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Proceedings of the PSARC Habitat Subcommittee Meeting March 4 – 5, 2002

J. Pringle
Habitat Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

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Canada

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
HABITAT SUBCOMMITTEE MEETING

SUMMARY

The PSARC Habitat Subcommittee met March 4 and 5, 2002 at the Institute of Ocean Sciences, Sidney, B.C. to review two Working Papers, the first on science gaps in relation to the lifting of the federal oil and gas moratorium in Queen Charlotte Basin; the second, on the validity of techniques and parameters used to measure changes to the benthic systems under and near British Columbia's marine salmon net-pen farms. In addition, an "emerging issue" paper was delivered on an analysis of flows and water temperature in the Fraser River system, both historic and future, as predicted by climate change models.

The senior author of the large oil and gas Working Paper presented a detailed overview, which included the geographical location of potential reserves; the geological setting; state-of-knowledge of Queen Charlotte Sound (QCS) marine ecosystems; properties, fate and effects of crude oils and natural gas; industry operational impacts; fate and effect models for marine ecosystems; mitigating technologies and a discussion of environmental risk assessment processes. Both reviewers and Subcommittee agreed the Working Paper provided a wealth of information, but the task set out for the authors was too large for the time and resources available. In addition, it was felt the questions provided by the habitat managers were either inappropriate from a DFO-mandate perspective, or were too general. Considerable discussion took place on some of the coverage gaps of the Working Paper:

- Failure to point out the serious lack of information on the spatial and temporal zones of highest biological activity and sensitivity in QCS;
- Inadequate comparison of the Pacific coast situation with other marine areas of oil and gas production such as the North Sea, Alaska, the NW Atlantic and southern California;
- Insufficient reference to the 1986 review (West Coast Oil Exploration Environmental Assessment), the logical starting point of the current work; and
- Lack of information provided on commercial species such as eulachon, and sub-lethal effects of hydrocarbons on aquatic organisms.

In addition, there were concerns the cross-chapter synthesis of information was inadequate, as was the attempt to provide directed responses to the questions posed.

The Subcommittee noted the topic area is large and dynamic, with scientific information emanating on a range of scientific disciplines, and from a wide variety of countries and laboratories: a task too large and too complex for the resources provided the authors. It is recommended the Working Paper not be upgraded to a Research Document.

Given the importance of the offshore oil and gas issue and the need for information and knowledge, considerable time was spent discussing publishing options for the

material in the Working Paper. It was agreed, the material is most valuable and should either be published as a Departmental technical report, or that the questions submitted by Habitat Management be rewritten and the Working Paper be re-drafted to answer these questions.

The Working Paper, on methods to measure change to the benthos in and around salmon net-pen farming, was requested because of controversy surrounding the tentative Performance Based Standards (PBS) approach as advocated by B.C.'s Ministry of Water, Land and Air Protection (MWLAP). The approach uses a topical sulfide-organismal relationship that includes a single free-sulfide ($S^{=}$) standard for all sites over a range of ecological conditions from soft sediments through to hard substrate. The authors drew on the peer-reviewed literature (scarce for coastal B.C.), the "gray" literature, and unpublished data. The reviewers and the Subcommittee felt the authors did a commendable job in pulling the Working Paper together in a short period of time. The authors duly reported on each of four submitted questions. The Subcommittee's conclusions were as follows:

1. That the PBS approach, that of using a single metric (free $S^{=}$) to monitor the environmental impact of salmon net-pen farms over soft-sediment sites, is useful only at the site level, and only then as a "warning system" that will trigger a broader-based monitoring protocol; for ecosystem-based management, the use of a more-synoptic approach is required;

2. That the current PBS system is designed for soft–bottom sediments only, and is likely inappropriate for hard or gravel/shell substrates; and

3. That the relationship between environmental organic loading from salmon net-pen farms and a HADD (Harmful Alteration, Destruction and Disturbance) needs development.

The Subcommittee recommended the Working Paper be upgraded to a Research Document following minor revisions.

SOMMAIRE

Le Sous-comité du CEESP sur l'habitat s'est réuni les 4 et 5 mars 2002 à l'Institut des sciences de la mer, situé à Sidney (C.-B.), pour examiner deux documents de travail. Le premier porte sur les lacunes scientifiques liées à la levée du moratoire sur l'exploration pétrolière et gazière imposé par le gouvernement fédéral pour le bassin de la Reine-Charlotte, et le deuxième, sur la validité des techniques et paramètres employés pour mesurer les changements que subissent les écosystèmes benthiques près des enclos de salmoniculture marine de la Colombie-Britannique. En outre, on présente un document « nouvel enjeu » concernant une analyse des températures de l'eau et débits passés et futurs (prévus selon les modèles de changement climatique) dans le réseau fluvial du Fraser.

