Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2009/066

STOCK ASSESSMENT REPORT ON PACIFIC HERRING IN BRITISH COLUMBIA

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

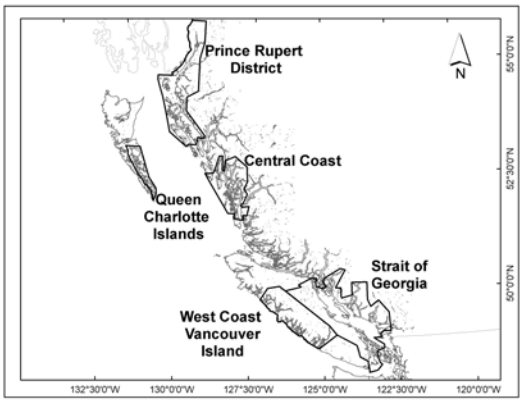

Figure 2. The five major British Columbia herring stock assessment regions

Context

Pacific herring is a pelagic species which inhabits in inshore and offshore waters of the North Pacific. In the eastern Pacific herring distribution 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 (SOG) 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 above the Cutoff in Prince Rupert District (12,100 t) and the Strait of Georgia (21,200 t) for 2010, and should continue to sustain both commercial and aboriginal fisheries in 2010. The current assessment indicates that the 2010 forecast of 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).

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 2009.
- The forecast mature stock biomass for 2010 is 5,750 tonnes, which is below the fishing threshold (10,700 t), and only food, social, or ceremonial harvest in 2010 is consistent with the harvest decision rule.

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 2009 was 635 tonnes or 6% of the coastal total and the validated catch was 713 tonnes. The roe herring gillnet TAC in 2009 was 1,179 tonnes or 11% of the coastal total and the validated catch was 1,286 tonnes.
- The 2010 mature stock biomass forecast is 15,499 tonnes, which is above the fishing threshold (12,100 t). The recommended maximum allowable harvest for 2010 is 3,100 t.

Central Coast

- All Pacific herring spawning in Kitasu Bay (Statistical Area 6), those in Statistical Area 7, and part of Area 8 (Kwakshua Channel and Fitz High Sound) 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 2009.
- The forecast of mature stock biomass for 2010 is 7,577 tonnes, which is below the fishing threshold (17,600 t). Only food, social or ceremonial harvest in 2010 is consistent with the harvest decision rule.
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Strait of Georgia

- All herring spawning within the Strait of Georgia (SOG) are assumed to belong to a single stock that migrates into the SOG 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 2009 was 5,228 tonnes or 49% of the coastal total and the validated catch was 5,685 tonnes. The roe herring gillnet TAC in 2009 was 3,617 tonnes or 34% of the coastal total and the validated catch was 3,937 tonnes.
- The forecast mature stock biomass for 2010 is 45,001 tonnes, well above the fishing threshold (21,200 t). The recommended maximum allowable harvest for 2010 is 9,000 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 2009.

- The forecast of mature stock biomass for 2010 is 6,063 tonnes, which is below the fishing threshold (18,800 t). Only food, social or ceremonial harvest in 2010 is consistent with the harvest decision rule.

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.

