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Stock Assessment for British Columbia Herring in 2001 and Forecasts of the Potential Catch in 2002

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Abstract

Herring stock abundance in British Columbia waters was assessed for 2001 and forecasts were made for 2002 using two analytical methods: (1) escapement model; and (2) age-structured model. These models have been applied to assess herring abundance since 1984 but for the current assessment a number of changes were introduced in the age-structured model to account for temporal change in the spawn index. This revised age-structured model incorporates a fixed spawn conversion factor for the dive survey era since 1988 and a free fitted parameter for the earlier surface survey period. The revised age-structured model was adopted as the basis for the assessment of abundance in all five stock areas. 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 2001 was 211,000 tonnes based on the revised age-structured model. This represents a 14% increase over the 2000 abundance level. This slight increase reflects the recruitment of an average 1998 year-class in most areas of the coast except the Central where recruitment was poor.

The estimated harvestable surplus in 2002 (20% of the 2002 forecast herring run) based on forecast abundance to the five assessment regions is 38,950 tonnes for the 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 the Pacific Scientific Advice Review Committee (PSARC) review of these data, forecast run sizes, and harvestable surpluses, are subject to change.

Résumé

La pêche commerciale canadienne de la sardine du Pacifique s'est terminée à la fin des années 1940 parce que l'espèce était moins abondante au large de la Californie. Absente pendant près de 50 ans, la sardine est réapparue en Colombie-Britannique au début des années 1990, et une pêche commerciale a commencé en 1995. Devant l'intérêt grandissant pour le rétablissement de la pêche commerciale, on a étendu très progressivement la pêche expérimentale, avec 10 détenteurs de permis (7 bateaux de pêche à la senne, 2 au filet de fond et 1 au filet maillant) récoltant un quota de 1 600 tonnes en 2001. Des relevés d'été continus au chalut fournissent un indice de l'abondance relative de l'espèce en zone hauturière, et il semble qu'en 2001, les sardines se trouvaient plus au sud et étaient moins abondantes que lors des relevés de 1997 et de 1999. Ces résultats sont cohérents avec l'évaluation des É.-U. qui révèle une légère diminution de l'abondance de sardine en 2001.

L'évaluation canadienne du stock repose sur les prévisions de l'abondance faites par les É.-U. et suppose qu'en moyenne, environ 10 % du stock migre vers les eaux de la C.-B. d'après les taux de capture historiques et les estimations de la biomasse découlant du relevé au chalut. L'industrie canadienne devenant de plus en plus experte de la capture et de la manutention des sardines, il a été recommandé d'adopter, pour la pêche de la C.-B., le taux de récolte des É.-U. basé sur les conditions de température près des frayères. Selon l'évaluation des É.-U. pour 2002, la biomasse de sardine fléchit légèrement, mais au taux de récolte recommandé de 15 %, on prévoit un excédent potentiel de 15 864 tonnes dans les eaux canadiennes. Cette récolte constitue un plafond et, si les températures en juillet et en août 2002 au large de la côte ouest de l'île de Vancouver sont près ou en dessous du seuil de migration de 12 ºC, la biomasse des sardines qui migrent vers la C.-B. pourrait être inférieure aux prévisions.

1. 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 1951-2001 and forecast pre-spawning abundance for the 2002 season. Forecasts of upcoming run size are based on the combination of estimates of surviving repeat spawners and newly recruiting spawners which are presented as poor, average, and good, based on historic recruitment levels.

1.1. STOCK CONSIDERATIONS

The stock concept used for managing British Columbia herring is based on current knowledge of stock structure that is necessarily incomplete. Given incomplete knowledge of population structure it is prudent to manage fisheries to ensure maintenance of the greatest potential biological diversity. In addition, 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 smaller, spatially discrete spawning groups. In the 2001 spawning season, the research study using a combination of coded wire tagging and micro-satellite DNA analysis to further investigate stock structure of British Columbia herring was continued. Results of these studies are presented in separate reports.

The stock groupings used for the current assessments are identical to those used since 1993 (Fig. 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 that 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. An escapement model estimate of current stock abundance is available for these areas but no forecast of abundance in the coming year is possible.

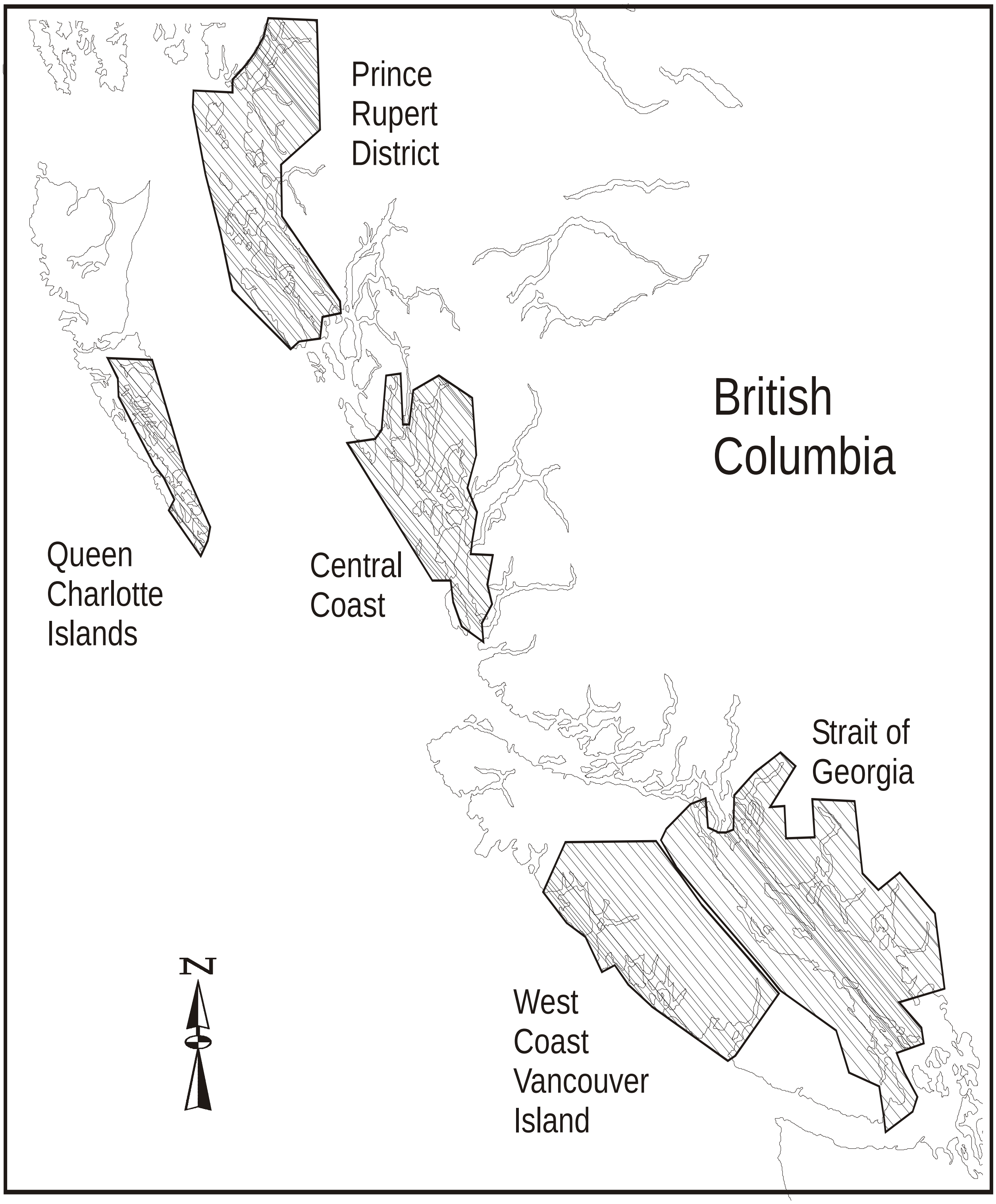


Fig. 1. Herring stock assessment regions in British Columbia.

1.2. DATA BASE

The primary data sources for the stock assessments are spawn survey data, commercial catch landing data, and age composition data from biological samples of commercial fishery, pre-fishery charter, and research catches. These data are available on computer files for the period 1951 to 2001. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period that 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 51 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 egg beds have been assessed using Scuba rather than traditional surface survey methods. We assume all surveys provide accurate estimates of spawn bed width and egg density and these data have been used in the escapement model where available. All major herring spawning beds were surveyed in 2001, as were many of the minor spawning beds outside the assessment areas. In addition, an underwater video system was used in a portion of Area 23 to locate and delimit any spawning events deeper than 30 meters. However, no such areas were identified although areas of spawn in shallower locations were accurately identified by the video system.

Catch information was obtained from landing slip and monitoring of plant offload data. Both models use the landing slip data summed by fishery season (seasons run from July 1 to June 30). The 1997/98 catch figures are based on verified plant offload weights, a result of the introduction of the individual vessel quota ('pool fishery') system for all fisheries except the Strait of Georgia and Prince Rupert gillnet fisheries. Since 1998/99 verified plant offload weights are available for all food and roe fisheries coastwide. 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. For assessment purposes, since it has been assumed that the 100 tons (91 tonnes) allocated to each license are killed (Shields et al. 1985) and this is treated as an additional seine removal. Additional information on the scope of the SOK fishery which began in 1975 is being tabulated for inclusion in future assessments.

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 samples taken from the catch particularly in 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 estimates of the mean weight-at-age. During the 2000/01 season a total of 291 herring samples (68 roe, 13 food, 173 test fishery and 37 miscellaneous others) were collected and processed compared to 339 in the previous year. Of the roe and test fishery samples, 9 were taken in the Queen Charlotte Islands assessment area (another 5 from Area 2W), 66 in the Prince Rupert area, 55 in the Central Coast, 81 in the Strait of Georgia, 23 on the west coast of Vancouver Island, and another 17 samples were obtained from SOK operations. With the exception of Area 27 where only 2 SOK samples were obtained, this level of sampling coverage is adequate to estimate age composition and mean weight at age for 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.

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. Scuba surveys have been found to be superior to surface surveys for spawn assessment because they provide more accurate estimates of both spawn bed width and the intensity of egg deposition. 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 again virtually no DFO effort directed to surface surveys in 2001, particularly outside of the assessment regions. No organized surface surveys were conducted in any of the major assessment regions. However, all areas did receive good Scuba survey coverage. Limited surface surveys occurred in the Johnstone Strait and in Area 2W, through industry funded contractors. Coastwide there was a marked increase in the total length of spawn surveyed by Scuba and surface surveys relative to 2000. The difference is attributable to substantial increases in spawn in all areas except the Central Coast and west coast of Vancouver Island.

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, 1998-2001.

	1998			1999			2000			2001		
Assessment Region	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total
Queen Charlotte Is.	58.4	0.0	58.4	42.1	2.4	44.5	25.1	0.0	25.1	38.9	0.0	38.9
Prince Rupert District	47.1	0.0	47.1	83.7	1.1	84.8	73.5	0.0	73.5	97.9	0.0	97.9
Central Coast	141.0	23.4	164.4	159.4	3.2	162.6	96.5	0.7	97.2	99.3	0.0	99.3
Strait of Georgia	140.8	6.2	147.0	133.8	3.5	137.3	152.1	0.0	152.1	172.2	0.0	172.2
W.C. Vancouver Is.	42.9	0.5	43.4	48.9	0.3	49.2	40.7	0.0	40.7	37.5	0.0	37.5
Other Areas	26.1	13.8	39.9	28.3	48.1	76.4	23.4	1.1	24.5	13.2	37.1	50.3
Coastwide Total	459.3	50.0	509.4	496.2	58.6	554.8	411.3	1.8	413.1	459.0	37.1	496.1

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 mature 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 1951-2001. 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 average weights-at-age from the previous season.

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 may be used to estimate pre-fishery biomass for each area (Schweigert 1993) if all pertinent data are available:

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

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.

However, estimates of fecundity and are not available each year so a simpler method is used to estimate biomass from the estimate of total egg deposition. The total catch is obtained from sales slip information except for the current season when verified plant landed weight data are available. Dive survey observations of egg deposition are used directly in the equations below while surface survey observations are adjusted to emulate Scuba estimates. Total spawning bed area is calculated as the product of: total length parallel to the shore of each spawning bed and the observed or adjusted width of the spawning bed. The egg density is estimated from the average number of egg layers determined from the surface survey. For Scuba surveys the average egg density is predicted for each sampled quadrat from observations of egg layers and type of vegetation substrate. For kelp beds the average number of egg layers on the kelp and the number of kelp fronds and used to estimate egg density. The product of total area and egg density or plant density and egg density (kelp beds) are used to estimate total egg deposition for each egg bed. Total egg deposition estimates for all spawning beds from all three types of survey (surface, dive, and kelp) are summed within each assessment region and the total egg deposition is converted to tonnes of spawning fish based on an estimate of 100 eggs per gram of herring on average (Hay 1985).

Surface Surveys

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 1951-2001, 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 were an grouping of herring spawning locations which were geographically adjacent and probably geomorphologically similar. Hence, diver width estimates developed for such a 'pool' were felt to be characteristic of all herring locations within that pool. For the small number of locations which could not be assigned to a pool, the median width for the herring section (Haist and Rosenfeld 1988) was used to adjust width estimates for the herring 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 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 for each spawning bed.

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:

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

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 appear to be 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 grabs with a spawn drag or rake or snorkelling to define the limits of the areas of egg deposition. A systematic sampling regime is employed whereby transects are set across the egg bed perpendicular to shore at 350 m intervals. 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, where the weighting is based on the length of 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 using non-linear regression ($P<0.0001$):

$$Eggs_{ij} = 1033.6694\, L_{ij}^{0.7137}\, P_{ij}^{1.5076}\, V_{ij}\, Q_j.$$

where

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

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

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

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 have been collected since 1997 and model predictions of egg numbers per sample quadrat are assumed to be unbiased for use in the assessment of egg density.

<u>Eggs on Bottom and *Macrocystis*</u>

Eggs on rock are estimated from the product of the proportion of the quadrat covered by eggs, number of egg layers, and 340,000 eggs/m^2 (Haegele *et al*. 1979). Eggs on rock also includes eggs on other inorganic 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:

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

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

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 1971-2001 roe period (Table 2.1) and are used to forecast 2002 abundance.

Table 2.1. Geometric mean age-specific apparent survival estimated for each stock assessment region over the roe fishery period, 1971-2001.

	Age Class				
Assessment Region	2^+-3^+	3^+-4^+	4^+-5^+	5^+-6^+	6^+-7^{++}
Queen Charlotte Is.	1.47	1.17	0.95	0.85	0.52
Prince Rupert	1.27	1.18	1.05	0.88	0.56
Central Coast	1.44	1.21	1.06	0.92	0.63
Georgia Strait	0.83	0.68	0.59	0.56	0.40
W.C. Vancouver Is.	1.02	0.81	0.77	0.70	0.45

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

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

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

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 1971-2001.

	Queen Charlotte Islands			Prince Rupert District			Central Coast		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	13616	102	13718	9751	3500	13252	6056	3615	9671
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	6192	16222	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	5993	41984	46038	8756	54795
1992/93	5405	3951	9356	21440	7177	28617	39713	11060	50773
1993/94	4895	1387	6282	13439	5413	18852	29781	12332	42113
1994/95	4946	0	4946	15858	2877	18735	18918	10307	29225
1995/96	5827	0	5827	22104	4178	26282	17941	5209	23150
1996/97	11686	273	11959	20744	6542	27286	25208	4806	30011
1997/98	18871	2100	20971	16734	4218	20952	29386	9965	39351
1998/99	9714	3792	13506	25699	3114	28813	28924	8738	37662
1999/00	5119	2674	7793	15658	5316	20974	23811	8640	32451
2000/01	14113	408	14521	33336	3917	37253	24012	7075	31087

Table 2.3. Estimates of spawning stock biomass, catch, and pre-fishery stock abundance (tonnes) for the southern stock assessment regions from 1971-2001.

	Strait of Georgia			W.C. Vancouver Island		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	47312	1694	49005	32476	0	32476
1971/72	25875	8811	34686	36069	6894	42963
1972/73	18255	7649	25903	16219	18303	34522
1973/74	64619	4004	68622	24775	16334	41110
1974/75	76692	6179	82871	44594	26109	70703
1975/76	57133	12235	69368	63335	38825	102160
1976/77	58003	17509	75512	57398	30043	87441
1977/78	97082	24002	121084	39931	22745	62676
1978/79	59041	20337	79378	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	27587	11035	38622	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	17650	78512	19764	6310	26075
1994/95	59708	13190	72897	25039	2586	27625
1995/96	76291	14113	90404	31929	1516	33445
1996/97	53442	16571	69266	39114	7383	46497
1997/98	68669	13604	82303	36898	7363	44261
1998/99	70165	13285	83450	18829	4824	23653
1999/00	67694	15203	82897	10940	1990	12930
2000/01	95138	15974	111112	13593	364	13957

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 1971-2001.

	Area 2W*			Area 27		
Season	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	1307	1395	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	105	1703
1997/98	372	180	552	1732	105	1837
1998/99	0	0	0	564	105	669
1999/00	290	0	290	967	105	1072
2000/01	31	0	31	178	105	283

*- No estimates of stock biomass are available in area 2W for 1995-97 and 1999. Spawning activity was observed in the area but no surveys were conducted or surveys did not detect spawn.

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 that 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 recruitment to the spawning stock. Model parameters are estimated simultaneously using a maximum likelihood method. The model uses escapement model estimates of spawning stock biomass as the abundance or spawn index for parameter estimation beginning in 1994 (Schweigert and Fort 1994). The model is implemented in the C^{++} programming language using AD model builder software (Otter Research Ltd, 1996).

The structure of the herring catch-age model has remained essentially unchanged since the late 1980s. Concern by the PSARC Pelagics Subcommittee that catch-age model assessments of biomass were inconsistent with escapement model estimates resulted in a herring workshop being held in Nanaimo from June 12-14, 2001. A number of alternative formulations for components of the age-structured model were discussed at the workshop and some additional analyses have resulted in the development of a number of alternative models for the current assessment. Effects of the following modifications to the current version of the model are presented below:

- Removal of sample size adjustment based on between sample variance;
- Increase in penalty weight for spawn data from 10 to 50;
- Fixing of the spawn conversion parameter at values of 0.7, 0.8, and 0.9;
- Introduction of separate spawn conversion parameters for the surface and dive survey eras;
- Fixing of the dive survey spawn conversion parameter at 0.8, and 1.0.

3.2. METHODS

<u>The Population Model</u>

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

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

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

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

and, for $r < p$

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

where

C_{ijr}	is the catch of age class *j* in season *i* for period *r*,
F_{ijr}	is the fishing mortality of age class *j* in season *i* for period *r*,
M_r	is the natural mortality for period *r*,
N_{ijr}	is the number of fish in age class *j* in season *i* for period *r*,
p	is the number of fishing periods (p=3),
n	is the number of seasons (n=51),
k	is the number of age classes (k=9).

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

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

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

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

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

$$\lambda_{ij} = \lambda_{\bullet j} ,$$

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),

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

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,

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

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

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

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

As in last year's assessments, a natural mortality parameter, $M_{\bullet}$, is estimated. A series of alternative assumptions about natural mortality were also investigated in the current assessment and are discussed in more detail in Section 6. 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,

$$M_1 = 0.95M_{\bullet}$$
$$M_2 = M_3 = 0.025M_{\bullet}$$

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

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

and the spawning stock biomass, which is assumed to be proportional 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

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

where *q* is a spawn conversion factor and ξ_i is a normally distributed random variable with mean 0 and variance σ_1^2. 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*,
$\lambda_j^{\bullet}$, 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 $\lambda_j^{\bullet}$ 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 multinominal sampling distribution).

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

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

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

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

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

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

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

$$-\sum_i \frac{(\ln(I_i) - \ln(q R_i))^2}{2\sigma_1^2} \qquad 3.6$$

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_1^2, 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:

$\sigma_1^2 = 0.05$,
$\sigma_3^2 = 0.0025$,

These correspond to approximately a 4% coefficient of variation in estimates of the total number of fish caught and an 18% coefficient of variation in spawn index observations.

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.

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:

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

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

$$s^2_{\hat{p}_j} = \frac{\sum_k \left(p_{jk} - \hat{p}_j\right)^2}{K - 1}$$

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:

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

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:

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

<u>Effects of modelling alternatives and tuning</u>

The first modification to the existing herring age-structured model (ASM) was investigation of the effects of removing the sample size adjustment based on the between sample variance as described above (see also Eq. 3.5). The result is presented in panel 1 of Figures 2a-e which displays 4 sets of lines: the escapement model, the current age-structured model, the current age-structured model without sample size weighting (RASM) and with penalty weights of 10 and 50. The increase in penalty weight is equivalent to assuming that the variance on the spawn index data is 0.01 rather than 0.05, ie. it is about 5 times less variable than presently assumed or has a CV of about 10%. The effect of removing the sample size adjustment is minimal, in some areas it results in a slight increase in biomass relative to the current ASM, whereas in other areas it results in a slight decrease in biomass. Increasing the penalty on the spawn data likelihood component also does not have dramatic effects on stock levels but in most areas it results in biomass estimates that are nearer to the ESM estimates than provided by the current ASM (Fig. 2a-e). During the herring workshop there was much discussion about the confounding of two parameters, M and q, and the need to try and fix one at a known value to facilitate estimation of the other parameter. The spawn conversion parameter, q, is implicitly assumed to be equal to 1 since the spawn index is felt to be an assessment of the total spawning stock biomass. However, other factors such as egg loss and incomplete surveys could result in a lower value as determined by the following equation:

Obs spawn = PS (TSP*EL)

where

Obs spawn = total spawn observed by the survey,
PS = Proportion of total spawn surveyed,
TSP = true spawn produced by the population,
EL = proportion of the total spawn lost to predation and other factors.

A best estimate of q=0.8 was proposed after extensive discussion at the herring workshop and results of fitting the RASM with q=0.8 and penalty weights on the spawn index data ranging from 10 to 100 are presented in panel of Figure 2a-e. Fitting the model with a fixed q=0.8 generally results in quite different biomass levels than when q was estimated but differing penalty weights do not have significant impacts on abundance levels. In all areas, except the Central Coast, fixing q=0.8 resulted in biomass levels more similar to the ESM than with q estimated. The third panel in Figures 2a-e examines the impact of differing fixed values for q ranging from 0.7-0.9. Clearly, the lower the value of q the higher the level of abundance. The final panel in Figure 2 examines the effect of fixing q and changing penalty weight on the model fit to the entire time series and to the roe fishery data alone. Fixing q=0.8 results in virtually identical abundance estimates for the roe period and for the entire time period with a penalty of 50. Decreasing the penalty weight on the spawn data results in substantially increased abundance levels during the last several years of the time series for the roe fishery data.

During the herring workshop there was also some discussion about the consistency in the spawn survey data for the surface and dive survey eras and one option to investigate this question is to fit separate q parameters for the surface and dive spawn survey periods. Figures 3a-e present the results of analyses that investigate this option. The top panel in Figures 3a-e presents the result of fitting the RASM with a single q, with 2 estimated q’s, with one estimated q for the surface era and q=0.8 for the dive era, and with one estimated q for the surface era and q=1.0 for the dive era. It is evident that fixing q resulted in abundance levels more similar to the ESM estimates than having either a single or two estimated q parameters. There were also some differences in abundance with two q’s with one fixed at 0.8 or 1.0, but no clear rationale for choosing between them. The bottom panel in Figures 3a-e compares the ESM estimates with the RASM and 2q’s. It appears from these figures that fitting the dive era with q=1.0 provides abundance estimates which are more similar to the spawn index than with q=0.8 for the period since 1990 suggesting that this is model is preferred since the spawn index is assumed to be an absolute estimate of abundance. The second panel in Figures 3a-e investigated the effect of one fixed q versus 2 fixed q’s versus 2 fixed q’s with a lower penalty weight. Results again indicate that 2 q’s fit closer to the spawn index than a single q but that the differing penalty weight has little impact on stock level.

A comparison of the spawn index data and the spawn length, which is the only parameter measured consistently in both the surface and dive survey eras, indicates a very good linear relationship in all stock assessment areas but moderate scatter in Prince Rupert and the west coast of Vancouver Island (Figures 4a-e). Panels 2-4 in this figure present the relationship between the spawn index and the resulting spawning stock biomass for the RASM model with a single q or with two q's where q is fixed at 0.8 and 1.0 for the dive era. For most areas the RASM does not fit the spawn index data very well but it is not significantly worse than for the models with q fixed (Panel 2 versus panels 3 and 4, Fig. 4a-c). The two models with 2 q's both fit the spawn index data slightly better than the RASM but the spawn index does not predict abundance well for the northern stocks especially in the pre-dive era (QCI, PRD, and CC, Figures 4a-c). On the other hand, both models appear to fit the dive era data quite well in all five stocks with the latter model (RASM, 2q=q,1.0) providing a marginally better overall fit to the spawn index data.

Stock Forecasts

Forecasts of stock abundance for 2002 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 2001/02 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 1951-2001 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. Profile likelihoods of the forecast biomass are also determined for each stock as a predictor of the most probable level of abundance for 2002.

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. For the 1994 and more recent assessments, 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 RASM and the RASM with 2q=q,1.0 are presented in Appendix Tables 2.1-2.5 and 3.1-3.5 for all assessment regions.

