Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Stock Assessment Secretariat
Research Document 99/124

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/124

Not to be cited without permission of the authors[1]

Ne pas citer sans autorisation des auteurs[1]

Evaluation of a new assessment and management framework for shrimp stocks in British Columbia

J.A. Boutillier, J.A. Bond, and H. Nguyen

Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC, V9R 5K6

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au secrétariat.

ISSN 1480-4883
Ottawa, 1999

Abstract

In response to conservation concerns as a result of recent major shifts of effort into the shrimp trawl fishery in British Columbia, a quota management system for shrimp, incorporating catch ceilings and designated Shrimp Management Areas, was adopted in 1997. This new system required a different assessment data and information system, including the development of assessment tools which can be used to evaluate the dynamics of the stocks.

This paper summarizes the stock assessment activities carried out in 1997 and 1998, including both field and analytical assessment methods, identifies proposed changes, and discusses what will be required in the future under this new quota management system. The assessment tools used in 1997 and 1998 are evaluated, the setting of initial catch ceilings through forecasting of surveyed areas is discussed, and the extrapolation of information from surveyed areas to make inseason adjustments to non-surveyed areas is considered. Recommendations are made for the 1999/2000 shrimp trawl fishery. In addition, the management systems implemented in 1998 are discussed, and suggestions for 1999/2000 are made.

The paper notes that meeting objectives of conservation and developing databases that are required to understand the stock dynamics will require a long process of refinement of management and assessment systems. Over the long term, the management and assessment systems for these fisheries will undergo a number of changes as information is received on the key issues of biomass estimation, how populations respond to exploitation, and the appropriate management decision rules that should be adopted.

Résumé

En 1997, un régime de gestion par quotas comportant des maximums et des zones de gestion a été adopté pour la pêche au chalut de la crevette en Colombie-Britannique, en réaction à des préoccupations relatives à la conservation découlant de réorientations majeures de l'effort de pêche. Le nouveau régime exigeait un système différent pour l'évaluation des données et de l'information, notamment l'élaboration d'outils d'évaluation pouvant être utilisés pour estimer la dynamique des stocks.

Le présent document résume les travaux d'évaluation des stocks qui ont été réalisés sur le terrain et par des méthodes analytiques en 1997 et en 1998. On y fait état de projets de changements et on y traite des besoins futurs en vertu du nouveau régime de gestion. La discussion porte en outre sur l'examen des outils d'évaluation utilisés en 1997 et en 1998, l'établissement de maximums initiaux de capture fondés sur les prévisions pour les zones où les relevés ont été effectués et la possibilité d'extrapoler les données à d'autres zones, afin de permettre des ajustements en cours de saison. Des recommandations sont formulées pour la saison de pêche à la crevette en 1999-2000. Il est question notamment des systèmes de gestion adoptés en 1998 et des suggestions sont faites pour la saison 1999-2000.

Il ressort enfin qu'un long processus de mise au point des systèmes de gestion et d'évaluation sera nécessaire pour atteindre les objectifs de conservation fixés et constituer les bases de données nécessaires à la compréhension de la dynamique des stocks. À long terme, les systèmes de gestion et d'évaluation de cette pêche subiront de nombreuses modifications au fur et à mesure de l'acquisition de renseignements sur les éléments clés que constituent l'estimation de la biomasse, la réaction des populations à l'exploitation et une gestion pertinente de règles de décision à adopter.

TABLE OF CONTENTS

1 Introduction

In 1997/1998, the assessment for the shrimp trawl fishery underwent significant changes as a result of the adoption of a new precautionary management strategy, which incorporated catch ceilings and designated shrimp management areas (SMA) (Southey et al. 1998). This new precautionary approach was in response to conservation concerns as a result of major shifts of effort into the fishery (Boutillier et al. 1996).

The adoption of a quota management system for shrimp necessitates that two pieces of information be available to fisheries managers: 1) an assessment of the stock or stock complex and 2) a set of management decision rules. Many of these shrimp trawl fisheries are new or developing and there is little or no information available from which to assess the stocks or optimise decision-making. Without the appropriate information the assessment and management program can only proceed in a very precautionary manner. The objectives for assessment of this fishery are to ensure conservation and to develop the databases necessary to understand the stock dynamics so that the fisheries can develop in a sustainable manner. Our approach is a multi-faceted, step-wise process that requires:

1. Development of assessment indices that reflect trends in abundance of the shrimp stocks. We are trying to develop assessment indices in a number of index areas using research surveys, commercial catch and effort data and biological samples of the commercial catch. The fishery has been permitted to proceed but only in a manner that does not put the stocks at risk of overfishing and ensures that conservation is not compromised.
2. Once we are confident that the assessment data reflects trends in abundance, we can use this data to refine our understanding of the dynamics of the stocks and their responses to fishing pressure. To do this, an experimental management system will start to systematically evaluate a range of fisheries exploitation rates on different species and stocks. Through this experimental management process we hope to understand and quantify the compensatory and depensatory responses that various populations of shrimp exhibit. We would then use this to model population productivity of the each species at various levels of abundance, under different exploitation rates and under different environmental conditions.
3. The final step will be the development of optimal harvest strategies for the various species and stocks based on their population dynamics and the long-term industry economic goals in management objectives. During these last two phases the primary conservation objective will not be compromised.

At this point in time, we are at the first step in this process. Appropriate assessment indices must be developed, and a complementary management approach must be in place before we can even consider proceeding to the second step.

The shrimp trawl fishery targets on a number of species of shrimp and takes place on at least 58 separate grounds within the 34 SMA. The fishing grounds range from large offshore grounds to small isolated inshore waters. There are seven species of shrimp that are harvested commercially in British Columbia. The complexity of the fisheries vary depending on whether the fleet is targeting on a single or multiple species of shrimp.

The new management strategy adopted in 1997/98 (of catch ceilings and designated SMA) required different assessment data and information. The key aspects to the system require the development of abundance indices, which will be used to evaluate the dynamics of the stocks under varying fishing and environmental conditions. The first step, as noted above, is to develop a system to obtain reliable biomass indices of key stocks. To address this issue, Stock Assessment conducted a series of systematic area swept trawl surveys in selected areas in 1998. The purpose of these surveys was to develop a network of fisheries with the type and quality of data required to properly assess the impacts of fisheries on shrimp populations over a range of areas and species mixes.

Collection of fishery independent data is new to most of these fisheries, the one exception to this being the research survey that has been conducted in select locations off the West Coast of Vancouver Island (WCVI). Some areas off the WCVI have been regularly surveyed since 1973; however, even this long-established survey changed this year with a major expansion into adjacent areas.

This paper is being prepared as an evaluation of this new assessment and management framework.

2 Methods

Information presented in this report covers the period up to the end of October 1998. Surveys and fishery information gathered after that time were not included due to time constraints.

2.1 Evaluation of the Field Assessment Process

Information used in the assessment of the index areas came from three sources of data: research area-swept surveys; logbooks; and commercial catch sampling.