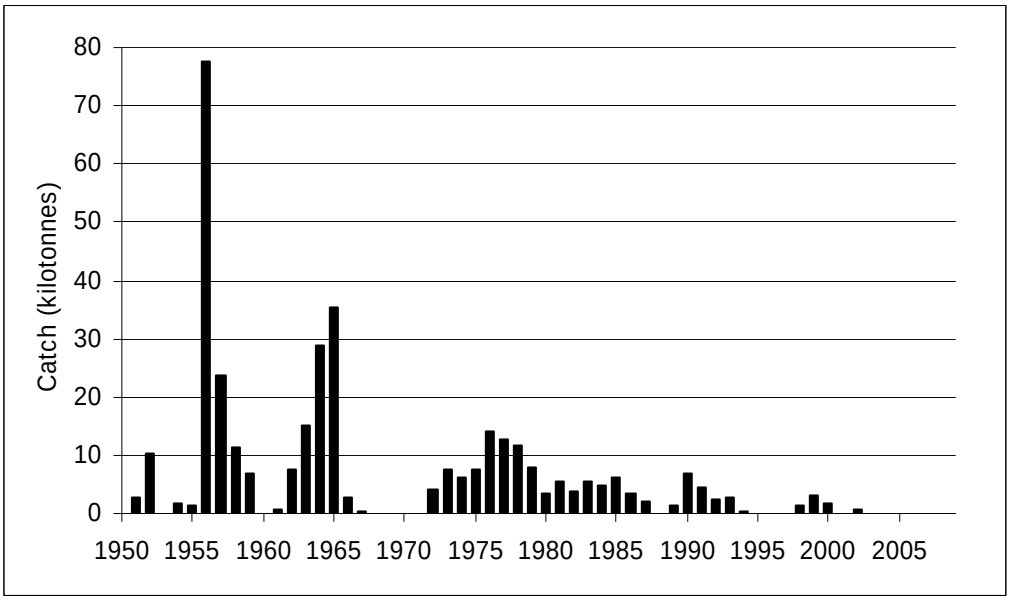

Figure 3a. Estimated herring catch from all fisheries except spawn-on-kelp in the Queen Charlotte Islands from 1951-2009.

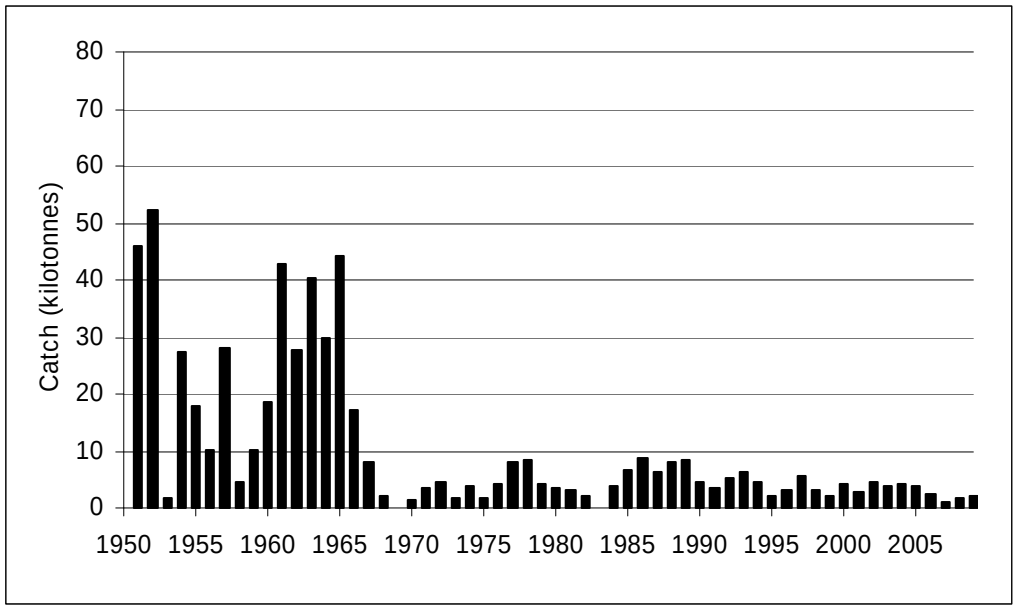

Figure 3b. Estimated herring catch from all fisheries except spawn-on-kelp in the Prince Rupert District from 1951-2009.

