



STOCK ASSESSMENT REPORT ON PACIFIC HERRING IN BRITISH COLUMBIA



Figure 1. Adult Pacific herring. Source Fisheries & Oceans Canada

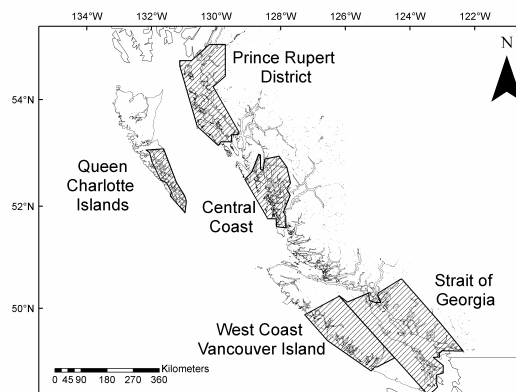


Figure 2. The five major British Columbia herring stock assessment regions

Context

Pacific herring is a pelagic species which occurs in inshore and offshore waters of the North Pacific. In the eastern Pacific it ranges from California to the Beaufort Sea. Herring mature and recruit to the spawning stock predominantly between ages 2 and 5. Within this range, age-at-recruitment tends to increase with latitude. The five major B.C. herring stocks include the Queen Charlotte Islands (QCI), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SG) and west coast of Vancouver Island (WCVI) (Figure 2). The fishery began here at the turn of the century, but did not become extensive until the expansion of the dry-salted fishery in the late 1920s and reduction fishery in the 1940s. The stocks declined as part of the coastwide collapse from overfishing in the early 1960s, and the commercial reduction fishery was closed in 1967. Following a combination of favourable environmental conditions and a low harvest rate, the stocks recovered by the mid-1970s. The current roe fishery began in 1972. The target harvest rate of roe herring is fixed at 20% of the forecast mature stock biomass, when the stock size is sufficiently above a minimum spawning stock biomass or Cutoff. This stock-specific Cutoff is a commercial fishing threshold intended to maintain the reproductive capacity of the stock or rebuild stock biomass following years when stock size falls below the Cutoff. Recent assessments indicate that the mature herring biomass remains well above the Cutoff in Prince Rupert District (12,100t) and the Strait of Georgia (21,200 t) for 2009, and should continue to sustain both commercial and aboriginal fisheries in 2009. The current assessment indicates that the forecast mature herring biomass is below the fishing threshold for Queen Charlotte Islands (10,700 t), Central Coast (17,600 t), and west coast of Vancouver Island (18,800 t) and no fishery is recommended for 2009 in these areas.

SUMMARY

Queen Charlotte Islands

- All Pacific herring spawning from Cumshewa Inlet in the north to Louscoone Inlet in the south are assumed to be part of a single Queen Charlotte Islands (QCI) stock that migrates inshore in the late fall and leaves, after spawning, in late March and early April.
- No commercial herring fishery occurred in this area in 2008.
- The forecast mature stock biomass for 2009 is 3,647 tonnes, which is below the fishing threshold (10,700 t), and only food, social, or ceremonial harvest is anticipated for 2009.

Prince Rupert District

- All herring spawning within Statistical Areas 3 to 5 are assumed to belong to the Prince Rupert District (PRD) stock that migrates inshore from Hecate Strait in the late fall and leaves, after spawning, in late March and early April.
- The roe herring seine total allowable catch (TAC) in 2008 was 454 tonnes or 4% of the coastal total and the validated catch was 513 tonnes. The roe herring gillnet TAC in 2008 was 1,089 tonnes or 10% of the coastal total and the validated catch was 1,148 tonnes
- The 2009 mature stock biomass forecast is 17,342 tonnes, well above the fishing threshold (12,100 t), with an allowable harvest of 3,468 tonnes.

Central Coast

- All Pacific herring spawning in Kitasu Bay (Statistical Area 6), those in Statistical Area 7, and most of Area 8 are assumed to be part of a single Central Coast (CC) stock that migrates inshore in the late fall and leaves, after spawning, in late March and early April.
- No commercial herring fishery occurred in this area in 2008.
- The forecast mature stock biomass for 2009 is 6,207 tonnes, which is below the fishing threshold (17,600 t), and will not support a commercial fishery in 2009.

Strait of Georgia

- All herring spawning within the Strait of Georgia (SG) are assumed to belong to a single stock that migrates into the SG in the late fall and leaves, after spawning, in March. A few areas in the Strait also contain what appear to be resident or non-migratory herring throughout the summer. For stock assessment purposes these fish are considered part of the Strait of Georgia herring stock.
- The roe herring seine total allowable catch (TAC) in 2008 was 5,783 tonnes or 51% of the coastal total and the validated catch was 6,046 tonnes. The roe herring gillnet TAC in 2008 was 4,014 tonnes or 35% of the coastal total and the validated catch was 2,752 tonnes.
- The forecast mature stock biomass for 2009 is 58,985 tonnes, well above the fishing threshold (21,200 t), with an allowable harvest of 11,797 tonnes.

West coast Vancouver Island

- All herring spawning within Statistical Areas 23 to 25 are assumed to belong to the west coast of Vancouver Island (WCVI) herring stock that migrates inshore in the late fall and leaves, after spawning, in late February through March.
- No commercial fishery occurred on the west coast of Vancouver Island in 2008.
- The forecast mature stock biomass for 2009 is 3,894 tonnes, which is below the fishing threshold (18,800 t), and will not support a commercial fishery in 2009.

