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Report of the PSARC Invertebrate Subcommittee Meeting, June 19-22, 2000

M. Stocker and I. Perry (Editors)
Pacific Scientific Advice Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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Canada

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 00-03
JULY 2000

INVERTEBRATES

SUMMARY

The PSARC Invertebrate Subcommittee met 19 June to 22 June, 2000 in the Seminar Room at the Pacific Biological Station in Nanaimo, B.C. The Subcommittee reviewed eight working papers, 12 Fishery Updates, and 1 stock status report.

Working Paper I00-01: Preliminary review of experimental harvest rates in the depuration fishery for intertidal clams

This paper reviews eight beaches managed experimentally in the depuration fishery for intertidal clams. The paper recommends that the harvest rates used in the current framework be reduced, that alternatives to constant harvest rate management be considered, that protocols for estimating total landed weight and species composition be established, and that beaches managed using constant total allowable catches from a single baseline survey be re-assessed and this management framework be re-evaluated.

The Subcommittee accepted the recommendations in the paper concerning reductions in harvest rates for the depuration fishery; the need to develop protocols to distinguish the species composition and to estimate total landings in the depuration fishery; and that beaches that are managed under a constant Total Allowable Catch (TAC) derived from a baseline survey need to be reassessed. In addition, fisheries managers should consider a sliding harvest rate.

Working Paper I00-02: Harvesting Methuselah's clams – Is the geoduck fishery sustainable, or just apparently so?

This paper was produced by researchers at the University of Washington on contract for the B.C. Underwater Harvesters Association, and is a comparison of data and geoduck management styles in B.C. and Washington State. The paper identifies three major concerns: 1) an apparent long-term declining trend in recruitment over large geographic scales; (2) geographic variations in recruitment and bed recovery rates, which may then need different harvest strategies; and (3) depensatory dynamics. The Subcommittee recommended: (1) Long-term recruitment trends and their spatial coherence need to be investigated to determine if there is a long-term decline, and (2) Studies need to be conducted to identify issues relating to minimum densities below which geoduck recruitment is impaired.

Working Paper I00-03: Development of a fishery for Tanner crab (*Chionoecetes tanneri*) off the coast of British Columbia

Deep water Tanner crab has been proposed as a new fishery in B.C. This paper presents the results of a DFO trawl survey and a trap survey conducted by industry. It recommends total allowable removals of male crabs greater than 112

mm carapace width of 249 t for the west coast of Vancouver Island. It notes there is substantial by-catch of Tanner crab in the deep water groundfish trawl fishery, which may take up to 50% of the total allowable catch calculated for Tanner crab.

The Subcommittee recommended completion of the trap survey and the need for fishery-independent trawl surveys to assess Tanner crab stocks. It also recommended the formation of a DFO working group to define an experimental protocol to test alternative harvest strategies. Concerns were expressed on the by-catch of Tanner crabs in the groundfish trawl fishery and the proposed expansion of this deep water groundfish fishery. These need to be considered within a broad ecosystem approach.

Working Paper I00-04: Reconstructing the offshore *Pandalus jordani* trawl fishery off the west coast of Vancouver Island and simulating alternative management policies

This paper uses research and commercial catch-effort data to reconstruct the *Pandalus jordani* stocks off the west coast of Vancouver Island, to examine stock-recruitment relationships, changes in catchability, and fishing power differences between different research vessels. Results of this population reconstruction are then used to develop and parameterise a simulation model to explore four alternative management strategies for this fishery. It recommends a quota system based on pre-season stock estimates.

The Subcommittee recognised the need for increased biological information, in particular catch-at-age data for the commercial fishery. It agreed with the need to continue fishery-independent surveys, and with the recommendation to adopt a quota-based system for the whole west coast Vancouver Island offshore *P. jordani* fishery.

Working Paper I00-05: Evaluation of horse clam stock dynamics for a directed subtidal Horse clam (*Tresus capax* and *Tresus nuttallii*) fishery in British Columbia

Biological information essential for addressing ecological concerns, assessing population stock dynamics, and evaluating fishing strategies for a directed fishery proposed for horse clams were examined. A simulation model was used to develop precautionary limit Reference Points, target Reference Points, and corresponding precautionary exploitation rates.

The Subcommittee agreed with recommendations for bed-specific surveys to determine regional biological information. It also noted that the specific Reference Points may not be adequately precautionary due to parameter uncertainties, and that more information is needed.

Working Paper I00-06: Quota options for the geoduck clam (*Panopea abrupta*) fishery in British Columbia for 2001 and 2002

Quota options for geoduck clams for the 2001 and 2002 fisheries were calculated using the habitat-based approach, but with new parameter estimates. Calculated quota were 48 to 68% larger than previous estimates, due to revised parameter estimates and increases in bed areas. Fishery managers are recommended to consider the estimates as upper limit Reference Points rather than quota targets.

The Subcommittee concurred that these quota options should be considered as limit Reference Points, considering the uncertainties involved in the calculations. Bed areas in particular need to be refined. A formal stock assessment is required which would consider all available data. The areas of geoduck beds remain problematic and need to be better defined.

Working Paper I00-07: Framework for Pink (*Chlamys rubida*) and *Spiny (C. hastata*) scallop fisheries in waters off the west coast of Canada

A framework for assessment and management of the pink and spiny scallop dive and trawl fisheries is presented. Data requirements and management options for a precautionary fishery are outlined including removal estimates, biomass estimates, and biological information.

The Subcommittee supported the recommendations in the paper concerning the need to delineate appropriate “scallop management units”, the need for biomass surveys of these units and for additional biological data, including species composition. The Subcommittee noted that the limit Reference Point of 50% of current biomass suggested for this fishery may be too high, and a more conservative value should be used.

Working Paper I00-08: Catch composition of British Columbia shrimp trawls and estimations of by-catch

Withdrawn.

Fishery Updates

Fisheries Management staff, in consultation with Conservation and Protection and Stock Assessment Divisions, prepare fishery updates. The updates provide summaries of commercial fishery performance, including significant management, enforcement, and stock assessment activities on an annual basis. The updates provide the opportunity to identify high priority issues that affect assessments and conservation concerns. The fishery updates for geoducks, euphausiids, sea cucumbers, shrimp by trawl, octopus, goose barnacles, intertidal clams, horse clams, scallops, green sea urchins, and flying squid were presented at this meeting.

Emerging Issues

Four emerging issues were identified by the Subcommittee during its deliberations:

1. *Communication across species groups within DFO, in particular on by-catch.* Species groups (invertebrates, groundfish, pelagics) within PSARC, Stock Assessment, and Fisheries Management are only weakly coupled with respect to by-catch issues. The Subcommittee recognised a need to work across species groups to compare by-catch with allowable catches in directed fisheries, i.e. what proportion of allowable catches are taken as by-catch in other fisheries? In addition, the Subcommittee recommended that observer programs improve their sampling of non-target species; that a mechanism to share data across species groups be developed; and that the development of new or expansion of existing fisheries follow the phased approach, which would include consideration of potential by-catch problems. This should lead towards a multi-species or broad ecosystem basis for these fisheries.
2. *Confidentiality of data.* The requirement for fisheries data to remain confidential unless there are more than two sources involved is beginning to limit Stock Assessment Division's ability to conduct assessments for some species, and may limit the extent of the public PSARC review. Advice needs to be obtained from the Department of Justice with respect to the details of these confidentiality problems, and what is actually permissible.
3. *Problems with saleslip data.* Saleslip information, and from which official landing statistics are derived, have become so unreliable in many invertebrate fisheries that they are no longer used by Fisheries Management or Stock Assessment staff. The reasons for the problems with saleslip data need to be investigated and resolved.
4. *Dependence of stock assessment and management programs on Industry funding.* Many invertebrate stock assessment and management programs depend on Industry funding to conduct surveys and related activities. As fishing decreases or as fishing regulations increase, some fishing industries are becoming less willing to support these assessment activities. The Subcommittee could provide no clear recommendations for resolution of this problem, other than decreasing the reliance of core assessment and management activities on outside funding.

INTRODUCTION

The PSARC Invertebrate Subcommittee met at the Pacific Biological Station Nanaimo, B.C., from 19-22 June, 2000. The Subcommittee Chair opened the meeting by welcoming the participants. He provided introductory remarks on the roles and responsibilities of the Subcommittee, and the roles and responsibilities of external participants and observers. The Subcommittee accepted the agenda (Appendix 1). During its proceedings, the Subcommittee reviewed eight working papers (Appendix 2), 12 fishery updates, and 1 stock status report. This Advisory

Document provides the record of the Subcommittee's deliberations and recommendations.

A number of external participants and observers attended the meeting. All participants at the meeting and the days they attended are presented in Appendix 3.

EMERGING ISSUES

Four issues emerged from the meeting for special consideration:

Communication across species groups within DFO, in particular on by-catch.