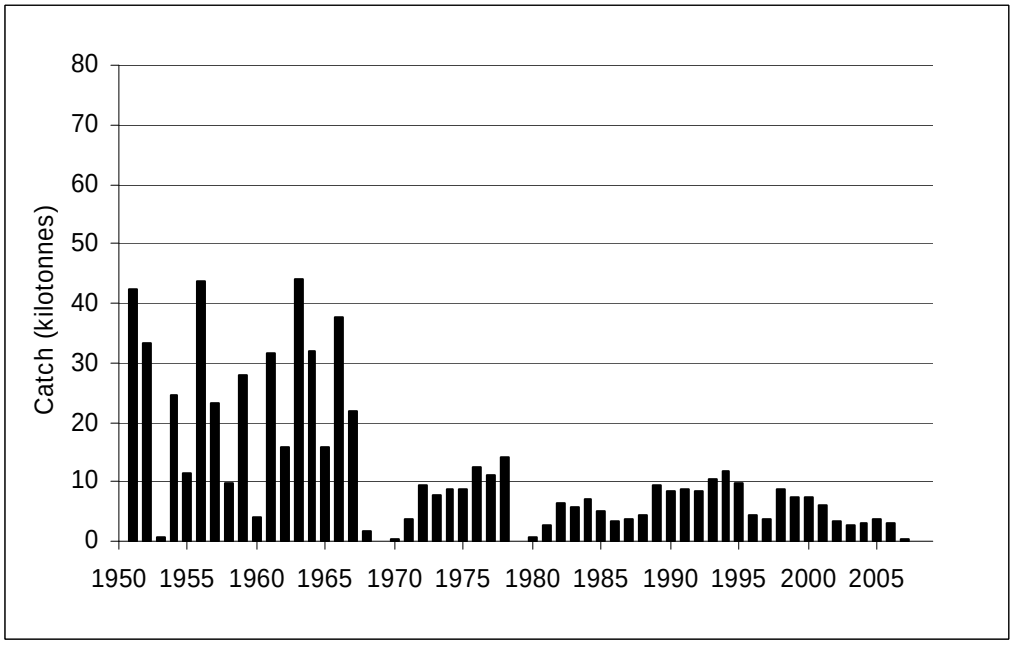

Figure 3c. Estimated herring catch from all fisheries except spawn-on-kelp in the Central Coast from 1951-2009.

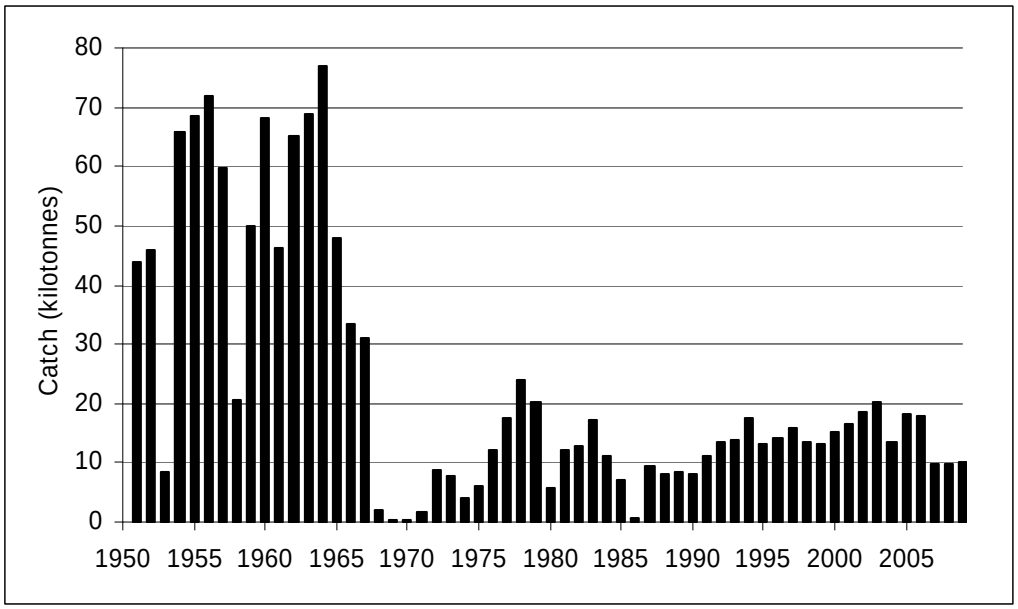

Figure 3d. Estimated herring catch from all fisheries except spawn-on-kelp in the Strait of Georgia from 1951-2009.

