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The Design & Monitoring of Marine Reserves

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The Design & Monitoring of Marine Reserves

Fisheries Centre, University of British Columbia, Canada

UBC FISHERIES CENTRE WORKSHOP

THE DESIGN & MONITORING OF MARINE RESERVES

February 18-20 1997

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Edited by Tony J. Pitcher

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THE DESIGN & MONITORING OF MARINE RESERVES - INTRODUCTION TO THE ISSUES

Tony J. Pitcher
Director UBC Fisheries Centre

From 18-20 February 1997, the Fisheries Centre at UBC hosted a meeting of over 60 researchers from around the world who share an interest in marine reserves. Many of the most internationally-acclaimed authorities on marine reserves were present, and groups represented included: Atlantic and Pacific coast universities of both Canada and the USA; scholars from Central America, Europe and Oceania; First Nations groups; commercial fishers; conservation groups; and graduate students of fisheries, ecology and conservation.

Marine reserves, areas protected from fishing, seem to offer the only buffer that can hedge against uncertain stock assessments, a changing environment and heavy fishing pressure. Their key selling point is that such refugia may represent the only credible way of sustaining and increasing fisheries catches in the long term.

Accordingly, this workshop aimed to describe the science of design and monitoring that must be created if we are to underpin the policy of establishing Marine Reserves. Areas protected from fishing (= 'no-take marine reserves') provide a long list of benefits. Marine Reserves may:

- restrict fishing mortality
- protect against stock collapse
- insure against overfishing
- buffer ineffective control over fisheries effort
- provide a buffer against our ignorance of stock biomass
- enhance spawning biomass, recruitment, survival of older fish
- allow habitat to recover in the absence of perturbations like bottom trawling or dragging
- hedge against irreducible and intrinsic uncertainty
- insure against unforeseen management mistakes
- increase fisheries catches in contiguous areas
- allow natural unharvested ecosystems to survive

Although most of these benefits have been modelled rather than directly demonstrated in the wild, most agree that in the long term such refugia will sustain both fisheries and fish populations. But the increasingly popular agenda to establish Marine Reserves raises significant scientific questions that are largely unsolved.

1. How should Marine Reserves be designed?
2. How may Marine Reserves be monitored?

Some design attributes that fall under question 1 are:

- size
- geometry
- corridors & linkages to other reserves.
- corridor design
- inclusion of habitat types
- replication
- proximity to fishing port
- spawning grounds
- priorities of site selection criteria

Evaluation of the balance of costs and benefits that influence design criteria include population dynamics, food web structure, habitat characteristics, the economics of the fishery and social impacts on coastal communities.

Some monitoring attributes that fall under question 2 are:

- surveys of fish biomass
- surveys of fish species - biodiversity
- surveys of fish food organisms
- surveys of habitat structure
- frequency of surveys
- fishery benefits
- cost-effectiveness
- adaptive management.

The workshop provided a platform for discussion of the design and monitoring criteria for different types of aquatic animals: fish, sharks, marine mammals, invertebrates. Seabirds and marine reptiles were important taxonomic groups not covered at the meeting.

Book planning

The workshop was also used to plan a book on this topic for the *Chapman & Hall Fish and Fisheries Series*, edited by Nick Polunin and Tony Pitcher. All papers for the book will be solicited by the editors, and will undergo peer review and editing to accord with the theme of the meeting.

It is hoped that the book will be published during 1998: current details are available on the Fisheries Centre's web site at fisheries.com.

SUMMARY OF THE WORKSHOP

By the Rapporteurs and Keynote Speakers

Although not everyone who came was convinced of the use of marine reserves, almost all saw them as an appropriate and effective tool for fisheries management by end of the wrap-up session. The most significant principles of marine reserves discussed were:

- The terminology of a "marine reserve" should only be applied to a no-take area. Since all users refrain from harvesting when such an area is set up, all share the costs, and all later reap the benefits of the reserve in an equitable fashion.

- Experience from pioneering work on marine reserves in New Zealand and the Philippines shows that even small areas increase biomass and diversity of marine species. More reserves and protected areas foster biological links that increase these advantages even further.

- Marine reserves promote biodiversity, which has been threatened by humans, and will provide researchers with pristine ecosystems that contrast fished ones to help better understand how human activities shape the structure of the ocean environment.

One of the most significant participants in the workshop was Dr Bill Ballantine from New Zealand, who was directly involved in the creation of the first no-take marine protected area in the world. The process involved much time and effort but succeeded for two reasons. First, scientists had to develop the principles, define the constraints and describe the benefits of marine protected areas to the general public. Secondly, when empowered with this information representatives were able to determine the order, rate of creation and location of marine protected areas in a democratic process. Dr. Ballantine stated that there is no mystery to many of the issues involved when creating marine reserves if their function is understood. It merely takes the will of the people to get on with the process. One of Dr. Ballantine's most poignant quotations came when he was challenged about the fact that precise benefits of marine reserves can not be determined. He responded that since there is only one definition of a dead ecosystem any actions to the contrary are positive.

Dr. Tony Pitcher, director of the Fisheries Centre, summed up the lessons of the workshop:

> "No-take marine reserves act like your retirement savings scheme. The immediate returns are low, but in the longer term the accumulated interest on natural capital will pay back valuable and sustainable dividends. For politicians and decision makers, no-take marine reserves are win-win policies: in the long-term they will ensure that we have a fishing industry that maximises wealth, jobs and food at the same time as the conserving habitat, rebuilding the biodiversity of all ocean creatures and creating many recreational opportunities for humans. As natural ecosystems recover in the absence of harvesting in a no-take reserve, the abundance of large high-value fish species will gradually increase. Such fish and their offspring will become available to commercial and recreational fisheries outside of the reserve area. No-take reserves also act as in insurance policy against mistakes by science and management: for example they might have saved the Newfoundland cod.
>
> I believe that the first country in the world to have the courage to declare large parts of its ocean as permanent no-take marine reserves will be the country, and given present trends it may be the *only* country, with healthy sustainable fisheries in 50 years time. Global figures show that seafood demand is increasingly outstripping supply: the fish product markets of the future will place a valuable premium on high-quality, large traditional table-fish species. No-take marine reserves that are sufficiently large, of the order of 30% , will help to ensure those market opportunities."

A tabular summary of the benefits of no-take Marine Reserves follows, and is adapted from a listing produced by the Center for Marine Conservation in 1995.

NON-FISHING BENEFITS OF MARINE RESERVES

A. Protect Ecosystem Structure, Function, and Integrity

Protect physical habitat structure
  from fishing gear impacts
  from other anthropogenic and incidental impacts
Protect biodiversity at all levels
Restore population size and age structure
Restore community composition (species presence and abundance)
Protect genetics from direct and indirect fisheries selection
Protect ecological processes:
  Keystone species
  Cascading effects
  Threshold effects
  Second order effects
  Food web and trophic structure
  System resilience to stress
Maintain high quality feeding areas for fish and wildlife
Leave less room for irresponsible development
Allows the distinction of natural from anthropogenic changes
Promote ecosystem management
Encourage holistic approach to management

B. Increased Knowledge and Understanding of Marine Systems

Provide long-term monitoring sites
Provide focus for study
Provide continuity of knowledge in undisturbed sites
Provide opportunity to restore or maintain natural behaviors
Reduce risks to long-term experiments
Provide experimental sites needing natural areas
Provide synergism of knowledge and cumulative understanding

Provide natural reference areas for assessing anthropogenic impacts (including fisheries)
Provide undisturbed natural sites for certain experiments
Provide sites for enhanced primary and adult education
Provide sites for high-level graduate education

C. Improves Non-Consumptive Opportunities

Enhance and diversifies economic opportunities
Enhance and diversifies social activities
Improve peace-of-mind
Enhance non-consumptive recreation
Enhance aesthetic experiences
Provide wilderness opportunities
Enhance spiritual connection
Enhance educational opportunities
Promote ecotourism
Improve appreciation of conservation
Increase sustainable employment opportunities
Create public awareness about environment
Stabilizes economy

POTENTIAL FISHERY BENEFITS OF MARINE RESERVES

Increase abundance of overfished stocks inside reserves
Increase abundance of overfished stocks outside reserves
Allow increased fishing mortality outside of reserves
Reduce overfishing of vulnerable species
Reduce bycatch mortality inside reserves
Simplify enforcement and compliance
Reduces conflicts within and among sectors of users
Maintain sport trophy fisheries
Maintain diversity of fishing opportunities
Provide some resource protection without data or other information
Benefit reproduction:
- Increase spawning stock biomass
- Increase spawning density
- Provide undisturbed spawning conditions and habitats
- Increase spawning potential and stock fecundity
- Increase egg and larval production
- Enhance recruitment

Export juveniles and adults to fishing grounds
Reduce chance of recruitment overfishing
Accelerate stock recovery after collapse
Facilitate stakeholder involvement in fisheries management
Provide data for improved fisheries management
Increase public understanding and acceptance of fishery management
Protection intraspecific genetics from fishery selection
Reduce variance in yield
Reduce impacts on fisheries of environmental variability
Allow studies of basic fisheries biology
Support marine ethic
Provide ecosystem level protection

ABSTRACTS OF PAPERS & DISCUSSION

Keynote Papers

DESIGN PRINCIPLES FOR SYSTEMS OF 'NO-TAKE' MARINE RESERVES

W.J. (Bill) Ballantine
Leigh Marine Laboratory, Auckland, New Zealand

Abstract

Systems of 'no-take' marine reserves will have emergent properties, which will give them broader and more important values than can exist for single reserves. 'No-take' reserve systems can be made self-sustaining, supportive of total ecosystem dynamics and helpful in the management of harvested species. The creation of such systems does not require detailed survey data or calculations of cause and effect. The principles for such systems would be: representation, replication, and a network design. The area required would be ~ 20-30% of the total.

At present the creation of 'no-take' marine reserves is localised, analytical and sectoral. This approach requires scientists to make detailed predictions about the benefits of particular reserves before they are established, and leaves politicians to decide what principles should guide the whole process. This role-reversal produces a lot of confusion but very little action.

Despite this, existing examples of 'no-take' marine reserves' and widely-accepted biological principles show how the situation could be improved. Scientists should focus on developing the principles, defining the natural constraints, exploring the interactions of these for systems of 'no-take' reserves and expressing the consequences in clear terms to the general public.

The priority order, rate of implementation, and precise location of reserves should be left to the politicians and the democratic process. When these roles are restored, it will become clear that the establishment of systems of `no-take' marine reserves is scientifically necessary, politically practical, economically sensible and socially desirable.

Creating systems of marine reserves, using the emergent principles, greatly simplifies decision-making both scientifically and politically. For scientists, difficult distinctions at one level translate into major decisions at the next. The principle of representation means that border-line biogeographic distinctions are easily handled as major ecological decisions. Problematic ecological differences can be subsumed in straightforward replication. Subtle difficulties with replication become simple decisions in network design. Most problems with network design are settled by a decision in principle on the total amount. Furthermore, when representation, replication and a network design are accepted as scientific principles, there is no need to acquire detailed data to calculate 'priorities'. The available information is quite sufficient to recommend action.

Politicians are accustomed to arranging the priorities and details of action including handling local and sectional interests, but can only do so effectively when clear and important principles are at stake. The general public will give active support to sensible principles, whereas one-by-one approaches attract little attention except from those adversely affected.

Discussion

Joe Truscott
Regarding the terminology of 'no-take' areas and options made available to the public, what do you call areas where some fishing is allowed?

BB
This sort of thinking will lead to trouble. We must settle on one definition and stick with it. International experience is already cluttered with many definitions. It is best to think in terms of no-take areas as opposed to all others being under some type of fisheries management.

Simon Jennings
I would like to make a philosophical point regarding marine reserves. Many people perceive fisheries an a common right. Therefore, with reserves you are suggesting changing fisheries to a state owned resource.

BB
I disagree because I must hold to the principle that something has to be done. Arguments like the one in the question are just pretense, after all there is only one definition of dead. The first no-take marine reserve in New Zealand was imposed. When the second was created it had been agreed upon to allow a little bit of a fishery. That opened the door enough to create a problem, despite the initial general belief that a little bit of fishing wouldn't hurt.

Simon Jennings
I could also cite the example of the Seychelles, where limited fishing areas have given incentive to locals to self police.

BB
I believe the United Kingdom has about three marine reserves with a little fishing allowed in

them and from what I understand they are ineffective. The matters you discuss for the Seychelles are fine, but a home grown solution to local problems.

THE CRITICAL NEED FOR MARINE RESERVES IN FISHERY MANAGEMENT

Jim Bohnsack
NMFS, Miami, USA

Abstract

Fishery management faces two major problems: developing a social policy to protect resources in the face of increased demands for exploitation; and an inability of traditional methods to effectively control fishing effort and, thus, fishing mortality. Due to a variety of biological and social factors, traditional fishery management practices have often failed to maintain sustainable fisheries and protect biodiversity. In fact, goals of fully exploiting all areas are incompatible with protecting biodiversity.

Networks of `no-take' marine reserves, areas protected from all extractive activities, are the most practical option for reducing fishing mortality, protecting biodiversity, and maintaining sustainable fisheries. Spatial protection is consistent with habitat and ecosystem management and is ideally suited to the ecology of most marine organisms. Marine Reserves treat problems of serial overfishing and detrimental genetic selection, as well as growth and recruitment overfishing. Besides providing fishery benefits and protecting marine ecosystems, marine reserves can improve non-consumptive recreational opportunities, diversify the coastal economy, increase scientific understanding of resource dynamics, and facilitate social appreciation and protection of marine resources.

The use of marine reserves appears to attract more entrenched opposition than other management methods intended to control fishing effort. I suggest that the intensity of opposition is precisely because marine reserves are likely to be more effective for controlling effort than more traditional measures. Exploiters prefer other management measures in part because they are much easier to circumvent. Despite initial opposition, once established marine reserves appear to generate public support that ensures the persistence of reserves and resists efforts to undermine their effectiveness. A major problem is getting a sufficiently area protected. Ideally, reserves should include representative areas of all habitats, allow no extractive activities, and include sufficient area to support viable populations.

Discussion

(Unidentified)
How do we address the problem of more predators coming into the reserve, won't that decrease the numbers of some prey species?

JB
That's not a problem, that's a goal - the increased general health of the system, and predators are a part of that. The marine reserve philosophy is thus holistic.

Robert Mooney
What happens when large predators are gone? Do you try to pump prime nature by artificially increasing predators or decreasing other species?

JB
Not in principle. The idea is to let nature take care of itself. Trying to direct it by treatments is difficult since we can't be sure of what all the future effects of them may be.

Nina Mollett
For the United States federal government the purpose of marine reserves is to ensure minimum human disturbance of the habitat. Therefore, its not fishery management *per se*.

JB
Whether it benefits fishery management is not an issue in itself since we aren't able to predict the exact benefits of its implementation. The point is that the general concept will lead to a net benefit.

WHY DO FISHERIES COLLAPSE? HOW CAN PROTECTED MARINE RESERVES HELP?

Colin Clark & Gordon Munro
Depts of Mathematics & Economics, UBC, Canada

Abstract

The reasons behind fisheries collapses are many. We classify causes as proximate (predation, natural fluctuations, environmental changes, overfishing, habitat degradation) or ultimate (common property, time discounting, overcapitalization, subsidization). For unregulated fisheries, collapses are well explained in ultimate terms by Gordon's 1954 theory of bionomic equilibrium (Canada having now designed things to make this equilibrium equivalent to extinction for almost every species). The case of managed fisheries is more problematical; one needs to consider the economic motivations of fishers, the dynamics of

development and capitalization, the role of uncertainty and uncontrollability, and the science and practice of fisheries management. It is doubtful that fishery models are capable of producing the results that they promise, a fact that managers have until recently been loathe to accept.