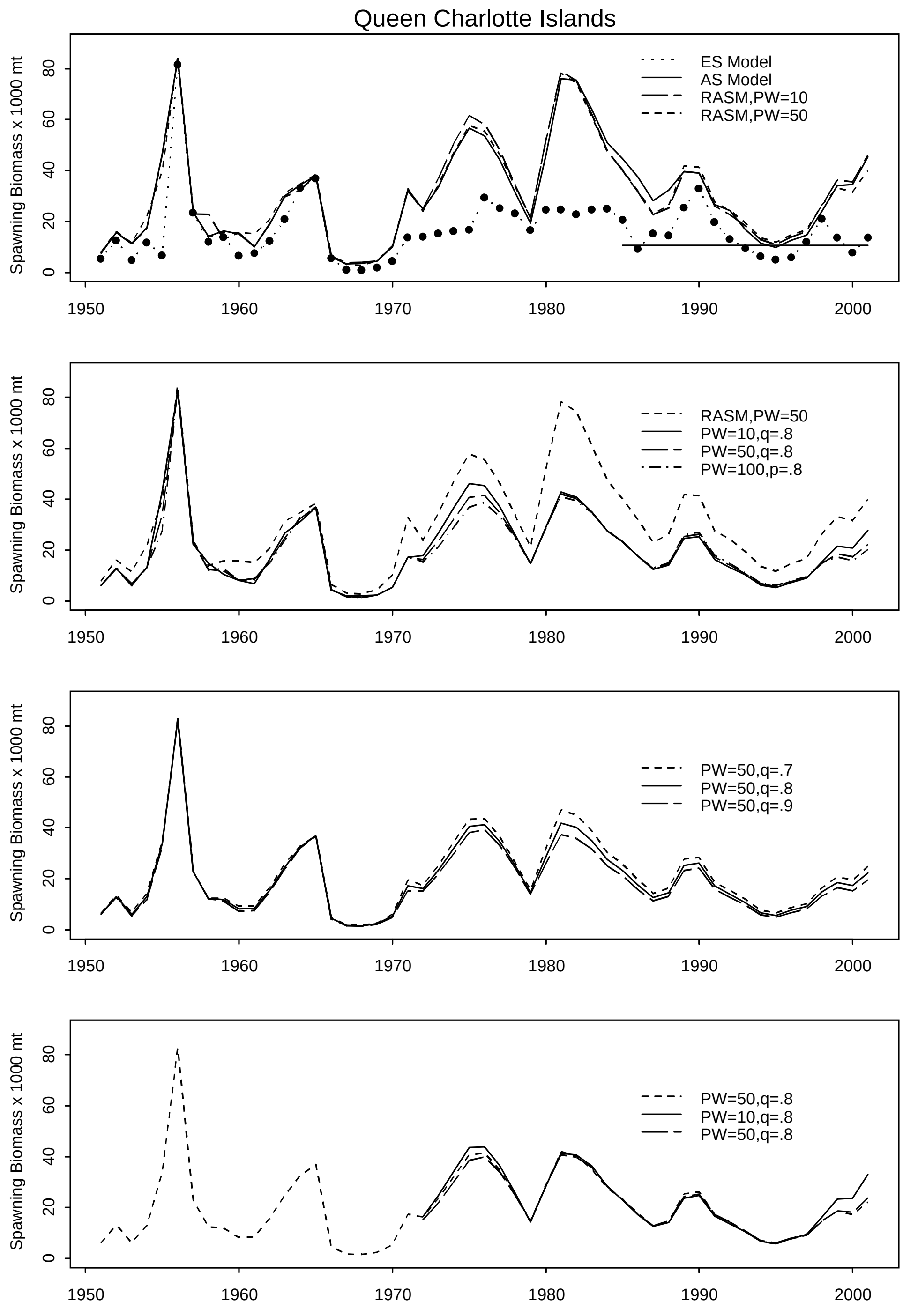


Figure 2a. Estimated spawning stock biomass for the Queen Charlotte Islands from age-structured analyses for 1951-2001.

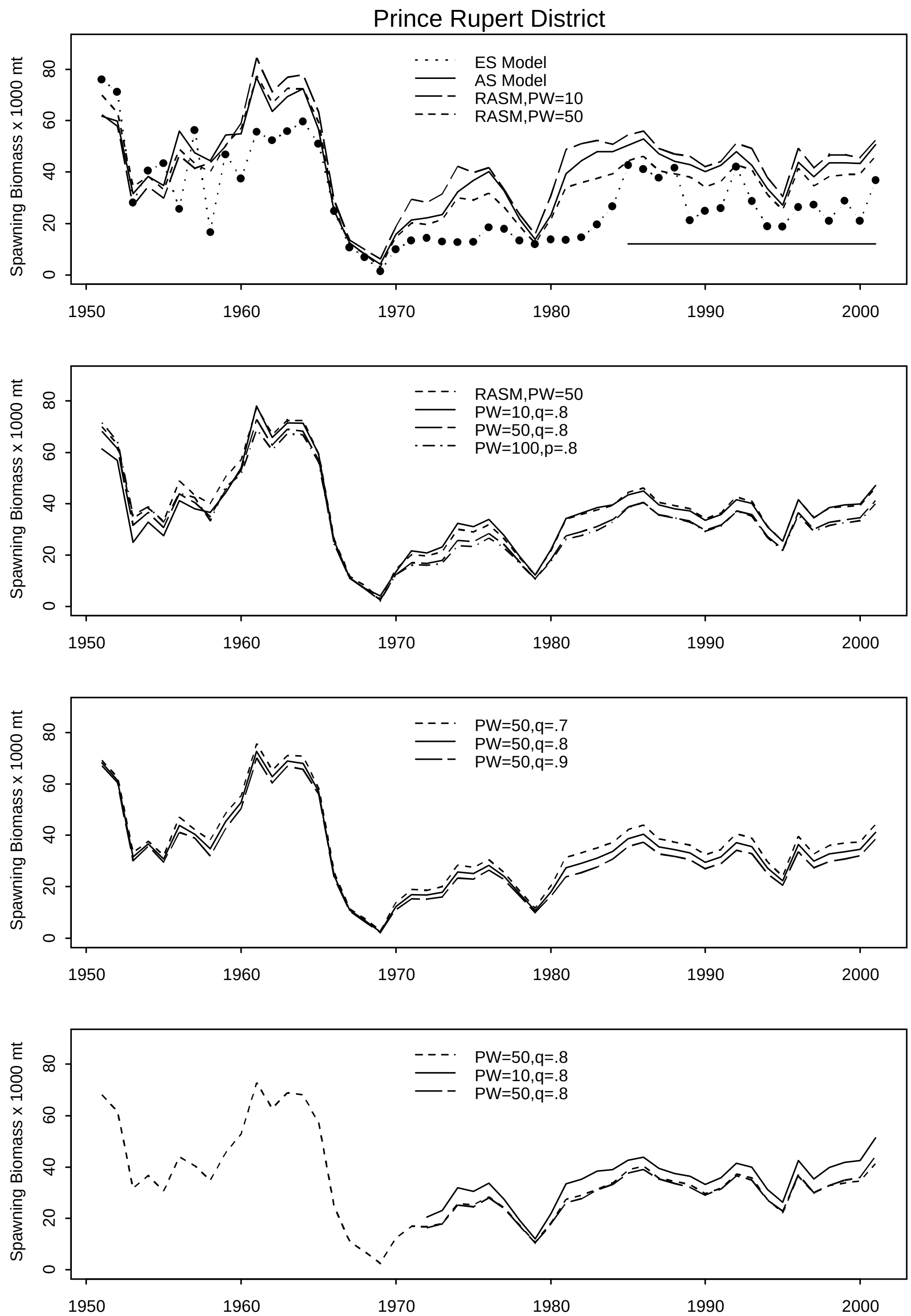


Figure 2b. Estimated spawning stock biomass for the Prince Rupert District from age-structured analyses for 1951-2001.

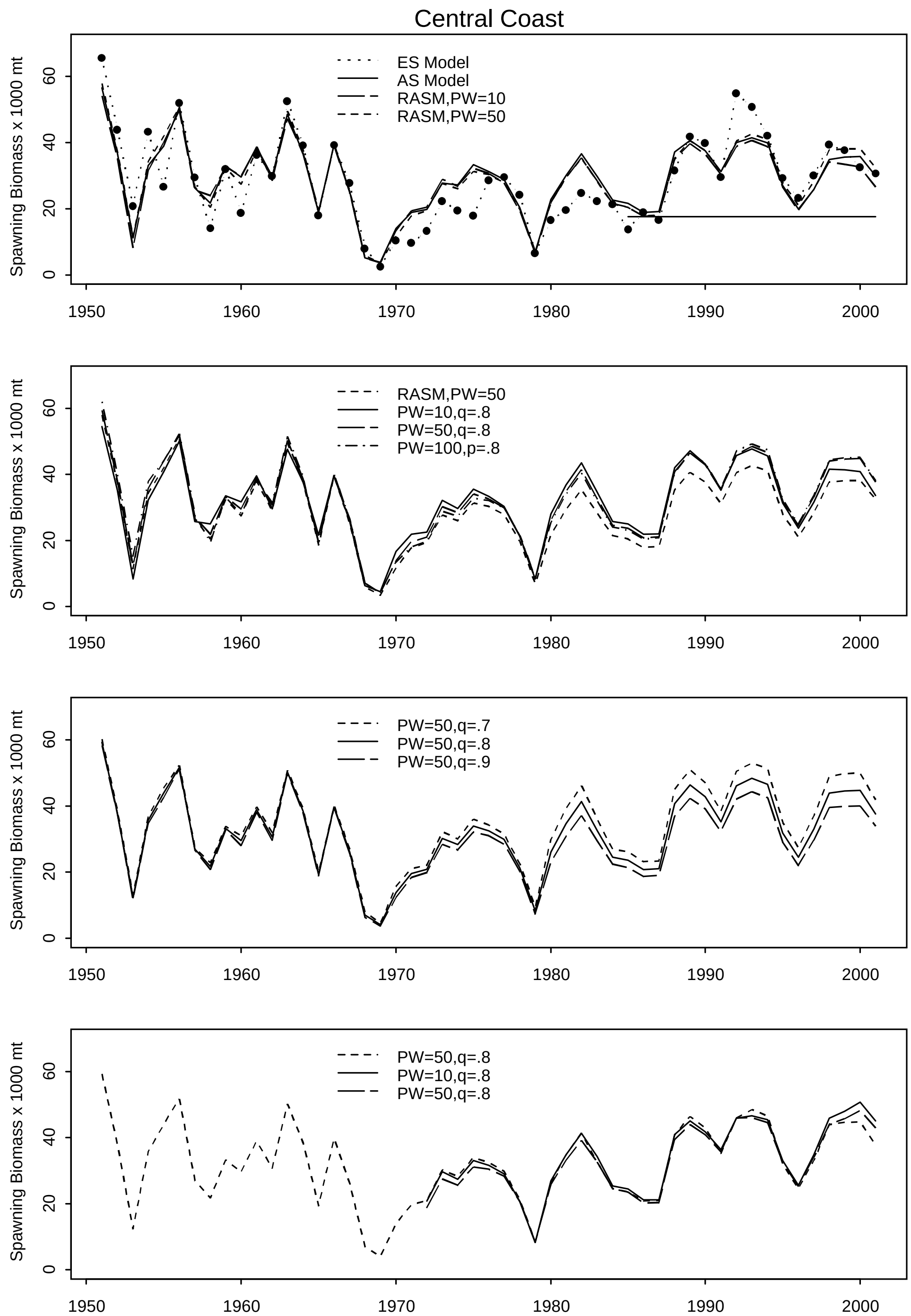


Figure 2c. Estimated spawning stock biomass for the Central Coast from age-structured analyses for 1951-2001.

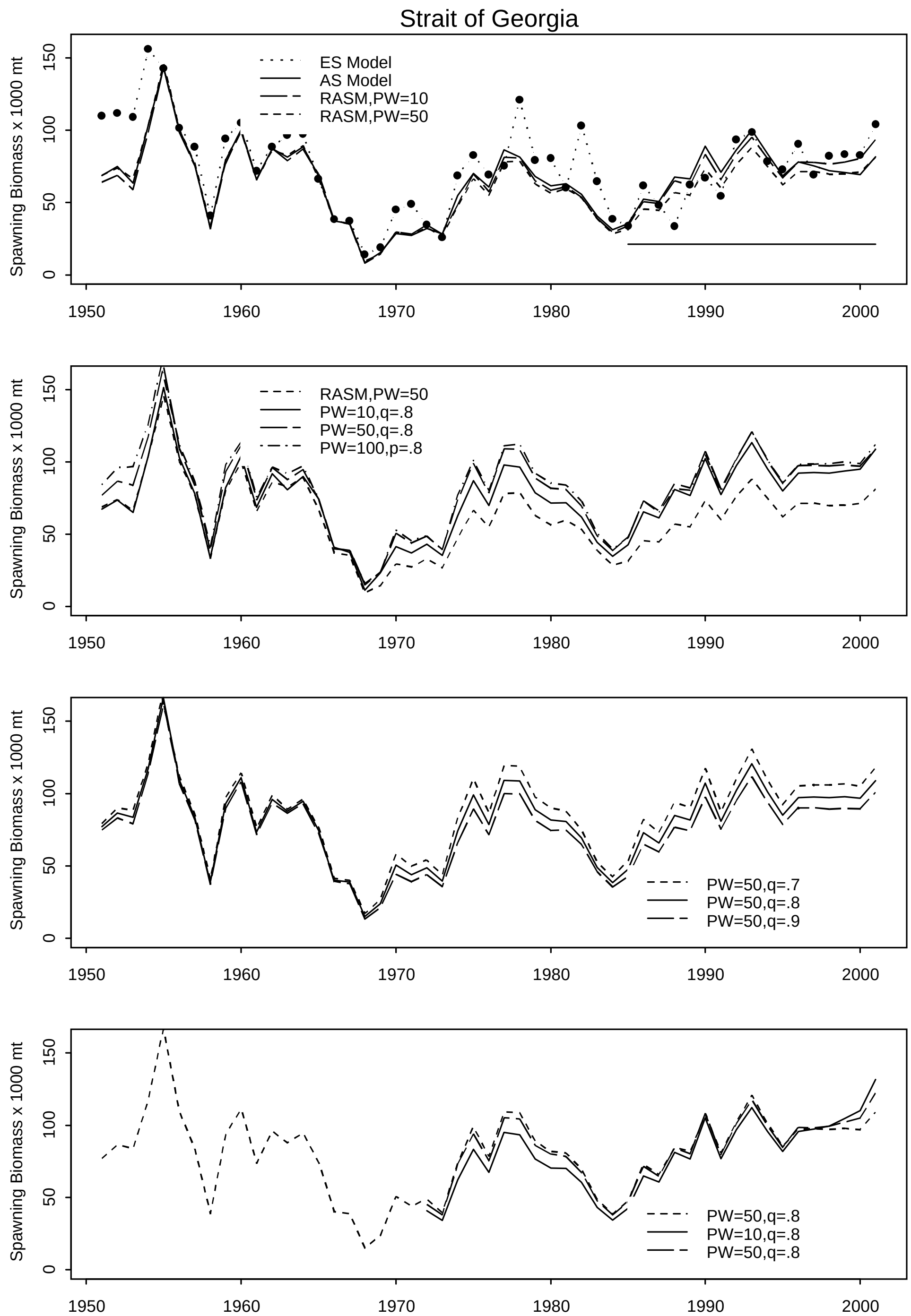


Figure 2d. Estimated spawning stock biomass for the Strait of Georgia from age-structured analyses for 1951-2001.

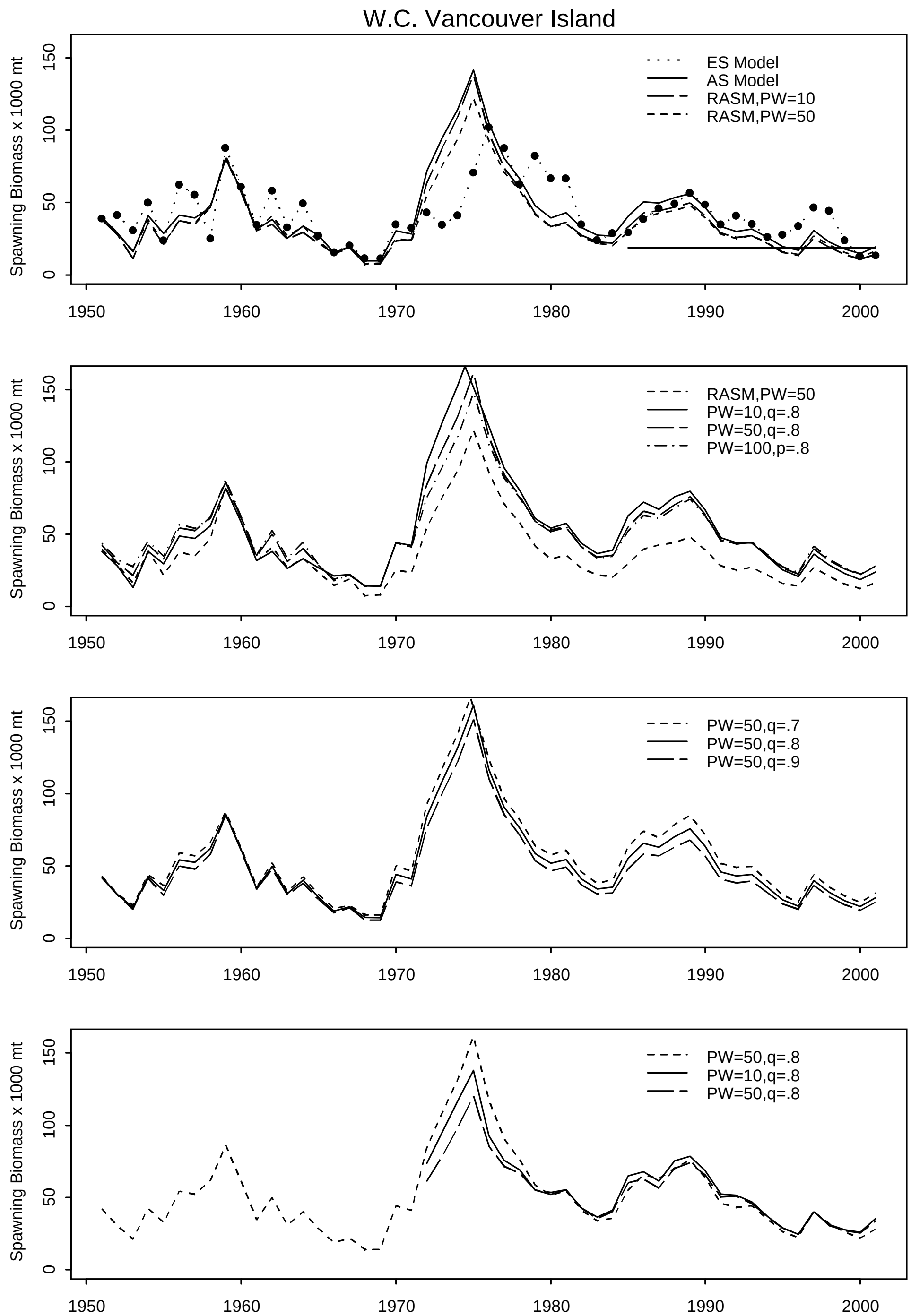


Figure 2e. Estimated spawning stock biomass for the west coast of Vancouver Island from age-structured analyses for 1951-2001.

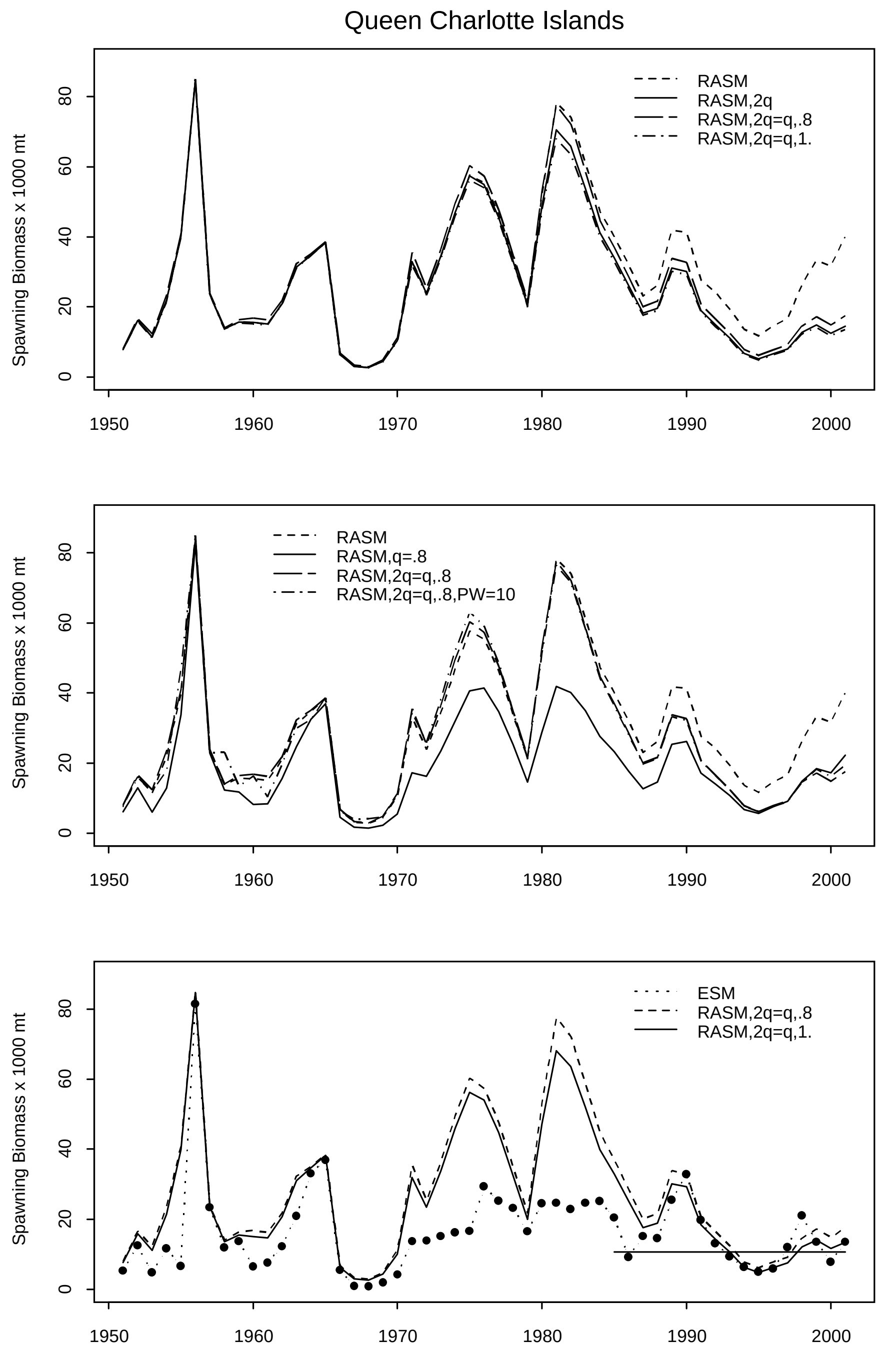


Figure 3a. Spawning stock biomass estimates for the Queen Charlotte Islands and differing values for the spawn conversion coefficient from 1951-2001.

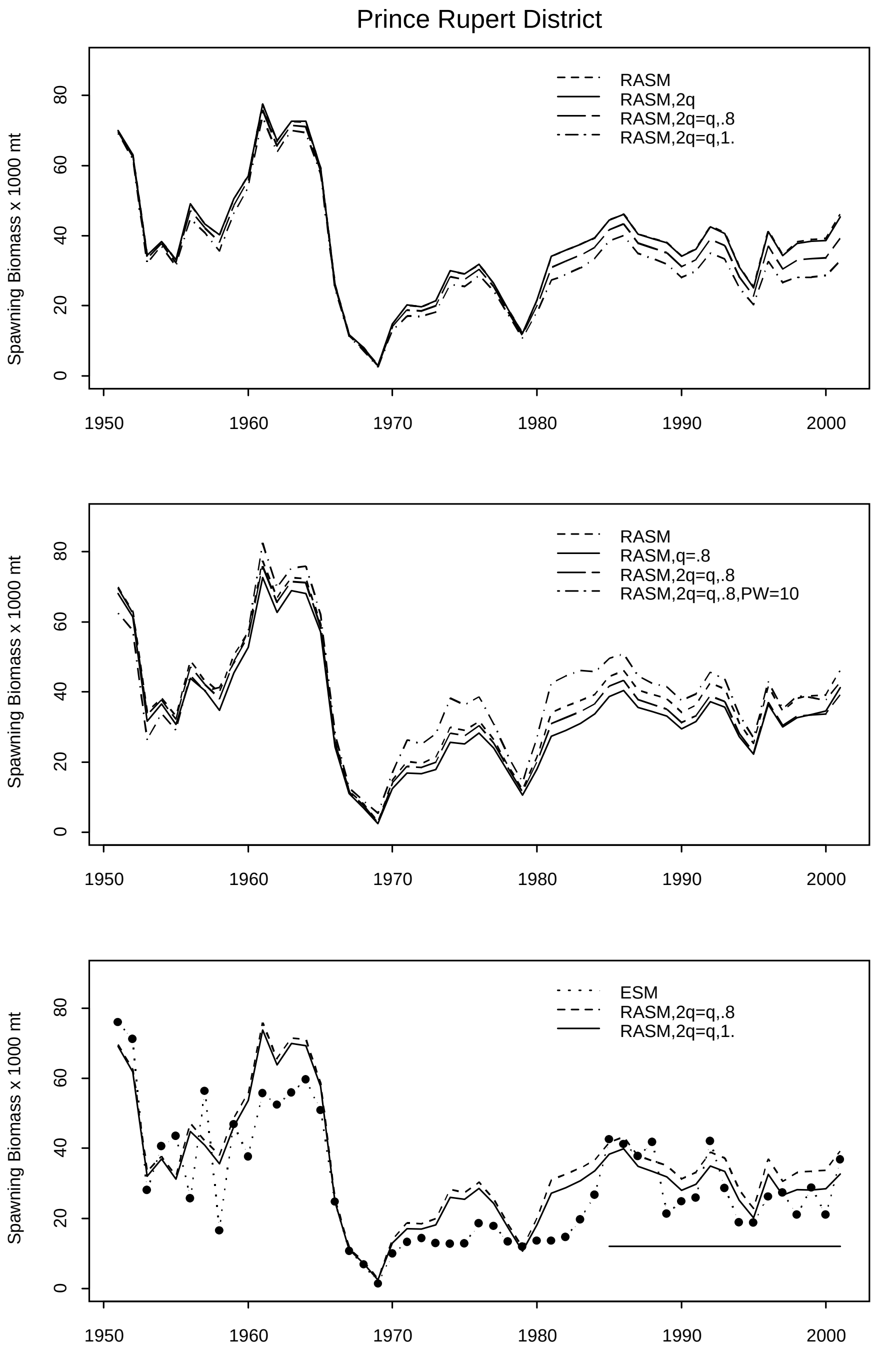


Figure 3b. Spawning stock biomass estimates for the Prince Rupert District and differing values for the spawn conversion coefficient from 1951-2001.