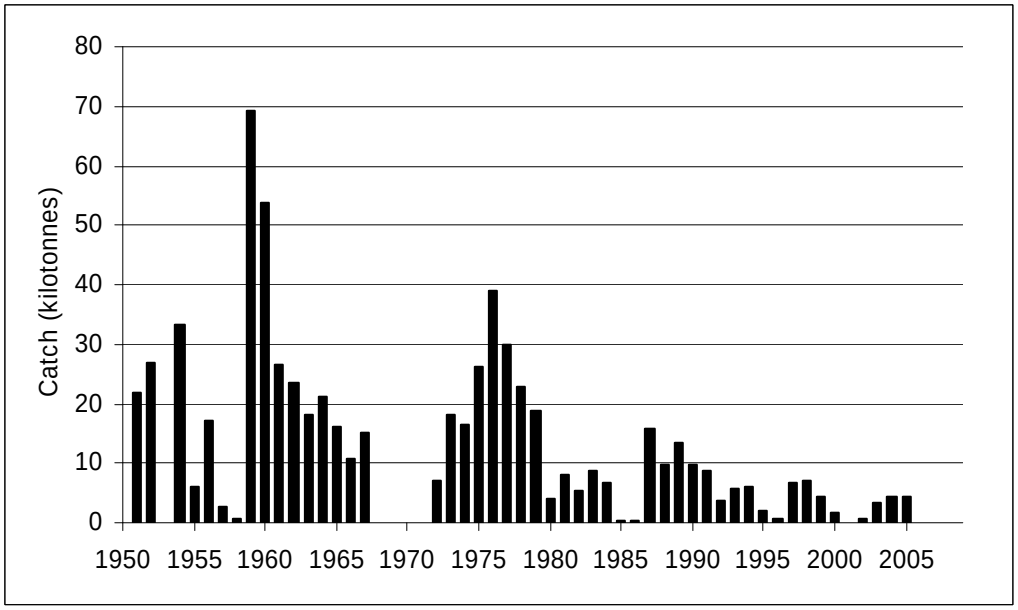

Figure 3e. Estimated herring catch from all fisheries except spawn-on-kelp in the west coast of Vancouver Island from 1951-2009.

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 (commercial fishing threshold or 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), and fishing was restricted to aboriginal food, social and ceremonial (FSC) harvest and commercial spawn-on-kelp. In 1995, 1996, and more recently 2005 through 2009 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 247 t has occurred over the past decade[1].

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 3,090 t over the past decade[1].

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 through 2009 this area was closed to commercial harvest. An average roe catch of 2,979 t has occurred over the past decade[1].

Strait of Georgia

In response to reduced stock levels, the Strait of Georgia roe fishery was closed in 1986 to allow for rebuilding. Subsequently, the stock recovered to a historic high in 2003, but has declined dramatically since then. The Strait of Georgia fishery has sustained an average catch of 15,027 t over the past decade[1].

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 2009. Despite these closures, the stock provided an average roe catch of 1,469 t over the past decade[1].

[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.

Table 1. Recent removals (excluding SOK) from the five major B.C. herring stocks (x 1,000 tonnes).

	2005	2006	2007	2008	2009
Queen Charlotte Island (QCI)	0.0	0.0	0.0	0.0	0.0
Prince Rupert District (PRD)	3.8	2.6	1.0	1.7	2.0
Central Coast (CC)	3.8	3.1	0.4	0.0	0.0
Strait of Georgia (SoG)	18.2	18.0	9.8	9.9	10.3
West coast Vancouver Island (WCVI)	4.3	0.0	0.0	0.0	0.0

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 assessment uses information from biological samples for determining the population age composition and average weight-at-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 previous years model (HCAM) was adopted as the best estimator of stock abundance (Christensen et al. 2009). Minor modifications to HCAMv2 were made for the 2009 stock assessment (Cleary et al. 2009).

Queen Charlotte Islands

The assessment indicates that herring stock biomass in the Queen Charlotte Islands assessment region remained relatively constant from 2000 through 2008 with a slight upward trend in 2009 (Fig. 4a). Spawning biomass (pre-fishery) for the area is estimated at 7,837 t in 2009, an increase of 1,073 t, or 16% below the 2008 level. Recruitment has alternated between poor and average over the last 10-years, with 2009 estimated as average recruitment, contributing to the continuing low level of abundance. The recruiting age 2+ fish dominated the 2009 run accounting for 64% of the total, while the age 3+ contributed only 8% to the run.

