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Proceedings of the Central Coast Marine Environmental Quality Indicators Workshop

Compte rendu de l'atelier de travail sur les indicateurs de la qualité de l'environnement marin de la côte centrale de la C.-B.

March 10-12, 2004, Parksville, BC

Glen S. Jamieson[1] and Brenda McCorquodale[2]

[1] DFO, Pacific Biological Station, Nanaimo, BC V9T 6N7
[2] DFO, PO Box 2159, Unit 10, 9250 Trustee Rd, Port Hardy V0N 2P0

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[2] DFO, PO Box 2159, Unit 10, 9250 Trustee Rd, Port Hardy V0N 2P0

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CSAS@DFO-MPO.GC.CA

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SUMMARY

A second Pacific Region Marine Environmental Quality (MEQ) Indicators Workshop was held in March, 2004, as a continuation of the regional initiative to determine operational objectives for monitoring the success of ecosystem-based management in the pilot proposed Pacific North Coast Integrated Management Area (PNCIMA). This workshop differed from the first workshop (summarized in Jamieson et al. 2003) in that while keeping in mind the high level, nationally-defined conceptual ecosystem objectives, it considered a “bottom-up” perspective in an effort to allow better focusing on those human activities actually impacting the local environment. The development of MEQ objectives and indicators was determined by looking at key issues or “stressors” on ecosystem components in three areas: a potential Coastal Management Area (Quatsino Sound CMA), the deep-water trawled areas of Queen Charlotte Sound, and in the overall proposed PNCIMA, i.e., a potential Large Ocean Management Area. This “bottom-up” approach utilised estimates of tangible threats to marine ecosystem health in the assessment of potential MEQ objectives and indicators. Workshop summary comments for next steps towards developing MEQ indicators and practising Integrated Management related to DFO’s future role in developing MEQ indicators, the potential for the Federal/Provincial Oceans’-related MOU on the Pacific Coast to advance this issue, and the importance of integrating effective involvement of all relevant regional DFO Branches in future MEQ indicator initiatives.

SOMMAIRE

Un deuxième atelier sur les indicateurs de la qualité de l'environnement marin (QEM) a eu lieu en mars 2004 dans la Région du Pacifique pour donner suite à l'initiative régionale d'établissement des objectifs opérationnels nécessaires à la mesure du succès de la gestion écosystémique appliquée dans le cadre du projet pilote de Zone de gestion intégrée de la côte nord du Pacifique (ZGICNP). Cet atelier a été différent du premier atelier (résumé dans Jamieson *et al.*, 2003). En effet, tout en gardant à l'esprit les objectifs de gestion écoystémique définis à l'échelle nationale et de haut niveau, les participants à ce deuxième atelier ont adopté une démarche ascendante en tentant de mieux se concentrer sur les activités humaines ayant effectivement une incidence sur l'environnement local. L'établissement des objectifs et des indicateurs de la QEM s'est fait en examinant les principaux agents d'agression touchant les composants écosystémiques de trois zones : une zone de gestion côtière potentielle (détroit de Quatsino); la zone de chalutage en eaux profondes du détroit de la Reine-Charlotte; la zone de gestion intégrée de la côte nord du Pacifique (ZGICNP), c'est-à-dire une vaste zone de gestion océanique potentielle. En utilisant cette démarche ascendante, les participants se sont servis d'estimations de menaces concrètes pour la santé de l'écosystème marin pour évaluer d'éventuels objectifs et indicateurs de la QEM. Les commentaires sur les prochaines étapes de l'élaboration des indicateurs de la QEM et de la mise en œuvre de la gestion intégrée exposés dans le sommaire de l'atelier traitent du rôle que le MPO devra jouer dans l'élaboration d'indicateurs de la QEM, du recours possible au protocole d'entente fédéral-provincial sur les océans pour faire progresser ce dossier lié à la côte du Pacifique, et de l'importance d'une participation efficace de toutes les directions générales régionales du MPO visées aux futures initiatives sur les indicateurs de la QEM.

EXECUTIVE SUMMARY

A second Pacific Region MEQ Indicators Workshop was held in March, 2004, as a continuation of the regional initiative to determine operational objectives for monitoring the success of ecosystem-based management in the pilot proposed Pacific North Coast Integrated Management Area (PNCIMA). This workshop differed from the first (Jamieson et al. 2003) in that while keeping in mind the high level, nationally-defined conceptual ecosystem objectives, it considered a “bottom-up” perspective in an effort to allow better focusing on those human activities actually impacting on the environment.

Objectives were:

1. To inform participants of the work to date on and current status of:
    a. The national Marine Environmental Quality (MEQ) Framework;
    b. Related federal work to develop marine indicators at large [i.e., Large Ocean Management Area (LOMA)] and local [i.e., Coastal Management Area (CMA)] scales; and
    c. Related British Columbia provincial work to develop marine indicators.

2. At the CMA and LOMA scales, to:
    a. Recommend a draft candidate ‘suite’ of MEQ indicators that would provide an assessment of the overall health and impacts of stressors of relevant marine ecosystems; and
    b. Evaluate the utility of using a “bottom-up process” to develop such a candidate suite of MEQ indicators.

3. To suggest appropriate “next steps” for parties involved in identifying MEQ indicators at the CMA and LOMA scales for the Pacific Region.

The development of MEQ objectives and indicators was determined by looking at key issues or “stressors” on ecosystem components in three areas: the potential Quatsino Sound CMA, the deep-water trawled areas of Queen Charlotte Sound, and in the overall proposed PNCIMA, which is a potential LOMA. This “bottom-up” approach utilised estimates of tangible threats to marine ecosystem health in the assessment of potential MEQ objectives and indicators. Overall, this approach had merit and resulted in a more tractable suite of potential indicators than resulted from the solely top-down approach investigated at the earlier workshop (Jamieson et al. 2003). Many suggestions were provided as to how to effectively utilize this approach, but a key concern raised by participants was that progress was being impeded due to the perceived low priority given to this issue by senior management within DFO. Participants raised concern about the ability of the department to move forward on these initiatives without a significant increase in the allocation of resources to ecosystem-based management initiatives. Workshop summary comments for next steps towards developing MEQ indicators and practising Integrated Management thus related to DFO’s future role in developing MEQ indicators, the potential for the Federal/Provincial Oceans’-related Memorandum of Understanding on the implementation of Canada’s Oceans Strategy to advance this issue, and the importance of integrating effective involvement of all relevant regional DFO Branches and personnel in future MEQ initiatives.

In summary, the workshop, as reflected in this report, clearly met Objectives 1 and 3. There was much discussion around Objective 2, but the expectation at this first workshop was not to develop a final unified list of candidate MEQ indicators. Rather, it was to evaluate the potential of a bottom-up process in the identification of an acceptable mix of appropriate MEQ indicators to monitor. While we struggled with this evaluation, we feel we made progress in the sense that MEQ indicators were identified by each group, and that a bottom-up process should become a significant evaluation of any final determination of MEQ indicators. Major challenges relate to addressing scale issues in terms of how EOs in CMAs and LOMAs relate to each other, if at all; and in determining how completely relevant higher level ecological objectives can be addressed by primarily considering indicators relevant for a few known impacts.

ACKNOWLEDGEMENTS

We would particularly like to thank Luanne Chew for her work in preparing background material for the workshop, Midori Nicholson for her administrative organization of the workshop, and Doug Swift, who as acting Integrated Management Coordinator in the Central Coast Area assumed overall responsibility for workshop planning.

Members of the MEQ Science Subcommittee, Peter Ross, Dario Stucchi, John Holmes, Don Sinclair, Brad Mason, Pat Lim (unable to attend), Duncan Johannessen, and Midori Nicolson, provided overall direction regarding definition of workshop objectives, coordination, and report finalization, as well as volunteering to help facilitate small working groups at the workshop. We would also like to thank all the speakers at the workshop, at it was their talks that gave substance to the deliberations. Finally, we would like to acknowledge the constructive participation of all the attendees at the workshop, as it was because of their willingness to get involved that ultimately allowed us to evaluate a “bottom-up” approach to MEQ monitoring indicator establishment.

INTRODUCTION

Integrated Management (IM) is one of three key principles of Canada's *Oceans Act.* As part of Canada's Oceans Strategy, the *Policy and Operational Framework for the Integrated Management of Estuarine, Coastal, and Marine Environments in Canada* (Canada, 2002), describes how ecosystem objectives (EOs) will be established as a part of an Ecosystem-based Management (EBM) process at the Large Ocean Management Area (LOMA) and Coastal Management Area (CMA) scale. Ecosystem Objectives, which should be consistent within DFO-defined ecoregions, are set at the LOMA scale, and Marine Environmental Quality (MEQ) objectives and indicators are developed at the CMA scale to ensure that EBM is being achieved.

In March 2001, a national workshop was held to identify broad conceptual objectives that could be used in IM under the overarching objectives of conservation of species and habitat. A national framework for identifying ecosystem objectives was developed whereby a set of high level conceptual objectives would be defined with increasing detail and specificity down to operational MEQ objectives in a process termed "unpacking" (Jamieson et al. 2001).

In the Pacific Region, the Central Coast Integrated Management (CCIM) initiative held an MEQ workshop on June 5-7, 2002, and attempted to apply the national framework to a potential LOMA in the British Columbia Central Coast and within it, the Quatsino Sound CMA, as an initial evaluation of the process to determine a potential suite of MEQ objectives and indicators. The CCIM is now being considered as part of a larger proposed Pacific North Coast Integrated Management Area (PNCIMA). The output of that workshop was that through a solely top-down process, because there are potentially thousands of potential MEQ objectives, the ones proposed for selection are to a large extent determined by the mix of discipline expertise that participants brought to the unpacking process. In general, it was felt that such a process was thus likely to be biased, since appropriate expert participation is difficult to achieve, and thus not particularly useful, since an inadequate 'suite' objectives would likely be proposed (Jamieson et al. 2003). There have been continued attempts at both the national and regional levels to refine the definition of an ecosystem approach to IM (e.g. O'Boyle and Keizer 2003; O'Boyle and Jamieson submitted), and in February, 2004, there was a national workshop that suggested guidelines (J. Rice, unpublished) for the determination of MEQ objectives from national conceptual EOs.

A second Pacific MEQ Indicators workshop was held, March 10 – 12, 2004 (Appendices 1-5), as a continuation of the previous Pacific Region initiative. This workshop differed in that while keeping in mind the high level conceptual ecosystem objectives, it also considered a "bottom-up" perspective. MEQ objectives and indicators were determined by looking at key issues or "stressors" on ecosystem components in three areas: the potential Quatsino Inlet CMA, the deep-water trawled areas of Queen Charlotte Sound, and in the overall proposed PNCIMA, which is a potential LOMA. This "bottom-up" approach utilised an estimation of tangible threats to marine ecosystem health for developing MEQ objectives and indicators. This approach has previously been used to assess and monitor marine ecosystem health, but on a much smaller scale (Mark et al. 2003). The following section provides a summary of workshop presentations and discussions. The statement of workshop objectives, the workshop agenda, and the list of workshop participants are provided in Appendices 1, 2 and 3, respectively.

WORKSHOP PRESENTATIONS AND DISCUSSIONS

Day 1:

Introduction to the Workshop

Workshop co-chairs Glen Jamieson and Brenda McCorquodale welcomed workshop participants and reviewed the objectives for the session. Members of the Pacific Region MEQ Science Subcommittee were introduced and acknowledged, and included, in addition to the co-chairs, Peter Ross, Dario Stucchi, John Holmes, Don Sinclair, Brad Mason, Pat Lim (unable to attend), Duncan Johannessen, and Midori Nicolson.

