Strait of Georgia Roe Herring

Fishery Report Card *

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*The first in a series, prepared for The Sierra Club of Canada – BC Chapter
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1. Report Card

This report assesses the performance of Fisheries and Oceans Canada and the roe herring fishing industry in regard to five criteria considered to be fundamental indicators of biologically sustainable fisheries management.

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OVERALL GRADE

B

1.1 Main Findings

- The Strait of Georgia roe herring fishery is currently well managed.
- Current fishing practices do not place herring populations at risk of extirpation or severe depletion.
- Environmental conditions influence herring populations much more than the current level of harvest.
- Ecosystem considerations need to be included in the herring fisheries’ management policy.
- For herring populations that are below long-term average biomass, Fisheries and Oceans Canada must re-examine its fishery cut-off rates in the context of ecosystem considerations and public values.
- Total catch, including overages, are within a sustainable harvest level, but should be more tightly controlled.
- All present and former herring spawning habitat needs to be formally subjected to protective measures to ensure long-term sustainability and to protect other ecosystem values.
2. Preamble

Marine fish and invertebrate populations interact with numerous physical, biological, and anthropogenic forces. The combination of these forces presents an inherent difficulty in understanding the population dynamics of marine species, and hence the “sustainable yield” of those species. Given this difficulty, it is unrealistic to expect fisheries management to operate a fishery under perfect knowledge.

Strait of Georgia herring, the focus of this report card, have a long history of use by First Nations, commercial and recreational interests. These human interactions are embedded in a dynamic, ever-changing ecosystem. This leads to a complex array of impressions as to the exact impact humans have had and continue to have on herring populations. What is the truth?

One thing is certain - the whole truth will never be known. Working in conditions of imperfect knowledge, fisheries management must utilize the best available information and apply precautionary approaches to management to ensure long-term biological sustainability. Failing this, fisheries are unjustified, from a conservationist point of view.

3. Purpose of Report Card Series

British Columbia is endowed with a biologically diverse and productive marine ecosystem. Human utilization of our living marine resources has varied over the last seven millennia, but now in the 21st century we have the technological ability to access and harvest all marine species when and where we want to. Our ability to harvest a given species outweighs our understanding of the complexity of the life histories and ecosystems in which they are found. In British Columbia, we harvest over 100 marine species comprised of thousands of genetically and geographically separate populations. The fate of these species and populations is in our hands.

Harvest of marine resources in B.C is undertaken by commercial, First Nations, and recreational interests. Commercial harvest still accounts for the bulk of fisheries landings in British Columbia. In total, there are 31 commercial license categories, which are often further subdivided into areas and seasons resulting in a complex fisheries management system. It is challenging for the public to fully understand the system.

To assist in understanding the vast array of management issues associated with various fisheries, the Sierra Club of Canada - BC Chapter is creating a series of “Sustainable Fisheries Report Cards”. The goal is to provide the public with a conservationist-oriented assessment of the sustainability of B.C.’s various fisheries. The report cards will “grade” fisheries based on a set of well-established assessment criteria, highlighting both positive and negative aspects of the fishery including interactions with the associated ecosystems.
By our definition of sustainable, some of B.C.’s fisheries are conducted in a sustainable manner. These fisheries should be publicly acknowledged. However, as the Sierra Club of Canada – BC Chapter has pointed out in previous reports, other B.C. fisheries violate the basic principles of The United Nations Code of Conduct for Responsible Fisheries.

Our report cards will employ the following five criteria: (1) Knowledge of species’ life history; (2) Stock assessment and sustainable quota determination; (3) Management system; (4) Ecosystem considerations; and (5) Precautionary measures and long-term sustainability.

Our intent is not to simply criticize the fishing industry or unjustifiably criticize Fisheries and Oceans Canada (FOC). The Sierra Club of Canada – BC Chapter supports sustainable fisheries. Our goal in this series of report cards is to examine a variety of fisheries in the context of conservation of the resource, ecosystem considerations, and the public interest in species and ecosystem protection. Report cards will continue to be issued over time, and should not be considered static.

Primary questions guiding the assessment:

- Do current fishing practices place the species or populations at risk of depletion, collapse or extirpation?
- Does fishing impede the rate of recovery of depleted populations?
- To what extent does fishing impact non-targeted species and other ecosystem components?

Specific questions that guide our assessment:

- Is there sufficient biological knowledge about the targeted species to warrant a fishery?
- Is there adequate, up-to-date stock status information?
- Does FOC have a handle on how much of each species is being caught in the fishery?
- Is the fishery being managed in a precautionary way with the best available management and stock assessment methods?
- Do the fishery management plans consider ecosystem effects?

1 For the purpose of the report cards, sustainability is defined as the persistence of the stock to be utilized by both humans and other components of the ecosystem. We are not looking at other sustainability issues, such as the consumption of fossil fuels to undertake a fishery or socio-economic factors.
Our intention is that by answering these questions we can identify areas of concern and convey this to decision makers and to the owners of the resource – the Canadian public.

We acknowledge that at best, fisheries are managed with imperfect information, and fisheries are managed under assumptions that may change over time. As a consequence, fisheries management must always be guided by risk-averse approaches.

We will provide a historical context where appropriate, without dwelling unnecessarily on historical mismanagement. Our focus will be on current fisheries-management practices, and the ability of managers to properly manage fisheries on existing populations and to allow the rebuilding of populations to former abundances in cases of fisheries-related declines.

