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Stock Assessment for British Columbia Herring in 1997 and Forecasts of the Potential Catch in 1998

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Science Branch, Pacific Region
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ABSTRACT

Schweigert, J. F., C. Fort, and R. Tanasichuk. 1998. Stock assessments for British Columbia herring in 1997 and forecasts of the potential catch in 1998. Can. Tech. Rep. Fish. Aquat. Sci. 2217: 64 p.

Herring stock abundance in British Columbia waters was assessed for 1997 and forecasts were made for 1998 using two analytical methods: (1) escapement model; and (2) age-structured model. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 1997 was 189,800 tonnes which represents an 9% increase over 1996 abundance levels. This increase reflects the recruitment of an above average 1994 year-class in 1997 in all assessment areas.

Forecasts of the pre-fishery spawning stock biomass in 1998 are obtained by weighting the estimates from the two analytical models. Stock forecasts for the northern and southern stock assessment regions are 98,300 and 112,800 tonnes assuming average recruitment to all areas except the west coast of Vancouver Island where a poor recruitment is anticipated.

The recommended 1998 catch (20% of the 1998 forecast herring run) is 42,200 tonnes for the entire B.C. coast. Stock levels in all assessment regions are increasing except for the Strait of Georgia which is experiencing a slight decline.

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

RÉSUMÉ

Schweigert, J. F., C. Fort, and R. Tanasichuk. 1998. Stock assessments for British Columbia herring in 1997 and forecasts of the potential catch in 1998. Can. Tech. Rep. Fish. Aquat. Sci. 2217: 64 p.

L'abondance des stocks de hareng dans les eaux de la Colombie-Britannique a été évaluée pour 1997, et des prévisions ont été établies pour 1998 à l'aide de deux méthodes d'analyse: 1) modèle de l'échappée, et 2) modèle structuré selon l'âge. À l'échelle de la côte, pour toutes les zones d'évaluation, la biomasse du stock avant la pêche en 1997 a été estimée à 189,800 tonnes, ce qui représente une augmentation de 9% par rapport aux niveaux d'abondance de 1996. Cette hausse est attribuable au recrutement en 1997 de la classe de 1994, qui est supérieure à la moyenne, dans toutes les zones d'évaluation.

Pour 1998, les prévisions de la biomasse des géniteurs avant la pêche sont calculées par pondération des estimations des deux modèles d'analyse. Les prévisions pour les zones d'évaluation du nord et du sud sont respectivement de 98,300 et 112,800 tonnes, si l'on suppose un recrutement moyen dans toutes les zones sauf sur la côte ouest de l'île de Vancouver, où on prévoit un faible recrutement.

Le volume recommandé des captures pour 1998 (20% des retours prévus de hareng) est de 42,200 tonnes pour l'ensemble de la côte de Colombie-Britannique. Dans toutes les zones d'évaluation, les niveaux des stocks montent, sauf dans le détroit de Georgia qui connaît une légère baisse.

Mots clés: *Clupea pallasi*, hareng du Pacifique, évaluation des stocks, prévisions, analyse par structure d'âge.

1. INTRODUCTION

1.1 GENERAL

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

In 1972 herring fisheries for a roe product developed. These fisheries occur just prior to spawning when the fish are tightly schooled and highly aggregated. Initially the roe fisheries were managed in-season to fixed escapement targets (Hourston 1981). This management system was untenable because of problems in obtaining accurate in-season stock estimates, uncertainty about appropriate escapement targets, and difficulty in controlling fishing effort. Since 1983 herring fisheries have been managed with a fixed quota system. Under this system catch levels are determined prior to the season based on a fixed percentage (20%) of forecast stock abundance. In addition, a threshold biomass or Cutoff level was 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 1951-1997 and forecast pre-spawning abundance for the 1998 season. Forecasts of newly recruited spawners are presented as poor, average, and good, based on historical recruitment levels. Although a few studies have attempted to provide techniques for forecasting recruitment (e.g. Schweigert and Noakes 1991, Stocker and Noakes 1988), additional validation is required before implementing such an approach on a routine basis.

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 1997. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period starting in the early 1970s.

Of the three data sets, the spawn data contain the largest measurement errors. We feel that the quality of spawn surveys has improved greatly over the 46 year span of these observations. This improvement is a result of increased numbers of people and vessels being involved in spawn surveys, increased attention to data measurements, increased coverage of subtidal spawnings, and increased research on estimating egg deposition from spawn observations. The consistent observations made during all years of surveys are the length, the width, and a measure of intensity of spawnings. The escapement model estimates absolute egg numbers from these observations by employing mean width estimates from diving surveys to adjust surface width estimates and correct for the inability to adequately survey subtidal spawns from the surface. Since 1987 an increasing number of spawn beds have been surveyed using Scuba methods. We assume that these surveys provide reasonably accurate estimates of spawn bed width and egg density and these data have been used in the escapement model where available. All major herring spawnings were surveyed in 1997, although due to weather conditions a few areas on the west coast of Vancouver Island such as Hesquiat Harbour received reduced survey coverage.

Catch information was obtained from landing slip data. Both models use the landing slip data summed by season (seasons run from July 1 to June 30). The 1996/97 catch figures are based on hailed estimates because sales slip data are not available in time for analysis. The spawn-on-kelp (SOK) fishery includes a total of 39 licensed operators (expanded in-season during 1997 to 43) who pond a substantial quantity of herring of which an unknown quantity dies each year. Since 1990, it has been assumed that the 100 tons (91 tonnes) allocated to each license is killed and it is treated as additional seine catch.

Age structure data are used in both models. The information from catch samples is used for years when there were commercial fisheries. Pre-fishery charter samples are used in addition to catch samples for areas with no fisheries, or when catch samples are few in number or not representative of the entire catch. Additional data used in both models are annual mean weights-at-age. During the 1997 season a total of 344 herring samples were collected and processed compared to 366 in the previous year. Of these, 18 were taken in the Queen Charlotte Islands assessment area, 35 in the Prince Rupert area, 78 in the Central Coast, 95 in the Strait of Georgia, and 96 on the west coast of Vancouver Island, with the remaining 22 samples taken from minor stock areas. We believe that this provides minimal but adequate coverage of all the assessment regions for the age-structured and escapement model assessment analysis.

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

1.3 STOCK CONSIDERATIONS

The stock concept used for managing British Columbia herring is a compromise between biological and management considerations. Given poor or incomplete knowledge of population structure it is prudent to manage fisheries to ensure maintenance of the greatest potential diversity. Unfortunately, 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 for over-harvesting any small, spatially discrete spawning groups.

The stock groupings used for the current assessments are identical to those used since 1993 (Fig. 1.1). The Queen Charlotte Islands stock assessment region spans from Cumshewa Inlet in the north to Louscoone Inlet in the south. The stock concept for the Prince Rupert District encompasses Statistical Areas 3 to 5. The central coast stock management unit separates the major migratory stocks from the minor spawning populations in the mainland inlets. The areas included in the central coast assessment region are Statistical Area 7 plus Kitasoo 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. 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 any areas outside of the major assessment regions, 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 stock trends. Recent attempts to conduct a complete age-structured assessment for Areas 2W and 27 have been unsuccessful. However, an escapement model estimate of current stock abundance is available for these areas but no forecast of abundance in the coming year is possible.

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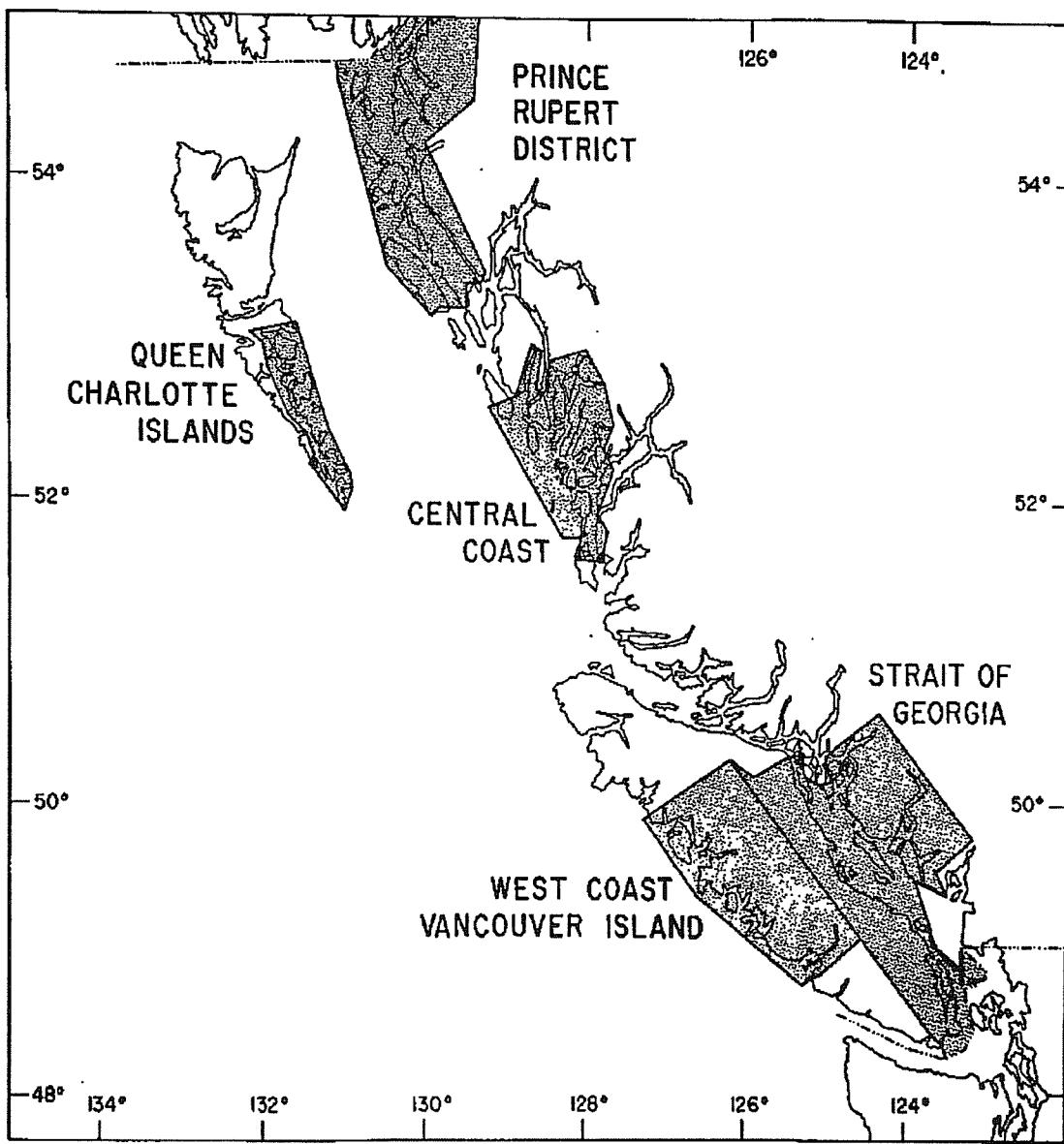


Fig. 1.1. Herring stock assessment regions in British Columbia.

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2. ESCAPEMENT MODEL

2.1 INTRODUCTION

The escapement model, developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988), is based on egg deposition information and provides a direct estimate of escapement from the fishery. For most stock assessment regions, recent estimates of escapement are based on a combination of surface and Scuba survey data. Scuba surveys have been used routinely since 1987 and an increasing proportion of the herring spawning beds have been surveyed using this technique. A summary of the recent spawn survey coverage for the British Columbia coast is presented below. As a result of reductions in DFO resources and the consequent contracting of diving surveys to industry there was virtually no DFO effort directed to surface surveys in 1997, particularly outside of the assessment regions. No surface surveys were conducted in the Queen Charlotte Islands, Prince Rupert District, and Central Coast assessment areas. However, these areas did receive good Scuba survey coverage. Limited surface surveys occurred in the Strait of Georgia, Johnstone Strait, and Central coast, primarily outside of the major stock areas. Coastwide there was a moderate increase in the total length of spawn surveyed by Scuba and surface surveys relative to 1996. Total length of spawn outside of the major assessment areas declined in 1997 probably reflecting the decline in effort rather than a real decline in abundance.

Summary of the kilometres of herring spawning beds surveyed by scuba and surface methods for major and minor stocks on the British Columbia coast in recent years, 1994-1997.

| Assessment Region | 1994 | | | 1995 | | | 1996 | | | 1997 | | |
|------------------------|-------|---------|-------|-------|---------|-------|-------|---------|-------|-------|---------|-------|
| | Scuba | Surface | Total |
| Queen Charlotte Is. | 36.5 | 3.6 | 40.1 | 20.7 | 2.4 | 23.1 | 25.3 | 0.0 | 25.3 | 36.4 | 0.0 | 36.4 |
| Prince Rupert District | 54.3 | 0.0 | 54.3 | 42.3 | 0.0 | 42.3 | 49.9 | 0.0 | 49.9 | 68.9 | 0.0 | 68.9 |
| Central Coast | 91.2 | 105.2 | 196.4 | 123.8 | 12.4 | 136.2 | 114.1 | 0.0 | 114.1 | 143.1 | 0.0 | 143.1 |
| Strait of Georgia | 116.7 | 0.3 | 117.0 | 133.8 | 1.3 | 135.1 | 128.4 | 3.1 | 131.5 | 119.9 | 3.3 | 123.1 |
| W.C. Vancouver Is. | 41.4 | 7.3 | 48.7 | 41.9 | 6.0 | 47.9 | 39.2 | 0.0 | 39.2 | 78.1 | 0.0 | 78.1 |
| Other Areas | 22.3 | 123.8 | 146.1 | 16.5 | 77.3 | 93.8 | 15.7 | 111.2 | 126.8 | 14.3 | 48.7 | 63.0 |
| Coastwide Total | 362.4 | 240.2 | 602.6 | 378.8 | 99.4 | 478.2 | 372.6 | 114.3 | 486.9 | 460.6 | 52.0 | 512.6 |

2.2 METHODS

In the escapement model, the forecast run size is based on the estimated escapement in the previous season, growth of the escaped fish during the current season, an age-specific apparent survival rate which accounts for both survival and partial recruitment of recruited year-classes, and an estimate of age 2⁺ recruitment to each stock. Recruitment is estimated for poor, average, and good levels by calculating the means of the third poorest, the middle third, and the third best recruitments observed during the historical time series from 1951-1997. Estimates of total catch (tonnes) and spawn abundance (billions of eggs) are converted to fish-at-age based on the sampling data for each area. For each area the age structure and average weight-at-age are calculated from samples available for that region. For some years no data are available for a region and information from an adjacent area is utilized in the analysis. Forecasts of repeat spawners and recruit fish are converted to forecast tonnages using predicted average weights-at-age as outlined in Haist and Schweigert (1990). The method for estimating escapement from surface and Scuba survey data is described below.

Pre-fishery Biomass and Spawn Index Estimates

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

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

where

B_j = total pre-fishery mature biomass in tonnes in year j ,

C_j = total catch in tonnes in year j ,

$Eggs_j$ = total egg deposition in billions in year j ,

P_{ij} = proportion of fish at age i in year j in the spawning run,

F_{ij} = fecundity of females of age i in year j ,

SR_{ij} = sex ratio or proportion of females at age i in year j ,

W_{ij} = mean weight of fish at age i in year j in tonnes.

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

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

Surface Surveys

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

To provide a consistent coastwide assessment of total egg deposition throughout the time period from 1951-1997, it was necessary to intercalibrate the surface and Scuba surveys of egg deposition. Initially, the intercalibration took the form of linear equations which converted the surface survey estimates of spawning bed width and egg layers to comparable Scuba estimates (Schweigert and Stocker 1988). However, the data available for this intercalibration were limited in time and space to particular spawning beds over the course of a few years. As Scuba surveys of the spawning beds became widespread, an extensive database of estimates of the dimensions of herring spawning beds in most areas of the coast became available and a new procedure for calibrating the width of herring spawning beds estimated by surface surveys was proposed (Schweigert et al. 1993). The methodology consisted of defining spawn pools which consisted of one or more geographically adjacent and geomorphologically similar herring spawning locations. Hence, diver width estimates developed for such a 'pool' were felt to be characteristic of all locations within that pool. For the small number of locations which could not be assigned to a pool, the median width for the section (Rosenfeld and Haist 1988) was used to adjust width estimates for the location. The median width was preferable to the mean because of the non-normal distribution of the spawn width estimates. Any pools for which fewer than 25 observations of median width existed were also adjusted using the section median. For the rare instances where no median estimate was available at the section level the median width for the assessment region was applied to calculate spawn area. The long term median spawn width for each pool was then applied to each surface survey record to estimate a 'diver' width and combined with the estimated surface length to determine the total area of egg deposition.

To estimate egg density we assumed that surface and dive survey estimates of the number of egg layers in a spawning bed were equivalent and employed the database of 5111 observations of egg density per square meter from laboratory egg counts of Scuba surveyed quadrat samples to develop a predictive model of egg density from egg layers:

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

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

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

Scuba Surveys

For Scuba surveys spawning bed lengths are determined by exploratory raking or snorkelling to define the limits of the areas of egg deposition and corresponding spawning bed widths are estimated as the mean of all transect lengths within the spawning bed. Estimates of mean egg density are based on a two-stage sampling design (Schweigert et al. 1985, 1990). Average egg density for each spawning area is estimated as the weighted mean of the means of a series of quadrats located along each transect. For each quadrat, observations are made on several variables: type of algal substrate; proportion of the quadrat covered by each algal type; number of layers of eggs on each algal type; proportion of the bottom substrate covered by eggs; and an estimate of the number of egg layers on the bottom substrate. In some areas, assessments are also made of the egg deposition on the giant kelp as described in a following section.

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

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

where

Eggs_{ij} = estimated number of eggs in thousands per m^2 on vegetation type i in quadrat j ,
 L_{ij} = number of layers of eggs on algal substrate i in quadrat j ,
 P_{ij} = proportion of quadrat covered by algal substrate i in quadrat j ,

V_{1j} = 0.9948 parameter for sea grasses in quadrat j ,
 V_{2j} = 1.2305 parameter for rockweed in quadrat j ,
 V_{3j} = 0.8378 parameter for flat kelp in quadrat j ,
 V_{4j} = 1.1583 parameter for other brown algae in quadrat j ,
 V_{5j} = 0.9824 parameter for leafy red and green algae in quadrat j ,
 V_{6j} = 1.0000 parameter for stringy red algae in quadrat j ,
 Q_1 = 0.5668 parameter for 1.00 m² quadrats,
 Q_2 = 0.5020 parameter for 0.50 m² quadrats,
 Q_3 = 1.0000 parameter for 0.25 m² quadrats.

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

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

Eggs on Bottom and *Macrocystis*

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

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

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

where

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

This equation estimates the number of eggs occurring on a plant of a specific

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

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

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

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

Enumerated Egg Samples

Since 1988 samples of algae and the attached eggs from entire quadrats were collected to validate model predictions of egg density relative to sample egg counts. Due to funding shortfalls, no samples were collected in 1997 and model predictions of egg numbers per sample quadrate were assumed to be unbiased for use in the assessment of egg density. A review and evaluation of the data from counted samples and corresponding visual estimates of egg layers collected to date will be presented in the next assessment.

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:

where

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

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

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

Comparison of the estimated numbers of returning fish at age with the escapement estimate the previous year indicated a tendency to underestimate recruitment and led to the adoption of the apparent survival rate. The apparent age-specific survival rate includes not only the effect of survival, but also factors such as: biases in estimates of the spawning stock, partial recruitment of the younger age classes, and inconsistencies in the age composition data. To ensure that forecasts of stock abundance are consistent with the observed data the geometric means of the age-specific apparent survivals for each stock assessment region were re-calculated for the entire the 1971-1997 roe period (Table 2.1) and are used to forecast 1998 abundance.

Table 2.1. Geometric mean age-specific apparent survival estimated for each stock assessment region over the roe fishery period, 1971-1997. Table 2.5. Geometric mean age-specific apparent survival estimated for each stock assessment region (SAR) over the roe fishery period, 1972-1995. Table 2.5. Geometric mean age-specific apparent survival estimated for each stock assessment region (SAR) over the roe fishery period, 1972-1995.2.5. Geometric mean age-specific apparent survival estimated for each stock assessment region (SAR) over the roe fishery period, 1972-1995.2.5. Geometric mean age-specific apparent survival estimated for each stock assessment region (SAR) over the roe fishery period, 1972-1995.

| Assessment Region | Age Class | | | | |
|---------------------|-------------|-------------|-------------|-------------|----------------|
| | $2^+ - 3^+$ | $3^+ - 4^+$ | $4^+ - 5^+$ | $5^+ - 6^+$ | $6^+ - 7^{++}$ |
| Queen Charlotte Is. | 1.46 | 1.23 | 1.01 | 0.88 | 0.53 |
| Prince Rupert | 1.32 | 1.22 | 1.13 | 0.89 | 0.58 |
| Central Coast | 1.45 | 1.25 | 1.03 | 0.90 | 0.60 |
| Georgia Strait | 0.82 | 0.68 | 0.59 | 0.56 | 0.43 |
| W.C. Vancouver Is. | 1.05 | 0.86 | 0.80 | 0.75 | 0.47 |

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

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

where

$B_{i+1,j+1}$ = forecast tonnes of mature biomass at age $i+1$ in year $j+1$,
 N_{ij} = estimated number of fish at age i in the escapement in year j ,
 A_{ij} = estimated apparent survival rate of fish at age i in year j ,
 $W_{i+1,j+1}$ = forecast average weight at age $i+1$ in year $j+1$.