2.1.1 Shrimp abundance index surveys

Estimates of abundance indices are based on a series of fishery independent surveys of select shrimp grounds. The surveys were completed using various combinations of: on-bottom shrimp trawls, longline shrimp traps fished on the bottom in trawlable and untrawlable areas, and longline shrimp traps fished vertically from the bottom to the surface. The trawl sampling provided an estimate of density of shrimp in the trawlable areas. The on-bottom traps catches provided a comparison of the relative density of shrimp in trawlable and untrawlable areas as well as the limits of shrimp distribution. While the vertical traps sets provide an estimate of the proportion of shrimp available to the trawl during the survey.

The initial trawl sampling locations were systematically spaced over the known fishing grounds. In the event that shrimp were still abundant at the edge of the known grounds, then trawl sampling was expanded using the same grid spacing until shrimp were no longer evident in the catches or the bottom became untrawlable.

Vertical sets were made in the areas of the trawl tows that produced shrimp. The vertical sets were soaked for a 4-hour period, and no sets were made that extended past dusk.

Horizontal sets were only utilised when it was likely that significant areas of untrawlable bottom contained shrimp. Horizontal trap lines were to be placed in paired sets on adjacent grid areas of trawlable and untrawlable grounds. Horizontal sets were soaked overnight.

The logistics of the surveys conducted in 1998 are summarised in Appendix Table 1. Details of 1997 surveys are summarised in a technical report (Boutillier et al. 1998).

There are a number of tasks that were conducted with each research shrimp survey. These activities include:

1. Pre-survey digitising and mapping work to be completed prior to the survey using logbook data.
2. Preparation of sampling manuals, data sheets and field equipment for observers and boats participating in the surveys including but not limited to the trapping gear, scales, buckets, calculators, safety equipment, etc.
3. Pre-survey meetings to plan logistics from digitised material and direct industry input.
4. Effort standardization (for multiple vessel surveys) of the vessels participating in the survey, from logbook information.
5. Conducting the survey of tows and trap sets jointly agreed upon in the pre-survey meeting plus adaptations to the program in situ as required.
6. Collecting biological samples from each tow for retention and processing upon return to the laboratory.
7. Sample processing including identifying, sexing and measuring the animals, and collation of the data into an electronic format. The time allotted to this process varies depending on the complexity of the area with respect to the spatial scales and number of species concerned.
8. Compiling and analysing the data by area for species, age and size composition.
9. Compiling logbook data, catch validation records and biological samples (if available) from the survey area for inclusion in the final biomass estimation procedure.
10. Estimating the biomass and age composition of the various targeted shrimp species for each unique area.
11. Reporting to fishery managers and industry participants on the results of the survey (results are forwarded to fishery managers within two weeks of completion of the survey).

These steps are described below in further detail.

All data was collected in a standard format and stored in an ACCESS 97 relational database. Survey information from each sample set included detailed area, time and catch information. Biological samples of 100 (if available) shrimp by species were collected from each tow for later processing by size and sex.

Surveys were conducted either using multiple commercial vessels using different trawl sizes and designs or with a single research vessel using a standard sampling trawl. The switch to using a standard vessel and equipment to develop a time series of assessment indices came about as a recommendation by the industry in order to avoid a number of problems that arise in conducting multiple vessel surveys. It should be noted that time series of surveys in select areas off WCVI have almost exclusively been surveyed with a single vessel and standard gear (Boutillier et al. 1997).

For surveys conducted using multiple vessels, effort standardization became an issue. In particular there were two areas of concern: between vessel differences and between gear differences.

2.1.1.1 Between Vessel Differences

Prior to any multiple vessel survey, logbook records of the fishers participating in the survey were examined and compared to see if there were significant differences between the effective fishing power of each vessel. When two vessels fished the same area on the same day, pairwise comparisons were made between the catch per unit effort (CPUE) distributions. If a vessel could not be compared then it was assumed to have a fishing efficiency of one similar to the most efficient vessel that was compared. This would result in more conservative biomass estimates. While comparative fishing experiments to determine efficiency would have been preferable, resources were not available to permit that option.

With the use of a single research vessel and standard trawl, no within year or between year effort standardization was necessary.

2.1.1.2 Between Trawl Differences

Surveys were conducted with both beam trawls and otter trawls, although within a single survey only one type was used.

For the WE Ricker, the effective horizontal opening of the NMFS shrimp trawl net was estimated to be 10.7 m (Boutillier 1977). This net design has been utilized for this type of survey since 1977.

For beam trawls, the effective net opening was calculated to be 0.6 meters shorter than the beam length. All of the nets used were high-rise beam trawls that were estimated to open vertically approximately 4 to 5 meters. The approximate opening was given to us by net manufacturers that had participated in testing scale models of their trawls in a specially designed evaluation tank on the East coast of Canada in the spring of 1997.

The effective opening of the otter trawls was estimated to be half the length of the footrope (Hannah 1995). All of the nets used were high-rise trawls that had an estimated vertical opening of approximately 4 to 5 meters. The survey vessel used an otter trawl specified by the industry.

Many of the vessels participating in the surveys had taken the initiative to use fish exclusion devices in their nets during their normal commercial operations to reduce the bycatch. In some of the earlier surveys, it was felt that this equipment might reduce the catch of shrimp and therefore the separator gear was removed from the trawls for the surveys. In later surveys, because of the problems with handling the fish bycatch, which slowed the survey and compromised the number of survey sites that could be sampled, vessels opted to conduct the surveys with the exclusion devices in place. For surveys using a single research vessel and trawl, the gear was initially fished without a grate; however, again because the effort required to handle by-catch severely hampered the number of samples that could be completed, the grate was subsequently reinstalled. To date, any particular survey was conducted completely with or without the grates installed. No adjustments were made to account for shrimp lost through the grate.

2.1.2 Logbooks

The logbooks and gear questionnaires were redesigned in April 1997 to incorporate geo-referencing of the tow locations and more detailed gear specifications including information on fish exclusion devices. Logbook data are used to provide a number of pieces of information used in the assessment process.

1. Logbooks provide locations of shrimp trawl activity. This data was incorporated into CompuGrid, the proprietary raster-based geographic information system (GIS) utilised by DFO, Shellfish StAD, and displayed in relation to land mass, Pacific Fishery Management Areas and depth contours. This information was then used to develop masks of survey areas which were drawn around the areas of most concentrated effort (clusters of location points), using the 50 m and 200 m contour lines as rough guides. These masks were subsequently modified as a result of consultation with the industry and the survey results. The masks were also captured digitally and incorporated into the GIS.
2. Logbook data formed the basis for the between vessel effort standardization process mentioned previously.
3. Logbook data was used to evaluate concerns by the industry that the surveys are not occurring at optimal times. Catch and effort data was examined to determine catch rates throughout the year.
4. The logbook data was compared with survey and biological sampling data to determine the reliability of the landing data with respect to species composition. Biological samples are sorted by species, but fishers often sort their shrimp catch on the basis of size rather than species. The reported catch of ‘pink’ shrimp is often made up of several species of pinks as well as small sidestripe shrimp. Thus, landing data is not always reliable.