We discuss the concept of Marine Reserves from the point of view of hedging against uncertainty and uncontrollability, accepting that reserves would have many other desirable characteristics. To be useful, it appears that reserves will have to encompass major areas of our oceans, protecting fish stocks in critical areas and at critical times. While such measures may encounter resistance from the industry as currently constituted, I argue that improved property rights in the form of ITQs have the potential for defining a climate in which truly rational, sustainable fisheries would be possible in Canada.

Discussion

Jamie Hopkins
You mentioned quotas on your list of "reasons why fisheries collapse". Why are quotas a failure?

CC
Quotas are not a failure *per se*, and I am an advocate of ITQ's. They are a failure only in the sense that they have been unable to stem off overexploitation.

Colin Levings
How does your economic model cope with the monetary value of real estate on coastal zones? (e.g. Rockfish in Howe Sound).

G. Munro
Habitat is like a supporting piece of capital. Habitat is a natural endowment from nature and is fundamental for maintaining the resource. There is an impact of running down this bit of capital, it will damage the resource. To destroy this habitat for development, is "like maintaining an engine but letting the tracks go to hell

---

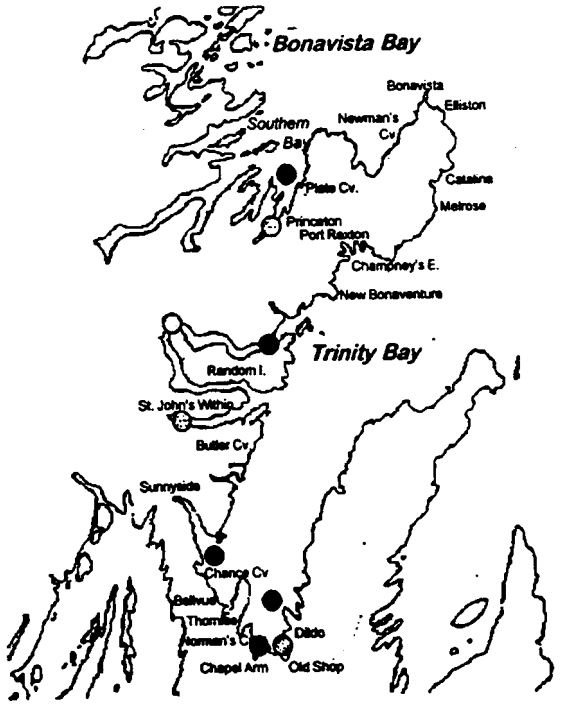
FISHERIES WORKERS ECOLOGICAL KNOWLEDGE AND THE DESIGN, MONITORING AND ACCEPTANCE OF MARINE RESERVES

Barbara Neis
Dept of Sociology, Memorial University, Newfoundland, Canada

Abstract

Fishery Workers acquire ecological knowledge through intergenerational transmission and lived experience in particular locales. Their understanding of both the human and natural intergenerational temporal scale can provide significant contributions to the successful design and monitoring of different kinds of marine reserves. This presentation draws upon findings from research on fishery workers' ecological knowledge in Newfoundland, Palau (Johannes, 1981) and Brazil (Cordell, 1989) to illustrate these potential contributions. At the design stage, information from fishers can facilitate the identification of past and contemporary spawning locations and the timing, direction and range of migrations for important commercial species.

TEK - Interviews:



Fishers can also offer information on the benthic environment, feeding patterns, past and contemporary structures of local fish assemblages, abundance, the location of biodiversity hotspots, interactions between fisheries, the location of fishing grounds, local systems of marine tenure, and the impacts of previous management initiatives on local fisheries. During monitoring, fishers can provide information on spatial and species shifts in effort, changes in catchability, size and range for commercial species, and changes in the composition of local assemblages. Systems of design and monitoring marine reserves that incorporate fishers and their knowledge are, perhaps, more likely to be accepted in the longer term.

Discussion

Mary Yoklavich
With reference to your method of scoring information from interviews, how would answers to your questionnaire have differed if you told fishers you were trying to make a fisheries reserve (i.e. potential economic consequences to them)? Does the purpose of your survey influence how willing fishers are to respond/respond truthfully?

BN
The aim of these interviews was to collect an oral history of fishing - ie. what type of boat did you use in such a such year, how many nets, etc. This information can be checked for reliability with other family members and fishing receipts. I also did follow up interviews, and plan to compare responses to questions the from two different times. At the time I conducted the interviews, the fishery had been closed and fishers were politically angry . As a consequence, the fishers were ready to say what they knew about the stock. What fishers say in a one-to-one interview probably different from what they'll say to the DFO (i.e. won't tell the DFO to close the fisheries, they don't want to take away anyone's livelihood). To gather this type of information from fishers, you need to conduct informal, anonymous one-to-one interviews.

MARINE PROTECTED AREAS AS TOOLS FOR MARINE ECOSYSTEM REHABILITATION

Daniel Pauly & Villy Christensen
Fisheries Centre, UBC, Canada & ICLARM, Manila, Philippines

Abstract

There is a vast literature on the rehabilitation of terrestrial ecosystems which has no explicit counterpart for marine systems. On the other hand, the growing literature on *no take* Marine Protected Areas (MPAs) implicitly deals with this topic. However, developing a theory of marine ecosystem rehabilitation would involve studying not only how MPAs lead to rebuilding of biomasses, of 'important species' - however defined - but also how MPAs enable the reestablishment of linkages among functional groups (small and large herbivores and carnivores, detritivores, etc.) that have been suppressed by exploitation. Hence we would see the re-establishment of the complex food web characterizing mature ecosystems.

To analyze some of the modalities of such rehabilitation, a simple Monte-Carlo simulation was performed wherein the top predator biomass of two ecosystem models, previously balanced using the Ecopath software, was gradually increased, while all other model parameters except primary production (herbivore biomasses, production biomass ratio, diet compositions, etc.) were allowed to vary about the baseline inputs. The models thus modified were that of Opitz (1993), representing an unfished Virgin Island coral reefs, and that of Browder (1993), representing the heavily fished shelf of the northern Gulf of Mexico.

Model responses corresponded closely with predictions derived from E.P. Odum's theory of ecosystem development (Odum 1969; Christensen 1995), especially with regard to the increase of detritus recycling. Also, as expected, the Virgin Islands reef model was found to be closer to carrying capacity than the Golf of Mexico model, carrying capacity being defined as the maximum biomass a system can reach, given its food web structure and a unchanging primary production (Pauly and Christensen 1996).

The implication of these findings, and of related studies linking detritus recycling to the stability of ecosystem models (Vasconcellos *et al.*, submitted), is that MPA, by allowing the rebuilding of depleted stocks of detritivores and omnivores in previously fished systems, help reestablish the ability of such systems to internalize detritus flows, and thus, locally at last, help reestablish their ecological integrity.

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Discussion

Nicolas Polunin
One problem with the emergent properties of the Ecopath approach is inferring matters such as recycling, which are iffy to nail down. How can you provide concrete results upon which to make decisions for fishery policy?

DP
With the Ecopath approach you must define a network of possible flows. Yes, there are uncertainties, but there are also known answers which are nonsensical and can therefore be discarded, and many components which are accurately known. Thus, we know there must be some framework, although we won't know it exactly. Obviously this can not be the sort of material presented to decision makers. However, we can present it among groups of scientists to show each other what we do about the ecosystem modelled.

Peter Auster
Were any open shelf systems modelled with Ecosim and what were their recovery times? These are more "leaky" than many of the other systems you discussed.

DP
Yes, the Nova Scotia and B.C. coasts have both been modelled. There are many "leaky" ecosystems with consequentially low recycling. Therefore, they have been seen to have longer recovery periods.

Laura Rogers-Bennett
If the trophic structure of an ecosystem can be enhanced by the addition of physical structures can they also enhance an ecosystem's complexity?

DP
The structure I am most concerned with in these models is the arrangement of groups.

Laura Rogers-Bennett
Yes, but what is behind the system's ability to retain detritus?

DP
Detritivores.

L.R.-B.
Couldn't a physical structure do this?

DP
No.

L.R.-B.
Alright but what if you were comparing a flat habitat versus where there was much contour and relief.

DP
There still must be organisms present in the environment to recycle the nutrients.

Jake Rice
It seems that the issue of habitat complexity is outside of the domain of Ecopath because if you create more physically structured habitat, you are changing the associated community and imbueing it with different possible features.

FISHING EFFECTS ON TARGET SPECIES AND THE DESIGN OF RESERVES FOR RECOVERY

Nicolas Polunin
Dept of Marine Sciences & Coastal Management
University of Newcastle, UK

Abstract

Comparisons between protected and unprotected areas to date provide a poor basis for marine fishery reserve (MFR) design, because they offer little insight into fishing effects at low fishing intensities. Focal functions of MFRs that have been demonstrated or can reliably be expected are (a) increase in numerical abundance, mean size and biomass of depleted fishes, (b) larval export and ultimately recruitment, and (c) greater fish availability to the fishery through 'spillover'. Rules of thumb are needed for successful prediction of MFR efficacy in these aspects of stock recovery. I argue that functions (b) and (c) will depend on fish abundance, and should be predictable from biomass data. Underwater visual census (UVC) data on biomass of target species on reefs in the main Seychelles and Fiji indicate that the biomass of groups of target species tends to decline rapidly at very low levels of effort (1,2,3); this is corroborated by catch per unit effort data on the fisheries involved4. Implications are that protection must be almost total if the unexploited biomass is to be restored, that any recovery process proportional to biomass will be greatly reduced with even a small amount of fishing, and that UVC data on biomass are a poor basis for assessing the progress of recovery. Recovery of the unexploited biomass and maximal larval export will be slow (e.g., >10 years) for large sedentary slow-growing species (e.g., $L\infty$=65 cm, K=0.5), as the longevities of many tropical species are indicating (5,6,7), and a model of population fecundity increase following closure illustrates(8, Fig. 1). Spillover effects can also be expected to be slow to reach a maximal level, if they are biomass dependent.

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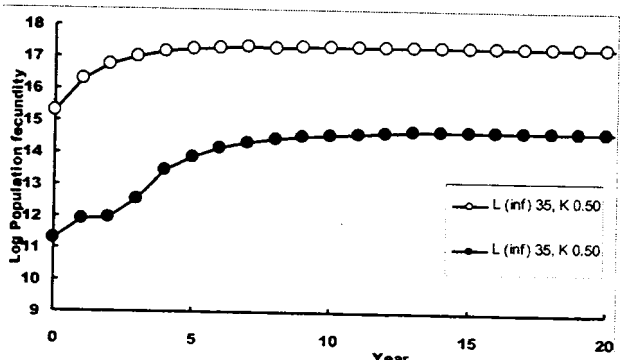

Fig. 1 Increase in population fecundity of sedentary large [L(inf) 65 cm] slow-growing [K=0.05] and small [L(inf) 35 cm] fast-growing [K=0.50] fish

Discussion
(There was no time for questions)

GOAL ORIENTED DESIGN AND IMPLEMENTATION OF MARINE RESERVES

Richard M. Starr
California Sea Grant, Moss Landing, CA, USA

Abstract

The extent to which a marine reserve reaches its potential is dependent upon the intended goals of the reserve and its size, shape, and location. Many reserves along the west coast of the United States have been established without specific goals or consideration of a target species or species group. Often, fishery reserves were instituted without regard to the size or shape necessary to encompass typical movements of the species targeted for protection. In those cases, the effectiveness of the reserves for fisheries management may be limited, and benefits are more difficult to understand or measure.

One of the most important assumptions related to harvest refugia is that adult fishes will remain inside reserve boundaries, and that as fish density increases, juveniles will emigrate to adjacent, unprotected areas. Size and shape of the fishery reserve, size of the home range of adult fishes, and rates of movement of adult and juvenile fishes are all factors that will influence the effectiveness of a specific fishery reserve. The scientific community is divided in its debate over the value of refugia to enhance adjacent fisheries, largely because many of these fundamental assertions have not been evaluated. Several field studies have documented increases in abundance and size of targeted species in a marine reserve, however few studies have provided evidence of increased fishery yield outside a reserve.

A direct measurement of fisheries enhancement is difficult because baseline fishing data prior to reserve establishment are often lacking. Benefits of refugia to local fisheries can be inferred by tagging individuals of targeted species within and outside a reserve, and estimating net movements across reserve boundaries. We have begun to estimate movements of rockfishes, a species group that is a mainstay of commercial and recreational fisheries in California. Results of our studies will help define the size and shape of reserves necessary to successfully enhance marine fisheries.

Discussion

Jack Sobel
In California, there are about 104 protected areas. In total, how many square miles are protected?

RS
It is a small percentage of the California coast, I don't know exact figure.

(Unidentified)
From looking at GIS maps, can you tell what percentage of area is protected relative to areas of high density?

RS
The information is available but this analysis hasn't been done yet.

IMPLEMENTING MARINE RESERVES WITH SUBSISTENCE COMMUNITIES

Amanda C.J. Vincent
Dept of Biology, McGill University, Montreal, Canada

Abstract

Marine Protected Areas (MPAs) are probably most successful if they are designed and implemented by local people. Socio-economic and political realities may produce MPAs that are perhaps not ideal in purely biological terms yet still succeed better than the biologists' preferred option.

The people of Handumon village in the central Philippines established - and successfully patrol -

a 33 ha sanctuary where no exploitation of marine life is permitted. Handumon sited the MPA where it had previously tried to eliminate illegal fishing so historic decisions about habitat types, human need and enforcement were central to the MPA design: (a) fishers had perceived corals to be most important for protection, not realising the role of seagrasses, and (b) villagers had limited the sanctuary's size both to avoid disenfranchising the very poor shore-based fishers, and to ensure that it could all be watched from the main landing area.

As will often be the case in developing countries, the Handumon sanctuary is more about restoration than conservation. Protecting a severely degraded and depleted area - as in Handumon - offers advantages over seeking to protect a healthy area: the local community will more readily set aside substantial tracts and will more easily notice the effects of protection.
Handumon villagers' reports of increased sizes, numbers and species of fish in and around the sanctuary (from their monitoring and from fishing yields) have prompted neighbouring villages to initiate sanctuaries and to begin enforcing declared reserves. This growing local conviction that MPAs are Good Things will allow increased scientific input in designing the placement and shape of new MPAs, but local opinion will remain the deciding factor.

Discussion
(There was no time for questions)

Contributed Papers

CRITICAL HABITAT ASSEMBLAGES FOR THE DESIGN OF MARINE FISHERY RESERVES

Richard S. Appeldoorn
Dept of Marine Sciences, Univ. of Puerto Rico

Abstract

Marine habitats possess attributes which are critical in varying degree to long term stability and production of local fish populations. For each protected population, any viable Marine Fishery Reserve (MFR) must represent a mix of habitats which support or protect each life history stage, i.e., settlement ground, juvenile nursery, and adult feeding/spawning grounds. In areas where local people have become heavily dependent upon coastal fisheries, taking fishing grounds out of production to create MFRs is often not popular. In these situations, to be accepted, MFRs must be "small", at least until positive fishery impacts of the MFR are locally accepted. We suggest that functionally large MFRs may be "assembled" from smaller components containing the habitats most critical to satisfying objectives of MFRs. To achieve this, critical habitats must be identified and described in terms of their structural, geomorphological and functional properties. The latter includes quantifying dynamic habitat attributes most relevant to MFR design, e.g., recruitment and other demographic rates for dominant fish species for purposes of assessing the degree of connectivity among habitats necessary to achieve goals of conservation and fisheries production.

Discussion

Joshua Noullis
Commenting on the proposed design of no-take MPAs, why is it important to avoid any kind of concession for fisheries in the protected nursery habitats ?

RA
Because targeting adult fishes in nursery areas can disturb the critical habitats for juveniles.

Amanda Vincent
Fishers are good in detecting fish movements. Is the movement of fishes too fast between reserves for fishermen to catch them ?

