrat j ,
 V_{2j} = 1.2305 parameter for rockweed in quadrat j ,

V_{3j} = 0.8378 parameter for flat kelp in quadrat j ,
 V_{4j} = 1.1583 parameter for other brown algae in quadrat j ,
 V_{5j} = 0.9824 parameter for leafy red and green algae in quadrat j ,
 V_{6j} = 1.0000 parameter for stringy red algae in quadrat j ,
 Q_1 = 0.5668 parameter for 1.00 m² quadrats,
 Q_2 = 0.5020 parameter for 0.50 m² quadrats,
 Q_3 = 1.0000 parameter for 0.25 m² quadrats.

Total egg density (thousands of eggs per m²) for each quadrat is then estimated by summing the egg density estimates over the vegetation types,

$$Eggs_j = \sum_i eggs_{ij}.$$

Eggs on Bottom and *Macrocystis*

Eggs on rock are estimated from the product of the proportion of the quadrat covered by eggs, number of egg layers, and 340,000 eggs/m² (Haegele *et al.* 1979). Eggs on rock also includes eggs on other inorganic substrata as well as egg deposition on very short (1-2 cm) red algae, calcareous encrusting algae, worm tubes, logs, etc. Total egg density for each quadrat is the sum of eggs on vegetation plus eggs on rock.

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

$$Eggs/Plant = 0.073 Layers^{0.673} Height^{0.932} Fronds^{0.703}$$

where

$Eggs/Plant$ = total number of eggs on the *Macrocystis* plant in millions,
 $Layers$ = average number of egg layers on each *Macrocystis* plant,
 $Height$ = total height of the *Macrocystis* plant in metres,
 $Fronds$ = total number of fronds per *Macrocystis* plant.

This equation estimates the number of eggs occurring on a plant of a specific height with a certain number of fronds and egg layers. In practice, the synoptic Scuba survey estimates only the average number of egg layers per plant, the average plant height, and the average number of fronds per plant along each transect. These quantities are used in the above

equation to estimate the total egg numbers per plant for each transect. These estimates are averaged across transects to obtain an average number of eggs per plant for the entire *Macrocystis* bed.

This information may then be combined with the estimate of the density of plants and the estimated area of the *Macrocystis* bed to obtain an estimate of the total number of eggs deposited on the kelp:

$$\text{Total Eggs on Macrocystis} = \text{Eggs Plant}^{-1} \bullet \text{Plants m}^{-2}$$

This egg deposition is then added to the estimated eggs on the understorey vegetation to determine a total egg deposition for that spawn pool.

Enumerated Egg Samples

Beginning in 1988 samples of algae and the attached eggs from entire quadrats were collected and processed to evaluate model predictions of egg density relative to sample egg counts. Due to funding shortfalls, no samples were collected in 1997 or 1998 and model predictions of egg numbers per sample quadrat are assumed to be unbiased for use in the assessment of egg density.

Abundance Forecasts and Survival Estimates

The escapement model forecasts abundance of returning adult spawners by applying an apparent survival rate to the estimate of spawning escapement in the most recent year. Mean age-specific apparent survival rates were introduced in 1991 to adjust for apparent under-forecasting of returning adults based on their abundance in the previous year's escapement due to partial recruitment of younger age-classes and other factors.

Several estimates of the instantaneous natural mortality rate are available for British Columbia herring. Tester (1955) estimated the age-specific mortality for the Strait of Georgia (0.45 to 0.79) and west coast of Vancouver Island (0.43 to 1.14) for ages 3⁺ to 6⁺. Taylor (1964) reported a natural mortality rate of 0.55 for ages 5⁺ to 8⁺ for Barkley Sound samples taken from unfished stocks. Schweigert and Hourston (1980) estimated natural mortality at 0.36 from Barkley Sound catch and effort data during 1954 to 1967 for ages 2⁺ to 4⁺. Since the spawning herring stocks currently consist mostly of ages 2⁺ to 7⁺ we used an instantaneous natural mortality of 0.45, implying an annual survival rate of 64 percent, in forecasting the number of returning adults (3⁺ and older fish) prior to the 1991 assessment. Subsequently, we have used the ratio of the estimated number of returning fish at age this year relative to the estimated escapement at the previous age last year to provide an estimate of the apparent age-specific survival rate:

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

where

A_{ij} = apparent survival of age j fish in season i ,

E_{ij} = estimated number of spawning fish at age j in season i ,

O_{ij} = estimated number of age j fish in the catch in season i .

Comparison of the estimated numbers of returning fish at age with the escapement estimate the previous year indicated a tendency to underestimate recruitment and led to the adoption of the apparent survival rate. The apparent age-specific survival rate includes not only the effect of survival, but also factors such as: biases in estimates of the spawning stock, partial recruitment of the younger age classes, and inconsistencies in the age composition data. To ensure that forecasts of stock abundance are consistent with the observed data the geometric means of the age-specific apparent survivals for each stock assessment region were re-calculated for the entire the 1971-1998 roe period (Table 2.1) and are used to forecast 1999 abundance.

Table 2.1. Geometric mean age-specific apparent survival estimated for each stock assessment region over the roe fishery period, 1971-1998.

Assessment Region	Age Class				
	2 ⁺ -3 ⁺	3 ⁺ -4 ⁺	4 ⁺ -5 ⁺	5 ⁺ -6 ⁺	6 ⁺ -7 ⁺⁺
Queen Charlotte Is.	1.46	1.18	1.01	0.87	0.54
Prince Rupert	1.24	1.20	1.07	0.86	0.54
Central Coast	1.44	1.24	1.09	0.86	0.64
Georgia Strait	0.81	0.67	0.58	0.55	0.41
W.C. Vancouver Is.	1.05	0.87	0.80	0.73	0.48

Hence, the equation used to forecast the tonnage of herring expected to return in the coming season is:

$$B_{i+1,j+1} = N_{ij} A_{ij} W_{i+1,j+1}$$

where

$B_{i+1,j+1}$ = forecast tonnes of mature biomass at age $i+1$ in year $j+1$,

N_{ij} = estimated number of fish at age i in the escapement in year j ,

A_{ij} = estimated apparent survival rate of fish at age i in year j ,

$W_{i+1,j+1}$ = forecast average weight at age $i+1$ in year $j+1$.

Forecasts of mature biomass for each stock assessment region based on this analysis are presented in Section 4.

2.3 RESULTS

Estimates of historical and current year stock abundance and total catch for the major stock assessment regions are presented in Tables 2.2 and 2.3. Similar estimates for the minor stocks in Areas 2W and 27 are presented in Table 2.4 and discussed in Section 4.

Table 2.2. Estimates of spawning stock biomass, catch, and total pre-fishery abundance (tonnes) for the northern stock assessment regions for 1971-1998.

Season	Queen Charlotte Islands			Prince Rupert District			Central Coast		
	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	13616	102	13718	9751	3500	13252	6056	3614	9670
1971/72	9951	3972	13923	9852	4494	14346	3928	9279	13207
1972/73	7706	7520	15226	11260	1607	12867	14471	7799	22270
1973/74	9903	6318	16221	8893	3819	12712	10624	8887	19511
1974/75	8951	7724	16675	11109	1702	12811	9165	8739	17903
1975/76	15143	14116	29258	14213	4307	18520	16134	12411	28545
1976/77	12516	12635	25151	9736	8142	17877	18481	11106	29587
1977/78	11452	11726	23177	4738	8588	13325	10097	14046	24143
1978/79	8657	7953	16610	7554	4317	11871	6550	5	6555
1979/80	21204	3316	24520	10236	3425	13661	15978	538	16517
1980/81	19023	5631	24654	10532	3090	13622	16949	2573	19522
1981/82	19009	3778	22788	12631	1984	14616	18412	6370	24782
1982/83	19082	5597	24679	19653	0	19653	16618	5640	22258
1983/84	20438	4647	25084	22927	3706	26633	14197	7171	21368
1984/85	14393	6109	20501	35858	6747	42605	8480	5209	13689
1985/86	5636	3503	9140	32526	8679	41205	15534	3386	18920
1986/87	13132	2061	15193	31422	6271	37693	12992	3615	16607
1987/88	14456	32	14488	33680	7968	41647	27018	4527	31544
1988/89	23986	1461	25448	12783	8474	21257	32335	9442	41776
1989/90	25011	7801	32812	19398	5505	24903	31048	8805	39853
1990/91	14220	5530	19750	21544	4326	25869	20155	9357	29512
1991/92	9500	3612	13112	35992	4992	40984	46036	8756	54792
1992/93	5405	3951	9356	21440	7717	29157	39713	11060	50773
1993/94	4895	1387	6282	13439	5413	18852	29781	12332	42113
1994/95	4946	0	4946	15858	2877	18738	18919	10308	29227
1995/96	5827	0	5827	22104	4178	26282	17941	5209	23150
1996/97	11686	0	11686	20744	6815	27559	25208	4806	30011
1997/98	18806	2100	20906	16734	4218	20952	29386	9965	39351

Table 2.3. Estimates of spawning stock biomass, catch, and pre-fishery stock abundance (tonnes) for the southern stock assessment regions from 1971-1998.

Season	Strait of Georgia			W.C. Vancouver Island		
	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	47312	1694	49005	32476	0	32476
1971/72	25875	8811	34686	36069	6894	42963
1972/73	18257	7649	25906	16219	18303	34522
1973/74	64619	4004	68622	24774	16334	41108
1974/75	76692	6179	82871	44594	26109	70703
1975/76	57135	12238	69372	63335	38825	102160
1976/77	58003	17509	75512	57398	30043	87441
1977/78	97082	24002	121084	39931	22745	62676
1978/79	59042	20338	79380	63663	18694	82357
1979/80	74848	5818	80666	62619	3982	66601
1980/81	48230	12052	60282	58518	8090	66608
1981/82	90239	12833	103072	29424	5486	34911
1982/83	47423	17218	64641	15329	8575	23904
1983/84	27588	11045	38632	22142	6577	28719
1984/85	26629	7030	33659	29132	178	29310
1985/86	61097	594	61690	38347	204	38551
1986/87	39037	9353	48390	29915	15934	45849
1987/88	25351	8215	33566	39289	9724	49013
1988/89	54078	8369	62447	43331	13289	56620
1989/90	58912	8119	67031	38337	10121	48458
1990/91	43421	11103	54524	25907	8906	34813
1991/92	80122	13419	93541	36811	3986	40797
1992/93	84961	13741	98702	29237	5884	35122
1993/94	60862	17647	78509	19764	6310	26075
1994/95	59708	13190	72897	25039	2586	27625
1995/96	76291	14113	90404	31929	1516	33445
1996/97	53442	19809	73251	39114	7383	46497
1997/98	68669	13604	82303	36898	7363	44261

Table 2.4. Estimates of spawning stock biomass, catch , and pre-fishery stock abundance (tonnes) for the minor stocks in areas 2W and 27 for 1971-1998.

Season	Area 2W*			Area 27		
	Spawners	Catch	Stock	Spawners	Catch	Stocks
1970/71	655	0	655	356	0	356
1971/72	1026	0	1026	333	0	333
1972/73	1782	706	2488	2293	0	2293
1973/74	1705	403	2109	0	526	526
1974/75	1446	449	1895	1409	0	1409
1975/76	1066	0	1066	227	79	306
1976/77	1228	0	1228	568	0	568
1977/78	1898	575	2472	3016	150	3166
1978/79	547	691	1237	6067	693	6760
1979/80	2658	0	2658	12094	519	12613
1980/81	2016	770	2786	1683	671	2354
1981/82	6348	1225	7573	3452	571	4023
1982/83	6120	2518	8638	2256	163	2419
1983/84	2552	0	2552	2520	171	2690
1984/85	1544	199	1743	1408	0	1408
1985/86	649	0	649	3772	0	3772
1986/87	757	0	757	2643	0	2643
1987/88	3202	0	3202	1518	0	1518
1988/89	3696	0	3696	3835	0	3835
1989/90	10487	2272	12759	4645	245	4890
1990/91	2789	2558	5347	3277	245	3522
1991/92	3564	1284	4848	2682	539	3221
1992/93	88	1306	1393	5216	707	5923
1993/94	193	0	193	3120	708	3828
1994/95	0	0	0	2014	542	2556
1995/96	0	0	0	1501	363	1864
1996/97	0	0	0	1598	273	1871
1997/98	372	180	552	1732	273	2005

* - No estimates of stock biomass are available in area 2W for 1995-97. Spawning activity was observed in the area but no surveys were conducted.

3. AGE-STRUCTURED MODEL

3.1. INTRODUCTION

An age-structured model, based on the error structure suggested by Fournier and Archibald (1982), has been used to assess B.C. herring stocks since 1982. Ongoing revisions to the model have made it more consistent with the life history of herring and the fisheries which are analyzed. The current version uses auxiliary information in the form of spawning escapement data, separates catch and age composition data by gear type, and includes availability parameters to estimate partial recruitments to the spawning stock. Model parameters are estimated simultaneously using a maximum likelihood method. The model formulation used this year is the same as that used beginning with the 1994 assessment (Schweigert and Fort 1994). The model uses escapement model estimates of spawning stock biomass as the abundance or spawn index for parameter estimation. The model is implemented in the C++ programming language using AD model builder software (Otter Research Ltd, 1996) for derivative calculations replacing the AUTODIF version used in recent assessments. A comparison of abundance estimates from the two versions of the age-structured model were presented in the 1997 assessment.

3.2. METHODS

The Population Model

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

Let T_{ij} be the total number of fish in age class j at the beginning of season i , where season is equivalent to year, 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

$$N_{ij1} = \lambda_{ij} T_{ij}, \text{ where } 0 < \lambda_{ij} < 1 \quad 3.1$$

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

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

and, for $r < p$

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

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 ($n=48$),
- k is the number of age classes ($k=9$).

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

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

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

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

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

$$\lambda_{ij} = \lambda^*_{ij},$$

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

the exception of the final year. In the final year the availabilities for age 1+ and 2+ fish are set equal to the average over all years in the time series.

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

$$\ln(F_{ij3}) = \alpha_{i3} + b_j \quad 3.2a$$

where α_{i3} represents the general level of fishing mortality due to the gillnet fishery in season i , and b_j represents the relative selectivity of the gear for age-class j . The b_j are reparameterized such that age selectivity is modelled as a function of annual average weights-at-age. A modified logistic equation is used,

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

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

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

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

As in last year's assessments a natural mortality parameter, M_* , is estimated. It is assumed that most of the natural mortality occurs following spawning and over the course of the summer and early winter prior to the first fishery (period 1). Little or no natural mortality is assumed during the course of the roe fisheries (periods 2 and 3) which occur over a roughly 2 week period at the end of the year. Hence, various proportions of the annual natural mortality for the three fishing periods is modelled as,

$$\begin{aligned} M_1 &= 0.95M_* \\ M_2 &= M_3 = 0.025M_* \end{aligned}$$

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

$$G_{ij} = N_{ijp} \exp(-F_{ijp} - M_r) \quad \text{where } j > 1$$

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

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

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

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

where q is a spawn conversion factor and ξ_i is a normally distributed random variable with mean 0 and variance σ_1^2 . For the model described above the parameters to be estimated are:

T_{i1} , for all seasons i ,
 T_{ij} , for age classes 1+ to k ,
 λ_j^* , for age classes 3+ to 5+,
 λ_{ij} , for age classes 1+ and 2+, for seasons 1 to $n-1$,
 α_{ir} , for all fisheries I, r ,
 $\rho, \tau, \omega, M_\bullet$ and q .

The λ_j^* and λ_{ij} are parameterized to constrain their values between 0 and 1. The parameter σ_1^2 is not estimated in the reconstructions, but is fixed as discussed later on.

The Objective Function

Data input to the stock reconstruction are:

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

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

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

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

The assumption of log-normal measurement error in the observed spawn-actual spawn relationship introduces the following contribution to the log-likelihood function:

$$- \sum_i \frac{(\ln(I_i) - \ln(q R_i))^2}{2\sigma_I^2} \quad 3.6$$

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

The objective function described above (eqn. 3.5 & 3.6) incorporates measurement error in the proportion at age data, the total catch data and the spawn index data, with the relative magnitude of the errors related through the variance terms σ_I^2 , 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 these observations, with the exception of scaling the S_{ijr} , the variance terms are not estimated but are held at fixed values. The following variances are assumed:

$$\begin{aligned} \sigma_I^2 &= 0.05, \\ \sigma_3^2 &= 0.0025, \end{aligned}$$

These correspond to approximately a 4% average error in estimating the total number of fish caught and an 18% average error in spawn index observations.

The actual number of fish aged could be used in the objective function, however, this may not give a realistic estimate of the precision of the proportion-at-age data. That is, the biological samples obtained may not reflect a homogeneous population. The among-load (i.e. samples from different catching vessels) variability in age composition is significantly different

among years, and this is related more to the spatial and temporal distribution of the fisheries than to the number of loads sampled or total fish aged. Therefore, the information in the subsamples (between load samples), which are pooled to obtain an estimate of the age composition for a given fishery, is used to scale the S_{ijr} .

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

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

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

$$s_{\hat{p}_j}^2 = \frac{\sum_k (p_{jk} - \hat{p}_j)^2}{K-1}$$

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

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

These theoretical sample sizes, calculated from the among sample variance of age 3+ fish (Appendix Table 1), are used in the objective function.

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

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

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

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

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

Stock Forecasts

Forecasts of stock abundance for 1999 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 1998/99 season multiplied by survival for the first period and the estimated availability at age. Recruitment is calculated for three scenarios based on estimated numbers-at-age 2⁺ for the 1951-98 time series. Poor, average, and good recruitment are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of historic age 2⁺ numbers.

Input data used for age-structured model analysis are shown in Appendix Tables 1.1 to 1.5 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. Beginning with the 1994 assessment the estimate of total egg deposition as determined by the escapement model is used as the spawn index. Estimates of numbers of fish at age from the age-structured model are presented in Appendix Tables 2.1 to 2.5 for all stock groupings.

Prince Rupert District

In recent assessments of this stock concern had been expressed about the apparently unrealistically high estimates of abundance. Schweigert (1999) re-examined the input data for this assessment and determined that many of the fall food fishery samples appeared to be biased and as a result argued that they should be excluded from future assessments. In the current assessment we have removed any fall food fishery samples collected in this assessment area since 1972 from the time series and conducted the analysis as in the past. Results are presented in the following sections and we feel that the revised assessment is a more realistic reflection of stock abundance and trend than those presented in recent years.

4. STOCK TRENDS, FORECASTS AND POTENTIAL CATCH

4.1 STOCK TRENDS

Estimates of pre-fishery stock biomass over the period 1972 to 1998 from the age-structured and escapement models are shown in Figures 4.1 and 4.2 for the five major coastal regions and for Area 27.

For the Queen Charlotte Islands region the two models indicate similar trends in stock biomass. However, the age-structured model suggests much higher peaks in abundance in the mid 1970s and the early 1980s resulting from good recruitment of the 1971, 1972 and 1977 year-classes. Both models suggest a decrease in abundance from 1990 through 1995 with increasing abundance during the past two years. The 1993, 1994, and 1995 year classes all appear to be of average or above average abundance. The recruiting 1995 year-class of age 2⁺ fish dominates with 53% of total abundance while the 1994 and 1993 year-classes account for 28 and 12% of the spawning run, respectively. The estimates of 1998 mature biomass are 39,600 and 20,900 tonnes from age-structured and escapement model analyses, respectively.

Estimates of 1998 stock abundance for the Prince Rupert District assessment region are more consistent for the two models than in recent assessments (Fig. 4.1). Both models indicate a decline in abundance from 1992 through 1995 with a moderate upturn in 1996. The age-structured model suggests a slight decline in 1997 with an increase in 1998 while the escapement model shows the reverse pattern. The estimate of 1998 mature biomass is 42,900 and 21,000 tonnes from the age-structured and escapement models, respectively. The dominant 1993 year-class still comprises 36% of the stock. The 1994 year-class represents 22% of the run while the recruiting 1995 year-class accounted for another 33% of the spawning biomass.

Estimates of pre-fishery biomass for the Central Coast assessment region are very similar for the two models (Fig. 4.1). Both models indicate significant increases in abundance since 1996. The abundant 1994 year-class of age 3⁺ fish comprised 42% of the stock while the recruiting 1995 year class accounts for 36% of the spawning run. The rest of the run is divided evenly among the older age groups. The 1998 mature biomass estimates are 47,300 and 39,400 tonnes from age-structured and escapement model analyses, respectively.

For the Strait of Georgia assessment region the pre-fishery stock trends estimated by the two models are similar, with the escapement model suggesting more erratic fluctuations in abundance (Fig. 4.2). However, both models indicate a slight to moderate decline from the 1993 recent high abundance level. The age-structured model indicates a slight decline in abundance since 1996 while the escapement model indicates an increase in stock size in 1996 followed by a decline in 1997 and another increase in 1998. The 1993 year-class remains dominant contributing 36% of the stock while the 1994 year-class constituted 22% of the run. The recruiting 1995 year-class contributed another 33% of the total run. The age-structured model estimate of pre-fishery abundance in 1998 is 62,000 tonnes while the escapement model estimate is 82,300 tonnes.

The pre-fishery biomass estimates for the west coast of Vancouver Island stock follow similar trends since the mid 1970s (Fig. 4.2). Both models indicate a long-term decline in abundance since 1989 with the escapement model indicating a slight increase since 1994 whereas the age-structure model indicates an increase beginning in 1996. The 1994 year-class is dominant in this stock comprising 60% of the run while the recruiting 1995 year-class accounts for another 22% of the total run. The escapement model estimate of 1998 mature biomass is 44,300 tonnes while the age-structured model estimate is 34,400 tonnes.

Mature biomass estimates for Area 27 stocks were available only from the escapement model and indicated that 2,000 tonnes returned to this area during 1998. Although abundance estimates are erratic it appears that abundance has declined since 1993 (Fig. 4.2). The 1994 year-class comprised 49% of the run while the recruiting 1995 year-class accounted for 39% of the total run.

Mature biomass estimates for Area 2W stocks indicated that 600 tonnes returned to the area during 1998 but it appears that a substantial portion of the spawnings were not surveyed due to weather so this should be viewed as a minimum estimate. The biological samples from the area indicated an abundance of ages 1+ though 4+ fish. The 1993 year-class constituted 19% of the run while the 1994 year-class added 23%. The recruiting 1995 year-class was predominant contributing 35% to the total. The pre-recruit 1996 year-class also appears to be abundant contributing an additional 18% of the spawning run.

4.2 STOCK FORECASTS AND POTENTIAL CATCH

Management Considerations

PSARC has reviewed the biological basis for target exploitation rate, considering both the priority of assuring conservation of the resource and allowing sustainable harvesting opportunities (Schweigert and Ware 1995). The review concluded that 20% is an appropriate exploitation rate for those stocks that are well above Cutoff or minimum spawning biomass threshold levels (PSARC 1995). 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 (Hall et al. 1988, Zheng et al. 1993). 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:

$$\text{Catch} = \text{Forecast Run} - \text{Cutoff}.$$

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

As described in the 1995 report, a bootstrap procedure was used to annually re-

evaluate Cutoff levels for each major assessment region beginning in 1993/94. The bootstrap procedure relies on the recruitment estimates from the age-structured model (N_{it}), to forecast recruitment and assumes the natural mortality rate estimated by the age-structured model for each area in the population simulations (Efron and Gong 1983). The average of 100 estimates of the mean of 200 years of simulated stock sizes was taken as the measure of the equilibrium unfished biomass. Cutoff levels were established at one-fourth the unfished average biomass. However, in 1995 the Subcommittee recommended that a fixed Cutoff level should be established for each stock based on the long-term production characteristics in relation to current environmental conditions and that this Cutoff level need not be re-evaluated on an annual basis. As a result, the Subcommittee fixed Cutoff at 1994/95 levels until the analyses of individual stock productivities could be completed. These Cutoff levels for the five major stocks are:

	1992/93 Cutoff ^a	1994/95 Cutoff	1996/97 Cutoff	1997/98 Cutoff	1998/99 Cutoff^c
Queen Charlotte Islands	11700	10700	10700	10700	10700
Prince Rupert District ^b	12100	12100	12100	12100	12100
Central Coast	10600	18800	17600	17600	17600
Strait of Georgia	22100	21200	21200	21200	21200
W.C. Vancouver Island	20300	18800	18800	18800	18800

^a - Cutoff level based on simulation model with stock-recruitment relationship, and two assessment areas on the WCVI.

