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Report of the PSARC Pelagic Subcommittee Meeting, August 28-31, 2000

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Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

September 2000

Canada

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

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SUMMARY

The PSARC Pelagic Subcommittee met August 28-31, 2000 at the Pacific Biological Station in Nanaimo, B.C. The Subcommittee reviewed four Working Papers, one Fishery Update and two other reports. External participants from First Nations and the fishing industry attended the meeting.

Stock Status and Recommended Yield

The five major herring stocks in B.C. are managed by a fixed harvest rate policy in conjunction with a Cutoff level. Cutoff levels are set at 25 percent of unfished average biomass. Yield recommendations are set at 20 percent of forecast annual biomass unless the forecast is close to or below Cutoff levels. Assessments of major stocks in 2000 have been conducted using two versions of the age-structured model (ASM & RASM) and the escapement model (EM). For several years, the Subcommittee noted divergence of results between the ASM and EM. In 1999, Herring staff examined the underlying assumptions of the age-structured model and submitted the ASM model to diagnostic tests to resolve the discrepancies between the two models. For the 2000 assessment, an upgraded version of the ASM was introduced. This Revised Age Structured Model (RASM) incorporates a time varying mortality rate by decade and shows signs of being more realistic in assessing the stocks. While substantial progress has been made, there are still some unresolved issues that need further work.

For the five major stock assessment regions in B.C., the forecast biomass for 2001 is 165,770 tonnes. Application of the harvest policy results in a potential harvest of 28,500 tonnes for 2001.

Queen Charlotte Islands - The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 8,700 tonnes (50% CI: 6910-10360 tonnes) assuming average recruitment. At the 50% probability level, the forecasted returning biomass is below the Cutoff of 10,700 tonnes. Applying the decision rule resulted in a potential harvest of zero.

Prince Rupert District – The pre-fishery biomass forecast for 2001 at the 50% probability is 23,150 tonnes (50% CI: 20520-27230 tonnes) assuming average recruitment. At the 50% probability level, the forecasted returning biomass is above the Cutoff of 12,100 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a potential harvest of 4,630 tonnes.

Central Coast - The pre-fishery biomass forecast for 2001 at the 50% probability is 36,760 tonnes (50% CI: 34390-43460 tonnes) assuming average recruitment. At the 50% probability level, the forecasted returning biomass is well above the Cutoff of 17,600 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a potential harvest of 7,350 tonnes.

Strait of Georgia - The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 82,610 tonnes (50% CI: 67820-95660 tonnes) assuming average recruitment. At the 50% probability level, the forecasted returning biomass is well above the Cutoff of 21,200 tonnes. Application of the 20 percent harvest rate to the forecast resulted in a potential harvest of 16,520 tonnes.

West Coast Vancouver Island - The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 14,550 tonnes (50% CI: 13650 -16110 tonnes) assuming poor recruitment. At the 50% probability level, the forecasted returning biomass is well below the Cutoff of 18,800 tonnes. Applying the decision rule resulted in a potential harvest of zero.

Minor Stocks - Some Area 27 spawn in Klaskish Inlet may not have been surveyed. The Subcommittee identified a potential harvest of 124 tonnes, computed as 10 percent of the assessed 2000 biomass of 1240 tonnes from the escapement model.

Soundings indicated a small biomass of herring in 2W and a single biological sample was collected in 2000. There was no potential harvest identified for Area 2W in 2001.

<u>Comments on Working Papers</u>

Working Paper P00-1: Status of the eulachon (*Thaleichthys pacificus*) in Canada

The Subcommittee accepted the paper subject to revisions.

The Subcommittee felt the paper represented a thorough review of the scientific and other relevant information available on eulachon for the COSEWIC to consider the status of “threatened” suggested by the authors.

Working Paper P00-2: Stock assessment for British Columbia herring in 2000 and forecast of the potential catch in 2001

The Subcommittee accepted the paper subject to revisions. The Subcommittee recommended again that PSARC sponsor a workshop to thoroughly examine the input data, model parameterization and the treatment of error variances in all assessment models. It was further suggested that if the workshop does not provide adequate direction to select a preferred forecast model, that a decision framework be developed and implemented to allow for a consistent approach to selecting a forecast tool.

Working Paper P00-3: Offshore herring biology and the 2001 recruitment forecast for the West Coast Vancouver Island stock assessment region

The Subcommittee accepted the paper subject to revisions, but did not accept the recruitment forecast for the Strait of Georgia, as it was generally felt that there was a need for more evaluation and confirmation of the forecasting procedure in this area. The

Subcommittee noted that there may be potential in this technique for the future and encouraged the author to submit this element as a separate working paper next year.

Working Paper P00-4: Factors affecting the straying rates of stock structure of British Columbia herring

The Subcommittee accepted the paper subject to revisions. The Subcommittee requested that the conclusions presented in the oral presentation be included in the revised paper. The Subcommittee supported the recommendation that the biological and management implications of the observed straying rate patterns on the dynamics of the five major B.C. herring stocks should be evaluated.

INTRODUCTION

The Subcommittee met on August 28-31, 2000 at the Pacific Biological Station in Nanaimo, B.C. to review the status of herring stocks in 2000 and to forecast abundance and potential harvest for 2001. The Chair of the PSARC Pelagic Subcommittee opened the meeting, welcoming the participants. During the introductory remarks, the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda (Appendix 1). The Subcommittee reviewed four working papers (Appendix 2), one fishery update, two other reports, and evaluated the impacts of pertinent assessment criteria (Appendices 4-8) in the formulation of advice to fisheries managers. The Subcommittee provided recommendations specific to the working papers in addition to general recommendations for further assessment work in support of management. Working paper titles, authors, and reviewers are listed in Appendix 2. A list of meeting participants is included as Appendix 3.

The Subcommittee evaluated a set of assessment indicators for each of the five major assessment regions. These criteria included:

- *Data quality*: catch data, spawn survey adequacy, consistency in age composition data;
- *Spawn and stock trends*: age-structured model and escapement model biomass estimates, spawn indices;
- *Perception of stock status*: based on charter skipper and district staff field observations;
- *Recruitment trends*: age-structured model estimates, auxiliary survey data;
- *Cutoff*: minimum spawning biomass level for stock conservation;
- *Forecast abundance (run size)*: for age-structured and escapement models, and evaluation of recruitment assumptions;
- *Additional information*: independent predictions of recruitment, size-at-age trends.

Subcommittee review of the assessment documents, in conjunction with the assessment criteria, was used to draw conclusions about the current biological status of the stocks and to provide yield recommendations for harvest in 2000. The following abbreviations are used throughout the Advisory Document:

ASM	Age-structured model
RASM	Revised Age-structured model
EM	Escapement model
CC	Central Coast
FSC	Food, Social, Ceremonial
HCRS	Herring Conservation and Research Society
PR	Prince Rupert District
QCI	Queen Charlotte Islands
SG	Strait of Georgia
WCVI	West Coast Vancouver Island
CI	Confidence Interval

Stock status reports have been completed for each of the five major herring stocks and will be updated to reflect the 2000 fishery and assessment.

MANAGEMENT STRATEGY

Major Stocks

Five major British Columbia herring stocks are currently managed by a fixed harvest rate strategy in conjunction with a fishing threshold or "Cutoff" level. Potential harvest is calculated at 20 percent of the forecast biomass for each of the major assessment regions, provided that the potential harvest does not reduce the biomass below the Cutoff. The 20 percent harvest rate is considered to represent a conservative level of removals given the biological productivity of the major herring stocks. Cutoff levels are set at 25 percent of the estimated unfished average biomass, as determined by simulation analyses. As the forecast abundance approaches the Cutoff, the potential harvest is calculated as the difference between the forecast abundance and the Cutoff. When the forecast falls below the Cutoff, a decision may be made to close the fishery to rebuild the stock. The objective of a Cutoff is to prevent relatively large fishery removals on stocks at low levels of abundance. This harvest strategy has been in place since 1983, prior to which the fishery was managed through a fixed escapement policy. A recent review (PSARC Working Paper H95-02) concluded that "*... the current management policy provides an adequate level of protection to conserve the stocks from a fishery collapse, and generates high long-term yields.*"

A summary of the performance of the forecasting procedure for 2000 herring fisheries is shown in Table 1, which compares the 1999 forecast of abundance in each stock assessment region to observed biomass in 2000 based on spawn surveys, catch, and model estimates. Note that all numbers were rounded to the nearest 100 tonnes after the requisite calculations.

Table 1 Comparison of 1999 PSARC forecasts of 2000 herring abundance with estimates of 2000 observed biomass, catch, and escapement (tonnes). The recruitment assumption that generated the forecast biomass (poor, average, good) and the observed recruitment category are shown in brackets. All numbers rounded to the nearest 100 tonnes.

Management Region	**1999 Forecast of 2000 Biomass**	**2000 Observed Biomass**	**2000 Validated Roe Catch***	**2000 Escapement**
Queen Charlotte Islands	15,100 (average)	7,600 (poor-average)	1,800	5,200
Prince Rupert	37,000 (average)	20,400 (average)	4,300	15,700
Central Coast	47,000 (average)	32,100 (average)	7,400	23,800
Strait of Georgia	84,700 (average)	77,400 (average)	14,000	67,700
West Coast Vancouver Island	21,500 (poor-average)	12,500 (v. poor)	1,600	10,900
Totals	205,300	150,000	29,100	123,300

*includes test fish catch

Minor Stocks

There are small or "minor" herring stocks that exist outside the five major stock assessment regions. The minor stocks are assessed opportunistically due to their inaccessibility, so the data series is neither continuous nor extensive. In its 1993 report, the PSARC Herring Subcommittee advised that there is no basis for fishing minor stocks above the 20 percent harvest rate established for the major stocks, and that the Department of Fisheries and Oceans should also protect a minimum spawning biomass for the minor stocks.

At the 1994 PSARC Herring meeting, the Subcommittee recommended that, because of incomplete historic data, minor stock harvests should be based on the estimated biomass of spawners in the previous season. Consequently, the Subcommittee recommended that the maximum biomass of fish harvested should not exceed 10 percent of the estimated previous season biomass. The recommended harvest rate for minor stocks is more conservative than the rate adopted for the major stocks; it is intended to compensate for the fact that minor stock survival and recruitment levels cannot be reliably predicted. The data do not allow accurate estimation of minor stock Cutoff levels. The Subcommittee advised that the Department of Fisheries and Oceans should review biomass levels in light of available historic information prior to allocating minor stock harvests to clients. It noted that some minor stocks exhibit large fluctuations in abundance, therefore, the opportunity for harvest may not be available every year.

CATCH TRENDS

Herring in British Columbia waters have supported some form of commercial fishery since 1877. Reliable records of place, date, and quantity caught are available since 1950. A fishery for a dry salted market from 1904 to 1934 (with catches up to 85,000 tonnes annually) was followed by a reduction fishery (1935 to 1967). During the reduction, fishery catches were taken during the inshore spawning migrations from October to February. Very large catches (200,000 tonnes annually) in the early 1960s, in conjunction with a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery allowed a gradual recovery of stocks. The roe herring fishery began in 1972. Herring are now caught on or near the spawning grounds by both purse seines and gillnets.

In 2000, there were 240 seine licenses eligible to fish. Another 12 seine licenses were retired in the test fishing program. There were 1,250 gillnet licenses eligible to fish after seven licenses were retired for the test fishing program. Pool fishery management was continued in all roe seine and gillnet fisheries in 2000. Total roe landings in 2000 were 29,100 tonnes, slightly more than the average of 28,400 tonnes for the last five years.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were provided. The PSARC recommended yield, actual quota in the roe fishery, and roe catches (thousands of tonnes) since 1983 are listed in Table 2.

Table 2 Stock biomass forecast, recommended yield, actual roe fishery quota, and roe catches (tonnes x 1000) since 1983.

