Conference Steering Committee

Interim Summary

Contents

FOREWORD

Deepsea 2003 was held in Queenstown, New Zealand, from 1–5 December 2003, following a series of pre-conference workshops in Dunedin. The conference delegates represented a broad cross section of expertise with individuals from almost 40 countries attending. The conference programme was specifically developed to allow for the coordination of research and management efforts targeted at deepsea fisheries, and in this regard the conference was very successful. Your constructive debate made a significant contribution towards identifying possible future directions required for successful governance and management of deepsea fisheries.

A number of conference participants asked if a report on the conference could be provided prior to the end of the year. It has not been possible for the Conference Steering Committee to complete its report of the conference within that timeframe (the full conference report will be prepared in early 2004). In the interim, we have compiled a brief summary of Themes 1–7 of the conference (endorsed by the Conference Steering Committee), and included summary reports of the pre-conference workshops. At this stage, we have not attempted to summarise Friday morning's "The Way Ahead" session, nor synthesise material across the themes. Such a synthesis will be included in the full report of the Conference Steering Committee.

I would like to thank the members of the Steering and Programme Committees who have spent time assisting with the preparation for the conference, and the conference sponsors for their generous support.

John Annala
Conference Convener

REPORTS FROM THEMES 1–7

Theme 1: Environment, Ecosystem, Biology, Habitat, and Diversity, Oceanography

1 Papers and posters in this theme covered a wide range of topics including biological characteristics of deepsea fish, physical oceanography, oceanographic variability, habitat mapping, seamount communities, canyon productivity, deep-water biodiversity research, and covered a wide range of geographical areas and taxa.

2 The effects of a range of oceanographic factors on fisheries were highlighted. An important factor is the variability of deepsea fisheries habitats, which appears greater than has typically been assumed. The seabed interacts with currents and weather to form a variable and dynamic deepwater fisheries habitat. Variability occurs on a range of scales and this variability affects distribution and biology of deepsea fish and other species.

3 Important biological characteristics of deepsea species and deepsea ecosystems were noted. There are a wide variety of life history strategies including long-lived and slow growing. Productivity of species also varies but for many species is low, making them vulnerable to overfishing. Vertical migration of mesopelagic animals is an important component of energy transport from surface waters to deeper levels. Limits on the food availability in deepsea environments restrict productivity. Stock structure and relationships are often poorly known.

4 Advances in fishing technologies and efficiency mean that there are now few refuges from fishing for deepsea species. However, the increased precision of fishing operations may hold potential to contribute to the sustainable management of deepsea fisheries. Survival of fish that escape from fishing nets and discards are likely to be very low and, therefore, impact of fishing on target and non-target species is not represented solely by retained catch.

5 Management must recognise the variability of the deepsea fisheries habitat, although the scale and long-term nature of some environmental changes makes this difficult. Appropriate spatial and temporal scales should be used for management. It is important to adopt an ecosystem approach to address the effects of the environment on deepsea fish species and fisheries, and the effects of fishing on the environment. Such an approach should address: trophic linkages and energy flow, fishing impacts on target and non-target fish and other deepsea marine life and their habitats, importance of spatial scale, distributions of habitats and species, and production processes.Innovative uses of technology—including *in situ*, analytical, and laboratory studies—can reveal much about deepsea species and ecosystems, which are generally difficult to study. Appropriate use of this technology will allow evaluation of the effects of environmental variability on fisheries. The potential impact of research activities on deepsea habitats and species abundance should be considered. Collecting detailed information over large areas is costly, however, there are good opportunities to work with industries to collect data. A synthesis of current information programmes and projects in the area would assist the Census of Marine Life and other relevant initiatives.

Theme 2: Population Biology and Resource Assessment

7 Papers and posters in this theme drew from a range of deepsea fisheries examples to highlight current issues and developments in our understanding of population biology and resource assessments. From information presented in this theme it is possible to identify information requirements for resource assessments of deepsea fish species. Key information includes:

- Management objectives and identification of the information required to support management to achieve the objectives
- Catch data from logbook and observer programmes
- Time series of abundance indices based on a variety of methods
- Stock identity and distributional information
- Life history information (maximum age, fecundity, growth, maturity)
- Age-frequency information
- Information on density-dependent processes (recruitment, growth, maturity, etc.).

8 The papers in this theme also highlighted a number of directions for future biological investigations and resource assessment for deepsea species.

9 Assessments need to avail themselves of a range of technologies and analytical methods. They should consider explicitly uncertainties and alternative interpretations of information. However, it must be remembered that modeling is not a substitute for good quality data.

10 It will be important to obtain more information on predator-prey interactions and energy flows. For example, are deepwater species “sustained” by advected material? There is also a need to consider mixed-species fishery assemblages rather than focusing on single species assessments. There is also a need to obtain information on wide range of species—even those that are not currently subject to target fisheries. There is considerable potential to improve data collection through collaboration between scientists and industry. It will be necessary to ensure the credibility of this data, possibly through verification by observers.

11 There is a need to make more use of meta-analysis for data-poor and developing fisheries. Use of this technique may help to determine how to avoid repeating the same mistakes. Examples include predicting abundance and distribution from physical characteristics and inferring productivity from life-history parameters. It may also provide information on possible management options such as the use of deepsea MPAs. Of particular importance is the issue of what to do when there is insufficient data to provide scientific information on which to base management advice. What should managers and decision-makers do in this situation?

12 Future research will need to support the move towards ecosystem-based management, application of the precautionary approach, and multi-species management. Increased collaboration between scientists will be important if data is to be provided in a cost-effective manner.

Theme 3: Harvesting and Conservation Strategies for Resource Management

13 Papers in this theme described experiences in managing a variety of deepwater fisheries. A number of issues and problems were identified.

14 It is easy to over-estimate the productivity of deepsea fisheries—as demonstrated by abundant experience despite managers trying to be precautionary in some cases. This results in part from the lack of information about deepsea fish stocks and possibly also from the "delusional optimism" of scientists, managers, industry, and decision-makers. Institutional inertia may result in retention of existing management measures despite their poor performance.

15 Critical to management of deepwater fisheries is development of a strategy covering all aspects of the fishery from the science through to selection of policy choices and including a framework for implementation and governance. We have workable examples and counterexamples of all of these components. Implementation of a management strategy requires appropriate governance—something that is lacking in most deepsea fisheries in high seas areas. Without effective governance it will be difficult to manage or even characterize catch levels, bycatch, fishing capacity, and the effects of fishing on bottom habitats. The lack of such strategies also hinders implementation of the precautionary approach, effective science programmes, and marine protected areas. One component of implementing a management strategy is to assess the environmental risks posed by a deepsea fishery.

16 It is important that management strategies incorporate both ecosystem and precautionary approaches. A number of fishery management agencies have adopted the precautionary approach in principle but few have implemented it in a comprehensive manner. CCAMLR provides a good example of practical implementation of the precautionary approach although it should be noted that this has taken 20 years and is still work in progress. An important element of the precautionary approach is to ensure that fisheries are developed in a phased, controlled manner that is paced according to the amount and quality of information regarding the stock and the effects of fishing on the stock and related components of the ecosystem. Development stages can include setting principles, reviewing, experimenting, exploring, and establishing a commercial fishery. Possible elements of a development strategy include collecting basic ecological data, setting management objectives, establishing reference points to allow rapid response to changing circumstances, and implementing effective monitoring, reporting and enforcement mechanisms. There are a number of examples of strategies for developing fisheries.

17 Evaluation of management strategies gives the opportunity to test strategies prior to implementation. This approach involves agreeing on goals, agreeing objectives, setting criteria and comparing different strategies on a quantitative basis through simulation. Importantly, it allows stakeholders to consider the trade-offs in an explicit manner.

18 The examples considered clearly show the need for the immediate development of strong management frameworks and their wide application to deepsea fisheries. It should include a strategy evaluation, external input, risk assessment, and national and international governance frameworks for management.

19 New tools that enable better strategy assessment should be applied. These include phased fishery development strategies, ecological risk assessment, management strategy evaluation, and use of external references.

Theme 4: Technology Requirements

20 Deepsea science is largely technology driven—mostly from geophysical and military applications. We need to look at technologies from other sectors for use in fisheries. Fisheries and biological applications are often under-funded and in many cases there is poor data. The focus must be to provide the information necessary for management. Four main areas were identified where new technology can help management of deepsea fisheries: data, platforms, methods, and surveillance.

21 In respect of data, technological advances mean catch data can now be made almost instantly available. It also allows more precise information on fish abundance—both relative and absolute and additional information on species distribution (including hot spots), and benthic habitats. Fish metric information is important for management of deepsea fisheries but modelers often do not use available information. There is particular opportunity for collection of oceanographic information by collaboration with geophysics sector. The major development of stock assessment models, computer capability, and modeling wizardry has significantly changed the nature of stock assessments over the last 20 years.