L'auteur principal du gros document de travail sur les ressources pétrolières et gazières présente un aperçu détaillé du dossier, notamment la localisation des réserves potentielles; le cadre géologique; l'état des connaissances sur les écosystèmes marins du détroit de la Reine-Charlotte; les propriétés, le devenir et les effets du pétrole brut et du gaz naturel; les impacts de l'exploitation industrielle; les modèles du devenir et des effets dans les écosystèmes marins; les technologies d'atténuation des effets; une discussion sur les processus d'évaluation des risques pour l'environnement. Les examinateurs du document et le Sous-comité conviennent que le document fournit une foule de renseignements, mais que la tâche confiée aux auteurs était démesurée par rapport au temps et aux ressources disponibles. En outre, on estime que les questions posées par les gestionnaires de l'habitat étaient soit non appropriées vu le mandat du MPO, soit trop générales. Certaines des lacunes du document de travail en ce qui concerne les aspects abordés ont fait l'objet de beaucoup de discussion :

- Le document ne relève pas le grave manque d'information sur les zones et périodes où l'activité et la vulnérabilité biologiques sont les plus élevées dans le détroit de la Reine-Charlotte.
- La comparaison de la situation de la côte du Pacifique avec celles de régions d'exploitation pétrolière et gazière, comme la mer du Nord, l'Alaska, l'Atlantique nord-ouest et le sud de la Californie, n'est pas adéquate.
- Le document ne fait pas suffisamment référence à l'examen de 1986 (évaluation environnementale de l'exploration pétrolière sur la côte Ouest), qui est le point de départ logique du travail actuel.
- Le document manque d'information sur des espèces commerciales comme l'eulakane et sur les effets non mortels des hydrocarbures sur les organismes aquatiques.

En outre, on s'inquiète de la mauvaise synthèse de l'information contenue dans le document et des réponses insuffisantes aux questions posées.

Le Sous-comité remarque que le sujet est vaste et dynamique et que l'information scientifique provient d'un large éventail de disciplines scientifiques, de laboratoires et de pays : il s'agissait d'une tâche trop grosse et trop complexe pour les ressources mises à la disposition des auteurs. On recommande de ne pas élever le document de travail au niveau de document de recherche.

Étant donné l'importance du dossier des ressources pétrolières et gazières en mer ainsi que le besoin en information, le Sous-comité discute longuement des options pour la publication de l'information contenue dans le document de travail. On convient que cette information est précieuse et qu'on devrait la publier sous forme

d'un rapport technique du Ministère ou réécrire les questions présentées par la Gestion de l'habitat et remanier le document de travail pour répondre à ces questions.

On a demandé de rédiger le document de travail sur les méthodes de mesure des changements que subit le benthos près des enclos de salmoniculture en raison de la controverse au sujet de la méthode des normes axées sur la performance (NAP) préconisée par le ministère de la Protection des eaux, des terres et de l'air de la Colombie-Britannique. La méthode est axée sur la relation entre la concentration de sulfure et les organismes benthiques qui comprend une seule norme de sulfure libre (S^{2-}) pour tous les sites, pour un éventail de conditions écologiques allant de sédiments mous à des substrats solides. Les auteurs ont consulté des publications examinées par des pairs (il y en a peu qui portent sur la côte de la C.-B.), la littérature « grise » et des données non publiées. Les examinateurs et le Sous-comité estiment que les auteurs ont effectué un travail louable en produisant le document de travail en si peu de temps. Les auteurs ont dûment fait rapport sur chacune des quatre questions posées. Voici les conclusions du Sous-comité :

1. La méthode des NAP, qui n'utilise qu'une seule mesure (la concentration de S^{2-} libre) pour surveiller l'impact environnemental d'enclos de salmoniculture installés au-dessus de sédiments mous, n'est utile qu'au niveau du site et encore seulement en tant que « système d'avertissement » qui déclencherait un protocole de surveillance élargi. Une gestion écosystémique nécessite une démarche plus synoptique.

2. La méthode des NAP actuelle ne s'applique qu'aux sédiments mous; elle ne convient vraisemblablement pas aux substrats durs ou constitués de gravier ou de coquillages.

3. Il faut davantage préciser la relation entre la charge organique provenant des enclos de salmoniculture et la DDPH (détérioration, destruction ou perturbation de l'habitat).

Le Sous-comité recommande d'élever ce document de travail au niveau d'un document de recherche après qu'on l'ait légèrement révisé.

INTRODUCTION

The PSARC Habitat Subcommittee met March 4 and 5, 2002, at the Institute of Ocean Sciences in Sidney, British Columbia. The Subcommittee Chair, J. Pringle, opened the meeting by welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, along with the protocol to be observed by external participants and observers. The Subcommittee accepted the meeting agenda.

The Subcommittee reviewed two Working Papers and one Emerging Issues paper: Summaries of each are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

DETAILED COMMENTS FROM THE REVIEW

H2002-01: Knowledge Gaps and Risks of Concern for B.C. Marine Environments from Offshore Oil & Gas Exploration, Development, Production, Transportation and Decommissioning.

W. Cretney, B. Burd, C. Wright, W. Crawford, J. Cherniawsky, B. Bravender, J. Fargo, R. Lauzier, L. Nichol, S. Vagle, M. Yunker, T. Hamilton, D. Rodden and G. Rogers ** Not Accepted**

Rapporteurs: Mike Foreman & Vaughn Barrie

The four questions submitted by Habitat Management to be answered by the Working Paper authors were as follows:

1. What are the marine environmental risks and impacts of the various works and activities (e.g. seismic exploration, test and production drilling, etc.) associated with oil and gas exploration, development and production in a seismically-active area such as the B.C. West Coast?