To develop objective report cards such as these often requires facts to be deciphered from speculation, and from politically-charged assumptions. This is an exceedingly difficult task. The mixture of scientific uncertainty and economic and political conditions makes assessments of the type we intend very difficult.

However, the Sierra Club of Canada – BC Chapter believes that it is important when informing the public about a fishery to demonstrate some humility. The information we will base our assessments upon may contain inaccuracies, but we will endeavor to conduct our assessments based on the best available information, as well as consultation with leading fisheries scientists and the fishing community. Future information, and future conditions, may positively or negatively affect the report card “grade” assigned to any particular fishery.
4. Report Card on the Strait of Georgia Roe Herring Fishery

The Strait of Georgia roe herring fishery was chosen as the first of the Sierra Club of Canada – BC Chapter’s report-card assessments for several reasons. First, Strait of Georgia herring are known to play a significant role in the Strait’s marine ecosystems. Second, the Strait of Georgia spawning population is the largest on B.C.’s coast. Third, most of B.C.’s human population lives within the coastal zone of the Strait and therefore there are significant and diverse non-fishery public values that need to be considered. Fourth, the Strait’s roe herring fishery has been the subject of much controversy and public anxiety over the past few years.

4.2 A Cautionary Note

Our assessment will examine the biological and ecological sustainability of the Strait of Georgia roe herring fishery. Many coastal First Nations have expressed grave misgivings about herring-fishery management practices, and First Nations’ leaders routinely complain about the lack of adequate consultation, and about inadequate access to the resource. Also, there are deeply held local concerns about the conduct of the fishery, and the conduct of fishery participants (i.e. shooting seals that interfere with fishing operations), especially in the Strait of Georgia. There are also many justifiable concerns that the B.C. coast’s roe herring fishery has become increasingly “privatized.” These concerns are related to the ability of licence-holders to effectively “rent” fishery participation to working fishermen who are obliged to lease licences in order to fish. These conditions may well have long-term, adverse implications for the sustainability of the fishery. Indeed, if we had examined these conditions in any detail, it is likely that the overall “grade” we have assigned to the fishery would be significantly lower. However, issues of access to the fishery and control of the resource were not considered in this assessment. These concerns should be further and more fully examined.

4.2 General Background Information on Pacific Herring Biology and Fisheries

4.2.1 Biological and Ecological Information

The biology of a harvested species dictates the type of management system that can be applied in fisheries directed upon the species. Herring is a pelagic species that occupies a variety of habitats throughout their life history. Although they have been recorded to live to twenty years of age, most of the spawning population is comprised of individuals between two and five years. Typically herring will recruit to the spawning population at age three and will spawn annually. Ocean environmental conditions are critical for larval and juvenile survival, which in turn determines the annual and decadal variability of herring populations.

For management purposes, Pacific herring (*Clupea harengus pallasi*) in British Columbia are divided into 5 populations: Strait of Georgia, the West Coast of Vancouver Island, the Central Coast, the Southeast Coast of the Queen Charlotte Islands, and the Prince Rupert District (North Coast).
Genetic evidence and tagging studies indicate that there is considerable mixing between these populations, and therefore stock delineation is somewhat arbitrary, especially from a genetic viewpoint (Beacham et al. 2001). Despite sufficient genetic exchange between stock assessment areas that may “dilute” genetic differences, it is estimated that most of the population returns to the same assessment regions between years (Hay et al. 2001).

Herring populations are controlled primarily by three environmental conditions - hake biomass (hake is a principal herring predator), water temperature during the first year of life, and winter-wind stress (Ware 1995). When the combinations of these conditions are favourable, herring populations increase. Likewise, poor year-classes are associated with above-average hake abundance, above-average temperatures, and high winter-wind stress.

4.2.2 Fishing History

B.C.’s coastal aboriginal peoples have harvested herring by a variety of methods from the earliest times. From the archeological record, evidence shows that herring was harvested as early as 7,000 years ago, at Namu, on B.C.’s central coast (Carlson, 1992). In the Central Coast area, dried herring eggs were a significant trade commodity. In the Strait of Georgia area, Coast Salish peoples utilized herring for their flesh, and for their roe. Dip-nets were drawn through the water from canoes, as were “herring rakes,” which were fir poles up to four meters in length, two meters of which were carved flat and embedded with “teeth” (usually sharpened bone). The rake was drawn through the water, impaling abundant herring, which were shaken into canoes. Herring eggs were a prized delicacy, harvested directly from eelgrass beds, or by the use of fir and cedar boughs, which were sunk directly in the herring spawning grounds and retrieved at the close of a spawning event (Suttles, 1951).

B.C.’s commercial herring fisheries began in 1877. Throughout the long period of industrial exploitation, herring have been utilized for a variety of purposes. The bulk of historical herring removals from B.C. waters were for reduction purposes into animal feed and fertilizer. Huge amounts of herring were removed between 1940 and 1970, reaching a maximum in 1963 exceeding 250,000 tonnes (Figure 1). Herring populations crashed in the late 1960s from over-harvesting and poor recruitment conditions. The fishery was closed for a few years, and then reopened under a different form of management.
Strait of Georgia herring fisheries have followed the same trend as the rest of British Columbia (Figure 2). Since 1975, herring landings have remained relatively constant, but the biomass in the Strait has increased considerably since the late 1980s.

Research into the impacts of B.C.’s 20th-century herring fisheries has produced evidence that dozens of small stocks disappeared in association with uncontrolled industrial fishing. However, herring are also known to come and go from spawning areas, even in the absence of fishing (Hay and McCarter 1999). Undoubtedly, the sheer magnitude of early fisheries would have impacted herring, along with the trophic interactions within associated
ecosystems. As we cannot change the historical impacts, our analysis is focusing on what is here today and how it is managed.