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

2.3 RESULTS

Estimates of stock abundance and total catch (including all fisheries and spawn-on-kelp allocations) for the major stock assessment regions are presented in Tables 2.2 and 2.3. Estimates for 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 1971-1997.

| Season | Queen Charlotte Islands | | | Prince Rupert District | | | Central Coast | | |
|---------|-------------------------|-------|-------|------------------------|-------|-------|---------------|-------|-------|
| | Spawners | Catch | Stock | Spawners | Catch | Stock | Spawners | Catch | Stock |
| 1970/71 | 13616 | 102 | 13718 | 9751 | 3500 | 13252 | 6056 | 3614 | 9670 |
| 1971/72 | 9951 | 3972 | 13923 | 9852 | 4494 | 14346 | 3928 | 9279 | 13207 |
| 1972/73 | 7706 | 7520 | 15226 | 11260 | 1607 | 12867 | 14471 | 7799 | 22270 |
| 1973/74 | 9903 | 6318 | 16221 | 8893 | 3819 | 12712 | 10624 | 8887 | 19511 |
| 1974/75 | 8951 | 7724 | 16675 | 11109 | 1702 | 12811 | 9165 | 8739 | 17903 |
| 1975/76 | 15143 | 14116 | 29258 | 14213 | 4307 | 18520 | 16134 | 12411 | 28545 |
| 1976/77 | 12516 | 12635 | 25151 | 9736 | 8142 | 17877 | 18481 | 11106 | 29587 |
| 1977/78 | 11452 | 11726 | 23177 | 4738 | 8588 | 13325 | 10097 | 14046 | 24143 |
| 1978/79 | 8657 | 7953 | 16610 | 7554 | 4317 | 11871 | 6550 | 5 | 6555 |
| 1979/80 | 21204 | 3316 | 24520 | 10236 | 3425 | 13661 | 15978 | 538 | 16517 |
| 1980/81 | 19023 | 5631 | 24654 | 10532 | 3090 | 13622 | 16949 | 2573 | 19522 |
| 1981/82 | 19009 | 3778 | 22788 | 12631 | 1984 | 14616 | 18412 | 6370 | 24782 |
| 1982/83 | 19082 | 5597 | 24679 | 19653 | 0 | 19653 | 16618 | 5640 | 22258 |
| 1983/84 | 20438 | 4647 | 25084 | 22927 | 3706 | 26633 | 14197 | 7171 | 21368 |
| 1984/85 | 14393 | 6109 | 20501 | 35858 | 6747 | 42605 | 8480 | 5209 | 13689 |
| 1985/86 | 5636 | 3503 | 9140 | 32526 | 8679 | 41205 | 15534 | 3386 | 18920 |
| 1986/87 | 13132 | 2061 | 15193 | 31422 | 6271 | 37693 | 12992 | 3615 | 16607 |
| 1987/88 | 14456 | 32 | 14488 | 33680 | 7968 | 41647 | 27018 | 4527 | 31544 |
| 1988/89 | 23986 | 1461 | 25448 | 12783 | 8474 | 21257 | 32335 | 9442 | 41776 |
| 1989/90 | 25011 | 6712 | 31723 | 19398 | 4689 | 24087 | 31048 | 8351 | 39399 |
| 1990/91 | 14220 | 4442 | 18662 | 21544 | 3510 | 25053 | 20155 | 8903 | 29058 |
| 1991/92 | 9815 | 2524 | 12339 | 36307 | 5176 | 41483 | 46211 | 8361 | 54573 |
| 1992/93 | 5825 | 2700 | 8525 | 21755 | 6320 | 28076 | 39888 | 10516 | 50404 |
| 1993/94 | 5245 | 299 | 5544 | 13719 | 4688 | 18406 | 29956 | 11879 | 41834 |
| 1994/95 | 4946 | 0 | 4946 | 16138 | 2061 | 18199 | 19164 | 9582 | 28745 |
| 1995/96 | 5827 | 0 | 5827 | 22524 | 3086 | 25610 | 18291 | 4299 | 22590 |
| 1996/97 | 11791 | 0 | 11791 | 21129 | 6621 | 27750 | 25663 | 3822 | 29485 |

Table 2.3. Estimates of spawning stock biomass, catch, and pre-fishery stock abundance (tonnes) for the southern stock assessment regions from 1971-1997.

| Season | Strait of Georgia | | | W.C. Vancouver Island | | |
|---------|-------------------|-------|--------|-----------------------|-------|--------|
| | Spawners | Catch | Stock | Spawners | Catch | Stock |
| 1970/71 | 47312 | 1694 | 49005 | 32476 | 0 | 32476 |
| 1971/72 | 25875 | 8811 | 34686 | 36069 | 6894 | 42963 |
| 1972/73 | 18257 | 7649 | 25906 | 16219 | 18303 | 34522 |
| 1973/74 | 64619 | 4004 | 68622 | 24774 | 16334 | 41108 |
| 1974/75 | 76692 | 6179 | 82871 | 44594 | 26109 | 70703 |
| 1975/76 | 57135 | 12238 | 69372 | 63335 | 38825 | 102160 |
| 1976/77 | 58003 | 17509 | 75512 | 57398 | 30043 | 87441 |
| 1977/78 | 97082 | 24002 | 121084 | 39931 | 22745 | 62676 |
| 1978/79 | 59042 | 20338 | 79380 | 63663 | 18694 | 82357 |
| 1979/80 | 74848 | 5818 | 80666 | 62619 | 3982 | 66601 |
| 1980/81 | 48230 | 12052 | 60282 | 58518 | 8090 | 66608 |
| 1981/82 | 90239 | 12833 | 103072 | 29424 | 5486 | 34911 |
| 1982/83 | 47423 | 17218 | 64641 | 15329 | 8575 | 23904 |
| 1983/84 | 27588 | 11045 | 38632 | 22142 | 6577 | 28719 |
| 1984/85 | 26629 | 7030 | 33659 | 29132 | 178 | 29310 |
| 1985/86 | 61097 | 594 | 61690 | 38347 | 204 | 38551 |
| 1986/87 | 39037 | 9353 | 48390 | 29915 | 15934 | 45849 |
| 1987/88 | 25351 | 8215 | 33566 | 39289 | 9724 | 49013 |
| 1988/89 | 54078 | 8369 | 62447 | 43331 | 13289 | 56620 |
| 1989/90 | 58912 | 8119 | 67031 | 38337 | 9849 | 48186 |
| 1990/91 | 43421 | 11103 | 54524 | 25907 | 8634 | 34541 |
| 1991/92 | 80122 | 13419 | 93541 | 36916 | 3713 | 40629 |
| 1992/93 | 84961 | 13741 | 98702 | 29307 | 5612 | 34920 |
| 1993/94 | 60862 | 17647 | 78509 | 19869 | 6038 | 25908 |
| 1994/95 | 59708 | 13190 | 72897 | 25284 | 1951 | 27235 |
| 1995/96 | 76291 | 14113 | 90404 | 32209 | 790 | 32999 |
| 1996/97 | 53442 | 19809 | 73251 | 39394 | 7970 | 47364 |

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 1971-1997.

| Season | Area 2W* | | | Area 27 | | |
|---------|----------|-------|-------|----------|-------|--------|
| | Spawners | Catch | Stock | Spawners | Catch | Stocks |
| 1970/71 | 655 | 0 | 655 | 356 | 0 | 356 |
| 1971/72 | 1026 | 0 | 1026 | 333 | 0 | 333 |
| 1972/73 | 1782 | 706 | 2488 | 2293 | 0 | 2293 |
| 1973/74 | 1705 | 403 | 2109 | 0 | 526 | 526 |
| 1974/75 | 1446 | 449 | 1895 | 1409 | 0 | 1409 |
| 1975/76 | 1066 | 0 | 1066 | 227 | 79 | 306 |
| 1976/77 | 1228 | 0 | 1228 | 568 | 0 | 568 |
| 1977/78 | 1898 | 575 | 2472 | 3016 | 150 | 3166 |
| 1978/79 | 547 | 691 | 1237 | 6067 | 693 | 6760 |
| 1979/80 | 2658 | 0 | 2658 | 12094 | 519 | 12613 |
| 1980/81 | 2016 | 770 | 2786 | 1683 | 671 | 2354 |
| 1981/82 | 6348 | 1225 | 7573 | 3452 | 571 | 4023 |
| 1982/83 | 6120 | 2518 | 8638 | 2256 | 163 | 2419 |
| 1983/84 | 2552 | 0 | 2552 | 2520 | 171 | 2690 |
| 1984/85 | 1544 | 199 | 1743 | 1408 | 0 | 1408 |
| 1985/86 | 649 | 0 | 649 | 3772 | 0 | 3772 |
| 1986/87 | 757 | 0 | 757 | 2643 | 0 | 2643 |
| 1987/88 | 3202 | 0 | 3202 | 1518 | 0 | 1518 |
| 1988/89 | 3696 | 0 | 3696 | 3835 | 0 | 3835 |
| 1989/90 | 10487 | 2272 | 12759 | 4645 | 0 | 4645 |
| 1990/91 | 2789 | 2558 | 5347 | 3277 | 0 | 3277 |
| 1991/92 | 3564 | 1284 | 4848 | 2787 | 335 | 3122 |
| 1992/93 | 88 | 1306 | 1393 | 5356 | 367 | 5723 |
| 1993/94 | 193 | 0 | 193 | 3260 | 345 | 3605 |
| 1994/95 | 0 | 0 | 0 | 2189 | 88 | 2277 |
| 1995/96 | 0 | 0 | 0 | 1641 | 0 | 1641 |
| 1996/97 | 0 | 0 | 0 | 1703 | 0 | 1703 |

* - Although no estimate of stock biomass is available in area 2W since 1994, spawning activity occurred in the area but it was not surveyed indicating that some spawning biomass is present.

3. AGE-STRUCTURED MODEL

3.1 INTRODUCTION

An age-structured model, based on the error structure suggested by Fournier and Archibald (1982), has been used to assess B.C. herring stocks since 1982. Ongoing revisions to the model have made it more consistent with the life history of herring and the fisheries which are analyzed. The current version uses auxiliary information in the form of spawning escapement data, separates catch and age composition data by gear type, and includes availability parameters to estimate partial recruitments to the spawning stock. Model parameters are estimated simultaneously using a maximum likelihood method. The model formulation used this year is the same as that used beginning with the 1994 assessment (Schweigert and Fort 1994). The model uses escapement model estimates of spawning stock biomass as the abundance or spawn index for parameter estimation. The model is implemented in the C⁺⁺ programming language using AUTODIF for derivative calculations. Details of the equations and implementation of the model are described in detail in previous reports and are not presented here (Schweigert et al. 1996, 1997).

3.2 METHODS

The Population Model

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

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

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

3.1

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

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

and, for $r < p$

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

where

- C_{ijr} is the catch of age class j in season i for period r ,
- F_{ijr} is the fishing mortality of age class j in season i for period r ,
- M_r is the natural mortality for period r ,
- N_{ijr} is the number of fish in age class j in season i for period r ,
- p is the number of fishing periods ($p=3$),
- n is the number of seasons ($n=46$),
- k is the number of age classes ($k=9$).

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

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

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

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

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

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

Because 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, the availabilities for these two age classes are estimated for each year for which there is age-composition data with the exception of the final year.

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

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

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

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

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

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

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

As in last year's assessments a natural mortality parameter, M_* , is estimated. Natural mortality for the three fishing periods is modelled as,

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

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

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

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

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

where w_{ij} is the average weight-at-age j in season i . The error in the spawn index observations

(I_i) are assumed to be multiplicative so that

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

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

- T_u , for all seasons i ,
- T_{ij} , for age classes 1+ to k ,
- λ_j^* , for age classes 3+ to 5+,
- λ_{ij} , for age classes 1+ and 2+, for seasons 1 to $n-1$,
- α_{ir} , for all fisheries I, r ,
- ρ, τ, ω, M and q .

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

The Objective Function

Data input to the stock reconstruction are:

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

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

- 1) the S_{ijr} are obtained from ageing random samples of fish from the catch and there are no ageing errors (i.e. a multinomial sampling distribution).
- 2) the error structure for the estimated number of fish caught (O_{ir}) is log-normal. That is,

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

where C_{ir} is the actual number of fish caught in period j in season i ($C_{ir} = \sum_j C_{jr}$)

and the ξ_i are independent normally distributed random variables with mean 0 and variance σ_3^2 .

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

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

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

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

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

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

The objective function described above (eqn. 3.5 & 3.6) incorporates measurement error in the proportion at age data, the total catch data and the spawn index data, with the relative magnitude of the errors related through the variance terms σ_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:

$$\begin{aligned}\sigma_1^2 &= 0.05, \\ \sigma_3^2 &= 0.0025,\end{aligned}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

The second term in this equation is a constant. Inclusion of this term allows comparison of the contribution to the lack of fit for the age composition data for each fishery. If the predicted and

observed proportion at age data were identical, the V_{ir} would be zero.

Stock Forecasts

Forecasts of stock abundance for 1998 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 1997/98 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 1951-97 time series. Poor, average, and good recruitment are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of historic age 2⁺ numbers.

Input data used for age-structured model analysis are shown in Appendix Tables 1.1 to 1.5 for all stock groupings. Where no sample data are available, but catches were taken, the catch is included with an alternate fishery where age-structure data are available. Beginning with the 1994 assessment the estimate of total egg deposition as determined by the escapement model is used as the spawn index. Estimates of numbers of fish at age from the age structured model are presented in Appendix Tables 2.1 to 2.5 for all stock groupings.

3.3 RESULTS

Results from the stock reconstructions are presented in Appendix tables 2.1 to 2.5 for all assessment regions. A discussion of stock trends and forecasts is presented in Section 4. The standard deviates of the observed versus predicted proportions-at-age are presented in Figures 4.7-4.11.

4. STOCK TRENDS, FORECASTS AND POTENTIAL CATCH

4.1 STOCK TRENDS

Estimates of pre-fishery stock biomass over the period 1972 to 1997 from the age-structured and escapement models are shown in Figures 4.1 and 4.2 for the five major coastal regions and for Area 27. For the Queen Charlotte Islands region the two models indicate similar trends in stock biomass. However, the age-structured model suggests much higher peaks in abundance in the mid 1970s and the early 1980s resulting from good recruitment of the 1971, 1972 and 1977 year-classes. Both models suggest a decrease in abundance from 1990 through 1995 with a slight increase in 1996, followed by a moderate increase in 1997. The 1993 year-class of age 3⁺ fish dominates with 33% of total abundance while the recruiting 1994 year-class accounted for 26% of the spawning stock. The 1995 year-class of pre-recruits accounts for a surprising 23% of the spawning run. The estimates of 1997 mature biomass are 22,000 and 11,800 tonnes from age-structured and escapement model analyses, respectively.

Estimates of 1997 stock abundance for the Prince Rupert District assessment region are more consistent for the two models than in recent assessments, although age structure estimates remain unreasonably high (Fig. 4.1). Both models indicate a decline in abundance from 1992 through 1995 with a moderate upturn in 1996 with an additional slight increase in 1997. The estimates of 1997 mature biomass are 54,400 and 27,750 tonnes from the age-structured and escapement models, respectively. The dominant 1993 year-class comprised 56% of the stock. The recruiting 1994 year-class accounted for another 18% of the spawning run.

Estimates of pre-fishery biomass for the Central Coast assessment region are very similar for the two models (Fig. 4.1). Both models indicate stock declines over the past few years. The escapement model estimates of abundance have shown a declining trend since 1992 from a historical high level while the age-structured model indicates a moderate decline since 1994. Both models indicate a substantial increase in stock strength in 1997. The abundant 1989 year-class of age 7⁺ fish comprised 8% of the stock while the 1993 year-class contributed 17% of the total. The recruiting 1994 year class dominates the run accounting for 57% of the stock. The 1997 mature biomass estimates are 39,300 and 29,500 tonnes from age-structured and escapement model analyses, respectively.

For the Strait of Georgia assessment region the pre-fishery stock trends estimated by the two models are similar, with the escapement model suggesting more erratic fluctuations in abundance (Fig. 4.2). However, both models indicate a moderate decline from the 1993 recent high abundance level through 1995. Both models also suggest a slight to moderate increase in abundance in 1996 followed by a decline in 1997. The 1993 year-classes contributed 23% of the stock while the recruiting 1994 year-class constituted 52% of the run. The pre-recruit 1995 year-class contributed another 8% of the total run. The age-structured model estimate of pre-fishery abundance in 1997 is 78,300 tonnes while the escapement model estimate is 73,300 tonnes.

The pre-fishery biomass estimates for the west coast of Vancouver Island stock follow similar trends since the mid 1970s (Fig. 4.2). Both models indicate a long-term decline in

abundance since 1989 with the escapement model indicating a slight increase since 1994 whereas the age-structure model indicates an increase beginning in 1996. There have been no dominant year-classes in this stock since the 1989 year-class. The 1993 year-class comprised 8% of the stock while the recruiting 1994 year-class constituted 69% of the total run. The escapement model estimate of 1997 mature biomass is 48,100 tonnes while the age-structured model estimate is 36,100 tonnes.

Mature biomass estimates for Area 27 stocks were available only from the escapement model and indicated that 1,700 tonnes returned to this area during 1997. Although abundance estimates are erratic it appears that abundance has declined since 1993 (Fig. 4.2). The 1993 year-class comprised 7% of the run while the recruiting 1994 year-class accounted for 77% of the total run.

Biomass estimates were unavailable for Area 2W stocks because the few spawnings which were observed were not surveyed. There have been no biological samples collected in the area since 1994.

4.2 STOCK FORECASTS AND POTENTIAL CATCH

Management Considerations

We recommend catch levels at 20% of the forecast stock biomass for those stocks that are well above Cutoff or minimum spawning biomass threshold levels (Schweigert and Ware 1995). The 20% harvest rate is based on an analysis of stock dynamics which indicates this level will stabilize both catch and spawning biomass while foregoing minimum yield over the long term (Hall et al. 1988, Zheng et al. 1993). A fixed escapement policy would theoretically produce higher yields and spawning stock stability but is not attainable at the operational level. For those stocks which are marginally above Cutoff we recommend the following reduced catch level:

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

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

As described in the 1995 report, a bootstrap procedure was used to annually re-evaluate Cutoff levels for each major assessment region since 1993/94. The bootstrap procedure relies on the recruitment estimates from the age-structured model (N_{il}), to forecast recruitment and assumes the natural mortality rate estimated by the age-structured model for each area in the population simulations (Efron and Gong 1983). The average of 100 estimates of the mean of 200 years of simulated stock sizes was taken as the measure of the equilibrium unfished biomass. Cutoff levels were established at one-fourth the unfished average biomass. However, in 1995 the Subcommittee recommended that a fixed Cutoff level should be established for each stock based on the long-term production characteristics in relation to current environmental conditions and

that this Cutoff level need not be re-evaluated on an annual basis. As a result, the Subcommittee fixed Cutoff at 1994/95 levels until the analyses of individual stock productivities could be completed. These Cutoff levels for the five major stocks are:

| | 1992/93 Cutoff* | 1994/95 Cutoff | 1996/97 Cutoff | 1997/98 Cutoff |
|--------------------------|-----------------|----------------|----------------|----------------|
| Queen Charlotte Islands | 11700 | 10700 | 10700 | 10700 |
| Prince Rupert District** | 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 |

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

** - 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.

During the 1996 Subcommittee discussions it was noted that the Cutoff level for the Central Coast stock was equivalent to that for the west coast of Vancouver Island and so appeared unrealistically high based on estimates of long term stock abundance. As a result, the Cutoff level was re-evaluated for the Central Coast based on current information and was revised to 17,600 tonnes. Consequently, 1997/98 Cutoff levels will remain the same as last year.

No minimum stock levels or Cutoff have been determined for stocks in Area 27 or on the west coast of the Queen Charlotte Islands because of the absence of a consistent time series of information.

To provide an overall stock forecast we assign subjective probabilities to the two assessment models. With the inclusion of estimates of apparent survival in the forecast procedure for the escapement model, forecasts should be consistent with future abundance estimates from this model. However, if escapement estimates from spawn surveys are consistently underestimated, forecasts from this model could also be biased. For these reasons we assume an equal probability for both models for most assessment regions. We suggest not weighting the age-structured model forecast for the Prince Rupert District because of unrealistically high abundance estimates in this area.

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

Abundance Forecasts and Potential Catches

An accurate forecast of abundance for herring requires a good estimate of returning adults and of upcoming recruitment. Figures 4.3 and 4.4 present cumulative probability

distributions of forecast abundances for the age-structured and escapement models and their weighted average. These figures represent plots of the expected run size in the coming year given the escapement last year, average growth and survival of this adult biomass and the addition of each of the historically observed recruiting year-classes to the projected adult biomass. In addition, Fig. 4.5 and 4.6 present the age-structured or escapement model estimates of historical recruitment of three year old fish to the spawning runs in each assessment region.

The forecast weighted run size to the Queen Charlotte Islands in 1998 is 19,800 tonnes assuming average recruitment (Table 4.1). This represents a substantial increase from the 1997 forecast and brings the stock well above the Cutoff level suggesting that a moderate harvest of 3,960 tonnes could be available in this area for 1998 (Table 4.2). Indications are that both the 1993 and recruiting 1994 year-classes are above average contributing to the increase in abundance (Fig. 4.5). The projected stock abundances indicate that there is 0% probability of the 1998 run being below Cutoff based on the weighted forecasts from the two assessment models (Fig. 4.3). There are no indications of significant residuals from either the fit to the spawn index data or age-structure data during the last few years (Appendix Table 2.1, Fig. 4.7-4.9).

The age-structured model stock estimates for the Prince Rupert District continue to be a source of uncertainty. There are indications that the fit to the spawn index data in recent years has not been very good (Appendix Table 2.2) and there are a number of large residuals from the fit to the proportion-at-age data for the gillnet fishery during the past four seasons and to the seine data in the late 1970s and early 1980s (Fig. 4.8). Consequently, we forecast a run size of 34,100 tonnes based solely on the escapement model estimate which is similar to the forecast for 1997 (Table 4.1). Assuming an average recruitment level, a catch of 6,810 tonnes should be available for the Prince Rupert District in 1998 based on the escapement model alone (Table 4.2). The 1993 year-class appears to be strong based on the age composition of this stock and the escapement model estimates it to be above average, comparable to the 1989 year-class while the 1994 year-class is average (Fig. 4.5). The projected stock abundances indicate that there is zero probability that the 1998 run will be below the Cutoff level (Fig. 4.3).

The weighted forecast for the Central coast in 1998 with average recruitment is 44,500 tonnes, a substantial increase from 1997 (Table 4.1). The 1993 year-class was average but the recruiting 1994 year-class is strong comparable to those of 1985 and 1989 (Fig. 4.5). The projected stock abundances indicate that there is no chance that the 1998 run will be below the Cutoff level (Fig. 4.3). Based on the forecast run a catch of 8,910 tonnes should be available assuming average recruitment (Table 4.2). The spawn index data fit the model well in recent years (Appendix Table 2.3) and there are a couple of moderate residuals from the fit to the gillnet data in the recent years requiring some additional investigation (Fig. 4.9).

The weighted forecast run to the Strait of Georgia in 1998 is 72,650 tonnes assuming average recruitment a level similar to 1997 (Table 4.1). The 1993 year-class appears to be average while the recruiting 1994 year-class is good (Fig. 4.6). The projected stock abundances indicate that this stock remains well above the Cutoff level (Fig. 4.4). The projected abundance level should provide a potential catch of about 14,530 tonnes (Table 4.2). There are no indications of lack of fit to either the spawn index data (Appendix Table 2.4) or proportion-at-age data (Fig. 4.10) although the fall food and bait fishery shows some moderate residuals in recent

years. Since this fall fishery represents only a small proportion of the total annual catch this should not substantially affect the assessment results.

The run forecast to the west coast of Vancouver Island assessment region, assuming average recruitment, is 46,900 tonnes, which is substantially above the forecast for 1997 (Table 4.1). While the 1993 year-class was poor the recruiting 1994 year-class is good comparable to the strong 1985 year-class and larger than that of 1989. The projected stock biomass for 1998 indicates that there is zero probability of the run being below Cutoff (Fig. 4.4). An average recruitment assumption for this stock would result in a potential catch of 9,300 tonnes (Table 4.2). The age-structure model fit to the spawn index data is reasonable (Appendix Table 2.5) and there are no significant residuals from the fit to the catch-at-age data in recent years (Fig. 4.11).

There is no forecast run size available for the minor stocks in Area 27. However, based on recent policy for this area the estimated pre-fishery biomass of 1,703 tonnes permits a harvest of no more than 10% of the 1997 biomass in 1998. This suggests a maximum potential harvest of 170 tonnes for the area. Estimates of recent recruitments indicate a poor 1992 and average 1993 year-class followed by a strong 1994 recruiting year-class which does not support the recent decline in this stock (Fig. 4.2, 4.6).

The catch levels suggested in this summary are based purely on biological considerations, reflecting the best biological analyses given the available data bases. Management of the various fisheries has practical constraints not considered in this report. Hence, the quotas ultimately adopted in the annual herring management plan may differ from those suggested herein.