RA
Answered that it is not so much the speed of fishes migrating from one are to the other that difficult the catch but the fact the movement is not coordinated and fishermen still have to go through a search process.

DELINEATING AND MONITORING HABITAT MANAGEMENT UNITS FOR A TEMPERATE DEEP-WATER MARINE PROTECTED AREA A CASE STUDY FROM STELLWAGEN BANK NATIONAL MARINE SANCTUARY

Peter J. Auster
National Undersea Research Center, Univ. of Connecticut at Avery Point, Groton, CT, USA

Abstract

Stellwagen Bank National Marine Sanctuary is located in the Gulf of Maine off the Massachusetts coast north of Cape Cod. Stellwagen Bank, a sandy and gravelly topographic high of glacial origin, is the major feature in the sanctuary. Bounded by Stellwagen Basin to the west and the Gulf of Maine to the east, it rises from a depth of 90m to less than 20m below sea level. Stellwagen Bank is an erosional feature isolated from sediment sources. While tidal currents on the bank are weak, reaching maximum speeds of only 20-30 cm s-1, this area lies in the path of strong northeasterly storms. Currents generated by storm waves in the deep waters of the Gulf of Maine modify the seabed as they pass over this sill-like feature.

Baseline data was needed to delineate habitat distributions and associated fish assemblages. High resolution bathymetric and sidescan sonar data was used to produce georeferenced maps of seafloor habitats. These data have shown the seafloor to be a mosaic of sediment types and bedform features. Video from a remotely operated vehicle was used to census fish assemblages in features delineated from the remote sensing data. Ecologically equivalent habitats were determined based on analysis of the distribution of fishes using multivariate techniques. Four groups were defined and were correlated with mud, sand, gravel, and piled boulder habitats. Within these broader sedimentary categories, small scale "microhabitat" features (e.g., sedimentary bedforms, shell deposits, emergent epifauna, deep crevices within piled boulders) were identified from the video and their distributions quantified based on categories of complexity.

This small scale perspective, based on microhabitat features, was chosen as it is these features which provide cover from predators for juvenile fishes and is a direct link to the "nursery" function of the bank. In addition, this technique allowed us to identify "sensitive" habitats. That is, those habitat features which are sensitive to disturbance. Transect length was compared with percent habitat cover to determine the minimum effort required to utilize video imagery to monitor changes in habitat complexity.

Discussion

Bill Ballantine
You have showed a fantastic amount of data. But, suppose you are trying to choose some areas of the sanctuary as no-take marine protected areas. Which type of data will tell you the appropriate area to protect and at which scale the data should be collected?

PA
A representative sample would be mud to boulder. Data already gathered with side scan is sufficient for the establishment of a MPA. The process has been started but stuck in politics.

Todd Columbia
Is the any sampling of sea floor in-fauna.

PA
The University of Maine has preliminary data

WHY INVOLVE COMMERCIAL FISHERS IN THE DESIGN AND MONITORING OF MARINE RESERVES?

James Austin & Grant Dovey
Underwater Harvester's Association, Qualicum Beach, BC, Canada

Abstract

The Underwater Harvester's Association (UHA) represents the geoduck clam and horse clam license holders of British Columbia. The UHA accepts the fact that Marine Reserves (MR's) will be established and recognizes their value in protecting ecosystems, habitats and individual species.

The objective of this contribution to the Fisheries Centre Research Report is to outline three reasons for including commercial fishers in the design and monitoring of MR's: fishery workers have a wealth of local knowledge and experience; there are potential advantages of fisheries concessions; and success of the proposed Marine Protected Areas (MPA's) in B.C. will depend upon support from all stakeholders.

Some speakers at the workshop pointed out that scientific data is very limited for many coastal areas. Fishery workers' local knowledge, when combined with science, can provide a wealth of biological, ecological and physical information which could be used to classify the coastline and aid in the design of MR's. Depending on the goal of a particular MR, certain fishing concessions could assist in monitoring. For example, allowing limited harvesting of shellfish in a MR designed to protect lingcod and rockfish populations will result in a number of groups having a stake in the MR. Limited harvesting could support shellfish fisheries striving to be sustainable and conservatively managed, reduce opposition to the MR, improve enforcement within the MR and still protect lingcod and rockfish. Some fisheries, such as the geoduck fishery, are self monitoring and have enforcement presence in all north coast openings. Otherwise, with decreasing government funding, there is no enforcement presence in many coastal areas.

The advantages of any MR are lost if there is no enforcement of no-take areas or closures. A prime example of this in B.C. is the abalone fishery. Abalone fishing has been closed coast wide in B.C. for a number of years due to previous overfishing. Essentially, the coast of B.C. is one of the largest MR's ever set aside for one species, but managers estimate that there is more abalone harvested now than when the fishery was open. This is a result of a huge lack of enforcement and insufficient penalties.

Finally, MR's will more likely succeed if fishers are approached for input, instead of simply establishing MR's without taking into account the concerns of the people whose livelihoods depend on the proposed MR's. MPA's in B.C. would receive more support from fishery workers if specific criteria for establishing them and an outline of how much area will be included in MPA's was developed at the planning stage. In addition, scientists must treat all stakeholders as equals and not stereotype fishers as exploiters striving for short term gains.

Many fisheries, including the geoduck fishery, are striving for long term success and are working cooperatively with scientists and managers to ensure a viable future.

METAPOPULATION THEORY AND THE DESIGN OF MARINE PROTECTED AREAS FOR FISHERY MANAGEMENT

Laura Rogers-Bennett
Friday Harbor Laboratories, WA, USA

Abstract

Metapopulation theory predicts some patches will act as "sources" where local reproduction exceeds local mortality and these areas will supply "sinks" with new recruits. We know populations are not homogenous and Levins first described populations of populations. If marine protected areas can be designed to encompass "sources" these areas have the potential to supply fished areas with new recruits. Dispersal of larvae, juveniles, and adults in marine habitats are

facilitated by oceanographic processes and there are few barriers to dispersal. In economic jargon this is akin to maintaining the principle (e.g. broodstock in marine protected areas) and spending the interest (e.g. surplus recruits which spill-over into fished habitats). One advantage of MPA compared with traditional management strategies is that MPA can work with natural temporal fluctuations in recruitment by preserving brood stock in poor recruitment years and utilizing surplus recruits in good recruitment years.

This theory may sound appealing yet do we have any examples from fisheries where these principles are applied? In fact we do. In Florida, lobsters are protected in shallow lagoons where juveniles are allowed to recruit and grow unmolested by traps and then are fished when they move offshore into deeper water as they grow older and larger (Davis and Dodrill, 1980). In the north Pacific fur seal fishery, bull males and their harems are protected in rookeries and bachelor males are fished in the water (Bonnor, 1982). MPA can also help rebuild depleted stocks. Stocks of northern abalone have been fished down and are now closed to fishing. Despite this, illegal harvesting still takes place and densities are low and sizes are small except in front of a prison with armed guards which serves as a "de facto" abalone reserve where densities are high and individual size is large (S. Wallace pers. comm).(see page 25)

Are there any fished populations structured as metapopulations which would make ideal candidates for MPA management? There are at least two invertebrate examples. The first is the Tehuelche scallop fishery in Argentina which is structured as a metapopulation with many high density beds interconnected by larval dispersal (Orensanz, 1986). Some inshore beds appear to be important for reproduction because local water circulation patterns facilitate the spread of larvae from these beds to other beds. In addition these "source" beds are located so that they are less susceptible to stranding, an important source of scallop mortality in the area (Orensanz, 1986). This fishery produced good yields for many years until recently when increasing prices, demand, and fishers, harvested previously undisturbed beds, small scallops and deep water scallops resulting in the fishery collapse (Orensanz, pers. comm). Red sea urchin are also structured as metapopulations with high density beds in shallow habitats (Rogers-Bennett et al., 1995). Urchin in these high density beds have access to abundant drift algae and have 4 times the gonad mass of similar sized urchins in other habitats. High density will act to enhance fertilization success in free spawners such as scallops and urchins. In addition, these shallow areas appear to act as nursery habitats with high densities of juvenile urchins residing under the spine canopy of shallow adults. If MPA encompassed these shallow beds, 10% of the catch would be impacted while the gains could be much greater and their harvest could be detrimental.

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Discussion

Richard Appledoorn
One of the problems is that identifying the source and sink areas would be very difficult. It would require multi-year, expensive studies to get such information.

LR-B
I dont consider that this may necessarily be the case. There are ways of identifying the likely areas with methods that cost less and are easier. For example, identifying areas of good recruitment and high densities may be indicative of source areas

Richard Appledoorn
It is suggested to be the opposite that in fact, and areas of good recruitment would be more indicative of a sink.

LR-B
Yes, perhaps, but it is still the case that if we look at the distribution and number of juveniles we may get a good idea of potential source areas. The point that must be emphasized is that the rationale for the establishment of marine reserves should not be devoid of science

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ARE NO-TAKE MPAS AN ALTERNATIVE FOR SHARK FISHERIES MANAGEMENT?

Ramon Bonfil
Fisheries Centre, UBC, Canada

Abstract

Marine reserves can be classified into three broad categories according to their main objectives: ecological (conservation of biodiversity and habitats), economic (fisheries enhancement and protection), and social (tourism, education). In practice, many MPAs fulfill several or all of these objectives at the same time. The utilisation of no-take marine reserves as a fisheries management tool has been applied to a variety of resources, most commonly teleosts from tropical and temperate waters. However, there is very limited experience in the usage of MPAs for the protection or enhancement of shark stocks. Worldwide information on the protection status of sharks indicates the existence of only one no-take marine reserve used as a fisheries management tool for sharks. However, there are several *de facto* MPAs for sharks that have different objectives and which offer various degrees of protection. General criteria commonly utilised for the design of MPA's are reviewed while attempting to evaluate their application and feasibility for the implementation of MPA's for different kinds of sharks.

PARKS CANADA'S NEW NATIONAL MARINE CONSERVATION AREAS LEGISLATION

Doug Burles
Gwaii Haanas Haida Heritage Site/National Park Reserve

Abstract

National Parks in Canada have a long history of protection of terrestrial areas of significance but it is only recently that the Department of Canadian Heritage has taken major steps towards extending its' jurisdiction to the marine environment. Under current policy, National Marine Conservation Areas (NMCAs)are identified as the marine equivalent of National Parks. The objective of conservation of representative areas remains the same for both, however. Outside of certain highly protected zones, activities such as commercial shipping, fishing and hunting will be considered appropriate provided they do not seriously degrade the area's ecosystems. Traditional aboriginal rights such as hunting and gathering will also continue. In 1995, the National Marine Conservation Areas System Plan Sea to Sea to Sea (Mercier and Mondor, 1995) was released. It summarises 29 marine regions identified on the basis of their biological and oceanographic features. The long term goal is to establish NMCAs that are representative of each of these regions. Five NMCAs are in the final stages of establishment, while 13 others at the selection stage. Parks Canada is currently working on developing legislation that would allow for the creation of NMCAs. The existing National Parks Act was developed to manage land based activities and facilities, and is not well suited to administer NMCAs, especially those located beyond Canada's territorial seas. Wherever possible, this new legislation will complement, rather than duplicate existing legislation. Regulations will provide for the protection of ecosystems and ecosystem components, the protection of cultural, historical and archaeological resources, the management and control of hunting, public safety, the protection and control of scientific research activities, zoning and terms and conditions on access and use within zones, the control of aircraft landings and overflights, and the ability to license or permit any activities. Dumping of wastes, seabed mining and oil and gas exploration and extraction will be prohibited. Outside of certain highly protected zones, activities such as commercial shipping, Parks Canada will be consulting on this proposed legislation in the near future. If you would like more information, please contact: Mr. Dave McBurney, National Parks Directorate, Room 408, Jules Leger Building, 25 Eddy Street, Hull, Quebec, Canada.

MONITORING MARINE RESERVES WITH RADIO-ACOUSTIC POSITIONING AND TELEMETRY (RAPT) SYSTEMS

Ron O'Dor
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Abstract

Marine reserves typically serve multiple purposes, including: (1) protecting habitats of threatened species, (2) providing breeding reserves for commercial species, (3) elevating public awareness and (4) accommodating ecotourism. When we began developing commercial RAPT systems with Vemco Ltd. in 1985, they were seen as tools for studying the behaviour, physiology and energetics of marine animals, but, as they have been applied to such studies, their potential for monitoring environments and habitats became clear. Buoys triangulate positions of transmitters on animals while telemetering encoded data on animal or habitat. With respect to (1), they provide tremendous detail about an individual's range and responses over long periods. For (2), they can follow behavioral interactions between individuals with a resolution of one meter and insure that reserve areas fully contain critical life history events. For (3), they allow the public on land to view real-time actions of animals regardless of weather or visibility without interfering with animals or even getting their feet wet. For (4), they give tourists precise coordinates of the interesting

animals and even monitor welfare and compliance with regulations of divers.

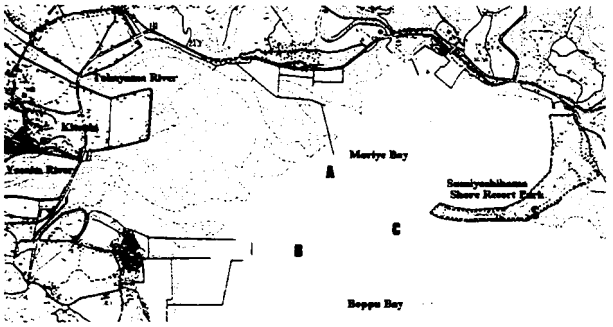

Figure A RAPT array (A, B, C) monitoring horseshoe crab breeding activities near Kitsuki City, Kyushu Island, Japan, would telemeter to Sumiyoshihama Park basestation and promote conservation activities between City, Fishery Coop and Park for a rare breeding populations in Japan

Although there have been no fully developed applications of RAPT for defining or monitoring marine reserves, the potential will be illustrated from research experiences with spawning horseshoe crabs in a conservation area proposed by a citizen group near the privately owned Sumiyoshihama Park in Kitsuki, Japan (1), squid spawning grounds adjacent to Tsitsikama National Park in South Africa (2) and a combination reserve and ecotourism coral reef site on Lizard Island, Australia (3, 4). This site will combine long term monitoring of numerous mobile territorial species with use of the system to track divers as they video-survey sessile reef species.

Discussion

Paul Leblond:
What was the range of detection for the tags?

RD
For the largest animals and tags it can be up to 3km. For small animals it is around 300m. This can change depending on conditions.

THE ROLE OF THE BELIZE GOVERNMENT IN MARINE PARK DESIGNATION : A CASE STUDY OF COLLABORATIVE MANAGEMENT

Vincent Gillette
Fisheries Centre, UBC, Canada

Abstract

The establishment of marine protected areas is a means of providing protection to critical spawning stock and also a mechanism by which marine resources and biodiversity are conserved. Some governments however, though cognizant of this tool are unable to single handedly designate and manage these reserves. This paper demonstrates how fishers, community groups, scientist, marine resource users, various agencies of the Government of Belize and other parties in the local and international Non-Governmental community, have together developed a dynamic relationship which has led to the establishment of five marine parks.

This collaborative management approach is being promoted as the means by which marine reserves must be developed, given the availability of financial, technical and managerial resources resident in Belize.

Table 1. Existing and Proposed Marine Protected Area and their management.

