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Proceedings of the Pacific Scientific Advice Review Committee (PSARC) Invertebrate Subcommittee Meeting: Review and advice for stock assessment and quota options for Green sea urchin, reference points and a precautionary harvest strategy for the Razor clam fishery on Haida Gwaii, survey methodologies for monitoring for Olympia Oyster, sea cucumber assessment framework, and for rockfish bycatch in the commercial prawn trap fishery.

Compte rendu de la réunion du sous-comité sur les invertébrés – Comité d'examen des évaluations scientifiques du Pacifique (CEESP) : examen et avis relatifs à l'évaluation des stocks et des options de quotas pour la pêche à l'oursin vert; aux points de référence et à la stratégie de pêche fondée sur l'approche de précaution pour la pêche au couteau dans le secteur Haida Gwaii; aux méthodes de relevé pour la surveillance de l'huître plate du Pacifique; au cadre d'évaluation pour le concombre de mer; aux prises accessoires de sébaste dans la pêche commerciale à la crevette au casier.

December 1-3, 2009

**Pacific Biological Station
Nanaimo, BC**

Ray Lauzier, Chairperson

1 et 3 décembre 2009

**Station biologique du Pacifique
Nanaimo, CB**

Ray Lauzier, président de la réunion

March 2010

Mars 2010

Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings include research recommendations, uncertainties, and the rationale for decisions made by the meeting. Proceedings also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

Avant-propos

Le présent compte rendu a pour but de documenter les principales activités et discussions qui ont eu lieu au cours de la réunion. Il contient des recommandations sur les recherches à effectuer, traite des incertitudes et expose les motifs ayant mené à la prise de décisions pendant la réunion. En outre, il fait état de données, d'analyses ou d'interprétations passées en revue et rejetées pour des raisons scientifiques, en donnant la raison du rejet. Bien que les interprétations et les opinions contenus dans le présent rapport puissent être inexacts ou propres à induire en erreur, ils sont quand même reproduits aussi fidèlement que possible afin de refléter les échanges tenus au cours de la réunion. Ainsi, aucune partie de ce rapport ne doit être considéré en tant que reflet des conclusions de la réunion, à moins d'indication précise en ce sens. De plus, un examen ultérieur de la question pourrait entraîner des changements aux conclusions, notamment si l'information supplémentaire pertinente, non disponible au moment de la réunion, est fournie par la suite. Finalement, dans les rares cas où des opinions divergentes sont exprimées officiellement, celles-ci sont également consignées dans les annexes du compte rendu.

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SUMMARY

Participants from Fisheries and Oceans Canada (DFO) Science, Habitat Management and Fisheries and Aquatic Management Sectors and external participants from the non-governmental organizations (NGO) community, industry, and the general public including invited biological consultants attended a PSARC invertebrate review on December 1-3, 2009 to assess and develop advice for the following working papers:

- Estimation of reference points and a precautionary harvest strategy for the razor clam (*Siliqua patula*) fishery at Haida Gwaii
- Evaluation of survey methodologies for monitoring Olympia Oyster (*Ostrea lurida* Carpenter, 1864) population in British Columbia
- Assessment framework for Sea Cucumber (*Parastichopus Californicus*) in British Columbia
- Rockfish bycatch in the British Columbia commercial prawn trap fishery

One Science Advisory Report (SAR) was reviewed:
- Stock assessment and quota options for the Green Sea Urchin (*Strongylocentrotus droebachiensis*) fishery in British Columbia, 2010-2013

Comments received on the four working papers and SAR are presented in these Proceedings. The papers were accepted subject to revisions. Products of the meeting will be four CSAS Research Documents and a CSAS Science Advisory Report.

SOMMAIRE

Les participants, incluant des représentants de Pêches et Océans Canada (MPO) des secteurs des Sciences, de Gestion de l'habitat et de Gestion des pêches et de l'aquaculture ainsi que des représentants d'organisations non gouvernementales (ONG), de l'industrie et du grand public, y compris des consultants en biologie invités, ont pris part à un examen du CEESP sur les invertébrés du 1er au 3 décembre 2009. Dans le cadre de cet examen, ils ont évalué les documents de travail suivants et formulé des avis sur ceux-ci.

- Estimation des points de référence et stratégie de pêche fondée sur l'approche de précaution pour la pêche au couteau (*Siliqua patula*) dans le secteur Haida Gwaii.
- Évaluation des méthodes de relevé pour la surveillance de la population d'huître plate du Pacifique (*Ostrea lurida*; Carpenter, 1864) de la Colombie-Britannique.
- Cadre d'évaluation pour le concombre de mer (*Parastichopus Californicus*) en Colombie-Britannique.
- Prises accessoires de sébaste dans la pêche commerciale à la crevette au casier en Colombie-Britannique.

Un avis scientifique (AS) a été examiné.
- Évaluation des stocks et des options de quotas pour la pêche à l'oursin vert (*Strongylocentrotus droebachiensis*) en Colombie-Britannique (2010-2013).

Le présent compte rendu résume les commentaires formulés à propos des quatre documents de travail et de l'AS. Les documents ont été acceptés sous réserve de révisions. Les produits de la réunion comprendront quatre documents de recherche et un avis scientifique du SCCS.

INTRODUCTION

The PSARC Invertebrate Subcommittee met December 1-3, 2009 at the Pacific Biological Station, in Nanaimo, British Columbia. External participants from industry, First Nations and conservation groups attended the meeting. The Subcommittee Chair, R. Lauzier opened the meeting by welcoming the participants, reviewed the agenda and referred to the terms of reference. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda.

The Subcommittee reviewed four working papers and one Science Advisory Report. Summaries of each working paper are included as Appendix 1, the meeting agenda appears as Appendix 2, the terms of reference is Appendix 3 and the list of attendees is Appendix 4.

DETAILED COMMENTS FROM THE REVIEWS

STOCK ASSESSMENT AND QUOTA OPTIONS FOR THE GREEN SEA URCHIN (*STRONGYLOCENTROTUS DROEBACHIENSIS*) FISHERY IN BRITISH COLUMBIA, 2010-2013
B. Waddell, Z. Zhang and I. Perry

Science Advisory Report accepted with revisions

General Discussion

There were two reviewers for this paper and both found the paper to be well written, clear and concise. The first reviewer could find no major or minor fault with the methodology, data analysis, and interpretation of the results or recommendations. Both reviewers agreed that increasing the collection and analysis of fishery-independent data would reduce risk and uncertainty. The authors pointed out this was a small fishery with limited funding, which reduces the opportunity for fishery-independent surveys. The second reviewer raised the question of why there were different harvest rates between the two main fishing zones, Northeast Vancouver Island (NEVI: PFMA 12-13) and Southeast Vancouver Island (SEVI: PFMA 18-19). It was explained that a lower harvest rate was needed in SEVI as there are increased uncertainties (lack of fishery-independent surveys) in this region. The second reviewer also pointed out the increasing biomass and CPUE during the last 5 years in PFMA 12 may be due to less than 50% of the Total Allowable Catch (TAC) being harvested due to unfavourable market conditions, and the impact of the set TAC's could not truly be assessed since the recommended TAC's were not reached. In reply, the authors argued that setting the TAC is independent of whether the full TAC is actually reached. The second reviewer agreed with the authors that new index sites should be established for PFMA 13 and 18.

