SUMMARY OF 1986 HERRING STOCK ASSESSMENT

by

V. Haist and J. Schweigert

Fisheries Research Branch

Department of Fisheries and Oceans

Pacific Biological Station

Nanaimo, British Columbia V9R 5K6

Submitted to the

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

by the

CANADIAN NATIONAL SECTION

September 1986

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:

Haist, V. and J. Schweigert. 1986. Summary of 1986 herring stock assessment. 7 p. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, October 1986.) Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, B.C., Canada V9R 5K6.

Introduction

Forecasting the potential catch that can be removed from herring stocks requires an assessment of the present status and the determination of factors which affect stock dynamics, in particular recruitment. Traditionally, equilibrium based methods such as yield models have been favoured. They assume constancy in age structure, growth, and mortality. However, herring are strongly affected by changes in environmental conditions thus making equilibrium models unattractive. The models we use estimate current stock conditions on the basis of which potential catches are recommended. Catch levels have been formulated to ensure conservation of the stocks.

In this report we present two methods to assess present herring stock status: 1) an escapement model (Schweigert and Stocker 1987); and 2) an age-structured model (Fournier and Archibald 1982). Both methods use a 36 year time series of catch and spawn deposition information and age structure and size at age data obtained from pre-fishery and fishery samples.

The stock concept introduced for the 1985 assessment is used again this year for both assessment models. In the Queen Charlotte Islands the fish spawning in the Skincuttle-Selwyn area (sections 21,24 and 25) are treated as one stock. The stock concept for the Prince Rupert District remains unchanged encompassing fish in areas 3 to 5. The revised central coast stock separates the migratory component from the local stocks. The areas included in the current analyses are sections 67, 72-76, and 85. The Strait of Georgia is separated into two stock groupings. The northern group includes section 132, all of areas 14 to 16, and 17N. The southern stock comprises area 17S, 18, and 19. The two stock groupings used for the west coast of Vancouver Island are combined areas 23 and 24 and areas 25 to 27.

The escapement method of assessment has been modified this year to incorporate age structure information. This has the advantage of explicitly separating the growth and recruitment components of stock production. In addition, for the first time, stock biomass estimates obtained from diver spawn surveys are used wherever available. In all other areas the model continues to use data from surface surveys. The surface surveys are adjusted to "diver" observations based on information obtained from dual surveyed spawns.

The age structured model is little changed from that used in previous years. The main exception is that the catch equations were reparamatized to include an availability term which accounts for partial recruitment to the spawning, and therefore, fishable, stock.

Escapement model

The estimates of 1986 spawning biomass from the escapement model are obtained from diver survey information for most major spawnings with the exception of spawns in the Queen Charlotte Islands stock assessment region. While this model does not currently account for egg loss prior to the surveys, which may lead to a negative bias in estimates of spawning biomass, we feel the diver surveys allow fairly accurate estimation of spawners from this model.

The estimated 1986 spawning biomass in the Queen Charlotte Islands was 4,400 tonnes. However, because a substantial portion of the spawn in this area occurs subtidally on Macrocystis which is difficult to survey from the surface we feel the escapement method, using only surface spawn data, underestimates the spawning stock. The stock trends from this model indicate a significant decline in spawning stock since 1981, particularly from 1985 to 1986. These trends are consistant with results from the age-structured model.

The 1986 spawning biomass in the Prince Rupert District stock assessment region was estimated at 24,300 tonnes from the escapement model. This stock has been rebuilding rapidly since the closure of the roe fishery in this area in 1982. It appears to be approaching the 25-40,000 tonne levels of the 1950s and 1960s. Good recruitment of both the 1977 and 1981 year-classes has contributed to the increased stock level. The central coast stock has been declining since 1983 and appears to be below historical levels of 30-40,000 tonnes. The 1986 spawning biomass was estimated at 15,200 tonnes. Recruitments have been poor to average since the strong 1977 year-class, however, the 1983 year-class appears to be above average so the decline may have abated.

The stocks in the south coast all appear to be rebuilding following the sharp declines observed in recent years. The 1986 spawning estimate for the northern Strait of Georgia is 37,200 tonnes while the estimate for the southern area is 7,000 tonnes. Spawning estimates for the west coast of Vancouver Island stocks are 25,600 and 7,300 tonnes for the southern and northern stocks, respectively. All four stock assessment regions on the south coast received an above average influx of recruiting fish in 1986.

Age-structured model

The age-structured model used for the 1986 herring stock assessments is essentially as described in Haist et al. (1986), with only minor changes. The model uses a maximum likelihood function to find the best fit to the observed age-structure data given the constraints of the catch equations. Spawning information, obtained from fisheries officers assessments, are included in the model in the form of spawn indices and are an additional constraint on the estimation procedure. This year only a single stock reconstruction was conducted for each region, however, because of the high proportion of juvenile fish observed in two of the stock assessment regions additional constraints were incorporated in the model for the analysis of these areas.