22 There have been significant developments in the nature of scientific platforms available for fisheries research. Examples include:

- Instrumented commercial fishing vessels (only just started to use this opportunity)
- Autonomous Underwater Vehicles & Remote Operated Vehicles being used more extensively (expensive but costs coming down)
- Manned submersibles
- Landers and floaters
- Instrumented moorings (geophysics-oceanography)
- Satellites

23 Technological developments have allowed major advances in scientific methods and surveillance of fisheries. Geolocation has changed all types of research. There have been major advances in acoustics with multi-frequency and broadband technology and problems such as target strength, shadow zone, and species identification are likely to be resolved. Multi-beam mapping is becoming common and underwater camera and video technology are changing the way we think about deepsea habitats. Advances in capture technology (e.g., smart, instrumented nets and habitat-friendly fishing equipment) are opening the way for significantly reducing the environmental effects of fishing. Electronic tagging provides opportunities for new research, and satellite monitoring has enhanced the potential effectiveness of fisheries compliance.

24 Deep ocean science must become more collaborative: across borders, institutions, disciplines, and commercial activities. We need to be innovative to lower costs of data collection and analysis. New technology, if used correctly, can be used to facilitate stakeholder involvement in data collection such as use of acoustic surveys by commercial vessels. Validation of information provided by stakeholders should be considered. We should be wary of reliance on virtual data for management decisions.

Theme 5: Monitoring, Compliance and Controls

26 Compliance and enforcement regimes are essential components of any fishery management regime. Therefore, fisheries management plans must include compliance strategies to achieve both fisher and state compliance. Creating the necessary incentives can influence compliance behaviour. Fisher compliance is best achieved through maximising voluntary compliance and delivering an effective deterrent "the big stick". Compliance comprises more than just enforcement.

27 VMS is used to both detect and deter offending. Until recently, it was unclear if evidence from Vessel Monitoring Systems (VMS) alone was sufficient to support a prosecution. In a recent case in USA the court found VMS to be accurate and reliable. This did not prove that illegal fishing occurred but did provide a precedent for the reliability and accuracy of VMS. There is a wide range of surveillance tools, assets and technology available to detect and deter offending. Interoperability is an important consideration since this reduces costs.

29 The ability to detect and prosecute fishery offences retrospectively offers additional opportunities to detect and deter offending. This approach requires specialist skills and expertise. However, real time monitoring is still needed to detect illegal activities by fishers operating without legal authority and that do not carry VMS. Opportunities for legal fishing operators to report on possible IUU fishing operations and notify authorities may prove a cost-effective contribution to surveillance, especially in remote areas such as the Southern Ocean.

30 Compliance and enforcement is growing increasingly sophisticated as fisheries crime continues to evolve to evade regulation. As a result, specialist, multidisciplinary teams are being employed. To ensure effective investigations, compliance and enforcement officers need to work cooperatively with researchers and fisheries managers. Consideration should be given to the incentives and disincentives in fisheries management regimes since these have an important effect on compliance. It is also important to educate the judiciary on the significance of the environmental impacts in order to achieve deterrent penalties.

31 Inconsistency in sentencing is a major impediment to deterrence, turning it into a lottery rather than a certainty. One example of such inconsistency is whether or not the environmental impacts of illegal fishing are taken into account by the judiciary and the resulting sentencing levels.

32 In respect of state compliance, there is a need for officials to develop a compliance strategy to underpin international fisheries management. Three principles of compliance can be used to assess whether the regime design will encourage compliance.

- State self-interest
- States' perceptions of the perceived merit of complying
- Capacity of states to comply

33 It is important to aim for a regime that will remain equitable over time.

Theme 6: Review of Existing Policies and Instruments

34 Descriptions of management approaches for deepsea fisheries by CCAMLR, and the European Community, and orange roughy fisheries in Namibia, New Zealand, and the South Tasman Rise were presented. In all cases, management problems were identified, and some successes too.

35 CCAMLR has been working for many years on management measures for deepwater fisheries that embody ecosystem and precautionary approaches. The organization has developed practical mechanisms for applying these approaches and this work is continuing. In contrast, the European Community has only very recently attempted to manage fisheries in particularly deep waters, despite earlier scientific recommendations from ICES.

36 The South Tasman Rise orange roughy fishery management agreement contains an innovative decision rule that recognizes alternative hypotheses concerning intermittent aggregation. The default management is based on the worst-case scenario and allows for increases in catch levels should the more optimistic hypothesis appear correct.

37 Management of Namibian orange roughy was designed from the start to incorporate the precautionary approach. Catch limits were area-specific, spread of fishing effort was required, and triggers were established to respond to newly found aggregations. However, catches and CPUE declined and, over time, it was realized that even the precautionary catch limits were too high. Two of the three fisheries were closed for a period. The lesson is that extreme caution is required when using initial estimates of biomass. Future management of the fisheries is looking promising.

38 There were major changes in estimates of abundance of New Zealand orange roughy fisheries due to changes in assumptions, data collection methods, and analysis during the development of these fisheries. This led to questions about the credibility of the assessments. It was due to emerging data and analytical techniques in what were the first major orange roughy fisheries. Reliable biomass estimates were not available until the 1990s, at which time appropriate management measures were implemented. As with Namibia, despite best intentions, catch levels was set too high causing a reduction in a number of stocks to undesirable levels. Experience shows that it should be possible to manage larger orange roughy stocks sustainably, but smaller stocks may prove more difficult.

39 Meta-analyses of seamount fisheries are proving useful for setting initial guidelines for new fisheries. It was noted that information on the impact of fishing on recruitment would not be available for at least 20-30 years. The profound influences of climate and oceanographic factors appear to be at least as important as bottom topography in determining whether deepsea bottom structures support productive fishery habitat. This makes predictive modelling of likely deepsea fish habitat more difficult.

40 Experience shows that high levels of precaution are required to manage deepsea fisheries in a sustainable manner. Advice needs to properly reflect known uncertainties in the data and allow for potential unknown uncertainties. Concerns were raised whether the property rights approach in New Zealand was appropriate for orange roughy fisheries due to absence of consideration of wider environmental values and propensity to “mine” the resource due to low production rates. Both a moratorium on deepsea bottom trawling and the establishment of deepsea marine protected areas were suggested as mechanisms for protecting deepsea biodiversity.

Theme 7: Governance and Management

41 There was widespread agreement that we need to improve multi-lateral governance of the deepsea fisheries in high seas areas but varying views on the "what?", "where?", and "how?" to make improvements. In relation to "what?", a decision must be made on whether changes should focus on sustainable management of deepsea fisheries or more broadly on deepsea biodiversity and the wide range of possible activities that might affect deepsea biodiversity. It was noted that activites other than fishing also have potential to impact on conservation of deepsea biodiversity. In relation to "where?", views ranged from exclusive focus on the high seas, to the continental margins, and EEZs. It was note that conservation concerns apply to both the high seas and EEZs, but high seas areas pose greater management challenges because governance structures in high seas areas are currently inadequate. In relation to "how?", there is convergence of views that it should be done within the framework of the LOS and a variety of legal mechanisms were suggested such as new binding and non-binding agreements, guidelines, amendment of existing multi-lateral agreements (including UNFSA), UN General Assembly resolutions, new UNCLOS implementation agreements, amendment of the LOS from 2004, global fisheries bodies and utilising RFMOs.

42 Each option has advantages and disadvantages including the length of time taken to achieve an outcome, the enforceability of agreements, and the likely level of support by states. It is possible pursuing a number of options simultaneously would allow the most progress to be made. There may be a need for interim and longer-term solutions.

43 A number of suggestions were made concerning improving the performance of RFMOs. These include different forms of peer review of RFMOs, and to make an organization or body accountable for coordinating RFMOs and facilitating cooperation between them.

44 It was suggested that too few countries have signed the UNFSA & Compliance Agreement to be confident that they will be implemented, although it was agreed that broader signature and implementation would go a significant way to improve governance of high seas areas. "IUU fishing" on the high seas is not in fact illegal if the flag state has not signed the relevant regional agreement. Therefore, it may be difficult to exclude non-party fishers. The ability to coerce non-parties through the use of trade sanctions may be limited. We should look for points of leverage to deal with Flags of Convenience. The possibility of states using litigation through ITLOS or ICJ as a way of encouraging compliance was suggested.

45 It was suggested that the value of high seas deepsea trawl fisheries may not be as high as generally portrayed and that deepsea catches only make a small contribution to the world's food security. Therefore, the consequences of restricting such fishing may be relatively small overall, although for some countries it may be more significant. It was also suggested that among the wide range of issues affecting world fisheries, concern about management of deepsea fisheries is relatively recent and not the most critical. On the other hand, it was recognised that pressure on deepsea stocks is likely to continue to grow and that it is easier to put in place an effective management regime before that occurs.

46 In order to secure cooperation from non-party States it will be important to address allocation of fishing rights and benefits—especially among developing countries. Currently there is no global oversight to determine actions for priority, and to ensure benefits are shared equitably.

PRE CONFERENCE WORKSHOP REPORTS

Report on the Workshop on Management of Small-scale Deep-sea Fisheries

University of Otago, Dunedin, New Zealand
27 – 29 November

1. Background

Small-scale deepwater fisheries usually occur along the shelf break and shelf slope wherever the continental shelf is relatively narrow and such fishing grounds are accessible to fishermen who use smaller fishing boats. These fisheries are characteristically exploited using drop lines that are retrieved using hand-powered, electric or hydraulic reels. The fish catch may be iced but otherwise little other processing is undertaken at sea.