2.1.3 Biological Samples

Biological samples were collected routinely as part of the surveys and the at sea by-catch monitoring program. Biological samples of 100 or more (if available) shrimp by species were collected from each tow for later processing by size and sex. Additional samples were collected from processing plants to supplement the biological data samples whenever possible. Each sample was then processed to determine the number of shrimp per kilogram, and the size and sex of each individual animal. The histogram and length frequency distributions for all samples were analyzed to proportion out the size and number at age using Schnute and Fournier's (1980) length frequency modal analysis (a minimal desirable total sample size is 1000 animals). Using the resulting mean sizes for each year class plus and minus a proportionally calculated standard deviation, the minimum and maximum sizes of animals assigned to an age class were calculated. These minimum and maximum sizes for each age class allowed us to estimate the age composition for each sample.

This biological data was then used to:

1. Develop year class indices and distribution maps for the different areas surveyed.
2. Validate the accuracy of the species mix reported in the landing and logbook systems.
3. Determine variations in species mix and size at age data between different fishing areas within and outside a SMA.
4. Determine the incidence of berried females (females carrying eggs) in the catch from the spring opening.

2.2 Evaluation of the Analytical Process

The systematic survey design was chosen over random designs such as stratified random because it provided a opportunity to map the area of distribution of shrimp and is logistically easier to implement. With this type of sampling we cannot calculate an unbiased estimate of the mean and variance as we would if the samples were drawn randomly. Because of this, we use geo-referenced modelling of the systematic survey data to estimate the indices of biomass and year class abundance. The modelling is conducted by mapping the total survey mask area and dividing it into cells. The size of the cells varied from 90,000 square meters (i.e. squares with sides of length of 300 meters) in most areas to 25,600 square meters (i.e. squares with sides of length 160 meters) in some of the smaller areas. The centre point of each sample tow or trap set was assigned to the appropriate cell. The area swept on each tow was calculated by multiplying the effective opening of the net by the distance travelled during the tow. The weight or age class density information from the tow then became the value for that cell.

Density values for the empty cells within the mask were then estimated by interpolating between the cells filled with survey density data. Both sector and bicubic geospatial interpolators were used to model the density of animals and estimate values for the empty cells.

The sector interpolation examined an area within a circle with a radius of ten cells (1600 to 3000 meters), from the target cell (cell for which the value is being calculated) in the centre of the circle. The circle is divided into six sectors, and the value for the target cell was estimated using an inverse distance-weighted average of the nearest sample in each of the sectors. Thus, samples closer to the target cell have a greater influence on the interpolated value. In contrast, the bicubic geospatial method fitted bicubic splines to the survey data to interpolate between known values.

Once blank cells were filled in with interpolated values, indices of biomass and year class abundance were calculated by adding the values in each cell within the entire survey masked area. The calculations of the indices were done within the CompuGrid GIS software package.

Information from the vertical trap sets was run through a Kernel estimator to provide a probability density function of the shrimp available to the trawl. The density of animals in tows adjacent to the vertical trap sets were then adjusted to reflect the availability of the shrimp in the area.

Information from the horizontal trap sets was used to better establish the mask area so that it reflected the area occupied by different shrimp species. The trap sets were used to estimate the density in cells in untrawlable areas by comparing the relative abundance (shrimp per trap) with trap sets in trawlable areas. Estimates of density of the shrimp for trap sets in trawlable areas were obtained from the trawl tows in close proximity to the trap sets.

There were two aspects to this assessment process that were evaluated this year:

1. With the survey of SMA 12OUT, we were able to compare the difference in the estimates obtained using the two interpolators and the mean model (i.e. taking the mean density of all the tows and multiplying this number by the area of the shrimp grounds).
2. With the survey in Chatham Sound, we tested the effects that cell size had on the interpolators and the resulting biomass estimates. To test the sensitivity of the effects of cell size we recalculated the biomass estimate from a range of cell sizes of 160 and 200 to 700 meters (using 50 meter increments) on a side.

3 Results

3.1 Evaluation of the Field Assessment Process

In 1997 three shrimp surveys were completed. The offshore areas of the West Coast of Vancouver Island (WCVI) were surveyed in May aboard the R.V. W.E.Ricker. SMA 12IN was surveyed in April and November, and SMA 12OUT was surveyed in November. Both the April and November surveys used multiple commercial vessels (see Figure 1 for a map of the SMA). Prior to commencing the surveys in 1998, the Shrimp Trawl Sectoral Committee was given a list of potential survey areas and asked to examine a set of criteria for selection of key index areas and comment on the areas to be surveyed. The surveys conducted in 1998 were basically as described in the initial list although the timing for some did change as a result of requests from the industry in-season. A number of new areas were surveyed in 1998 and the WCVI survey (SMA 21OFF, 23OFF, 124OFF, and 125OFF) was expanded to include Barkley Sound (including SMA 23IN). New surveys completed to the end of October 1998 include: Queen Charlotte Sound (SMA QCSND), PFMA 28 and 29 (SMA FR), Chatham Sound (portions of SMA PRD), PFMA 9 (SMA 9IN), and PFMA 12 (SMA 12IN and 12OUT). A survey of several Georgia Strait areas (SMA GSTE, 17, 18, and 19) was completed in November 1998 but will not be covered in this paper.