For the Queen Charlotte Islands stock grouping the downward trend in spawning biomass is continuing from the peak in 1981. Recruitments to this stock have been poor to average since the large 1977 year-class and this trend is likely to continue for 1987. For the Prince Rupert area the spawn index has been increasing steadily since 1978, however the estimates of spawning biomass from the stock reconstruction indicate a decrease from 1983 to a 1986 level of 29,500 tonnes. The stock reconstruction for the central coast indicates an increase in spawning biomass from 1979 to a peak in 1982 followed by a rapid decline that is now slowing. The spawn index indicates that spawning has declined only slightly since 1982. The estimated spawning biomass in 1986 was 23,100 tonnes.

Indications are that all stocks on the south coast were buoyed by above average recruitment in 1986. The spawn indices for the Strait of Georgia are up sharply in 1986 in the northern area and stable in the southern area. The estimated spawning stock in 1986 was 40,300 and 12,700 tonnes in the northern and southern Georgia Strait, respectively. Spawning stock biomass was up sharply in the north and moderately in the south from the 1985 levels.

The spawn indices for the southern and northern west coast of Vancouver Island stock indicate a continuing upswing and a marked increase, respectively. Current information suggests that spawning stock biomass bottomed out in both areas in 1984 and has been increasing during the past two years.

Catch recommendations

We recommend catch levels at 20% of the "best" forecasts of the 1987 pre-fishery stock biomass for those stocks that are well above CUTOFF levels. 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 minimal yield over the long term. While a fixed escapement policy would provide the theoretical optimal solution, that is, highest yields and stock stability, this policy is not attainable at the operational level. For stocks that are marginally above CUTOFF we recommend the following catch:

Catch = Weighted Run - CUTOFF

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

CUTOFF levels are established at one-forth of the unfished equilibrium biomass. The unfished equilibria were estimated using computer simulations. For the seven areas as defined in Haist et al. (1985), the following CUTOFF levels were estimated:

Queen Charlotte Islands	13,100 tonnes
Prince Rupert District	8,900 tonnes
Central Coast	11,100 tonnes
Strait of Georgia-north	14,600 tonnes
Strait of Georgia-south	6,200 tonnes
W.C. Vancouver Is.-south	15,400 tonnes
W.C. Vancouver Is.-north	6,000 tonnes

To determine the "best" stock forecasts we used a two step procedure. First, for each of the two methods, and for each stock grouping, one recruitment scenario (i.e. poor, average, or good) was chosen. The information used to choose a particular recruitment scenario includes both forecasted year class strength from either a stock-environment-recruitment model or time-series model (Stocker 1986) and recent trends in stock and recruitment levels. Secondly, we assigned subjective probabilities to the two alternate assessment methods. Based on intuition, and past performance we believe that the age-structured model makes the most likely predictions of forecast runs. However the escapement method incorporates dive survey information for most major spawns in 1986, and we feel this direct measure of egg deposition should be a reasonably accurate estimate of current stock levels. Therefore, we assigned

equal subjective probabilities to the two models for all areas in which we did not have additional information to discount one of the methods. Because of the problem with the assessment of spawn on Macrocystis using surface surveys, and the lack of diver surveys in the Queen Charlotte Islands we discounted the forecast from the escapement method for this area. Additionally we felt the age-structured model results may contain bias for the southern Strait of Georgia and northern West coast of Vanocuver Island stock assessment regions because additional model constraints were required to obtain reasonable stock reconstructions for these areas. Accordingly, for these three areas we used a 80:20 weighting in favour of the preferred model.

The assigned probabilities were used to weight the forecast "best" runs obtained from each method to provide a single "weighted run" for each of the stock groupings (Table 1).

The predicted level of recruitment to the Queen Charlotte Islands stock assessment regions was average from a stock-environment-recruitment model (Stocker 1986). However, because this stock has decreased steadily since 1981 and all recruiting year classes have been below average since the strong 1977 year class the assumption of average recruitment may be overly optimistic. Therefore the midway point between poor and average recruitment was chosen giving a weighted forecast of 15,300 tonnes. This forecast is only marginally above the CUTOFF so we recommend a catch level of 2,210 tonnes for the Queen Charlotte Islands.

An average level of recruitment is predicted for the Prince Rupert area, however, given the steady increase in spawning stock and observed average to good recruitments in recent years, a slightly more optimistic recruitment assumption may be warranted. We therefore use a recruitment level midway between average and good for a weighted forecast of 32,050 tonnes. The recommended catch is then 6,410 tonnes for the Prince Rupert district.

For the Central coast migratory stock the weighted run is predicted at 23,000 tonnes with average recruitment. This represents an increase over 1986 and a recommended catch of 4,600 tonnes. The above average recruitment in the south appears to have favourably affected the production of the Central coast stock, however, recruitment in the latter stock is not expected to exceed average.

The south coast stocks have all rebounded dramatically in 1986 and recruitment is forecast to be average in all areas for 1987. The weighted forecasts for the Strait of Georgia are for 42,950 and 10,000 tonnes in the northern and southern areas. The forecast in the southern stock represents an 80:20 weighting in favour of the escapement model and relies on recruitment information for the roe fishing period only. The recommended catches are 8,590 and 2,000 tonnes for the north and south stocks, respectively. It was also recommended that the latter catch be taken in the fall food fishery if possible.