Table 4.1. Summary of 1998 forecast spawning stock biomass (thousands of tonnes) from age-structured and escapement models and weighted runs for poor, average, and good age 2⁺ recruitment levels

| Assessment Regions | AGE-STRUCTURED MODEL | | | | | | ESCAPEMENT MODEL | | | | | | WEIGHTED RESULTS | | | | | |
|-------------------------|----------------------|-------|--------------------------------|-------|--------------------|-------|--------------------------------|-------|----------|-------|------------------------------|-------|------------------|--|--|--|--|--|
| | Age 3 ⁺ | | Age 2 ⁺ Recruitment | | Age 3 ⁺ | | Age 2 ⁺ Recruitment | | Relative | | Age 2 ⁺ and older | | | | | | | |
| | Poor | Avg | Good | Poor | Avg | Good | Poor | Avg | Weight | Poor | Avg | Good | | | | | | |
| Queen Charlotte Islands | 19.46 | 20.46 | 23.15 | 30.05 | 14.02 | 14.55 | 16.42 | 21.46 | 50.50 | 17.50 | 19.78 | 25.75 | | | | | | |
| Prince Rupert District | 56.85 | 58.70 | 62.59 | 75.59 | 29.55 | 30.93 | 34.06 | 44.85 | 0.100 | 30.93 | 34.06 | 44.85 | | | | | | |
| Central Coast | 42.63 | 44.44 | 47.33 | 56.69 | 37.62 | 39.12 | 41.73 | 52.61 | 50.50 | 41.78 | 44.53 | 54.65 | | | | | | |
| Strait of Georgia | 50.04 | 59.50 | 73.04 | 89.29 | 45.95 | 56.62 | 72.26 | 96.18 | 50.50 | 58.06 | 72.65 | 92.73 | | | | | | |
| W.C. Vancouver Island | 27.71 | 31.90 | 38.12 | 54.09 | 43.32 | 48.22 | 54.84 | 70.75 | 50.50 | 40.06 | 46.48 | 62.42 | | | | | | |

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

| Assessment Regions | Abundance Forecast | | | Cutoff Level | Potential Harvest | | |
|-------------------------|--------------------|-------|-------|-----------------|-------------------|-------|-------|
| | Poor | Avg | Good | | Poor | Avg | Good |
| Queen Charlotte Islands | 17.50 | 19.78 | 25.75 | 10.70 | 3.50 | 3.96 | 5.15 |
| Prince Rupert District | 30.93 | 34.06 | 44.85 | 12.10 | 6.19 | 6.81 | 8.97 |
| Central Coast | 41.78 | 44.53 | 54.65 | 17.60 | 8.36 | 8.91 | 10.93 |
| Strait of Georgia | 58.06 | 72.65 | 92.73 | 21.20 | 11.61 | 14.53 | 18.55 |
| W.C. Vancouver Island | 40.06 | 46.48 | 62.42 | 18.80 | 8.01 | 9.30 | 12.48 |

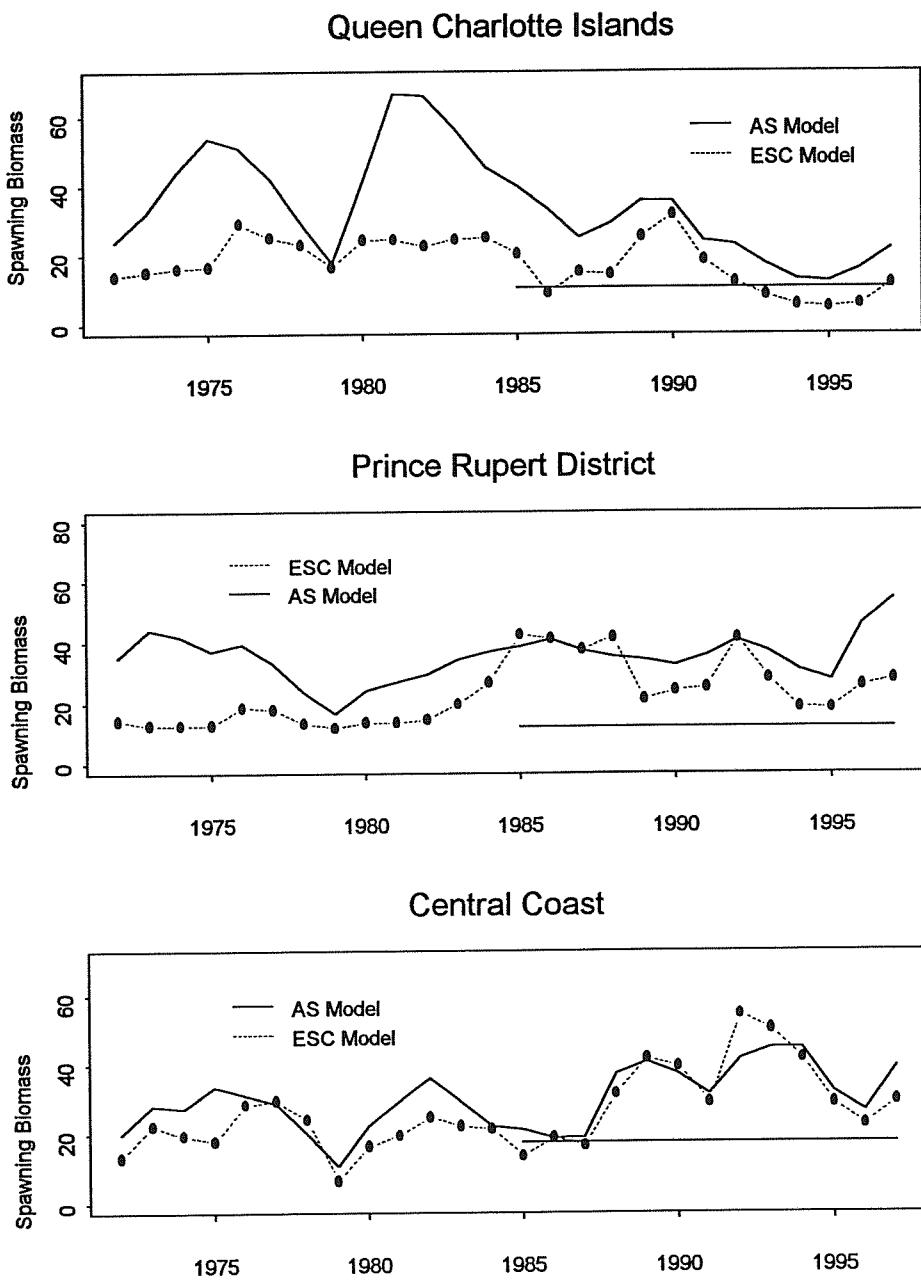


Fig. 4.1 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1997. Horizontal line indicates the Cutoff level for each stock.

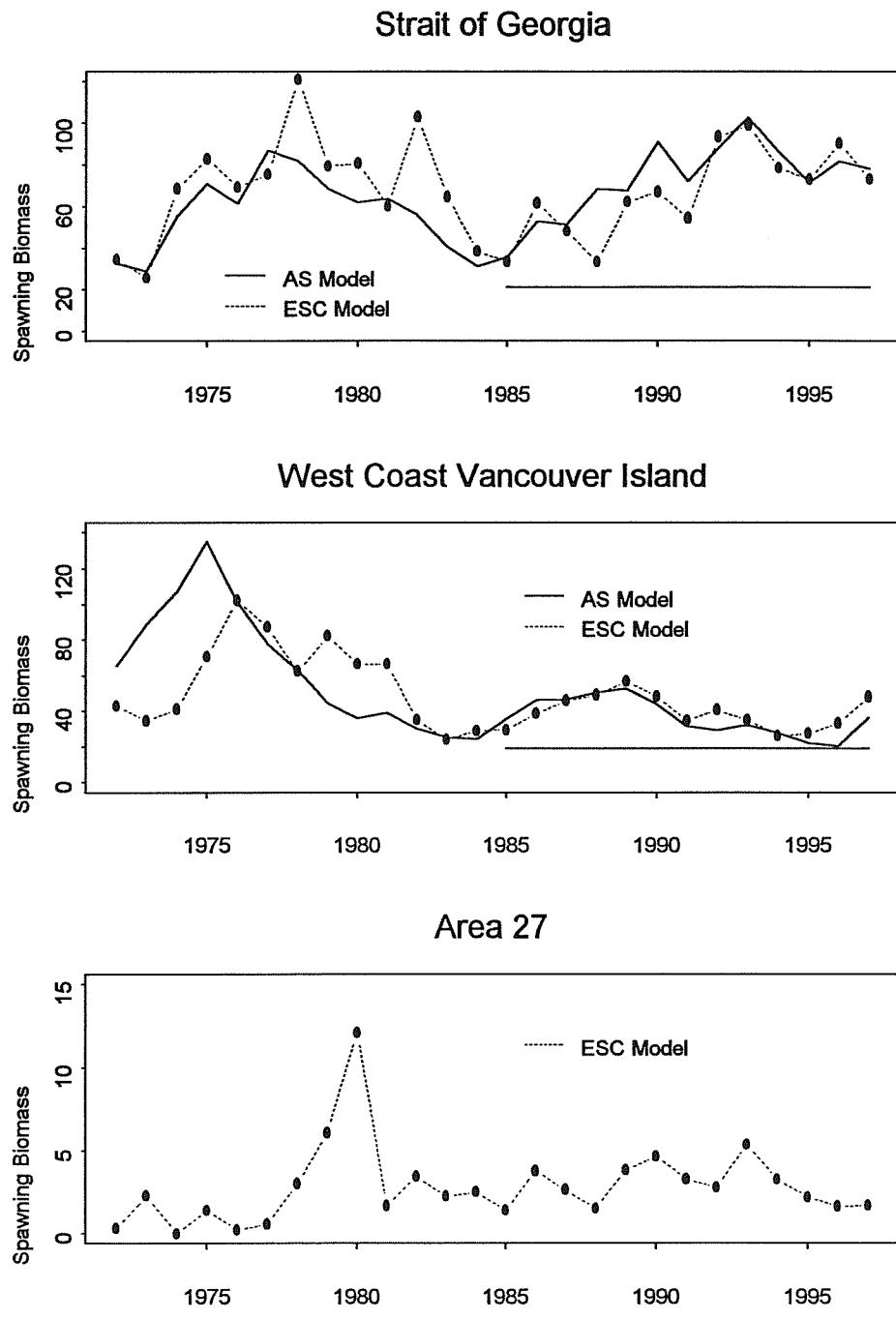


Fig. 4.2 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions and Area 27, 1972-1997. Horizontal line indicates the Cutoff level for each stock.

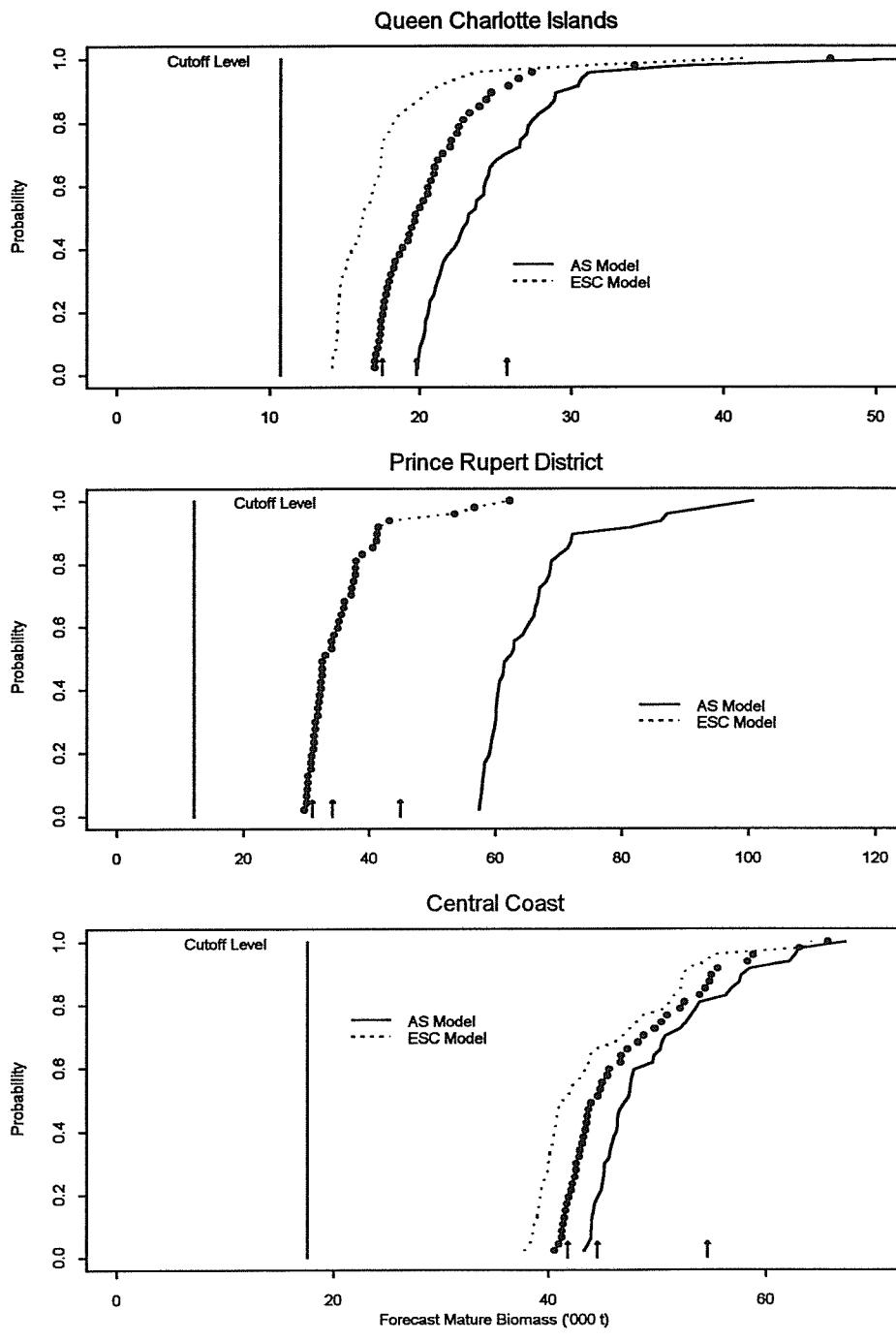


Fig. 4.3. Cumulative probability distributions of forecast spawning biomass for northern B.C. herring stock assessment regions in 1998. Dots represent the mean of the two model estimates. Arrows indicate forecasts assuming poor, average, and good recruitment.

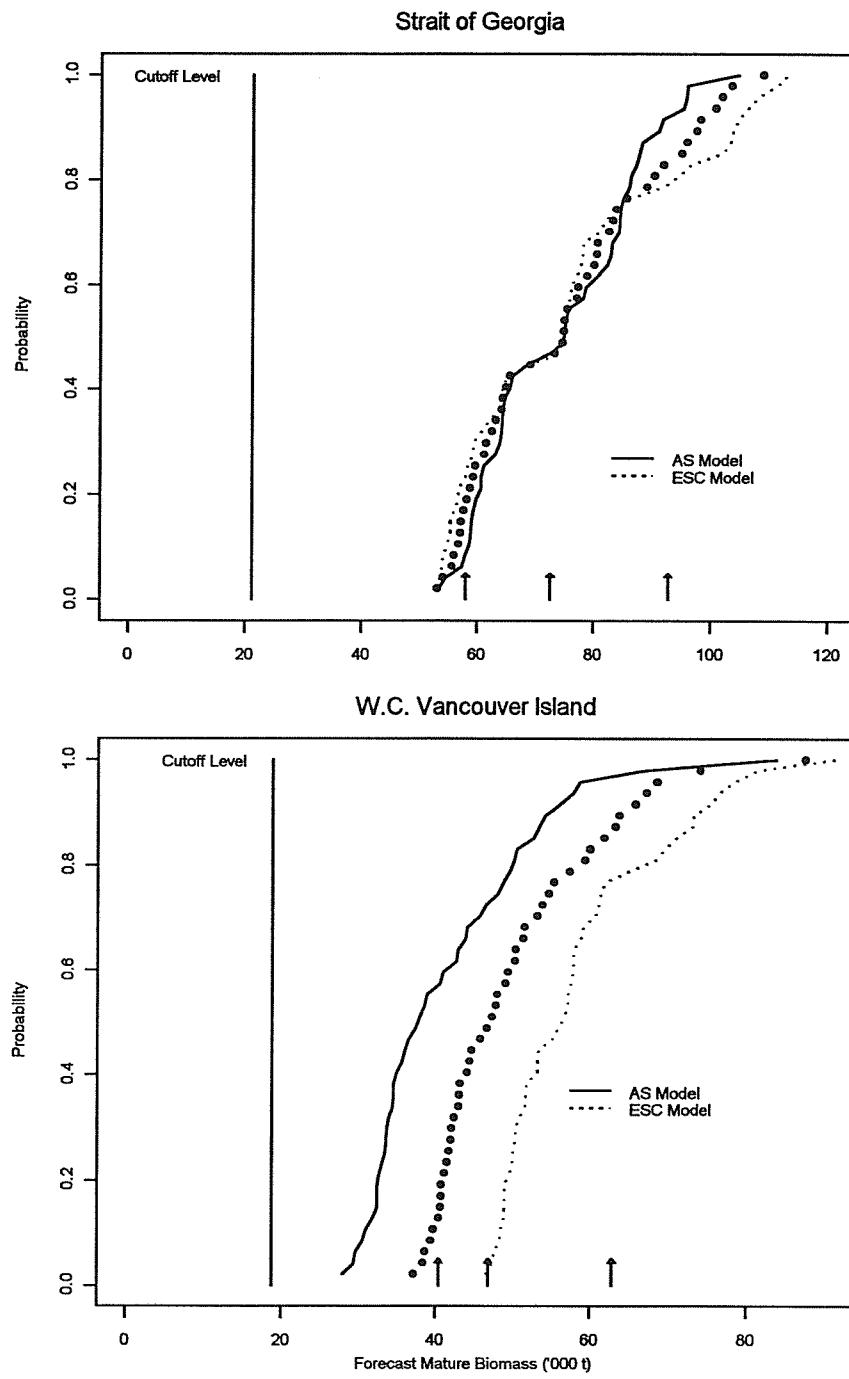
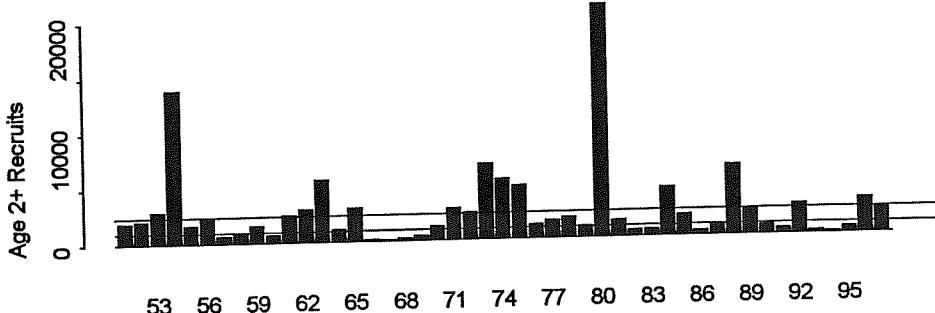
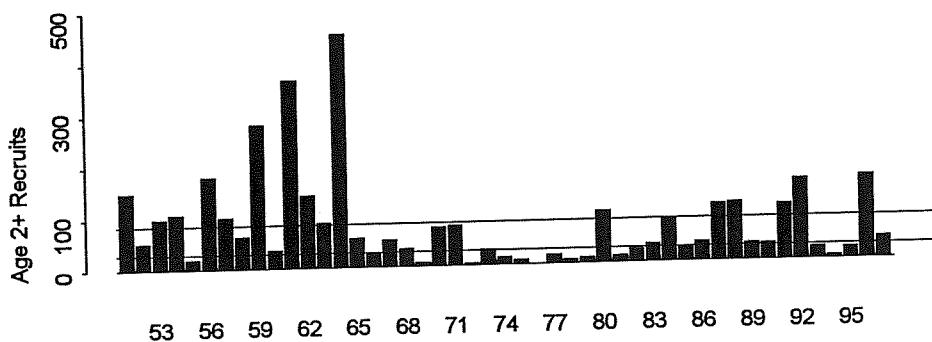


Fig. 4.4. Cumulative probability distributions of forecast spawning biomass for southern B.C. herring stock assessment regions in 1998. Dots represent the mean of the two model estimates. Arrows indicate forecasts assuming poor, average, and good recruitment.