INTRODUCTION

From the mid-1940s until the late 1960s, herring were harvested and processed (reduced) into relatively low value products such as fishmeal and oil. Catches increased dramatically in the early 1960s, but were unsustainable. By 1965, most of the older fish had been removed from the spawning population by a combination of overfishing, and a sequence of weak year-classes, attributed to unfavourable environmental conditions and a low spawning biomass. As a result, the commercial fishery collapsed (Fig. 3a-e), and was closed by the federal government in 1967 to rebuild the stock.

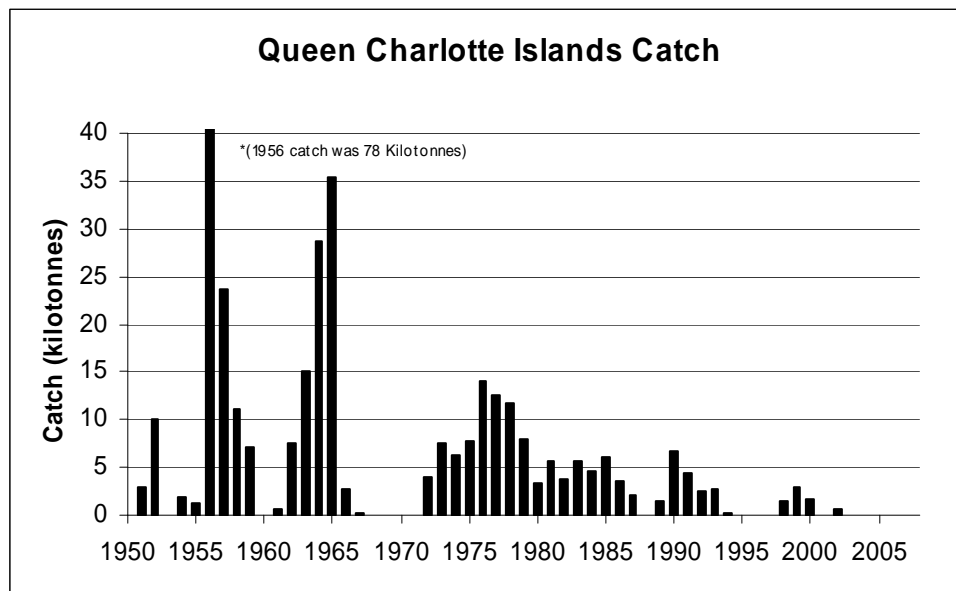


Figure 3a. Herring catch in the Queen Charlotte Islands from 1951-2008.

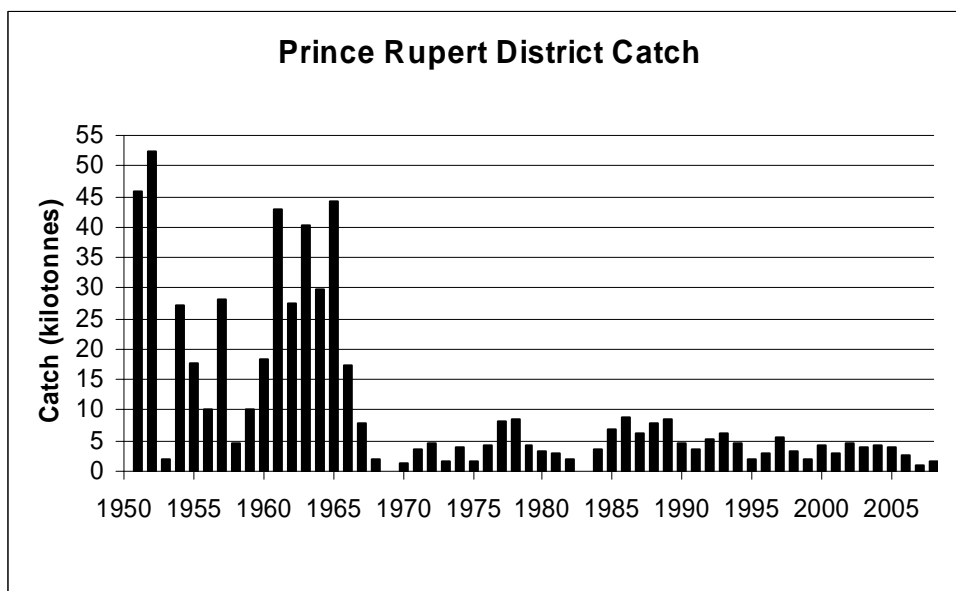


Figure 3b. Herring catch in the Prince Rupert District from 1951-2008.