^b - Because of the poor performance of the age-structured model in this region in the past the Cutoff has not been recalculated using the bootstrap approach but is based on a stock-recruitment relationship.

^c - A Cutoff of 14,000 tonnes was proposed for the Central Coast. Concerns about ASM performance in 1998 resulted in retention of the existing Cutoff for 1999.

Central Coast Cutoff

During the 1996 Subcommittee discussions it was noted that the Cutoff level for the Central Coast stock was equivalent to that for the west coast of Vancouver Island and so appeared unrealistically high based on estimates of long term stock abundance. As a result, the Cutoff level was re-evaluated for the Central Coast based on current information and was revised to 17,600 tonnes for 1996/97.

Discussions about the relatively high value of the Cutoff level estimated for this stock continued at the 1997 PSARC meeting. Hence, in an effort to provide a sounder biological basis for this value additional analyses have been conducted on this stock. Stock recruitment analysis for the entire 1951-1997 time series indicates an alpha parameter value of 1.73 and beta of -0.073 suggesting that maximum recruitment and stock productivity results from a spawning biomass of approximately 15,000 tonnes (Fig. 4.14). A similar fit to the reduction fishery data alone determined alpha=1.90 and beta=-0.025. A population simulation model developed for this stock using these relationships suggests an unfished equilibrium biomass of approximately 45,000 to 65,000 tonnes which equates to a Cutoff level of between 11,000 and 16,000 tonnes. A Cutoff near the midpoint of 14,000 tonnes would appear to be precautionary and is in the range of maximal stock production. Based on age-structured model results the pre-fishery biomass has been below 14,000 tonnes only 5 times in the past 47 years. In each instance, the stock has

recovered rapidly. This implies that the Central Coast fishery would be closed about 10% of the time.

In addition, bootstrap simulations, identical to those used previously to determine Cutoff were conducted on the most recent abundance estimates from the age-structured model. These simulations suggest a value of 17,500 tonnes, similar to the current level. However, an analysis for the roe period alone suggests a value of 13,000 tonnes based on lower stock productivity in the recent period. This analysis was also conducted for a range of estimates of natural mortality and indicated that Cutoff and stock productivity is very sensitive to the natural mortality rate assumed in the simulation. The current estimate of M for this stock is quite low ($M=0.267$) and so may result in an artificially high estimate of the Cutoff level. Schweigert and Tanasichuk (1998) demonstrated that the age-structured model estimate of natural mortality is well determined but variable enough that it could approach 0.40 which is similar to the rate observed in other British Columbia herring stocks. A natural mortality rate for the Central Coast stock of between 0.30-0.40 would imply a Cutoff value of 10-15,000 tonnes, similar to the value proposed above.

Without an independent assessment of the natural mortality rate for a stock it is not possible to determine Cutoff precisely. In addition, natural mortality and stock production are likely to vary with changes in large scale environmental phenomena as has been found for the west coast Vancouver Island herring stock. The proposed Cutoff level of 14,000 tonnes for the Central Coast stock is a compromise between uncertainty in stock productivity and stock response to environmental forces but should be precautionary given historical experiences with these factors.

Due to concerns about age-structured model performance in 1998, the Subcommittee decided to retain Cutoff levels for all stocks at the 1997/98 levels. No minimum stock levels or Cutoff have been determined for stocks in Areas 2W or 27 because of the absence of a consistent time series of biological information.

To provide an overall stock forecast we assign subjective probabilities to the two assessment models. With the inclusion of estimates of apparent survival in the forecast procedure for the escapement model, forecasts should be consistent with future abundance estimates from this model. However, if escapement estimates from spawn surveys are consistently underestimated, forecasts from this model could also be biased. For these reasons an equal probability for both models is usually assumed for most assessment regions. Because of the unresolved questions regarding age-structured model performance, these estimates were down-weighted in determining the forecast in each 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 4.1).

Abundance Forecasts and Potential Catches

An accurate forecast of abundance for herring requires good estimates of the

numbers of returning adults, growth rate of each age group over the year, and an estimate of upcoming recruitment. Prior to the 1990 assessment, the observed weight-at-age from the previous season was used as the best forecast of the weight-at-age for the coming year. Since 1990 forecast weights-at-age from a predictive equation were used in forecasting the mature biomass for the next season. Analyses conducted during 1998 indicate that weight-at-age has been declining for several years and that the equations used to forecast weights for the coming year are inflated (Tanasichuk and Schweigert 1998). As a result, the current assessment has reverted to using observed weights-at-age from the present season as the best forecast of weight-at-age for the upcoming year. Figures 4.3 and 4.4 present cumulative probability distributions of forecast abundances for the age-structured and escapement models and their weighted average. These figures represent plots of the expected run size in the coming year given the escapement last year, average growth and survival of this adult biomass and the addition of each of the historically observed recruiting year-classes to the projected adult biomass. In addition, Fig. 4.5 and 4.6 present the age-structured or escapement model estimates of historical recruitment of three year old fish to the spawning runs in each assessment region.

The forecast weighted run size to the Queen Charlotte Islands in 1999 is 28,210 tonnes assuming average recruitment (Table 4.1). This represents a substantial increase from the 1998 forecast and brings the stock well above the Cutoff level suggesting that a moderate harvest of 5,640 tonnes could be available in this area for 1999 (Table 4.2). Indications are that the 1993-1995 year-classes are average or above average contributing to the increase in abundance (Fig. 4.5). The cumulative probability plots indicate that there is 0% probability of the 1999 run being below Cutoff based on the weighted forecasts from the two assessment models (Fig. 4.3). There are no indications of lack of model fit for residuals from either the fit to the spawn index data or age-structure data during the last few years (Appendix Table 2.1, Fig. 4.7-4.9).

The revised age-structured model for the Prince Rupert District provides estimates of abundance which are more consistent with escapement model estimates than recent assessments for this stock. There are no indications of serious lack of fit to the spawn index data in recent years (Appendix Table 2.2) and there are no large residuals from the fit to the proportion-at-age data for the seine or gillnet fishery recently although there appear to be problems with the data from the 1970s (Fig. 4.8). Consequently, the weighted forecast run size of 24,420 tonnes is based on only the escapement model estimate (Table 4.1). Assuming an average recruitment level, a catch of 4,840 tonnes could be available for the Prince Rupert District in 1999 (Table 4.2). The 1993 and 1995 year-class appear to be above average while the 1994 year-class is average (Fig. 4.5). The projected stock abundances indicate that there is zero probability that the 1999 run will be less than the Cutoff level (Fig. 4.3).

The weighted forecast for the Central coast in 1999 with average recruitment is 43,430 tonnes, a substantial increase from 1998 (Table 4.1). The 1993 year-class was average but the recruiting 1995 and the recently recruited 1994 year-classes are both above average (Fig. 4.5). The cumulative probability plots indicate that there is zero probability that the 1999 run will be below the Cutoff level (Fig. 4.3). Based on the forecast run size a catch of 8,860 tonnes should be available assuming average recruitment (Table 4.2). The spawn index data fit the model well in recent years (Appendix Table 2.3) and there are no indications of lack of fit to the catch at age data (Fig. 4.9).

The weighted forecast run to the Strait of Georgia in 1999 is 78,900 tonnes assuming average recruitment a level similar to 1998 (Table 4.1). The 1993 year-class appears to be average while the recruiting 1995 and the 1994 year-classes are above average (Fig. 4.6). The projected stock abundances indicate that this stock remains well above the Cutoff level (Fig. 4.4). The projected abundance level should provide a potential catch of about 15,780 tonnes (Table 4.2). There are no indications of lack of fit to either the spawn index data (Appendix Table 2.4) or proportion-at-age data (Fig. 4.10) although the fall food and bait fishery shows some moderate residuals in recent years. Since this fall fishery represents only a small proportion of the total annual catch this should not substantially affect the assessment results.

The run forecast to the west coast of Vancouver Island assessment region, assuming a poor recruitment, is 39,600 tonnes, which is slightly less than the forecast for 1999 (Table 4.1). While the 1994 year-class was above average the recruiting 1995 year-class is poor and unlikely to sustain the recent stock increase. The projected stock biomass for 1999 indicates that there is zero probability of the run being below Cutoff (Fig. 4.4). An average recruitment assumption for this stock would result in a potential catch of 7,920 tonnes (Table 4.2). The age-structure model fits the spawn index data reasonably well (Appendix Table 2.5) and there are no significant residuals from the fit to the catch-at-age data in recent years except for the 1994 gillnet data (Fig. 4.11).

There is no forecast run size available for the minor stocks in Area 27. However, based on recent policy for this area the estimated pre-fishery biomass of 2,000 tonnes permits a harvest of no more than 10% of the 1998 biomass in 1999. This suggests a maximum potential harvest of 200 tonnes for the area. Estimates of recent recruitments indicates poor 1992 and 1993 year-classes followed by above average 1994 and recruiting 1995 year-classes which could result in future increase in abundance (Fig. 4.2, 4.6).

Profile Likelihoods

The AD model builder software package provides a useful feature to investigate variation in any model parameters using Bayesian inference. In this case, it is possible to evaluate the posterior distribution of the forecast stock biomass from the age-structured model. In the model the forecast biomass is calculated differently than shown in Table 4.1 where three levels of average recruitment are added to the estimate of returning adult abundance. In determining the forecast biomass for the profile likelihood analysis, the estimate of numbers of fish at age in 1998 at ages 2-9 is projected ahead to 1999 at age 3-10 assuming the average natural mortality rate, average availability, and current weight-at-age to estimate mature stock biomass. The estimated probability distributions of forecast 1999 biomass for the five assessment regions are presented in Figures 4.12 and 4.13. In the Queen Charlotte Islands and Prince Rupert District the profile likelihoods correspond well with the forecasts using the traditional weighting procedure. In the Central Coast the profile likelihood is most consistent with a poor recruitment scenario and for the two southern stocks the profile likelihoods fall below the poor forecast point estimate. This latter result is not surprising since in both the southern stocks the age-structured model estimate of stock size is less than that estimated by the escapement model assessment.

However, the likelihood profiles do provide some insight into the range of variability in stock forecast in each area and also of the probable lower bound of projected abundance in 1999 for the age-structured assessment.

Table 4.1. Summary of 1999 forecast spawning stock biomass (thousands of tonnes) from age-structured and escapement models and weighted runs for poor, average, and good age 2⁺ recruitment levels.

Assessment Regions	AGE-STRUCTURED MODEL				ESCAPEMENT MODEL				WEIGHTED RESULTS			
	Age 3 ⁺		Age 2 ⁺ Recruitment		Age 3 ⁺		Age 2 ⁺ Recruitment		Age 2 ⁺ and older		Relative	
	And older	Poor	Avg	Good	And older	Poor	Avg	Good	Poor	Avg	Weight	Good
Queen Charlotte Islands	37.60	38.40	40.83	47.71	26.02	26.49	28.21	33.08	26.49	28.21	0:100	33.08
Prince Rupert District	36.91	38.50	41.81	52.59	20.98	22.02	24.42	32.40	22.02	24.42	0:100	32.40
Central Coast	43.20	44.79	47.54	55.72	39.70	41.00	43.43	53.01	41.00	43.43	0:100	53.01
Strait of Georgia	39.52	47.53	59.32	71.38	56.78	65.64	78.90	98.69	65.64	78.90	0:100	98.69
W.C. Vancouver Island	23.82	27.29	32.00	45.88	35.38	39.60	45.13	58.93	39.60	45.13	0:100	58.93

Table 4.2. Summary of 1998 Cutoff levels and forecast potential harvest levels given poor, average, and good age 2⁺ recruitment for each of the assessment regions.

Assessment Regions	Abundance Forecast			Cutoff Level	Potential Harvest		
	Poor	Avg	Good		Poor	Avg	Good
Queen Charlotte Islands	26.49	28.21	33.08	10.70	5.30	5.64	6.62
Prince Rupert District	22.02	24.42	32.40	12.10	4.40	4.88	6.48
Central Coast	41.00	43.43	53.01	17.60	8.20	8.69	10.60
Strait of Georgia	65.64	78.90	98.69	21.20	13.13	15.78	19.74
W.C. Vancouver Island	39.60	45.13	58.93	18.80	7.92	9.03	11.79

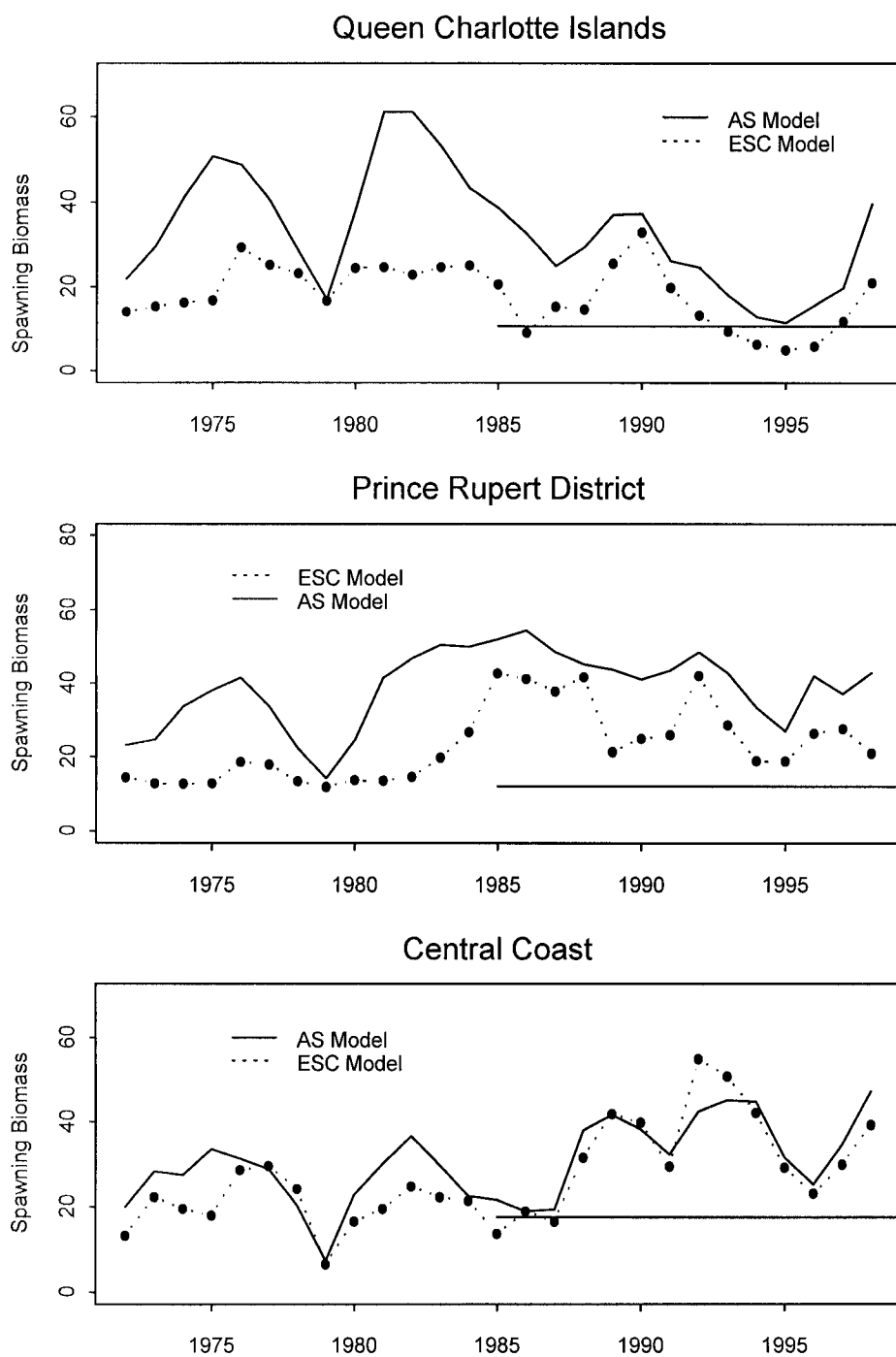


Fig. 4.1 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1998. Horizontal line indicates the Cutoff level for each stock.

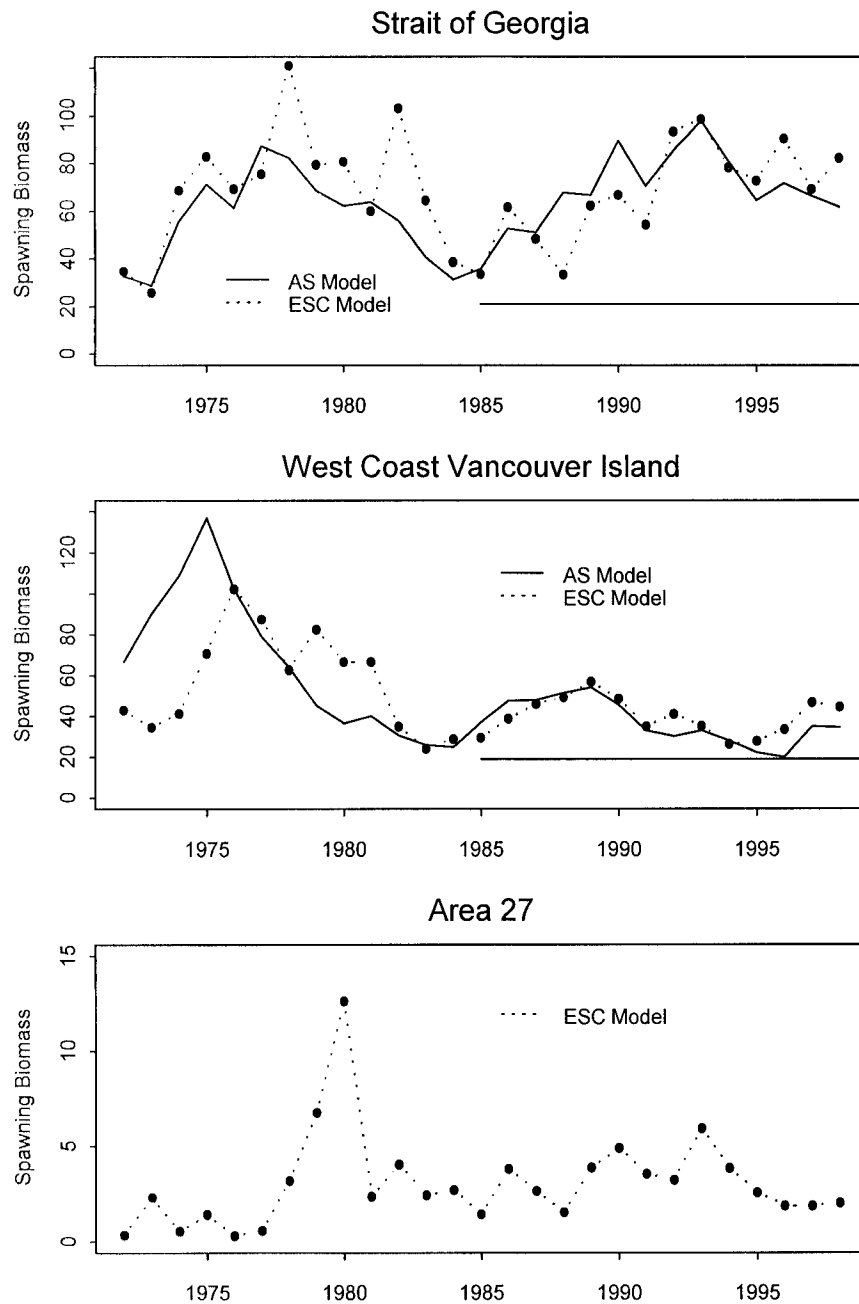


Fig. 4.2 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions and Area 27, 1972-1998. Horizontal line indicates the Cutoff level for each stock.

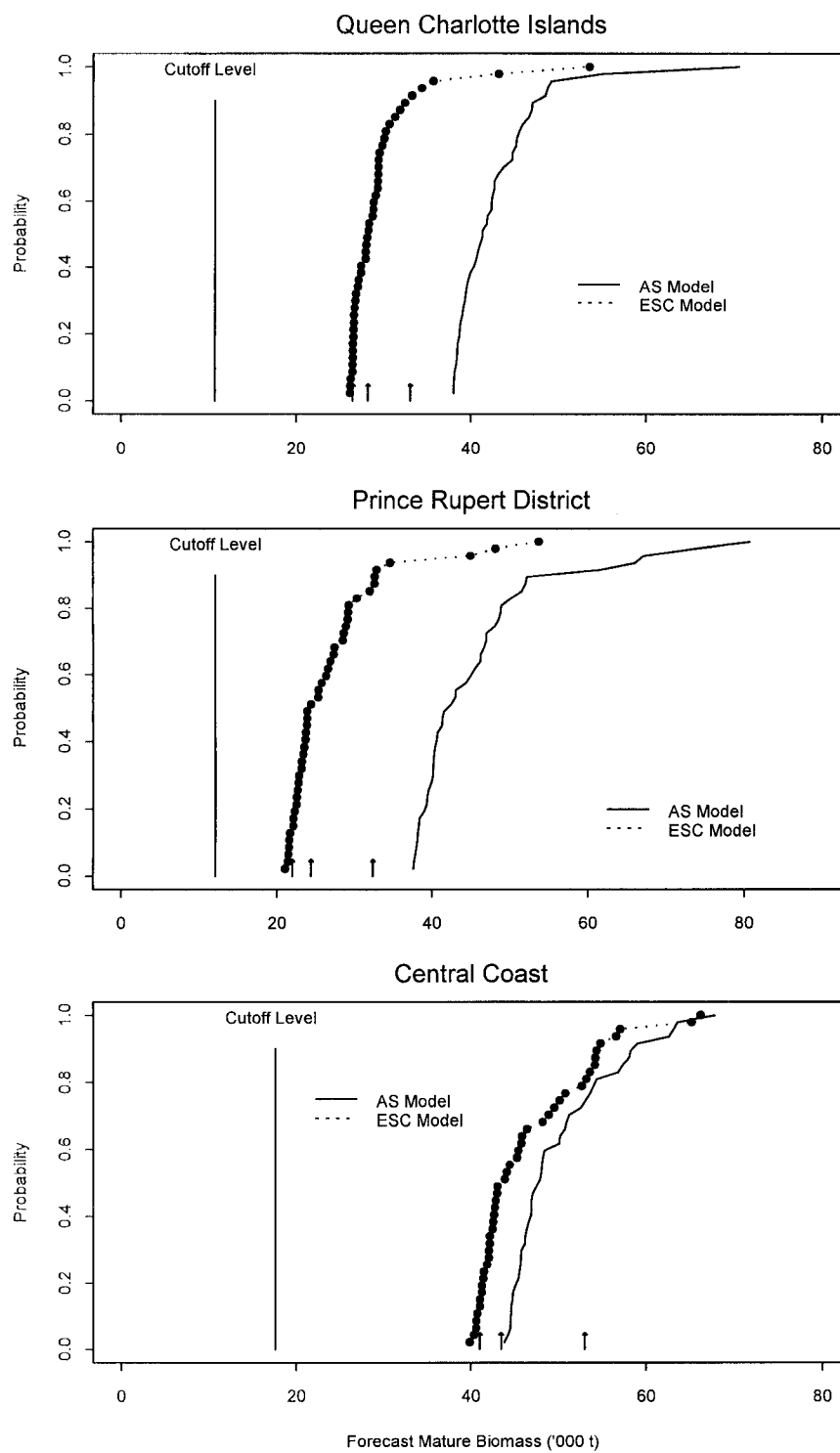


Fig. 4.3. Cumulative probability distributions of forecast spawning biomass for northern B.C. herring stock assessment regions in 1999. Dots represent the weighted mean of the two model estimates.