During the Subcommittee discussion, the issue of setting reference points to be compliant with the precautionary approach was raised. It was recognized that Maximum Sustainable Yield (MSY) is a limit reference point, and target reference points would be a smaller proportion of the MSY. At present, the limit reference point is set (as the MSY) but a range of potential target reference points (and their probabilities of exceeding the limit point) are provided for selection by the fisheries managers. The question was raised

as to why Fulford Reef was selected as an index site, when it is the target of a very intensive fishery, with most of the PFMA 19 quota being taken from this site. The authors explained that the objective of surveying Fulford Reef is to assess the impact of an intensive fishery, which is comparable to the surveys at the index site in PFMA 12 with three sites: intensive harvesting; no harvesting and moderate harvesting.

There were concerns raised about localized area overharvesting and how it could be managed. Diver (harvester) behaviour has changed as harvester experience increases resulting in high production and high quality areas being targeted. However, it was pointed out by a commercial diver that harvesters make an effort to leave a number of urchins in order to encourage recruitment; because in previous experience by industry, fishing down particular beds to very low levels has resulted in poor recovery of legal-sized green urchins. There is no bed by bed assessment in this fishery, and the harvested areas are assumed to consist of open populations that are getting recruits from depth and adjacent locations. In the case of Fulford Reef, after the 2009-2010 fishing season ends in March 2010, there will be another fishery-independent survey at this location to examine the impact of the intensive 2009-2010 fishery, and there will be a closer examination of controls on targeted effort on high production areas for future fishing seasons.

Conclusions

It was recognized this is a small fishery with limited funding, which reduces the opportunity for fishery-independent surveys which are recommended to reduce risk and uncertainty.

It was recognized that diver behaviour has changed as experience increases, resulting in targeted harvests in highly productive areas with high quality product. A fishery-independent survey in March 2010 will assess the impact of an intensive harvest at Fulford Reef in PFMA 19 during the 2009-2010 fishing season to assist in determining whether controls would be necessary on localized intensive harvests.

Recommendations

1. The Subcommittee recommended acceptance of the Science Advisory Report with revisions.
2. The Subcommittee recommended that two documents be produced from this Science Advisory Report:
    a. An expanded version, including information on methodology, and more details on fishery-independent surveys, that will result in a Canadian Science Advisory Secretariat (CSAS) Research Document,
    b. A condensed version that will result in a Science Advisory Report that does not include the table of previous management actions, or the references, and generally contains a reduced number of tables.

ESTIMATION OF REFERENCE POINTS AND A PRECAUTIONARY HARVEST STRATEGY FOR THE RAZOR CLAM (*SILIQUA PATULA*) FISHERY AT HAIDA GWAII
R. Jones, S. Jeffery, B. DeFreitas, and C. Schwarz

Working paper accepted with revisions

<u>**General Discussion**</u>

There were two reviewers for this paper, one external and one internal. Both reviewers had concerns with the incomplete description of some aspects of the biomass estimation process, and the need for an evaluation of recommended options in order to present them in a form suitable for consideration by Fishery Managers.

The first reviewer found the paper difficult to follow, and in particular, was concerned that the lack of detail on how the data was used to draw conclusions and make recommendations impeded the reviewer from evaluating the data, analyses and conclusions. The reviewer suggested an introduction to the models and inputs of the Yield Version 1.0 software would greatly improve the understanding of the processes used. In addition, the reviewer suggested a discussion on how data shortfalls such as missing survey estimates of ageing error may have impacted the analysis and conclusions. The reviewer pointed out there were errors, omissions and the use of non-standard terms that contributed to the difficulty of interpreting the analysis and conclusions, and provided examples. It should be noted that some of this reviewers concerns about the illegibility of the equations used were due to the conversion of the original Word document to a PDF document sent to reviewers. The first reviewer believes with better explanation of the methods used and with editing, this paper would provide useful insight into razor clam management on Haida Gwaii as well as elsewhere.

The second reviewer compared the original information requests for the working paper with what was delivered with this working paper and noted some omissions. The author agreed that some of the objectives remain to be addressed, and that the goal of the anticipated revisions is to meet the original objectives of the working paper. The second reviewer believes that the presentation and utilization of the available data from the fishery are relatively complete. A new framework consistent with the Precautionary Approach is proposed in the paper, and the reviewer would have preferred to see both a retrospective analysis of the framework using historic stock levels, as well as forecasting simulations of the framework rather than simulations of a singles harvest rate. While new reference points and a new management framework are presented based on updated information, the reviewer does not believe there is enough information for managers to decide if they are appropriate or for managers to be able to predict potential outcomes of these new measures. This reviewer agreed that a more comprehensive description of the Yield Version 1.0 is needed to better evaluate the significance of the outputs. The reviewer does not believe there is sufficient information to support increasing the harvest rate from 0.123 to a maximum of 0.29. The reviewer suggested that presenting a Management Strategy Evaluation (MSE) in which the fishing mortality F varies with the Management Framework (i.e. changes from target level in the Healthy Zone to a lower level in the Cautious Zone to 0 in the Critical Zone) would better inform managers of the performance of a range of potential F values. The reviewer suggested a review of the performance of recruitment forecasts from previous years would inform managers on the

reliability of the technique and would allow the assessment of risks of departing from the current method of using mean estimates to predict biomass at the beginning of the year.

The author responded to the reviewers' specific comments and concerns, concurring with most criticisms and the suggestion that more information on the Equilibrium Yield Per Recruit model be added. More information on the software (Yield Version 1.0) will be requested from the programmers. In addition, it was noted that more information is needed on the implications of making choices around harvest rate and reference points. The author informed the Subcommittee that Total Allowable Catch options for 2010 will be available for discussion once ageing is complete on 2009 clams. He noted that the "transient analyses" conducted to gain the range of possible harvest rates was performed in lieu of a more complex harvest strategy simulation. As detailed in the Sustainable Fisheries Framework policy recommendations for provisional reference points, the authors chose to recommend the standard 0.4 and 0.8. Comparison of the proposed new harvest rates to the current 0.123 is needed. Forecasting recruitment for the biomass model was recognized as potentially problematic, and some retrospective analysis has been done to verify the assumptions. There is quite a bit of variability in the data, which could be a result of sampling error due to differences between beach substrate and clam density.