		1983[e]	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999[d]	2000[d]
QCI[f]	Forecast[a]					15.3	12.1	13.7	35.3	23.2	18.1	17.7	12.4	7.7	6.7	11.0	19.8	28.2	15.1
	Rec. Yield[b]					2.2	0.0	2.7	7.1	4.6	3.6	3.5	1.0	0.0	0.0	0.3	4.0	5.6	3.0
	Roe Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3	3.0	0.0	0.0	0.0	0.0	1.6	3.0	1.4
	Roe Catch[c]	8.1	5.0	6.3	3.6	2.0	0.3	1.4	9.0	7.0	3.8	4.0	0.3	0.0	0.0	0.0	1.4	3.0	1.8
PR	Forecast[a]					32.1	43.8	42.6	23.3	19.4	30.5	55.1	34.1	21.9	21.2	36.1	34.0	24.4	37.0
	Rec. Yield[b]					6.4	8.7	8.5	4.7	3.9	6.1	11.0	6.8	4.4	4.2	7.2	6.8	4.9	7.4
	Roe Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2	5.4	4.9	2.3	2.4	5.5	5.5	2.0	4.1
	Roe Catch[c]	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.9	3.5	5.0	6.3	4.7	2.1	3.1	5.5	3.2	2.1	4.3
CC	Forecast[a]					23.0	23.8	48.5	43.2	38.2	37.7	70.1	69.8	54.4	25.8	20.7	44.5	43.4	47.0
	Rec. Yield[b]					4.6	4.8	9.7	8.6	7.6	7.5	14.0	14.0	10.9	5.2	3.1	8.9	8.7	9.4
	Roe Quota	*	6.6	4.1	2.3	3.3	3.7	7.8	7.4	6.2	5.3	7.8	10.3	8.5	3.2	1.4	7.8	6.9	6.3
	Roe Catch[c]	5.7	7.2	5.2	3.3	3.6	4.5	9.5	8.4	8.9	8.3	10.5	11.9	9.6	4.3	3.6	8.6	7.5	7.4
SG	Forecast[a]					53.0	46.7	49.4	55.2	69.8	59.2	91.8	97.4	69.5	63.4	77.2	72.7	78.9	84.7
	Rec. Yield[b]					10.6	9.3	9.9	11.0	14.0	11.8	18.3	19.5	13.9	12.7	15.5	14.5	15.8	16.9
	Roe Quota	11.7	11.6	4.7	0.0	8.0	6.4	7.4	7.1	9.1	9.7	11.0	14.4	11.9	10.8	13.2	13.0	11.5	13.2
	Roe Catch[c]	16.4	10.2	6.2	0.2	9.1	7.5	7.4	7.9	10.6	12.5	13.1	16.7	12.5	13.6	15.4	12.7	11.8	14.0
WCVI[g]	Forecast[a]					48.3	39.6	52.6	35.9	33.9	29.1	NA[h]	36.3	20.8	21.4	24.1	40.1	39.6	21.5
	Rec. Yield[b]					9.7	7.9	10.5	7.2	6.8	5.8	3.4[h]	7.3	2.0	2.0	4.8	8.0	7.9	2.7
	Roe Quota	4.5	4.5		0.0	9.4	8.1	10.3	7.2	6.7	2.9	2.7	5.0	1.3	0.9	3.7	7.5	5.1	1.1
	Roe Catch[c]	8.7	6.7	0.2	0.2	15.9	9.7	13.4	9.9	8.6	3.7	5.6	6.0	2.0	0.8	6.7	7.0	4.4	1.6
Coast	Forecast	0.0	0.0	0.0	0.0	171.7	166.0	206.8	192.9	184.5	174.6	234.7	250.0	174.3	138.5	169.1	211.1	214.5	205.3
	Rec. Yield	0.0	0.0	0.0	0.0	33.5	30.7	41.3	38.6	36.9	34.8	50.2	48.6	31.2	24.1	30.9	42.2	42.9	39.4
	Roe Quota	28.0	31.3	18.8	12.5	27.5	25.7	33.7	30.7	29.3	25.4	29.9	34.6	24.0	17.3	23.8	35.4	28.5	26.1
	Roe Catch	38.9	32.6	24.4	15.6	36.7	29.9	40.2	40.1	38.6	33.3	39.5	39.6	26.1	21.8	31.1	32.9	28.8	29.1

[a] PSARC stock forecast used to derive recommended yield;
[b] PSARC recommended yield, includes allocations to non-roe fisheries;
[c] Roe catch includes all test fishery catches;
[d] Catch in 1999 and 2000 was the dockside validated catch;
[e] In 1983, the quota for North of Cape Caution was 11.8 tonnes;
[f] In 1983, 1985, 1990, 1991, 1992 and 1993 catch for QCI included both areas 2E and 2W;
[g] Includes Area 27 catch in 1983 & 1984 but excludes it in 1992, 1993, 1994, 1995 following removal from assessment region;
[h] No consensus on stock status, recommended that catch not exceed 1992 level.

STOCK STATUS AND FORECASTS FOR MAJOR ASSESSMENT REGIONS

Management Regions for Major Stocks

The stock assessment regions for major herring stocks are shown in Figure 1. For northern British Columbia, the stock assessment regions used for the 2000 assessments are the same as those used in previous years. In the Queen Charlotte Islands (QCI), the assessment region extends from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District (PR) stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast (CC) assessment region encompasses Area 7, Kitasu Bay in Area 6, and Kwakshua Channel in Area 8. As recommended by the Herring PSARC Subcommittee in 1991, the Strait of Georgia (SG) is considered a single stock complex which includes Deepwater Bay and Okisollo Channel in Area 13 and all of Areas 14 to 19, 28 and 29. In 1993, the northern (Area 25) and southern (Area 23/24) Statistical Areas were combined into the West Coast Vancouver Island (WCVI) assessment region.

Stock Assessment

Three analytical models, an age-structured model (ASM), a revised age-structured model (RASM), and an escapement model (EM), are applied to each management region. At the direction of the Subcommittee the ASM was submitted to diagnostic tests with respect to the interaction of the natural mortality parameter with other model parameters. The assumption that the tuning index is proportional to stock biomass was also examined in 1999. After consideration of the in depth examination of the ASM, (see below) the Subcommittee decided to adopt the model forecast for 2001 that was most appropriate for a particular management region.

The potential recruitment of age 2+ fish to each stock is calculated for each model as the mean of the top one-third, middle one-third and bottom one-third of the recruitment estimates from the 1951 to 2000 time series for the ASM. In the absence of additional information to forecast recruitment, the average recruitment forecast is used. Recruitment is added to the expected age 3+ and older abundance to obtain the forecast abundance. The potential harvest is calculated as 20 percent of the forecast abundance. If this yield would reduce the escapement biomass of a stock below the Cutoff, the potential harvest is calculated from the following equation:

$$\text{Potential Harvest} = \text{Forecast} - \text{Cutoff}$$

Thus, progressively smaller potential harvests are identified when a stock approaches its Cutoff level. The Cutoff is calculated independently for each stock assessment region.

An example of potential harvest (yield) calculations for three levels of forecast biomass is shown in Figure 2. The Cutoff for this example is set at 10,000 tonnes (dashed vertical lines). The upper panel shows catch (tonnes) as a function of the forecast biomass, while the lower panel shows harvest rate as a function of the forecast biomass. There are three scenarios denoted by A, B, and C on the figure panels:

(A) The forecast biomass of 7,500 tonnes is below the Cutoff, so the potential harvest is 0, and the harvest rate is 0.
(B) If the 20 percent harvest rate was applied, the forecast biomass of 11,000 tonnes would yield 0.2*11,000=2,200 tonnes. However, this yield would bring the stock size below the Cutoff value to 11,000-2,200=8,800 tonnes. Thus, the potential harvest is 11,000-10,000=1,000 tonnes. This is equivalent to a harvest rate of 1,000/11,000=0.09, a value roughly half that of the rate of 0.2 used at higher levels of biomass.
(C) The forecast biomass of 20,000 tonnes is well above the Cutoff, so the potential harvest is 0.2*20,000=4,000 tonnes.

<u>Potential Coast-Wide Harvest for 2001</u>

The recruitment assumption, corresponding 2001 pre-fishery biomass forecast, and the potential harvest for each of the major stock regions are listed in Table 3. The spawning stock biomass trends based on the age-structured model (ASM), the revised age-structured model (RASM) and escapement model (EM) are shown in Figures 3 and 4 respectively. These trends were interpreted in light of the assessment criteria listed in Appendices 4-8 for each management region to determine the potential harvest. Regional synopses are provided below. The Subcommittee noted that the total potential harvest of approximately 28,500 tonnes for 2001 is a 28 percent decrease from the total recommended yield of 39, 470 tonnes in 2000.

Table 3 Potential Harvest in 2001 for Major Herring Stocks

Assessment Region	Cutoff Biomass (tonnes)	Recruitment Assumption	Forecast Biomass (tonnes)	Potential Harvest (tonnes)
Queen Charlotte Islands	10,700	Average	8,700	0
Prince Rupert District	12,100	Average	23,150	4,630
Central Coast	17,600	Average	36,760	7,350
Strait of Georgia	21,200	Average	82,610	16,520
West Coast Vancouver Island	18,800	Poor	14,550	0
Total			165,770	28,500

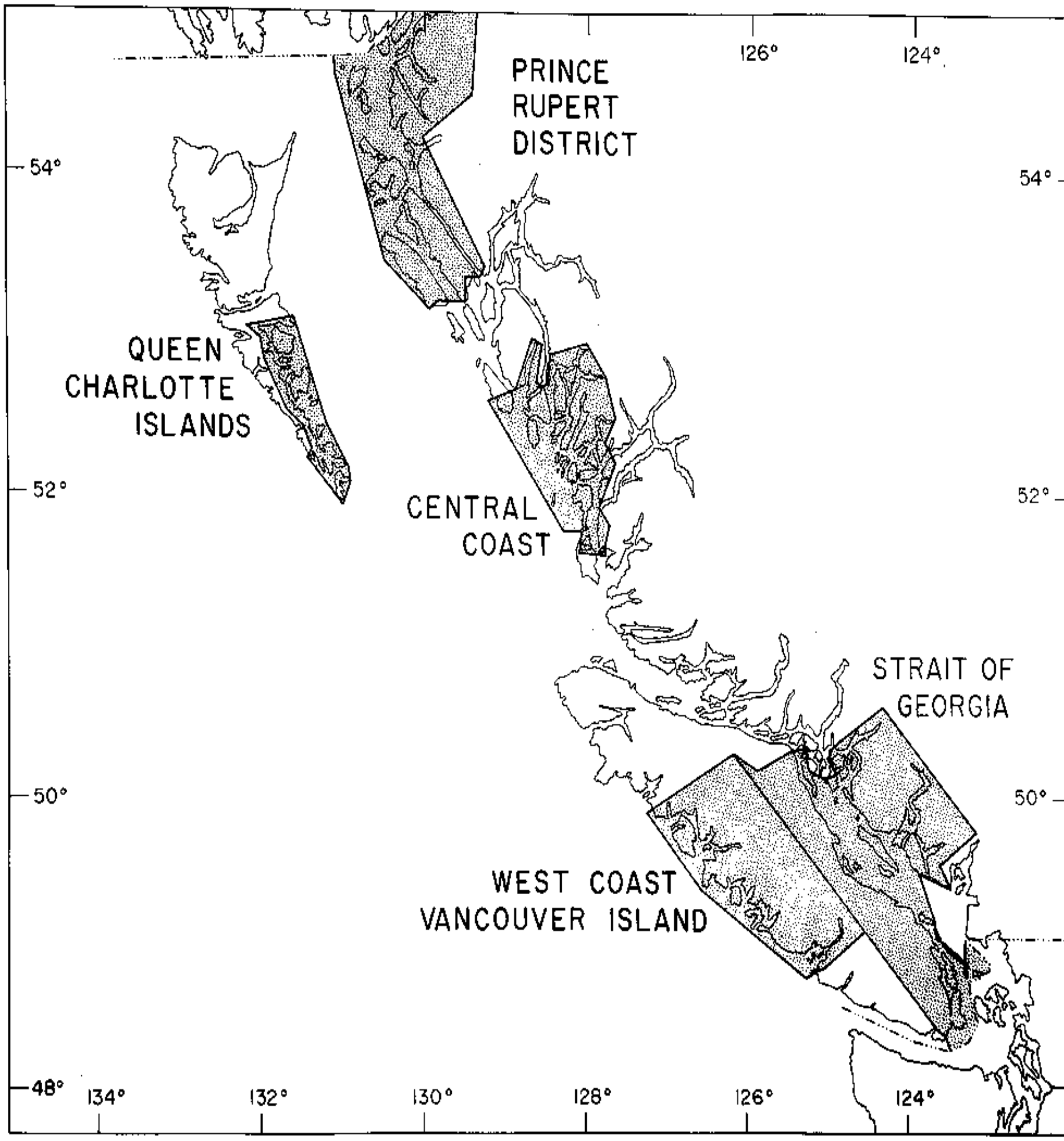

Figure 1. Herring stock assessment regions in British Columbia.