4.2.3 Contemporary Fisheries

Since 1972 herring have been harvested at a much lower volumes than historically, and are harvested primarily for their roe. The fishery is conducted during the spring, with the roe taken directly from the herring in the roe fishery or else collected on kelp or other materials in the spawn-on-kelp fishery. Most roe products are sold primarily to Japanese markets. There is also a small special-use fishery conducted year round, which amounts to roughly 3.5% of the total coast-wide catch. The special-use fishery harvests herring for bait, food, and aquaria.

For the 2003 fishing season, the coast-wide forecasted spawning biomass was 224,160 tonnes, of which 130,000 tonnes is associated with the Strait of Georgia. This is a remarkable movement of living animal tissue.

Most people will find it difficult to appreciate the scale of the coast’s spawning biomass of herring. It is roughly equivalent to the biomass of half a million buffalo.

Each of the five major coastal spawning populations is subjected to a stock assessment, and a spawning biomass is forecasted. Since 1983, the fishery has been managed using a fixed exploitation rate of 20% of each spawning population. If the population biomass is estimated to be below a pre-determined cut-off point for that population, then no removal is permitted. For the 2003 season, the Queen Charlotte Island population is considered to be below the cut-off point and therefore no fishery was conducted on this population. On B.C.’s central coast, plans for commercial roe herring fisheries were hotly disputed by the Heiltsuk Nation, which engages in significant commercial spawn-on-kelp.

The recommended coast-wide yield for 2003 was 43,390 tonnes – but only 67.7% of that potential yield was allocated to be harvested.

This peculiarity – quotas falling below recommended yields – routinely occurs in the roe herring fishery, mainly because of the industry’s inability to handle such volumes, concerns about roe quality, and the related market impacts of high production levels.

There are two licence categories in the commercial roe fishery - herring seine (HS) and herring gillnet (HG). A total of 252 seine licences and 1,257 gillnet licences are issued annually, of which 25% are held by individual aboriginal people or directly by First Nations. For the 2003 season, 152 seine licence holders and 913 gillnet licence holders were entitled to fish the Strait of Georgia population. Each seine licence had access to 57.45 tonnes, and each gill net licence had access to 9.13 tonnes.

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2 Stock assessments are determined in metric tonnes (1000 kg) whereas catch quotas are allocated in short tons (2000 pounds or 907 kg). For simplicity we will report all weight measures in metric tonnes (t).
Although the price of herring roe has dropped over the last few years, it is still an extremely valuable fishery. Average prices in the roe herring fishery from 1999-2001 were $1,481 per tonne, with an average annual total landed value of approximately $37.6 million.
5. Grading Criterion #1: Knowledge of Species Life History

Grade    B

The degree to which relevant life history information required for sustainable fisheries is known.

A  Every aspect of the species life history is well understood. There are no outstanding concerns regarding habitat requirements, reproduction, migration or distribution.
B  Sound understanding sufficient to make informed and risk adverse management decisions.
C  Limited understanding which may place the species or populations at risk to over-harvest
D  Poorly understood life history which compromises the long term sustainability of the fishery and places severe risk to the species and populations.
E  Nothing known. No justification for a fishery.

Herring worldwide have received considerable scientific attention over the last 100 years. Pacific herring in B.C. are no different in this respect. Rather than reviewing everything known about Pacific herring, we have developed a table, which lists the relevant life history topics and the current state of knowledge. Overall, much is known about herring life history, in comparison to other commercially fished species in B.C. (Table 1).

Table 1: Assessment of life history and biology knowledge required for sustainable herring-fisheries management (1 = nothing known, 2 = poorly understood, 3 = limited understanding, 4 = sound understanding, 5 = excellent understanding)

<table>
<thead>
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<th>Biology and Life History Topic</th>
<th>Knowledge Base</th>
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<td>Distribution and Migration</td>
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<tr>
<td>Genetic and spatial structure of populations</td>
<td>3</td>
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<tr>
<td>Longevity</td>
<td>5</td>
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<td>Age of maturity</td>
<td>5</td>
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<td>Habitat requirements</td>
<td>4</td>
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<td>Spawning requirements</td>
<td>4</td>
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<td>Prey source</td>
<td>4</td>
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<td>Predation and Mortality</td>
<td>4</td>
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<tr>
<td>Ecosystem role</td>
<td>3</td>
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<tr>
<td>Environmental conditions and recruitment</td>
<td>3</td>
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<tr>
<td>Score</td>
<td>39/50</td>
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5.1 Room for Improvement

Herring-fishery management focuses on five major assessment areas, comprised of stocks that are considered to be genetically similar throughout all of British Columbia (Beacham et al. 2001). There are, however, numerous small spawning populations. Regardless
of genetic similarity, these stocks contribute to the widespread distribution of the herring population.

One of the most contentious issues surrounding the roe fishery in the Strait of Georgia is the potential for its adverse impacts upon small, “resident” and peripheral populations in the Strait. There is certainly evidence that spawning populations disappeared in certain areas in the Strait after intense industrial fishing during the early period. These disappearances have been cited to support the claim that fishing has the potential to wipe out small populations. On the other hand, there is also evidence that spawning is occurring in areas where spawning has never been recorded, and that growth in spawning biomass has been the greatest in heavily fished areas. The question remains: Are small populations at risk from current fishing practices? Given the current spatial and temporal restrictions of the roe fishery, it is unlikely that fishing is having too great a direct impact on small populations.