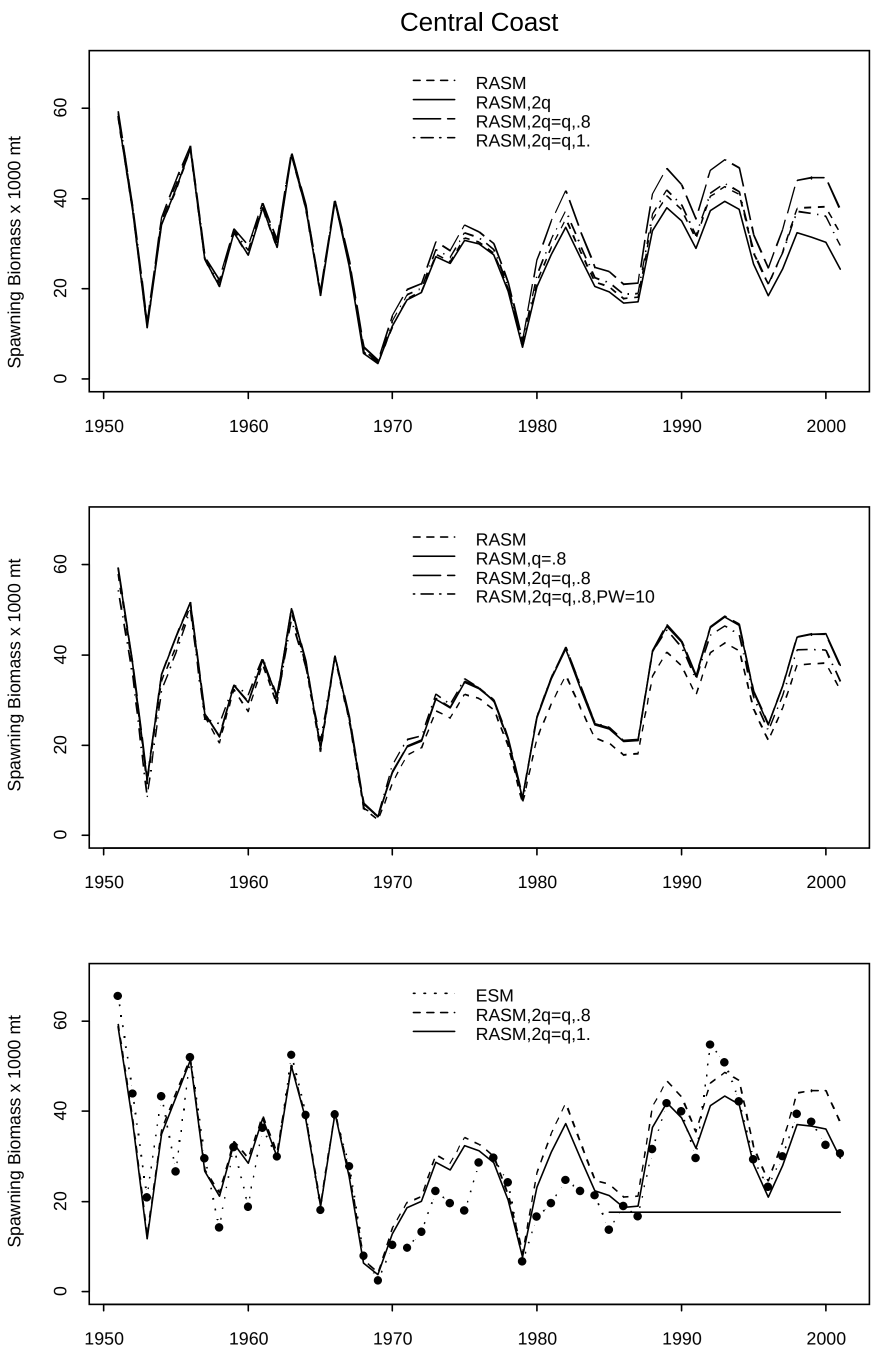


Figure 3c. Spawning stock biomass estimates for the Central Coast and differing values for the spawn conversion coefficient from 1951-2001.

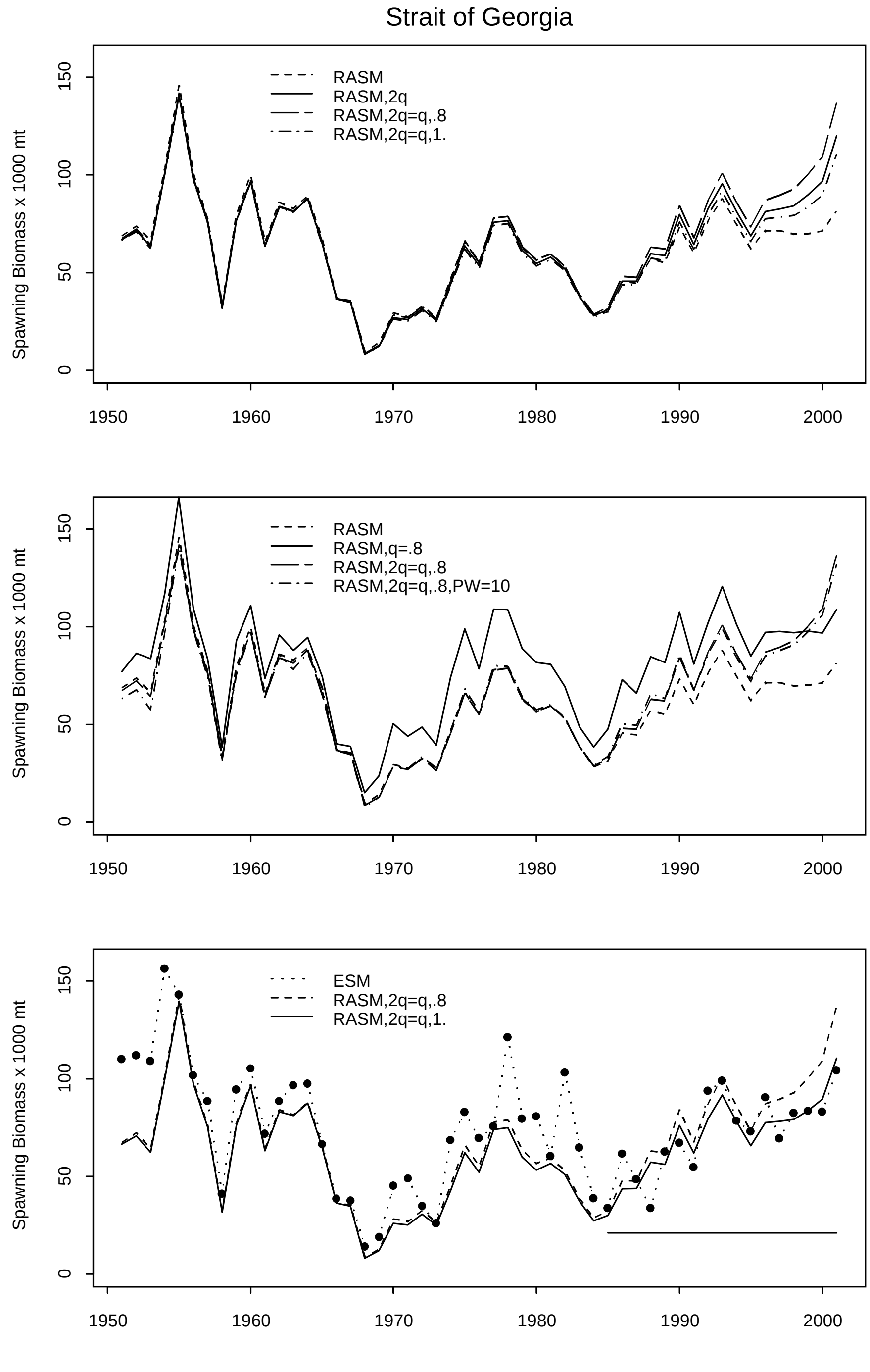


Figure 3d. Spawning stock biomass estimates for the Strait of Georgia and differing values for the spawn conversion coefficient from 1951-2001.

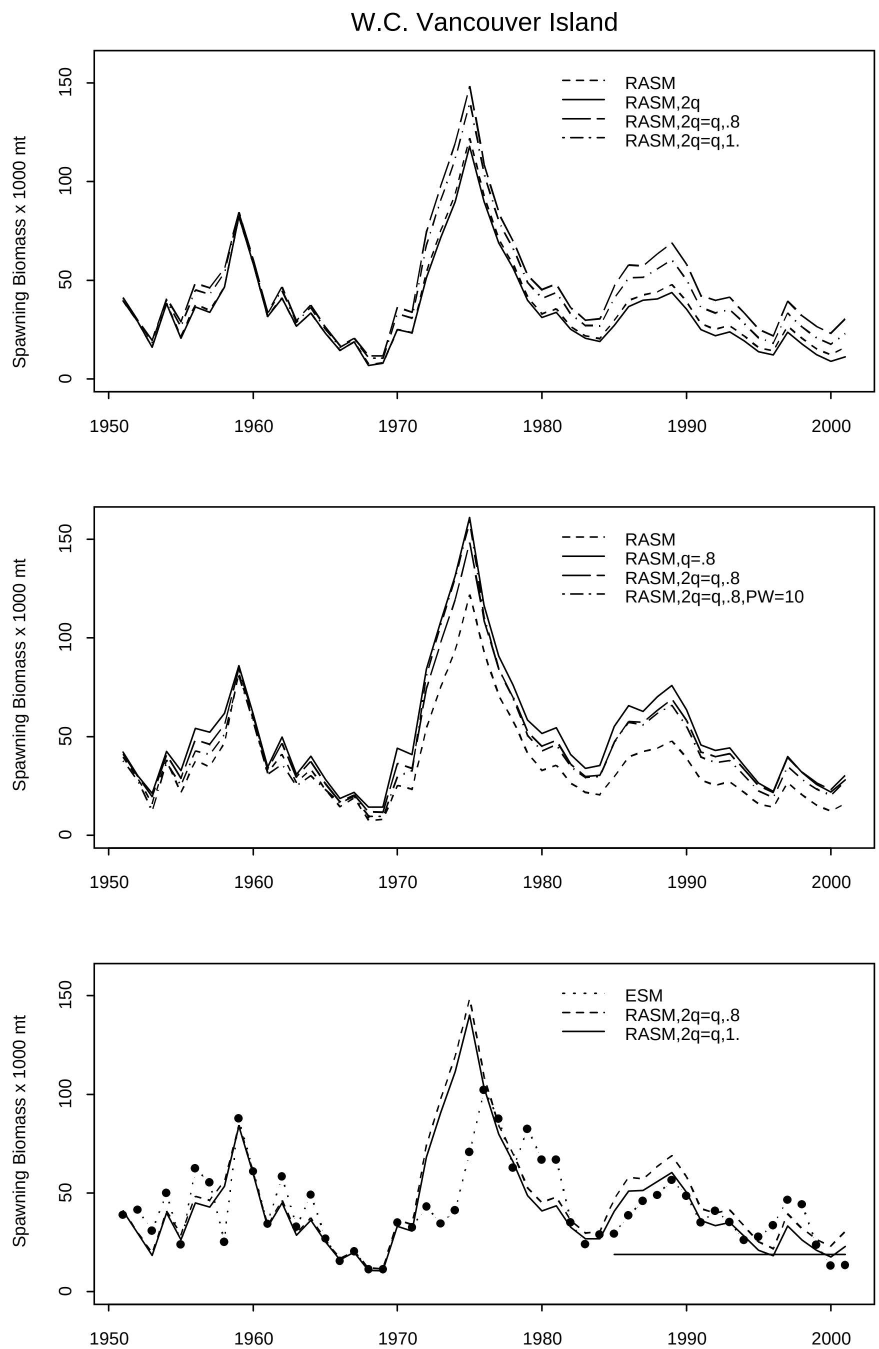


Figure 3e. Spawning stock biomass estimates for the west coast of Vancouver Island and differing values for the spawn conversion coefficient from 1951-2001.

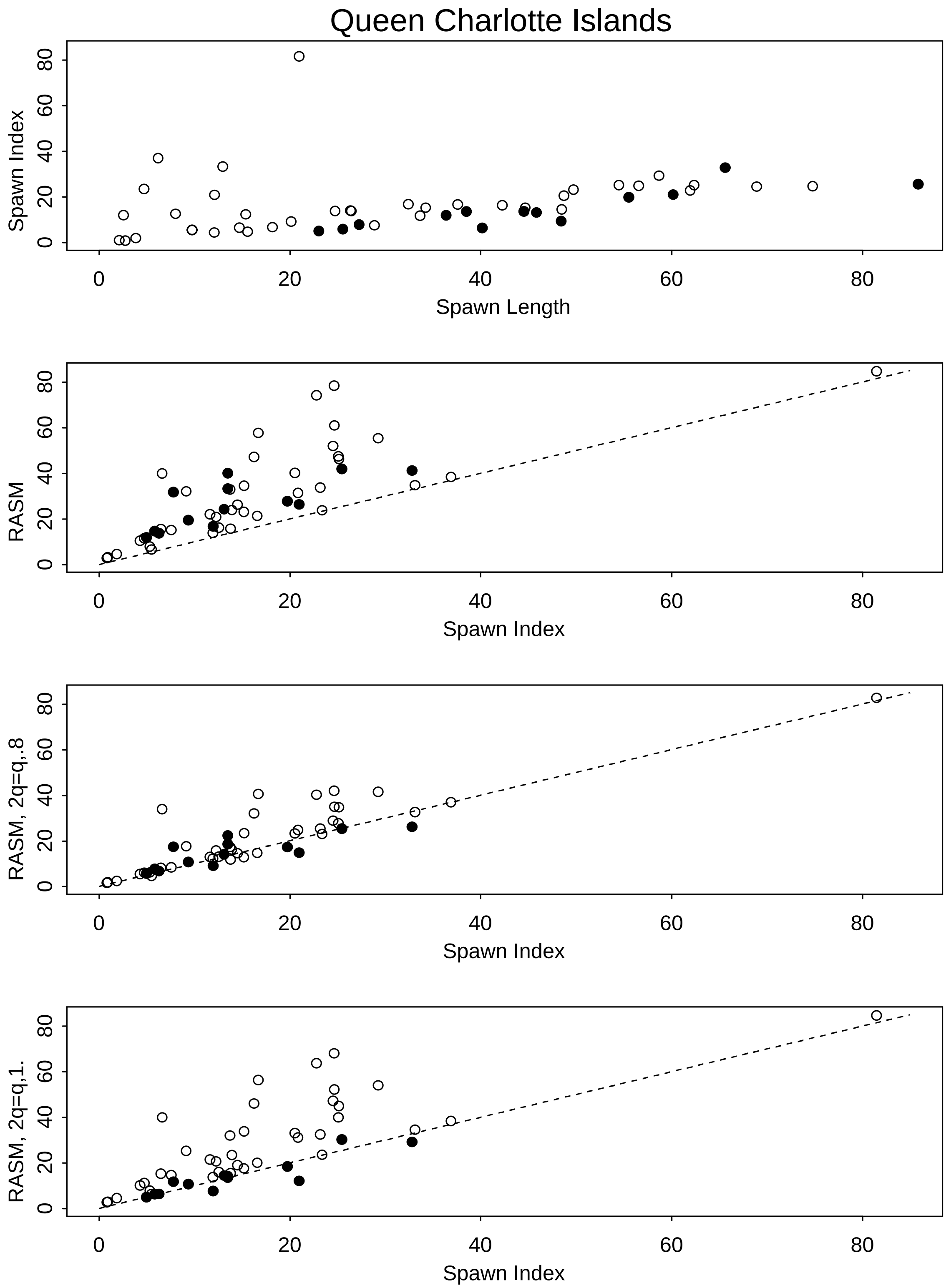


Figure 4a. Relationship between spawn length and the spawn index, and the spawn index and various estimates of stock abundance for the Queen Charlotte Islands from 1951-2001. Open circles represent surface survey data and closed circles dive survey data.

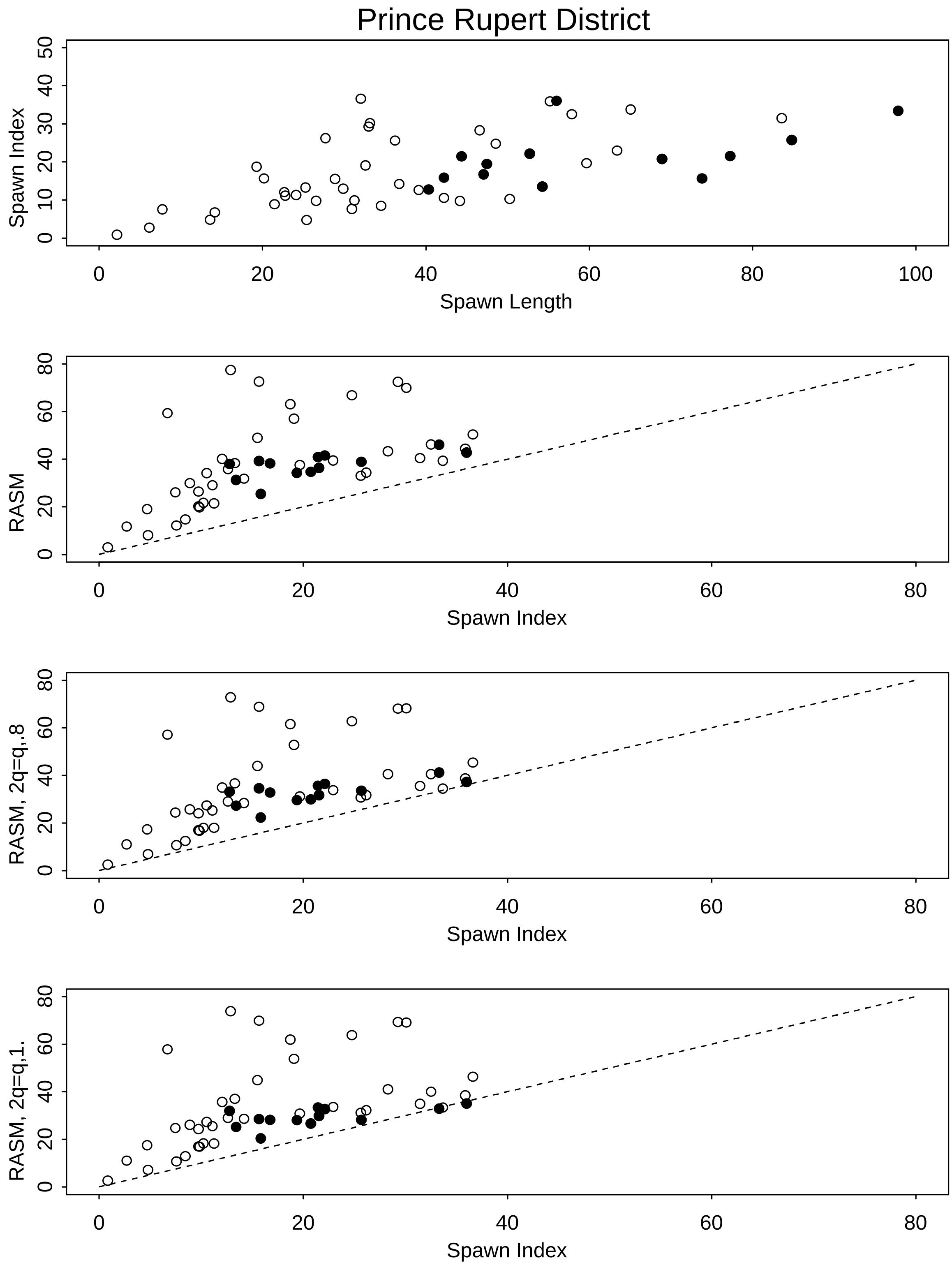


Figure 4b. Relationship between spawn length and the spawn index, and the spawn index and various estimates of stock abundance for the Prince Rupert District from 1951-2001. Open circles represent surface survey data and closed circles dive survey data.

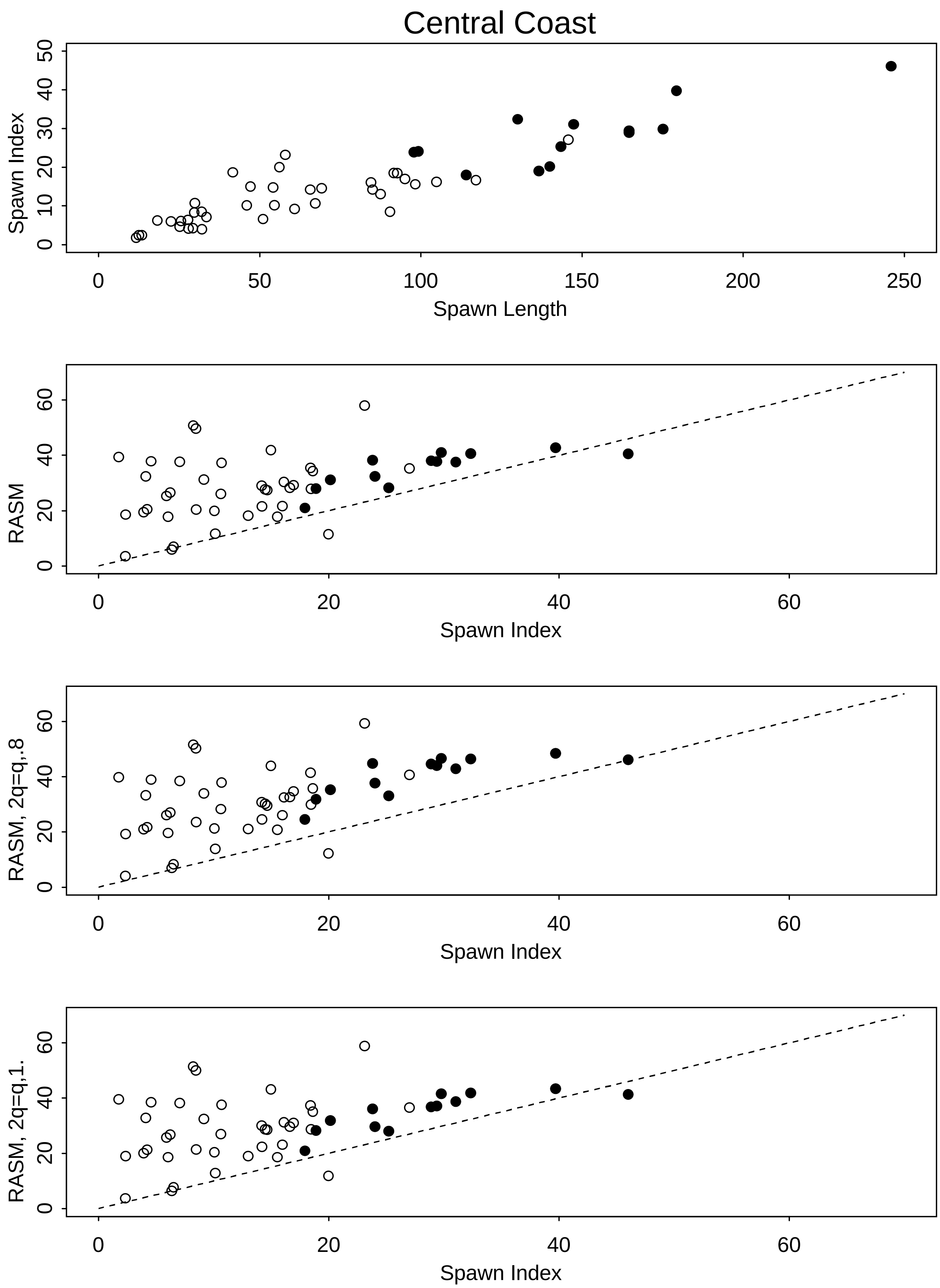


Figure 4c. Relationship between spawn length and the spawn index, and the spawn index and various estimates of stock abundance for the Central Coast from 1951-2001. Open circles represent surface survey data and closed circles dive survey data.

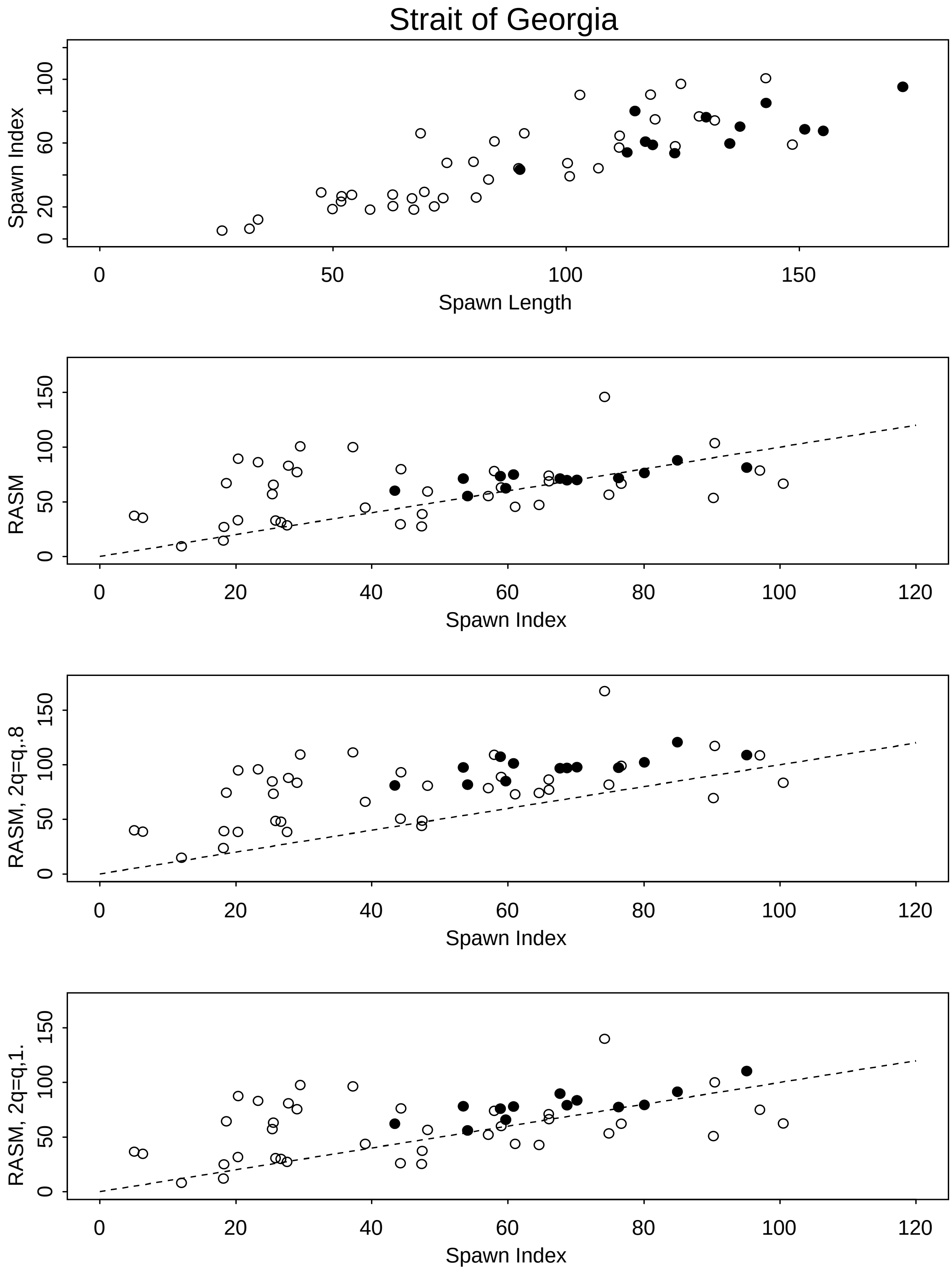


Figure 4d. Relationship between spawn length and the spawn index, and the spawn index and various estimates of stock abundance for the Strait of Georgia from 1951-2001. Open circles represent surface survey data and closed circles dive survey data.