Protected area	Size (ha)	Type	Year estab-lished	Management objective	Organizations participating*
Half Moon Caye	3,925	Natural Monu-ment	1982	Bird protection Nature Tourism	Belize Audubon Society
Hol Chan Ambergris Caye	1,116	Marine Reserve	1987	Biodiversity conservation	WCS, FD, USAID, HCMC
Glovers Reef	32,876	Marine Reserve	1993	Biodiversity conservation	WCS,FD CZMP, MC
Bacalar Chico Ambergris Caye	1140 0	Marine Reserve	1996	Biodiversity conservation	ITCF,CCC IUCN,FD, CZMP, MC
Laughing Bird Caye	12	Nat'nal Park	1991	Protection Preservation	For.D LBCAC
Caye Caulker	?	Marine Reserve	?	Biodiversity conservation	Siwa-Ban, FD/CZMP
South water Caye	?	Marine Reserve	?	Biodiversity conservation	CCC,FD, CZMP,SI
Port Honduras	?	Marine Reserve	?	Biodiversity conservation	BCES,TNC,FD,CZMP
Sapodilla Cayes	?	Marine Res'ves	?	Biodiversity conservation	FD,CZMP CCC

*Coral Caye Conservation (CCC), Coastal Zone Management Project (CZMP), Fisheries Department (FD),Forestry Department (For D), Glovers Reef Management Committee (GRMC), Hol Chan Management Committee (HCMC), International Tropical Conservation Foundation(ITCF), World Conservation Union (IUCN), Laughing Bird Caye Advisory Committee (LBCAC), Managing Committee (MC), Smithsonian Institution (SI), The Nature Conservancy (TNC), United States Agency for International Development (USAID), Wild Life Conservation Society (WCS).

Table 1 summarizes the number of existing and proposed marine protected areas and the organization(s) involved in their establishment and management. It is important to note that the Fisheries Department has responsibilities for the Fisheries Act and consequently for any Marine Reserves created under it. However, the Act makes no provisions for delegation of managerial responsibility. Advisory committees or management committees are therefore policy instruments designed specifically to ensure public participation in reserve management.

AN AGE-STRUCTURED MODEL DEMONSTRATING THE BENEFITS OF MARINE RESERVES AGAINST OVEREXPLOITATION

Sylvie Guenette & Tony Pitcher
Fisheries Centre, UBC, Canada

Abstract

Modelling of no-take marine reserves has generally employed equilibrium models, assuming random movements of the fish, and has not included biological factors such as recruitment or the higher fecundity of larger fish. These models predict that a marine reserve would result in a decrease in fishery yield, an increase of spawning stock biomass and that movements of fish outside the reserve could annihilate its benefits. We present a dynamic pool model, based on a Northern cod population that includes stock-recruit and fecundity relations.

The indicator variables used to evaluate the impact of the reserve are the number of years of weak recruitment, the biomass of older females and the yield. We compare an *experimental* regime, including a no-take reserve, and a *control* regime where only usual fishery management rules are applied. Inside the *experimental* regime, fish transfer from the reserve to the fished area is a function of the size of the reserve, while the transfer back to the reserve is a function of the relative abundance in the fished area. As exploitation rate increases, the number of years of weak recruitment increases sharply in the *control* while the biomass of old females decreases. The larger the no-take reserve, the more stable these two parameters are. At low exploitation rates, marine reserves result in a decrease in yield to the fishery. However, when the exploitation rate is larger than the MSY (maximum sustainable yield), a common situation in fisheries, the population does not decrease as fast in the Experimental regime and hence yields stay higher than in the *control* regime. Large transfer rates of fish from the reserve decrease the benefits, but the biomass of old females and the level of recruitment still provide advantages for the *experimental* regime.

The model is sensitive to transfer rates and to the recruitment curves used, but it shows that, even for highly mobile fish, a stock protected with a marine reserve would be more resilient to exploitation than when managed with the usual fishery management tools.

Discussion

Jake Rice
Many of your model results show that yield and biomass are asymptotic for a wide range of exploitation rates. The inference people will derive from that is that as long as you have marine protected areas you can fish the stock at any level of exploitation rate. Is that the interpretation of your model ?

SG
First of all these are exploratory results, second I don't think it doesn't preclude the use of other management controls outside the marine protected area.

Jake Rice
To pursue this, if you assume that MPAs are sufficient management tools what would be the reason to manage the fishery in the open area?

SG
I don't think you should consider marine reserves as the single big solution for our problems. But if we add marine reserves to the overall existent management controls, that could help insuring the resilience of the fishery against overfishing and collapse.

Jake Rice
But for people who will analyze your results, people who want more fish, that is the interpretation they would give to your model results.

SG
That's why I assume that there is some minimal management controls in the open areas, such as minimal size of capture.

Paul LeBlond
The results will be different if you change the size of the reserve.

Tony Pitcher
The generic results are the same as the one obtained by Beverton and Holt. The difference is that this model shows that benefits kick in earlier for a smaller reserve area.

SG
Another point is that even with the wide range of management tools and fishing effort measures currently available, we are unable to efficiently control fishing exploitation rate. Marine Reserves can be a way to get around this problem of assuring the proper implementation of exploitation rates

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DIVER TRAIL SYSTEMS

Bruce Higgins
Seattle, WA, USA

Abstract

The ability to return to the same site repeatedly over a period of time by observers is one key to successful site monitoring. The use of diver trails to provide a baseline system from which measurements can be make over many seasons is one system for site monitoring. This paper discusses the pros and cons of different trails methods. Different trail design elements are discussed as well as their implementation. As with upland trails, underwater trails can impact the environment and steps can be made to minimize these impacts.

At Edmonds underwater park, Edmonds, Washington there are over 2500 feet (800 metres) of trail system to allow for the monitoring and maintenance of park features. The success and failure of some design elements are discussed as examples of trail use and failure. Trails have been established at three other sites within Puget Sound; each have a unique focus and the successes and failures are discussed. Some initial observations which the trail system has allowed are discussed.

The trail system can be tailored to the site so that natural features can be used to confirm measurements. Steps from underwater mapping texts are noted as reminders on how to have closure on each observation period and confirm the observations

Discussion

Colin Levings
Is there a way of capturing the data from observations in a systematic way?

BH
We have tried to have a form that people fill in to report there observations to them to complement their observations over time. But since we do not have a mandate to produce a report, there has not been anything more formal.

MARINE PROTECTED AREAS IN TEMPERATE WATERS: CONSERVATION OF BIOTIC PHYSICAL STRUCTURE VERSUS HABITAT AND ITS PRODUCTION POTENTIAL

Glen Jamieson & Colin D. Levings
DFO, Nanaimo, & West Vancouver Canada.

Abstract

In terrestrial environments where both light and liquid water are available, rooted vegetation predominantly structures ecosystems and determines habitats. In shallow nearsurface marine waters in tropical regions away from upwellings, a typically stable thermocline results in relatively low productivity, and animals, notably reef-building corals with symbiotic algae that collectively deposit calcium carbonate to build colonies, provide a long-lasting physical structure for ecosystems. In shallow temperate marine waters, nutrients are generally less limited because of regular deep-water replenishment, and biotic sea floor physical structure is largely determined by sea grasses and algae. In all three environments, greatest biodiversity is typically associated with structural species providing the most complex, long-lasting habitats. Coral reefs and forests often take centuries to fully develop, while temperate marine plant communities are relatively ephemeral, being comprised either of annuals or species living only a few decades at most.

Protected areas on land and in tropical waters often protect obvious, long-lived structural life forms (e.g. coral reefs and forests) rather that a specific physical habitat per se. In temperate waters, however, physical habitat, and its potential community structure, are more often the focus of conservation. Dyking, harbour construction and so on can completely destroy historic nearshore habitats, many of which are considered rare (e.g. estuaries). Documenting the functional importance of a portion of a large area of perceived similar habitat is logistically difficult, and consequently seldom attempted. Annual settlements of benthic species are often patchy and sporadic, with no obvious area deemed exceptional. Loss through attrition over time may be so gradual that real loss is not readily perceived. There are also few, if any, measures of the particular role a portion of a habitat ad in a given year for important highly-mobile bird or marine species that are only seasonally present.

Collectively, this makes it relatively difficult to use science to assign priority status for protection to many specific geographical areas. This lack of empirical data to help rationalize optimum size and location of potential temperate marine protected areas (MPAs) means that subjective criteria and lobbying by interest groups may be the main basis for establishing many MPAs in the short-term. Designation of an arbitrary percentage of a region's habitats for protection may be the most pragmatic short-term approach, but this should be coupled with a long-term monitoring commitment to evaluate if identified objectives are being achieved.

Discussion

Joe Truscott
There is an option in-between arbitrary and empirical criteria. Ecological classification systems based on biophysical and geomorphologic characteristics may be useful.

GJ
Even so the information is still sparse. If we use what we have I still think that implementation will be fairly arbitrary.

Pete Auster
Existing data allows breaking down in biogeographycal regions. At least you have some idea of which areas to concentrate on.

GJ
A concern I have is that any large scale reserve will be difficult to implement. One of the big problems in British Columbia is the salmonids. Trying to deal with this migratory species will be challenging.

Bill Ballantine
Commented the question about data availability. Even if you know the distribution of all species in British Columbia, where would you put the Marine Protected area?....why worry about it? Comparatively to others regions you have lots of data. Get on with it !

Todd Columbia
If you go with public demand for a certain percentage of area protected, considering the experience in terrestrial systems, you will probably end up protecting areas of little use.

GJ
He acknowledged the comment and agrees. But when we start to implement we go for areas where people don't scream the loudest.

DESIGN AND MANAGEMENT OF MARINE RESERVES ON TROPICAL REEFS: CONSERVING HABITATS AND NON TARGET FISHES

Simon Jennings & Ivor Williams
School of Biological Sciences, University of East Anglia, and MAFF Lowestoft, UK
&
Centre for Tropical Coastal Management Studies, The University of Newcastle, UK

Abstract

If marine reserves are designed and managed according to sound scientific principles they are likely to provide an effective means of conserving tropical reef habitats and their associated biota. We review the scientific understanding of processes which determine rates of reef accretion and the abundance of fishes which are not targeted by fishers. A primary aim of marine reserve design may be to prevent the loss of coralline habitats which act as coastal defences and provide habitats for the reef biota. If this aim is accepted, then there is little scientific evidence to suggest that the capture of piscivorous fishes (which are generally favoured by fishers) should be banned. The removal of such fishes appears to have little impact on the abundance, diversity or community structure of non-target species or on processes which determine rates of reef accretion and bioerosion. Conversely, theoretical and empirical studies suggest that fishing for invertebrate feeding or herbivorous fishes may lead, directly and indirectly, to increased rates of bioerosion and should not be permitted. The provision of fishing concessions for some piscivorous fishes may provide a socioeconomic incentive for local people to support and police marine reserves and therefore reduce the cost of management. The potential benefits of marine reserves, and the costs associated with management, will also be determined by their size and location. Smaller reserves may be easier to establish and police but they may be ineffective because the biota within them is influenced by processes acting on much larger scales. Short term data sets (months and years) suggest that remarkably small areas ($<10^6$ m^2) could provide useful protection for reef habitats and non-target fishes, even if they provided ineffective protection for roving target species. However, it is not clear whether such small areas will be of value on longer timescales (decades) and we advocate a precautionary approach to marine reserve design. We discuss the monitoring procedures which are needed to ensure that reserves are functioning effectively and the possibility of remedial management following undesirable ecosystem shifts

Discussion

Bill Ballentine
Would you agree that three forms of management may be sufficient for the conservation of fisheries resources and habitats:

1. no-take areas
2. much bigger areas, with some sort of habitat protection
3. bigger still, that has standard fisheries management tools and any improvements.

SJ
Yes, it is necessary to gets things going and trying to achieve maximum protection. But, the global perception of marine reserves is somewhere that can be fished.

WHY INVOLVE FIRST NATIONS IN MARINE RESERVE DESIGN IN BRITISH COLUMBIA?

R. Russ Jones
Haida Fisheries Program

Abstract

Common sense dictates that First Nations should be involved in initial discussions, planning and implementation of Marine Reserves in their territory at an early stage. Gwaii Haanas National Park Reserve is a good example of the type of cooperative arrangements possible between First Nations and government that could be applied to Marine Reserves. First Nations have distinct traditional territories and continue to practice stewardship and resource-harvesting in these territories. Marine Reserves that incorporate no-take zones or restrict a First Nation's access without their consent may encounter critical legal and organizational obstacles. Most First Nations are engaged in a process with Canadian federal and provincial governments to negotiate treaties to address issues of ownership and jurisdiction. Aboriginal rights are already protected under Canada's constitution. According to the 1990 Sparrow decision, the aboriginal right to fish has priority over commercial and recreational uses and government regulations cannot unduly infringe on the rights unless proper justification such as conservation, can be proven.

In a 1992 agreement, Canada and the Haida Nation established a joint management board for Gwaii Haanas National Park Reserve and committed to establish a Marine Park by 1994. The Haida Nation participates in monitoring and management of tourism through Haida "watchmen" situated at key ancient village sites which could be readily applied to management of a Marine Reserve. Formation of the Marine Park has been delayed and a variety of issues need to be resolved including the impact on major commercial fisheries.

Discussion

Laura Rogers-Bennett
Is there an opportunity to develop an underwater park like Edmonton Park like the one in Seattle.

RJ
Developing such a park on the grounds of tourism is not really in the mandate of the council of Haida first nations.

Robert Mooney
As the treaty process continues, do you expect any conflicts?

RJ
It is this area where prior agreements are important to prevent such conflicts. Putting things down in writing helps in this sense.

Jennifer Lash
Do you think 1st Nations will respect the 'no-take' principle?

RJ
Individual groups have to decide on their own goals. They may have other interests that we are not aware of.

Bill Ballentine
How is it that First Nations people have no control of the large recreational fishery in northern Haida Gwaii.

RJ
They have tried to put in their own management plan, and put in limits on the number of lodges and control the boat limits. There were some interim agreements but they fell apart and there are consequently no limits on the recreational fishery.

COFRI'S INTEREST IN MARINE PROTECTED AREAS

Paul H. LeBlond
COFRI, Galiano Island, BC, Canada

Abstract

The Canadian Ocean Frontier Research Initiative (COFRI) Foundation is a non-profit society whose objectives are to support research in marine science, technology and management with primary focus on Canada's Pacific Exclusive Economic Zone. COFRI is distinguished by its dedication to the creation of partnerships between industry, universities and government agencies to promote sustainable development of marine resources and job creation. It also wishes to promote awareness and education related to the oceans.

COFRI has identified a number of focus areas where partnerships are needed to tackle pressing marine problems and/or should lead to job creation and the development of exportable goods and services: integrated coastal zone management, the safe exploitation of marine mineral resources, sustainable fisheries, and the development of reliable and affordable observation tools and vehicles.

Marine Protected Areas (MPA's) are an important emerging concept in the management and preservation of living ocean resources and biodiversity. Their creation will require collaboration between all levels of government and the participation of local conservation and fishing communities. Practical monitoring and enforcement of MPA's will encourage development of simple observation platforms. MPA's also offer opportunites for community involvement in learning about the ocean ecosystems.

For all these reasons, COFRI is delighted to be have been able to assist in holding this important and stimulating workshop.

A MARINE PROTECTED AREAS STRATEGY FOR THE PACIFIC COAST OF CANADA: POLICY OVERVIEW AND UPDATE

Kaaren Lewis
Land Use Coordination Office, Prov Govt of BC

Abstract

In 1994, the federal and provincial governments agreed to jointly develop a Marine Protected Areas (MPA) Strategy for the Pacific coast of Canada. All agencies have committed to an integrated and coordinated approach. The establishment of the federal-provincial MPA Steering Committee and Working Group are two key structures currently in place in B.C. to help ensure this happens. The strategy and its policy and technical components are presently under development in consultation with a full range of local stakeholders, interests and levels of government. A multi-stakeholder forum held in December of 1995 and two additional forums, scheduled for March of this year, should result in substantive progress. Several designations and legislative authorities necessary to establish MPAs are already in place: the Park Act, Ecological Reserves Act, National Parks Act, and Fisheries Act. Three new legal instruments were introduced between 1994-1996: amendments to the Canada Wildlife Act; passage of the Oceans Act; and intent to proceed with a new National Marine Conservation Areas Act.