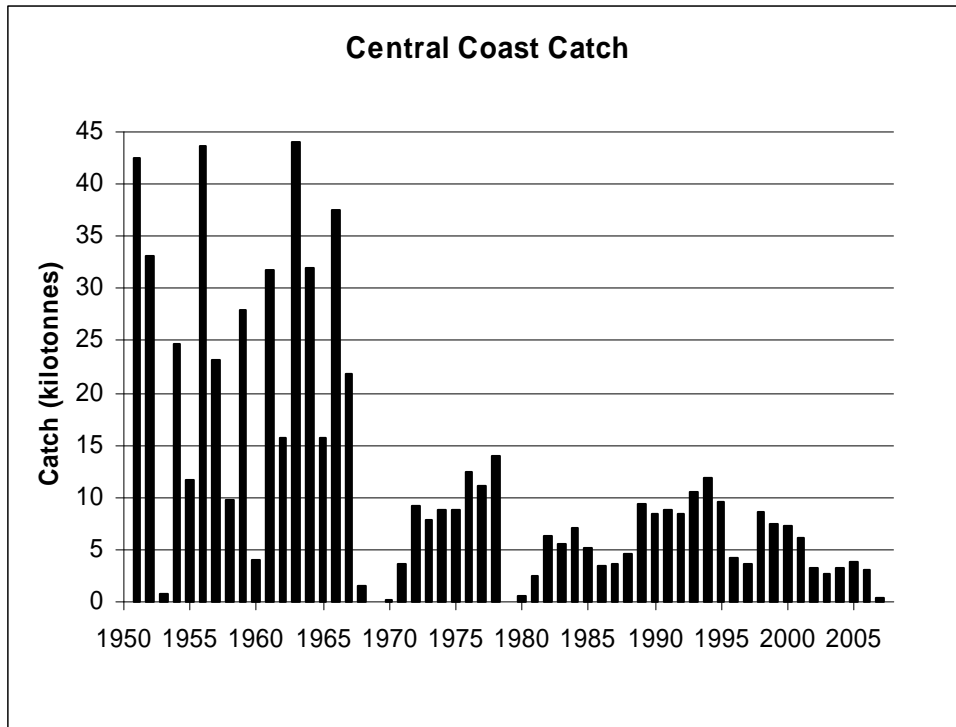


Figure 3c. Herring catch in the Central Coast from 1951-2008.

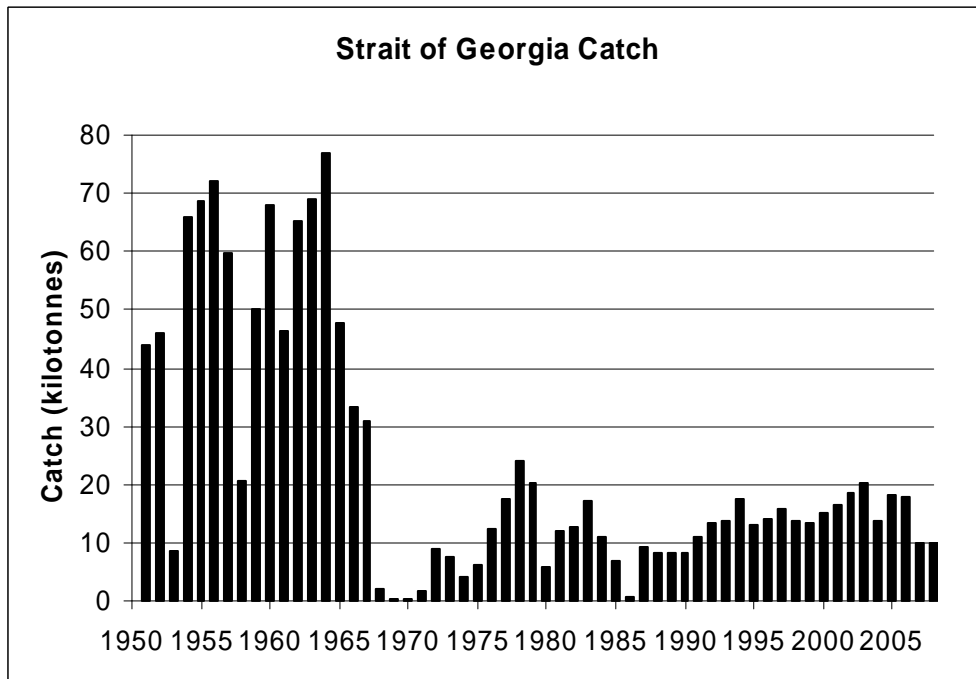


Figure 3d. Herring catch in the Strait of Georgia from 1951-2008.

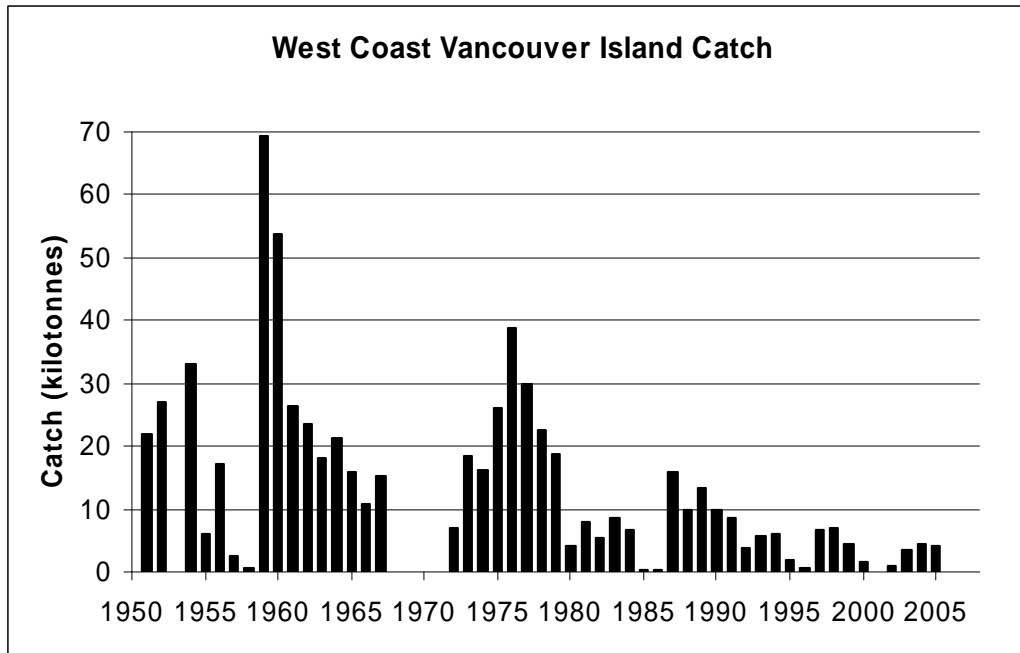


Figure 3e. Herring catch in the west coast of Vancouver Island from 1951-2008.