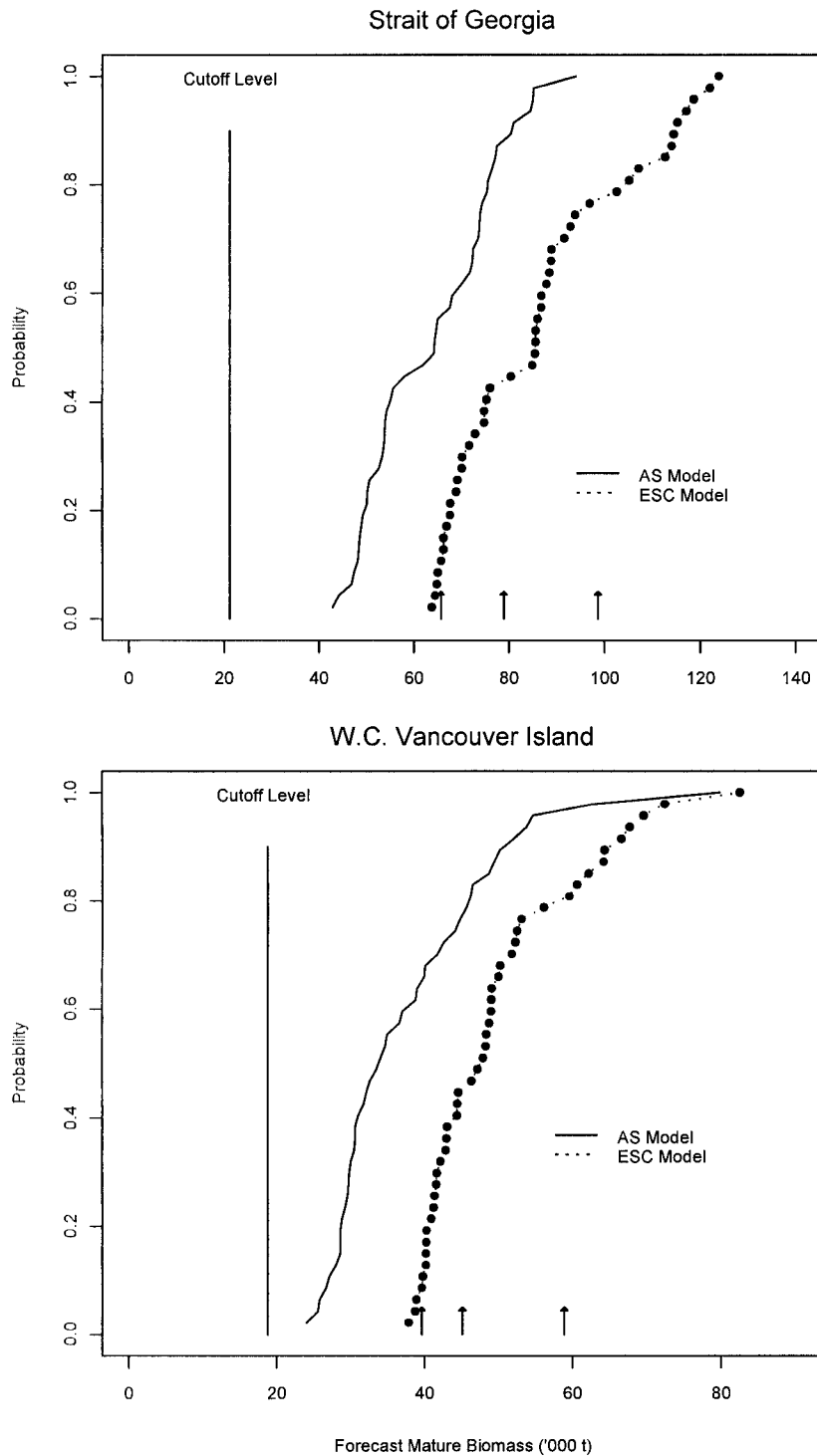


Fig. 4.4. Cumulative probability distributions of forecast spawning biomass for southern B.C. herring stock assessment regions in 1999. Dots represent the weighted mean of the two model estimates.

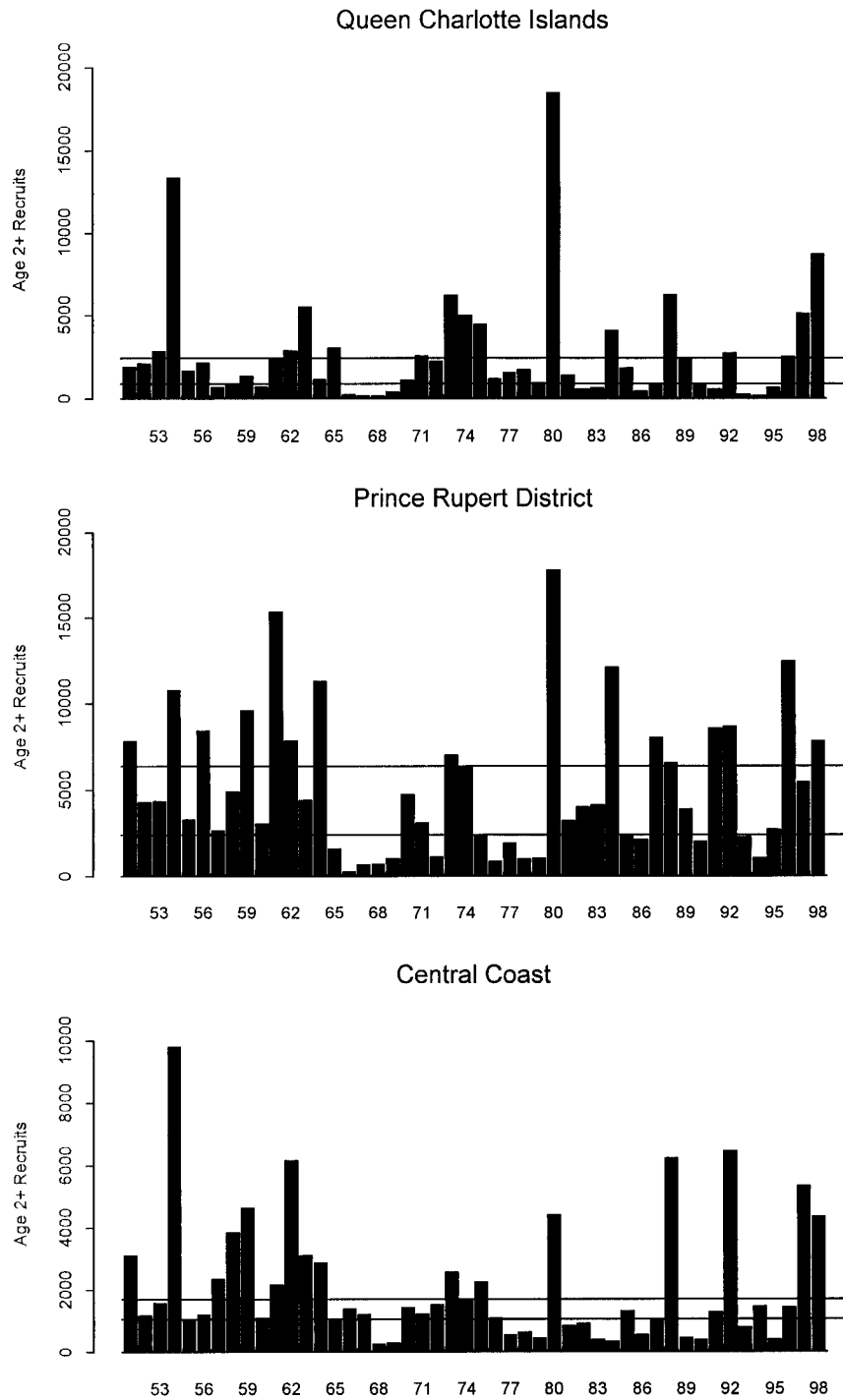


Fig. 4.5. Estimates of abundance of recruiting age 2⁺ year-classes from age-structured analysis for northern B.C. herring stock assessment regions, 1951-1998. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

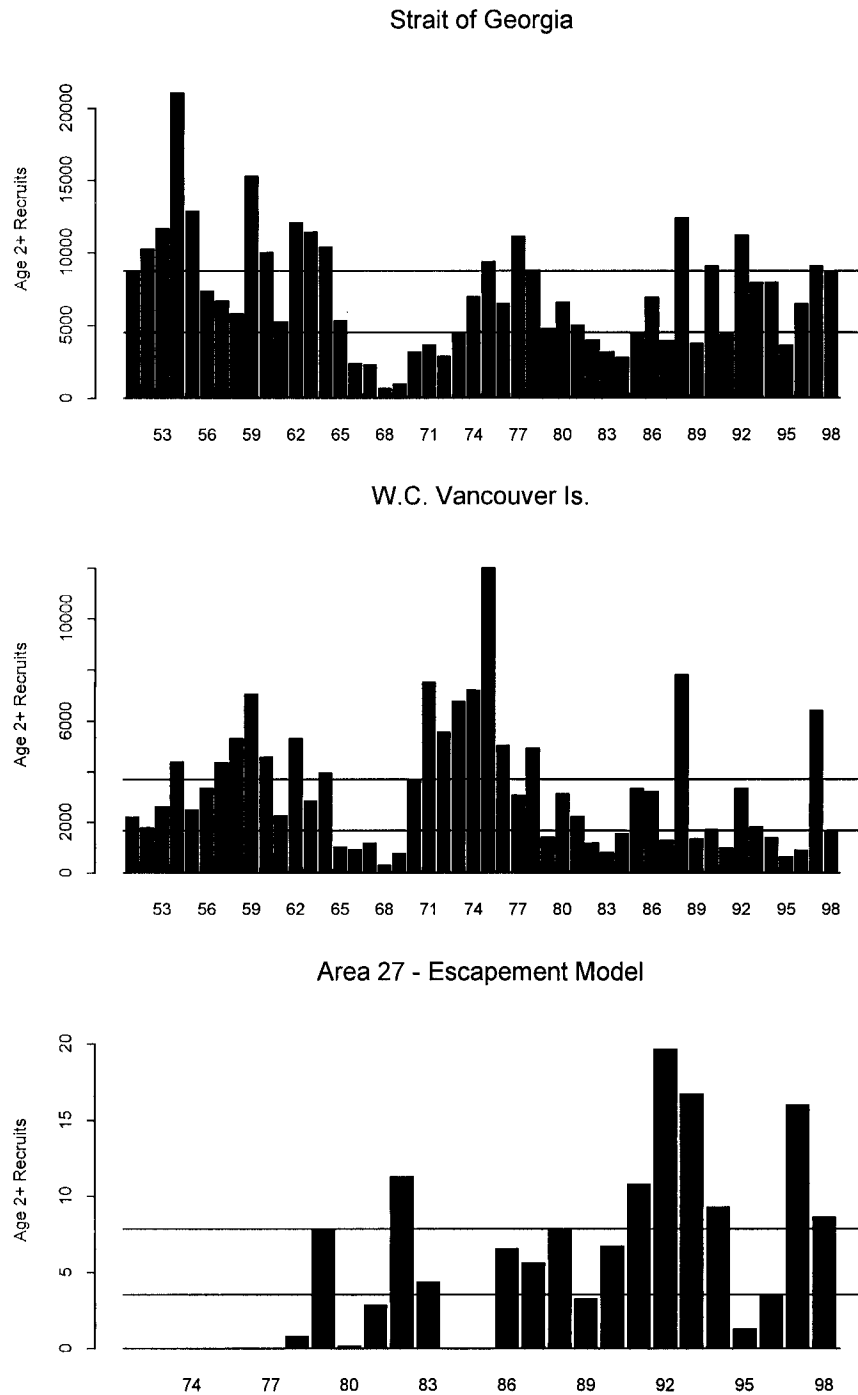


Fig. 4.6. Estimates of abundance of recruiting age 2⁺ year-classes from age-structured analysis for southern B.C. herring stock assessment regions, 1951-1998 and for the minor stock in area 27 for 1972-1998. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

Queen Charlotte Islands

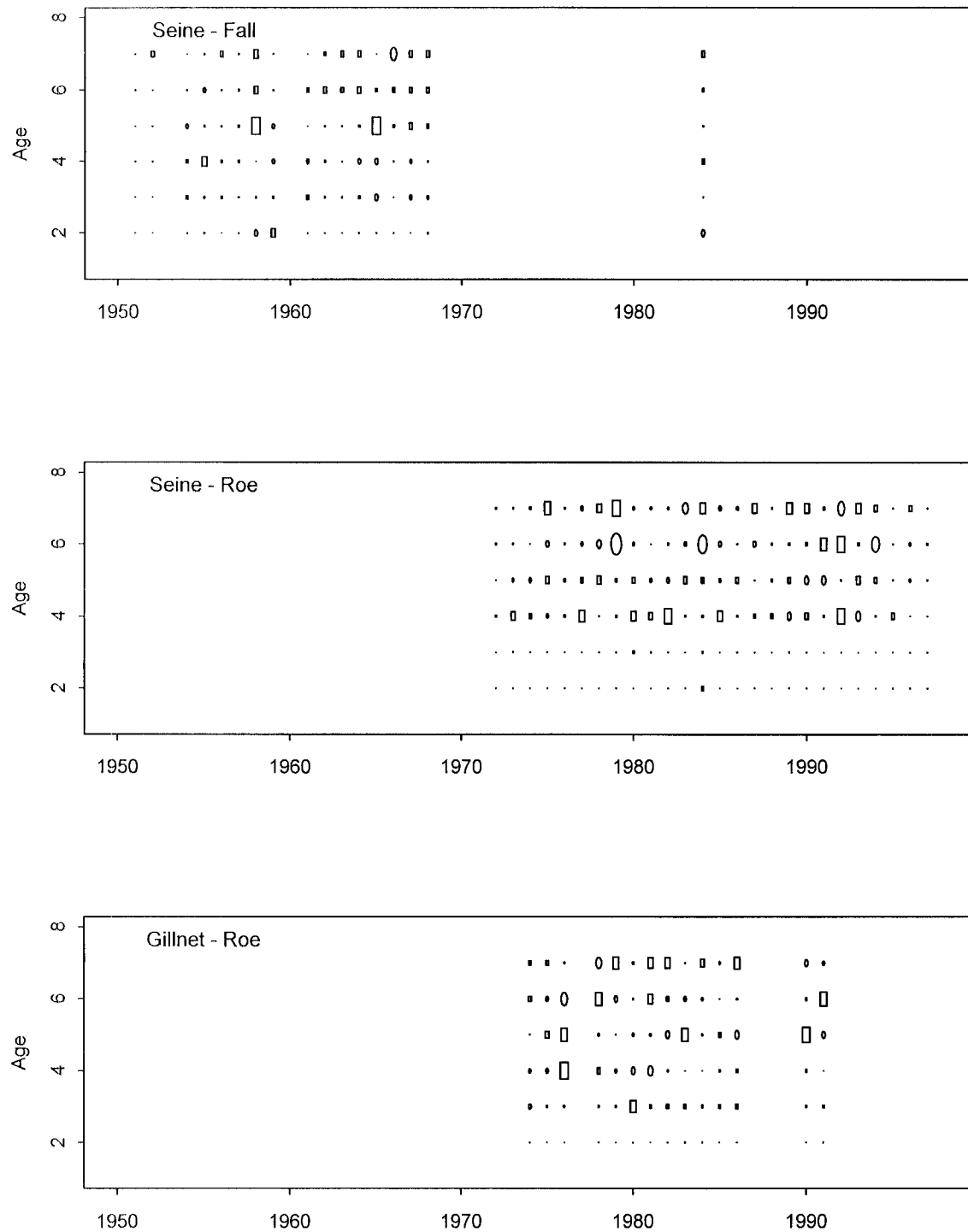


Figure 4.7. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Queen Charlotte Islands stock assessment region during three modelled fishing periods from 1951-1998. Ellipses denote positive residuals and rectangles negative residuals.

Prince Rupert District

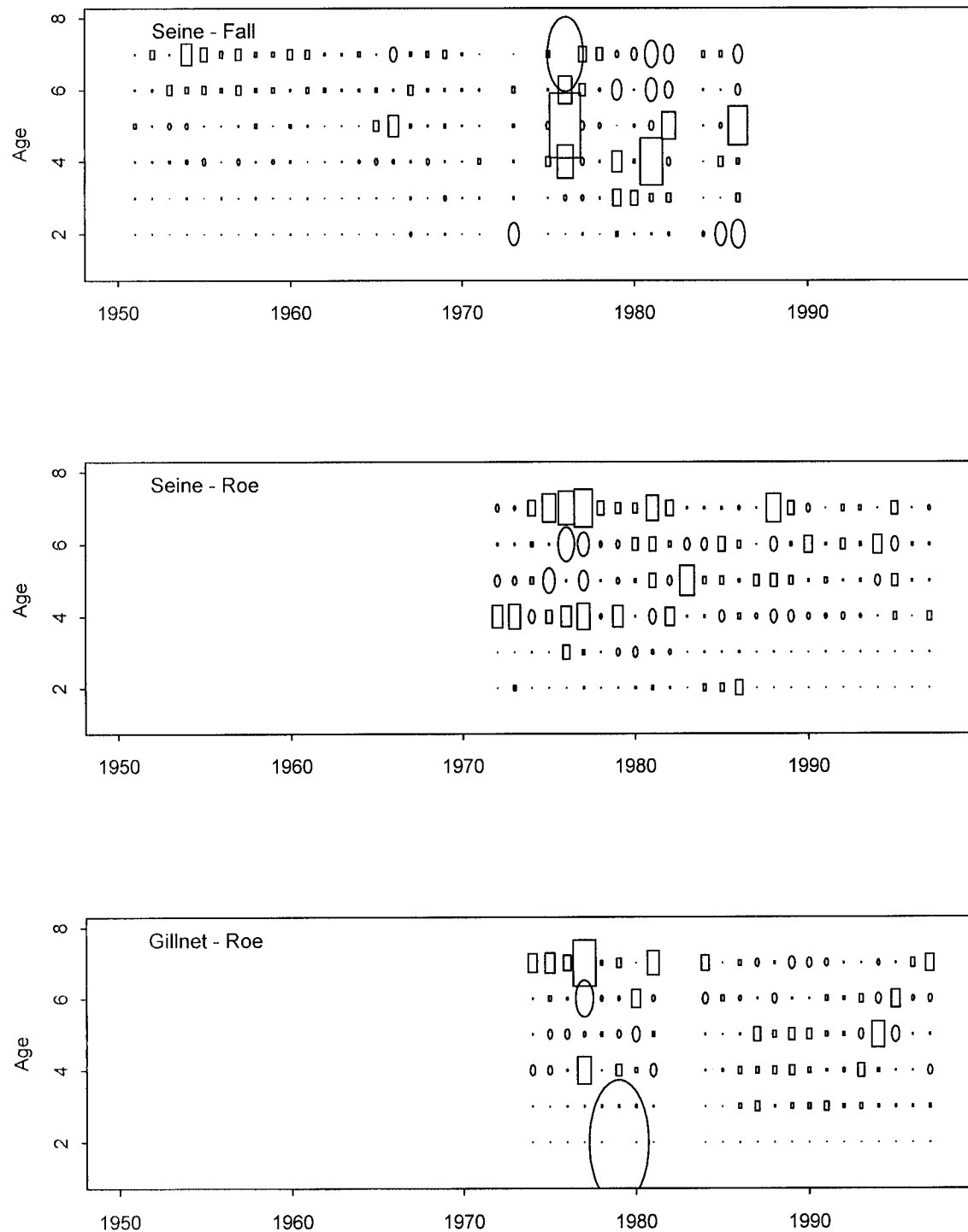


Figure 4.8. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Prince Rupert District stock assessment region during three modelled fishing periods from 1951-1998. Ellipses denote positive residuals and rectangles negative residuals.

Central Coast

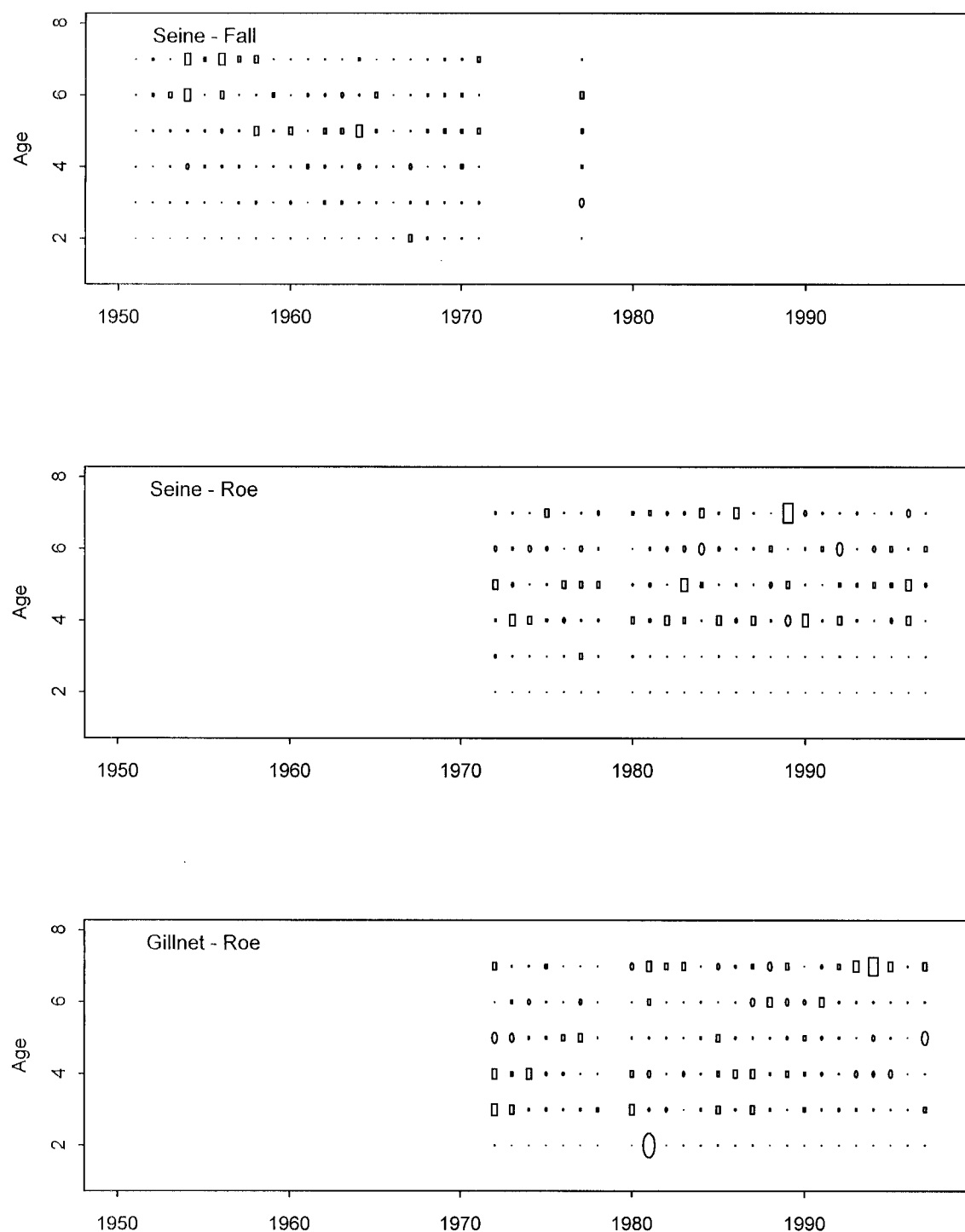


Figure 4.9. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Central Coast stock assessment region during three modelled fishing periods from 1951-1998. Ellipses denote positive residuals and rectangles negative residuals.