These fisheries are particularly important to small island states that have few other demersal fish resources though they are also widely found along the continental margins of many continents in tropical and sub-tropical areas. As a consequence of the limited size of slope fish habitats, the fisheries resources occupying these areas are modest in size and of relatively low productivity. Fish that are targeted by these fisheries tend to have longevities of 30 to 50 years, and while they fish may grow to relatively large sizes (50 – 100 cm), growth rates are slow.

Many of the most valuable species are found in aggregations that occur for spawning, feeding or some other life-function purpose. This will make these resources particularly vulnerable to overexploitation and rapid depletion. Further, because of the limited habitats, stock sizes tend to be small, and different spawning populations of the same species may be separated by the smallest of distances. Despite their often relatively modest resource size these resources have the potential to provide sustainable benefits in terms of employment, food security, export revenues and the creation of economic wealth. For smaller countries they represent major renewal resources.

Many countries, both developed and developing, that possess slope fishery resources have inadequate institutional and technical capacity to effectively manage their slope-water fishery resources. Compounding this difficulty is that such boutique-like small-scale deepwater resources require the same complexity of management and many of the same management costs as that associated with large scale fisheries. Data must be collected to support assessments and the provision of resource harvesting advice. Regulations must be drafted, gazetted and enforced. Most of the management problems are generic in nature and so are common to both small-scale and large-scale deep-water fisheries.

A consequence of the high costs to effectively manage slope resources is the risk, if not the reality, that such fisheries develop without an associated improvement in institutional and technical management capacity.

Addressing the problems of managing small-scale deepwater fisheries will require that economies of scale are obtained through providing generic support on a collective basis for countries facing the same management challenges.

2. Issues

2.1 Information and Data Collection

Disaggregation of data to show the geographical scale of fisheries
Because slope fisheries are small-scale in nature and are locally diverse in structure, data describing fishing activities, even for single species fisheries, must record fine-scale position coordinates to enable effective management of local-area distinct reproductive populations. Collecting such information requires the cooperation of fishermen and the regulatory ability to ensure the data are provided.

Confidentiality of Data
A common concern of fishing operators when providing their detailed catch location data is concern about how confidentially the data will be treated once it is in the possession of the management authority. Of possible concern is the sale of data by government employees and the failure to ensure that data are securely archived. These problems may be as much one of perception – but they still require appropriate management attention.

Provision of Generic Log Books and other Data Recording and Collection Logistics
Many national small-scale deepwater fisheries often involve few vessels, often less than 10 and commonly on the order of two or three. Providing appropriate log books (which must be designed and printed) for a few vessels is expensive and usually beyond the capacity of small-country fishery management authorities. This argument may also apply to other data collection requirements, e.g. other related data collection sheets and the funding of port collection activities and associated logistics.

2.2 Resource Assessment / Estimation of Resource Abundance

Knowledge on stock structure
Available information on stock structure indicates that such resources may be highly restricted in their movement if not almost territorial in the diel movements. Thus fisheries, even in small areas, will probably exploit more than one stock. Management that avoids overexploitation must account for the stock structure of the exploited populations, or adopt risk-averse decision policies that may forgo potential benefits. Resolving this problem will require taxonomic studies to investigate assumptions concerning species distributions and their sub-population structure.

Availability of accurate population biology parameters
Analysis of the population parameters of slope water species shows that results for the 'same' species from different areas may differ widely. Thus, fish considered to be the same species but found in different areas may be different species. In such cases, extrapolating in the use of population parameters will cause errors in estimates of resource productivity and what are desirable levels of resource harvesting.

Use of CPUE as an abundance indicator
The suitability of CPUE as an aid in fisheries management, in what are characteristically data poor situations, is well recognized. However, it was noted that there were many grounds for concern in the use of CPUE as a proxy for resource abundance.

i. Where CPUE data were from targeted fisheries, it was important to recognize the danger of overestimating abundance because of failures of assumptions implicit in the $F = q f$ relationship.[1]

ii. Many examples were noted of fisheries prosecuted by only a few vessels where the arrival or departure of a single high-liner radically changed conclusions about resource abundance implied by trends in the CPUE. It was apparent that the effect of a single skipper may change average fleet catch rates by more than double.

iii. These effects emphasized the need for, and care required in, undertaking trend analysis based on CPUE without accurate standardization of measures of effort. It was noted that it may be impossible to avoid at least some error from this cause.

Gear affects on measures of CPUE
Different gears and gear configurations will influence CPUE (and conclusions based on it) irrespective of any underlying change of resource abundance.

Rapid methods for estimating stock biomass
Direct estimation methods commonly used in the management of for shelf fish stocks are, by necessity, being used for slope resources. These involved estimating local area abundance, using, e.g. depletion estimates and visual observation, and then raising the estimate by the inverse of the sampling fraction. Concern was expressed about the potential for error as a consequence of:

i. the multiplicative effect of errors in the estimates

ii. uncertainty in the size of the population habitat area.

In this context, it was deemed highly desirable that

iii. decisions based on the resource abundance estimates be appropriately risk averse.

2.3 Resource Management - Provision of Harvesting Advice

Reference points
Few examples of the use of management reference points in management of slope water fisheries were available. Note was taken of the use of a *spawning potential ratio* and the use of the ration, $B/B_{MSY.}$ The existence of other appropriate reference points was also noted.

Managing species complexes – multi-species management
Experiences presented at the workshop indicated that most slope-water fisheries unavoidably caught several species or which at least two would be present in commercially significant amounts. Thus single-species approaches to resource management would sub-optimize management of at least one of the species (if not causing serious damage) while multi-species approaches would be impractical and be subject to well known constraints. It was noted that the consequences to the sustainability of less abundant species in catches must be monitored and investigated when harvesting decisions were based on one, or a few, more abundant indicator species. Risk averse management approaches included that of basing harvesting decisions on the sustainability requirements of the more slowly growing and less productive species.

2.4 Current Governance Desiderata

[1] F, the rate of fishing mortality is conventionally assumed to be linearly proportional to fishing effort.

Management of small-scale deepwater fisheries should address common current management objectives such as the "*ecological approach to management*" and the "*Precautionary approach in decision making*". Much concern was expressed about the ability of many management authorities to satisfy such requirements, particularly when these management approaches were understood at the operational level in only a general context. Of greater concern was the view that many managers lacked the resources to undertake the basic requirements for management – collection and analysis of data, ability to provide advice on a timely basis, etc.

Current management paradigms need to be considered in terms of the priorities of governance needs. It was agreed that the danger of a multiplicity of management and conservation requirements might complicate efforts at governance and be counterproductive in terms of more certainly achieving less ambitious management objectives.

2.5 Conservation of Biodiversity & Bycatch Issues

While it was recognized that managers should remain cognizant of the issues of bio-diversity and bycatch, the experience of the workshop participants was that most small-scale deepwater fisheries were 'clean' fisheries with low amounts of bycatch and lower amounts of discards as they primarily used hook and line fishing gear or fish traps.

2.6 Quality Control

Deepwater fishes, through living at greater depths where ciguatera is not a concern, do not pose any danger of toxic products. However, these fish are often caught in countries where the threat of ciguatera is common. When ciguatera-prone species are marketed in fillet form, it is extremely difficult to distinguish these products from those derived from deepwater fishes. However, when toxic product enters the market, authorities rightly ban the sale of all fish products, safe or otherwise, from the country, or region, where the toxic product originated.

This problem is regional in nature. To avoid such costly failures in quality control, a coordinated programme is required to (a), educate those in government who are responsible for undertaking quality and health control programmes to detect ciguatera-toxic product, (b) educate those in industry how to avoid or minimize the risk of exporting ciguatera-contaminated product and (c), institute regional programmes to address this problem.

2.7 Protection of Spawning Populations and Sub-populations

Commonly, many of the more valuable species comprising these fisheries depend on harvesting spawning aggregations. In such it is necessary to avoid extirpating, or severely depleting, local-area spawning subpopulations. Feeding aggregations and aggregations formed for other life history reasons, pose similar threats to resource sustainability.

2.8 Governance Concerns

Management Costs

The relative high cost of managing low-yield low-productivity deepwater fisheries and the challenges this raises for justifying the costs such management involves was noted. Various solutions to this problem were reviewed such as the following.

i. collaborating in the production of, e.g., generic log books on a regional basis

ii. regional collaboration in stock assessments

iii. analysis of the costs and benefits of management with appropriate consideration of externalities such as conservation of bio-diversity and other 'public good' expenses that may reasonably be attributed stakeholders other than fishermen.

Timely management planning
Because of their small-scale nature considerable uncertainty usually exists as to whether trial, or new fisheries, will be profitable. Thus, the incentives to start commercial fishing in a least-cost manner were recognized. This often meant the start of fishing operations before a management framework could be established to ensure:

i. data were collected during the extremely important start-up phase of the fishery when resources may be close to their unexploited, or virgin biomass, levels
ii. regulatory mechanisms were in place to control the expansion of fishing effort to ensure conservation of the stocks avoid dissipation of rent and
iii. balancing the supply of fish to market demand so as to maximize the benefits to be derived from the fishery resources.