Following the fishery closure, a series of above average year-classes occurred in the early 1970s rapidly rebuilding the stock and providing new fishing opportunities.

During the closure from 1967-1973, the small traditional fisheries continued locally for food and bait (Hourston 1980). At this time there was a growing interest to harvest roe herring for export to Japan as their stocks became decimated. A small experimental roe harvest began in 1971, and expanded rapidly until 1983, when fixed quotas were introduced to regulate the catch.

The objective of the current herring fishery is to obtain a low volume, high-quality product that is economically profitable and ecologically sustainable. The fishery is managed by setting a fixed quota based on a harvest rate of 20% of the forecast mature stock biomass. To meet management objectives, the harvest strategy also enforces a minimum spawning stock biomass (Cutoff). If the forecast biomass in a given area falls below the stock-specific Cutoff managers have chosen to close the commercial fishery to allow for stock recovery. This harvest strategy is designed to minimize the number of years of commercial fishery closures.

Queen Charlotte Islands

Low stock levels resulted in the closure of the QCI roe fishery in 1988. Abundance rebounded in 1997, but a cautious harvest approach was taken. In 1994, 2001, 2003 and 2004, the forecast run was close to the Cutoff (10,700 t), so fishing was restricted to aboriginal food, social and ceremonial (FSC) harvest and commercial spawn-on-kelp. In 1995, 1996, and more recently 2005 through 2008 only aboriginal FSC harvest was permitted. Small roe fisheries did take place in QCI between 1998 to 2000 and 2002. An average roe catch of 544 t has occurred over the past decade¹.

¹ Excluding years where commercial fisheries were closed. Only anecdotal reports of food, social, and ceremonial harvests are available and so are not included here.

Prince Rupert District

In response to reduced stock levels the PRD fishery was closed in 1983. Subsequently, the stock has rebuilt and sustained an average roe catch of 3,101 t over the past decade¹.

Central Coast

In response to reduced stock levels the Central Coast fishery was closed in 1979. Subsequently, the stock rebounded, reaching a peak in abundance in 1998. Declines in recent years brought the CC stock below Cutoff (17,600) in 2006 and in 2008 this area was closed to commercial harvest. An average roe catch of 3,725 t has occurred over the past decade¹.

Strait of Georgia

In response to reduced stock levels, the Strait of Georgia fishery was closed in 1986 to allow for rebuilding. Subsequently, the stock has recovered with a historic high in 2003, but has decreased dramatically since then. The Strait of Georgia fishery has sustained an average catch of 15,339 t over the past decade¹.

West coast Vancouver Island

In response to reduced stock levels the WCVI fishery was closed in 1985, 1986, 2001, and most recently in 2006 through 2008. Despite these closures, the stock provided an average roe catch of 1,906 t over the past decade¹.

¹Table 1. Recent removals (all fisheries) from the five major B.C. herring stocks

	2004	2005	2006	2007	2008
Queen Charlotte Island (QCI)	0.0	0.0	0.0	0.0	0.0
<i>QCI SOK allocation²</i>	1	0.0	0.0	0.0	0.0
Prince Rupert District (PRD)	4.1	3.8	2.6	1.0	1.7
<i>PRD SOK allocation²</i>	1.0	1.0	1.0	1.0	1.0
Central Coast (CC)	3.2	3.8	3.1	0.4	0.0
<i>CC SOK allocation²</i>	0.6	0.6	0.6	0.6	0.0
Strait of Georgia (SoG)	13.6	18.2	18.0	9.8	9.9
West coast Vancouver Island (WCVI)	4.5	4.3	0.0	0.0	0.0
<i>WCVI SOK allocation²</i>	0.4	0.4	0.4	0.4	0.4

² Spawn-on-kelp (SOK) allocation (short tons) refers to live fish impounded to develop product.

ASSESSMENT

Data collected for use in the assessment of herring stocks are: spawn survey data, commercial catch landings, and age composition data taken from biological samples of the commercial fishery, pre-fishery charters, and research catches. Herring stock assessments use information from biological samples for determining the population age composition and average weight-at-

² Excluding years where commercial fisheries were closed. Only anecdotal reports of food, social, and ceremonial harvests are available and so are not included here.

age, historical catch data, and an assessment of the distribution and intensity of egg deposition in each stock assessment area. A catch-at-age model is then used for the annual stock assessment, producing estimates of current abundance and spawning biomass used in the calculation of quotas.

Prior to the 2002 assessment, the forecast of the pre-fishery biomass of mature herring was estimated by two assessment models: an age-structured model and an escapement model. Recently, only an age-structured model has been used and in 2008 a modified version (HCAMv2) of the 2007 model (HCAM) was adopted as the best estimator of stock abundance (Schweigert, Christensen, and Haist 2008).

