SUMMARY OF 1985 HERRING STOCK ASSESSMENT

by

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INTRODUCTION

Forecasting the potential catch that can be removed from herring stocks requires an assessment of their status and determination of the factors which affect their dynamics. Traditionally, yield models have assumed equilibrium conditions, implying no change in age structure, growth, or mortality over time. However, herring are strongly affected by inter-annual variations in environmental conditions thus making equilibrium models unattractive. The methods we use try to estimate current stock conditions; we then use these assessments to recommend potential catches that will not have deleterious effects on the stocks.

In this report we present two stock assessment methods:

(1) escapement model (Schweigert and Stocker 1985), and (2) age-structured model analysis (Fournier and Archibald 1982). Both methods use a 35 year time series of catch and spawn deposition information; the second method also uses age composition data.

A revised stock concept is used for age-structured model analysis; escapement model results are available by management unit as well as by the new stock groupings. In the Queen Charlotte Islands the stock analysed is the Skincuttle-Laskeek stock (Sections 21,24 and 25). For the Prince Rupert District there is no change in stock concept; this stock grouping includes all of Statistical Areas 3 to 5. The new central coast stock attempts to separate the major migratory component from the local stocks. The area included in the current analyses are Sections 67, 72-76, and 85. The Strait of Georgia is separated into two stock groupings. The northern stock includes Section 132, all of Areas 14 to 16, and 17N. The southern stock comprises Areas 17S, 18, and 19. The two stock groupings used for the west coast of Vancouver Island are Combined Areas 23 and 24, and combined Areas 25 to 27.

Three sets of analyses using the age structured model with different assumptions were done for each stock grouping. The first analysis uses a low weighting on the spawn time series; that is, the model is more closely tied to age structure information than to spawn index information. The second analysis places a high weighting on the observed spawn index for the last five years which forces the model to follow recent trends in spawn to a greater degree. The third set of analyses incorporate the assumption of density dependent natural mortality.

Because the stock reconstructions from age-structured analysis deviate greatly from recent trends in the spawn indices for all south coast stock groupings, forecasts of 1986 stock size are based on the second set of analyses only. Stock reconstructions for the north coast stocks generally follow recent trends in the spawn indices. For these stock groupings forecasts of stock abundance are averaged from the first and third set of analyses.

The escapement method of assessment uses surface based spawn data that has been adjusted using divers' spawn observations. It uses diver information to adjust trends in the surface based measurements of width, and intensity. Forecasts are made for Management Units, as well as for stock groupings outlined above.

ESCAPEMENT METHOD

The forecast stock size for the entire coast in 1986 assuming average recruitment is 185,680 tonnes - an decrease of 68 percent over 1985 levels. On the other hand a poor recruitment, which is anticipated from other biological indicators suggests a 1986 run of 115,732 tonnes comparable to the 1985 figure of 110,543 tonnes. With average recruitment a potential catch of 37,136 tonnes is forecast. Generally, stocks in the northern areas are in average to good condition while those in the south are near the low levels recorded in the late 1960s.

The forecast run to the Queen Charlotte Islands assuming average recruitment is 27,729 tonnes. This stock has been stable at this level since 1976 but has declined slightly since 1981. A poor recruitment in this area would lower the forecast to 12,534 tonnes. Given average recruitment a catch of 5,546 tonnes is indicated. The forecast runs for the North Coast with average and poor recruitment are 31,519 and 17,458 tonnes, respectively. Given average recruitment a 6,304 tonne fishery would be expected. This stock has been rebuilding steadily to the 10-20,000 tonne range since the early 1970s (Table 2.1). It appears to be approaching the 25-40,000 tonne level of the 1950s and 1960s. Forecasts for the Central Coast are 34,547 and 18,937 tonnes with average and poor recruitment, respectively. Anticipated catch is 6,909 tonnes. This stock also appears to be below historical levels of 40-50,000 tonnes but has been stable at 25-40,000 tonnes since the early 1970s.