"Canada's Approach to Ecosystem-based Management"

Presentation by Glen Jamieson, DFO Science

This presentation by the Chair of the regional MEQ Science Subcommittee was intended to provide workshop participants with an overview of key policy and legislation and science-based workshops to date that have influenced thinking about MEQ objectives and indicators. Relevant provisions of Canada's *Oceans Act*, enacted in 1997, and the approach to Ecosystem-based Management (EBM) initiated under the Act were briefly reviewed. Work relating to the designation of ecosystem management areas in Canada's coastal and marine waters, and the links to the establishment of Large Ocean Management Areas (LOMAs), were discussed. The *Oceans Act* provides a rationale for Integrated Management (IM) and setting clear objectives for ecosystem-based planning. DFO's National Policy Committee in June of 2000 proposed a framework for setting ecosystem objectives that included developing a suite of objectives, indicators and reference points for the maintenance of biodiversity, productivity and water quality within coastal ecosystems of concern. Subsequently, there has been considerable work – but as yet no overall consensus – to define and determine operational objectives for the environmental dimension. Conceptual objectives for the social and cultural, economic and institutional dimensions have yet to be determined. Finalised conceptual objectives for the environmental dimension are:

- To conserve enough components (ecosystems, species, populations, etc.) so as to maintain the natural resilience of the ecosystem;
- To conserve each component of the ecosystem so that it can play its historical role in the foodweb (i.e., not cause any component of the ecosystem to be

altered to such an extent that it ceases to play its identified historical role in a higher order component); and

- To conserve the physical and chemical properties of the ecosystem.

Examples of EBM frameworks that might be used in Canadian waters include the Index of Biotic Integrity (IBI) and the Traffic Light Approach (TLA). The IBI rates broadly-occurring indicators on a simple numerical scale in comparison to values observed in reference areas. The TLA rates indicators as “good” (green), “satisfactory” (yellow), or “bad” (red) through an expert opinion (Delphic) process.

A workshop (J. Rice, DFO, Ottawa, ON, pers. comm.) involving about 20 representatives representing all regions was held in February 2004 in Halifax to determine guidelines for operationalising ecosystem objectives. This workshop was the first concerted attempt to determine the utility of conceptual objectives at an operational level. Workshop output was summarised with respect to the utility and application of conceptual objective terms and elements such as:

- Mean generation time;
- Bounds of natural variability;
- Primary productivity;
- Historic role in the food web;
- Resilience;
- Habitat;
- Communities;
- Species; and
- Populations.

Questions and discussion through and following the presentation focused on direction arising from the Halifax workshop. Specific comments from participants in Parksville were focused around the following subject areas.

- Caution was advised when considering *bounds of natural variability* outside of human activities and anthropogenic changes – and the difficulty in differentiating between “pristine” and “altered” systems. There is sometimes a “terminology understanding” gap between managers and scientists with respect to the meaning of terms, and terminology proposed and used should be as clear as possible. It is important to differentiate “variability” from “trend”.
- It was suggested that *primary productivity* is not a very useful indicator in large or complex systems where many variables are outside of the influence of ocean management (IM) actions. This variable is perhaps most relevant in nearshore ecosystems or relatively “closed” systems such as inlets or lakes where causal factors, if local, may be more evident.
- With respect to *trophic structure*, it was suggested that top (or apex) predators (e.g., sea birds, marine mammals, etc.) in various oceanic realms should be considered when setting EOs. This approach is consistent with experience in the Great Lakes, where EOs have been

debated for at least 30 years. The most successful example there of a top predator EO involves lake char, which is considered a keystone species in these aquatic systems (John Holmes, DFO, Nanaimo, Pers. comm.). For example, it may be that seabirds should be included in "allotted takes" of fisheries, which would encourage cooperation between DFO and the Canadian Wildlife Service (CWS).

- EOs for *habitat* will need to incorporate *Species At Risk Act* Critical Habitat requirements for listed species.

"BC Provincial Experience: Coast and Marine Environment of BC – 2005"

Presentation by James Quayle, British Columbia Ministry of Water, Land and Air Protection (MWLAP)

A process is underway to identify and report on environmental indicators for the coast and marine environment of BC, due for publication and distribution in July 2005, was outlined. The report will utilize the experience of MWLAP in public reporting of environmental indicators – with the aim of contributing to informed decisions and positive actions. A workshop that will include provincial and federal government agencies and academics will be convened on April 20th 2004 at the Institute of Ocean Sciences in Sidney. The workshop will utilise a conceptual framework based on *pressure, state and response indicators*. It is also worthwhile noting that a Memorandum of Understanding (MOU) on Oceans signed on September 18, 2004, between the Canadian and British Columbian governments states they have agreed to jointly develop sub-agreements on implementation measures, including indicators for oceans management and state of the environment reporting for the BC coast (http://www-comm.pac.dfo-mpo.gc.ca/pages/release/p-releas/2004/nr053_e.htm)

"LOMA Scale Issues and Work To Date"

Presentation by Duncan Johannessen, DFO Science

This presentation reviewed some of the history and methods involved in establishing the boundaries of the original "Central Coast Integrated Management (CCIM)" LOMA and its evolution to the "Pacific North Coast Integrated Management Area (PNCIMA). The current proposed PNCIMA encompasses both terrestrial (watershed) and marine realms. Some boundaries for marine components were based on bathymetry which approximated different habitat characteristics. In some cases, sudden changes in substrate type (i.e., between clay and silt) were used to delineate the boundary between the previous North Coast/QCI and Central Coast units of the PNCIMA. The southern boundary – between the Strait of Georgia and Johnstone Strait – was delineated using differences in tidal current speed, as well as substrate type. . More detail on the boundary definition can be found in Johannessen et al. (2004).

The upcoming requirement for an *Ecosystem Overview Report* (EOR) was described, and it was suggested that it could serve as a resource for managers and scientists involved in MEQ indicator development and IM objective-setting. The aim of an EOR is to provide IM planners, managers and stakeholders with relevant information on ecosystem properties and components, based on the best science and knowledge available. An EOR will therefore have to be regularly updated to make it the reference document that Management needs for inserting ecological considerations into IM and MPA plans. Another reference of potential use was the recent review of contaminant sources, types and risks in the Central Coast of British Columbia (Haggarty et al. , 2003), which provides an overview and annotated summary of information sources for this area. The Canadian Wildlife Service has mapped "areas of interest" along the Pacific Coast based on needs and use by migratory seabirds. The Living Oceans Society (an environmental non-governmental organization) has quantitatively identified areas of importance (or "conservation hot spots") along BC's Pacific Coast based on "conservation utility."

Beyond British Columbia, another tool of potential value is the "habitat template" developed for the Eastern Scotian Shelf of Nova Scotia (Arbour and Kostylev 2002; Kostylev 2004). The resulting map does not display "hard lines" between habitat types but rather portrays gradations in habitat that can be viewed and analysed at both coarse and fine scales. "Stability" (disturbed/stable) was plotted against "adversity" (benign/adverse scope for growth), with risk of HADD aligned with stability and population recovery aligned with adversity. The matrix is a relatively simple means of communicating complex information and comparing status of indicators for some key parameters. In essence, this template and its associated analyses may describe for the first time the climate portion of marine biogeoclimatic zones.

"Establishing the Context for MEQ Workshop Discussions: CMA Scale Issues and Case Study Work Done to Date"

Presentation by Brenda McCorquodale, DFO Oceans and Acting Central Coast Area Director

This presentation reviewed the experience gained from the earlier Pacific MEQ workshop (Jamieson et al. 2003), and outlined Integrated Management scales and Coastal Management Area (CMA) scale issues in preparation for the second day of workshop discussions. The goal of the previous workshop was to evaluate the process of "unpacking" broad ecosystem for a potential LOMA in the British Columbia Central Coast and MEQ objectives using the Quatsino CMA as a case study. Participants generally found the "top-down" unpacking approach difficult and overwhelming at a practical level. Hence, a combined "top-down, bottom-up" approach that used identified "environmental stressors" is being tested at this workshop.

A review of an Integrated Management (IM) development process was presented, that will ultimately take place at the Pacific Region, LOMA and CMA scales; on an inter-governmental basis, including First Nations and local government; and that would involve a broad stakeholder engagement. This process will include:

- Increased communication;
- Improved information management and access; and
- Development and implementation of adaptive management processes.

Some CMA scale planning activities that are relevant to workshop discussions here include:

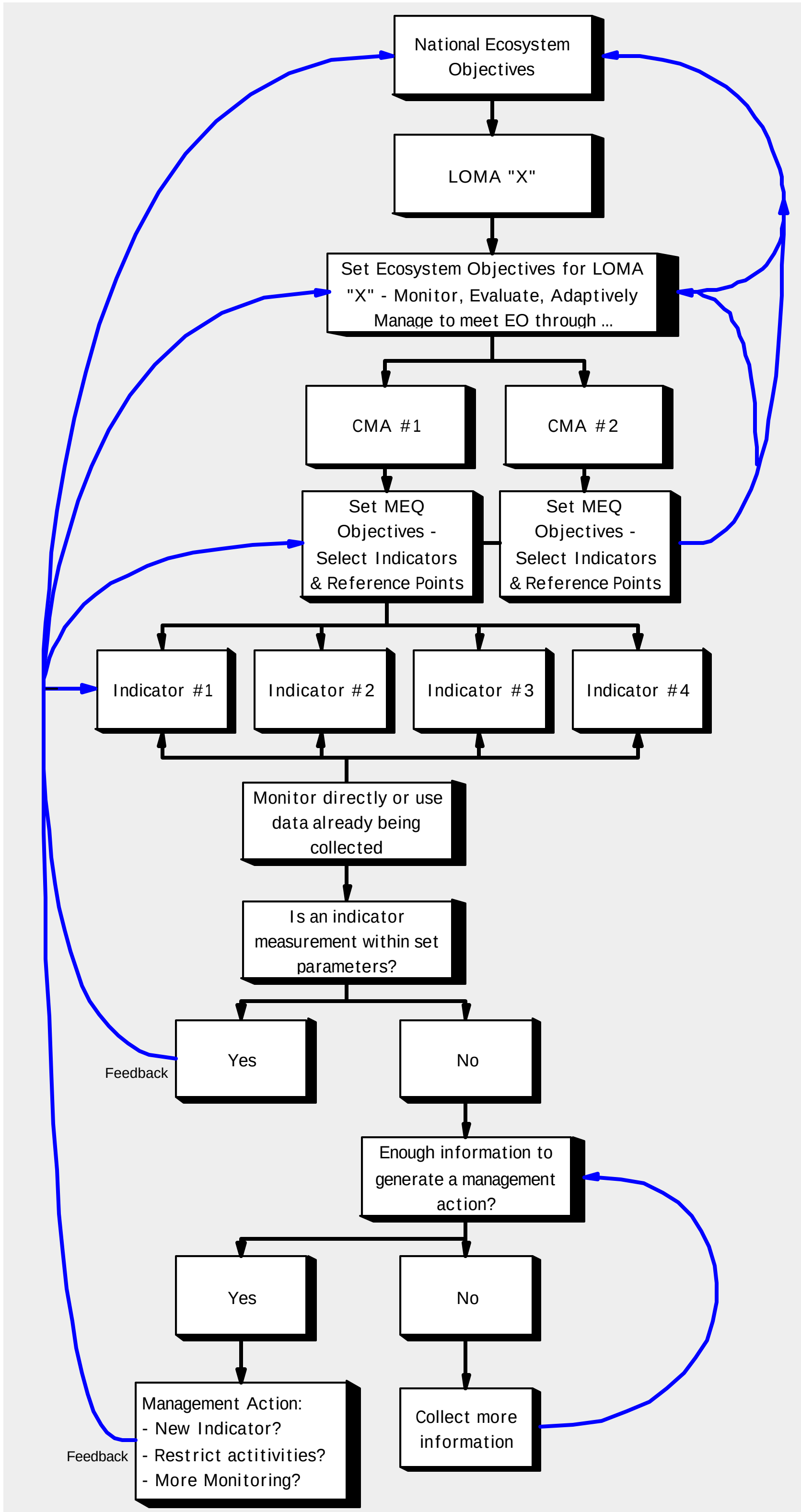
- The *Turning Point* initiative (http://www.davidsuzuki.org/Forests/Turning_Point.asp) involving several North and Central Coast First Nations, which addresses both terrestrial and marine issues; and
- Joint initiatives that involve four levels of government, including several BC-led coastal plans, and the pilot federal/provincial integrated Quatsino Sound Coastal Plan.