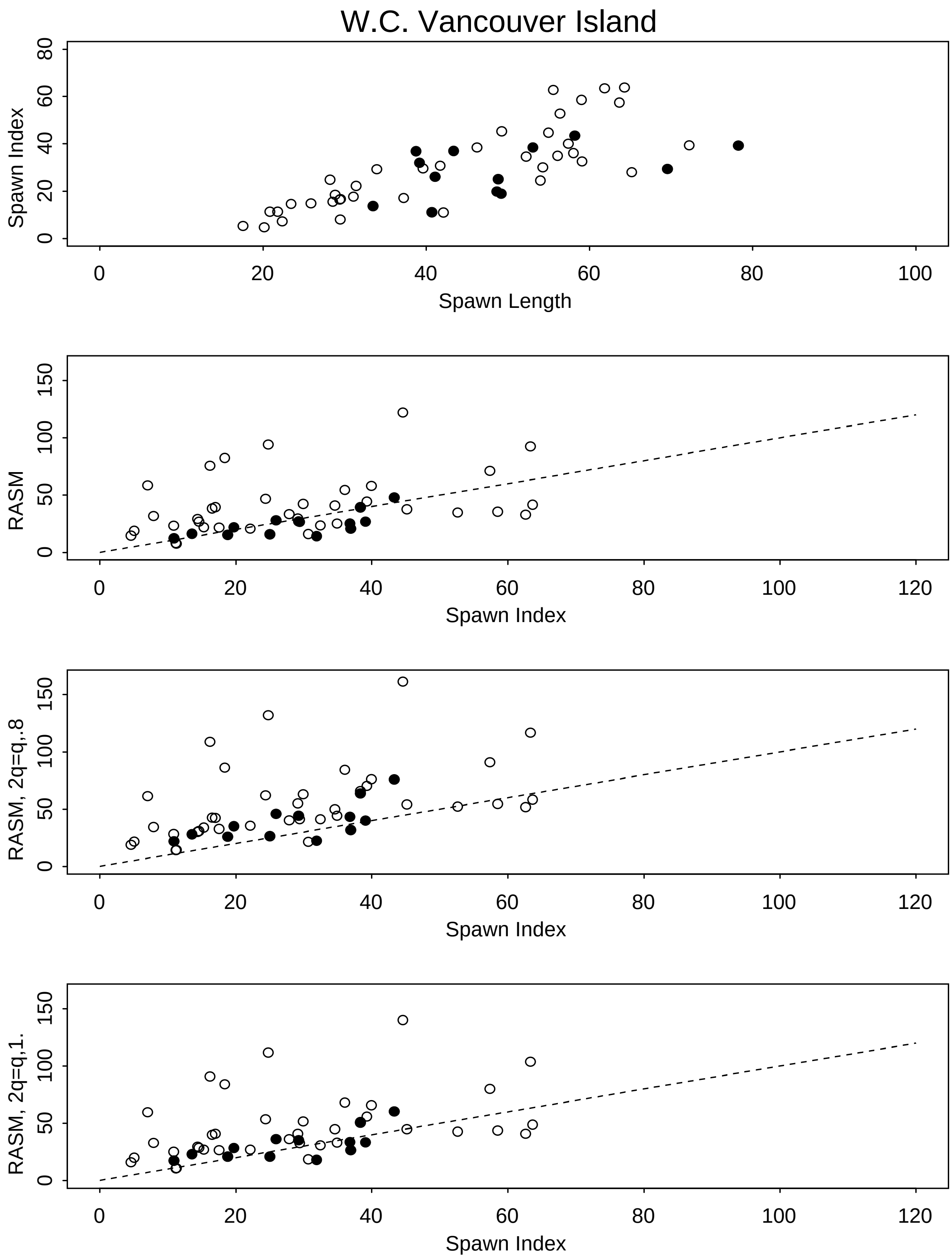


Figure 4e. Relationship between spawn length and the spawn index, and the spawn index and various estimates of stock abundance for the west coast of Vancouver Island from 1951-2001. Open circles represent surface survey data and closed circles dive survey data.

4. STOCK TRENDS AND ABUNDANCE FORECASTS

4.1 STOCK TRENDS

Estimates of pre-fishery stock biomass over the period 1951 to 2001 from the revised age-structured model (RASM, no sample size weighting and spawn penalty weight = 50), escapement (ESM) model, and for the revised age-structured model with two q parameters (RASM-2q=q,1.) are shown in Figures 5.1 and 5.2 for the five major coastal regions and for Area 27.

For the Queen Charlotte Islands region the models indicate similar trends in stock biomass. However, the age-structured models suggests much higher peaks in abundance in the mid 1970s and the early 1980s resulting from good recruitment of the 1971-73 and 1977 year-classes (Fig. 5.1, 6.1). All models suggest a decrease in abundance from 1990 through 1995 with increasing abundance subsequently. The ESM and RASM-2q models suggest a decline or levelling in 1998 whereas the RASM indicates a significant increase in abundance. The 1995 year-class is above average, the 1996 is poor and 1997 and 1998 year-classes have been average (Figure 6.1). The recruiting 1998 year-class accounted for 33% of the run and the pre-recruit 1999 year-class contributed 12% of the total and appears average. The estimates of 2001 mature biomass are 39,900, 13,500, and 14,500 tonnes from RASM, RASM-2q, and ESM analyses, respectively.

Estimates of 2001 stock abundance for the Prince Rupert District assessment region are more consistent for the three models than in recent assessments (Fig. 5.1). All models indicate a decline in abundance from 1992 through 1995 with variable but increasing abundance subsequently. The 2001 estimate of mature biomass is 46,000 tonnes from the RASM, 32,700 from the RASM-2q, and 37,300 tonnes from the ESM, respectively. The 1995 and recruiting 1998 year-classes have been good (Fig. 6.1), contributing 16 and 42% of the run, respectively. The pre-recruit 1999 year-class accounted for only 2% of the run and appears poor (Fig. 6.1)

Estimates of pre-fishery biomass for the Central Coast assessment region are virtually identical for all three models (Fig. 5.1). All models indicate a series of fluctuations in abundance with the most recent increase beginning in 1996-98 followed by slight declines since then. Recruitment of strong 1994 and 1995 year-classes have supported elevated abundance levels (Fig. 6.1) but poor-average 1996-98 year-classes have resulted in the recent decline. The 2001 mature biomass estimate from the RASM is 32,300, from the RASM-2q is 29,600 and from the ESM is 30,600. The 1995 and 1997 year-classes accounted for 26 and 28% of the run while the recruiting 1998 and pre-recruit 1999 year-classes contributed only 8 and 2% of the total and appear to be poor.

For the Strait of Georgia assessment region the pre-fishery stock trends estimated by all three models are similar although the RASM suggests lower levels in recent years than the other two models (Fig. 5.2). All models indicate a long-term trend of increasing abundance since 1985. The RASM estimate of pre-fishery abundance in 2001 is 81,300 tonnes, the RASM-2q is 110,400, and the ESM estimate is 82,900 tonnes. The 1992 year-class was poor but all subsequent year-classes have been average or good (Fig. 6.2). Both the 1997 and recruiting 1998 year-classes were good accounting for 28 and 44% of the run. The pre-recruit 1999 year-class appears to be average and contributed 7% to the total.

The pre-fishery biomass estimates for the west coast of Vancouver Island stock follow similar trends since the mid 1970s (Fig. 5.2). All models indicate a long-term decline in abundance since 1989 with a recent recovery through 1997 followed by declines the past four years. The ESM estimate of 2001 mature biomass is 14,000 tonnes while the RASM estimate is 16,200 tonnes and the RASM-2q estimate is 23,000 tonnes. The last good year-class occurred in 1994 and still contributed 10% to the 2001 run (Fig. 6.2) while the 1995-1997 year-classes were poor. The recruiting 1998 year-class accounts for 46% of the 2001 spawning run and appears to be average as is the pre-recruit 1999 year-class that contributed 7% to the total

The mature biomass estimate for Area 27 stocks was available only from the ESM and indicated that only 451 tonnes returned to this area during 2001. However, it is known that spawning in Klaskish Inlet was not surveyed. Although abundance estimates are erratic it appears that abundance has declined since 1993 (Fig. 5.2).

In 2001 limited surveys of spawn deposition occurred in Area 2W. A small spawn in Port Louis accounted for 30 tonnes of stock. Biological samples indicated a predominance of fish from the 1996 and 1997 year-classes, 24 and 41%, respectively.

Retrospective Analysis

Schweigert (1996) first 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. No explanation for this conflicting trend was apparent but it appeared to be related to the inverse relationship between the estimated natural mortality and the spawn index conversion parameters. The retrospective plots presented in the current assessment (Figures 7.1 and 7.2), are based on the RASM with 2 q's where the q for the dive survey era is fixed at a value of 1.0 and the q for the surface era is estimated. The lines plotted in Figure 7 show the results of fitting the available data for each stock for each of the last ten years beginning in 1991. Then successive additional years of data are added to the dataset and the analysis is rerun for each year. The current year result is shown by the dashed line. A consistent result over the entire ten year period would indicate an adequate model that consistently interprets the available time series of data despite the addition of another year of data. Results from this analysis indicate a consistent retrospective pattern for all areas with very little over and under forecasting evident in recent years. In all areas there is a slight tendency to over forecast abundance in recent years.

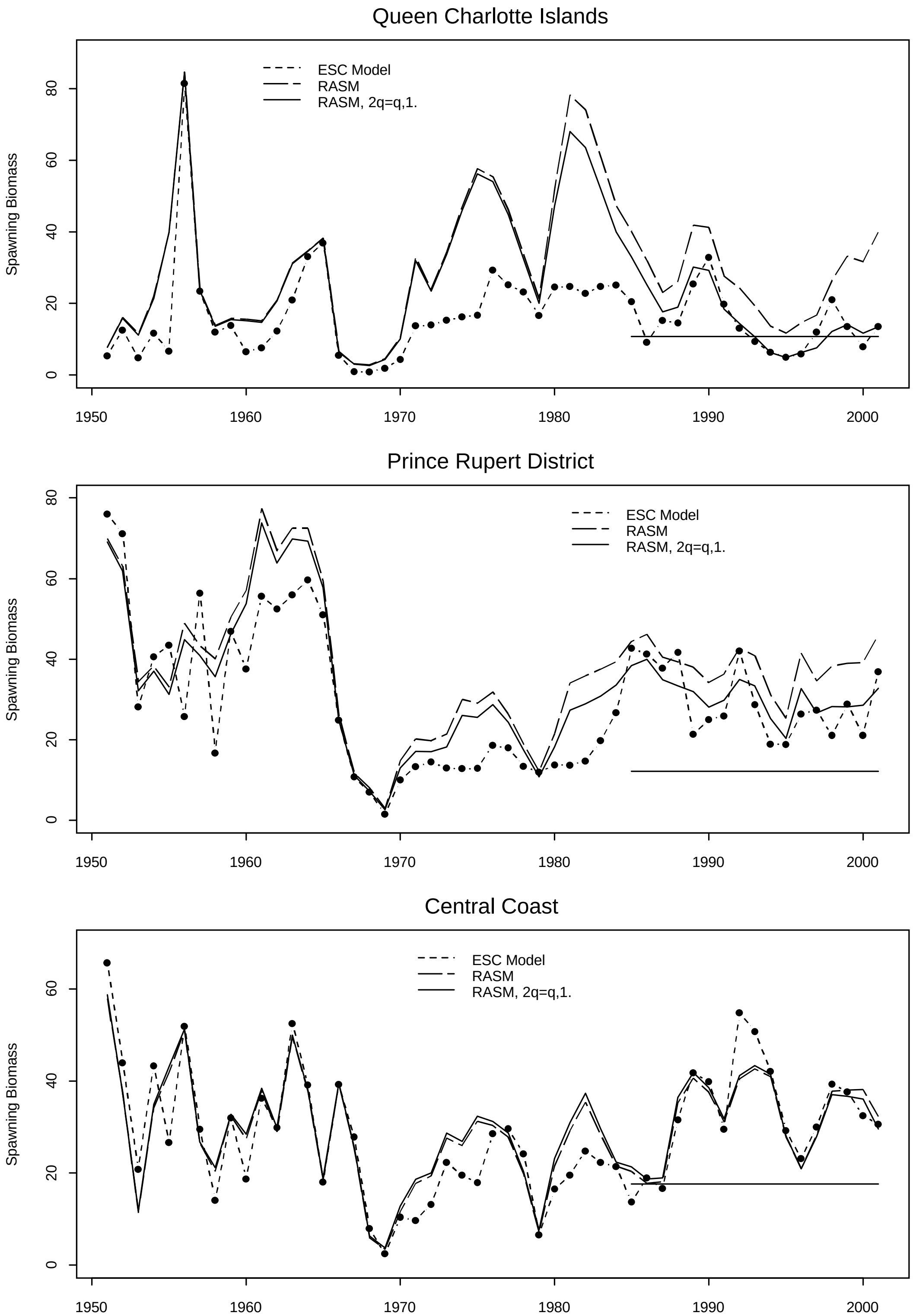


Figure 5.1. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured (RASM and RASM-2q) and escapement model (ESM) analyses for northern B.C. herring stock assessment regions, 1951-2001. Horizontal line indicates the Cutoff level.

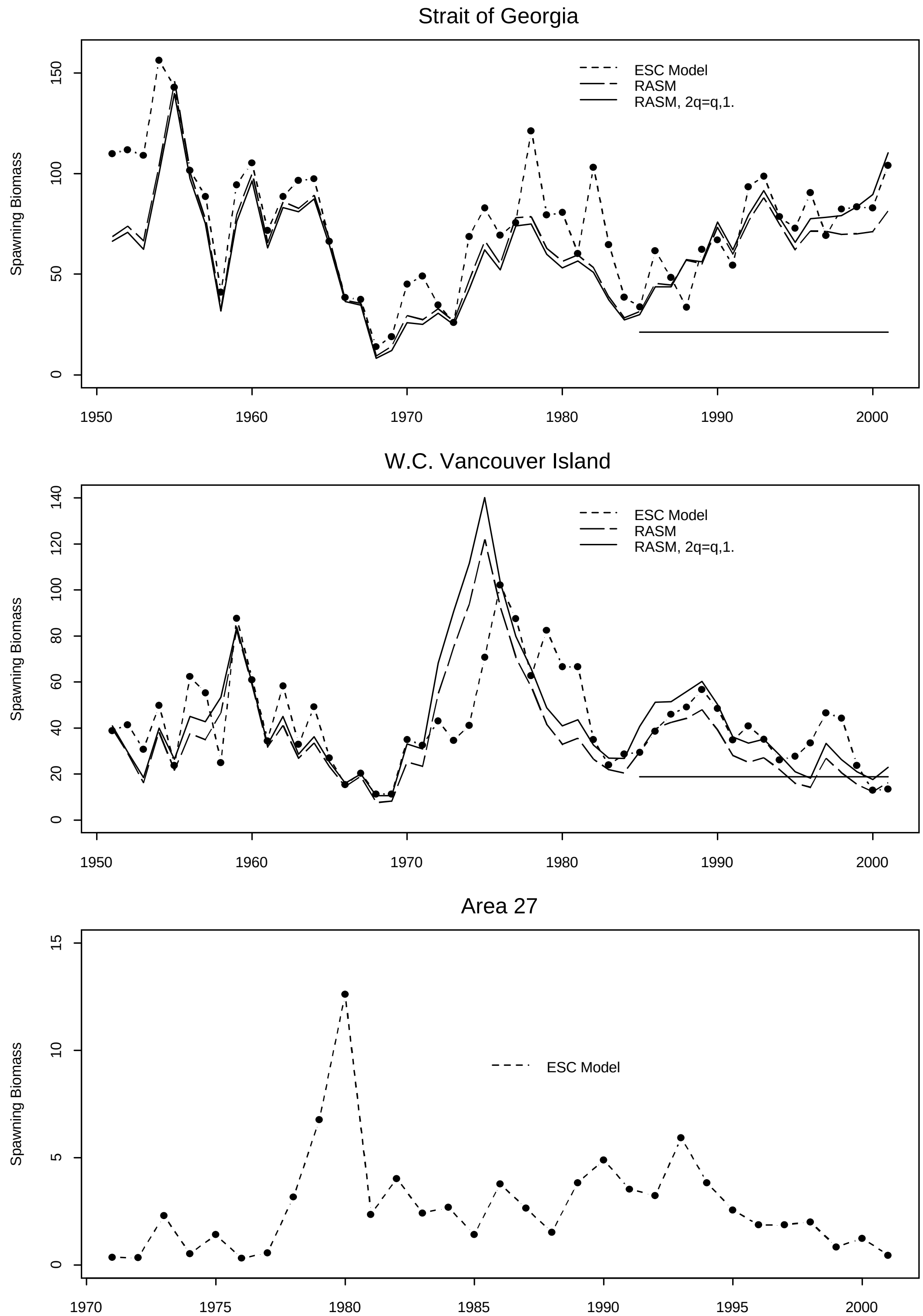


Fig. 5.2. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured (RASM and RASM-2q) and escapement model (ESM) analyses for southern B.C. herring stock assessment regions and Area 27, 1951-2000. Horizontal line indicates the Cutoff level.

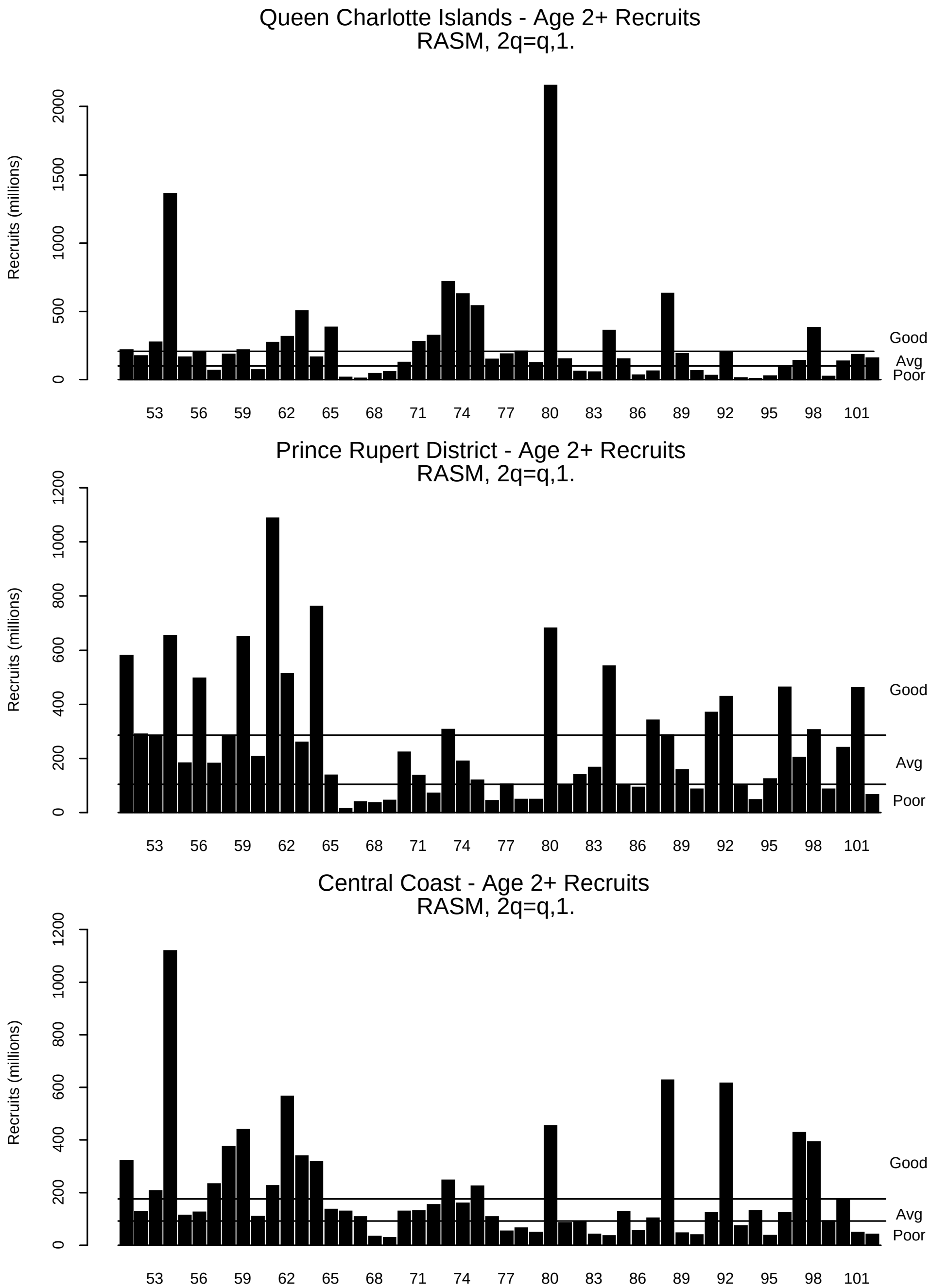


Figure 6.1. Estimates of abundance of recruiting age 2^+ year-classes from age-structured analysis for northern B.C. herring stock assessment regions, 1951-2001. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution. The 2002 data point represents the ASM recruitment forecast for the coming season.

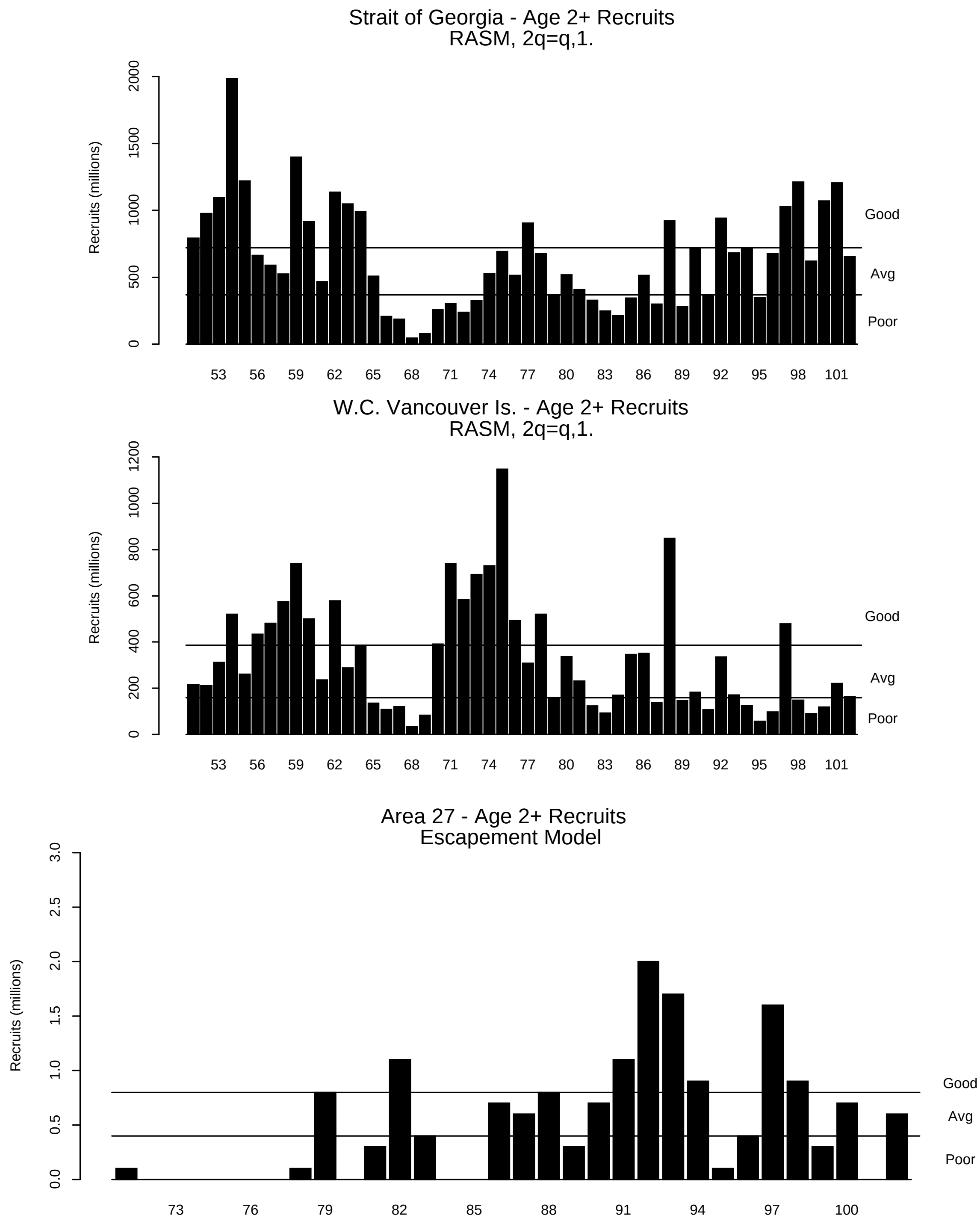


Figure 6.2. Estimates of abundance of recruiting age 2^+ year-classes from age-structured analysis for southern B.C. herring stock assessment regions, 1951-2001 and for the minor stock in area 27 for 1972-2001. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution. The 2002 data point represents the ASM recruitment forecast for the coming season.