Hay and McCarter (1999) reviewed 60 years of coast-wide herring spawn distribution and concluded that there has been a reduction of spawning distribution, but an increase in overall abundance. Fishing is potentially to blame, but the leading hypothesis points to changes in ocean temperature patterns. Assuming the genetic evidence is correct (i.e., one major coast-wide “metapopulation”), then the removal of herring biomass by fishing may decrease the potential for herring to spread or return to other areas. There is some evidence that during periods of population increase, as is currently occurring in the Strait of Georgia, increased spawning densities lead to greater spatial overflow and distribution. Therefore, it is possible that fishing is indirectly limiting the potential for herring to return to their former distribution.

Overall, however, there is sufficient understanding of Pacific herring biology to warrant a fishery. For this category, a grade of B has been given. Future research, however, should focus on the ecosystem role herring play (see Criterion 4), and on developing a better understanding of the factors that determine herring recruitment, and on a greater understanding of stock delineation.

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3 Doug Hay, Pacific Biological Station, telephone communication with author March 12, 2003.
4 Carl Walters, University of British Columbia, email communication with author March 3, 2003.
6. Grading Criterion #2: Stock Assessment and Sustainable Quota Determination

Grade B

**The degree to which Fisheries and Oceans Canada is able to estimate stock size and consequently allocate sustainable quotas.**

A  An excellent estimate of current (inseason) stock size based on validated models, fishery-independent methods of measuring abundance, historical information, most advanced system known, solid understanding of all populations and species directly impacted by fishing.

B  Excellent estimates of major stocks based on validated models utilizing fisheries-independent indices of abundance. No method of accurately assessing in-season stock size. Some understanding of minor stocks.

C  A reasonable estimate of major stocks based on historical assessments and fisheries-dependent indices of abundance.

D  Quotas based on outdated stock assessment information with no method of assessing sustainability. The stock assessment is on the primary targeted species with no consideration to minor species landed in the same fishery.

E  No stock assessment conducted on the target species or other species directly impacted by the fishery (bycatch). High potential for overexploitation or impact to incidental populations.

Having an estimate of population size for all impacted populations is critical in developing sustainable fisheries. This criterion examines the capacity of FOC to determine the size of the fished populations and allocate a sustainable quota based on a stock assessment.

Historically, the herring industry undoubtedly over-harvested herring populations (see Figures 1 and 2). Catch rates from 1950 until 1970 were 5 times higher than they have been in the last 20 years. The high economic value of the roe fishery, however, has provided a rationale for conducting annual stock assessments in each of the five management areas. Generally speaking, there is considerable biological sampling and validated models.

To forecast the spawning population, two models are used: (1) Escapement model (spawning index) and (2) Age-structured model. The age-structured model is the primary tool used in the stock assessment of the five major populations. In comparison to other B.C. fisheries, herring has considerable amount of raw input data for the assessment models including proportions caught at each age, average weight at age, a suitable number of fish aged, and a spawn index (see Appendix 1 for more information on how herring forecasts are estimated).

The current stock assessment age-structured model has been utilized for over twenty years (Fournier and Archibald 1982) with aspects of the database in existence for over 50 years. The model is in a state of continual revision to reflect increased information on the life history of herring and the conduct of the fishery itself. Overall, the model performance is considered to be reliable within an acceptable determined error. Similar age-structured models have been proven effective in other jurisdictions to manage herring fisheries.
6.1 Room for Improvement

Despite the fact that Strait of Georgia herring populations are at the highest recorded levels, there are still concerns. One concern is the ability of FOC to make accurate inseason adjustments. The quotas are assigned based on the forecast; however there is no way of determining the accuracy of the forecast until after the fishery has been executed. There have been some attempts of inseason estimates using echo sounding but they are considered to be less accurate than modeled stock assessments for the purpose of reevaluating quotas but they can provide a crude estimate (Tanasichuk, 1999).

The 2003 management plan states "if recruitment is more or less than predicted, the predetermined target will not be adjusted in the current year" (FOC 2003). The danger is that there is potential to overharvest a population that returns in numbers lower than expected. However, if in-season information from echo sounding points towards a drastic reduction in the expected returns, the fisheries manager has the authority to reduce the quota or close the fishery at any time for conservation purposes. To date, the forecasts have not been much different than actual returns, and in fact the forecasts often underestimate the actual spawning biomass (Stocker 1993).

In comparison to other fisheries on the coast, FOC has demonstrated the ability to undertake relatively accurate stock assessments on the Strait of Georgia herring population.
7. Grading Criterion #3: Management System

GRADE B

The degree to which the management system is able to control and account for catches of targeted and incidentally caught species in a timely way.

A There is an excellent management system to account for the quantities being landed, spatial extent of the fishing effort, and timely information required for in-season controls where appropriate. Catch levels of incidentally-caught and discarded fish are well understood and documented. No harvest on depleted or rebuilding populations. Minimal illegal fishing.

B There is a working system to account for inseason quantities being landed and the spatial extent of the fishing effort, but improvement is necessary. Good understanding of non-reported or illegal catches. Low levels of catch on rebuilding populations.

C Reasonable estimate of catch and spatial distribution of catch, but not bycatch. Insufficient understanding of the level of illegal or non-reported catches. Evidence that depleted populations are harvested at rates that may prevent maximum rebuilding.

D Poor estimate of catch and poorly understood spatial distribution of fishing. No understanding or controls of bycatch in the fishery. Unknown levels of illegal or non-reported catch.