The sum of the Johnstone Strait and Georgia Strait forecasts are 55,014 and 21,611 tonnes with average and poor recruitments. This translates into 11,003 or 4,323 tonne catch quotas. Stocks in both these areas have been declining since 1980 and are now comparable to the levels of the late 1960s. Forecast runs to the west coast of Vancouver Island are 36,871 and 19,320 tonnes, respectively indicating potential catches of 7,374 or 3,864 tonnes for average and poor recruitment. Stocks in this area have also been on the decline since 1979 and are at the 1969 or 1970 level, well below the 40-50,000 tonnes of the early 1960s and mid-1970s.

Table 1 summarises the estimated biomass by management unit and division for the period 1970 - 1985. Recruitment (production) was estimated as the time series average of the difference between stock size in one year and survivors from the spawning escapement the previous year.

AGE-STRUCTURED MODEL ANALYSIS

The age-structured model used for the 1986 herring stock assessments is essentially as described in Haist et al. (1985), 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 spawn assessments, are included in the model in the form of spawn indices and are an additional constraint on the estimation procedure.

For the Skincuttle-Laskeek stock grouping the stock reconstructions from the three model runs are very similar, indicating a peak spawning biomass in 1981/82. Both spawn indices show peak spawning in 1980, however, the overall trend in observed spawn is similar to the trend in estimated spawning biomass. For the Prince Rupert area both the spawn indices and estimates of spawning biomass show a steady increase from 1979 to 1985. The SSM spawn index is somewhat more erratic than Hay's index which follows the spawning biomass estimates more closely. Stock reconstructions for the central coast indicate an increase in spawning biomass from 1979 to 1982 followed by a steady decline in stock levels. This trend is very similar to that from the SSM spawn index. Hay's index indicates that spawning has been steady since 1982. For all three north coast stocks estimated spawning biomass is in general accord with at least one of the spawn indices even for the runs without a high penalty weight on the spawn relationships. Forecasts of stock biomass in 1986 are therefore based on the average of the predictions from the low spawn weight and the density dependent stock reconstruction for the north coast stocks (Table 2). Because of the indications of severe decline of spawners in the central coast we recommend that the catch quota for this area is based on age 4 and older fish only.

For all four stock groupings the spawn indices indicate drastic declines in spawn between 1979 and 1985. The stock reconstructions from age-structured analysis show these stocks declining between 1979 and 1984, however, they show a significant increase in spawning biomass in 1985. This results from a high proportion of 2-yr-old fish in the biological samples in 1984 and 1985. The model interprets this as a large cohort entering the fishery (4-yr olds in 1986). However, there may be alternative explanations for the observed high proportions of 2-yr-old fish.

Both spawn indices for the northern Strait of Georgia stock show a dramatic decline in recent years; the trend in spawners predicted from age-structured stock reconstructions is less severe. The computer run with a high penalty weight on spawn for the last five years estimates a smaller increase in spawners between 1984 and 1985 than the other two runs. The two spawn indices for the southern Strait of Georgia stock are qualitatively very different. Hay's spawn index shows a decrease in spawn between 1979 and 1985, and follows the biomass trends estimated from age-structured analysis more closely.

The two spawn indices for the northern west coast of Vancouver Island stock are qualitatively similar and show a continuous decline in spawn between 1979 and 1985. Both the general stock reconstruction and reconstruction assuming density dependent natural mortality show an unbelievable increase of spawners between 1983 and 1985. The run with high spawn penalty weight is more similar to the trends in the spawn indices. The southern west coast of Vancouver Island stock is the only south coast stock where the spawn indices are higher in 1985 than in 1984. The stock reconstruction with a high spawn penalty weight shows a similar increase in spawning biomass to the indices. The two other reconstructions indicate a much bigger increase in spawners in 1985.