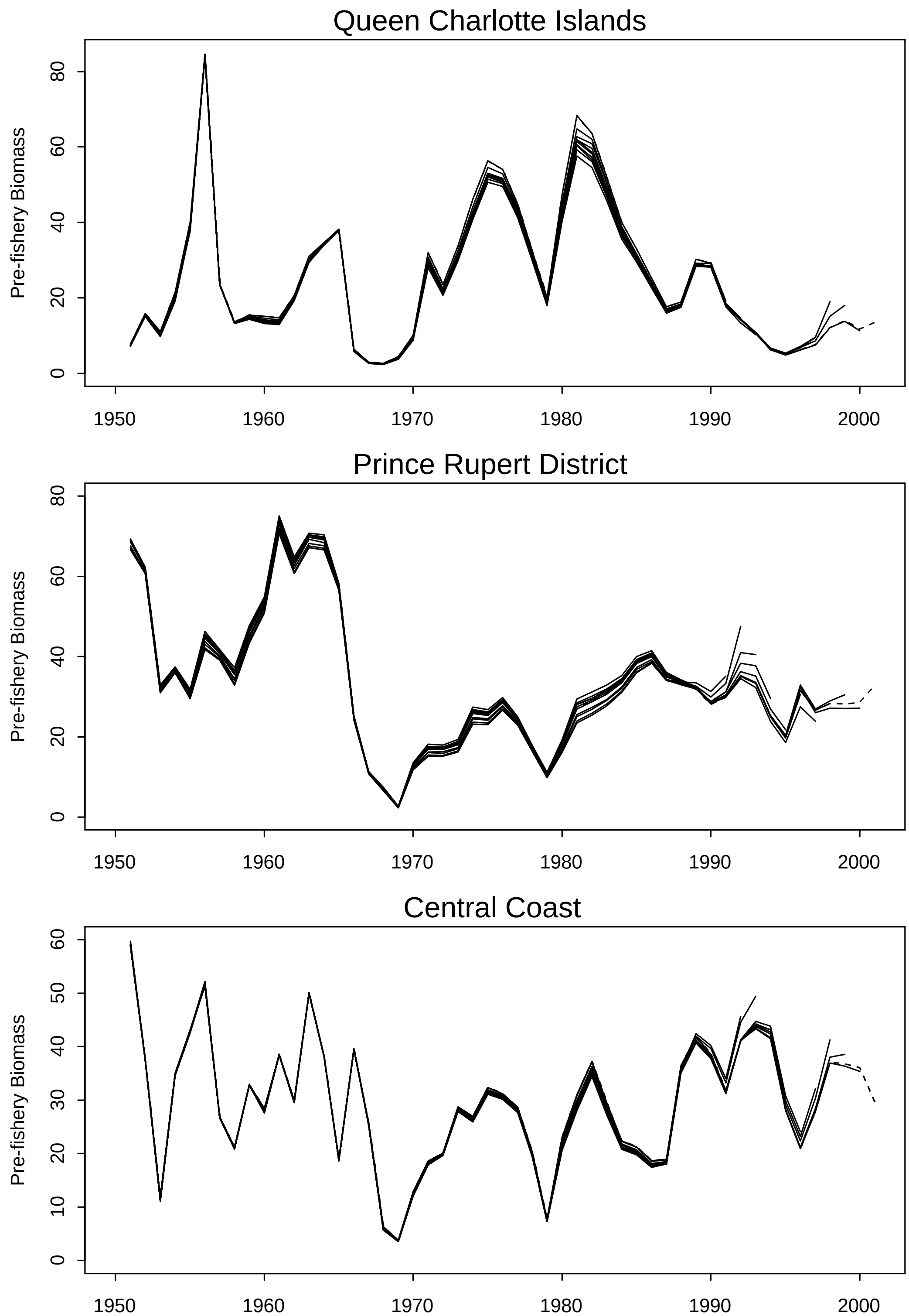


Figure 7.1. Retrospective analysis of estimated spawning biomass from RASM-2q assessment for northern B.C. herring stocks from 1951-2001. Dashed line indicates the most recent assessment.

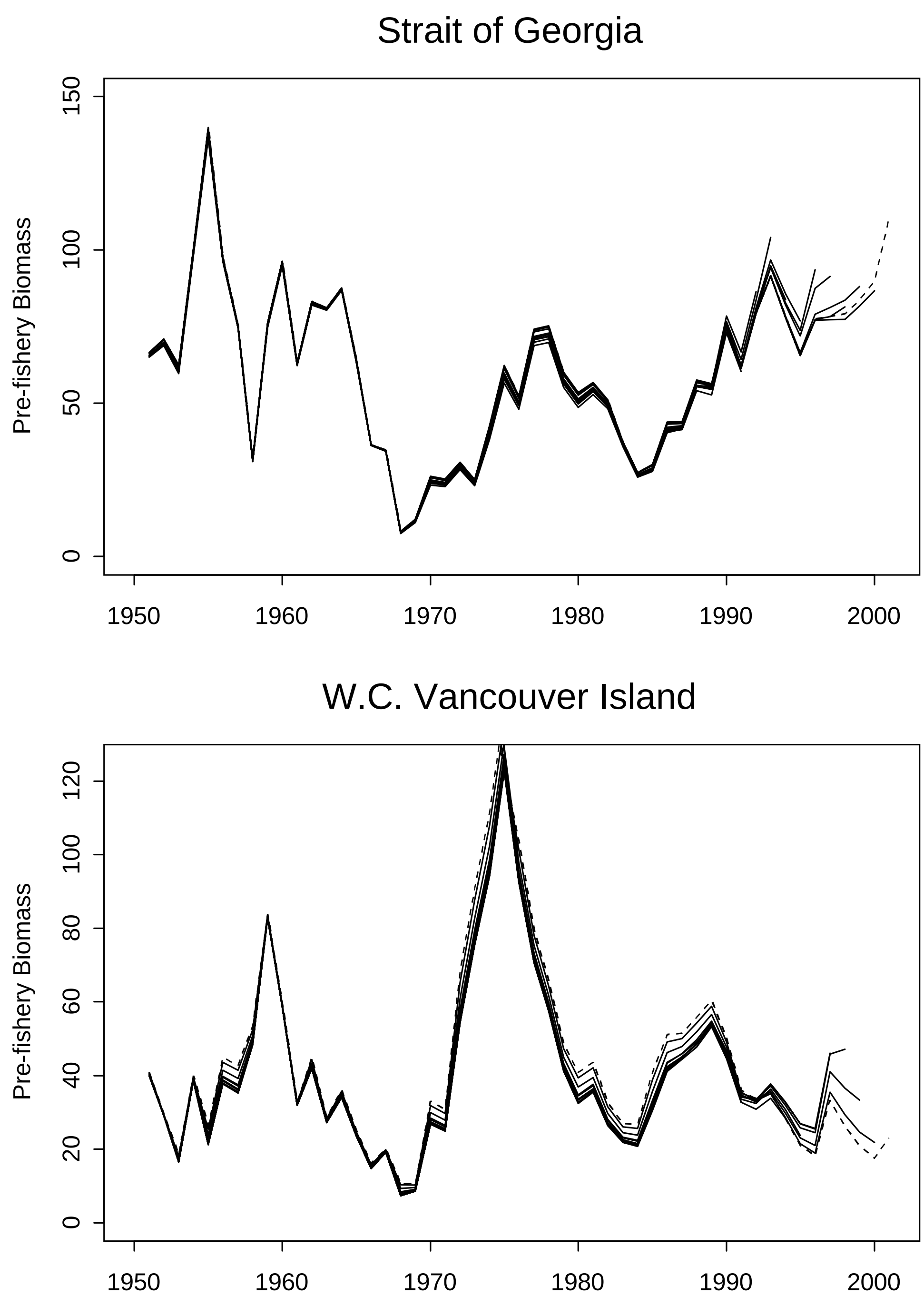


Figure 7.2. Retrospective analysis of estimated spawning biomass from RASM-2q assessment for southern B.C. herring stocks from 1951-2001. Dashed line indicates the most recent assessment.

4.2. ABUNDANCE FORECASTS AND HARVESTABLE SURPLUS

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:

Catch = Forecast Run - Cutoff.

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

Cutoff levels have been established through a stock-recruitment curve or bootstrapping of the observed recruitment time series. Changes in model structure have historically resulted in a parallel change in Cutoff level. To minimize confusion, 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 ongoing basis. As a result, the Subcommittee fixed Cutoff at 1994/95 levels until the analyses of individual stock productivity could be completed. These Cutoff levels for the five major stocks are:

	1992/93 Cutoff[a]	1994/95 Cutoff	1996/97 Cutoff	**2001/02 Cutoff[c]**
Queen Charlotte Islands	11700	10700	10700	**10700**
Prince Rupert District[b]	12100	12100	12100	**12100**
Central Coast	10600	18800	17600	**17600**
Strait of Georgia	22100	21200	21200	**21200**
W.C. Vancouver Island	20300	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 in 1998. Uncertainty about ASM performance in 1998 resulted in retention of the existing Cutoff.

Abundance Forecasts and Harvestable Surplus

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. Forecasts from both escapement and age-structured models are based on projections of returning adults and the addition of new recruits. Point forecasts for poor, average, and good recruitment are provided in Table 4.1. In addition, Figures 8.1 and 8.2 present the cumulative probability distributions of forecast abundance for the three assessment models. 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. Thus the combination of the forecast adult returning biomass and the historical recruitment time series provides a probability distribution of forecast run size. The historical time series of recruitment for the RASM-2q is presented in Figures 6.1 and 6.2.

Profile Likelihoods

The herring age-structured model is programmed with AD Model builder software which provides a feature to estimate variation in any model parameters using Bayesian methods. One application of this procedure is to evaluate the posterior distribution of the forecast stock biomass from the age-structured models. The profile likelihood provides an estimate of the relative probability of various biomass forecasts for the age-structured model based on the current set of model parameter values. It is the standardized marginal of the likelihood function. The estimated probability distributions of forecast 2002 biomass for the five assessment regions are presented in Figures 9.1 and 9.2.

Queen Charlotte Islands

The forecast run sizes to the Queen Charlotte Islands in 2002 are 36,900 tonnes from the RASM, 14,000 tonnes from the RASM-2q, and 20,200 tonnes from the ESM assuming average recruitment (Table 4.1). This represents a moderate increase from the 2001 forecasts which were below Cutoff. Age-structured model projections project an average recruitment in 2002. The cumulative probability plots indicate a high probability that the forecast biomass will be less than 20,000 tonnes (Figure 8.1). The RASM forecast and profile likelihood appear to be unrealistically high. The RASM-2q profile likelihood indicates 95% a confidence interval of 11-18,000 tonnes for 2002. Assuming the average projected recruitment would provide for a harvestable surplus of about 2,800 tonnes (Table 4.1).

Prince Rupert District

The RASM and RASM-2q models provide quite different forecasts of abundance in 2002. The RASM, RASM-2q, and ESM forecasts are for 47,000, 34,100, and 47,200 tonnes, respectively (Table 4.1). The cumulative probability plots indicate abundance levels well above the Cutoff with a high probability that abundance could approach 40,000 tonnes (Fig. 8.1). ESM and RASM forecasts are well above those for the RASM-2q model. The likelihood profiles for both the RASM and RASM-2q project poor recruitment for 2002 (Fig. 9.1, 6.1) with 95% confidence intervals of 38,900-49,800 and 27,600-35,600 tonnes (Fig. 9.1). Based on a poor recruitment projection in 2002, the RASM-2q forecast is for 31,300 tonnes and a harvestable surplus of 6,250 tonnes (Table 4.1).

Central Coast

The forecast run size for the Central coast in 2002 with average recruitment is variable ranging from 25,400 tonnes for the RASM-2q, to 28,000 tonnes for the RASM, to 31,000 tonnes for the ESM (Table 4.1). Overall, indications from the cumulative probability plots are that abundance will exceed 20,000 tonnes in 2002 (Fig. 8.1). However, indications are that recruitment in 2002 could again be poor (Fig. 6.1, 9.1). The profile likelihood for the RASM and RASM-2q models indicate 95% confidence intervals of 21,500-29,600 tonnes and 19,300-25,900 tonnes, respectively. Indications from both age-structured models suggest that abundance will be less than projected by the ESM (Fig. 8.1,9.1). The 2002 forecast assuming poor recruitment for the RASM-2q model is 22,890 tonnes providing a harvestable surplus of 4,580 tonnes.

Strait of Georgia

The Strait of Georgia remains the most productive stock on the coast and forecast run size in 2002 assuming an average recruitment ranges from 73,000 tonnes (RASM), to 95,500 tonnes (RASM-2q), to 106,600 tonnes (ESM) (Table 4.1). Projections for the ESM and RASM-2q models are considerably higher than for the RASM (Fig. 8.1) but all three models indicate an expected run approaching 100,000 tonnes. The projection in 2002 is for an average recruitment (Fig. 6.2, 9.2). although the RASM likelihood profile suggests that recruitment may be less than average. The projected 95% confidence intervals in 2002 are 58,100-75,900 tonnes (RASM) and 83,900-110,100 tonnes (RASM-2q). The 2002 forecast run size for the RASM-2q model is 95,500 tonnes providing a harvestable surplus of 19,100 tonnes.

West Coast Vancouver Island

Abundance in the west coast of Vancouver Island assessment region remains depressed although indications are that the stock is rebuilding. The forecast run size based on an average recruitment for the RASM, RASM-2q, and ESM would be 21,600, 27,900, and 23,700 tonnes, respectively. However, cumulative probability plots for the RASM and ESM models indicate a 30% chance that abundance could be less than Cutoff. While an average recruitment was observed in 2001, projections are that recruitment in 2002 will be poor-average (Fig. 6.2). Both likelihood profiles also suggest recruitment will be less than average (Fig. 9.2). The 95% confidence intervals from the profile likelihoods (Fig. 9.2) project abundances of 14,300-22,800 tonnes (RASM) and 20,300-30,300 tonnes (RASM-2q). The resultant forecasts with poor recruitment for the RASM and ESM are below the Cutoff (Table .1). The RASM-2q forecast of 22,400 tonnes provides for a small harvest of 3,640 tonnes. However, given the retrospective pattern for this stock and its tendency to overforecast (Fig. 5.2), it would be precautionary to accept the ESM as a minimum abundance level for 2002.

Minor Stocks

There is no forecast run size available for the minor stocks in Area 27. However, based on recent policy for this area the estimated spawning biomass of 178 tonnes permits a harvest of no more than 10% of the 2001 biomass in 2002. This suggests a maximum potential harvest of 18 tonnes for the area. However, it is recognized that spawning in Klaskish was not surveyed which makes this a minimum assessment of abundance for this stock unit.

Table 4.1. Summary of 2002 abundance forecast, Cutoff levels, and harvestable surplus given poor, average, and good age 2+ recruitment for each of the assessment regions based on the RASM, RASM-2q, and ESM. The 95% confidence interval for the profile likelihood is also presented.

		Abundance Forecast			P.L.	Cutoff	Harvestable Surplus		
Assessment Regions	Model	Poor	Avg	Good	95% C.I.	Level	Poor	Avg	Good
Queen Charlotte Is.	RASM	34.27	36.91	45.48	33.3-53.0	10.70	6.85	7.38	9.10
	RASM-2q	11.97	13.99	21.82	11.4-17.8	10.70	0.00	2.80	4.36
	ESM	18.31	20.16	25.40		10.70	3.66	4.03	5.08
Prince Rupert District	RASM	43.63	46.96	56.48	38.9-49.8	12.10	8.73	9.39	11.30
	RASM-2q	31.26	34.13	42.59	27.6-35.6	12.10	6.25	6.83	8.52
	ESM	44.29	47.22	56.81		12.10	8.86	9.44	11.36
Central Coast	RASM	25.60	28.01	36.11	21.5-29.6	17.60	5.12	5.60	7.22
	RASM-2q	22.89	25.38	33.62	19.3-25.9	17.60	4.58	5.08	6.72
	ESM	28.53	31.10	41.73		17.60	5.71	6.22	8.35
Strait of Georgia	RASM	59.33	72.96	87.23	58.1-75.9	21.20	11.87	14.59	17.45
	RASM-2q	81.88	95.49	110.7	83.9-110.1	21.20	16.38	19.10	22.09
	ESM	89.69	106.54	130.80		21.20	17.94	21.31	26.16
W.C. Vancouver Island	RASM	16.98	21.60	36.30	14.3-22.8	18.80	0.00	2.80*	7.26
	RASM-2q	22.44	27.86	44.63	20.3-30.3	18.80	3.64*	5.57	8.93
	ESM	17.60	23.73	39.97		18.80	0.00	4.74	7.99

* Available harvest is the forecast-Cutoff to maintain stock at or above the Cutoff level.

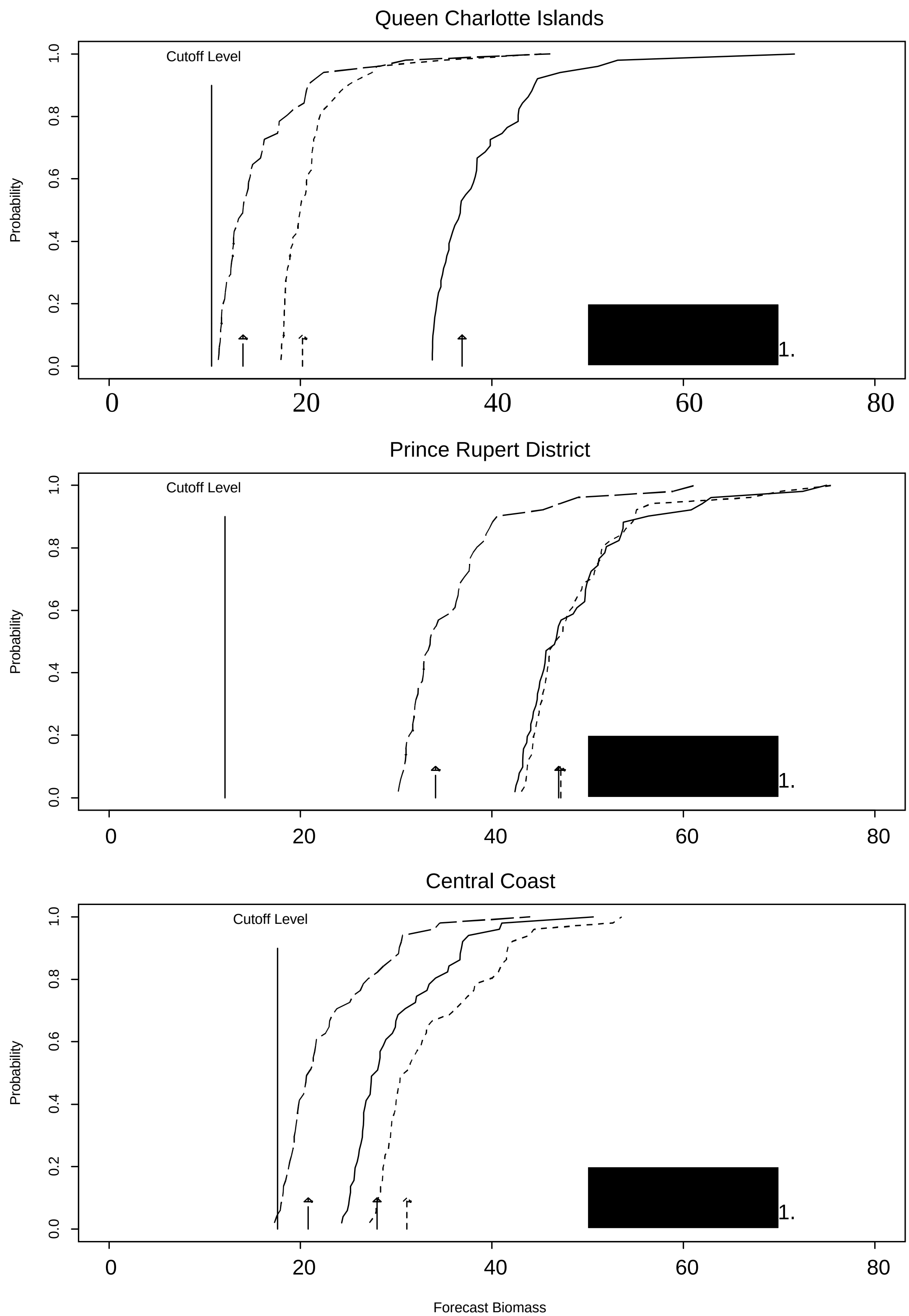


Fig. 8.1. Cumulative probability distributions of forecast spawning biomass for northern B.C. herring stock assessment regions in 2002. Arrows represent forecasts assuming average recruitment.

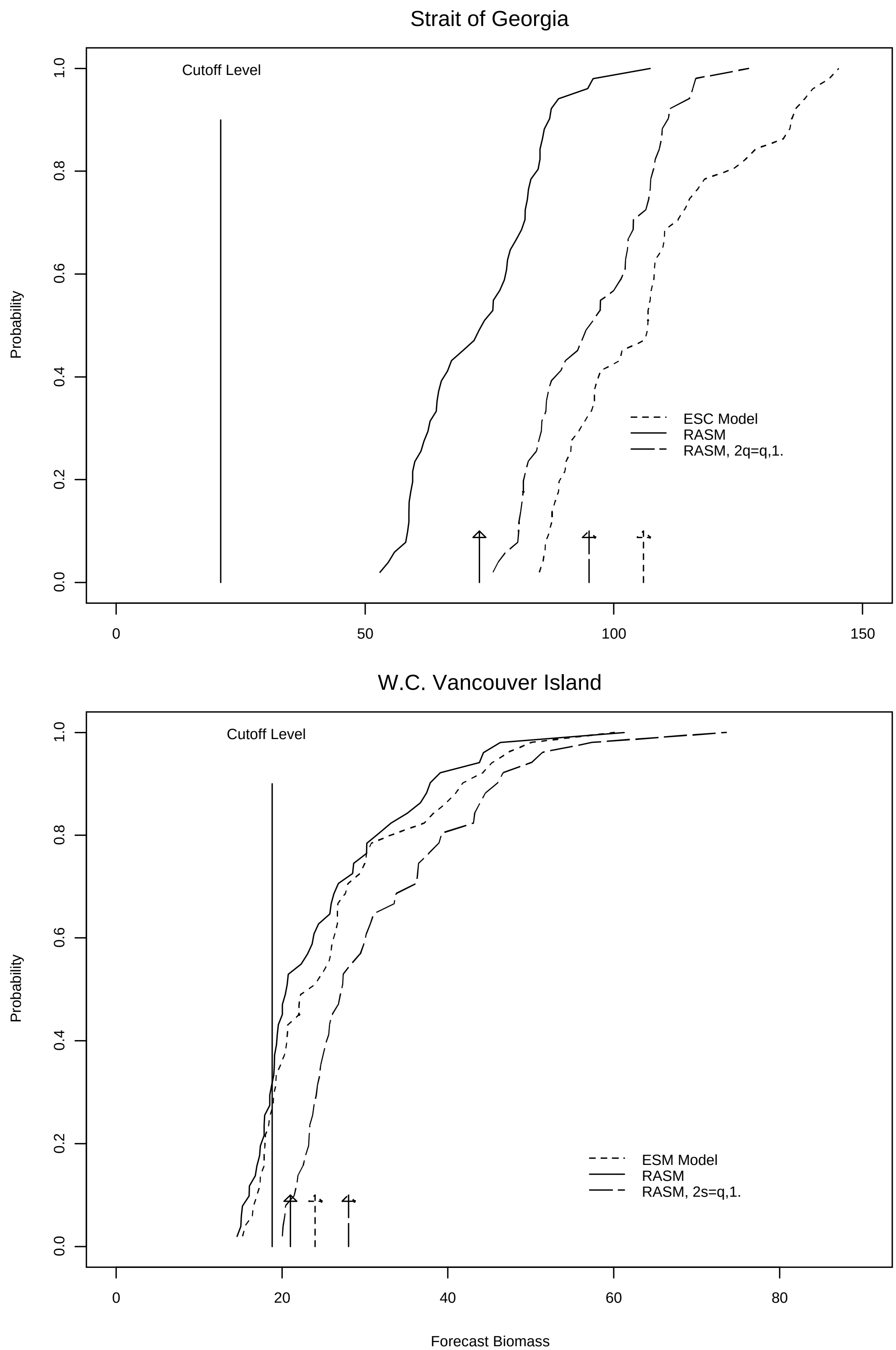


Fig. 8.2. Cumulative probability distributions of forecast spawning biomass for southern B.C. herring stock assessment regions in 2002. Arrows represent forecasts assuming average recruitment.

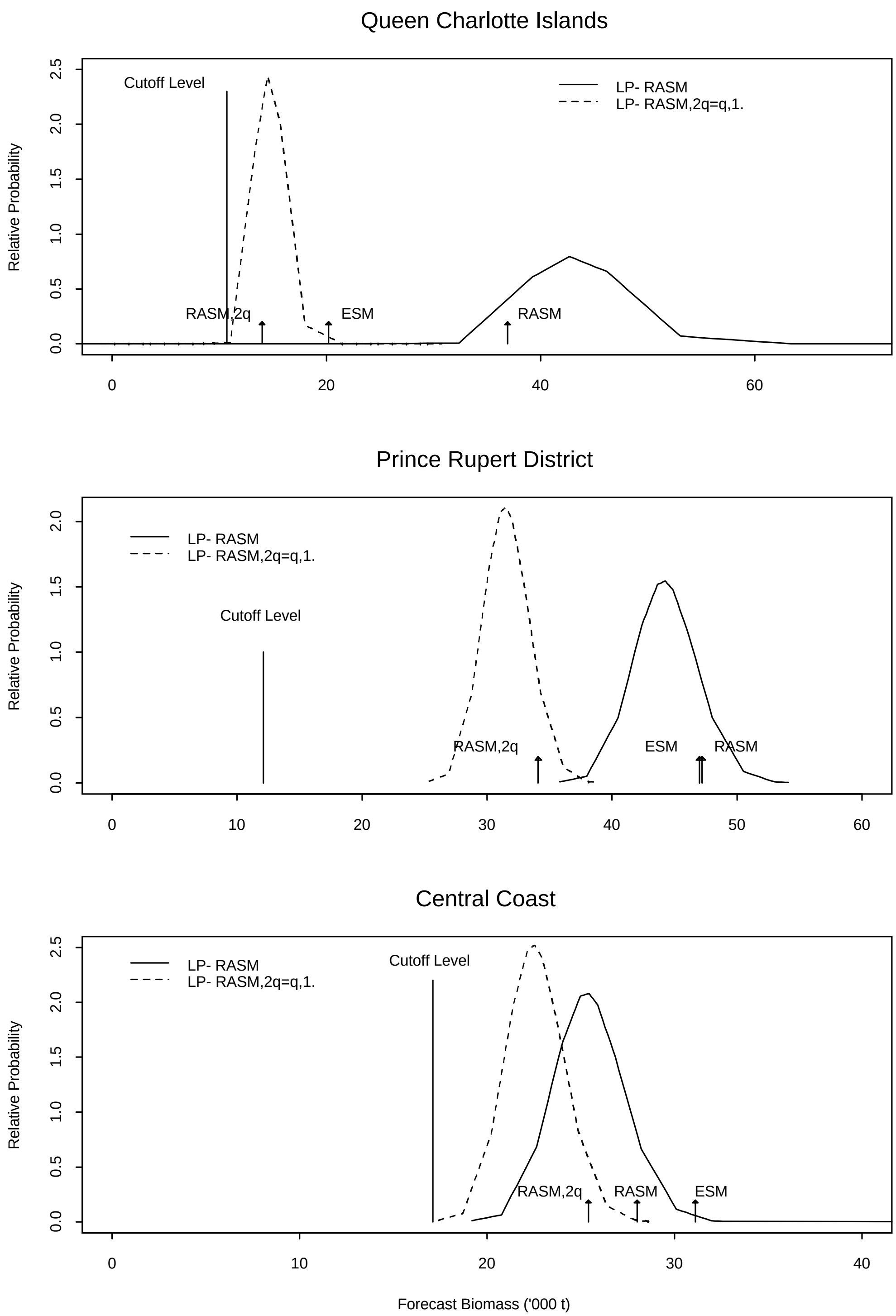
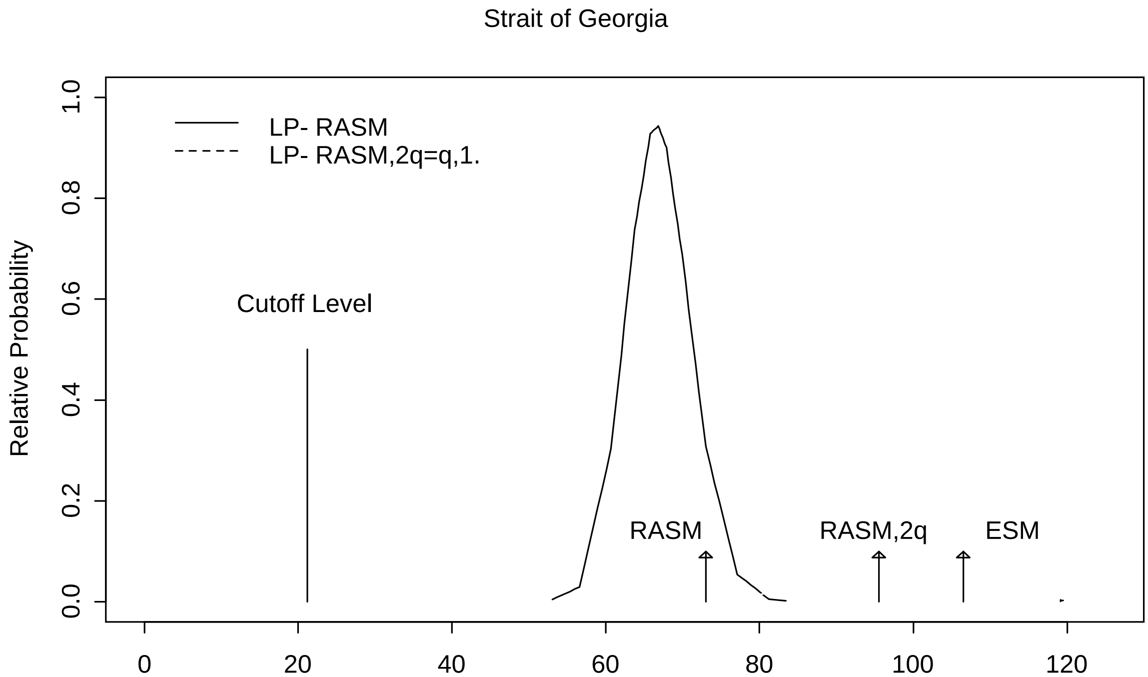


Fig. 9.1. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 2002 mature biomass in the northern stock assessment regions. The arrows denote the forecasts assuming average recruitment for escapement and age-structured models.