E No idea of quantities of catches or spatial distribution of fishing. No understanding or controls of bycatch in the fishery.

The previous section on stock assessment examined the scientific ability to calculate a sustainable harvest rate. This section looks at the management system’s ability to ensure that a sustainable harvest rate actually takes place during the fishery. This includes knowledge regarding the spatial extent of the fishery, timely and reliable catch information, controlled levels of incidental catch, and reasonable estimates of unreported or illegal catch. The management system is ultimately responsible for the sustainable execution of the fishery.

7.1 Timely and Accurate Landing Information

The season for roe herring is brief. Typically within a week of an opening the entire quota in an assessment area is landed. Because spawning aggregations are extremely susceptible to over-harvest it is essential to have a system in place that accounts for landings in a timely way. The 2003 Integrated Fisheries Management Plan has a primary management objective to “collect accurate and timely catch, effort, and landings for roe herring by geographic location and time period” (FOC 2003).

Does the existing system ensure accurate and timely catch information?

Between 1985 and 2002, catch overages have been a regular occurrence in all five roe herring fisheries, averaging 20% more than the established quota (Figure 3a). Occasionally, on some fishing grounds, overages have been more than 2.5 times the allocation. As recently as last year, the fleet caught twice the WCVI quota (Figure 3a).

The absence of timely catch information increases the potential for over-harvesting the quota. In 1998, herring-fisheries managers implemented two major reforms to facilitate accurate and timely catch monitoring. First is the pooling of licenses, which effectively decreases the number of boats participating in the fishery; the second is an individual quota
system, which eliminates the race for fish. Since 1998, the overages have averaged 5% in total, but in some assessment areas overages are still unacceptably high.\footnote{Average based on data found in Schweigert 2002.} The Strait of Georgia roe fishery has performed well in comparison to the other areas in terms of the percentage of over-harvest relative to quota, but the Strait also has the highest quota. Therefore, the net overage is still quite high but as a percentage it is low (Figure 3a).

It should be noted that the actual quotas agreed upon each season are typically less than what the recommended yield would allow (Figure 3b). Therefore, although actual landings are often higher than the agreed-upon quotas, the landings still tend to fall below the recommended yield – an unusual condition of the fishery, which indirectly introduces a further control on fishing and offers further evidence that the fishery is not placing herring populations at undue risk.

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure3a}
\caption{(a) Roe herring catch compared to actual quota allocation in the five assessment regions; (b) roe herring catch compared to the recommended yield developed from stock assessment models. Data used for graphs from Schweigert (2002).}
\end{figure}

During the course of a fishery, an “overage” produced by a group of pooled licences requires the pool to distribute its excess catch to other pools in the licensed area which have not reached their quota. If all pools have reached their quota, then the value of the overage is assigned to test-fishing costs, and to the Herring Conservation and Research Society (HCRS).\footnote{The Herring Conservation and Research Society is responsible for undertaking research and maintaining databases.}
These rules provide clear disincentives to overfishing, but in the absence of direct penalties, the rules also offer a slight incentive to catch herring in amounts that at least marginally exceed quotas. That is because overages assure that fleet quotas are reached, and also provide benefits that accrue to the HCRS, which is an industry group.

7.2 Spatial and Temporal Controls in the Fishery

For all roe herring fisheries, there are numerous regulations in place to control the geographic extent and season. In more than half of the coast, no herring fisheries are executed at all. The roe fisheries, because they target spawning aggregations, are confined to small, manageable areas. There are no major problems in controlling the spatial and temporal extent of the fishery.

7.3 Rebuilding Populations and Problems of Low Abundance

It has been known for a long time that herring populations fluctuate due to natural causes at scales much greater than the current rates of harvest (Tester 1955). Under current herring-fisheries management, the population biomass of a given assessment area is primarily a function of environmental conditions. As a result, the highest ever recorded spawning biomasses currently observed in the Strait of Georgia are in part attributable to conservative catch quotas implemented 20 years ago, but are mostly due to favourable environmental conditions. Under the same management regime, populations could easily and will likely decrease in coming years.

This is likely the present case with other populations in B.C. The low herring biomass currently observed on the Queen Charlotte Islands, resulting in a fishery closure, is not likely solely a result of fisheries-management management failure. In fact, the ability of the department to detect low abundance, and to close a fishery, can be considered a success of the ability of the management system to handle this fluctuation, and not a failure.

Although the coast-wide spawning population in 2003 is forecasted to be higher than the 20-year average, 3 of the 5 management units (Central Coast, West Coast Vancouver Island, and Queen Charlotte Islands) have forecasts for returns lower than the 20-year average. Given that all populations will fluctuate over time, at what level of decline should fisheries still be prosecuted?

The current cut-off rates are arbitrarily set at 25% of the “unfished equilibrium,” which is considered to be risk-averse (Stocker 1993). There is considerable evidence indicating that the size of herring spawning populations (stocks) is not proportional to the resulting recruitment (Haist and Stocker 1985). Fisheries managers are left with the difficult question of determining the appropriate biomass where fishing should cease.

When current cut-off restrictions are compared to the last 17 years of forecasted yields, it is found that for most years and areas, the cut-off level has been below the lowest forecasted yields (Figure 4). Of the 85 forecasts (17 years and 5 areas), on only five occasions has the forecasted yield dropped below cut-off. Using the Strait of Georgia herring population as an
example, the current cut-off policy would permit a fishery even in the case of the population dropping to well below the long-term lowest biomass (Figure 4d).