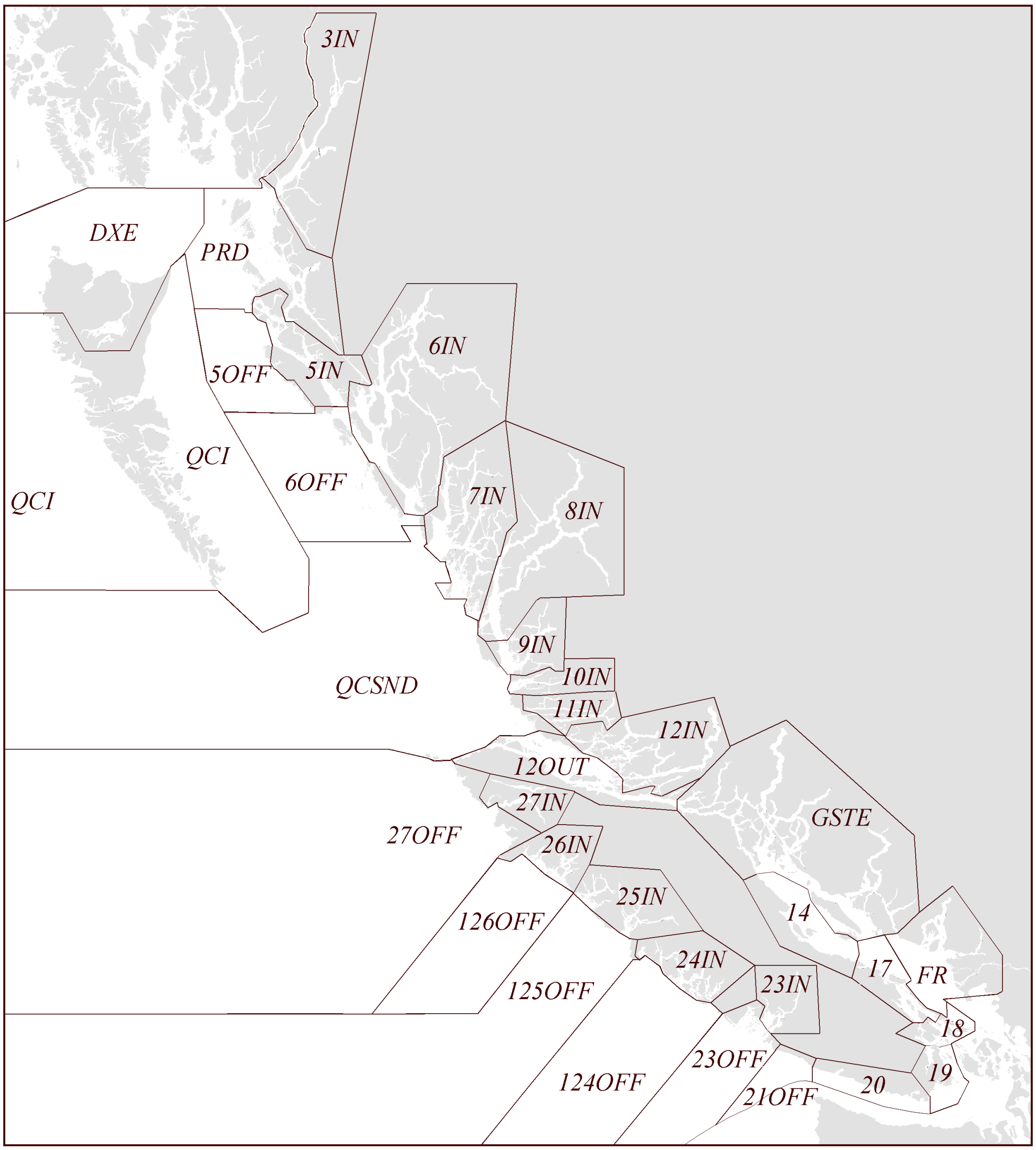

Figure 1: Designated Shrimp Management Areas (SMA) of British Columbia.

A number of logistical problems occurred in implementing this program in 1998. These included:

1. Difficulty in standardising the effort between vessels in a multiple vessel survey. Many of the fisheries were so new that there was insufficient data for standardization comparisons.
2. Volunteers were unwilling to complete systematic sampling. They were only willing to fish the known hotspots and were unwilling to risk fishing in marginal areas.
3. Complaints from volunteers that they were surveying while the rest of the industry were fishing.
4. Inconsistency of repair of the gear and vessels. Some volunteer vessels were found to be in major disrepair and unsafe to work on.
5. Inability of volunteer vessels to conduct the trap sampling.
6. Excessive requirements for trained personnel in multiple vessel surveys required sending out marginally trained personnel. This at times compromised the sampling and data quality and resulted in programs not being carried out as defined.
7. Inability to find an acceptable shrimp trawl skipper to operate the research vessel.
8. Planning was delayed by funding uncertainty in 1998 so that it was not possible to obtain the use of the research vessel at prime times.
9. Preliminary masks of fishing areas far exceeded the trawlable areas, and a great deal of time was spent exploring areas.
10. Unwillingness of fishers to volunteer when they felt that the survey would result in increased catches and an influx of new vessels into the area.
11. Insufficient time to complete the surveys. This generally led to a situation where only the most productive portions of the grounds were surveyed and there was insufficient time to find the limits of the grounds. This would tend to bias the survey and result in higher density estimates.
12. The areas that were indicated as being fished in the logbooks were substantially larger then actual trawlable areas. This was mainly due to inaccurate reporting of latitude and longitude data from the commercial shrimp trawls.
13. There were substantial differences between the validated catch, logbook catch, biological samples and survey results with respect to the relative proportions of species that should have occurred in the catch. In particular, the sidestripe catches in validated landings were underreported because only the large animals were sorted out and reported separately while the small animals remained mixed in with the pink shrimp catches.

Upon completion of the field portion of any survey, the biological samples were processed and analyzed along with the survey catch data and the results were given to the managers for their deliberations within two weeks. As this process developed, a survey update and management action bulletin was produced that detailed the results to the industry. Summaries of survey logistics are shown in Appendix Table 1, and Appendix Table 2 summarises the contents of the bulletins detailing the results to industry. Included in this table are sections describing some of the problems and areas of concern with the surveys. These include things such as discrepancies between species composition of validated landings, surveys, logbooks and at-sea observer sampling.

There was concern from the industry that the Area 23 portion of the May 1998 survey was conducted at the wrong time of year. Industry indicated that shrimp catches were always greater later on in the year, in particular during July. Table 1 below shows the standardised catch per minute towed (CPUE) for beam trawls in Area 23 for 1998. It is clear that the commercial catch rate during the survey period was greater than during any other period with the exception of April.

Table 1: The CPUE for beam trawls in Area 23 in 1998.

Month	Beam trawl CPUE
April	1.303
May	1.297
June	1.263
July	1.034
August	1.120
September	0.906

Over the year, the field survey logistics changed to address some of the problems outlined above. Included in these changes was the shift from conducting the survey with multiple vessels and gear to conducting the surveys with a standard vessel and gear. To address the issue of delimiting the area of shrimp distribution, the collection of information on bottom type has begun using a Questor Tangent Bottom Profiler. This work is in the developmental stages at this time.

3.2 Evaluation of the Analytical Process

In addition to the changes in the survey logistics outlined in Appendix Table 1, with the hiring of a dedicated shrimp trawl biometrician in July 1998, we started investigating the sensitivity of the analytical procedure to both the interpolator and the cell size of the calculation matrix.

A comparison of the interpolators was conducted only for the sidestripes in the SMA 12OUT survey. In addition, biomass was calculated using a mean model (a mean model takes the average density of shrimp per unit area found in survey tows and multiplies by the total survey area to achieve an estimate of the total weight of shrimp in the survey area). The results of the two interpolators, as well as the estimated population using a mean model are presented in Table 2 below.

Table 2: Estimated biomass (t) of sidestripes in the SMA 12OUT survey, for varying cell sizes, calculated using the two interpolators and a mean model. NB: the results for the mean model vary due to the fact that the estimate of total survey area changes slightly with different cell sizes.

Cell Size	Sector Interpolation	Bicubic Spline Interpolation	Mean Model
200	72.70	98.20	122.60
250	86.10	105.80	122.88
300	95.10	117.90	122.83
350	99.80	160.20	123.25
400	98.60	92.60	122.16
450	99.30	105.40	122.36
500	99.30	95.70	122.69

The examination of the sensitivity of the analytical procedures to the cell sizes was conducted for the assessment of the Chatham Sound (SMA PRD) and Area 12 (SMA 12OUT) surveys. The biomass estimates that were reported to the managers were the median values of the range of estimates once the values became more or less asymptotic. Re-calculations of the surveys conducted prior to this time were conducted as part of this analysis and the results are reflected in Appendix Table 2. These results were not available initially and do not represent the estimates used to determine the inseason management actions taken this year. The management actions taken in surveyed areas are summarised as part of Appendix Table 3.