Overall, the author felt that the method presented in the paper was an improvement on the current biomass estimation process, even with the fine-tuning noted. He will add more discussion to clarify the reviewers' main questions, but noted it will be difficult to model much of the additional requests.

There was Subcommittee discussion on the objectives for the paper, as outlined in the Request for Working Paper, and the applicability of the advice for Fisheries Management. There was some discussion on the goals for the fishery. There may be a desire to keep the harvest rate low, as harvesters do not want to glut the market, considering there is still frozen product from last year's or previous years' harvest. At present, 20% of the harvest is for the food market and the remainder is for crab bait. There is recognition that bringing management goals into the analysis is key.

A more detailed discussion occurred on the need for information on the model used, on the different options available to estimate Fishing Mortality, F (i.e. Yield per Recruit analysis), and on the range of proportions of F considered in this paper ($F_{0.1}$, $F_{0.2}$). The Subcommittee felt that a greater range of options could be presented to Fishery Managers, with discussion on the relative risk of using each.

There was Subcommittee discussion on the use of Age 2+ animals in the estimate of Fishing Mortality, F, particularly as the estimate of Natural Mortality, M, considered only Age 3+ animals. It was noted that if the main interest is to estimate M, it is better to use Age 3+ animals. The author noted that some comparison of the two strategies had been done, and showed an insignificant (2%) difference.

The Subcommittee noted a general concern for the small difference between the legal harvestable size limit (90mm) and the calculated age at maturity (87mm, 50% population). This concern has been raised by the authors in previous papers, and should be discussed again in light of new ageing data.

There was a discussion about survey scheduling and the use of annual biomass estimates to provide a "check" on the choice of harvest rate, if increased as recommended. For example, what are the decision rules for choice of harvest rate, and how quickly can new biomass be determined in order to track a potentially large change in a short time frame so as to prevent long term damage? Surveys are conducted annually, so any change should be apparent and response possible within a season. In addition, annual ageing data now used for forecasting recruitment provides a new level in certainty of biomass estimates.

The Subcommittee discussed the second reviewer's recommendation that a Management Strategy Evaluation (MSE) be conducted on the use of provisional reference points and a new harvest rate. The MSE considers all goals and objectives, including socio-economic goals, and makes a determination on how often a particular strategy will force a population into the Cautious and Critical Zones. From this type of analysis, Fishery Managers can determine risk and level of comfort, and discuss these concepts with harvesters. For example, the use of F_{msy} is a reasonable approach if reference points are used to truncate the fishery; the difficulty comes in defining the "ramp-down" rate as the harvest approaches or enters the Cautious zone (i.e. is it perfectly linear?).

Finally, there was significant discussion on the feasibility of implementing the recommended increased harvest rate (0.22, from the current 0.123). Through the history of the fishery, there have been numerous times where the current harvest rate has been exceeded, and there were concerns that this could continue to happen with the new harvest rate, putting the population at higher risk. Conversely, it was noted that the biomass following some of those years of 'high harvest' did not appear to reflect the additional effort negatively, and, in fact, was higher than the previous in some years.

Conclusions

The Subcommittee agreed that the description on some aspects of the biomass estimation process was incomplete and felt that an evaluation of recommended options be addressed in the revisions.

The Subcommittee recommended that a Management Strategy Evaluation be conducted on the use of provisional reference points and new harvest rate.

The Subcommittee recommended two future papers on razor clams for peer-review: (1) documentation of forecasting recruitment before including forecasted recruit in biomass estimates; and (2) a future analysis with more sophisticated models.

Recommendations

1. The Subcommittee recommended acceptance of the working paper with major revisions.

2. The Subcommittee accepted Recommendation No. 1 of the draft working paper with the following note: "The current harvest rate of 0.123 be increased to 0.22 (F0.2), but without adding a forecast of recruitment to biomass estimates. Only survey estimates of biomass will be used."

3. The Subcommittee accepted Recommendation No. 2 of the draft working paper: "Implement provisional reference points of 0.4 B_{msy} and 0.8 B_{msy}. This is implemented at $F_{0.2}$, and harvest should never exceed F_{max} (0.37)."

4. The Subcommittee recommend a future paper be written to document the forecasting of recruitment and to remove forecasting from biomass estimation until the process is documented and peer-reviewed.

5. The Subcommittee recommended a second future analysis should consider more sophisticated models. For example, this analysis appears to be restricted to using one value of Natural Mortality, M.

6. The Subcommittee recommended a retrospective analysis of the provisional reference points and new harvest rate be conducted, to determine how past years would have performed under this strategy with a Management Strategy Evaluation (MSE). The MSE should consider providing a range of options at the proportion of F_{msy} (i.e. $F_{0.2}$), and provide an analysis of performance in terms of the Precautionary Approach The Subcommittee recognized this is a complex analysis, and would not be undertaken within the revisions in the current working paper.

7. The Subcommittee recommended an age-specific mortality analysis to reduce uncertainty in forecasting be completed.

EVALUATION OF SURVEY METHODOLOGIES FOR MONITORING OLYMPIA OYSTER (*OSTREA LURIDA* CARPENTER, 1864) POPULATIONS IN BRITISH COLUMBIA
T. Norgard, S. Davies, L. Stanton and G. Gillespie

Working paper accepted with revisions

General Discussion

There were two reviewers for this working paper, one external and one internal. The first reviewer thought the objectives of the working paper were clearly stated and the attention to detail was impressive in explaining the data and methods, to the extent they were assessed. The reviewer was impressed with the amount of thought combined with on the ground practicality to evaluate survey methodologies. The reviewer agreed with the authors that coupling a GPS mapping tool with the outlined methods is very useful in better defining oyster bed boundaries for improved monitoring of temporal variability. The second reviewer made suggestions for improving the structure of the methods section based on issues and options. This reviewer also had concerns about Equations 5 and 6 in the working paper and suggested that more explanation was necessary for a clearer understanding of the purpose of Equation 5.

There was concern expressed during the Subcommittee discussion on the quantitative methods and the impact on the degree of certainty. One is more sophisticated and would be used for detailed surveys; the second method uses GPS technology, but the certainty

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provided by this method still needs to be determined. It was recognized that consistent methods need to be used with repeat surveys.