A preliminary MPA Strategy policy paper has been drafted for discussion purposes. Policy proposals include:

- a proposed definition for MPAs, including minimum management standards;
- proposed goals and objectives, including: conservation of biodiversity and ecosystem representation; conservation of fisheries resources; protection of cultural heritage; and provision of recreation and tourism opportunities;
- three potential broad management regimes and associated permissible uses, ranging from no take (or most restrictive) to resource conservation (or least restrictive); and- a proposed process for decision making, consisting of eight key steps.

Steps include the identification of key marine values; identification and technical evaluation of areas of interest (AOIs); identification of socio-economic issues and concerns associated with AOIs; making recommendations to protect areas through planning processes; formal designation of new MPAs; and management of MPAs. Key issues for resolution include: whether, prior to making decisions to protect an area, some form of interim management is required and if so what form this should take; and what type of planning process(es) to use to make MPA recommendations. There is agreement in principle that a logical approach would be to use existing and future comprehensive, participatory planning processes at a sub-regional scale (e.g. provincial land and resource management planning processes [LRMP]) for regions of the coast currently undergoing or about to embark on an LRMP (i.e. Central Coast and Queen Charlotte Islands). Several options are advanced for consideration in regions without an LRMP or where plans have previously been completed for the land component.

THE FLORIDA KEYS NATIONAL MARINE SANCTUARY AND PRIMATE BEHAVIOUR

Nina Mollet
NOAA, Silver Spring, Maryland, USA

(No Abstract received)

Discussion

Bill Ballentine
Comparing examples of both Florida and New Zealand, the levels of bureaucracy are exactly the same. The problems are also probably exactly the same.

NM
Then this confirms my point that it is perhaps a species problem.

Jim Bonsack
Can you suggest any solutions?

NM
No not any practical ones. But probably we need somehow to step back and look at ourselves as primates.

Wayne Palsson:
The same thing seems to be happening in state waters. One of the problems is the way the concept of marine protected areas are introduced to the public. When people here the word sanctuary, they run for cover. Perhaps we need a way of softening the terminology to explain to people clearly.

NM
In answer to the solution- we should perhaps ask why is it happening and why is it coming apart? We need to get to the roots of the problems. The answers may lie in the need for people feeling part of the process.

Richard Paisley

It is necessary to learn the social structures of geographically delimited areas we are concerned with. In this way it is a sort of adaptive management. In the example of the Philippines study that Amanda Vincent showed us, it is necessary to get to the grass roots to learn the social structure.

Amanda Vincent
We have a group of biologist and social workers, but we never could have got to the area without local community acceptance.

LESSONS FOR RESERVE DESIGN FROM MODELS OF ADULT AND LARVAL TRANSPORT

Joshua Sladek Nowlis
University of the Virgin Islands

Abstract

Previous authors have suggested that we may achieve higher fisheries yields by using permanently closed fishing areas than by allowing fishing everywhere. Field evidence, while encouraging, is sparse, in large part because it is difficult to perform manipulative field experiments on this topic. Models allow one to manipulate various system components in a rigorous fashion and can provide us with important insight.

I compared models that focused on different mechanisms for providing reserve benefits and compared their predictions regarding two key questions: can reserves enhance overall fish yields? and, if so, how should reserves be designed to maximize these benefits?

Polacheck (1990) examined possible fisheries enhancements that would accrue if adults grew larger when protected and then dispersed to fishing areas. This mechanism only produced benefits if the fishery was heavily overfished. Even under the most extreme circumstances, this mechanism predicted only minor overall catch enhancements from reserves.

Sladek Nowlis and Roberts (in review) also examined reserve benefits but focused on the dispersal of eggs and larvae from reserves to fishing areas. These models predicted potentially huge fishery gains, but only when fisheries were overfished (Fig. 1).

The contrasting results of these similar models have strong implications for the design and function of marine fishery reserves. In particular, reserve units should be designed to minimize adult movement to fishing grounds while maximizing the transport of eggs and larvae

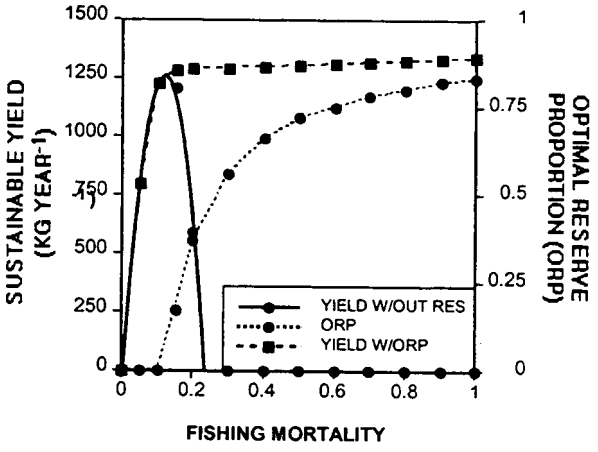

Figure 1. Fish catches and optimal reserve proportions. This graph for the white grunt (*Haemulon plumieri*) shows qualitative relationships that were consistent across all species we examined. The solid line illustrates how long-term sustainable yields (in kilograms per year) from the whole management area changed with fishing mortality (the probability that a fishery-recruited fish is caught in a year). The dotted line shows how the optimal reserve proportion (that which maximized fishery yields for a particular fishing mortality) changed with fishing mortality. The dashed line represents the yields produced by the fishery if an optimal proportion of the management area was set aside as a reserve

Discussion

Jake Rice
When you talk about fishing intensity, do you mean on the whole population or just the part of the fishery that is open?

JN
Just the part that is open.

Paul LeBlond
Is this an individual based model?

JN
No

REPRODUCTIVE RESERVES AND ZONING OF USES AS THE ONLY VIABLE FRAMEWORK TO PREVENT OVERFISHING AND PROTECT WILDLIFE IN THE SAN JOSÉ GULF MARINE PARK (ARGENTINE PATAGONIA)

Lobo Orensanz, Ana M. Parma & Néstor F. Ciocco
School of Fisheries, Univ. Washington, USA, International Pacific Halibut Commission, Seattle, USA & Centro Nacional Patagónico, Puerto Madryn, Argentina

Abstract

The San José Gulf (Argentine Patagonia) is the only marine park in the southwest Atlantic (Pascual et al., MS). The primary motivation for its creation was that it harbors the most important inshore mating and calving grounds for the southern right whale (*Eubalaena australis*). A commercial diving shellfishery developed ca. 25 years ago initially targetting the Tehuelche scallop (*Aequipecten tehuelchus*) stock, a metapopulation composed of several grounds interconnected by larval dispersal (Orensanz, 1986).

The fishery survived as a sustainable operation for over 20 yrs even in the face of limited assessment, management and enforcement, only because important segments of the stock functioned as a reproductive reservoir: deeper beds, low density areas, and animals below marketable size yet sexually mature. As economic and social changes led to changes in fishing practices and a new market developed for smaller scallops, the stock declined rapidly during the last three years and it is now commercially extinct (Ciocco and Orensanz, MS)

Beyond decline in total abundance, there was a dramatic change in the concentration profile (Orensanz et al., MS) of the metapopulation between 1975 and 1996 (Figure). This can potentially have depensatory effects, as fertilization rate in broadcast spawners declines when concentration is low. Seen in retrospect, only the explicit creation of a reproductive reserve might have prevented the collapse of the scallop stock. Based on macroscopic aspects of the metapopulation's dynamics, one ground (Tehuelche) is proposed as the candidate to become a refuge area.

Currently, conflict is growing between the agendas of the tourism industry, fishermen searching for substitute resources, and conservation priorities (Pascual et al. MS). Looking forward, only a zoning plan designed with the involvement of the parties, and which contemplates the various agendas, can provide for effective conservation and sustained shellfishing. A substantial dialogue between most sectors has led to specific agreements, particularly a tentative zoning plan that contemplates protected areas as well as zones for recreation, aquaculture and commercial diving.

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THE RESPONSE OF ROCKY REEF FISHES TO MARINE PROTECTED AREAS IN PUGET SOUND

Wayne A. Palsson
Washington State Dept. of Fish & Wildlife, Mill Creek, WA, USA

Abstract

Several MPAs have been established in Puget Sound. The Underwater Park at Edmonds has protected fish and shellfish from harvest since 1970 and several MPA's in the San Juan Archipelago have protected non-anadromous fishes and most shellfish since 1990. Two diving surveys were undertaken to examine whether these marine protected areas have benefitted the density, size, or reproductive effort of lingcod (*Ophiodon elongatus*) and rockfish. In the San Juans, diving surveys were conducted to determine whether lingcod size, density or nesting activity differed among harvested and non-harvested sites. Two divers conducted a line transect survey between depths of 5 m and 18 m and covering a lineal distance of 250 m at three sites over a period of three years. Paired differences t-tests revealed interannual and seasonal differences: Lingcod densities were typically greater and larger lingcod were observed at the MPA. than at the harvested site. During the spawning season, greater nest densities were observed at the MPA than the harvested site. Copper rockfishes were larger and more common at the protected areas than at the fished site.

In Central Puget Sound, rockfish and lingcod living at four harvested sites and the Edmonds MPA. have been monitored by divers for a four year period. Two divers counted and measured reef fishes along three strip transects each covering an area of 90 square meters at each site. Analysis of variance techniques revealed more and significantly larger copper *rockfish (Sebastes caurinus)*, quillback rockfish (*S. maliger*), and lingcod were present at the MPA. than at the harvested sites. Rockfish measuring 40 cm or greater were rarely observed at harvested sites, while most rockfish at the Edmonds MPA were 40 cm or greater. The patterns observed for size and

density were similar between inter- and intra-annual treatments. Estimates of reproductive output were made for lingcod and copper rockfish combining their observed densities and sizes with published estimates of fecundity with size. Egg production of copper rockfish and lingcod were 100 times greater and 10 times greater, respectively, at the Edmonds marine protected area than at any harvested site in Central Puget Sound. The potential benefits of marine protected areas in temperate regions are discussed.

Discussion

Bill Ballentine
How long has it taken for these effects to observed in Sandy Cove, and how long has Edmonton Park been a no take area?

WP
6 years for Sandy Cove and sine 1970 for Edmonton Park.

Trevor Willis
Have you looked at other rockfish that do not show strong site attachment?

WP
For the majority of the species no. Only the migratory black rockfish and a few others have been recorded.

LEGAL ASPECTS OF MARINE RESERVES

Richard Paisley
UBC Fisheries Centre, Canada

(No Abstract received)

Discussion

Paul LeBlond
How do you think the main confusion over terminology can be overcome?

RP
Using a working group such as the Federal and Provincial Marine Protected Area working group may be central in developing a standard terminology. Having someone who could champion the movement, someone powerful and charismatic may be useful.

Jake Rice
Do you have any optimism that the Canada Oceans Act is going to unravel some of these jurisdictional problems?

RP
Yes, I have cautious optimism. One of the things that should be in the Canada Oceans Act that would be most useful is to see a mechanism for resolving disputes in a non-threatening way.

Joe Truscott
I can give one example where federal an provincial groups have been working together quite harmoniously for over 3 years now. There needed to be a cooperative arrangement because you can't create a MPA just using one particular government. There is major symposium so that will tell if there is to talk or action. Since the last workshop there has been lots of progress so we are optimistic.

CORRIDORS AS A TOOL IN RESERVE DESIGN

Fiona Schmeigelow
Biodiversity Centre, UBC, Canada

Abstract

Central to the concept of a "network" of reserves is the understanding that these protected areas will operate as an interconnected group or system. A foremost consideration, then, is ensuring that movement of individuals from one reserve to another is possible. Connecting areas with corridors to facilitate movement has been suggested many times as a conservation solution, although empirical support is sparse. A first step in evaluating the utility of corridors is to move beyond the narrow definition of linear strips of habitat connecting larger habitat areas, to the broader concept of maintaining movement patterns. In this context, permanent, spatial fixtures are not always necessary. Other management strategies, such as temporal regulation of human activities, could maintain important movement corridors. Evaluation of the need for corridors in reserve design must consider (1) the type of movements important for population persistence (e.g. juvenile/adult dispersal, foraging, seasonal migration), (2) the spatial and temporal scale of these movements, (3) natural levels of connectivity in the system, and (4) the context in which the reserves are located. If reserves are not big enough to provide for large populations and all life-history requirements, and if the surrounding matrix represents a hostile environment, then establishment of corridors might provide a mechanism for maintaining local populations. The spatial and/or temporal attributes of a given corridor will then be determined by the specific requirements of the species of concern. Once a clear set of objectives have been established for a corridor, the efficacy of this management strategy must then be assessed by monitoring movement

rates within and outside the corridor, and trends in 'connected' and 'isolated' populations. All reserve designs have ecological and economic trade-offs that should be explicit in planning and implicit in monitoring. Corridors, with their emphasis on maintaining connections, reinforce the need for integrated management of reserve and non-reserve areas, if the objective of establishing healthy populations and self-sustaining ecosystems in reserve networks is to realized.

Discussion
(There was no time for questions)

MARINE RESERVES FOR MARINE MAMMALS

Andrew Trites

Marine Mammal Research Unit, Fisheries Centre, UBC, Canada

Abstract

There are 119 species of marine mammals in the world consisting of baleen whales, toothed whales, dolphins, porpoises, manatees, dugongs, seals, seal lions, walrus, otters and polar bears. Some have small localized home ranges, while others migrate tens of thousands of kilometers each year. Some species are endangered or threatened with extinction, while others are increasing or have an uncertain status.

A reserve for marine mammals might be created for any number of reasons such as conservation, recreation, aesthetics, inherent values, research and education. In most cases, the fundamental justification for establishing a marine mammal reserve is to provide refuge from undesirable human activities such as shooting, entanglement, oil spills, waste dumping, fishing, and disturbance from noise, human proximity and collisions with vessels.

Marine mammals are increasingly valued by society for their intrinsic qualities rather than their harvestable economic worth. Arguments justifying reserves from a fisheries perspective do not apply in most cases to marine mammals. It is not enough to simply stop fishing the marine mammals. Reserves for marine mammals can at best protect important, but limited, areas used by marine mammals for resting, breeding and feeding. In most cases, the large temporal and spatial ranges of marine mammals precludes creating reserves that are large enough to have biological integrity.

Nevertheless, there is inherent value in establishing temporary and permanent marine mammal reserves, whether in response to perceived crisis or through visionary forethought. Unfortunately, it is difficult, if not impossible to assess the success of a reserve for marine mammals when the sole measure is typically an estimate of population abundance. This may be sufficient when populations are increasing, but will not be enough when populations decline. Ultimately, designing reserves for marine mammals requires knowing the animal and the ultimate goal desired.

Public acceptance of reserves may be easier to establish for marine mammals than for fisheries because of the emotional linkage that much of society has with marine mammals. Fisheries stand to benefit from the establishment of such reserves because protecting marine mammals can ultimately result in protection for all trophic levels.

Discussion

Jim Bonshack
Is there any one looking at fish at the no-entry zones in the Aleutians.

AT
No, because they are trying to keep completely out of the protected zones. No one wants to go in, because they are afraid of changing what may be a good story.

Colin Levings
Undesirable activities are also applicable to fishes. Therefore, in principle, concerning the benefits of MPAs marine mammals are not that much different from fishes.

Glen Jamieson
What are the advantages and is there an urgency for marine protected areas for endangered species such as the Sea Otter?

AT
There is a perception that we need to have them, but we don't know if they are effective. It's difficult to monitor and evaluate the effects.