Because the stock reconstructions from age-structured analysis deviate strongly from the spawn indices for all south coast stocks we use only forecasts of 1986 abundance from the run with high penalty weight on the spawn relationships. These are somewhat more in line with the trends in F.O. spawn assessments. These stocks all appear to have declined dramatically in recent years, with the possible exception of the southern west coast of Vancouver Island stock. For this reason we recommend that the 1986 catch quotas are only based on estimates of returning adults (Table 2).

CATCH RECOMMENDATIONS

We recommend catch levels at 20% of the "best" forecasts of the 1986 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 20% harvest rate would bring the escapement down to dangerously low levels.

Preliminary CUTOFF levels are established at one-forth of the unfished equilibrium biomass. The unfished equilibria were estimated using computer simulations. For the five 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 and Johnstone Strait	20,800 tonnes
West coast of Vancouver Island	21,400 tonnes

We plan to estimate these levels for the new stock groupings as well. 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 production/recruitment scenario (i.e. poor, average, or good) was chosen. 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. The escapement method makes a direct interpretation of spawn survey data, and has good predictive ability regarding returning spawners. However, the other component, predicting stock productivity, is probably not as well determined. We thus assigned subjective probabilities as follows:

Age-structured model	p(AS) = 0.60
Escapement method	p(ESC)= 0.40

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 3). Thus the resulting forecasts follow somewhat more closely the age-structure information, but still gives the current spawn information a high weight.

For the Skincuttle - Laskeek stock (Queen Charlotte Islands) the weighted run is predicted at 19,900 tonnes for a recommended catch of 4,000 tonnes. This is lower than last year's recommendation for two reasons. Firstly, the new stock grouping encompasses a smaller area, and secondly there is a downward trend in the stock. The Prince Rupert District stock is continuing to increase, and at least average production/recruitment is predicted (see other document this meeting). Thus, the weighted run is predicted at 33,200 tonnes, yielding a catch of 6,600 tonnes. In contrast to the southern areas, there appear to be no unfavourable environmental conditions affecting recruitment for these two northern stocks.

For the Central coast migratory stock the weighted run is predicted as 17,000 tonnes. This low level reflects both, the new stock concept as well as the substantial decline of the stock. At this level, our recommendation is for a catch of 3,400 tonnes. It appears that the unfavourable environmental conditions in the south are also affecting the production of the Central coast stock.

On the south coast we are now experiencing the effects of the unusually warm water temperatures of 1983 in the form of low predicted production/recruitment for 1986. Also, the escapement was very low on the south coast in 1985. The combined effects is low forecast stock sizes of 21,600 tonnes and 19,300 tonnes for the Strait of Georgia, and the west coast of Vancouver Island respectively. For the Strait of Georgia the prediction is marginally above the CUTOFF level, and we recommend only a small catch of 800 tonnes (Table 3). As the predicted run size is below CUTOFF level for the west coast of Vancouver Island we recommend on purely biological grounds that the area be closed to fishing in 1986.

The catch levels recommended in this summary are based purely on biological considerations, reflecting the currently unfavourable environmental conditions in the south and Central coasts for herring production. We should 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 recommended by the Stock Assessment Committee, and those ultimately adopted by DFO may differ from those recommended herein. We should also point out that the catch levels recommended herein include all fisheries. Catches from food, bait, and special fisheries must be subtracted from recommended catch levels to determine roe herring quotas.

INPFC SUMMARY

This year two stock assessment methods were used: (1) escapement model, and (2) age-structured model analysis. Both methods use a 35-year time series of catch and spawn deposition information; the second method also uses age composition data. 1985 has seen a further decline in the abundance of most herring stocks, particularly in the south coast. The 1985 estimated escapements were 136,300 tonnes and 78,100 tonnes for the age-structured model and escapement model respectively. For the north coast the estimated escapements were 73,600 tonnes and 49,800 tonnes for the two methods, whereas, south coast estimates were 62,700 tonnes, and 28,300 tonnes.