Queen Charlotte Islands



Prince Rupert District - Escapement Model



Central Coast

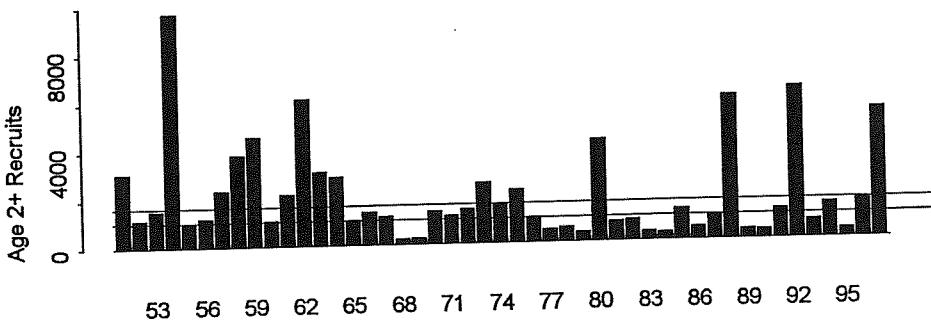


Fig. 4.5. Estimates of abundance of recruiting age 2⁺ year-classes from age-structured analysis for northern B.C. herring stock assessment regions, 1951-1997. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

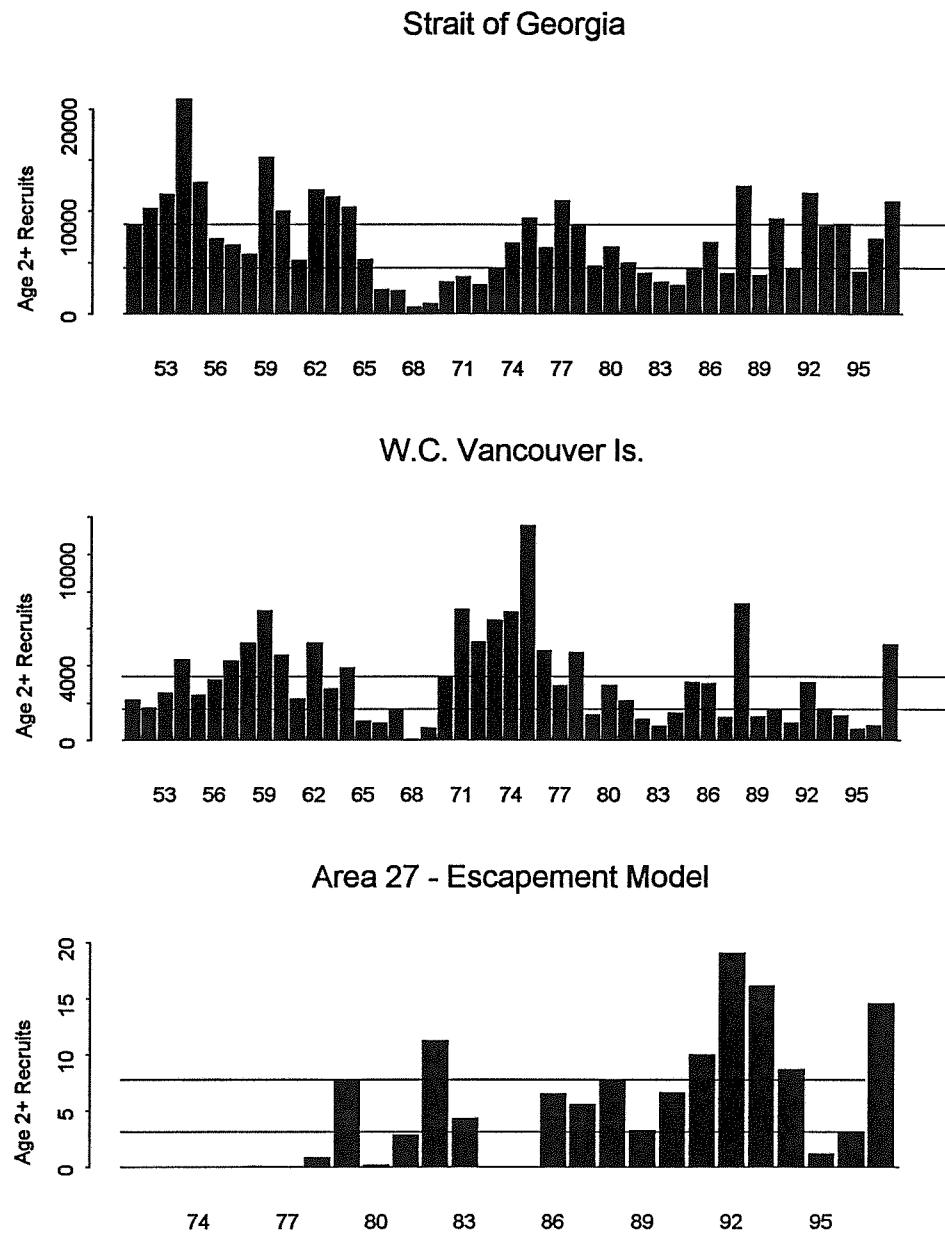


Fig. 4.6. Estimates of abundance of recruiting age 2⁺ year-classes from age-structured analysis for southern B.C. herring stock assessment regions, 1951-1997 and for the minor stock in area 27 for 1972-1997. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

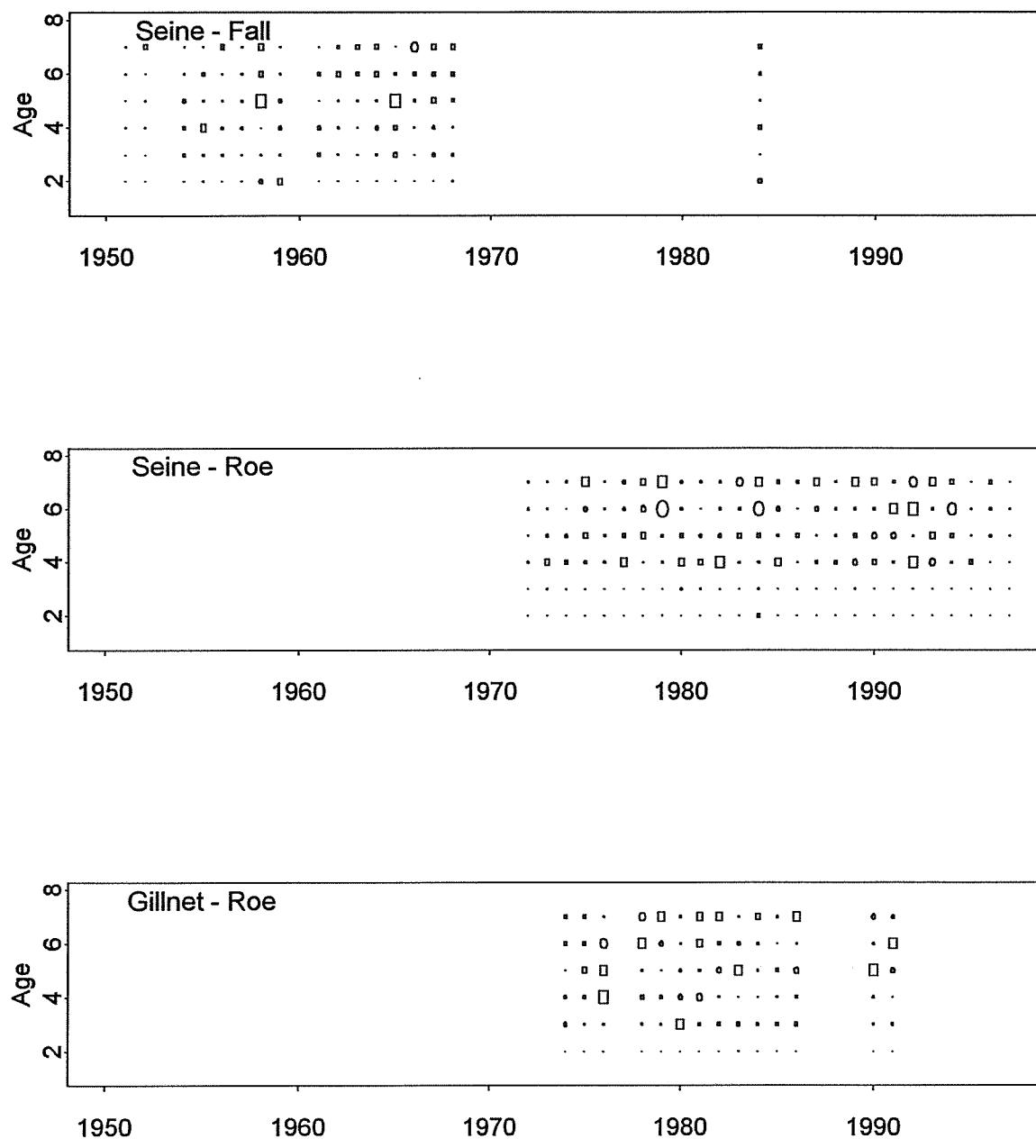


Figure 4.7. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Queen Charlotte Islands stock assessment region during three modelled fishing periods from 1951-1997. Circles denote positive residuals and squares negative residuals.

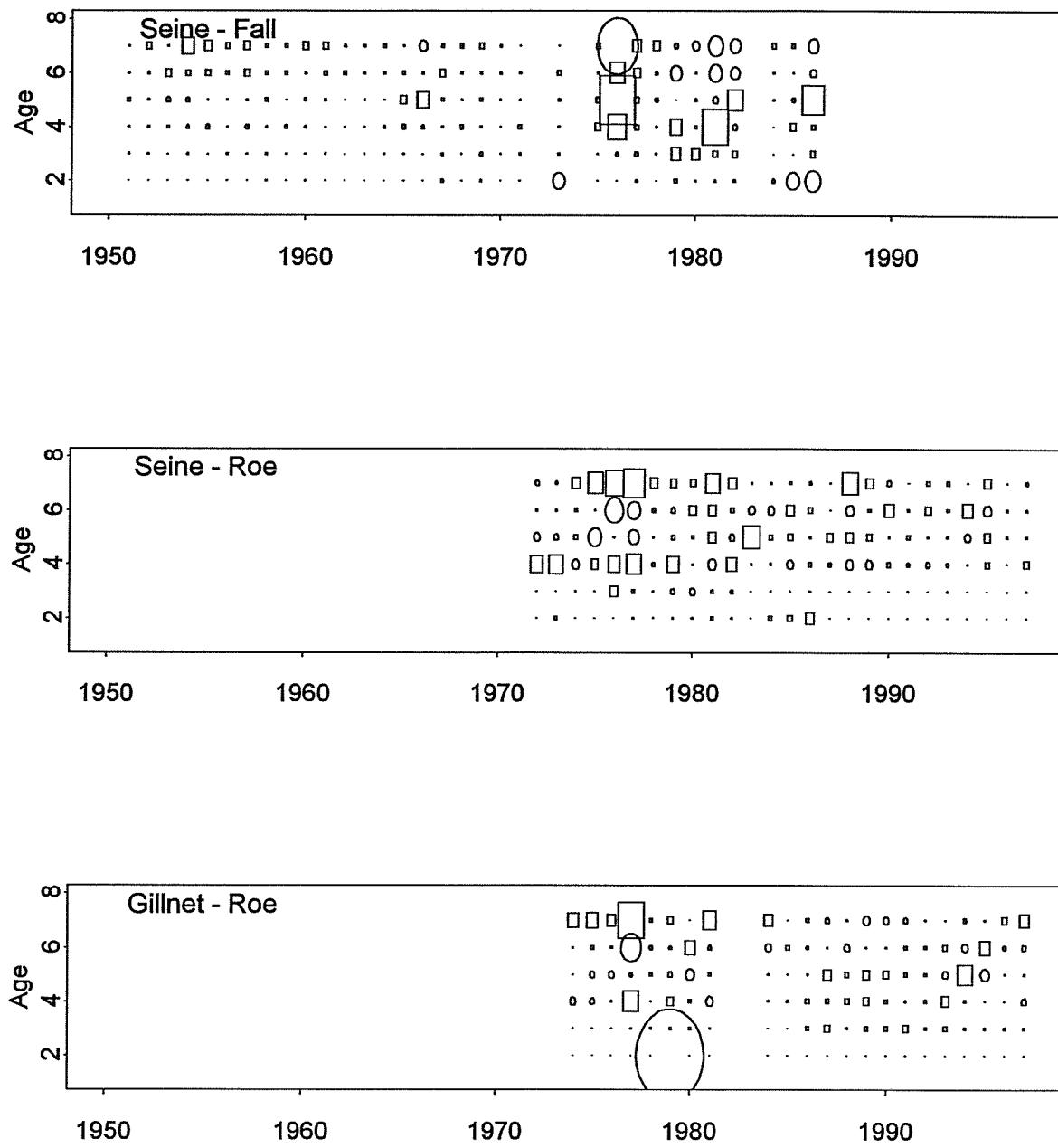


Figure 4.8. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijt}) for the Prince Rupert District stock assessment region during three modelled fishing periods from 1951-1997. Circles denote positive residuals and squares negative residuals.

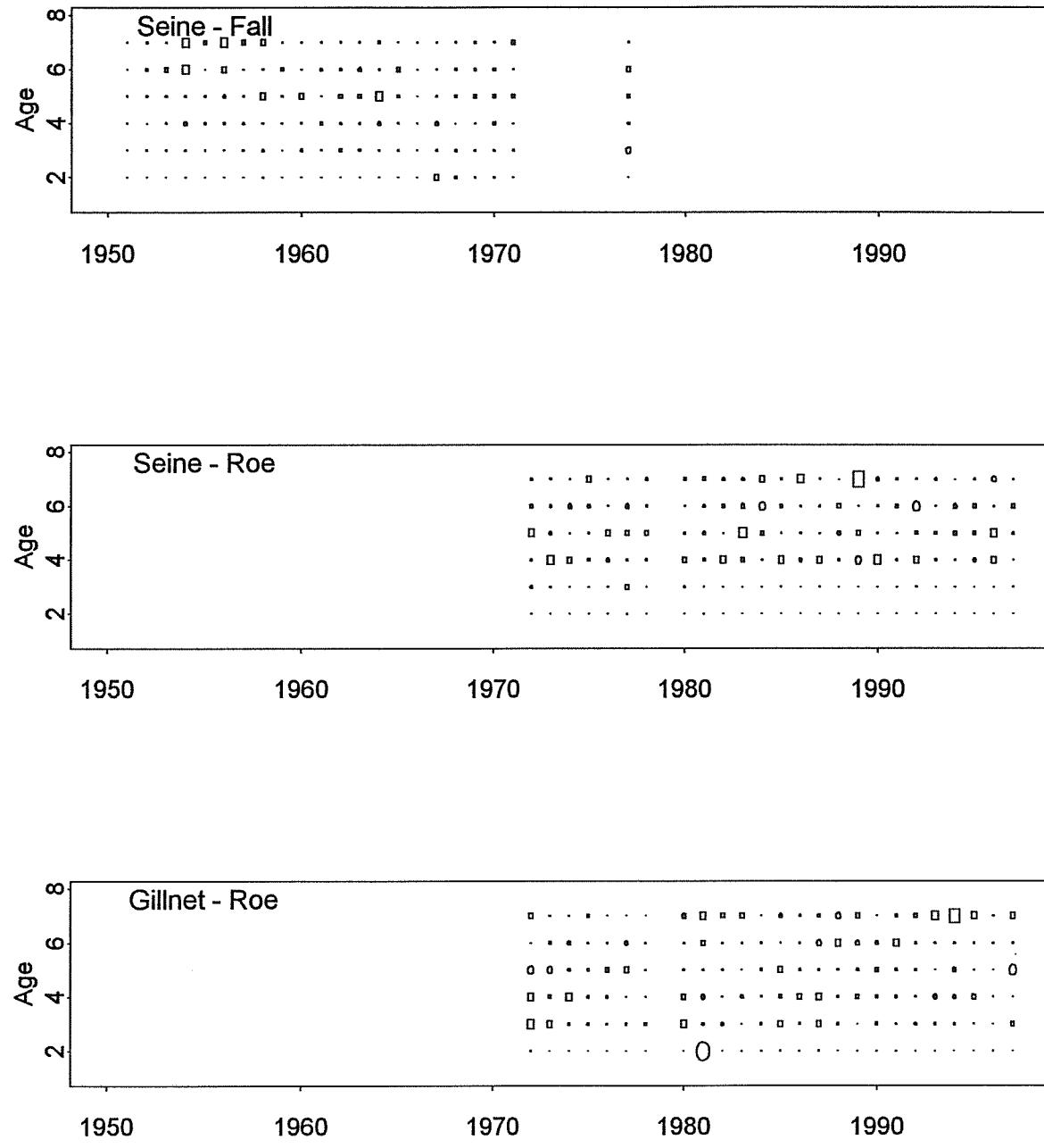


Figure 4.9. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Central Coast stock assessment region during three modelled fishing periods from 1951-1997. Circles denote positive residuals and squares negative residuals.

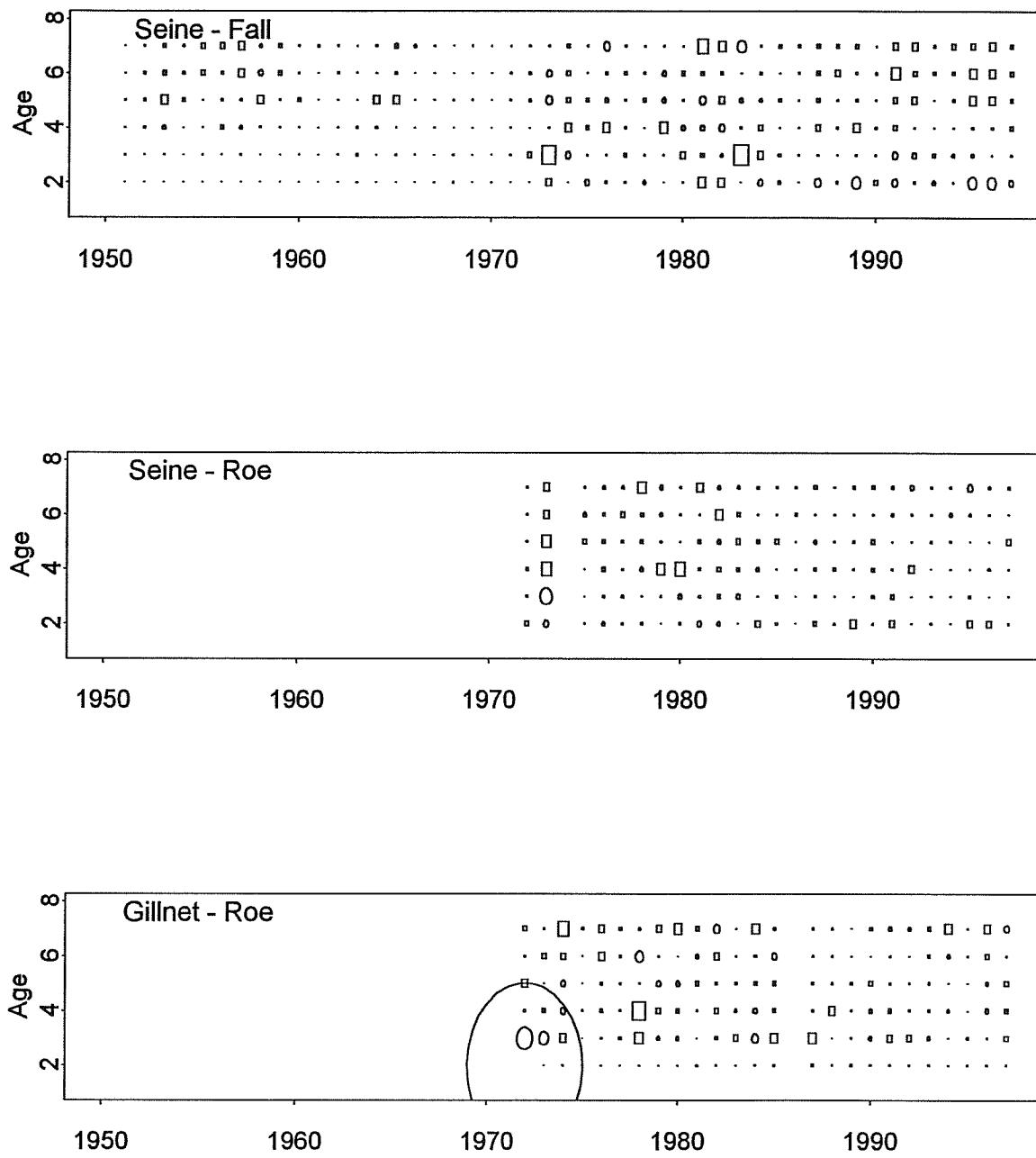


Figure 4.10. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Strait of Georgia stock assessment region during three modelled fishing periods from 1951-1997. Circles denote positive residuals and squares negative residuals.

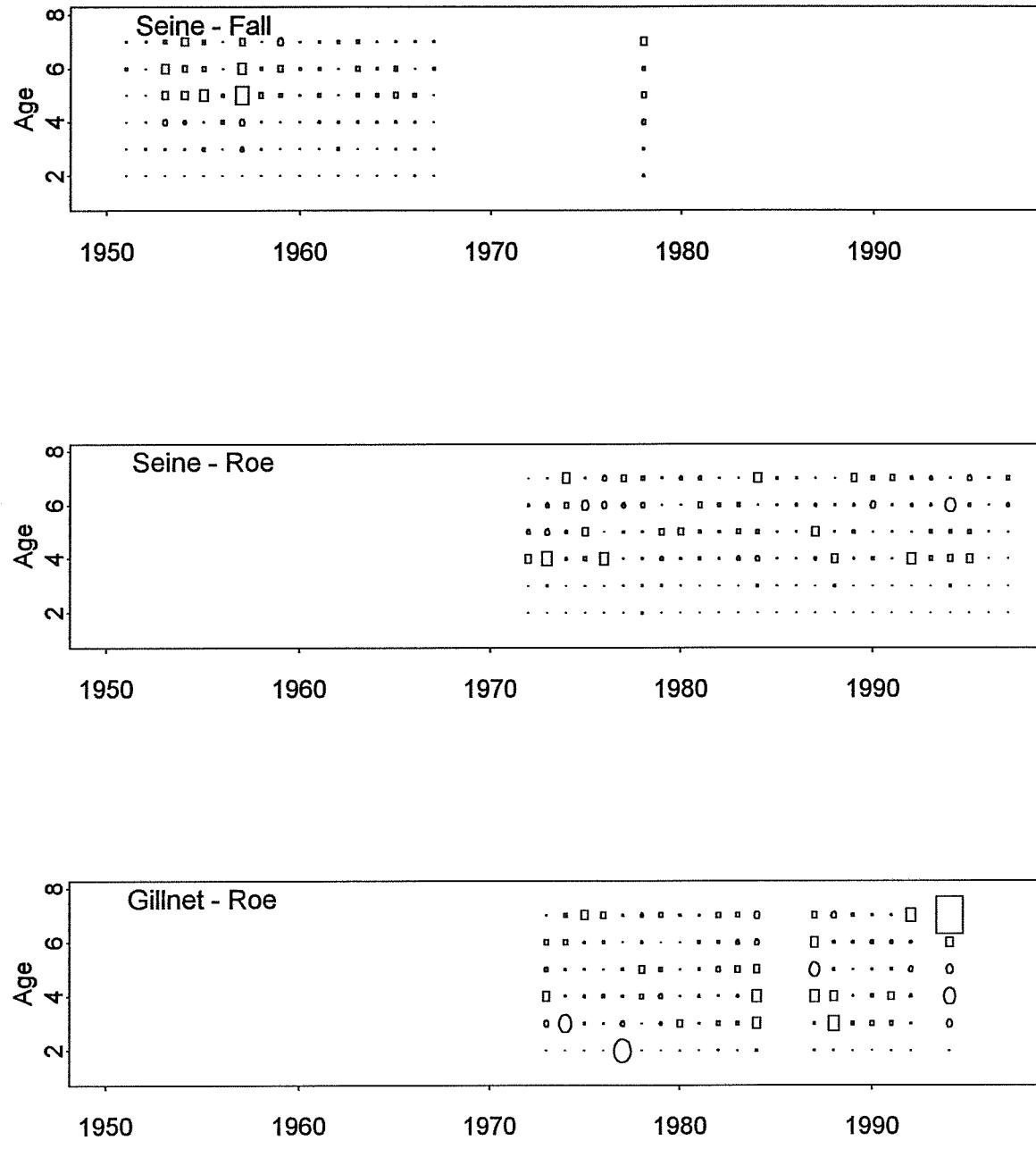


Figure 4.11. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the west coast of Vancouver Island stock assessment region during three modelled fishing periods from 1951-1997. Circles denote positive residuals and squares negative residuals.

5. RETROSPECTIVE ANALYSES

Age-structured Model

Schweigert (1996) presented a retrospective analysis for the herring age-structured model which indicated a tendency for slight over-forecasting in the northern assessment regions and under-forecasting in the southern assessment areas. An explanation for this conflicting trend was not evident but appears to be related to the inverse relationship between estimated natural mortality and the spawn index conversion factor. This effect persists in the current assessment which has been updated to include retrospective plots to and including the current year (Fig. 5.1, 5.2). In the northern assessment areas estimates of current spawning biomass and consequent forecasts of run sizes have been quite consistent with a few minor exceptions in the Queen Charlotte Islands and Central Coast. Estimates for Prince Rupert have generally been much too high, a trend that appears to be continuing although the most recent assessment is more in line with estimates of spawn deposition from egg surveys. In the southern assessment regions, stock reconstructions have been fairly conservative within the Strait of Georgia and to a lesser extent on the west coast of Vancouver Island. However, the 1993 reconstruction for the WCVI stock erroneously indicated abundance at less than half of the current estimate which could have resulted in closure of the area for stock rebuilding. Further investigation of the causes of these conflicting trends is required to fully understand the retrospective abundance estimates.

Escapement Model

Tanasichuk and Schweigert (1997) present an evaluation of the retrospective performance of the escapement model which compares forecasts of stock size with the subsequently observed run size for the fully recruited component (age 4⁺) of the stock on the west coast of Vancouver Island. Figure 5.3 presents the retrospective comparison of escapement model forecasts and subsequent run sizes for the total spawning stock for all assessment regions from 1988-1997. For simplicity it was assumed that the average recruitment option was adopted in developing the stock forecast. However, this has not occurred in all areas or years and the actual forecast adopted by the Herring Subcommittee has included other considerations which have lead to a more subjective assessment of recruitment and consequent run size. Based on forecasts which assumed average recruitment, results have been reasonably accurate only for the Strait of Georgia and to a lesser extent the west coast of Vancouver Island assessment areas. In the northern areas and for the WCVI during 1993-95 forecasts were too high during a period of declining abundance for most of these stocks. It is probable that the Subcommittee would have adopted the poor recruitment option during many of these years, bringing 'forecasts' more in line with actual run sizes. Based on the available data there are no indications that the apparent survival rate estimates currently employed in the escapement model are biased.