Prince Rupert District

The assessment indicates that herring stock biomass in the Prince Rupert District assessment region increased from 2000 through 2003, and has declined slowly through to 2009 (Fig. 4b). The pre-fishery biomass for the area is estimated at 17,834 t in 2009, a decrease of 3,214 t, or 18% below the 2008 level. During the past decade, recruitment for most year-classes has been average or better, with the exception of 2004 and 2008 which were poor. The 2009 recruitment is estimated as average. The spawning run consisted of about 46% age 4+ fish, 24% age 2+ recruiting fish and only 14% age 3+ fish.

Central Coast

The assessment indicates that herring stock biomass in the Central Coast assessment region has steadily decreased since the late 1990s with slight increases in 2003 and 2009 (Fig. 4c). The spawning biomass (pre-fishery) for the area is estimated at 10,897 t in 2009, an increase of 2,449 t, or 29% above the 2008 level. Over the past decade, five years had average or better recruitment, while poor recruitment was observed in 2001, 2004 and 2006 through 2008. The 2009 recruitment is estimated as average. The recruiting age 2+ fish accounted for 73% of the total 2009 run while the age 3+ fish only contributed 11% of the run.

Strait of Georgia

The assessment indicates that abundance in the Strait of Georgia assessment region has declined significantly since the 2003 historic high with a slight increase in 2009 (Fig. 4d). The pre-fishery biomass for the area is estimated at 61,380 t in 2009, an increase of 7,370 t, or 14% above the 2008 level. Recruitment during the past decade has been average or better in all years, except for poor recruitment in 2008. Some of the largest recruitment levels observed in the past 59 years occurred in the early 2000s and in 2007. The recruiting age 2+ fish made up 67% of the 2009 run. The age 3+ and 4+ fish contributed 14 and 13% of the 2009 run, respectively. The pre-recruit age 1+ fish contributed less than 1% of the run and will fully recruit in 2010. This year-class is forecast to be poor based on the offshore survey.

West coast Vancouver Island

The assessment indicates that herring abundance in the west coast of Vancouver Island assessment region has declined steadily from 2003 with a slight increase in 2009 (Fig. 4e). The spawning biomass (pre-fishery) for the area is estimated at 5,523 t in 2009, an increase of 716 t, or 15% above the 2008 level. Abundance in 2006 through 2008 is well below the lowest level observed in the 59-year time series of data for this stock. During the past decade most year-classes have been poor, except for 2001 to 2003 which were average. The majority of the 2009 run was comprised of the age 2+ fish, while poor, contributed 66% of the run. Age 3+ and 4+ fish contributed 16% and 13%, respectively. The pre-recruit age 1+ fish made up only 2% of the 2009 run and is forecast to be poor based on the offshore survey. Overall stock levels continue to be depressed from the highs of the 1970's and late 1980's. The recent pattern of below average recruitment to the stock may improve as the ocean climate returns to an average, or cool state. Other contributing factors to prolonged low stock biomass include increases in predator communities and decreases in prey availability for juvenile herring.