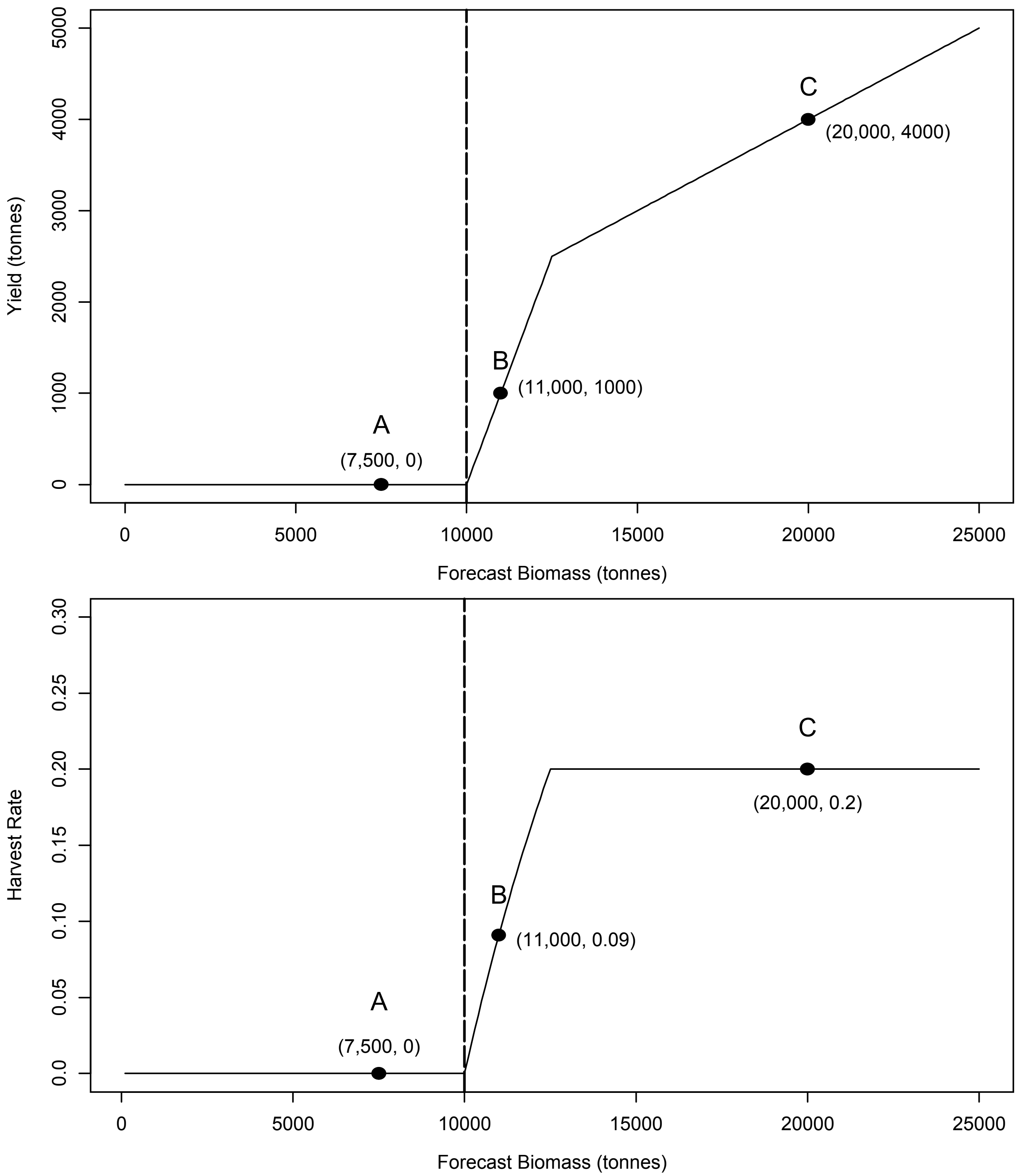

Figure 2. Examples of yield and harvest rate at three different levels of forecast biomass. The letters A, B, and C denote three harvest scenarios as described in the text.

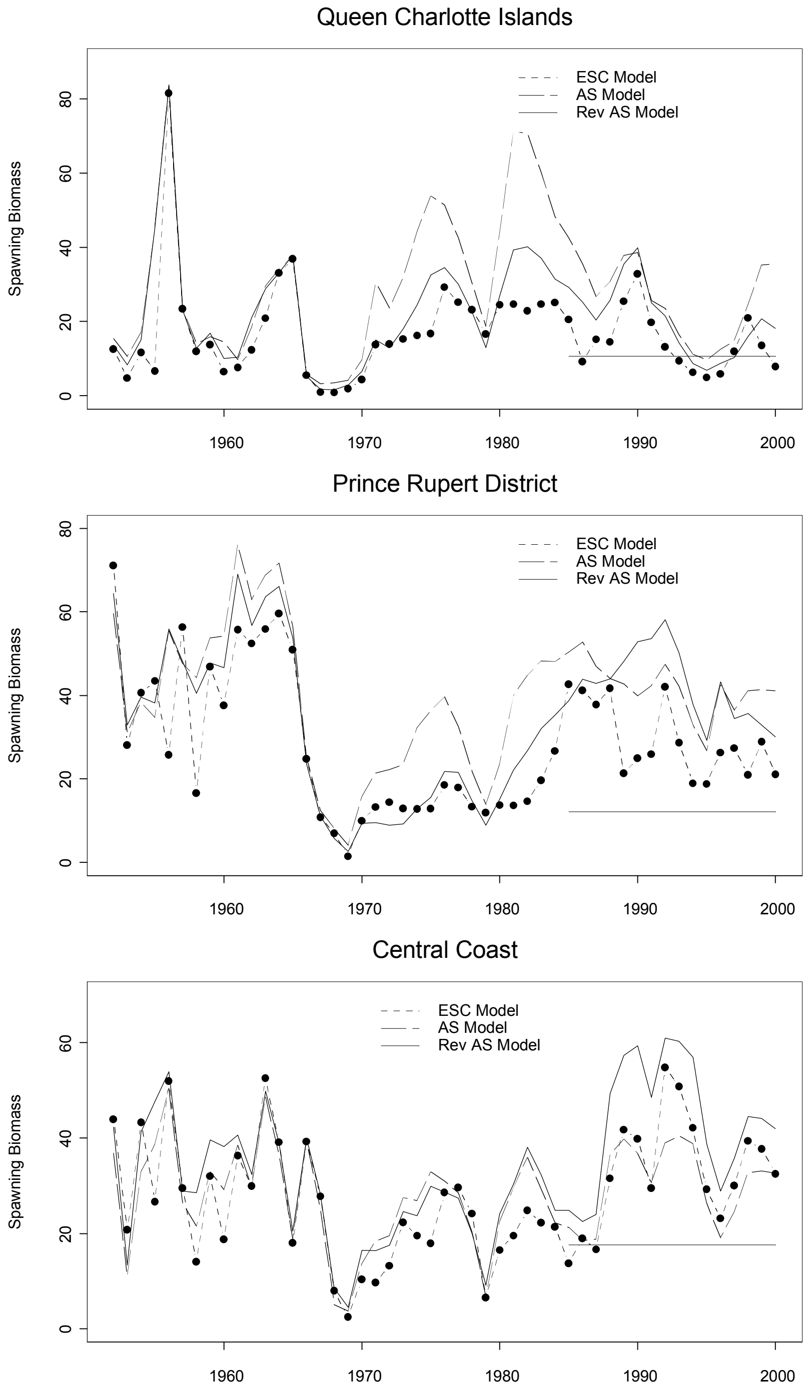

Figure 3. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured (ASM and RASM) and escapement model (EM) analyses for northern B.C. herring stock assessment regions, 1951-2000. Horizontal line indicates the Cutoff level for each stock.

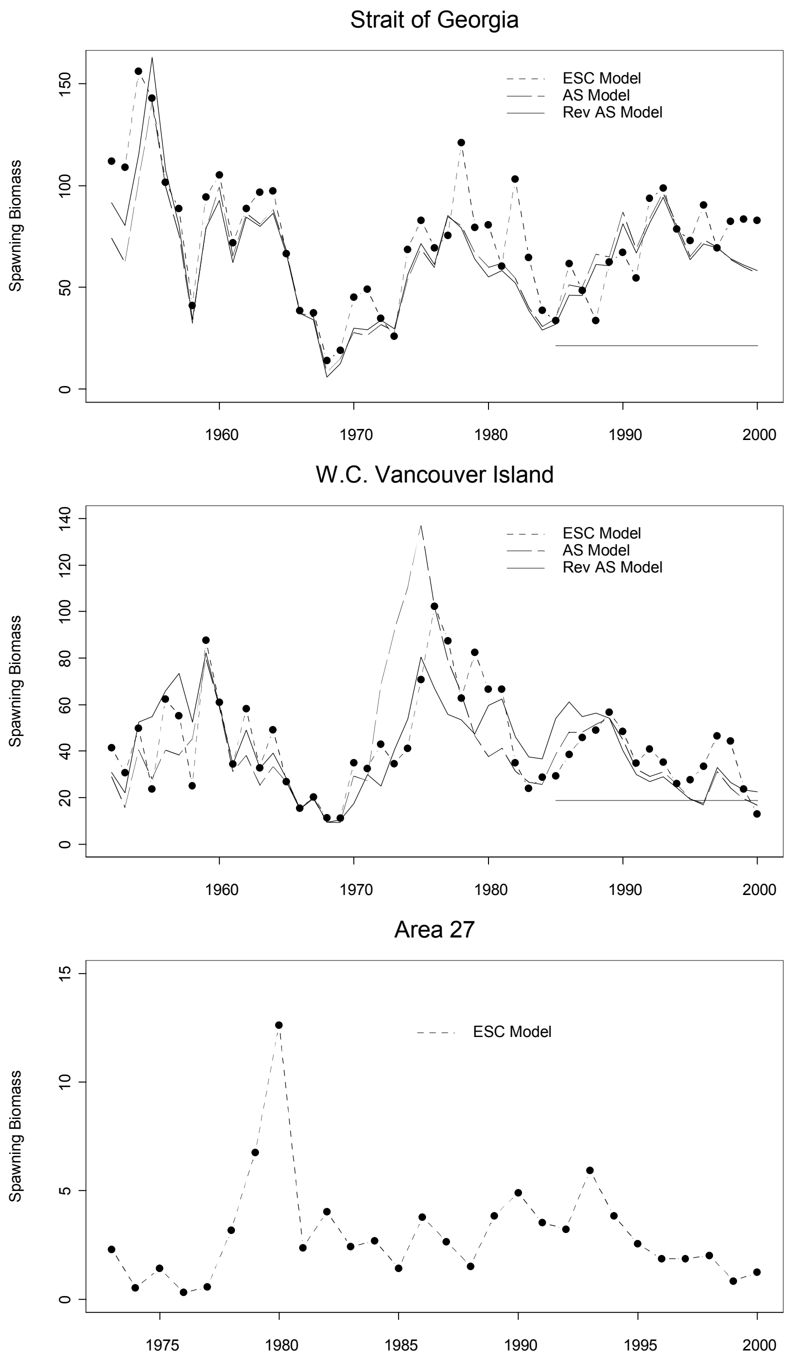

Figure 4. Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured (ASM and RASM) and escapement model (EM) analyses for southern B.C. herring stock assessment regions and Area 27, 1951-2000. Horizontal line indicates the Cutoff level for each stock.