Queen Charlotte Islands

The assessment indicates that the Queen Charlotte Islands assessment region herring population decreased in abundance from 1998 through 2005, increased moderately in 2006 and 2007 and declined again in 2008 (Fig. 4a). Spawning biomass for the area is estimated at 4,872 t in 2008, a decrease of 1,719 t, or 26% below the 2007 level. Recruitment has been generally poor for the last decade, except for the 2000 and 2004 year-classes which were average, contributing to the continuing low level of abundance. The age 3+ fish from the 2004 year-class dominated the 2008 run accounting for 63% of the total, while the recruiting 2005 year-class contributed only 7% to the run.

Prince Rupert District

The assessment indicates that the Prince Rupert District assessment region herring population has been relatively stable since 1990 with a recent peak in 2003 (Fig. 4b). Abundance has subsequently declined through to 2008. The pre-fishery biomass for the area is estimated at 19,021 t in 2008, a decrease of 1,383 t, or 7% below the 2007 level. During the past decade, recruitment for most year-classes has been average or better. The 1998, 2000 and 2004 year-classes were good while those in 2001, 2003 and 2005 were poor. The spawning run in 2008 consisted of about 57% age 3+ recruits from the 2004 year-class and only 10% from the recruiting 2005 year-class.

Central Coast

The assessment indicates that the Central Coast assessment region peaked in 1998 and then decreased through to 2002. Abundance increased slightly in 2003 and 2004, but then decreased steadily through 2008 (Fig. 4c). The spawning biomass for the area is estimated at 6,534 t in 2008, a decrease of 2,880 t, or 31% below the 2007 level. During the past decade four year-classes were average or better. The 2000 year-class was good, 2002 year-class above average, and the 1997 and 1999 year-classes were average. The other year-classes have all been poor. The 2004 year-class was abundant accounting for 45% of the total 2008 run while the recruiting 2005 year-class only contributed 10% of the run. The above average 2002 year-class contributed another 16% of the run in 2008.

Strait of Georgia

The assessment indicates that abundance in the Strait of Georgia assessment region has increased dramatically since the fishery closure in 1986 to a historical high in 2003. Abundance has declined dramatically the past five years (Fig. 4d). The pre-fishery biomass for the area is estimated at 44,320 t in 2008, a decrease of 21,480 t, or 33% below the 2007 level. The recruitment during the past decade has been average or better in all years with the 1996 and 2003 year-class being the weakest in this period. The 1999 to 2000 and 2004 year-classes appear to be the largest observed in the past 58 years. The 2003 and 2004 year-classes contributed 17 and 65% of the 2008 run, respectively. The recruiting 2005 year-class was 7% of the 2008 run and is poor. Based

on an offshore survey of the stock in August 2008 the abundance of the pre-recruit 2006 year-class is forecast to be good.

West coast Vancouver Island

The assessment indicates that herring abundance in the west coast of Vancouver Island assessment region has declined steadily from 1998 through 2008, with modest increases in 2002 and 2003 (Fig. 4e). The spawning biomass for the area is estimated at 2,730 t in 2008, a decrease of 127 t, or 4% below the 2007 level. Abundance in 2008, like 2007, is well below the lowest level observed in the 58-year time series of data for this stock. During the past decade most year-classes have been poor, except for the 1998 to 2000 year-classes which were average. The majority of the 2008 run consisted of three year-classes. The 2003 year-class accounted for 11% of the 2008 run, while the 2004 year-class contributed another 54% to the total. The recruiting 2005 year-class, while poor, contributed 25% of the run. Based on an offshore survey of the stock in August 2008 the abundance of the pre-recruit 2006 year-class is forecast to be poor, accounting for about 5% of the run. Overall stock levels continue to be depressed from the highs of the 1970's and late 1980's. The recent pattern of a generally below average recruitment to the stock is not expected to improve until the current warm climate moderates, and returns to an average, or cool state.

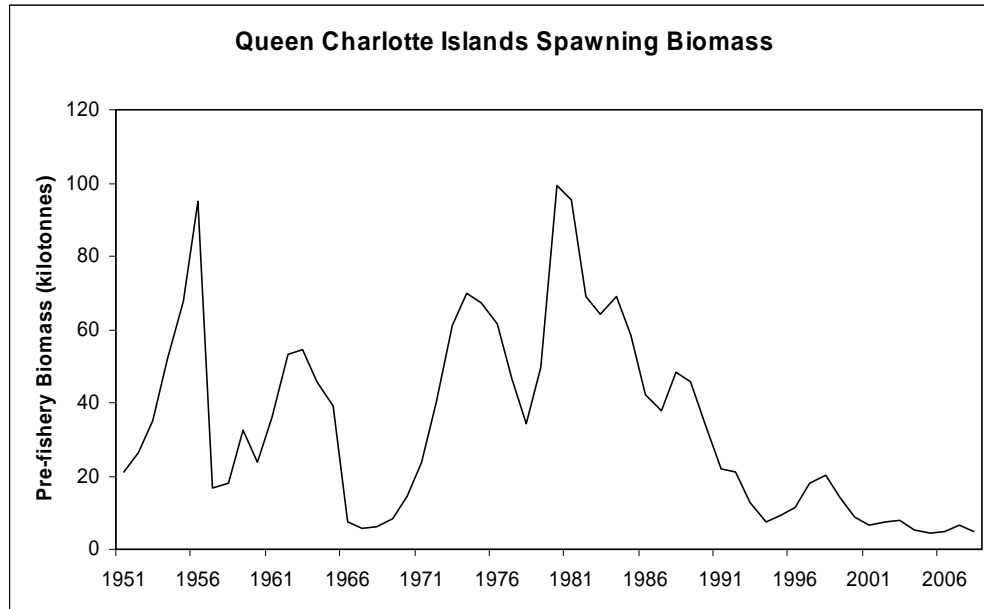


Figure 4a. Estimated herring spawning biomass from 1951 to 2008 for Queen Charlotte Islands.