Issue: Species groups (invertebrates, groundfish, pelagics) within PSARC, Stock Assessment, and Fisheries Management are only weakly coupled with respect to by-catch issues. By-catch of non-target species can represent significant proportions of allowable removals from other fisheries, thereby adversely affecting the sustainability and/or profitability of these other fisheries.
Discussion: By-catch of non-target species is a concern with most trawl fisheries. Yet by-catch impacts on commercially or culturally-important species are seldom considered in detail, in part because of lack of knowledge of the intensity of these impacts. This emerged as a particular issue during the analyses of the surveys for Tanner crab and calculation of initial total allowable removals. This analysis determined that 50% of the total allowable removals for Tanner crab off the west coast of Vancouver Island (the only area proposed to be open) are likely to be taken as by-catch in the deep water groundfish trawl fishery. This represents a severe impediment to the development of a new fishery for Tanner crab. Determining by-catch impacts as proportions of allowable catches was also suggested in discussions of the shrimp trawl fishery.
Recommendations: The Subcommittee recognised a need to work across species groups to compare by-catch with allowable catches in directed fisheries, i.e. what proportion of allowable catches are taken as by-catch in other fisheries? The Subcommittee recommended that observer programs improve their sampling of non-target species, and that a mechanism to share these data across species groups needs to be developed. The presence of other commercial (or those with commercial potential) finfish and invertebrate species need to be recorded in catches, along with some estimation of sizes where possible. Further, the Subcommittee recommended that the development of new or expansion of existing fisheries follow the phased approach, which would include consideration of potential by-catch problems. This should lead towards a multi-species or broad ecosystem basis for these fisheries.

Confidentiality of data

Issue: The requirement for fisheries data to remain confidential unless there are more than two sources involved is beginning to limit Stock Assessment Division's

ability to conduct assessments for some species, and may limit the extent of the public PSARC review.
Discussion: The Privacy Act requires that fisheries data from less than 3 sources for a particular area remain confidential so that commercial livelihoods are not adversely affected. This is a particular problem for new and developing fisheries, which have only a few proponents at their beginning. In the case of geoducks, there are important questions regarding the delineation of geoduck beds for which the detailed experience of fishers would be helpful, yet confidentiality issues prevent these discussions. In addition, an individual licence holder can be shown their own data, but in many fisheries the licence holder is not the actual person who does the fishing. In the depuration fishery for clams, none of the beaches are harvested by more than two processors, so landings and harvest rates must be kept confidential. The issue of the confidentiality of information gathered under scientific permit is also unclear. These problems place serious constraints on public involvement in the PSARC process and publication of the resulting Research Documents.
Recommendations: Advice needs to be obtained from the Department of Justice with respect to the details of these confidentiality problems, and what is actually permissible.

Problems with saleslip data

Issue: Saleslip information, from which official landing statistics are derived, have become so unreliable in many invertebrate fisheries that they are no longer used by Fisheries Management or Stock Assessment staff.
Discussion: An example of this problem is provided by the Fishery Update for intertidal clams, which did not use any saleslip data, instead reporting the hailed catches. The problems with saleslip data can occur at all three steps in the process: with initial reporting of landings; with data entry; and with coding decisions and database management by DFO. These problems make it extremely difficult to develop a long-term record of fishery removals for stock assessment analyses.
Recommendations: The reasons for the problems with saleslip data need to be investigated and resolved.

Dependence of stock assessment and management programs on Industry funding

Issue: Many invertebrate stock assessment and management programs depend on Industry funding to conduct surveys and related activities. As fishing decreases or as fishing regulations increase, some fishing industries are becoming less willing to support these assessment activities.
Discussion: Examples of reduced willingness of industry to support invertebrate assessment and management activities are becoming more numerous. As more clam beaches are removed from the depuration fishery, industry has become less willing to survey control beaches. The geoduck and red sea urchin industries

have expressed greater reluctance to provide resources to support DFO activities on these species. The shrimp industry has expressed reluctance to fund by-catch observer programs. This is expected to become a greater problem if DFO moves to cost-recovery in catch monitoring, i.e., an industry is likely to be reluctant to support the costs of monitoring any species other than its target. This will make multi-species and ecosystem approaches to fisheries management very difficult.
Recommendations: The Subcommittee could provide no clear recommendations for resolution of this problem, other than decreasing the reliance of core assessment and management activities on outside funding.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

I00-01: Preliminary review of experimental harvest rates in the depuration fishery for intertidal clams

G. Gillespie
Accepted subject to revisions

Summary

This paper reviews eight beaches managed experimentally in the depuration fishery for intertidal clams in British Columbia. The beaches were surveyed annually between 1997 and 1999, and total allowable catches calculated by applying harvest rates of 0.50, 0.25 or 0 to the estimated legal biomass of Manila clams.

Three of four beaches managed using a 0.50 harvest rate exhibited drastic declines, and were removed from the fishery. The fourth beach maintained stock levels at actual harvest rates of approximately 0.40. One of two beaches assigned a 0.25 harvest rate declined and was removed from the fishery. The second maintained stock levels for at least one year of harvest at an actual rate of 0.23. Three control beaches exhibited different stock trends: one showed increased legal densities, one remained relatively unchanged at low stock levels, and one declined throughout the three-year program. From these preliminary results, it was apparent that the harvest rates used were too high, and that there is no single harvest rate that ensures sustainability for all beaches.

Because recruitment is sporadic in clam populations, little information regarding recruitment patterns was gathered in the first three years of the program. The three beaches that exhibited significant recruitment were in a similar geographic area, perhaps indicating that recruitment fails or succeeds over larger areas, as opposed to on a beach-by-beach basis. However, these beaches all had relatively large stocks of legal clams, perhaps indicating that a large proportion of the larvae produced from a beach remain in the vicinity and settle on the same beach where they were spawned. The two hypotheses are not exclusive; conditions required for good recruitment may occur over a larger area, with the

magnitude of recruitment on individual beaches in that area related to spawning stock size.

The paper proposes a management framework using biologically-based Reference Points. The limit Reference Point is a density of 20 legal clams/m^2, at which time the beach is closed for recovery. Harvest rates increase gradually with increasing legal density, from 0.10 at densities between 20 and 60 legal clams/m^2 to 0.20 at densities between 60 and 130 legal clams/m^2, and finally to 0.40 at densities greater than 130 legal clams/m^2. Beaches closed can be re-opened at densities above 60 legal clams/m^2. This framework allows moderation of harvest rates in response to stock characteristics, benefiting the stock when densities are declining, and allowing increased production when densities are increasing.

The paper recommends that the harvest rates used in the current framework be reduced, that alternatives to constant harvest rate management be considered, that protocols for estimating total landed weight and species composition be established, and that beaches managed using constant total allowable catches from a single baseline survey be re-assessed and this management framework be re-evaluated.

Reviewers' Comments

Reviewer #1

Reviewer #1 felt that the paper was well written with clearly stated objectives, that the data and methods were explained in sufficient detail, and the recommendations would be useful for fisheries managers in managing clam stocks in a more precautionary and sustainable manner. Of note in this review was a suggestion for modifications to the Reference Points recommended in the paper. These revised Reference Points were based on estimates from a simple surplus production-type analysis. The reviewer noted that the change in density is much less related to the sub-legal clam density and felt further comment was warranted. A suggestion was made for estimating carrying capacity, even though the reviewer acknowledged it is difficult to accurately estimate due to the short time series. Final comments were for clarifications and editorial suggestions.

Reviewer #2:

Reviewer #2 felt that the paper was well written and provided comment on the topics covered in the request for working paper. Given the data limitations, the conclusions were felt to be appropriate and the recommendations reasonable. The work was seen to address some critical questions in bivalve management. The reviewer felt that the purpose of the paper was clearly stated, the data and methods supported the conclusions, the recommendations were useful and reflected the uncertainty in the data in their conservative nature. Final comments

from the reviewer suggested some additions to methodologies and some editorial comments, and made some suggestions that could be incorporated into the assessment program. In summary, the review concluded that, “although the results are preliminary and limited in their direct applicability, they provide an important example of harvest rates in a somewhat controlled situation” and the reviewer recommended that the work be published so that it can be cited and used in other studies.

Subcommittee Discussion

The author intends to make editorial and clarification changes as noted by the reviewers. In reference to the comment from reviewer #1 on the correlation between sub-legal and legal abundance, an age structured analysis is being developed which will look at the reviewers concerns.

The long-term intent is to look at production modelling once there is a longer time series of data, but there are insufficient data to do so at this time. It was noted that survey data collected prior to the years used in the paper are not comparable with present analyses due to differences in the survey designs. Concerns were raised for other factors (unauthorised harvest, hydrological effects) that may have influenced the dramatic declines in abundance that were observed. The Provincial initiatives with shellfish aquaculture may also influence ongoing experiments. Recognition that the environment has not been “controlled” could be noted in the paper to make it clear these are not strictly controlled experiments. It was suggested that a graph could augment the table of densities. It was noted that although Booth Bay has the highest quota and production, it has never actually achieved its quota – some comment in the paper as to why this is so is warranted. Data for littlenecks has been included in the tables, therefore some reference could be made to littlenecks, or these data could be removed from the paper. Comment was made that local geography and a lack of advection of larvae away from the beach may be important factors in determining areas with good recruitment.

The Subcommittee noted that more than 10 beaches are presently managed under a TAC derived from surveys conducted several years previously. Considering the analyses from this paper which suggest that substantial changes in stock abundance can occur over a two year period, it must be noted that changes to the stocks on these beaches may also have occurred since they were last surveyed. Therefore, the Subcommittee concurred with the paper that these beaches need to be reassessed.

The Subcommittee gave consideration to the comment raised by reviewer #1 on the use of alternative Reference Points to those recommended in the paper, but did not suggest specific values.