Introduction of Rights-Based Management Practices
The potential that rights-based management approaches may offer through providing incentives for better management were discussed. There was agreement that this management approach had been successful in better achieving management objectives and ensuring sustainability of resources in a variety of other fisheries situations.

Management of Marine Protected Areas / Restricted Fishing Areas
The workshop recognized the potential and popularity of marine protected areas (MPAs) and, or, RFAs, as management and conservation tools. However it was recognized that such management methods impose significant costs for enforcement. It was noted that the use of MPAs requires genuine commitment to dialogue that goes beyond treating such consultations as part of a normative management process. As a consequence, in negotiating such zones, stakeholders may seek objectives that are inconsistent with the primary management objectives.

3. A Programme for Action

3.1 Governance Context

The governance of small-scale deepwater fisheries may be seen within the context of a few critical elements.

i. Deepwater fisheries prosecuted along continental slopes by small-scale fisheries are characteristically small, often with sustainable yields of only a few hundred tonnes.
ii. Commercial fisheries for such fisheries rely on aggregating behaviour of the fish, often for spawning but also for feeding or some other reason.
iii. Thus, such fisheries are particularly vulnerable to rapid depletion, at times even before it is realized that management action is necessary or possible.
iv. Despite their small size, management of these fisheries requires most, of not all, of the activities required for management of large-scale fisheries. Therefore, in many cases, cost-benefit ratios of management interventions are high and many countries will have great difficulty in funding the research and management activities required to ensure their fisheries remain sustainable.

The workshop identified a number of necessary or desirable actions.

i. The need to adequately document exploratory fishing and commercial fishing activities, particularly in the early stages of fisheries to facilitate subsequent management efforts.

ii. "Old" date should be secured and entered into databases to ensure that the information is not lost, especially where operations cease and interest is diminished or lost in the fishery.

iii. Generic Log Book and other Data Recording Aids - IGO and regional fisheries bodies should undertake or assist in the preparation of generic data recording aids – log books, data recording sheets. Thus recording aids would thus be quickly available to management regimes where such fisheries were currently being exploited or were starting to develop.

iv. Data collection programmes require resources to enter the information in to computer data bases – this requires adequate funding. If data are not in a readily accessible form, they are of little use.

v. Managers must convey to fishermen the expectation that data **must** be provided, using either incentives or penalties to ensure compliance.

vi. Managers should consider the option of rotational harvesting where the small scale nature of the fishery may prevent other means of profitably exploiting the fishery

vii. Appropriate management protocols must be established. These must recognize the importance of the spatial scale of the fisheries and the likelihood that even spatially proximal fisheries may be exploiting different stocks.

viii. Management will inevitably be multi-species in nature and may focus on one or two indicator species. This requires appropriate resource modelling cognizant of the possibility that optimal exploitation of one or a few species in the fishery may result in depletion (or under-harvesting) of others.

ix. Attention should be given to current fashionable approaches in fisheries management and those that are appropriate be adopted. Effective consultation with those directly affected is recommended to maximize the chances of industry support.

3.3 "Rapid" Management Approaches

Note was taken of the forthcoming workshop[2] to be hosted by the Western Pacific Fishery Management Council, Hawaii, and to be held in January 2004. The outcomes and success of the workshop should be evaluated to determine if there would be benefits in duplicating the programme in other areas or supplementing any of the workshop activities.

[2] Workshop on the Development of Bottom Fish Resource Assessment Methodologies for the U.S. Central and Western Pacific Fisheries. Western Pacific Fishery Management Council, Hawaii. 13 – 16 January 2004.

Report of the FAO Workshop on the Assessment and Management of Deepwater Fisheries

27 – 29 November 2003
Dunedin, New Zealand
(Revised 5 Dec 03)

The purpose of this workshop was to discuss technical issues related to the assessment and management of deepwater stocks. This report, prepared by session chairs, summarises discussions and considerations of possible ways forward. A list of participants, the agenda and abstracts are appended.

Session 1- Abundance Estimation

Presentations in this session covered aspects of trawl, acoustic and egg surveys; the use of catch per unit effort (CPUE) data; and tag and recapture data. The presentations referred to ongoing work in the northeast, northwest and southeast Atlantic, the Ross Sea and waters around New Zealand. Species covered included orange roughy, redfish, smooth oreo dory, Antarctic toothfish, and a wide range of species from the northeast Atlantic.

In discussion, the question arose as to what made abundance estimation of deepwater and deepsea species special (or not). For some deepwater species, such as orange roughy, it was noted that they have low productivity, are highly aggregating, often but not exclusively around underwater features, and that they react to survey and fishing gear not just at the time of capture but also over longer periods. The reasons for aggregating behaviour (e.g. suitable conditions or learned behaviour) were discussed but no conclusions were reached. It was recognized that more work on fish behaviour is highly desirable. It was also noted that low productivity in deepwater may not be universal. Some "deepwater" species (particularly those with long pelagic phases, strong diurnal migration patterns, or preferred depths above about 800 m) have moderate levels of productivity.

Egg surveys were discussed but were considered unlikely to be a good means of estimating abundance for a variety of reasons. Problems with the use of CPUE to index abundance were noted (also in Session 3). Trawl and acoustic surveys were viewed as potentially the most useful methods for estimating abundance. Both could be used to create relative abundance indices, although the use of acoustics is difficult even for relative abundance estimation when the target species is also associated with other species during the survey period. Both methods present problems with respect to the estimation of absolute abundance. For acoustics, difficulties include target strength identification and target species identification. For trawl surveys, estimating catchability is problematic.

The use of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) was discussed. The potential to use such technology in its own right for abundance estimation, or in experiments to estimate catchability of trawls was noted.

Most participants agreed that technical work alone was not sufficient for the many problems associated with abundance estimation to be solved. Rather, a greater understanding of fish behaviour (natural and in response to fishing and research vessels and gear) is needed. In particular, further work is needed on factors influencing aggregating behaviour. ROVs and AUVs may offer opportunities in this respect.

Other issues of concern included those relating to stock structure, distribution and movement. Obtaining some form of relative or absolute abundance estimates may be feasible, but their validity will depend on appropriate survey designs that take account of underlying distributions and movements.

In general, it was accepted that there is no one best way to estimate abundance but that often a range of methods analysed individually or in combination could offer the best way forward. In some areas, trawl and acoustic surveys are in regular use and the estimates and indices derived are used in stock assessments with varying degrees of success – often depending on the availability and quality of other data sources.

The costs of surveys are high and it was recognised that the cost-benefit of surveys was a consideration in deciding on best ways forward in any circumstance. Dedicated research cruises undoubtedly provide the best means of providing abundance estimates, and can often undertake a wider range of associated work at the same time. However, the use of industry-based surveys (especially acoustic surveys) may provide useful inputs for stock assessments.

Session 2 – Biology and Age and Growth

This was a varied session, with nine papers covering a wide range of topics. These included biological characteristics of deepwater fish species in the North Atlantic, New Zealand and Chile, stock structure, age and growth, climate change effects, and relationships between oceanographic features and fisheries. In addition, IFREMER researchers presented a video on an ROV cruise that examined aspects of catchability between video and trawl catches.

Given the variety of presentations, and the time available, the discussion was limited and focused on key gaps in knowledge.

1. Biological characteristics can vary widely between species, but many feature high longevity, slow growth rates, high age at maturity and low fecundity. Session participants recognised that many (but not all) deepwater species have relatively low annual production to biomass ratios. For such stocks, this means that sustainable yield levels are relatively low, and recovery from depleted states can be slow.

2. Routine data collection and analysis is critical, and this should not be restricted to data needed for immediate stock assessment purposes. Biological characteristics (e.g. size-at-maturity) can change as fish stock size changes. Such characteristics should therefore be monitored as ancillary inputs to evaluating stock status. Density dependent effects need to be considered in the stock assessment, as estimates of catchability, maturity, growth rates, spawning success and other factors may change.

3. Stock structure is generally poorly known for most deepwater species. Their depth means that direct methods to monitor distribution and movements (like tagging) can rarely be applied. Methods to determine stock relationships were not reviewed, but the importance of knowing stock boundaries to plan research and management was acknowledged.

4. Biological parameters are often poorly known, and variable. It was noted in discussion that several deepwater species (e.g. orange roughy and hoki) do not spawn each year. This means that reliance upon gonad stage data to determine age at maturity, or the maturity ogive, may be misleading. In the case of orange roughy, there is a transition zone in the otolith that appears to mark the onset of spawning. However, the frequency of spawning is important, in terms of the proportion of the population available to the fishery or the biomass survey each year, particularly if the proportion varies between years.

5. Ageing is a requirement for monitoring population status, as well as evaluating changes over time. Technology has given a lot more confidence to the interpretation of otolith rings as annual, with chemical and radiometric methods and improved validation. In the absence of initial data, general age and growth estimates may be available from other areas or fisheries. Production ageing is still needed, however, in the major fisheries.

6. There is a pressing need to try to understand the ecological processes affecting biological variability. Without this, predictive modelling can be misleading. At the least, consideration should be given to trophic interactions and links between deepwater demersal fish and the mesopelagic energy source.