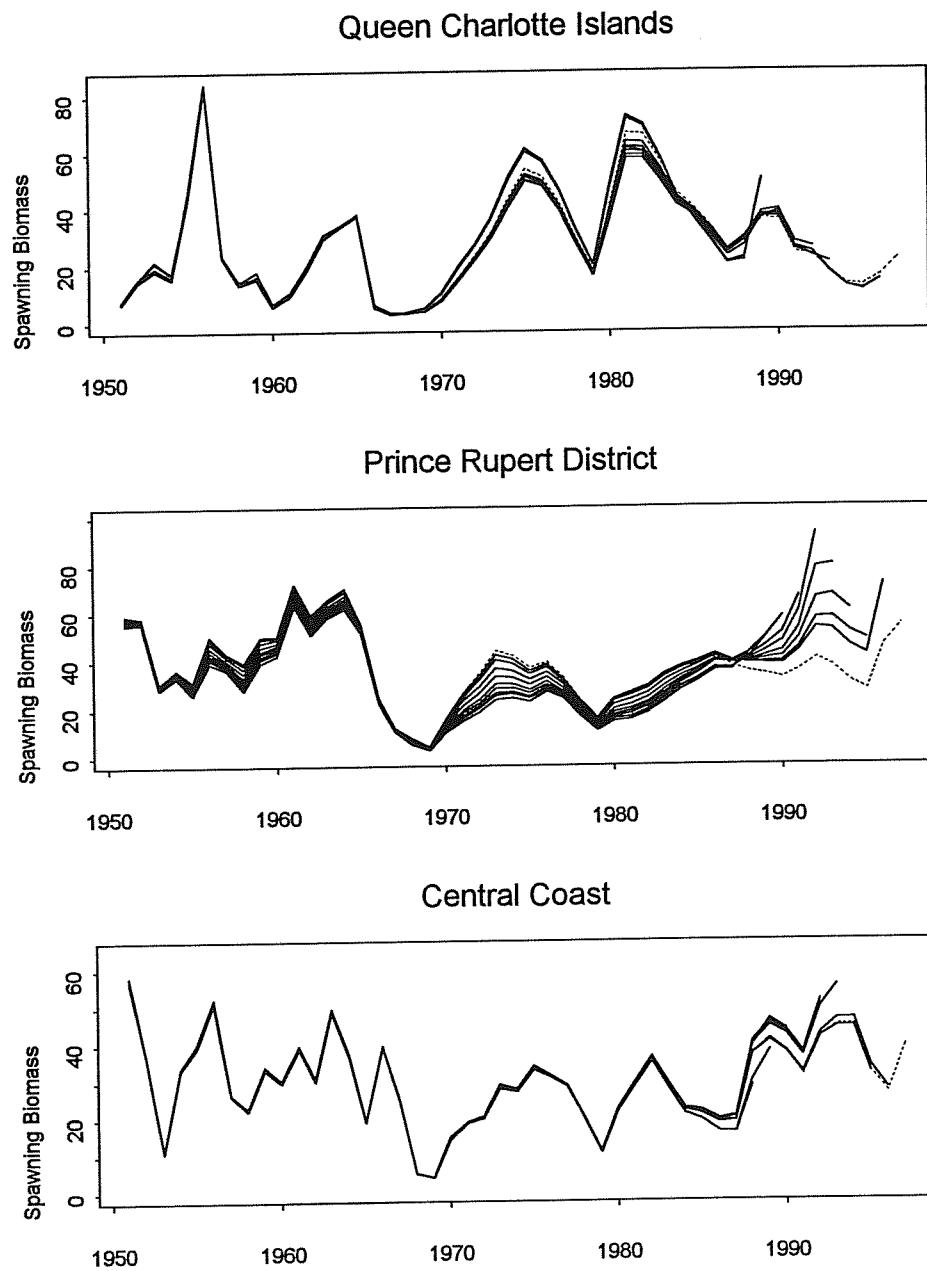


Figure 5.1. Retrospective analysis of estimated spawning biomass from age-structured modelling for northern B.C. herring stocks from 1951-1997. Dashed line indicates the most recent assessment.

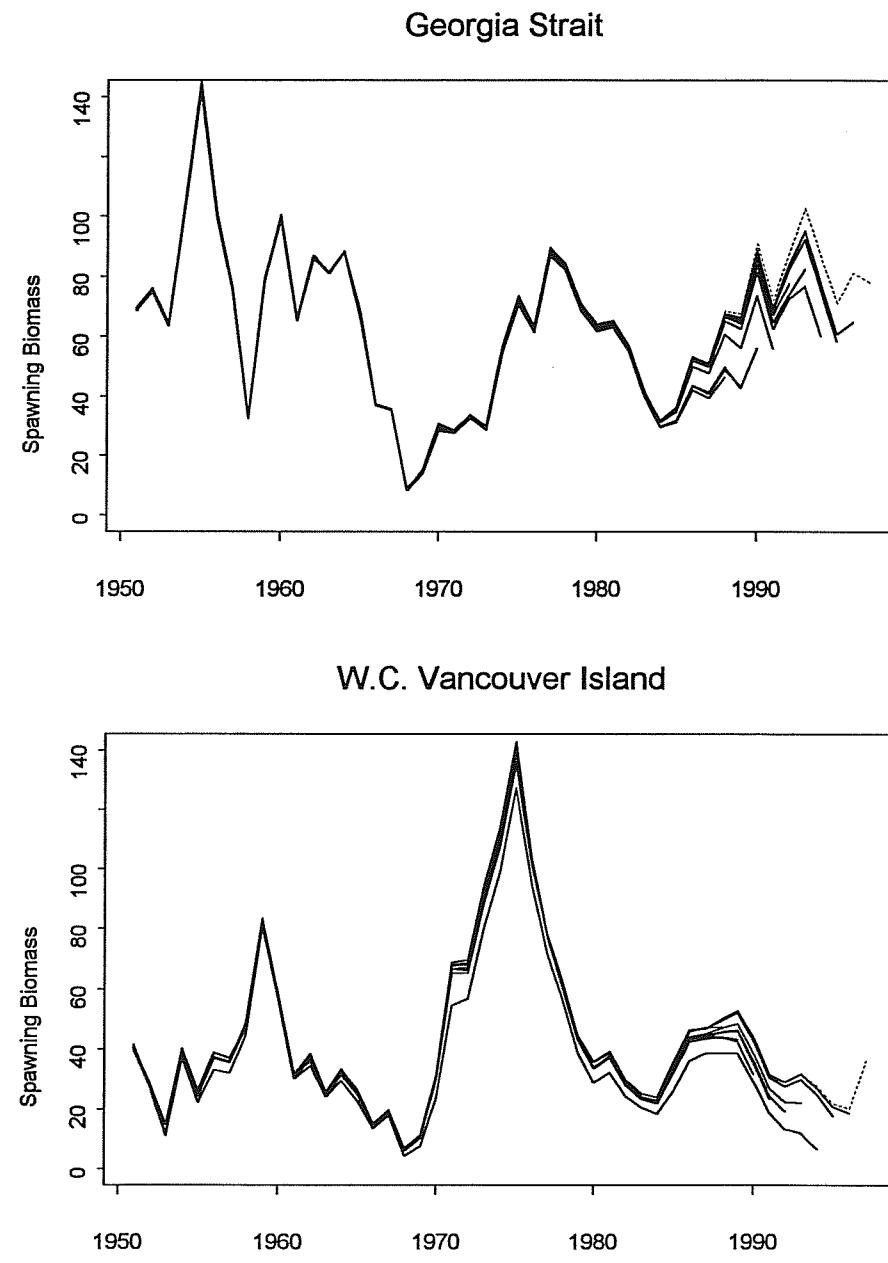


Figure 5.2. Retrospective analysis of estimated spawning biomass from age-structured modelling for southern B.C. herring stocks from 1951-1997. Dashed line indicates the most recent assessment.

Escapement Model - Retrospective Evaluation

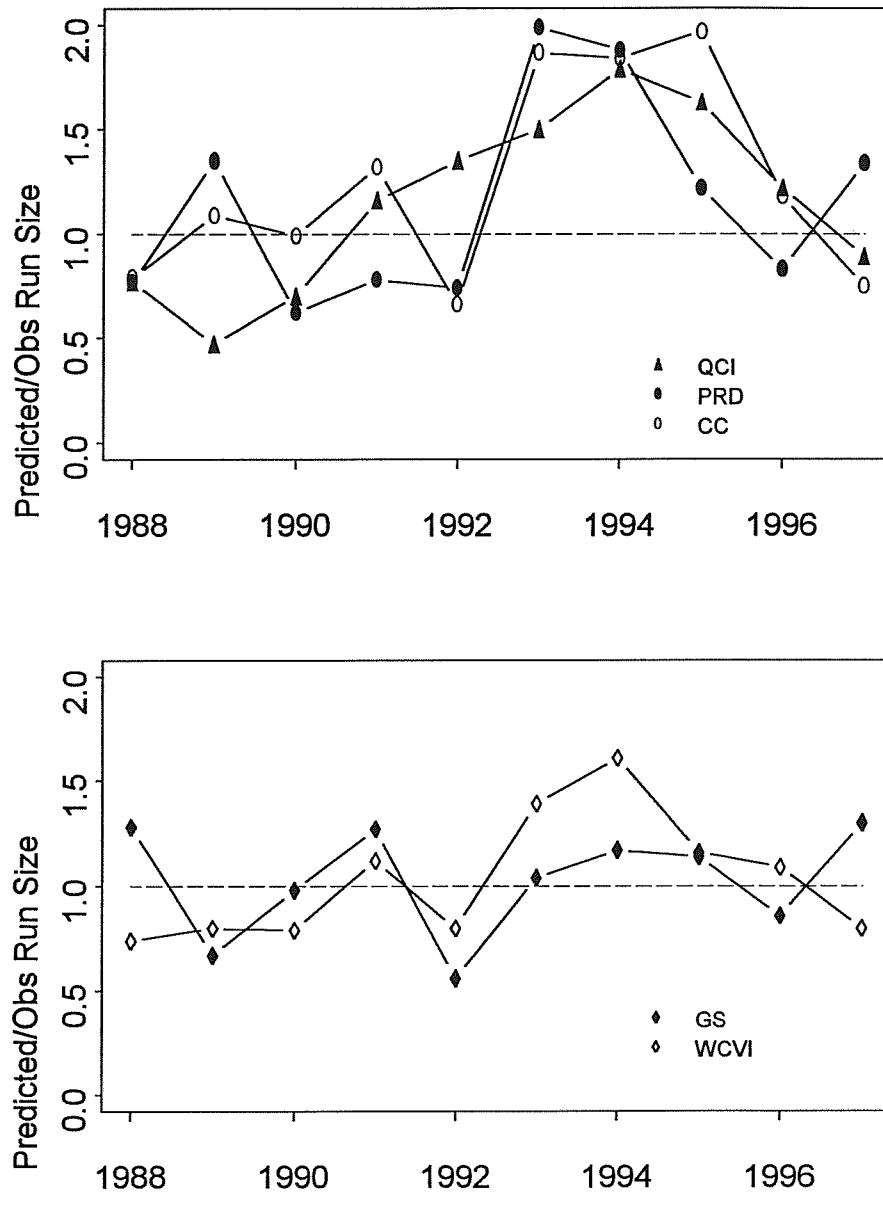


Fig. 5.3. Comparison of escapement model forecasts of spawning runs versus actual run sizes assuming average recruitment for 1988-97 for all major assessment areas.

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7. APPENDIX TABLES

Appendix Table 1.1. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Queen Charlotte Islands stock assessment region. These data are used for age-structured model analysis.

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10 ³) |
|---------|---------|----------------|-------|-------|-------|-------|-------|-------|-------|------|-------------|---------------|-------------------------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | WINTER | 0.07 | 15.31 | 52.91 | 15.31 | 11.52 | 4.20 | 0.61 | 0.07 | 0.00 | 1476 | 1544 | 317.44 |
| 1951/52 | WINTER | 17.13 | 21.81 | 34.17 | 21.54 | 4.14 | 1.12 | 0.09 | 0.00 | 0.00 | 2224 | 166 | 1124.25 |
| 1953/54 | WINTER | 2.96 | 29.02 | 21.28 | 33.66 | 10.19 | 1.93 | 0.71 | 0.19 | 0.06 | 0* | 25 | 231.66 |
| 1954/55 | WINTER | 8.74 | 14.08 | 39.42 | 18.06 | 14.85 | 4.37 | 0.29 | 0.10 | 0.10 | 0* | 25 | 52.94 |
| 1955/56 | WINTER | 0.15 | 16.02 | 9.64 | 62.17 | 8.38 | 2.74 | 0.74 | 0.00 | 0.15 | 1348 | 681 | 6551.83 |
| 1956/57 | WINTER | 20.77 | 24.13 | 15.76 | 9.59 | 26.73 | 2.45 | 0.44 | 0.13 | 0.00 | 4733 | 2180 | 2089.67 |
| 1957/58 | WINTER | 81.89 | 16.42 | 1.23 | 0.18 | 0.14 | 0.14 | 0.00 | 0.00 | 0.00 | 2838 | 514 | 2146.22 |
| 1958/59 | WINTER | 1.05 | 63.16 | 28.42 | 7.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 95 | 6 | 735.74 |
| 1960/61 | WINTER | 4.21 | 32.63 | 36.00 | 24.84 | 1.26 | 0.42 | 0.21 | 0.42 | 0.00 | 0* | 25 | 59.00 |
| 1961/62 | WINTER | 3.04 | 37.62 | 41.36 | 9.58 | 6.54 | 1.64 | 0.23 | 0.00 | 0.00 | 428 | 170 | 693.85 |
| 1962/63 | WINTER | 0.37 | 50.00 | 27.11 | 18.16 | 2.11 | 1.99 | 0.00 | 0.12 | 0.12 | 804 | 411 | 1342.32 |
| 1963/64 | WINTER | 0.95 | 15.34 | 59.47 | 17.80 | 5.30 | 1.14 | 0.00 | 0.00 | 0.00 | 528 | 297 | 2515.06 |
| 1964/65 | WINTER | 1.61 | 79.77 | 11.02 | 4.37 | 2.09 | 0.95 | 0.19 | 0.00 | 0.00 | 1053 | 165 | 3424.55 |
| 1965/66 | WINTER | 18.36 | 32.77 | 16.38 | 10.40 | 7.45 | 5.89 | 4.92 | 2.07 | 1.75 | 0* | 25 | 210.12 |
| 1966/67 | WINTER | 0.88 | 67.26 | 26.49 | 2.65 | 2.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0* | 25 | 18.83 |
| 1967/68 | WINTER | 29.95 | 50.57 | 17.23 | 2.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0* | 25 | 8.43 |
| 1971/72 | ROE-SN | 3.04 | 32.60 | 38.34 | 16.05 | 6.08 | 2.45 | 0.93 | 0.42 | 0.08 | 1184 | 94 | 276.24" |
| 1972/73 | ROE-SN | 0.17 | 40.56 | 21.55 | 27.29 | 8.00 | 1.68 | 0.75 | 0.00 | 0.00 | 1726 | 914 | 524.51 |
| 1973/74 | ROE-SN | 0.12 | 30.49 | 40.38 | 17.69 | 9.09 | 1.86 | 0.31 | 0.06 | 0.00 | 1617 | 185 | 482.78 |
| | ROE-GN | 0.00 | 5.73 | 48.41 | 25.48 | 16.56 | 3.18 | 0.00 | 0.00 | 0.64 | 157 | 25 | 8.24 |
| 1974/75 | ROE-SN | 0.63 | 25.31 | 34.21 | 27.90 | 9.53 | 1.95 | 0.37 | 0.10 | 0.00 | 6010 | 655 | 587.13" |
| | ROE-GN | 0.00 | 0.00 | 22.50 | 40.00 | 30.00 | 5.00 | 2.50 | 0.00 | 0.00 | 40 | 40 | 6.19 |
| 1975/76 | ROE-SN | 0.43 | 2.78 | 37.34 | 29.38 | 22.73 | 6.31 | 0.96 | 0.07 | 0.00 | 4170 | 247 | 813.57" |
| | ROE-GN | 0.00 | 0.00 | 0.75 | 21.80 | 60.90 | 14.29 | 2.26 | 0.00 | 0.00 | 133 | 186 | 91.86 |
| 1976/77 | ROE-SN | 0.09 | 19.57 | 8.01 | 29.41 | 22.95 | 15.09 | 4.47 | 0.40 | 0.00 | 3220 | 1113 | 801.25" |
| 1977/78 | ROE-SN | 0.16 | 26.18 | 17.34 | 9.48 | 26.18 | 14.10 | 5.27 | 0.97 | 0.32 | 1234 | 1932 | 620.46 |
| | ROE-GN | 0.00 | 0.61 | 4.85 | 11.52 | 19.39 | 39.39 | 20.00 | 3.64 | 0.61 | 165 | 126 | 129.55 |
| 1978/79 | ROE-SN | 5.59 | 4.41 | 31.57 | 18.73 | 21.27 | 15.10 | 2.84 | 0.39 | 0.10 | 1020 | 441 | 387.56" |
| | ROE-GN | 0.00 | 0.00 | 25.13 | 25.13 | 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 | 300.11" |
| | 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 | 187.24 |
| 1992/93 | ROE-SN | 0.32 | 3.45 | 60.34 | 4.45 | 6.06 | 12.07 | 11.75 | 1.16 | 0.40 | 3712 | 304 | 210.27 |
| 1993/94 | ROE-SN | 6.15 | 4.27 | 5.00 | 48.40 | 10.58 | 10.91 | 10.83 | 3.20 | 0.66 | 1219 | 1516 | 23.43 |
| 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 | 22.63 | 26.22 | 33.39 | 5.23 | 1.52 | 4.44 | 5.35 | 0.85 | 0.36 | 1644 | 298 | 1.00~ |

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 | 65.4 | 96.8 | 123.7 | 145.4 | 164.6 | 179.3 | 191.3 | 201.8 | 202.3 |
| ROE-GN | 0.0 | 119.8 | 141.4 | 152.5 | 169.3 | 178.5 | 191.1 | 188.9 | 195.8 |

* - Age composition from published reports.

- No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

' - includes catch from seine roe fisheries

~- includes catch from gillnet fisheries

Appendix Table 1.2. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Prince Rupert District stock assessment region. These data are used for age-structured model analysis.