The discussions focused on repeatability of proposed methods, especially on how methods are going to be used by different user groups that may not have a scientific background. There was discussion from several perspectives on the difficulty in defining the edge of the bed and the potential method(s) of doing so. Of particular concern was the fact that the GPS method field testing was not presented in the paper and therefore part of the recommendation for this method is not currently supported. The authors commented that some data are missing in the analysis and as a result, some overlaps of methodologies over the same site are not presented; the data may be available during revisions. The authors would like to develop standards to define the upper edge of the beds (the lower edge is generally easy to define). There were some discussions on what constitutes an index site, but this is not the aim of the paper. However, the authors have indicated that they will add some text about index sites in order to clarify one of the recommendations.

Conclusions

Two types of quantitative surveys, two stage or simple random sample are recommended where Olympia oysters are abundant and habitat is relatively simple.

Qualitative survey methods are recommended where Olympia oysters are present at extremely low densities or are cryptic, particularly if surveys would require disturbance of oyster habitat

Defining the edge of the bed is important and standards or criteria need to be developed to reduce the potential error in area estimates.

Methodology needs to be developed for the selection of index sites for Olympia oysters to be reviewed by the PSARC Invertebrate Subcommittee in the future.

Recommendations

1. The Subcommittee recommended acceptance of the working paper subject to minor revisions.

2. The Subcommittee accepted Recommendation #1 of the working paper, with the following changes made by the authors: "**Quantitative survey methods are recommended where Olympia oysters are abundant and habitat is relatively simple.** Either 2-stage or simple random sampling (with or without stratification) should be used. Investigate the utility of incorporating GPS technology, which has the advantage of providing a measure of bed area (not available in TS or StTS sampling)."

3. The Subcommittee accepted Recommendation #2. "**Qualitative survey methods are recommended where Olympia oysters are present at extremely low densities or are cryptic, particularly if surveys would require disturbance of oyster habitat.** The potential damage caused by turning rocks to detect oysters attached to the underside outweighs the benefits of quantitative information, particularly at sites on or near the limits of distribution of Olympia

oysters. In these cases, verification that the populations still exists may be the most responsible means of monitoring these populations."

4. The Subcommittee accepted Recommendation #3 of the working paper with the following modifications: **"Larger quadrat size is desirable, particularly in low density situations, but smaller quadrats may be adequate at high densities because of reduced processing time. In the absence of information to the contrary, a quadrat size of 0.25 m^2 is recommended in the interim.** Quadrat size and sampling rates require further examination before standards can be established. Surveys reviewed in this document suggest that a sampling rate of approximately 50 quadrats is sufficient to attain 30% precision when oyster density is high and the oysters are highly aggregated. In situations where oysters are present at low densities and dis-aggregated, sample sizes of up to 100 quadrats may be required to achieve this level of precision."

5. The Subcommittee accepted Recommendation #4 of the working paper with the understanding that the authors will add text supporting the sample size for biological monitor: **"Additional biological and ecological information should be collected in conjunction with abundance surveys.** Size frequency data should be collected as a matter of course. In the absence of age data, size frequency distributions provide the only information available on recruitment strength. This information will not provide complete age distribution information, but may allow assessment of relative recruitment rates between sites or years. If oysters are abundant and removals would not jeopardize the persistence of a population, oysters that were sampled for length data could also be opened to examine reproductive maturity (presence of larvae) or to take tissues for subsequent histological or molecular analyses. Samples from late summer or fall may be more instructive for reproductive studies, as samples taken early in the summer likely contain numerous individuals that have not matured."

6. The Subcommittee recommended that defining the edge of the bed is important and that standards or criteria need to be developed to reduce the potential error in area estimates.

7. The Subcommittee recommended that the methodology to be developed for the selection of index sites for Olympia oysters be reviewed by the PSARC Invertebrate Subcommittee in the future.

ASSESSMENT FRAMEWORK FOR SEA CUCUMBER (*PARASTICHOPUS CALIFORNICUS*) IN BRITISH COLUMBIA
N. Duprey, C. Hand, J. Lochead and W. Hajas

Working paper accepted with revisions

General Discussion

There were two reviewers for this paper, one external and one internal. The first reviewer thought this was a very well written paper, clearly advancing the knowledge necessary to effectively manage the sea cucumber fishery. The reviewer found the paper was appropriately concise, yet provided sufficient detail to understand and

evaluate the methods used. The reviewer made several suggestions on clarification and re-organizing the paper to make it easier for the reader to follow. The author addressed several comments from this reviewer. In response to the concern that removal of all individuals from permanent bio-transects could impact density and weight estimates in the following year, the authors explained that the number of sea cucumbers harvested from these bio-transects is very small in comparison to the total harvest from the harvested areas in which they lie, so any impact would be small in comparison with that of commercial harvest. It was also clarified that there would likely be 2-3 years between sampling events at these bio-transects. Other topics raised by the reviewer were reserved for Subcommittee discussion.

The second reviewer pointed out that, for animal weight estimates, no error measurement was included. The authors discussed an alternative approach to biomass estimation that incorporates uncertainty in all parameter estimates which would be investigated in future. The reviewer also suggested the addition of a section in the paper describing how quotas are calculated, and while this wasn't the intent of the paper, the authors agreed to add this information to complete the description of management procedures relating to stock assessment.

The Subcommittee discussed the validity of using a raster based estimate of shoreline length generated from a 1990's software program, in comparison with current vector-based GIS tools measurements that are potentially more accurate. It was argued that newer measurements of shoreline may not be more accurate, but simply use a different method; and, further, that highly accurate shoreline length estimates may not necessarily be appropriate for estimating subtidal populations. The question of accuracy can only be resolved by a comparison with ground-truthed measurements. It was further explained that vector-based shoreline length estimates are substantially larger in some areas (10% on average) and that this method would result in increased biomass estimates and quotas, while the biomass has not actually changed. Thus, using the original shoreline measurements is the more precautionary method. While there was agreement that it is not ideal to use an outdated method in perpetuity, the authors argued that the anticipated eventual change from using linear (shoreline length-based) biomass estimates in favour of spatially derived estimates may make it redundant to update methods for measuring shoreline length. Ultimately, a suggestion was made to include uncertainty in shoreline length estimates into biomass calculations, because absolute accuracy is not obtainable and likely unknowable.

While the Subcommittee agreed that no-take reserves should be established, they felt that the paper's suggestion that 20% of the harvestable coastline be designated was not adequately supported by scientific data. There was some discussion on how the appropriate size of reserves should be determined, and argument that the authors' guideline of the size being limited to what is feasible to survey in 2 days may not be appropriate, and the size should depend on whether biological objectives can be met.