The weighted forecast run to the west coast of Vancouver Island stocks is for 33,700 tonnes in the southern area and 14,620 tonnes to the northern area. This provides recommended catch levels of 6,740 and 2,920 tonnes, respectively.

The catch levels recommended in this summary are based purely on biological considerations, reflecting the best biological analyses given the available data bases. We point out that management of the various fisheries has practical constraints other than the biological considerations discussed in this report. Furthermore, there are certain economic considerations which we do not regard when making recommendations. Thus the quotas ultimately adopted by DFO may differ from those recommended herein. It should also be noted that the catch levels adopted by DFO include all fisheries. Catches from food, bait, and special fisheries are subtracted from the recommended catch levels to determine the roe herring quotas.

Summary

For the 1986 herring stock assessments two assessment methods were used: (1) an escapement model; and (2) an age-structured model. Both methods use a 36-year time series of catch, spawn deposition, and age composition data. 1986 has seen a substantial increase in the coastwide abundance of herring, primarily the result of above average recruitment to the south coast herring stocks. The 1986 estimated escapements were 174,600 and 121,000 tonnes for the age-structured and escapement models, respectively. The Prince Rupert district spawning stock is currently close to the maximum levels observed historically. Both the Queen Charlotte Islands and Central coast stocks continue to decline from the high levels observed in 1981, however the trend is more severe in the Queen Charlotte Islands. The recent decline in stock levels in the Strait of Georgia and on the west coast of Vancouver Island appears to be halted with substantial increases in spawning biomass observed in 1986.

The weighted run forecast for 1987 is 171,620 tonnes for the entire B.C. coast yielding a recommended catch of 33,470 tonnes. For the north coast the forecast is 70,350 tonnes for a recommended catch of 13,220 tonnes, whereas the forecast for the south coast is 101,270 tonnes for a recommended catch of 20,250 tonnes. Catch recommendations are based on a 20% harvest rate for all stocks which are substantially above CUTOFF levels. For the Queen Charlotte Islands stock, where the forecast stock size is only marginally above the CUTOFF, the recommended catch is the difference between the forecast and the CUTOFF.

References

Fournier, D. and C.P. Archibald. 1982. A general theory for analyzing catch at age data. Can. J. Fish. Aquat. Sci. 39: 1195-1207.

Haist, V., J.F. Schweigert and M. Stocker. 1985. Stock assessments for Britisn Columbia herring in 1985 and forecasts of the potential catch in 1985. Can. MS Rep. Fish. Aquat. Sci. 1889: 48 p.

Schweigert, J.F. and M. Stocker. 1987. A new method for estimating Pacific herring stock size from spawn survey data and its management implications. N. Am. J. Fish. Manag.(in press).

Stocker, M. 1986. Forecasting Pacific herring (Clupea harengus pallasi) year class strength. Working Paper H86-2: 6 p.

Table 1. Summary of spawning biomass in 1986 and forecasts of stock biomass in 1987 (1000 t) from Age-structured and Escapement models and weighted runs for poor, average, and good recruitment levels.

	Method												
	Age-structured model				Escapement Model					Weighted Results			
		Forecast stock with recruitment				Forecast stock with recruitment				Forecast stock with recruitment			
	1986 spawners	poor	avg.	good	1986 spawners	poor	avg.	good	Rel. weight	poor	avg.	good	Recommended Catch
Queen Charlotte Island Skincuttle-Selwyn	17.7	15.3	20.7	43.5	4.4	3.6	5.5	14.8	.8:.2	12.96	17.66	37.76	2.21[a]
Prince Rupert District	29.5	27.2	31.3	44.0	24.3	17.9	21.0	31.9	.5:.5	22.55	26.15	37.95	6.41[b]
Central Coast migratory stock	23.1	23.5	28.3	40.8	15.2	12.8	17.7	30.6	.5:.5	18.15	23.00	35.70	4.60[c]
Strait of Georgia northern stock	40.3	42.8	48.4	58.7	37.2	31.4	37.5	49.1	.5:.5	37.10	42.95	53.90	8.59[c]
southern stock	12.7	13.4	15.2	17.6	7.0	6.9	8.7	10.0	.2:.8	8.20	10.00	11.52	2.00[c]
West Coast of Vancouver Island southern stock	35.3	36.4	40.8	54.3	25.6	21.9	26.6	39.2	.5:.5	29.15	33.70	46.75	6.74[c]
northern stock	16.0	17.0	20.7	25.8	7.3	9.2	13.1	22.9	.2:.8	10.76	14.62	23.48	2.92[c]

[a]Recommended catch is difference between forecast stock biomass and CUTOFF assuming recruitment level midway between poor and average

[b]Recommended catch is 20% of forecast stock biomass assuming recruitment midway between average and good

[c]Recommended catch is 20% of forecast stock biomass assuming average recruitment