Strait of Georgia

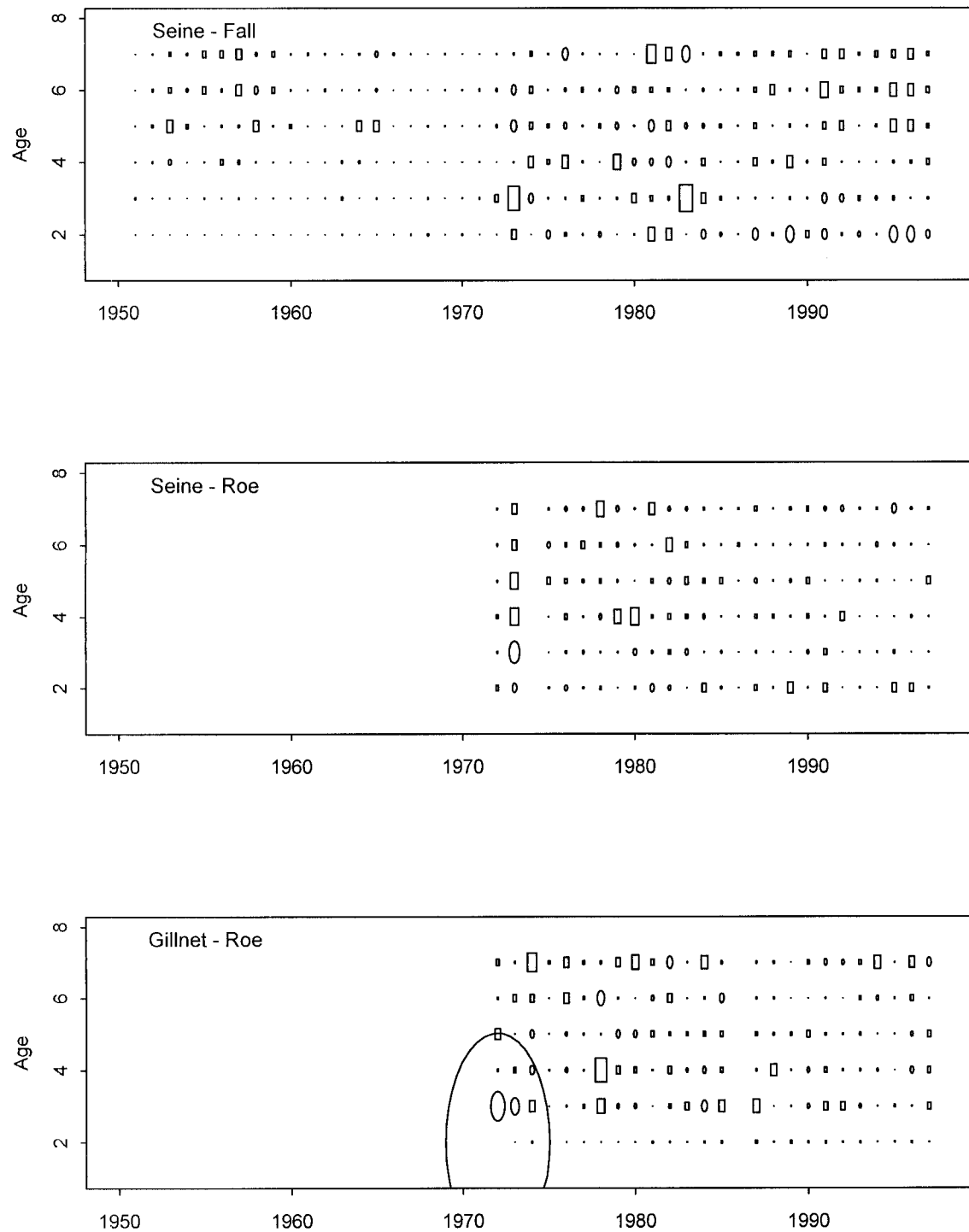


Figure 4.10. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Strait of Georgia stock assessment region during three modelled fishing periods from 1951-1998. Ellipses denote positive residuals and rectangles negative residuals.

W.C. Vancouver Is.

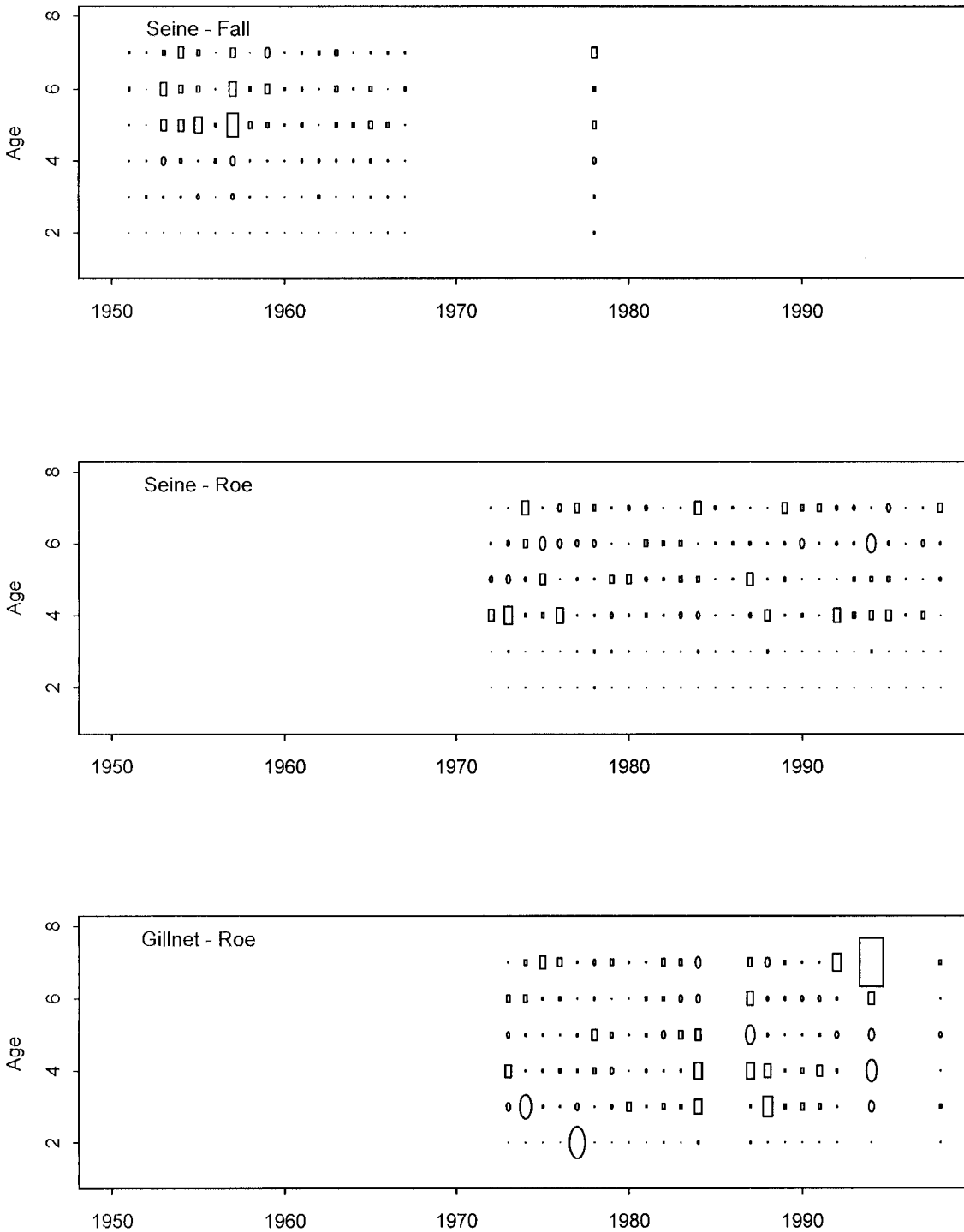


Figure 4.11. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the west coast of Vancouver Island stock assessment region during three modelled fishing periods from 1951-1998. Ellipses denote positive residuals and rectangles negative residuals.

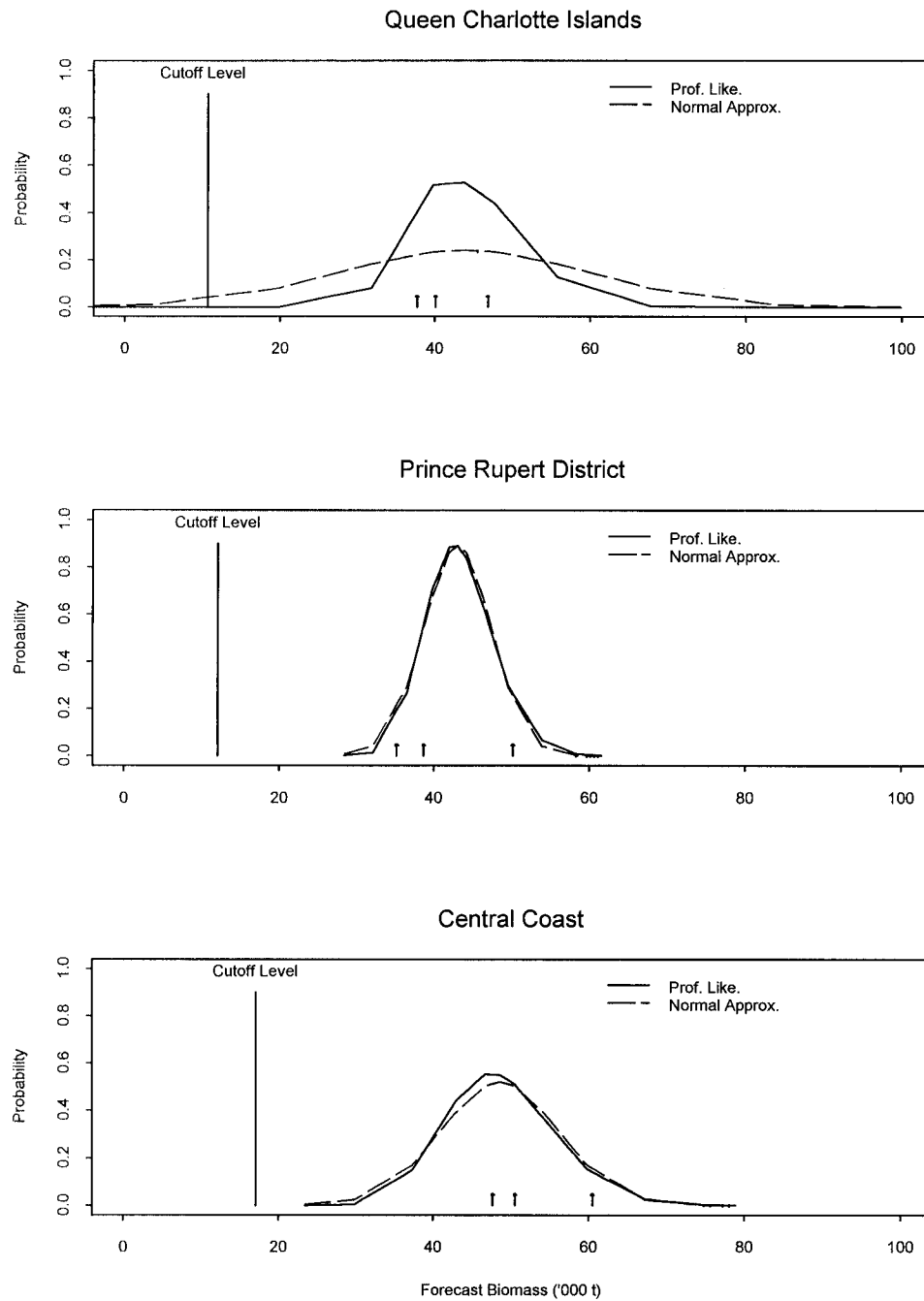


Fig. 4.12. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 1999 mature biomass in the northern stock assessment regions. The arrows denote the forecasts for poor, average, and good recruitments based on the traditional weighting scheme.

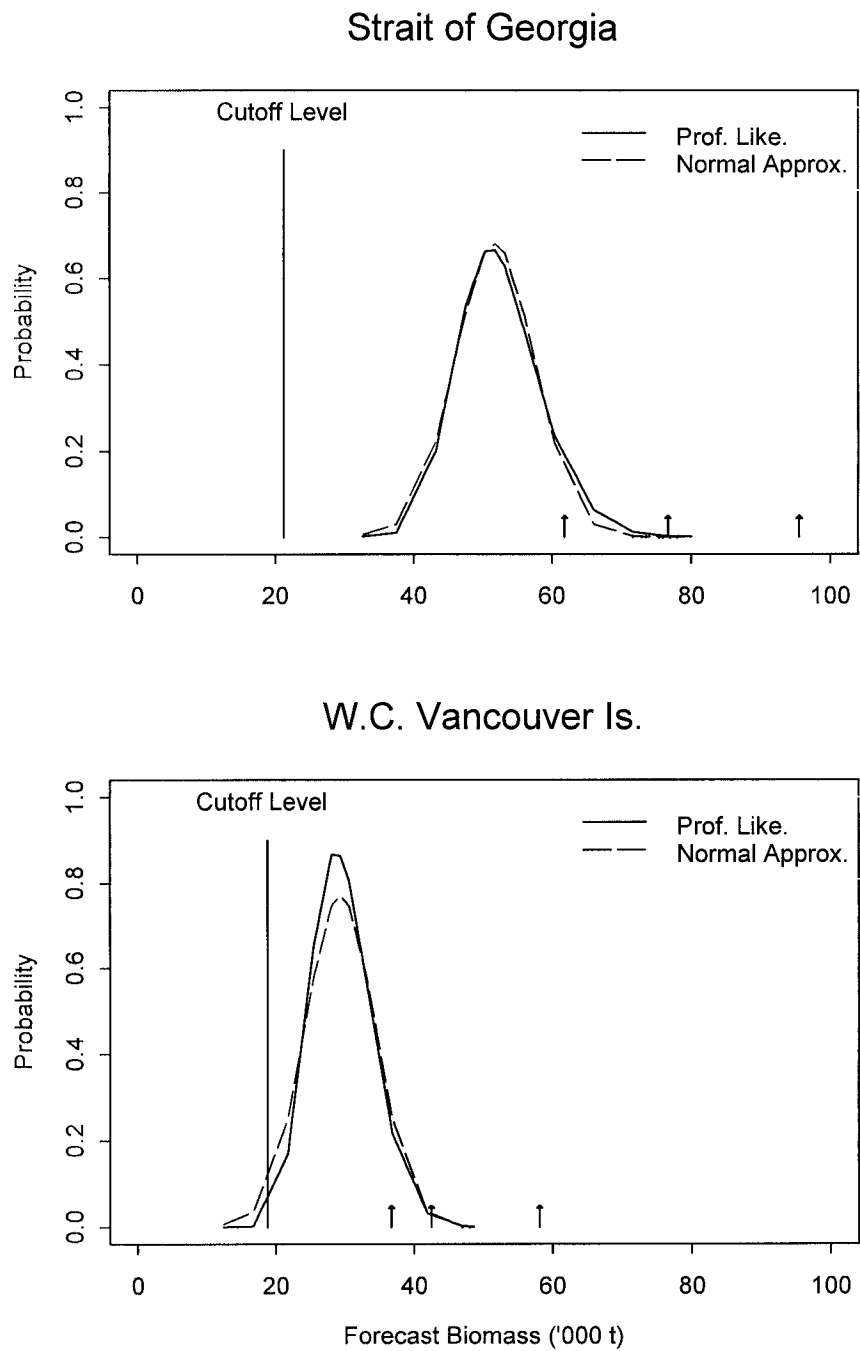


Fig. 4.13. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 1999 mature biomass in the southern stock assessment regions. The arrows denote the forecasts for poor, average, and good recruitments based on the traditional weighting scheme.

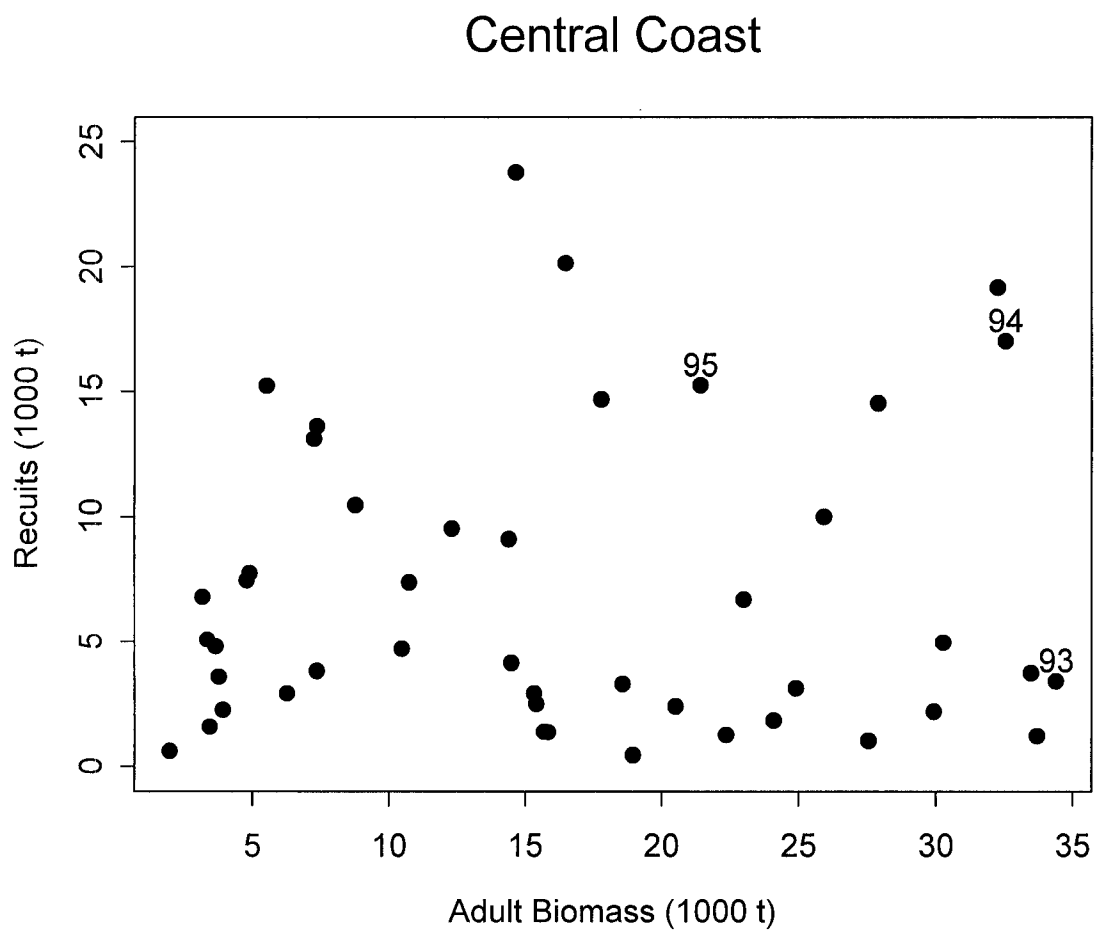


Figure 4.14. Stock and recruitment plot for Central Coast herring showing 1951-95 year-classes.

5. RETROSPECTIVE ANALYSES

Age-structured Model

Schweigert (1996) presented a retrospective analysis for the herring age-structured model that indicated a tendency for slight over-forecasting in the northern assessment regions and under-forecasting in the southern assessment areas. An explanation for this conflicting trend was not evident but appears to be related to the inverse relationship between estimated natural mortality and the spawn index conversion factor. This effect persists in the current assessment which has been updated to include retrospective plots to and including the current year (Fig. 5.1, 5.2). In the northern assessment areas estimates of current spawning biomass and consequent forecasts of run sizes have been quite consistent with a few minor exceptions in the Queen Charlotte Islands and Central Coast. Estimates for Prince Rupert have generally been much too high. The result for the current year is based on the revised data series for comparison to previous assessments. In the southern assessment regions, stock reconstructions have been fairly conservative within the Strait of Georgia and to a lesser extent on the west coast of Vancouver Island. Further investigation of the causes of these conflicting north and south trends is required.

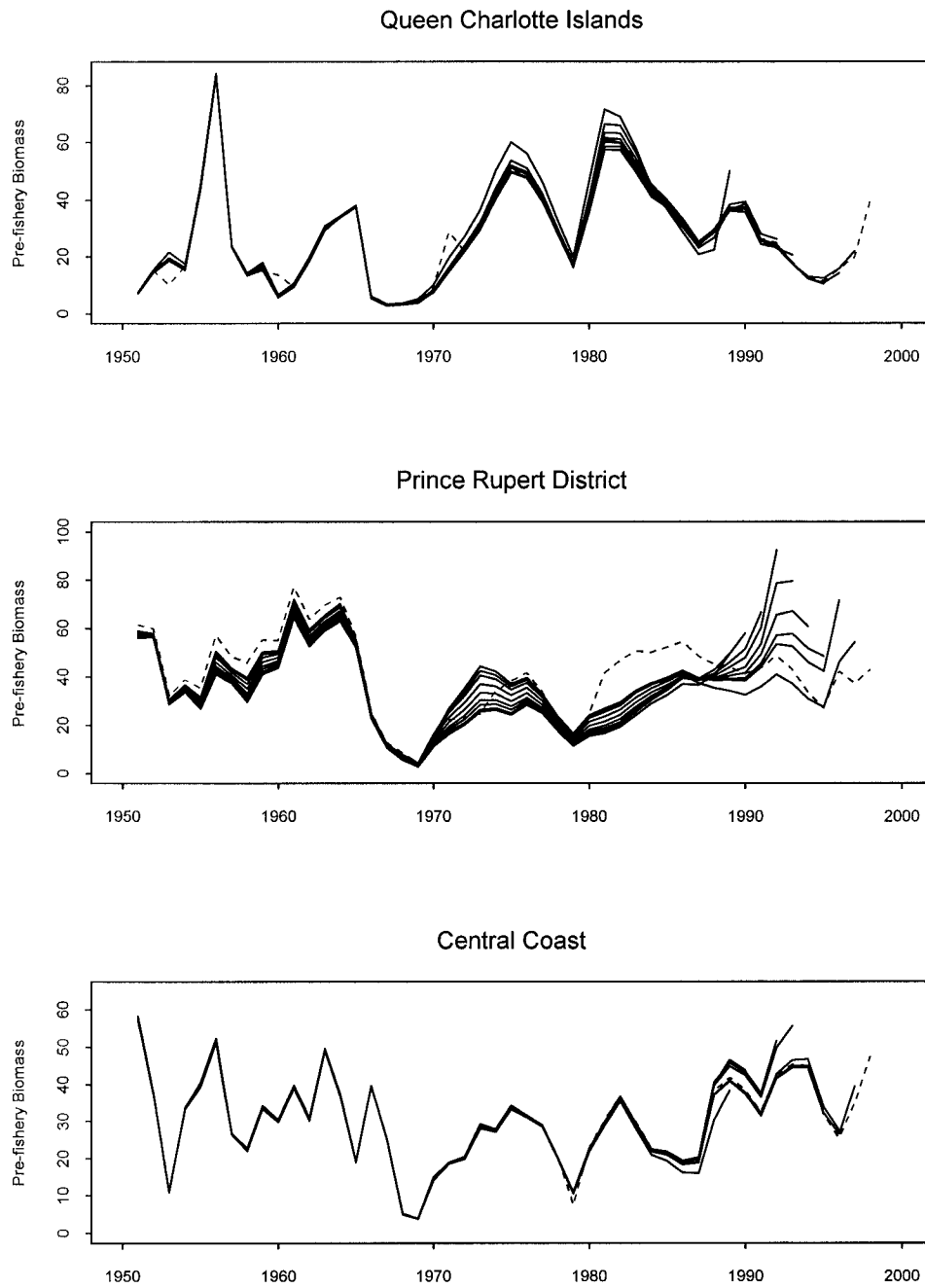


Figure 5.1. Retrospective analysis of estimated spawning biomass from age-structured assessment for northern B.C. herring stocks from 1951-1998. Dashed line indicates the most recent assessment.