The importance of defining objectives for reserves was recognized, and the main objectives discussed were as follows: spawning biomass reserves to provide sources of recruitment; adult spillover into adjacently harvested areas; and the use of reserves to monitor unharvested populations and habitats and compare them to harvested areas. It was agreed that objectives of the no-take reserves and design of on-going monitoring should be clearly defined. Several ideas of how reserves can be designed to maximize feasibility and enforceability were discussed. Industry stakeholders support the idea of

harvest reserves but expressed concern that a certain percentage of the coast should not be set in stone.

The Request for Working Paper asked the question of whether a range of biomass estimates could be provided instead of using just the lower 90% confidence bound of biomass estimates. The authors stated that their analysis can provide a distribution of results around the mean estimate, but that their advice is to use the 90% confidence bound in the interest of precaution.

There was some confusion over guidelines regarding the density below which an area could not support the recommended 6.7% harvest rate, and the advice to managers to not open Subareas where density estimates were less than 2.5 cucumbers per metre of shoreline in order to avoid depletion of high-density aggregations in otherwise low-density areas. The authors explained that these were two separate issues. It was reiterated that the 6.7% harvest rate was intended for all areas, with the exception of relatively unproductive and/or low density areas. The authors agreed to clarify, in the paper, the suggested minimum densities that would be used to define whether an area should be harvested at 6.7%. In particular, whether these minimum densities are mean estimates or 90% LCB density. The authors also agreed to clarify the other issue, of recommending that Subareas with low density (less that 2.5 c/m-sh) remain closed to harvest. The extent to which depleted areas are replenished through larval recruitment and lateral and vertical immigration is unknown and should be investigated.

Conclusions

Shoreline length estimation techniques will continue the methodology currently in use, as it is more precautionary than the methods available with newer technology.

Priorities for focussing future surveys were identified.

A planning process is recommended to identify biological objectives as well as assessment and management objectives in determining the size, shape and locations for no-take reserves incorporating habitat information and reserves from other fisheries.

Recommendations

1. The Subcommittee accepted the working paper subject to revisions

2. The Subcommittee agreed with the first recommendations in the working paper, to survey areas of high harvest-pressure where no data have yet been collected and to survey all new areas prior to opening the fishery, but suggested they be combined into a single recommendation that addresses survey priority-setting.

3. The Subcommittee supported the third recommendation of the working paper, to not open Subareas with cucumber densities lower than 2.5 c/m-sh (LCB), but recognized the difficulty of enforcing potentially small-scale closures that may be surrounded by Subareas open to harvest.

4. The Subcommittee accepted the fourth and fifth recommendation in the working paper, to determine protocols (sample size and re-sample schedule) for the

collection of sea cucumber weight and density data to optimize effort and precision.

5. The Subcommittee accepted recommendation #6 of the working paper to: "investigate the extent to which sea cucumbers re-colonize depleted areas", and recommendation # 7, "to investigate larval production and distribution"

6. The Subcommittee recommended that uncertainty in all parameter estimates be incorporated into the calculation of biomass estimates for consideration by fishery managers

7. The Subcommittee recommended a planning process be initiated to identify what the biological, assessment and management objectives are for no-take reserves to aid in determining the size, shape and locations and to incorporate habitat information and reserves from other fisheries. Research questions are needed to determine whether objectives are met, and how reserves should be designed to answer these questions.

ROCKFISH BYCATCH IN THE BRITISH COLUMBIA COMMERCIAL PRAWN TRAP FISHERY

D.T. Rutherford, K. Fong and H. Nguyen

Working paper accepted with revisions

General Discussion

There were three reviewers for this paper, one external and two internal.
The first reviewer made suggestions to improve the abstract for clarity, and asked that a short description of the prawn escapement-based model be included. The authors agreed that changes to the abstract and a description of the escapement-based model were appropriate. The reviewer questioned the use of the Poisson distribution and suggested this could be confirmed by testing which would be the most appropriate distribution. The question arose as to whether increased sampling effort would produce an increased encounter rate. Authors had conducted correlation analysis in response to reviewers concern and no correlation between sampling effort and encounter rate detected. The reviewer raised concerns on the quality of data from Area 28 as information the reviewer had from other sources tended to indicate a higher encounter rate in 2008 than the commercial sampling showed, and this led to further Subcommittee discussion. The reviewer suggested a discussion on the effects of bycatch mortality on the rockfish population, both in terms of numbers and maturity, would be helpful for an overall perspective. The authors acknowledged that this might be a next step but it is beyond the scope of this paper. Authors did agree to put some of the rockfish size data presented in the paper into context of maturity.

The second reviewer raised concerns on greater clarity in the methods and data that the author agreed to further explain and clarify. The reviewer also thought a description of the prawn spawner index sampling strategy should be included for clarity. While the data presented in the paper are useful for resource managers to assess the effect of the

commercial fishery, there is no data or analysis for the recreational and First Nations fisheries. The author responded that there are no data collected from these two fisheries.

The third reviewer thought the data and methods could be improved with a few minor changes. The reviewer raised concerns that the estimated bycatch in GMA 4B was a significant portion of the commercial TAC for the combined species aggregate. The reviewer would have preferred to see that data presented by Groundfish Management Area (GMA), rather than PFMA, but the author noted that a reader could easily roll up to GMA from the data tables in the report. The reviewer also would have liked to see data on the encounter rate in Rockfish Conservation Areas (RCAs).

There was Subcommittee discussion seeking clarification on the progressive increases in sampling rate in 2002 and 2003 and potential anomalies this could create. It was suggested that perhaps only the data from the consistent 2004 onward time period be analyzed and presented. The author agreed there should be a better explanation of the sampling rate changes in the initial years. There were also concerns raised about potential anomalies in the Howe Sound data. These may be partly related to problems of data quality (observation error) as well as the difference in spatial and temporal scales between commercial sampling and other source data presented by the reviewer. The issue of the use of the Poisson distribution was raised by the first reviewer as well as by the Subcommittee. If the variance is much bigger than the mean, then perhaps the negative binomial distribution would be a better fit, or the use of a zero-inflated model could be another alternative due to large number of zero encounters. The author did confirm the fit of the Poisson distribution following the suggestion of the first reviewer. The Subcommittee expressed concern regarding presentation of zero values for the lower confidence interval because catch occurred. A suggestion was made to only report the upper confidence intervals.