Current CMA level planning has focused on collecting available information for a specific area, and identifying the social preferences of local community members for the siting of various activities. Generalized available environmental data has been used to identify where various activities may or may not be appropriate. Improvements in the quality of environmental data is seen to be a key aspect of improving planning related to siting recommendations. Specifically, the development of CMA level MEQ objectives and indicators is seen as being an essential part of the development of ecosystem-based integrated management processes. A "flow chart and decision tree" (Figure 1) for the development and adaptation of MEQ objectives and indicators at LOMA and CMA scales was presented to provide a schematic overview of concepts for workshop participants.

In the final discussion for the day, the concept of "performance" and "health" indicators was raised. Performance indicators are those that if parameters were exceeded, would result in clear, direct management actions. Health indicators are broader measures of ecosystem health (e.g., the use of body temperature provides some information about general human health) and may not directly result in any specific management response until further research demonstrated that a specific response was relevant and appropriate. At a previous workshop, a ratio of 70% performance to 30% health indicators was suggested as a rough guide for determining an appropriate suite of indicators, based not necessarily on science or experience, but rather "common sense" at this time.

With respect to the flow diagram in Figure 1, there must also be LOMA EO objectives that are measured/monitored at the LOMA scale and that are not dependent on a rollup of CMA indicators, as:

1. the latter may not capture Ecosystem processes and features at the LOMA scale (e.g.; maintain integrity of HEX sponge reef complexes in the Queen Charlotte Basin VS protect eelgrass beds of x m^2 size in Chatham Sound), and
2. there may be few CMA's within the LOMA area, LOMA VS CMA pressures (hence the indicators and objectives) may be different, and monitoring resources are limited, meaning all indicators cannot be monitored at all desired locations.



3.

Figure 1: A flow diagram demonstrating how decisions at a CMA scale may be made with respect to the establishment of indicators and responses to indicator measures.

Day 2:

Case Study #1: Quatsino Sound CMA and influence/opportunity from multiple stressors

"Environmental Stressors in Quatsino Sound CMA"

Presentation by Luanne Chew, Consultant

"Environmental Stressor Factsheets" (Appendix 6) prepared for the workshop provided background information on four identified stressors in Quatsino Sound:

- Forestry;
- Mining;
- Finfish aquaculture; and
- Shellfish aquaculture.

Each factsheet included background information on the environmental stressor, MEQ components that are considered at risk, considerations related to scale, a starting list of potential indicators for small group discussions, and suggested further readings and information sources.

The second tool provided for small group discussions was a spreadsheet of potential "indicator selection criteria" for groups to use when assessing the utility of potential indicators. The spreadsheet included criteria under four major headings:

1. Relevance:
   - Measurement of ecosystem health
   - Anthropogenic stresses
   - Relevance to National Objectives
2. Feasibility of Implementation:
   - Validatable (and commonly accepted – indicator and ecological component)
   - Measurable with accuracy and precision
   - Ease/Logistic issues
   - Cost effectivness to monitor (data management to be considered)
   - Possible reference points (availablity)
   - Information currently being collected
   - Baseline conditions
   - Time series
   - Facilitates decision-making
3. Response Variability:
   - Diagnostic ability
   - Stress response time
   - Remedial action response time
4. Interpretation and Utility
   - Simple to interpret/communicate
   - Scaleability
   - Does it relate well with other indicators

- Link to management decision making
- Elasticity

"Additional Background Information on Quatsino Sound CMA"

Presentation by Steve Diggon, DFO Oceans

This presentation provided visual images and additional spatial information for workshop participants to utilise in their small group discussions related to the Quatsino Sound Coastal Management Area. The Quatsino First Nation includes five different tribal groups within the Sound; archaeological evidence of First Nations activity in the area dates from 1000 BC.

There are a number of small communities in the Sound, including:

- *Coal Harbour* – site of a failed coal mine and a copper mine from 1970-1995 and with a current population of about 215 people;
- *Port Alice* – site of a pulp mill (upgraded to non-chlorine bleaching process) with an uncertain future and a current population of about 850 people;
- *Holberg* – forestry is the main employer for the population of about 150;
- *Quatsino* – a village accessible only by boat with a population of approximately 100; and
- *Winter Harbour* –about 25 people but a sheltered harbour; historically significant commercial fish landings and significant herring spawning areas nearby.

The Quatsino Sound Coastal Plan (currently in "near final" draft) has identified "Areas of Ecological Significance" in the Sound through a "non-scientific" advisory committee process. Areas identified are considered significant on the basis of: biodiversity, reproductive, rare and unique habitats, productivity, and/or mammal haul-out sites. As well, additional "localized areas of significance" were identified and mapped with community input. The Plan document, which can be obtained from the B.C. Ministry of Sustainable Resource Management, includes much information and references for obtaining additional data relevant to Quatsino Sound.

Small Group Discussions – Quatsino Sound CMA

Group 1:

This group focused first on *finfish aquaculture* in order to begin fleshing out some possible indicators for Quatsino Sound. *Relevance*, *potential objectives* and *recommended indicators* were examined, beginning with the suggested finfish aquaculture indicators identified on the "environmental stressor" handout sheets. The group began by outlining some of the indicators directly involved with this industry, and then broadened the scale of discussion to consider potential impacts from an ecosystem point of view. The first indicators discussed were *escaped farmed salmon*, *sea lice* and *benthic community structure*.

When discussion was broadened to include impacts of finfish aquaculture across the entire Quatsino Sound ecosystem, the group recommended consideration of indicators that could monitor:

- *Cumulative impacts*;
- *Physical changes to the ecosystem;* and
- C*hemical and contaminant loads in water, sediments and biota*.

In terms of a *process for identifying indicators*, the group recommended considering all the activities within Quatsino Sound and bringing together experts with knowledge on specific stressors to form working groups in order to understand the commonalities between all stressors, with the intention of maximising overlap, so that a few indicators could be identified that might be of relevance for a variety of stressors.

Group 2:

This group looked at all of the major stressors within Quatsino Sound and tried to come up with indicator indices for all of them. The group considered the following stressors:

- *Forestry*;
- *Shellfish aquaculture*;
- *Finfish aquaculture*;
- *Mining*; and
- *External stressors to Quatsino Sound*.

The group developed a list of indicator indices for each of the stressors and then looked at commonalities between them. Common indices included:

- *Shellfish Health Index;*
- *Shore Zone Impact Index;*
- *Benthic Health Index;* and
- *Stream/Drainage Water Quality Index.*

The following areas were identified as key gaps in the MEQ indicator identification process:

- *Monitoring;*
- *Baseline studies;*
- *Data compilation and interpretation;*
- *Multi-agency communication and coordination;*
- *Basic research;* and
- *The ability to engage all stakeholders within processes.*

The final suggestion for those who may be involved in choosing MEQ indicators posed by the group was: "*Consider whether indicators will be sufficiently proactive*."

Group 3:

This group looked for common indicators across all stressors rather than at indicators specific to individual stressors. Suggested indicators as adequate measures of health were:

- *Dissolved Oxygen (DO);*
- *Salmon diversity and escapement;*
- *Forage fish abundance;*
- *Commercial harvest of invertebrates;*

- *Local Environmental Knowledge relating to the 'quality' of the marine environment;*
- *Biodiversity;*
- *Plankton blooms;*
- *Metal and contaminant concentrations in tissues;* and
- *Eelgrass and kelp abundance*.

This set of indicators was chosen in recognition of existing data sets and ease of initiating practical monitoring programs (utility and practicality). Data mining and analysis of existing data sets (as compared to instituting new monitoring programs) was recommended as a cheap method for gathering initial information. Ideally, monitoring programs could be "piggybacked" on other programs in order to be cost-effective and meaningful. Data sharing between all industries (and government agencies and others) is another important aspect of information gathering that could make monitoring more cost effective. The group discussed the indicators above in the context of their use to inform management and decision-making in a broad sense.

Group 4:

This group focused on a process for selecting indicators – as opposed to starting with a list of potential indicators and going through the selection criteria for each. The group felt that they needed a conceptual model to demonstrate linkages between the stressors and the critical ecosystem components/processes that could be affected. An approach similar to that used by Parks Canada was suggested and described in a preliminary fashion. It involved developing a qualitative conceptual model that could show key interactions between stressors in order to allow for informed decisions about human use within the ecosystem.

The *Pressure/State/Response* model for choice of indicators was suggested as a way to build understandings among diverse users of MEQ information and to encourage the practice of adaptive management. *Pressure* indicators measure the magnitude and extent of the stressor. *State* indicators measure either the impacts of the stressor (performance) or aspects of MEQ that are not related to anthropogenic stressors (health). Response indicators measure the effect of management activities that are intended to reduce pressure and are initiated when a change in state is observed. A qualitative sub-model for each critical ecosystem component and relevant stressors could demonstrate potential indicators, which could then be brought into the larger conceptual model. Eelgrass could be used as an example of this process, using the figure below, as eelgrass is an important component of the ecosystem in question. The sub model shows eelgrass health to be dependent upon parameter 3 (e.g., turbidity). Parameter 3 is in turn affected by stressors 1, 2, and 3 (e.g., industries that contribute to turbidity). By monitoring parameter 3, we are able to monitor an aspect of the environment and how it is affected by 3 stressors. This system develops a clear indication of the relevance of certain parameters to key aspects of the ecosystem and identifies the stressors that can affect them.

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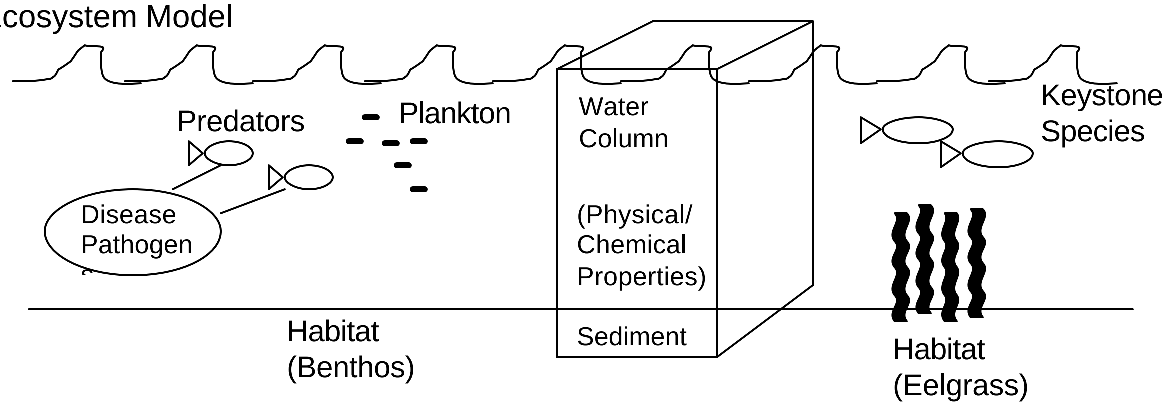
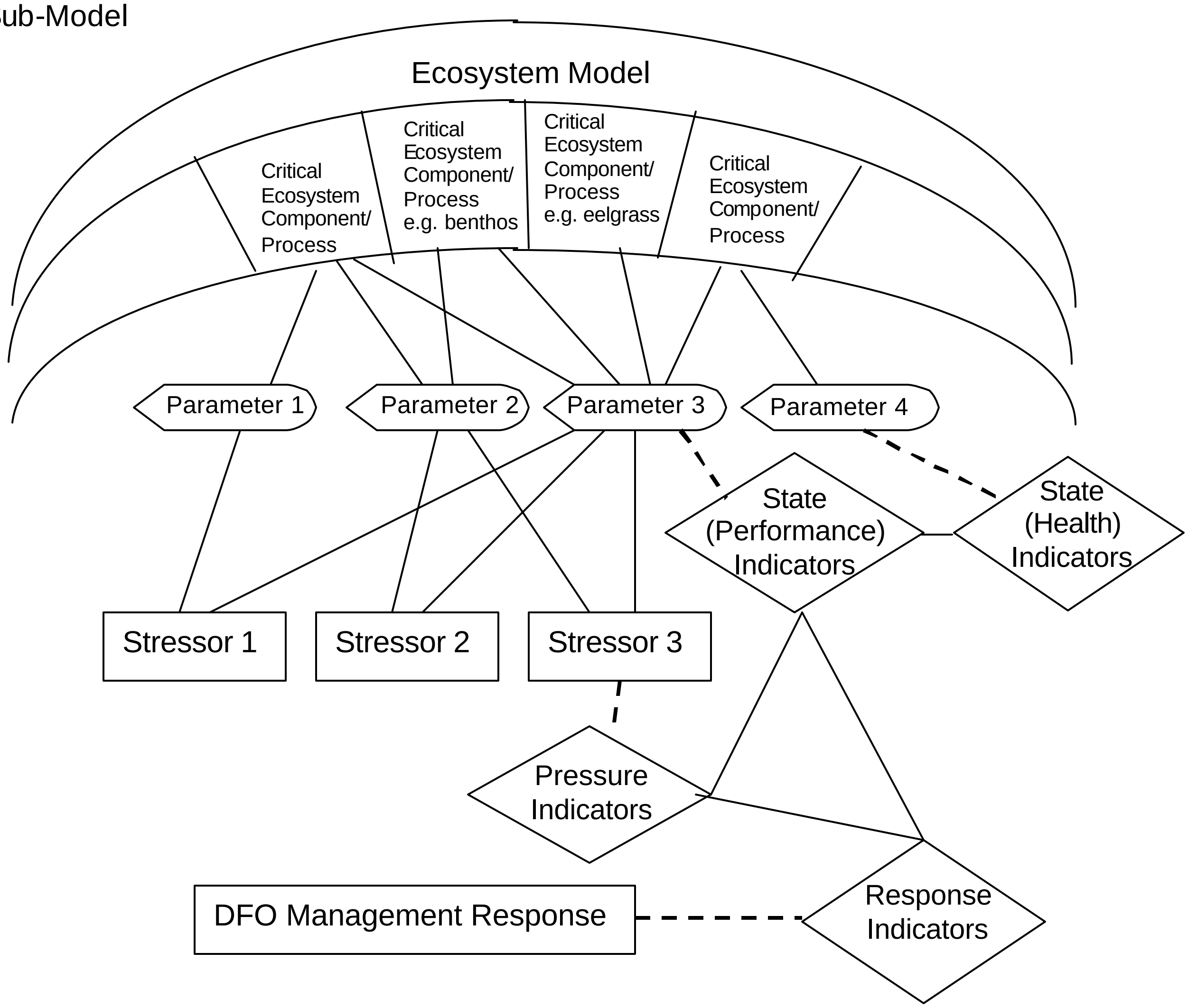
The inclusion of all stakeholders was viewed as a very important step in the process in order to fill in any potential gaps that may exist. If there are data gaps found, data gathering will need to occur, followed by analysis, interpretation and reporting. They suggested starting by addressing what the critical ecosystem components within Quatsino Sound might be. Once these are defined, pick out the commonalities between them in terms of stressors and indicators.