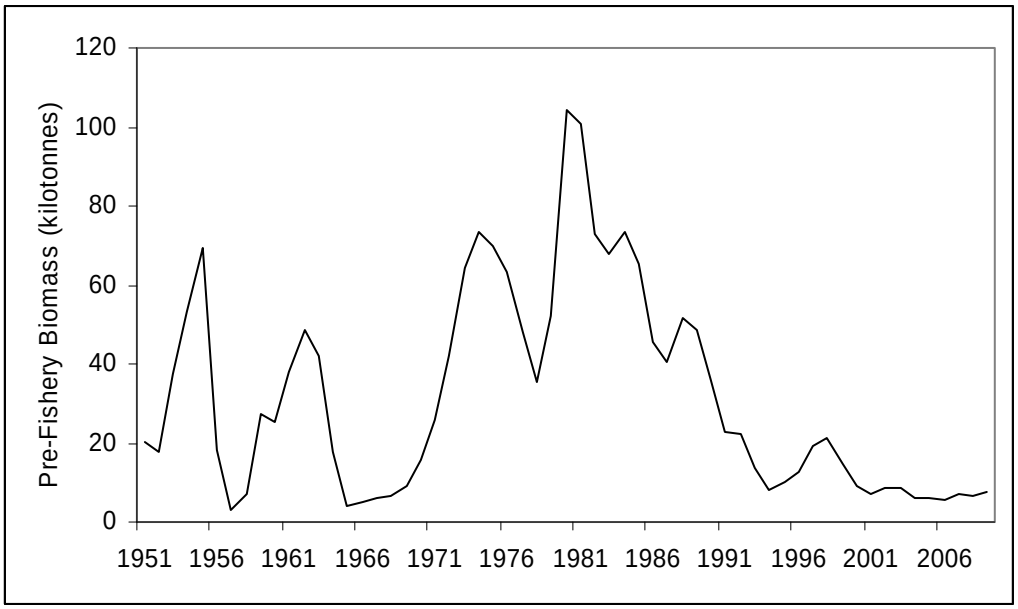

Figure 4a. Estimated pre-fishery herring biomass from 1951 to 2009 for Queen Charlotte Islands.

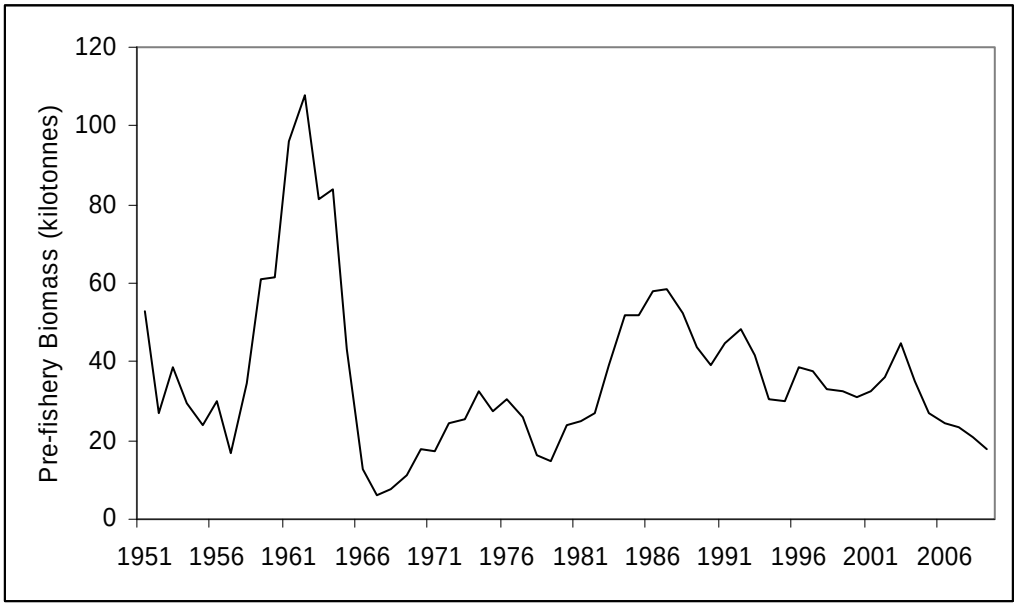

Figure 4b. Estimated pre-fishery herring biomass from 1951 to 2009 for Prince Rupert District.