2. What is the state-of-the-art and adequacy of technological tools to reduce or eliminate the various risks and impacts identified in above question?

3. Are existing environmental data and databases sufficient to achieve satisfactory protection of the B.C. marine and coastal environments exposed to such activities? If not, what further research would be required? And,

4. Are there unique or rare habitats and species that could be at particular risk if oil and gas exploration, development and production went ahead?

These questions were to be used to guide the Subcommittee discussion. However, following the presentation by the principal investigator, and the formal reviewers' comments, the immediate questions requiring answers by the Subcommittee were first: Are questions 1 and 2 appropriate given the mandate of DFO Science?; and secondly: Does the Working Paper, where possible, adequately address these questions?

It was pointed out that the environmental impacts and risk assessments referred to in question one are tasks done by the proponent while in consultation with the regulatory agency, not by the agency alone. Furthermore, a reviewer most-experienced in the provision of science advice to the east coast industry, suggested

"Adequate conclusions to the questions and objectives …were not achievable…and the provision of environmental impact statements and/or environmental risk assessments should be the responsibility of the…proponents…", along with the provision of "…information on…state-of-the-art and adequacy of technological tools to reduce or eliminate potential…risks and impacts." It was thus deemed inappropriate for the Subcommittee to assess the Working Paper against the first two questions. As well, for the Subcommittee to re-write the questions to match the Paper's content would undermine the PSARC process. Many felt the questions required re-definition, and that they be better focused and made tractable.

The three reviewers felt the Working Paper was "…comprehensive…" with an "…impressive and extensive review of the literature…", a "…comprehensive summary of the data….", with provisions of the "…data bases required to assess… impact…", and an "…excellent overview of the commercial fisheries at risk and the knowledge gaps that must be addressed to conduct an ecological risk assessment." Overall the Subcommittee found much worthwhile information in the Working Paper, information that would be most useful to the Department in setting research priorities and in reviewing proponent's Strategic Environmental Assessments (SEA). Indeed the authors were congratulated for collating a large amount of information in a relatively short period of time. Concerns were expressed, however, regarding the appropriateness of the document for the PSARC process.

1. There were deficiencies in many aspects. For example, it was suggested there was:

    - Too much emphasis placed on accidental oil spills and too little emphasis on operational activities;
    - Too little emphasis placed on both the west coast oil and gas review from the '80's, and research results from Alaska, Eastern Canada and the North Sea;
    - Insufficient merit paid to Sub-lethal effects. (We now know from recent results from the North Sea that small concentrations of contaminant hydrocarbons alter reproductive success of certain fish); and
    - There was no mention of either fish flesh tainting or cumulative impacts.

2. The treatment of the various chapters by the respective authors was felt to be uneven. Some were blessed with considerable detail, while others were deemed most sparse.

3. And there was little attempt to synthesize the material across chapters and to directly answer the questions posed.

In addition, it was agreed that an inventory of available biological and ecological data from the Queen Charlotte Basin area would be required to guide environmental assessments, for input to models and for other uses. An attempt was made to provide such an inventory by the Working Paper authors, but it was felt much was missed. One reviewer felt this section would have benefited from an assessment of

the quality of data provided. (The senior author noted that much Departmental inventory data were inaccessible) In addition, reference to more local oil and gas activities such as in Cook Inlet, Alaska and off Southern California was missing.

The Working Paper Recommendations tended to focus on future research requirements. It was noted that, based on the eastern Canadian experience, the Region should be focussing research that would underpin scientifically defensible guidelines; guidelines that would direct proponents in their environmental assessments.

Considerable discussion focussed on the fate of the information present in the Working Paper were the paper not to be upgraded to a Research Document. All felt the work had considerable merit, and that it was important it not be lost. A minority felt it important that advice on this high priority topic be provided to the Department and that a mechanism be developed to allow it to be upgraded. A number of options were considered, including it being published in the Department's Technical Report Series; splitting out the controversial inventory information into a separate document; rewriting the document with a focus on revised questions; or consider it to be a "work in progress" within the PSARC process, and that it be reviewed at a Subcommittee meeting called solely to vet the revised Working Paper. The latter option was deemed not appropriate by the PSARC Chair.

Conclusions

1. The questions posed by Habitat Management were either aimed at tasks not within DFO's mandate or were too encompassing for the time and resources available.

2. That while a large amount of knowledge and information is provided in the Working Paper and that it should be published, the quality of the sections varied significantly, and the Paper lacked a full synthesis with focus on the questions posed. It thus could not stand as a definitive work under the PSARC banner.

3. That the Queen Charlotte Basin Oil and Gas issue, from a hazards and environmental impact perspective, is large and complex. And there are areas of the world - e.g. Alaska, California, Canada's east coast, and the North Sea - with years of experience in dealing with environmental offshore oil issues that could provide the Region with models and guidance.