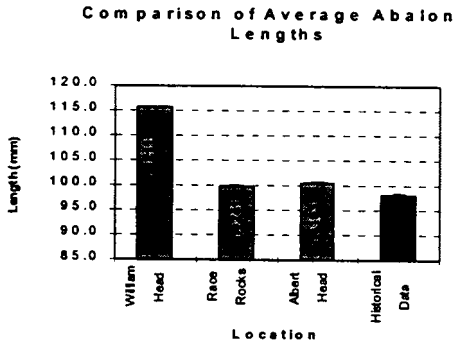
THE ROLE OF MARINE RESERVES IN THE MANAGEMENT OF NON-MIGRATORY SPECIES IN COASTAL BRITISH COLUMBIA

Scott Wallace
Inst. Resources & Environment, UBC, Canada

Abstract

Over the last 45 years there has been a dramatic increase in commercial catches of non-migratory species in British Columbia (BC). For example, in

1970 the combined landed weight of all non-migratory species was $9x10^3$ tonnes and reached a maximum of $69x10^3$ tonnes in 1990. These species account for over 25% of landed biomass in BC. Non-migratory species, defined by species exhibiting sessile, resident, or territorial behaviours during the adult stage of their life cycle, are susceptible to over-fishing and amenable to spatial protection.



This paper presents results of a study on northern abalone (*Haliotis kamtschatkana*) conducted on the south coast of Vancouver Island. The focus of the study was to assess abalone size and density in a restricted area adjacent to William Head penitentiary. Eight control areas were surveyed based on previous Department of Fisheries and Oceans (DFO) studies which in turn were based on commercial fisher's logbooks. Abalone densities in all but two areas were insufficient to conduct a study. Abalone size at William Head, Albert Head, Race Rocks, were statistically evaluated to determine the effects of *de facto* protection. Furthermore, historical data collected from DFO was included in the analysis.

The abalone at William Head were on average 16mm larger which corresponds to an age difference of approximately 8 years. Density was determined by conducting counts per unit efforts. Abalone were found to be most abundant at Albert Head followed by William Head and Race Rocks. The relative densities of the areas were used to assess the relative fecundity of the areas by applying a length-fecundity model. It was shown that per unit area, William Head was 1.2 times as fecund as Albert Head, and 1.4 times as fecund as Race Rocks. Densities in all areas were substantially lower than pre-exploitation levels suggesting that the reserve area is not self-recruiting

Discussion

Glen Jamieson
Is there any evidence of substantially increased larval density in areas downstream from the reserve?

SW
There is only one instance where this has been recorded and is a subject for further investigation.

Jake Rice
Perhaps count per unit effort may have been more comparable to historical values if the time spent measuring abalone was ignored.

SW
Unlikely, since I estimate that the time spent measuring is only about 40% greater than of just collecting, and this would not be sufficient to account the huge observed differences in count per unit effort to those historical values.

ADAPTIVE POLICIES FOR EVALUATION OF MARINE RESERVES

Carl Walters
Fisheries Centre, UBC, Canada

Abstract

We have very little practical experience with issues of how large marine reserves should be, what activities should be allowed in them, and how to enforce restrictions in use. There is a need to proceed with experimental policies to resolve these key uncertainties. Experimental designs should emphasize planned comparisons of reserves of different sizes, use intensities (not just yes-no), and methods for using cooperation with fishing/local interests to obtain needed monitoring and enforcement.

(Abstract only)

ALTERATION OF BEHAVIOUR OF AN EXPLOITED REEF FISH (PAGRUS AURATUS: SPARIDAE) DUE TO MARINE RESERVE PROTECTION

Trevor Willis
Leigh Marine Laboratory, University of Auckland New Zealand

Abstract

Marine reserve protection may directly or indirectly alter the behaviour of fish populations as well as their density. New Zealand's oldest marine reserve, Cape Rodney - Okakari Point (CROP) in the northeast of the North Island, was gazetted in 1975, and has since proven to be extremely popular with visitors. The number of visitors and their tendency to feed fish (both

from the beach and on scuba) has altered the behaviour of snapper (Pagrus auratus) in areas of public access. Diver positivity has become marked at these sites, meaning that comparisons of fish densities using traditional survey techniques such as visual strip transects are invalid. Snapper are not usually approachable by divers, so between-site comparisons must be made using other methods. Attempts to use remote sampling methods, such as underwater video and catch-per-unit-effort (CPUE) assessments based on hook-and-line angling, have pointed to some lesser, but still important bias due to behavioural variability. This paper documents site-related variability in catchability (q) as measured by responses to bait. Resulting indices can be used to estimate the behavioural component of q, and therefore adjust the CPUE model (Pij = Cij / qfij) to make relatively unbiased estimates of fish abundance. Workers conducting surveys for monitoring purposes should be aware that fish behaviour can cause error in the estimation of reserve effects.

Discussion

(Unidentified)
With regards to your data from baited traps, how did you account for differences between areas?

TW
The survey was done over a large number of replicates.

Laura Bennett-Rogers
There is good agreement between all 3 censusing techniques, except the diver estimates are biased. Given fish are attracted to bait as well as divers, why is the diver estimate so negatively biased?

TW
In the reserve area, locals are influencing fish behaviour by feeding them. This interferes with divers ability to feed the fish at lower depths. This negatively biases the number of large fish counted by divers. The video camera connected to the bait trap can pick up big fish at further distances away - couldn't get this with visual surveys.

Laura Bennett-Rogers
So there is a differential size bias?

TW
Yes, and this is why you should ignore little schooling fish in estimates.

Jim Bohnsack
Fish habituate quickly to divers - perhaps you would get better estimates if you stopped moving for a while and then did census. Have you tried this?

TW
Yes, I tried doing this but if you stay still the fish will start biting you. This method works okay in winter but in summer the fish become quite aggressive.

Jim Bohnsack
What about late in the day, is this still a problem?

TW
Yes, they are always hungry.

THE IDENTIFICATION OF CANDIDATE SITES FOR MARINE RESERVES USING A MARINE ECOLOGICAL CLASSIFICATION: A PACIFIC COAST OF CANADA CASE STUDY

Mark Zacharias & Don E. Howes
Land Use Coordination Office, Victoria, BC, Canada

Abstract

This paper presents and applies a methodology for the identification of candidate sites for marine protected areas. This approach uses a combination of biological and human-use data from the British Columbia Coastal Resource Inventory (CRI), and the recently created British Columbia Marine Ecological Classification (BCMEC).

The CRI maps most of the aboriginal, commercial, and recreational fisheries in the Province, most marine mammals and seabirds, and species that provide habitat (i.e. kelp and eelgrass). The inventory also maps human activities in these environments including industry, recreation, and transportation routes and facilities. The BCMEC is a hierarchical marine classification which delineates Provincial marine areas into 12 "ecosections" based on biophysical characteristics, and 619 "ecounits" based on currents, depth, exposure, relief, and substrate.

The combination of the BCMEC and CRI provide the basis for a representative systems approach to the identification marine reserves. The physical based ecounits provide a framework for the identification of various physical environments, and the resource and human-use information is used to assess and rank these environments for diversity, uniqueness, and anthropogenic impacts. This methodology combined with the more traditional site and species specific approach to the identification of candidate sites permits a systematic examination of over 450000 km^2 of marine area in the Pacific coast of Canada.

Results of this research to date have determined that that 4.22% of British Columbia's non-abyssal

(<1000m) environments have some degree of protection, and that 14.36% of British Columbia's coastline is protected in some way. Results also indicate that areas composed of combinations of shallow (20 - 200m) depth, high current, high relief, and high wave exposure are the most protected. Ecounit and coastal resource data are currently being used to identify and rank candidate sites for marine protected areas in British Columbia's Queen Charlotte Strait and Central Coast regions. In addition, a regional study in the Strait of Georgia has redefined the ecounits with the addition of salinity, temperature and current information derived from a three-dimensional hydrodynamic model.

General Discussion Arising from the Papers

Discussion was started by asking the audience if they had any additional questions for any of the speakers.

Doug Barrows
(to either Bill Ballantine or Trevor Willis) I got the impression that that diving time and number of divers doing censuses is influencing fish behaviour? Is this true?

Bill Ballantine
No, it doesn't seem so. Marine reserves will allow for this type of hypothesis to be tested if there were many more reserves to provide replicates. We just need 10 more reserves!

Jake Rice
(to Josh Nowlis) If technology will always push fishing mortality up, will the reserve really stop a decline or just delay it?

Josh Nowlis
Yes, you can have a fishing mortality of 1 outside the reserve and still protect the stock as long as the reserve is very big. Different species were tested, and most can go to high exploitation rates if at least 60% of their habitat is protected and all can go to high exploitation rates if 80% of more of their habitat is protected.

Tim Lauck
You can always increase the size of an MPA to guarantee survival, we need a paradigm shift. As oppose to thinking about protecting a fixed area for MPA's, we should maybe invert the notion and start thinking about setting a fixed percentage for fishing, and designing corridors for fishers. This may be very unrealistic however, given that we have a difficult time getting even 1% aside for MPA's.

Tony Pitcher
Yes, Carl Walters has suggested that we think of the whole ocean as an MPA, with no fishing being the normal situation.

Josh Nowlis
Most fishers are opposed to having more than 10% of marine areas closed to fishing, and are openly opposed to having 60-80% closed.

Glen Jamieson
People have viewed the ocean as the last frontier - limitless. Lake fishermen, however, know there are limits. We may have to consider only a few areas as open, the rest being closed.

Tony Courtney
With respect to Tim's point, you must always consider the longevity and demography of the species you work with in mind. For example, with prawns, it is better to protect their habitat over a critical period of their life history. This temporal protection is better than closing off a large area, which will just cause a reduction in maximum yield.

Robert Mooney
The speakers today have focused mainly on one species. How many people want to protect one species? Is this single species focus a subtext of management objectives or do they really want to preserve ecosystems?

Tony Pitcher:
I agree. In addition to the ecological value, there are economic benefits to protecting an entire ecosystem. They have to be pointed out.

Jim Bohnsack
The closure systems we currently use are good for single species, but they do nothing for the whole system. The whole point of preservation needs to be to maintain the entire ecosystem. The only way to do this is by creating a no-take MPA. We must go beyond traditional fisheries methods.

Jake Rice
The problem is not the concept of ecosystem management, the issue is getting the currency to prove whether you're achieving it. For example, if you use the currency of biodiversity, probably the best thing you can do is fish. Fishing reduces dominance and increase evenness in the community. It is hard to create indices that measure ecosystem health.

Bill Ballantine
The effects of different gears and human impact are confounding when trying to ascertain changes in community composition and stocks. For example, there was a paper written about the effect of trawling on fish communities in the North sea. The control treatments were areas near oil rigs where no trawling could be done. A while later there was another paper looking at the impact of oil rigs on fish communities. There is no real control, and we cannot know what is really going on. This is bad science, but we can get no better controls without the creation of no-take MPA's.

Sylvie Guenette
I don't agree that fishing gives the appearance of species evenness (with respect to Jake Rice's comment). It's not that hard to come up with better indicators of community health. Based on my work with about 50% of the area as MPA, I believe such indices could be established.

Unidentified
We could debate for 3 days whether species evenness is a reasonable goal of reserves. In developed countries, the best data we have is for

fish and other exploited marine species. Can we use these organisms as umbrella species for the response of the entire system?

Simon Jennings
With respect to the North Sea, communities are so adapted to fishing disturbances it is impossible to differentiate their state from a pristine environment. Based on data going back from the early twentieth century, there is no indications of community changes.

Jim Bohnsack
Whooaaaaa! I disagree. Look back to the 1700's when there were rays and other species in the North Sea that went extinct. The world did not being in the 1900's. The draggers used to bring up lots of fossils in the North Sea, now there are none. Therefore the habitat has changed drastically.

Simon Jennings
Yes, but it is very hard to prove change has occurred, even with a 70 year data set. We need a longer data set.

Tony Pitcher
Why that's Daniel's point about the concept of shifting balance We would need a 1000 year old data set to prove change has happened.

Glen Jamieson
If these sorts of changes are always happening, we have to keep in mind that trophic fluxes will make it difficult to re-establish pre-existing communities.

Unidentified
In any work we do we are constrained by the type of data we collect. Many organisms are not well sampled and we have no long term data sets on any of them. For example, isopods are not well sampled using grab methods - in the absence of long term data sets we can't say how trawling has impacted them.

Tony Pitcher
Yes, we don't know what the North Sea looked like before trawling. If you look at another area, ie. the Arafua Sea where trawling has been more recently initiated, you can observe how trawlers have changed the bottom habitat and now, how new trawl techniques can allow habitat reconstruction of sponge forest.

Jake Rice
I'd like to mention the latest ICES volume on the North Sea. One of the advantages of ICES working groups is that they don't represent just one narrow point of view, they are a diverse group which aims at getting consensus opinions. For example, it is generally agreed that fishing a pristine ecosystem will alter it. One group may want to recreate a pristine ecosystem, but they have to openly identify their aims as such and define what pristine is. People in fisheries on the other hand, don't necessarily want to recreate pristine ecosystems. They may not care if trophic dynamics have changed if they are still catching the same amount of biomass.

Bill Ballantine
Are you saying that if you collapsed the entire herring industry in the North Sea it wouldn't matter?

Simon Jennings
Species stability in the North Sea has been very high since the mid 70's.

Laura Rogers-Bennett
The goal with MPA's is not to preserve pristine habitat, but to allow habitat to heal itself. It can do this better than we can. Therefore fisheries managers will be interested this as a management tool.

Jake Rice
Have I disagreed with this?

Laura Rogers-Bennett
You suggest this isn't good fisheries management - but it is. It will let the system heal.

Jake Rice
Are there any other fisheries managers in the room? Scientists have different goals from managers.

Tim Lauck
You must remember that monitoring for 60 years is nothing! If you are scientifically honest, you realize you need a much longer data set to say anything about ecological change.

Jim Bohnsack
With respect to the consensus process of ICES, this is often not effective. What is the point of consensus science when the consensus is only as good as the people there? It is worthless to throw out the extremes, they may be the right answers. Science makes and tests hypotheses, it doesn't just have groups decide which are right.

Fiona Schmiegelow
There is a real need for controls. You can't need measure the effect of fragmentation in a system where all species effected by disturbance went extinct before you could measure it. We need controls in areas that haven't been disturbed.

Jake Rice
It has never been the conclusion of anyone to say fisheries have had no impact relative to undisturbed areas, but if we're going to use MPA's as a management tool, we must ask managers what their objectives are. These objectives may be different from what an

"ecologically wise" fisheries manager should have. Most managers would never say their goal is to restore a pristine system.

Glen Jamieson
Fisheries managers are only responsible to a small part of society, they are going to have to be responsible to the overall public also.

Tony Pitcher
Shouldn't we ask fishers first?

Jennifer Lash
Maybe there should be a changing role of fisheries managers towards working with fishers to obtain ecosystem protection.

Josh Nowlis
Remember, we shouldn't have to specify one purpose for an MPA. Despite the fact that managers are only interested in increasing harvest, MPA's will accomplish this and protect the ecosystem.

Jack Sobel
Fisheries managers are traditionally responsible to fishers as they are the most vocal on fisheries issues. Think of traditional forest management. It's aim is to produce lumber. If we left decisions up to them, there wouldn't be much left. Managers need to be responsible to both fishers and the public.

Barbara Neis
In the literature, there is no consensus as to what the goal of reserves should be. This has led to much confusion. With respect to the cod in Newfoundland, closing 80% of the overall area wouldn't be a problem. This used to be the situation before trawling.

PROCEEDINGS OF WORKING GROUPS

WORKING GROUP A

MARINE PROTECTED AREAS IN BRITISH COLUMBIA

Chair: Glen Jamieson
Rapporteur: Steven Mackinson
Participants: Andrew Trites, Todd Columbia, Scott Wallace, James Austin, Kathy Heise, Ed Bowlby, Doug Berls, Dana Haggarty, Gord Heath, Wayne Palsson, Sabine Jessen, Richard Paisley, Bill Ballentine, Tony Pitcher.

Glen Jamieson opened discussion with a review of the current status of MPA's in British Columbia, summarised below.