Queen Charlotte Islands

Background

Landings during the reduction fishery period (1951 to 1968) were highly variable, targeting on a few strong year classes. The maximum catch taken during this period was over 77,000 tonnes; however, there were 6 years when catches were less than 1,000 tonnes. Catches have been more stable since the beginning of the roe fishery and have generally been in the range of 4,000 to 8,000 tonnes. The area was closed to roe herring fisheries in 1988 due to stock concerns. The stock recovered after the closure but declined from 1990 to 1995. In response to the observed decline, annual roe fishery catches were reduced from 7,800 tonnes in 1990 to 2,700 tonnes in 1993. In 1994, the forecast return was close to Cutoff, and fishing was restricted to Food, Social and Ceremonial (FSC) harvest and spawn-on-kelp only. For 1995 and 1996, the forecast abundance was below Cutoff so fishing was limited to FSC harvest only. In 1997, FSC harvest was permitted, and three spawn on kelp operators used a maximum of 150 tonnes of herring to obtain their quota. The roe fishery was re-opened in 1998, with a harvest of 1,400 tonnes. In 1999 and 2000 roe harvests of 3,000 and 1,800 tonnes were removed.

Assessment Criteria

All catch was reported. In-season stock sampling and spawn assessment programs were carried out in a manner considered acceptable for stock assessment purposes. Biological samples were obtained from all fisheries. Fisheries management felt that the spawning was light and that stock biomass was less than had been forecast. Test fishing skippers felt that the spawn was patchy and that the fish behaved differently than in other years.

The ASM shows an increasing trend in biomass since 1995. The revised ASM shows abundance comparable to the EM, which, in turn, shows a decline to near historic low levels. Spawn length has declined to the level at which the fishery was closed in 1996. The ASM and revised ASM recruitment estimates suggested that the recruiting year-classes were poor in 1999 and average in 2000. The ASM projected average recruitment for 2001. The retrospective analysis indicates that the ASM and revised ASM models both have a tendency to slightly over-forecast prefishery biomass.

The Subcommittee adopted the EM with average recruitment because it is most consistent with other observations. The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 8,700 tonnes (50% CI: 6910-10360 tonnes). At the 50% probability level, the forecasted returning biomass is below the Cutoff of 10,700 tonnes. Application of the decision rule resulted in a potential harvest of zero.

An attempt was made to apply a decision-making framework proposed for the herring assessment to this stock. There was considerable discussion about the appropriateness of some of the criteria and the weightings to be applied to them relative to others, particularly stock trend, forecast biomass and recruitment history. In the end, the Subcommittee decided that the methodology showed promise but required more extensive discussion and testing than the current meeting could accommodate. As a result, it was recommended that this approach be dealt with in the modeling workshop or as part of a separate workshop.

Prince Rupert District

Background

During the period of the reduction fisheries, herring catches in the Prince Rupert District were generally in the range of 10,000 to 50,000 tonnes annually. Since the beginning of the roe herring fishery, catches have averaged 5,000 tonnes and have not exceeded 9,000 tonnes. Since 1972, the fishery was closed only in 1983. The area has supported substantial roe herring and spawn-on-kelp fisheries in recent years. However, there was no seine fishery carried out in the traditional location (Kitkatla Inlet) from 1996 to 1999 due to the low biomass of spawners in recent years. In 1998 and 1999 spawn distribution returned to a more normal pattern. A modest roe fishery of 4,300 tonnes occurred in the area in 2000.

Assessment Criteria

There was no FSC catch reported in the Prince Rupert District. All major spawns were surveyed. In-season stock sampling and spawn assessment programs were carried out in a manner considered acceptable for stock assessment purposes. Biological samples were obtained from all fisheries. Sample collection later in the pre-fishery period for Areas 3-4 was difficult as fish moved into the shallows and became inaccessible to the test fishing seine. Management staff felt that biomass had declined. Test fishing skippers felt that biomass in Kitkatla had declined from 1999, but that stocks in areas 3 / 4 looked healthy.

The ASM shows no trend in biomass over the last several years and indicates stock levels are considerably higher than those for the revised ASM and the EM. The latter two models show a decline in stock size in 2000. There was a slight decline in spawn width and length and there has been a long-term decline in the number of egg layers. ASM recruiting abundance estimates show that recruitment was poor in 1999 and average in 2000. Profile likelihood plots projected that recruitment would be average in 2001. The revised ASM abundance trends have been consistent with the EM biomass estimates.

The Subcommittee adopted the EM with average recruitment because retrospective performance of the ASM indicates a tendency to over forecast abundance. The Subcommittee also noted that the revised ASM estimate of current stock size is very similar to that of the EM. The pre-fishery biomass forecast for 2001 at the 50% probability is 23,150 tonnes (50% CI: 20520 -27230 tonnes). At the 50% probability level, the forecasted returning biomass is above the Cutoff of 12,100 tonnes. Applying the decision rule of a 20% harvest rate resulted in a potential harvest of 4,630 tonnes.

Central Coast

Background

Landings during the reduction fishery period (1950-1968) ranged to just over 44,000 tonnes and were generally around 10,000 to 35,000 tonnes. During the subsequent roe fishery period (1972 to present), landings have averaged 7,145 tonnes and reached a maximum of 14,000 tonnes in 1978. No harvest was permitted in the Central Coast in 1979, but fisheries have occurred annually since that time. Harvests were approximately 10,000 tonnes from 1993 to 1995, then were reduced to 3,200 tonnes in 1996 in response to declining abundance. Abundance increased dramatically over the following three years as a result of good 1994 and 1995 year-classes. However, abundance declined slightly in 2000.

Assessment Criteria

No FSC catch was reported for the Central Coast. In-season stock sampling and spawn assessment programs were carried out in a manner considered acceptable for stock assessment purposes. Biological samples were obtained from all fisheries. It was noted that only three biological samples were collected from Kitasu Bay. Management staff felt that stock biomass was average and noted that there appeared to be a buildup of herring in the Fisher and Fitz-Hugh Sound. It was also noted that the total area of spawn had contracted relative to recent years. Test fishing skippers felt that biomass in Area 7 declined slightly but was good in the East Higgins Pass area and in Areas 8 and 10.

All three stock assessment models showed a small decline in stock abundance since 1998. There was a slight decrease in spawn length, a slight increase in spawn width and an increase in egg layers in 2000. ASM estimates of recruitment showed that it was poor in 1999 and average in 2000. The ASM projection from the profile likelihood suggests that recruitment in 2001 should be average. It was noted that the ASM and the revised ASM both have a tendency to over-forecast slightly. There was some discussion about the apparent survival rate that results in a moderate increase in forecast 2001 biomass given the 2000 escapement.

The Subcommittee adopted the EM with average recruitment. The pre-fishery biomass forecast for 2001 at the 50% probability is 36,760 tonnes (50% CI: 34390-43460 tonnes). At the 50% probability level, the forecasted returning biomass is well above the Cutoff of 17,600 tonnes. Applying the decision rule of a 20% harvest rate resulted in a potential harvest of 7,350 tonnes.

Strait of Georgia

Background

Annual herring landings from the Strait of Georgia during the reduction fishery period

(1951 to 1968) were less variable than from other areas of the coast. With the exception of the 1952/53 season when industry disputes curtailed the herring fishery, and the 1967/68 season when stocks had collapsed, landings ranged from 31,000 tonnes (1966/67) to 72,000 tonnes (1955/56). During the period of roe herring fisheries, catches have averaged 11,600 tonnes. The area was closed to roe herring fishing in 1986, after which time harvests have increased to a peak of 16,304 tonnes in 1997 and a catch of 13,604 tonnes in 1998. The high catches in the 1990s have been supported by near record high stock abundance in the Strait of Georgia.

Assessment Criteria

All catch was reported. All spawns were surveyed except for some small spot spawns and a 1000 metre spawn near Powell River. In-season stock sampling and spawn assessment programs were carried out in a manner considered acceptable for stock assessment purposes. Biological samples were obtained from all fisheries. Management staff felt that stocks continued to look very healthy.

The ASM and revised ASM suggest a slight decline in stock abundance since the mid-1990s. The EM shows stock abundance to be higher and stable since 1998. Spawn length increased in 2000 but spawn width decreased slightly. The number of egg layers was similar to recent years. ASM estimates of recruitment suggest that recruitment was above average in 1997 and 1998, poor in 1999 and average in 2000. The ASM profile likelihood projects that recruitment should be average in 2001. The retrospective analyses indicate that the ASM and revised ASM models have a tendency to over-forecast biomass slightly.

The Subcommittee adopted the EM with average recruitment. The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 82,610 tonnes (50% CI: 67820-95660 tonnes). At the 50% probability level, the forecasted returning biomass is well above the Cutoff of 17,600 tonnes. Applying the decision rule of a 20% harvest rate resulted in a potential harvest of 16,520 tonnes.

West Coast Vancouver Island

Background

During the period of the reduction fishery, catches from the West Coast of Vancouver Island reached nearly 70,000 tonnes in the 1958/59 season. In general, catches were in the range of 10,000 to 25,000 tonnes. During this period, annual harvests in the southern region (Area 23/24) exceeded harvests in the north (Area 25) for all but three years (51/52, 59/60, 62/63), often by large amounts. Since the roe fishery began in 1972, catches have been below the earlier levels, except from 1975 to 1978, when they ranged from 26,000 to 39,000 tonnes. In 1985 and 1986, the commercial fishery was closed along the entire west coast of Vancouver Island due to serious stock concerns. The stock subsequently rebuilt and the 1987 harvest of nearly 16,000 tonnes was the largest since

1979. However, the stock has experienced a declining trend since 1989; catches have averaged 5,400 tonnes since 1990 compared to an average harvest of 22,200 tonnes prior to 1980. Effort was restricted in 1995 and 1996 since forecast abundance was marginally above Cutoff in both years. In 1997, the forecast abundance was well above the Cutoff. The stock has shown a declining trend since 1997 and only a small harvest of 1,600 tonnes was permitted in 2000.

Assessment Criteria

The reporting of FSC catch is incomplete. In-season stock sampling and spawn assessment programs were carried out in a manner considered acceptable for stock assessment purposes. Biological samples were obtained from all fisheries. Management staff felt that sounded abundance in Area 23 was similar to 1999, poor later in the season in Area 24 and higher in Area 25. Test fishing vessel skippers commented on biomass in Area 25 being very high. Stock levels in the Esperanza area were considered to be better than previous years but those near Friendly Cove were very poor.

All stock assessment models show a considerable decline in stock biomass since 1998. Spawn indices showed a slight decline in spawn length but a substantial decline in number of egg layers from 1999. ASM estimates of recruits suggest that recruitment has been poor for the last three years. The recruitment forecast from the offshore survey projects a poor recruitment for 2001.

The Subcommittee adopted the EM with poor recruitment. The pre-fishery biomass forecast for 2001 at the 50% probability (i.e. 50% chance that the pre-fishery biomass will exceed this forecast) is 14,500 tonnes (50% CI: 13650-16110 tonnes). At the 50% probability level, the forecasted returning biomass is well below the Cutoff of 18,800 tonnes. Applying the decision rule resulted in a potential harvest of zero.