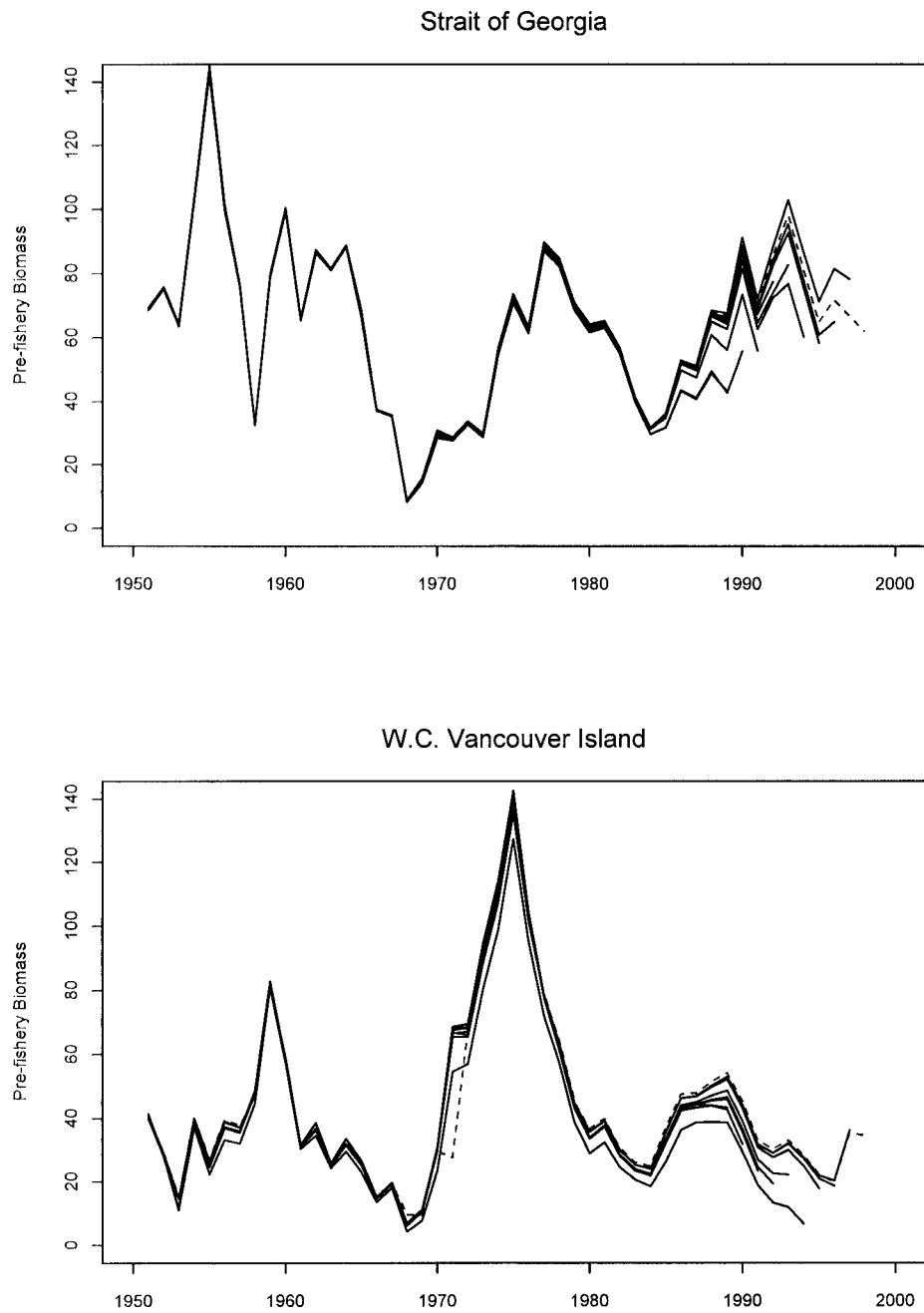


Figure 5.2. Retrospective analysis of estimated spawning biomass from age-structured assessment for southern B.C. herring stocks from 1951-1998. Dashed line indicates the most recent assessment.

6. ROE FISHERY ANALYSIS

During the 1997 PSARC meeting there was discussion about the accuracy and applicability of the historical reduction fishery data (pre-1970) to the current assessment of stock abundance. To examine this question age-structured analyses were performed on the data from the roe fishery period alone and compared with the results for the entire time series. The results are presented in Figures 6.1 and 6.2 for the northern and southern assessment regions, respectively. For the roe fishery analysis runs were conducted in which the model attempted to estimate the natural mortality as is currently done for the entire time series. These runs were successful in all but the Prince Rupert stock where no solution was reached. However, it is evident in the figures that the runs for the other 4 stocks all resulted in unrealistically high estimates of stock size.

In addition, runs were conducted for the roe fishery data in which the natural mortality rate was fixed at the level estimated by the age-structured assessment from the entire time series of information. These runs resulted in estimates of stock size and trajectory virtually identical to those obtained from the entire time series. These results suggest that the roe fishery data alone do not contain enough information to estimate the natural mortality rate for each stock and hence the relative stock size and trajectory. The results also demonstrate that the inclusion of the reduction fishery data in the assessment for the entire time series does not impact the estimated abundance level or stock trajectory obtained from the roe fishery period.

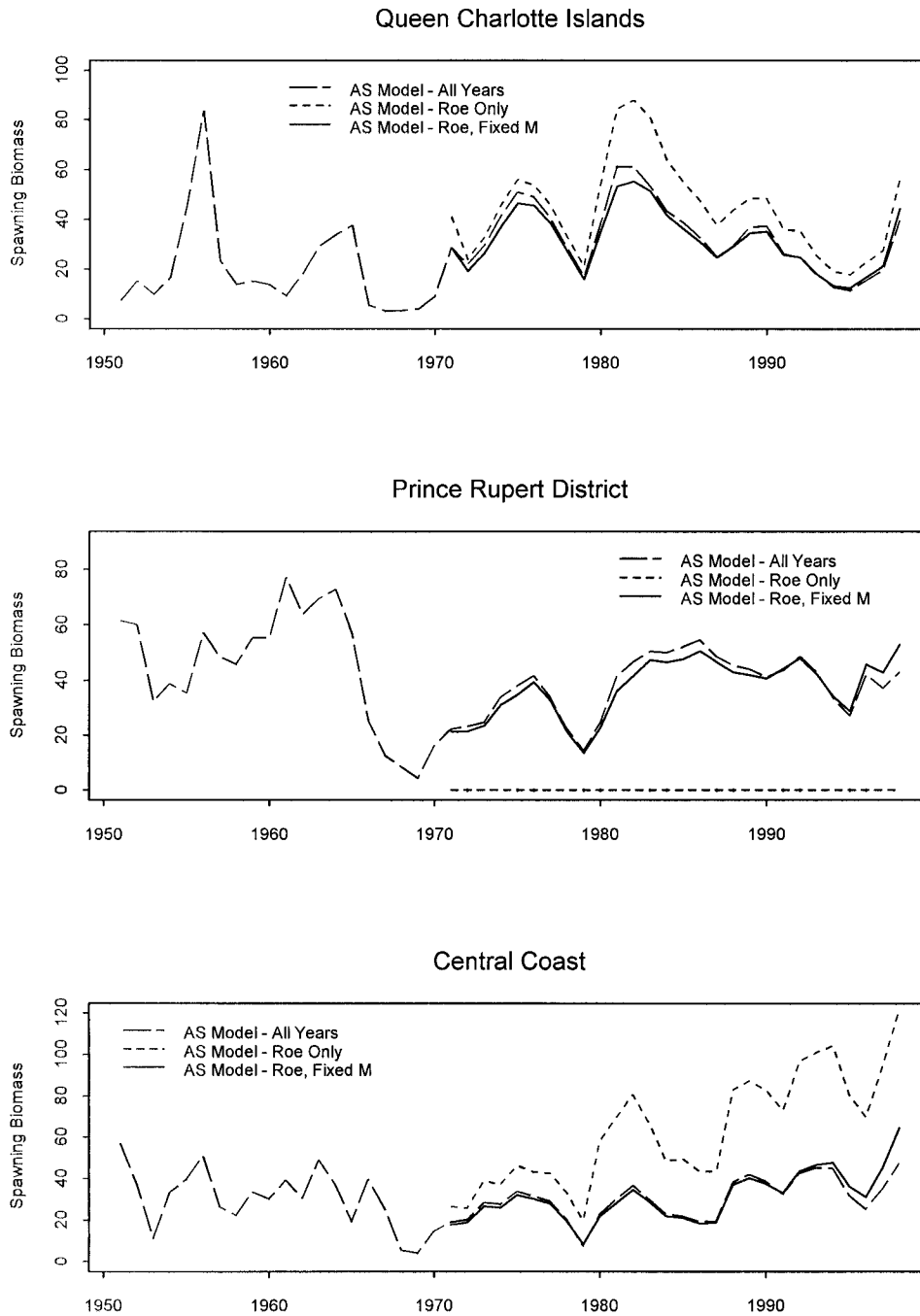


Figure 6.1. Estimates of pre-fishery biomass for the roe fishery period (fixed and estimated M) and for the entire time series for northern stock assessment regions from 1951-1998.

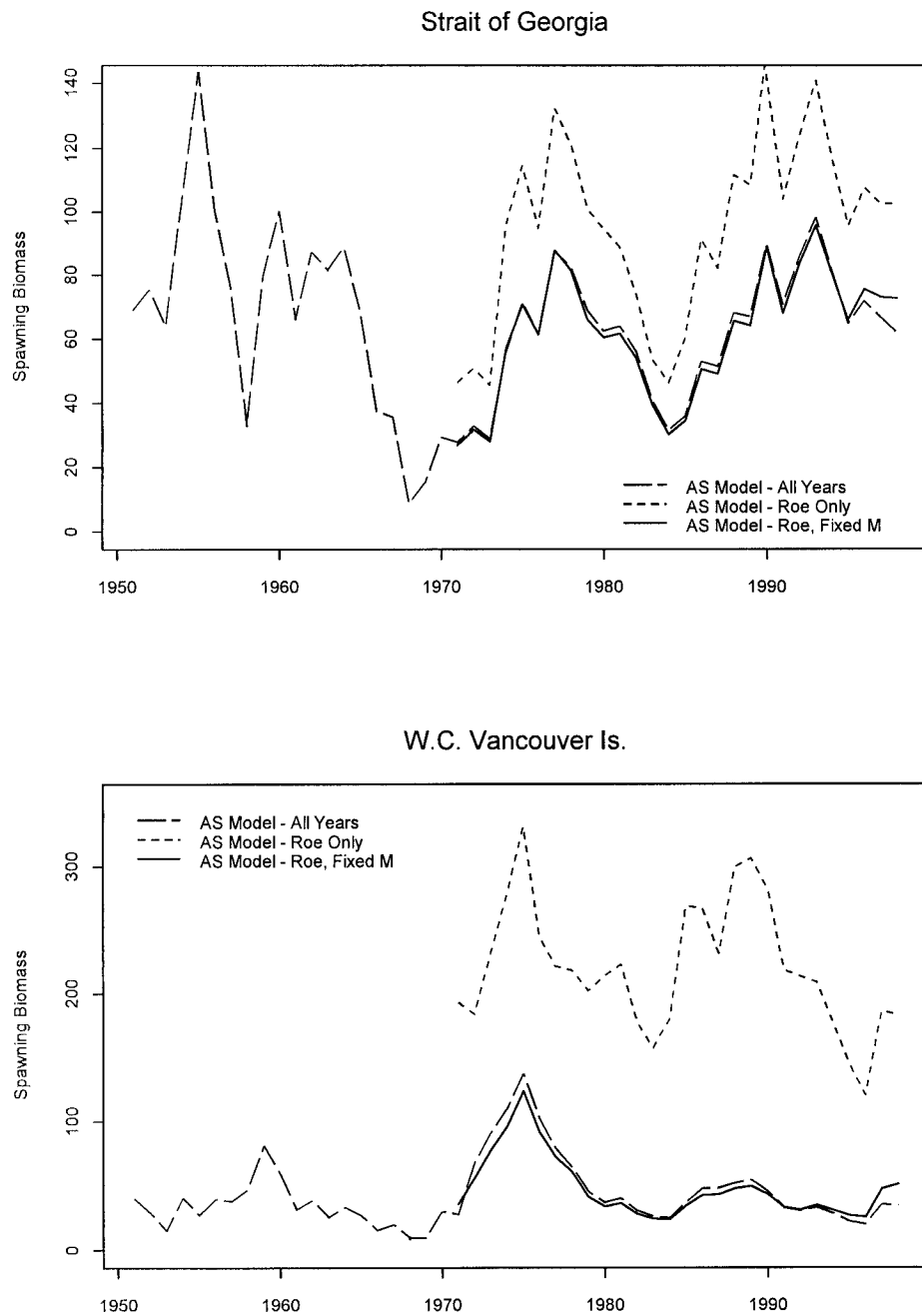


Figure 6.2. Estimates of pre-fishery biomass for the roe fishery period (fixed and estimated M) and for the entire time series for southern stock assessment regions from 1951-1998.

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8. APPENDIX TABLES

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									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10 ³)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	WINTER	0.07	15.31	52.91	15.31	11.52	4.20	0.61	0.07	0.00	1476	1544	317.44
1951/52	WINTER	17.13	21.81	34.17	21.54	4.14	1.12	0.09	0.00	0.00	2224	166	1124.25
1953/54	WINTER	2.96	29.02	21.28	33.66	10.19	1.93	0.71	0.19	0.06	0*	25	231.66
1954/55	WINTER	8.74	14.08	39.42	18.06	14.85	4.37	0.29	0.10	0.10	0*	25	52.94
1955/56	WINTER	0.15	16.02	9.64	62.17	8.38	2.74	0.74	0.00	0.15	1348	681	6551.83
1956/57	WINTER	20.77	24.13	15.76	9.59	26.73	2.45	0.44	0.13	0.00	4733	2180	2089.67
1957/58	WINTER	81.89	16.42	1.23	0.18	0.14	0.14	0.00	0.00	0.00	2838	514	2146.22
1958/59	WINTER	1.05	63.16	28.42	7.37	0.00	0.00	0.00	0.00	0.00	95	6	735.74
1960/61	WINTER	4.21	32.63	36.00	24.84	1.26	0.42	0.21	0.42	0.00	0*	25	59.00
1961/62	WINTER	3.04	37.62	41.36	9.58	6.54	1.64	0.23	0.00	0.00	428	170	693.85
1962/63	WINTER	0.37	50.00	27.11	18.16	2.11	1.99	0.00	0.12	0.12	804	411	1342.32
1963/64	WINTER	0.95	15.34	59.47	17.80	5.30	1.14	0.00	0.00	0.00	528	297	2515.06
1964/65	WINTER	1.61	79.77	11.02	4.37	2.09	0.95	0.19	0.00	0.00	1053	165	3424.55
1965/66	WINTER	18.36	32.77	16.38	10.40	7.45	5.89	4.92	2.07	1.75	0*	25	210.12
1966/67	WINTER	0.88	67.26	26.49	2.65	2.72	0.00	0.00	0.00	0.00	0*	25	18.83
1967/68	WINTER	29.95	50.57	17.23	2.25	0.00	0.00	0.00	0.00	0.00	0*	25	8.43
1971/72	ROE-SN	3.04	32.60	38.34	16.05	6.08	2.45	0.93	0.42	0.08	1184	94	276.24"
1972/73	ROE-SN	0.17	40.56	21.55	27.29	8.00	1.68	0.75	0.00	0.00	1726	914	524.51
1973/74	ROE-SN	0.12	30.49	40.38	17.69	9.09	1.86	0.31	0.06	0.00	1617	185	482.78
	ROE-GN	0.00	5.73	48.41	25.48	16.56	3.18	0.00	0.00	0.64	157	25	8.24
1974/75	ROE-SN	0.63	25.31	34.21	27.90	9.53	1.95	0.37	0.10	0.00	6010	655	587.13"
	ROE-GN	0.00	0.00	22.50	40.00	30.00	5.00	2.50	0.00	0.00	40	40	6.19
1975/76	ROE-SN	0.43	2.78	37.34	29.38	22.73	6.31	0.96	0.07	0.00	4170	247	813.57"
	ROE-GN	0.00	0.00	0.75	21.80	60.90	14.29	2.26	0.00	0.00	133	186	91.86
1976/77	ROE-SN	0.09	19.57	8.01	29.41	22.95	15.09	4.47	0.40	0.00	3220	1113	801.25"
1977/78	ROE-SN	0.16	26.18	17.34	9.48	26.18	14.10	5.27	0.97	0.32	1234	1932	620.46
	ROE-GN	0.00	0.61	4.85	11.52	19.39	39.39	20.00	3.64	0.61	165	126	129.55
1978/79	ROE-SN	5.59	4.41	31.57	18.73	21.27	15.10	2.84	0.39	0.10	1020	441	387.56"
	ROE-GN	0.00	0.00	25.13	25.13	20.10	3.52	0.50	0.50	0.50	199	65	128.20
1979/80	ROE-SN	0.50	83.22	4.45	5.37	2.77	1.89	1.15	0.56	0.09	3390	2427	222.15
	ROE-GN	0.00	3.73	4.48	40.09	20.79	22.28	6.93	1.60	0.11	938	1028	74.53
1980/81	ROE-SN	0.18	3.54	84.99	5.40	3.05	1.82	0.71	0.18	0.12	4943	489	331.92"
	ROE-GN	0.00	0.22	74.81	8.29	9.39	4.86	1.88	0.55	0.00	905	339	121.41
1981/82	ROE-SN	0.84	4.46	4.43	84.63	2.42	1.62	0.95	0.53	0.14	3591	1725	185.38"
	ROE-GN	0.00	0.19	3.42	88.21	3.42	2.66	1.14	0.76	0.19	526	341	99.20
1982/83	ROE-SN	4.88	5.23	3.51	6.86	72.87	3.91	1.58	0.91	0.25	1968	1609	317.79"
	ROE-GN	0.00	0.00	1.34	2.81	89.02	3.08	2.54	0.67	0.54	747	637	58.91
1983/84	WINTER	5.91	36.56	2.15	4.30	8.60	39.25	2.15	0.54	0.54	186	186	9.25
	ROE-SN	2.06	35.34	4.90	2.77	10.53	42.85	1.03	0.35	0.16	3104	1554	312.33
	ROE-GN	0.00	2.81	1.28	4.60	8.95	80.05	1.79	0.26	0.26	391	427	34.59
1984/85	ROE-SN	1.32	14.93	31.83	4.05	4.50	11.36	31.47	0.45	0.08	3556	699	311.61"
	ROE-GN	0.00	0.00	15.28	2.08	4.17	11.11	66.67	0.69	0.00	144	83	85.78
1985/86	ROE-SN	0.21	2.83	21.99	40.19	4.04	3.27	8.03	19.12	0.32	4733	2821	157.73
	ROE-GN	0.00	0.00	11.85	50.62	5.43	5.19	10.37	16.05	0.49	405	383	55.79
1986/87	ROE-SN	1.74	10.42	5.85	24.35	37.76	3.84	4.33	5.79	5.91	3281	1144	131.07"
1987/88	ROE-SN	3.64	51.01	7.52	4.77	11.75	14.86	1.37	1.67	3.40	1676	575	2.56"
1988/89	ROE-SN	2.27	17.46	66.35	4.01	1.57	3.90	2.78	0.62	1.04	3563	199	121.30"
1989/90	ROE-SN	0.22	9.64	18.17	60.02	3.94	1.84	3.82	1.70	0.65	5053	409	411.22"
	ROE-GN	0.00	0.46	8.31	43.65	10.16	8.55	17.09	8.55	3.23	433	397	77.90
1990/91	ROE-SN	6.70	4.13	10.66	28.70	38.47	3.69	1.80	3.99	1.86	3387	1964	383.94"
	ROE-GN	0.00	0.00	2.54	21.57	44.42	9.14	6.85	10.41	5.08	394	457	35.85
1991/92	ROE-SN	0.71	38.51	4.93	8.36	12.45	30.73	2.39	0.59	1.33	3228	2333	267.96
1992/93	ROE-SN	0.32	3.45	60.34	4.45	6.06	12.07	11.75	1.16	0.40	3712	304	314.80"
1993/94	ROE-SN	6.15	4.27	5.00	48.40	10.58	10.91	10.83	3.20	0.66	1219	1516	108.79
1994/95	ROE-SN	14.14	16.93	1.92	4.71	39.09	8.73	7.33	4.71	2.44	573	252	1.00~
1995/96	ROE-SN	10.77	53.87	9.31	3.24	3.35	15.59	2.41	1.15	0.31	956	410	1.00~
1996/97	ROE-SN	22.64	26.17	33.41	5.23	1.52	4.44	5.36	0.85	0.37	1643	299	27.99
1997/98	ROE-SN	0.30	53.28	28.17	11.85	2.92	0.69	1.33	1.07	0.39	2329	1450	239.76

FISHERY	AVERAGE WEIGHT AT AGE (gms)								
	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	52.0	84.4	106.6	125.9	147.7	156.8	172.1	147.3	183.5
ROE-SN	65.3	96.2	122.2	144.0	163.0	177.7	189.4	199.6	199.8
ROE-GN	0.0	119.8	141.4	152.5	169.3	178.5	191.1	188.9	195.8