Ecosystem Model



Sub-Model



Case Study #2: Queen Charlotte Basin and influence/opportunities relating to one key stressor (trawling)

Sensitive Habitat in the Queen Charlotte Basin: "Sponge Reefs with Protected Fishery Management Areas"

Presentation by Glen Jamieson, DFO Science

A brief presentation describing the nature of the sponge reefs in the Queen Charlotte Basin and the current status of trawl fisheries in the area was provided. The reefs were first identified by Natural Resources Canada in the late 1980's. The sponges in the Queen Charlotte Basin are unusual one-celled organisms that build on the skeletons of past sponges and "grow" into reef structures, and while the species present are ubquitously distributed spatially in coastal BC, their reef-building is unique world-wide and elsewhere is only found in the fossil record. They are found between about 195-210 m in depth and form structures that can be over 18 metres in height. Unique conditions are needed for their growth – glacial scouring to expose the underlying hard substrate, adequate concentration of dissolved silicon, and appropriate ocean currents for sediment movement and food transport. Trawling activities destroy the sponge reefs by killing the living sponges on the top of the reefs, as well as damaging or destroying the underlying structure (or skeletons). Fisheries data suggest that trawls can be over 20 km in length, with an average tow length of about 9 km. There is a voluntary closure of the (trawl) shrimp fishery in the waters surrounding the sponge reefs. In 1999, all trawlers were asked to stop fishing in these areas, and in 2003, groundfish trawl closures were established in the areas of known sponge reefs.

"A Rapid Overview of BC Groundfish Trawl Fishery in Hecate Strait and Queen Charlotte Sound"

Presentation by Alan Sinclair, DFO Science

A summary of the trawl fishery in Queen Charlotte (QC) Sound was given, based on data collected from the fishery since the 1950's. The fishery has been active since the 1940's, with a catch and effort database available for the years between 1954 and 1995, and more detailed information is available from observer coverage on all trawlers since 1996. Coast-wide, the groundfish industry annually contributes $1.3 million to research and $3.0 million to management.

The fisheries dataset for the area includes a Hecate Strait assemblage survey done since 1984, a Queen Charlotte Sound multi-species survey started in 2003, various single species monitoring surveys over the years, and port sampling of catch size and age compositions. Most fishing effort is during the summer months because of severe winter weather conditions. About 15-20% of the bottom area (north of Vancouver Island to QC Sound, west to 1000 m depth) is trawled per year. Twenty-four fish species make up 95% of the total catch. Invertebrate taxa make up 0.8% of total catch by weight (1,548 tonnes since 1996), with 15 tonnes of marine mammal and bird "bycatch" recorded since 1996. In general, the various target fish species for the groundfish trawl fishery appear to be in fairly good "health." There are, however, gaps in stock assessment and Integrated Fisheries Management Plan information. For example, specific to Queen Charlotte Sound/Hecate Strait, only seven of the fished species have "frequent" stock assessments.

Trawl fishery Catch per Unit Effort (CUPE) and survey indices might be developed as indicators of trawl effects on incidental non-targeted species (bycatch) and effects on benthic habitat quality and quantity, and a more comprehensive list of other fisheries (herring, crab, shrimp, salmon, hook and line fisheries) could be considered for inclusion in future MEQ analyses.

"Coral and Sponge Bycatch in BC's Bottom Trawl Fishery: A Case Study for Discussion of MEQ Indicators"

Presentation by Jeff Ardron, Living Oceans Society

An analysis of coral and sponge bycatch was presented as an example of "data exploration and mining" for information about ecosystem health and MEQ. Data from British Columbia's bottom trawl fishery was used, which included numerical distribution of trawls (by depth, effort, and speed), spatial distributions and trends, and taxa of recorded catches. Stratifying data for coral and sponge bycatch (between 1996 and 2002), specific areas could be identified where bycatch of these species had a higher likelihood of occurring. It was noted that back-casting (using data mining) can only look at what *has* happened, and cannot say what *will* happen (e.g., through shifting effort to different fishing areas or using different fishing technologies). With specific reference to corals and sponges and the bottom trawl fishery, it was noted that present day closures restrict only 1.4% of historic and current trawling areas. Bycatch of corals and sponges was high around current closed areas (the Hecate Sponge Reefs), it is the first tow that causes most of the damage over the reefs, and we do not necessarily know if there are sponges in new areas being trawled. Further information about this research and related initiatives can be viewed at "www.livingoceans.org/trawl_maps.htm".

Small Group Discussions – Queen Charlotte Basin

Group 1:

The group found it difficult to begin outlining indicators, as they felt that there were serious knowledge gaps in information about the area. The group recommended building on the existing fisheries management framework in order to adequately monitor fishing pressure, stock assessments, damage done to unique habitats, and spatial shifts in fishing effort. Recommended actions included:

- Establishment of *target* and limit reference points for commercial and non-target species;
- Effective monitoring of time series data; and
- Monitoring of expansion of fishing effort into new areas.

Time series *data collection* was recommended for stock size and production of commercial species, relative abundance of non-target species, relative abundance of species aggregates, size distribution of species and species aggregates and spatial distribution of fishing effort. Key information needs (or gaps) that were identified were:

- Locations and extent of sponge and coral reefs;
- Activities outside of fished areas;
- Fishing technology advancements factored into catch trends;
- Stock assessments for all commercial fish species;
- Information on sensitive species; and
- An assessment of information gathered by commercial fisheries and how it could be used to assess community structure and biodiversity.

Group 2:

The group identified the following stressors for the Queen Charlotte Basin:

- *Catch*;
- *Bycatch*;
- *Physical habitat destruction*; and
- *Habitat enhancement*. (The idea here was that while trawling was generally destructive to invertebrates and most fish species (both directly through mortality and indirectly via habitat destruction), smoothing out the bottom may be beneficial for some species. For example, when ROVs have been used to look at trawl tracks, they sometimes observed fish such as Pacific cod moving along the trawl furrows.)

Physical destruction of sponge and coral reefs was seen by the group as a major problem, and two indicators were chosen to monitor structural and biological/ecological changes. The structural change indicator would measure management actions, such as the number of closures per area versus the compliance and effectiveness of those closures. The biological/ecological change indicator would monitor physical destruction of habitats, such as sponge and coral reefs, with video or still picture imagery and/or side scan sonar.

Data mining is viewed as valuable exercise for information gathering and was suggested for information gathering about:

- Landings and catch characteristics (age, size, species, sex ratio);
- Fishing effort (CPUE, # of boats, length of trawls, locations); and
- Surveys independent of commercial fishing.

Data and understanding gaps that were identified included:

- The need for basic understanding of globally unique habitats/features to empower indicator selection and development; and
- The rate of regeneration/colonization of sponge and coral reefs and other habitats.

Group 3:

In initial discussions, the group considered potential common data and management needs at LOMA and CMA scales. While some stressors operate at the LOMA scale, there is a common need to understand “causes and effects” in relation to environmental and habitat impacts. The group suggested looking at “common design principles” for choice of indicators (e.g., to guide observation, interpretation and management decisions; to provide information on “pressure, state and response elements”).

Some indicators may be more important or only effectively measured at a LOMA scale (e.g., steric height (annual change in height (volume) because of temperature change), sea levels, sea surface temperature). However, suggestions for indicators that may be common at both CMA and LOMA scales included:

- Salmon escapement (comparison at different scales can allow differentiation of impacts affecting escapement);
- Bird populations and breeding rookeries (can be an indicator of health of local ecosystems at the CMA scale, while reflecting broader issues across the range of their migration);
- Marine mammals (e.g., harbour seal, sea lion haulouts/breeding areas) (data from local haulouts provide an indicator of local ecosystem health, while providing information for analysis of trends at the LOMA scale – counts are a primary tool and diet information provides an additional level of detail, collecting data every 4-5 years provides a long-term time series for a variety of potential uses);
- Contaminants (some data (e.g., contaminants in crabs) can be collected at CMA scale and rolled up to provide information for an overview of LOMA-scale marine contaminant levels); and
- Dissolved oxygen (DO) (while more relevant at the CMA scale, could be relevant to particular stressors at broader scales).

In terms of recommended process, the group advised to focus first on utility, i.e., what is practical and important. While initial indices may be data-driven, there are no doubt other elements that are ecologically important but for which we currently lack data.

Three steps (or elements) were seen in the data analysis process for MEQ indicators:

1. Collect existing information (on an inter-governmental/stakeholder basis);
2. Analyse in new ways; and
3. Generate new information to address key needs and gaps.

Further refinement of key objectives at LOMA and CMA scales can provide a focus for discussion of indicator suites. Movement is needed “now” on something real (e.g., a science-driven exercise to solicit proposals from Science, reviewed by the MEQ Committee using criteria like cost and representation, to develop an initial suite of indicators) that can be applied in a pilot CMA, and modified through an adaptive management process once existing/initial data has been assembled and analysed.

Group 4:

This group began by identifying the objectives that may be related to the stressor of bottom trawling. Suggested objectives were:

- Maintaining biodiversity;
- Developing a sustainable bottom fishery;
- Maintaining trophic structure; and
- Limiting the level of habitat alteration/destruction to acceptable limits.

Criteria for acceptable levels for each of these objectives would need to be developed. The group considered the New Zealand fish stock indicator system for potential application in this situation. The method does a good job of pulling multiple data sets together on different species in order to gain a picture of trophic structure for a large area, and thus can be used to portray the possible effects of fishing.

A key data limitation is the spatial extent of trawling; start and end points do not necessarily convey the entire area covered by trawls. Another data gap is the need for more fisheries independent data for use in indicators. While fisheries data help define "pressure" indicators, non-fisheries data can help define some "state" indicators. Another data limitation is clearly baseline information on current benthic habitat structure and community function.