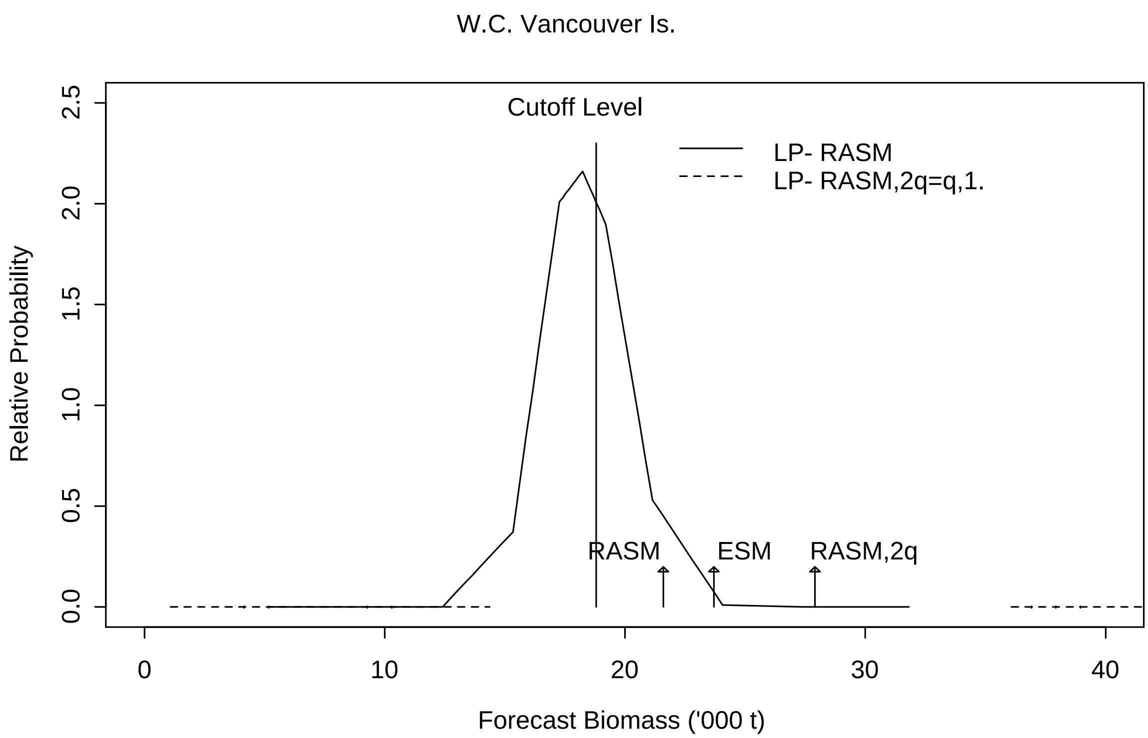


Fig. 9.2. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 2000 mature biomass in the southern stock assessment regions. The arrows denote the forecasts assuming average recruitment for escapement and age-structured models.

7. SIZE AT AGE TRENDS

A major issue during the 1998 assessment review was the recent downward trend in the size at age of herring and its impacts on estimates of forecast biomass as well as the availability and catchability of herring for the gillnet fleet. Since 1999, adjustments to the available harvests have been made to incorporate the effects of decreased size of herring on tonnages available to the gillnet sector. Figure 10.1 presents the available data on size at age of herring since 1971 and indications are that size at age in 2001 has increased slightly for most age-classes in all areas. The increasing trend in size at age observed over the past few years should provide better opportunities for gillnet fisheries.

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Peter Midgley updated the catch and sampling data bases and reviewed all 2001 biological sampling data. Chuck Fort updated and reviewed the spawn survey databases. Howard Stiff provided programming support for the Access databases used to summarize the catch and spawn data. Database upgrades were funded by the Herring Conservation and Research Society.

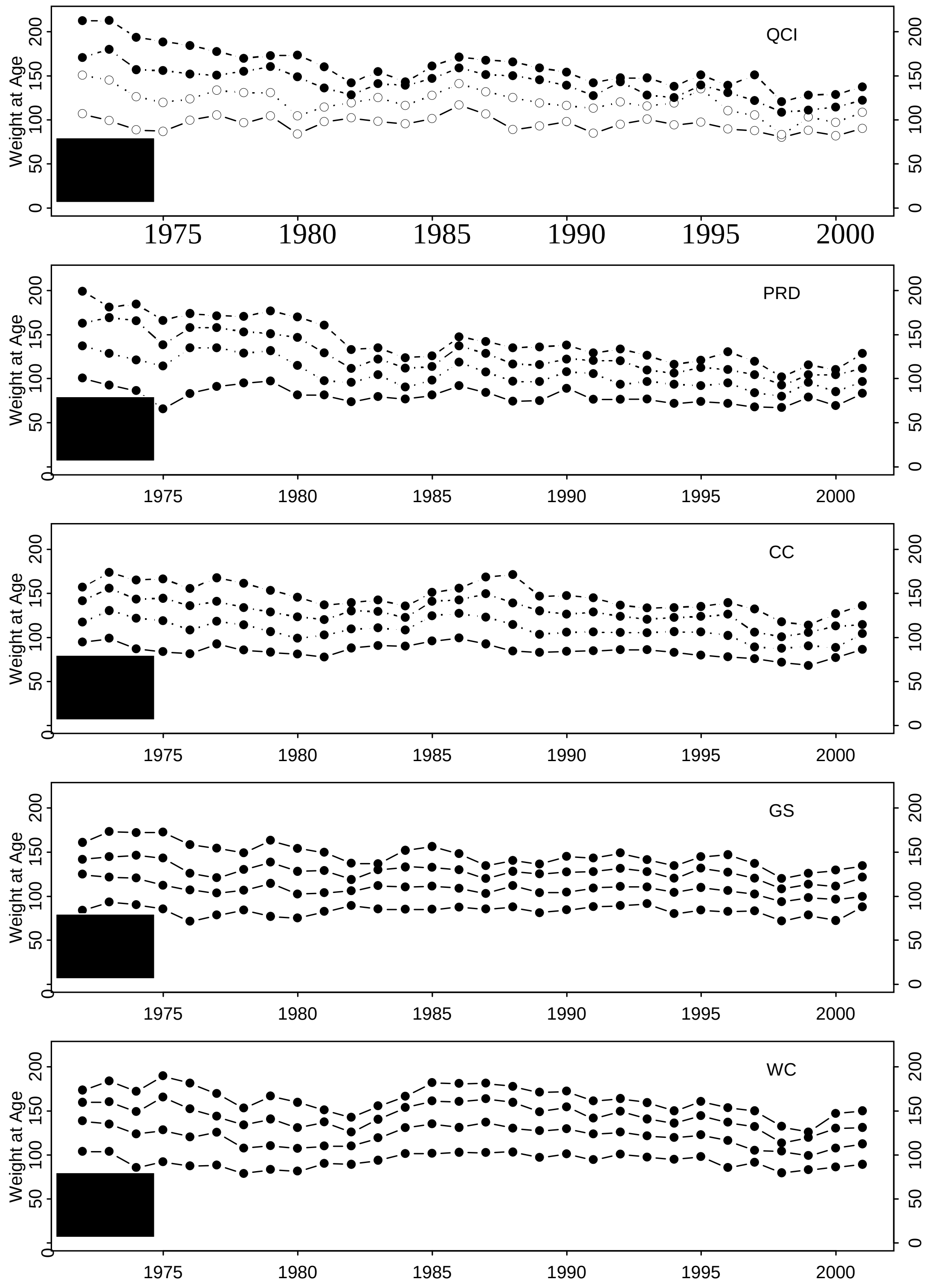

Figure 10.1. Estimates of weight-at-age (g) for 3-6 year old herring from 1951-2001 for the five major assessment areas.

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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.

		PERCENT AT AGE									NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
1950/51	WINTER	0.07	15.31	52.91	15.31	11.52	4.20	0.61	0.07	0.00	1476	1544	317.44
1951/52	WINTER	17.13	21.81	34.17	21.54	4.14	1.12	0.09	0.00	0.00	2224	166	1124.25
1953/54	WINTER	2.96	29.02	21.28	33.66	10.19	1.93	0.71	0.19	0.06	0*	25	231.66
1954/55	WINTER	8.74	14.08	39.42	18.06	14.85	4.37	0.29	0.10	0.10	0*	25	52.94
1955/56	WINTER	0.15	16.02	9.64	62.17	8.38	2.74	0.74	0.00	0.15	1348	681	6551.83
1956/57	WINTER	20.77	24.13	15.76	9.59	26.73	2.45	0.44	0.13	0.00	4733	2180	2089.67
1957/58	WINTER	81.89	16.42	1.23	0.18	0.14	0.14	0.00	0.00	0.00	2838	514	2146.22
1958/59	WINTER	1.05	63.16	28.42	7.37	0.00	0.00	0.00	0.00	0.00	95	6	735.74
1960/61	WINTER	4.21	32.63	36.00	24.84	1.26	0.42	0.21	0.42	0.00	0*	25	59.00
1961/62	WINTER	3.04	37.62	41.36	9.58	6.54	1.64	0.23	0.00	0.00	428	170	693.85
1962/63	WINTER	0.37	50.00	27.11	18.16	2.11	1.99	0.00	0.12	0.12	804	411	1342.32
1963/64	WINTER	0.95	15.34	59.47	17.80	5.30	1.14	0.00	0.00	0.00	528	297	2515.06
1964/65	WINTER	1.61	79.77	11.02	4.37	2.09	0.95	0.19	0.00	0.00	1053	165	3424.55
1965/66	WINTER	18.36	32.77	16.38	10.40	7.45	5.89	4.92	2.07	1.75	0*	25	210.12
1966/67	WINTER	0.88	67.26	26.49	2.65	2.72	0.00	0.00	0.00	0.00	0*	25	18.83
1967/68	WINTER	29.95	50.57	17.23	2.25	0.00	0.00	0.00	0.00	0.00	0*	25	8.43
1971/72	ROE-SN	3.04	32.60	38.34	16.05	6.08	2.45	0.93	0.42	0.08	1184	94	276.24"
1972/73	ROE-SN	0.17	40.56	21.55	27.29	8.00	1.68	0.75	0.00	0.00	1726	914	524.51
1973/74	ROE-SN	0.12	30.49	40.38	17.69	9.09	1.86	0.31	0.06	0.00	1617	185	482.78
	ROE-GN	0.00	5.73	48.41	25.48	16.56	3.18	0.00	0.00	0.64	157	25	8.24
1974/75	ROE-SN	0.63	25.31	34.21	27.90	9.53	1.95	0.37	0.10	0.00	6010	655	587.13"
	ROE-GN	0.00	0.00	22.50	40.00	30.00	5.00	2.50	0.00	0.00	40	40	6.19
1975/76	ROE-SN	0.43	2.78	37.34	29.38	22.73	6.31	0.96	0.07	0.00	4170	247	813.57"
	ROE-GN	0.00	0.00	0.75	21.80	60.90	14.29	2.26	0.00	0.00	133	186	91.86
1976/77	ROE-SN	0.09	19.57	8.01	29.41	22.95	15.09	4.47	0.40	0.00	3220	1113	801.25"`
1977/78	ROE-SN	0.16	26.18	17.34	9.48	26.18	14.10	5.27	0.97	0.32	1234	1932	620.46
	ROE-GN	0.00	0.61	4.85	11.52	19.39	39.39	20.00	3.64	0.61	165	126	129.55
1978/79	ROE-SN	5.59	4.41	31.57	18.73	21.27	15.10	2.84	0.39	0.10	1020	441	387.56"
	ROE-GN	0.00	0.00	25.13	25.13	25.13	20.10	3.52	0.50	0.50	199	65	128.20
1979/80	ROE-SN	0.50	83.22	4.45	5.37	2.77	1.89	1.15	0.56	0.09	3390	2427	222.15
	ROE-GN	0.00	3.73	4.48	40.09	20.79	22.28	6.93	1.60	0.11	938	1028	74.53
1980/81	ROE-SN	0.18	3.54	84.99	5.40	3.05	1.82	0.71	0.18	0.12	4943	489	331.92"
	ROE-GN	0.00	0.22	74.81	8.29	9.39	4.86	1.88	0.55	0.00	905	339	121.41
1981/82	ROE-SN	0.84	4.46	4.43	84.63	2.42	1.62	0.95	0.53	0.14	3591	1725	185.38"
	ROE-GN	0.00	0.19	3.42	88.21	3.42	2.66	1.14	0.76	0.19	526	341	99.20
1982/83	ROE-SN	4.88	5.23	3.51	6.86	72.87	3.91	1.58	0.91	0.25	1968	1609	317.79"
	ROE-GN	0.00	0.00	1.34	2.81	89.02	3.08	2.54	0.67	0.54	747	637	58.91
1983/84	WINTER	5.91	36.56	2.15	4.30	8.60	39.25	2.15	0.54	0.54	186	186	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
1998/99	ROE-SN	3.46	2.20	64.78	17.03	8.09	2.71	0.70	0.47	0.56	2138	1188	312.26
	ROE-GN	0.00	0.67	30.78	22.80	29.12	9.98	2.66	1.33	2.66	601	413	35.99
1999/00	ROE-SN	4.98	18.51	3.91	59.07	7.95	4.51	0.42	0.47	0.19	2150	1827	248.93`
2000/01	ROE-SN	11.69	32.68	22.04	6.15	22.34	3.45	1.20	0.30	0.15	667	349	41.14

AVERAGE WEIGHT AT AGE (gms)

FISHERY	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	64.5	95.0	120.0	141.0	159.5	173.7	185.4	194.4	197.4
ROE-GN	0.0	119.8	140.3	150.9	166.9	176.1	188.2	186.0	192.7

* - 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.

						PERCENT AT AGE					NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
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
1998/99	ROE-SN	0.99	5.52	41.05	20.35	24.71	4.42	1.05	0.87	1.05	1720	305	121.60
	ROE-GN	0.00	0.00	10.82	16.50	49.51	13.45	4.58	1.94	3.19	721	331	147.57
1999/00	ROE-SN	1.91	28.02	9.57	28.25	12.49	16.51	2.30	0.52	0.44	3876	3384	234.58
	ROE-GN	0.00	0.12	2.10	23.06	20.47	42.17	9.37	1.11	1.60	811	428	230.02
2000/01	ROE-SN	1.87	41.68	20.87	5.60	15.85	6.93	6.17	0.88	0.14	4978	2054	221.76
	ROE-GN	0.00	0.31	5.22	8.99	32.29	20.79	25.91	5.64	0.84	957	468	141.41

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	51.8	79.8	105.6	126.6	143.1	155.7	167.8	176.2	185.9
ROE-GN	90.3	115.2	129.6	138.8	148.5	154.4	161.1	167.2	173.3

* - 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 1.3. 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.

		PERCENT AT AGE									NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
1950/51	WINTER	2.43	28.56	50.66	12.00	5.06	1.24	0.06	0.00	0.00	5316	2487	3904.06
1951/52	WINTER	5.18	20.07	30.08	38.13	4.50	1.53	0.45	0.04	0.02	5156	1431	2925.93
1952/53	WINTER	9.36	28.09	23.99	26.62	10.15	1.33	0.44	0.00	0.00	2926	543	73.57
1953/54	WINTER	3.95	69.68	20.26	4.61	1.29	0.16	0.00	0.06	0.00	3189	478	3476.95
1954/55	WINTER	6.66	7.72	74.62	9.09	1.54	0.38	0.00	0.00	0.00	2344	165	1235.03
1955/56	WINTER	16.88	13.62	9.20	57.01	2.89	0.34	0.04	0.00	0.02	5052	1347	4134.75
1956/57	WINTER	16.74	50.70	10.79	6.23	14.78	0.73	0.02	0.00	0.00	4688	1703	2635.45
1957/58	WINTER	23.51	61.39	12.66	1.28	0.59	0.56	0.00	0.00	0.00	3743	847	1445.86
1958/59	WINTER	3.80	49.52	36.89	8.10	0.80	0.44	0.42	0.02	0.00	4974	1352	3293.36
1959/60	WINTER	43.50	23.16	26.48	5.58	1.13	0.07	0.07	0.00	0.00	1416	165	639.45
1960/61	WINTER	16.08	32.23	10.79	29.69	10.08	0.93	0.11	0.07	0.04	2799	1227	3463.55
1961/62	WINTER	9.65	57.43	17.95	2.60	9.90	2.35	0.12	0.00	0.00	808	146	1721.99
1962/63	WINTER	0.37	30.27	57.96	5.43	2.85	2.94	0.18	0.00	0.00	1087	885	4376.33
1963/64	WINTER	13.12	47.38	27.74	10.25	1.43	0.08	0.00	0.00	0.00	1258	198	3507.73
1964/65	WINTER	8.17	36.40	33.77	15.83	5.43	0.34	0.06	0.00	0.00	1750	684	1326.51
1965/66	WINTER	67.32	20.43	7.33	3.60	1.13	0.19	0.00	0.00	0.00	0*	25	5216.79
1966/67	WINTER	37.40	46.19	13.10	2.04	1.02	0.17	0.07	0.01	0.00	0*	25	2514.89
1967/68	WINTER	32.53	48.02	17.02	2.11	0.25	0.00	0.06	0.00	0.00	0*	25	170.14
1968/69	WINTER	32.21	27.70	26.72	11.30	1.95	0.12	0.00	0.00	0.00	0*	25	10.08
1969/70	WINTER	54.02	44.42	1.16	0.40	0.00	0.00	0.00	0.00	0.00	0*	25	28.32
1970/71	WINTER	14.39	39.60	36.87	3.78	4.20	0.95	0.11	0.11	0.00	952	136	339.30
1971/72	ROE-SN	4.35	29.83	27.65	25.69	6.91	4.35	1.14	0.05	0.00	1837	598	762.73"
	ROE-GN	0.00	0.91	14.89	65.05	10.64	7.90	0.61	0.00	0.00	329	503	8.47
1972/73	ROE-SN	1.20	50.45	18.60	15.51	11.75	1.88	0.45	0.15	0.00	1328	593	539.55"
	ROE-GN	0.00	2.53	25.32	44.94	20.89	4.43	1.27	0.63	0.00	158	114	71.26
1973/74	ROE-SN	2.77	17.71	38.63	19.72	13.36	6.62	0.95	0.25	0.00	1587	202	282.57
	ROE-GN	0.00	0.40	22.78	37.70	24.80	12.30	1.81	0.20	0.00	496	101	332.81
1974/75	ROE-SN	1.16	32.96	25.51	27.84	8.59	3.18	0.67	0.07	0.02	8896	3314	278.00
	ROE-GN	0.00	3.28	25.63	46.24	16.38	6.36	2.12	0.00	0.00	519	117	348.42
1975/76	ROE-SN	3.01	11.76	41.23	20.89	16.83	4.54	1.48	0.24	0.02	5418	973	511.14
	ROE-GN	0.00	0.82	18.82	29.79	35.27	11.78	3.03	0.41	0.08	1222	253	383.45
1976/77	WINTER	1.01	32.83	18.69	29.80	8.08	6.57	3.03	0.00	0.00	198	144	32.75
	ROE-SN	0.68	17.43	22.64	31.77	16.59	8.53	1.92	0.40	0.04	2496	925	284.27
	ROE-GN	0.00	1.10	13.02	35.54	31.57	13.47	3.97	1.32	0.00	453	169	411.71
1977/78	ROE-SN	0.21	25.72	15.19	19.91	23.14	10.89	3.51	1.07	0.36	1396	589	354.31
	ROE-GN	0.00	1.30	8.93	29.58	38.14	17.67	3.81	0.47	0.09	1075	474	576.00
1979/80	ROE-SN	3.68	73.08	6.43	9.02	3.99	2.59	0.70	0.39	0.12	2582	1401	1.12"
	ROE-GN	0.00	3.28	2.55	24.82	23.72	26.28	11.31	6.57	1.46	274	210	32.46
1980/81	ROE-SN	1.96	12.30	66.57	8.40	7.05	2.64	0.64	0.34	0.10	2952	492	25.75"
	ROE-GN	0.26	1.50	50.72	13.61	15.36	10.61	5.47	1.82	0.65	1536	276	163.04
1981/82	ROE-SN	1.68	15.62	10.72	60.21	5.19	4.56	1.45	0.48	0.09	3508	2296	188.15"
	ROE-GN	0.00	2.39	5.91	75.99	6.66	5.91	2.32	0.75	0.07	1337	301	287.08
1982/83	ROE-SN	0.53	7.00	15.43	10.82	57.10	5.03	3.10	0.73	0.26	5445	1082	154.75
	ROE-GN	0.00	0.50	7.19	13.05	69.44	5.02	3.90	0.61	0.28	1793	994	244.49
1983/84	ROE-SN	4.35	7.31	10.12	18.16	16.14	40.73	2.26	0.83	0.10	6293	2210	282.42"
	ROE-GN	0.00	0.26	2.93	13.11	17.26	60.05	4.75	1.12	0.52	1159	338	242.25
1984/85	ROE-SN	2.66	37.54	7.47	8.55	13.11	11.94	18.19	0.45	0.10	5157	5529	222.13
	ROE-GN	0.00	3.18	5.43	9.39	19.49	22.52	38.20	1.01	0.78	1288	1407	143.53
1985/86	ROE-SN	3.92	16.39	40.25	8.59	6.27	6.68	6.08	11.26	0.55	5819	2074	163.81"
	ROE-GN	0.00	1.78	23.95	11.97	10.01	16.00	13.19	22.26	0.84	1069	262	73.95
1986/87	ROE-SN	4.13	22.57	14.59	32.18	5.72	4.55	5.84	4.66	5.78	5038	2319	193.73
	ROE-GN	0.00	0.82	7.75	44.85	11.72	7.85	9.89	8.15	8.97	981	1199	55.71
1987/88	ROE-SN	1.14	67.92	11.67	6.28	7.12	1.68	1.46	1.50	1.23	5194	2730	343.88"
	ROE-GN	0.00	4.24	10.25	14.84	27.21	15.19	7.42	10.07	10.78	566	158	59.81
1988/89	ROE-SN	1.28	4.61	76.21	9.16	3.58	2.80	0.74	0.80	0.82	5642	1939	596.24
	ROE-GN	0.00	0.28	27.61	25.07	17.32	16.48	5.77	3.66	3.80	710	259	195.14
1989/90	ROE-SN	0.97	5.66	4.99	72.59	7.49	3.82	2.95	0.75	0.78	6677	6353	415.05
	ROE-GN	0.00	0.00	1.18	65.05	16.88	6.26	7.79	1.06	1.77	847	502	203.56
1990/91	ROE-SN	2.03	18.82	6.76	6.19	55.55	6.38	2.34	1.48	0.46	7105	5044	576.33
	ROE-GN	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-SN	2.01	58.38	11.40	2.74	3.44	18.75	2.13	0.61	0.54	7264	4356	722.92"
	ROE-GN	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-SN	2.85	6.71	64.15	9.68	2.02	2.55	10.46	1.12	0.46	8664	3221	784.75
	ROE-GN	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-SN	1.19	21.29	8.52	52.95	7.48	2.01	2.76	3.48	0.32	7127	4910	875.10
	ROE-GN	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-SN	0.75	6.06	23.16	9.44	48.04	6.46	2.01	2.31	1.76	9148	4236	700.37
	ROE-GN	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-SN	11.63	19.56	5.81	16.70	6.81	30.61	5.96	1.49	1.43	5316	3344	398.77
	ROE-GN	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-SN	2.13	56.65	16.89	3.62	6.14	3.99	8.49	1.54	0.55	6870	3214	451.35
	ROE-GN	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-SN	0.53	36.34	42.39	8.47	2.38	3.12	3.04	2.97	0.77	6473	3967	1023.85
	ROE-GN	0.00	0.48	14.45	13.77	8.73	17.75	15.91	21.05	7.86	1031	222	45.17
1998/99	ROE-SN	0.71	8.76	42.65	34.28	6.52	1.66	2.18	1.95	1.29	4816	1689	711.10
	ROE-GN	0.00	0.11	14.24	44.88	17.91	6.69	5.50	6.15	4.53	927	411	116.52
1999/00	ROE-SN	0.35	19.11	10.82	34.72	26.20	5.81	1.17	0.91	0.91	4527	2678	683.06
	ROE-GN	0.00	0.44	2.04	40.44	41.61	10.36	1.61	0.88	2.63	685	2114	73.07
2000/01	ROE-SN	2.40	7.74	27.52	11.91	25.75	19.05	4.19	0.80	0.65	4132	1760	564.04
	ROE-GN	0.00	0.00	4.88	5.75	52.75	28.13	7.13	1.13	0.25	800	260	38.21