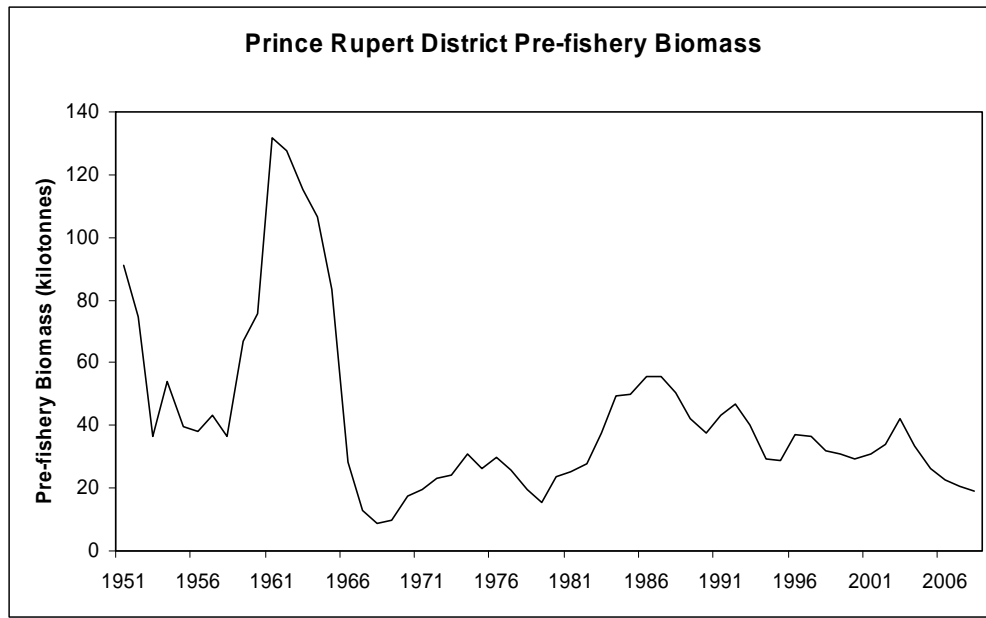


Figure 4b. Estimated mature pre-fishery herring biomass from 1951 to 2008 for Prince Rupert District.

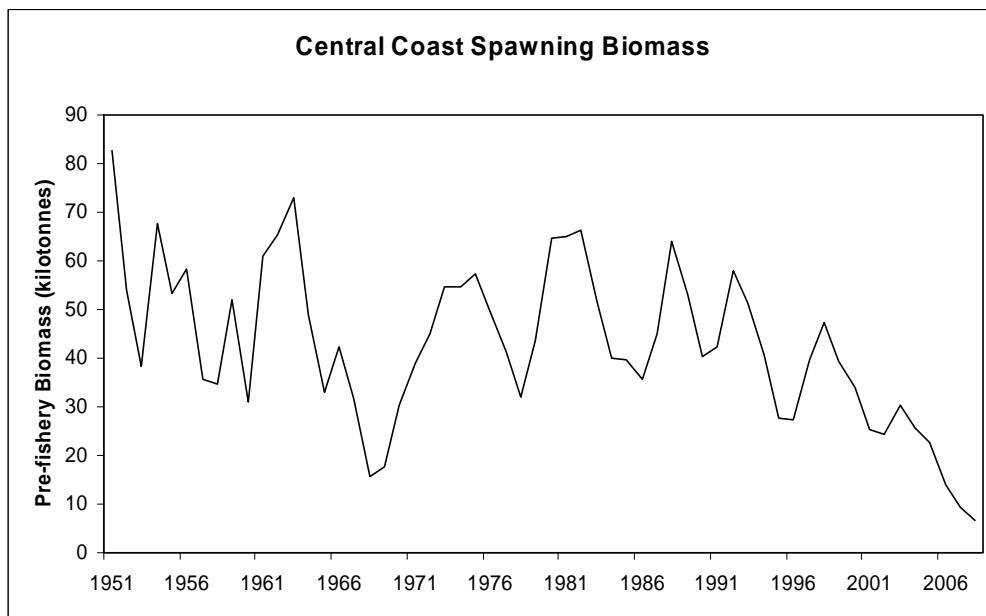


Figure 4c. Estimated herring spawning biomass from 1951 to 2008 for the Central Coast.