Subcommittee Recommendations

1. The Subcommittee recommended that the paper be accepted with revisions;
2. The Subcommittee accepted the recommendations in the paper concerning reductions in harvest rates for the depuration fishery (the amount of reduction will depend on the surveyed density of clams); the need to develop protocols to distinguish the species composition and to estimate total landings in the depuration fishery; and that beaches that are managed under a constant TAC derived from a baseline survey need to be reassessed.
3. The Subcommittee agreed with recommendation #2 that managers should consider alternatives to a constant harvest rate policy (the recommended alternative is a sliding harvest rate which changes based on stock density), but that alternative methods to estimating the particular Reference Points be examined.

I00-02: Harvesting Methuselah's clams – Is the geoduck fishery sustainable, or just apparently so?

J.M. Orensanz, R. Hilborn, and A.M. Parma
**Accepted **

Summary

In mid 1998, the Underwater Harvesters Association (UHA) requested research into how Washington State harvested geoducks. Information was required on the management regime, including the higher exploitation rate, and highgrading and poaching issues. Fishery managers were referred to J.M. Orensanz and R. Hilborn, and this paper presents the results of an industry-funded review of the Washington State and B.C. geoduck fisheries.

The authors suggest that both fisheries show evidence of a long-term decline in recruitment (beginning prior to the onset of commercial fishing). They discuss the major implications of the two management strategies used and the influence of depensatory mechanisms on the apparent decline in recruitment. The paper presents three major concerns: (1) an apparent long-term declining trend in recruitment over large geographic scales; (2) geographic variations in recruitment and bed recovery rates, which may then need different harvest strategies; and (3) depensatory dynamics. Specific recommendations in the paper on most urgently needed research were:
1. An extensive ageing program with broad geographic coverage is urgently needed in both areas to reconstruct historical time series of year-class strength.
2. Washington's recovery experiment needs to be further analysed for knowledge of the dynamics of harvested geoduck populations.
3. Catch and effort data from the B.C. fishery need to be analysed.
4. A geographic information (GIS) component should be added to stock assessments on both jurisdictions.

External reviewers were asked by the Subcommittee chair to comment on:
1. Any insight into the flexibility of quota calculations.
2. The applicability of the recommendations to B.C.
3. Whether the management strategy in Washington is of value to B.C.
4. Any useful suggestions in additional areas.

Reviewers' Comments

Reviewer #1

The reviewer felt this was a good paper, which included as much data as was possible to access. The analysis was complete and good examples of other types of analyses to use were given. The reviewer commented on the following three main points:

1. Year class strength analysis (looking at past recruitment): the authors tended to overstate many of the observations based on the data available. Nonetheless, the evidence of declining recruitment from back-calculated year-class strengths is hard to argue with, and this approach should be pursued with recently-collected age frequency distributions.
2. Density-dependent mechanisms: There is weak but consistent evidence for post-dispersal depensation, and weak support for recovery relationships.
3. Washington State method of fishing: it was not clearly described that the Washington fishery often "fishes down" a tract population to on average 30% of its original size. Studies relating to recovery are not as applicable to the B.C. situation as to Washington's.

On the recommendations in the paper, the reviewer had the following comments:

1. Age frequency distribution data should be collected.
2. Geographic variations should be considered in harvest strategies. Is a single exploitation rate appropriate and should these exploitation rates vary with the productivity of a bed? Studies are needed on this problem.
3. Scrutinize B.C. catch per unit effort data – these data should be looked at, under a highly controlled analysis, recognizing that the accuracy of the most recent CPUE data is in question.
4. Investigate spatial dynamics – it would be useful to investigate the depletion process. B.C. is using GIS to fine-tune spatial allocation of effort, and a lot of data (survey and logbook) are available that would enable investigations into spatial relationships.

Reviewer #2

This reviewer felt the paper represented a very important contribution to the PSARC process. The main question appeared to be "So, what is the Department going to do with this information now?"

The reviewer noted the existence of a mountain of unpublished B.C. data such as age frequency distributions, experimental plots and basic life history. He also questioned whether a single harvest strategy is valid for large areas. He felt the four recommendations were sound, and again queries what the next steps will be within the Department.

Reviewer #3

This reviewer also felt this paper presented a well-written and comprehensive review of geoduck stock assessment. However, he had significant reservations on some of the conclusions and focussed on the following key issues:

1. Long term declining trend in recruitment: recruitment seems to have declined in both B.C. and Washington in the last 15 years, and the data presented suggests that this declining trend stretches back considerably further. This gives rise to questions such as to how to exploit a population that is naturally going extinct and whether one should even exploit such a population. The reviewer recognized that a new set of age frequency distributions is required in order to reconstruct historical year-class strength.
2. Depensation: How hard should an individual tract be fished before leaving it to recover? Further experimental fishing is required at different levels to see if recovery rates depend on the amount of biomass left. Suggestions were made for pre- and post-fishing survey work. The reviewer noted that if depensation is occurring, one should search for the harvest rate that best accommodates both the practical aspects of management and provides for sustainable fishing at some level.
3. Geographic pattern in recruitment: this is the section of the paper with which the reviewer was most skeptical. He did not find much convincing evidence of fast and slow recovery clusters in the Washington data. Although he disagreed with the authors' specific analysis of these data, he concurred that the matter deserves more attention.

With respect to the recommendations, the reviewer concurred with the first two, and noted that post-harvest surveys should be contemplated for all sites. He did not place much emphasis on a review of the B.C. CPUE data, but agreed that GIS components such as spatial tracking of harvest should be considered.

The reviewer also commented on: the authors discussion of highgrading, noting that post-harvest surveys at all fished tracts in Washington are needed to provide an estimate of the true harvest rate; on the rationale for F40% in Washington; the

estimate of M; and on post-harvest recovery data analysis. In conclusion, the reviewer agreed that there is a concern for sustainability, and noted that slow population dynamics and low harvest rates may not only mask long term trends, but also make it unlikely that any sort of fishery collapse is imminent.

Subcommittee Discussion

The majority of the Subcommittee discussion focussed on the application of the information presented in the paper to the fishery in B.C. It was recognised that long-term planning of assessment and management activities is required in both B.C. and Washington. Questions were raised with regard to the concentration of effort, minimum density requirements for recruitment success, effects of relative densities, stock structure (and the applicability of source/sink theories), and the difference between low harvest rates over large areas (B.C.) versus high harvest rates over small tracts (Washington).

Discussion also revolved around the concept of harvest refugia and the need for consideration of their use in this, and other, B.C. shellfish fisheries. Highgrading was not considered to be a large concern in B.C., although there are no data to verify this. The fishing protocol and self-management by industry appears to alleviate this issue.

In summary, the Subcommittee agreed:
1. The paper represents a good analysis and a broad view of geoduck assessment and management in B.C. and Washington.
2. Long term trends and variation in recruitment should be identified. Data analyses are required to review the conclusions drawn in the paper. The Subcommittee noted that efforts along these lines are ongoing within DFO, including south and north coast comparisons.
3. Depensatory studies are needed to investigate the possible requirement for a minimum density of geoducks to promote recruitment.
4. Recovery rate conclusions appear to be more appropriate to Washington where the tracts are fished down heavily.
5. Currently, highgrading does not appear to be as much of a problem in B.C., but there are no quantitative data.
6. GIS analyses are ongoing. Geographical differences in recruitment and effects on exploitation rates should be considered.

Subcommittee Recommendations

The Subcommittee recommended:
1. The paper be accepted.
2. Long-term recruitment trends and their spatial coherence need to be investigated to determine if there is a long-term decline.
3. Studies need to be conducted to identify issues relating to minimum densities below which geoduck recruitment is impaired.

I00-03: Development of a fishery for Tanner crab (*Chionoecetes tanneri*) off the coast of British Columbia

G. Workman, A. Phillips, J. Boutillier, and F. Scurrah
Accepted subject to revisions

Summary

The deep water Grooved Tanner crab (*Chionoecetes tanneri*) is being investigated as one of several species proposed as new fisheries off the coast of British Columbia. Investigation of the fishery potential of this species is following a phased approach for the provision of scientific information for new and developing fisheries. Phase 0 and Phase 1 framework papers have been reviewed by the Pacific Scientific Advice Review Committee. This paper is a progress report on studies initiated to determine the distribution and abundance of *C. tanneri* over its entire geographic range off the coast of British Columbia.

The results from a Department of Fisheries and Oceans trawl survey and partial results of a structured trap survey conducted by the fishery proponents are summarized. Using these two sources of data we calculated total allowable removals (TAR) by all gear types for five Pacific Fisheries Management Areas (PFMA) off the west coast of Vancouver Island (WCVI). TAR was computed using a simple surplus production model with biomass estimates computed from the area swept trawl survey data, mortality rate estimates derived using a generalized mortality model with a maximum age of 16, and scaling factors of 0.5 and 1.0. The mean size at 50 % maturity for male *C. tanneri* was estimated to be 112 mm from the biological data collected during the DFO trawl survey. Consequently, the biomass estimate used to compute TAR was the lower bound of a 50 % confidence interval of the estimated biomass of male *C. tanneri* larger than 112 mm. Estimates of biomass were weighted by the relative trap catch rates between PFMA from the structured trap survey. Weights were computed using the mean number of male crabs larger than 112 mm per trap by PFMA. This resulted in an estimated TAR of 237.4 metric tons for the WCVI for 2000/2001.