Recommendations

1. That the working paper not be upgraded to a Research Document.

2. That the authors of the Working Paper be encouraged to "polish" the present document using certain of the comments made by reviewers and the Subcommittee, and that it be published in the Department's Technical Report

Series or, that habitat and oceans managers, along with Science staff, develop appropriate and focused questions to replace those originally posed, and the Working Paper be re-drafted to answer these questions.

3. That the Region consider the Queen Charlotte Basin Oil and Gas activity a large and complex issue with multi-agency implications. If offshore oil and gas is deemed a high priority, resources be assigned to establish a Regional working team of habitat and ocean managers, socio-economics staff and a scientist(s) to develop a multi-year program for submission to the Pacific Policy Committee that will result in the development of appropriate scientific advice, including the ability to quickly and thoroughly assess industry-generated environmental impact statements and risk analyses. The team would be guided through consultations with Departmental oil and gas experts from the east coast.

4. That Queen Charlotte Basin multi-agency data inventories be collated and interpreted in the context of developing guidelines to provide direction to proponents in support of potential environmental assessments.

5. That Regional scientific research concentrate, over the next couple of years, on studies that would allow the Department to assess environmental impact statements for the exploration stage of O & G activities. This would include the sending of Regional delegates to a 2003 workshop in eastern Canada.

H2002-02: Scientific techniques and parameters for measuring changes to the marine ecosystem related to finfish aquaculture in B.C.

C. Levings, J. Helfield, S. Petersen and T. Sutherland **Accepted subject to revisions**

Rapporteur: Jeremy Hume

The senior author presented an overview of the Working Paper, and the first reviewer presented his comments orally. The other review was read to the Subcommittee. The first reviewer found the document well laid out technically, and the conclusions sound. He noted the conclusions of the authors' were closely aligned to those of B.C.'s Ministry of Water, Land and Air Protection (MWLAP) Scientific Advisory Group (SAG), whose mandate is to provide guidance on the development of a new aquaculture waste management regulation under B.C.'s Waste Management Act.

The second reviewer, and the Subcommittee, agreed the title should be changed to reflect the general focus of the Working Paper, which is the impact on the benthos of organic waste from salmon aquaculture. Dissolved oxygen in coastal waters is considered, but only as it relates to sediment and benthic community variables in response to organic loading. There is no direct mention of environmental effects due to eutrophication in the water column. In addition, this reviewer suggested that a

second table be constructed using sensitive steady state variables such as dissolved oxygen, organic carbon sedimentation rates, etc. (means, ranges and SD) from B.C. monitoring programs. As well the table could include farm site data such as mean water depth.

1. Is a Performance Based Standard (PBS) approach ecologically meaningful and has PBS been scientifically validated in other jurisdictions or for other industries?

It is important to note that the PBS approach is useful only in measuring site-specific impacts, i.e. the impact of a single farm on the near-field system. It is not designed to be used to assess Marine Environmental Quality (MEQ) at the ecosystem level. Indeed, farm operators are licensed for their site, and their site alone. Thus, scale is of prime importance, as the scale chosen can radically affect the interpretation of results. It was pointed out by one reviewer that the PBS approach need not be a single numerical criteria, as deployed by B.C.'s MWLAP. PBS should reflect the government's policy decisions for environmental protection. This does not preclude the fact waste discharge from any farm site could exceed the assimilative capacity of the system. PBS was likened to typical "state of environment" indicators by one reviewer. The Subcommittee felt a need for guidance on how the indicators are related to HADD (Habitat Alteration, Disturbance and Destruction) and the Department's No Net Loss and The Precautionary Approach. The Subcommittee asked if there was evidence of remedial action when PBS indicators were exceeded?

It was pointed out that the PBS does not directly link to management objectives of environment quality, but that it can be useful as an indicator for further, more detailed, environmental monitoring to assess impacts.

The Subcommittee had difficulty understanding the applicability of the current PBS ($S^{=}$ levels) to hard bottom or shell/gravel substrate communities. These communities were indeed neglected by the advocates and developers of PBS, and with the exception of one DFO-funded project this deficit is not being tackled through coordinated research. The second reviewer agreed that relating the findings from soft-sediment research and free $S^{=}$ levels, as found in the Bay of Fundy, is inappropriate for hard and shell/gravel substrates of coastal B.C. waters. He nevertheless concluded for B.C. soft-bottom sites, that "Many of the conclusions from coastal sites in B.C. farm and reference sites …are similar to those from SWNB (South West New Brunswick - read, Bay of Fundy)….". He goes on to note that Eh (redox potential) and free $S^{=}$ "…are useful for evaluating changes in benthic community structure and biomass…" in these sites. He concluded, that the PBS approach is appropriate if the objective is to protect each farm site; if the objectives are broader, say ecosystem-based, then "…other more synoptic methods are required."

It was suggested a workshop is needed to develop the research required to develop appropriate response variables and that the Working Paper authors agreed to provide research direction in the revised document.

2. Are the chemical surrogates and sampling methods currently being used in impact assessment and monitoring in B.C. providing meaningful information about the ecological condition of the environment near finfish farms?