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10 ³) |
|---------|---------|----------------|-------|-----------|-------|-------|-------|-------|------|------|-------------|---------------|----------------------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | WINTER | 4.34 | 18.20 | 58.50 | 10.38 | 5.62 | 2.65 | 0.26 | 0.04 | 0.02 | 4682 | 2200 | 4953.11 |
| 1951/52 | WINTER | 4.76 | 8.81 | 33.67 | 45.24 | 6.15 | 1.03 | 0.30 | 0.03 | 0.00 | 5922 | 2508 | 4390.81 |
| 1952/53 | WINTER | 1.20 | 38.13 | 23.04 | 25.44 | 11.13 | 0.99 | 0.07 | 0.00 | 0.00 | 1419 | 752 | 173.50 |
| 1953/54 | WINTER | 2.11 | 28.35 | 29.07 | 24.02 | 13.22 | 2.60 | 0.60 | 0.04 | 0.00 | 2656 | 891 | 2522.89 |
| 1954/55 | WINTER | 2.74 | 4.86 | 70.29 | 15.65 | 5.22 | 1.06 | 0.18 | 0.00 | 0.00 | 1131 | 467 | 1698.85 |
| 1955/56 | WINTER | 10.04 | 58.11 | 9.51 | 18.95 | 2.55 | 0.53 | 0.18 | 0.12 | 0.00 | 1683 | 555 | 1218.10 |
| 1956/57 | WINTER | 11.49 | 17.76 | 39.79 | 13.21 | 16.04 | 1.37 | 0.32 | 0.03 | 0.00 | 3491 | 515 | 2827.98 |
| 1957/58 | WINTER | 45.81 | 30.22 | 8.03 | 11.81 | 1.77 | 2.36 | 0.00 | 0.00 | 0.00 | 847 | 123 | 644.16 |
| 1958/59 | WINTER | 3.10 | 56.69 | 20.85 | 5.80 | 9.88 | 1.72 | 1.90 | 0.06 | 0.00 | 1741 | 349 | 1037.09 |
| 1959/60 | WINTER | 49.14 | 6.25 | 28.20 | 8.89 | 4.14 | 2.52 | 0.67 | 0.19 | 0.00 | 4206 | 337 | 2451.31 |
| 1960/61 | WINTER | 9.74 | 58.33 | 7.28 | 18.00 | 4.35 | 1.60 | 0.58 | 0.12 | 0.00 | 4300 | 763 | 4815.52 |
| 1961/62 | WINTER | 3.04 | 30.30 | 44.66 | 6.88 | 9.92 | 3.41 | 0.92 | 0.54 | 0.33 | 1845 | 752 | 2476.36 |
| 1962/63 | WINTER | 39.30 | 13.29 | 18.18 | 22.05 | 3.60 | 2.96 | 0.50 | 0.06 | 0.06 | 3415 | 433 | 4788.66 |
| 1963/64 | WINTER | 3.71 | 64.94 | 10.12 | 10.94 | 8.85 | 0.71 | 0.59 | 0.12 | 0.03 | 3400 | 1914 | 3555.87 |
| 1964/65 | WINTER | 5.98 | 13.57 | 50.95 | 8.54 | 11.01 | 8.45 | 1.04 | 0.33 | 0.12 | 3360 | 459 | 3649.12 |
| 1965/66 | WINTER | 0.00 | 5.29 | 21.38 | 23.45 | 16.32 | 19.08 | 9.66 | 3.22 | 1.61 | 435 | 59 | 1071.96 |
| 1966/67 | WINTER | 57.22 | 32.21 | 5.37 | 1.88 | 2.70 | 0.41 | 0.20 | 0.00 | 0.00 | 0* | 25 | 1218.55 |
| 1967/68 | WINTER | 34.87 | 39.74 | 19.40 | 4.59 | 0.73 | 0.26 | 0.14 | 0.27 | 0.00 | 0* | 25 | 274.98 |
| 1968/69 | WINTER | 30.04 | 45.04 | 20.58 | 3.90 | 0.18 | 0.21 | 0.04 | 0.00 | 0.00 | 0* | 25 | 69.11 |
| 1969/70 | WINTER | 18.67 | 62.91 | 15.11 | 3.12 | 0.03 | 0.08 | 0.08 | 0.00 | 0.00 | 0* | 25 | 183.69 |
| 1970/71 | WINTER | 6.49 | 50.42 | 29.28 | 7.99 | 4.33 | 0.83 | 0.50 | 0.17 | 0.00 | 601 | 38 | 413.67 |
| 1971/72 | ROE-SN | 0.00 | 5.32 | 17.93 | 64.43 | 5.88 | 3.78 | 2.38 | 0.14 | 0.14 | 714 | 209 | 278.66" |
| 1972/73 | WINTER | 22.88 | 47.71 | 7.84 | 13.07 | 4.58 | 2.61 | 1.31 | 0.00 | 0.00 | 153 | 14 | 35.70 |
| | ROE-SN | 0.25 | 33.00 | 4.39 | 30.36 | 26.60 | 3.39 | 1.25 | 0.75 | 0.00 | 797 | 662 | 94.37 |
| 1973/74 | ROE-SN | 0.16 | 17.88 | 53.16 | 7.44 | 16.46 | 4.43 | 0.32 | 0.16 | 0.00 | 632 | 121 | 174.36" |
| | ROE-GN | 0.00 | 0.96 | 39.42 | 21.15 | 34.62 | 2.88 | 0.96 | 0.00 | 0.00 | 104 | 83 | 90.07 |
| 1974/75 | WINTER | 1.16 | 10.47 | 15.12 | 43.02 | 13.95 | 11.63 | 2.33 | 2.33 | 0.00 | 86 | 86 | 14.18 |
| | ROE-SN | 1.30 | 9.40 | 22.19 | 43.10 | 11.16 | 9.63 | 2.47 | 0.59 | 0.16 | 3074 | 778 | 116.23 |
| | ROE-GN | 0.00 | 0.00 | 31.91 | 59.57 | 8.51 | 0.00 | 0.00 | 0.00 | 0.00 | 47 | 47 | 0.76 |
| 1975/76 | WINTER | 0.00 | 4.94 | 6.79 | 9.88 | 16.67 | 17.90 | 35.19 | 8.64 | 0.00 | 162 | 1661 | 30.99 |
| | ROE-SN | 0.00 | 0.84 | 6.87 | 31.70 | 50.07 | 7.29 | 2.38 | 0.84 | 0.00 | 713 | 654 | 204.01 |
| | ROE-GN | 0.00 | 0.00 | 15.79 | 57.89 | 22.81 | 3.51 | 0.00 | 0.00 | 0.00 | 57 | 57 | 17.93 |
| 1976/77 | WINTER | 0.39 | 23.48 | 15.66 | 22.90 | 16.63 | 10.76 | 7.44 | 2.35 | 0.39 | 511 | 276 | 61.55 |
| | ROE-SN | 0.08 | 16.03 | 3.74 | 22.67 | 37.79 | 15.04 | 3.28 | 0.92 | 0.46 | 1310 | 1344 | 370.40 |
| | ROE-GN | 0.00 | 1.07 | 2.14 | 19.93 | 54.09 | 14.59 | 6.76 | 1.42 | 0.00 | 281 | 1104 | 89.48 |
| 1977/78 | WINTER | 1.32 | 9.57 | 27.80 | 18.23 | 18.13 | 14.56 | 6.92 | 2.44 | 1.02 | 982 | 124 | 238.36 |
| | ROE-SN | 1.13 | 11.70 | 32.83 | 9.56 | 21.13 | 20.38 | 2.39 | 0.63 | 0.25 | 795 | 131 | 136.94 |
| | ROE-GN | 0.00 | 0.00 | 20.53 | 5.96 | 32.45 | 33.11 | 6.62 | 1.32 | 0.00 | 151 | 37 | 181.42 |
| 1978/79 | WINTER | 1.81 | 9.27 | 9.83 | 25.85 | 17.77 | 16.17 | 9.55 | 5.71 | 4.04 | 1435 | 856 | 118.66 |
| | ROE-SN | 2.71 | 18.16 | 11.48 | 29.23 | 11.48 | 18.27 | 6.47 | 1.36 | 0.84 | 958 | 1475 | 84.40 |
| | ROE-GN | 1.15 | 1.15 | 8.05 | 41.38 | 15.71 | 22.22 | 8.05 | 1.92 | 0.38 | 261 | 255 | 74.00 |
| 1979/80 | WINTER | 1.12 | 61.15 | 6.55 | 7.92 | 8.18 | 6.55 | 4.91 | 2.07 | 1.55 | 1161 | 560 | 66.18 |
| | ROE-SN | 0.64 | 77.94 | 7.26 | 5.09 | 3.81 | 3.49 | 1.28 | 0.39 | 0.11 | 2811 | 535 | 171.81 |
| | ROE-GN | 0.00 | 3.45 | 8.72 | 31.24 | 22.31 | 21.10 | 9.13 | 3.45 | 0.61 | 493 | 915 | 63.73 |
| 1980/81 | WINTER | 1.01 | 7.37 | 54.61 | 9.33 | 10.22 | 9.29 | 4.31 | 2.31 | 1.53 | 6524 | 1129 | 137.14 |
| | ROE-SN | 0.46 | 11.18 | 81.22 | 3.30 | 1.73 | 1.51 | 0.37 | 0.15 | 0.06 | 3238 | 1059 | 106.00 |
| | ROE-GN | 0.00 | 0.47 | 38.88 | 15.46 | 22.95 | 14.75 | 5.62 | 1.87 | 0.00 | 427 | 557 | 23.77 |
| 1981/82 | WINTER | 1.54 | 11.54 | 20.53 | 41.10 | 10.49 | 6.59 | 5.02 | 2.06 | 1.12 | 2669 | 555 | 138.82 |
| | ROE-SN | 2.72 | 18.78 | 7.38 | 66.32 | 2.85 | 1.36 | 0.39 | 0.19 | 0.00 | 1544 | 576 | 16.50 |
| 1982/83 | ROE-SN | 1.35 | 20.82 | 17.74 | 5.26 | 49.16 | 3.73 | 1.13 | 0.59 | 0.22 | 4583 | 1448 | 1.00 |
| 1983/84 | WINTER | 2.75 | 36.24 | 15.75 | 13.91 | 9.79 | 16.36 | 2.75 | 1.07 | 1.38 | 654 | 303 | 18.03 |
| | ROE-SN | 0.49 | 35.46 | 14.42 | 10.29 | 14.38 | 23.62 | 0.99 | 0.25 | 0.11 | 2837 | 618 | 159.00 |
| | ROE-GN | 0.00 | 0.99 | 1.98 | 12.87 | 21.39 | 57.43 | 3.37 | 1.19 | 0.79 | 505 | 961 | 127.31 |
| 1984/85 | WINTER | 15.37 | 8.24 | 25.83 | 28.21 | 11.73 | 5.39 | 4.12 | 0.79 | 0.32 | 631 | 45 | 28.24 |
| | ROE-SN | 0.22 | 7.75 | 54.69 | 11.93 | 6.39 | 10.56 | 8.19 | 0.14 | 0.14 | 3664 | 969 | 278.16 |
| | ROE-GN | 0.00 | 0.36 | 16.36 | 14.91 | 15.82 | 21.82 | 29.82 | 0.36 | 0.55 | 550 | 543 | 235.00 |
| 1985/86 | WINTER | 11.73 | 9.91 | 7.95 | 21.25 | 18.64 | 11.73 | 6.65 | 6.91 | 5.22 | 767 | 512 | 25.39 |
| | ROE-SN | 1.75 | 13.76 | 9.44 | 46.26 | 10.80 | 5.27 | 7.09 | 5.53 | 0.09 | 5655 | 4566 | 277.60 |
| | ROE-GN | 0.00 | 0.39 | 4.32 | 53.85 | 19.00 | 8.71 | 7.77 | 5.73 | 0.24 | 1274 | 558 | 311.02 |
| 1986/87 | ROE-SN | 0.89 | 38.64 | 10.21 | 6.89 | 29.87 | 5.90 | 3.49 | 2.87 | 1.25 | 4731 | 4068 | 187.95" |
| | ROE-GN | 0.00 | 0.57 | 3.01 | 6.93 | 55.25 | 16.07 | 8.80 | 5.96 | 3.41 | 1761 | 819 | 270.57 |
| 1987/88 | ROE-SN | 0.45 | 30.94 | 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 | 134.02" |
| | 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 | 143.41" |
| | 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 | 212.03" |
| | 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 | 219.68" |
| | 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 | 63.35 |
| | 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 | 1.00 |
| | 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 | 1.00" |
| | ROE-GN | 0.00 | 0.16 | 19.49</td | | | | | | | | | |

| FISHERY | 1+ | 2+ | 3+ | AVERAGE WEIGHT AT AGE (gms) | | | | | | |
|---------|------|-------|-------|-----------------------------|-------|-------|-------|-------|-------|--|
| | | | | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | |
| WINTER | 43.9 | 79.3 | 107.9 | 128.2 | 146.1 | 163.1 | 173.5 | 188.7 | 206.8 | |
| ROE-SN | 52.4 | 81.3 | 108.4 | 130.5 | 147.8 | 161.1 | 173.2 | 182.1 | 192.3 | |
| ROE-GN | 90.3 | 114.3 | 131.1 | 141.2 | 152.0 | 158.6 | 165.5 | 173.1 | 179.1 | |

* - Age composition from published reports.

~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

' - includes catch from seine roe fisheries

^ - includes catch from gillnet fisheries

Appendix Table 1.3. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Central Coast stock assessment region. These data are used for age-structured model analysis.

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10 ³) |
|---------|---------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|---------------|-------------------------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | WINTER | 2.43 | 28.56 | 50.66 | 12.00 | 5.06 | 1.24 | 0.06 | 0.00 | 0.00 | 5316 | 2487 | 3904.06 |
| 1951/52 | WINTER | 5.18 | 20.07 | 30.08 | 38.13 | 4.50 | 1.53 | 0.45 | 0.04 | 0.02 | 5156 | 1431 | 2925.93 |
| 1952/53 | WINTER | 9.36 | 28.09 | 23.99 | 26.62 | 10.15 | 1.33 | 0.44 | 0.00 | 0.00 | 2926 | 543 | 73.57 |
| 1953/54 | WINTER | 3.95 | 69.68 | 20.26 | 4.61 | 1.29 | 0.16 | 0.00 | 0.06 | 0.00 | 3189 | 478 | 3476.95 |
| 1954/55 | WINTER | 6.66 | 7.72 | 74.62 | 9.09 | 1.54 | 0.38 | 0.00 | 0.00 | 0.00 | 2344 | 165 | 1235.03 |
| 1955/56 | WINTER | 16.88 | 13.62 | 9.20 | 57.01 | 2.89 | 0.34 | 0.04 | 0.00 | 0.02 | 5052 | 1347 | 4134.75 |
| 1956/57 | WINTER | 16.74 | 50.70 | 10.79 | 6.23 | 14.78 | 0.73 | 0.02 | 0.00 | 0.00 | 4688 | 1703 | 2635.45 |
| 1957/58 | WINTER | 23.51 | 61.39 | 12.66 | 1.28 | 0.59 | 0.56 | 0.00 | 0.00 | 0.00 | 3743 | 847 | 1445.86 |
| 1958/59 | WINTER | 3.80 | 49.52 | 36.89 | 8.10 | 0.80 | 0.44 | 0.42 | 0.02 | 0.00 | 4974 | 1352 | 3293.36 |
| 1959/60 | WINTER | 43.50 | 23.16 | 26.48 | 5.58 | 1.13 | 0.07 | 0.07 | 0.00 | 0.00 | 1416 | 165 | 639.45 |
| 1960/61 | WINTER | 16.08 | 32.23 | 10.79 | 29.69 | 10.08 | 0.93 | 0.11 | 0.07 | 0.04 | 2799 | 1227 | 3463.55 |
| 1961/62 | WINTER | 9.65 | 57.43 | 17.95 | 2.60 | 9.90 | 2.35 | 0.12 | 0.00 | 0.00 | 808 | 146 | 1721.99 |
| 1962/63 | WINTER | 0.37 | 30.27 | 57.96 | 5.43 | 2.85 | 2.94 | 0.18 | 0.00 | 0.00 | 1087 | 885 | 4376.33 |
| 1963/64 | WINTER | 13.12 | 47.38 | 27.74 | 10.25 | 1.43 | 0.08 | 0.00 | 0.00 | 0.00 | 1258 | 198 | 3507.73 |
| 1964/65 | WINTER | 8.17 | 36.40 | 33.77 | 15.83 | 5.43 | 0.34 | 0.06 | 0.00 | 0.00 | 1750 | 684 | 1326.51 |
| 1965/66 | WINTER | 67.32 | 20.43 | 7.33 | 3.60 | 1.13 | 0.19 | 0.00 | 0.00 | 0.00 | 0* | 25 | 5216.79 |
| 1966/67 | WINTER | 37.40 | 46.19 | 13.10 | 2.04 | 1.02 | 0.17 | 0.07 | 0.01 | 0.00 | 0* | 25 | 2514.89 |
| 1967/68 | WINTER | 32.53 | 48.02 | 17.02 | 2.11 | 0.25 | 0.00 | 0.06 | 0.00 | 0.00 | 0* | 25 | 170.14 |
| 1968/69 | WINTER | 32.21 | 27.70 | 26.72 | 11.30 | 1.95 | 0.12 | 0.00 | 0.00 | 0.00 | 0* | 25 | 10.08 |
| 1969/70 | WINTER | 54.02 | 44.42 | 1.16 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0* | 25 | 28.32 |
| 1970/71 | WINTER | 14.39 | 39.60 | 36.87 | 3.78 | 4.20 | 0.95 | 0.11 | 0.11 | 0.00 | 952 | 136 | 339.30 |
| 1971/72 | ROE-SN | 4.35 | 29.83 | 27.65 | 25.69 | 6.91 | 4.35 | 1.14 | 0.05 | 0.00 | 1837 | 598 | 762.73" |
| | 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 | 541.68 |
| | 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 | 687.64" |
| | 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 | 760.36 |
| | 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 | 843.80 |
| | 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 | 649.64 |
| | 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 | 329.52 |
| | 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 | 367.69 |
| | ROE-GN | 0.00 | 1.36 | 2.92 | 6.23 | 22.76 | 19.26 | 38.33 | 7.20 | 1.95 | 514 | 477 | 29.41 |

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 | 53.9 | 86.5 | 111.0 | 131.9 | 149.5 | 164.1 | 176.8 | 188.1 | 196.9 |
| ROE-GN | 39.3 | 115.4 | 134.7 | 146.4 | 156.0 | 165.5 | 173.8 | 179.2 | 178.1 |

* - Age composition from published reports.

~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

^ - includes catch from seine roe fisheries

~ - includes catch from gillnet fisheries

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

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10 ³) |
|---------|---------|----------------|-------|-------|-------|-------|-------|-------|------|------|-------------|---------------|----------------------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | WINTER | 4.17 | 56.48 | 30.35 | 7.12 | 1.41 | 0.35 | 0.10 | 0.03 | 0.00 | 7813 | 1085 | 4404.07 |
| 1951/52 | WINTER | 11.17 | 55.37 | 25.06 | 6.74 | 1.32 | 0.27 | 0.07 | 0.01 | 0.00 | 9025 | 1541 | 4821.55 |
| 1952/53 | WINTER | 9.47 | 56.02 | 28.96 | 4.09 | 1.23 | 0.20 | 0.05 | 0.00 | 0.00 | 8640 | 1489 | 1038.41 |
| 1953/54 | WINTER | 1.52 | 45.67 | 36.81 | 11.55 | 3.28 | 0.94 | 0.21 | 0.02 | 0.00 | 13162 | 4357 | 6463.55 |
| 1954/55 | WINTER | 4.40 | 48.63 | 39.05 | 6.73 | 1.08 | 0.11 | 0.00 | 0.00 | 0.00 | 5291 | 805 | 7070.11 |
| 1955/56 | WINTER | 7.00 | 35.08 | 28.78 | 23.67 | 4.45 | 0.73 | 0.21 | 0.05 | 0.02 | 9832 | 2632 | 7200.60 |
| 1956/57 | WINTER | 1.40 | 59.78 | 22.33 | 10.70 | 5.08 | 0.60 | 0.07 | 0.01 | 0.03 | 7478 | 2184 | 5972.40 |
| 1957/58 | WINTER | 8.98 | 54.48 | 22.13 | 5.99 | 5.06 | 2.89 | 0.41 | 0.07 | 0.00 | 7397 | 1589 | 2238.02 |
| 1958/59 | WINTER | 17.11 | 63.89 | 15.48 | 2.58 | 0.55 | 0.24 | 0.12 | 0.02 | 0.01 | 9964 | 3899 | 6104.01 |
| 1959/60 | WINTER | 7.70 | 51.34 | 36.56 | 3.61 | 0.53 | 0.16 | 0.08 | 0.00 | 0.03 | 3742 | 1215 | 6919.14 |
| 1960/61 | WINTER | 31.53 | 27.21 | 26.87 | 12.73 | 1.49 | 0.16 | 0.00 | 0.00 | 0.00 | 4351 | 820 | 5244.59 |
| 1961/62 | WINTER | 9.05 | 70.06 | 13.18 | 5.28 | 2.03 | 0.37 | 0.03 | 0.00 | 0.00 | 3203 | 936 | 7130.68 |
| 1962/63 | WINTER | 17.63 | 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 | 3.4 | | | | | | | |

| | | | | | | | | | | | | | |
|---------|--------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|---------|
| 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 | 204.20 |
| | ROE-SN | 7.85 | 52.10 | 23.23 | 6.01 | 6.51 | 2.59 | 1.51 | 0.13 | 0.07 | 7107 | 3423 | 1191.70 |
| | ROE-GN | 0.00 | 4.74 | 17.85 | 16.43 | 31.91 | 17.06 | 8.53 | 2.53 | 0.95 | 633 | 501 | 524.94 |

| FISHERY | AVERAGE WEIGHT AT AGE (gms) | | | | | | | | |
|---------|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ |
| WINTER | 54.8 | 90.6 | 115.9 | 139.4 | 154.1 | 168.3 | 179.6 | 188.2 | 203.0 |
| ROE-SN | 58.3 | 84.2 | 109.6 | 130.3 | 149.0 | 163.7 | 173.1 | 179.9 | 193.6 |
| ROE-GN | 66.2 | 118.2 | 134.9 | 145.9 | 156.0 | 163.6 | 173.4 | 172.6 | 176.3 |

Appendix Table 1.5. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the west coast of Vancouver Island stock assessment region. These data are used for age-structured model analysis.

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH |
|-----------|---------|----------------|-------|-------|-------|-------|-------|------|------|------|-------------|---------------|----------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | WINTER | 12.58 | 37.63 | 41.27 | 6.74 | 1.44 | 0.30 | 0.02 | 0.02 | 0.00 | 4037 | 580 | 2223.54 |
| 1951/52 | WINTER | 1.97 | 29.16 | 24.99 | 37.07 | 4.98 | 1.46 | 0.33 | 0.04 | 0.00 | 4921 | 2483 | 2287.45 |
| 1952/53 | WINTER | 14.28 | 56.10 | 27.45 | 1.64 | 0.48 | 0.05 | 0.00 | 0.00 | 0.00 | 3957 | 607 | 2.46 |
| 1953/54 | WINTER | 2.68 | 63.23 | 27.59 | 5.55 | 0.69 | 0.15 | 0.08 | 0.02 | 0.02 | 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 |
| 1973/74 | ROE-GN | 0.00 | 7.85 | 22.92 | 51.76 | 13.46 | 2.88 | 0.96 | 0.16 | 0.00 | 624 | 526 | 95.73 |
| 1974/75 | ROE-SN | 8.04 | 43.04 | 23.95 | 13.62 | 8.86 | 2.21 | 0.22 | 0.04 | 0.02 | 5420 | 3103 | 1112.16 |
| 1975/76 | ROE-GN | 0.00 | 26.14 | 30.68 | 26.14 | 13.64 | 3.41 | 0.00 | 0.00 | 0.00 | 176 | 30 | 288.53 |
| 1976/77 | ROE-SN | 0.59 | 53.76 | 19.82 | 11.40 | 7.97 | 4.99 | 1.29 | 0.17 | 0.01 | 10114 | 4380 | 1451.92" |
| 1977/78 | ROE-GN | 0.00 | 2.97 | 30.48 | 37.92 | 21.19 | 7.06 | 0.37 | 0.00 | 0.00 | 269 | 145 | 493.67 |
| 1978/79 | ROE-SN | 0.21 | 8.86 | 46.93 | 19.80 | 12.96 | 8.08 | 2.72 | 0.43 | 0.00 | 9230 | 1628 | 1626.81 |
| 1979/80 | ROE-GN | 0.00 | 0.68 | 40.26 | 33.87 | 15.68 | 6.62 | 2.51 | 0.30 | 0.08 | 1314 | 127 | 1053.75 |
| 1980/81 | ROE-SN | 0.52 | 12.42 | 31.09 | 37.16 | 12.36 | 4.46 | 1.66 | 0.28 | 0.04 | 6746 | 1395 | 1281.46" |
| 1981/82 | ROE-GN | 0.56 | 3.53 | 16.48 | 42.74 | 17.60 | 12.29 | 5.31 | 1.40 | 0.28 | 358 | 49 | 813.02 |
| 1982/83 | ROE-SN | 1.27 | 43.83 | 23.50 | 13.70 | 14.21 | 2.16 | 0.81 | 0.30 | 0.21 | 2357 | 521 | 257.67 |
| 1983/84 | ROE-SN | 0.69 | 40.18 | 17.88 | 16.77 | 18.51 | 4.43 | 1.29 | 0.18 | 0.07 | 5963 | 2622 | 457.42 |
| 1984/85 | ROE-SN | 0.77 | 13.64 | 50.60 | 14.26 | 10.66 | 7.88 | 1.54 | 0.51 | 0.13 | 3885 | 564 | 849.26" |
| 1985/86 | ROE-SN | 0.00 | 1.23 | 25.92 | 26.62 | 25.04 | 18.91 | 1.93 | 0.35 | 0.00 | 571 | 257 | 519.39 |
| 1986/87 | ROE-SN | 2.86 | 43.86 | 14.95 | 22.01 | 7.26 | 6.06 | 2.43 | 0.47 | 0.10 | 3003 | 469 | 152.30" |
| 1987/88 | ROE-GN | 0.00 | 0.00 | 5.31 | 47.12 | 22.57 | 14.38 | 9.73 | 0.66 | 0.22 | 452 | 497 | 145.27 |
| 1988/89 | ROE-SN | 20.47 | 53.62 | 14.22 | 3.71 | 2.74 | 3.17 | 1.70 | 0.13 | 0.23 | 3745 | 853 | 433.90" |
| 1989/90 | ROE-SN | 3.78 | 50.45 | 29.70 | 8.29 | 3.13 | 2.24 | 1.76 | 0.58 | 0.07 | 5046 | 2597 | 204.20" |
| 1990/91 | ROE-GN | 4.21 | 22.56 | 21.87 | 21.90 | 17.66 | 4.43 | 5.40 | 1.06 | 0.90 | 3205 | 1818 | 477.79 |
| 1991/92 | ROE-SN | 0.00 | 0.35 | 14.19 | 23.82 | 44.83 | 6.48 | 9.81 | 0.35 | 0.18 | 571 | 159 | 176.62 |
| 1992/93 | ROE-SN | 21.73 | 37.22 | 13.58 | 9.16 | 10.04 | 5.91 | 1.07 | 1.07 | 0.23 | 3079 | 1182 | 492.56 |
| 1993/94 | ROE-GN | 0.00 | 1.68 | 6.72 | 17.98 | 32.61 | 31.93 | 5.38 | 3.36 | 0.34 | 595 | 464 | 55.40 |
| 1994/95 | ROE-SN | 2.56 | 60.97 | 7.66 | 14.75 | 9.87 | 2.80 | 0.74 | 0.44 | 0.21 | 7459 | 4721 | 667.13 |
| 1995/96 | ROE-SN | 0.00 | 5.40 | 7.00 | 40.80 | 29.40 | 12.80 | 3.00 | 1.20 | 0.40 | 500 | 607 | 86.67 |
| 1996/97 | ROE-SN | 0.24 | 15.81 | 60.96 | 6.58 | 8.67 | 4.53 | 0.68 | 0.18 | 0.04 | 5712 | 2510 | 756.40 |
| 1997/98 | ROE-SN | 0.00 | 0.26 | 54.45 | 10.99 | 22.25 | 9.42 | 1.57 | 1.05 | 0.00 | 382 | 145 | 232.76 |
| 1998/99 | ROE-SN | 0.48 | 27.17 | 12.43 | 47.33 | 4.49 | 5.94 | 1.83 | 0.23 | 0.09 | 6831 | 6315 | 563.72 |
| 1999/2000 | ROE-SN | 0.00 | 1.35 | 7.87 | 68.99 | 8.31 | 10.34 | 2.47 | 0.67 | 0.00 | 445 | 428 | 125.93 |
| 2000/2001 | ROE-SN | 6.59 | 21.41 | 21.11 | 10.67 | 33.10 | 3.01 | 3.43 | 0.66 | 0.03 | 7311 | 4577 | 477.28 |
| 2001/2002 | ROE-SN | 0.00 | 0.29 | 7.16 | 11.75 | 63.90 | 8.02 | 8.02 | 0.57 | 0.29 | 349 | 223 | 147.29 |
| 2002/2003 | ROE-SN | 1.62 | 47.83 | 10.54 | 13.43 | 6.02 | 17.01 | 2.11 | 1.22 | 0.22 | 5979 | 3775 | 238.52 |
| 2003/2004 | ROE-SN | 0.00 | 6.29 | 13.49 | 30.76 | 13.85 | 29.86 | 2.88 | 2.52 | 0.36 | 556 | 617 | 40.66 |
| 2004/2005 | ROE-SN | 3.94 | 27.77 | 40.59 | 6.85 | 7.51 | 4.11 | 7.72 | 0.94 | 0.57 | 5430 | 2772 | 451.42 |
| 2005/2006 | ROE-SN | 2.98 | 22.32 | 23.76 | 30.53 | 8.05 | 5.10 | 5.41 | 1.59 | 0.25 | 6098 | 3120 | 425.61" |
| 2006/2007 | ROE-GN | 0.00 | 4.78 | 31.96 | 56.01 | 5.44 | 1.15 | 0.49 | 0.16 | 0.00 | 607 | 581 | 53.41 |
| 2007/2008 | ROE-SN | 0.83 | 13.35 | 24.05 | 20.45 | 25.99 | 6.85 | 4.55 | 3.21 | 0.72 | 4832 | 1060 | 137.42" |
| 2008/2009 | ROE-SN | 14.20 | 21.22 | 13.04 | 18.79 | 13.11 | 14.17 | 3.15 | 1.37 | 0.95 | 6126 | 3332 | 64.59" |
| 2009/2010 | ROE-SN | 2.49 | 68.99 | 8.13 | 4.51 | 6.60 | 4.98 | 3.39 | 0.56 | 0.35 | 5698 | 3736 | 761.50 |

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 | 64.7 | 94.1 | 122.6 | 146.8 | 166.3 | 180.1 | 190.2 | 198.5 | 202.8 |
| ROE-GN | 45.5 | 116.0 | 136.9 | 151.8 | 162.8 | 173.5 | 178.8 | 183.0 | 179.6 |

* - Age composition from published reports.