The weighted run forecast for 1986 is 111,000 tonnes for the entire B.C. coast. The recommended catch for this low level of population size is 14,800 tonnes. For the north coast the forecast is 70,100 tonnes for a recommended catch of 14,000 tonnes, whereas the forecast for the south coast, suffering from low production due to unfavourable environmental conditions, is only 40,900 tonnes for a recommended catch of 800 tonnes for the Strait of Georgia, and a recommended closure for the west coast of Vancouver Island.

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Table 1. Forecast of the 1986 runs and potential catch in tonnes of fish by management unit and division for poor, average and good recruitment.

Division and Management unit	Adults	Recruits -1Std	Recruits Ave.	Recruits +1Std	Forecast Run Poor	Forecast Run Ave.	Forecast Run Good	Potential Catch Poor	Potential Catch Ave.	Potential Catch Good
Queen Charlotte Is.										
North Coast	0	-923	547	2017	-923	547	2017	-185	109	403
Louscoone Inlet	407	-250	1236	2722	157	1643	3130	31	329	626
Other Area 2W	1597	-551	1190	2931	1046	2787	4528	209	557	906
Laskeek Bay	1539	-1178	1014	3206	361	2553	4745	72	511	949
Skincuttle Inl	6833	-4528	9149	22826	2305	15982	29659	461	3196	5932
Other Area 2E	602	-846	4490	9826	-244	5092	10427	-49	1018	2085
All QCI	10978	1556	16751	31946	12534	27729	42924	2507	5546	8585
North Coast										
Catham Sound	8573	-1779	4580	10939	6795	13153	19512	1359	2631	3902
Porcher Island	6277	621	4061	7501	6898	10338	13778	1380	2068	2756
Other North Coas	234	-4112	7794	19700	-3878	8028	19934	-776	1606	3987
All NC	15084	2374	16435	30496	17458	31519	45580	3492	6304	9116
Central Coast										
Kitasu Bay	3830	-800	3797	8394	3031	7627	12224	606	1525	2445
Milbanke Sound	2898	-821	6551	13923	2078	9449	16821	416	1890	3364
Queen's Sound	27	-514	4228	8970	-487	4255	8998	-97	851	1800
Kwakshua Channel	989	-528	2243	5014	461	3232	6004	92	646	1201
Burke Channel	372	-653	1245	3143	-281	1617	3515	-56	323	703
River's Inlet	368	-403	1417	3237	-35	1785	3605	-7	357	721
Smith Inlet	418	-109	678	1465	309	1096	1882	62	219	376
Other Central	1091	-415	5196	10807	676	6287	11898	135	1257	2380
All Central	9994	8943	24553	40163	18937	34547	50158	3787	6909	10032
Johnstone Strait										
Upper Johnstone	62	-209	1504	3217	-147	1566	3280	-29	313	656
Knight Inlet	266	-448	776	2000	-181	1042	2266	-36	208	453
Other Johnstone	32	-1196	8924	19044	-1164	8956	19076	-233	1791	3815
All JS	9252	-308	11204	22716	53	11565	23077	11	2313	4615
Strait of Georgia										
Powell River	1517	-1325	1648	4621	192	3165	6138	38	633	1228
Nanaimo-Comox	3454	2050	13768	25486	5505	17222	28940	1101	3444	5788
Yellow Point	2375	-3859	3407	10673	-1484	5782	13048	-297	1156	2610
Ganges-Plumper	653	-704	2672	6048	-51	3325	6702	-10	665	1340
Other Str Georgia	0	-745	752	2249	-746	752	2249	-149	150	450
Other Vancouver I	0	-1687	13960	29607	-1687	13960	29607	-337	2792	5921
All Str Georgia	7999	23938	35450	46962	21558	43449	65340	4312	8690	13068
West Coast Vancouver Island										
West Barkley	5246	-1892	4556	11004	3354	9802	16251	671	1960	3250
Other area 23	1167	-1795	8661	19117	-628	9828	20284	-126	1966	4057
South Clayoquot	2465	-1117	2554	6225	1348	5019	8690	270	1004	1738
Other area 24	524	-766	2829	6424	-242	3353	6947	-48	671	1389
Nootka Inlet	25	-2187	1280	4747	-2162	1305	4772	-432	261	954
Nuchatlitz Inl	807	-2096	3985	10066	-1288	4792	10873	-258	958	2175
Quatsino Sound	0	-3744	4677	13098	-3744	4677	13099	-749	935	2620
All WCVI	10235	9086	26636	44186	19320	36871	54421	3864	7374	10884