<u>Minor Stocks</u>

Some Area 27 spawn in Klaskish Inlet may not have been surveyed. The potential harvest for Area 27 is 124 tonnes, computed as 10 percent of the assessed 2000 biomass of 1,240 tonnes from the escapement model.

Soundings indicated a small biomass of herring in 2W and no biological samples were collected in 2000. There was no potential harvest identified for 2001 because of the paucity of historic and recent spawn data, biological sampling and acoustic soundings for Area 2W.

STOCK ASSESSMENT WORKING PAPERS

This section presents a summary of working papers and corresponding reviews. Subcommittee discussion is recorded, along with recommendations for revision of each working paper and directions for future analyses. General recommendations from the Subcommittee appear later in the report.

P00-1 Status of the eulachon (*Thaleichthys pacificus*) in Canada.

D.E. Hay and P.B McCarter ** Accepted with revisions **

Summary

The anadromous eulachon (*Thaleichthys pacificus*) is a small (<20 cm) species of smelt that spawns in the lower reaches of coastal rivers and streams from northern California to the southern Bering Sea, Alaska. They do not occur outside this range. There is only a limited amount of information available about the distribution and biology of eulachons, and this paper attempts to summarize the key information, and present some new data and information on age, and stock discrimination. Also, the paper summarizes available information on the apparent decrease in eulachons in parts of its range. This information, taken in conjunction with the available biological information, is used to comment on the status of eulachons relative to criteria such as those used by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). A COSEWIC review of eulachons is expected in the near future. COSEWIC designations apply to broad geographical jurisdictions, preferably over the entire range of a species. Within that range, however, there may be local populations, or management units, that vary in abundance. This certainly applies to eulachons, and for this reason, we attempt to comment on the status of key individual rivers within BC.

Eulachons spawn in the spring, from February to April. They live only to age 3 or 4 and die after spawning in the lower reaches of rivers and streams. Their small (1 mm) demersal eggs incubate in freshwater for 2-4 weeks before hatching. Emerging pelagic larvae drift rapidly to the sea where they will remain for 3-4 years, before returning to spawn. The degree of homing to natal rivers is uncertain, and the evidence is mixed. River-specific spawning times and other biological data suggest that most home to natal rivers (or perhaps the general vicinity of natal rivers), but there is little evidence of genetic and phenotypic variation over small spatial distances, and evidence of only small genetic variation over large areas. Within their range, eulachons spawn in only a limited number of rivers, and seem to prefer those with spring freshets, and that drain snowpacks or glaciers. A total of 34 B.C. rivers and streams have records of any eulachon spawning and only about 14 of these rivers have regular annual spawning. In California, the few regular eulachon spawning populations appear to have disappeared 15-20 year ago. Within southern BC, Washington and Oregon, most eulachon spawning populations appear to have declined in the last 5-10 years, with a sudden decline in the Columbia and Fraser rivers, and perhaps other rivers, in 1993 and 1994. Although there were some reports of strong eulachon runs in 1998 for populations in the central and northern B.C. coastal rivers, the southern runs were low. In 1999 and 2000 however, only one B.C. river, the Nass, appears to have had a normal run. All other systems have had either very weak or negligible runs, except perhaps for the Fraser River in 2000, which had a late but improved spawning runs compared to the previous 3 years. Also, in 2000 there is evidence from monitoring of bycatch in shrimp fisheries, of a sudden increase in the abundance of age 1+ eulachons (1999-year class) in southern marine waters.

The causes of eulachon declines are uncertain and this paper reviews and comments on the main possibilities and explanations. Climate change or change in ocean condition is implicated as a cause of a general decline, but other factors cannot be overlooked, including local habitat alterations and bycatch in commercial trawl fisheries. The decline of eulachons is a concern for many First Nations, for whom the eulachon is of major cultural significance, especially as a source of an important traditional staple called 'grease'. The status of eulachons also is a concern to fisheries managers and the commercial fishing industry because eulachons are common as bycatch in shrimp trawls in some areas. The decline of eulachons has prompted specific management actions to limit eulachon bycatch and restrict other activities such as dredging, and some forest industry activities. The paper concludes with a suggestion that the most appropriate COSEWIC designation would be the 'threatened' category, which is defined as one that is at risk of becoming endangered unless nothing is done to reverse factors leading to its extirpation or extinction. In this paper, and in other reports cited within this paper, a number of potentially deleterious factors are described, such as high bycatch in offshore trawl fisheries and riverine and estuarine habitat degradation. Reversal of deleterious factors will require the development and implementation of management policy specifically for eulachons. Therefore, the paper concludes with a suggestion for the rapid but careful development and adoption of such policy. In this regard, as a potential template in the development of policy, the authors include as an appendix, a short section of recommendations, modified to suit eulachons, based on a recent DFO report called the 'Draft Wild Salmon Policy' paper.

Reviewers' Comments

Reviewer #1 agreed with the authors' concept for managing eulachon at the estuarine rearing area level, however reviewer #2 thought there was insufficient data to support many of the conclusions, and that the classifications were not supported by the data.

Reviewer #1 requested more information on how ocean conditions may have affected eulachon populations. Reviewer #2 thought there was too much emphasis on the trawl bycatch issue, and not enough emphasis put on environmental factors such as change to snow packs and subsequent freshet flow in recent years; predator / prey abundance; and ocean conditions in general.

Reviewer #1 thought the framework, or advice, for management was unclear. Reviewer #2 also thought much of the data was anecdotal and weak. Additionally, the methods used to develop classifications were not described in sufficient detail. The recommendations were not provided in a form that is useful to fishery managers. Reviewer #1 noted that, from a COSEWIC perspective, the status of the whole unit has to be evaluated, and this paper didn't do that. He also recommended that author should look at more rigid COSEWIC criteria before classifying stocks.

Subcommittee Discussion

It is not the role of PSARC to determine or recommend a specific COSEWIC status label and participants agreed that any recommendation made about status are those of the authors and not necessarily those of PSARC. The role of PSARC is to determine stock status. COSEWIC has the criteria to identify threatened species. What this Subcommittee has to ask is "Does this paper contain the information that they will need to evaluate the status of eulachon stocks?"

STOCK CONCEPT: The evidence from a study of mitochondrial DNA summarized in this Working Paper indicate that all eulachon populations surveyed should be considered part of the same Evolutionarily Significant Unit (ESU) because the samples do not demonstrate any measurable discontinuity in gene flow. However, the paper points out that just because there are no DNA differences, it doesn't necessarily mean that there is no stock structure. There is evidence of homing, as demonstrated by differences in spawn timing and meristic differences. This reinforces the concept that there are different stocks that can be classified as "management units". If defined properly, a management unit (or stock, or conservation unit) will be *demographically uncoupled* from other units. Demographic uncoupling is defined as having an immigration rate of less than 10% per generation. Demographically uncoupled stocks may exhibit different trends in abundance, and may therefore require different management decisions. The author suggested that the default position for conservation and management should be to treat each river-estuary complex as a management unit.

The Subcommittee noted that the last two years of spawning have been very poor. Eulachon only live until age 3, and only spawn once, so things are looking very serious and bleak.

The Subcommittee was appreciative of the amount of effort that went into writing this paper. In particular, the information contained in the biology and life history sections was very thorough. It was noted that, in general, the quality of data on abundance available for many areas is anecdotal and poor. Information on eulachons is scattered, and this publication is a valuable and timely reference.

The Subcommittee noted that not all principles in the draft "wild salmon policy document" are achievable for eulachon (e.g. #3 "minimum and target levels of abundance will be determined for each conservation unit"). The authors, however, felt that these draft policies may have great utility to eulachons.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to revisions.

The Subcommittee felt the paper represented a thorough review of the scientific and other relevant information available on eulachon for the COSEWIC to consider the status of "Threatened" suggested by the author.

The Subcommittee requested some revisions be made to the paper:

1. Table 11 should be redone to provide more concise information about stock status. The COSEWIC labels should be replaced with non-COSEWIC labels such as “low”, “very low”, etc. Another label of “insufficient information” should be included. Sources of information should be referenced if possible.

2. The authors were encouraged to limit the discussion in the paper of sections that comment on industry and management perspectives.

3. Sections on ocean climate and predator / prey relationships should be expanded.

4. The authors advised that the “Scenarios at Risk” section will be removed.

5. The authors advised that the “Recommendations” section would remain in the paper.

P00-2 Stock assessment for British Columbia herring in 2000 and forecast of the potential catch in 2001

J. Schweigert ** Accepted with revisions**

Summary

Herring have been one of the most important components of the British Columbia commercial fishery over the past century with catch records dating from 1877. The fishery has evolved from a dry salted product in the early 1900s, to a reduction fishery in the 1930s that collapsed in the late 1960s. After a four year closure the current roe fishery began in 1972. Roe fisheries occur just prior to spawning when the fish are highly aggregated and very vulnerable to exploitation. Since 1983, herring roe fisheries have been managed with a fixed quota system. Under this system harvest levels are determined prior to the season based on a fixed percentage (20%) of forecast stock size. In addition, threshold biomass or Cutoff levels were introduced in 1985 to restrict harvest during periods of reduced abundance.

In this report, stock assessments from two analytical models which have been developed explicitly for British Columbia herring: (1) a modification of the escapement model described by Schweigert and Stocker (1988); and (2) a modification of the age-structured model described by Fournier and Archibald (1982) are presented. In addition, a third analytical model a variation on the age-structured model assuming time varying natural mortality, is developed. All models reconstruct stock abundance for the period 1951-2000 and forecast pre-spawning abundance for the 2001 season. Forecasts of upcoming run size are based on the combination of estimates of surviving repeat spawners and newly recruiting spawners which are presented as poor, average, and good, based on historic recruitment levels. Coastwide, abundance was reduced in 2000 with the recruitment of a

poor to average 1997 year-class. Forecasts for 2001 generally indicate run sizes similar to or reduced from those observed in 2000.

The presentation of the assessment focussed on investigations of new parameterizations for the natural mortality parameter in the ASM (age-structured model). This included an examination of Tanasichuk's (1999) age-specific estimates of M for B.C. herring, where M increases exponentially with age and Hampton's suggestion that M is a U-shaped function of age. Both of these formulations resulted in biomass estimates comparable to the age independent M in the current model. In addition, time varying M was investigated and a revised age-structured model proposed (RASM) which estimated separate M parameters for each decade of the time series. Annual, 5, and 25 year periods were also investigated but did not provide plausible stock reconstruction. The resulting recruitment and biomass time series were presented and discussed. Results indicated that the form of the ASM with M varying among decades provided the closest agreement with the escapement model. Implications of adopting the RASM included the direct effect on the potential harvest and a different perspective of long-term productivity requiring a review of the Cutoff level for each assessment region.

Reviewers' Comments

Neither reviewer was present. The Subcommittee Chair summarized the reviews. Both reviewers felt that the approach was well documented and the comments were mainly editorial. Reviewer #1 suggested that the temporal changes in availability, changing size at age, and time varying M should be examined. Reviewer #1 suggested that the author provide some plots of goodness-of-fit for the models in the revision. Reviewer #2 commented that it might be difficult to assess whether the time-varying M was real or an artifact of the modeling.

Subcommittee Discussion

Discussion focussed on the revised ASM. It was unclear whether the fishing mortality estimates had changed markedly in conjunction with changes in the time varying M particularly where large changes in recruitment were observed. In addition, there was discussion about how q (the spawn conversion factor) differed between the ASM and the revised ASM. In theory if the RASM fit closer to the spawning biomass it should be reflected in the estimate of q approaching unity. The author suggested that this was probably true but noted that q should not be interpreted as a parameter that directly reflected the absolute spawning biomass from the spawn index. There was a request to add a series of appendix tables, like 2.1 – 2.5, which would provide residuals for the revised ASM to illustrate whether there was a closer fit to the spawn data. There was some discussion of what the biological basis for the selection of the 10-year time period for estimating M could be. A brief discussion occurred about the impacts of a time trend in selectivity related to the observed time trend in size-at-age. The author noted that an age specific time trend in availability had been investigated but the same analysis in relation to decreasing size at age had not been completed.