	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	53.0	84.5	108.2	128.3	145.6	160.2	172.7	184.1	192.3
ROE-GN	39.3	114.5	133.1	143.9	152.8	161.8	169.6	174.8	174.3

* - 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	1+	2+	3+	4+	PERCENT AT AGE 5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
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	50.93	26.85	2.99	1.00	0.52	0.09	0.00	0.00	2309	403	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	0.11	2653	911	518.05
	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	2.49	49.82	15.90	17.71	9.86	2.61	1.23	0.27	0.12	4139	1495	16.94
	ROE-GN	0.00	1.99	9.15	44.56	33.42	8.75	1.86	0.27	0.00	754	1139	215.21
1980/81	WINTER	3.66	34.26	34.21	15.60	8.57	3.02	0.52	0.16	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	8.08	37.75	28.97	12.93	7.16	3.33	1.13	0.49	0.15	7152	1852	392.25
	ROE-GN	0.00	7.05	30.16	31.07	19.19	9.27	1.70	0.65	0.91	766	759	421.50
1984/85	WINTER	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	14.86	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	0.22	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	0.00	2.27	26.21	36.79	26.11	5.61	2.37	0.43	0.22	927	340	586.53
1995/96	WINTER	25.36	49.46	11.99	9.46	2.47	1.08	0.18	0.00	0.00	1660	473	62.22
	ROE-SN	12.98	48.36	14.05	14.43	5.80	3.38	0.69	0.23	0.08	8296	4663	759.67
	ROE-GN	0.00	3.86	15.81	45.40	21.88	10.29	1.84	0.74	0.18	544	452	449.47
1996/97	WINTER	21.96	59.61	13.73	3.14	0.78	0.20	0.39	0.20	0.00	510	53	56.14
	ROE-SN	7.85	52.10	23.23	6.01	6.51	2.59	1.51	0.13	0.07	7107	3423	989.32
	ROE-GN	0.00	4.74	17.85	16.43	31.91	17.06	8.53	2.53	0.95	633	501	449.74
1997/98	WINTER	4.09	47.22	40.06	6.70	1.19	0.57	0.11	0.06	0.00	1760	293	110.55
	ROE-SN	4.15	47.43	30.99	11.94	2.57	1.97	0.74	0.19	0.02	8416	3225	676.28
	ROE-GN	0.00	3.22	32.19	31.33	13.23	13.66	4.08	1.86	0.43	1398	383	548.84
1998/99	WINTER	11.48	27.62	42.83	14.28	3.08	0.57	0.14	0.00	0.00	1394	109	160.79
	ROE-SN	6.41	24.85	41.04	18.58	6.46	1.77	0.69	0.15	0.05	4069	1088	519.83
	ROE-GN	0.00	2.15	29.31	36.72	21.05	6.70	3.35	0.60	0.12	836	338	522.51
1999/00	WINTER	24.62	42.94	15.11	12.25	3.79	1.05	0.12	0.12	0.00	1714	437	151.32
	ROE-SN	10.15	37.80	19.13	21.73	8.66	2.05	0.28	0.19	0.01	6770	3633	715.41
	ROE-GN	0.00	1.10	14.42	44.95	27.99	9.08	2.12	0.34	0.00	1179	1017	566.28
2000/01	WINTER	7.93	48.78	28.40	7.40	4.88	1.92	0.52	0.17	0.00	1148	867	141.08
	ROE-SN	6.81	43.52	28.45	9.01	8.65	2.70	0.71	0.11	0.05	6517	2785	754.43
	ROE-GN	0.00	3.21	18.42	25.48	33.40	15.74	2.89	0.64	0.21	934	187	577.12

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	54.6	89.7	114.3	137.2	151.8	165.1	176.5	182.8	203.0
ROE-SN	57.6	83.1	107.8	127.9	145.9	160.3	169.5	176.0	185.9
ROE-GN	66.2	117.5	133.3	143.6	153.1	160.4	169.8	168.1	171.5

* - 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 1.5. 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.

		PERCENT AT AGE											
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
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	0.02	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	0.44	0.21	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	7.51	4.11	7.72	0.94	0.57	5430	2772	473.30
1993/94	ROE-SN	2.98	22.32	23.76	30.53	8.05	5.10	5.41	1.59	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
1998/99	ROE-SN	1.52	22.66	24.18	38.63	7.78	2.72	1.40	0.74	0.37	4077	3893	359.48
	ROE-GN	0.00	0.90	11.94	59.35	17.91	4.95	3.49	1.35	0.11	888	173	50.80
1999/00	ROE-SN	6.23	23.32	19.68	17.72	27.32	3.73	1.24	0.58	0.18	4447	2883	110.10
	ROE-GN	0.00	1.28	7.52	27.04	52.80	6.24	2.56	2.24	0.32	625	475	48.21
2000/01	ROE-SN	7.16	45.82	20.00	7.94	7.67	9.65	1.34	0.23	0.18	2165	634	34.45

	AVERAGE WEIGHT AT AGE (gms)								
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	56.0	90.1	112.4	131.0	148.2	155.4	173.2	176.0	183.6
ROE-SN	63.9	92.8	120.2	143.5	162.3	176.2	185.5	193.3	197.9
ROE-GN	45.5	117.0	135.8	149.7	159.9	169.8	174.8	178.1	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 1.6. 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.

						PERCENT AT AGE					NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
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
1998/99	ROE-SN	7.07	32.51	26.86	27.92	4.24	0.71	0.35	0.35	0.00	283	369	28.81
1999/00	ROE-SN	2.34	52.21	23.64	10.65	9.35	1.56	0.00	0.00	0.26	385	313	27.54
2000/01	ROE-SN	No Samples											

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	208.7	0.0
ROE-SN	56.8	93.8	118.0	138.1	157.0	171.2	181.9	200.4	212.3
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.

						PERCENT AT AGE					NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
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
1998/99	ROE-SN	15.60	32.38	28.09	14.30	7.28	1.56	0.52	0.26	0.00	769	201	1.00~
1999/00	ROE-SN	14.77	63.64	18.18	0.00	2.27	0.00	1.14	0.00	0.00	88	88	1.00~
2000/01	ROE-SN	4.37	8.48	40.62	24.42	12.08	6.94	2.06	0.51	0.51	389	162	1.00~

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	67.9	104.4	133.9	162.4	184.6	191.0	202.6	209.2	212.7
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 RASM analysis for the Queen Charlotte Is. stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	3011	2278	1155	230	128	54	0	0	0	4937	2510	0.20
1951/52	5003	1808	1331	562	101	54	23	0	0	5944	2398	-0.03
1952/53	23211	2862	904	515	167	26	14	6	0	11441	4759	0.00
1953/54	2794	13942	1719	543	309	100	16	8	4	20157	9853	0.16
1954/55	3361	1671	8267	999	311	176	57	9	7	39297	6143	-0.98
1955/56	1157	2018	1002	4937	595	185	105	34	9	7208	4014	0.29
1956/57	3661	692	559	274	674	50	16	9	4	1891	1578	0.70
1957/58	6398	1921	92	149	35	49	4	1	1	2631	787	-0.33
1958/59	1294	2234	833	27	24	4	5	0	0	8899	6940	0.63
1959/60	4700	767	920	401	12	10	2	2	0	15550	6469	0.00
1960/61	5427	2823	461	553	241	7	6	1	2	14503	6975	0.15
1961/62	8614	3257	1670	272	324	141	4	3	1	13174	4654	-0.16
1962/63	2804	5158	1766	799	116	132	57	2	2	16590	6177	-0.11
1963/64	6486	1680	2596	786	304	41	47	20	1	5823	4224	0.56
1964/65	373	3878	713	808	149	43	6	7	3	2890	1446	0.18
1965/66	243	180	193	180	86	7	2	0	0	3762	2764	0.57
1966/67	786	97	72	92	76	34	3	1	0	2861	710	-0.52
1967/68	1056	472	55	41	51	42	19	2	1	2654	750	-0.39
1968/69	2241	633	282	32	24	30	24	11	1	4510	1876	0.00
1969/70	4910	1346	380	169	19	14	18	15	7	10353	4307	0.00
1970/71	5688	2949	809	228	102	12	9	11	13	32730	13616	0.00
1971/72	12609	3416	1771	486	137	61	7	5	14	19912	9950	0.18
1972/73	10991	7565	1962	955	249	69	31	3	10	26907	7706	-0.37
1973/74	9540	6601	4331	1015	461	117	32	14	6	40690	9903	-0.54
1974/75	2671	5729	3821	2387	537	239	61	17	11	49913	8950	-0.84
1975/76	3345	1601	3301	2109	1266	280	125	32	14	41259	15142	-0.13
1976/77	3844	2006	941	1713	1001	573	126	56	21	33536	12516	-0.11
1977/78	2442	2308	1057	473	792	447	256	56	34	21938	11452	0.23
1978/79	42765	1466	1230	517	199	309	171	98	35	13369	8657	0.44
1979/80	3071	25665	863	593	205	72	110	61	47	48573	21204	0.05
1980/81	1264	1843	15230	503	316	103	36	54	53	72602	19024	-0.46
1981/82	1168	759	1095	8785	277	165	52	18	55	70359	19009	-0.43
1982/83	7632	700	447	641	5048	156	91	29	40	55317	19083	-0.19
1983/84	3323	4569	405	255	355	2758	85	49	38	42683	20438	0.14
1984/85	759	1989	2634	230	140	193	1490	46	47	33990	14394	0.02
1985/86	1549	452	1148	1453	120	71	96	744	46	28486	5637	-0.74
1986/87	15215	930	267	647	788	64	37	51	419	21004	13132	0.41
1987/88	4640	9137	546	151	358	432	35	21	258	26123	14457	0.29
1988/89	1675	2787	5487	327	91	215	259	21	167	40375	23985	0.36
1989/90	834	1003	1653	3223	191	53	125	150	109	34532	25011	0.55
1990/91	6338	500	563	905	1658	95	26	61	126	22089	14220	0.44
1991/92	452	3781	285	299	450	796	45	12	88	20643	9500	0.10
1992/93	282	270	2167	155	155	230	406	23	51	15332	5405	-0.17
1993/94	924	168	151	1129	76	74	109	193	35	12232	4895	-0.04
1994/95	3725	549	96	85	617	41	40	59	123	11734	4946	0.01
1995/96	5167	2237	329	58	51	370	24	24	109	14608	5827	-0.04
1996/97	14853	3103	1343	198	35	31	222	15	80	16408	11686	0.54
1997/98	1028	8915	1856	798	117	21	18	131	56	24261	18871	0.63
1998/99	6373	617	5225	1059	445	65	11	10	103	29358	9714	-0.23
1999/00	9013	3817	363	2922	571	231	32	6	57	28940	5119	-0.86
2000/01	7783	5402	2248	206	1620	313	127	18	34	39533	14112	-0.15

Estimated average availability at age (S_i): 0.10 0.39 0.63 0.90 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.01 0.04 0.21 0.56 0.79 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.42

Estimated instantaneous natural mortality rate is 0.510

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 RASM analysis for the Prince Rupert stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	5497	6554	8609	1238	452	239	0	0	0	24028	30098	0.65
1951/52	5320	3413	3564	3347	382	119	63	0	0	10668	18725	0.99
1952/53	11741	3293	1904	1061	636	50	16	8	0	32425	26180	0.21
1953/54	3464	7643	2090	1202	664	396	31	10	5	11002	13290	0.62
1954/55	9075	2207	4322	714	297	129	77	6	3	15254	25629	0.95
1955/56	3435	5868	1364	1850	257	96	42	25	3	38700	15498	-0.49
1956/57	5613	2135	3240	775	1005	136	51	22	15	15248	28279	1.05
1957/58	12115	3391	977	1248	236	261	35	13	9	35540	12044	-0.65
1958/59	3766	7657	2061	592	739	138	152	21	13	40118	36608	0.34
1959/60	20616	2425	4500	1184	326	397	74	82	18	38473	19072	-0.27
1960/61	9698	12408	1450	2353	573	151	184	34	46	34631	12881	-0.56
1961/62	4646	5921	5736	614	834	181	48	58	25	39173	24760	-0.03
1962/63	15458	2967	3276	2848	276	353	77	20	35	32251	15652	-0.29
1963/64	2548	8620	1444	1424	1050	92	117	25	18	42081	29266	0.07
1964/65	454	1562	3907	719	643	447	39	50	19	15052	6710	-0.38
1965/66	626	150	687	1403	194	142	99	9	15	8718	7487	0.28
1966/67	1268	408	52	282	474	58	42	29	7	3667	2719	0.13
1967/68	1108	458	76	17	68	88	11	8	7	5888	4788	0.22
1968/69	4540	599	235	43	9	35	45	6	8	2382	843	-0.61
1969/70	2704	2949	382	132	23	5	18	23	7	13204	8437	-0.02
1970/71	1476	1732	1828	235	79	13	3	11	18	16608	9753	-0.10
1971/72	6256	940	969	1076	134	44	8	2	16	15160	9853	0.00
1972/73	3817	4073	597	537	565	68	23	4	9	19701	11261	-0.13
1973/74	2323	2485	2617	370	327	341	41	14	8	26112	8893	-0.65
1974/75	826	1512	1589	1584	208	179	186	22	12	27308	11109	-0.47
1975/76	2014	536	973	995	980	128	110	114	21	27457	14213	-0.23
1976/77	943	1311	347	579	574	555	72	62	76	18180	9736	-0.20
1977/78	1013	614	790	183	277	260	250	33	62	10303	4738	-0.35
1978/79	14929	655	359	384	72	95	88	85	32	7792	7554	0.40
1979/80	2213	9714	389	185	172	29	39	36	47	18066	10236	-0.14
1980/81	2960	1440	6133	228	93	80	14	18	38	30922	10532	-0.65
1981/82	3489	1926	908	3768	134	52	45	8	31	33819	12631	-0.56
1982/83	11114	2266	1219	569	2336	82	32	28	24	37479	19652	-0.22
1983/84	2049	7236	1475	794	371	1521	54	21	33	35581	22927	-0.01
1984/85	1916	1333	4650	929	484	217	856	30	31	37623	35858	0.38
1985/86	7204	1247	845	2848	538	260	107	422	30	37436	32525	0.29
1986/87	6063	4685	769	501	1550	277	129	53	224	34148	31422	0.35
1987/88	3328	3946	2975	473	283	807	137	64	137	31249	33679	0.50
1988/89	1822	2165	2460	1794	262	134	346	59	86	29500	12783	-0.41
1989/90	8025	1184	1333	1470	970	115	52	133	56	29464	19398	0.01
1990/91	9345	5224	734	815	853	525	59	27	97	31891	21544	0.04
1991/92	2136	6082	3298	452	475	473	274	31	64	36627	35992	0.41
1992/93	1001	1390	3867	2052	253	235	214	124	43	33657	21440	-0.02
1993/94	2895	651	872	2344	1156	119	93	85	66	25773	13439	-0.22
1994/95	11248	1883	410	523	1331	611	53	41	67	22428	15858	0.08
1995/96	5013	7319	1205	255	313	769	335	29	60	37289	22104	-0.09
1996/97	7520	3263	4685	762	153	160	367	160	42	28036	20744	0.13
1997/98	2128	4895	2102	2950	421	59	35	79	44	34008	16734	-0.28
1998/99	5910	1385	3145	1330	1777	230	13	8	27	35792	25699	0.10
1999/00	11213	3847	895	1984	819	1040	126	7	19	33822	15658	-0.34
2000/01	1568	7296	2439	557	1170	459	532	64	13	42122	33335	0.19

Estimated average availability at age (S_i): 0.09 0.45 0.68 0.88 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.00 0.01 0.16 0.46 0.70 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.65

Estimated instantaneous natural mortality rate is 0.429

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 RASM analysis for the Central Coast stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	1696	3103	4022	738	298	77	0	0	0	15452	23134	0.45
1951/52	2754	1222	1438	1410	187	69	18	0	0	4001	10709	1.03
1952/53	14020	1985	433	351	171	18	7	2	0	10606	20001	0.68
1953/54	1601	10759	1505	317	254	124	13	5	1	9591	18635	0.71
1954/55	1669	1079	5587	481	68	49	24	2	1	30225	14984	-0.65
1955/56	3783	1203	739	3374	272	38	27	13	2	7220	8244	0.18
1956/57	5168	2249	395	191	469	31	4	3	2	3260	6223	0.70
1957/58	5894	3616	653	103	27	54	4	1	1	10562	4226	-0.87
1958/59	1472	4196	1927	310	42	11	21	1	0	4481	4105	-0.04
1959/60	3146	1032	1940	522	48	5	1	3	0	23400	14684	-0.42
1960/61	7692	2179	687	1335	350	32	4	1	2	6170	4567	-0.25
1961/62	4475	5479	821	201	242	55	5	1	0	13255	14180	0.12
1962/63	4049	3296	3370	392	82	96	22	2	0	5520	8466	0.48
1963/64	2222	3096	1480	872	55	9	11	2	0	5606	7058	0.28
1964/65	1784	1283	838	387	125	6	1	1	0	2848	2365	-0.14
1965/66	5151	1267	528	219	55	15	1	0	0	1868	1773	0.00
1966/67	2105	1040	94	108	16	2	1	0	0	3381	5904	0.61
1967/68	429	297	147	26	18	2	0	0	0	4381	6366	0.42
1968/69	1570	256	177	93	16	11	1	0	0	3341	2331	-0.31
1969/70	1611	1204	195	133	69	12	8	1	0	11363	10134	-0.06
1970/71	1936	1226	916	148	100	52	9	6	1	14136	6056	-0.80
1971/72	3065	1445	831	599	93	62	33	6	4	10087	3928	-0.89
1972/73	1964	2321	897	402	248	37	25	13	4	19781	14471	-0.26
1973/74	2761	1502	1525	543	220	132	19	13	9	17102	10624	-0.43
1974/75	1314	2113	1102	921	260	91	53	8	9	22470	9164	-0.85
1975/76	668	1006	1529	709	482	123	42	24	8	17889	16133	-0.05
1976/77	780	499	717	934	333	193	46	15	12	16676	18481	0.15
1977/78	567	596	320	434	446	135	75	18	11	5761	10097	0.61
1978/79	5404	434	352	148	99	49	11	6	2	6885	6551	0.00
1979/80	1015	4149	333	270	114	76	38	9	7	21040	15979	-0.23
1980/81	1056	779	3181	254	198	80	52	26	11	26587	16949	-0.40
1981/82	497	810	593	2348	171	120	43	28	20	29011	18413	-0.40
1982/83	421	378	589	416	1477	102	68	24	27	22568	16618	-0.26
1983/84	1560	322	278	411	264	882	59	39	29	14288	14197	0.04
1984/85	673	1186	226	178	232	135	429	29	33	15123	8480	-0.53
1985/86	1270	511	824	145	102	128	71	226	33	14391	15532	0.13
1986/87	7713	969	365	551	91	62	77	43	156	14495	12992	-0.06
1987/88	559	5914	701	243	340	55	37	46	119	30665	27016	-0.08
1988/89	485	425	4310	488	159	214	34	23	103	31137	32335	0.09
1989/90	1545	365	300	2835	281	85	107	17	63	28761	31047	0.13
1990/91	7706	1182	257	200	1738	160	46	58	44	21790	20156	-0.03
1991/92	939	5905	799	158	112	924	82	24	52	31714	46038	0.42
1992/93	1692	706	4106	518	96	66	531	47	44	31569	39713	0.28
1993/94	470	1277	488	2585	298	52	33	270	46	28633	29780	0.09
1994/95	1569	350	790	296	1411	154	25	16	155	17612	18918	0.12
1995/96	5587	1200	227	452	150	681	72	12	80	15717	17941	0.18
1996/97	5174	4242	840	143	265	86	387	41	52	23429	25208	0.12
1997/98	1247	3963	2998	568	93	167	53	240	58	27792	29385	0.11
1998/99	2418	952	2664	1850	327	51	86	28	154	29269	28924	0.04
1999/00	668	1852	669	1731	1118	190	25	43	90	29521	23811	-0.17
2000/01	594	510	1291	433	1052	657	108	14	75	25392	24012	-0.01

Estimated average availability at age (S_i): 0.15 0.56 0.78 0.96 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.00 0.03 0.21 0.50 0.76 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.95

Estimated instantaneous natural mortality rate is 0.264

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 RASM analysis for the Strait of Georgia stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	17576	8121	3061	677	133	45	0	0	0	24916	66064	0.68
1951/52	20182	10095	2931	831	178	34	12	0	0	27982	66048	0.57
1952/53	35275	11321	3774	784	215	45	9	3	0	58061	100512	0.26
1953/54	21712	20451	6146	1986	411	113	24	5	2	37948	90437	0.58
1954/55	12274	12552	9425	1566	488	99	27	6	1	77226	74225	-0.33
1955/56	11270	6892	4554	3278	534	165	33	9	2	28503	29493	-0.26
1956/57	9417	6174	2090	976	669	106	33	7	2	17461	28997	0.22
1957/58	24936	5423	1213	410	181	120	19	6	2	12408	20357	0.20
1958/59	17519	14360	2249	333	109	47	31	5	2	29764	44280	0.11
1959/60	8934	9413	5438	608	87	28	12	8	2	31828	37222	-0.13
1960/61	21954	4805	2856	1299	139	20	6	3	2	19273	25521	-0.01
1961/62	19220	11599	1781	657	286	30	4	1	1	20717	23282	-0.17
1962/63	19021	10728	3228	351	122	52	5	1	0	13907	27751	0.40
1963/64	9322	10094	3406	499	50	17	7	1	0	12238	20366	0.22
1964/65	4523	5096	2495	415	54	5	2	1	0	19262	18627	-0.32
1965/66	4037	2115	1062	539	85	11	1	0	0	3720	5109	0.03
1966/67	2808	1801	471	106	47	7	1	0	0	4331	6344	0.09
1967/68	1617	487	190	59	12	5	1	0	0	7354	12021	0.20
1968/69	4771	853	244	96	30	6	2	0	0	13485	18207	0.01
1969/70	5492	2733	477	136	54	17	3	1	0	28498	44195	0.15
1970/71	4312	3170	1557	272	78	31	9	2	1	25661	47312	0.32
1971/72	5951	2496	1800	865	151	43	17	5	2	23997	25875	-0.22
1972/73	9480	3392	1195	797	378	66	19	7	3	19007	18255	-0.33
1973/74	12393	5512	1860	527	331	154	27	8	4	43109	64619	0.11
1974/75	9187	7195	3153	1004	254	147	66	11	5	60213	76691	-0.05
1975/76	16136	5340	4110	1683	454	108	62	28	7	42814	57133	0.00
1976/77	12106	9365	3037	2073	720	158	36	21	12	60427	58003	-0.33
1977/78	6500	7015	5019	1463	880	284	60	14	12	54612	97082	0.28
1978/79	9276	3764	3638	2290	573	312	97	21	9	42525	59041	0.04
1979/80	7268	5383	2038	1644	894	208	111	35	11	50493	74847	0.10
1980/81	5859	4224	3043	1123	838	427	98	52	21	47418	48230	-0.27
1981/82	4436	3381	2268	1556	513	353	175	40	30	40485	90239	0.51
1982/83	3808	2552	1753	1112	704	205	131	65	26	21450	47423	0.50
1983/84	6080	2194	1247	656	309	173	41	26	18	17294	27587	0.18
1984/85	8975	3496	1097	500	181	67	36	9	9	24205	26629	-0.20
1985/86	5047	5134	1867	503	180	55	19	10	5	44809	61097	0.02
1986/87	15375	2931	2961	1076	290	104	31	11	9	35194	39037	-0.19
1987/88	4676	8911	1573	1458	435	95	28	9	5	48670	25351	-0.94
1988/89	11844	2712	5026	793	638	173	35	10	5	46751	54078	-0.15
1989/90	6045	6866	1535	2653	353	257	65	13	6	65122	58912	-0.39
1990/91	15416	3516	3951	844	1257	148	103	26	8	48932	43420	-0.41
1991/92	11118	8955	1996	2055	377	501	56	39	13	62752	80120	-0.05
1992/93	11694	6449	4929	1000	874	144	184	20	19	74196	84961	-0.16
1993/94	5552	6724	3518	2479	436	344	53	68	15	57063	60862	-0.23
1994/95	10625	3203	3634	1705	976	138	99	15	24	48918	59708	-0.09
1995/96	15574	6132	1754	1804	717	376	50	36	14	57309	76291	-0.01
1996/97	17244	8944	3168	865	771	271	137	18	18	55487	53442	-0.33
1997/98	8340	9945	4641	1504	350	257	83	42	11	56033	68699	-0.09
1998/99	13579	4822	5419	2313	634	117	59	19	12	56620	70165	-0.08
1999/00	14954	7853	2635	2737	1025	238	38	19	10	55951	67694	-0.10
2000/01	7720	8595	4245	1320	1210	354	69	11	9	64944	92830	0.07

Estimated average availability at age (S_i):0.13 0.73 0.96 0.99 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 0.57 0.85 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.34