Also presented are the results of investigations into the incidental mortalities of *C. tanneri* in other ongoing fisheries. The authors identify the current deep water slope rockfish fishery as the most significant source of incidental fishing mortality with an unknown incidental fishing mortality attributed to the sablefish trap fishery. Based on the incidental by-catch of *C. tanneri* by the groundfish trawl fishery in 1999 it is anticipated that this gear type will harvest approximately 120 metric tons of *C. tanneri* in 2000, resulting in an estimate of total allowable catch (TAC) by trap gear of 117.4 metric tonnes.

The paper discusses the ecosystem impacts of trap and trawl gear by looking at catches of other species caught by each gear type.

Reviewers' Comments

Reviewer #1

Reviewer #1 felt that the paper should include a clear statement of purpose. She questioned the use of PSARC as a forum for non- scientific information and felt that it probably should be included in an alternate document. Several methods and procedures were not described clearly enough to permit verification of results and it was felt that the paper should be a stand alone document. Reviewer #1 had concerns on the use of Hoenig's method for estimating instantaneous natural mortality considering the lack of data on maximum age of tanner crabs and the use of parameter estimates derived from 'Non-crustacean' taxa. She felt it was important to make a distinction between the uncertainty as imprecision that results from statistical survey methods and the uncertainty in the accuracy of estimates that may result from the violation of various assumptions. She also suggested that Fishery Managers would benefit from a more explicit treatment of uncertainty in parameter estimates by gaining a clearer understanding of the possible range of biomass estimates and maximum or optimum sustainable yields that can result from a range of possible parameter values. She also felt that the development of the tanner crab fishery presented an excellent opportunity to implement an experimental or adaptive management approach and that the implementing of two fixed harvest rates may not be the best use of this opportunity. Reviewer #1 felt that the paper's conclusion needed to be strengthened to more comprehensively describe the major conclusions of the paper.

Reviewer #2

Reviewer #2 felt that it may be preferable to base the harvest allocation on the actual point estimate for biomass rather than the 25th percentile but use a more conservative scaling factor in the early stages of a fishery development. This reviewer suggested that the authors include a summary table of parameters and their uncertainties in the statistical analysis and how these uncertainties and errors effect the end result. This was to give the reader a feeling on how sensitive the final numbers are to error and to guide the future information needs. He felt that the survey protocol was a defensible, and for the most part reasonable, way of integrating the trawl survey, which can only be conducted in a limited area, and the trap survey which can be used across the entire coast. He felt that tag recovery studies were unlikely to provide much information and that there was a need for a multi- year plan to be included in the document.

Reviewer #3

Reviewer #3 felt that there was a significant amount of experience with deep water crabs in other jurisdictions that was ignored by the authors. He specifically suggested the authors read a paper by Orensanz *et al.* (1998. Rev. Fish Biol.

Fish. 8(2): 117-176). His major concerns were the collapses of deep water crab species worldwide, that they are a long lived species, that pockets may be fished out, and the movement of larvae to restock areas. This reviewer felt that there was a need to be incredibly cautious for this species and that there was a considerable concern with the catch from the groundfish trawl fleet. To be precautionary, this reviewer felt that we should assume that there was a terminal moult and manage to this assumption. Reviewer #3 felt that it was premature to make the recommendations proposed in the paper.

Reviewer #4

Reviewer #4 felt that the overall approach taken seemed quite sound and the phased approach was a logical way to proceed. He felt that if it was not possible to increase sampling intensity that the best practical approach would be to develop reliable indices for some small representative areas which could be related to some less stringent index for the broader area. He had serious reservations about the reliability and utility of the trawl-based biomass estimates and was concerned about absolute interpretation of the trawl survey biomass estimate. He felt that these surveys should be considered to represent an index only. This reviewer felt that there was nothing to be gained by extrapolating the trawl survey biomass estimate to the broader area based on trap catch rates and that the trap survey catch rates should be left as an independent index of biomass. Priority should be given to initiating a time series that can be used to monitor changes in population structure. He felt that the basis of the size limit for males of 112 mm should be elaborated. He questioned the reliability and value of the estimates of natural mortality (M) and the maximum sustainable yield (MSY) and felt that such estimates were unnecessary at this stage. It is still unclear whether this species has a terminal moult across a variable size range and which sizes of males are required for mating. These are very important issues which bear upon suitable exploitation levels and minimum legal size limits.

Subcommittee Discussion

There was discussion by the Subcommittee on the need for a more concise description of some of the methods used within the paper and the need for PSARC papers to be “stand alone” documents.

There was detailed discussion of the phase 1 framework for dividing the coast up into three areas: 25% fishing at a fixed exploitation rate, 25% research area and 50% reserve area and how this might work on the continental slope habitat. There is a crucial need to choose areas as reserves for Tanner Crab in conjunction with other fisheries, especially the groundfish trawl. There is need for multi-species protected (or reserve) areas and a defined process for deciding on their locations and features, i.e. taking a broader ecosystem-based approach with these deep water assemblages. The potential gear conflicts with groundfish trawl and the sablefish trap fisheries are expected to be severe. The

Subcommittee noted that of the proposed Total Allowable Catch for Tanner crab off the west coast of Vancouver Island (237.4 t), 50% of this is expected to be taken as by-catch by the groundfish trawl fleet. It is assumed 100 % mortality by any gear type for Tanner crab brought to the surface. By-catch of this magnitude represents a serious impediment to the development of a Tanner crab fishery.

The utility of M and MSY approaches as used in the paper was questioned and there was discussion of a fixed quota, alternative exploitation rates, and target and limit Reference Points. Present data are insufficient to implement many of these alternative approaches. Data will continue to be gathered and the methods modified as more information on the biology of the species becomes available, including terminal moult, spatial distribution of the species, and seasonal migrations. There was agreement within the Subcommittee for the need for a table depicting the uncertainties of the statistical methodologies and the ripple through effects of these uncertainties. The need for a similar table to depict the known and unknown aspects of the biological information was also agreed.

It was agreed that there was a need for a long term strategy to be included in the paper. This strategy needs to be explicit and to provide details as to where to go in the future with this species. In addition, this strategy needs to have multi–species input (including DFO assessment and management staff with groundfish trawl, sablefish trap and tanner crab responsibilities). The objectives of the experimental fishery design need to be clarified and included in the document.

A discussion ensued on the appropriate forum to discuss process issues and whether they should be included in this scientific document. Process issues include the collaboration and interaction of DFO with community and fishing interests in developing this Phase 1, what worked well and what could be improved. After much discussion it was decided that process comments could be included here as they relate to the scientific issues, but that they should also be discussed in more detail in another document. This other document needs to be a collaborative effort between Industry and DFO.

Subcommittee Recommendations

1. The paper was accepted with major revisions.
2. The Subcommittee accepted the recommendation for the need for the trap survey for tanner crab to be completed for the remainder of the central and north coasts.
3. The Subcommittee agreed with the need for fishery independent trawl surveys to be used to assess tanner crab stocks.
4. The Subcommittee recommended the formation of an internal working group to define the experimental protocol to test alternative harvest strategies and to develop biological information using a precautionary approach, so as to move forward with this new fishery. Total annual removals of male Tanner crabs (the only group that should be harvested) from the west coast of Vancouver Island

should not exceed 237.4 tons.

5. The Subcommittee expressed serious concerns on the by-catch of tanner crab in the groundfish trawl fishery and in particular the proposed expansion of the longspine thornyhead fishery into other areas of the coast north of Vancouver Island.
6. The Subcommittee agreed on the need to obtain tanner crab by-catch and size information from the groundfish trawl and sablefish trap fisheries. By-catch in the Tanner crab fishery should also be examined.
7. The Subcommittee endorsed the recommendation that species harvested from the continental slope be managed on an ecosystem basis rather than on an arbitrary assemblage basis or a fishery by fishery basis. Consideration should be given to the habitat impact and selectivity of various gear types.
8. The Subcommittee agreed with the authors that limit Reference Points be developed that would close the fishery when populations reached certain criteria, but felt that although this was the direction to proceed there was much work that needed to occur prior to reaching this point.
9. The Subcommittee felt that the authors did not provide sufficient information on softshell timing in tanner crab to support the recommended fishing season (Oct. to Feb).

I00-04: **Reconstructing the offshore *Pandalus jordani* trawl fishery off the west coast of Vancouver Island and simulating alternative management policies**

S. Martell, J. Boutillier, H. Nguyen, and C. Walters
Accepted subject to revisions.

Summary

Shrimp trawl fisheries in Pacific Fishery Management Areas 124 and 125 have historically been boom or bust fisheries. The authors use research data and commercial catch and effort data to reconstruct the *Pandalus jordani* stocks off the WCVI and examine stock-recruitment relationships, changes in catchability, and fishing power differences between two separate research vessels, the GB Reed and the WE Ricker. The authors then use the results of the population reconstruction to develop and parameterize a simulation model for exploring four alternative management policies for this fishery. The results of the population reconstruction suggest that recruitment, in years of low spawning biomass, may be in the form of immigration; however, using a synthesis approach to reconstructing the population suggests there is a clear stock-recruitment relationship. Survey biomass estimates from annual research surveys are good predictors of pre-season vulnerable biomass, and in conjunction with a formal stock assessment model could be used to calculate annual total allowable catches. We also found that catchability had increased over the last 10 years, however, we are uncertain whether these changes are due to range collapse or improvements in fishing technology. Simulation results suggested that there were no long-term or short-term gains to be made by aggressively managing this

fishery. To maintain an economically viable fishery, the authors suggest a cautious approach to management. The fishery in areas 124-125 should be closed in years when the estimated biomass is less than 1,000 tonnes, and a maximum exploitation rate of 35% applied when the biomass exceeds 1,000 tonnes. The authors also suggest that consideration be given to setting up a quota-based management system in which annual TAC are based on pre-season stock estimates.