Many reports comment that there is over 2000km of protected area in B.C. However, based on no-take criteria, this figure is reduced to only 214 km. One of the major problems that is faced in B.C. is that of terminology. 'Protected' means many different things to different people. It is a term that can easily be manipulated to suit any situation. Currently, there are only 3 'No-take' fully protected areas in B.C.: Race rocks, Porteau Cove and Whycliffe park.

Recent legislation in the from of the Canada Oceans Act 1996, has now given authority to establish MPA's (even though it doesn't define what an MPA is). Eight sites were proposed as MPA's in B.C. Areas were chosen that were likely to receive little opposition to implementation. Typically, they are areas associated with terrestrial parks or in areas where no fishing occurs. If any of the proposed sites was opposed strongly by any group, it was dropped. It is likely that 3-4 MPA sites will be announced in the near future. Richard Paisely commented that these were easy wins, allowing the DFO to shine.
Comments were made indicating that neither industry or science was involved in the selection process. This was contented by Richard Paisley who made note that consultation with both industry and First Nations in the form of meetings, had been ongoing for over 6 years. These meetings were in part for the selection of the 8 sites but more generally to discuss the concepts of MPA's in B.C.

The director general organised a forum to bring together stakeholders. Richard Paisely provided a summary of it's first meeting: Despite wrongfully being billed as the first step, the forum was a well intentioned, sincere attempt to create a coalition to help develop a systematic network of MPA's. The first meeting was dominated by First Nations issues covering subjects broader than MPA's. Richard commented on his optimism for the next meeting in the near future. Glen Jamieson added that he was no so optimistic. It was likely that next meeting would similarly be dominated by First Nation issues. First Nations land claims in B.C. are so complex that it is likely that such issues may slow the progress for MPA's. In parallel to the land claims issues, the government has done nothing but talk on the subject of MPA's. Richard Paisley was cynical, suggesting that we may be raising our expectations too high when we should not have the confidence in the government to do so.

Wayne Palsson interjected. He expressed that as an outsider it appeared that B.C. does not have its goals clearly defined, and until it does progress is unlikely. He added that without grass roots support MPA's are likely to fail. Providing an example from San Juan County, he suggested it is possible to get communities to 'buy-in' to the process without local government support. The 'bottom-up' approach is fundamental for success. This notion was clearly supported by discussion group members. Jennifer Lash commented that indeed, the success of the current MPA's in B.C. were dependent on community support. James Austin, a gooeduck fishermen, added that the 'parachute-in, fly-out' approach of agencies advocating marine reserves was inappropriate. They were not the ones who would stick around and continue to monitor and ensure the success.
Wayne Palsson turned discussion, asking the question what are we going to do? At this point conversation became more focused on clear objectives. It was agreed that some definitions and criteria for MPA's in B.C was required. Bill Ballentine joined the group and help provide some guidelines for consideration.

The results of discussion presented at the afternoon plenary sessions are given below. In essence the approach can be considered 'bottom-up'. It relies on attaining core no-take MPA's first, followed by adding further buffer zones in which various activities are limited.

PRINCIPLES FOR MARINE PROTECTED AREAS IN BRITISH COLUMBIA

Statement

A representative network of *no-take* areas should be from the core of a system of Marine Protected Areas (MPA's) in British Columbia.

What are no-take areas?

A *no-take* area minimises human impacts on all marine species and fundamental ecosystem dynamics. In NO-TAKE areas:

- the removal of marine species and modification of habitat is prohibited and,

- other human disturbance restricted.

What is a Representative Network?

To be *representative* means a minimum of six biophysical areas should be considered. Within each of these, are at least four ecological regions that should further be considered.

Biophysical regions

1. Strait of Georgia
2. WCVI/W.Charlottes
3. Johnson Strait
4. Queen Charlotte Sound
5. Hecate Strait
6. Dixon Entrance

Ecological regions

1. harbours, estuaries, fjords
2. sheltered waters (bays etc.)
3. open coast inner waters
4. open water and outer shelf

Replication of *no-take* zones within the representative system is required for the following:

- Logic - measure variance and demonstrate generality
- Ecological management principles - best not to 'put all eggs in one basket'
- Community - ease of access for community participation

Recognising that 'larger' *no-take* areas are better but accepting that reality will restrict size of individual MPA's, spatial arrangement becomes important. The spatial arrangement of replicates should be a *network* that is designed to promote 'all the good things forever'. The system should be self perpetuating and be able to grow over time.

The creation of further MPA's over time could be a 'fill-in' process with connections developed as a appropriate.

Around the core *no-take* zones, we recommend a network of representative buffer areas as part of Integrated Coastal Zone Management, where exploitation of species may occur so long as resource objectives are not negatively effected.

Current scientific data suggests that maximal resource benefits (wealth, jobs, conservation) would occur when around 50% of marine areas are protected.

MPA's must be effectively managed and monitored with partnerships between communities, First Nations and to assure these goals are achieved.

WORKING GROUP B

MODELS AND DESIGN

Chair: Sylvie Guenette
Rapporteur: Marcelo Vasconcellos
Participants: Bill Ballantine; Suzan Dionne; Joshua Sladek Nowlis; Jake Rice; Anthony Courtney; Michelle Paddack; Trevor Willis; Tim Lauck.

Group discussions were structured around four basic topics:

1. What types of models could be used to address questions and goals associated with Marine Protected Areas ?
2. What are the basic questions or properties of MPAs we want to address with models ?
3. What kind of information is required to develop models and evaluate the effect of MPAs ?
4. Where do we go from here ?

Types of models

On the potential utility of models for the analysis and design of Marine Protected Areas, both simple and complex models are thought to be appropriate. Simple models are particularly useful for addressing the fundamental processes and proprieties of MPAs, besides being easier to understand and to communicate. The more complex models can be applied to explore the intricacies of the system, but are substantially constrained by data availability. In this spectrum from simple to complex models lay the single-species and the multi-species, ecosystem models. Bill Ballantine rose the point that in the evaluation of the benefits of MPAs all sorts of models should be used. Regardless the complexity of the models and the characteristic as deterministic or stochastic, the group agreed that there are three levels of modelling efforts to be applied in MPAs:

1. models with general ideas and principles that could point the overall benefits of MPAs;
2. exploratory models, designed to answer specific questions related to the effectiveness of MPAs in relation to specific goals;
3. exploratory models applied to specific areas and hence based on empirical information.

Questions to be addressed with models

Models are tools designed to understand the nature of the system being managed, to highlight our fundamental uncertainties at the population and ecosystem level and to help design of management strategies. Considering this set of objectives, the group elaborated a list of questions to be addressed with models:

- analysis of robustness of MPAs against extreme environmental conditions and human disturbances;
- design of hedging strategies to deal with uncertainties;
- prognosis of changes in stock biomass and recruitment;
- prognosis of changes in species diversity and habitat rehabilitation;
- assessment of the time scale of changes in population and ecosystem properties;
- analysis of the effect of MPAs on the biology of endangered species;
- assessment of the impact of species introduction and invasion in MPAs;
- assessment of the impact of human disturbances (e.g. new fishing activities, whale watching, etc.) to the protected areas.

Information required to model and design MPAs

In order to access the efficiency of MPAs in achieving defined goals, the group identified areas of research that should be emphasized. At the population level, information on important biological processes and key life history traits is fundamental to carry on exploratory models. This include information on recruitment, migration, feeding and reproductive behavior, larval transport, and location of spawning, feeding and nursery areas. The benefits of MPAs as a tool for ecosystem management and rehabilitation of impacted habitats will require the monitoring of certain ecosystem properties and characteristics. In this regard, it was a general consensus that there is still a lack of understanding of ecosystem functions and development and that, therefore, more research should be directed to the development of indices and measures of ecosystem properties such as species diversity, stability and resilience.

The success of MPAs as a fisheries management tool should be measured by careful analysis of the benefits to fishery production, and the costs and practicality of enforcing the regulation. Enforcement could be expensive and especially difficult in the case of spatial closures. Therefore, it is important to evaluate the level of non-compliance which would dissipate the benefits gained from closed areas.

Finally, the development of comparative studies between no-take and partial access MPAs, where, for instance, some fisheries practices are allowed, would provide valuable information for the evaluation of the effect of punctual disturbances of particular user groups, and hence provide the basis for the design of management policies associated with MPAs.

Where do we go from here ?

As concluding remarks on the use of models in the design of MPAs, the group considered as important next steps:

- the need to widely sell the idea of MPAs for fund agencies and potential sponsors that could bring more incentives for research in the area;
- foster more interaction between model studies and field work;
- consider stock spatial structure and processes on population dynamics models;
- analysis of the effect of MPAs on fishery yield and catch rates in short and long term, including more explicit assumptions about effort redistribution;
- consider the value of MPAs as a protection measure against assessment errors, uncertainties and the risk of stock collapse;
- develop more research on ecological criteria for choosing locations for MPAs and on ecosystem properties that could be used to monitor the benefits of MPAs as an ecosystem management tool+.

WORKING GROUP C

SOCIAL AND ECONOMIC CONSIDERATIONS FOR MARINE PROTECTED AREAS

Chair: Nina Mollet
Rapporteur: David Preikshot,
Participants: James Austen, Jim Bohnsack, Vincent Gillett, Steve Heizer, Bruce Higgins, Nina Mollett, Robert Mooney, Silvia Salas

Jim Bohnsack suggested that a useful way to develop some discussion topics would be to conduct a brainstorming session. The issues suggested in this were: stakeholder involvement; traditional knowledge; take versus no take areas; social versus capital costs and benefits; enforcement; monitoring; contrasting temperate and tropical areas; processes to implement MPA's; administrative structures; and ethics. Two issues, however, dominated the ensuing discussions, in that all of the other issues were tied to them in an integral fashion: stakeholders and social versus capital costs and benefits. By focussing on those two topics it was found that many of the issues arising from the other areas would be examined.

Given this framework, the group agreed that there was a need for different user groups, or "players", to be involved in all discussions on MPA implementation at each stage of the implementation process. The most representative and inclusive process that was identified to facilitate this can be described as follows:

- All groups should be able, and should be encouraged, to exchange information and knowledge.

- If principle 1 is satisfied then all groups should experience much mutual legitimisation and understanding.
- If 2 and 3 exist then it should be possible to identify common goals, and the methods to achieve those goals, in the implementation of MPA's.

Education is therefore necessary between the different players, as this is what fosters a climate of respect and good faith within which the above three conditions can be achieved.

In a process like that outlined above it will be necessary to have a clear working definition of an MPA before beginning discussions on their creation. It was pointed out several times in the discussion group that the definition of an MPA as a "no take zone" is the one that must be stressed. This is because it soon became apparent that any other definition would be some kind of *de facto* management scheme. If MPA's are to be seen a valuable, they must be clearly distinguishable from traditional management techniques. It was also felt to be quite important that, in an MPA, no sector or user group should be given special permission to fish. Such a situation would create confusion and animosity among user groups and would be simply management by gear restriction transferring attitudes from previous policies to the newly created limited take MPA's. Such attitudes would inevitably spill over to sully the reputation of even no take MPA's since they would be seen as the same by people not allowed to fish in either. All users must, therefore, share the perceived burdens of not fishing MPA's.

Concerns over the effect of an MPA on different groups became the focus of a lengthy discussion on the importance in distinguishing social versus capital costs and benefits when weighing the pros and cons of deciding where and when to establish them. It was noted several times that one of the failures of traditional fisheries management was focusing on purely financial gains an losses as they pertained to a particular species. If the emphasis remains on purely capital costs then the task of implementing an MPA is made much more difficult as the only recognisable effect is a short term loss of income for many of the fishing user groups.

MPA's, by helping to maintain the existence of a resource, do provide many social benefits that have, only recently, become recognised as valid, or even measurable, considerations in fisheries policy making. For example, they provide the basis for the continued existence of fishing communities, especially when these communities are given a chance to meaningfully participate in the process of MPA design and monitoring. Also, MPA's recognise the implicit aesthetic value of maritime ecological systems *per se* and serve as an ecological investment program, to extend the analogy.

One concern, that repeatedly arose was the inappropriateness of unilateral action by governments. It was stressed that fishing communities and user groups that will be affected by the creation of MPA's will likely not respond favourably to their imposition if it is done in a manner that seems to be purely geared to the environmental lobby. It was noted that in BC, Florida and other jurisdictions, fishing user groups may actively work against MPA's if not consulted. This is especially so when there is an "exclusive" consultation process in which participants from outside the community, the so-called "parachuting" phenomenon, are perceived to be given too large a say in the MPA design and monitoring process.

All members of the working group were given an opportunity to make some concluding remarks. It seemed appropriate that all felt that social concerns would best be addressed when the MPA design and monitoring process was done in a way to take account of all user groups' views. This, of course reflects the change in the philosophy fisheries policy making reflected by MPA's themselves. That is, they are a tool that helps manage whole ecosystems, rather than its singular components, thus minimising detriment of other groups, and indeed the value and beauty of the community as a whole.

WORKING GROUP D

ISSUES OF DESIGN, MONITORING AND ENFORCEMENT OF MPA'S

Chair: Barbara Neis
Rapporteur: Heather Ferguson
Participants: R. A. Appeldorn, P. J. Auster, E. Buchary J. Dalsgaard, D. Fenton, S. Jennings, N. Jiddawi, F. Mercier, R. O'Dor, L. Orensanz, C. Soiseth, A. Vincent, M Yoklavich

Establishing a framework

The discussion started by considering the fact that the design, monitoring and enforcement of an MPA will be influenced by both the goal and/ or location of the preserve. We tried to establish what factors are most important in distinguishing MPA's; and how these differences might influence management. The following five factors were proposed as general schemes for distinguishing between MPA's:

1) Goal: Management of an MPA might vary depending whether the aim is to protect a single species or an entire ecosystem.

2) Geography: There will be differences between MPA's in the tropics versus those temperate zones.

3) Economic: There will be differences between MPA's in the developed versus non-developed world.

4) Eco-regions: MPA' should be distinguished as a function of the eco-region in which they occur.examples of different eco-regions being:
   Tropical reef
   Temperate reef
   Tropical soft bottom
   Temperate soft bottom
   Vegetated (ie. mangroves)

5) Stability: Need to consider whether an MPA will be located in an environment with high spatial and temporal stability, or a highly variable one.

These categories are not mutually exclusive, they are merely a list of considerations that should be taken into account when discussing the design, monitoring, and enforcement of MPA's.

While all these factors are important, it was decided that the discussion should focus on the differences between MPA's aimed to protect a single species, and those aimed to protect an entire ecosystem. We thought that it was very difficult to comment on problems of design and enforcement without knowing whether the end goal of the MPA was maximizing fishing benefit or conservation. Your agenda (ie. stock productivity versus biodiversity conservation) ultimately influences both the objectives and guiding principles of MPA design. Of course the aim of an MPA need not be solely to increase productivity or alternatively just biodiversity protection - these goals are representative only of extremes in a continuum. Increasing productivity and protecting biodiversity are not mutually exclusive. We imposed this dichotomy simply to examine how design principles, monitoring and enforcement vary as a consequence of the guiding aim.

Exploring differences between MPA's for single species and ecosystems

At one end of the spectrum, managers may choose to establish MPA's for the sole purpose of increasing stock productivity. In such cases, the objective of the MPA is usually to enhance one economically valuable species. As such, single species models should be employed in MPA design. At this level, MPA design should be concerned primarily with the metapopulation structure of the focal species. MPA's should not only encompass identifiable populations, but ensure dispersal routes between patches are maintained. Habitat connectedness should be a primary concern when designing MPA's for single species enhancement.