7. Stock-recruitment relationships, and levels of recruitment, are poorly known for most, if not all, deepwater species. Yet this is important for understanding changes in stock size, and for the management of sustainable fisheries.

Session 3 – Assessment of Deepsea Fisheries

A total of seven papers were presented in this session; however, two of these were more closely related to the topic of Session 4 (below). Topics covered in the other five papers included hyper-depletion in orange roughy fisheries (the situation where commercial CPUE decreases at a faster rate than abundance itself), and assessment methodologies and results for Namibian orange roughy, Patagonian toothfish, New Zealand hoki, and northeast Atlantic (ICES region) deepwater sharks.

Based on the presentations and the outcome from ensuing discussions, session participants identified a number of key data gaps and data needs for stock assessments of deepwater species. The three most important data needs, in order of priority, are:

1. Catch data – at the minimum, it is essential to know the amount and location of fisheries catches. This needs to be collected at an appropriate spatial scale given the localised aggregations formed by many deepwater species. It would also be useful to collect data on length frequency distributions of target species, and catches of by-catch species;

2. Valid indices of relative abundance – preferably, these should be fishery-independent but, realistically, they are likely to be fishery-dependent commercial catch rates. It will be extremely difficult to develop "valid" interpretations of the indices at the beginning of a fishery; however, programmes should be developed to collect data on relevant factors such as the relationship between commercial CPUE and abundance, selectivity by fisheries, stock boundaries, migration patterns, and the dynamics of aggregating behaviour; and

3. Estimates of absolute abundance – ultimately, these are needed to estimate long-term sustainable yields. They can be obtained either from a fishery-independent survey that

provides estimates of absolute abundance (e.g., an acoustic survey) or an assessment model that estimates absolute abundance based on catch and relative abundance.

Other data needs that may be crucial for some stocks, and will almost always improve the accuracy and precision of assessments if available, include:

4. Relative or absolute estimates of recruitment;
5. The relationship between stock size and recruitment; and
6. Age data.

Regarding the importance of ageing fish, although age information is essential for estimating population productivity, session participants concluded that it is less important to devote resources to ageing stocks for which age and growth information already exists for other stocks of the same species. Estimation of ages – which enables estimation of growth rates, natural mortality, and sometimes recruitment – was crucial for determining sustainable yields for orange roughy fisheries when they were first initiated. It wasn't until development of a validated ageing system that it became evident that orange roughy is characterised by unusually low growth rates, low natural mortality, high age at maturity, and high longevity. Ageing of other orange roughy populations has demonstrated some differences in these life history parameters, but such differences may not be sufficient to justify initiation of major research initiatives on ageing, particularly if resources are limited. It may make more sense to give higher priority to other data needs, such as the need for abundance indices, and simply adopt the age-length keys, growth parameters and natural mortality estimates from a similar stock.

Finally, in order to satisfy wider objectives that are often mandated by international agreements or national policy, it may be necessary to augment existing, or to set up new, programmes to provide data on:

7. Ecosystem considerations, such as by-catch species, other associated species, and effects of fishing on habitat.

Session participants also briefly discussed the situation of multi-species fisheries for which it is extremely difficult to obtain species-specific data on catch and abundance. These may need to be assessed and managed as species assemblages, with application of the precautionary approach with regards to setting catch or effort limits.

Session 4 – Management of Deepsea Fisheries

Presentations in this session covered descriptions of management arrangements for high seas orange roughy, deepsea and deepwater fisheries in New Zealand; development of high seas fisheries in the western Indian Ocean; and frameworks for management advice including reference points.

Discussion time did not permit consideration of all issues. Some issues (e.g. the need for new legal instruments and the use of MPAs in fisheries management) were therefore intentionally deferred, as it was thought highly likely that they would receive much attention at the Deepsea 2003 conference to be held the following week. Discussion was focused on four main areas:

1. Biological reference points: Session participants discussed differences between advisory

frameworks based on control rules using target and limit reference points, and management procedures that consider the assessment and management systems in concert using various performance measures to evaluate outcomes. In general, the use of evaluation approaches to derive robust management procedures is seen as desirable. However, in the case of many information poor fisheries, the feasibility of doing this is questionable (see 3 below). Appropriate target reference points were discussed and it was noted that for many low productivity stocks, target biomass levels used for management purposes vary from about 30% to 55% or higher of the unexploited level. It was suggested that rather than setting targets, a more useful approach may be to concentrate on avoiding a lower biomass (typically 20% of unexploited) with a high probability (typically 90%). Depending on the uncertainty inherent in any assessment and projection, the implied target biomass would vary but would likely fall within the range of typically adopted targets. The use of fishing mortality reference points was briefly discussed. Some scientists consider fishing mortality reference points to be superior.

2. The need for an ecosystem approach to fisheries management: It was generally agreed that the single most important first step in moving towards an ecosystem approach to fisheries management is to get single species fishing mortality under control and, in particular, to reduce it to appropriate levels where necessary. In order for this to happen, it is essential to develop better integration of assessment and management of marine resources with appropriate management frameworks that ensure single stock management whilst taking account of wider environmental or ecosystem issues.

3. Data-poor situations: There was considerable discussion on how to deal with data poor situations. In many cases, there may be little or no information available to set initial catches or to assess stock status or estimate reference points. Adaptive management may be useful but there is a tension between adaptive management procedures that probe for information (and therefore require that catches be high enough (or low enough) to create contrast in datasets) and the adoption of a precautionary approach (which would suggest low catches for low productivity stocks; see 4 below). Evaluated (adaptive) management procedures may also be problematic in that as information rapidly accrues, the assumptions used in modeling may quickly become untenable and lead to the need for re-evaluation. Discussed here and in Session 2 was the possibility of conducting meta-analyses as a means of garnering the maximum possible benefit from the dispersed global data on deepwater stocks, fisheries and associated habitats. Such an analysis could provide a means for setting initial catch limits for new fisheries as a basis for adaptive and/or precautionary management.

4. Precautionary Approach: The approach of treading carefully and restricting catches in early fishery phases was advised. In New Zealand, new orange roughy fisheries are voluntarily capped at 500t while information is gathered. CCAMLR does not allow new fisheries unless they are explicitly permitted, with permit conditions such as data collection requirements. Although there was general support for such approaches, it was pointed out that the approach has generally failed to halt apparently rapid declines in biomass of low productivity stocks for which it appears that initial biomass has almost invariably been overestimated.

General Discussion

The workshop considered the potential value of a hypothetical RFMO: “The Commission for the Conservation of Deepwater Fish Stocks”. There was no discussion on the logistics of creating such an organization, but rather whether or not it could have merit from a scientific and management viewpoint. It was recognized that to have merit, such an organization would need to be global and that it would need to consider a carefully agreed set of stocks. Although such an organization would have no ability to manage stocks within national jurisdictions, it could serve a management purpose for high seas fisheries by, for example, setting catch limits; determining data collection protocols, research planning and coordination; and providing compliance regimes. It would also provide a forum for the better exchange of data, technologies and assessment-management approaches. This would be highly advantageous given the lack of data or information on deepwater fish species globally, as it would enhance the ability of scientists working on such fisheries to exchange information and views.

A related proposal was presented during Session 3. It was suggested that a network be established for the investigation of deepsea fisheries and resources among scientists belonging to APEC economies. Again, workshop participants generally supported the concept, but did not discuss the logistics of such an endeavour in detail.

Overall, whilst recognizing the wide variety of life histories of deepwater fish species, workshop participants highlighted the observation that many species have a low productivity to biomass ratio and will therefore also have low sustainable yields. As for all fisheries, the pressing need is for complete and accurate catch and effort information, ideally at a highly disaggregated level, together with valid biomass indices (relative at least and ideally absolute if possible). Abundance estimates may be based on suitably modelled commercial catch rates (CPUE), or on trawl, acoustic or possibly visual techniques. The integration of commercial-based and research vessel-based data collection schemes needs further investigation. In addition to basic catch data and abundance information, early fishery and ongoing otolith sampling should be undertaken to give the potential of ultimately incorporating age information into assessments.

Whilst stock assessment or management procedures may be able to provide good bases for decision-making, the collection of appropriate ancillary biological data to be used in more comprehensive analyses may be crucial for elucidating patterns in population distribution and viability (e.g. contractions or expansions of spatial or temporal distribution).

The need for further work on stock structure was also identified as another key area of research.

Summary: Best Ways Forward

Workshop participants identified the following eight actions as the main immediate priorities for improving the assessment and management of deepsea resources.

1. Formulate management objectives more explicitly;

2. Incorporate biological reference points and/or performance measures into management procedures;

3. Implement management systems that promote data collection (e.g. adaptive management);

4. Conduct cooperative research with the industry and other stakeholders;

5. Implement management procedures that don't have high information needs (e.g. design "triggers" for opening and closing fisheries);

6. Integrate assessment and management (using, for example, Management Strategies Evaluation (MSE) techniques);

7. Ensure use of collective experience world-wide (using, for example, "meta-analyses"); and

8. Adhere more closely to the precautionary approach.

Conclusions of Deepsea Chondrichthyan Workshop

University of Otago, Dunedin, New Zealand
27 – 29 November

Background

Deepsea chondrichthyan fishes are defined as bathyal species, occurring deeper than 200m (the shelf break). They are characterised by low growth rates, reproductive rates, high longevity, and low metabolic rates. This means that certain deepsea chondrichthyans are more vulnerable to over-exploitation than perhaps any other marine species group, and certainly more than those that occur in shallow water. Preliminary results from the IUCN Shark Specialist Group's Red List assessments indicate that commercially-exploited species of deepsea sharks are among the marine taxa at highest risk of extinction.