Reviewers' Comments

Reviewer #1

Reviewer 1 felt that the analyses were sound and that the recommendations of the working paper were clear and useful. There were many requirements for improved descriptions of components of the analysis and areas that required more explanation or justification. Inconsistencies and errors were pointed out.

Reviewer #2

Reviewer 2 was complementary and said this was an impressive assessment. He also noted the need for additional information or clarification. Suggestions for improvements included an appendix to summarize model assumptions and data requirements, and a figure showing model results with survey data. It was also suggested that a figure of biomass vs. yield with the predicted trajectory for a couple of scenarios would show where the proposed strategies would take the resource in the near future. The most troublesome shortcoming is the lack of diagnostics in the various model fits.

Subcommittee Discussion

The Subcommittee was impressed by the extent and quality of the analyses, and commended the authors.

The Subcommittee noted the phenomenon of the change in catchability between the two research vessels. The timing of the switchover occurred at a stock minimum, and it is not clear whether the difference was due to a change in fishing power or to a coincident shift in natural mortality. This issue should be elaborated in the working paper. The question of whether Statistical Areas 124 and 125 are two separate stocks with sequential northward recruitment, or a single population, was discussed. There is not yet sufficient data to explain the west coast stock structure, and it was concluded that the lumping of areas was acceptable, but that the authors should include a paragraph describing the potential limitations with this assumption and the implications for management.

It was pointed out that the paper lacked recommendations for the fishery in Area 123. The lack of time-series data from Area 123 precluded such advice, however

in the absence of such data, the Subcommittee agreed that similar control rules recommended for Areas 124 and 125 should be applied to Area 123. This is considered more precautionary than opening the 123 fishery seasonally.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to revisions.
2. The Subcommittee concurred with recommendations 1 through 3 of the working paper, which all referred to the need for increased biological information. There is a need to analyze existing catch-at-age data and to continue the collection of these data. Commercial catch-at-age data requires a fuller and separate examination.
3. The Subcommittee concurred with the recommendation to continue the collection of fishery-independent survey data for forecasting stock size estimates.
4. The Subcommittee concurred with the adoption of a biologically-based quota system for Areas 124 and 125. It also agreed with the recommendation, based on modelling studies, that Total Allowable Catches be calculated using a conservative approach, where no more than 35% of the available surplus is harvested. In addition, it was suggested that the approach could be applied to the entire west coast of Vancouver Island offshore shrimp fishery.

I00-05: Evaluation of Horse clam stock dynamics for a directed subtidal horse clam (*Tresus capax* and *Tresus nuttallii*) fishery in British Columbia

Z.Y. Zhang and A. Campbell
Accepted subject to revisions.

Summary

Biological information essential for addressing ecological concerns, assessing population stock dynamics, and evaluating fishing strategies for a directed fishery proposed for horse clams was examined. A stochastic rotation simulation model was developed to evaluate the effect of fishing schemes and exploitation rates on the dynamics of horse clam populations based on known natural mortality and growth rates and age at vulnerability to fishing. Little is known about the ecological impact of a directed horse clam fishery, especially on eelgrass and other valuable bivalves such as geoduck, and will require experimental evaluation. Surveys are required to determine horse clam biomass distribution in relation to eelgrass distribution to estimate appropriate quotas. A precautionary limit Reference Point (at least 40% of the virgin spawning stock biomass), a target Reference Point (at least 60% of virgin spawning stock biomass) and correspondingly precautionary exploitation rates were recommended.

Reviewers' Comments

Reviewer #1

Reviewer #1 felt that the working paper was difficult to read in part due to the modelling concepts presented, but also felt the paper could be better organized and formatted. The reviewer expressed concern that although the objectives of the paper were clearly stated, they varied from the objectives and did not adequately address the questions set out in the request for working paper. The reviewer found that in comparison to the request for working paper, the working paper was more limited in scope. In particular, comment was made that a number of components typical to a 'Phase 1' and reference to the 'Phase 0' were missing from this paper. The reviewer had some question as to whether data and methods were adequate to support the conclusions and felt that other aspects of assessment plans could be explored. The first recommendation requires elaboration on the "required biological information" and the Reference Points (specifically as referred to in the recommendations) require clarification. Suggestions were made for further research on harvesting impacts on eelgrass and that concerns for eelgrass warrant further discussion in the paper. Specific formatting, restructuring and editing comments were also provided.

Reviewer # 2

Reviewer #2 concentrated specifically on reviewing the model. The reviewer felt that the paper proposes classic modelling theory, and felt it translates the data sources into a management decision rule, but urged some caution in its interpretation and implementation. The reviewer felt that the lack of data on a stock-recruitment relationship was circumvented, although a stock-recruitment relationship could be an important factor. The conclusion that stocks with high natural mortality can be subjected to high exploitation rates fits classical theory, but the reviewer questioned whether this would always be the case. High natural mortality may also indicate that a stock is in trouble, in which case the model would be wrong, and urged caution in the application of a higher exploitation rate for a higher natural mortality as presented in the model. The reviewer urged consideration be given to reviewing other models in order to investigate further the problems with the interpretation of natural mortality. The reviewer complimented the standardisation of a phased approach to new and developing fisheries that is being undertaken for shellfish fisheries.

Subcommittee Discussion

There were two important comments raised by reviewers that the Subcommittee discussed: 1) while the model is useful to managers, is the paper too narrowly focused and should it have included broader information in consideration of the request for this working paper (i.e. more like a 'Phase 1')? 2) whether alternative models should be considered.

In response to reviewer's comments, it was noted that this paper was based on the data available and used one model to look at setting Reference Points. It is acknowledged that this model is preliminary and further analysis and biological information is needed prior to a fishery.

Natural mortality is a key component of the model and one of the most uncertain, and some discussion should be included in the paper on how the natural mortality estimates were derived as the data have not yet been published. It was acknowledged that there are questions about some of the model's assumptions. The model assumes recruitment is constant, but it may not be; generally, episodic recruitment events do occur in invertebrates. The assumptions used and the uncertainties in the model should be identified; a table could be included that identifies the assumptions, known parameters, and makes note of the outstanding biological information that is needed. Revisions should include options for other models. In revisions, the authors should clarify whether the term "Spawning Stock Biomass (SSB) per recruit" or "SSB" should be used throughout the paper, and also provide an explanation of it (i.e. clarify the operational use of the recommended Reference Points). The discussion warrants expanding on some of the points that were outlined in the request for this working paper (compare working paper to the request). Based on the uncertainty in the assumptions, consideration could be given to more pre-cautionary reference limits and/or setting different exploitation rates in different areas/beds to examine the response within an experimental framework. It was agreed that the use of experimental plots or adaptive management could be considered in an experimental fishery and that from this paper, there is information to develop surveys. It was discussed whether surveys, assessments and management should be done on a bed-by-bed or subarea basis. It was concluded that there are fewer horse clam beds than geoduck beds, and that management on a bed-basis is preferred. This level of management may be needed to take account of concerns for eelgrass beds, and to take account of differences in species composition and natural mortality rates (since there are two species involved in this harvest).

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to revisions;
2. The Subcommittee agreed with recommendation #1 concerning the need for surveys to provide the required biological information prior to a directed horse clam fishery. These surveys need to be bed-specific, and would take account of the differing species composition of horse clams. Extrapolation of results to a larger area is not recommended;
3. The Subcommittee noted that the specific Reference Points in the working paper may not be adequately precautionary due to uncertainties in the model (i.e. in natural mortality). More biological information is needed to determine the appropriate Reference Points.

I00-6: Quota options for the geoduck clam (*Panopea abrupta*) fishery in British Columbia for 2001 and 2002

C. Hand and D. Bureau
Accepted subject to revisions

Summary

Quota options for geoduck clams (*Panopea abrupta*, Conrad 1849) for the 2001 and 2002 fisheries were calculated using new parameter estimates, and presented by Geoduck Management Area for the North Coast Region, West Coast of Vancouver Island Region, and Inside Waters Region. The habitat-based approach was continued from previous assessments, where virgin biomass is estimated as the product of the spatial area of geoduck beds, estimated geoduck densities and mean geoduck weights. Error ranges in each parameter estimate were combined to provide a range of biomass estimates, and a harvest rate of 1% was applied to derive quota options. Past harvest amounts in each geoduck bed were considered in the application of a $B_{50\%}$ limit Reference Point, which resulted in a reduction in quota of 30% and 20% of the total potential quota in 2001 and 2002 and the closing of 55 and 24 geoduck beds, respectively.