Day 3:

"Linkages to LOMA"

Comments by Glen Jamieson and Brenda McCorquodale

Direction was given for small group discussions around indicators that might be used at both LOMA and CMA scales, and that may be specific to the LOMA scale. Questions that the small groups were directed to consider included:

- Are there any common indicators?
- Is there anything missing at the larger scale from what might be monitored at the CMA scale?
- How will scale change the indicator monitoring?
- Are there particular indicators of "health" (e.g., regime shifts, El Niño) related to the LOMA scale?
- How can/should features relating to wide-ranging species (such as migratory birds) be utilised as indicators at LOMA and CMA scales?

Small Group Discussions – LOMA-level

Note: there were only three small groups for this discussion.

Group 1:

This group looked at a variety of possible indicators and whether or not they were, first, important and, second, practical. At the LOMA scale, the following indicators were suggested as appropriate:

- Temperature change;
- Apex predator prey analysis;
- Plankton assessments;
- Percentage change in near shore habitat (quantity and quality);
- Percentage of area under protection;
- Number of species at risk;
- Number of introduced species; and
- An index of biodiversity and supporting habitat.

Key messages arising from the group's discussions highlighted "needs" that should be addressed for MEQ and Integrated Management to be successful:

- Integrated management of human activities;
- Objective-based ecosystem management;
- Support for the core mandate of government agencies such as DFO;
- Better infrastructure support;
- A high level vision of what sustainable development is;
- A focus on key science issues, not politically driven ones; and
- Better coordination between different sectors, agencies, industries, academics, First Nations and NGO's.

Group 2:

This group identified numerous subject areas where data to determine indicators at a LOMA scale would be relevant:

- Large marine mammals and migratory birds as indicator species for ecosystem health;
- Long range toxic pollutants within the LOMA;
- International fishing pressure;
- Shipping traffic impacts;
- Health of fish stocks; and
- Global climate change.

The group suggested "practical data sources" in which data collection is on-going to consider in the development of indicators and indices:

- Oceanographic data;
- Satellite data; and
- Migratory bird data.

Marine mammals and birds were identified as key species to monitor further, as Canada is lacking potentially useful data that could be used in conjunction with data sets in adjacent areas in the United States. These species may be key indicators of overall ecosystem health as they are top predators, are often quite sensitive to oceanographic changes and pollutant loadings, several are listed under Canada's

Species at Risk Act (e.g.: Northern and Southern resident killer whales; leatherback turtles), and some species have globally significant populations within Canada, such as the Cassin's Auklet.

Key messages from the group's discussion included:

- LOMA scale data collection is very expensive – even using existing and ongoing data sets;
- Hope that info from indicators being used will be acted upon by managers, even if they provide bad news to the public; and
- A need for the MEQ Science Committee (and DFO Policy Committee?) to clarify the conceptual framework for CMAs and LOMAs. The present understanding is that a LOMA may be both an aggregation of CMAs and/or in some cases, CMAs only be specific areas within a LOMA. Understanding the spatial patterns of CMAs within any LOMA is critical for data collection and exchange, and consideration of scale issues re specific indicators.

Group 3:

This group looked at some indicators that were common at both the CMA and the LOMA scales but focused discussion on the conceptual idea of a LOMA versus a CMA. It was noted that we need to better understand environmental and habitat impacts and methods for management at the CMA level, but this understanding will roll up to the LOMA scale. The group discussed, but did not resolve, the question: "Are LOMAs within an Ecoregion (if more than one occur) different enough to warrant different management?"

The group identified indicators that are common at the CMA and LOMA scales, including:

- Salmon escapement;
- Bird populations and breeding rookeries;
- Marine mammal haul out sites; and
- Contaminants within the marine ecosystem.

The group looked at each of these potential indicators in terms of differing data and analysis needs and utility at each scale. There is a need for new data management techniques involving collecting existing information on an intergovernmental and stakeholder basis, analysing it in new ways, and then generating new information. There was a strong sense that we need to move to something concrete that can be applied in a pilot CMA to get a better handle on how MEQ will be effected, i.e. an adaptive management process with associated MEQ indicators.

The summary comment from group was: "Three workshops now and we are still at the theoretical construct stage." The group identified that the objective of developing a draft suite of indicators had not been achieved, but that the building blocks were there for a smaller more focussed effort to achieve this objective.

Final Plenary Discussion – Overall Messages

In the final plenary discussion, workshop participants reviewed small group discussions and raised the following points as summary comments for workshop organisers in considering next steps towards developing MEQ indicators and practising Integrated Management.

1. Advice on the role of the DFO in developing MEQ indicators:
   - There is a need to confirm and follow through with the core mandate of the agency;
   - There needs to be a drive within the agency for achieving these (MEQ) objectives;
   - Better coordination and cooperation among branches within the agency is needed;
   - DFO needs to improve its processes of collaboration and coordination with other federal and provincial agencies, specifically with respect to information management;
   - DFO also needs to improve its processes of collaboration and cooperation with industry, local governments, First Nations; and
   - There are too many similar or overlapping projects underway, which is not an efficient use of limited agency resources and staff time.

2. Federal/Provincial MOU on the Pacific Coast:
   - This is a good starting point for building better communications;
   - The MOU also provides an enabling structure to build upon; and
   - Mention of the National Oceans Action Plan in the last Throne Speech is a good sign, indicating the likely intention of the present government to act.

3. Integrated Management and MEQ:
   - All (different Branches of DFO, other interests) have something to offer;
   - A technical team needs to be pulled together to take the next steps – e.g., further developing MEQ objectives and indicators and implementing IM;
   - Senior level buy in is needed in order to move forward; and
   - Key questions need to be addressed if IM and MEQ is to be successfully implemented: How to pull this team together? What funding is needed to support them? Where will this funding be found?

Closing Comments (Dick Carson)

Dick Carson provided closing comments to the workshop, drawing on his observations of workshop discussions and implications for current and future direction for DFO. He noted the value of bringing a group with a "good cross section of expertise" and including different federal and provincial agencies, as well as academics and representatives of NGOs. In terms of taking intentions and responsibilities for IM "to the next step", Dick noted that the Oceans Action Plan involved 19 federal agencies, many with similar issues and all facing competing demands on their budgets. The challenge now is how they can be brought together to work effectively on a common initiative. One positive sign is an "omnibus submission" (involving a collection of agencies jointly asking for funding to implement the Oceans Action Plan) presently before the Federal Cabinet. Agencies, however, have to recognize that they have to commit dollars from their existing budgets, as well as asking for new funds.

Dick reviewed the fact that the *Oceans Act* can be the umbrella that brings together resources to address MEQ and IM. He noted several good ideas (such as establishing a technical team with a specific mandate to develop indicators) brought forward at this workshop on how to support implementation of the Act, and that "we need to work further to this end." This workshop will support the work of the Oceans Task Group in Ottawa – which is recognizing the experiences and understandings regarding IM that have been gained in British Columbia. A recent presentation in Ottawa on the Central Coast planning experience by John Bones of the British Columbia Ministry of Sustainable Resource Management contained many insights. The MOU that is currently near signing between the Provincial and Federal governments is another example of growing cooperation. The MOU addresses information management (as a step in information sharing) and has potential linkages to reporting in the future (e.g., through State of Environment Reporting). Once the MOU is signed, part of the challenge in moving forward will be to reconcile differences in approaches between the partners. Dick pointed to the saying ***"Think LOMAlly, Act Locally"*** raised in one of the small group discussions as a potential motto to be remembered by those involved in acting on the MOU.

Final Workshop Conclusions

In final discussions and comments, the following suggestions were raised by Dick and other workshop participants to help move MEQ forward:

- MEQ currently is a "DFO thing", done within a sector, and the concept and approach needs to be adopted more broadly (and at a national level) for it to be successfully adopted;
- A "concrete proposal" of specific initial indicators for MEQ is needed to help in communicating the concept and fostering support;
- A broader group of interests (including people from within and beyond DFO) could be brought together to work with a few indicators and stressors in a focused and real situation. Representatives within this group may have differing mandates, but should share ideas about their objectives in an effort to establish a common approach;
- MEQ indicators should "give warnings before chaos happens"; and
- Higher level agency managers or those not involved to date with MEQ may have problems understanding the concept and its application. Case studies, or even a simulation, might be used to help them better comprehend the potential values and results that could be achieved using MEQ objectives and indicators in a "real-life" Integrated Management situation.

REFERENCES

Anon. 2002. *Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada.* Fisheries and Oceans Canada. 43pp.

Arbour, J. and V.E. Kostylev. 2002. Proceedings of a Benthic Habitat Classification Workshop Meeting of the Maritimes Regional Advisory Process. Maintenance of Diversity of Ecosystem Types. A framework for the conservation of benthic communities of the Scotian-Fundy area of the Maritimes region. CSAS Proc. Ser. 2002/023: 94 pp.

Haggarty, D.R., B. McCorquodale, D.I. Johannessen, C.D. Levings and P.S. Ross. 2003. Marine Environmental Quality in the Central Coast of British Columbia, Canada: A Review of Contaminant Sources, Types and Risks. Canadian Technical Report of Fisheries and Aquatic Sciences 2507: 153 pp.

Jamieson, G.S., R. O'Boyle, J. Arbour, D. Cobb, S. Courtenay, R. Gregory, C. Levings, J. Munro, I. Perry and H. Vandermeulen. 2001. Proceedings of the National Workshop on Objectives and Indicators for Ecosystem-based Management. Sidney, British Columbia 27 February – 2 March 2001. CSAS Proceedings 2001/09.

Jamieson, G.S., B. Bauer and H. Vandermeulen. 2003. Proceedings of the Central Coast Integrated Management Marine Environmental Quality Workshop. June 5-7 2002, Parksville, BC. CSAS Proceedings 2003/013.

Johannessen, D., D. Haggarty, and J. Pringle. 2004. Boundary Definition for the Central Coast Integrated Management Area. PSARC Working Paper H2004-04. in press.

Kostylev, V.E. 2004. Habitat management template for Scotian Shelf habitat mapping. CSAS Res, Doc.: In press.

Mark, S., L. Provencher and J. Munro. 2003. Approach for the assessment and monitoring of marine ecosystem health with application to the *Mya-Macoma* community. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2491.

O'Boyle, R. and P. Keizer. 2003. Proceedings of Three Workshops to Investigate the Unpacking Process in Support of Ecosystem-Based Management. February – July 2002. CSAS Proceedings 2003/004.

APPENDICES

Appendix 1: Statement of Workshop Objectives

1. To inform participants of the work to date on and current status of:
    a. The national Marine Environmental Quality (MEQ) Framework;
    b. Related federal work to develop marine indicators at large [i.e., Large Ocean Management Area (LOMA)] and local [i.e., Coastal Management Area (CMA)] scales; and
    c. Related British Columbia work to develop marine indicators.

2. At the CMA and LOMA scales, to:
    d. Recommend a candidate suite of MEQ indicators that will provide an assessment of the overall health and impacts of stressors of relevant marine ecosystems; and
    e. Evaluate the utility of using a “bottom-up process” to develop such a candidate suite of MEQ indicators.

3. To suggest appropriate “next steps” for parties involved in identifying MEQ indicators at the CMA and LOMA scales for the Pacific Region.

Appendix 2: Workshop Agenda

<u>DAY 1</u> – Wednesday, March 10th 1:00 – 5:00 pm

1:00 – 1:30 Welcome, introduction to the workshop, and review of objectives,
Brenda McCorquodale, Glen Jamieson – Co-Chairs

- What are the objectives and anticipated outcomes of the workshop?
- Who is attending the meeting and why?