* - Age composition from published reports.
 ~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
 ~ - includes catch from "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	1+	2+	3+	4+	PERCENT AT AGE					NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
						5+	6+	7+	8+	9+			
1950/51	WINTER	4.34	18.20	58.50	10.38	5.62	2.65	0.26	0.04	0.02	4682	2200	4953.11
1951/52	WINTER	4.76	8.81	33.67	45.24	6.15	1.03	0.30	0.03	0.00	5922	2508	4390.81
1952/53	WINTER	1.20	38.13	23.04	25.44	11.13	0.99	0.07	0.00	0.00	1419	752	173.50
1953/54	WINTER	2.11	28.35	29.07	24.02	13.22	2.60	0.60	0.04	0.00	2656	891	2522.89
1954/55	WINTER	2.74	4.86	70.29	15.65	5.22	1.06	0.18	0.00	0.00	1131	467	1698.85
1955/56	WINTER	10.04	58.11	9.51	18.95	2.55	0.53	0.18	0.12	0.00	1683	555	1218.10
1956/57	WINTER	11.49	17.76	39.79	13.21	16.04	1.37	0.32	0.03	0.00	3491	515	2827.98
1957/58	WINTER	45.81	30.22	8.03	11.81	1.77	2.36	0.00	0.00	0.00	847	123	644.16
1958/59	WINTER	3.10	56.69	20.85	5.80	9.88	1.72	1.90	0.06	0.00	1741	349	1037.09
1959/60	WINTER	49.14	6.25	28.20	8.89	4.14	2.52	0.67	0.19	0.00	4206	337	2451.31
1960/61	WINTER	9.74	58.33	7.28	18.00	4.35	1.60	0.58	0.12	0.00	4300	763	4815.52
1961/62	WINTER	3.04	30.30	44.66	6.88	9.92	3.41	0.92	0.54	0.33	1845	752	2476.36
1962/63	WINTER	39.30	13.29	18.18	22.05	3.60	2.96	0.50	0.06	0.06	3415	433	4788.66
1963/64	WINTER	3.71	64.94	10.12	10.94	8.85	0.71	0.59	0.12	0.03	3400	1914	3555.87
1964/65	WINTER	5.98	13.57	50.95	8.54	11.01	8.45	1.04	0.33	0.12	3360	459	3649.12
1965/66	WINTER	0.00	5.29	21.38	23.45	16.32	19.08	9.66	3.22	1.61	435	59	1071.96
1966/67	WINTER	57.22	32.21	5.37	1.88	2.70	0.41	0.20	0.00	0.00	0*	25	1218.55
1967/68	WINTER	34.87	39.74	19.40	4.59	0.73	0.26	0.14	0.27	0.00	0*	25	274.98
1968/69	WINTER	30.04	45.04	20.58	3.90	0.18	0.21	0.04	0.00	0.00	0*	25	69.11
1969/70	WINTER	18.67	62.91	15.11	3.12	0.03	0.08	0.08	0.00	0.00	0*	25	183.69
1970/71	WINTER	6.49	50.42	29.28	7.99	4.33	0.83	0.50	0.17	0.00	601	38	413.67
1971/72	ROE-SN	0.00	5.32	17.93	64.43	5.88	3.78	2.38	0.14	0.14	714	209	278.66"
1972/73	ROE-SN	0.25	33.00	4.39	30.36	26.60	3.39	1.25	0.75	0.00	797	662	109.21"
1973/74	ROE-SN	0.16	17.88	53.16	7.44	16.46	4.43	0.32	0.16	0.00	632	121	174.36"
	ROE-GN	0.00	0.96	39.42	21.15	34.62	2.88	0.96	0.00	0.00	104	83	90.07
1974/75	ROE-SN	1.30	9.40	22.19	43.10	11.16	9.63	2.47	0.59	0.16	3074	778	127.95"
	ROE-GN	0.00	0.00	31.91	59.57	8.51	0.00	0.00	0.00	0.00	47	47	0.76
1975/76	ROE-SN	0.00	0.84	6.87	31.70	50.07	7.29	2.38	0.84	0.00	713	654	237.22"
	ROE-GN	0.00	0.00	15.79	57.89	22.81	3.51	0.00	0.00	0.00	57	57	17.93
1976/77	ROE-SN	0.08	16.03	3.74	22.67	37.79	15.04	3.28	0.92	0.46	1310	1344	420.46"
	ROE-GN	0.00	1.07	2.14	19.93	54.09	14.59	6.76	1.42	0.00	281	1104	89.48
1977/78	ROE-SN	1.13	11.70	32.83	9.56	21.13	20.38	2.39	0.63	0.25	795	131	373.38"
	ROE-GN	0.00	0.00	20.53	5.96	32.45	33.11	6.62	1.32	0.00	151	37	181.42
1978/79	ROE-SN	2.71	18.16	11.48	29.23	11.48	18.27	6.47	1.36	0.84	958	1475	204.57"
	ROE-GN	1.15	1.15	8.05	41.38	15.71	22.22	8.05	1.92	0.38	261	255	74.00
1979/80	ROE-SN	0.64	77.94	7.26	5.09	3.81	3.49	1.28	0.39	0.11	2811	535	249.07"
	ROE-GN	0.00	3.45	8.72	31.24	22.31	21.10	9.13	3.45	0.61	493	915	63.73
1980/81	ROE-SN	0.46	11.18	81.22	3.30	1.73	1.51	0.37	0.15	0.06	3238	1059	275.60"
	ROE-GN	0.00	0.47	38.88	15.46	22.95	14.75	5.62	1.87	0.00	427	557	23.77
1981/82	ROE-SN	2.72	18.78	7.38	66.32	2.85	1.36	0.39	0.19	0.00	1544	576	193.03"
1982/83	ROE-SN	1.35	20.82	17.74	5.26	49.16	3.73	1.13	0.59	0.22	4583	1448	1.00~
1983/84	ROE-SN	0.49	35.46	14.42	10.29	14.38	23.62	0.99	0.25	0.11	2837	618	175.68"
	ROE-GN	0.00	0.99	1.98	12.87	21.39	57.43	3.37	1.19	0.79	505	961	127.31
1984/85	ROE-SN	0.22	7.75	54.69	11.93	6.39	10.56	8.19	0.14	0.14	3664	969	301.45"
	ROE-GN	0.00	0.36	16.36	14.91	15.82	21.82	29.82	0.36	0.55	550	543	235.00
1985/86	ROE-SN	1.75	13.76	9.44	46.26	10.80	5.27	7.09	5.53	0.09	5655	4566	305.47"
	ROE-GN	0.00	0.39	4.32	53.85	19.00	8.71	7.77	5.73	0.24	1274	558	311.02
1986/87	ROE-SN	0.89	38.64	10.21	6.89	29.87	5.90	3.49	2.87	1.25	4731	4068	187.95"
	ROE-GN	0.00	0.57	3.01	6.93	55.25	16.07	8.80	5.96	3.41	1761	819	270.57
1987/88	ROE-SN	0.45	30.94	39.00	5.95	8.34	11.56	1.94	1.45	0.38	4221	2992	353.54"
	ROE-GN	0.00	0.42	6.48	7.18	21.55	44.79	11.69	5.07	2.82	710	421	276.81
1988/89	ROE-SN	0.61	21.68	36.14	27.68	4.92	4.48	3.57	0.64	0.28	3616	1265	357.83"
	ROE-GN	0.00	0.00	4.62	30.46	13.66	23.53	21.85	3.36	2.52	476	432	317.93
1989/90	ROE-SN	0.65	18.15	22.55	28.24	20.52	4.01	3.31	2.15	0.41	5068	3572	194.38"
	ROE-GN	0.00	0.00	6.25	21.32	42.46	10.29	11.58	6.07	2.02	544	180	161.00
1990/91	ROE-SN	0.95	48.03	9.49	12.60	15.75	9.49	1.65	0.87	1.17	4120	2451	214.06"
	ROE-GN	0.00	0.00	4.26	18.67	31.44	31.33	6.66	4.37	3.28	916	502	148.32
1991/92	ROE-SN	0.35	39.84	37.21	5.89	5.35	6.73	3.42	0.61	0.61	4265	529	228.23"
	ROE-GN	0.00	0.35	13.08	9.35	22.78	26.29	19.16	3.97	5.02	856	114	260.14
1992/93	ROE-SN	0.12	10.73	44.28	30.20	4.02	4.40	4.35	1.56	0.35	4027	372	293.46"
	ROE-GN	0.00	0.00	8.32	40.54	9.53	18.52	13.29	8.19	1.61	745	666	306.61
1993/94	ROE-SN	0.68	4.88	13.36	48.68	22.64	4.12	3.68	1.42	0.54	6459	1430	287.05"
	ROE-GN	0.00	0.00	2.38	17.62	47.55	12.73	11.19	6.43	2.10	715	760	174.03
1994/95	ROE-SN	3.19	15.32	6.76	11.27	43.21	15.75	2.44	1.27	0.80	4393	2013	136.57
	ROE-GN	0.00	0.12	1.18	16.98	34.79	39.39	4.13	1.89	1.53	848	1013	103.11
1995/96	ROE-SN	1.09	64.00	9.79	3.17	4.61	11.06	5.70	0.35	0.23	1736	1241	122.25
	ROE-GN	0.00	0.78	4.11	5.68	25.83	32.68	26.42	3.13	1.37	511	171	230.53
1996/97	ROE-SN	0.94	18.40	56.15	8.59	3.10	5.40	5.07	2.11	0.23	2130	489	110.79
	ROE-GN	0.00	0.16	19.49	11.57	13.95	20.29	20.60	11.09	2.85	631	568	415.50
1997/98	ROE-SN	0.19	33.18	21.98	36.29	4.44	1.42	1.09	1.28	0.14	2116	1270	120.37
	ROE-GN	0.00	0.65	3.05	43.07	20.52	9.89	11.28	7.02	4.53	1082	851	251.59
AVERAGE WEIGHT AT AGE (gms)													
FISHERY		1+	2+	3+	4+	5+	6+	7+	8+	9+			
WINTER		40.6	79.0	107.8	128.1	145.3	161.4	172.0	181.5	194.1			
ROE-SN		52.1	80.7	107.4	129.1	146.1	159.5	171.6	180.8	190.5			
ROE-GN		90.3	114.6	130.4	140.4	150.9	157.4	164.2	171.4	177.2			

* - 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 1.3. 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									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10 ³)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	WINTER	2.43	28.56	50.66	12.00	5.06	1.24	0.06	0.00	0.00	5316	2487	3904.06
1951/52	WINTER	5.18	20.07	30.08	38.13	4.50	1.53	0.45	0.04	0.02	5156	1431	2925.93
1952/53	WINTER	9.36	28.09	23.99	26.62	10.15	1.33	0.44	0.00	0.00	2926	543	73.57
1953/54	WINTER	3.95	69.68	20.26	4.61	1.29	0.16	0.00	0.06	0.00	3189	478	3476.95
1954/55	WINTER	6.66	7.72	74.62	9.09	1.54	0.38	0.00	0.00	0.00	2344	165	1235.03
1955/56	WINTER	16.88	13.62	9.20	57.01	2.89	0.34	0.04	0.00	0.02	5052	1347	4134.75
1956/57	WINTER	16.74	50.70	10.79	6.23	14.78	0.73	0.02	0.00	0.00	4688	1703	2635.45
1957/58	WINTER	23.51	61.39	12.66	1.28	0.59	0.56	0.00	0.00	0.00	3743	847	1445.86
1958/59	WINTER	3.80	49.52	36.89	8.10	0.80	0.44	0.42	0.02	0.00	4974	1352	3293.36
1959/60	WINTER	43.50	23.16	26.48	5.58	1.13	0.07	0.07	0.00	0.00	1416	165	639.45
1960/61	WINTER	16.08	32.23	10.79	29.69	10.08	0.93	0.11	0.07	0.04	2799	1227	3463.55
1961/62	WINTER	9.65	57.43	17.95	2.60	9.90	2.35	0.12	0.00	0.00	808	146	1721.99
1962/63	WINTER	0.37	30.27	57.96	5.43	2.85	2.94	0.18	0.00	0.00	1087	885	4376.33
1963/64	WINTER	13.12	47.38	27.74	10.25	1.43	0.08	0.00	0.00	0.00	1258	198	3507.73
1964/65	WINTER	8.17	36.40	33.77	15.83	5.43	0.34	0.06	0.00	0.00	1750	684	1326.51
1965/66	WINTER	67.32	20.43	7.33	3.60	1.13	0.19	0.00	0.00	0.00	0*	25	5216.79
1966/67	WINTER	37.40	46.19	13.10	2.04	1.02	0.17	0.07	0.01	0.00	0*	25	2514.89
1967/68	WINTER	32.53	48.02	17.02	2.11	0.25	0.00	0.06	0.00	0.00	0*	25	170.14
1968/69	WINTER	32.21	27.70	26.72	11.30	1.95	0.12	0.00	0.00	0.00	0*	25	10.08
1969/70	WINTER	54.02	44.42	1.16	0.40	0.00	0.00	0.00	0.00	0.00	0*	25	28.32
1970/71	WINTER	14.39	39.60	36.87	3.78	4.20	0.95	0.11	0.11	0.00	952	136	339.30
1971/72	ROE-SN	4.35	29.83	27.65	25.69	6.91	4.35	1.14	0.05	0.00	1837	598	762.73"
1972/73	ROE-GN	0.00	0.91	14.89	65.05	10.64	7.90	0.61	0.00	0.00	329	503	8.47
	ROE-SN	1.20	50.45	18.60	15.51	11.75	1.88	0.45	0.15	0.00	1328	593	539.55"
1973/74	ROE-GN	0.00	2.53	25.32	44.94	20.89	4.43	1.27	0.63	0.00	158	114	71.26
	ROE-SN	2.77	17.71	38.63	19.72	13.36	6.62	0.95	0.25	0.00	1587	202	282.57
1974/75	ROE-GN	0.00	0.40	22.78	37.70	24.80	12.30	1.81	0.20	0.00	496	101	332.81
	ROE-SN	1.16	32.96	25.51	27.84	8.59	3.18	0.67	0.07	0.02	8896	3314	278.00
1975/76	ROE-GN	0.00	3.28	25.63	46.24	16.38	6.36	2.12	0.00	0.00	519	117	348.42
	ROE-SN	3.01	11.76	41.23	20.89	16.83	4.54	1.48	0.24	0.02	5418	973	511.14
1976/77	ROE-GN	0.00	0.82	18.82	29.79	35.27	11.78	3.03	0.41	0.08	1222	253	383.45
	ROE-SN	1.01	32.83	18.69	29.80	8.08	6.57	3.03	0.00	0.00	198	144	32.75
1977/78	ROE-GN	0.68	17.43	22.64	31.77	16.59	8.53	1.92	0.40	0.04	2496	925	284.27
	ROE-SN	0.00	1.10	13.02	35.54	31.57	13.47	3.97	1.32	0.00	453	169	411.71
1978/79	ROE-GN	0.21	25.72	15.19	19.91	23.14	10.89	3.51	1.07	0.36	1396	589	354.31
	ROE-SN	0.00	1.30	8.93	29.58	38.14	17.67	3.81	0.47	0.09	1075	474	576.00
1979/80	ROE-GN	3.68	73.08	6.43	9.02	3.99	2.59	0.70	0.39	0.12	2582	1401	1.12"
	ROE-SN	0.00	3.28	2.55	24.82	23.72	26.28	11.31	6.57	1.46	274	210	32.46
1980/81	ROE-GN	1.96	12.30	66.57	8.40	7.05	2.64	0.64	0.34	0.10	2952	492	25.75"
	ROE-SN	0.26	1.50	50.72	13.61	15.36	10.61	5.47	1.82	0.65	1536	276	163.04
1981/82	ROE-GN	1.68	15.62	10.72	60.21	5.19	4.56	1.45	0.48	0.09	3508	2296	188.15"
	ROE-SN	0.00	2.39	5.91	75.99	6.66	5.91	2.32	0.75	0.07	1337	301	287.08
1982/83	ROE-GN	0.53	7.00	15.43	10.82	57.10	5.03	3.10	0.73	0.26	5445	1082	154.75
	ROE-SN	0.00	0.50	7.19	13.05	69.44	5.02	3.90	0.61	0.28	1793	994	244.49
1983/84	ROE-GN	4.35	7.31	10.12	18.16	16.14	40.73	2.26	0.83	0.10	6293	2210	282.42"
	ROE-SN	0.00	0.26	2.93	13.11	17.26	60.05	4.75	1.12	0.52	1159	338	242.25
1984/85	ROE-GN	2.66	37.54	7.47	8.55	13.11	11.94	18.19	0.45	0.10	5157	5529	222.13
	ROE-SN	0.00	3.18	5.43	9.39	19.49	22.52	38.20	1.01	0.78	1288	1407	143.53
1985/86	ROE-GN	3.92	16.39	40.25	8.59	6.27	6.68	6.08	11.26	0.55	5813	2074	163.81"
	ROE-SN	0.00	1.78	23.95	11.97	10.01	16.00	13.19	22.26	0.84	1069	262	73.95
1986/87	ROE-GN	4.13	22.57	14.59	32.18	5.72	4.55	5.84	4.66	5.78	5038	2319	193.73
	ROE-SN	0.00	0.82	7.75	44.85	11.72	7.85	9.89	8.15	8.97	981	1199	55.71
1987/88	ROE-GN	1.14	67.92	11.67	6.28	7.12	1.68	1.46	1.50	1.23	5194	2730	343.88"
	ROE-SN	0.00	4.24	10.25	14.84	27.21	15.19	7.42	10.07	10.78	566	158	59.81
1988/89	ROE-GN	1.28	4.61	76.21	9.16	3.58	2.80	0.74	0.80	0.82	5642	1939	596.24
	ROE-SN	0.00	0.28	27.61	25.07	17.32	16.48	5.77	3.66	3.80	710	259	195.14
1989/90	ROE-GN	0.97	5.66	4.99	72.59	7.49	3.82	2.95	0.75	0.78	6677	6353	415.05
	ROE-SN	0.00	0.00	1.18	65.05	16.88	6.26	7.79	1.06	1.77	847	502	203.56
1990/91	ROE-GN	2.03	18.82	6.76	6.19	55.55	6.38	2.34	1.48	0.46	7105	5044	541.68
	ROE-SN	0.00	0.50	2.32	6.80	69.15	9.95	7.30	3.15	0.83	603	423	116.55
1991/92	ROE-GN	2.01	58.38	11.40	2.74	3.44	18.75	2.13	0.61	0.54	7264	4356	722.92"
	ROE-SN	0.00	6.92	6.92	4.23	6.54	60.90	9.74	3.33	1.41	780	544	69.73
1992/93	ROE-GN	2.85	6.71	64.15	9.68	2.02	2.55	10.46	1.12	0.46	8664	3221	784.75
	ROE-SN	0.00	0.26	43.79	14.34	5.63	5.76	27.02	2.18	1.02	781	188	146.71
1993/94	ROE-GN	1.19	21.29	8.52	52.95	7.48	2.01	2.76	3.48	0.32	7127	4910	875.10
	ROE-SN	0.00	1.47	4.95	65.08	12.66	3.36	4.42	7.18	0.88	1698	838	158.40
1994/95	ROE-GN	0.75	6.06	23.16	9.44	48.04	6.46	2.01	2.31	1.76	9148	4236	700.37
	ROE-SN	0.00	0.22	9.37	8.11	64.45	10.25	2.06	2.36	3.17	1356	746	105.27
1995/96	ROE-GN	11.63	19.56	5.81	16.70	6.81	30.61	5.96	1.49	1.43	5316	3344	398.77
	ROE-SN	0.00	0.35	1.41	18.02	11.48	54.06	10.42	2.12	2.12	566	175	27.42
1996/97	ROE-GN	2.13	56.65	16.89	3.62	6.14	3.99	8.49	1.54	0.55	6870	3214	451.35
	ROE-SN	0.00	1.36	2.92	6.23	22.76	19.26	38.33	7.20	1.95	514	477	24.01
1997/98	ROE-GN	0.52	35.84	42.09	8.55	2.45	3.20	3.23	3.29	0.82	6562	3475	1016.41
	ROE-SN	0.00	0.53	13.91	13.69	8.81	18.58	15.82	20.49	8.17	942	188	45.06
AVERAGE WEIGHT AT AGE (gms)													
FISHERY		1+	2+	3+	4+	5+	6+	7+	8+	9+			
WINTER		43.8	79.8	104.7	125.6	138.1	150.4	156.2	153.5	179.0			
ROE-SN		53.4	85.9	110.1	130.7	148.3	163.2	175.7	186.8	195.3			
ROE-GN		39.3	114.4	134.2	145.6	155.1	164.7	172.7	178.1	177.3			