Biomass estimates and quota options are higher in each Region in 2001 and in 2002. Increases result from generally higher estimates for mean geoduck weight and density, but especially for spatial area. In the areas to be fished in 2001, 315 ha of new geoduck beds were identified, and in the areas to be fished in 2002, 374 ha of new geoduck beds were identified. Additional increases in bed area were due to the adjustment or removal of bed-area scaling factors, the inclusion of beds not fished in the last rotation for logistical reasons, or the conversion from imperial to metric charts. For the 2001 fishery, recommended low, medium and high quota options are 2.8, 5.7 and 9.6 million lb, an average increase of 68% over previous quotas. Quota options for the 2002 fishery are 3.3, 6.3 and 10.1 million lb, an increase of 48%. Given the uncertainty in parameter estimates, most particularly bed areas for south coast regions, fishery managers are recommended to consider the estimates as upper limit Reference Points rather than quota options. It is recommended that a large-scale bed verification and mapping program be initiated, that more extensive analysis of survey and fishery data be undertaken with spatial software, and that a rigorous assessment of the resource and management system be conducted.

Reviewers' Comments

Reviewer #1

Reviewer #1 felt the paper was generally well written but had a concern with the calculation of virgin biomass (B_0). The reviewer noted that, for the long term, the Department should not be trying to estimate virgin density unless it has sound biological information by area to use in the calculations. The average density

obtained through surveys should be used as a surrogate for virgin density . The reviewer questioned the need to "backcalculate" to B_0 when many areas have measured bed areas and densities with which to calculate current biomass (B_c). In the reviewer's interpretation of the methods, he felt that in adding fishery removals to the survey density to back-calculate B_0, the overall exploitation rate would increase in small increments. The reviewer suggested that either (1) the authors clarify the calculation and use of B_0 in the paper, or (2) use B_c for quota calculations.

Subcommittee Discussion

The Subcommittee discussion focussed on the use of virgin versus current biomass estimates to calculate quotas, and the sources of error implicit in the calculations using what could be inaccurate estimates of bed area, density and mean geoduck weight. There was considerable discussion on the assumptions made around equilibrium of recruitment and natural mortality, and the fact that incidental mortalities are not accounted for. The Subcommittee queried to what extent the confidence intervals of B_c and B_0 would overlap and recommended that this comparison be made to estimate the magnitude of the difference. It was recognised that more explanation on methods to estimate virgin density is required.

One of the major problems with the quota calculations appears to be the way the geoduck beds are mapped. It appears that bed size may be overestimated through the process of redrawing fishers' marks on a chart into a polygon that can be digitised and measured, then extrapolating these polygons to fit chart depth contours, and finally, by translating the original imperial charts to newer metric charts. Since the polygons are drawn to fit to depth contours, it is likely that a shift from maximum of 10 fathoms to maximum of 20 metres has resulted in an increase in the size of the digitised area. It was recognised that more explanation on this source of error is required.

The Subcommittee noted that as beds are fished down towards their sustainable biomass, the intensity of harvest actually increases (because the same harvest rate is now being applied to a lower biomass), and is likely to be greater than 1%. Details were requested to be added to the paper to identify what present exploitation rates are based on the present biomass.

The technical issues that need to be addressed in the working paper were summarised:

1. Are densities from surveys preferable to virgin densities for quota calculations? Authors will compare the two methods.
2. The paper needs elaboration of the issues around measurement of bed area.
3. The authors may consider a review of those beds with known estimates of density in order to calculate the actual exploitation (to compare to the target exploitation rate of one percent).

Calculation of the uncertainties surrounding the biomass estimates require correction.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to revisions;
2. The Subcommittee recommended that fishery managers use these numbers as limits that should not be exceeded rather than quota options, considering the increase in calculated quotas resulting from changes in parameter estimates that can have large uncertainties;
3. A formal stock assessment is required (in place of, or in conjunction with quota options papers). Such an assessment would include information from the full 3-yr rotation period. This assessment would also consider whether the 95% confidence interval about the mean biomass represents a sufficiently precautionary harvest range;
4. Precise determination of bed areas remains a problem. Advice needs to be obtained from the Department of Justice on the privacy issues surrounding the release of bed area information. Since the fishers are a readily available source of information on bed area accuracy, DFO needs to be able to discuss the fishing location charts with industry to help refine bed areas.
5. The Subcommittee recommended the authors consider separating the calculations of bed quotas and the presentation of quota options to indicate areas for which information is more certain and to identify those areas for which greater uncertainties remain. For these latter locations, a more precautionary management approach may be warranted;
6. The recommendation in the working paper to discontinue the two-year quota option paper was not accepted, pending development of the full stock assessment.

I00-07: **Framework for Pink (*Chlamys rubida*) and Spiny (*C. hastata*) scallop fisheries in waters off the west coast of Canada**

R. Lauzier, S. Campagna, and R. Hinder
Accepted subject to revisions

Summary

A framework for assessment and management of the pink and spiny scallop dive and trawl fisheries is presented for these fisheries to proceed under scientific licence, and in a manner which collects key information for ongoing assessments and management. Components of the framework incorporate previously expressed concerns including distribution and abundance information, assessment of West Coast trawl gear impacts, development of the trawl fishery with a phased approach, locallized stock depletions, difficulty in species selectivity in the dive fishery. Suggestions for the resolution of these concerns are presented. Data requirements for a precautionary fishery are outlined including removal estimates, biomass estimates, and biological information.

Assessment models and their data requirements are discussed. Alternative hypotheses, harvest strategies and effort controls are presented. Management options and their data requirements are presented.

Recommendations are made for the development of the pink and spiny scallop dive and trawl fisheries to follow the phased approach described in the Pacific Region Policy for New and Developing Fisheries, with suggestions on how this may be accomplished.

Reviewers' Comments

Reviewer #1

Reviewer 1 felt that the purpose of the paper was clearly stated, but recommended some explanation of the phased system in the introduction would help readers. She also noted that the authors have done a good job of reviewing various approaches to calculating abundance and mortality, and found the precautionary conclusions appropriate.

The reviewer noted that discussion of management tools in the paper is not reflected in the recommendations, and she is unclear whether the authors feel the measures discussed are useful or not.

It was pointed out that "critical densities" and "nearest neighbour measurements" are not discussed in the paper. The reviewer noted that trawl surveys in 100 m of water that are 15 minutes in duration and cover >1 km do not provide data on the spatial scale required. It was also recommended that dive surveys should be considered as they may provide an opportunity to evaluate spatial scale patterns and possible effects on recruitment.

The reviewer asked questions related to distribution and competition of the two scallop species, and noted this was unclear in the paper. The reviewer also noted seasonal affects on meat weights.

Reviewer #2

Reviewer #2 stated that the objectives of the paper have been achieved– but also noted that the paper has limited utility, as it does not contain sufficient information to provide long-term management options. The reviewer found the paper somewhat disjointed.

Reviewer #2 believes the paper addresses each of the Subcommittee concerns from the Phase 0 paper in a satisfactory manner. It was noted that the general question of distribution was not addressed in this paper and this will likely be an important consideration in terms of selecting refugia. The reviewer also expressed concern over the multi-species nature of these studies, which involve

two similar species. He pointed out the benefits of monitoring catch for species composition, as this may provide an indication of depletion of the preferred species (spiny scallops).

Concerns were raised regarding the management of two species as a single species and the calculation steps for the biomass estimates. In addition, questions of survey design and data collection were raised.

The reviewer also noted that the discussion in the paper regarding re-assessment of size-limits are not mentioned in the recommendations section of the paper. A concern was also raised that the recommended limit Reference Point of 50% of current biomass may not be appropriate given the fact that most beds are already highly exploited.

Subcommittee Discussion

There was general discussion on technical issues, including biomass calculations from the trawl surveys. Questions were raised about the calculations for determining densities – the working paper requires clarification and editing. Concern was raised about the ability to delineate beds and errors in calculating bed areas.

The Subcommittee suggested that a systematic survey design with spatial interpolation would be more appropriate at present, when little information is available on appropriate stratifying variables.

The Subcommittee noted that remote sensing methods (such as acoustics) that map habitat may not be applicable for determining scallop densities, but could be used to determine habitat types. Work needs to be done to confirm relationships with particular benthic habitat types. Remote cameras and video were discussed as possible alternatives.

The Subcommittee discussed feasibility of conducting dive and trawl surveys to compare results on a single bed. The Subcommittee echoed the concern of Reviewer #2 regarding the need to remember that two species are involved in these studies.

The Subcommittee noted that although the paper suggests an initial target harvest rate should range from 3 to 9% of the original unexploited biomass, there are large uncertainties associated with the input parameters and at present the unexploited biomass is unknown. The Subcommittee also noted this rate (3-9%) is much lower than the harvest rate (20%) applied to date. It was further noted that the limit Reference Point of 50% of current biomass suggested in the paper may be too low, considering the uncertainties in the input parameters.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to revisions;
2. The Subcommittee supported the recommendations in the working paper concerning the need to delineate appropriate "scallop management units" and the need for biomass surveys of these units. It was noted that Sub-area 29-5 may not represent "unfished" biomass if there are spill-over effects from harvesting in adjacent sub-areas;
3. The Subcommittee supported the recommendation for additional biological data, including species composition;
4. Subcommittee noted that the limit Reference Point of 50% of current biomass suggested for this fishery may be too low, and that a more conservative value (higher percentage of the current biomass) should be used to trigger closures. This Reference Point should be applied to the legally-harvestable biomass, since a minimum size limit is in place;
5. The Subcommittee supported the consideration of refugia and research study sites for this species as part of an adaptive management plan.