The Subcommittee asked whether the PBS approach was meaningful to meeting environmental objectives between farm scale and the broad coastal zone management scale, and if the technique could be linked to impacts on fish habitat using the literature cited? The authors agreed to cover this aspect in their re-write.

The Subcommittee agreed the PBS approach, using free sulfides $S^{=}$, may provide a trigger (a threshold of harm or proxy determination that has been met or exceeded, which results in more monitoring, documentation, review and possible remedial action) in a few soft-bottom, benthic environments, but that there is no direct link beyond benthic infaunal organisms, and other epi-pelagic organisms such as fish and macro-invertebrates. It was noted by the second reviewer that the vast majority of near-shore, benthic faunal prey of epipelagic organisms, have little tolerance to sediment-surface sulfides; hence the validity of using such a trigger was questioned.

It was pointed out by the first reviewer that the natural variability of sulfide (1 to 100,000 μM) in the Working Paper is overstated. With the exception of anoxic fjords, e.g. Saanich Inlet, the upper-end values are rarely attained. The range is more likely to be 0 to 300 μM within the top few centimeters of sediments in most unperturbed environments.

The second reviewer noted that the SWNB thresholds for response to increasing $S^{=}$ and those observed in B.C. were similar, e.g. "…oxic conditions <200 μM with significant increases in opportunistic infaunal species and decreases in total taxa above 300 μM up to approximately 5,000 μM. Above this threshold, the number of infauna taxa and biomass decrease rapidly…The abundance of tolerant species increases while the total number of taxa decreases as $S^{=}$ increases from 300 to 5000 μM." He agreed there is not a single threshold value for these continuous changes.

This reviewer suggested that the Table 1 data (SWNB data) be complemented with data generated from coastal B.C. (the data are available in reports by Brooks and by Erickson *et al*).

This reviewer concluded that sediment sulfides alone provide only limited information on benthic conditions and choice of a single threshold ($S^{=}$ 1300 μM) "…may be inappropriate for habitat protection.", though the approach is cost effective. It does

provide a “coarse screening tool…” for evaluating the general oxic conditions in soft sediments.

Overall, the Subcommittee expressed concern in the use of a single metric, free $S^{=}$, to monitor environmental health rather than a range of metrics.

3. What are the chemical surrogates and sampling methods currently being used?

The Subcommittee noted that little emphasis was placed on this question by the Working Paper authors. They also asked what additional key variables should be monitored? The authors agreed to cover this question during re-write. It is known that $S^{=}$ married with redox potential is used to monitor impact under and near Bay of Fundy salmon net-pen farms. One reviewer noted that other countries employ remote methods such as video, digital imagery, and acoustic surveys.

The Subcommittee suggested that a list of the priority parameters not collected in B.C. be included in the revised document; the senior author agreed to insert the list. One reviewer suggested that the PBS methodology adopt a grid of stations as recommended in the Working Paper, rather than using point transects.

4. What are the recommended parameters and appropriate thresholds to indicate that an important ecological change has occurred? Considerations should be given to spatial and temporal factors as well as critical values or ranges of values for these parameters.

The Subcommittee expressed concern for the “trigger” level of $S^{=}$ at 1300 μM, the level recommended in the PBS. The impact on ecological integrity was felt to be significant given the natural range for $S^{=}$ in the majority of natural benthic sediments (top few cm) is 0-300 μM, with occasional extreme upper levels of ~2000 μM. There is tolerance across species to $S^{=}$, but as one reviewer pointed out, those tolerant (few in number) have evolved sulfide detoxification systems or have evolved a relationship with sulfur-oxidizing microbial symbionts.

The Fisheries Act employs the concept of HADD to protect fish habitat, and the Oceans Act supports sustainable ecosystems. The Subcommittee noted a paucity of information and guidance in the Working Paper on the relationship between $S^{=}$, benthic invertebrate productive capacity, epipelagic foraging species and a HADD. The senior author agreed, and argued that few data are available to link these relationships. Using the precautionary approach, the authors recommended that “…no statistically significant change from measured baseline…” for invertebrate bio-diversity indices be tolerated at salmon net-pen farm sites. One reviewer felt, in recommending this approach, we must be wary of the “…power of monitoring techniques to detect ecologically relevant change.” He noted elsewhere, that current ecological theory and knowledge does not allow us to place faith in some arbitrary

reduction in taxa in relation to some reference state of ecological integrity. The cutoff points are usually decided in an arbitrary fashion.

Conclusions

1. That the PBS approach of using a single metric such as free $S^{=}$ to monitor the environmental impact of salmon net-pen farms over soft-sediment sites, is useful only at the site level, and only then as a "warning system" that will invoke deployment of a broader-based monitoring protocol; for ecosystem-based management, the use of a more synoptic approach is required.

2. That the current PBS system is designed for soft–bottom sediments only, and is not appropriate for hard or gravel/shell substrates.

3. That the relationship between organic loading from salmon net-pen farms and a HADD is not understood, and thus needs development.