There was Subcommittee discussion on the use and applicability of the estimates produced, using examples of coastwide and Strait of Georgia total bycatch biomass for quillback and yellow eye extrapolated and provided by the second reviewer for 2008. However, this was based on mean estimates and the data are inadequate to calculate appropriate confidence intervals. It was suggested that alternative statistical techniques are available, but these are complicated and not always considered reliable. The Subcommittee agreed that the data may not be adequate for the example calculations of the bycatch biomass presented by the second reviewer. Limitations of the species composition data needs to be more explicit in the working paper. The Subcommittee also learned from the author that more accurate and precise estimates of rockfish bycatch coastwide, by species, could not be adequately assessed because of the small sample size and low number of rockfish encountered and would not improve with more years of data under the current program. The Subcommittee noted that knowing rockfish encounters by species is particularly important due to the recent designation of quillback rockfish as a threatened species by COSEWIC. The Subcommittee recognized that if quillback get listed under SARA, all sources of mortality will need to be accounted for in a quillback rockfish Recovery Potential Assessment (RPA) and there will be requirements to mitigate rockfish bycatch in prawn traps.

There was considerable discussion on the objectives of the working paper. Because there was no formal written request and the source of the original request was uncertain, it is extremely difficult to address all the recent questions arising from rockfish bycatch in

the prawn trap fishery. The original request was for an estimate of the total rockfish bycatch in the commercial prawn fishery, and that has been met. However, the results give rise to a number of other questions, such as bycatch from RCAs, and presumably other concerns and priorities of the Groundfish Management Unit and prawn fishery managers. There may not be sufficient data for a realistic estimate of bycatch from RCAs, even if all RCAs are rolled up. The author pointed out that any increase in sampling effort will require a new program and funds, as the resources are already totally committed in the present program. There is also the outstanding issue of bycatch in the recreational and First Nations prawn fisheries, where no data are collected. It was noted in some areas of the coast, trap hauls in recreational and First Nations prawn fisheries may exceed the commercial prawn trap fisheries. The Subcommittee recognized that recreational and First Nation fishing effort data need to be collected in order to fully address the over impact of rockfish bycatch in all the prawn trap fisheries.

The Subcommittee was apprised of observed trap fishing characteristics by an external observer and the ongoing work of academia/industry collaboration on prawn trap designs to reduce rockfish bycatch.

The Subcommittee was concerned that groundfish management or assessment staff were not present for further input during the Subcommittee discussion. Their presence and input would have been very helpful in determining what would be the next steps to take in the immediate future as well as plan for further monitoring requirements considering the implementation and management of RCAs as well as impending decisions on Species At Risk Act (SARA) listing of specific rockfish species.

Conclusions

The original request for an estimate of total rockfish bycatch in the commercial prawn trap fishery has been met. However, caveats concerning the data and estimates need to be explicit to ensure appropriate interpretation of the results.

There is an emerging issue concerning the apparently high proportion of quillback in the rockfish bycatch that needs to be addressed, considering the recent designation as a threatened species by COSEWIC and the potential listing under SARA. There is also the issue of determining bycatch levels from RCAs, which may not be adequately assessed with the present monitoring program.

There is no estimate of bycatch from the recreational and First Nations prawn trap fisheries, and this information is required for an overall assessment of rockfish bycatch in all prawn trap fisheries. Furthermore, prior to any development of new sampling programs to address rockfish bycatch in the commercial prawn fishery, there needs to be involvement from groundfish management and assessment staff to identify questions and objectives.

Recommendations

1. The Subcommittee recommended acceptance of the working paper subject to revisions.

2. There is no explicit advice for managers in the working paper, therefore the Subcommittee recommended that the groundfish management and assessment staff meet with the prawn management and assessment staff along with industry representatives to discuss the next steps, including what questions should be formulated, and how the data collected will be used to manage the co-occurring species to provide for conservation of the species of concern.

3. The Subcommittee recommended a data collection program be designed for the recreational and First Nations prawn trap fisheries in order to adequately assess the overall rockfish bycatch in all the prawn trap fisheries. This process will need to be documented and peer reviewed.

**PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE
INVERTEBRATE SUBCOMMITTEE MEETING**

December 1-3, 2009

**Pacific Biological Station
Seminar Room
Nanaimo, BC**

Tuesday, December 1	
Introduction and procedures	9:00 – 9:15
Review of Working Paper, "*Stock assessment and quota options for the Green Sea Urchin (Strongylocentrotus droebachiensis) fishery in British Columbia, 2010-2013*"	9:15 – 12:00
Lunch Break	12:00 – 1:00
Review of Working Paper, "Estimation of reference points and a precautionary harvest strategy for the razor clam (*Siliqua patula*) fishery at Haida Gwaii"	1:00 – 4:00
Wednesday, December 2	
Review of Working Paper*, "Evaluation of survey methodologies for monitoring Olympia Oyster (Ostrea lurida* Carpente*r, 1864) population in British Columbia*	9:00-12:00
Lunch Break	12:00 – 1:00
Review of Working Paper *"Assessment Framework for Sea Cucumber (Parastichopus Californicus) in British Columbia*	1:00-4:00
Thursday, December 3	
Review of Working Paper, *"Rockfish bycatch in the British Columbia commercial prawn trap fishery*"	9:00-12:00
Lunch Break	12:00-1:00
Next meeting dates, Subcommittee discussion, wrap-up	1:00-4:00
Adjournment	4:00

Appendix 2. List of Attendees

NAME	Tues	Wed	Thur
EXTERNAL PARTICIPANTS	√	√	√
Duff, Stefanie			√
Favaro, Brett			√
Holmes, Heather	√	√	√
Jones, Russ	√	√	
Morrison, Jim	√	√	√
Ridgway, Ken	√	√	
Sporer, Chris			√
DFO MEMBERS	**Tues**	**Wed**	**Thur**
Boutillier, Jim	√	√	√
Brown, Tom G		√	√
Bureau, Dominique	√	√	
Carolsfeld, Wolfgang	√		
Cass, Alan (PSARC Chair)	√		
Clark, Dan	√	√	√
Convey, Laurie			√
Davies, Sandra	√	√	
Davies, Sarah	√	√	
Dunham, Jason			√
Duprey, Nicholas	√		
Fong, Ken			√
Gillespie, Graham	√	√	√
Hand, Claudia	√	√	√
Hansen, Christine	√	√	√
Hajas, Wayne	√	√	√
Lauzier, Raymond (Subcommittee Chair)	√	√	√
Lessard, Joanne		√	√
MacConnachie, Sean		√	
Mylchreest, Russell	√	√	√
Norgard, Tammy	√	√	
Nguyen, Hai			√
Parker, Guy			√
Pearce, Chris	√	√	
Perry, Ian	√	√	√
Ridings, Pauline	√	√	
Rogers, Juanita	√	√	√
Rutherford, Dennis	√	√	√
Stanton, Lily		√	
Surry, Maria	√	√	√
Waddell, Brenda	√	√	√
Watson, Nicolette		√	√
Wylie, Erin	√	√	
Yamanaka, K. Lynne			√
Zhang, Zane	√	√	√

The reviewers for the PSARC paper presented at this meeting are listed below. Their assistance is invaluable in making the PSARC process work.