Figure 4: A comparison of the current cut-off level (straight line) with forecasted biomass by management area from 1987 to 2002. The (b) Prince Rupert District, (c) Central Coast and the (d) Strait of Georgia assessment areas have never had a forecasted biomass below cut-off.

The current cut-off is designed around the notion of a minimal threshold required to maintain a population that is able to rebound from natural declines or errors in fisheries management. At present, there is little consideration of the long-term historical biomass of areas and the ecosystem functions herring perform (see Criterion 4).

One option would be to adjust the cut-off to be within a range of the long-term average population biomass (e.g., 5% confidence interval from the mean). Given the uncertainty of marine ecosystems, this may have no more scientific rationale than the existing 25% rate, but it does provide an additional precautionary level and acknowledges ecosystem considerations, which have previously been ignored.

Using the 2003 fishing season as an example, a cut-off level using the long-term average would not drastically alter the recommended yield (Table 2). Other benefits of using a long-term average are that it utilizes a proven trend rather than a fixed percentage based on a modeled assumption, it is easier to justify from a public policy point of view (i.e., not just
fishing interests are being considered), and finally, it may help alleviate some of the ongoing concerns voiced by First Nations (i.e. fishing during times of low abundance).

Table 2: A revised cut-off rate using the lower 95% confidence interval of the long-term average and 2003 forecasts.

<table>
<thead>
<tr>
<th>Location</th>
<th>2003 Forecast (t)</th>
<th>Max. Rec. yield (t)</th>
<th>Current Cut-off (t)</th>
<th>Long term average forecast (t)</th>
<th>Lower 95% confidence interval (t)</th>
<th>Increase in Cut-off (# of times)</th>
<th>Revised yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>QCI</td>
<td>7,200</td>
<td>0</td>
<td>10,700</td>
<td>16,188</td>
<td>12,787</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td>PRD</td>
<td>31,660</td>
<td>6,330</td>
<td>12,100</td>
<td>32,050</td>
<td>27,325</td>
<td>2.3</td>
<td>6,330</td>
</tr>
<tr>
<td>CC</td>
<td>25,260</td>
<td>5,050</td>
<td>17,600</td>
<td>40,769</td>
<td>33,381</td>
<td>1.9</td>
<td>0</td>
</tr>
<tr>
<td>SG</td>
<td>130,010</td>
<td>26,000</td>
<td>21,200</td>
<td>72,163</td>
<td>62,244</td>
<td>2.9</td>
<td>26,000</td>
</tr>
<tr>
<td>WCVI</td>
<td>30,030</td>
<td>6,010</td>
<td>18,800</td>
<td>32,013</td>
<td>26,532</td>
<td>1.4</td>
<td>6,010</td>
</tr>
<tr>
<td>TOTAL</td>
<td>224,160</td>
<td>43,390</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38,340</td>
</tr>
</tbody>
</table>

The cut-off system is in the process of being reviewed – and this in itself is evidence that fisheries-management is not relying too heavily on entrenched assumptions. Further analyses and public consultation may result in a conclusion that the existing level is adequate. In the meantime FOC should consider increasing the cut-off levels to reflect long-term average of spawning biomasses.

7.4 Illegal Harvest

The herring fishery has had some concerns of the potential of circumnavigating the dockside monitoring program (DMP). Overall, the herring fishery is considered to have low levels of illegal or unreported harvests.

7.5 Summary of the Management System

On the whole, the management system has proven successful in allowing the rebuilding of Strait of Georgia herring spawning populations. A few areas need to be addressed to ensure long-term sustainability. In particular the cut-off system should be re-examined with ecosystem and precautionary measures in mind.
8. Grading Criterion #4: Ecosystem Considerations

GRADE C

The degree to which ecosystem-based approaches are incorporated into management decisions.

A  Ecosystem-based approaches are central to the management of the fishery. This includes an understanding of impacts to non-targeted species, spatial reserves where relevant, protection of habitats, and an understanding of trophic interactions.

B  Ecosystem-based approaches are acknowledged and are being incorporated into management plans.

C  No consideration for ecosystem approaches or impacts to other ecosystem components but fishery very limited in the amount landed and spatial distribution. No disruption of habitat.

D  No consideration for ecosystem approaches or impacts to other ecosystem components. Fishing method does not physically impact habitats.

E  No consideration for ecosystem approaches or impacts to other ecosystem components. Severe known damage to habitats and non-targeted species.

The previous sections have primarily addressed issues pertaining to the biological persistence of the fishable population over time. The ecological role of Pacific herring has not yet factored into the report card.

From an ecosystem perspective, herring are one of the most important marine species on B.C.’s coast. Understanding the precise role of herring in the marine ecosystem is a formidable task. It is well known that herring are consumed by numerous species on the coast, ranging from jellyfish to baleen whales (Environment Canada 1994). However, determining how much and where herring should be left for ecosystem considerations is not something that Fisheries and Oceans Canada has paid much attention to.

The position of Fisheries and Oceans Canada is:

“At this time there is no information available on the appropriate conservation limits for the ecosystem as it pertains to the herring stocks. It is recognized that herring play a critical role in the ecosystem and are a food source for a variety of species. The precautionary harvest rate of 20% of the mature biomass ensures that 80% of the adult population is available to predator species. Additionally, since no harvest occurs on the immature herring all of these fish are available to support ecosystem processes. Research is ongoing to better understand these ecosystem processes and the role herring plays in maintaining the integrity and functioning of the ecosystem” (FOC 2003).