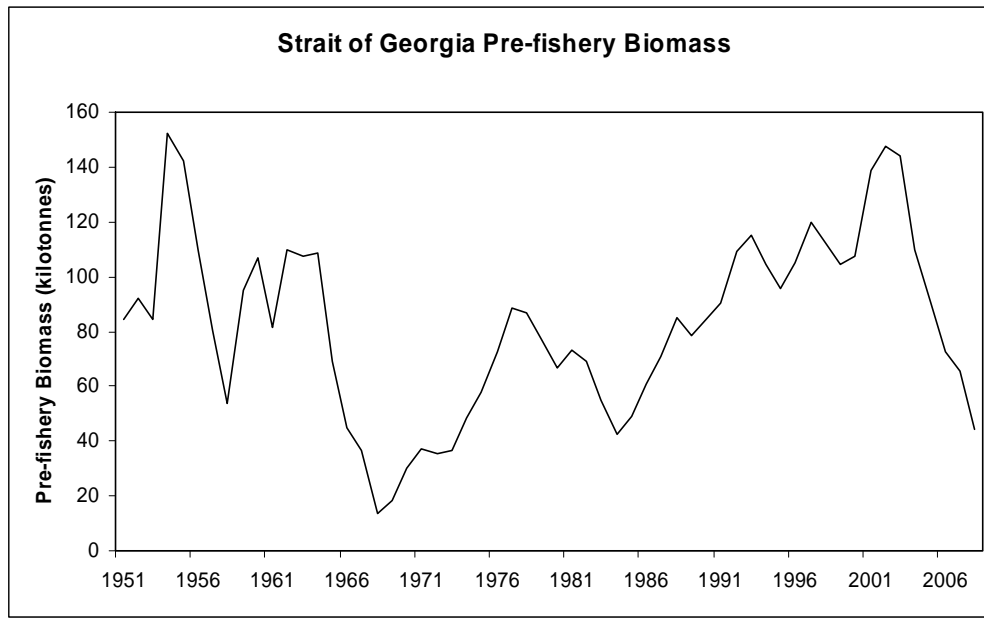


Figure 4d. Estimated mature pre-fishery herring biomass from 1951 to 2008 for the Strait of Georgia.

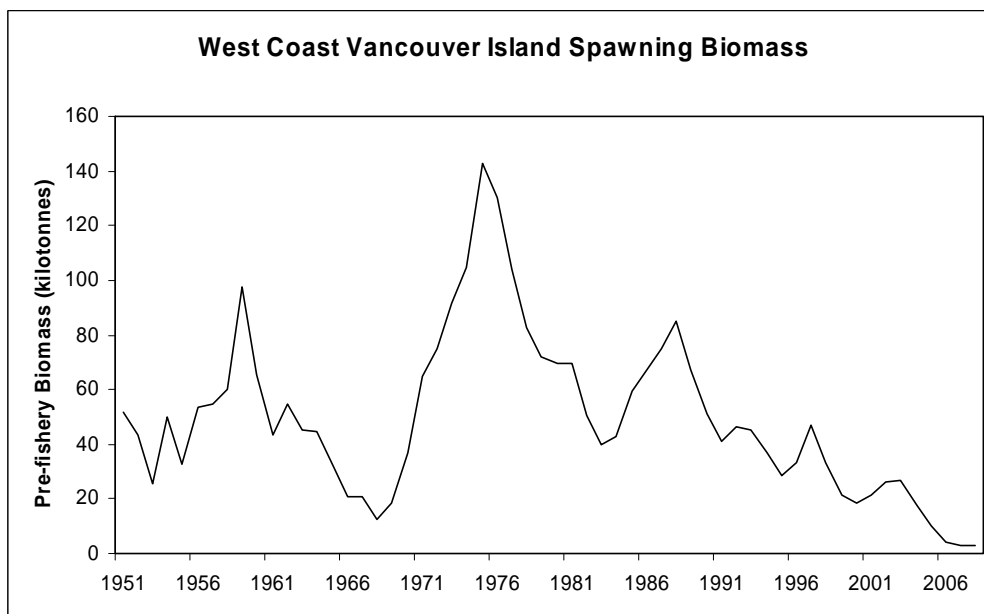


Figure 4e. Estimated herring spawning biomass from 1951 to 2008 for the west coast of Vancouver Island.

CONCLUSIONS AND ADVICE

Herring stocks are managed with a fixed 20% harvest rate, in conjunction with a fishing threshold or Cutoff level. A decision rule has been adopted by management to close all commercial fisheries when the stock is forecast to be below the Cutoff level. The Cutoff levels are established at 25% of the estimated unfished average mature biomass, a threshold intended to maintain the reproductive capacity of the stock.

Queen Charlotte Islands

For the Queen Charlotte Islands, a poor recruitment option was adopted for 2009 resulting in a pre-fishery biomass forecast of 3,647 t and projecting abundance well below the Cutoff level (10,700 t). Continued closure of this area is recommended as any commercial harvest below the Cutoff is expected to reduce the rate of stock rebuilding.

Prince Rupert District

In the Prince Rupert District, an average recruitment option was adopted for 2009 resulting in a pre-fishery biomass forecast of 17,342 t and a potential harvest of 3,468 t. The stock is well above the Cutoff level of 12,100 tonnes. Roe and spawn-on-kelp fisheries are anticipated for 2009.

Central Coast

On the Central Coast, a poor recruitment assumption was adopted for 2009 resulting in a pre-fishery biomass forecast of 6,207 tonnes and projects abundance below the Cutoff level of 17,600 t. As a result, no commercial harvest is recommended in 2009 for this stock.

Strait of Georgia

In the Strait of Georgia, a good recruitment option was adopted for 2009 based on the offshore survey resulting in a pre-fishery biomass forecast of 58,985 t and a potential harvest of 11,797 t. The stock remains well above the Cutoff level of 21,200 t. Recruitment during the past decade has been average or better maintaining the stock at a healthy abundance level.

West coast Vancouver Island

On the west coast of Vancouver Island, the recruiting 2006 year-class is forecast to be poor based on the offshore survey, thus a poor recruitment option was adopted for 2009 resulting in a pre-fishery biomass forecast of 3,894 t which is well below the Cutoff level (18,800 t). Any commercial harvest below the Cutoff is expected to reduce the rate of stock rebuilding.