Colin Rankin - Facilitator

- Review of workshop agenda and the roles of the organizers, facilitators, and recorders
- Introduction of workshop participants

1:30 – 5:00 Establishing the context and framework for workshop discussions

(20 minute presentations with time for questions following each presentation and plenary discussion at the conclusion of presentations)

1:30 – 2:30	"Canada's approach to Ecosystem-Based Management" ("Dunsmuir, Tigh-na-Mara and Halifax Workshops") – Glen Jamieson, Chair MEQ Sub-Committee
2:30 – 3:00	"BC Provincial Experience" Provincial CME Indicator development - James Quayle, BC MSRM
3:00 – 3:30	Break
3:30 – 4:00	"LOMA scale issues and work to date" MEQ and the LOMA - Duncan Johannessen, IOS
4:00 – 4:30	"CMA scale issues and case study of work to date" MEQ and Quatsino Sound CMA - Brenda McCorquodale, A/Central Coast Area Director
4:30 – 5:00	Plenary discussion: key issues for consideration in the workshop, suggestions for day two small group discussions
5: 00	Workshop resource team (MEQ Science Sub-Committee) meet to review Day Two discussion questions and assignments (others welcome)

<u>DAY 2</u> – Thursday, March 11th 9:00 – 5:00 pm

9:00 – 9:15	Review of the day's agenda – discussion questions, desired outcomes and structure of small groups - Colin Rankin

9:15am – 1:30pm Quatsino Sound CMA

9:15 – 9:30 Introduction of Objectives – Brenda McCorquodale
Presentation of “Environmental Stressor” sheets - Luanne Chew

9:30 – 10:00 Additional Background Information on Quatsino Sound – Steve Diggon, Brenda McCorquodale

10:00 – 12:00 Small group discussion: MEQ Indicators for Quatsino Sound CMA

4 small groups will break out to review the background material on the environmental stressors and indicators for Quatsino Sound CMA with the following tasks:

- Assess the list of potential indicators to identify a suite of common or “high priority” indicators that have utility in providing an assessment of the overall health of the marine ecosystem and impacts across several environmental stressors.
- Comment on the utility of the “bottom up process” for identifying a suite of indicators (e.g., information required, effectiveness of worksheets, recommendations for improving the process)

12:00 – 12:45 Lunch

12:45 – 1:30 Quatsino Sound CMA: Plenary Review of Group reports on recommended suite of indicators and process for determining them.

1:30 – 5:00 Queen Charlotte Basin

1:30 – 2:00 Introduction to Queen Charlotte Basin –Al Sinclair, Glen Jamieson, Jeff Ardron

2:00 – 4:00 Small group discussion: MEQ Indicators for Queen Charlotte Basin - Break out Groups – same process as morning session but with Queen Charlotte Basin

4:00 – 4:30 Queen Charlotte Sound: Plenary Review of Small Group Reports on Recommended Suite of Indicators and Process for Determining Them

4:30 – 5:00 Plenary Discussion: Insights from the Day’s Discussions and Implications for MEQ Indicator Development

5: 00 Workshop resource team (MEQ Science Sub-Committee) meet to review Day Three discussion questions and assignments (others welcome)

<u>DAY 3</u> – Friday, March 12th 8:30 – 12:00 pm

8:30 – 8:45 Review of progress toward achieving workshop objectives - key points and issues for discussion– Colin Rankin

8:45 – 9:30 Linkages to LOMA - Glen Jamieson, Brenda McCorquodale, Duncan Johannessen

9:30 – 11:30 Small group discussions. Considering the insights gained from Day 2 discussions, recommend:

a. A suite of indicators that "roll up" well from the CMA to the LOMA scale;

b. A scientifically sound and practical process for developing MEQ indicators at the LOMA scale; and

c. Appropriate "next steps" for parties involved in identifying MEQ indicators at the CMA and LOMA scales for the Pacific Region

11:30 – 12:00 Plenary Report of Small Group Discussions and Assessment of success in meeting workshop objectives.

- A recommended suite of indicators appropriate at LOMA and CMA scales;
- Relative merits of "top down" and "bottom up" approaches to identifying MEQ indicators and how they could mesh
- Suggestions for next steps in identifying MEQ indicators at the CMA and LOMA scales for the Pacific Region.

Appendix 3: List of Participants

PBS = Pacific Biological Station, Nanaimo, BC; IOS = Institute of Ocean Sciences, Sidney, BC; RHQ = Regional Headquarters, Vancouver, BC; CCA = Central Coast Area, Port Hardy, BC; SCA = South Coast Area, Nanaimo, BC; C&A = Central and Arctic; MAFF = Ministry of Agriculture, Food and Fisheries; WLAP = Ministry of Water, Land and Air Protection, MSRM = Ministry of Sustainable Resource Management

Name	**Organization**	**Email**
Al Sinclair	DFO, PBS	sinclaird@pac.dfo-mpo.gc.ca
Bill de la Mare	Simon Fraser University	delamare@sfu.ca
Bill Heath	BC MAFF	Bill.Heath@gems8.gov.bc.ca
Brad Mason	DFO, RHQ	masonb@pac.dfo-mpo.gc.ca
Brenda McCorquodale	DFO, CCA	mccorquodaleb@pac.dfo-mpo.gc.ca
Bruce McCarter	DFO, PBS	mccarterb@pac.dfo-mpo.gc.ca
Colin Rankin (facilitator)	C.A. Rankin & Assoc.	crankin@saltspring.com
Cliff Robinson	Parks Canada	Cliff.Robinson@pc.gc.ca
Dale Gueret	DFO,	gueretd@pac.dfo-mpo.gc.ca
Dario Stucchi	DFO, IOS	stucchid@pac.dfo-mpo.gc.ca
Don Sinclair	DFO, Campbell River	sinclaird@pac.dfo-mpo.gc.ca
Doug Swift	DFO, CCA	swiftd@pac.dfo-mpo.gc.ca
Duncan Johannessen	DFO, IOS	johannessend@pac.dfo-mpo.gc.ca
Gary Taccogna	DFO, CCA	taccognag@pac.dfo-mpo.gc.ca
Glen Jamieson	DFO, PBS	jamiesong@pac.dfo-mpo.gc.ca
Jack Mathias	DFO, C&A	mathiasj@pac.dfo-mpo.gc.ca
James Boutillier	DFO, PBS	boutillierj@pac.dfo-mpo.gc.ca
James Quayle	BC WLAP	James.Quayle@gems9.gov.bc.ca
Jeff Ardron	Living Oceans Society	jardron@livingoceans.org
John Holmes	DFO, PBS	holmesj@pac.dfo-mpo.gc.ca
John Lewis	DFO,	lewisj@pac.dfo-mpo.gc.ca
Kelly Francis	DFO, SCA	FrancisK@pac.dfo-mpo.gc.ca
Ken Morgan	Canadian Wildlife Service	Ken.Morgan@ec.gc.ca
Linda Gilkeson	BC WLAP	Linda.Gilkeson@gems9.gov.bc.ca
Luanne Chew	DFO, CCA	chewl@pac.dfo-mpo.gc.ca
Marlow Pellatt	Parks Canada	PellattMarlowPCH@dfo-mpo.gc.ca
Melody Farrell	DFO, HEB, RHQ	farrellm@pac.dfo-mpo.gc.ca
Midori Nicolson	DFO, CCA	nicolsonm@pac.dfo-mpo.gc.ca
Peter Olesiuk	DFO, PBS	Olesiukp@pac.dfo-mpo.gc.ca
Peter Ross	DFO, IOS	rossp@pac.dfo-mpo.gc.ca
Rob Paynter	BC MSRM	Rob.Paynter@gems1.gov.bc.ca
Rosaline Cannessa	University of Victoria	rcanessa@office.geog.uvic.ca
Sally Bertram (recorder)	C. Rankin & Assoc.	sallybertram@shaw.ca
Shellee Hamilton	DFO,	hamiltons@pac.dfo-mpo.gc.ca
Shelley Jepps	DFO,	jeppss@pac.dfo-mpo.gc.ca
Steve Diggon	DFO, CCA	diggons@pac.dfo-mpo.gc.ca

Appendix 4: Glossary of Terms

Term	Definition
Action Plan	Summary of MEQ Objectives for the Central Coast. It should include an outline of current research, monitoring, or operational activities, a gap analysis, and the development of proposals to fill in the gaps. (also see work plan)
Central Coast Integrated Management (CCIM) Initiative	Pacific Region's lead Integrated Management initiative that is working to develop and implement a comprehensive and participatory planning and management regime that will maintain the integrity of Central Coast ecosystems while minimizing user conflicts and fostering ecologically sustainable economic development.
Coastal Management Area (CMA)	Management area, nested within a LOMA, comprising a more restricted geographic space. Ecosystem-based objectives will be reflected as Marine Environmental Quality objectives in a CMA Integrated Management plan.
Dunsmuir Workshop	Multidisciplinary workshop held in Sidney B.C. from Feb.27 – Mar 2, 2001. Sponsored by DFO to identify ecosystem-level objectives, with associated indicators and reference points, that could be used in managing ocean activities.
Ecosystem	"Any unit that includes all of the organisms (i.e. the community) in a given area interacting with the physical environment so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles (i.e. exchange of material between living and non-living parts) within the system." – Dunsmuir The system of interactive relationship among organisms (e.g. energy transfer), and between organisms and their physical environment (e.g. habitat) in a given geographical unit. – IM framework
Ecosystem objective	A narrative or numeric statement on the desired condition of an ecosystem, or of one of its constituents. Objectives may be set at various levels of detail, for example conceptual objectives that establish desired conditions, measurable objectives that allow for monitoring and operational objectives relating to concrete implementation measures. Ecosystem objectives will be set for Large Ocean Management Areas.
Ecosystem	Characterises the status of the ecosystem prior to management

Overview	actions and establishes baseline data against which the success of management plans can be assessed. A comprehensive overview is essential to evaluate ecosystem health, identify resources in need of special protection, and to determine management actions required to maintain healthy marine ecosystems.
Integrated Management (IM)	A continuous process through which decisions are made for the sustainable use, development, and protection of areas and resources. IM acknowledges the interrelationships that exist among different uses and the environments they potentially affect. It is designed to overcome the fragmentation inherent in a sectoral management approach, analyzes the implications of development, conflicting uses and promotes linkages and harmonization among various activities.
Large Ocean Management Area (LOMA)	An area covering a large portion of one of Canada's three oceans or coastal zones, typically extending from the coast out to the limit of Canada's jurisdiction, with boundaries that are drawn using a mix of ecological considerations and administrative boundaries. The area will be sufficiently large so as to provide an appropriate context for management action in consideration of ecosystem characteristics.
Marine Environmental Quality	"is an overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities" (Skjoldal, 1999)
MEQ indicator	A measure (physical, chemical, or biological) or parameter that provides evidence as to the condition or state of specific components of the ecosystem.
MEQ objective	A numerical value or narrative statement describing a desired condition for a given ecosystem, taking into account ecological characteristics and uses.
MEQ guidelines	Generic numerical values or narrative statements that are recommended as upper or lower limits to protect and maintain healthy marine ecosystems. These values are not legally binding.
MEQ standards	A legally enforceable numerical limit or narrative statement, such as in a regulation, statue, contract, or legally binding document, that has been adopted from a criterion or an objective.

MEQ criteria	A numerical value or narrative statement for physical, chemical or biological characteristics of water, biota, soil, or sediment that must be respected to protect and maintain healthy marine ecosystems.
Marine Protected Area	An area of the sea that forms part of the internal waters of Canada, the territorial sea of Canada or the exclusive economic zone of Canada; and has been designated for special protection under the *Oceans Act* for one or more purposes.
National Integrated Management Framework	"Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada". Frequently referred to as it contains substantive information regarding concepts put forth in the *Oceans Act.*
Work Plan	After the action plan is completed specific MEQ objectives will be identified as requiring more attention, laid out in a work plan. They could include milestones, roles and responsibilities, budgets, partnerships and prioritization of activities.