Table 1

Agenda	Objectives	Principles	Constraints
Stock Productivity	Sustaining single species	Habitat Connectedness (species level)	* knowledge *environmental uncertainty * social factors
Biodiversity Conservation	No entry MPA	Habitat Representativeness (community level)	

Alternatively if your goal is entire ecosystem protection, both connectedness and representativeness are important. In the absence of complete knowledge, we can use habitat diversity as a surrogate measure of species diversity - characteristic species assemblages being associated with distinct eco-regions. If each eco-region is represented in an MPA network, we can ensure all species receive some degree of protection. MPA's designed for full ecosystem protection must necessarily be no-take and no-entry. These measures will not only preserve the ecological integrity of the system, but minimize all human created disturbance.

Table 2

	Objectives: Single Species	Objectives: Ecosystem
Approach	Decouples system	Holistic
Design	Connectedness	Representativeness & Connectedness
	More knowledge available	Less knowledge available
	Smaller size	Larger size
	Tied to specific location(s)	Flexibility in locations
	Economic justification easier	Economic justification harder
Monitoring	Well defined objectives	Broad objectives
	Success easy to measure	Harder to define success
	Easier to monitor	Harder to monitor
	One species, smaller size	Many species, larger size
	Disrupted by natural variability	Natural variability provides data ,doesn't have to imply failure
	Less research opportunity (except for applied)	More research opportunity (pure)
Enforce-ment	Harder to enforce per unit area (have to check entire catch to make sure focal species not taken)	Easier to enforce (anyone seen in the in the MPA is breaking the law
	Less bureaucratically complex	More bureaucratically complex

Whether your concern in stock productivity or conservation, MPA success will be constrained by incomplete knowledge, environmental stochasticity and social factors. However, the importance of these limitations will vary between single species and no-take MPA's. We discussed these problems and how they might differentially impact the design, monitoring, and enforcement of single species versus ecosystem MPA's

DISCUSSION OF REPORTS FROM WORKING GROUPS

Rapporteurs
Steven Mackinson and Marcelo Vasconcellos

Tony Pitcher asserted that if British Columbia has the political sense to implement MPA's, then perhaps in the next 100 years there will still be a fishery. Fishery scientists around the world are in grave doubt that if we don't do this then fisheries will be on a slippery slope. The political message has to be a hard-nosed offer of the jobs, food, and wealth that will come form saving the fishery. If we can get that message over we may actually achieve our goal in setting up substantial no-take MPAs.

Simon Jennings commented that this is the same statement that was used to sell traditional fisheries management and that has failed. He asked, why should this do any better?

Bill Ballantine suggested that they were both right. But, suggested they should see what happens when you try it! In answer to Simon question he added that the advantage of MPA's as a fisheries management tool, is that they are very obvious. Unlike traditional fisheries management, people may actually understand what they are being sold.

Jake Rice raised the point that in his opinion there appears to be agreement on the value of MPA's. We know where we want to be, but the problem is that all politician are interested in is how to get there. How do we implement them?

Tony returned the question asking Jake what do you think would be necessary for us to do to get there? Amanda Vincent responded. She asserted that it could only be done with a ground-swell of public opinion and consensus. This is what policy makers understand and follow. The methods we need to use to influence popular opinion are techniques such popular articles, television, radio presentation, etc. The science needs to be disseminated through media to be able to effect public opinion.

Jennifer Lash agreed, but adding that these methods are not a new idea. They have been talking about this for a long time, what is required now is to make a jump between scientific work and the real world. We need to find a way to tie in the scientists with those who are already doing the advertising.

Tony Pitcher said that, indeed, the dichotomy between the science and the public is something we need to break down in order for the politicians to get the message.

Coming back to Amanda Vincent's point, Glen Jamieson supported the notion that we are not really talking with the people who are important. The information is not being published in a manner readily available for the people who matter. So far the effort of individuals has been large and there is not enough time to do this for all areas of B.C. Jennifer Lash urged that in fact it was not necessary to start from the ground floor. The framework is already there to develop upon.

Ron O'Dor emphasized that although one of the things that scientist dislike most is been followed around by the press, we cannot say no to the media. The media is powerful exposure. A way of getting our message accross.

Laura Rogers-Bennett added that it is essential that we have fishers support if we are going to implement MPA's. How are we going to sell it to fishermen. What kind of concessions should we use ? Shall we say lets toss out conventional fisheries management tools and just adopt MPA's?.

Nicolas Polunin was not convince that that we have enough strong case stories to provide confidence to fishers, let alone suggest we throw out conventional fisheries management.
In aggreement, Simon Jenings expressed that he didn't feel that fisheries scientists are well believed. We have given them disasters before, now we have to make sure we get them on side.

Jake Rice gave two concerns; one that fishers feel suspicious of this initiative. Secondly, before we sell to fishers the idea of MPA's we should openly listen to them first. He suggested that we go out to the dock side and talk with individual fishers.

Daniel Pauly interceded with a few interesting points. "If we were a different discipline such as physics, chemistry, we would have carried out proof of concept." It seems that the science is done, but the application is lacking. Whether it should be the role of scientists to get involved with the application is questionable. Perhaps we should work with those who do. "One of the problems with science is that we never accept success. We never let go".

In support of Daniel, Amanda Vincent agreed that we worry about our role as scientists. It seems most people agree on the benefits of MPAs, we should just get in there!

Laura Rogers-Bennett, argued that she doesn't think that's a good reason not to do science. Consider the example of artificial reefs, which were not adequately scientifically monitored after they were implemented.

Tony Pitcher suggested that the scientific message that we are failing to get over to the

public is the one of uncertainty, and the lack of knowledge we really have. However, MPA's appears the only tool that we know does work in the face of all this uncertainty.

Barbara Neis posed the question as to whether there was an example of any no-take area that worked? We have to keep monitoring. There is no point at which we can stand up and say " we have done it, it works". Science has to go on.

Examples were given of *de facto* no-take areas that in fact did work, such as the North Sea, Nicaragua and the Gulf of Tonkin.

Daniel Pauly pointed out that science is not only classified by what it does but also by what it doesn't do. He asserted that we have to focus on things worth investigating. If we think that we need lots more active research on results of MPA's this will undermine the ability to get them implemented.

Joshua Nowlis said that one perfect and good reason for setting up MPA's is that if we don't, we will never figure it out.

Barbara Neis threw out a hypothetical question: What have achieved in terms of sustainability if I displace a bunch of artisanal fishermen, set up a Marine Reserve, and then allow a traditional ITQ fishery outside the reserve?

Amanda Vincent disagreed strongly against the fundamental premise of the question, commenting that if you use this approach it will fail. The approach we should use is to develop one from grassroots, with community participation. Examples show that it can be achieved in countries where people are starving, so why not other areas ? If we can do it you can do it.

Having remained quiet and poised throughout discussion, Bill Ballantine interceded: "I've been listening to the conversation and I charge you all. You are all looking for quick fix. You are impatient. I do not believe there is a magical button. What I ask is, can you really stick it out that long ?

Jennifer Lash echoed Ballentine's sentiment adding that not only is staying in the power required, but that you must also be able to play on the team.

WORKSHOP WRAP-UP STATEMENTS FROM THE KEYNOTE SPEAKERS

Rapporteur: Dave Preikshot

Bill Ballantine

There are no magic answers or quick fix solutions that will create MPA's, they will necessarily involve much time and effort to implement. Modelling can provide us with some ideas of potential long term effects of MPA's not possible now due to their relatively recent appearance in fisheries science. We can't wait 200 years for results of long term studies as we know there is a problem now. An appropriate metaphor is the wheel. While we all agree that wheels should be round, we still do research on the materials they are made of. Similarly we all now agree we need MPA's to protect populations, the specifics of how will be answered after they are established. Some of the principles we have to keep in mind regarding MPA's are:

Undistubed areas have a scientific experiment value as ecologic "controls", and there already is much evidence to show they would help populations.

Representation is the key to solving the problem of "ecological ignorance".

It is necessary to talk to average members of interest groups, not just the designated representatives, as they tend to be more dogmatic than their constituents.

Children must be educated on the value of marine ecosystems, as they will carry this value system through their adolescence and adulthood.

Jim Bohnsack

As recently as five years ago MPA's were ignored as a topic by people discussing fisheries in B.C. Now, however, they are generally accepted as a valid policy option. This is representative of a paradigm shift in how people think about the oceans. Fisheries science used to with fish as single species comodities but this has become to be seen as simplistic. We have enough of an impact on the environment that we can see the negative effects within our own lifetimes. Thus many have adopted the ecosystem approach, which values the system as a whole not the financial value of its parts. It is usefull to recall the principles of Aldo Leopold regarding ecosystems; integrity, stability, and beauty. With respect to integrity, the first rule of tinkering with any system is to make sure you have first saved all the parts. As to stability, we must remember that things do not always go as planned. Regarding beauty, this is impossible for science to quantify, but it is the measure the public uses to judge the ecosystem. To conclude, we must shift away from economic biology to a biology that seeks to preserve the whole system.

Barbara Neis

We must remember that fishers have much knowledge which we must use as part of the planning process. We must also remember that any MPA, when introduced, will elicit a response. This response may even be as extreme as simply finding new target species, which could themselves become at risk, or further concentrate fishing effort on the place away from the MPA. An area that is closed for one fishery will have to be closed to all so that all users are seen as equally bearing the responsibility of maintaining it. Lastly MPA's should not be sold as a panacea.

Nicolas Polunin

There does appear to be more willingness in general to create MPA's but there is a conflict between scientists and politicians on what MPA's should be like. Regarding advocacy by scientists, the science does not seem strong enough yet. The responsibility of scientists will be to provide rules of thumb for where MPA's will be helpful. One problem with conservation is that areas set up are often done so under a panoply of reasons. However, as scientists we have to focus on a relatively few well defined objectives to help in MPA design and implementation. With respect to aims, being more specific will make MPA's more robust to falling prey to counter-productive uses. There is a ground swell in support of MPA's in the scientific community, but we still have much work yet to do to get the message out to the public.

Amanda Vincent

In the past there were three major players in fisheries management; managers, economists, and policy makers. All these approaches have failed due to the effects of uncertainty. When discussing the oceans we are dealing with a huge part of the globe, of which little is known. Given uncertainty and lack of ecosystem knowledge, we need some form of insurance, and this is what MPA's represent. Further, we need as many as we can get to the limit of public acceptance. MPA's are, however, only part of the answer we also need to look at land - water interactions since nearshore species are most influenced by the combined effects of fisheries and human activities on land. I would also echo Jim

Bohnsack's notation of a global paradigm shift in the perception of a need for MPA's. Noteable too is how it was possible in the tropics, in a place where the people were on the verge of starvation, to work towards an MPA (Handumon in the Philippines). Also significant is the tendency to crisis that is being manifested in most of the world's fisheries. Economic and ecological concerns often can not be reconciled and thus will not provide the means for developing solutions to fisheries issues. There is a ground swell of support for MPA's not limited to scientists, from users who have first hand experience of MPA's that do work, as in Handumon. By bringing these third world "believers" to the first world to talk we may be able to convince many more people in the developed world of the value of MPA's.

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DESIGN AND MONITORING OF MARINE RESERVES WORKSHOP

PROGRAMME

18TH FEB - DAY 1		
08.30am	Registration - Ralph Yourke room, Hut B-8, UBC	
09.00am	Welcome to the workshop	Dr. Paul LeBlond *COFRI*
09.10am	Introduction to the workshop	Dr. Tony Pitcher *Fisheries Centre, UBC*
Chair	*Tony Pitcher*	
09.20am	Design Principles for Systems of 'No-take' Marine Reserves	Dr. Bill Ballantine *University of Auckland, NZ*
10.00am	Fishing Effects, Recovery and the Application of Fishery Reserves to Target Reef Fishes	Dr.Nicolas Polunin *University of Newcastle, UK*
10.20am	*COFFEE BREAK*	
10.40am	The Critical Need for Marine Reserves in Fishery Management	Dr. Jim Bohnsack *NOAA, USA*
11.20am	Adaptive policies for evaluation of marine reserves	Dr. Carl Walters *Fisheries Centre, UBC*
11.40am	MPAs as tools for marine ecosystem rehabilitation	Dr. Daniel Pauly *Fisheries Centre, UBC*
12.00pm	*LUNCH*	
Chair	*Nicolas Polunin*	
01.40pm	Why do Fisheries Collapse? How can Protected Marine Reserves Help?	Dr. Colin Clark & Dr. Gordon Munro *University of British Columbia*
02.20pm	Goal Oriented Design and Implementation of Marine Reserves	Rick Starr *University of California, USA*
02.40pm	Corridor theory	Fiona Schmiegelo *University of British Columbia*
03.00pm	*BREAK*	
03.20pm	Fisheries Workers' Ecological Knowledge and the Design and Monitoring of Marine Reserves	Barbara Neis *Memorial University, Canada*
04.00pm	The importance of Socio-economic factors in establishing Marine Reserves	Dr. Amanda Vincent *McGill University, Canada*
04.20pm	Lessons for Reserve Design from Models of Adult and Larval Transport	Dr. Joshua Nowlis *University of Virgin Islands, USA*
04.40pm	Shore species	Vincent Gillette

		University of British Columbia
05.00pm	Alteration of behaviour of an exploited reef fish (Pagrus auratus: Sparidae) due to marine reserve protection	Trevor Willis *University of Auckland, NZ*
05.20pm	General discussion	

19TH FEB - DAY 2

Chair	*Nicolas Polunin*	
09.00am	Pelagic fish and Marine Reserves	Sylvie Guenette *Fisheries Centre, UBC*
09.20am	Delineating and Monitoring Habitat Management Units for a Temperate Deep-Water Marine Protected Area	Peter Auster *Stellwagen Bank National Marine Sanctuary, USA*
09.40am	Critical Habitat Assemblages for the Design and Monitoring of Marine Fishery Reserves	Richard Appeldoorn *University of Puerto Rico*
10.00am	Design and management of marine reserves on tropical reefs: conserving habitats and non target fishes	Simon Jennings *University of East Anglia, UK*
10.20am	*COFFEE BREAK*	
10.40am	Are No-Take MPA's an Alternative for Shark Fisheries Management?	Dr. Ramon Bonfil *Fisheries Centre, UBC*
11.00am	Marine Mammals and Marine Reserves	Dr. Andrew Trites *University of British Columbia*
11.20am	The San Jose' Gulf marine park	Dr. Lobo Orensanz *University of Washington, USA*
11.40am	Marine Protected Areas in Temperate Waters: Conservation of Biotic Physical Structure versus Habitat and its Production Potential	Dr. Glen Jamieson & Colin Levings *PBS, Department of Fisheries and Oceans, Canada*
12.00pm	*LUNCH*	
Chair	*Tony Pitcher*	
01.40pm	Set up working groups	
02.00pm	?	Nina Mollette Alaska
02.20pm	Diver Trail Systems	Bruce Higgins, USA
02.40pm	Delimiting and monitoring marine reserves with radio-acoustic positioning and telemetry (RAPT).	Ron O'Dor *Dalhousie University, USA*
03.00pm	*BREAK*	

03.25pm	Legal Aspects of Marine Reserves	Richard Paisley *University of British Columbia*
03.40pm	Why Involve First Nations in Marine Reserve Design in British Columbia?	Russ Jones *Haida Fisheries Program, Canada*
04.00pm	The Response of Rocky Reef Fishes to Marine Protected Areas in Puget Sound	Wayne Palsson *Washington State Dept. of Fisheries & Wildlife, USA*
04.20pm	Human Predation on Non-migratory Species in Coastal British Columbia: The Role of Marine Reserves	Scott Wallace *University of British Columbia*
04.40pm	General discussion	

20TH FEB - DAY 3

Chair *Tony Pitcher*

09.00am Working groups
- topics of working groups will be discussed on Day 2
- election of a working group chair
- all working group discussions will be documented by a rapporteur

10.20am *COFFEE BREAK*

10.40am Working groups continued

12.00pm *LUNCH*

01.40pm Working group Chairs report to plenary session

03.00pm *BREAK*

03.20pm Suggestions for Chapman & Hall book

03.40pm General discussion on the output of the workshop