3.3 Application of the Assessment Process in 1999/2000

One of the areas of concern is that management controls be implemented over a time frame that reflects the biological year of the animal. In this instance the biological year begins when the eggs have hatched. This means that once a quota is achieved and the fishery has been closed, it should not reopen until hatching is complete. Hatching for the shrimp species being exploited is generally completed in the spring of each year. The information by species and SMA on the prevalence of egg-bearing females during April and May from 1997/1998 presented in Appendix Table 4 provide information about the earliest possible time to reopen the fishery for different species and areas.

4 Discussion

As discussed above, we are proceeding through a multi-step process in order to meet the objectives of conservation and the development of databases required to understand the stock dynamics:

1. Development of assessment indices hand in hand with a precautionary management approach.
2. Probing the range of fisheries impacts on different species and stocks.
3. Development of optimal harvest strategies based on stock dynamics and long-term management goals and objectives.

As pointed out previously, at the moment we are at the first step in this process. At this point there are two main things that must be developed: the assessment indices; and the associated management decision rules. We discuss each of these below.

4.1 The Assessment Indices

There are three types of assessment indices that need to be calculated for this fishery: 1) inseason assessment of index areas for fishery independent surveys; 2) forecasting of abundance in index areas from survey, logbook and biological samples for setting next year's initial catch ceilings; and 3) extrapolation of information from index areas surveys, logbooks, and biological samples to other areas that do not receive a fishery independent survey.

4.1.1 Inseason Assessment of Index Areas

4.1.1.1 Present Situation

This was the first year that the funding has been available to develop a coast-wide program to provide stock abundance indices for shrimp trawl fisheries. These indices were obtained from 11 of 34 representative Shrimp Management Areas (SMA) along the British Columbia coastline.

Typically a survey of a single shrimp management area requires several independent assessments for each isolated ground and for several different species. For example, a survey of SMA 12-IN requires a minimum of 19 separate assessments of distinct area/species combinations.

In general, the 1998 field and analytical components of the inseason assessments went fairly well considering the problems outlined above. The results of the surveys are still only first estimates with known bias. The results from the surveys were used to adjust inseason catch ceilings. These adjustments resulted in both increases and decreases in the preliminary arbitrary catch ceilings, depending on the biomass estimates from the surveys. This resulted in reduction of the quota in one area and increases in all the remaining areas. The coast-wide increase in catch ceilings was approximately 635 tonnes of shrimp.

4.1.1.2 Suggested Changes to Inseason Assessment of Index Areas for 1999/2000

To address the field and analytical problems and discrepancies that were previously documented, we propose to pursue the following adjustments for the 1999 inseason assessments:

1. Use a standard vessel and gear whenever possible.
2. Allow more time for completion of the surveys so that we can ensure that we sample the entire area occupied by the shrimp.
3. Investigate other techniques for evaluating vertical distribution of shrimp such as the use of a multiple-net tucker trawl with shrimp web.
4. Include on-bottom trapping as a component in selected surveys.
5. Ensure that biological samples are collected more regularly from the commercial fishery. These samples are critical in the evaluation of fishery impacts by species, area and time. In 1997/98, it was obvious that there are large discrepancies between what is being reported in the fisheries landing reports and what the samples from the commercial catch and surveys would suggest is being caught with respect to species composition.
6. Continue development of the bottom typing data collection and analysis. There is still considerable developmental work, which needs to be completed before this data can be used for stock assessment. Once this data is available for assessments, it will provide useful information on the size and nature of the area of shrimp concentrations. It will then be possible to test the current design characteristics of the survey and compare with other sampling designs such as a stratified random sampling program.
7. Investigate the applicability of other interpolators such as kriging to be used in the analysis of the survey data. The evaluation of the interpolator and the cell size shows how varying these can cause differences in the abundance estimates. The selection of the best interpolator may be a function of the size and shape of the fishing grounds. We will evaluate this by incorporating both subjective and objective criteria. Subjective criteria would include visual examination of the density plots to see if the results look realistic given the available sample data. Objective criteria would make use of resampling tools such as jack-knifing and bootstrapping to obtain modelling error measurements. The selection of the appropriate cell size varied between calculations. It is planned to present the results as the median value (because it is more robust) estimated from a range of cell sizes where the estimates tended to level off.

A number of the solutions recommended above are closely allied to main forms of information that Walters and Pearse (1996) outline.

In the future, further adjustments to the assessment process will include:

1. Investigation of the use of other assessment techniques such as change in ratio estimates, depletion estimates, etc.
2. Development of a formal approach to adjusting the exploitation rate.
3. Assessment of the implications of selective fisheries.

4.1.2 Forecasting Initial Catch Ceilings

4.1.2.1 Present Situation

The initial catch ceilings were set at arbitrary levels or on the basis of historical catches in each area. In 1998 we forecasted the initial catch ceilings for Area 12-IN from the age specific estimated results from the previous year's survey. Applying growth and natural mortality estimates to the previous year's biomass indices allowed us to forecast the expected biomass at the beginning of the fishery. Growth and natural mortality estimates were based on an animal living four years and functioning as a female in its' final year of life. The major drawback to this approach is that there is very limited information on area, sex and species specific growth and mortality rates. Components of the forecasting process are biased low because the previous year's 1+ cohort was only partially recruited. The partial recruitment factors vary between species and probably also vary between years. Other estimates may be biased high if compensatory growth and sexual maturity affect age and sex specific mortality rates. For example, if primary females are subject to higher mortality rates than males of the same age and if their growth rates are reduced since they can not grow while they are carrying eggs then the forecasts will be biased high for fisheries with a high proportion of primary females.

Table 3 below shows the forecasted quotas for 1998 for Area 12-IN (determined using the data from surveys conducted in April and November 1997), and the annual quotas later estimated from the June 1998 survey results. Note that in all cases the forecasted quotas are lower than the quotas estimated from the survey. This reflects the fact that there is limited area and species specific information on growth, natural mortality and partial recruitment functions.

Table 3: Forecasted annual quotas for Area 12-IN and the annual quotas estimated from the survey. *The first value is the estimated quota using vertical trap information from the November 1997 survey, while the second value is the estimated quota using vertical trap information from the April 1997 survey.

Species	Forecasted Annual Quota (t)	Annual Quota Estimated From Survey (t)
Pinks and Coonstripes	46.3	142.7, 151.0*
Humpbacks	5.2	10.5
Sidestripes	3.4	11.0

4.1.2.2 Suggestion for Setting Initial Catch Ceilings in 1999/2000

We suggest initiating forecasts of areas that have been surveyed in 1998. Despite the shortcomings to the present forecasting system, the estimates reflect the best information available at this time and there is less risk to the stock than by setting arbitrary quotas. As more information is collected, we may be able to eliminate or reduce some of the biases that were discussed above. For areas where there is no survey information, there would be no pre-season forecasts for 1999/2000 and arbitrary quotas would have to be set. However, forecasts for these areas would be developed in the future if the inseason extrapolating of index site information is shown to be reliable.

4.1.3 Inseason Extrapolation from Index Areas

4.1.3.1 Present Situation

We have not extrapolated the information from the index areas to make in-season adjustments to the catch ceilings for non-surveyed areas. To do this we must assume that production characteristics between populations in different areas may be similar. There are also certain types of data that must be obtained from the un-surveyed area before any extrapolation can proceed:

1. Species-specific annual CPUE for the commercial fishery.
2. Estimates of the area fished over time.
3. Species composition of the catch.
4. Age structure of the catch.