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

SEASON	FISHERY	PERCENT AT AGE									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10 ³)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	WINTER	4.17	56.48	30.35	7.12	1.41	0.35	0.10	0.03	0.00	7813	1085	4404.07
1951/52	WINTER	11.17	55.37	25.06	6.74	1.32	0.27	0.07	0.01	0.00	9025	1541	4821.55
1952/53	WINTER	9.47	56.02	28.96	4.09	1.23	0.20	0.05	0.00	0.00	8640	1489	1038.41
1953/54	WINTER	1.52	45.67	36.81	11.55	3.28	0.94	0.21	0.02	0.00	13162	4357	6463.55
1954/55	WINTER	4.40	48.63	39.05	6.73	1.08	0.11	0.00	0.00	0.00	5291	805	7070.11
1955/56	WINTER	7.00	35.08	28.78	23.67	4.45	0.73	0.21	0.05	0.02	9832	2632	7200.60
1956/57	WINTER	1.40	59.78	22.33	10.70	5.08	0.60	0.07	0.01	0.03	7478	2184	5972.40
1957/58	WINTER	8.98	54.48	22.13	5.99	5.06	2.89	0.41	0.07	0.00	7397	1589	2238.02
1958/59	WINTER	17.11	63.89	15.48	2.58	0.55	0.24	0.12	0.02	0.01	9964	3899	6104.01
1959/60	WINTER	7.70	51.34	36.56	3.61	0.53	0.16	0.08	0.00	0.03	3742	1215	6919.14
1960/61	WINTER	31.53	27.21	26.87	12.73	1.49	0.16	0.00	0.00	0.00	4351	820	5244.59
1961/62	WINTER	9.05	70.06	13.18	5.28	2.03	0.37	0.03	0.00	0.00	3203	936	7130.68
1962/63	WINTER	17.63	55.93	26.85	2.99	1.00	0.52	0.09	0.00	0.00	2309	409	8123.36
1963/64	WINTER	5.94	60.95	29.88	2.56	0.52	0.10	0.05	0.00	0.00	4026	1190	7537.03
1964/65	WINTER	14.90	55.13	26.15	2.54	0.96	0.18	0.15	0.00	0.00	3350	910	4622.10
1965/66	WINTER	25.15	34.78	23.38	13.51	2.12	1.06	0.00	0.00	0.00	851	98	3229.67
1966/67	WINTER	36.90	45.72	12.18	3.21	1.59	0.29	0.05	0.06	0.00	0*	25	3307.57
1967/68	WINTER	30.37	50.62	14.68	3.04	0.88	0.18	0.23	0.00	0.00	0*	25	199.84
1968/69	WINTER	62.04	27.10	8.08	2.06	0.72	0.00	0.00	0.00	0.00	0*	25	95.62
1969/70	WINTER	25.64	60.32	9.49	3.27	0.72	0.56	0.00	0.00	0.00	0*	25	89.93
1970/71	WINTER	12.38	40.17	36.49	7.14	2.83	0.92	0.07	0.00	0.00	1414	370	147.08
1971/72	WINTER	10.32	31.86	34.62	18.21	3.49	1.34	0.14	0.03	0.00	3663	1460	229.07
	ROE-SN	8.50	36.12	32.86	17.93	3.46	0.99	0.12	0.02	0.00	5036	766	545.88
	ROE-GN	4.44	11.50	46.47	28.99	6.86	1.45	0.19	0.10	0.00	1035	251	9.76
1972/73	WINTER	1.00	27.94	31.02	25.45	12.51	1.74	0.30	0.04	0.00	4707	1573	295.59
	ROE-SN	4.22	54.88	21.37	12.93	6.07	0.53	0.00	0.00	0.00	379	615	141.70
	ROE-GN	0.00	17.41	30.36	37.50	11.16	3.13	0.45	0.00	0.00	224	106	136.90
1973/74	WINTER	17.44	73.26	8.14	1.16	0.00	0.00	0.00	0.00	0.00	86	86	112.05^
	ROE-GN	0.00	4.85	42.22	31.31	16.67	4.04	0.91	0.00	0.00	990	548	196.73
1974/75	WINTER	22.35	61.06	12.44	2.07	1.38	0.46	0.00	0.23	0.00	434	16	70.07
	ROE-SN	3.68	54.91	27.96	7.86	3.35	1.60	0.48	0.17	0.00	5194	1210	46.28
	ROE-GN	0.00	4.97	43.09	35.91	12.15	3.31	0.55	0.00	0.00	181	20	351.18
1975/76	WINTER	6.25	20.45	41.35	21.52	6.27	2.77	0.93	0.41	0.05	4401	1271	401.26
	ROE-SN	12.02	24.84	40.61	14.78	3.38	2.32	1.51	0.45	0.09	1123	164	20.37
	ROE-GN	0.00	0.57	39.48	43.55	12.67	2.94	0.68	0.11	0.00	884	354	468.85
1976/77	WINTER	4.15	50.85	22.01	16.55	4.45	1.24	0.49	0.15	0.00	2681	911	518.09
	ROE-SN	3.35	55.79	20.11	14.47	3.86	1.27	0.76	0.25	0.13	2357	1054	394.81
	ROE-GN	0.00	3.38	28.54	47.25	16.46	3.75	0.50	0.13	0.00	1598	147	514.34
1977/78	WINTER	2.31	36.01	40.47	10.34	7.42	2.64	0.41	0.28	0.12	2466	380	1182.89
	ROE-SN	0.85	35.31	43.14	11.57	7.39	1.37	0.29	0.03	0.06	3424	2450	354.62
	ROE-GN	0.00	0.71	20.32	30.04	35.69	11.48	1.41	0.35	0.00	566	1022	485.32
1978/79	WINTER	1.76	18.25	37.65	28.52	8.38	3.95	1.08	0.27	0.13	5463	1858	1085.01
	ROE-SN	1.63	20.01	32.72	27.96	9.37	5.18	2.06	0.64	0.43	1409	389	1.00~
	ROE-GN	0.00	1.15	23.23	54.70	13.51	5.77	1.48	0.00	0.16	607	290	441.80
1979/80	WINTER	2.99	43.51	23.26	18.15	8.30	2.16	1.24	0.31	0.08	4914	3044	228.46
	ROE-SN	2.08	49.82	15.90	17.71	9.86	2.61	1.23	0.27	0.12	4139	1495	16.94
	ROE-GN	0.00	1.95	19.15	44.55	33.42	8.75	2.86	0.27	0.11	754	1133	215.21
1980/81	WINTER	3.66	34.26	34.21	15.60	8.57	3.02	0.52	0.15	0.00	5160	2376	421.38
	ROE-SN	6.92	36.99	30.47	11.33	9.61	3.73	0.63	0.28	0.03	7731	2525	202.00
	ROE-GN	0.09	2.19	18.16	22.98	37.37	16.05	2.81	0.26	0.09	1140	338	333.10
1981/82	WINTER	3.36	38.13	31.72	16.14	5.74	3.80	0.91	0.08	0.12	2528	1506	316.45
	ROE-SN	6.31	34.70	25.07	20.87	4.69	5.22	2.50	0.56	0.07	5400	2796	313.69
	ROE-GN	0.00	4.44	15.37	28.45	14.77	20.77	14.17	1.68	0.36	833	543	367.36
1982/83	WINTER	3.06	19.28	30.43	21.91	12.30	4.45	5.26	2.78	0.53	2090	1037	58.60
	ROE-SN	2.99	31.42	28.48	17.84	11.47	3.19	3.06	1.25	0.29	11962	7026	696.76
	ROE-GN	0.00	0.49	27.76	29.48	23.59	9.34	7.37	1.72	0.25	407	305	563.81
1983/84	WINTER	14.82	31.77	23.11	17.06	8.13	3.35	1.01	0.43	0.32	1882	581	70.14
	ROE-SN	37.75	28.97	12.93	7.16	3.33	1.33	0.49	0.05	0.11	7152	1852	392.25
	ROE-GN	0.00	7.05	30.16	31.07	19.19	9.27	1.70	0.65	0.31	766	759	421.50
1984/85	WINTER	27.95	40.76	19.11	7.61	3.09	1.03	0.36	0.08	0.00	2522	507	77.78
	ROE-SN	23.91	43.83	18.95	7.92	3.40	1.33	0.59	0.06	0.01	7832	3009	297.73
	ROE-GN	0.09	3.10	26.09	32.48	23.63	9.22	3.74	0.82	0.82	1096	650	237.16
1985/86	WINTER	13.44	58.05	20.51	5.79	1.74	0.35	0.12	0.00	0.00	863	185	40.18
	ROE-SN	12.56	56.18	22.20	6.18	1.92	0.75	0.14	0.08	0.00	6411	1413	17.24
1986/87	WINTER	21.77	34.69	30.95	9.98	1.93	0.45	0.23	0.00	0.00	882	204	22.53
	ROE-SN	9.34	33.15	37.03	15.29	3.55	1.07	0.38	0.13	0.07	7689	2111	318.01
	ROE-GN	0.00	2.50	35.63	33.44	16.51	8.49	2.60	0.57	0.26	1920	944	413.31
1987/88	WINTER	3.50	60.18	17.29	15.32	2.74	0.66	0.22	0.11	0.00	914	1104	69.17
	ROE-SN	4.38	60.06	14.92	15.22	4.09	1.03	0.22	0.07	0.00	5912	1835	148.13
	ROE-GN	0.00	9.14	1.85	48.11	19.49	5.48	2.31	0.37	0.24	821	383	414.24
1988/89	WINTER	26.50	16.59	42.90	7.05	5.91	0.86	0.19	0.00	0.00	1049	298	93.71
	ROE-SN	10.01	18.01	53.48	9.45	7.10	1.59	0.31	0.03	0.02	6423	1619	140.64
	ROE-GN	0.00	1.58	40.22	21.99	25.88	7.78	2.19	0.36	0.00	823	1143	421.70
1989/90	WINTER	4.97	57.32	13.69	19.33	2.15	2.55	0.00	0.00	0.00	745	323	22.74
	ROE-SN	7.92	57.18	10.74	18.96	3.01	1.72	0.41	0.05	0.02	5644	2499	1.00~
	ROE-GN	0.00	8.39	11.67	56.24	12.18	9.70	1.46	0.29	0.07	1371	815	556.90
1990/91	WINTER	18.35	32.39	35.45	6.46	6.34	0.79	0.23	0.00	0.00	883	439	54.37
	ROE-SN	9.42	21.74	40.64	9.20	15.06	2.27	1.45	0.20	0.02	5106	1604	103.87
	ROE-GN	0.00	1.29	28.15	17.20	40.11	7.27	4.69	1.20	0.09	1087	637	644.61
1991/92	WINTER	3.96	69.60	16.30	9.03	0.66	0.22	0.00	0.00	0.00	454	143	91.46
	ROE-SN	5.10	54.85	13.72	16.74	3.49	5.16	0.60	0.32	0.02	5036	4330	346.46
	ROE-GN	0.00	6.33	14.88	43.63	11.72	18.91	2.65	1.45	0.43	1169	865	600.81
1992/93	WINTER	25.90	31.04	32.48	6.89	2.67	0.31	0.62	0.10	0.00	973	75	62.36
	ROE-SN	15.17	37.83	31.39	6.87	5.75	1.36	1.45	0.15	0.04	5445	1959	440.36
	ROE-GN	0.00	11.47	40.02	16.98	21.61	4.08	5.40	0.22	0.22	907	562	633.26
1993/94	WINTER	5.65	50.00	25.43	16.30	1.52	1.09	0.00	0.00	0.00	460	142	92.93
	ROE-SN	4.67	42.19	26.71	18.77	3.99	2.82	0.70	0.15	0.00	5968	3788	528.54
	ROE-GN	0.00	3.53	25.10	44.92	15.20	7.98	2.43	0.67	0.17	1191	703	865.23
1994/95	WINTER	22.08	27.18	34.32	10.90	4.46	0.71	0.28	0.00	0.07	1413	360	63.14
	ROE-SN	8.98	21.79	36.13	17.73	11.08	2.74	1.10	0.35	0.11	5658	3092	397.08
	ROE-GN	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 west coast of Vancouver Island stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	WINTER	12.58	37.63	41.27	6.74	1.44	0.30	0.02	0.02	0.00	4037	580	2223.54
1951/52	WINTER	1.97	29.16	24.99	37.07	4.98	1.46	0.33	0.04	0.00	4921	2483	2287.45
1952/53	WINTER	14.28	56.10	27.45	1.64	0.48	0.05	0.00	0.00	0.00	3957	607	2.46
1953/54	WINTER	2.68	63.23	27.59	5.55	0.69	0.15	0.08	0.02	0.00	6092	1607	3570.83
1954/55	WINTER	16.82	59.39	19.69	3.43	0.64	0.04	0.00	0.00	0.00	2509	698	715.69
1955/56	WINTER	10.00	58.10	9.50	19.00	2.60	0.50	0.20	0.10	0.00	0*	25	1751.84
1956/57	WINTER	2.72	71.94	24.83	0.34	0.17	0.00	0.00	0.00	0.00	588	497	314.44
1957/58	WINTER	12.94	48.66	27.06	6.30	2.86	1.68	0.42	0.08	0.00	1190	344	69.90
1958/59	WINTER	4.23	45.02	27.39	14.41	3.85	2.40	2.02	0.57	0.11	3665	2199	7436.55
1959/60	WINTER	8.86	54.74	23.32	8.76	2.82	0.94	0.35	0.14	0.07	2877	2160	5631.14
1960/61	WINTER	41.08	37.18	17.69	3.90	0.15	0.00	0.00	0.00	0.00	667	84	3143.83
1961/62	WINTER	4.68	81.76	10.31	2.46	0.79	0.00	0.00	0.00	0.00	1261	551	2543.14
1962/63	WINTER	1.73	43.62	49.16	4.69	0.62	0.18	0.00	0.00	0.00	2258	893	1779.64
1963/64	WINTER	2.53	60.22	25.76	10.39	0.84	0.25	0.00	0.00	0.00	1184	1057	2078.97
1964/65	WINTER	2.18	34.34	49.88	9.95	3.28	0.36	0.00	0.00	0.00	824	372	1302.20
1965/66	WINTER	13.59	26.83	26.12	23.17	9.07	1.23	0.00	0.00	0.00	0*	25	791.48
1966/67	WINTER	12.86	60.28	20.52	4.84	1.15	0.18	0.15	0.02	0.00	0*	25	1289.24
1971/72	ROE-SN	3.25	18.52	48.12	24.63	3.50	1.15	0.76	0.06	0.00	1571	650	503.52
1972/73	ROE-SN	0.70	30.43	24.26	31.95	10.75	1.55	0.27	0.08	0.00	2576	1744	1204.92
	ROE-GN	0.00	7.85	22.92	51.76	13.46	2.88	0.96	0.16	0.00	624	526	95.73
1973/74	ROE-SN	8.04	43.04	23.95	13.62	8.86	2.21	0.22	0.04	0.02	5420	3103	1112.16
	ROE-GN	0.00	26.14	30.68	26.14	13.64	3.41	0.00	0.00	0.00	176	30	288.53
1974/75	ROE-SN	0.59	53.76	19.82	11.40	7.97	4.99	1.29	0.17	0.01	10114	4380	1451.92"
	ROE-GN	0.00	2.97	30.48	37.92	21.19	7.06	0.37	0.00	0.00	269	145	493.67
1975/76	ROE-SN	0.21	8.86	46.93	19.80	12.96	8.08	2.72	0.43	0.00	9230	1628	1626.81
	ROE-GN	0.00	0.68	40.26	33.87	15.68	6.62	2.51	0.30	0.08	1314	127	1053.75
1976/77	ROE-SN	0.52	12.42	31.09	37.16	12.36	4.46	1.66	0.28	0.04	6746	1395	1281.46"
	ROE-GN	0.56	3.35	16.48	42.74	17.60	12.29	5.31	1.40	0.28	358	49	813.02
1977/78	WINTER	1.27	43.83	23.50	13.70	14.21	2.16	0.81	0.30	0.21	2357	521	257.67
	ROE-SN	0.69	40.18	17.88	16.77	18.51	4.43	1.29	0.18	0.07	5963	2622	457.42
	ROE-GN	0.00	1.16	4.46	20.66	46.94	19.17	6.61	0.66	0.33	605	168	936.91
1978/79	ROE-SN	0.77	13.64	50.60	14.26	10.66	7.88	1.54	0.51	0.13	3885	564	849.26"
	ROE-GN	0.00	1.23	25.92	26.62	25.04	18.91	1.93	0.35	0.00	571	257	519.39
1979/80	ROE-SN	2.86	43.86	14.95	22.01	7.26	6.06	2.43	0.47	0.10	3003	469	152.30"
	ROE-GN	0.00	0.00	5.31	47.12	22.57	14.38	9.73	0.66	0.22	452	497	145.27
1980/81	ROE-SN	3.36	34.58	29.40	11.00	12.95	5.79	2.40	0.51	0.00	3745	853	433.90"
	ROE-GN	0.00	1.78	21.00	14.95	36.30	18.86	7.12	0.00	0.00	281	81	207.25
1981/82	ROE-SN	3.17	23.98	27.76	26.08	5.45	9.24	2.62	1.41	0.30	5046	2597	204.20"
	ROE-GN	0.00	0.58	11.94	43.34	11.70	27.11	4.06	1.16	0.12	863	365	221.31
1982/83	ROE-SN	4.21	22.56	21.87	21.90	17.66	4.43	5.40	1.06	0.90	3205	1818	477.79
	ROE-GN	0.00	0.35	14.19	23.82	44.83	6.48	9.81	0.35	0.18	571	159	176.62
1983/84	ROE-SN	21.73	37.22	13.58	9.16	10.04	5.91	1.07	1.07	0.23	3079	1182	492.36
	ROE-GN	0.00	1.68	6.72	17.98	32.61	31.93	5.38	3.36	0.34	595	464	55.40
1984/85	ROE-SN	20.47	53.62	14.22	3.71	2.74	3.17	1.70	0.13	0.23	2995	644	16.34"
1985/86	ROE-SN	3.78	50.45	29.70	8.29	3.13	2.24	1.76	0.58	0.07	4151	602	16.77"
1986/87	ROE-SN	14.83	16.59	34.39	21.45	7.35	2.55	1.38	1.08	0.38	4708	1971	1007.50
	ROE-GN	0.00	1.82	24.55	61.82	5.45	2.18	2.91	0.91	0.36	550	408	144.31
1987/88	ROE-SN	2.56	60.97	7.66	14.75	9.87	2.80	0.74	0.20	0.00	7459	4721	667.13
	ROE-GN	0.00	5.40	7.00	40.80	29.40	12.80	3.00	1.20	0.40	500	607	86.67
1988/89	ROE-SN	2.56	15.81	60.96	6.58	8.67	4.53	0.68	0.18	0.04	5712	2510	756.40
	ROE-GN	0.00	0.26	54.45	10.99	22.25	9.42	1.57	1.05	0.00	382	145	232.76
1989/90	ROE-SN	0.48	27.17	12.43	47.33	4.49	5.94	1.83	0.23	0.09	6831	6315	563.72
	ROE-GN	0.00	1.35	7.87	68.99	8.31	10.34	2.47	0.67	0.00	445	428	125.93
1990/91	ROE-SN	6.59	21.41	21.11	10.67	33.10	3.01	3.43	0.66	0.03	7311	4577	497.89
	ROE-GN	0.00	0.29	7.16	11.75	63.90	8.02	8.02	0.57	0.29	349	223	147.29
1991/92	ROE-SN	1.62	47.83	10.54	13.43	6.02	17.01	2.11	1.22	0.22	5979	3775	259.62
	ROE-GN	0.00	6.29	13.49	30.76	13.85	29.86	2.88	2.52	0.36	556	617	40.66
1992/93	ROE-SN	3.94	27.77	40.59	6.85	5.11	4.85	5.51	0.85	0.57	5430	2772	473.30
1993/94	ROE-SN	2.98	22.32	23.76	30.53	8.05	5.10	5.41	1.20	0.25	6098	3120	447.32"
	ROE-GN	0.00	4.78	31.96	56.01	5.44	1.15	0.49	0.16	0.00	607	581	53.41
1994/95	ROE-SN	0.83	13.35	24.05	20.45	25.99	6.85	4.55	3.21	0.72	4832	1060	182.15"
1995/96	ROE-SN	14.20	21.22	13.04	18.79	13.11	14.17	3.15	1.37	0.95	6126	3332	123.92"
1996/97	ROE-SN	2.49	68.99	8.13	4.51	6.60	4.98	3.39	0.56	0.35	5698	3736	705.43
1997/98	ROE-SN	2.33	21.78	60.30	6.46	2.86	3.10	1.76	1.13	0.30	5065	2119	571.46
	ROE-GN	0.00	0.56	38.26	11.01	9.68	20.13	12.35	5.67	2.34	899	424	111.91

FISHERY	AVERAGE WEIGHT AT AGE (gms)							
	1+	2+	3+	4+	5+	6+	7+	8+
WINTER	56.0	90.1	112.4	131.0	148.2	155.4	173.2	176.0
ROE-SN	64.4	93.6	121.9	145.6	165.0	178.7	188.7	196.9
ROE-GN	45.5	116.5	136.5	151.0	161.7	172.0	177.3	181.2

- * - 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 1.6. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for Area 27. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10 ³)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1953/54	WINTER	0.00	47.57	40.45	10.11	0.75	1.12	0.00	0.00	0.00	267	4376	206.40
1954/55	WINTER	6.80	34.77	49.72	6.94	1.42	0.28	0.07	0.00	0.00	1412	510	614.00
1963/64	WINTER	0.00	46.32	30.53	22.11	1.05	0.00	0.00	0.00	0.00	95	440	29.70
1964/65	WINTER	1.41	18.31	36.62	33.10	7.04	0.70	1.41	1.41	0.00	142	131	55.25
1975/76	ROE-GN	0.00	3.74	41.18	27.27	17.65	6.42	3.74	0.00	0.00	187	18	5.55
1977/78	WINTER	1.41	53.52	5.63	19.72	16.90	2.82	0.00	0.00	0.00	71	71	14.38
1978/79	ROE-SN	1.25	12.50	68.75	12.50	2.50	1.25	1.25	0.00	0.00	80	80	40.35
	ROE-GN	0.00	1.06	48.94	17.02	20.21	11.70	1.06	0.00	0.00	94	3599	18.68
1979/80	ROE-GN	0.00	4.00	9.33	70.67	12.00	2.67	1.33	0.00	0.00	75	39	36.66
1980/81	ROE-SN	2.23	13.50	61.21	8.26	13.24	1.57	0.00	0.00	0.00	763	412	59.41
1981/82	ROE-SN	0.66	35.00	9.93	41.53	4.07	7.95	0.76	0.09	0.00	1057	656	20.77
	ROE-GN	0.00	0.92	6.42	55.05	9.17	25.69	2.75	0.00	0.00	109	187	22.70
1982/83	ROE-SN	3.96	20.79	31.68	10.89	28.71	0.00	3.96	0.00	0.00	101	2997	1.00-
	ROE-GN	0.00	0.00	8.75	15.00	62.50	2.50	11.25	0.00	0.00	80	80	11.73
1983/84	ROE-GN	0.00	0.00	4.17	42.13	16.67	33.33	2.55	1.16	0.00	432	206	11.07
1985/86	ROE-SN	2.21	23.62	63.47	2.58	1.48	1.85	2.58	2.21	0.00	271	101	1.00-
1986/87	ROE-SN	17.02	27.66	15.96	35.46	1.06	0.00	1.06	0.35	1.42	282	216	1.00-
1987/88	ROE-SN	2.16	62.53	11.05	6.20	15.36	1.62	0.81	0.00	0.27	371	406	1.00-
1988/89	ROE-SN	0.21	12.66	57.51	8.15	8.37	11.37	1.29	0.43	0.00	466	139	1.00-
1989/90	ROE-SN	1.84	22.68	14.25	39.63	5.83	7.13	7.78	0.65	0.22	926	785	1.00-
1990/91	ROE-SN	8.97	39.40	8.97	10.33	22.55	2.72	4.89	2.17	0.00	368	257	19.05
1991/92	ROE-SN	3.48	71.21	11.21	3.40	2.91	5.04	0.99	1.28	0.50	1410	668	46.16
1992/93	ROE-SN	10.50	33.33	40.88	5.52	1.29	1.66	5.71	0.37	0.74	543	310	30.55
	ROE-GN	0.00	3.28	53.28	14.09	7.92	7.53	11.58	0.97	1.35	518	283	25.02
1993/94	ROE-SN	1.48	31.75	24.55	30.90	5.50	2.12	2.86	0.53	0.32	945	677	30.39
	ROE-GN	0.00	1.28	19.40	61.19	9.81	3.41	3.84	0.43	0.64	469	325	24.55
1994/95	ROE-SN	1.68	6.37	35.29	24.37	24.65	4.13	1.33	1.61	0.56	1428	421	41.24
1995/96	ROE-SN	14.18	22.70	6.38	20.57	15.60	16.67	2.84	0.35	0.71	282	403	30.09
1996/97	ROE-SN	4.01	76.83	7.32	1.57	4.01	4.70	1.57	0.00	0.00	574	142	30.38
1997/98	ROE-SN	1.39	38.89	48.61	4.86	0.35	2.78	2.43	0.69	0.00	288	393	30.08

AVERAGE WEIGHT AT AGE (gms)										
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	
WINTER	69.2	91.1	119.9	146.3	164.8	174.1	202.7	208.8	0.0	
ROE-SN	56.8	95.0	120.4	140.3	160.4	176.5	184.6	202.6	215.7	
ROE-GN	0.0	114.9	134.4	144.1	152.1	155.8	166.3	179.0	196.2	

* - 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 1.7. Age composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for Area 2W. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE									NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
		1+	2+	3+	4+	5+	6+	7+	8+	9+			
1956/57	WINTER	0.00	63.41	31.71	2.44	2.44	0.00	0.00	0.00	0.00	41	41	12.10
1964/65	WINTER	0.00	46.00	8.00	28.00	8.00	6.00	4.00	0.00	0.00	50	50	85.99
1972/73	ROE-SN	0.00	7.80	19.86	18.44	46.81	4.96	1.42	0.71	0.00	141	655	43.98
1973/74	ROE-SN	7.62	25.71	23.33	21.90	8.10	11.43	1.90	0.00	0.00	210	110	32.07
1974/75	ROE-SN	0.53	45.72	32.89	12.57	3.48	3.74	1.07	0.00	0.00	374	161	30.56
1975/76	ROE-SN	23.71	6.70	41.24	23.71	4.64	0.00	0.00	0.00	0.00	194	593	1.00-
1977/78	ROE-SN	0.00	7.28	25.73	10.19	41.75	6.31	5.83	2.91	0.00	206	124	34.05
1978/79	ROE-SN	1.49	18.84	22.95	16.23	22.95	13.81	1.87	1.12	0.75	536	91	45.46"
1979/80	ROE-SN	0.00	70.00	15.29	6.47	4.71	2.94	0.00	0.59	0.00	170	45	1.00-
1980/81	ROE-SN	4.35	3.78	66.50	11.66	7.06	4.60	1.64	0.41	0.00	1218	100	57.30
1981/82	ROE-SN	1.80	37.54	1.45	51.39	4.11	2.14	1.16	0.35	0.06	1726	939	87.26
1982/83	ROE-SN	0.69	1.34	56.41	3.01	33.10	2.92	1.25	0.74	0.54	3356	140	161.04
1983/84	ROE-SN	6.45	1.61	0.60	35.28	2.42	51.01	1.81	0.60	0.20	496	427	1.00-
1984/85	ROE-SN	0.50	2.90	5.21	2.80	21.82	2.80	63.16	0.70	0.10	999	381	9.62
1985/86	ROE-SN	0.82	0.27	11.48	11.75	5.46	20.77	7.38	41.53	0.55	366	38	1.00-
1986/87	ROE-SN	22.14	61.32	0.25	1.27	1.27	1.27	8.14	1.02	3.31	393	398	1.00-
1987/88	ROE-SN	1.79	74.01	19.31	0.26	0.53	0.66	0.79	1.65	0.99	1512	166	1.00-
1988/89	ROE-SN	0.49	3.42	76.06	15.88	0.49	0.49	0.98	0.81	1.38	1228	330	1.00-
1989/90	ROE-SN	0.20	1.47	1.72	77.69	16.84	0.45	0.20	0.57	0.86	2447	2792	135.97
1990/91	ROE-SN	0.52	12.62	1.64	2.43	65.78	15.24	0.79	0.46	0.52	3288	2178	153.62
1991/92	ROE-SN	1.53	9.10	13.25	1.53	2.72	58.38	12.01	0.54	0.94	2023	804	71.79
1992/93	ROE-SN	1.01	13.77	16.84	14.48	2.06	4.69	41.15	5.25	0.75	2666	681	81.95
1993/94	ROE-SN	5.32	12.23	43.62	14.89	9.57	2.13	5.85	5.32	1.06	188	104	1.00-
1997/98	ROE-SN	18.50	34.75	23.10	18.68	2.62	0.63	1.53	0.18	0.00	1108	449	14.90

AVERAGE WEIGHT AT AGE (gms)									
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	50.0	89.2	122.1	125.7	166.0	196.0	216.5	0.0	0.0
ROE-SN	67.5	105.3	135.9	162.6	184.8	192.7	211.9	210.0	214.7
ROE-GN	53.2	81.9	139.8	162.0	187.7	191.9	199.0	0.0	0.0

* - 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 2.1. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Queen Charlotte Islands stock assessment region.