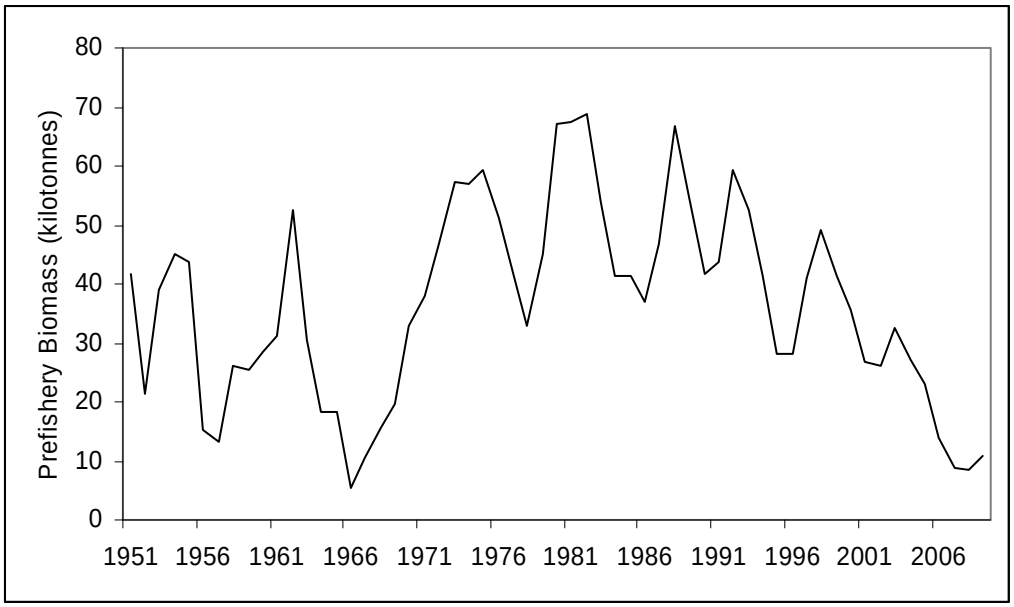

Figure 4c. Estimated pre-fishery herring biomass from 1951 to 2009 for the Central Coast.

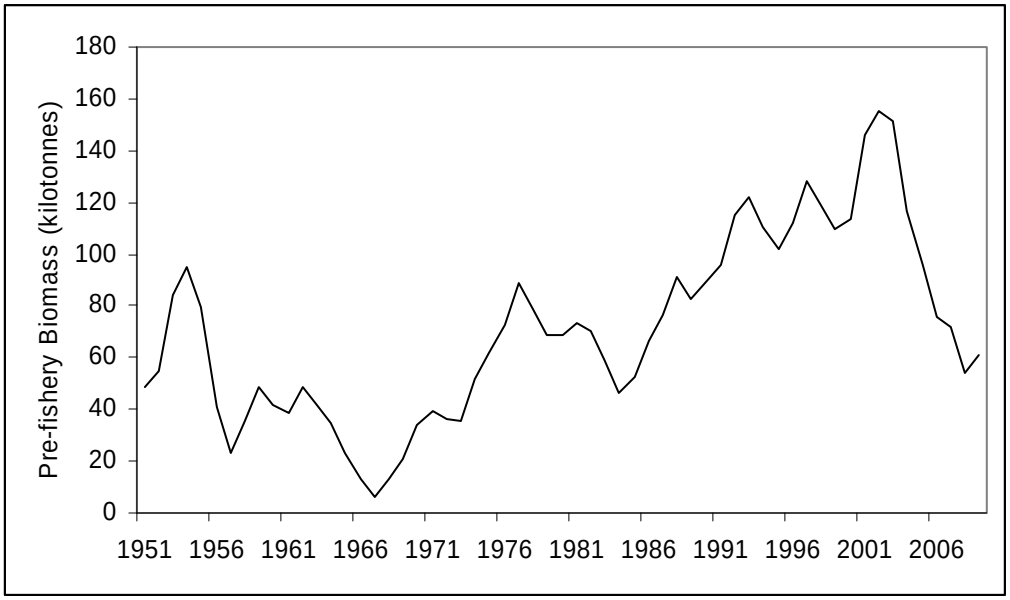

Figure 4d. Estimated pre-fishery herring biomass from 1951 to 2009 for the Strait of Georgia.