~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

^- includes catch from seine roe fisheries

` - includes catch from gillnet fisheries

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

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10) |
|---------|---------|----------------|-------|-------|-------|-------|-------|-------|------|------|-------------|---------------|---------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1953/54 | WINTER | 0.00 | 47.57 | 40.45 | 10.11 | 0.75 | 1.12 | 0.00 | 0.00 | 0.00 | 267 | 4376 | 206.40 |
| 1954/55 | WINTER | 6.80 | 34.77 | 49.72 | 6.94 | 1.42 | 0.28 | 0.07 | 0.00 | 0.00 | 1412 | 510 | 614.00 |
| 1963/64 | WINTER | 0.00 | 46.32 | 30.53 | 22.11 | 1.05 | 0.00 | 0.00 | 0.00 | 0.00 | 95 | 440 | 29.70 |
| 1964/65 | WINTER | 1.41 | 18.31 | 36.62 | 33.10 | 7.04 | 0.70 | 1.41 | 1.41 | 0.00 | 142 | 131 | 55.25 |
| 1975/76 | ROE-GN | 0.00 | 3.74 | 41.18 | 27.27 | 17.65 | 6.42 | 3.74 | 0.00 | 0.00 | 187 | 18 | 5.55 |
| 1977/78 | WINTER | 1.41 | 53.52 | 5.63 | 19.72 | 16.90 | 2.82 | 0.00 | 0.00 | 0.00 | 71 | 71 | 14.38 |
| 1978/79 | ROE-SN | 1.25 | 12.50 | 68.75 | 12.50 | 2.50 | 1.25 | 1.25 | 0.00 | 0.00 | 80 | 80 | 40.35 |
| | ROE-GN | 0.00 | 1.06 | 48.94 | 17.02 | 20.21 | 11.70 | 1.06 | 0.00 | 0.00 | 94 | 3599 | 18.68 |
| 1979/80 | ROE-GN | 0.00 | 4.00 | 9.33 | 70.67 | 12.00 | 2.67 | 1.33 | 0.00 | 0.00 | 75 | 39 | 36.66 |
| 1980/81 | ROE-SN | 2.23 | 13.50 | 61.21 | 8.26 | 13.24 | 1.57 | 0.00 | 0.00 | 0.00 | 763 | 412 | 59.41 |
| 1981/82 | ROE-SN | 0.66 | 33.00 | 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 |
| 1991/92 | ROE-SN | 3.48 | 71.21 | 11.21 | 3.40 | 2.91 | 5.04 | 0.99 | 1.28 | 0.50 | 1410 | 668 | 28.71 |
| 1992/93 | ROE-SN | 10.50 | 33.33 | 40.88 | 5.52 | 1.29 | 1.66 | 5.71 | 0.37 | 0.74 | 543 | 310 | 1.00 |
| | 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 | 1.00 |
| | 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 | 6.67 |
| 1995/96 | ROE-SN | 14.18 | 22.70 | 6.38 | 20.57 | 15.60 | 16.67 | 2.84 | 0.35 | 0.71 | 282 | 403 | 1.00 |
| 1996/97 | ROE-SN | 4.01 | 76.83 | 7.32 | 1.57 | 4.01 | 4.70 | 1.57 | 0.00 | 0.00 | 574 | 142 | 1.00 |

AVERAGE WEIGHT AT AGE (gms)

| FISHERY | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ |
|---------|------|-------|-------|-------|-------|-------|-------|-------|-------|
| WINTER | 69.2 | 91.1 | 119.9 | 146.3 | 164.8 | 174.1 | 202.7 | 208.8 | 0.0 |
| ROE-SN | 57.6 | 96.2 | 121.9 | 142.9 | 162.7 | 179.6 | 186.7 | 207.5 | 215.7 |
| ROE-GN | 0.0 | 114.9 | 134.4 | 144.1 | 152.1 | 155.8 | 166.3 | 179.0 | 196.2 |

* - Age composition from published reports.

~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

' - includes catch from seine roe fisheries

- includes catch from gillnet fisheries

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

| SEASON | FISHERY | PERCENT AT AGE | | | | | | | | | NUMBER AGED | SAMPLE WEIGHT | CATCH (x 10) |
|---------|---------|----------------|-------|-------|-------|-------|-------|-------|-------|------|----------------|------------------|------------------|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1956/57 | WINTER | 0.00 | 63.41 | 31.71 | 2.44 | 2.44 | 0.00 | 0.00 | 0.00 | 0.00 | 41 | 41 | 12.10 |
| 1964/65 | WINTER | 0.00 | 46.00 | 8.00 | 28.00 | 8.00 | 6.00 | 4.00 | 0.00 | 0.00 | 50 | 50 | 85.99 |
| 1972/73 | ROE-SN | 0.00 | 7.80 | 19.86 | 18.44 | 46.81 | 4.96 | 1.42 | 0.71 | 0.00 | 141 | 655 | 43.98 |
| 1973/74 | ROE-SN | 7.62 | 25.71 | 23.33 | 21.90 | 8.10 | 11.43 | 1.90 | 0.00 | 0.00 | 210 | 110 | 32.07 |
| 1974/75 | ROE-SN | 0.53 | 45.72 | 32.89 | 12.57 | 3.48 | 3.74 | 1.07 | 0.00 | 0.00 | 374 | 161 | 50.56 |
| 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~ |

| FISHERY | AVERAGE WEIGHT AT AGE (gms) | | | | | | | | |
|---------|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 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 | 67.3 | 105.3 | 136.0 | 162.4 | 185.3 | 193.7 | 212.6 | 210.9 | 214.7 |
| ROE-GN | 53.2 | 81.9 | 139.8 | 162.0 | 187.7 | 191.9 | 199.0 | 0.0 | 0.0 |

* - Age composition from published reports.

- No seine roe fishery in this season. Age composition from pre-fishery charter samples only.

" - includes catch from "other" fisheries

' - includes catch from seine roe fisheries

- includes catch from gillnet fisheries

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

| Season | Estimated numbers at age ($\times 10^5$) for period 1 | | | | | | | | | SB | SI | RES |
|---------|---|-------|-------|------|------|------|------|-----|-----|-------|-------|-------|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | 3363 | 1945 | 1026 | 206 | 135 | 57 | 0 | 0 | 0 | 4455 | 2510 | 0.19 |
| 1951/52 | 4864 | 2097 | 1176 | 512 | 91 | 57 | 24 | 0 | 0 | 4839 | 2398 | 0.07 |
| 1952/53 | 22337 | 2890 | 1124 | 457 | 146 | 22 | 14 | 6 | 0 | 19602 | 4759 | -0.65 |
| 1953/54 | 2714 | 13932 | 1802 | 701 | 285 | 91 | 14 | 8 | 4 | 14581 | 9853 | 0.38 |
| 1954/55 | 3518 | 1687 | 8622 | 1070 | 407 | 164 | 52 | 8 | 7 | 44353 | 6143 | -1.21 |
| 1955/56 | 1109 | 2191 | 1048 | 5351 | 662 | 252 | 101 | 32 | 9 | 6386 | 4014 | 0.30 |
| 1956/57 | 2051 | 685 | 633 | 297 | 712 | 46 | 17 | 7 | 3 | 1706 | 1578 | 0.69 |
| 1957/58 | 4587 | 972 | 69 | 177 | 38 | 44 | 3 | 1 | 1 | 2714 | 787 | -0.47 |
| 1958/59 | 1700 | 1567 | 349 | 22 | 34 | 5 | 6 | 0 | 0 | 9987 | 6941 | 0.40 |
| 1959/60 | 4009 | 791 | 729 | 184 | 11 | 16 | 2 | 3 | 0 | 5998 | 6470 | 0.84 |
| 1960/61 | 4823 | 2501 | 493 | 455 | 115 | 7 | 10 | 1 | 2 | 9547 | 6976 | 0.45 |
| 1961/62 | 9113 | 3006 | 1539 | 299 | 273 | 68 | 4 | 6 | 2 | 11645 | 4654 | -0.15 |
| 1962/63 | 1867 | 5669 | 1685 | 757 | 130 | 111 | 28 | 2 | 3 | 15407 | 6176 | -0.15 |
| 1963/64 | 4917 | 1160 | 3029 | 775 | 293 | 46 | 40 | 10 | 2 | 5215 | 4223 | 0.56 |
| 1964/65 | 393 | 3049 | 428 | 961 | 141 | 36 | 6 | 5 | 1 | 2233 | 1446 | 0.33 |
| 1965/66 | 302 | 208 | 138 | 115 | 108 | 6 | 2 | 0 | 0 | 2926 | 2764 | 0.71 |
| 1966/67 | 380 | 157 | 77 | 65 | 46 | 40 | 2 | 1 | 0 | 2894 | 710 | -0.64 |
| 1967/68 | 745 | 237 | 91 | 46 | 38 | 27 | 23 | 1 | 0 | 3325 | 750 | -0.72 |
| 1968/69 | 2067 | 463 | 145 | 56 | 28 | 23 | 16 | 14 | 1 | 4281 | 1877 | -0.06 |
| 1969/70 | 4653 | 1289 | 289 | 91 | 35 | 17 | 14 | 10 | 9 | 8436 | 4308 | 0.10 |
| 1970/71 | 4006 | 2902 | 804 | 180 | 57 | 22 | 11 | 9 | 12 | 16252 | 13616 | 0.59 |
| 1971/72 | 10992 | 2499 | 1810 | 502 | 112 | 35 | 14 | 7 | 13 | 19957 | 9951 | 0.07 |
| 1972/73 | 8803 | 6848 | 1470 | 1017 | 268 | 59 | 18 | 7 | 10 | 24724 | 7706 | -0.40 |
| 1973/74 | 7779 | 5490 | 4062 | 787 | 504 | 128 | 28 | 9 | 8 | 37754 | 9903 | -0.57 |
| 1974/75 | 2037 | 4851 | 3282 | 2316 | 428 | 269 | 68 | 15 | 9 | 45964 | 8951 | -0.87 |
| 1975/76 | 2649 | 1267 | 2883 | 1870 | 1261 | 228 | 143 | 36 | 13 | 36918 | 15143 | -0.12 |
| 1976/77 | 3000 | 1648 | 769 | 1524 | 888 | 562 | 101 | 63 | 22 | 29489 | 12516 | -0.09 |
| 1977/78 | 1719 | 1871 | 875 | 393 | 704 | 392 | 248 | 45 | 38 | 17975 | 11452 | 0.32 |
| 1978/79 | 33785 | 1071 | 1007 | 431 | 161 | 259 | 140 | 89 | 29 | 9947 | 8657 | 0.63 |
| 1979/80 | 2437 | 21051 | 651 | 483 | 159 | 52 | 81 | 44 | 37 | 37772 | 21204 | 0.19 |
| 1980/81 | 985 | 1519 | 12946 | 391 | 260 | 79 | 25 | 39 | 39 | 60805 | 19023 | -0.39 |
| 1981/82 | 1057 | 614 | 936 | 7712 | 220 | 135 | 40 | 13 | 39 | 62184 | 19009 | -0.42 |
| 1982/83 | 7085 | 658 | 374 | 567 | 4580 | 128 | 76 | 22 | 29 | 50954 | 19082 | -0.21 |
| 1983/84 | 3137 | 4404 | 394 | 221 | 325 | 2575 | 71 | 42 | 29 | 40740 | 20438 | 0.08 |
| 1984/85 | 722 | 1949 | 2634 | 232 | 126 | 182 | 1435 | 40 | 40 | 33838 | 14393 | -0.09 |
| 1985/86 | 1459 | 446 | 1170 | 1514 | 126 | 66 | 94 | 742 | 41 | 29848 | 5636 | -0.90 |
| 1986/87 | 10171 | 910 | 274 | 687 | 857 | 70 | 36 | 52 | 432 | 23133 | 13132 | 0.20 |
| 1987/88 | 3860 | 6342 | 554 | 162 | 398 | 491 | 40 | 21 | 277 | 29143 | 14456 | 0.07 |
| 1988/89 | 1338 | 2407 | 3954 | 345 | 101 | 248 | 306 | 25 | 186 | 34533 | 23986 | 0.40 |
| 1989/90 | 869 | 832 | 1480 | 2403 | 207 | 60 | 148 | 183 | 126 | 28924 | 25011 | 0.61 |
| 1990/91 | 4407 | 541 | 479 | 831 | 1253 | 103 | 29 | 72 | 149 | 19823 | 14220 | 0.44 |
| 1991/92 | 376 | 2729 | 325 | 269 | 440 | 638 | 51 | 14 | 110 | 20615 | 9815 | 0.03 |
| 1992/93 | 256 | 233 | 1631 | 190 | 152 | 245 | 356 | 29 | 69 | 14735 | 5825 | -0.16 |
| 1993/94 | 933 | 159 | 138 | 918 | 102 | 80 | 129 | 187 | 51 | 12682 | 5245 | -0.12 |
| 1994/95 | 5108 | 581 | 98 | 85 | 561 | 62 | 49 | 78 | 145 | 12420 | 4946 | -0.15 |
| 1995/96 | 3589 | 3186 | 362 | 61 | 53 | 350 | 39 | 30 | 139 | 15905 | 5827 | -0.24 |
| 1996/97 | 9202 | 2239 | 1987 | 226 | 38 | 33 | 218 | 24 | 106 | 21993 | 11791 | 0.14 |

Estimated average availability at age (S_i)

0.09 0.43 0.61 0.89 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.01 0.03 0.19 0.54 0.79 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.46

Estimated instantaneous natural mortality rate is 0.472

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

| Season | Estimated numbers at age ($\times 10^5$) for period 1 | | | | | | | | | | SB | SI | RES |
|---------|---|-------|-------|------|------|------|-----|-----|-----|-------|-------|-------|-----|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | | |
| 1950/51 | 5251 | 6220 | 7980 | 1107 | 406 | 215 | 0 | 0 | 0 | 13159 | 30098 | 1.26 | |
| 1951/52 | 5356 | 3264 | 3384 | 3106 | 311 | 75 | 39 | 0 | 0 | 5624 | 18726 | 1.63 | |
| 1952/53 | 12067 | 3341 | 1847 | 1130 | 628 | 26 | 6 | 3 | 0 | 28571 | 26180 | 0.34 | |
| 1953/54 | 3584 | 7867 | 2126 | 1171 | 708 | 389 | 16 | 4 | 2 | 9145 | 13290 | 0.81 | |
| 1954/55 | 9508 | 2293 | 4540 | 822 | 324 | 127 | 70 | 3 | 1 | 13617 | 25629 | 1.06 | |
| 1955/56 | 3108 | 6163 | 1429 | 2095 | 314 | 101 | 40 | 22 | 1 | 39701 | 15498 | -0.51 | |
| 1956/57 | 5732 | 1930 | 3465 | 840 | 1177 | 169 | 54 | 21 | 12 | 15293 | 28280 | 1.05 | |
| 1957/58 | 11284 | 3483 | 858 | 1499 | 287 | 307 | 44 | 14 | 9 | 34337 | 12044 | -0.62 | |
| 1958/59 | 3609 | 7140 | 2134 | 526 | 895 | 167 | 179 | 26 | 13 | 39259 | 36608 | 0.36 | |
| 1959/60 | 20121 | 2328 | 4185 | 1254 | 295 | 481 | 90 | 96 | 21 | 31896 | 19072 | -0.08 | |
| 1960/61 | 10015 | 12183 | 1399 | 2232 | 607 | 130 | 212 | 40 | 52 | 28724 | 12882 | -0.37 | |
| 1961/62 | 5528 | 6164 | 5759 | 632 | 824 | 179 | 38 | 63 | 27 | 31481 | 24760 | 0.19 | |
| 1962/63 | 16677 | 3546 | 3430 | 2895 | 279 | 318 | 69 | 15 | 35 | 24810 | 15652 | -0.03 | |
| 1963/64 | 2163 | 9420 | 1820 | 1531 | 1046 | 80 | 91 | 20 | 14 | 38917 | 29266 | 0.15 | |
| 1964/65 | 553 | 1308 | 4348 | 935 | 699 | 425 | 32 | 37 | 14 | 11027 | 6709 | -0.07 | |
| 1965/66 | 823 | 196 | 479 | 1644 | 248 | 115 | 70 | 5 | 8 | 7144 | 7487 | 0.48 | |
| 1966/67 | 1377 | 537 | 83 | 207 | 559 | 64 | 30 | 18 | 4 | 3823 | 2719 | 0.09 | |
| 1967/68 | 1667 | 543 | 147 | 33 | 60 | 108 | 12 | 6 | 4 | 5378 | 4788 | 0.32 | |
| 1968/69 | 8067 | 1006 | 266 | 82 | 17 | 29 | 53 | 6 | 5 | 3457 | 844 | -0.98 | |
| 1969/70 | 5974 | 5249 | 642 | 160 | 48 | 10 | 16 | 30 | 6 | 14102 | 8436 | -0.08 | |
| 1970/71 | 2764 | 3869 | 3335 | 400 | 98 | 29 | 6 | 10 | 22 | 23319 | 9751 | -0.44 | |
| 1971/72 | 5303 | 1783 | 2382 | 2043 | 238 | 57 | 17 | 3 | 18 | 30606 | 9852 | -0.70 | |
| 1972/73 | 5001 | 3458 | 1149 | 1447 | 1204 | 137 | 33 | 10 | 12 | 42695 | 11260 | -0.90 | |
| 1973/74 | 2201 | 3260 | 2215 | 733 | 915 | 754 | 86 | 20 | 14 | 38300 | 8893 | -1.03 | |
| 1974/75 | 1282 | 1435 | 2096 | 1379 | 438 | 533 | 439 | 50 | 20 | 35425 | 11109 | -0.73 | |
| 1975/76 | 2441 | 835 | 924 | 1332 | 866 | 272 | 331 | 273 | 43 | 35235 | 14213 | -0.48 | |
| 1976/77 | 1240 | 1592 | 536 | 566 | 793 | 503 | 158 | 192 | 184 | 24730 | 9736 | -0.50 | |
| 1977/78 | 1206 | 808 | 966 | 302 | 295 | 385 | 244 | 77 | 182 | 15120 | 4738 | -0.73 | |
| 1978/79 | 11776 | 782 | 491 | 519 | 141 | 122 | 158 | 100 | 106 | 12141 | 7554 | -0.04 | |
| 1979/80 | 2645 | 7674 | 483 | 278 | 270 | 68 | 58 | 76 | 99 | 20754 | 10236 | -0.28 | |
| 1980/81 | 3218 | 1722 | 4850 | 292 | 154 | 141 | 35 | 30 | 91 | 23760 | 10532 | -0.38 | |
| 1981/82 | 3548 | 2097 | 1104 | 3003 | 173 | 88 | 80 | 20 | 69 | 27418 | 12631 | -0.34 | |
| 1982/83 | 10304 | 2311 | 1348 | 701 | 1886 | 108 | 54 | 50 | 55 | 34177 | 19653 | -0.12 | |
| 1983/84 | 2035 | 6719 | 1507 | 879 | 457 | 1229 | 70 | 35 | 68 | 33161 | 22927 | 0.06 | |
| 1984/85 | 1952 | 1325 | 4319 | 953 | 536 | 264 | 688 | 39 | 58 | 31818 | 35858 | 0.55 | |
| 1985/86 | 7300 | 1270 | 840 | 2651 | 547 | 279 | 128 | 334 | 47 | 32274 | 32526 | 0.44 | |
| 1986/87 | 6077 | 4752 | 786 | 499 | 1436 | 274 | 137 | 63 | 187 | 31057 | 31422 | 0.44 | |
| 1987/88 | 3710 | 3961 | 3023 | 485 | 280 | 736 | 137 | 68 | 125 | 27305 | 33680 | 0.64 | |
| 1988/89 | 1937 | 2418 | 2475 | 1831 | 265 | 128 | 315 | 58 | 82 | 25654 | 12783 | -0.27 | |
| 1989/90 | 8190 | 1261 | 1500 | 1487 | 975 | 111 | 49 | 122 | 54 | 27718 | 19398 | 0.07 | |
| 1990/91 | 8921 | 5339 | 785 | 923 | 864 | 526 | 58 | 26 | 92 | 32311 | 21544 | 0.03 | |
| 1991/92 | 2525 | 5816 | 3416 | 494 | 552 | 491 | 287 | 32 | 64 | 35579 | 36307 | 0.45 | |
| 1992/93 | 1293 | 1646 | 3732 | 2164 | 281 | 277 | 233 | 136 | 46 | 30788 | 21755 | 0.08 | |
| 1993/94 | 3239 | 843 | 1051 | 2310 | 1244 | 134 | 118 | 99 | 77 | 26192 | 13719 | -0.22 | |
| 1994/95 | 24370 | 2110 | 539 | 650 | 1361 | 680 | 65 | 57 | 86 | 25364 | 16138 | -0.02 | |
| 1995/96 | 6511 | 15889 | 1366 | 345 | 405 | 821 | 395 | 38 | 83 | 43083 | 22524 | -0.22 | |
| 1996/97 | 1095 | 4246 | 10356 | 883 | 214 | 221 | 431 | 208 | 64 | 47814 | 21129 | -0.39 | |