The information that would be used in these extrapolations would have to come from the logbook program and an expanded program of sampling the commercial fishery.

The extrapolation process would require that the populations of shrimp in index sites and in extrapolated areas meet the following criteria:

1. Both areas must have the same species composition.
2. For each species, both areas must have similar age structures.

If these criteria are met, the estimated biomass, B_{Xt}, would be calculated as:

$$B_{Xt} = (B_{It}/A_{Itseason}) * (CPUE_{Xtseason}/CPUE_{Itseason}) * A_{Xtseason}$$

Where B_{Xt} is the biomass of the area X in year t, B_{It} is the estimated biomass of index area I at the beginning of year t, $CPUE_{Xtseason}$ and $CPUE_{Itseason}$ are standardized catch per unit effort indices for area X and index area I for year t during the period of the season prior to the survey of index area I, $A_{Itseason}$ and $A_{Xtseason}$ are the calculated areas reportedly fished in area X and index area I for year t during the period of the season prior to the survey of index area I.

4.1.3.2 Suggestions for the 1999/2000 Inseason Extrapolation from Index Areas

There is a risk of overestimating the biomass estimates using these types of comparisons due to the hyperstability of CPUE estimates. This occurs because the animals tend to concentrate in the most productive area and as stock is fished down animals in marginal areas come into the more productive areas. This results in the CPUE staying high while the stock declines. Hopefully we will at least partially compensate for this by comparing the size of the areas fished.

We will start to develop the process for extrapolation this year starting with the ideas discussed above.

4.2 Management Decision Rules

We have considered a suite of precautionary management principles from which to base decision rules for these fisheries. This arose as a result of discussions and concerns outlined in PSARC assessments of inshore (Boutillier et al. 1996) and offshore (Boutillier et al. 1997) shrimp fisheries. The management systems implemented in 1998 utilised either input or output controls to try and achieve these precautionary principles. Output controls put limits on the amount of shrimp that is removed from an area, while input controls limit the amount of effort that goes into an area. The controls used in 1998 are outlined below.

4.2.1 Output Controls

For all of the inshore fisheries and a number of offshore areas, the precautionary management approach used was based on an output control system where each SMA was assigned an arbitrary, historically based, or forecasted[1] catch ceiling. Inseason catch ceilings adjustments were made in selected index areas, which either raised or lowered the initial estimates. These adjustments resulted from information based on fishery independent biomass indices and commercial catches. When survey biomass information became available, an adjusted catch ceiling quota was set using a maximum harvest rate target of 33% (Boutillier et al. 1996).

A further refinement to the precautionary approach occurred in the Fraser River SMA where the exploitation rate was reduced to 25%. The target exploitation rate was reduced in this area due to an ongoing concern that the population had been overfished (Boutillier et al. 1996). The reduced harvest rate for this area was set at an arbitrary level in 1998. However there are formalised processes in place (such as using target rate references that correspond to biological reference points such as $F_{35\%}$, F_{high}, F_{low}, and F_{med}) that are used to refine exploitation levels in rebuilding situations. This type of rebuilding strategy has been adopted in the USA for stocks that fall below B_{MSY} (Thompson and Mace 1997). Harvest rate decreases linearly as a function of stock size. The decline in harvest rate continues and reaches zero at a point where the population reaches a very low level (conservation target level).

This shutdown level varies in fisheries literature from 5% B_{MSY} (Thompson and Mace 1997) to the level where the spawning stock biomass per recruit is 20-30% of the value for the virgin stock (Mace and Sissenwine 1993, Zheng et al. 1993, Myers et al. 1994, Garcia 1996). The use of biological reference points has been the subject of some major initiatives in recent years. In particular, it is the key element in defining the code of practice that organizations such

---

[1] Forecasting only took place in Pacific Fisheries Management Area 12 where there was information from research trawl surveys conducted the previous year (both in April and November 1997).

as FAO, ICES, and NAFO are adopting. In the USA, the Magnuson-Stevens Act requires that each Fish Management Plan specify objective and measurable criteria for identifying when stocks are overfished. Zheng et al. (1993) compared seven methods to calculate limit thresholds and noted that different methods are preferable depending on the data available. They concluded that if a stock-recruit relationship is available, the default percentage method is recommended. They found that 25% of pristine biomass was among the optimal threshold levels when the increase in mean yield and decrease in standard deviation are weighted.

The criteria to establish an appropriate critical conservation limit threshold where no further fishing is allowed should be determined by taking into account the animals' life history production characteristics. These criteria would consider production characteristics such as the resilience of the species to recover and likelihood of the stocks being subjected to depensatory mechanisms. More important, however, in the final selection of criteria, is the uncertainty of the parameter estimates of the stock dynamics.

If the precautionary process is instituted at the beginning of the fishery there should be little likelihood of having to implement these critical conservation limit thresholds. It should be recognised, however, that during the probing stages of the management process, some stocks will be overfished, where overfished means that the population will fall below B_{MSY} and that a rebuilding strategy must be implemented.

4.2.2 Input Controls

The use of input controls to achieve precautionary management principles was implemented for the offshore fisheries in the southern and central regions off the West Coast of Vancouver Island (WCVI). In this case, a six-month opening was implemented from May 1 to October 31, 1998. Garcia (1996) points out that fishing seasons could be established as a management tool if the aim is to ensure some average escapement. He does point out that this strategy could work for long-lived animals with low recruitment variability but that for short-lived animals with highly variable recruitment, long-term average controls would need to be 'fine tuned' inseason to account for year-to-year variability. Walters and Pearse (1996) note that input controls using area and time closures have been successful in instances where the effort is constant and time can be varied to achieve predefined limits. In the salmon seine fishery, harvest rate targets are achieved with very short openings. The effort is so efficient in this fishery that all the fish in the area can be taken with the fleet in the area. Therefore, the opening time depends on the estimated proportion of fish that are migrating through the area during the opening period. For the shrimp trawl fishery off WCVI, the 6-month opening is not very restrictive and is not likely to achieve the desired harvest rate target, as there is no control on the amount of effort. Use of this type of input control would have to balance the effective effort in the area with the time the fishery was open. Other input controls such as the use of large Marine Protected Areas (MPAs) may be considered if critical areas such as recruitment areas for a metapopulation can be identified. The recruitment process for these offshore stocks appears to be strongly influenced by environmental factors such as ocean transport. There also appears to be a strong south to north recruitment interdependence between grounds (Boutillier et al. 1997). An input control system using area restrictions, such as an MPA, might protect large portions of the southern grounds.

Another key component of the management system is the spatial scale for the present SMA system. The results of this year's surveys show that there appears to be a number of discrete stock areas within a single SMA. These areas were determined to be discrete because of their species composition and growth rates. This would argue that there may be some localised stock dynamics and as such, setting a single quota for a large SMA might lead to severe localised overfishing problems.

The criteria discussed above for shrimp management on the Pacific coast of Canada was the first step of this process in data limited situations. Over the long term, the management and assessment of these fisheries will undergo a number of changes that reflect a better understanding of these initial thresholds. These changes will result from management and assessment based on unbiased estimates of biomass and the evaluation of the effect of management decision rules.