Season	Estimated numbers at age (x 10 ⁻⁵) for period 1										SB	SI	RES
	1+	2+	3+	4+	5+	6+	7+	8+	9+				
1950/51	3303	1895	998	202	132	56	0	0	0	4429	2510	0.17	
1951/52	4654	2102	1169	505	91	56	24	0	0	4906	2398	0.03	
1952/53	20978	2816	1152	461	147	22	14	6	0	10000	4759	0.00	
1953/54	2582	13350	1792	733	294	93	14	9	4	14773	9853	0.34	
1954/55	3387	1637	8431	1084	434	172	55	8	7	45092	6143	-1.25	
1955/56	1074	2153	1038	5338	685	274	108	35	10	6183	4014	0.31	
1956/57	1717	676	622	295	708	46	18	7	3	1669	1578	0.69	
1957/58	4139	780	67	175	38	43	3	1	1	2549	787	-0.43	
1958/59	1528	1323	236	22	33	5	6	0	0	8265	6941	0.57	
1959/60	3634	689	596	123	10	15	2	3	0	13567	6470	0.00	
1960/61	4489	2313	438	380	78	6	9	1	2	8649	6976	0.53	
1961/62	8632	2854	1449	271	231	47	4	6	2	10546	4654	-0.08	
1962/63	1771	5477	1621	713	116	93	19	2	3	14450	6176	-0.11	
1963/64	4780	1123	2973	748	276	41	33	7	2	4994	4223	0.57	
1964/65	368	3023	415	947	136	34	5	4	1	2127	1446	0.36	
1965/66	282	196	133	112	106	6	1	0	0	2804	2764	0.73	
1966/67	257	149	72	62	45	39	2	1	0	2827	710	-0.64	
1967/68	587	164	88	44	37	26	23	1	0	3268	750	-0.73	
1968/69	1705	372	102	55	27	23	16	14	1	3939	1877	0.00	
1969/70	3965	1085	237	65	35	17	15	10	10	9040	4308	0.00	
1970/71	3494	2523	690	151	41	22	11	9	13	28565	13616	0.00	
1971/72	9752	2223	1606	439	96	26	14	7	14	17919	9951	0.15	
1972/73	7843	6198	1324	911	236	50	14	7	11	22051	7706	-0.31	
1973/74	6981	4991	3735	712	451	112	24	7	9	34874	9903	-0.52	
1974/75	1833	4442	3034	2158	392	242	60	13	8	43034	8951	-0.83	
1975/76	2390	1163	2684	1752	1189	211	130	33	11	34697	15143	-0.09	
1976/77	2662	1517	719	1433	837	531	94	58	20	27806	12516	-0.06	
1977/78	1482	1693	812	371	666	370	235	41	34	16857	11452	0.35	
1978/79	29067	942	918	403	152	243	131	83	27	9055	8657	0.70	
1979/80	2119	18476	582	441	147	48	74	40	33	34832	21204	0.24	
1980/81	870	1347	11573	356	239	72	23	35	35	55581	19024	-0.33	
1981/82	946	553	846	7003	202	125	36	12	36	57364	19009	-0.36	
1982/83	6422	600	343	522	4226	119	71	21	27	47651	19082	-0.17	
1983/84	2870	4072	366	206	303	2408	67	40	27	38642	20438	0.10	
1984/85	668	1819	2479	219	119	172	1361	38	38	32522	14393	-0.07	
1985/86	1369	421	1111	1448	121	63	90	712	40	29087	5636	-0.90	
1986/87	9808	871	263	665	834	68	35	51	422	22931	13133	0.18	
1987/88	3811	6239	541	159	393	487	40	21	276	29389	14456	0.03	
1988/89	1338	2425	3969	344	101	250	310	25	189	35584	23986	0.35	
1989/90	866	849	1522	2462	211	62	152	189	131	30617	25011	0.54	
1990/91	4298	550	501	875	1321	108	31	76	159	20610	14220	0.37	
1991/92	354	2710	335	281	458	663	53	15	115	20965	9500	-0.05	
1992/93	235	223	1622	194	156	249	361	29	71	13931	5405	-0.21	
1993/94	994	149	132	886	98	76	122	177	49	11327	4895	-0.10	
1994/95	3915	626	90	78	510	56	43	69	128	11438	4946	-0.10	
1995/96	8002	2491	398	57	50	324	35	28	126	15624	5827	-0.25	
1996/97	13680	5092	1585	253	36	32	206	23	97	19477	11686	0.23	
1997/98	170	8699	3233	1000	159	23	20	129	75	37500	18806	0.05	

Estimated average availability at age (S_i)

0.13 0.43 0.62 0.88 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.01 0.03 0.19 0.54 0.79 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.48

Estimated instantaneous natural mortality rate is 0.452

Appendix table 2.2. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Prince Rupert stock assessment region.

Season	Estimated numbers at age ($\times 10^5$) for period 1									SB	SI	RES
	1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	7491	7804	9270	1242	448	237	0	0	0	15510	30098	1.21
1951/52	7602	4284	3982	3487	340	87	46	0	0	7471	18726	1.46
1952/53	18167	4354	2263	1297	696	34	9	5	0	30158	26180	0.40
1953/54	5591	10755	2528	1307	741	394	19	5	3	11369	13291	0.70
1954/55	14264	3270	5822	963	367	150	80	4	2	17416	25629	0.93
1955/56	4584	8411	1873	2622	369	121	49	26	2	46847	15498	-0.56
1956/57	8692	2623	4458	1023	1374	187	61	25	14	20259	28280	0.88
1957/58	16507	4906	1176	1904	357	394	54	18	11	41106	12044	-0.68
1958/59	5196	9567	2775	664	1051	193	214	29	16	45028	36608	0.34
1959/60	27415	3052	5219	1511	347	530	97	108	23	36652	19072	-0.11
1960/61	13783	15345	1695	2621	695	148	226	42	56	34359	12883	-0.44
1961/62	7535	7815	7026	739	949	211	45	69	29	36034	24760	0.17
1962/63	21333	4406	4071	3344	311	358	80	17	37	29205	15652	-0.08
1963/64	2817	11258	2145	1749	1180	91	105	23	16	42417	29266	0.17
1964/65	679	1571	4969	1033	751	458	35	41	15	12560	6709	-0.08
1965/66	1075	246	578	1808	264	128	78	6	10	7939	7487	0.48
1966/67	1707	637	103	238	591	68	33	20	4	4573	2719	0.02
1967/68	1838	667	183	40	68	123	14	7	5	6144	4788	0.29
1968/69	8002	1012	310	96	19	32	57	7	6	3633	844	-0.92
1969/70	5233	4727	585	171	51	10	16	30	6	14674	8436	-0.01
1970/71	1898	3073	2711	333	96	28	6	9	20	18630	9751	-0.10
1971/72	11849	1104	1668	1499	178	50	15	3	15	18618	9852	-0.09
1972/73	10770	7016	639	888	756	86	24	7	9	23054	11260	-0.17
1973/74	4031	6377	4119	366	500	420	48	13	9	29917	8893	-0.67
1974/75	1430	2386	3746	2315	193	254	213	24	11	36344	11109	-0.64
1975/76	3213	845	1401	2168	1325	109	144	121	20	37181	14213	-0.42
1976/77	1635	1902	498	786	1181	705	58	77	75	25543	9736	-0.42
1977/78	1737	968	1058	259	375	527	314	26	67	13666	4738	-0.52
1978/79	30044	1024	530	512	105	130	182	108	32	9915	7554	0.27
1979/80	5429	17783	569	267	229	42	52	72	56	20979	10236	-0.17
1980/81	6758	3213	10342	313	131	103	19	23	58	38403	10532	-0.75
1981/82	6984	4000	1873	5898	172	69	54	10	42	44674	12631	-0.72
1982/83	20379	4130	2334	1084	3377	97	39	31	30	50455	19653	-0.40
1983/84	3827	12066	2445	1382	642	1999	58	23	36	46251	22927	-0.16
1984/85	3591	2265	7082	1418	781	349	1055	30	31	45289	35858	0.31
1985/86	13484	2125	1317	4023	768	393	164	496	29	45678	32526	0.20
1986/87	11050	7978	1215	733	2081	374	187	78	249	42182	31422	0.25
1987/88	6530	6541	4650	693	390	1028	178	89	156	37297	33680	0.44
1988/89	3386	3865	3766	2613	362	177	432	75	103	35335	12783	-0.47
1989/90	14426	2003	2212	2104	1339	153	67	165	68	36391	19398	-0.09
1990/91	14644	8540	1149	1257	1144	682	75	33	114	39209	21544	-0.06
1991/92	3800	8669	4955	656	686	594	338	37	73	42454	35992	0.38
1992/93	1782	2249	5040	2843	344	318	257	146	48	35658	21440	0.03
1993/94	4550	1055	1301	2831	1492	150	121	98	74	27997	13439	-0.19
1994/95	21019	2692	611	727	1502	733	64	51	73	24103	15858	0.12
1995/96	9215	12441	1573	350	401	796	371	32	63	37830	22104	0.01
1996/97	13166	5455	7287	911	193	188	351	163	42	30545	20744	0.16
1997/98	228	7795	3209	4211	469	68	38	71	42	38651	16734	-0.29

Estimated average availability at age (S_i)

0.07 0.36 0.54 0.80 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.13 0.19 0.48 0.74 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.58

Estimated instantaneous natural mortality rate is 0.524

Appendix table 2.3. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Central Coast stock assessment region.

Season	Estimated numbers at age ($\times 10^5$) for period 1										SB	SI	RES
	1+	2+	3+	4+	5+	6+	7+	8+	9+				
1950/51	1670	3111	4052	749	302	78	0	0	0	0	14647	23134	0.57
1951/52	2241	1191	1428	1414	185	67	17	0	0	0	3919	10709	1.12
1952/53	12903	1579	414	360	178	18	6	2	0	0	10464	20001	0.76
1953/54	1535	9815	1184	301	258	128	13	5	1	1	8766	18635	0.87
1954/55	1663	1050	5346	401	71	54	27	3	1	1	27894	14983	-0.51
1955/56	3873	1200	724	3229	227	39	30	15	2	2	7355	8244	0.23
1956/57	5535	2347	427	198	493	28	5	4	2	2	3170	6224	0.79
1957/58	6460	3850	682	112	28	54	3	1	1	1	12304	4226	-0.95
1958/59	1583	4625	2177	352	51	12	24	1	1	1	5513	4105	-0.18
1959/60	3152	1100	2162	632	61	7	2	3	0	0	25924	14684	-0.45
1960/61	8704	2168	735	1492	425	41	5	1	2	2	7248	4567	-0.35
1961/62	4279	6167	734	226	290	71	7	1	1	1	14491	14181	0.09
1962/63	3811	3109	3811	358	95	117	29	3	1	1	4892	8467	0.66
1963/64	1878	2888	1290	961	45	9	11	3	0	0	4786	7058	0.50
1964/65	1932	1054	814	339	134	5	1	1	0	0	3443	2365	-0.26
1965/66	5447	1379	393	240	61	20	1	0	0	0	1982	1774	0.00
1966/67	1906	1206	155	85	19	3	1	0	0	0	3344	5905	0.68
1967/68	456	256	162	44	14	3	0	0	0	0	3652	6366	0.67
1968/69	1874	289	143	98	25	8	1	0	0	0	3771	2331	-0.37
1969/70	1613	1424	218	107	73	18	6	1	0	0	14397	10134	-0.24
1970/71	2036	1216	1075	164	80	55	14	4	1	1	15325	6056	-0.81
1971/72	3428	1510	822	709	104	50	34	9	3	3	10735	3928	-0.89
1972/73	2238	2576	945	405	299	42	20	14	5	5	20521	14471	-0.23
1973/74	2970	1697	1694	570	220	157	22	11	10	10	18575	10624	-0.44
1974/75	1434	2253	1241	1039	278	93	64	9	8	8	24910	9165	-0.89
1975/76	737	1088	1620	804	547	131	42	29	8	8	18964	16134	-0.05
1976/77	834	546	767	988	371	210	46	15	13	13	17788	18481	0.15
1977/78	576	632	348	468	471	148	80	18	11	11	6263	10097	0.59
1978/79	5810	438	379	168	114	54	13	7	2	2	7350	6550	0.00
1979/80	1118	4422	333	288	128	87	41	10	7	7	22363	15978	-0.22
1980/81	1200	851	3362	252	211	89	59	28	12	12	27549	16949	-0.37
1981/82	533	913	643	2473	170	127	48	31	21	21	30271	18412	-0.38
1982/83	449	403	662	451	1556	101	71	26	29	29	24103	16618	-0.26
1983/84	1746	341	295	463	288	934	59	41	32	32	15410	14197	0.03
1984/85	733	1317	238	189	265	148	458	29	36	36	16478	8480	-0.55
1985/86	1384	552	914	153	110	147	79	244	34	34	15688	15534	0.10
1986/87	8208	1047	392	613	97	67	88	48	168	168	15839	12992	-0.08
1987/88	584	6240	754	262	381	59	40	53	130	130	33478	27018	-0.10
1988/89	521	441	4516	526	172	241	37	25	115	115	32261	32335	0.12
1989/90	1687	389	308	2963	301	90	117	18	68	68	29929	31048	0.15
1990/91	8513	1280	272	206	1819	170	49	63	47	47	22995	20155	-0.02
1991/92	1068	6468	866	169	116	975	89	25	57	57	33697	46036	0.43
1992/93	1953	798	4497	565	103	69	563	51	48	48	34398	39713	0.26
1993/94	560	1464	554	2867	330	57	36	292	51	51	32538	29781	0.03
1994/95	1899	416	928	344	1620	177	29	18	174	174	21413	18919	-0.01
1995/96	7082	1440	275	553	185	830	88	14	95	95	20169	17941	0.00
1996/97	5748	5344	1018	179	341	112	499	53	66	66	30213	25208	-0.07
1997/98	234	4366	3815	703	120	223	72	323	77	77	37549	29386	-0.13

Estimated average availability at age (S_i)

0.15 0.57 0.76 0.95 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.03 0.20 0.52 0.78 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.89

Estimated instantaneous natural mortality rate is 0.273

Appendix table 2.4. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Strait of Georgia stock assessment region.

Season	Estimated numbers at age ($\times 10^5$) for period 1									SB	SI	RES
	1+	2+	3+	4+	5+	6+	7+	8+	9+			
1950/51	18791	8680	3247	708	138	47	0	0	0	25056	66063	0.74
1951/52	21791	10274	3051	881	182	35	12	0	0	29479	66048	0.57
1952/53	38193	11681	3784	862	237	48	9	3	0	55461	100513	0.36
1953/54	23319	21074	6045	1900	431	118	24	5	2	37484	90437	0.65
1954/55	13627	12839	9538	1626	485	107	29	6	1	74980	74227	-0.24
1955/56	12680	7322	4660	3317	549	161	35	10	2	28324	29494	-0.19
1956/57	10574	6665	2273	1036	684	109	32	7	2	16572	28997	0.33
1957/58	27819	5797	1273	432	179	112	18	5	2	12102	20358	0.29
1958/59	19404	15259	2347	347	112	45	28	4	2	29465	44278	0.18
1959/60	10115	10005	5693	639	90	28	11	7	2	32195	37223	-0.09
1960/61	23869	5227	3056	1397	147	20	6	3	2	19691	25519	0.03
1961/62	21404	12067	1903	716	305	31	4	1	1	21851	23281	-0.17
1962/63	20558	11405	3248	395	136	55	6	1	0	12630	27751	0.56
1963/64	10120	10397	3435	489	52	16	7	1	0	11658	20366	0.33
1964/65	5163	5298	2622	450	54	5	2	1	0	20619	18628	-0.33
1965/66	5042	2378	1161	610	98	11	1	0	0	4056	5108	0.00
1966/67	2813	2246	562	132	56	8	1	0	0	4519	6345	0.11
1967/68	1864	677	227	74	15	6	1	0	0	6694	12022	0.35
1968/69	5789	981	311	106	34	7	3	0	0	14604	18208	-0.01
1969/70	6612	3163	525	167	57	18	4	1	0	28400	44194	0.21
1970/71	5189	3642	1713	285	90	31	10	2	1	26007	47312	0.37
1971/72	8323	2859	1973	909	151	48	16	5	2	23940	25875	-0.15
1972/73	12585	4536	1341	844	382	63	20	7	3	21249	18257	-0.38
1973/74	16988	6960	2379	584	346	153	25	8	4	51754	64619	-0.01
1974/75	11724	9391	3796	1234	271	149	64	10	5	65097	76692	-0.07
1975/76	20104	6487	5126	1949	541	112	61	26	6	49374	57135	-0.09
1976/77	15924	11109	3525	2531	836	193	38	21	11	69793	58004	-0.42
1977/78	8612	8787	5719	1665	1062	327	73	15	12	58487	97082	0.27
1978/79	11884	4755	4437	2543	637	366	109	24	9	48548	59042	-0.04
1979/80	9043	6566	2485	1992	1004	235	133	40	12	56512	74848	0.05
1980/81	7256	5001	3549	1315	985	468	108	61	24	51854	48231	-0.30
1981/82	5756	3991	2584	1755	582	401	185	43	34	43233	90239	0.50
1982/83	5082	3158	1998	1225	767	223	143	66	27	23608	47423	0.47
1983/84	8241	2792	1516	755	352	195	47	30	20	20447	27588	0.07
1984/85	12646	4520	1368	617	219	81	43	10	11	28819	26629	-0.31
1985/86	7134	6916	2339	626	229	70	25	13	7	52242	61097	-0.08
1986/87	22377	3944	3803	1285	344	126	38	14	11	41922	39037	-0.30
1987/88	6792	12354	2057	1841	524	116	36	11	7	59820	25351	-1.09
1988/89	16400	3752	6685	1018	807	211	43	13	7	58562	54078	-0.31
1989/90	7901	9053	2035	3430	451	326	80	16	8	81383	58912	-0.56
1990/91	20241	4372	4969	1075	1583	185	129	32	10	59528	43421	-0.55
1991/92	14388	11190	2371	2508	473	624	69	48	15	72034	80122	-0.13
1992/93	14507	7945	5921	1158	1055	179	228	25	23	84295	84961	-0.22
1993/94	6576	7957	4161	2894	494	408	65	83	18	63385	60862	-0.27
1994/95	11764	3613	4130	1962	1115	153	115	18	28	51602	59708	-0.09
1995/96	16585	6468	1895	1980	798	414	53	40	16	57678	76291	0.05
1996/97	15910	9070	3182	896	807	286	142	18	19	50837	53442	-0.18
1997/98	4971	8726	4466	1431	338	245	78	39	10	48375	68699	0.12

Estimated average availability at age (S_i)

0.11 0.70 0.93 0.98 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.02 0.21 0.59 0.86 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.26

Estimated instantaneous natural mortality rate is 0.591

Appendix table 2.5. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the west coast Vancouver Island stock assessment region.

Season	Estimated numbers at age ($\times 10^{-5}$) for period 1										SB	SI	RES
	1+	2+	3+	4+	5+	6+	7+	8+	9+				
1950/51	3098	2194	2664	388	108	26	0	0	0	0	18227	17007	-0.24
1951/52	4085	1795	781	1026	134	36	9	0	0	0	1963	14383	1.82
1952/53	6770	2620	694	120	81	8	2	1	0	0	14960	30675	0.55
1953/54	3970	4394	1699	450	78	52	5	1	0	0	6934	16556	0.70
1954/55	5319	2499	1007	357	65	10	7	1	0	0	20800	17555	-0.34
1955/56	6902	3358	1305	546	188	34	5	4	0	0	22328	45168	0.54
1956/57	8205	4353	1364	580	226	76	14	2	2	2	34978	52651	0.24
1957/58	10873	5319	2660	842	355	138	47	8	2	2	46152	24399	-0.81
1958/59	7417	7050	3426	1713	541	228	89	30	7	7	11626	18396	0.29
1959/60	4047	4573	2013	685	226	63	27	10	4	4	5108	7039	0.15
1960/61	9697	2251	647	327	61	16	5	2	1	1	5024	7912	0.29
1961/62	4539	5313	551	136	47	8	2	1	0	0	14660	34579	0.69
1962/63	6121	2853	1803	190	40	14	2	1	0	0	7256	14618	0.53
1963/64	1643	3949	1245	516	44	9	3	0	0	0	12078	27863	0.67
1964/65	1449	1025	1575	412	146	12	2	1	0	0	10636	10864	-0.15
1965/66	1916	918	324	549	125	43	3	1	0	0	4294	4584	-0.10
1966/67	641	1180	473	91	123	26	9	1	0	0	4417	5118	-0.02
1967/68	1193	297	211	118	17	22	5	2	0	0	9530	11278	0.00
1968/69	5702	774	193	137	77	11	14	3	1	1	9474	11206	0.00
1969/70	11565	3701	502	125	89	50	7	9	3	3	29526	34923	0.00
1970/71	8569	7506	2402	326	81	58	32	5	8	8	27485	32476	0.00
1971/72	10455	5562	4871	1559	212	53	37	21	8	8	59954	36069	-0.68
1972/73	11124	6770	3519	2893	913	124	31	22	17	17	71875	16219	-1.66
1973/74	18625	7212	4021	1905	1502	469	63	16	20	20	92690	24774	-1.49
1974/75	7771	12002	4212	2295	1015	780	242	33	18	110851	44594	-1.08	
1975/76	4758	5036	7019	2319	1140	493	378	117	25	63491	63335	-0.17	
1976/77	7597	3085	3126	3416	864	387	166	127	48	48802	57398	-0.01	
1977/78	2198	4924	1845	1495	1374	313	138	59	62	41399	39931	-0.20	
1978/79	4834	1421	2923	1008	585	422	86	38	33	26573	63663	0.71	
1979/80	3437	3131	801	1436	355	170	118	24	20	32669	62619	0.48	
1980/81	1830	2227	1965	492	822	188	88	61	23	31834	58518	0.44	
1981/82	1250	1173	1290	1110	243	380	83	39	37	25081	29424	-0.01	
1982/83	2429	805	710	755	590	115	169	37	34	17268	15329	-0.29	
1983/84	5305	1556	414	350	321	235	45	65	27	18111	22142	0.03	
1984/85	4957	3337	834	208	162	146	106	20	42	36807	29132	-0.40	
1985/86	1993	3214	2158	539	134	105	94	68	40	47318	38347	-0.38	
1986/87	12243	1293	2078	1395	348	87	68	61	70	31849	29915	-0.23	
1987/88	2111	7799	673	979	600	146	36	28	55	41710	39289	-0.23	
1988/89	2657	1353	4656	368	505	305	74	18	42	40861	43331	-0.11	
1989/90	1541	1706	758	2434	174	230	138	34	27	35587	38337	-0.09	
1990/91	5174	997	954	409	1233	87	114	68	30	23902	25907	-0.09	
1991/92	2799	3326	541	495	194	560	39	51	44	26217	36811	0.17	
1992/93	2171	1812	2034	314	277	108	309	21	53	27024	29237	-0.09	
1993/94	1015	1391	1047	1125	169	148	58	166	40	21696	19765	-0.26	
1994/95	1372	646	802	559	568	83	72	28	100	19375	25039	0.09	
1995/96	9908	889	395	470	323	326	48	42	74	18285	31929	0.39	
1996/97	2610	6413	551	240	283	194	196	29	69	27729	39114	0.18	
1997/98	1273	1677	3683	295	125	146	100	101	50	27056	36898	0.14	

Estimated average availability at age (S_i)

0.09 0.67 0.84 0.97 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.03 0.31 0.70 0.91 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.18

Estimated instantaneous natural mortality rate is 0.432