There was discussion about the EM (escapement model). The Subcommittee asked that error estimates for the EM be provided. It was suggested that a bootstrapping method could be used to estimate error on the egg observations. The author noted that it would be very difficult to incorporate all sources of error in the bootstrap analysis. In addition, there was a request to provide a more complete description of the model calculations to facilitate its evaluation. There was some concern expressed about apparent and small variations in relative fecundity in relation to changes in condition factor but it was felt that this would have little impact on the biomass estimates.

Subcommittee Recommendations

The Subcommittee was supportive of the revised ASM because it appears to capture biological reality and expressed its appreciation to the author for his efforts. The Subcommittee recommended that the merits of the three stock assessment models be addressed on a stock-by-stock basis. The Subcommittee re-iterated its recommendation for a modeling workshop that should now also include the development of a decision-making process to expand on the framework proposed for the current assessment and incorporate other criteria into the assessment evaluation process.

P00-3 Offshore herring biology and the 2001 recruitment forecast for the West Coast Vancouver Island stock assessment region

R. Tanasichuk **Accepted with revisions**

Summary

An offshore trawl survey was done between July 25 and 30, 2000 to collect information on fish distribution and feeding, and to sample herring schools for a recruitment forecast for the 2001 fishing season. Herring (*Clupea pallasi*) dominated the pelagic biomass. Schools were numerous and distributed widely over the study area. Several sardine (*Sardinops sagax*) schools were observed. Pacific hake (*Merluccius productus*), traditionally the dominant pelagic fish, was absent. Stomach content examination indicated that herring continued to feed exclusively on euphausiids and that the daily ration estimate was similar to that for other years, in other words, feeding conditions were typical. Data analysis for the traditional recruitment forecast, for the West Coast Vancouver Island (WCVI) stock, included three evaluations of potential bias. Results of the first test showed no effect of sampling time on forecast accuracy. The second test involved replicating the survey to compare estimated proportions of age 3. There was no significant difference in the estimated proportions. The third test showed no change in the forecast performance between years. The performance of the WCVI forecast did not change over the 1990s when WCVI recruitments were declining while Strait of Georgia recruitments were increasing. This suggested that any interaction between the two stocks did not affect the forecasting procedure. The forecasting procedure was re-expressed as a regression so that the uncertainty of the forecasts could be described. The forecasted biomass of recruits is poor. A risk analysis for WCVI recruitment suggested that it should be poor or average.

Reviewers' Comments

Both reviewers felt that because of the lack of background material it was hard to evaluate the paper and put current information into context. It was also difficult to judge whether the data and methods are adequate to support the conclusions because they were not explained in sufficient detail. Both reviewers questioned the value of this paper to fishery managers in its present form. Both reviewers also mentioned the lack of references.

Subcommittee Discussion

Discussion from the Subcommittee centered on the inclusion of a Georgia Strait recruitment forecast in this paper. This method has been shown to be effective for the West Coast but does not have a track record for the Strait of Georgia. Concern was expressed about using this information at this time even though the data does seem to indicate a relationship.

There were a number of questions for clarification. Among the issues questioned was the assumption that any fish that is age 3 is a recruit as well as the methodology for aging. The author advised that his assumption is that all age 3 fish in schools including older fish are recruiting to the fishery. Ages are determined by using length frequencies on the vessel. Samples are taken for scale analysis but no actual aging is done onboard the vessel.

It was noted that if there is a decline in the population there might be a change in the length at age. On the East Coast the length is more important than the age in determining maturity. The Subcommittee wondered if length at age might be a factor to consider, however, if there is a difference in age at maturity it doesn't seem to affect the model.

Finally the Subcommittee questioned the data that was used to forecast recruitment and wondered if the same data were used for the West Coast and the Strait of Georgia. The author confirmed that the same data was used.

Subcommittee Recommendations

The Subcommittee accepted the Working Paper subject to revisions recommended.

The Subcommittee did not accept the recruitment forecast for the Strait of Georgia. It felt that there was need for more evaluation and confirmation of the forecast. There may be potential for the future and the evaluation should be presented as a separate working paper.

P00-4 Factors affecting the straying rates and stock structure of British Columbia herring

D. Ware, C. Tovey, D. Hay and B. McCarter **Accepted with revisions**

Summary

Tag release and recovery information compiled between 1950-55 and 1980-92 for the five major subpopulations (or stocks) of British Columbia herring were reanalyzed. The results indicate a high 'fidelity' rate of adult herring to the spawning area where they were tagged; 75% to 96% of tagged fish at-large for one year tended to be recovered near the spawning areas where they were released. However, these results also indicate that a significant amount of straying occurs (4-25%). A comparison between the two tagging periods indicates that the mean proportion of herring straying between subpopulations was significantly lower in the early 1950s (7%) than it was in the 1980s (22%). The proportion of herring straying to other subpopulations decreased exponentially with the distance between subpopulations. Forty-one percent of the herring that strayed moved 200 km in one year, 12% moved 600 km and a few exceptional individuals (7%) dispersed a distance of 800 km. This important finding indicates that the subpopulations are linked by an 'isolation by distance' model of gene flow. Tag recoveries during both time periods confirm that the southernmost herring subpopulations in B.C. exchange individuals (and genes) with the most northern subpopulations. Although there are other complicating factors, our analysis suggests that the straying rate is density-dependent -- it appears to increase asymptotically as the population approaches the carrying capacity of the available spawn habitat. Evidence supporting this density-dependent dispersal response is apparent in 4 of the 5 major populations. Our analysis explains several stock assessment anomalies, and has significant implications for herring stock structure and management. The authors conclude that the high observed fidelity rate provides the biological basis for managing B.C. herring stocks, because it means that most of the adult herring that spawn in one of the major subpopulations return to the same region to spawn the following year. Consequently, the current stock assessment areas (subpopulations) form the basic units for managing B.C. herring. However, the significant observed straying rates indicate that the five, major migratory herring subpopulations are linked by variable degrees of gene flow and therefore form a single, large metapopulation.

Reviewers' Comments

Reviewer #1 asked for the purpose of the paper to be more clearly stated. Reviewer #2 asked about the possibility of sampling bias in the data (e.g. variations in tag recovery effort). He agreed that this was a useful framework to look at tagging data but suggested further discussion of competition mechanisms that could lead to increased rates of straying. He also noted the difficulty when moving to smaller spatial scales of deciding where to draw boundaries and commented that straying may be an artifact of the boundary. The author suggested that straying may be an evolutionary mechanism to increase the reproductive potential of a herring stock since additional spawners contribute little to a population near carrying capacity. Also stock boundaries have largely been determined for management purpose and do not necessarily have a scientific basis.

Subcommittee Discussion

The Subcommittee noted that the analysis for the 1980s tagging data (Table 1) spans a period of eight years. The estimated straying rate is the average rate for this period. The main data limitation during this period was the small number of tag returns. Hence, the authors had to bin the tag recoveries during this period in order to estimate the average fidelity and straying rates. The Subcommittee noted that it was not clear how much the straying rate varied over time during this period. As a first approximation, the authors felt that it was reasonable to bin the data. The new CWT herring tagging program may be able to quantify how much the straying rate varies over time. One Subcommittee member felt that the straying rate estimates may not be consistent with the observed variation in size-at-age between the west coast of Vancouver Island and Strait of Georgia. The summer catch recoveries were not analyzed in the paper because the objective was to determine how much straying occurred from one spawning season to the next. Variations in the harvest rates between periods were acknowledged and discussed in the paper. The amount of straying to Alaskan and Washington herring subpopulations was not evaluated because of the lack of data. The new CWT program could carry out this work. The herring DNA analysis project will indicate the genetic similarity between subpopulations. The subpopulations may need to be redefined once the DNA results are available.

With respect to the apparent density-dependent variation in the straying rates between the 1950s and 1980s, the Subcommittee noted that it wasn't clear whether the apparent response was curvilinear or linear. The existing data are not adequate to resolve this point, although the curvilinear function provided a slightly better fit to the data. The new CWT program may be able to clarify this point. The authors suggested that an increasing density of fish on the spawning grounds may stimulate an increase in the straying rate. They noted that as the spawning stock approaches its carrying capacity the reproductive success (measured as the recruits/spawner) of an individual herring declines to a very low level. Hence, there may be a selective advantage for individual herring to stray to other spawning areas as the spawning stock approaches its carrying capacity. The Subcommittee also noted that the density of fish on the offshore feeding grounds could have an affect on the straying rate.

Subcommittee Recommendations

The Subcommittee accepted the paper and recommended investigations of density dependent effects (e.g. metapopulation models that incorporate the effects of straying).

Some Subcommittee members felt that the data were not sufficient to support some of the conclusions. However, the problems encountered with the data in this paper are similar to other PSARC analyses, where the data need to be combined to estimate average parameter values such as, for example, the natural mortality rate. The Subcommittee concluded that the paper complements other work that is being done and presents some hypotheses that can be tested by the DNA and CWT programs. Accordingly, the paper was accepted subject to revisions requested by the reviewers.

The Subcommittee also requested that the conclusions presented in the oral presentation be included in the revised paper. The Subcommittee supported the authors recommendation that the biological and management implications of the observed straying rate patterns (including possible temperature-dependent and time-dependent changes in straying rates) on the dynamics of the five, major B.C. herring stocks should be evaluated.

FISHERY UPDATE

A draft version of "A Review of 1999 / 2000 British Columbia Herring Fisheries" was distributed. In this report, 1999 PSARC stock assessment results and forecasts are briefly summarised, and allocations to all 1999 / 2000 herring fisheries are documented. Management structures of the various fisheries are described, and catch information is presented. Sections documenting the dates and locations for roe herring fisheries, winter food and bait fisheries, and test fisheries are also included.

OTHER REPORTS

Effects of fishing and on timing and location of spawn

D.E. Hay and P.B. McCarter

A key question that has not been addressed explicitly in previous work is whether there is any effect of catches on subsequent spawn distribution. Specifically, have catches in specific areas been followed by a decline in spawning in the same area? If so, can we explain the changes in spawn distribution by the location and sizes of catches from herring fisheries? Clearly, the informal answer to this is an emphatic NO! Most careful and conscientious observers of the roe herring fishery see no such relationship between catches and spawn distribution. Instead, and as pointed out by Hay and McCarter (1998) over the last 20 years, spawning has declined in some areas without fisheries (i.e. areas outside the 'assessment areas') and tended to increase in most areas with fisheries (the assessment areas). Regardless, the task of systematically comparing possible relationships between the catches and spawn in specific areas remains to be completed, but the work is underway.

The default assumption (or null hypothesis) is that herring spawn distribution is dynamic, and changes geographically for various reasons but that recent (post-1980) changes are not related to the distribution of herring catches. In particular, a specific null hypothesis is that the declines of herring spawning in some areas is not a function of the local depletion of a biological stock of herring associated with specific locations. To address this issue we need to examine the distribution and timing of catches for each year in as small a geographical area as is practical. Mainly this will be the level of the 'section' for most areas.

This has been an on-going effort and further information has been added to the database over the past year including both pre- and post-1951 catch data. Another new development is that the database is now available on the web.

In addition to the possible affect of catches on herring spawn distribution, there are other factors that affect changes in herring spawn distribution. To address these issues, we need to consider a number of potential factors, some of which operate at different geographical scales. For instance, climate-induced changes probably affect broad areas, whereas local anthropogenic changes have local effects - the 1989 Nestucca oil spill is an example of the latter but we also could include the potential effects of factors such as pulp mills, log booms, sewer outfalls, etc.