4.2.3 Suggestions for 1999/2000 Management Decision Rules

1. Initially, critical conservation limit thresholds should be set quite high. Mace and Sissenwine (1993) suggest that maintaining at least 30% of the maximum historic SPR is a conservative strategy when there is no basis for estimating replacement rates.
2. Quotas set for large areas such as the presently defined SMA will likely lead to localised depletion. Management with output controls needs flexibility with respect to openings and closures of portions of SMA.
3. Management with input controls needs to be refined to ensure that controls meet target threshold levels.

5 Acknowledgements

We gratefully acknowledge the assistance provided by a great number of people during the surveys conducted in 1998. These include the officers and crews on the fisheries vessels W.E. Ricker and Caligus, and the commercial vessels Diligent, Foxy Lady II, Frigga, Lady Luoma, Mae Ann, Maile III, Ocean Dancer, Pacific Rancher, Parr Four, Sonora II, Trident Isle, Westerly Gail, and Western Clipper. In addition we would like to thank Laurie Convey, Mike Erikson, Steve Head, Roy Hinder, Sean Kask, Jeff Olsson, Peter Mattson, Annie Smith, and Debbie Tufnail, all of whom participated in one or more surveys as biological technicians.

6 References

Boutillier J.A., A.N. Yates and T.H.Butler. 1977. G.B.Reed shrimp Cruise 77-S-1 May 3-14, 1977. Fish and Marine Serv Data Report No. 37: 42 p.

Boutillier J.A., M. Joyce, J. Bond and I. Winther. 1996. Assessing the Inshore Shrimp Fisheries: Data Status, Model Requirements, Problems. PSARC Working Paper I-96-11.

Boutillier J.A., R. I. Perry, B. Waddell and J. Bond. 1997. Assessment of the Offshore *Pandalus jordani* Trawl Fishery Off the West Coast of Vancouver Island. PSARC Working Paper I-97-11.

Boutillier J.A., J.A. Bond and R.M. Harbo. 1998. 1997 Industry Sponsored Shrimp Surveys and Resulting Management Actions – Area 12, April and November 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2458: 94 p.

Garcia. S.M. 1996. Stock-Recruitment Relationships and the Precautionary Approach to Management of Tropical Shrimp Fisheries. Mar. Freshwater Res. 47: 43-58.

Hannah, R.W. 1995. Variation in Geographic Stock Area, Catchability, and Natural Mortality of Ocean Shrimp (*Pandalus jordani*): Some New Evidence for a Trophic Interaction with Pacific Hake (*Merluccius productus*). Can. J. Fish. Aquat. Sci. 52: 1018-1029.

Mace, P.M. and M.P. Sissenwine. 1993. How much spawning per recruit is enough? *In* S.J. Smith, J.J. Hunt and D.Rivard [ed.] Risk evaluation and biological reference points for fisheries management. Can. Spec. Publ. Fish. Aquat. Sci. 120.

Myers R.A., A.A. Rosenberg, P.M. Mace, N. Barrowman and V.R.Restrepo. 1994. In search of thresholds for recruitment overfishing. ICES Jour. Of Mar. Sci. 51. 191-205.

Schnute, J. and D. Fournier. 1980. A New Approach to Length-Frequency Analysis : Growth Structure. Can. J. Fish. Aquat. Sci. 37(9): 1337-1351.

Southey, K., R. Harbo, and J. Boutillier. 1998. Shrimp Trawl Fishery – 1997/98. PSARC Fishery Update.

Walters, C. and P.H. Pearse. 1996. Stock information requirements for quota management systems in commercial fisheries. Rev. in Fish Bio and Fish. 6. Pp 21-42.

Thompson G.G. and P. Mace 1997. The evolution of precautionary approaches to fisheries management, with focus on the United States. NAFO SCR Document 97/26. 14p.

Survey	Vessel(s) Used	Gear	Survey Design	Vertical Traps Used?	Biomass Procedure
WCVI (May 5-16)	WE Ricker (Areas 121, 123, 124, and 125) and 3 commercial beam vessels : FV Lady Luoma, FV Sonora II, FV Trident Isle (Area 23)	18.6 m high rise otter trawl (WE Ricker), 14.6 to 15.2 m high rise beam trawls (commercial vessels)	Systematic	Yes, no adjustments necessary	Bicubic Spline 300 m grid
Area 12-IN (June 3-5)	5 commercial beam vessels (FV Diligent, FV Foxy Lady II, FV Frigga, and FV Mae Ann for trawling, FV Maile III for trapping)	13.1 to 14.0 m beam trawls	Systematic	Yes, adjustments made	Sector Search 160 m grid
QC Sound (July 14-15)	5 commercial door vessels (FV Ocean Dancer, FV Pacific Rancher, FV Parr Four, FV Westerly Gail, Western Clipper)	23.2 to 27.4 m high rise otter trawls with 1.5 to 2.1 m trawl doors	Systematic	No	Bicubic Spline 300 m grid
FR (Aug. 12-21)	Caligus	17.7 m high rise otter trawl with 1.7 m Whitewater trawl doors	Systematic	Yes, no adjustments necessary	Bicubic Spline 300 m grid
Chatham Sound (Aug. 29-Sept.7)	Caligus	17.7 m high rise otter trawl with 1.7 m Whitewater trawl doors	Systematic	Yes, adjustments made	Bicubic Spline Median value for range of 200-500 m
Area 12-OUT (Sept. 11-15)	Caligus	17.7 m high rise otter trawl with 1.7 m Whitewater trawl doors	Systematic	Yes, no adjustments necessary	Sector Search Median value for range of 200-500 m

Appendix Table 1: Logistics of shrimp surveys conducted between April and October 1998.

Area	Subarea or SMA	Area(km2)	Species	Total Biomass(t)	Quota (t) from survey	Initial Quota (t)
WCVI	23-IN	89.28	Pinks & Sidestripes	222.862	73.545	175
(May 4-17, 1998)	23-OFF & 21-OFF	1485.63	Pinks & Sidestripes	1103.176	N/A	
	124-OFF	2567.79	Pinks	281.683	N/A	
	125-OFF	2029.86	Pinks	44.066	N/A	
12-IN	12-26, 12-39,		Pinks & Coonstripe(1)*	424.913	140.221	46.27
(June 3-5, 1998)	12-40 and 12-42	115.20	Pinks & Coonstripe(2)*	400.191	132.063	
			Sidestripes	52.602	17.359	3.4
			Humpbacks	34.858	11.503	5.16
QC Sound	9IN		Pinks	138.716	45.776	
(July 14-15, 1998)			Sidestripes	101.223	33.404	
	7IN		Pinks	56.098	18.512	
			Sidestripes	11.616	3.833	
	QCSOUND		Pinks	2899.468	956.824	
			Sidestripes	227.664	75.129	
	All of QC Sound	1721.16	Pinks & Sidestripes	3434.785	1133.479	600
FR	28-1, 29-2, 29-3		Northern Pinks	485.990	160.377	
(Aug. 12-21, 1998)			Smooth Pinks	10.550	3.482	
			Sidestripes	242.661	80.078	
	Total FR	572.04	Pinks & Sidestripes	739.201	243.936	90
PRD	3-02, 4-05,		Sidestripes	390.248	128.782	100
(Aug. 27 - Sept. 7, 1998)	4-09 and 4-12	682.20				
			Northern Pinks	500.879	165.290	
			Smooth Pinks	346.753	114.428	
			Humpbacks	1.023	0.338	
			Other Shrimp	848.655	280.056	100
12-OUT	12-07	289.80	Northern Pinks	14.708	4.854	
(Sept. 11-15, 1998)			Smooth Pinks	25.139	8.296	
			Sidestripes	103.006	33.992	
			All	142.853	47.141	10

*The two estimates of pink+coonstripes are from the results of vertical trapping in Apr. 1997 [Pink&Coonstripe(1)] and in Nov. 1997[Pink&Coonstripe(2)]

Appendix Table 2: Areas surveyed, median biomass estimates, quotas from surveys, and initial quotas.