Bureau, Dominique	Fisheries and Oceans Canada
Davis, Joth	Taylor Shellfish Farms and University of Washington
Duff, Stefanie	Vancouver Island University
Gillespie, Graham	Fisheries and Oceans Canada
Hajas, Wayne	Fisheries and Oceans Canada
Hoyt, Zachary	Alaska Department of Fish and Game
Li Ou, Wan	Fisheries and Oceans Canada
Pearce, Chris	Fisheries and Oceans Canada
Sauchyn, Leah	Fisheries and Oceans Canada
Szarzi, Nicky	Alaska Department of Fish and Game
Yamanaka, Lynne	Fisheries and Oceans Canada

Appendix 3. Terms of Reference

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Terms of Reference

Regional Advisory Meeting

Evaluation of survey methodologies for monitoring Olympia Oyster (*Ostrea lurida* Carpenter, 1864) population in British Columbia

Stock Assessment and Quota Options for the Green Sea Urchin (*Strongylocentrotus droebachiensis*) fishery in British Columbia, 2010-2013.

Assessment Framework for Sea Cucumber (*Parastichopus californicus)* in British Columbia

A review of the Haida razor clam fishery

Rockfish bycatch in the British Columbia commercial prawn trap fishery

Pacific Scientific Advice Review Committee (PSARC)
1-3, December 2009
Pacific Biological Station
Nanaimo, BC

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Chairperson: Ray Lauzier

Context

The PSARC Invertebrate Subcommittee meets routinely to conduct peer reviews of scientific information in support of management decision making. A peer review of five working papers on five NE Pacific invertebrate species are planned for December 2009: 1) Evaluation of survey methodologies for monitoring Olympia Oyster (*Ostrea lurida* Carpenter, 1864) population in British Columbia; 2) Stock Assessment and Quota Options for the Green Sea Urchin (*Strongylocentrotus droebachiensis*) fishery in British Columbia, 2010-2013; 3) Assessment Framework for Sea Cucumber (*Parastichopus californicus)* in British Columbia; 4) A review of the Haida razor clam fishery; and 5) Rockfish bycatch in the British Columbia commercial prawn trap fishery

Objectives

A review and recommended survey methodologies for monitoring Olympia oyster (*Ostrea lurida*) populations at proposed index sites:

This paper is an evaluation of different survey protocols used to make relative abundance estimates of Olympia oyster beds. The advantages and disadvantages of each type of survey design are identified as well as a review of the field data for the

protocols that were tested. The different habitats of Olympia oyster are defined and the challenges in conducting assessments within these diverse habitats are outlined. Recommendations are made on how to best monitor abundance at sites that may be complex in structure and/or remote in location and difficult to access, including how to best measure relative abundance over time at a specific site where quantitative assessments are not feasible. Appropriate survey designs are developed and the variables needed to obtain reliable distribution information and quantitative estimates of abundance are identified.

Stock Assessment and Quota Options for the Green Sea Urchin (*Strongylocentrotus droebachiensis*) fishery in British Columbia, 2010-2013:

Fisheries and Aquaculture Management is requesting that Green Sea Urchin quota options be updated from the previous 2005 analysis by incorporating the information obtained from recent stock assessment survey data and logbook data into the quota analysis for the green urchin fishery. A new 3 year IFMP (2010-2013) will be developed following advice from this paper and the PSARC committee

Assessment Framework for Sea Cucumber (*Parastichopus californicus)* in British Columbia

Stock assessment framework to provide a detailed description of assessment protocols, including data collection, data precision and accuracy and the decision rules for applying results to biomass estimation. The paper includes a discussion of the development of reserves for conservation and to aid in stock assessment, and a discussion on target and limit reference points. Recommendations on research priorities to support monitoring and stock assessment are provided.

Estimation of reference points and a precautionary harvest strategy for the razor clam (*Siliqua patula*) fishery at Haida Gwaii

The review of the Haida Razor Clam fishery includes a review of MSY calculations and quota determination using current data as well as the development of a framework for providing quota options to Resource Management, including analyses of variability in biomass estimates. The objectives of this paper are to determine appropriate reference points as well as designing a new precautionary harvest strategy, thus providing managers with a more current foundation for recommending quota options to stakeholders; and providing greater confidence to DFO Managers and stakeholders in quota determination by considering all factors affecting available biomass and recruitment levels based on more recent data; and providing greater confidence for the stakeholders (Council of the Haida Nation, Razor Clam Diggers Association) in stock assessment and TAC determination processes and a TAC that accurately reflects current conditions and available stock.

Rockfish bycatch in the British Columbia commercial prawn trap fishery:

This paper will document the methodology used to estimate total rockfish bycatch in the commercial prawn trap fishery. Results from the bycatch monitoring program from 2002 to 2008 will also be included. This paper has been prepared in response to a request from FAM for a report on rockfish bycatch in the commercial prawn trap fishery.

Products

- CSAS Proceedings document summarizing the discussion (1)
- CSAS Science Advisory Report (1)
- CSAS Research Document (4)

Location and Date

Seminar Room, Pacific Biological Station, Nanaimo, BC, December 1-3, 2009

Participants

Participants will include internal DFO representatives and potentially participants from the Province of British Columbia, academia, First Nations, NGO's and industry.

Estimation of reference points and a precautionary harvest strategy for the razor clam (*Siliqua patula*) fishery at Haida Gwaii
R. Jones, S. Jeffery, B. DeFreitas, and C. Schwarz

This paper summarizes the results of surveys of razor clams on beaches near Massett, Haida Gwaii from 1994 to 2008 and estimates the sustainable harvest rate and a precautionary harvest strategy for the fishery. Beaches near Massett, Haida Gwaii have significant populations of razor clams that have supported a major commercial fishery since 1923 and a small but important non-commercial fishery. Commercial landings over this period have fluctuated widely depending on market demand, fishing effort and fluctuations in populations (Fig. 1, Table 1). There have been several assessments of razor clam populations in the past (Bourne 1969; Jones et al. 1998; Jones et al. 2001). Jones et al. 2001 estimated the sustainable harvest rate in the fishery to be 12.3% (2/3 of MSY) based on a surplus production model and one year of data (1994). The assessment by Jones et al. 2001 reviewed survey information collected over a seven year period and presented trends in abundance, biomass and recruitment in the fishery but did not examine the sustainable harvest rate. The present analysis considers age data collected over a 14 year period from 1994 to 2008.