Appendix 5: List of Acronyms Used

BC: British Columbia

CCIM: Central Coast Integrated Management

CMA: Coastal Management Area

CPUE: Catch per unit Effort

CWS: Canadian Wildlife Service

DFO: Department of Fisheries and Oceans; Fisheries and Oceans Canada

DO: Dissolved Oxygen

EBM: Ecosystem-based Management

EO: Ecosystem Objectives

EOR: Ecosystem Overview Report

HADD: Harmful Alteration, Disruption or Destruction of fish habitat

IBI: Index of Biotic Integrity

IM: Integrated Management

LOMA: Large Ocean Management Area

MEQ: Marine Environmental Quality

MOU: Memorandum of Understanding

MSRM: Ministry of Sustainable Resource Management

MWLAP: Ministry of Water, Land and Air Protection

NGO: Non-Governmental Organisation

PFMA: Pacific Fisheries Management Area

PNCIMA: Pacific North Coast Integrated Management Area

QCI: Queen Charlotte Islands

TLA: Traffic Light Approach

Appendix 6: Stressor Fact Sheets

1. Finfish Aquaculture

Background

There are six finfish aquaculture tenures in the Quatsino Sound CMA, five located in Quatsino Sound, and one in Holberg Inlet. The facilities employ 30 full-time employees. The estimated total production of the farms for the 2002 calendar year is roughly $9 million, and this figure is expected to double in the next few years as the farms reach full production. All six farms rear Atlantic salmon (*Salmo salar*). There have been reports of adult Atlantic salmon sightings or capture in the marine waters and in four freshwater streams of the CMA, but no reports of juvenile Atlantic salmon. The finfish aquaculture activities that are potential stressors on the marine environment of the Quatsino Sound CMA are:

- Escapes of Atlantic salmon from net pens
- Destructive predator control methods – pinniped shootings
- Inputs of organic waste - uneaten feed and faeces
- Inputs of chemical waste - feed additives, pesticides, disinfectants, antibiotics, antifoulants

MEQ Components at Risk

Finfish aquaculture has the potential to impact the marine ecosystem of the Quatsino Sound CMA in the following ways:

1. Interaction with escaped Atlantic salmon can alter the ecosystem components and function of native populations of Pacific salmonids through competition for food and habitat, and disease or pathogen (e.g. sea lice) transfer
2. Destructive predator control methods can alter the ecosystem components and function of native populations of marine mammals
3. Nutrient loading of organic waste can alter primary production levels
4. The input of soluble and particulate waste can degrade water column properties and bottomscape features
5. Inputs of organic and chemical wastes can cause a decline in water, sediment and biota quality

Considerations for Scale

The majority of finfish aquaculture impacts on ecosystem properties are limited to the immediate area below and surrounding the facility. The degree of disturbance varies with farming practices such as stocking density, net cage structure, fallowing schedule, predator control methods, and the nature, bioavailability and frequency of inputs of organic and chemical wastes. The dilution and dispersion of waste inputs are a function of local oceanographic conditions of depth, current speed and direction and sediment type which control the assimilative capacity and recovery rate of the receiving environment. The sensitivity of biota to finfish aquaculture activities can also vary with the characteristics of native species such as mobility, life stage and behaviour. When the cumulative effect of all operations in a “basin” is considered, the overall impact could have a much greater spatial and temporal impact on the productive capacity of the ecosystem, an issue which is considered for new farms subject to CEAA reviews. The impact of escaped farmed salmon also has much wider ranging and potentially irreversible effects. The spatial aggregation and proximity of farms to critical habitats such as salmonid spawning and rearing streams and pinnipeds rookeries also play a role, although the current siting regulations require farms to be located at least 1 km from these areas.

Potential Indicators

- Abundance, distribution, or behaviour of Atlantic salmon – currently monitored by the Atlantic Salmon Watch Program at PBS
- Sea lice
- Benthic invertebrate community structure
- Physical sediment parameters - sediment grain size distribution, organic content, sedimentation rates
- Chemical sediment parameters –total volatile solids, redox potential, sulphide content, DO levels, chlorophyll-a, nutrient concentrations, biochemical oxygen demand (BOD), metals (Zn, Cu)
- Monitoring data for contaminant releases under the BC waste discharge regulations
- Timing, location and frequency of plankton blooms, HABs
- Extent / distribution of area of seafloor affected leased for aquaculture
- Location of farms relative to critical habitat
- Number of pinniped predator interactions (shootings)

Suggested Readings

Haya, K., L.E. Burridge and B.D. Chang. 2001. Environmental impact of chemical wastes produced by the salmon aquaculture industry. ICES Journal of Marine Science 58: 492-496.

Janowicz, M. and J. Ross. 2001. Monitoring for benthic impacts in the southwest New Brunswick salmon aquaculture industry. ICES Journal of Marine Science 58: 453-459.

Levings, C.D., J.M. Helfield, D.J. Stucchi, T.F. Sutherland. 2002. A perspective on the use of Performance Based Standards to assist in fish habitat management on the seafloor near salmon net pen operations in British Columbia. DFO Canadian Science Advisory Secretariat Research Document 2002/075.
http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2002/RES2002_075e.pdf

2. Shellfish Aquaculture

Background

There are currently five shellfish tenures in the Quatsino Sound CMA. The Quatsino First Nation holds three shellfish tenures on Holberg Inlet, and two tenures were recently approved in Quatsino Sound at Hecate Cove and Drake Island. Both intertidal and off-bottom farming is conducted rearing Manila clam, Pacific oyster, geoduck clam, and gallo mussels. There was no shellfish production for the year 2002, but the tenures are anticipated to begin delivering product by 2005. The shellfish aquaculture activities that are potential stressors on the marine environment of the Quatsino Sound CMA are:

- Introduction of exotic shellfish species
- Cultivation of a high density of cultured animals
- Structural modification of the foreshore – fencing, berm building, beach clearing, channelisation of estuaries and deltas
- Modification of foreshore substrate – addition of gravel, tilling, and harvesting practices
- Predator control methods – predator exclusion netting and predator removal
- Inputs of organic waste - faeces and pseudofaeces
- Terrestrial vehicle and boat usage in the intertidal zone

MEQ Components at Risk

Shellfish aquaculture has the potential to impact the marine ecosystem of the Quatsino Sound CMA in the following ways:

6. Interaction with cultured species can alter the ecosystem components and function of native populations of shellfish through competition for food and habitat, and transfer of disease or pathogens (reviews of all seed introductions are conducted by the introductions and transfers committee to ensure it is disease free)
7. Sedimentation and organic enrichment can alter of the ecosystem components and function of benthic faunal communities
8. Predator control methods can alter the ecosystem components and function of migratory waterfowl, shorebirds and macroinvertebrate predators
9. Disturbance of critical habitat can indirectly alter the ecosystem components and function of juvenile salmonids, migratory waterfowl and shorebirds, and juvenile forage fish species –
10. Nutrient loading of organic waste can alter primary production levels
11. Structural and substrate modification of the foreshore and vehicle usage in the intertidal zone can degrade water column properties and bottomscape features due to the alteration of natural hydrologic and sedimentary regimes
12. The input of organic wastes and the use of predator control netting can lead to a decline in water, sediment and biota quality

Considerations for Scale

The majority of effects of shellfish aquaculture on ecosystem physical and chemical properties are limited to the immediate area below and surrounding the facility. Farming practices such as stocking densities, production levels, and the density and orientation of structures can control the intensity of impact and potential effects. The assimilative capacity and recovery rate of the receiving environment is a function of local oceanographic conditions of depth, current speed and direction, and substrate composition which control the dilution, dispersion, and resuspension of organic waste inputs. The production of biodeposits can also vary seasonally due to variations in food concentration (primary production) and filtration rates which are controlled by water temperature, salinity and concentration of suspended solids. The sensitivity of biota can also vary with the characteristics of native species such as mobility, life stage and behaviour. When the cumulative effect of all operations in a "basin" is considered, the overall impact could have a much greater spatial and temporal impact on the productive capacity of the ecosystem. Similarly, the establishment of a population of non-native species has much wider ranging and potentially irreversible effects. The spatial aggregation and proximity of aquaculture operations to critical habitats such as estuaries, coastal wetlands, sea grass beds and kelp beds should also be considered.

Potential Indicators

- Abundance, diversity, composition of benthic communities
- physiochemical parameters – sedimentation, sediment grain size distribution, organic content, redox potential DO levels, chlorophyll-a, carbon, nutrient concentrations (nitrogen, phosphorous), biochemical oxygen demand (BOD)
- timing, location and frequency of plankton blooms, HABs
- location of farms relative to critical habitat
- extent / distribution of area of area leased for aquaculture

Suggested Readings

Hayakawa, Y., M. Kobayashi and M. Izawa. 2001. Sedimentation flux from mariculture of oyster (*Crassostrea gigas*) in Ofunato estuary, Japan. *ICES* Journal of Marine Science 58: 435-444.

Jamieson, G.S., L. Chew, G. Gillespie, A. Robinson, L. Bendell-Young, B. Heath, B. Bravender, A. Tompkins, D. Nishimura and P. Doucette. Phase 0 Review of the Environmental Impacts of Intertidal Shellfish Aquaculture in Baynes Sound. DFO Canadian Science Advisory Secretariat Research Document 2001/125. http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2001/RES2001_125e.pdf

Kaiser, M.J., I. Lainge, S.D. Utting, and G.M. Burnell. 1998. Environmental impacts of bivalve mariculture. Journal of Shellfish Research 17(1): 59-66.

Simenstad, C.A. and K.L. Fresh. 1995. Influence of intertidal aquaculture on benthic communities in Pacific Northwest estuaries: scales of disturbance. Estuaries 18(1A): 43-70.

3. Forestry

Background

Forestry in the Quatsino Sound area is the largest contributor to the local economy and is estimated to support employment for the equivalent of 1250 people on the BC coast. The majority of harvested timber is delivered to tidewater at various locations throughout the sound and towed to haul-out sites at Jeune Landing and Rupert Inlet. From there they are transferred to barges for tow to mills on Vancouver Island and the southern mainland. Logs are also towed to the sulphite pulp mill near Port Alice, which has been in operation on Neroutsos Inlet since 1917. However, production at the pulp mill has been relatively low over the past couple years. The forestry activities that are potential stressors on the marine environment of the Quatsino Sound CMA are:

- Removal of forest cover
- Building of logging roads and stream crossings
- Log handling and storage
- Releases of pulp mill effluent
- Herbicide /pesticide use

MEQ Components at Risk

Forestry operations have the potential to impact the marine ecosystem in the following ways:

1. The removal of forest vegetation, and building logging roads and stream crossings can cause erosion leading to degradation of critical landscape/bottomscape features and water column properties such as increasing suspended sediment concentrations, siltation of spawning gravels and sedimentation of benthic habitat
2. Removal of vegetative cover and building logging roads can also impact critical landscape/bottomscape features and water column properties through the alteration of watershed hydrology resulting in increased peak flows and stream temperatures
3. Improperly installed logging road stream crossing can indirectly impact the ecosystem components of Pacific salmon by creating barriers to upstream fish habitat
4. Log handling and storage can alter critical landscape/bottomscape features and water column properties through sedimentation and the input of organic waste materials which can smother benthic habitat with woody debris, which then decompose leading to a decrease in dissolved oxygen and release of hydrogen sulphide
5. Log handling operations can also alter critical landscape/bottomscape features by shading of the substrate by log booms, and substrate disturbance by grounded logs in shallow waters
6. Installation and enhancement of log handling facilities can alter critical landscape/botomscape features by the infilling of intertidal and subtidal habitat.

7. Pulp mill effluent can cause a decline in water, sediment and biota quality through the release of contaminants including chlorinated organic compounds such as dioxins and furans, and hydrogen sulphide
8. Inputs of herbicides and pesticides can degrade water, sediment and biota quality

Considerations for Scale

The intensity of forest harvesting, road building, log handling and storage, and pulp mill production can control the degree of impact on the marine environment. The toxicity of pulp mill effluent can also vary with the types of mill processes and effluent treatments applied. The timing, location and distribution of forestry operations in the CMA should also be considered, particularly in relation to areas of critical habitat. Local oceanographic conditions which control the dilution and dispersion of inputs of organic material and contaminants, can also play a role in the degree of impact and recovery rates, as can the characteristics of potentially impacted biota such as life stage, behaviour, mobility and growth rates.

Potential Indicators

- Extent / distribution of cutblocks, roads, stream crossings
- Topography, rate of cut and soil conditions of areas being harvested.
- Volume, rate and content of pulp mill effluent
- Suspended sediment concentrations, turbidity
- Sediment characteristics – organic content, grain size distribution, sedimentation rate
- Dissolved oxygen (DO)
- Biochemical oxygen demand (BOD)
- Contaminant concentrations in water / sediments / tissues (shellfish, seabird eggs)
- Benthic invertebrate community surveys
- Fish community surveys
- Sublethal toxicity testing
- Extent / condition of critical habitat relative to forestry operations
- Areas closed to fishing by dioxin and furan contamination
- Pulp and paper mill environmental effects monitoring by Environment Canada

Suggested Readings

Environment Canada. 1998. The Pulp and Paper Technical Guidance for Aquatic Environmental Effects Monitoring. http://www.ec.gc.ca/eem/english/PulpPaper/Guidance/default.cfm

Waldichuk, M. 1993. Fish habitat and the impact of human activity with particular reference to Pacific salmon. In Parson, L.S. and W.H. Lear (eds.) *Perspectives on Canadian Marine Fisheries Management.* Canadian Bulletin of Fisheries and Aquatic Sciences 266: 446p.