Although the world's continental slope habitat represents only a relatively small area of the oceans compared with shelf and pelagic habitats, it supports the greatest diversity of chondrichthyan species. Most occur within a limited depth range and have a much more restricted distribution than species in other habitats.

Most deepsea chondrichthyans are taken in multispecies fisheries or as bycatch in target fisheries for more abundant, valuable teleosts and crustaceans. There are some important target deepwater chondrichthyan fisheries, some of which are driven by international demand for their products (particularly liver oil). Although most attention is focused on sharks, batoid and chimaeroid biodiversity and fisheries are important in some regions.

Fisheries

Those deepwater chondrichthyan fisheries for which baseline data are available have been unsustainable. Unfortunately, however, data are only available for a very few fisheries. Case studies presented at the workshop (e.g. Australia, Namibia) demonstrate that small numbers of vessels operating target fisheries can seriously deplete previously unexploited stocks in just a few years of fishing. While localised fishing pressure depletes local stocks rapidly, adjacent populations may, in some cases, be relatively unaffected. Recovery of depleted stocks is likely to be extremely slow because of these species' life history constraints.

Although most target fisheries for deepsea chondrichthyans are short-lived because of this pattern of rapid depletion, these species will still continue to be taken as bycatch. Mixed deepwater fisheries are, in most cases, not managed for chondrichthyans, which may potentially be extirpated by fisheries supported by more abundant or productive teleosts or invertebrates.

These results highlight the importance of obtaining baseline data prior to the development of new deepwater fisheries in previously unexploited areas. This can only be achieved by significant investment in research or by monitoring the very early stages of carefully regulated exploratory fisheries.

Species composition and stocks

Much of the world's oceans remain unexplored and regional bathyal faunas remain undefined.

Species composition in deepwater fisheries is incompletely known. Chondrichthyan taxonomy is uncertain and recording often poor and inaccurate. This is partly due to the lack of up to date identification tools and inadequate monitoring. In many chondrichthyan fisheries there is little or no effort to undertake species identification or monitoring at species level. Monitoring for species, sex and size composition at landing sites is hampered by the landing of 'trunks' without heads, fins or claspers, or livers and fins without carcasses; these data are essential for stock assessment and management.

Complete stock structure and distribution is unknown for all species of deepsea chondrichthyan fish; and completely unknown for most species in most regions.
Some species are endemic to small areas and do not range far. Others are apparently very widely distributed and highly migratory, but because different sexes, reproductive stages and age classes are often segregated in separate areas and at different depths, it is relatively easy to remove a whole vital section of the population (e.g. all pregnant females) in a relatively localised fishery. Different States may also catch different parts of the stock, different sexes or life stages, and set their own quotas and management measures without considering what is happening to the stock in other parts of its range.

Recommendations for fisheries management and monitoring

Although this group of fishes does not require any unique management measures compared with those applicable to other species, management is more challenging because the available stock and sustainable harvest potential is so much lower for all chondrichthyans, even more so in relatively unproductive deep water. Management is made more complex by the international or high seas location of some fisheries, where state fisheries management may not be applied other than by controls over flag vessels.

Given their vulnerability, it is absolutely essential that a precautionary approach be taken for the management of deepsea chondrichthyans.

Adequate monitoring of catches and landings is essential for effective management of fisheries. This requires the following actions:

- Recording of reliable species data in catches, landings and trade.
- Preparation of good identification guides and wider use of these in observer programmes and landing sites monitoring.
- Improved use of observers in commercial fisheries
- Development of standard carcass forms: Sharks should be landed with fins attached in order to improve reportings of landings and facilitate identification at species level. Batoids should be landed with wings attached. Trunks should be landed with livers. Reporting should include both species and their products.

Educational programmes are needed to explain to managers and stakeholders why far more careful management is needed for this group than for other taxa.

In the absence of resources for research, it is particularly important to involve fishers in the monitoring and management of the resource and to take full advantage of data collection on board commercial vessels.

Given the extremely low productivity of this taxonomic group, it will be necessary to adopt a fishery area management approach. This will require a thorough understanding of the relative productivities of teleosts and chondrichthyan species and their critical habitats. It is important to implement a suite of management tools, which should include effort reduction or restriction and the establishment of large closed areas covering a maximum depth range on the slope, in order to yield optimum benefits for both target and bycatch species and biodiversity conservation.

Ideally, deepwater fisheries should not be initiated until fisheries-independent surveys have been undertaken in order to produce a baseline, stock assessments and management advice. In those States (the majority) where resource limitations make this approach impossible, it is essential to minimise the impact of the early stages of the fishery and carefully monitor developing fisheries from the outset, ensuring that managers and scientists work closely with fishers to obtain maximum data from exploratory fisheries.

Closed areas can be an important fisheries management and biodiversity conservation tool. If closed areas are to be used, managers ideally need to understand stock structures, movements and long term migrations to determine critical habitats, how large an area should be closed, and whether there is scope for seasonal closures as a management tool. Their establishment must be accompanied by baseline surveys (e.g. population size, structure) at time of closure in order to be able to determine the effects of closure. Where such surveys are not possible, the establishment of large closed areas (particularly if possible before fisheries become established) may be very important for species conservation and reducing the overall impact of fisheries on deepwater stocks.

Provision of regional workshops for transfer of expertise, training in appropriate monitoring tools and methods, are important for training scientists and managers in the management of these vulnerable species.

Recommendations for Research

An improved research baseline is essential for management of deepsea chondrichthyans. This requires significantly increased research investment, including fishery-independent surveys, more use of fisheries data, tagging, telemetry, genetic analysis *etc*. Effort needs to be focused on the following subjects:

1) Taxonomy

Many species are still undescribed. Large numbers of sympatric species complexes are not yet resolved. These issues must be resolved in order to prepare the basic identification guides necessary for accurate data collection and to define species and stock distribution. Must have:

- More collection and better curation of specimens using standardised methods
- Morphometric data collection and analysis
- Photographic records
- Genetic analysis as a supplement to other techniques

2) Life history

- **Age and growth**. Techniques for determining age and growth are problematic and data largely lacking for most deepsea species. Validation so far not achieved for any species and may not be possible for some using current techniques.

- **Reproductive parameters**. Reproductive parameters (annual fecundity, maternity ogives) are essential for the simplest modelling but largely unknown for most species. Annual production of young/eggs, duration of development and interbreeding intervals are all needed, but extremely poorly understood. These data are important to determine recruitment and required for construction of basic demographic models, but are available for only a small number of species. Information necessary for stock assessment (time series of abundance and extracted catch) is incomplete or absent for all species.
- **Trophic ecology**. Determination of tropic level is needed to define community structure and provide data for ecosystem models (which should distinguish clearly between chondrichthyans and teleosts). Include consumption rates and interspecies dynamics. Food habits are known for some species, but not for most, while ontogenetic, regional and seasonal variation is largely unstudied. Partitioning between co-occurring species is also often overlooked and unrecorded. Basic metabolic studies necessary for trophic modelling are wholly absent. More direct observations of behaviour and movements from submersibles.

- **Physiology.**

3) Stock structure

- Identify unit stocks
- Define geographic and depth distribution and movement patterns
- Investigate geographic segregation by size, sex and ontogenetic stage
- Determine proportion of stocks occurring outside fished areas
- Modelling.

Ecosystem models require far better understanding of environmental parameters associated with different species (productivity, temperature, depth etc.), life histories, productivity etc.
Research tools include population genetics, telemetry, pop up tags, sonic tags.

4) Bioamplification and bioaccumulation

Much higher natural levels of mercury in tissues; much higher levels of PCBs and other toxic substances regardless to proximity to sources of anthropogenic contamination. Significant bioamplification occurs because of high trophic level and bioaccumulation through long life-span. Average contamination is often more than double WHO standards. Squaloids, in particular, appear to accumulate particularly high levels of contamination. Studies in both the northern and southern hemisphere have identified high levels of reproductive malformation (hermaphroditism) in a number of species of deepsea sharks.

Report of the Workshop on Bioprospecting in the High Seas

University of Otago, Dunedin, New Zealand
28 – 29 November 2003

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A group of delegates met at the University of Otago in Dunedin to discuss bioprospecting in the high seas. The objective of the meeting was to identify and discuss the nature of current activities, including sustainability, limits to growth, timelines, regulatory requirements and potential environmental consequences. The program and the list of participants are attached as Appendix I and 2 respectively.

OVERVIEW OF PRESENTATIONS

Science

Research scientists working on sponges, microorganisms and fish gave an overview of their experiences with regard to sample collection, laboratory investigation, findings and knowledge of the bioprospecting industry.