Recommendations

1. That the Working Paper be upgraded to a research document.

2. That impact assessment protocols be developed, which allow for the use of multiple indicators over a variety of sampling scales and substrate types for B.C. coastal ecosystems supporting finfish farms. Indicators will include physical/chemical and ecological parameters in addition to $S^{=}$.

3. That operational definitions of HADD for finfish farm sites be developed through consistent application of scientific criteria.

4. A scientific workshop be held to evaluate and assess the utility of various response variables. The workshop would include a review and evaluation of the variables and data sets now being collected at B.C. salmon net-pen farms.

Emerging Issue:

Climate change in the Fraser River Watershed: Flow and temperature projections.

J. Morrison, M. Foreman and M. Quick

Summary

An analysis of the historic flows and water temperatures of the Fraser River system has detected trends in both the annual flow profile and the summer temperatures.

This study was undertaken to determine if these trends are likely to continue under the conditions predicted by various global circulation models. To do this, existing flow and temperature models were run with weather data that were derived from actual weather observations, but modified using changes predicted by the global circulation models. The validity of the flow model results is supported by very close agreement with the historical record. The potential exposure of salmon to water temperatures above 20° C, which may degrade their spawning success, is predicted to increase by a factor of 20 by the end of the century. Water conditions at this time are projected to be worse than the critical year 50% of the time.

Subcommittee Discussion

The approach of applying global climate models that make predictions for very large geographical cells, to a much smaller area within that cell was queried. One author noted, a technique termed, “downscaling” is used, which is well accepted by the modelling community.

The modelling approach used is precise, however, the results were presented with no confidence limits. It was explained that there is only one climate change model, a Canadian model, that gives useful rainfall and temperature data for the Fraser River basin. Because it takes months to run, and creates large data sets, the scientists do not replicate their experiments and hence there is no measure of variance for the predictions. It was explained that there are many models and they report similar findings, thus there is some degree of confidence in the predictions.

One Subcommittee member suggested that the discussion of the impacts could be expanded beyond migrating adult sockeye to include other life history stages such as incubating eggs, juvenile rearing and smolting, and other species.

Overall there was a general agreement the authors had presented a well developed and thought provoking paper, the results of which should be monitored by the Region.

APPENDIX 1: Working Paper Summaries

H2002-01: Knowledge Gaps and Risks of Concern for B.C. Marine Environments from Offshore Oil & Gas Exploration, Development, Production, Transportation and Decommissioning.

W. Cretney, B. Burd, C. Wright, W. Crawford, J. Cherniawsky, B. Bravender, J. Fargo, R. Lauzier, L. Nichol, S. Vagle, M. Yunker, T. Hamilton, D. Rodden and G. Rogers

Risk is the product of the probability of threat (hazard) and the probability of exposure with predictable effects, for short: risk equals threat times exposure-effects. In the case of the risk of offshore oil and gas, if exploration were to be forbidden, then the probability of threat would be zero and the risk, zero. Of course, without risk there would be no benefit. For the purposes of this document, the assumption is made that oil and gas related activities will proceed, so this part of threat probability is one. The threat posed by these activities is therefore addressed in this document, as are the consequences of exposure.

The risks addressed in this document are environmental ones. Economic, sociological, legal risks are not addressed directly, although these risks may be implicit. Concerning the offshore oil and gas industry, environmental risks may be categorized as arising from threats by the environment or to the environment. Hence, a portion of this document considers such environmental threats as giant earthquakes and waves. In the main, however, the document focuses on the risk of the industry to the environment.

The exposure part of the environmental risk equation requires knowledge about what is at risk. Hence, a major part of this document considers what is known about the ecosystems of the Queen Charlotte basin and the organisms that live within them. It does not just review the current state of knowledge, but attempts to identify gaps in our knowledge that are relevant to the threat proposed by the offshore oil and gas industry.

The document recognizes that a modern understanding and management of ecosystems requires the generation of quantitative ecosystem, mass balance models. Such models provide the means to reveal critical knowledge gaps and to assess the effects of change through time and space. They can provide insights into critical functions and species. These models are discussed at some length.

Models need good and complete data for input. This document provides a review of what is known about species in the B.C. north coast. More to the point, it identifies knowledge gaps that must be filled before realistic models can be developed.

Not all species are necessary to functioning ecosystems, knowledge that is emphasized by models. Unique habitats and odd species, nevertheless, have a right

to be protected. This document addresses what is known and what is knowable about such habitats and species, which may be at particular risk from an offshore oil and gas industry.

The threat part of the risk equation requires knowledge of what characteristics of the industry may pose a threat to the environments. Again, an attempt is made to review the current state of knowledge gaps. For example, the compositions of crude oil and natural gas are considered to determine what is, and is not known, about the toxicants in their compositions. In addition, bio-marker compounds that can be used to distinguish among natural, petroleum and combustion products are considered in the context of providing a regional benchmark. The benchmark can be used to identify and quantify newly released compounds resulting from an offshore oil and gas industry. Such a benchmark will avoid the controversy over source identification that has plagued other areas following a spill.