OTHER CONSIDERATIONS

Queen Charlotte Islands

Since relatively little is known about the factors that affect recruitment in this stock, it is difficult to forecast future stock trends. The increased abundance in the late 1990s was due to the strong 1994 and 1995 year-classes. The weak year-classes over the past decade, except for the 2000 and 2004 year-class accounts for the subsequent low abundance levels.

Various studies have suggested that herring recruitment is determined by variations in the size of the parent stock, and environmental conditions during the first year of life. Recruitment variability in the QCI stock has been correlated with March sea surface salinities and sea levels in the stock area during the year of birth. Although there is a risk that these correlations might be spurious (i.e. not meaningful), they could have a biological basis. For example, variations in sea surface salinity and sea level reflect differences in wind induced upwelling and mixing, freshwater runoff and nutrient supply. These factors could directly affect the planktonic food supply of the young herring, and indirectly alter juvenile herring losses to predators. Research on these factors is being pursued.

Prince Rupert District

Since very little is known about the factors that affect recruitment in this stock, it is difficult to forecast future stock trends. However, the recent history of recruitment to the stock has indicated a good year-class occurring about every fourth year, a pattern similar to that in southeastern Alaska. If this pattern continues it will result in increased stock stability and resource levels that should sustain current levels of harvest. During the past decade, most recruitment for year-classes have been average or better, except for the poor 2001, 2003 and 2005 year-classes, which should maintain the stock at healthy levels in the short term.

Central Coast

The factors affecting recruitment in this stock are not well understood making it difficult to forecast future stock trends. However, the health of the stock is directly correlated with the recruitment of strong year-classes and these have occurred at regular intervals over the past two decades. The low abundance of the 2003, 2004 and 2005 year-classes accounts for the decline in abundance of the last few years.

Strait of Georgia

The recruitment process is not understood for this stock making it difficult to forecast future stock trends. However, the Strait of Georgia has enjoyed an extended period of above average herring recruitment with consistent strong year-classes every second or third year since the mid-1980s. The 1997 to 2000 year-classes appear to be among the largest observed in the past 58 years. The recent year-classes from 2001-2003 were weaker. The recruitment for 2008 is forecast to be one of the worst years in the 58 year time series of data for this stock. However, even with the decrease in biomass, the stock should continue to support moderate fisheries in the short term.

West coast Vancouver Island

Research has shown that the growth and survival of WCVI herring are sensitive to natural variations in ocean climate. These recurring climatic changes, which last for a decade or two, cause significant shifts in the structure and productivity of the coastal ecosystem where the herring live. Specifically, the productivity of the WCVI herring stock changes in response to interannual and decadal time scale variations in the climate of the coastal ocean (indexed by water temperature), and spawning biomass (Ware 1991). Recruitment is the most important process determining the productivity of B.C. herring populations. Long-term research has shown that both recruitment and adult survival tend to be below average in warm years, particularly when migratory herring-predators (like Pacific hake and mackerel) are abundant off the west coast of Vancouver Island. The coastal ocean has been in a protracted warm state since 1978. When this occurs, the productivity of the copepod and krill populations that herring feed on, appear to decline (Ware 1991). Also, more Pacific hake migrate for the summer to the WCVI stock assessment area, where they prey on herring. Pacific mackerel and hake tend to be particularly abundant during warm El Niño summers.

Stock reconstructions indicate that herring cohorts born in cool years are twice as large, on average, as those born in warm years. Surplus production calculations indicate that the unfished carrying capacity of the WCVI population is about 111,000 t when the environment and ecosystem are in a cool climate state, but is less than half as large (about 49,000 t) during a warm climate state (D. Ware, Pacific Biological Station, Nanaimo, BC V9T 6N7. H96-3, unpublished data). Retrospective stock production analyses indicate that the WCVI stock can sustain catches exceeding 20,000 tonnes during cool climate states. However, the sustainable catch is less than 8,000 t during warm climate states.

SOURCES OF INFORMATION

Christensen, L.B., V. Haist, and J. Schweigert. 2009. Modeling herring population dynamics: Herring Catch-at-Age Model version 2. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/073: 64p.

Hourston, A.S. 1980. The decline and recovery of Canada's Pacific herring stocks. Rapp. P.-v. Reun. Cons. Int. Explor. Mer, 177: 143-153.

Schweigert, J., L.B. Christensen, and V. Haist. 2009. Stock assessments for British Columbia herring in 2008 and forecasts of the potential catch in 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/019: vi + 61p.

Ware, D.M. 1991. Climate, predators and prey: behaviour of a linked oscillating system, p. 279-291. In Long-term variability of pelagic fish populations and their environment. T. Kawasaki et al. [ed.] Pergamon Press, Tokyo, 402p.

FOR MORE INFORMATION

Contact: Jake Schweigert
Pacific Biological Station
Nanaimo, B.C.
V9T 6N7

Tel: (250) 756-7203
Fax: (250) 756-7138
E-Mail: Jake.Schweigert@dfo-mpo.gc.ca

Contact: Jaclyn Cleary
Pacific Biological Station
Nanaimo, B.C.
V9T 6N7

Tel: (250) 756-7321
Fax: (250) 756-7138
E-Mail: Jaclyn.Cleary@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Pacific Region
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC V9T 6E1

Telephone: (250) 756-7208
Fax: (250) 756-7209
E-Mail: psarc@pac.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)
© Her Majesty the Queen in Right of Canada, 2009

La version française est disponible à l'adresse ci-dessus.



CORRECT CITATION FOR THIS PUBLICATION

DFO, 2009. Stock Assessment Report on Pacific Herring in British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/059.