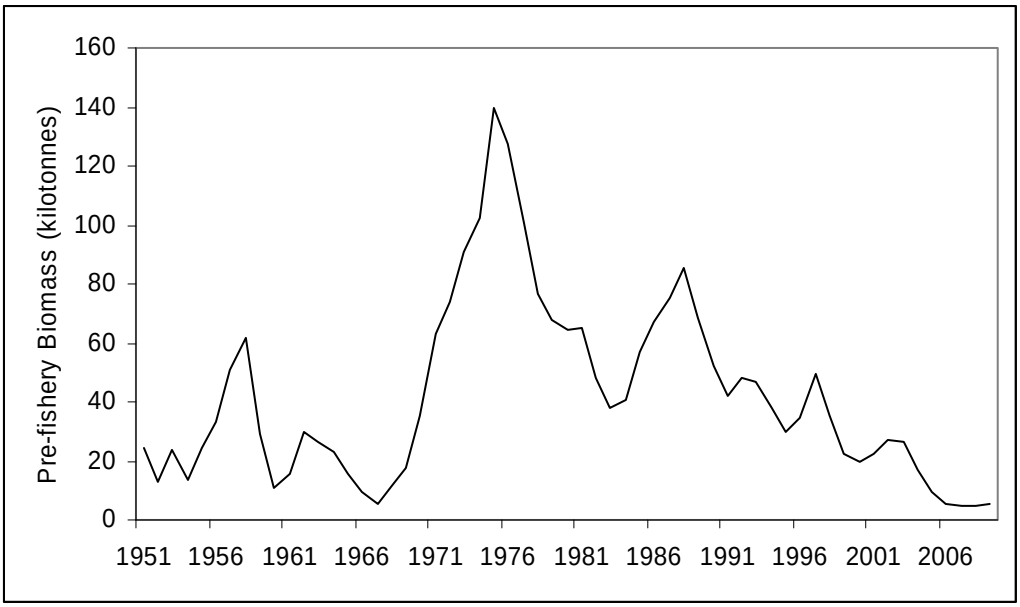

Figure 4e. Estimated pre-fishery herring biomass from 1951 to 2009 for the west coast of Vancouver Island.

CONCLUSIONS AND ADVICE

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

Queen Charlotte Islands

For the Queen Charlotte Islands, a poor recruitment option was adopted for 2010 resulting in a pre-fishery biomass forecast of 5,750 t, 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 2010 resulting in a pre-fishery biomass forecast of 15,499 t and a potential harvest of 3,100 t. This stock is above the Cutoff level of 12,100 tonnes. Roe and spawn-on-kelp fisheries are anticipated for 2010 based on the decision rule.

Central Coast

On the Central Coast, a poor recruitment assumption was adopted for 2010 resulting in a pre-fishery biomass forecast of 7,577 t, projecting abundance well below the Cutoff level of 17,600 t. As a result no commercial harvest is recommended in 2010 for this stock.

Strait of Georgia

In the Strait of Georgia, a poor recruitment option was adopted for 2010 based on the offshore survey resulting in a pre-fishery biomass forecast of 45,001 t and a potential harvest of 9,000 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, a poor recruitment option was adopted for 2010 based on the offshore survey resulting in a pre-fishery biomass forecast of 6,063 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 recruitment in 1992 and 1998. The poor or average recruitment over the past decade 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.

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 recruitment 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, recruitment has been average or better, except for poor recruitment in 2004 and 2008, 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 strong recruitment and these have occurred at regular intervals over the past two decades. Poor recruitment in 2001, 2004, and 2006 through 2008 accounts for decreased abundance in 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 recruitment every second or third year since the mid-1980s. Recruitment during the past decade has been average or better in all years, except for poor recruitment in 2008. These trends suggest that despite recent declines 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 (Ware, D.M. Pacific Biological Station, Nanaimo, B.C. V9T 6N7, unpublished data, H96-3). 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. Adv. Secr. Res. Doc. 2009/019: 65p.

Cleary, J.S., J.F. Schweigert, and V. Haist. 2009. Stock Assessment and Management Advice for the British Columbia Herring Fishery. 2009 Assessment and 2010 Forecasts. DFO Can. Sci. Adv. Secr. Res. Doc. 2009/079: 86p

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.

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.

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