Survey	Shrimp Management Area	Management Actions	Concerns Identified
WCVI (May 4-17, 1998)	23IN	• Area opened April 1, 1998 • Initial catch ceiling reduced as a consequence of survey results (from 175 t to 67 t) • New catch ceiling attained and area closed May 29, 1998	• Shrimp stocks in the inshore areas are showing classic signs of fishery induced compensatory mechanisms (eg increased growth rates and early maturation)
	21OFF 23OFF 124OFF 125OFF	• No catch ceiling assigned • Areas managed with a 6-month seasonal opening from May 1 to October 31, 1998 • No actions as a result of survey	• 124OFF and 125OFF continue to show severe declines in abundance • 21OFF and 23OFF are in better shape but are also experiencing severe declines • The southern areas (21OFF and 23OFF) appear to be critical to the recruitment of stocks in the more northerly offshore areas
12 Inside (June 3-5, 1998)	12IN	• Area opened May 15, 1998 and closed on May 25, 1998 when the initial catch ceiling was attained • Area re-opened June 26, 1998, with an additional quota of 77 t of mixed pinks, based on survey results • The second catch ceiling was attained and the area closed on July 2, 1998	• Discrepancies between catch records and survey and bycatch results indicate that many of the smaller sidestripes are included in the pink shrimp landings, thus landing records under-estimate sidestripe catch and over-estimate pink catch
QC Sound (July 14-15, 1998)	QCSND	• Area opened April 1, 1998 with the requirement of amended licence conditions and closed July 12, 1998, when the initial catch ceiling was attained • Area re-opened August 8, 1998, with an additional quota of 270 t, based on survey results • The second catch ceiling was attained and the area closed on August 22, 1998	• The survey did not include several known shrimp producing areas, such as Goose Island Gully and the Stump Ranch areas
	9IN	• Area opened April 1, 1998 and closed July 2, 1998 when the initial catch ceiling was attained • Area re-opened August 8, 1998, with an additional quota of 35 t, based on survey results • The second catch ceiling was attained and the area closed on August 26, 1998	
	7IN	• Area opened on April 1, 1998 and closed July 21, 1998, when the initial catch ceiling was attained • Area re-opened August 5, 1998, with an additional quota of 12 t, based on survey results • The second catch ceiling was attained and the area	

		closed on October 2, 1998	
Fraser River (August 12-21, 1998)	FR	• Area opened April 1, 1998 and closed July 1, 1998, when the initial catch ceiling was attained • Additional quota was calculated using a 25% exploitation rate (as opposed to a 33% rate) because of conservation concerns • Area re-opened November 6, 1998, with an additional quota of 100 t, based on survey results	• Majority of Northern Pink shrimp was found to be made up of a single year class (over 80% age 1+ animals) • Discrepancies between catch records and survey and bycatch results indicate that many of the smaller sidestripes are included in the pink shrimp landings, thus landing records under-estimate sidestripe catch and over-estimate pink catch
Chatham Sound (August 27 – September 7, 1998)	PRD	• Area opened April 1, 1998 • Initial quota was adjusted based on survey results (an additional 29 t of sidestripes and 180 t of all other species was assigned)	• Due to logistics, the known shrimp grounds off Dundas Island were not surveyed • Percentage of age 2+ sidestripes was found to be low in comparison to the percentage of age 3+ sidestripes, which would indicate that there will be a reduced number of large (3+) sidestripes in the 1999/2000 fishery • Discrepancies between landing records and survey or bycatch results is usual due to the sorting of shrimp on the basis of size rather than species – normally it is expected that many of the small sidestripes will be mixed in with the pink shrimp catch, however, discrepancies in this area were not what was expected, which may indicate that some boats are successfully targeting through gear and area selectivity on large sidestripes, or dumping of pinks is occurring
12-Outside	12OUT	• Area opened May 15, 1998 and closed on June 22, 1998, when the initial catch ceiling was attained • Area re-opened on November 6, 1998 with an additional quota of 29 t of sidestripes based on survey results	• Discrepancies between catch records and survey results indicate that many of the smaller sidestripes are included in the pink shrimp landings, thus landing records under-estimate sidestripe catch and over-estimate pink catch • The proportion of age 2+ sidestripes was low in comparison to the age 1+ and age 3+ animals, and also low in comparison to the number of 2+ and 3+ animals seen in the November 1997 survey – it is likely that the number of large sidestripes available in the 1999 fishery will be lower than in both 1997 and 1998 • Not all of 12OUT was surveyed

Appendix Table 3: Areas surveyed, management actions taken, and concerns identified

		% Egg Bearing	
Area	Species	April	May
7	Smooth Pinks		0.40%
	Sidestripes		0.78%
9	Smooth Pinks		0.00%
	Sidestripes		1.00%
10	Smooth Pinks		0.00%
	Sidestripes		1.01%
12	Northern Pinks	5.31%	0.00%
	Humpbacks	20.98%	0.24%
	Smooth Pinks		0.00%
	Sidestripes	8.48%	1.24%
14	Smooth Pinks		0.07%
	Sidestripes		0.37%
18	Northern Pinks	0.00%	0.00%
	Coonstripes	19.09%	8.14%
	Smooth Pinks	3.31%	
	Sidestripes	0.88%	
19	Coonstripes		2.08%
23	Smooth Pinks	0.00%	0.00%
	Sidestripes	0.57%	0.00%
27	Smooth Pinks		0.00%
	Sidestripes		0.00%
28	Northern Pinks	6.02%	
	Smooth Pinks	4.35%	
	Sidestripes	5.28%	
29	Northern Pinks	7.26%	
	Sidestripes	6.37%	
107	Smooth Pinks		0.00%
108	Smooth Pinks		0.00%
	Sidestripes		0.00%
109	Smooth Pinks		0.00%
121	Smooth Pinks		0.76%
123	Smooth Pinks	0.00%	0.02%
	Sidestripes		0.05%
124	Smooth Pinks		0.02%
125	Smooth Pinks	0.00%	0.00%
127	Smooth Pinks		0.00%

Appendix Table 4: Percentage of egg-bearing shrimp, by area and species, taken in biological samples in 1997 and 1998.