I00-08: Catch composition of British Columbia shrimp trawls and estimations of by-catch

N. Olsen, J.A. Boutillier, and L. Convey

Withdrawn.

FISHERY UPDATES

Geoduck

The geoduck fishery landed 3,960,676 lb. of geoducks for a value of $34 million in 1999. 55 licences were fished on 41 vessels. Some concerns with the assessment process were raised: assessment documents every two years do not show the "full picture" of the rotational fishery; calculated quotas often differ from those assigned in the management plan; some questions with regard to the assessment process are not being addressed; the Department is holding lots of unanalyzed data which could be of use to the future management of this fishery; and a long term plan for research activities is required.

Quotas have been stable since 1997, which implies the prospect for the fishery appears good. This was discussed further after the quota options paper was presented. Management issues during and following the 1999 fishing season included: fishers would like a small increase in quota as a sign to the marketplace that the fishery is stable and not in any risk of decline; poaching is occurring at unknown levels and the Department is not addressing it (the UHA is considering funding a fishery officer to work solely on geoduck issues); aquaculture and enhancement experimentation is ongoing, without any solid

guidelines, and the moratorium on development is due to be reviewed and lifted in 2001; PSP problems in the North Coast forced managers to consider changing the schedule in order to complete the remaining IQs – this type of in-season change did not receive wide consultation.

Euphausiids

This fishery is managed under a 500 t TAC, and is in its second year of an industry-funded hail and validation program. Harvest data quality is improving. The bulk of the product is frozen and sold after the season, so fish slip reports are not accurate; however, validated landing reports provide good landings information. The CPUE was the highest it has ever been in 1998, and the priority issues are unchanged from last reporting (underfunded for enforcement etc.).

Sea Cucumber

This fishery is in its fifth year of successive two year pilot IQ programs – it is not anticipated that any changes will be made to the pilot in the foreseeable future. TAC, Individual Quota and subsequent landings in 1999 were increased by approximately 26% as a result of density surveys in Area 6. Information on the value of the fishery was not yet available. Most management issues remain the same as 1998, with the following additions: industry has requested that it be permitted to stack more than 3 licences per vessel; poor hail notification is creating problems on the grounds; fishers need more advance time to buy licences and travel to the fishing grounds prior to fishery opening; the fishing season may be too short considering the recent increases in IQ; harvest chart submission will be reviewed for the 1999 fishing season; the Pacific Sea Cucumber Harvesters Association is considering assigning “on-grounds coordinators” to aid in accurate hail notification and broadcast of information on remaining quotas.

The Subcommittee expressed concern for the process followed under the adaptive management plan. Although only 25% of the coast is actually open to fishing, it may be biased toward being the most productive portion of the coast. A summary of areas previously fished which are now closed under the adaptive management plan was requested.

Neon Flying Squid

This experimental fishery was one of the original 4 selected for development in 1996. This highly selective jig fishery captures only females, as the males seldom migrate into Canadian waters. Flying squid live only one year during which time they undertake a return migration from latitude 20° N up to 50° N to feed. This fishery is managed by a precautionary quota set at 1500 tonnes which has remained unchanged since 1996. A fishery has taken place every year since 1996 with 4 – 6 participating vessels and landings varying from 7.4 – 63 tonnes.

Landings were down from 63 tonnes in 1998 to 38 tonnes in 1999 due to lower than normal surface water temperatures which caused schools to be broken and difficult to locate. Nevertheless, fishermen are learning to locate and fish this stock. A new development in 1999 was the introduction of lighting at depth (300m) which attracts schools of squid and allows them to be fished during daytime. Previously they could only be fished at night with surface lighting. Maximum fishing production is 1-2 kg/jig hr.

All catch is processed and frozen at sea. Fishermen receive up to $4.00/lb for landed product and from $6.00 - $8.00 for specially processed product sold to Asian markets. The 1999 catch remains largely unsold due to market oversupply.

Issues:
There is a need to improve the quality of the biological data base, as logbook entries are inconsistent.

Intertidal Clams

This commercial fishery targets mainly Manila and native littleneck clams, mostly from the south coast, however there are landings of Razor clams from the north coast of the Queen Charlottes with modest landings of Butter clams. Wild harvest is by quota allocated by beach. Diggers are individually licensed and licences are limited and non-transferable. The licence limitation appeal period expired in 1999. Of the 1160 eligible licensees, only 960 licenses were issued in 1999. The shortfall is mainly due to First Nations diggers, which represent roughly half of the eligible participants failing to apply. It is noted that some of the licenses obtained are not being actively fished and that 30 diggers were removed from eligibility for failure to exercise their privilege to fish the resource.

Harvest for 1999 of 1568 tons was down slightly from 1998. Of these landings, approximately 863,000 lbs were from depuration harvest. Estimated value of the entire clam fishery is about $5.1 million. Diggers received an average of $1.76 per pound for wild clams and $1.26 per pound for depurated product. Average annual income to diggers is $5,000 – $7,000, representing an increase in revenue of some 3 times since institution of licence limitation.

Issues:
Saleslip data do not accurately represent landings. Stock status is now based on best estimate of landings from hail reports which is a verbal estimate in most cases. Past landings are therefore not directly comparable due to observed large discrepancies in reported sales to actual harvest. Problems appear to occur with each step of the process: initial reporting; data entry; and processing by DFO.

Numerous governmental agencies are involved with this fishery, but there is little co-ordination among them. This results in events such as the provincial initiative to expand aquaculture leases which resulted in removal of some wild beaches

from harvest, including one DFO index beach.

Increasing dependence of management of resource on industry funding. Whereas contribution of funds in area B towards increased PSP monitoring has resulted in increased quota, failure to provide funding in area F may result in declassification of some beaches (including some leases).

The collaborative agreement with depuration harvesters (of which 60% are Native participants) expires in Oct. 2000.

Horse clams

There are 55 licenses since geoduck and horse clam licenses are linked. In 1999 there were 155 boat days reported for total landings of 4.7 tonnes. Increased landings from 1998 are thought to be the result of some fishermen attempting to demonstrate entitlement by showing landings.

Shrimp by trawl

The shrimp by trawl fishery includes Smooth and Northern Pink, Humpback, Sidestripe and Coonstripe shrimp. Licenses are limited to 248 of which 179 fished in 1999/2000. The coast is managed by individual shrimp management areas, with quotas set in all areas except the offshore areas of the west coast of Vancouver Island for which a season is set. Initial area “catch ceilings” are adjusted in-season as a result of Stock Assessment analyses (which are largely Industry funded) in many of these areas. Landings for 1999 were 2725 tons, down from 3300 tons in 1998, most of which came from the West Coast of Vancouver Island (WCVI) and Prince Rupert. Stocks off the WCVI have been at low abundances over the last 2 years, however, the May 2000 survey indicates abundance recruitment of juveniles, mainly in the south. The expectation is for improved west coast shrimp abundances in the next couple of years. The season opening for the west coast offshore areas was reduced in 1999/2000 compared to the previous season. Queen Charlotte Sound catches were low compared in 1999/2000 compared to previous years.

Issues

- The main concern in this fishery is overcapacity of the fleet. A major factor contributing to overcapacity resulted from the Salmon license buy-back which caused single shrimp licences, which were previously “married” with salmon licences, to become dedicated (economically and in effort) to the shrimp fishery. The Industry has approached the Minister regarding a buyback of Shrimp licenses.
- Lack of stock assessment information. Numerous Stock Assessment programs depend on industry funding and support, and assessments remain a time constraint to industry expectations.
- A method needs to be developed to collect management fees by the 2001

fishing season.

- There remains a lack of enforcement, due to a low Regional priority for this fishery.
- Incidental by-catch of eulachons remains an issue.

Goose Barnacle

This fishery was closed as of May 31, 1999, as directed by RMEC. The development or continuation of this fishery will depend on the results of a stock assessment and an ecological impact assessment and meeting the criteria for a new and developing fishery. A goose barnacle working group (two harvesters' associations, the Nuu-chah-nulth Tribal Council, DFO, Parks Canada, BC Parks and others) has been meeting since March 28, 2000 to define the logistics of scientific studies to define the distribution, biomass and ecological assessment framework.

Octopus

This fishery is primarily a bait fishery with some interest in developing a food fishery. Last year the trap fishery for octopus was discontinued. In 1999 forty licences were issued in the fishery, however, only 15 have reported landings. The fishery is open all year, however, the bycatch landings of octopus from other trap licences (e.g. prawn, crab) are only open seasonally. There is also limited landings as by-catch from the shrimp and groundfish trawl fisheries. The total landings for 1999 were at their lowest levels since 1986 at about 50 tons. The majority of landings from the dive fishery are from Area 12.

For the Year 2000, the fishery has changed to a scientific licence to respond to concerns that the fishery is data-limited, and the known continuation of the use of bleach. Eligibility by historic landings is now required to obtain a scientific permit. This current eligibility would create a maximum of 20 licences. With the scientific licences, each fisher was required to sign a letter indicating that he would not be using bleach. To date, only hydrogen peroxide looks like a reasonable alternative to bleach (as it breaks down quickly and is non-chlorinated), however, its effects have not been fully tested. Concerns were raised that DFO needs to be involved in the testing of these alternatives. The logbooks have been modified to include biological data. Issues raised were the enforceability of the no bleach requirement.