Given the ecological role of herring, there is an argument to be made that herring should not be harvested at all. Some may argue that the annual removal of ~25,000 tonnes of biomass, of which only a small portion is directly consumed by humans, is a waste of fish that perhaps is more valuable in the ecosystem. Exactly how the removal of this biomass impacts the marine ecosystem will never be fully known. There are too many dynamic processes at work. So, we are left with a dilemma. The fishery itself is managed sustainably from the point of view of biological persistence, but how much should be left to provide for other ecosystem needs?
Ecosystem models can give some insight into the role of herring, but the science is not advanced enough to inform decisions on proper ecosystem allocations. Given scientific uncertainty, herring must be managed in a precautionary manner in regards to its critical ecosystem role.

The state of Washington Department of Fish and Wildlife has developed a *Forage Fish Policy* that formally recognizes the ecological importance of herring and places the needs of the ecosystem ahead of any user group. The policy states “the availability of forage fish to provide a source of food for salmon, other fish, marine birds and marine mammals will be a primary consideration. To achieve this, potential catch will be foregone if needed” (WDFW 1998). As part of the Forage Fish Policy, it was decided that the protection of herring spawning habitat in the form of reserves was paramount to the policy.

Currently in Canada, ecosystem-based principles have not been formally recognized in the management of herring. In January 2003, FOC developed a discussion paper under the new Objectives Based Fisheries Management initiative. The paper is entitled *Objectives Based Fisheries Management and the Science Based Review of Pacific Herring Management*. As part of this process, fishing plans “will expand and take an ecosystem-based view of the fisheries and will address not only the conservation and sustainability of the target species, but also, the impact of the fisheries on ecosystem dynamics, including non-target species” (FOC 2003).

The dynamic nature of marine ecosystems (and our lack of understanding of how these systems “work”) precludes the opportunity for a precise scientific answer to the question of how much herring needs to be left for ecosystem functioning. Herring populations exhibit substantial natural fluctuations over time, which would ripple through marine ecosystems regardless of human involvement. The question then becomes, how much and where should harvesting take place to minimally impact upon the dynamics of any given population? If that question can be answered, then our harvest rates can be adjusted to be within the bounds of large-scale natural fluctuations. Under the present management system of a 20% harvest rate, humans are still a major predator of herring, possibly within the appropriate scale, possibly not.

Any decided-upon harvest level will be based on best guesses. Given the uncertainty of ecosystem requirements, FOC needs to further develop precautionary measures including a revision of the cut-off level (see Criterion #3), protection of historical and present herring spawning habitat, and protection of small spawning populations. Also, FOC should explore herring population dynamics in the context of ecosystem-based management. Furthermore, more work could be done to develop fisheries and markets that use non-lethal methods of obtaining roe. The spawn-on-kelp component of the herring fishery provides a model system on how to access the product (roe) with minimal harm to the spawning population. However, whether there is room for expansion of this sector of the roe fishery is a matter of much debate among participants in the fishery.
The coastal zone of the Strait of Georgia is host to two thirds of B.C.’s human population. There are many public values embedded in the Strait of Georgia ecosystem. There is also an onslaught of non-fishing related human activities, which impact the marine ecosystem. Given the importance of herring, policy direction must further explore the non-fishery values of herring. This includes revisiting the cut-off rates and an assessment of potential activities which threaten critical herring spawning habitats.
9. Grading Criterion #5: Precautionary Measures and Long-term Sustainability

GRADE C

The degree to which risk-averse, precautionary approaches are incorporated into management decisions to ensure sustainability.

A A well incorporated and understood system of precautionary measures are utilized by management and accepted by industry. This includes spatial refuges, conservative quotas, and mechanisms to allow for rebuilding.

B Some precautionary measures taken but not to a full extent to allow for conservation or rebuilding of populations.

C A good understanding of biological and fisheries information on how to integrate precautionary measures, but none taken (e.g. spatial reserves, reduced quotas, size limits etc.).

D Gaps in understanding of basic scientific knowledge to sustainably manage a fishery are well-documented, but no risk-averse actions have been taken.

E The fishery is executed despite the absence of basic knowledge required to manage a fishery. No precautions taken, resulting in high mortality rates of targeted or incidentally caught species well above natural mortality. Fishing practices place targeted populations or incidentally caught species at severe risk of depletion.

Principle 15 of the Rio Declaration brought the precautionary approach to a global level. It is now considered a fundamental principle in the management of fisheries. In essence the precautionary approach states “where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”

The harvest of any wild fish population involves a considerable level of uncertainty. How a management system deals with that uncertainty is critical to the long-term sustainability of the resource. To the credit of FOC and industry, the herring fishery has adopted numerous risk-adverse precautionary strategies into the management.

The overall management principle of the herring fishery is:

*To ensure conservation and protection of Pacific herring stocks through the application of scientific management principles applied in a risk averse and precautionary manner based on the best scientific advice available.* (FOC 2003)

Some degree of uncertainty is present at every level of herring management including population structure, population forecasting, recommended yield, protection of depleted populations, accuracy of landings, and ecosystem requirements. Many of these concerns have been recognized for decades, and have been integral in the development of herring fisheries management policies.
9.1 Population Forecasting, Recommended Yield, and Quotas

Due to the complexities of marine ecosystems, there is an inherent danger in forecasting the spawning biomass and consequently the recommended yield. The models currently utilized have typically underestimated the actual spawning biomass. At one level this trend provides a sense of assurance, but it also shows that the models themselves are working on imperfect information.