Estimated instantaneous natural mortality rate is 0.542

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 RASM analysis for the west coast Vancouver Island stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	2777	1920	2355	347	88	21	0	0	0	17737	17006	-0.37
1951/52	3699	1701	666	881	121	30	7	0	0	2054	14383	1.61
1952/53	6538	2536	720	80	64	9	2	1	0	16064	30676	0.32
1953/54	2989	4537	1759	500	56	45	6	2	0	5045	16554	0.86
1954/55	5021	1971	699	232	42	5	4	1	0	15359	17555	-0.20
1955/56	5511	3378	1000	365	118	21	2	2	0	20530	45167	0.46
1956/57	6790	3631	1377	430	149	48	9	1	1	32158	52651	0.16
1957/58	9329	4705	2353	897	279	96	31	6	1	45904	24399	-0.96
1958/59	6917	6467	3239	1618	616	191	66	21	5	12989	18396	0.02
1959/60	3607	4544	1759	565	212	80	25	9	3	4482	7040	0.12
1960/61	8724	2116	761	205	39	14	5	2	1	5120	7912	0.10
1961/62	3688	5021	528	136	28	5	2	1	0	17311	34579	0.36
1962/63	4835	2461	1744	189	45	9	2	1	0	8559	14618	0.20
1963/64	1751	3330	1051	492	47	11	2	0	0	12138	27862	0.50
1964/65	1446	1171	1234	329	138	13	3	1	0	7110	10863	0.09
1965/66	1585	979	431	327	75	32	3	1	0	3631	4584	-0.10
1966/67	349	1098	431	100	63	15	6	1	0	3697	5119	-0.01
1967/68	705	117	179	88	16	10	2	1	0	7445	11277	0.08
1968/69	3486	489	81	124	61	11	7	2	1	8048	11206	0.00
1969/70	7050	2419	340	56	86	42	8	5	2	25080	34923	0.00
1970/71	5826	4892	1679	236	39	60	29	5	5	23326	32477	0.00
1971/72	7153	4043	3395	1165	164	27	42	20	7	47598	36070	-0.61
1972/73	7746	4948	2716	2085	708	99	16	25	17	57079	16218	-1.59
1973/74	12452	5368	3080	1480	1094	369	52	9	22	77534	24775	-1.47
1974/75	5194	8559	3275	1822	817	589	197	28	16	95784	44594	-1.10
1975/76	3195	3597	5222	1876	943	416	298	100	22	53551	63335	-0.16
1976/77	5270	2215	2369	2578	698	318	138	99	41	40825	57398	0.01
1977/78	1582	3651	1397	1150	1064	260	116	50	51	35073	39931	-0.20
1978/79	3288	1092	2260	779	466	345	74	33	29	22818	63664	0.69
1979/80	2330	2276	646	1120	284	143	101	22	18	28787	62619	0.45
1980/81	1246	1613	1509	418	671	156	77	54	21	27348	58519	0.43
1981/82	932	850	956	870	207	311	68	33	33	20910	29424	0.01
1982/83	1628	640	535	575	469	99	137	30	29	13173	15329	-0.18
1983/84	3373	1109	331	251	228	174	35	49	21	13818	22143	0.14
1984/85	3442	2232	585	160	112	100	76	15	30	29397	29130	-0.34
1985/86	1399	2386	1541	404	111	77	69	52	31	39363	38347	-0.36
1986/87	8439	970	1647	1064	279	76	53	48	58	26474	29914	-0.21
1987/88	1455	5712	509	763	452	117	32	22	44	34429	39289	-0.20
1988/89	1797	993	3559	283	400	235	61	17	34	34519	43332	-0.10
1989/90	1036	1228	570	1881	136	185	107	28	23	29137	38338	-0.06
1990/91	3219	716	701	311	967	69	93	54	26	19051	25906	-0.02
1991/92	1663	2202	392	362	147	438	31	41	35	21097	36811	0.23
1992/93	1228	1150	1404	235	209	84	249	17	44	21122	29236	-0.01
1993/94	573	834	669	782	128	114	46	136	33	15463	19764	-0.09
1994/95	949	385	479	348	384	61	54	22	80	13273	25039	0.30
1995/96	4791	657	243	284	203	224	36	31	59	12570	31929	0.60
1996/97	1419	3307	430	152	176	126	139	22	56	19384	39114	0.37
1997/98	845	967	1785	220	76	87	63	69	39	13161	36898	0.70
1998/99	1028	572	541	858	96	27	27	19	33	10521	18829	0.25
1999/00	1976	708	311	278	404	44	11	11	21	10199	10940	-0.26
2000/01	1395	1364	465	191	161	224	24	6	17	15841	13593	-0.48

Estimated average availability at age (S_i): 0.11 0.72 0.92 1.00 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.00 0.04 0.30 0.66 0.87 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.39

Estimated instantaneous natural mortality rate is 0.365

Appendix table 3.1. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from RASM,2q analysis for the Queen Charlotte Is. stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	2893	2175	1119	225	126	53	0	0	0	4878	2510	0.19
1951/52	4803	1752	1280	545	99	53	22	0	0	5739	2398	-0.02
1952/53	22473	2765	878	490	160	26	14	6	0	11136	4759	0.00
1953/54	2736	13612	1675	532	297	97	16	8	4	19643	9853	0.16
1954/55	3274	1650	8139	980	307	170	56	9	7	39445	6143	-1.01
1955/56	1129	1982	998	4900	589	184	102	33	9	7188	4014	0.27
1956/57	3530	681	545	269	664	49	15	9	4	1847	1578	0.69
1957/58	6240	1861	89	143	34	48	4	1	1	2520	787	-0.31
1958/59	1236	2169	806	25	22	4	5	0	0	8638	6940	0.63
1959/60	4497	738	891	387	11	9	1	2	0	15136	6469	0.00
1960/61	5216	2724	447	540	235	7	6	1	1	14129	6975	0.14
1961/62	8372	3157	1625	266	319	138	4	3	1	13006	4654	-0.18
1962/63	2720	5055	1722	778	114	130	56	2	2	16343	6177	-0.12
1963/64	6375	1644	2558	765	295	40	46	20	1	5732	4224	0.54
1964/65	361	3843	698	786	144	42	6	7	3	2804	1446	0.19
1965/66	235	174	188	173	82	7	2	0	0	3621	2764	0.58
1966/67	721	94	69	89	72	33	3	1	0	2772	710	-0.51
1967/68	990	437	53	40	50	40	18	2	1	2589	750	-0.39
1968/69	2114	598	263	31	23	29	24	11	1	4390	1876	0.00
1969/70	4633	1280	362	159	19	14	18	14	7	10078	4307	0.00
1970/71	5367	2806	776	219	97	11	9	11	13	31859	13616	0.00
1971/72	11886	3251	1700	470	133	58	7	5	14	19491	9950	0.18
1972/73	10325	7191	1879	920	242	67	30	4	10	26211	7706	-0.37
1973/74	8944	6253	4143	974	445	114	32	14	6	39690	9903	-0.54
1974/75	2484	5417	3644	2294	518	232	59	16	11	48527	8950	-0.84
1975/76	3092	1501	3140	2021	1223	271	122	31	14	39879	15142	-0.12
1976/77	3441	1869	889	1632	959	553	122	55	20	32125	12516	-0.09
1977/78	2078	2083	985	447	753	427	246	55	34	20690	11452	0.26
1978/79	35595	1258	1105	479	186	290	161	93	33	12070	8657	0.52
1979/80	2519	21539	745	525	184	65	100	55	43	43872	21204	0.12
1980/81	1030	1525	12860	436	278	91	32	49	48	62408	19024	-0.34
1981/82	941	623	912	7426	238	143	46	16	49	59773	19009	-0.30
1982/83	5991	568	369	535	4270	134	78	25	35	46376	19083	-0.04
1983/84	2511	3614	328	210	295	2310	72	42	33	35320	20438	0.30
1984/85	543	1514	2077	185	114	158	1232	38	40	26844	14394	0.23
1985/86	1056	325	870	1129	94	56	76	591	38	21718	5637	-0.50
1986/87	10422	640	192	484	598	49	29	39	323	15575	13132	0.68
1987/88	3126	6310	374	108	263	320	26	15	194	18888	14457	-0.27
1988/89	1087	1893	3821	226	65	159	194	16	127	28681	23985	-0.18
1989/90	493	656	1126	2242	131	38	92	112	82	22525	25011	0.10
1990/91	3454	298	358	595	1081	60	17	41	86	12865	14220	0.10
1991/92	223	2067	165	179	269	460	25	7	52	10767	9500	-0.13
1992/93	129	133	1150	84	84	122	209	11	27	6643	5405	-0.21
1993/94	420	77	71	534	34	32	47	81	15	4949	4895	-0.01
1994/95	1689	248	42	37	261	16	15	22	45	4872	4946	0.02
1995/96	2322	1023	150	26	22	158	10	9	41	6267	5827	-0.07
1996/97	6320	1406	619	91	15	13	95	6	30	7321	11686	0.47
1997/98	389	3822	844	366	53	9	8	56	21	10071	18871	0.63
1998/99	2251	235	2187	455	188	27	5	4	39	10297	9714	-0.06
1999/00	3062	1352	135	1102	208	77	10	2	16	9061	5119	-0.57
2000/01	2628	1842	773	69	527	96	36	5	8	13070	14112	0.08

Estimated average availability at age (S_i): 0.10 0.40 0.64 0.90 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.01 0.04 0.22 0.57 0.80 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.43, 1.00

Estimated instantaneous natural mortality rate is 0.50

Appendix table 3.2. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from RASM,2q analysis for the Prince Rupert stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	4475	5794	7977	1170	430	228	0	0	0	23198	30098	0.55
1951/52	4390	2889	3234	3094	360	114	60	0	0	9469	18725	0.97
1952/53	9536	2830	1654	928	555	44	14	7	0	30193	26180	0.14
1953/54	2728	6524	1882	1093	608	361	29	9	5	9711	13290	0.60
1954/55	7323	1818	3801	624	258	113	67	5	3	13405	25629	0.93
1955/56	2786	4971	1169	1604	219	81	35	21	2	34634	15498	-0.52
1956/57	4489	1802	2803	681	890	118	44	19	13	12852	28279	1.07
1957/58	9820	2806	816	1047	197	218	29	11	8	31088	12044	-0.66
1958/59	3063	6482	1769	512	639	119	131	17	11	36107	36608	0.30
1959/60	17412	2069	3938	1045	289	353	65	72	16	35282	19072	-0.33
1960/61	8069	10873	1284	2096	513	136	166	31	41	31038	12881	-0.59
1961/62	3873	5124	5070	540	732	160	42	52	22	36159	24760	-0.09
1962/63	13263	2592	2919	2559	246	315	69	18	32	29657	15652	-0.35
1963/64	2154	7615	1281	1273	944	82	105	23	17	38936	29266	0.00
1964/65	414	1375	3484	649	584	409	36	45	17	13541	6710	-0.42
1965/66	559	137	609	1229	171	126	88	8	13	7479	7487	0.29
1966/67	1125	383	47	245	399	48	36	25	6	3116	2719	0.15
1967/68	838	358	67	15	56	70	9	6	5	5015	4788	0.24
1968/69	3269	441	186	38	8	29	37	4	6	1994	843	-0.58
1969/70	2028	2230	293	105	20	4	15	19	5	11440	8437	-0.02
1970/71	1057	1359	1431	187	66	13	3	9	15	13536	9753	-0.04
1971/72	4488	702	770	860	108	37	7	1	14	12449	9853	0.05
1972/73	2783	3072	466	432	453	55	19	4	8	16574	11261	-0.10
1973/74	1739	1904	2067	300	273	284	35	12	7	22199	8893	-0.63
1974/75	627	1190	1274	1295	172	152	158	19	11	23774	11109	-0.48
1975/76	1527	428	803	832	835	110	97	101	19	24335	14213	-0.25
1976/77	694	1045	291	495	496	488	64	57	70	16110	9736	-0.22
1977/78	708	475	652	156	240	227	222	29	58	8814	4738	-0.34
1978/79	9951	480	285	317	60	80	74	73	29	6416	7554	0.45
1979/80	1491	6804	291	146	139	24	31	29	40	14719	10236	-0.08
1980/81	2026	1019	4464	174	73	63	11	14	31	24170	10532	-0.55
1981/82	2434	1385	667	2830	104	41	36	6	25	26849	12631	-0.47
1982/83	7896	1661	913	435	1820	67	26	23	20	30773	19652	-0.16
1983/84	1467	5404	1136	625	298	1245	46	18	29	29845	22927	0.02
1984/85	1367	1003	3636	746	396	180	716	26	27	31633	35858	0.41
1985/86	4987	935	663	2310	444	216	89	353	26	31289	32525	0.32
1986/87	4172	3408	596	405	1274	230	107	44	188	28587	31422	0.38
1987/88	2294	2854	2256	380	233	666	113	53	114	25415	33679	0.28
1988/89	1259	1568	1844	1402	213	109	276	47	69	23385	12783	-0.60
1989/90	5398	860	996	1131	764	91	39	100	42	23346	19398	-0.19
1990/91	6268	3693	552	629	669	415	46	20	72	25442	21544	-0.17
1991/92	1442	4288	2424	351	374	376	215	24	48	28981	35992	0.22
1992/93	677	986	2842	1566	199	184	166	95	32	26199	21440	-0.20
1993/94	1814	463	642	1774	894	91	69	62	47	19757	13439	-0.39
1994/95	6761	1239	302	395	1017	469	38	29	46	17366	15858	-0.09
1995/96	2975	4623	827	195	242	598	257	21	41	28454	22104	-0.25
1996/97	4464	2035	3084	545	120	123	278	119	29	20075	20744	0.03
1997/98	1260	3054	1371	2020	306	45	23	53	28	23965	16734	-0.36
1998/99	3508	862	2048	901	1239	165	7	4	12	25044	25699	0.03
1999/00	6746	2400	583	1339	569	730	88	4	9	23196	15658	-0.39
2000/01	953	4612	1577	374	794	315	354	43	6	28798	33335	0.15

Estimated average availability at age (S_i): 0.10 0.48 0.71 0.90 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.00 0.01 0.16 0.44 0.70 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.75, 1.00

Estimated instantaneous natural mortality rate is 0.379

Appendix table 3.3. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from RASM,2q analysis for the Central Coast stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	1789	3210	4126	753	304	78	0	0	0	16326	23134	0.50
1951/52	2905	1276	1493	1458	194	73	19	0	0	4346	10709	1.06
1952/53	14787	2068	453	365	179	19	7	2	0	11003	20001	0.75
1953/54	1685	11190	1547	328	261	128	14	5	1	10341	18635	0.74
1954/55	1750	1126	5806	501	72	53	26	3	1	31476	14984	-0.59
1955/56	3949	1247	764	3490	283	40	29	14	2	7694	8244	0.23
1956/57	5422	2326	408	197	486	33	5	3	2	3501	6223	0.73
1957/58	6225	3750	676	106	28	59	4	1	1	11346	4226	-0.83
1958/59	1560	4388	1999	325	44	11	24	2	0	4957	4105	-0.03
1959/60	3287	1082	2030	549	52	6	2	3	0	24435	14684	-0.35
1960/61	8027	2254	715	1384	365	34	4	1	2	6750	4567	-0.23
1961/62	4656	5648	849	212	259	61	6	1	1	14231	14180	0.15
1962/63	4205	3386	3441	409	88	104	24	2	0	5922	8466	0.51
1963/64	2342	3171	1512	894	58	10	12	3	0	6055	7058	0.31
1964/65	1822	1352	862	399	131	7	1	2	0	3237	2365	-0.16
1965/66	5204	1277	568	231	60	17	1	0	0	2079	1773	0.00
1966/67	2139	1073	104	116	17	3	1	0	0	3721	5904	0.62
1967/68	462	322	162	29	20	3	0	0	0	4811	6366	0.44
1968/69	1701	278	194	103	18	12	2	0	0	3666	2331	-0.30
1969/70	1725	1287	209	144	76	13	9	1	0	12587	10134	-0.06
1970/71	2076	1295	966	157	107	56	10	7	1	14993	6056	-0.75
1971/72	3299	1531	870	628	98	66	35	6	5	10752	3928	-0.85
1972/73	2123	2466	944	422	262	39	27	14	4	20878	14471	-0.21
1973/74	2976	1601	1608	569	231	140	21	14	10	18051	10624	-0.37
1974/75	1415	2246	1161	966	273	97	56	8	10	23609	9164	-0.79
1975/76	725	1068	1607	741	505	129	44	26	8	18801	16133	0.00
1976/77	861	535	752	975	348	204	48	17	13	17536	18481	0.21
1977/78	632	650	341	453	466	142	80	19	12	6279	10097	0.63
1978/79	5990	478	386	159	107	56	13	7	3	7658	6551	0.00
1979/80	1117	4535	362	292	121	81	42	10	8	22592	15979	-0.19
1980/81	1156	846	3430	272	212	84	55	29	12	28390	16949	-0.36
1981/82	542	874	636	2502	182	129	45	30	22	30930	18413	-0.36
1982/83	459	407	628	442	1568	109	72	26	29	23941	16618	-0.21
1983/84	1697	347	296	435	279	935	63	42	32	15212	14197	0.09
1984/85	730	1273	242	188	245	143	458	31	36	16106	8480	-0.49
1985/86	1370	547	877	154	108	135	76	243	35	15280	15532	0.17
1986/87	8292	1031	386	582	96	66	81	46	167	15323	12992	-0.01
1987/88	597	6271	737	255	357	58	39	48	127	31936	27016	-0.17
1988/89	515	448	4516	508	165	224	36	24	109	32425	32335	0.00
1989/90	1635	382	312	2944	291	88	111	18	66	29785	31047	0.04
1990/91	8136	1234	266	207	1791	165	48	60	46	22427	20156	-0.11
1991/92	985	6149	827	162	115	950	85	25	55	32452	46038	0.35
1992/93	1760	731	4231	532	98	67	542	48	45	32300	39713	0.21
1993/94	488	1311	500	2642	303	53	34	275	48	29187	29780	0.02
1994/95	1620	359	805	301	1433	156	26	17	157	17826	18918	0.06
1995/96	5704	1222	231	457	152	688	73	12	81	15746	17941	0.13
1996/97	5196	4272	845	143	265	86	387	41	52	23160	25208	0.08
1997/98	1227	3925	2978	563	92	165	53	237	57	27118	29385	0.08
1998/99	2327	923	2597	1808	319	50	83	27	149	27959	28924	0.03
1999/00	631	1757	637	1656	1068	181	24	40	84	27403	23811	-0.14
2000/01	553	476	1200	403	977	608	99	13	68	22695	24012	0.06

Estimated average availability at age (S_i): 0.15 0.56 0.78 0.96 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 0.50 0.76 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.86, 1.00

Estimated instantaneous natural mortality rate is 0.278

Appendix table 3.4. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from RASM, 2q analysis for the Strait of Georgia stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1										
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	16950	7921	2991	658	128	43	0	0	0	22648	66064	0.60
1951/52	19490	9754	2833	797	167	31	11	0	0	25041	66048	0.50
1952/53	34115	10949	3614	742	199	40	8	3	0	53909	100512	0.15
1953/54	21041	19821	5945	1898	388	104	21	4	1	34382	90437	0.50
1954/55	11805	12191	9144	1503	456	90	24	5	1	71142	74225	-0.43
1955/56	10777	6638	4397	3151	504	150	29	8	2	25412	29493	-0.32
1956/57	9095	5910	1996	932	624	95	28	6	2	15726	28997	0.14
1957/58	24233	5250	1170	396	171	108	16	5	1	11022	20357	0.14
1958/59	17029	13985	2165	313	101	42	27	4	2	26239	44280	0.05
1959/60	8684	9161	5281	570	79	24	10	6	1	28246	37222	-0.20
1960/61	21430	4676	2760	1234	126	17	5	2	2	16935	25521	-0.06
1961/62	18731	11343	1731	620	260	25	3	1	1	17800	23282	-0.20
1962/63	18570	10474	3148	330	109	43	4	1	0	12162	27751	0.35
1963/64	9253	9875	3332	484	45	14	5	1	0	10519	20366	0.19
1964/65	4445	5074	2443	407	51	4	1	0	0	16684	18627	-0.36
1965/66	4146	2075	1051	505	78	9	1	0	0	3088	5109	0.03
1966/67	2663	1875	458	106	42	5	1	0	0	3682	6344	0.07
1967/68	1506	473	172	56	11	4	0	0	0	6219	12021	0.19
1968/69	4493	799	230	85	27	5	2	0	0	11289	18207	0.01
1969/70	5205	2577	447	128	47	15	3	1	0	25122	44195	0.09
1970/71	4121	3014	1466	254	73	27	9	2	1	23462	47312	0.23
1971/72	5659	2390	1713	814	141	40	15	5	1	21848	25875	-0.30
1972/73	9029	3230	1138	749	350	60	17	6	3	17246	18255	-0.42
1973/74	11878	5261	1770	495	305	139	24	7	4	38673	64619	0.04
1974/75	8834	6912	3015	953	236	133	59	10	4	55911	76691	-0.16
1975/76	15551	5147	3954	1607	428	99	55	24	6	39888	57133	-0.11
1976/77	11648	9046	2932	1989	681	145	32	18	10	56474	58003	-0.45
1977/78	6243	6764	4848	1406	837	264	55	12	10	50975	97082	0.17
1978/79	8924	3623	3505	2202	545	291	89	18	8	39535	59041	-0.07
1979/80	7019	5190	1961	1575	849	193	101	31	9	47437	74847	-0.02
1980/81	5681	4088	2937	1081	800	403	90	47	19	44577	48230	-0.39
1981/82	4310	3285	2196	1501	491	333	163	37	27	38104	90239	0.39
1982/83	3707	2484	1703	1075	675	194	122	60	23	20115	47423	0.39
1983/84	5979	2140	1215	637	297	163	38	24	16	16267	27587	0.06
1984/85	8964	3445	1070	486	174	63	33	8	8	22903	26629	-0.32
1985/86	5144	5139	1842	489	173	52	18	9	5	43076	61097	-0.12
1986/87	15874	2994	2971	1064	282	100	30	10	8	34455	39037	-0.35
1987/88	4874	9222	1615	1470	433	93	27	8	5	49084	25351	-0.66
1988/89	12351	2834	5219	820	650	174	35	10	5	47783	54078	0.12
1989/90	6320	7177	1609	2772	370	265	66	13	6	67876	58912	-0.14
1990/91	16140	3684	4141	888	1323	156	108	27	8	50937	43420	-0.16
1991/92	11734	9397	2098	2167	401	533	59	41	13	66019	80120	0.19
1992/93	12488	6822	5194	1061	934	155	199	22	20	77887	84961	0.09
1993/94	6037	7202	3740	2636	468	373	58	75	16	60392	60862	0.01
1994/95	11679	3493	3917	1832	1053	150	110	17	27	52596	59708	0.13
1995/96	17832	6760	1926	1969	786	414	56	41	16	63400	76291	0.19
1996/97	20939	10279	3534	966	862	306	156	21	22	62432	53442	-0.16
1997/98	10690	12121	5419	1716	404	301	99	50	14	65523	68699	0.05
1998/99	18443	6203	6696	2765	754	145	77	25	16	70310	70165	0.00
1999/00	20842	10707	3446	3481	1290	306	52	28	15	74457	67694	-0.10
2000/01	11316	12048	5918	1792	1644	502	105	18	15	94058	92830	-0.01

Estimated average availability at age (S_i): 0.12 0.71 0.94 0.97 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries:0.00 0.02 0.22 0.58 0.85 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.60, 1.00

Estimated instantaneous natural mortality rate is 0.539

Appendix table 3.5. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from RASM, 2q analysis for the west coast Vancouver Island stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	3624	2143	2625	384	97	23	0	0	0	19052	17006	-0.17
1951/52	4907	2108	732	978	132	33	8	0	0	2540	14383	1.68
1952/53	8117	3116	903	103	86	11	3	1	0	18425	30676	0.45
1953/54	4208	5204	1997	579	66	55	7	2	0	6736	16554	0.84
1954/55	6919	2597	930	316	61	7	6	1	0	20253	17555	-0.20
1955/56	7793	4336	1317	485	161	31	3	3	0	27844	45167	0.43
1956/57	8971	4812	1857	594	209	69	13	1	1	40161	52651	0.22
1957/58	11531	5745	2926	1136	362	127	42	8	2	52871	24399	-0.83
1958/59	8206	7387	3659	1862	722	230	81	27	6	14620	18396	0.17
1959/60	4282	5003	1978	676	253	94	30	11	4	5666	7040	0.16
1960/61	10563	2360	822	270	56	19	7	2	1	6382	7912	0.16
1961/62	4643	5775	602	167	42	8	3	1	1	21238	34579	0.43
1962/63	6064	2882	2019	225	57	14	3	1	1	10340	14618	0.29
1963/64	2187	3863	1213	610	60	15	4	1	0	14904	27862	0.57
1964/65	1729	1359	1431	403	183	18	4	1	0	9115	10863	0.12
1965/66	1878	1086	503	420	103	46	4	1	0	5211	4584	-0.18
1966/67	713	1202	463	138	99	24	11	1	0	4862	5119	0.00
1967/68	1290	339	225	109	26	18	4	2	0	10674	11277	0.00
1968/69	6102	827	217	144	70	17	12	3	1	10608	11206	0.00
1969/70	11511	3913	530	139	93	45	11	8	3	33060	34923	0.00
1970/71	9078	7381	2509	340	89	59	29	7	7	30749	32477	0.00
1971/72	10815	5821	4733	1609	218	57	38	18	9	61279	36070	-0.58
1972/73	11382	6919	3643	2766	930	126	33	22	16	72495	16218	-1.55
1973/74	18027	7290	4082	1932	1419	474	64	17	19	95192	24775	-1.40
1974/75	7706	11476	4221	2299	1026	737	245	33	19	114054	44594	-0.99
1975/76	4812	4933	6632	2304	1150	505	362	120	25	64647	63335	-0.08
1976/77	8127	3083	3034	3183	867	398	173	123	50	49755	57398	0.09
1977/78	2497	5205	1834	1440	1310	327	147	64	64	43036	39931	-0.13
1978/79	5272	1596	3067	983	585	440	99	45	39	30061	63664	0.70
1979/80	3625	3374	912	1508	376	195	141	32	27	36894	62619	0.47
1980/81	1954	2320	2094	554	862	201	102	74	31	35508	58519	0.44
1981/82	1460	1238	1327	1167	274	405	90	46	47	27138	29424	0.03
1982/83	2664	930	740	763	615	131	183	41	42	18319	15329	-0.23
1983/84	5577	1688	485	355	322	246	51	71	32	20226	22143	0.04
1984/85	5459	3469	900	242	166	149	113	23	48	40538	29130	-0.39
1985/86	2146	3497	2216	575	154	106	95	72	45	50884	38347	-0.34
1986/87	13445	1375	2234	1416	367	99	68	61	75	35499	29914	-0.23
1987/88	2304	8477	719	1053	622	159	43	29	59	46070	39289	-0.16
1988/89	2867	1461	5032	391	547	320	82	22	45	47043	43332	-0.08
1989/90	1673	1820	818	2637	190	259	150	38	31	40127	38338	-0.05
1990/91	5281	1070	1015	440	1352	96	131	76	35	27140	25906	-0.05
1991/92	2665	3355	581	526	213	634	45	60	51	29447	36811	0.22
1992/93	1976	1705	2027	336	295	119	352	25	62	29176	29236	0.00
1993/94	923	1249	965	1109	180	158	64	189	47	21845	19764	-0.10
1994/95	1514	579	702	503	552	88	77	31	114	18343	25039	0.31
1995/96	7484	969	347	402	284	311	50	43	82	16620	31929	0.65
1996/97	2345	4781	595	206	236	167	183	29	73	25922	39114	0.41
1997/98	1435	1485	2562	305	103	117	83	91	51	18894	36898	0.67
1998/99	1857	906	824	1262	139	41	42	29	50	16062	18829	0.16
1999/00	3443	1185	496	433	623	67	18	19	36	15476	10940	-0.35
2000/01	2556	2201	734	294	246	344	37	10	30	22590	13593	-0.51

Estimated average availability at age (S_i): 0.09 0.68 0.89 0.99 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries: 0.00 0.04 0.31 0.67 0.88 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.06, 1.00

Estimated instantaneous natural mortality rate is 0.444