A major part of this document is devoted to a discussion of quantitative oil spill and ecosystem chemical fate models that have been developed mainly over the last two decades. Such quantitative models have enjoyed greater advances than any other component of the technological toolbox that can be used to assess and reduce the environmental risks of routine activities and random accidents of the offshore oil and gas industry.

Several models have been developed for or adapted to provide quantitative ecological risk assessments. Thus, ecological risk assessment no longer is a mainly qualitative exercise. Furthermore, the models provide a tool for ecological risk management. It is now possible, to examine the consequences of management decisions with a computer model. Indeed, a spectrum of different management scenarios can be run in models and the outcomes studied. This capability allows decisions to be made with the inclusion of all interested parties.

H2002-02: Scientific techniques and parameters for measuring changes to the marine ecosystem related to finfish aquaculture in B.C.

C. Levings, T. Sutherland, J. Helfield, and S. Petersen

In this paper we consider scientific techniques and parameters for measuring changes to the marine ecosystem related to finfish aquaculture in British Columbia, focusing on salmon net-pen operations. Our review is limited to seafloor habitats and draws in information from the peer reviewed literature and unpublished data as appropriate. We found an almost complete absence of peer reviewed (journal) papers in the literature from B.C.. Because we do not support the idea of extrapolation of the extensive published data from other parts of the world to Pacific Region without local verification, our response to specific questions from habitat managers was conditioned by the lack of research publications.

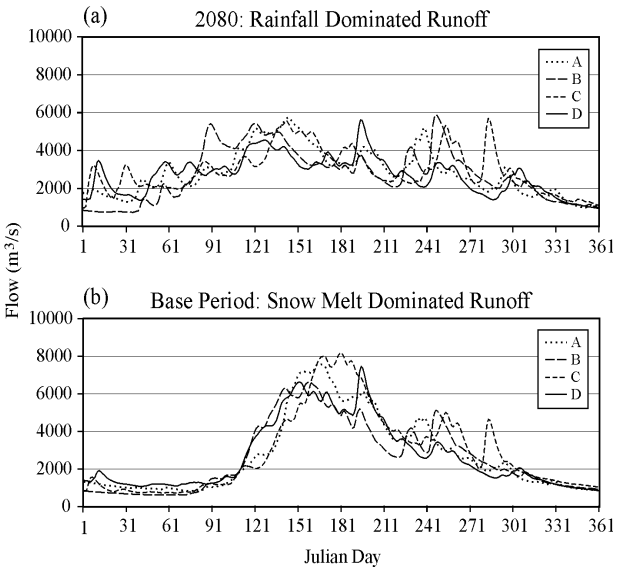
The Performance Based Standards (PBS) approach is used to assess problems with narrow objectives such as sediment management and has been scientifically validated for a variety of industries, including fin-fish aquaculture. One of the topical PBS methods recommended for salmon net-pen rearing is based on sulfide-organism relationships. For fish farm wastes, based on the field correlation data available in the scientific literature, there is a scientific basis for these PBSs in the particular ecosystems where they have been verified. However, there are limitations for applying them in B.C. until methods have been developed which allows them to be used on a variety of sediment types, and with an improved mapping scheme. In our view, PBSs are not effective for integrated coastal management, a finding we have made to the Department. The choice of parameters and thresholds to indicate that an important ecological change has occurred from salmon net-pens is dependent on the objectives that managers have selected for a particular ecosystem. The objectives will determine the spatial and temporal extent of the change and the scale at which it is assessed. A number of biological and physico-chemical variables have been suggested as criteria for assessment of fish farm effects elsewhere, but comprehensive peer reviewed data sets on them are not available from B.C.. As a first principle, however, we would not recommend that a single number for any parameter be used as a threshold value. As data are provided from research and monitoring projects related to fish farming in B.C., we suggest that a scientific workshop be convened to discuss the results and variables used in the work. The recommendations for variables and methods from this workshop should be subjected to the peer review process used by scientific journals.

Climate change in the Fraser River Watershed: Flow and temperature projections.

J. Morrison, M. Foreman and M. Quick

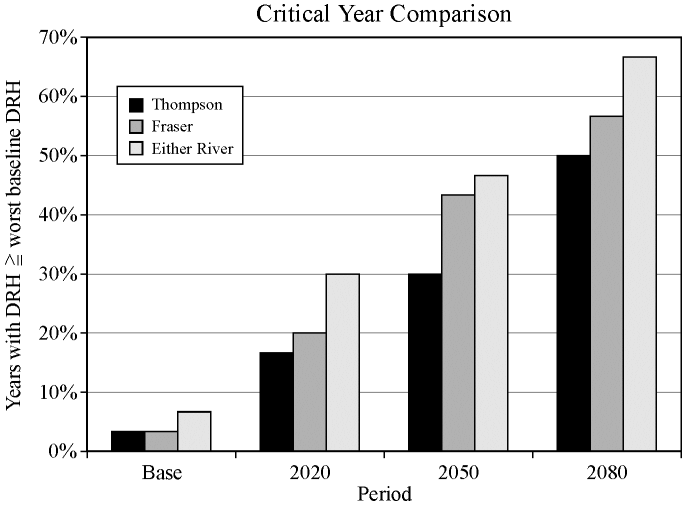
An analysis of the historic flows and water temperatures of the Fraser River system has detected trends in both the annual flow profile and the summer temperatures. This study was undertaken to determine if these trends are likely to continue under the conditions predicted by various global circulation models. To do this, existing flow and temperature models were run with weather data that were derived from actual weather observations, but modified using changes predicted by the global circulation models.