The author described the information as a tool that presents a large amount of data in a geographic context and may help to identify long term effects for further study. An example was given of northward trends in spawning locations in the Strait of Georgia.

Subcommittee Discussion

The time trends in location of spawns in the Strait of Georgia from south to north was discussed. A herring manager noted that this was consistent with a northern trend in herring holding areas that he had observed. The Subcommittee agreed that the new database is a useful tool for identifying trends prior to detailed analysis. One of the authors suggested that information on winter holding areas for herring could also be compiled. Concern was raised about compiling a duplicate database of spawn and catch information. Also, since the new database is being compiled from the original documents, are discrepancies with the existing spawn and catch database being corrected? The author noted that most discrepancies have been minor and the only major differences found have occurred due to the changes in total catch when going from a split herring cycle year (July 1 to June 30 season) to a calendar year.

Update on coded wire tagging study – results from 1999

J. Schweigert and L. Flostrand

The paper summarized results of the feasibility study conducted in 1999 to evaluate the application and recovery of coded wire tags for Pacific herring. This study represents part of a larger effort to investigate herring stock structure with a combination of genetic analysis and tagging. The scope of this report includes the outcomes from tagging herring in 1999 and all of the 1999 tags that were recovered from herring harvested in the year 2000.

The 1999 herring spawning season was the first time that coded wire tags (CWTs) were applied on a large scale to Pacific herring on the coast of British Columbia. All tagging events were conducted from the 15m research vessel Walker Rock. This vessel was also used to capture small quantities (2 tonnes or less) of spawning herring in less than 10m of water. Tagging was done in the Strait of Georgia (SG) and Queen Charlotte Islands

(QCI) herring assessment regions. In the latter case, fish were captured by and tagged aboard the test fishing vessel Nimpkish Producer.

The DFO *Salmon Mark Recovery Program* provided all the CWTs applied from their collection of remnant spools. The year 2000 was the first year that British Columbia roe herring harvests prospectively containing herring with CWTs were screened. Two CWT detector units (commercially produced by *Northwest Marine Technology* and known as *R9500*'s) were supplied by the DFO *Salmon Mark Recovery Program* and an engineer was hired to help design, construct and repair recovery unit operation for use in processing plants while herring conveyance was occurring. During the 2000 roe fisheries it became apparent that limited opportunities existed for screening offloads and that recovery logistics would be improved by screening fish carcasses conveyed during processing operations (roe popping) rather than during vessel offloading. Operations at the CFC plant and at and *Icicle Seafoods Inc* (Icicle) accommodated the recovery units and the J.O. Thomas staff who managed each of them. The recovery units operated throughout the period of roe popping conducted at each plant. A total of 109 tag recoveries of 1999 taggings occurred in 2000 and overall just under 25% of the coastwide catch was searched for tags. CWT appear to be a viable means for tagging herring and monitoring interannual movement and straying.

Subcommittee Discussion

There was general interest and support for the coded wire tagging work. There was some discussion of the tag returns from the Central Coast and West Coast of Vancouver Island in 2000. A question was raised about the plans for the tagging work in 2001 and the level of available funding. Also, the need for a clear description of the hypothesis being addressed and the appropriate study design to test it was raised.

GENERAL SUBCOMMITTEE RECOMMENDATIONS FOR 2000

The following general recommendations were developed as a result of review of the working papers and Subcommittee discussion:

1. The Subcommittee strongly recommended that a PSARC sponsored workshop be convened in 2001 to examine the Age Structured Model, including the data inputs and parameters used in the model. There would be an opportunity to incorporate other biological information, and to examine alternative model formulations. Procedures for estimating uncertainty in the spawning biomass should also be discussed and recommendations made.

2. The Subcommittee also recommended that a meeting be held as soon as possible to develop a framework for the provision of advice that includes presenting uncertainty in parameters and model structure. The intent would be to rationalize the relationship between the different forecasting models and identify a mechanism for quantifying the level of uncertainty contained in the advice.

3. The forecasting of recruitment for the West Coast of Vancouver Island from the summer offshore survey provides an important component to the annual stock assessment. Consequently, it should be incorporated into the routine stock assessment procedure. Since annual recruitment contributes a large component (30% to 50%) to the herring spawning biomass, it is important to have an increased understanding of herring recruitment as the key to determining the productivity of stocks and to identifying harvest opportunities. The Subcommittee recommended that the potential for recruitment forecasting for other major stocks continue to be investigated.

4. The Subcommittee recommended that the analysis of juvenile survey data in the Strait of Georgia as a recruitment forecaster be repeated for the 1996 and 1997 surveys after these year classes have recruited in year 2000 and monitored in catch samples for 2 years, in 2000 and 2001.

5. It was noted that stock identification remains a key biological issue and that coded wire tagging work and nuclear DNA work initiated in 1999, should be continued in 2001. However, the potential and limitations of the coded wire tagging program should be more clearly identified and evaluated.

6. There are emerging remote sensing techniques and technologies that may have some merit. Therefore, the Subcommittee recommended that these continue to be investigated.

7. The Subcommittee reiterated the importance of conducting spawn surveys outside the major stock assessment regions and outside of the current charter programs length / scope. It was suggested that using partnerships with local groups be developed to facilitate further gathering of this information and spawn data acquisition.

8. The Subcommittee reiterated the need for more complete Food, Social and Ceremonial catch data.

9. In response to a concern about the impact of fishing related mortalities, it was noted that a list of references on the topic may not have been complete and recommended that an annotated bibliography of the impact of gillnet drop out and potential sub-lethal mortalities be prepared for presentation at the 2001 meeting.

PROGRESS ON SUBCOMMITTEE RECOMMENDATIONS FOR 1999

Subcommittee recommendations from 1999 are listed below (*Italics*) along with progress reported at the meeting:

The following general recommendations were developed as a result of review of the working papers and Subcommittee discussion:

1. *The Subcommittee strongly recommended that a PSARC sponsored workshop be convened in 2000 to examine the Age Structured Model, including the data inputs and parameters used in the model. There would be an opportunity to incorporate other biological information, and to examine alternative model formulations. Procedures for estimating uncertainty in the spawning biomass should also be discussed and recommendations made.*

An initial planning meeting was held, however there was insufficient time available to conduct the workshop. It is anticipated that the workshop will be held in 2001.

2. *The Subcommittee also recommended that an internal meeting be held as soon as possible to develop a framework for the provision of advice that includes presenting uncertainty in parameters and model structure. The intent would be to rationalize the relationship between the different forecasting models and identify a mechanism for quantifying the level of uncertainty contained in the advice.*

This work was deferred and should be dealt with during the workshop above.

3. *Continue the work initiated as a result of the recommendation in the 1998 report which identified that since annual recruitment contributes a large component (30% to 50%) to the herring spawning biomass, it is important to have an increased understanding of herring recruitment as the key to determining the productivity of stocks and to identifying harvest opportunities. The Subcommittee recommended that offshore recruitment forecasting work for the west coast Vancouver Island herring stock continue, and that the potential for recruitment forecasting for other major stocks continue to be investigated.*

Initiated for Strait of Georgia, however additional work is required, including a retrospective evaluation.

4. *The Subcommittee recommended that the analysis of juvenile survey data in the Strait of Georgia be repeated for the 1996 and 1997 surveys after these year classes have recruited in year 2000.*

The paper has been deferred to 2001.

5. *It was noted that stock identification is a key biological question and that work initiated in 1999 should be continued in 2000.*

Tagging was carried out in Strait of Georgia in 2000, as well as tag recovery from 1999 applications. DNA samples were collected coastwide in 2000 and samples from previous years are being processed.

6. *There are emerging hydroacoustic techniques and technologies that may have some merit in Pacific herring management, and therefore the Subcommittee recommended that these be investigated.*

Discussions were held with a hydroacoustic industry representative. The process was not felt to be accurate enough for higher fish densities such as are common in Pacific herring. Accuracy limits are such that in small schools (i.e. +/- 10,000 tons) the range of accuracy may be as high as +/- the whole of the school. Technology as it stands was not felt to be feasible to estimate stock status biomass. However, there may be applications to conduct fine scale assessments.

7. *The Subcommittee again recommended that the analysis of variability in spawn timing and location be extended to assess the possible influence of fishing effects.*

The herring catch database has been updated and geo-referenced. It will be the subject of a future working paper.

8. *The Subcommittee reiterated the importance of conducting spawn surveys outside the major stock assessment regions.*

The HCRS funded surveys in the Johnstone Strait, however there is still some concern about limited assessment of late spawnings after charter programs have finished.

9. *The Subcommittee noted the need for more complete Food, Social and Ceremonial catch data.*

The Subcommittee noted that there has been limited progress in completing the FSC data, with some localized improvements (WCVI & Strait of Georgia).

10. *In response to a concern about the impact of fishing related mortalities, it was recommended that a literature review of the impact of gillnet drop out and potential sub-lethal mortalities be conducted for presentation at the 2000 meeting.*

Informal assessments during spawn surveys and a literature search were conducted. A list of pertinent reference material was made available to the Subcommittee and is included as Appendix 9.

Appendix 1. PSARC Pelagic Subcommittee Meeting Agenda, August 28-31, 2000

PSARC Pelagic Subcommittee Agenda	**August 28-31, 2000** **Pacific Biological Station, Nanaimo** **Seminar Room** **Meeting starts 1:00 p.m., Monday August 28**	
Monday, August 28, 2000		
Introductions and Review of Agenda	D. Radford	1300 - 1330
-Purpose of meeting and outline of Process		
-Assignment of Rapporteurs		
Eulachon		
P00-01: Status of the eulachon (*Thaleichthys pacificus*) in Canada	D. Hay and B. McCarter	1330 - 1600
Tuesday, August 29, 2000		
1. Review of Background Information		
Effects of Fishing on timing and location of spawn update	D. Hay and B. McCarter	9:00-10:00
• Break		10:00-10:15
Stock structure		
P00-04: Factors affecting the straying rates and stock structure of British Columbia herring	D. Ware	10:15-11:30
Fishery Update		
Fishery Update 1999/2000	L. Hamer	11:30-12:00
• Lunch		1200 - 1300
P00-03: Offshore herring biology and 2001 recruitment forecast for the west coast of Vancouver Island stock assessment region	R. Tanasichuk	13:00-14:15
• Break		14:15-14:30
Update on the Coded Wire Tagging program	J. Schweigert	14:30-15:30
Wednesday, August 30		
2. Review of 1999 Assessment and Stock Status Reports		

P00-02: Stock assessment for British Columbia herring in 2000 and forecast of the potential catch in 2001	J. Schweigert	8:30 – 15:00
• Break		10:00-10:15
• Lunch		12:00-13:00
• Break		15:00-15:15
Review and Finalization of Rapporteur's Reports from Day 1		15:15-16:30
Thursday, August 31		
3. Formulation of Advice and Recommendations		8:30-10:00
• Break		10:00-10:15
Review and Finalization of Rapporteur's Reports from Day 2		10:15-12:00
• Lunch		12:00-13:00
4. Concluding comments		13:00-13:15
5. Planning for next meeting		13:15-14:45
6. Adjourn		15:00

Appendix 2. PSARC Pelagic Working Papers for August 28-31, 2000

No.	Title	Authors
P00-01	Status of the eulachon (*Thaleichthys pacificus*) in Canada	D. Hay B. McCarter
P00-02	Stock assessment for British Columbia herring in 2000 and forecast of the potential catch in 2001	J. Schweigert
P00-03	Offshore herring biology and the 2001 recruitment forecast for the West Coast Vancouver Island stock assessment region	R. Tanasichuk
P00-04	Factors affecting the straying rates and stock structure of British Columbia herring	D. Ware C. Tovey D. Hay B. McCarter