Once handed the recommended yield (20% of estimated spawning biomass), managers work with industry to derive quotas. The quotas have typically been less than the recommended yield. This allows for overages (see Figure 3a) and some uncertainty in the models.

The biology of herring also limits the allocations in the seine fishery. The seine roe fishery requires large aggregations of mature, “ripe” herring. As mature herring get nearer to spawning, younger, less ripe fish move in. As a result, it is difficult to find large aggregations of mature herring suitable for the seine fishery. The larger the quota, the more difficult it is to find aggregations of mature fish. This has led the seine fishery to agree with managers that 8,000-9,000 tonnes is a biological maximum for any given area.7

Currently, the roe industry itself has additional built-in limits to the amount it can land. First, there is insufficient capacity to process and freeze a greater volume of fish than is currently landed. Second, the market is specialized and cannot absorb much more than is currently be caught. Third, the Japanese market at present time is depressed and therefore industry often recommends quotas LESS than recommended in order to maintain high product quality and prices.

In 2003, the spawning biomass in the Strait of Georgia is at a historic high. The industry chose to set their quotas below the recommended yield in order to maintain high values. Industry related practices, which limit the catch, do not strictly qualify as risk-averse management, but they are worth mentioning.

9.2 Protecting Depleted or Diminishing Populations

As mentioned previously, not all of B.C.’s five major populations are at high levels. The Queen Charlotte Island population is closed to fishing this year due to poor recruitment in recent years. All populations cycle through periods of low and high levels and therefore a precautionary strategy needs to be in place to prevent fishing in times of low stock abundance. The present cut-off system is intended to be a precautionary measure in that it prevents overfishing of a depleted or diminishing population while at the same time leaving enough biomass for quick population growth under favourable recruitment conditions. The cut-off is a theoretical acceptable level based on stock-recruitment relationships. The cut-off system has been described as a “matter of acceptable probabilities, rather than guarantees” (Stocker 1993). As described in Criterion #3, there is a need for a review of the cut-off rates in areas with a forecasted biomass below long-term average.

7 Jake Schweigert, email communication with author, February 25, 2003.
9.3 Ecosystem Impacts

The management of Pacific herring is quite robust in terms of precautionary measures to ensure the persistence of the population, but the current management system should more closely address ecosystem considerations. There are many commercial fish species that rely upon herring, such as Pacific cod (42% of diet), lingcod (71%), halibut (53%), coho (58%) and chinook salmon (58%) (Environment Canada 1994). Many of these species are exhibiting general or localized declines on the B.C. coast. When herring-dependent stocks fall to low levels, the 20% harvest rate – although it does leave 80% of the spawning biomass and numerous juveniles for ecosystem processes - may not be risk averse, especially in populations with biomasses below long-term averages.

But there is no magic number. The ecological consequences of any harvest rate will have vast uncertainty associated with it. Although the relationship between herring and other species may appear on the surface to be linear (i.e., more herring equals more salmon, rockfish, and lingcod) the truth may be the opposite. For example, chinook salmon abundance increased during the highest historical periods of herring removal (Walters 1995). There is a sound ecological mechanism that shows that competition for food between juvenile salmonids and herring may be more important in controlling adult salmon populations then herring availability as a prey source. This point is raised to emphasize the complexity of the problem, and that there is not a simple answer.

Given the biology of herring, modeled population structure, and current management practices, the Strait of Georgia roe herring fishery can be considered a sustainable fishery from a biological point of view. By our analysis, the fishery does not place any populations at a high risk of over-harvest, it is risk averse, and has a system of stringent management controls in comparison to many other fisheries. Further improvements include research on the cut-off levels and how to include ecosystem considerations.
10 Literature Cited


Weblinks

http://www.bcpawnonkelp.com/
http://www-sci.pac.dfo-mpo.gc.ca/herring/default.htm
http://www-sci.pac.dfo-mpo.gc.ca/herring/bulletin.htm
11. Appendix

How the spawning biomass of Pacific herring is forecasted

The calculated biomass for any given year’s fishery is based on a forecast from the previous year’s biological information. The forecast is calculated from an age-structured model which requires the following inputs: (1) age structure of spawning population, (2) average weight-at-age of spawning population, and (3) escapement (estimation of the # of fish alive after the fishery based on the amount of roe deposition). The model has numerous finer details to reflect the subtle details of the fishery, but the basic workings of the model is as follows.

The first data input is the catch-at-age information used to determine the proportion of herring at each age. Herring can live up to 20 years but rarely live beyond 9 years in the Pacific due to high natural mortality. By age 3, and sometimes age 2, herring are mature and therefore vulnerable to the fishery. For the model, there are 9 year classes assigned. Fish are sampled at random and then aged in a laboratory.

The weight of each herring in a given year class is determined and then a mean is calculated.

The escapement biomass are the number of fish surviving after the fishery. The amount of spawn is correlated to tonnes of fish that survived at each age.

Forecasting the biomass for the next year requires two steps. First, the number of herring surviving at each age is multiplied by the natural survival rate. This gives a biomass estimate of the existing mature herring. Second, the amount of herring anticipated to enter the fishery is calculated. Based on 52 years of data, it has been found that the number of age 3 herring in the current year is a good indicator of the following year’s recruitment.

The biomass can now be estimated within error parameters and quotas can be allocated to the various sectors of the fishing fleet based on a 20% harvest rate.

The coastwide recommended yield (i.e., 43,390 t in 2003) is then allocated to the various types of herring fisheries and gear sectors. In 2003, 67% of the recommended yield has been allocated to commercial fisheries.
Other Marine Reports:
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