The group heard that the oceans are the largest ecosystems on earth with immense biodiversity already known and thousands of new species being discovered as marine scientific research intensifies. Novel marine biodiversity is concentrated most specifically in four areas or *hot spots*: coral and temperate reefs, seamounts, hydrothermal vents and abyssal slopes and plains. These concentrations are largely untouched, despite being highly sought after by scientists, governments and companies that have speculated about the immeasurable pharmaceutical potential of novel structures. However, each of the *hot spots* also has idiosyncrasies that make it particularly vulnerable to other ocean uses such as trawl fishing.

Case studies of work in progress highlighted the nature of some current activities. A compound, IPL576,092 based on the sponge steroid *contignasterol*, completed US Phase I trials as an asthma drug in 2000. Cytotoxins from deep-water sponges found on the Chatham Rise 400 km off the New Zealand coast are also under investigation. Other work in progress involves the *Conus* venoms (the source of the first of the modern marine-based drugs and cytotoxic organic extracts); cold adapted enzymes from deep sea microbial extremophiles in the Southern Ocean and deep sea extreme environments such as hydrothermal vents; and genes for "anti-freeze" proteins from fish (Southern Ocean). The difficulties with assay and the long time frame of investigation of potential leads were explained. In the case of fish proteins, for example, it was noted that the proteins could be replicated from genetically modified organisms and did not require the direct harvesting of fish. In a similar fashion, most bacteria can be cultured. Sponges have historically been harvested, but it is also possible to culture them under certain conditions in a natural environment.

Potential applications from marine-sourced material include:

- Pharmaceuticals
- Enzymes
- Cryoprotectants
- Cosmaceuticals
- Fine chemicals
- Agrichemicals
- Bioremediators
- Nutraceuticals

Industry

A study of small-molecule new chemicals introduced globally as drugs between 1981-2002 showed that 61% can be traced to, or were inspired by, natural products (Newman et al 2003a). This figure rose to 80% in the year 2002-2003. Compounds from natural products are considered to be more agreeable to consumers and two-thirds of the anti-cancer drugs, for example, are derived from both terrestrial and marine natural products. Marine-sourced material (eg. from sea water/sediment) has a higher chance of a successful commercial *hit* because of its mega-diversity (using the formula: samples x biodiversity x assays = probability of a hit).

The USA National Cancer Institute (NCI) was one of the first organisations to begin systematic large scale collection of marine invertebrates and in the mid-1980s formal collection programs were initiated to protect access to the original material (Newman et al 2003b). The cost of sample collection, laboratory investigation and further downstream processing is very high, and there is only an estimated 1:50 chance of successfully producing a marketable product beyond a pre-clinical lead. For example, one kilogram of shallow water marine invertebrate collected, prepared for sampling, identified and transported costs approximately US$1,000 per sample. From the one-kilogram sample, only approximately 20-50 grams of liquid and 4-15 grams of organic material will be extracted, costing approximately US$200 per sample. Subsequent testing (in the 60 cell line screen, for example) may cost as much as US$300 per sample. If all associated costs (laboratory staff and equipment, for example) are included, the total rises to tens of thousands of dollars per sample. However only about 10% of samples are eventually determined to be 'active' (these figures refer to shallow water collections. Newman et al 2003b).

Sampling from shallow water is economically more viable than from the deep-sea, from which specimens may be difficult to retrieve. Early NCI collection programs used submersibles and ROVs, but the cost was too high and their deep-sea program was suspended. Others have had more success. Harbour Branch Oceanographic Institution does use manned submersibles and have successfully synthesised a molecule, *discodermolide*, from a previously undescribed deep-sea sponge. Another compound, *halichondrin B*, has also been isolated from a sponge species by a New Zealand joint venture. In the latter case, one metric tonne of sponge was harvested, which yielded 300 mg of pure *halichondrin B*. This process cost approximately US$500,000 (Newman et al 2003b:5-7).

The schema below represents the NCI approach to the processes of biological prospecting.

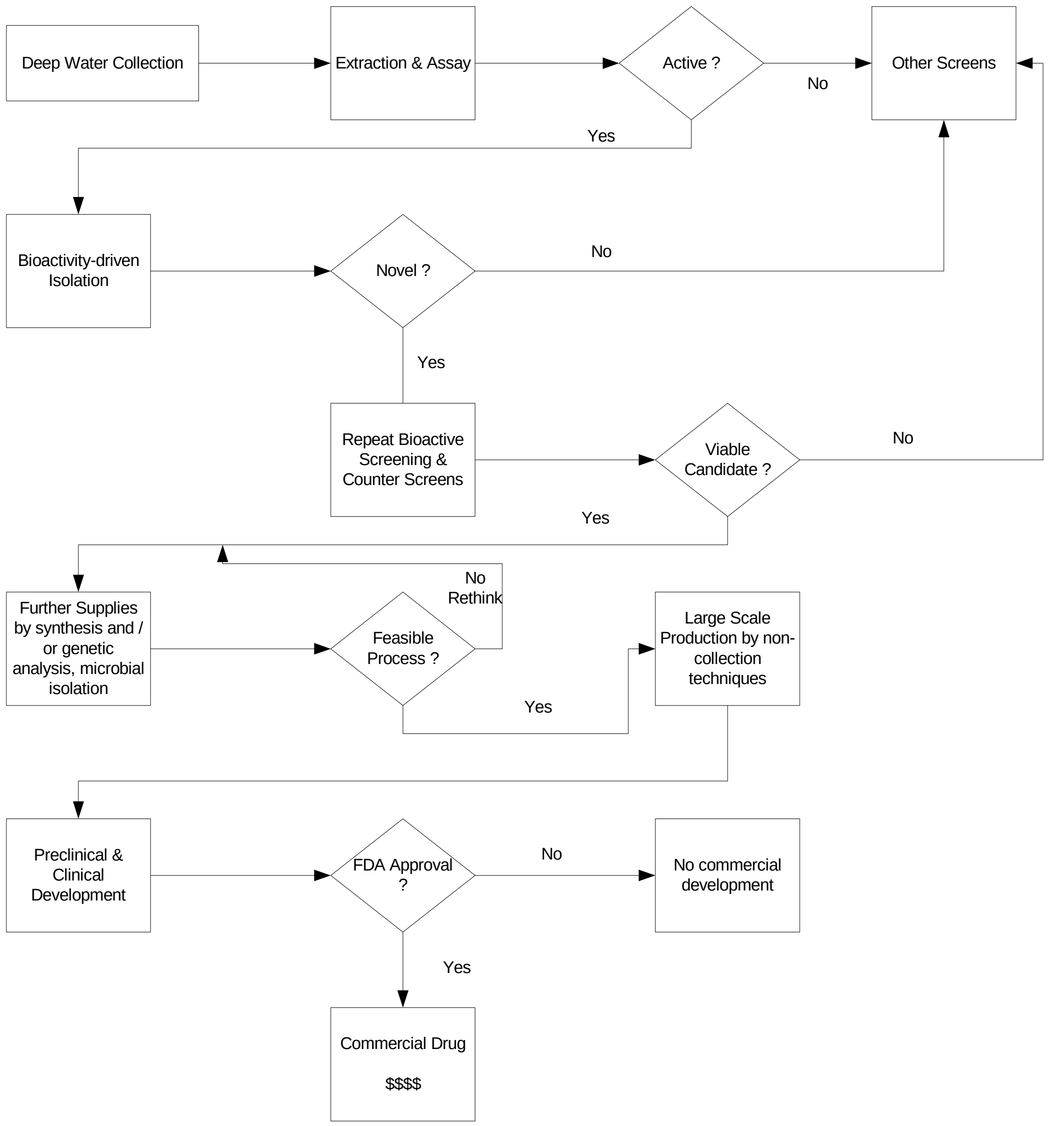

Figure 1: NCI schema of Bioprospecting Process (from Newman 2003b:12)

It is important to note that current US legislation prohibits government institutions from "encumbering a future invention" (Newman et al 2003b:4) therefore in terms of benefit sharing, they are prohibited from entering into royalty agreements in the phases of sample collection and testing. This may bring the government institutions into contravention of the Convention on Biological Diversity (CBD) if the US Government ratifies it. NCI approaches benefit sharing in a novel way, begun prior to the CBD but in many ways in conformity with the principles contained therein. It involves a 'letter of collection' agreement, which requires absolutely that any licencee of an NCI patent must involve the country of origin in the further development of the compound (Newman et al 2003b:4). Despite the argument that the acts of collection and routine testing of extracts are not inventions in themselves, institutions such as NCI cannot infringe US law by collecting in some countries where the CBD (and its royalty provisions) would apply. Another significant point is the fact that no sample collected by an NCI collector may be analysed by other researchers.

Ongoing access to material (ie. because it cannot be replicated in a laboratory or because further samples are sought) is of primary importance. Aquaculture and mariculture have both been used successfully in some cases (eg. shallow-water sponges).

Industry presentations placed great emphasis on the odds of success, with a figure of approximately only 1-2% of preclinical *candidates* actually becoming commercially produced.

Law and Policy

Presentations were made giving an overview of international law and international obligations, protecting the biodiversity of hydrothermal vents and the unique situation in the Southern Ocean. Relevant laws include intellectual property laws, environmental protection and biodiversity conservation laws, the United Nations Convention on the Law of the Sea (LOSC) and Antarctic-specific laws.