The validity of the flow model results is supported by very close agreement with the historical record. The differences between model output and the historical record for mean flow, mean peak flow, mean minimum flow and peak flow day were not statistically significant; furthermore, there was only a 3-4 day shift in the occurrence of cumulative flow milestones. The temperature model's mean water temperature was only 0.2° C higher than the historical record.



For the period 2070 – 2099 the summer mean water temperature is predicted to increase by 1.9° C. In the same period the flow model predicted a modest 5% (150 m^3/s) average flow increase but a decrease in the average peak flow of about 18% (1600 m^3/s). These peaks would occur, on average, 24 days earlier in the year even though for 13% of the years the peak flow occurred much later as a result of summer or fall rain, instead of the currently normal spring freshet. Part (a) of the figure on the left shows four hydrographs from the 2070 – 2099 period where the river was rainfall dominated. Part (b) shows the same years from the baseline period with typical snowmelt dominated hydrographs i.e. low winter flow with a sharp volume increase in the spring as the snowpack melts.

The potential exposure of salmon to water temperatures above 20° C, which may degrade their spawning success, is predicted to increase by a factor of 20. The chart below shows a measure of exposure called a Degree Reach Hour (DRH) that combines the temperature above the critical threshold with the spatial and temporal duration of exposure. 1962 was the year with the largest DRH in the baseline period (1961 – 1999). By the end of the century water conditions are projected be worse than this critical year 50% of the time.



Future trends in both Fraser River flows and temperature closely match the trends in the historical record, suggesting that the historical trends may already be related to climate change.

APPENDIX 2: PSARC Habitat Subcommittee Meeting Agenda MARCH 4 and 5, 2002

PSARC HABITAT SUBCOMMITTEE AGENDA
March 4th – 5th, 2002
AUDITORIUM – March 4, MILNE Room – March 5
IOS – Sidney, B.C.
Starting Time: 09:30

1. Introductions and PSARC meeting procedures.

2. Review Agenda.

3. Review Minutes of June 2001 meeting.

4. Review of WP H2002-01, *"Knowledge Gaps and Risks of Concern for B.C. Marine Environments from Offshore Oil and Gas Exploration, Development, Production, Transportation and Decommissioning".* W. Cretney, B. Burd, C. Wright, W. Crawford, J. Cherniawsky, B. Bravender, J. Fargo, R. Lauzier, L. Nichol, S. Vagle, M. Yunker, T. Hamilton, D. Rodden and G. Rogers.

5. Emerging Issue Paper: *"Climate change in the Fraser River Watershed: Flow and temperature projections".* J. Morrison, M. Foreman and M. Quick.

6. Review of WP H2002-02, *"Scientific techniques and parameters for measuring changes to the marine ecosystem related to finfish aquaculture in British Columbia".* Dr. C. Levings, J. Helfield, S. Petersen and Dr. T. Sutherland.

7. Change in date of next meeting to September 24-25th 2002.

APPENDIX 3. List of Attendees

Subcommittee Chair: John Pringle
PSARC Chair: Max Stocker

DFO Participants	**Tues.**	**Wed.**	
* Subcommittee Members			
Antcliffe, B.*	x	x	
Barry, K.		x	
Birtwell, I.*	x	x	
Carson, D.	x	x	
Cretney, W.	x	x	
Faulkner, G.	x	x	
Foreman, M.*	x	x	
Hume, J.*	x	x	
Hutton, K.	x		
Jamieson, G.*	x	x	
Knapp, W.		x	
Lauzier, R. *	x	x	
Lee, Ken	x	x	
Levings, C. *	x	x	
Mackas, D.	x	x	
McLaughlin, F.	x	x	
Pena, A.	x	x	
Reid B. *	x	x	
Non-DFO:			**Affiliation**
Barrie, V. *	x	x	Natural Resources Canada
Johnston, T. *	x	x	BC Ministry of Water, Land & Air Protection
Morrison, J	x	x	Vynx Inc.
Robinson, C. *	x	x	Parks Canada
External Participants:			
Atkinson, M.	x	x	PFRCC
Observers:			
Colvine, Sandy	x		Geological Survey of Canada
Dale, Alec	x	x	BC Ministry of Water, Land & Air Protection
Hunter, Lynne	x		David Suzuki Foundation
Langer, Otto	x		David Suzuki Foundation
Martin, Bo	x		Sierra Club of BC
O'Connor, Oono	x		Living Oceans Society
Slack, Terry	x		Fraser River Coalition
Wilts, Rodney	x	x	West Coast Environmental Law

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.

Bright, D.	Royal Roads University
Gallaugher, P.	Simon Fraser University
Hargrave, B.	DFO, Maritimes Region
Lee, K.	DFO, Maritimes Region
Sloan, N.	Parks Canada