The purpose of the review was:

1) to assess sustainable harvest rates and methods to determine quotas using recent data sets including annual age distributions for the population;
2) to assess recruitment trends and the accuracy of forecasts i.e. comparison of forecasts and biomass in the following year;
3) to determine a framework for providing quota options to Resource Management including analyses of variability in recruitment estimates (biomass estimates already incorporate variability); and
4) a review of management decisions since 2001 when quotas were first established with recommendations in light of the above results

Further analysis will be required to complete all the above objectives.

Evaluation of survey methodologies for monitoring Olympia Oyster (*Ostrea lurida* Carpenter, 1864) populations in British Columbia
T. Norgard, S. Davies, L. Stanton and G. Gillespie

Olympia oysters were harvested commercially from late 1880s to 1930 when stock decline and shift in market preference ended the fishery. In 2000 they were listed as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and under the Species at Risk Act (SARA) in 2003 (SARA 2003). As a requirement of SARA a management plan for the Olympia oyster was completed in 2009. One of the required actions identified was the development of survey protocols to measure their relative abundance along the BC Coast. This paper reviewed seven different survey protocols and tested four of them in the field. The results from these reviews have lead to recommendations depending on the population structure and density. On beaches where Olympia oysters populations are discrete or scattered and

exhibit high population densities a two stage design or simple random sampling with GPS mapping should be employed. The number of quadrats used at each beach will range from 50 to 100 depending on the population density. On beaches where Olympia oysters are in extremely low abundance (a few individuals under rocks) or in complex habitats such tidal pools or along rock walls a visual assessment of these populations will be necessary.

Assessment framework for Sea Cucumber (*Parastichopus Californicus*) in British Columbia
N. Duprey, C. Hand, J. Lochead and W. Hajas

The pacific sea cucumber (*Parastichopus californicus*) fishery in British Columbia has been undergoing a rigorous period of data collection, analysis and review since 1995, with the objective of developing a biologically-based stock assessment program and risk-averse fishery management. Here, we describe the historic and current stock assessment approaches that provide fishery managers with information and recommendations to calculate Total Allowable Catch. Protocols for estimating sea cucumber densities and weight for both surveyed and unsurveyed areas of the coast are described. Methods for measuring and calculating shoreline length are described, and rules for the application of different densities by exposure classes of shoreline. The precision and accuracy of density estimates is presented with a comparison of the accuracy of two different methods of calculating density; linear and spatial. New harvest rates, modeled from the results of the long-term Experimental Fishing Area (EFA) data, and the Limit Reference Point of 50% B_o is reviewed. Finally, no-take reserves are discussed in detail, especially in regard to the sea cucumber fishery and future development of a network of reserves throughout the BC coast. New research priorities are highlighted and several recommendations made, including surveying all new PFMA Subareas before they are opened to harvest, surveying currently unsurveyed yet exploited Subareas following the presented priority list, phasing out of harvest areas with a density less than 2.5 c/m-sh, determining the optimal sample size needed for acceptable precision of density estimates and developing a method to include error in shoreline length and weight estimates into biomass calculations.

Rockfish bycatch in the British Columbia commercial prawn trap fishery
D.T. Rutherford, K. Fong and H. Nguyen

A sampling program to estimate rockfish bycatch in the British Columbia commercial prawn trap fishery was initiated in 2002. The bycatch sampling program utilizes the third party on-ground monitors that have already been established to collect the data necessary for the in-season management of the prawn fishery. For the rockfish bycatch program, on-ground monitors sample a sub-set of traps and record rockfish encounters to the species level. This report documents the methods and analysis, and presents results of the rockfish bycatch monitoring from 2002 to 2008

Rockfish encounters in the commercial prawn fishery are a rare and random event and follow a Poisson distribution. The observed data was analyzed using maximum likelihood and bootstrap procedures to estimate total rockfish bycatch. Rockfish encounter rates (rockfish per trap) are presented by Pacific Fishery Management Area (PFMA) and year and ranged from a low of 0.000 to 0.045 rockfish/trap. Estimated total

annual coastwide rockfish bycatch ranged from a low of 13,867 pieces in 2005 to a high of 19,996 in 2002. The coastwide estimates of rockfish bycatch at the upper 95% CI ranged from 22,792 in 2005 to 40,780 in 2002.

Twenty three species of rockfish and a total of 2088 rockfish were observed during the bycatch monitoring program from 2002 to 2008. Quillback rockfish (*Sebastes maliger*) accounted for the greatest proportion of all rockfish sampled, with an average size of 0.233 kilograms. However rockfish bycatch, by species, on a coastwide basis could not be estimated due to small sample size and low encounter rates. If species composition is deemed to be an important variable that needs to be quantified with more precision, then sampling rate will have to be significantly increased along with verification of species identification.

Science Advisory Report summary

Stock Assessment and Quota Options for the Green Sea Urchin
***Strongylocentrotus droebachiensis* fishery in British Columbia, 2010-2013.**
B. Waddell, Z. Zhang, and R.I. Perry

Green sea urchins remain a small but important part of the British Columbia dive fisheries. Overall, green urchin populations in their two major fishing regions of British Columbia (Northeast Vancouver Island and Southeast Vancouver Island) appear to be under low fishing pressure. The catch per unit of effort has been steadily increasing since 1993-94 and is now at its highest level in the 22 year history of the fishery. Total landings and landed value decreased by approximately 50% each fishing season from 2003-04 (167 t, worth Cdn$0.725 million) to the lowest values in 2006-07 (22 t, worth Cdn$0.073 million; preliminary data). Although there was a 3-fold increase in landings and landed value from 2006-07 to 2007-08, and another slight increase in 2008-09, the last 5 fishing seasons were historically the lowest on record. This was a result of poor market prices in Japan, due to competition from Russia. A series of quota options [target reference points expressed as reductions from the Maximum Sustainable Yield (MSY) limit reference point] are provided for each fishery management area, along with the associated levels of probability that they may be equal to or greater than the true MSY. Quotas established at their 2009-10 levels (177.3 t in Northeast Vancouver Island; 25.5 t in Southeast Vancouver Island) would represent low probabilities of being equal to or greater than the true MSY (4.0% in Northeast Vancouver Island; 0.4% in Southeast Vancouver Island).