Regarding patentable inventions (ie. products and processes that provide a technical solution to a technical problem), it was noted that patenting involves elements of novelty, inventive step and industrial applicability (or utility: ie. can be commercialised). A grey area within the law, however, is the patenting of living organisms and products of nature. Whilst products of nature are currently excluded, even minor modification that introduces the elements noted above may allow patenting to proceed. Patentable biotechnological inventions may include genetically modified plants, animals, and microorganisms, and isolated, synthetically produced, cells, proteins and genes of known function. Key points for discussion were the potential for conflict between sovereign rights over resources and patent rights over inventions; bioprospecting and biopiracy, traditional knowledge and novelty (eg. does traditional knowledge compromise the element of *novelty*?); and equitable access and benefit sharing (consistent with the Convention on Biological Diversity but see earlier note regarding US legislation).

With regard to hydrothermal vents, the applicable legal regime, if any, to monitor activities and provide protection and regulation will depend on the location of the vents. If they are located within territorial waters and exclusive economic zones (EEZs), coastal state jurisdiction prevails over access to and use of genetic resources. If they are located on the continental shelf beyond the EEZ, the coastal state can only regulate access to sedentary species. If hydrothermal vents are located outside national jurisdiction, access is largely free and unregulated except where states regulate the activities of their nationals, consistent with the Convention on Biological Diversity and other international law (see Leary 2003). Discussion ranged across broad areas of potential international regulation, including expanding the mandate of the International Seabed Authority to include the superjacent waters above the Area.

It was acknowledged that the Southern Ocean is a special case because of the overlap of international law and Antarctic-specific law, as well as the unproven nature of sovereignty over the continent and, thus, the marine areas. This complex case highlights how the traditional freedoms of the sea have been modified in the Antarctic. A regional fishery body - the Commission for the Conservation of Antarctic Marine Living Resources - regulates the conservation and rational use of all Antarctic marine living resources (not including whales and seals). Furthermore, an environmental protocol - the Madrid Protocol to the Antarctic Treaty - requires environmental evaluation of all activities in the Antarctic Treaty Area (ie. south of 60° South) prior to the operation being undertaken. Activities in this case include marine scientific research. The initial phase of bioprospecting (sample collection) would be unlikely to breach either of these arrangements, but large-scale collection through harvesting would require closer scrutiny.

Consideration was also given to the Southern Ocean as a global commons and its resources, the "common heritage of mankind", not unlike the situation with the deep sea bed of the high seas.

Case Studies

The first case study described the extent of some of the leads discovered by one institution - the Australian Institute of Marine Science (AIMS). The collection housed by AIMS includes 10,000 species of marine bacteria, fungi and microalgae and 12,000 species of invertebrate macroorganisms.

The presentation also introduced new terminology and a new concept: a dichotomy between *biodiscovery* (primary collection to find leads) and *bioprospecting* (looking for more of the lead material - re-collection).

Biodiscovery was considered to have the following practical applications, in addition to the ones listed above: seafood toxin testing, antifoulants, bioremediation, environmental monitoring and as research tools. The latter is a lucrative application, with some marine natural products valued extremely highly, eg. Neosaxitoxin derived *inter alia* from dinoflagellates, blue-green algae and toxic shellfish is valued at US$21,400 per milligram. In terms of supply, however, AIMS (citing Garson 1994) noted the following quantities of original material required to yield relative quantities of lead material:

ORIGINAL MATERIAL	QUANTITY YIELDED
450 kg acorn worms	1 mg cephalostatin
1,600 kg sea hares	10 mg dolastatin
2,400 kg sponge	<1 mg spongistatin
847 kg moray eel livers	.35 mg ciguatoxin

The table above highlights the importance of sustainable methods of wild harvest, chemical synthesis, aquaculture, cell and tissue culture and genetic splicing.

The AIMS presentation also considered Australian policy. Prior to 1994 the AIMS collections were undertaken in conformity with a scientific research permit and no benefit sharing was applied. Subsequent collections were subject to new permit conditions, which meant that new permits became more difficult to obtain in some jurisdictions and doubt was cast over the legal certainty of some existing collections. In addition, permit conditions restricted use. Benefit sharing also became difficult, with questions arising about a lack of process and legislative basis, who should be beneficiaries, and what exactly are the benefits? As a result, AIMS put in place best practice guidelines on these issues. In addition, the Queensland government (the Australian state in which AIMS is located) is introducing a Biodiscovery Bill into Parliament, which will provide greater clarity as to the legal obligations in this area.

The presentation on environmental aspects of bioprospecting acknowledged that many agencies expect environmental impact to occur with bioprospecting activities because historically, extracting resources from the oceans (especially fishing) has had environmental consequences. Conversely, the proponents would be inclined to see bioprospecting as posing no, or only slight, risk to the environment. It is likely that the proponents see their activities this way because they are comparing their level of activity with hyper-extractive fishing, for example. It was considered, however, that this generation of bioprospectors represent only the artisanal stage of the activity. All human activities related to ocean usage have impact. Those relating to bioprospecting will be relative to the location; the modes of transport, support and sample retrieval; the discard of unwanted material; and the nature of the target (ie. compare microorganisms with fish). The presumption that extraction of target taxa will have negligible impact is only a presumption.

There are considerable legal obligations arising from, *inter alia*, the LOSC and CBD for the protection and preservation of the marine environment, including conducting environmental evaluation of proposed activities. The take-home message was that the juridical picture is a complex one and is still evolving.

CRITICAL POINTS & CONCLUSIONS EMERGING FROM GENERAL DISCUSSION

Definitions

It became apparent from the outset that there were divergent interpretations of the critical language – "bioprospecting" and "high seas" – and, therefore, it was important to define the way in which the terms were used throughout the meeting.

- "High Seas" = LOSC definition, ie. maritime areas "outside national jurisdiction". The group also included "the Area" (ie. the deep sea bed) and the sub-sea biosphere in its discussion. There was considerable discussion about the status of the Southern Ocean. Although there are similarities between the Southern Ocean and other high seas areas, the complex legal situation arising from unproven sovereignty means that the Southern Ocean is a special case subject also to the legal regimes established within the Antarctic Treaty System.

- There was no universally agreed definition of "bioprospecting" but rather it was viewed as a broad concept embracing a number of phases of research to investigate a region's biodiversity and to collect samples of biological organisms. It was suggested that the definition be split into two discrete terms: "biodiscovery" = the first phase of scientific research into a region's biodiversity, and "bioprospecting" = the second and subsequent phases of the re-collection of biological resources for the purposes of further investigation. It was noted that the distinction may, at times, be for expedience only and that the two classes of activity may have different objectives, different outcomes, and different requirements for permit conditions and environmental reporting, for example, attached to them.

Level of Activity & Future Potential

There is already a considerable amount of marine scientific research conducted in high seas areas, including biodiscovery, and this has the potential to expand into more substantial bioprospecting activities in the future. Biodiscovery activity can be both targeted (eg. at locations such as hydrothermal vents and seamounts, or events such as the death and decay of marine mammals) and serendipitous (eg. curiosity-driven marine scientific research, by-catch).

The rich biological diversity of the high seas has the potential to yield biological products of broad ranging applicability. In particular there are unique mega-diverse areas where the biodiversity is relatively untouched. Significantly, the ratio of potentially pharmaceutically useful compounds to compounds screened is higher in marine-sourced materials. There is, therefore, a higher probability of commercial success. However, marine research is expensive, and the high cost together with difficult technological challenges of retrieving material from the deep ocean, impose significant limitations on the industry.

Spin-offs

Spin-offs include dedicated technology that is required to assist in biodiscovery. It is important to note that technology developed from high seas experiences has much wider application.

Bioresource spin offs include:

- Contributions to the store of scientific knowledge about previously unexplored regions and taxa; and
- Identification of biodiversity *hot spots*, with new information contributing to the implementation of better management strategies.

Legal Status

Except in very general terms as prescribed in the LOSC and the CBD, biodiscovery and bioprospecting in the high seas is largely unregulated. Specifically there is no clear legal regime for:

- Environmental management
- Benefit sharing (who "owns" the resources?)
- Access

Patenting is the main avenue for securing economic benefit as a return for investment. But there is a dividing line between biodiscovery, bioprospecting and the requirement to share benefits from commercialisation.

Environmental Vulnerability

There is at present no evidence that biodiscovery and bioprospecting are having any greater impact on the marine environment than any other form of marine scientific research. Currently there are greater threats to high seas biodiversity from other activities such as various technical aspects of fishing and mining. However, a precautionary approach is indicated.

CONCLUDING REMARKS

In conclusion, three ways forward were advanced:

1. The approach to conditions for access and benefit sharing must be regionally and globally consistent;
2. Sample collection and associated activities must be sustainable and subject to environmental impact assessment; and
3. In lieu of economic benefit sharing, access to data, scientific knowledge and information that reveals intrinsic values may be considered appropriate alternatives.

The high seas is a global commons and it was considered that its biodiversity could, therefore, be considered “common heritage of mankind” in similar fashion to the mineral resources of the deep sea bed.

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