List of Reviewers

Name	**Association**
Candy, J.	DFO, Pacific Biological Station
Carlile, D.	Alaska Department of Fish and Game
Convey, L.	DFO, South Coast Division
Hand, C.	DFO, Pacific Biological Station
Schweigert, J.	DFO, Pacific Biological Station
Stephenson, R.	DFO, St. Andrew's Biological Station
Wood, C.	DFO, Pacific Biological Station
Yamanaka, L.	DFO, Pacific Biological Station

Appendix 3. List of Participants for August 28-31, 2000 PSARC Pelagic Meeting

Name	Association
Chalmers, D.*	DFO, South Coast Division
Convey, L.	DFO, South Coast Division
Daniel, K.	DFO, Pacific Biological Station
Fort, C.*	DFO, Pacific Biological Station
Gordon, L.*	DFO, Port Alberni
Greba, L.	Kitasoo Band Council
Hall, D.	Nuu-chah-nulth Tribal Council
Hamer, L.*	DFO, South Coast Division
Hay, D.*	DFO, Pacific Biological Station
Hepples, J.	DFO, South Coast Division
Holkestad, R.	Fishing Vessel Owners Association
Jones, R.	Council of Haida Nations
McCarter, B.*	DFO, Pacific Biological Station
McDiarmid, A.	DFO, South Coast Division
MacPhee, B.	Heiltsuk Tribal Council
Midgley, P.*	DFO, Pacific Biological Station
Moores, J.*	DFO, National Headquarters
Radford, D.* (Subcommittee Chair)	DFO, Regional Headquarters
Safarik, E.	Herring Conservation and Research Society
Schweigert, J.*	DFO, Pacific Biological Station
Stocker, M. (PSARC Chair)	DFO, Pacific Biological Station
Tanasichuk, R.*	DFO, Pacific Biological Station
Thomas, G.*	DFO, South Coast Division
Ware, D.	DFO, Retired
Webb, L.	Fishing Vessel Owners Association
West, K.	DFO, Fraser River Division
Winther, I.*	DFO, North Coast Division

* Subcommittee Members

Appendix 4. Criteria for assessment of stock status in 2000: Queen Charlotte Islands

Criteria	Status
1. Data Quality	
a) All catch reported	Yes
b) All spawn surveyed	Yes – late and early
c) Good sample coverage	Yes
2. Stock status and trends	
a) Age-structured model	Increasing – RASM decreasing since 1999
b) Escapement Model	Decreasing since 1998
c) Spawn indices	Both # of layers and length decreased last 2 yrs
3. Perceptions of Stock Status	
a) Charter skippers comments	Spawn below average – behaviour change
b) Management staff	Light spawn – below forecast stocks
4. Recruitment	
a) Age-structured model	96 year class poor – 97 average
5. Retrospective Analysis	
a) Consistency	ASM slight tendency to over forecast
6. Forecast Abundance	
a) Profile Likelihood	Projecting average recruitment
b) Recruitment Assumption	**EM** **ASM** **RASM**
• Poor	6.82 29.60 13.33
• **Average**	**8.70** 32.24 15.00
• Good	13.78 39.42 20.51
7. Additional Information	
a) Size-at-age	Still low, but increased from last year
8. Cutoff:	10,700 tonnes
9. Yield Recommendation	Nil

Appendix 5. Criteria for assessment of stock status in 2000: Prince Rupert District

Criteria	Status		
10. Data Quality			
d) All catch reported	No FSC		
e) All spawn surveyed	Yes, with difficulties		
f) Good sample coverage	Yes, but pre-fishery spawn		
11. Stock status and trends			
d) Age-structured model	No trend, RASM decline in 1999		
e) Escapement Model	Decline in 1999		
f) Spawn indices	Decline length in '99, decline layers from '98		
12. Perceptions of Stock Status			
c) Charter skippers comments			
d) Management staff	A3/4 looked good. A5 – down from prev. yrs.		
13. Recruitment	Stocks down somewhat		
b) Age-structured model			
14. Retrospective Analysis	Avg. '97, poor '96		
b) Consistency			
15. Forecast Abundance			
c) Profile Likelihood	Very consistent over last few years		
d) Recruitment Assumption	Projecting average recruitment		
• Poor			
• **Average**	**EM**	**ASM**	**RASM**
• Good	20.17	34.93	21.28
	23.15	38.46	24.79
16. Additional Information	32.21	49.85	35.27
b) Size-at-age			
17. Cutoff:			
	up slightly		
	12100 tonnes		
18. Yield Recommendation			
	Potential harvest of 4,600 tonnes		

Appendix 6. Criteria for assessment of stock status in 2000: Central Coast

Criteria	Status
19. Data Quality	
g) All catch reported	No FSC
h) All spawn surveyed	Yes
i) Good sample coverage	Yes – light in Kitasu
20. Stock status and trends	
g) Age-structured model	No trend – RASM slight decline in 98
h) Escapement Model	Slight decline since 98
i) Spawn indices	Length down slightly, width up
21. Perceptions of Stock Status	
e) Charter skippers comments	A7 down slightly E Higgins and areas 8 – 10 good
f) Management staff	Stocks avg. conc.
22. Recruitment	
c) Age-structured model	97 average, 96 poor
23. Retrospective Analysis	
c) Consistency	tendency to over forecast
24. Forecast Abundance	
e) Profile Likelihood	recruitment slightly less than average
f) Recruitment Assumption	**EM** **ASM** **RASM**
• Poor	33.87 31.75 26.33
• **Average**	**36.76** 34.30 29.05
• Good	47.33 46.81 37.35
25. Additional Information	
c) Size-at-age	slight increase
26. Cutoff:	17,600 tonnes
27. Yield Recommendation	potential yield of 7,350 tonnes

Appendix 7. Criteria for assessment of stock status in 2000: Strait of Georgia

Criteria	Status		
28. Data Quality			
j) All catch reported	Yes		
k) All spawn surveyed	1000 m - Powell R – some spot spawn missed		
l) Good sample coverage	Good – some areas low (Powell R) some later (Dodds Narrows)		
29. Stock status and trends			
j) Age-structured model	Decline last 2 yrs – RASM also		
k) Escapement Model	No trend		
l) Spawn indices	Length up, width down		
30. Perceptions of Stock Status			
g) Charter skippers comments	Stocks look very healthy except Area 15		
h) Management staff	Continue to look good		
31. Recruitment			
d) Age-structured model	Average in 1997. Poor in 1996		
32. Retrospective Analysis			
d) Consistency	Slight tendency to over forecast		
33. Forecast Abundance			
g) Profile Likelihood	Suggesting average recruitment		
h) Recruitment Assumption	**EM**	**ASM**	**RASM**
• Poor	66.59	45.09	43.01
• **Average**	**82.61**	52.96	54.59
• Good	103.62	68.99	68.27
34. Additional Information			
d) Size-at-age	increasing		
35. Cutoff:	21,200 tonnes		
36. Yield Recommendation	16,520 tonnes		

Appendix 8. Criteria for assessment of stock status in 2000: West Coast of Vancouver Island

Criteria	Status
37. Data Quality	
m) All catch reported	FSC Incomplete
n) All spawn surveyed	Yes
o) Good sample coverage	Yes
38. Stock status and trends	
m) Age-structured model	Declining – RASM also
n) Escapement Model	
o) Spawn indices	Slight decline in length, significant decline in layers
39. Perceptions of Stock Status	
i) Charter skippers comments	Esperanza better than previous, Friendly Cove poor, Area 24 down somewhat
j) Management staff	Sounding higher. Area 24 later in season, Area 23 similar to 1999
40. Recruitment	
e) Age-structured model	Poor for the third year
41. Retrospective Analysis	
e) Consistency	Tendency to over forecast
42. Forecast Abundance	
i) Profile Likelihood	Projecting poor – consistent with the offshore survey
j) Recruitment Assumption	**EM** **ASM** **RASM**
• **Poor**	**14.55** 22.02 15.98
• Average	20.79 27.38 21.09
• Good	34.97 50.78 37.11
43. Additional Information	
e) Size-at-age	up slightly
44. Cutoff:	18,800 tonnes
45. Yield Recommendation	Nil

Appendix 9. Results of a Literature review related to impacts of gillnets on survival.

SCALE LOSS, OSMOREGULATION AND MISC PHYSIOLOGICAL CONSIDERATIONS

1) **Experimental Studies of Pacific Herring Gillnets.** Hay, DE; Cooke, KD & Gissing, CV. 1986. Fisheries Research, 4 pp 191-211.

2) **Preliminary studies regarding the effects of scale loss on salmon.** Smith, L.S. 1965. –Circular – (University of Washington. Fisheries Research Institute); 241.

3) **Mortality of experimentally descaled smolts of coho *salmon (Oncorhyncus kisutch*) in fresh and salt water.** Bouck, GR; Smith, SD. 1979. Trans. Am. Fish. Soc. 108(1) pp 67-69.

4) **Trying to explain scale loss mortality: A continuous puzzle.** Smith, LS. 1993. Reviews in Fisheries Science 1(4) pp 337-355.

5) **Physiological status of coho salmon (Oncorhynchus kisutch) captured in commercial nonretention fisheries.** Farrell, A.P. et al. 2000. Can. J. Fish. Aquat. Sci. 57: 1668-1678.

6) **Ionic, osmotic and acid-based regulation in stress.** McDonald, G; Milligan, L. 1997. Cambridge University Press, Cambridge (UK), pp 119-144. Soc Exp. Biol. Ser. no 62.

7) **The anatomy and physiology of teleosts (Chapter 2).** Roberts, Ronald J. 1989. Fish Pathology 2nd Ed. Published by Bailliere Tindall, London England.

External wounding studies . . .

8) **Observations and externally scarred and marked Chinook and Coho salmon in the 1982 Southeastern Alaska commercial troll fishery.** Seibel, M; Davis, A; Kelly, J; Talley. L; Skannes, P. 1984. Alaska Department of Fish and Game. Informational Leaflet No. 240.

9) **1990 field operational manual for sampling Chinook and Coho harvested in the Southeast Alaska troll fishery for incidence of gear marked and scarred fish.** Southeast Region Division of Commercial Fisheries, Alaska Department of Fish and game, Juneau, Alaska. March 1990.

GN sockeye selective fishing trials with mesh size:

10) **Value adding new fisheries planned in BC.** Drouin, M. 1999. Pacific Fishing. 20(7): pp 38-39. July 1999.

Trawl . . .

11) **Skin injury and mortality of Baltic cod escaping from trawl codend equipped with exit windows.** Suuronen, P; Lehtonen, Esa; Tschernij, Vesa; Larson, P.O. 1995. ICES CM; 1995/B:8.

12) **Survival of vendence (*Coregonus albula*) escaping from a trawl cod end.** Suuronen, P: Turunen, T; Kiviemi, M; Karjalainen. 1995. Canadian Journal of Fisheries and Aquatic Sciences. 52(12) pp 2527-2533.

13) **Scale damage and survival of cod and haddock escaping from a demersal trawl**. Soldal, A.V. Isaksen, B; Marteinsson, J.E; Engas,A. 1991. ICES CM 1991/B:44.

14) **An assessment of the scale damage to and survival rates of young gadoid fish escaping from the cod-end of a demersal trawl**. Main, J; Sangster, GI. 1990. Scottish fisheries research report; 46.

Other fishing and handling impact assessments . . .

15) **Scale-loss and survival of juvenile yellowfin bream. *Aconthopagrus australis*, after simulated escape from a Nordmore-grid guiding panel and release from capture by hook and line.** Broadhurst, MK; Barker, DT; Kennelly, SI. 1999. Bulletin of Marine Science 64(2) pp 255-268. Mar 1999.

Other search topics:

ASFA Searches of “gill damage*” provide 59 unrelated articles mostly to do with chemical-pollutant damage. Nothing about nets. A search with “Net wounds” provided 0 topics.

L. Flostrand & J. Schweigert