Table 2. Forecast of 1986 stock biomass (in thousands of tonnes) for the B. C. coast stock groupings.

Stock grouping	1985 Spawners	1986 Forecast Age 4+	1986 Forecast Age 3	1986 Forecast Total
Queen Charlotte Islands Skincuttle-Laskeek				
run 1-Low spawn weight	15.8	14.1	7.0	
run 2-Density dependent mortality	20.2	18.1	4.1	
average of 2 runs	18.0	16.1	5.6	21.7
Prince Rupert District				
run 1-Low spawn weight	30.3	31.9	4.0	
run 2-Density dependent mortality	35.3	39.5	4.1	
average of 2 runs	32.8	35.7	4.1	39.8
Central Coast (migratory)				
run 1-Low spawn weight	21.9	19.1	6.1	
run 2-Density dependent mortality	23.8	20.1	5.2	
average of 2 runs	22.9	19.6	5.7	25.3
Strait of Georgia				
northern stock				
run 3-High spawn weight	22.8	17.3	10.9	28.2
southern stock				
run 3-High spawn weight	12.5	9.0	4.7	13.7
West Coast of Vancouver Island				
northern stock				
run 3-High spawn weight	11.4	8.6	6.0	14.6
southern stock				
run 3-High spawn weight	16.0	14.3	10.0	24.3

Table 3. Summary of 1986 "best"predicted and weighted herring runs (1000 t), and the 1986 catch recommedation. (The "best" predicted runs reflect the current unfavourable environmental conditions).

District	Method: Age-Structured model: Forecast: 1985 spawners	Age-Structured model: Forecast: Adults	Age-Structured model: Forecast: age3 Recruits	Age-Structured model: Forecast: Stock size	Escapement Method: 1985 spawners	Escapement Method: Forecast with production: low	Forecast with production: avg.	Forecast with production: high	1986: Weighted Run	1986: Recommended Catch
Queen Charlotte Islands -Skincuttle - Laskeek	18.0	16.1	5.6	21.7	13.1	12.2	17.1[b]	22.1	19.9	4.0
Prince Rupert District	32.8	35.7	4.1	39.8	24.6	19.5	23.4[b]	27.4	33.2	6.6
Central Coast -migratory stock	22.8	19.6	5.7[a]	19.6	12.1	13.2[b]	19.4	25.7	17.0	3.4
Strait of Georgia -north	22.8	17.3	10.9[a]	17.3	7.8	10.3[b]	23.0	35.6	14.5	
-south	12.5	9.0	4.7[a]	9.0	4.7	4.2[b]	9.7	15.2	7.1	
-north/south combined	-	-	-	26.3	12.5	14.5	32.7	50.8	21.6	0.8[d]
West coast of Vancouver Island -north	11.4	8.6	6.0[a]	8.6	1.3	1.6[b]	7.0	12.5	5.8	
-south	16.0	14.3	10.0[a]	14.3	14.5	12.2[b]	25.6	38.9	13.5	
-north/south combined	-	-	-	22.9	15.8	13.8	32.6	51.4	19.3[e]	0

[a] Recruitment not included in forecast stock size

[b] "Best" predicted run by escapement method

[c] Recruitment (1970-85) from Table 2.3

[d] Weightedrun - CUTOFF (CUTOFF see other document this meeting)

[e] Less than CUTOFF (CUTOFF see other document this meeting)