Estimated average availability at age (S_i)

0.08 0.40 0.56 0.79 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.02 0.25 0.57 0.81 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.65

Estimated instantaneous natural mortality rate is 0.428

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

| Season | Estimated numbers at age ($\times 10^5$) for period 1 | | | | | | | | | SB | SI | RES |
|---------|---|------|------|------|------|-----|-----|-----|-----|-------|-------|-------|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | 1643 | 3082 | 4027 | 745 | 301 | 77 | 0 | 0 | 0 | 14782 | 23134 | 0.57 |
| 1951/52 | 2200 | 1179 | 1416 | 1407 | 183 | 67 | 17 | 0 | 0 | 3943 | 10709 | 1.12 |
| 1952/53 | 12686 | 1558 | 408 | 355 | 173 | 18 | 6 | 2 | 0 | 10389 | 20001 | 0.77 |
| 1953/54 | 1510 | 9710 | 1175 | 298 | 256 | 125 | 13 | 5 | 1 | 8746 | 18635 | 0.87 |
| 1954/55 | 1641 | 1038 | 5304 | 397 | 69 | 54 | 26 | 3 | 1 | 27976 | 14983 | -0.51 |
| 1955/56 | 3830 | 1191 | 719 | 3219 | 225 | 39 | 30 | 15 | 2 | 7542 | 8244 | 0.21 |
| 1956/57 | 5452 | 2330 | 425 | 197 | 489 | 28 | 5 | 4 | 2 | 3180 | 6224 | 0.79 |
| 1957/58 | 6351 | 3811 | 676 | 111 | 27 | 54 | 3 | 1 | 1 | 12323 | 4226 | -0.95 |
| 1958/59 | 1558 | 4571 | 2163 | 350 | 51 | 12 | 24 | 1 | 1 | 5575 | 4105 | -0.19 |
| 1959/60 | 3113 | 1089 | 2137 | 627 | 60 | 7 | 2 | 3 | 0 | 25873 | 14684 | -0.45 |
| 1960/61 | 8584 | 2153 | 731 | 1483 | 424 | 40 | 5 | 1 | 3 | 7335 | 4567 | -0.36 |
| 1961/62 | 4222 | 6114 | 729 | 225 | 287 | 72 | 7 | 1 | 1 | 14541 | 14181 | 0.09 |
| 1962/63 | 3761 | 3085 | 3797 | 356 | 94 | 116 | 29 | 3 | 1 | 4960 | 8467 | 0.65 |
| 1963/64 | 1886 | 2867 | 1280 | 954 | 44 | 9 | 11 | 3 | 0 | 4848 | 7058 | 0.49 |
| 1964/65 | 1922 | 1068 | 806 | 336 | 131 | 5 | 1 | 1 | 0 | 3423 | 2365 | -0.25 |
| 1965/66 | 5413 | 1379 | 407 | 236 | 59 | 20 | 1 | 0 | 0 | 1990 | 1774 | 0.00 |
| 1966/67 | 1887 | 1203 | 155 | 87 | 18 | 3 | 1 | 0 | 0 | 3290 | 5905 | 0.70 |
| 1967/68 | 442 | 251 | 160 | 43 | 14 | 2 | 0 | 0 | 0 | 3566 | 6366 | 0.70 |
| 1968/69 | 1817 | 281 | 140 | 97 | 24 | 8 | 1 | 0 | 0 | 3742 | 2331 | -0.35 |
| 1969/70 | 1576 | 1390 | 213 | 105 | 72 | 18 | 6 | 1 | 0 | 14241 | 10133 | -0.22 |
| 1970/71 | 1988 | 1195 | 1055 | 162 | 79 | 55 | 14 | 4 | 1 | 15206 | 6056 | -0.80 |
| 1971/72 | 3331 | 1483 | 811 | 698 | 103 | 50 | 34 | 9 | 3 | 10704 | 3928 | -0.88 |
| 1972/73 | 2175 | 2519 | 931 | 400 | 295 | 42 | 20 | 14 | 5 | 20453 | 14471 | -0.23 |
| 1973/74 | 2884 | 1659 | 1662 | 564 | 218 | 155 | 22 | 11 | 10 | 18464 | 10624 | -0.43 |
| 1974/75 | 1390 | 2201 | 1220 | 1024 | 275 | 92 | 63 | 9 | 8 | 24785 | 9165 | -0.88 |
| 1975/76 | 710 | 1061 | 1591 | 795 | 540 | 130 | 42 | 29 | 8 | 18839 | 16134 | -0.04 |
| 1976/77 | 798 | 529 | 752 | 974 | 366 | 207 | 46 | 15 | 13 | 17656 | 18481 | 0.16 |
| 1977/78 | 550 | 609 | 338 | 460 | 465 | 146 | 79 | 17 | 10 | 6107 | 10097 | 0.62 |
| 1978/79 | 5561 | 420 | 364 | 163 | 109 | 51 | 12 | 7 | 2 | 10811 | 6550 | -0.38 |
| 1979/80 | 1073 | 4259 | 322 | 279 | 125 | 84 | 39 | 9 | 7 | 21852 | 15978 | -0.19 |
| 1980/81 | 1152 | 822 | 3258 | 245 | 205 | 88 | 57 | 27 | 11 | 26961 | 16949 | -0.35 |
| 1981/82 | 512 | 882 | 625 | 2410 | 166 | 124 | 46 | 30 | 20 | 29718 | 18412 | -0.36 |
| 1982/83 | 431 | 389 | 643 | 440 | 1519 | 99 | 69 | 26 | 28 | 23601 | 16618 | -0.23 |
| 1983/84 | 1674 | 329 | 286 | 452 | 282 | 913 | 57 | 40 | 31 | 15060 | 14197 | 0.06 |
| 1984/85 | 705 | 1270 | 231 | 184 | 258 | 145 | 446 | 28 | 35 | 16086 | 8480 | -0.52 |
| 1985/86 | 1325 | 534 | 885 | 149 | 106 | 143 | 77 | 237 | 33 | 15304 | 15534 | 0.13 |
| 1986/87 | 7820 | 1008 | 381 | 595 | 94 | 65 | 86 | 46 | 163 | 15477 | 12992 | -0.06 |
| 1987/88 | 556 | 5982 | 729 | 255 | 370 | 57 | 39 | 52 | 126 | 32725 | 27018 | -0.07 |
| 1988/89 | 496 | 422 | 4348 | 511 | 168 | 235 | 36 | 25 | 112 | 31288 | 32335 | 0.15 |
| 1989/90 | 1615 | 372 | 296 | 2857 | 291 | 87 | 113 | 17 | 66 | 28983 | 31048 | 0.19 |
| 1990/91 | 8239 | 1233 | 261 | 198 | 1751 | 164 | 47 | 61 | 45 | 22445 | 20155 | 0.01 |
| 1991/92 | 1044 | 6299 | 842 | 164 | 113 | 951 | 86 | 25 | 55 | 33305 | 46211 | 0.45 |
| 1992/93 | 1936 | 786 | 4419 | 555 | 101 | 68 | 555 | 50 | 47 | 34372 | 39888 | 0.27 |
| 1993/94 | 527 | 1461 | 550 | 2844 | 328 | 56 | 35 | 291 | 51 | 33022 | 29956 | 0.02 |
| 1994/95 | 2176 | 394 | 939 | 346 | 1631 | 179 | 29 | 18 | 176 | 22522 | 19164 | -0.04 |
| 1995/96 | 7049 | 1662 | 263 | 575 | 193 | 871 | 93 | 15 | 101 | 22189 | 18291 | -0.07 |
| 1996/97 | 734 | 5361 | 1208 | 178 | 374 | 123 | 554 | 59 | 74 | 35514 | 25663 | -0.21 |

Estimated average availability at age (S_i)

0.16 0.58 0.77 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 0.53 0.79 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.89

Estimated instantaneous natural mortality rate is 0.267

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

| Season | Estimated numbers at age ($\times 10^5$) for period 1 | | | | | | | | | SB | SI | RES |
|---------|---|-------|------|------|------|-----|-----|----|----|-------|--------|-------|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | 18698 | 8655 | 3241 | 706 | 138 | 47 | 0 | 0 | 0 | 25048 | 66063 | 0.76 |
| 1951/52 | 21685 | 10246 | 3045 | 881 | 182 | 35 | 12 | 0 | 0 | 29459 | 66048 | 0.59 |
| 1952/53 | 37987 | 11649 | 3777 | 862 | 238 | 48 | 9 | 3 | 0 | 55505 | 100513 | 0.38 |
| 1953/54 | 23224 | 21006 | 6041 | 1901 | 432 | 119 | 24 | 5 | 2 | 37506 | 90437 | 0.67 |
| 1954/55 | 13582 | 12815 | 9521 | 1628 | 486 | 107 | 29 | 6 | 2 | 74982 | 74227 | -0.22 |
| 1955/56 | 12650 | 7314 | 4658 | 3317 | 551 | 162 | 36 | 10 | 2 | 28326 | 29494 | -0.17 |
| 1956/57 | 10547 | 6663 | 2273 | 1037 | 686 | 109 | 32 | 7 | 2 | 16603 | 28997 | 0.34 |
| 1957/58 | 27723 | 5795 | 1274 | 433 | 180 | 112 | 18 | 5 | 2 | 12165 | 20358 | 0.30 |
| 1958/59 | 19352 | 15240 | 2351 | 349 | 113 | 45 | 28 | 5 | 2 | 29676 | 44278 | 0.19 |
| 1959/60 | 10091 | 9999 | 5695 | 643 | 91 | 29 | 11 | 7 | 2 | 32347 | 37222 | -0.07 |
| 1960/61 | 23789 | 5226 | 3060 | 1403 | 149 | 20 | 6 | 3 | 2 | 19836 | 25519 | 0.04 |
| 1961/62 | 21347 | 12050 | 1907 | 720 | 309 | 31 | 4 | 1 | 1 | 22106 | 23281 | -0.16 |
| 1962/63 | 20537 | 11400 | 3246 | 398 | 139 | 56 | 6 | 1 | 0 | 12718 | 27751 | 0.57 |
| 1963/64 | 10088 | 10408 | 3440 | 492 | 53 | 17 | 7 | 1 | 0 | 11783 | 20366 | 0.33 |
| 1964/65 | 5142 | 5292 | 2634 | 454 | 55 | 5 | 2 | 1 | 0 | 20955 | 18628 | -0.33 |
| 1965/66 | 5022 | 2372 | 1161 | 619 | 100 | 12 | 1 | 0 | 0 | 4136 | 5108 | 0.00 |
| 1966/67 | 2807 | 2240 | 561 | 133 | 58 | 8 | 1 | 0 | 0 | 4570 | 6345 | 0.11 |
| 1967/68 | 1849 | 673 | 229 | 75 | 15 | 6 | 1 | 0 | 0 | 6722 | 12022 | 0.37 |
| 1968/69 | 5754 | 975 | 310 | 107 | 35 | 7 | 3 | 0 | 0 | 14839 | 18208 | -0.01 |
| 1969/70 | 6579 | 3151 | 522 | 166 | 57 | 19 | 4 | 1 | 0 | 28429 | 44194 | 0.23 |
| 1970/71 | 5162 | 3632 | 1710 | 284 | 90 | 31 | 10 | 2 | 1 | 26045 | 47312 | 0.38 |
| 1971/72 | 8212 | 2851 | 1972 | 910 | 151 | 48 | 16 | 5 | 2 | 23993 | 25875 | -0.14 |
| 1972/73 | 12433 | 4485 | 1340 | 845 | 383 | 63 | 20 | 7 | 3 | 21325 | 18257 | -0.37 |
| 1973/74 | 16790 | 6892 | 2356 | 585 | 348 | 154 | 25 | 8 | 4 | 51538 | 64619 | 0.01 |
| 1974/75 | 11590 | 9302 | 3767 | 1224 | 273 | 150 | 65 | 11 | 5 | 64819 | 76692 | -0.05 |
| 1975/76 | 19890 | 6427 | 5089 | 1937 | 537 | 112 | 61 | 27 | 6 | 49108 | 57135 | -0.06 |
| 1976/77 | 15753 | 11015 | 3500 | 2517 | 832 | 191 | 39 | 21 | 11 | 69442 | 58003 | -0.39 |
| 1977/78 | 8521 | 8712 | 5680 | 1655 | 1057 | 325 | 73 | 15 | 12 | 58152 | 97082 | 0.30 |
| 1978/79 | 11768 | 4716 | 4406 | 2529 | 633 | 364 | 108 | 24 | 9 | 48237 | 59042 | -0.01 |
| 1979/80 | 8969 | 6516 | 2469 | 1980 | 999 | 234 | 133 | 39 | 12 | 56252 | 74848 | 0.07 |
| 1980/81 | 7205 | 4971 | 3530 | 1309 | 980 | 466 | 108 | 61 | 24 | 51665 | 48230 | -0.28 |
| 1981/82 | 5717 | 3971 | 2573 | 1749 | 580 | 400 | 185 | 43 | 34 | 43130 | 90239 | 0.52 |
| 1982/83 | 5052 | 3144 | 1992 | 1223 | 765 | 223 | 142 | 66 | 27 | 23566 | 47423 | 0.49 |
| 1983/84 | 8202 | 2781 | 1512 | 754 | 351 | 195 | 47 | 30 | 20 | 20435 | 27588 | 0.09 |
| 1984/85 | 12622 | 4509 | 1365 | 616 | 219 | 81 | 43 | 10 | 11 | 28849 | 26629 | -0.29 |
| 1985/86 | 7142 | 6918 | 2338 | 627 | 229 | 70 | 25 | 13 | 7 | 52367 | 61097 | -0.06 |
| 1986/87 | 22521 | 3957 | 3813 | 1288 | 345 | 126 | 38 | 14 | 11 | 42146 | 39037 | -0.29 |
| 1987/88 | 6874 | 12462 | 2069 | 1851 | 527 | 116 | 36 | 11 | 7 | 60337 | 25351 | -1.08 |
| 1988/89 | 16680 | 3806 | 6760 | 1027 | 815 | 213 | 44 | 14 | 7 | 59396 | 54078 | -0.31 |
| 1989/90 | 8112 | 9229 | 2070 | 3481 | 457 | 331 | 81 | 17 | 8 | 83081 | 58912 | -0.56 |
| 1990/91 | 21168 | 4499 | 5078 | 1097 | 1615 | 189 | 132 | 32 | 10 | 61109 | 43421 | -0.56 |
| 1991/92 | 15342 | 11729 | 2447 | 2575 | 486 | 642 | 71 | 50 | 16 | 74658 | 80122 | -0.14 |
| 1992/93 | 15950 | 8492 | 6235 | 1203 | 1095 | 187 | 239 | 27 | 24 | 89176 | 84961 | -0.26 |
| 1993/94 | 7462 | 8776 | 4475 | 3073 | 522 | 432 | 70 | 89 | 19 | 68843 | 60862 | -0.34 |
| 1994/95 | 13277 | 4113 | 4595 | 2139 | 1218 | 168 | 128 | 21 | 32 | 58266 | 59708 | -0.19 |
| 1995/96 | 19977 | 7322 | 2177 | 2240 | 901 | 472 | 62 | 47 | 19 | 67444 | 76291 | -0.09 |
| 1996/97 | 11011 | 10973 | 3666 | 1054 | 955 | 343 | 174 | 23 | 25 | 58474 | 53442 | -0.30 |

Estimated average availability at age (S_i)

0.11 0.70 0.93 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 0.61 0.88 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.24

Estimated instantaneous natural mortality rate is 0.589

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

| Season | Estimated numbers at age ($\times 10^5$) for period 1 | | | | | | | | | SB | SI | RES |
|---------|---|-------|------|------|------|-----|-----|-----|-----|--------|-------|-------|
| | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | 8+ | 9+ | | | |
| 1950/51 | 2997 | 2159 | 2634 | 384 | 107 | 26 | 0 | 0 | 0 | 18581 | 17007 | -0.25 |
| 1951/52 | 3912 | 1751 | 771 | 1019 | 134 | 37 | 9 | 0 | 0 | 1967 | 14383 | 1.83 |
| 1952/53 | 6559 | 2537 | 673 | 113 | 77 | 8 | 2 | 1 | 0 | 14765 | 30675 | 0.57 |
| 1953/54 | 3832 | 4306 | 1665 | 441 | 74 | 50 | 5 | 1 | 0 | 6861 | 16556 | 0.72 |
| 1954/55 | 5118 | 2438 | 970 | 339 | 62 | 10 | 6 | 1 | 0 | 20387 | 17555 | -0.31 |
| 1955/56 | 6660 | 3265 | 1282 | 528 | 179 | 33 | 5 | 3 | 0 | 21872 | 45168 | 0.56 |
| 1956/57 | 7951 | 4245 | 1328 | 567 | 218 | 73 | 13 | 2 | 2 | 34582 | 52651 | 0.26 |
| 1957/58 | 10594 | 5214 | 2622 | 828 | 351 | 134 | 45 | 8 | 2 | 46414 | 24399 | -0.80 |
| 1958/59 | 7295 | 6950 | 3398 | 1707 | 538 | 228 | 87 | 29 | 7 | 11983 | 18396 | 0.27 |
| 1959/60 | 3966 | 4547 | 1973 | 668 | 225 | 65 | 27 | 10 | 4 | 5130 | 7039 | 0.15 |
| 1960/61 | 9473 | 2227 | 650 | 308 | 57 | 16 | 5 | 2 | 1 | 5091 | 7912 | 0.28 |
| 1961/62 | 4393 | 5231 | 545 | 134 | 44 | 8 | 2 | 1 | 0 | 14769 | 34579 | 0.69 |
| 1962/63 | 5922 | 2791 | 1778 | 187 | 40 | 13 | 2 | 1 | 0 | 7391 | 14618 | 0.52 |
| 1963/64 | 1624 | 3864 | 1222 | 506 | 44 | 9 | 3 | 0 | 0 | 12127 | 27863 | 0.67 |
| 1964/65 | 1457 | 1025 | 1543 | 402 | 143 | 12 | 2 | 1 | 0 | 10624 | 10863 | -0.14 |
| 1965/66 | 2667 | 935 | 329 | 535 | 122 | 42 | 4 | 1 | 0 | 4313 | 4584 | -0.10 |
| 1966/67 | 243 | 1687 | 490 | 91 | 120 | 26 | 9 | 1 | 0 | 4489 | 5118 | -0.03 |
| 1967/68 | 994 | 43 | 554 | 121 | 17 | 21 | 5 | 2 | 0 | 6921 | 11278 | 0.33 |
| 1968/69 | 5219 | 652 | 29 | 364 | 79 | 11 | 14 | 3 | 1 | 10977 | 11206 | -0.14 |
| 1969/70 | 10724 | 3427 | 428 | 19 | 239 | 52 | 7 | 9 | 3 | 29901 | 34923 | -0.01 |
| 1970/71 | 8043 | 7042 | 2250 | 281 | 12 | 157 | 34 | 5 | 8 | 65379 | 32476 | -0.86 |
| 1971/72 | 9850 | 5281 | 4624 | 1477 | 185 | 8 | 103 | 22 | 8 | 58400 | 36069 | -0.64 |
| 1972/73 | 10521 | 6452 | 3377 | 2767 | 872 | 109 | 5 | 61 | 18 | 70298 | 16219 | -1.63 |
| 1973/74 | 17669 | 6900 | 3865 | 1838 | 1445 | 451 | 56 | 2 | 41 | 90930 | 24774 | -1.46 |
| 1974/75 | 7342 | 11516 | 4063 | 2224 | 986 | 755 | 235 | 29 | 22 | 109231 | 44594 | -1.06 |
| 1975/76 | 4479 | 4813 | 6792 | 2255 | 1111 | 483 | 369 | 115 | 25 | 62749 | 63335 | -0.15 |
| 1976/77 | 7146 | 2938 | 3019 | 3323 | 841 | 377 | 162 | 124 | 47 | 48090 | 57398 | 0.02 |
| 1977/78 | 2060 | 4685 | 1772 | 1449 | 1340 | 305 | 134 | 58 | 61 | 40601 | 39931 | -0.18 |
| 1978/79 | 4515 | 1348 | 2803 | 974 | 568 | 410 | 83 | 36 | 32 | 25855 | 63663 | 0.74 |
| 1979/80 | 3217 | 2958 | 764 | 1379 | 341 | 163 | 113 | 23 | 19 | 31765 | 62619 | 0.52 |
| 1980/81 | 1711 | 2108 | 1876 | 474 | 795 | 181 | 85 | 59 | 22 | 30990 | 58518 | 0.47 |
| 1981/82 | 1172 | 1109 | 1229 | 1066 | 234 | 368 | 80 | 37 | 35 | 24408 | 29424 | 0.03 |
| 1982/83 | 2258 | 763 | 676 | 724 | 569 | 111 | 164 | 35 | 32 | 16670 | 15329 | -0.25 |
| 1983/84 | 4935 | 1463 | 392 | 333 | 307 | 226 | 43 | 63 | 26 | 17377 | 22142 | 0.08 |
| 1984/85 | 4630 | 3134 | 784 | 196 | 154 | 139 | 102 | 19 | 40 | 35554 | 29132 | -0.36 |
| 1985/86 | 1868 | 3037 | 2050 | 513 | 128 | 101 | 91 | 66 | 39 | 46102 | 38347 | -0.35 |
| 1986/87 | 11382 | 1226 | 1986 | 1341 | 335 | 84 | 66 | 59 | 69 | 30875 | 29915 | -0.19 |
| 1987/88 | 1958 | 7327 | 638 | 933 | 574 | 141 | 35 | 27 | 54 | 40271 | 39289 | -0.19 |
| 1988/89 | 2454 | 1269 | 4404 | 350 | 482 | 292 | 71 | 18 | 41 | 39319 | 43331 | -0.06 |
| 1989/90 | 1419 | 1592 | 713 | 2304 | 166 | 219 | 132 | 32 | 27 | 33965 | 38337 | -0.04 |
| 1990/91 | 4796 | 929 | 892 | 384 | 1166 | 82 | 109 | 65 | 29 | 22812 | 25907 | -0.03 |
| 1991/92 | 2622 | 3118 | 508 | 466 | 184 | 532 | 37 | 49 | 42 | 25310 | 36916 | 0.22 |
| 1992/93 | 2062 | 1718 | 1932 | 299 | 264 | 103 | 298 | 21 | 51 | 26447 | 29307 | -0.06 |
| 1993/94 | 947 | 1336 | 1005 | 1082 | 164 | 144 | 56 | 162 | 39 | 21468 | 19869 | -0.24 |
| 1994/95 | 1184 | 609 | 782 | 544 | 555 | 82 | 71 | 28 | 100 | 19875 | 25284 | 0.08 |
| 1995/96 | 7818 | 776 | 382 | 475 | 327 | 333 | 49 | 43 | 77 | 19476 | 32209 | 0.34 |
| 1996/97 | 1432 | 5125 | 496 | 243 | 300 | 206 | 210 | 31 | 75 | 28166 | 39394 | 0.19 |

Estimated average availability at age (S_i)

0.09 0.70 0.86 0.98 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.03 0.32 0.72 0.92 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.18

Estimated instantaneous natural mortality rate is 0.421