4. Mining

Background

The largest mineral development in the Quatsino Sound area was the Island Copper Mine located on the northeastern shore of Rupert Inlet. During the operation of the mine from 1971 to 1995, more than 400 million tonnes of mine tailings were deposited into Rupert Inlet from an outfall at 50m depth in a process known as deep sea tailing placement (DSTP), causing infilling of the deepwater portions of Rupert and Holberg inlets. In addition, a large waste rock dump adjacent to the mine deposited over 500 million tonnes of material directly along the foreshore (intertidal and subtidal) of Rupert Inlet. To date, operational and postclosure environmental monitoring indicate that there has been no significant heavy metal bioaccumulation, and no impact on local recreational salmon and commercial crab fisheries, although the local prawn population was adversely affected. The face of the rock dump was recontoured as part of the reclamation program and intertidal biodiversity was re-established after two years. Benthic biodiversity of the seabed also recovered one to three years after the mining operations ceased, and has exhibited signs of sustainable ecological succession (Poling et al. 2003). Although there is currently no mining in the Quatsino Sound CMA, the area has mineral potential for copper, some precious metals, and molybdenum, in addition to minor amounts of coal, marble, limestone and aggregate. Accessible water access in the CMA provides low cost marine transport which would be considered favourable for future mineral development. Tailings deposition in coastal areas would be subject to Section 35 of the *Fisheries Act*, and the new Metal Mining Effluent Regulations (July 2002) would prohibit DSTP. However, other non-metal operations such as aggregate or coal mines are not subject to the new regulations. The mining activities that are potential stressors on the marine environment of the Quatsino Sound CMA are:

- Tailings deposition in coastal areas
- Releases of heavy metals or other contaminants used in extraction processes (e.g. cyanide used for certain gold processing methods)
- Resuspension of historical DSTP or coastal tailings containing contaminants
- Acid rock drainage

MEQ Components at Risk

Mining operations have the potential to impact the marine ecosystem in the following ways:

1. Mine tailings deposition and effluents can alter marine ecosystem components and function directly by smothering and clogging of gills, and indirectly through substrate instability and loss of habitat.
2. Bioaccumulation of heavy metal contaminants can alter benthic ecosystem components and function

3. Mine tailings deposition, sedimentation, and resuspension of sediment and contaminants can degrade critical habitat / bottomscape features and water column properties
4. Heavy metal contamination degrade water, sediment and biota quality
5. Acid rock drainage can alter water pH and cause leaching of heavy metals resulting in a decline of water, sediment and biota quality

Considerations for Scale

The degree of pressure on the marine ecosystem is dependent on several factors including the type of mining operation, method of tailings disposal, level of effluent treatment/quality, intensity of mining production, extraction process, and the mineral ore being extracted. The physical, chemical, and oceanographic characteristics of the receiving environment such as current speed and direction, depth, salinity, and bathymetry also play a role. The proximity of mining operations to critical habitat, and both wild and farmed commercial fishery resources such as aquaculture facilities should be considered. The significance of effects may also be related to the specific species that are present and their associated biotic response and recovery times which can vary depending on habitat characteristics, life stage, mobility, behaviour, and growth rates.

Potential Indicators

- Volume and rate of tailings deposition
- Benthic invertebrate community surveys
- Fish community surveys
- pH
- Contaminant concentrations in water / sediments / tissues
- Sublethal toxicity testing
- Extent / condition of critical habitat in the vicinity of mining operations
- Metal mining environmental effects monitoring by Environment Canada
- Fishery closures
- Shellfish bed closures

Suggested Readings

Burd, B.J. 2002. Evaluation of mine tailings effects on a benthic marine infaunal community over 29 years. Marine Environmental Research 53: 481-519.

Environment Canada. 2002. Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring. http://www.ec.gc.ca/eem/English/MetalMining/Guidance/default.cfm

Poling, G.W., D.V. Ellis, J.W. Murray, T.R. Parsons, C.A. Pelletier. 2003. Underwater Tailing Placement at Island Copper Mine: A Success Story. Society for Mining, Metallury, and Exploration, Inc. 204 p.

Waldichuk, M. 1993. Fish habitat and the impact of human activity with particular reference to Pacific salmon. In Parson, L.S. and W.H. Lear (eds.) *Perspectives* on Canadian Marine Fisheries Management. Canadian Bulletin of Fisheries and Aquatic Sciences 266: 446p.

5. Mobile Fishing Gear - Bottom Trawling

Background

Bottom trawling is a common fishing method in the Queen Charlotte Sound Basin, but there are also some fisheries conducted by mid-water trawl, hook and line, trap, longline and trolling. The groundfish and shrimp trawl fisheries began in the 1940s, and became more significant by the 1960s with the development of trawl bottom gear. Groundfish trawling is currently the largest fishery by volume on the Pacific coast, made up of over 70 landed species, including 28 stocks assessed and subject to annual total allowable catches (TACs). The shrimp trawl fishery is focused on three species, but also includes four others, and TACs are in place for most Shrimp Management Areas (SMAs). After being at relatively stable levels in Chatham Sound and Queen Charlotte Sound throughout the 1980s and early 1990s, the shrimp trawl fishery increased dramatically in the mid-1990s. However, this fishery has been closed in the Queen Charlotte Sound SMA since 2000 due to concerns around bycatch of central coast eulachon stocks. Trawling for groundfish and shrimp is carried out by dragging a large bag-shaped net held open by two otter doors made of iron-clad wood or metal along the ocean floor. The shrimp fishery is also conducted using beam trawls, which utilize a beam to hold open the mouth of the net. The trawling activities that are potential stressors on the marine environment of the Queen Charlotte Sound Basin are:

- Removal of all species (target and bycatch) of a minimum size determined by the mesh size of the cod-end of the trawl or selectivity devices
- Physical disturbance by mobile fishing gear as the otter trawl net, doors and/or beam are dragged along the ocean floor

MEQ Components at Risk

Trawling has the potential to impact the marine ecosystem of the Queen Charlotte Sound Basin in the following ways:

1. The removal of both target and bycatch species has the potential to alter biotic ecosystem components and function beyond the bounds of natural variability.
2. Gear impacts have the potential to alter critical landscape/bottomscape features including sensitive ecosystems such as glass sponge reefs and habit-forming corals, and reduce benthic habitat complexity resulting in a loss of biodiversity.
3. Gear impacts can indirectly alter biotic ecosystem components and function through loss of habitat.

Considerations for Scale

The degree of disturbance from bottom trawling is a function not only of gear type and design, but also the frequency and distribution of trawling effort. The physical and biological conditions of the bottom environment also play a role in the ecosystem effect of trawling. Physiographic characteristics such as oceanographic conditions, water depth, sediment grain size and organic content can control both the degree of impact and recovery rates from disturbance. In general, areas with more mobile sediments that are subject to frequent natural disturbance will have faster recovery times than more stable areas. Sensitivity to physical disturbance and recovery rates also vary with the characteristics of resident species including growth rate, fecundity, degree of aggregation and mobility.

Potential Indicators

- Level and distribution of trawling effort*
- Surveys – biomass, abundance
- Catch data* - species composition, abundance, trophic composition
- Bycatch (retained and discards)* – number of species, species composition, abundance, number of protected species
- Total allowable catch
- Extent / condition of benthic habitat / communities – side-scan sonar, multibeam surveys, manned submersibles, ROVs, video transects
- Extent / distribution of areas closed to fishing e.g. fishing closures, MPAs

* Since 1996, an increase in observer coverage for the groundfish and shrimp trawl fisheries has resulted in a great improvement in the quality and quantity of geo-referenced fishing location and catch (including bycatch) data. However, due to confidentiality concerns there are limitations on the use of catch data (the “three-boat rule” consider a short description?) that must be considered when selecting data for use as an indicator.

Suggested Readings

Auster, P.J., R.J. Malatesta, R.W. Langton, L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): implications for conservation of fish populations. Reviews in Fisheries Science 4(2): 185-202.

Cook, R. 2003. The magnitude and impact of by-catch mortality by fishing gear. In Sinclair, M. and G. Valdimarsson (eds.). Responsible Fisheries in the Marine Ecosystem, FAO.

Olsen, N., J.A. Boutillier and L. Convey. 2000. Estimated Bycatch in the British Columbia Shrimp Trawl Fishery. DFO Canadian Stock Assessment Secretariat Research Document 2000/168. http://www.dfo-mpo.gc.ca/csas/csas/DocREC/2000/PDF/2000_168e.pdf

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12(6): 1180-1197.

6. Environmental Stressors in the North Pacific

Background

The ecosystem health of the LOMA is a function of not only the environmental stresses at the CMA scale, but also the stresses and conditions of the much larger North Pacific and global scales. Although these external stressors do not fall within the realm of DFO management, monitoring for general ecosystem health variables can assist in the interpretation of indicators at the LOMA and CMA scales by providing a context of background conditions for evaluation of other, more direct indicators. The environmental stressors on marine ecosystem health that have implications for the LOMA are:

- Global climate change
- Interannual variability climate and temperature anomalies – Pacific Decadal Oscillation, El Niño – Southern Oscillation
- Long-range atmospheric transport of contaminants from global sources
- International fishing pressures

MEQ Components at Risk

North Pacific and global scale activities have the potential to impact the marine ecosystem in the following ways:

- Climate change can cause changes in sea water temperature and salinity which can alter ecosystem components and function by changing current patterns, the stability of the water column, and mixed layer depth, affecting upwelling and surface productivity with cascading effects to marine ecosystem components at higher trophic levels
- Climate change can also alter sea level which can degrade critical landscape features and water column properties by causing coastal erosion, flooding of low-lying coastal areas, and threatening sensitive coastal ecosystems
- The deposition of contaminants imported by long-range atmospheric transport can degrade water, sediment and biota quality
- International fishing pressures can alter ecosystem components and function of migratory species that travel through international waters such as whales, Pacific salmon and birds

Considerations for Scale

The responses to changes in atmospheric and oceanic conditions can vary between different time and space scales. The impact of global climate can vary between locations in coastal or offshore areas. Changes in temperature and salinity are likely to be more extreme in shallow, coastal waters which are more affected by local evaporation and precipitation rates, and freshwater runoff. Biotic response times to changes in climate can vary at different trophic levels. Changes in physical conditions such as surface temperature and upwelling invoke a fairly direct and rapid response in primary (phytoplankton) and secondary (zooplankton) production levels. However, the response of upper trophic level species is much more complex due to changes in habitat conditions and biological interaction such as predation and competition. Anthropogenic influences such as fishing and other LOMA and CMA scale stressors also come into play.

Potential Indicators

- Sea surface temperature
- Salinity
- Sea level change
- Current Patterns
- Seasonal, extreme marine climates
- Primary productivity – chlorophyll-a
- Phytoplankton and zooplankton – timing of plankton blooms, species mix, concentrations, and large-scale distribution
- High trophic level species – abundance, distribution, behaviour
- Endangered species listings – species at risk (COSEWIC), BC red and blue lists
- Catastrophic shifts in biotic communities – disappearance of populations, collapse of fishing stocks

Suggested Readings

Bertram, D.F., D.L. Mackas and S.M. McKinnell. 2001. The seasonal cycle revisited: interannual variation and ecosystem consequences. *Progress in Oceanography* 49: 283-307.

Francis, R.C., S.R. Hare, A.B. Hollowed and W.S. Wooster. 1998. Effects of interdecadal climate variability on the oceanic ecosystems of the NE Pacific. *Fisheries Oceanography* 7 (1): 1-21.

Macdonald, R.W., B. Morton and S.C. Johannessen. 2003. A review of marine environmental contaminant issues in the North Pacific: The dangers and how to identify them. *Environmental Reviews* 11: 103-139.