Scallops

Two species are fished – spiny and pink scallops. This fishery is now under a scientific licence with 10 licences issued. The fishery is restricted to the Strait of Georgia. The dive fishery harvests primarily spiny scallops, whereas the trawl fishery harvests primarily pink scallops. Licences are valid until July 31, 2000. Biological sampling is required under the scientific licences. One trawl survey has

been completed and there is another scheduled for later in the year. Issues from this fishery relate to confidentiality of data collected under scientific licences.

Green Sea Urchins

There are currently 49 licences with some vessels carrying more than one licence. The management plan is a two-year plan and the quotas remain unchanged for next year based on this plan. Landed value has partially increased. A limited number of areas are allowed to be fished. Areas not open can be fished under an exploratory protocol. In the North Coast, Area 4 is the only area open, and this past season there was a confrontation between the fishers and the Metlakatla Band. A court case is on-going. Dive surveys are being planned for the North Coast with (it is hoped) joint First Nation and Industry participation.

Crabs

The recent value of the crab fishery in B.C. is over $20 million. Trap limits have now been implemented coast-wide. The outstanding issues in crabs relate mostly to management (rather than conservation) concerns, except for the potential impacts on juvenile crabs of excessive and repeated handling in the major fishing locations.

Geoduck Enhancement "Update" (B. Clapp, Underwater Harvesters Association)

The Underwater Harvesters Association (UHA) biologist gave a presentation on the history and current activities of the association's geoduck enhancement program. Most recently, progress has been made in seed planting technology. In the past, the UHA has experimented with various methods of seeding hatchery-raised juvenile geoducks, with varying levels of success resulting from predation problems. The UHA have now constructed a prototype mechanical planter that enables divers to carefully deliver juvenile geoducks into the substrate, where they appear able to avoid large scale predation. Survival of the longest planted juveniles (3 years) is approximately 50 to 65% to date.

The Subcommittee was interested in the consistency of the quality of the seed geoducks, the effects of density of planting, the selection and use of broodstock collection areas, and the impacts of different habitat and current features at each outplanting site. A concern was raised about the classification of such activities as "enhancement" or "aquaculture". If the latter, then it will require B.C. provincial authorisation. It was also noted that a paper to develop a strategy for geoduck enhancement activities has been proposed for the next meeting of the Subcommittee.

STOCK STATUS REPORTS

One stock status report was reviewed and approved by the Subcommittee, on geoducks. This stock status report will be forwarded to the PSARC Secretariat for publication in the usual manner.

APPENDIX 1. PSARC INVERTEBRATE SUBCOMMITTEE MEETING AGENDA, 19-22 JUNE, 2000

	19 June Monday Start 0900	20 June Tuesday Start 0830	21 June Wednesday Start 0830	22 June Thursday Start 0900
AM 1	Introduction and Procedures Geoduck Fishery Update	I2000-03 (Tanner Crab surveys)	I2000-07 (Scallop Phase 1)	Review of Stock Status Reports for: Geoducks, Shrimp trawl Review of Wednesday's Rapporteur's Report Discussion / Confirmation of Dec 2000 PSARC priorities Emerging Issues Closure
Break				
AM 2	I2000-06 (Geoduck quotas)	I2000-04 (Shrimp Trawl catch ceilings)	I2000-01 (Clam depuration)	
Lunch				
PM 1	I2000-02 (Geoduck Management Comparisons)	I2000-08 (Shrimp Trawl by-catch)	I2000-05 (Horseclams Phase 1)	
Break				
PM 2	Geoduck enhancement "update" Fishery Updates: Euphausiids, Sea cucumber Emerging Issues	Fishery Updates: Shrimp trawl, Crab, Opal squid, Octopus, Goose barnacles Emerging Issues Review Rapporteur's Report	Fishery Updates: Clams, Scallops, Horseclams, Green urchins Flying squid Emerging Issues Review Rapp. Report	

APPENDIX 2: PSARC INVERTEBRATE WORKING PAPERS FOR JUNE 2000.

No.	Title	Authors
I00-01	Preliminary review of experimental harvest rates in the depuration fishery for intertidal clams	G.E. Gillespie
I00-02	Harvesting Methuselah's clams- Is the geoduck fishery sustainable, or just apparently so?	J.M. Orensanz R. Hilborn A.M. Parma
I00-03	Development of a fishery for Tanner crab (*Chionoecetes tanneri*) off the coast of British Columbia	G. Workman A. Phillips J. Boutillier
I00-04	Reconstructing the offshore *Pandalus jordani* trawl fishery off the west coast of Vancouver Island and simulating alternative management policies	S. Martell J. Boutillier H. Nguyen C. Walters
I00-05	Evaluation of Horse clam stock dynamics for a directed subtidal Horse clam (*Tresus capax* and *Tresus nuttallii*) fishery in British Columbia	Z. Zheng A. Campbell
I00-06	Quota options for the Geoduck clam (*Panopea abrupta*) fishery in British Columbia for 2001 and 2002	C. Hand D. Bureau
I00-07	Framework for Pink (*Chlamys rubida*) and Spiny (*C. hastata*) scallop fisheries in waters off the West Coast of Canada	R. Lauzier S.Campagna R. Hinder
I00-08	Catch composition of British Columbia shrimp trawls and estimations of by-catch	N. Olsen J.A. Boutillier C. Convey

APPENDIX 3: REVIEWERS FOR PSARC INVERTEBRATE WORKING PAPERS FOR JUNE 2000.

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

A. Bradbury	Washington Dept of Fish and Wildlife
J. Cahalan	Washington Dept of Fish and Wildlife
A. Campbell	DFO, Pacific Region
E. Dawe	DFO, Newfoundland Region
G. Gillespie	DFO, Pacific Region
W. Hajas	DFO, Pacific Region
C. Hand	DFO, Pacific Region
D. Hay	DFO, Pacific Region
G. Jamieson	DFO, Pacific Region
E. Kenchington	DFO, Maritimes Region
R. Lauzier	DFO, Pacific Region
R. Mohn	DFO, Maritimes Region
J. Osborne	Nuu-chah-nulth Tribal Council
M. Saunders	DFO, Pacific Region
J. Schnute	DFO, Pacific Region
C. Schwarz	Simon Fraser University
N. Sloan	Parks Canada
J. Watson	NOAA, NMFS
Z. Zhang	DFO, Pacific Region

APPENDIX 4: PARTICIPANTS AT INVERTEBRATE SUBCOMMITTEE MEETING, JUNE 2000

Subcommittee Chair: Ian Perry
PSARC Chair: Max Stocker

DFO Participants	Mon	Tues	Wed	Thurs
* Subcommittee Members				
B. Adkins*				
D. Bureau	✔	✔	✔	✔
J. Boutillier*	✔	✔	✔	✔
S. Campagna		✔	✔	✔
A. Campbell*	✔	✔	✔	
D. Clark	✔	✔	✔	✔
L. Convey		✔	✔	
G. Gillespie*	✔	✔	✔	✔
W. Hajas	✔	✔	✔	
C. Hand*	✔	✔	✔	✔
R. Harbo*	✔	✔	✔	
S. Heizer	✔		✔	✔
G. Jamieson*		✔		
M. Kattilakoski			✔	
B. Koke*	✔			
R. Lauzier*		✔	✔	✔
J. Lessard	✔		✔	✔
S. Martell	✔	✔	✔	✔
J. Moores*				
J. Morrison			✔	✔
R. Mylchreest*				
N. Olsen		✔		✔
G. Parker*	✔	✔	✔	✔
A. Phillips	✔	✔		
J. Rogers*	✔	✔	✔	✔
M. Saunders		✔		
J. Schnute		✔	✔	
F. Scurrah	✔	✔	✔	✔
A. SInclair		✔		
R. Webb			✔	
B. Shaw			✔	
K. West*	✔	✔	✔	✔
I. Winther*				
G. Workman	✔	✔	✔	✔
E. Wylie			✔	✔
Z. Zhang	✔	✔	✔	✔

External Participants:	Mon	Tues	Wed	Thurs
B. Heath* (B.C. Ministry of Fisheries)	✔	✔	✔	
R. Jones (Haida Fisheries Program)	✔	✔	✔	
J. Osborne (NTC Tribal Council)		✔		
C. Schwarz (SFU)		✔		

Observers:	Mon	Tues	Wed	Thurs
J. Austin (UHA)[1]	✔			
B. Clapp (UHA)[1]	✔			
G. Dovey (UHA)[1]	✔			
J. Edwards (WCSA[4])		✔		
P. Edwards (Tanner Crab Assoc.)		✔		
L. Glover (PSHA)[2]			✔	
W. Helgason (TCJ`V)[3]		✔		
R. Hinder (West Coast Scallop Harvesters Association)			✔	
M. James (UHA[1])	✔			
G. Krause (West Coast Scallop Harvesters Association)			✔	
L. Richards (West Coast Scallop Harvesters Association)			✔	
C. Sorensen (UHA)[1]	✔		✔	
T. Wickham (WCSA)		✔		

[1] UHA – Underwater Harvester's Association
[2] PSHA – Pacific Scallop Harvesters Association
[3] TCJV – Tanner Crab Joint Venture
[4] WCSA -- West Coast Sustainability Association